IEA, Advanced Motor Fuels

Annual Report 2003

IEA Advanced Motor Fuels

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Further information on the IEA ADVANCED MOTOR FUELS Programme can be obtained from the Chairman, the Secretary or the Delegates of the Executive Committee.

Names and Addresses are given in Appendix 5 to this Annual Report 2003.

The opinions and conclusions expressed in this report are those of the authors and not of the Swedish Energy Agency (STEM).

Cover photo: Fuel Cell bus run by the Tokyo Metropolitan Government for demonstration

Updated information on IEA/AMF is found on

a) **www.iea-amf.vtt.fi**
b) **www.iea.org/impag**

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Annual Report 2003

The IEA Committee for Research and Development (CERT) has recommended that an Annual Report shall be submitted by each of the IEA Agreements on Research, Development and Demonstration Co-operation.

This document contains the Annual Report 2003 of the Executive Committee of the IEA Advanced Motor Fuels Agreement.

The contributions from the Operating Agents to this report are gratefully acknowledged.

On behalf of the Executive Committee

Steve Goguen
Chairman

Claës Pilo
Secretary

Preface

The past year has seen many developments in advanced fuels for transportation including petroleum derived fuels as well as alternative fuels. The prospect for a hydrogen-fueled future transportation system has dominated the news, and nations are pouring funding into the research and development necessary to make such a vision become a reality. In the meantime, advances in petroleum-based fuels continue. Sulfur levels are due to be reduced drastically in the US and elsewhere. Canadian oil sands production is ramping up to very meaningful levels and might provide some relief from the dependence on the more traditional sources of petroleum. At the same time, oil exports from Russia are beginning to make a difference on the balance of imports, especially in the west. The AMF Implementing Agreement continues to keep pace with the world developments and to coordinate its research activities to suit the topical matters of the most current and important topics of the day.

The 2003 Executive Committee meeting was held in Paris in March. Representatives of nine of the ten AMF countries were present. This was an active meeting with the committee hearing progress reports on seven existing annexes and proposals for five new annexes. In committee actions, a Phase 2 for Annex XXVII – Standardization of Alternative Fuels was accepted and authorized, and three other proposers were asked to finalize their proposals and submit to the committee members before the next ExCo meeting. One of these proposals deals with the question of where the hydrogen will come from for transportation if the process for producing hydrogen must meet the criteria of zero impact on CO_2 and toxic emissions. The committee wishes that this particular annex proposal should be co-sponsored by other implementing agreements such as the Hydrogen, Advanced Fuel-Cells, Bioenergy, and Hybrid and Electric Vehicles agreements.

To foster this cooperation among implementing agreements, a separate meeting after the ExCo meeting was held at IEA headquarters with representatives of the other relevant implementing agreements. The purpose was to discuss this proposal and assess the interest of the other implementing agreements in participating with AMF in this annex. Out of this activity a new proposal will be prepared for the next AMF ExCo meeting.

The end-of-term report and new strategic plan for the next five years for the AMF must be completed in draft form before the next ExCo meeting. Dr. Claës Pilo will draft the end of term report and to help with the drafting of the strategic plan. Others will provide assistance as needed. Dr. Nils-Olof Nylund will lead the effort to draft a new strategic plan before the next meeting. The strategic plan will address various aspects of the operation of the AMF, from management issues to those dealing with the questions of which are the most appropriate technologies to pursue. Cooperation with other organizations will be stressed, including other IEA implementing agreements, the European Union, the standardization organi-

sations ISO and CEN, and other appropriate organizations in North America and Japan.

The committee elected Mr. Steve Goguen of the US Department of Energy (DOE) as Chairman of the AMF for the next two years and Dr. Nils-Olof Nylund, VTT, and Mr. Shigeaki Tonomura, NEDO, as vice chairmen for two years. The committee also re-elected Dr. Claës Pilo as Secretary to the Executive Committee.

It was agreed that the 29th meeting of the AMF ExCo will be held in Sweden in January 2004. The 30th ExCo meeting will be either in the UK or the US in late 2004.

The chairman wishes to thank all the participants for their efforts on behalf of the committee, and special thanks are in order for Mr. Thomas Howes, the Desk Officer at IEA, for Dr. Claës Pilo for his continuing service as the ExCo secretary, and for Dr. Nils-Olof Nylund for all of his service over the years as Chairman of the AMF ExCo.

Steve Goguen

Chairman of the Executive Committee
IA on Advanced Motor Fuels

1. Positioning the IEA Advanced Motor Fuels Programme

Road traffic is predominantly fuelled by gasoline and diesel, both fuels being produced from crude oil. During the past decades, there have been many different reasons to address automotive fuels. The International Energy Agency was established in 1974, following the first oil crisis. In that period, security of oil supply was the main concern. It spurred exploration activities outside the Middle East, to become less dependent on just one region for oil supply. It was also the time when the search for alternative energy carriers started. Fears about acid rain and smog were also emerging in the 1970s, and so environmental concerns gave additional impetus to exploring the possibilities of alternative fuels like natural gas, methanol, ethanol and biodiesel. Ethanol and biodiesel can be produced from biomass, so agricultural employment also became a supportive factor for alternative automotive fuels. Whilst the introduction of the exhaust catalyst has significantly reduced vehicles' emissions and the differences in emissions between conventional and alternatively fuelled vehicles have decreased, additional concerns have emerged. The combustion of oil and other fossil fuels results in carbon dioxide emissions (a greenhouse gas) causing concern for climate change. Shifts to other energy carriers – like natural gas and renewables – are therefore under investigation. The fact that oil reserves are finite and that they are consumed at an increasing rate is an additional driving force to look for alternatives.

Developments in vehicle engines have also influenced developments in automotive fuels. Exhaust catalysts – and especially particulate filters – require fuels that are low in sulphur content, to extend the life of these exhaust purifiers. Examples of engine parameters that put demands on fuel composition are: compression ratio, fuel injector design and the type of combustion process. Technical developments changing these parameters require the composition of the conventional fuels gasoline and diesel to evolve in time, and they are also important for alternative fuels. Today's gasoline and diesel composition is quite different from that of twenty or even ten years ago.

The automotive industry is constantly working on improving its products. For internal combustion engines this means increasing specific power output and simultaneously improving energy efficiency, while still lowering harmful emission levels. Currently, engine developments are for example on variable valve timing, increasing the amount of exhaust gas recirculation and improving of the combustion process. These developments influence future fuel composition.

Striving for further reductions in energy consumption and emissions, new propulsion concepts are being investigated. Two examples are the homogeneous charge compression ignition (HCCI) engine and the fuel cell. Such concepts each pose their own requirements on fuel characteristics. They may require an advanced conventional fuel or an alternative fuel. In contrast to putting requirements on fuel specifications, new propulsion concepts also may ease the introduction of an alternative fuel. Other, non-technical aspects influence motor fuel requirements as well, such as safety, legislation and developments in fuel production technology.

The attention for fuel cell vehicles is increasing rapidly, although it might be 2010 or even later before they will be a commercially viable option on the market. All large automakers have prototype fuel cell vehicles in their R&D programmes. Just some examples are DaimlerChrysler, Ford, General Motors, Honda and Toyota, who are all working on fuel cell passenger cars. Fuel cells are also under consideration for propelling heavy-duty vehicles. In the CUTE project (Clean Urban Transport for Europe) for example, fuel cell buses will be tested in nine European cities, starting in 2003. Fuel cells need hydrogen as a fuel. A hydrogen refuelling infrastructure does not exist yet, but the first prototype refuelling stations are in operation in Germany, Japan and in the USA. Another option is to produce hydrogen on board the vehicle from another fuel, using a fuel converter. These converters are still in an early stage of development, but hydrogen production from liquid and gaseous fuels like gasoline, ethanol, methanol, natural gas, propane, butane and diesel has been shown. Additional research is needed to increase conversion efficiency and to make fuel converters economically feasible. An example, indicating that industry is taking hydrogen seriously, is the establishment of the Clean Energy Partnership in Berlin, June 2002. In this partnership vehicle manufacturers (BMW, DaimlerChrysler, Ford, MAN and Opel) co-operate with an oil company (Aral) and miscellaneous other partners (BVG, GHW and Linde)* with the aim to demonstrate pioneering technologies and practical applicability of alternative energy, primarily hydrogen, on the road. An important goal is to verify the positive impact of the fuel on the environment, compared to conventional fuels.

The use of renewable fuels from biomass is increasing, although this is hardly visible for the consumer. In the USA for example, ethanol that is produced from agricultural products is blended up to 10 % in gasoline. Production capacity for biofuels is increasing in the USA. In the state of Iowa for example, additional plants to produce ethanol from corn are under construction. In Europe an EU directive was passed in 2003 where member states have to present plans for the introduction of renewable motor fuels. A market share of 2 % is recommended for the year 2005 and almost 6 % in 2010.

The role of gaseous fuels in automotive propulsion is increasing. Just some examples from all over the world are: Germany is rapidly building a natural gas refuelling infrastructure; Isuzu in Japan started developing a prototype natural gas truck; in Delhi (India) the bus and taxi fleets are being converted to natural gas and in Bangkok (Thailand) tuc-tucs (three wheeled rickshaw scooters) have been converted to run on LPG. AMF, so far only with members from industrialized countries, has started to investigate the possibilities to co-operate with developing countries and would like to welcome them as members of this agreement.

To reduce oil dependency and to make exploitation of remote natural gas fields economically feasible, GTL-fuels (gas to liquids) are gaining interest. Fischer-Tropsch and similar synthesis processes are being used in pilot plants to produce very clean grades of hydrocarbons from natural gas. When used in pure form, these fuels result in reduced levels of harmful engine emissions. Additionally,

* BVG = Berliner Verkehrsbetriebe
GHW = Gesellschaft für Hochleistungselektrolyseure zur Wasserstofferzeugung mbH

because GTL-fuels do not contain any sulphur, vehicle exhaust catalyst life increases substantially. GTL-fuels are currently being blended in low grade petroleum fuels to meet (for example Californian) fuel specifications.

Research on adverse health effects from road traffic continues to add knowledge and further improves insight in mechanisms that occur. Now, that particulate emissions (black smoke) from new diesel vehicles on the market go down steadily, research moves on to investigate the effects of ultra fine particulates.

These examples show that a lot has been achieved by improving motor fuels and engine performance but also that we are facing many new challenges. Results from the past give confidence that humanity will come up with solutions for current problems as well. The Implementing Agreement on Advanced Motor Fuels is dedicated to contribute positively to these developments.

Industries, research institutes and governmental agencies all over the world are pursuing these developments. Keeping abreast of all that is going on across the planet can be difficult and costly. To avoid duplicating pre-competitive research and to save on individual efforts and costs, parties find it useful to join an international engine performance but also collaborative research, development and demonstration, such as the IEA's Implementing Agreement on Advanced Motor Fuels.

2. How to Join the AMF Programme?

A number of IEA Member countries have found it efficient and cost effective to co-operate on research, demonstration and exchange of information regarding Advanced Motor Fuels (AMF) to develop new and improved technologies and facilitate their introduction into the market.

This collaboration programme takes the form of an *Implementing Agreement* under the legal guidance of the International Energy Agency (IEA). All countries concerned about energy and environment in the transport sector, whether or not they are members of the IEA, are welcome to join this international effort and share this experience.

The participating governments designate a government organisation or a private entity (industry) as their representative to the Programme.

