IEA-Advanced Motor Fuels
ANNUAL REPORT 2010

iea Energy Technology Network

ADVANCED MOTOR FUELS IEA-AMF

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Cover Photo: Sugarcane residue — called bagasse — is high in cellulose content, and tests are under way to produce commercial quantities of cellulosic ethanol. Bagasse is generated during the milling of sugarcane and is plentiful in places like Brazil and Hawaii.

Credit: Warren Gretz, Staff Photographer — National Renewable Energy Laboratory (NREL; United States)

International Energy Agency

Advanced Motor Fuels
Annual Report 2010

This Annual Report was produced by Kevin A. Brown (editing and project coordination/management), Andrea Manning (editing), Vicki Skonicki (document production), and Gary Weidner (printing) of Argonne National Laboratory. The cover was designed by Sana Sandler, also of Argonne National Laboratory.

Contributions were made by a team of authors from the Advanced Motor Fuels Implementing Agreement:

Country reports were delivered by the Contracting Parties or Observers:

Austria	Austrian Agency for Alternative Propulsion Systems (A3PS)
Canada	Natural Resources Canada
China	China Automotive Technology and Research Center (CATARC)
Denmark	Technical University of Denmark (DTU)
Finland	The Technical Research Centre of Finland (VTT)
Germany	Fachagentur Nachwachsende Rohsoffe (FNR)
Italy	ENI S.p.A.
Japan	National Institute of Advanced Industrial Science and Technology (AIST) New Energy and Industrial Technology Development Organization (NEDO) Organization for the Promotion of Low Emission Vehicles (LEVO)
Norway	Western Norway Research Institute
Spain	Instituto para la Diversificación y Ahorro de la Energía (IDAE)
Sweden	Swedish Transport Administration (STA)
Switzerland	Swiss Federal Office of Energy (SFOE) Laboratory for IC Engines and Exhaust Emissions Control (AFHB)
Thailand	National Science and Technology Development Agency (NSTDA) Ministry of Science and Technology
USA	United States Department of Energy (DOE)

Annex reports were delivered by the respective Operating Agents and Responsible Experts:

Annex XXVIII	Information Service & AMF Website (AMFI) and Fuel Info	Dina Bacovsky Päivi Aakko-Saksa
Annex XXXIV-2	Algae as Feedstock for Biofuels	Karen Sikes Ralph McGill
Annex XXXV-2	Particulate Measurements: Ethanol and Butanol in DISI Engine	Jesper Schramm Larry Johnson Jean-Francois Gagne
Annex XXXVI	Measurement Technologies for Hydrocarbons, Ethanol, and Aldehyde Emissions from Ethanol-Powered Vehicles	Olle Hadell Lennart Erlandsson

Annex XXXVII	Fuel and Technology Alternatives for Buses	Nils-Olof Nylund
Annex XXXVIII	Environmental Impact of Biodiesel Vehicles	Susumu Sato
Annex XXXIX-2	Emission Performance of HD Methane Engines Phase 2	Olle Hadell
Annex XL	Life Cycle Analysis of Transportation Fuel Pathways	Peter Reilly-Roe
Annex XLI	Alternative Fuels for Marine Applications	Ralph McGill
Annex XLII	Toxicity of Exhaust Gases and Particles from IC-Engines	Jan Czerwinski
Annex XLIII	Performance Evaluation of Passenger Car, Fuel, and Powerplant Options	Jukka Nuottimäki

Other sections of this report were delivered by the Chairmen and the Secretary:

Nils-Olof Nylund	VTT	Chairman 2010
Jean-Francois Gagne	Natural Resources Canada	Chairman 2011
Dina Bacovsky	BIOENERGY 2020+	Secretary

Contents

The IEA Advanced Motor Fuels Implementing Agreement

1.a Chairman's Message

In 2010, there was considerable news on and enthusiasm about electric vehicles. Major auto manufacturers are now beginning production of electric vehicles. However, start-up will be slow, and it will take many years — if not decades — before electric vehicles really make an impact.

Meanwhile, we have to make sure that internal combustion (ICE) -equipped vehicles become cleaner, more energy efficient, and — to some extent — more fuel-flexible. The development of engines, exhaust after-treatment, and fuels must go hand-in-hand. We cannot achieve very low emission levels with low-grade fuels. In the case of biofuels, to really make an impact, we need either improved biofuels or dedicated vehicles to enable the use of high-concentration biofuels. We also need sustainable biofuels from feedstocks that are not needed for food production. Here, we have a good opportunity for cooperation with International Energy Agency (IEA) Bioenergy. Both AMF and Bioenergy have worked on algal fuels, and a combined report with a common summary is forthcoming.

One could say that methane fuels are undergoing a renaissance. Horizontal drilling, along with hydraulic fracturing (often called fracking or hydrofracking), has increased the yields of natural gas. Vertical drilling has increased the yields of natural gas and is receiving a lot of interest. Biogas (bio-methane) is also receiving a lot of interest. On the vehicle side, bi-fuel light-duty vehicles are performing very well. As for heavy-duty vehicles, we need technologies like dual-fuel or direct-injection to reach diesel-like engine efficiency. One of the topical themes AMF is exploring is heavy-duty methane engines.

The Advanced Motor Fuels Implementing Agreement presented its new Strategic Plan and its request for extension to the Committee of Energy Research and Technology (CERT) of the International Energy Agency in 2009. At its June 2009 meeting, CERT approved the extension of AMF for a period of five years. Consequently, the year 2010 was the first full year of the new phase of AMF. In a way, renewal was the main theme in 2010 —

renewal in terms of implementation of the new strategic plan and the start of new Annexes but also renewal of administration.