The Advanced Motor Fuel collaboration programme was launched with 5 participating countries in 1984. Today 10 countries are involved in the Programme and form a very interesting and efficient network.

France joined the Advanced Motor Fuels collaboration programme in 2000, Denmark in 2001, and Spain in 2002.

The following countries and designated bodies are active today.

Canada	Department of Natural Resources Canada
Denmark	Technical University of Denmark (DTU)
Finland	Technical Research Center of Finland (VTT)
France	Agence de l´Environnement et de la Maîtrise de l´Energie (ADEME)
Italy	AgipPetroli Centro Ricerche EURON
Japan	New Energy and Industrial Technology Development Organization NEDO)
	Organization for the Promotion of Low-Emission Vehicles (LEVO)
Spain	Institute for the Diversification and Saving of Energy (IDAE)
Sweden	Swedish Energy Agency (STEM)
UK	Department for Transport, Local Government and the Regions (DTLR)
USA	US Department of Energy (DOE)

Those interested to participate as Observers at the meetings of the AMF Executive Committee (see para. 3.7) with the intention of joining the programme are welcome to contact the IEA/AMF secretary Claës Pilo, SDAB Transport & Environment, Karlavägen 93, SE-115 22 Stockholm, Tel +46 8 15 11 90, Fax +46 8 15 11 91, E-mail pilo.sdab@swipnet.se

3. The Implementing Agreement and the AMF Programme

(Status December 2003)

3.1 Strategic Plans

A first strategic plan was prepared in 1995. A second "Strategic Plan for 1999–2004" was adopted in October 1998. By the end of 2002 work has started to develop a new Strategic Plan.

3.2 Change of the Name

In 1984 the "Implementing Agreement for a Programme of Research, Development and Demonstration on ***Alcohol and Alcohol Blends as Motor Fuels (AMF)***" was signed in Paris. During the first period 1984–1990 the Agreement focused on alcohols (such as methanol, ethanol, and higher alcohols) and related oxygenated hydrocarbons (such as MTBE, and ETBE).

In 1990 it was broadened to address also other alternative motor fuels and was renamed "Implementing Agreement for a Programme of Research, Development and Demonstration on ***Alternative Motor Fuels (AMF)***".

Following the proposals in the "Strategic Plan for 1999–2004" the name was changed in October 1998 to "Implementing Agreement for a Programme on Research and Demonstration of ***Advanced Motor Fuels (AMF)***."

3.3 Objectives

Every new fuel has impacts on the whole fuel chain, on feedstock, fuel processing, fuel distribution and end-use including environmental impacts and possible vehicle modifications. It is therefore necessary to have a good understanding of the whole complex system when choosing future fuel options.

The objective of the Advanced Motor Fuels collaboration programme is to deal with such aspects by co-operation on research and demonstration, by exchange of information and creation of a network of experts in the field of advanced motor fuels. Participants are concerned about emissions, energy efficiency, field trials as well as system aspects (such as the CO_2 issue). The AMF collaboration programme forms a suitable platform for co-ordinated efforts on an international level to evaluate new fuel options where experts in Advanced Motor Fuels share experiences and results of their endeavours.

The emphasis of the present "Strategic Plan for 1999–2004" is on "Demonstrations" and "Preparations for Market Introduction" as we are approaching the market readiness. Co-operation with industry is also emphasised and encouraged.

Participants in the Programme welcome the submission of proposals for exploratory projects on fuels and emission control in areas such as road transport, other transport modes, off-road vehicles and other working machines, lubricants and standardisation of fuels, components and tests.

3.4 Advanced Motor Fuels

Fuels included under the definition of advanced motor fuels are fuels that fulfil one or more of the following criteria:

- Low toxic exhaust emissions
- Improved life cycle efficiency
- Reduced greenhouse gas emissions
- Renewable energy sources
- Fuels for new propulsion systems

Advanced motor fuels currently studied in the framework of the AMF Programme are:

- Alcohols (ethanol, methanol), ethers (DME, ETBE, MTBE, etc), esters (RME, etc), gaseous fuels (natural gas, biogas, hydrogen, LPG, etc).
- Reformulated gasolines and reformulated diesel fuels, including oxygenated versions.
- Of special interest is the use of such fuels as energy/hydrogen sources in fuel cells and new types of engines.

3.5 Projects/Annexes

Altogether, nineteen collaborative projects (Annexes) have been completed (Annexes I – XXI, see Attachment 1) since the programme began in 1984 and six others are presently running (see Chapter 4).

3.6 Participating Countries

Presently, ten countries participate in the IEA collaboration on advanced motor fuels:

Canada, Denmark, Finland, France, Italy, Japan, Spain, Sweden, United Kingdom, and United States.

Each participating country has designated one Contracting Party to sign the Implementing Agreement (IA), except Japan that has designated two Contracting Parties (NEDO and LEVO).

One Delegate and one Alternate represent each Contracting Party in the Executive Committee.

3.7 Executive Committee and Secretariat

The practical work within the IA is co-ordinated by an Executive Committee (ExCo). The ExCo of the IA on AMF is an active and authoritative group of persons, representing independent organisations. Thus, it is possible to supply governments participating in this IA with the results of studies that are objective and not coloured by industrial or political interests.

The Executive Committee meets each 9–12 months in different participating countries, reviews the progress and results of Annexes, approves new Annexes as proposed by participants, and determines other specific activities.

An IEA/AMF Secretariat assists the Executive Committee in planning meetings, initiating new Annexes, assisting Operating Agents, providing information to the IEA Secretariat, disseminating information and responding to member's inquiries.

3.8 Recent Initiatives

During its last meeting in March 2003 in Paris the Executive Committee took a number of initiatives.

- Steve Goguen, USA, was elected Chairman
- Two Observers were present (from CEN and EUWP)
- Work on a new Strategic Plan 2005–2009 will be started
- Work on an End-of-Term Report for the period 1999–2004 will be started
- USA was welcomed as Participant in Annex XXVII on standardization
- A Phase 2 of Annex XXVII was started
- Four preliminary proposals for new Annexes were presented
- One of these preliminary proposals being a Joint Annex with other Implementing Agreements
- Decision was taken to use common funds for a number of specific purposes

3.9 IEA/AMF on Internet

Updated information on IEA/AMF is found on

a) www.iea-amf.vtt.fi

b) www.iea.org/impag

4. Running Projects/Annexes

(Status December 2003)

Table 1. Running Projects/Annexes

The following six projects/annexes are presently running.

Annex	Title	Run time	Operating Agent	Participating Countries
Annex XVI	Biodegradable Lubricants	1998 – 2003	DTU (DK)	6
Annex XXII	Low Temperature Particles	2000 – 2003	VTT (FIN)	6
Annex XXIV	Information Exchange IEA AMF/AFIS	2000 – 2004	Innas (NL)	11
Annex XXV	Non-Road Engines	2001 – 2003	VTT (FIN)	4
Annex XXVI	Oxygenates in Diesel	2002 – 2004	Befri (S)	4
Annex XXVII	Standardisation of Alternative Motor Fuels Phase 1 Phase 2	 2002 – 2003 2003 – 2004	Atrax (S)	 6 4

Table 2. Running Projects/Annexes

Participation and financial commitments are shown in the following table.

Annex	Participating Countries and their Contributions *Œ denotes the Operating Agent. Amounts are given in 1 000 USD.*												
	B	**CDN**	**DK**	**ES**	**FIN**	**FR**	**I**	**J**	**NL**	**S**	**UK**	**US**	**Total**
XVI Biodegradable Lubricants			Œ 62.7		27.7		20	20	7.7	27.7		32.7	198.5
XXII Particle Emissions		22.5			Œ 91.5		22.5	22.5		28.5		22.5	210
XXIV Information Exchange IEA AFIS	X	X	X	X	X	X	X	X	Œ X	X	X	X	58
XXV Non-Road Engines					Œ 60	20				20		20	120
XXVI Oxygenates in Diesel		10					10	10		Œ –	10		40
XXVII Standardisation Alt Motor Fuels										Œ			
Phase 1		8			10	15		15		15		14	77
Phase 2		17						14		17		17	65
TOTAL													**769**

5. Progress Reports by the Operating Agents

(Status December 2003)

5.1 Annex XVI Environmental and Economical Aspects of Implementing Biodegradable Lubricants in Vehicle Engines

Operating Agent	Technical University of Denmark (DTU), Denmark
Project Duration	Phase 1: 1998-2000 Phase 2: 2000-?
Status/Schedule	Phase 1: Completed Phase 2: Active since January 2000
Participants	Phase 1: DK, FIN, NL, S, USA (5 countries) Phase 2: DK, FIN, I, J (LEVO), S, USA (6 countries)
Total Budget	Phase 1: USD 48 500 Phase 2: USD 150 000
Project Leadership	Prof. Jesper Schramm Technical University of Denmark Bldg 403 DK-2800 Lyngby Phone: +45 4525 4179 Fax: +45 4593 0663 E-mail: js@mek.dtu.dk

Background

Recently there has been increased interest in extending the use of biodegradable vegetable oils in lubricants, driven mostly by environmental as well as health and safety issues, and also arising from changes in economic and supply factors. There is a plentiful supply of vegetable oils in many parts of the world where mineral oil is expensive and in short supply. Biodegradable synthetic esters are used to a wide extend in outboard two-stroke engines, and also for other more specialised engines.

Biodegradable oils are desirable from many environmentally beneficial aspects, being advantageous from the viewpoint of oil spill or illegal waste and improved working environment in workshops.

Lubricants cause part of the emissions from vehicle engines. From the viewpoint of emissions, biodegradable lubricants are expected to behave differently from con-

ventional lubricants, particularly with respect to SOF emissions (Soluble Organic Fraction of particulate emissions). Vegetable oils do not contain polycyclic aromatic hydrocarbons, posing a great risk to human health. Vegetable oils are also low in potential pollutants like sulphur containing compounds. Sulphur containing compounds are in many cases environmentally undesired, but may also cause technical problems in connection with catalytic converters.

Objectives

The objectives of the project are to obtain an understanding of:

- lubricant characteristics
- presently available biodegradable lubricants on the international market
- the economical feasibility of implementing biodegradable lubricants in vehicles.
- the environmental consequences of implementing biodegradable lubricants in vehicles

Biodegradable lubricants are investigated by studying literature and taking contact directly to people involved with these lubricants in Phase 1 of this project. The purpose of Phase 2 is to investigate relevant biodegradable lubricants experimentally, in order to obtain a more quantitative estimate of the environmental benefits of implementing biodegradable lubricants for automotive purposes. This work is important since the results of Phase 1 of this project revealed that there is very little experimental information about emissions from biodegradable lubricants when applied to combustion engines. Biodegradability of used biodegradable lubricants is another unexplored topic.

Content of Work

Phase 1

Review of lubricant characterisation

In this part lubricant properties will be explained, based on a collection of information from relevant literature and experts in this field. Most emphasis will be put on biodegradability properties and test procedures.

Review of available biodegradable lubricants on the market

In this part the available biodegradable lubricant products will be summarised, based on a collection of information from relevant literature and experts in this field.

Economical feasibility study

In this part the economical feasibility of implementing biodegradable lubricants on engines running on conventional as well as alternative fuels will be evaluated,

based on a collection of information from relevant literature and experts in this field.

Environmental impact study

In this part the environmental impact of implementing biodegradable lubricants on engines running on conventional as well as alternative fuels will be evaluated, based on a collection of information from relevant literature and experts in this field.

Phase 2

Emission measurements on chassis dynamometer

In this part emission measurements on chassis dynamometer will be carried out. The purpose of these measurements will be to compare the emissions of CO, CO_2, NOx, THC, PM, lubricant-SOF and PAH from one compression ignition engine vehicle and one spark ignition engine vehicle using biodegradable lubricants and conventional lubricants. Lubricant consumption and energy consumption are other important parameters that will be estimated during the experiments. The CI engine vehicle will be running on ordinary diesel fuel and biodiesel, and both fuels will be tested with a reference lubricant and a biodegradable one. The SI engine vehicle will be running on ordinary gasoline fuel and alcohol, and both fuels will be tested with a reference lubricant and a biodegradable one. The driving patterns that will be applied in these experiments are the USA and EU test cycles.

Biodegradability test of new and used lubricants

Since the biodegradability of lubricants changes with age, it will be necessary to measure this change during the vehicle tests, carried out in activity 1, in order to obtain a full picture of the environmental impact of implementing biodegradable lubricants.

Reporting

In this activity the results of the emission test in activity 1 will be evaluated together with the results of the biodegradability test in activity 2. A detailed discussion will be carried out and conclusions will be drawn regarding the emissions from vehicles using biodegradable lubricants. A detailed discussion with conclusions regarding biodegradability of new and used lubricants will be carried out as well. The future of biodegradable lubricants for engine applications will be evaluated based on the test results obtained.

Administration

This part concerns the practical administration of the project.

Financial Status

Phase 1:

DK	12 700
FIN	7 700
NL	7 700
S	7 700
USA	12 700
TOTAL	USD 48 500

Phase 2:

DK	50 000
FIN	20 000
I	10 000
J	20 000
S	20 000
USA	20 000
TOTAL	USD 140 000

Results and Future Plans

Phase 1 is finished and a report was published December 1999.

In Phase 2 the CI engine vehicle experiments have been carried out and a final report was published in 2003. The SI engine vehicle experiments have been carried out as well, and a draft report will be presented at the next ExCo meeting in January 2004. When this final report is approved the annex will be closed.

5.2 Annex XXII Particle Emissions at Moderate and Cold Temperatures Using Different Fuels

Operating Agent	VTT Processes, Finland
Project Duration	June 2000 – June 2003
Status/Schedule	Active
Participants	CDN, FIN, I, J (NEDO, LEVO), S, USA (6 countries)
Total Budget	USD 210 000
Project Leadership	Ms. Päivi Aakko Technical Research Centre of Finland (VTT) P.O. Box 1601 FIN - 02044 VTT Phone: +358 9 456 5757 Fax: +358 9 460 493 E-mail: paivi.aakko@vtt.fi

Background

There is a great interest in particulate emissions of road traffic all over the world. So far most of the research work on particulate emissions has been carried out at normal ambient temperature. Even a slight reduction in temperature will increase particulate emissions. In real-life the average day temperatures, especially in the winter season, are far below the "normal" temperature (about +23 °C) of the exhaust emission test procedures.

For many years it has been obvious that the knowledge of the total particulate mass emissions is not enough. Quality of these particulates, especially polyaromatic hydrocarbons and the mutagenicity effect, has already been studied widely. Now there is also need to have more information on the fine particles, which can penetrate the lungs more easily. Research work on the particle size distribution is still in the early phase. Discussion and research work is going on about the correct sampling conditions, correct method to present the results etc. It is not even clear, whether the particle number or mass distribution is more determining. So far, the possible effect of temperature on particle size distributions has not been studied.

The project is targeted to cover different fuel and engine technologies, including gaseous fuels and biodiesel. In that respect, the work is continuation of Annex V (VTT) and XIII (ORNL and VTT) and also Annex XII (UK).

Objectives

The objective of the task is to produce new particulate emission data in "off-cycle" conditions with a variety of engines and fuels. The task will demonstrate the effect of temperature on particulate emissions including the assessment of the particle size and number distribution of alternative fuels in comparison with conventional and improved fuel qualities at different test temperatures.

Content of Work

Research work will be focused on different light-duty technologies. The tests with a medium-duty engine at low test temperatures are preliminary tests to evaluate the suitability of different measuring techniques.

The test fuel matrix includes European diesel fuel, a bled of European diesel fuel and RME, European grade gasoline, E85 (or M85), CNG, and LPG. The test engine/vehicle matrix includes a medium-duty diesel engine, a light-duty turbocharged direct injection diesel vehicle equipped with EGR and oxidation catalyst, a light-duty indirect injection vehicle with oxidation catalyst, a light-duty spark-ignition gasoline fuelled vehicle, a light-duty direct-injection gasoline fuelled vehicle, a light-duty CNG fuelled vehicle, a light-duty LPG fuelled vehicle and a light-duty E85 (or M85) fuelled vehicle. A DME vehicle will be included on the condition that it is available. The tests with the medium-duty diesel engine and with the light-duty diesel vehicles will be carried out with the European grade diesel fuel and a 30 % blend with RME.

The tests with the medium-duty engine will be carried out at selected loads. The tests with light-duty vehicles will be carried out with the European exhaust emission test cycle and selected tests also with the Japanese test cycle. The measurements will be carried out at moderate temperature (+5 °C), at low temperature (–7 °C) and for comparison also at normal test temperature (+23 °C).

The regulated gaseous emissions (CO, HC, NOx), total particulates and aldehydes (formaldehyde, acetaldehyde) will be measured. In addition, specified hydrocarbons will be measured with the light-duty vehicles. However, the main attention is given to particulate size distribution measurements with the Electrical Low Pressure Impactor (ELPI), which gives real-time information of both number and mass distribution of particles. ELPI equipped with so called "Filter stage" gives information of the particle sizes down to 8 nm almost real-time. Thus it will be seen how the particle number distribution changes when the engine is started and after that in selected time intervals. The gravimetric method with a low-pressure impactor (LPI) will be used to determine mass distribution results. A tapered element oscillating microbalance (TEOM) will be used in the medium-duty tests. Considerable amount of work is needed to select the suitable measuring conditions for each engine/vehicle. For example, the particle mass distribution measurement requires a collection time high enough for gravimetric determination but not so high that the particles would start "bouncing".

Funding

Canada	22 500
Finland	91 500
Italy	22 500
Japan	22 500
Sweden	28 500
USA	22 500
TOTAL	USD 210 000

Results and Reports

The effect of temperature was dependent on the engine technology. Significant increase in particle mass and number emissions was seen with some technologies when –7 °C temperature was compared to normal test temperature. Some engine technologies were rather insensitive to ambient temperature, e.g. the CNG car did not show any significant particle emission at normal or low temperatures.

If an increase in particle emissions was seen, it typically appeared immediately after the cold start. Ambient temperature had only a minor impact on the performance of a warmed-up engine. In some cases RME indicated more particles and/or a shift to lower mean diameter at low temperatures after the cold start than in the tests at normal temperature.

A number of reports have been prepared (see Appendix 3).

5.3 Annex XXIV Information Exchange IEA AMF/AFIS

Operating Agent	Innas BV, Breda, the Netherlands
Project Duration	2000–2004
Status/Schedule	Active
Participants	All countries (10)
Total Budget	USD 42 000 for the first three years Plus € 14 000 for the fourth year Paid by the AMF Common Fund
Project Leadership	Mr. Martijn van Walwijk Innas BV Nikkelstraat 15 NL 4823 AE Breda The Netherlands Phone: +31 76 5424 080 Fax: +31 76 5424 090 E-mail: mvwalwijk@innas.com

Background

Under the previous Annex IX –which terminated in June 1999- an information service called IEA AMF/AFIS (IEA Automotive Fuels Information Service) was set up and operated. IEA AMF/AFIS produced five volumes of the 'Automotive fuels survey' for AMF, and worked in parallel for third parties under separate contracts. During their meeting in June 1999, the participants in the AMF ExCo expressed that a continuation of the information service IEA AMF/AFIS under the auspices of the Implementing Agreement was desired. This annex forms that continuation.

Objectives

The objective of the annex is to produce three newsletters and to provide an institutional framework for the continuation of IEA AMF/AFIS as a service for third parties.

Due to its nature of being a low budget annex, this annex can help lowering the threshold for other countries to join the AMF Implementing Agreement.

Results

Each year three annual newsletters on automotive fuels are produced. The newsletters describe the latest worldwide developments on automotive fuels, with emphasis on activities that are covered by the Advanced Motor Fuels Implementing Agreement.

5.4 Annex XXV Fuel Effects on Emissions from Non-Road Engines

Operating Agent	VTT Processes, Finland
Project Duration	May 2001 – Mid 2003
Status/Schedule	Active
Participants	FIN, FR, S, USA (4 countries) Industrial partners: Fortum Oil and Gas Oy (fuels), Ecocat (former Kemira Metalkat Oy) (catalysts), Sisu Diesel Oy (CI engines) Also financial support from the industrial partners
Total Budget	USD 120 000
Project Leadership	Mr. Timo Murtonen Technical Research Centre of Finland (VTT) P.O. Box 1601 FIN - 02044 VTT Phone: +358 9 456 787 56 Fax: +358 9 460 493 E-mail: timo.murtonen@vtt.fi

Background

The emission regulations for non-road engines are less stringent than for on-road applications. A diversification of automotive diesel fuel and heating oil has started. As aromatics and sulphur is reduced in automotive diesel, it is expected that the aromatics and sulphur content of heating oil will not be reduced or might even increase. Some additives like cetane enhancers and lubricity additives might be left out of heating oils.

The engines used in hand-held equipment like chain saws and trimmers and also in equipment like lawn movers are quite simple, and therefore the specific emissions are extremely high compared for example with modern catalyst equipped gasoline cars. The emissions from small engines can be reduced by improving fuel quality and also by applying simple exhaust after-treatment systems. People using these small engines are normally subjected to the exhaust fumes. Therefore there is also in this case a clear concern for occupational safety.

This project recognizes the current international developments on the issue of fuels for and emissions from non-road engines, and also responds to the Strategic Plan on IEA AMF.

Objectives

The main objective is to produce a document on the effects of fuel quality and exhaust gas after-treatment on emissions from non-road machinery, both diesel and gasoline powered engines. On the international level, new emission regulations and fuel specifications for non-road machinery are under discussion. It is in the interest of the international community to stimulate a positive development in the reduction of emissions also from non-road machinery.

Due to the vivid ongoing discussions, the results of the study should be made available publicly as soon as possible. In addition to the conventional way of reporting, the results will also be made available over the IEA AMF web pages, the IEA AFIS Fuels Update newsletter and in technical conference papers.

Content of Work

The work will include experimental work with different combinations of engine, exhaust gas after-treatment and fuel. The work will cover both compression and spark-ignited engines. The main fuel parameters to be varied are fuel sulphur content and content of aromatic compounds.

In addition to the experimental work, the reporting will also cover work that already has been published. Such material is available from studies in Finland, and this information will be translated into English and used in the reporting.