AMF arranged two ExCo meetings in 2010: the spring meeting in Ottawa, Canada, and the fall meeting in Thessaloniki, Greece. The spring ExCo meeting was arranged in conjunction with the annual Transportation Technologies & Fuels Forum (TTFF), which was co-sponsored by Natural Resources Canada and the U.S. Department of Energy. This meeting gave an excellent opportunity for AMF to network with the North-American players in the field of vehicle technology and transportation fuels. It also gave an opportunity for researchers from Argonne National Laboratory (United States), Environment Canada, Natural Resources Canada, and VTT Technical Research Centre of Finland — all working in the Bus Project (Annex 37) — to meet face to face.

At the meeting in Ottawa, AMF selected a new Secretary. Claës Pilo — who has been with the committee since its start in 1984 and has served the Committee well as Secretary since 1997 — retired in 2010. The whole Committee acknowledges Claës Pilo for his dedicated and successful service to AMF. The new Secretary is Ms. Dina Bacovsky from Austria. Ms. Bacovsky is very knowledgeable in the field of biofuels. Moreover, she constitutes a natural link to IEA Bioenergy, as she is active within Bioenergy's Task 39, "Commercialising Liquid Biofuels from Biomass." To enable a smooth, seamless transition, Dina Bacovsky and Claës Pilo worked side-by-side in the fall of 2010.

Greece is one of the new countries interested in joining AMF. Hence, the fall meeting was arranged in Thessaloniki. The programme included interesting visits to facilities in the fuel industry, as well as research institutes. Greek researchers are very advanced in such areas as surface chemistry, nanomaterials, and fuel processing. The meeting in Thessaloniki was exceptional in the sense that no fewer that four new Annexes were started. The themes of the new Annexes are:

- Life Cycle Analysis of Transportation Fuel Pathways
- Alternative Fuels for Marine Applications
- Toxicity of Exhaust Gases and Particles from IC Engines
- Performance Evaluation of Passenger Car Fuel and Powerplant Options

In particular, the Annex on marine fuels represents an opening in a new direction.

The administrative regenerations also continued in Thessaloniki. Mr. Jean-Francois Gagne of Natural Resources Canada was elected new Chairman, and Dr. Shinichi Goto from the National Institute of Advanced Industrial Science and Technology (AIST) was chosen as new Vice Chairman for Asia. To provide continuity, the outgoing Chairman will continue as Vice Chairman for Europe.

To streamline operations, it was also agreed the new Secretary will take over production of the quarterly AMFI newsletter. Ms. Päivi Aakko-Saksa of VTT Technical Research Centre of Finland, who was responsible for the newsletter 2004–2010, was complimented on her efforts in making the AMFI newsletter a high-quality, widely spread publication.

Personally, I think that the AMF Implementing Agreement is in good shape and doing well. We are putting in some extra work in the 2010 Annual Report in an effort to reach out and make it more interesting and attractive to readers outside the AMF Committee. Renewal is one important element in keeping the Agreement alive and thriving. I'm confident that Jean-Francois will do a great job at the helm of AMF, assisted by Dina as a navigator. I would like to end this preface by repeating the whole Committee's sincere thanks to Claës for his long-lasting valuable service to the Committee. I also extend my thanks to Jean-Francois and Mr. Kazunori Nagai, who have served well as my Vice Chairmen.

Dr. Nils-Olof Nylund
Outgoing AMF Chairman

1.b Introduction to the International Energy Agency

The International Energy Agency (IEA) is an autonomous agency established in 1974. The IEA carries out a comprehensive programme of energy co-operation among 28 advanced economies, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The aims of the IEA are to:

- Secure member countries' access to reliable and ample supplies of all forms of energy — in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context — particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.

- Improve transparency of international markets through the collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organizations, and other stakeholders.

To attain these goals, increased co-operation among industries, businesses, and government organizations involved in energy technology research is indispensable. The public and private sectors must work together, sharing burdens and resources, yet multiplying results and outcomes at the same time.

The multilateral technology initiatives (Implementing Agreements) supported by the IEA are a flexible and effective framework for IEA member and non-member countries, businesses, industries, international organizations, and non-government organisations to research breakthrough technologies, to fill existing research gaps, to build pilot plants, and to carry out deployment or demonstration programmes — in short, to encourage technology-related activities that support energy security, economic growth, and environmental protection.

More than 6,000 specialists carry out a vast body of research through these various initiatives. To date, more than 1,000 projects have been completed. At present, 41 Implementing Agreements (IA) are working in the areas of:

- Cross-Cutting Activities (information exchange, modeling, technology transfer)
- End-Use (buildings, electricity, industry, transport)
- Fossil Fuels (greenhouse-gas mitigation, supply, transformation)
- Fusion Power (international experiments)
- Renewable Energies and Hydrogen (technologies and deployment)

The Implementing Agreement for a Programme on Research and Demonstration on Advanced Motor Fuels (IEA AMF) belongs to the End-Use category above.

The IAs are at the core of a network of senior experts consisting of the Committee on Energy Research and Technology (CERT), four working parties, and three expert groups. A key role of the CERT is to provide leadership by guiding the IAs to shape work programmes that address current energy issues productively, by regularly reviewing their accomplishments, and by suggesting reinforced efforts where needed. For further information on the IEA, the CERT, and the IAs, please consult www.iea.org/techagr.

1.c Implementing Agreement on Advanced Motor Fuels

The transport sector is facing many challenges. Today, this sector is practically totally dependent on fuels derived from crude oil. The number of vehicles around the world is increasing rapidly — and so are the environmental impacts and the use of energy in transport. Whereas many other sectors of society have been able to stabilize or cut CO_2 emissions, transport-related CO_2 emissions tend to be increasing both in relative and absolute terms.