The activities of the project is divided into three parts:

- Summarizing and processing existing information (literature review)
- Experimental work on diesel engines
- Experimental work on small gasoline engines

Diesel engines:

Two non-road diesel engines representing different levels of sophistication will be tested for exhaust emissions in an engine test bed. The engine versions are:

- turbocharged diesel engine, pre-EU Stage 1 emission level (“old engine”)
- turbocharged and after-cooled diesel engine, EU Stage 2 emission level (“advanced engine”)

The fuel matrix contains five fuel qualities, sulphur content being the main variable:

- Reformulated high quality automotive diesel (S< 50 ppm, EUD 2005)
- Automotive diesel fulfilling the EU year 2000 specifications (S< 350 ppm, EUD 2000)
- Biodiesel 1 (mixture of reformulated high quality automotive diesel and RME) 5 %
- Biodiesel 2 (mixture of reformulated high quality automotive diesel and RME) 30 %
- Light fuel oil (S ≅ 2000 ppm, DS 2000)

The engines will be tested for regulated exhaust emissions (gaseous and particulate mass emissions) according to the ISO 8178 standard. In addition, the following special emission measurements will be carried out:

- Smoke number
- Particulate phase PAH content
- Mutagenicity of the particulate phase
- Particle size distribution

The EU Stage 2 emission level engine will be tested also with an oxidation catalyst with two different fuels.

Small gasoline engines:

Within this part two small spark ignited engines will be tested:

- Air cooled two-stroke engine (chain saw or trimmer, "2 stroke air-cooled")
- Air cooled four-stroke engine (lawn mover or generator, "4 stroke air-cooled")

The air-cooled engines will be tested in a test rig.

Three fuel options will be tested:

- Gasoline fulfilling the EU year 2000 specifications (S< 150 ppm, EUG 2000)
- Special alkylate gasoline for small engines (S< 100 ppm, SEG)
- Alkylate gasoline with oxygenate (S< 100 ppm, SEGO)

If possible, the emission measurements for the small engines will be carried out according to the same scheme as for the diesel engines. When evaluating the particulate emissions, the particulate phase PAH and mutagenicity will be studied.

Funding

	USD
Nat. Technology Agency Tekes	25 000
Fortum Oil and Gas	15 000
Sisu Diesel	2500
Ecocat (former Kemira Metalkat)	4 500
VTT Processes	13 000
Total Finnish contribution	60 000
IEA Contribution (3 countries à 20 000 USD each)	60 000
France (confirmed)	
Sweden (confirmed)	
USA (confirmed)	
Grand Total	120 000

Results and Reports

The Annex came active in May 2001 and was completed in the summer 2003. Existing data have been put on the IEA AMF web site since autumn 2001. Monitoring the literature for relevant studies will continue through out the whole Annex.

The experimental work (base matrix) was completed in 2002. Measurements with small engines were done in the engine laboratory of Agricultural Engineering Research (Vakola, Finland). The experiments with diesel engines were carried out in VTT's facilities. In the autumn 2002, an interim report was published, and is available on IEA AMF web pages. The last measurements were done in December 2002.

The final report was published in June 2003. The public version of the final report can be downloaded on IEA-AMF web pages:

(http://www.vtt.fi/virtual/amf/annex_xxv/reports.htm)

5.5 Annex XXVI Evaluation of Practical Expericences of ongoing Projects around the World using Alcohols/Ethers as Oxygenates in Diesel Fuels

Operating Agent	Befri Konsult, Sweden
Assistant	SDAB Transport & Environment, Sweden
Project Duration	Two years
Status/Schedule	Started in 2002
Participants	CDN, I, J (NEDO, LEVO), UK (4 countries)
Total Budget	USD 40 000
Project Leadership	Mr. Rolf Berg Befri Konsult Hantverkaregatan 25 SE-252 26 Helsingborg Sweden Phone: +46 70 634 63 71 Fax: +46 42 24 06 51 E-mail: befrikonsult@netscape.net

Background

Because vehicles with diesel engines are more efficient than spark ignited gasoline engines this type of engines is becoming more usual not only in heavy-duty vehicles but also in private cars. This means that the use of diesel engines will increase and as they have higher emissions of particulates and nitrogen oxides they will contribute more to the air pollution than the gasoline engines do.

As the world will live with this kind of engines for a very long time before new systems such as fuel cells take over it is necessary to develop not only the diesel engines but also the diesel fuels.

Preliminary tests with alcohols/ethers added as oxygenates to existing diesel fuels, in existing diesel engines, show that particulate and nitrogen oxide emissions are reduced.

Use of fossil fuels as diesel also results in emissions of greenhouse gases (GHG). By substituting renewable alcohols/ethers for fossil diesel oil it is possible to reduce the GHG emissions. Use of additives produced from renewable raw materials could further decrease the GHG emissions.

Many projects with alcohols/ethers blended in diesel fuels have been carried out and more are on the way.

Both Australia and Sweden have reported trials with an emulsion of 15 % ethanol, 84 % diesel and an emulsifier. United States have tested different additives to keep ethanol in blend with diesel fuels and Brazil has made similar tests.

Swedish as well as US companies are now developing additives and working on how to make diesel-alcohol blends profitable and report they are close to success. Different types of additives have been used as well as different kinds of diesel fuels.

Tests have also been made in Finland, France, Thailand, and UK and are about to start in Canada, India, and Mexico.

To achieve an overview of ongoing projects around the world using alcohols/ethers in diesel fuels, it is proposed to start the annex by a survey (through literature and contacts) summarizing recently reported and ongoing tests and then specifying:

- Type of diesel fuel
- Type of alcohol
- Type of ether
- Type of additive

Purpose of the Project

By collecting data from ongoing and reported tests and projects and systematically compare them, we will try to get a picture of today's practical results and experiences of using alcohols/ethers as components in existing diesel fuels for existing diesel engines. This study of options that have reached commercially maturity is complementary to Annex XVIII "Greener Diesel Fuels" where scientific data are produced from laboratory tests.

The results of the proposed project will be valuable in guiding future research and development of oxygenates for diesel fuels.

Objectives

- Identification of the following parameters of the blends:

Type of	Diesel Alcohol (ethanol, methanol, higher alcohols, hydrous, anhydrous, etc) Ether (DME, MTBE, etc) Additives
Composition	Amount of alcohols Amount of ethers Amount of additives

Properties	Density
	Cetane number
	Cetane index
	Vapor pressure
	Viscosity
	Flash point
	Cloud point
	Sulfur content
	Aromatics
	Lubricity
	Water tolerance
	IBP (Initial Boiling Point)
	FBP (Final Boiling Point)
	Cold flow
	Energy content

The methods (ASTM, etc) to measure the above listed properties will be reported together with the results.

- Miscibility of alcohols or ether with different kinds of diesel fuels and additives
- Emissions from vehicles running on blended fuels
- Reduction of GHG
- Fuel consumption
- Drivability of vehicles used in test fleets
  (Torque and power compared to running on neat diesel fuel)
- Biodegradability of blended fuels
- Results from toxicity and health tests
- Estimated costs

Reporting

Short reports on the progress of the work will be distributed to the participants regularly.

A draft final report will be prepared and distributed. After having received comments a final report will be submitted to the participants.

Time Schedule

The annex is expected to take two years to complete.

Funding

Canada	10 000	USD
Italy	10 000	USD
Japan	10 000	USD
UK	10 000	USD
Total	**40 000**	**USD**

5.6 Annex XXVII Standardisation of Alternative Motor Fuels

Operating Agent	Atrax Energi AB, Sweden
Project Duration	Phase 1: 2002–2003 Phase 1: 2003–2004
Status/Schedule	Phase 1: Under completion Phase 2: Active
Participants	Phase 1: CDN, FIN, FR, J (LEVO), S. USA (6 countries) Phase 2: CDN, J (LEVO), S. USA (4 countries)
Total Budget	Phase 1: € 30 000 + USD 32 800 Phase 2: € 57 800
Project Leadership	Mr. Björn Rehnlund Atrax Energi AB Box 30192 SE-104 24 Stockholm Sweden Phone: +46 8 6574146 Fax: – E-mail: bjorn.rehnlund@atrax.se

Background

Alternative fuels have for more than three decades been analysed and discussed under the auspice of national and international organizations as for example IEA/AMF. During this time of exploration the need of specifications have been highlighted, not at least by producers of engines and vehicles. To some extent national specification has been set up and occasional also has been brought forward to national standards. Some work has also been done with standards on international level (for example in CEN with fatty acid methyl esters (FAME).

2002 the EU took decision on two directive concerning promotion of the use of bio fuels and taxation of bio fuels with the aim to enlarge the use of them to certain levels. To make it possible to enlarge the use of alternative fuels in Europe and then not at least to the level set up in the EU directive proposals (until 5,75% of the total use of fuels for transportation the year 2010) several actions of different kind have to be taken on national but maybe in first hand international level. One of the most important issues to deal with and to deal with prompt is the development of, negotiations concerning and decisions about international standards.
Already today the lack of standards is a serious obstacle when acting for an increased use of otherwise accepted alternative fuels as for example methane, FAME and ethanol. The use of alternative fuels today often means the use under the umbrella of a fleet test. If the society seriously wants to increase the use of alternative fuels up to a level of approximately 5% during the coming 5 to 10 years the

use of them has, so to speak, to be taken out from fleet tests and introduced into the normal market place much more than today. It will probably also be necessary to broaden the range of alternative fuels to other alcohols and ethers such as for example methanol and di methyl ether (DME) and in the long run also hydrogen. The need for international standards will in that case be of even more importance than today, not at least since vehicle manufactures demand fuels standards to allow free consumer use of alternative fuels in their vehicle. Without standards the producers will for example not be prepared to keep up to guarantee obligation concerning vehicles performance and exhaust gas catalytic cleaner performance (emission levels).

Today probably almost every OECD state to some extent has been and still is engaged with development of specifications and standards for alternative fuels. Instead of continuing this work mainly on a national level much could be gained if at least parts of the work could be coordinated on an international level. EU and CEN have the responsibility for that on a European level and ISO on a global level. However since standardisation of alternative fuels is a rather new issue for these organisations they might need and therefore also welcome different kind of help from organisations with knowledge and experience of alternative fuels.

IEA/ AMF has an almost unique competences and experiences in the field of alternative fuels. Because of that IEA/AMF could for example serve as an informal expert body for preparatory coordination of international standardisation efforts concerning alternative fuels. IEA/AMF could also serve as a body for informal international discussions about standardisations of alternative fuels, for example by arranging workshops about this issue.

To be able to act as such an informal international discussion forum IEA/AMF has to find a common base among the participating countries concerning the need for and also how to prioritise and handle future standardisation of alternative fuels.

Objectives

Phase 1

The objective of phase one of the annex is primarily to investigate, analyse and describe the state of the art on standards for alternative fuels in the participating countries and in international standardisation organizations such as CEN and ISO.

Main issues to investigate and report will be:

- Existing national and international standards for alternative fuels.
- National ongoing work with standardisation of alternative fuels.
- Ongoing and planned/discussed international work on standardisation of alternative fuels (CEN and ISO and EU).
- The participating countries opinion concerning their need for new and re-examined alternative fuel standards as well as their priority list among such standards.

From that material some first conclusions might be drawn concerning:

- A common line between the participating countries about the need for new and/or re-examined international alternative fuel standards.
- A common priority list among the production of such standards.

- Preliminary proposals how to work jointly (on an informal base) on the international arena.

Phase 2
The objectives of phase two of the annex is primarily to:

- Further work on the role that IEA/AMF could play in international standardization of alternative fuels.
- Further work on how IEA/AMF could act as an arranger of international workshops on standardization of alternative fuels.

This work should be carried out in discussion with representatives from CEN and ISO and when proper also national representatives.

The discussions with CEN and ISO aims to present a proposal for how and under which conditions IEA/AMF could co-operate with CEN and ISO in the form of for example affiliated member or as a liaison. Another result of phase two is an analyse of different internal organization forms for IEA/AMF under which IEA/AMF could co-operate with CEN and ISO.

Content of Work

Phase 1
Information for reporting and analyse will be search among existing public information available on for example websites etc.

New information will be search for among people handling and also in charge of standardisation of fuels and other relevant areas in the participating countries, authorities as well as institutes and industry, relevant international forums as CEN and ISO and if suitable also the EU Commission.

Analysing the result of this state of the art investigation and as far as possible finding joint areas and common needs as well as areas for possible cooperation and joint action in for example CEN and ISO.

As a second step the possibility to cooperate could be further elaborated and a proposal for some kind of informal cooperation “organisation” maybe as a part of IEA/AMF could be worked out.

As a third step the possibility for IEA/AMF to act as an international informal discussion forum and also the possibility for IEA/AMF to contribute to the discussions in CEN and ISO concerning standardisation of alternative fuels could be elaborated.

Phase 2
Discussions will be carried out with representatives from CEN and ISO to find different options for co-operation and also to analyse this options and as far as possible pinpoint these different options obstacle and advantages, for both IEA/AMF and CEN or ISO.

The result of the discussion will be further analysed and the different options will finally be presented for the participants including a proposal for #the best” solution.

With the discussions with CEN and ISO as a base different forms for internal organization of IEA/AMF's co-operation with CEN and ISO will also be analysed and discussed.

Financial Status

Phase 1	CDN	8 000 USD
	FIN	10 000 USD
	FR	15 000 €
	J (LEVO)	14 800 USD
	S	15 000 €
	USA	12 000 €
		32 800 USD + 42 000 €
Phase 2	CND	15 000 €
	J (LEVO)	12 800 €
	S	15 000 €
	USA	15 000 €
		57 800 €

Results

Phase 1

Phase 1 was reported orally at IEA/AMF ExCo-meeting in March 2003. In June 2003 a final draft report was distributed to the participants and in November the final printed report was distributed.

Phase 2

Phase 2 will be carried out during autumn 2003 and spring 2004.

A first draft report will be sent out in advance of IEA/AMF ExCo-meeting in January 2004. At the ExCo-meeting there will also be an oral presentation of the progress so far. A draft final report will be distributed in April 2004.

Appendix 1

Completed Projects/Annexes

(Status December 2003)

Main Results of Earlier Projects

Some more spectacular results of now completed projects are summarised here. Information about participating countries and their contributions is found in the following Tables 3 and 4.

Annex I Alcohols and Alcohol Blends as Motor Fuels

Operating Agent: SDAB (S)

This initial project/annex resulted in a state-of-the-art publication in three volumes printed in 2 000 copies which became a best seller in 1986.

Annex II Technology Information Exchange on Alternative Motor Fuels

Operating Agent: SDAB (S)

A number of studies on specific issues concerning various alternative motor fuels were reported in a series of "TRENDS". Altogether 21 different reports were prepared and distributed to the participating countries.

Annex III Alcohol Diesel Field Trials

Operating Agent: Sypher (CDN)

Data were collected, assessed and disseminated on the use of various methanol fuels in heavy-duty compression ignition engines used in trucks and buses as well as in rail, marine and stationary applications. The project resulted in 13 reports.

Annex IV Production of Alcohols and Other Oxygenates from Fossil Fuels and Renewables

Operating Agent: Natural Resources Canada (CDN)

The activities of the Annex were conducted in two phases. The second phase, which was completed in 1995, consisted of four studies, dealing with

- Natural Gas Supply, Demand and Price;
- Economic Comparisons of the LNG, Methanol and Synthetic Distillate;
- A Comparison of the Production of Methanol and Ethanol from Biomass; and
- Greenhouse Gas and Other Emissions to Air Resulting from Ethanol and Methanol Use as Alternative Fuels.

These studies demonstrated that feedstock availability for production of alternative fuels is not of concern, especially with regard to fossil fuels-based processes.

The production cost of alternative fuels, including the costs of feedstock, processing and transportation, has been provided for a large number of locations around the world.

The environmental benefits, as expressed in carbon dioxide-equivalent vehicle emissions, showed a great reduction for biomass-derived fuels, but minor variations for fossil fuel-based alternative fuels.

Annex V Cold Test Emissions

Operating Agent: VTT (FIN)

The first final report was published in March 1995 as a restricted report. After completing the later approved addendum on diesel vehicles, a new final report was published in February 1996 as a public report, according to decisions taken by the Executive Committee.

Altogether 3 engines and 14 cars were measured at 5 ambient temperatures, using new sophisticated emission analysis methods. The fuels used were different types of gasoline and diesel fuels as well as methanol and ethanol blends, LPG and CNG. The results indicated that M85 fuel can give lower emissions than gasoline in warm conditions, though the emission of unburned methanol must be controlled. Natural gas and LPG proved to be inherently clean fuels, which, using up-to-date engine technology, give low emissions in all conditions.

Annex VI Natural Gas as Motor Fuel

Operating Agent: Sypher (CDN). Assistant: SDAB (S)

International information and experience of present and future use of natural gas as a motor fuel was collected, analysed and synthesised. The project included the use of compressed natural gas (CNG) and liquefied natural gas (LNG) in light-duty vehicles and heavy-duty vehicles. The potential of methane produced from biomass (biogas) was also explored.

Annex VII Comparison of Relative Environmental Impacts of Alternative and Conventional Fuels

Operating Agent: ORNL (USA).
Assistant: Phase 1: SDAB (S). Phase 2: Innas (NL)

Results of the project were (1) a paperback book detailing the findings of the study and (2) an addendum to the book updating the findings with results of more recent research on environmental impacts of alternative fuels. Both publications are useful to policy makers when a decision is necessary on whether to employ alternative fuels in transportation.

Annex VIII Heavy-Duty Vehicles on Alternative Fuels

Operating Agent: VITO (B)

This annex was carried out in two phases. In the first phase an analysis of the results of 73 different demonstration projects set up in several countries around the world was carried out. Because demonstration projects have different goals, use different test methods and procedures, it was hard to compare the results. A unification of test methods, especially for emissions and energy consumption, will increase the value of the outcome of a demonstration for third parties.

In a second phase a leaflet with recommendation for demonstrations was developed based on the results of the first phase and on the results of a workshop with demonstration experts.

Annex IX Automotive Fuels Information Service (IEA AFIS)

Operating Agent: Innas (NL). Assistant: Atrax (S)

The result of this annex is an independent information service (IEA AFIS) that can answer strategic questions on automotive fuels. This information service has assisted in many other annexes of the Advanced Motor Fuels Implementing Agreement.

During the three operating years of the annex, five books have been produced in a series “Automotive Fuels Survey”.

The first two volumes “Raw Materials and Conversion” and “Distribution and Use” describe the relevant aspects of the well to wheel fuel chain of automotive fuels. Fuels included are: gasoline, diesel oil, LPG, natural gas, alcohol fuels, vegetable oils and biodiesels, hydrogen and dimethyl ether. Aspects covered are for example: energy consumption, emissions, costs, technology, infrastructure, legislation and safety.

The third volume “Comparison and Selection” describes a method to use the enormous amount of available information when a decision on automotive fuels has to be made. Examples are presented to clarify the working method. The examples include the fuels that are addressed in the first two volumes.

Volume four “Innovations or Illusions” addresses some special fuels that are not discussed in the first two volumes. Volume five “Mobile Machinery: Sector analysis” describes energy consumption and emissions of the mobile machinery sector, compared to road vehicles. It also discusses the role of alternative fuels in this sector.

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Annex X Characterisation of New Fuel Qualities

Operating Agent: VTT (FIN)

The final report was distributed in September 1997 as a restricted report.

The results showed that the traditional cetane number measurement well describes the ignition delay of heavy-duty engines at low and medium loads, but is more suitable for hydrocarbon fuels than for alternative fuels. Thus, the cetane number does not describe the combustion process with advanced light-duty vehicles. The cetane number overestimates the effect of cetane improvers, especially for biodiesels. Esters were also found to act as effective lubricity additives according to HFRR tests.

Annex XI Forecasting and Planning Tools for Alternative Fuels and Related Infrastructure

Operating Agent: Sypher (USA)

The final report provided an overview of the major computer models studied. Detailed comparisons were made of the U.S. DOE´s TAFVM, Califonia’s CALCARS, Canada’s AFIM, and the Netherlands´ Electric Vehicle Impact models. The Canadian alternative fuels infrastructure model (AFIM) was tested using Australian and New Zealand experience. The AFIM model was also used to predict electric vehicle demand in Finland.

Annex XII Particulate Emissions from Alternative Fuelled Vehicles

Operating Agent: ETSU (UK)

Annex XIII Emission Performance of Selected Biodiesel Fuels

Operating Agent: VTT (FIN). Assistant: ORNL (USA)

Oak Ridge National Laboratory (ORNL) and Technical Research Centre in Finland (VTT) carried out the project with complementary work plans. The work generated an extensive analysis of the exhaust emissions using biodiesel in new diesel engines. Several different engines were tested at the two sites, and some engines were tested also with emission control catalysts, both at ORNL and at VTT. ORNL concentrated on light and medium duty engines, while VTT emphasized a heavy-duty engine and also used a light duty car as a test bed. Common test fuels for two sites were rape methyl ester in 30 % blend and neat, soy methyl ester in 30 % blend and neat, used vegetable oil methyl ester (UVOME) in 30 % blend, and the Swedish environmental class 1 reformulated diesel (RFD). Results covered regulated emissions, aldehydes, composition of particulate matter, polyaromatic hydrocarbons and limited results of Ames tests on the mutagenicity (particulate matter).

Generally, the biodiesel fuels had higher NOx emissions but lower values of HC, CO, and particulates. Unregulated emissions varied greatly between fuels and engines. VTT's tests showed that the particulates generally seemed to be less harmful for neat bioesters than for diesel fuel. The changes in emissions were not as significant when 30 % bioester blends were compared with EN590 or RFD as when neat esters were used. No major differences were seen in emission performance between RME, SME (soy bean oil methyl ester) and UVOME, even though some benefit was seen for the UVOME fuel regarding CO, HC and aldehyde emissions with the TDI vehicle. The ethanol emulsion fuel gave some emission benefits regarding particulates. The hydrated tall oil blend gave worse emission figures than the other fuels, which is believed to be due to differences in the base fuel.

Both laboratories, ORNL and VTT, prepared final reports. In addition two publications are available.

Annex XIV Investigation into the Feasibility of Dimethyl Ether as a Fuel in Diesel Engines

Operating Agent: TNO (NL)

Annex XIV has been split up in the following seven tasks lead by different industrial enterprises.

- *Trade-off fuel quality versus costs:* Haldor Topsoe (DK) and Statoil (N)
- *Safety investigation (DME distribution and vehicles):* Renault (F), Akzo-Nobel (NL), TNO-WT and TNO-MEP (NL) and NRCanada (CDN)
- *Design guidelines:* AVL-List (A), AET (CDN), Renault (F) and DTU (DK)
- *DME from renewable feedstock:* IEA AFIS (Atrax Energi, S)
- *Life cycle analysis (LCA):* IEA AFIS (Innas, NL), Amoco (USA), Statoil (N), Haldor Topsoe (DK), Volvo Truck (S), Renault (F) and TN-WT (NL)
- *Costs of DME infrastructure:* IEA AFIS (Innas), Statoil (N) and Amoco (USA)
- *Workshops / newsletters:* TNO-WT (NL)

Annex XV Implementation Barriers of Alternative Fuels

Operating Agent: Innas (NL)

The report that has been produced under this annex presents an overview of the practical barriers associated with the introduction of an alternative fuel and analyses alternative fuels in broad terms with respect to these practical barriers. Fuels addressed in the report are: LPG, natural gas, ethanol, methanol, biodiesel and hydrogen. Also electric vehicles are included. Some remarks are made on the barriers that may be expected for dimethyl-ether.