At the same time, new possibilities are opening up — in fact, the array of options is expanding, not diminishing. This is true for both fuel and vehicle technology options. We are closer than ever to wide-scale use of alternative fuels. However, the increasing number of options makes decision-making more challenging for the private consumer, the fleet operator, communities, and the governments. One of the IEA AMF's most important tasks is to provide decision makers at all levels with unbiased and solid data on the performance and potential of various options.

We should note that regarding the IEA AMF, there are significant variations in commercial fuel properties and the sophistication of vehicles between different regions of the world.

All candidate future fuels face obstacles and barriers (bottlenecks) that might be either unique to a given fuel or in common with other fuels.

Because of their expertise, national delegates and other experts associated with the IEA AMF can point out the obstacles to and identify the types of R&D necessary to eliminate and/or overcome the obstacles. Making policy for alternative fuel implementation requires a prioritization of desirable attributes for the fuels and a balancing of the priorities with practical realities with regard to costs and benefits. The figure on the following page illustrates the process of defining the priorities along with the barriers, or bottlenecks.

Therefore the vision of the IEA AMF is:

To contribute to sustainable solutions through our system view of the entire fuel chain, from resource development to end-use. Our cooperative research in the field of transport fuels helps to facilitate the widespread use of sustainable fuels of high quality.

CRITICAL BOTTLENECKS	Fuel A	Fuel B	Fuel C
Feedstock availability			
Feedstock location/transport		●	
Fuel processing			
Fuel transport			
Dispensing	●		
Vehicle end-use	●		
Sustainability		●	
Overall environmental impact		●	
Overall energy use			
Overall costs	●		

The mission of the IEA AMF is:

The IEA AMF is one of the key players in the promotion of international collaboration in R&D, deployment, and dissemination of clean, energy-efficient, and sustainable fuels and related vehicle technology.

It will continue to provide a fuel-neutral platform for co-operative R&D, deployment, and dissemination; make use of the multifaceted expertise of its partners and networks; and provide a respected clearinghouse for information facilitating the widespread deployment of technologies for sustainable transport.

We foresee increased need for cooperation and collaboration with other transport-related Implementing Agreements, such as Bioenergy, HEV, and Combustion. Together with new AMF member countries, we are able to address a more diverse set of challenges in technology and local conditions.

We also work actively for energy conservation in transport.

Fuels included under the definition of Advanced Motor Fuels are fuels that fulfill one or more of the following criteria:

- Low toxic emissions
- Improved life-cycle efficiency
- Reduced greenhouse gas emissions
- Based on renewable energy sources
- Can be used in new propulsion systems
- Sustainable in transportation applications
- Secure supply

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

- Alcohols (ethanol, methanol), ethers (e.g., dimethyl ether [DME], ethyl tert-butyl ether [ETBE], methyl tert-butyl ether [MTBE]), esters (e.g., rapeseed oil methyl ester [RME]), gaseous fuels (e.g., natural gas, biogas, hydrogen, liquefied petroleum gas [LPG])
- Reformulated gasoline and diesel fuels, including oxygenated versions
- Synthetic fuels, such as Fischer-Tropsch fuels
- Fuels for new types of engines and fuel cells

1.d
How to Join the Advanced Motor Fuels Implementing Agreement

Participation in the multilateral technology initiative (IEA-AMF Implementing Agreement) is based on mutual benefit to the Implementing Agreement and the Interested Newcomer.

If you are interested in joining the Implementing Agreement, please contact the IEA AMF Secretary, Dina Bacovsky (dina.bacovsky@bioenergy2020.eu).

The Secretary will provide you with details on the Implementing Agreement and invite you to attend an Executive Committee Meeting as an Observer. By attending or even hosting an ExCo Meeting, you will become familiar with the Implementing Agreement.

Contracting Parties to IEA AMF are usually governments. Therefore, you need to seek support from your government to join the Implementing Agreement. The government will later appoint a Delegate and an Alternate to represent the Contracting Party in the Executive Committee.

Financial obligations of membership will include:

- An annual membership dues; currently 9,500 EUR
- Funding for participation of an ExCo Delegate at 2 annual meetings
- Cost-sharing contributions to Annexes in which you wish to participate; cost shares range from 10,000 EUR to 100,000 EUR

Participation in Annexes can take place through cost sharing and/or task sharing. The institution participating in an Annex does not necessarily need to be the institution of the ExCo Delegate.

The IEA AMF Secretary and IEA Secretariat will guide you through the formalities of joining the Advanced Motor Fuels Implementing Agreement.

2 The Global Situation for Advanced Motor Fuels

2.a Overview of Advanced Motor Fuels

2.a.i Statistical Information on Fuels and Fleets

In 2009, the worldwide demand for transport fuel for road transport was 1,701 Mtoe, representing a share of 42% of the global primary oil consumption. Alternative motor fuels contributed a share of 7.7% to the global demand for road transport fuel; biofuels, as a subset of alternative motor fuels, contributed 3% (Table 1).

Table 1 Volumes of Alternative Road Transport Fuels; Data Compilation

ROAD TRANSPORT ALTERNATIVE FUELS	Volumes	
	Mtoe/a	%
Total road transport worldwide[a]	**1.701,00**	**100,00**
Alcohols		
Ethanol[b]	38,7	2,3
Methanol[c]	3,0	0,2
Biodiesel		
FAME biodiesel[b]	10,5	0,6
Hydrotreated biodiesel[d]	2,5	0,1
Other liquid fuels		
GTL[e]	13,0	0,8
CTL[e]	10,0	0,6
Gaseous fuels		
Natural gas and biomethane[f]	33,0	1,9
LPG[g]	21,0	1,2
TOTAL		
Alternative fuels	**131,7**	**7,7**
Biofuels	**51,7**	**3,0**

Table 2 Volumes of Alternative Road Transport Fuels; Data Compilation (Cont.)