Annex XVII Real Impact of New Technologies for Heavy Duty Vehicles

Operating Agent: VITO (B)

The final report was distributed between the participants in December 2000.

Within this project, three city bus technologies were selected to compare emissions and fuel consumption in real traffic (city and rural), in several vehicle test cycles (CBDC, DUBDC, De Lijn) and in the main official engine test cycles (ESC, ETC, US-FTP, Japan 13-mode). The purpose was to look for clear relations between these test procedures.

The three buses were a Euro-2 diesel bus, a natural gas bus with stoichiometric fuel control and three-way catalyst and a natural gas bus with lean burn fuel control.

The stoichiometric natural gas bus reached very low emission levels compared to the diesel bus (regulated emissions were about 10 times lower). The lean burn natural gas bus needed some adjustments in the lambda control settings to lower its relatively high NOx emissions.

The test results showed that there is no unique relation between real city traffic emissions and the different engine or vehicle test cycles. The relation depends on engine technology, gearbox (and gear shifting strategy), and the engine load vs speed distribution during the test cycle.

Annex XVIII Future Greener Diesel Fuels

Operating Agent: Battelle (USA)

In order to support the use of oxygenates in diesel fuels, this annex provided data on the miscibility, flash point, cloud point, water tolerance, vapour pressure, and ignition quality over a range of diesel fuel-oxygenate blends and environmental temperatures through laboratory tests with diesel fuel and oxygenate samples.

The diesel fuels included a USA reference diesel, a Fischer-Tropsch diesel, and an oil sands diesel. The oxygenates tested included:

1. dipentyl ether,
2. tripropylene glycol monomethyl ether,
3. glycerol tributrate (tributrin),
4. 2-ethoxyethyl ether (diethylene glycol diethyl ether),
5. dibutyl maleate,
6. dibutoxymethane (butylal), and
7. diethyl maleate [Only limited work because of miscibility difficulties].

Oxygenate blend levels were 0 (diesel only), 5, 10, 30, and 100 (oxygenate only) volume percent. Test temperatures ranged from –30 to 30 C. Vapor pressure measurements were made using a gas chromatographic technique that distinguished fuel and oxygenate contributions to the total vapour pressure. Ignition quality measurements were made using the IQT constant volume combustion apparatus.

Annex XIX New Fuels for New Engines

Operating Agent: Innas (NL)

The final report was published in January 2001 as volume 6 in the Automotive Fuels Survey series of IEA AMF/AFIS under the title "Fuels for HCCI engines". It describes homogeneous charge compression ignition (HCCI) operation in four-stroke, two-stroke and free piston engines. The relation between fuel characteristics and HCCI operation is discussed. The report contains an extensive list of references and also lists organisations working on HCCI engines. Outside AMF the report has been distributed within the Clean Diesel III consortium, co-ordinated by SwRI in the USA.

Annex XX: DME as an automotive fuel II

Operating Agent: TNO (NL)

The result of the Annex XX is twofold:

A) Technical research in the area of DME fuel injection systems.
B) Support for international cooperation to stimulate the development of DME as a new fuel. This was supported by organising workshops and distributing newsletters.

The work also resulted in the foundation of the International DME Association and in a EU project about the development of a DME fuelled truck.

The technical work:

- A test procedure to test material (wear) properties with DME
- Advise on wear resistant coatings for DME fuel injection system parts
- Selection of elastomers suitable for sealing DME fuel systems
- Determination of influence of additives on DME lubricity and viscosity.

Annex XXI Deployment Strategies for Hybrid, Electric and Alternative Fuel Vehicles

Operating Agent: Innas (NL)

In the last years the harmful effects and the greenhouse gases resulting from the use of conventional vehicles created many concerns on continuing in the same direction. Hybrid or electric vehicles and alternative fuels like natural gas, ethanol or hydrogen are considered an essential element in reducing urban pollution and greenhouse gases. But only a wide dissemination of "clean vehicles and fuels" can have noticeable effects on the environment. Therefore governments, in addition to the support of research and development, more and more implement measures with the aim of promoting the market introduction of these new vehicle technologies – with different approaches and various effects.

Between 2000 and 2002 an international task force collected information on more than 100 programmes run in 18 countries. Evaluations and analyses of case studies showed that some approaches are successful, but they also identified weaknesses that are often repeated. The report elaborated by the task force provides recommendations on the base of conclusions drawn by the analyses. They will help government officials responsible for administering fleets, incentives and regulations with assessing the most promising strategy for their country for the market introduction of hybrid, electric and alternative fuel vehicles.

Table 3. Completed Projects/Annexes

The following 19 projects/annexes have been completed during the period 1984 – 2003..

Annex	Title	Run time	Operating Agent	Participating Countries
Annex I	Alcohols and Alcohol Blends as Motor Fuels	1984 – 1986	SDAB (S)	5
Annex II	Technology Information Exchange on Alt Motor Fuels	1984 –1992	SDAB (S)	7
Annex III	Alcohol Diesel Field Trials	1987 – 1992	Sypher (CDN)	6
Annex IV	Production of Alcohols and other Oxygenates	1987 – 1994	Energy, Mines and Resources (CDN)	5
Annex V	Performance Evaluation of Altern. Fuel/Engine Concepts	1990 – 1995	VTT (FIN)	9
Annex VI	State-of-the-art Report on Natural Gas as a Motor Fuel	1990 – 1992	Sypher (CDN) SDAB (S)	6
Annex VII	Environmental Impacts of Alternative and Conventional Fuels	1992 – 1997	ORNL (USA) Phase 1: SDAB (S) Phase 2: Innas (NL)	8
Annex VIII	Heavy-Duty Vehicles on Alternative Fuels	1994 – 1998	VITO (B)	8
Annex IX	Automotive Fuel Information Service (AFIS)	1995 – 1999	Innas (NL) Atrax (S)	7
Annex X	Characterisation of New Fuel Qualities	1995 – 1997	VTT (FIN)	7
Annex XI	Forecasting and Planning Tools for Alternative Fuels	1995 - 1996	Sypher (USA)	3
Annex XII	Particulate Emissions from Alternative-Fuelled Vehicles	1996 – 1997	ETSU (UK)	6
Annex XIII	Emission Performance of Selected Biodiesel Fuels	1997 – 1999	VTT (FIN) ORNL (USA)	7
Annex XIV	Feasibility of DME as a Fuel in Diesel Engines	1997 – 2000	TNO (NL)	7 +4 sponsors*)
Annex XV	Implementation Barriers of Alternative Fuels	1998 – 1999	Innas (NL)	5
Annex XVII	New Technologies for Heavy-Duty Vehicles	1998 – 2000	VITO (B)	7
Annex XVIII	Future Greener Diesel Fuels	1997 – 2002	Battelle (USA)	7
Annex XIX	New Fuels for New Engines	2000 – 2001	Innas (NL)	5
Annex XX	DME as Automotive Fuel II	2000 – 2002	TNO (NL)	7
Annex XXI	Deployment Strategies	2000 – 2002	Innas (NL)	4 from AMF 7 from HEV

**) Sponsors: AVL from Austria and IFP, PSA and Renault from France*

Table 4a. Completed Projects (Annex I–X)

Participation and financial commitments are shown in the following table.

Annex		Participating Countries and their Contributions *Œ denotes the Operating Agent. Amounts are given in 1 000 USD.*												
		B	**CDN**	**DK**	**ES**	**FIN**	**FR**	**I**	**J**	**NL**	**NZ**	**S**	**UK**	**US**	**Total**
I	**Alcohols as Motor Fuels**		35						35		15	Œ 25		35	145
II	**Information Exchange**											Œ			
	Phase 1 (1984–88)		40					40	40			40		40	200
	Phase 2 (1988–92)		60			60		60	60		30	60		60	390
III	**Alcohol Diesel Field Trials**		Œ 40.5			5		40.5	40.5			40.5		40.5	208
IV	**Production of Alcohols**		Œ												
	Phase 1 (1987–89)		60												60
	Phase 2 (1990–94)		40					32.1	40			40		40	192
V	**Cold Test Emissions**					Œ									
	Phase 1 (1990–93)		20			36		20	32.3	12		20		20	160
	Phase 2 (1993–94)	30	30			50			29	17.5		30	12.5	37	236
	Phase 2 (1994–95)	7				21			7	7		7	7	7	63
VI	**Natural Gas as Motor Fuel**		Œ 41.7			41.7		41.7	41.7			41.7		41.7	250
VII	**Environmental impacts**													Œ	
	Phase 1 (1992–95)	25	25			25		25	25	25		45		45	235
	Phase 2 (1996–97)	8	8			8			8	8		8		8	56
VIII	**Heavy Duty Vehicles**	Œ													
	Phase 1 (1994–98)	5	5			5			5	5		5	5	5	40
	Addenum (1996–98)	5	3.5			5			3.5	5		3.5	3.5	5	34
IX	**Information Service AFIS**	35	30			45				Œ 108		124	68.4	67.7	478
X	**New Fuel Qualities**	8	8			Œ 40			8	8		12		8	92

Table 4b. Completed Projects (Annex XI–XXVII)

Participation and financial commitments are shown in the following table.

Annex		Participating Countries and their Contributions *Œ denotes the Operating Agent. Amounts are given in 1 000 USD.*												
		B	**CDN**	**DK**	**ES**	**FIN**	**FR**	**I**	**J**	**NL**	**NZ**	**S**	**UK**	**US**	**Total**
XI	**Forecasting and Planning Tools**		15			10								**Œ** 35	75
XII	**Particulate Emissions**	22.7	22.7			22.7				22.7			**Œ** 22.7	22.7	136
XIII	**Biodiesel Fuels**	32	32			**Œ** 75			39.7	32		42		95	348
XIV	**DME as Fuel I**		110	90		20			40	**Œ** 85		180		80	787*
XV	**Implementation Barriers**					13			13	**Œ** 13		13		13	66
XVII	**Heavy-Duty Vehicles**	**Œ** 80				40		0**	40	40		40		40	280
XVIII	**Future Greener Diesel Fuels**		5			10	10		10	10		10		**Œ** 10	65
XIX	**New Fuels for New Engines**		8			8				**Œ** 8		8		8	40
XX	**DME as Fuel II**			10		10	30	10	10	**Œ** 20		10		10	150***
XXI	**Deployment Strategies**					X			X	**Œ** –		X		X	275
	TOTAL														**5 061**

*) In the sum USD 787 000 are included also contributions from the Sponsors IFP/PSA/Renault (France) with USD 55 000 and AVL (Austria) with USD 32 000. The former IA member Norway contributed USD 95 000.

**) Italy contributed to this annex on a task sharing base carrying out engine tests.

***) In the sum USD 150 000 are also included contributions from the Sponsors PSA and Renault (France), TNO and Helvoet (NL) with each USD 10 000.

Appendix 2

Workshops

(Status December 2003)

The following Workshops have been arranged during recent years.