[a] *Energy Efficiency Indicators in the Transport Sector, Natalie Trudeau. © OECD/IEA, 2011.*

[b] *Volume for 2009. IEA WEO 2010. Volume of hydrotreated biodiesel reduced from total biodiesel of 12.9 toe to represent FAME biodiesel volume.*

[c] *Volume for 2010. Source: Methanol Institute.*

[d] *Volume for 2010. Insludes Neste Oil's NExBTL capacity of 1.14 Mtoe (w/o Rotterdam) and capacity of ConocoPhillips, Syntroleum and Eni. Press releases and U.S. DOE's AFDC.*

[e] *Production capacity. IEA ETSAP - Technology Brief S02, May 2010.*

[f] *Volume for 2010. Calculated with general assumptions for the NGV population, which is 12.67 million in 2010 according to IANGV statistics (http://www.iangv.org/tools-resources/statistics.html).*

[g] *Volume for 2008. http://www.worldlpgas.com/gain/key-autogas-data.*

BTL = Biomass to Liquids; GTL = Gas to Liquids; CTL = Coal to Liquids; LPG = Liquefied Petroleum Gas

The main biofuel producers are the United States and Brazil for ethanol and the European Union for biodiesel. In 2009, the global production of ethanol was 38.7 Mtoe, and the global production of biodiesel was 12.9 Mtoe (Figures 1 and 2). Biodiesel production can be split into 10.5 Mtoe of FAME and 2.5 Mtoe of diesel derived from the hydrotreatment of vegetable oil.

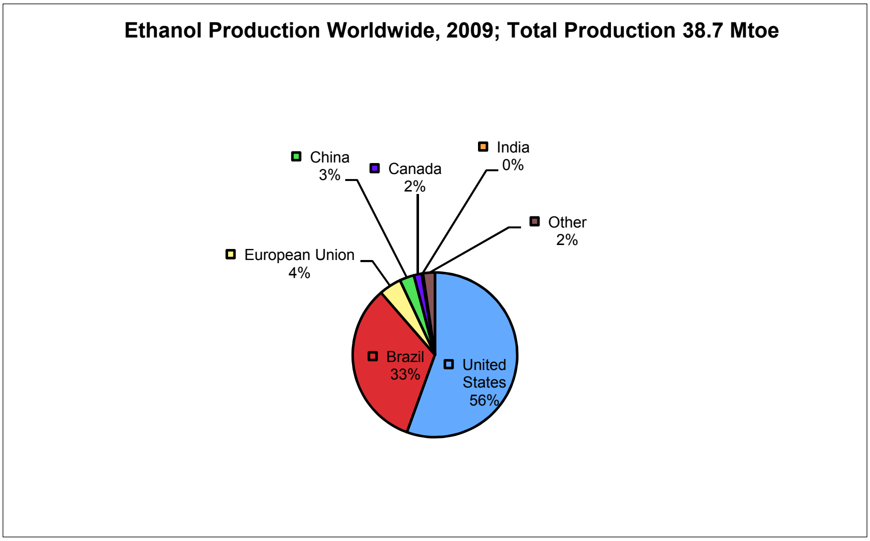

Fig. 1 Ethanol Production Worldwide, 2009; Source: IEA World Energy Outlook 2010

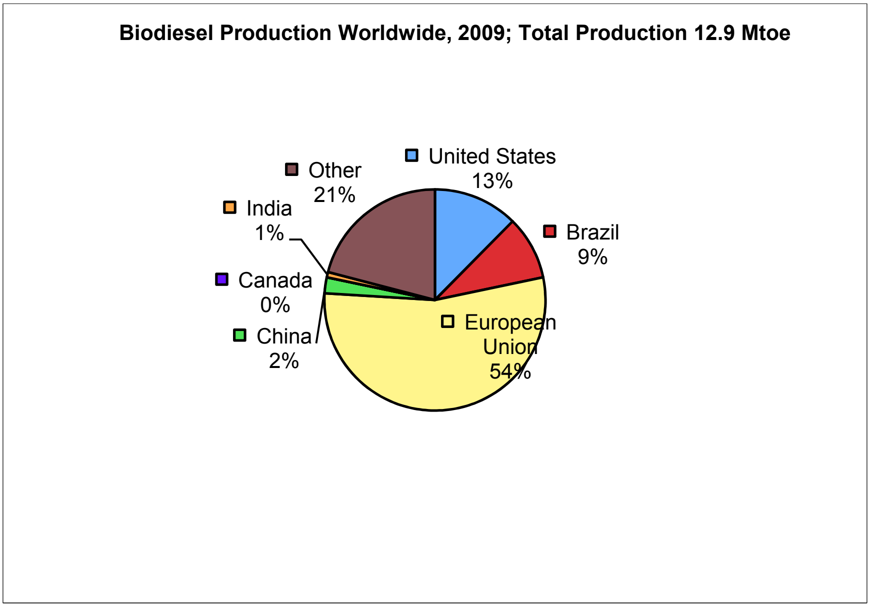

Fig. 2 Biodiesel Production Worldwide, 2009; Source: IEA World Energy Outlook 2010

Other alternative liquid fuels, apart from biofuels, comprise GTL (Gas-to-Liquids) and CTL (Coal-to-Liquids). These are the final products of the coal and gas liquefaction process, and these products are transport fuels similar to diesel and gasoline and other liquid chemical products, such as methanol and dimethylether (DME). Gas-to-Liquids (GTL) plants with a capacity of almost 13 Mtoe are currently in operation in Indonesia, Malaysia, Qatar, Mexico, New Zealand, South Africa, and Trinidad. South Africa has the world's largest CTL production capacity, thanks to locally available low-cost coal.

Gaseous alternative fuels comprise natural gas, biogas, liquefied petroleum gas (LPG, also called propane or autogas), and hydrogen. Natural gas production was 33.0 Mtoe in 2010 (calculated based on the NGV population), and LPG production was 21.0 Mtoe in 2008 (World LP Gas Association data). Main consumers of LPG in vehicles are Pakistan, Iran, Argentina, Brazil, and India. The number of LPG vehicles was 14.6 million in 2008 (WLPGA data), representing approximately 1.8% of vehicles; the main consumers of LPG in vehicles are South Korea followed by Turkey, Poland, Japan, and Australia.

While liquid alternative fuels can be used pure or in blends in the existing vehicle fleet, vehicles need to be adapted for the use of gaseous fuels. The total number of vehicles on the road worldwide was close to 800 million in 2010 (IEA data); the number of natural gas vehicles was 12.6 million by December 2010 (IANGV [International Association for Natural Gas Vehicles] data), representing approximately 1.6% of vehicles (Figure 3). Natural gas vehicles represent more than 60% of all vehicles in Pakistan and approximately 15% of vehicles in Iran and Argentina.

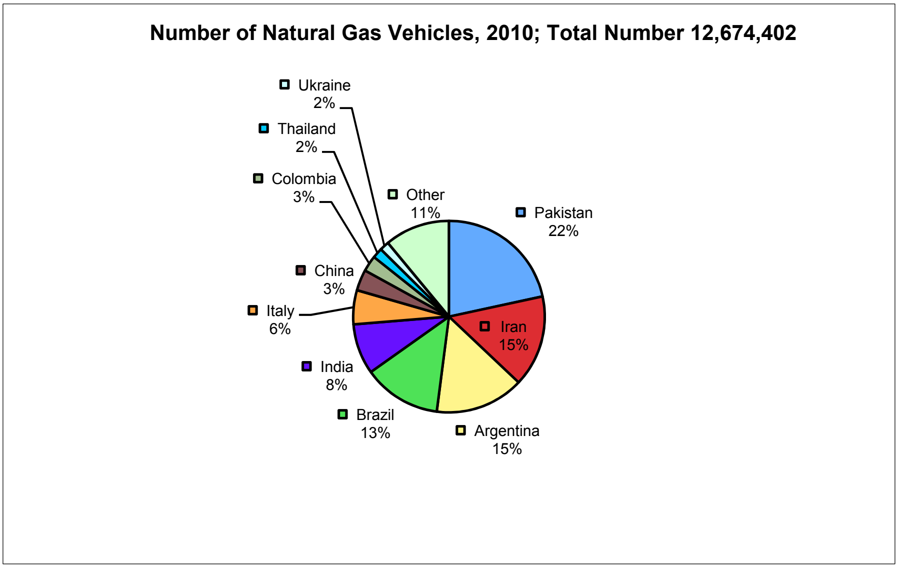

Fig. 3 Number of Natural Gas Vehicles in 2010; Source: International Association for Natural Gas Vehicles

The passenger-car and truck fleet worldwide is growing, and it is growing faster in China than anywhere else: preliminary data show that new car sales topped 13.6 million in 2009, overtaking sales in the United States for the first time. The total car fleet in China is now estimated at almost 40 million — more than twice as big as just three years ago. Car and truck sales are growing rapidly in many other non-OECD (non-Organisation for Economic Co-operation and Development) countries as well, particularly in Asia (Figure 4). Still, vehicle ownership rates in China are well below those in the OECD: there are only 30 cars for every thousand people in China, compared with around 700 in the United States and almost 500 in Europe.

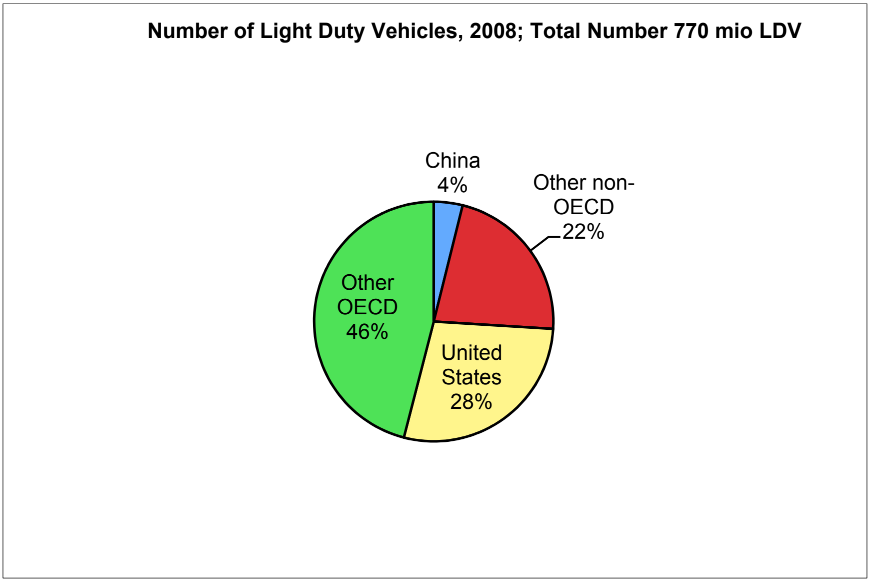

Fig. 4 Number of Light-Duty Vehicles, 2008; Source: IEA World Energy Outlook 2010

2.a.ii
National Goals for Advanced Motor Fuels

Many countries have adopted national goals for the use of biofuels or alternative motor fuels. Measures applied include biofuel production subsidies, biofuel mandates, tax reduction, and vehicle purchase incentives. Most countries rely on biofuels mandates, often combined with tax reduction. National goals for advanced motor fuels are listed in Table 2; the information given is based on data from the IEA WEO 2010.