- Heavy-Duty Vehicles on Alternative Fuels, Annex VIII
  Organized by: VITO (B) in Brussels, 5 December 1996

- 1st DME Workshop: DME as Fuel, Annex XIV
  Organized by: TNO (NL) in Delft, 14–15 November 1996

- 2nd DME Workshop: DME as Fuel, Annex XIV
  Organized by: TNO (NL) in Delft, 26–27 June 1997

- 3rd DME Workshop: DME as Fuel, Annex XIV
  Organized by: TNO (NL) in Naperville, Illinois, USA, 26–27 February 1998

- 4th DME Workshop: DME as Fuel, Annex XIV
  Organized by: TNO (NL) in Delft, 1–2 October 1998

- Clean Energy Vehicle Forum to discuss clean energy vehicle programmes in Japan and EU
  Organized by: NEDO, LEVO and JARI in Tsukuba, Japan, 21 October 1998

- 5th DME Workshop: DME as Fuel, Annex XIV
  Organized by: AVL (Austria) in Graz, 24–26 March 1999

- 6th DME Workshop: DME as Fuel, Annex XIV
  Organized by: Volvo (Sweden) in Göteborg, 2–3 December 1999

- Kick-off Workshop: Deployment Strategies, Annex XXI
  Organized by: Muntwyler (Switzerland) in Glattbrugg, 24–25 February 2000

- 7th DME Workshop: Dimethyl-ether as an automotive fuel II, Annex XX
  Organized by: AVL PTI (USA) in Plymouth [MI], 1–2 June 2000

- 8th DME Workshop: Dimethyl-ether as an automotive fuel II, Annex XX
  Organized by: The community of Växjö (Sweden), 17–18 January 2001

- Deployment Strategies, Annex XXI

  Workshop to discuss advanced vehicle programmes in Japan and the progress of Annex XXI

  Organized by: LEVO and NEDO in Kyoto, Japan, 6–7 June 2001

- IEA Information Centres Meeting

  *Organized by:*IEA, IEA HQ in Paris, 3 May 2002

- Deployment Strategies, Annex XXI

  Workshop to discuss 'Evaluation as a key to learning lessons/Defining goals of government promotion' and the progress of Annex XXI

  Organized by: Muntwyler in Vancouver, Canada, 10–11 June 2002

- Clean City Vehicles

  Workshop on "Clean City Vehicles with a special focus on Developing Countries"

  Organized by: T Månsson, EnEN, IEA HQ in Paris, 24–26 September 2002

- Clean City Vehicles

  Working meeting

  Organized by: T Månsson, EnEN, IEA HQ in Paris, 9 December 2002

Appendix 3

List of Reports

(Status December 2003)

Annual Reports

- IEA Alternative Motor Fuels. Annual Report 1994, NUTEK, B 1995:5 (ISBN 91-7318-2885)
- IEA Alternative Motor Fuels. Annual Report 1995, NUTEK, B 1996:9 (ISBN 91-7318-3008)
- IEA Alternative Motor Fuels. Annual Report 1996, NUTEK, B 1997:6 (ISBN 91-7318-3083-SE)
- IEA Alternative Motor Fuels. Annual Report 1997, STEM, EB 4:1998 (ISBN 91-89184-03-3)
- IEA Advanced Motor Fuels. Annual Report 1998, STEM, EB 2:1999 (ISBN 91-89184-12-2)
- IEA Advanced Motor Fuels. Annual Report 1999, STEM, EB 1:2000 (ISBN 91-89184-16-5)
- IEA Advanced Motor Fuels. Annual Report 2000, STEM, EB 1:2001 (ISBN 91-89184-26-2)
- IEA Advanced Motor Fuels. Annual Report 2001, STEM, EB 2:2002 (ISBN 91-89184-28-9)
- IEA Advanced Motor Fuels. Annual Report 2002, STEM, ET 7:2003 (ISBN 91-89184-28-9)

Annex I Alcohols and Alcohol Blends as Motor Fuels

Operating Agent: SDAB (S)

Results were reported in an IEA/STU publication "Alcohols and Alcohol blends as Motor Fuels". This report was printed in 2 000 copies for the participants. *Publicly available through SDAB.*

Annex II Technology Information Exchange on Alternative Motor Fuels

Operating Agent: SDAB (S)

Phase 1:

Results were reported in a series of "TRENDS".

Available only for Participating IEA-countries through SDAB.

- No 86:1 "(Alcohol Fuels in) Sweden"
- No 87:2 "U.S.A - Policy"
- No 87:3 "Europe - Environment"
- No 88:1 "Utilisation of Alcohol Fuels" (State-of-the-art report)

- No 88:2 "New Publications"
- No 88:3 "Fuel Alcohol Formulations"
- No 88:4 "Alcohol Fuels in Japan"

Phase 2:

Results were reported in a series of "TRENDS".

Available only for participating IEA-countries through SDAB.

- No 88:5 "Diesel Exhausts. Environmental and Health Effect"
- No 89:1 "U.S. Study on Flexible & alternative Motor Fuels"
- No 89:2 "Catalysts and filters on Diesel Engines"
- No 89:3 "Carbon dioxide"
- No 89:4 "Clean Motor Fuels in the U.S."
- No 90:1 "California Clean Air"
- No 90:2 "Reformulated Gasoline"
- No 91:1 "Unregulated Emissions"
- No 91:2 "Alcohol Vehicle Emissions"
- No 91:3 "Vehicle Emissions and Cancer Risks"
- No 91:4 "Catalytic Treatment of Emissions"
- No 92:1 "Future Electric Vehicles"
- No 92:2 "Automotive Emissions Test Systems"
- No 92:3 "Trends in Canada"

Annex III Alcohol Diesel Field Trials

Operating Agent: Sypher (CDN)

The following output has been submitted.

Available only for Participants in the Annex.

- "IEAMAIN" data collection system, Computer software, user guide and up-dates
- On-line methanol fuels database and access facilities
- Report (Nov. 1987), "Catalytic Converters for Emissions Control on Methanol Engines – Current Research and Development"
- Report (May, 1988), "Comparative Review of World-wide Emissions Legislation & Trends in Correlating Methanol Emissions Data"
- Report (May, 1988), "Annex III field Trials, Data Collection Status"
- Report (Oct, 1988), "Progress Report on Annex III"
- Report (Nov, 1988), "Comparative Review of World-wide Emissions Legislation & Trends in Correlating Methanol Emissions Data", revised
- Report (May, 1989), "Diesel Exhaust Emissions Legislation and Alcohol Fuelled Engines"

- Report (Oct, 1989), "Alcohol Fuels for Heavy Duty Engines – A survey of Current Status"
- Report (Oct, 1989), "Diesel Exhaust Emissions Legislation and Alcohol Fuelled Engines", revised
- Report (June, 1990), "Alcohol Fuels for Heavy Duty Engines – A survey of Current Status", revised
- Final Report, June 1992

Annex IV Production of Alcohols and other Oxygenates from Fossil Fuels and Renewables

Operating Agent: Natural Resources Canada (CDN)

Phase 1:
The results have presented in a final report, which was printed in 1990.
Available to all IEA countries through Natural Resources Canada.

The contents are:
- Methanol production from coal, natural gas and biomass
- Production of methanol and higher alcohols
- Transportation of methanol and other oxygenates
- Ethanol production by fermentation
- Culture of fermentation precursors
- MTBE production
- Biomass liquefaction

In addition, the OA developed a series of computer models and databases.

Phase 2:
Available only for participating IEA-countries through Natural Resources Canada.

- "Natural Gas Supply, Demand, and Price"
- "Economic Comparisons of LNG, Methanol and Synthetic Distillates"
- "A Comparison of the Production of Methanol and Ethanol from Biomass"
- "Greenhouse Gas (and other) Emissions from Methanol and Ethanol Production Processes"

A final report "Production of Alcohols and Oxygenates from Fossil Fuels and Renewables" was published in 1995. *Publicly available through Natural Resources Canada.*

Annex V Performance Evaluation of Alternative Fuel/Engine Concepts

Operating Agent: VTT Processes (FIN)

Phase 1:
Available only for Participants of the Annex through VTT.

- Current status of Phase 1, "Engine tests", 1992
- Cold-start and Cold Start Emissions of alcohol fuelled Light-Duty engines, *A literature study,* 1992

Phase 2:
Available only for Participants of the Annex through VTT.

- Final report of Phase 2, also including the work of Phase 1: "Performance Evaluation of Alternative Fuel/Engine Concepts", 1995

A final public report "Performance Evaluation of Alternative Fuel/Engine Concepts 1990 –1995" including an addendum on diesel vehicles was published in 1996. *Publicly available through VTT.*

- Nylund, N.-O. & Lappi, M. Evaluating Alternative Fuels for Light-Duty Applications. Presented at: International Fall Fuels & Lubricants Meeting, October 1997, Tulsa. Society of Automotive Engineers, 1997. 18.p. (SAE Paper 972974).

Annex VI State-of-the-art Report on Natural Gas as a Motor Fuel

Operating Agent: Sypher (CDN). *Assistant:* SDAB (S)

The final report, "Methane as Motor Fuel" (May 1992), was printed in book form. *Publicly available.*

The objective of this study was to provide the International Energy Agency with a "state-of-the-art" report regarding the current and potential future use of methane as a fuel for motor vehicles. In support of this overall objective, the study addressed the following topics:

- World-wide reserves and availability of natural gas; gas extraction, processing and distribution systems; potential supplies of biogas, adaptability of current situation to the transportation industry
- Current technologies used for operating vehicles on impressed and liquefied natural gas, and future trends in engine and vehicle development
- The economic and environmental consequences of expanding the use of methane as a vehicle fuel, and
- Technical and institutional barriers, which could act against the expansion of natural gas in the road transportation sector

The report provides conclusions regarding the current status of methane as a vehicle fuel, and recommendations for maximising the benefits of methane as a vehicle fuel, and expanding its use on a worldwide basis.

Annex VII Comparison of Relative Environmental Impacts of Alternative and Conventional Fuels

Operating Agent: ORNL (USA)

Assistant: Phase 1: SDAB (S). Phase 2: Innas (NL)

The final report "Comparison of Relative Environmental Impacts of Alternative and Conventional Motor Fuels" was printed in book form 1995.
Publicly available through ORNL/DOE.

Annex VIII Heavy-Duty Vehicles Using Alternative Fuels

Operating Agent: VITO (B)

A final report "Heavy-duty Vehicles on Alternative Fuels" and a report "Workshop on Demonstrations with Heavy-Duty Vehicles Running on AMFs – Report of the Workshop" have been distributed to the Executive Committee.
Further distribution has not yet been decided upon.

Annex IX The Automotive Fuels Information Service (AFIS)

Operating Agent: Innas (NL). *Assistant:* Atrax (S)

Five volumes have been published.
They are publicly available through Innas.

1. Raw Materials and Conversion (Dec 1996)
2. Distribution and Use (Dec 1996)
3. Comparison and Selection (Jan 1998)
4. Innovations or Illusions (Jan 1999)
5. Mobile Machinery: Sector analysis (May 1999)

Annex X Characterisation of New Fuel Qualities

Operating Agent: VTT Processes (FIN)

A final restricted report "Characterisation of New Fuel Qualities" was published and distributed to the Participants of the Annex in 1997.

- Nylund, N-O. & Aakko, P. Characterization of new fuel qualities. Presented at: State of Alternative Fuel Technologies 2000. Warrendale: Society of Automotive Engineers, 2000. 10 p. (SAE Paper 2000-01-2009).