Table 2 National policy measures regarding advanced motor fuels; Source: IEA World Energy Outlook 2010

Policy Measures	Fuel Production Subsidies	Fuel Mandates or Targets	Fuel Tax Reduction
Argentina		x	x
Australia		x	x
Brazil		x	x
Canada	x	x	
China	x	x	
Colombia		x	
France		x	x
Germany		x	x
India		x	
Italy		x	x
Japan		x	
Korea		x	
Paraguay		x	
Peru		x	
South Africa		x	x
Spain		x	x
Sweden		x	
Thailand		x	x
United Kingdom		x	x
United States	x	x	x
Zambia		x	

2.b
Country Reports

Most of the countries participating in the IEA Advanced Motor Fuels Implementing Agreement and Norway (which is currently participating as an Observer) have prepared reports to highlight the production and use and the existing policies of advanced motor fuels in their respective countries.

Austria

Introduction

The transport sector in Austria has the highest share of final energy consumption; the corresponding distribution for 2008 was 33,7% for transport, followed by industry (28,6%), private households (25%), and public and private services (10,4%). Of these, the sector also has the highest growth since 1990 (54,4%).

With a total of 21,7 million tons CO_2 eq., the GHG emissions from transport decreased by 0,9 million tons in 2009 compared to the previous year, yet the current values exceed the targets set by the Kyoto Protocol for Austria by 2,8 million tons (Austria should reduce GHG emissions by 13% in the period 2008 – 2012, with 1990 as reference year).

To reach the goals set by the European Climate and Energy Package, which includes a share of 10% of renewables in the transport sector by 2020, the National Energy Strategy of 2010 (Energiestrategie) identified several measures, including higher mineral fuels and vehicle taxation, as well as higher shares of biofuels in gasoline and diesel.

Sources:
http://www.lebensministerium.at/article/articleview/86563/?SectionIDOverride=110

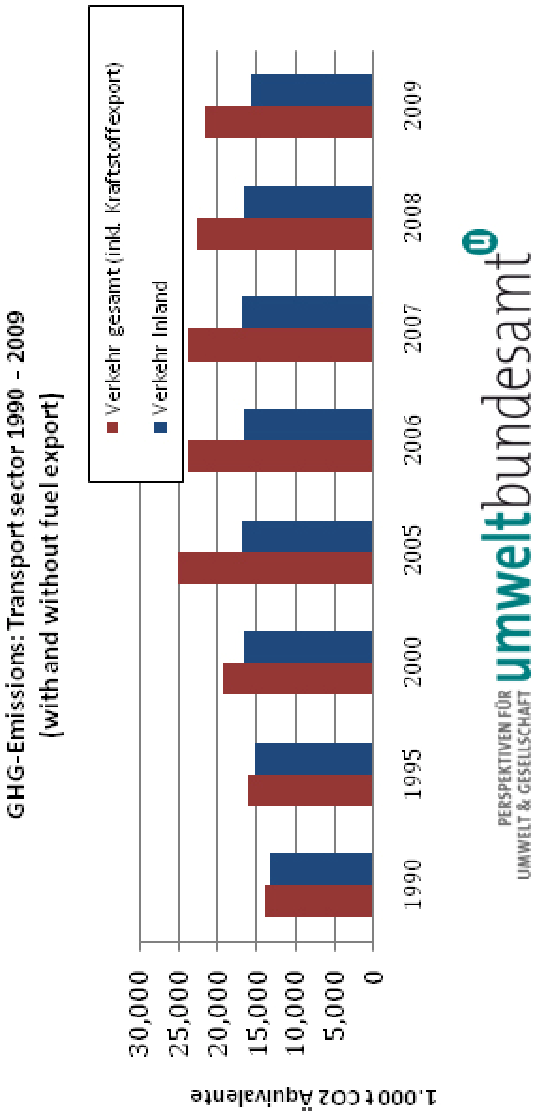

Fig. 1 Status of GHG emissions from transport sector in Austria
Source: Umweltbundesamt

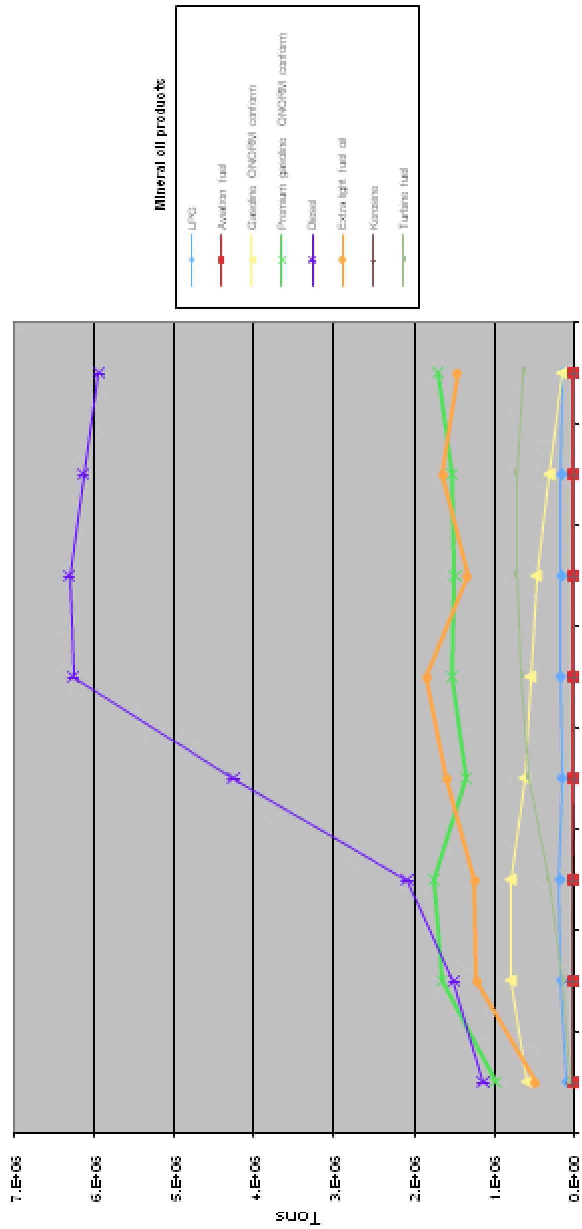

Fig. 2 Consumption of mineral oil products for the period 1970 – 2009
Source: Statistik Austria

Table 1 Mineral oil consumption by type of fuel

Mineral oil consumption 1970 – 2009 (tons)								
End product	1970	1980	1990	2000	2005	2007	2008	2009
LPG	88.746	156.363	179.145	150.300	171.530	157.895	151.521	142.877
Aviation fuel	1.645	2.896	2.910	2.039	2.787	2.856	2.938	3.268
Gasoline ÖNORM conform	589.521	791.130	794.504	622.820	545.331	474.145	310.500	149.523
Premum gasoline ÖNORM conform	984.308	1.645.176	1.757.750	1.357.577	1.528.108	1.491.941	1.524.494	1.692.339
Diesel	1.135.658	1.503.096	2.084.047	4.262.146	6.267.778	6.320.011	6.147.472	5.952.125
Extra light fuel oil	479.226	1.216.627	1.247.283	1.592.144	1.848.956	1.327.628	1.642.158	1.457.413
Kerosine	12.006	17.373	8.820	1.121	1.012	998	680	423
Turbine fuel	41.895	132.602	314.638	570.229	653.176	724.153	725.280	632.565

Source: BMWA from 2008 on BMWFJ. Diesel includes mixtures with Biodiesel from 2005 on. Extra light fuel oil corresponds to gas oil for heating purposes

Table 2 Natural Gas Supply in 2009

	Million cubic meter (2009)	GWh (2009)	Relative to 2008
Import	37.946	422.722	-3,0%
Production	1.667	18.569	9,1%
Export	30.383	338.467	-2,7%

Source: E-Control

Policies and Legislation

Fiscal measures:
The 1995 fiscal law for Mineral Oil was adjusted in December 2009, establishing the minimum biofuel content requirement for fuels to be applicable for lower tax rates.

The tax rates for 1000 l of fuel are as follows:

Table 3 Tax Rates for 1000 l Fuel (€)

Gasoline	Tax rate
After September 2007	
Max. sulphur content: 10 mg/kg and biofuel content at least 44 l	442
Else	475
After December 2009	
Max. sulphur content: 10mg/kg and biofuel content at least 46 l	442
Else	475
Diesel	**Tax rate**
After June 2007	
Max. sulphur content: 10 mg/kg and biofuel content at least 44 l	347
Else	375
After December 2009	
Max. sulphur content: 10 mg/kg and biofuel content at least 66 l	347
Else	375

Source: Umw eltbundesamt. 100% biofuel is from this tax exempted

Biofuel substitution:
The biofuel substitution goal set by the *Fuel Regulation* (Kraftstoffverordnung) beginning on 1 January 2009 is 5,75% (energy content) of the total Otto and diesel fuels consumption in Austria.

For 2009, the 5,75% goal was exceeded, reaching a share of biofuels of 7%.

In 2009, 5.952.125 tons of diesel were sold; 99% of this volume had a biodiesel average content in volume of 6,52%.

The average biogenous share of gasoline in 2009 was 4,95% in volume, which means total bioethanol consumption was 99.628 tons, including E85 consumption (from a total of Otto fuels of 1.841.711 tons that were mixed with bioethanol).

Source: Umweltbundesamt "Biokraftstoffe im Verkehrssektor 2010"

Tax modifications
An increase of the mineral oil tax applies since the beginning of 2011: +0,04 €/l for gasoline and +0,05 €/l for diesel.

Starting in July 2008, a new bonus-malus system was introduced for the taxation on the acquisition of new vehicles (NoVA - Normverbrauchsabgabe). A reduction of 300 € is applied for vehicles with CO_2 emissions lower than 120 g/km.

A further increase in the NoVA-Malus applies since 1 January 2011:

- Over 160 g/km increased to 25 €/g CO_2 (already since 1.1.2010)
- Over 180 g CO_2/km increased from 25 to 50 €/g CO_2
- Over 220 g CO_2/km increased from 25 €/g CO_2 to 75 €/g CO_2

Regarding NO_x emissions, gasoline vehicles with a maximum of 60 mg/km and diesel vehicles with a maximum of 80 mg/km and particle emissions not higher that 0,005 g/km receive a maximum tax reduction of 200 €.

Vehicles running on alternative fuels, such as E 85, CNG, and LPG among others, or hybrid vehicles obtain a reduction of maximum 500 €. This measure is planned until the end of August 2012.