Annex XI Forecasting and Planning Tools for Alternative Fuels and Related Infrastructure

Operating Agent: Sypher (USA)

A detailed progress report has been provided to the Participants of the Annex.

Annex XII Size and Compositional Analysis of Particulate Emissions from Alternative-fuelled Vehicles

Operating Agent: ETSU (UK)

Interim report "Size and Compositional Analysis of Particulate Emissions from Alternative-fuelled Vehicles". *Available only for Participants of the Annex through ETSU.*

Annex XIII Emission Performance of Selected Biodiesel Fuels

Operating Agent: VTT Processes (FIN). *Assistant:* ORNL (USA)

Two final reports, which are available through ORNL and VTT.

- Aakko, P., Westerholm, M., Nylund, N.-O., Moisio, M., Marjamäki, M., Mäkelä, T., Hillamo, R. IEA/AMF Annex XIII: Emission Performance of Selected Biodiesel Fuels – VTT's Contribution. 2000. VTT report ENE5/33/2000.

- Storey, J., Irick, D., Lappi, M., McGill, R. IEA/AMF Annex XIII: Emission performance for selected biodiesel fuels – ORNL's contribution. 2001. Oak Ridge National Laboratory. Research Report.

Two publications, which are available through FISITA and SAE Organisation.

- Aakko, P., Nylund, N.-O., Westerholm, M., Marjamäki, M., Moisio, M., Hillamo, R. and Mäkelä, T. The emissions from heavy-duty engine with and without aftertreatment using selected biofuels. 29th FISITA World Automotive Congress. Helsinki, FI, 2 – 7 June 2002.

- McGill, R., Storey, J., Wagner, R., Irick, D., Aakko, P., Westerholm, M., Nylund, N.-O. and Lappi, M. Emission performance of selected biodiesel fuels. JSAE/SAE International Spring Fuels & Lubricants Meeting, Yokohama, 19 – 22 May 2003. SAE Technical Paper 2003-01-1866.

Annex XIV Investigation into the Feasibility of Dimethyl Ether as a Fuel in Diesel Engines

Operating Agent: TNO (NL)

Task 1: ***Report of Annex XIV of the IA/AMF of IEA: "DME as an Automotive Fuel***, No 00.OR.VM.065.1/AvD, August 2000

Task 2: ***Toxicity aspects of Dimethylether in comparison with automotive fuels,*** No TNO-MEP-R99/015, January 1998

Proposal for safety provisions for DME fuelling systems and their installation in vehicle, No 98.OR.VM.051.1/JV, September 1998

Failure mode and effect analysis DME vehicle storage tank system, No TNO-MEP-R98/449, November 1998

Conversion of lPG distribution guidelines into DME distribution guidelines, No TNO-MEP-R99/050, February 1999

Task 3: ***Dimethylether as an Automotive fuel Annex XIV***, No BE 0472 (AVL), March 1999

Task 4: ***DME from Biomas,*** Atrax, February 1999

Task 5: ***Environmental effects of DME compared to other automotive fuels***, Innas, June 1999

Task 6: ***Automotive DME distribution infrastructure costs,*** Innas, July 1999

Task 7: ***Workshop Dimethylether as an automotive fuel***
No 97.OR.VM.003.1/RV, Jan 1997
No 97.OR.VM.091.1/RV, Dec 1997
No 98.OR.VM.016.1/RV, March 1998
No 98.OR.VM.065.1/JV, Nov 1998
No 99.OR.VM.025.1/JV, May 1999

DME Newsletter, 1 (June 1998), 2 (December 1998) and 3 (June 1999)

Annex XV Implementation Barriers of Alternative Fuels

Operating Agent: Innas (NL)

A final report "Implementation barriers of alternative fuels" was published in February 1999. *Publicly available through Innas.*

Annex XVI Environmental and Economical Aspects of Implementing Biodegradable Lubricants in Vehicle Engines

Operating Agent: DTU (DK)

van Walwijk, M., Hagenau, J., Schramm, J. "Biodegradable Lubricants", IEA Advanced Motor Fuels Agreement – Annex XVI. Report published by Dep. of Energy Engineering on behalf of IEA Advanced Motor Fuels Agreement, December 1999.

Schramm, J. "Biodegradable Lubricants – Phase 2. Diesel Type Vehicles.", IEA Advanced Motor Fuels Agreement – Annex XVI. Report published by Dep. of Energy Engineering on behalf of IEA Advanced Motor Fuels Agreement, December 2002.

Annex XVII Real Impact of New Technologies for Heavy-Duty Vehicles

Operating Agent: Vito (B)

A final restricted report 'Pelkmans L., De Keukeleere D., IEA-AMF, Annex XVII: Real Impact of New technologies for Heavy Duty Vehicles, VITO-report, December 2000' has been distributed to the Participants of the Annex. *Available only for Participants of the Annex through VITO.*

Annex XVIII Future Greener Diesel Fuels

Operating Agent: Battelle Memorial Institute (USA)

A final report on "Future Greener Diesel Fuels" was completed in April 2002. *Available only for Participants of the Annex through Battelle.*

Annex XIX New Fuels for New Engines

Operating Agent: Innas (NL)

A final report has been published in January 2001 as volume 6 in the Automotive Fuels Survey, and is titled "Fuels for HCCI Engines". *Publicly available through Innas.*

Annex XX DME as Automotive Fuel II

Operating Agent: TNO (NL)

TNO report: "The effect of DME on wear of fuel pump parts", December 2000

TNO report: End report of Annex XX of the IEA/AMF: "DME as an Automotive Fuel II, Part 1", November 2001

DTU report: End report of Annex XX of the IEA/AMF: "DME as an Automotive Fuel II, Part 2". November 2001

Available only for Participants of the Annex through TNO.

Annex XXI Deployment Strategies

Operating Agent: Innas (NL)

A final report "Deployment strategies for hybrid, electric and alternative fuel vehicles" has been published on CD-rom in December 2002. *Publicly available through Innas. Will soon be downloadable from www.ieahev.org.*

Annex XXII Particle Emissions at Moderate and Cold Temperature Using Different Fuels

Operating Agent: VTT Processes (FIN)

Three interim reports and one final report were distributed to the Participants of the Annex. They are available only for Participants of the Annex through VTT.

- Aakko, P. The results with the medium-duty engine. The 1st Interim report, May 2001. Restricted.
- Aakko, P. The results with two diesel cars. The 2nd Interim report, October 2001. Restricted.
- Aakko, P. The results with stoichiometric gasoline car and CNG car. The 3rd Interim report, April 2002. Restricted.
- Aakko, P. and Nylund, N.-O. IEA/AMF Annex XXII: Particle emissions at moderate and cold temperatures using different fuels. VTT report PRO3/P5057/03. Restricted.

The following publications are publicly available through SAE and VTT.

- Aakko, P. and Nylund, N.-O. Particle emissions at moderate and cold temperatures using different fuels. SAE Technical Paper 2003-01-3285.
- Paper for Windsor Workshop, June 2004 (Windsor Workshop in 2003 was cancelled).

Annex XXIV Information Exchange IEA AMF/AFIS

Operating Agent: Innas (NL)

Three newsletters "IEA AMF/AFIS Fuels Update" per operating year.

Publicly available through Innas, the ExCo members and the AMF Secretary. Can be downloaded from www.innas.com/fuel news.

Annex XXIV Information Exchange IEA AMF/AFIS

Operating Agent: Innas (NL)

Three newsletters "IEA AMF/AFIS Fuels Update" per operating year.

Publicly available through Innas, the ExCo members and the AMF Secretary. Can be downloaded from www.innas.com/fuel news.

Annex XXV Fuel Effects on Emissions from Non-Road Engines

Operating Agent: VTT Processes (FIN)

The complete final report is for the participants only and available through VTT. A public version of the final report can be downloaded on IEA-AMF web pages (http://www.vtt.fi/virtual/amf/annex_xxv/reports.htm).

- Murtonen, T. Fuel Effects On Emissions From Non-Road Engines, Iterim Report, October 2002
- Murtonen, T. and Nylund, N.-O. Fuel Effects On Emissions From Non-Road Engines, Final Report, June 2003

Annex XXVII Standardisation of Alternative Motor Fuels

Operating Agent: Atrax Energi AB (S)

A report covering data and information collected during Phase I as well as proposals for future work has been distributed in November 2003.

Publicly available through Atrax, the ExCo members and the AMF Secretary.

Appendix 4

AMF ExCo Meetings

1984–90 AMF = Alcohols as Motor Fuels
1990–98 AMF = Alternative Motor Fuels
1998– AMF = Advanced Motor Fuels

	Date	Chairman	Secretary
a Madrid	80/3	Staffan Ulvönäs, S	Folke Schippel
b Stockholm	80/7	“	“
1. Ottawa	84/5	Gene Ecklund, US	Folke Schippel, S
2. Stockholm	84/11	“	“
3. Dearborn	85/7	“	“
4. Vancouver	86/2	“	“
5 Paris	86/10	“	“
6. Tokyo	87/5	“	“
7. Milano	87/11	“	“
8. Kiruna, S	88/6	“	Kjell Isaksson, S
9. Tokyo	88/11	Shinichi Nakayama, J	Folke Schippel, S
10. Vancouver	89/6	“	“
11. Rome>	89/11	PierPaolo Garibaldi, I	“
12. Los Angeles	90/6	“	“
13. Stockholm	90/11	“	“
14. Espoo/Helsinki	91/8	“	“
15. Kyoto	92/6	“	“
16. The Hague	93/4	Bernie James, CDN	Kerstin Larsson, S
17. Antwerpen	94/2	“	Irene Kolare, S
18. Toronto	94/10	“	“
19. Saltsjöbaden, S	95/9	“	Lars Vallander, S
20. Oxford	96/6	“	“
21. Charleston	97/3	Ben van Spanje, NL	Claës Pilo, S
22. Rovaniemi, FIN	98/1	“	“
23. Tokyo	98/10	“	“
24. Espoo/Helsinki	99/6	Nils-Olof Nylund, FIN	“
25. Toronto	00/6	“	“
26. Copenhagen	01/5	Arie Brouwer, NL	“
27. Milano	02/5	Nils-Olof Nylund, FIN	“
28 Paris	03/3	“	“
29 Linköping	04/1	Steve Goguen, USA	“

Appendix 5

Executive Committee on Advanced Motor Fuels

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IEA Advanced Motor Fuels

Annual Report 2003

A joint research programme on alcohol fuels was set up by some IEA member states as a response to the oil crisis in 1973. The principal aim was to promote energy security through the development of substitutes for oil-derived motor fuels. In recent years the IEA has broadened its mandate to include preservation of the environment, particularly the integration of environmental and energy issues. The programme for alcohol fuels has thus been expanded to include other clean advanced motor fuels. According to the "Strategic Plan for 1999–2004" more emphasis will be put on demonstrations and preparations for market introduction as the fuels approach market readiness. Co-operation with industry is also emphasised and encouraged.

From the start of this Agreement in 1984 twenty-seven projects ("Annexes") have been initiated, of which six are active today:

Annex XVI	Biodegradable Lubricants
Annex XXII	Low Temperature Particles
Annex XXIV	Information Exchange IEA AMF/AFIS
Annex XXV	Non-Road Engines
Annex XXVI	Oxygenates in Diesel
Annex XXVII	Standardisation of Alternative Motor Fuels

This document contains the report of the Executive Committee of the IEA Advanced Motor Fuels Agreement as well as short reports from the Operating Agents of the active Annexes.

Ten countries participate actively in the Agreement.

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