Implementation: the Use of Advanced Motor Fuels

Table 4 Fleet Distribution by Drive Train in Passenger Cars as of 31.12.2009

Drive train	Total
Gasoline[1]	1.972.352
Diesel	2.381.906
Electric	223
LPG	1
Natural gas	1.105
Bivalent Gasoline/LPG	56
Bivalent Gasoline/Natural Gas	742
Hybrid Gasoline/Electric	3.559
Total	**4.359.944**

Source: Statistik Austria, Kraftfahrzeuge, Kfz-Bestand.
[1] *Includes Gasoline/Ethanol (E85).*

Table 5 New Registrations by Drive Train – Passenger Cars

New registrations of passenger cars in 2010 classified by type of drive train (absolute numbers, share in %)					
	Passenger cars				
Drive train	2010	Share in %	2009	Share in %	Difference in %
Gasoline[1]	159.740	*48,8*	170.847	*53,7*	*-7,0*
Diesel	167.130	*51,0*	146.962	*46,2*	*12,1*
Electric	112	*0,0*	39	*0,0*	*65,2*
Natural gas	171	*0,1*	270	*0,1*	*-57,9*
Bivalent: Gasoline/Natural Gas	30	*0,0*	40	*0,0*	*-33,3*
Hybrid Gasoline/Electric	223	*0,1*	224	*0,1*	*-0,4*
Total	**327.406**	***100,0***	**318.382**	***100,0***	***2,8***

Source: Statistik Austria, Kraftfahrzeuge, Kfz-Neuzulassungen.
[1] *Includes Gasoline/Ethanol (E85).*

Table 6 Filling Stations for Alternative Fuels – Status 2010

Fuel	Total
CNG	170
Biogas	1
E85	28
Vegetable oil	19

Source: http://www.raiffeisen-leasing.at/tankstellen.html

Research programmes: the funding budget for RD&D for the transport sector for 2009 and 2010 was increased by 50% (from 40 to 60 million €).

A3plus
This programme, funded by the Federal Ministry for Transport, Innovation and Technology, strives to make transportation of the future significantly more energy-efficient and environmentally friendly by promoting RD&D in innovative propulsion technologies and alternative fuels in order to achieve reductions in the energy consumed by surface transport vehicles and to reduce emissions from this sector. The programme also aims to develop such systems for rail and inland waterway transportation.

Calls for proposals for research projects are scheduled annually over the time frame of the IV2Splus programme.

A3plus core areas (4^{th} call – 2010) include the following:

- Alternative propulsion systems for road, rail, and waterways
- Automotive electronics for energy-efficient control and management of system operation
- Innovative storage concepts
- Alternative fuels
- Development of required infrastructure (recharging/filling stations) for alternative propulsion systems

The budget available for the 4^{th} call of this programme is 5 million €.

Neue Energien 2020
This programme, funded by the Climate and Energy Fund, was introduced in 2009.

Its goal is to support research on state-of-the-art technologies that target short- and medium-term efficiency improvements in road, rail, and waterways transport.

The areas covered are, among others, R&D projects for optimization of energy efficiency and emission reduction of ICEs and subsystems and new material technologies, such as those for lightweight construction.

Outlook

Beginning in January 2011, the mineral oil tax on gasoline will increase by 0,04 €/l, and on diesel, it will increase by 0,05 €/l.

Also effective January 2011, a further increase of the NoVA was implemented: the Malus was doubled from 25 to 50€ per exceeding gram of CO_2 (over 180 g CO_2/km). At over 220 g CO_2/km, the Malus was set at 75 €/g CO_2.

The goal set for transport by the European Climate and Energy Package is to substitute 10% of the fossil fuels consumption with renewable energy sources.

An upcoming measure reported by the National Energy Strategy of 2009 (Energiestrategie) is the introduction of E10 and B10 (presumably by 2012 and 2017, respectively), following the approval of the corresponding European Standard for these fuels.

Total use of the ethanol national production capacity is expected to save yearly 400.000 tons of CO_2 eq.

Further measures foreseen in the area of alternative fuels are:
- Higher utilization of B100, E85, vegetable oil and
- Significant increase in biogas utilization through the market introduction of Biogas-CNG mixture with at least 20% content, as well as an increase in the number of CNG cars to 200.000 by 2020.

Sources: http://www.energiestrategie.at

Additional References

Information for alternative fuels:
www.erdgasautos.at
http://www.gaswaerme.at/
http://www.virtuellesbiogas.at/
http://www.get.ac.at/Home.html (Güssing Energy Technologies – second-generation biofuels)
http://www.raiffeisen-leasing.at/tankstellen.html?&L=rzxpekllwpubntec (filling stations for alternative fuels)
www.methapur.com (Biogas filling stations)

Relevant institutions and programmes:
Klima:Aktiv Initiative: http://www.klimaaktiv.at/
Wirtschaftskammer Österreich: http://portal.wko.at/wk/startseite.wk
E-Control: http://www.e-control.at
Statistik Austria: http://www.statistik.at
Umweltbundesamt: http://www.umweltbundesamt.at

Canada

Introduction

Transportation plays a crucial role in the social, economic, and political activities of all Canadians. By moving both people and goods in a country as vast as Canada, transportation has a significant impact on where people choose to live, vacation, shop, and work. Transportation is also a major consumer of resources, such as fuel, materials, and land, which results in pressure on the environment.

Changes in the economy have a considerable impact on transportation demand. In 2009, GDP (gross domestic product) in the transportation sector fell by 4.3% to $55.8 billion, down from 2.3% annual growth in the 2001–2008 period. The sector nevertheless remained a strong contributor to Canada's overall GDP, accounting for 4.7% in 2009[1].

Canada currently produces about 2.5 million barrels of oil per day and consumes about 1.85 million barrels per day[2]. Overall, Canada imports about 930,000 barrels per day and exports about 1.63 million barrels per day (Figure 1). Therefore, Canada is a net exporter of petroleum products.

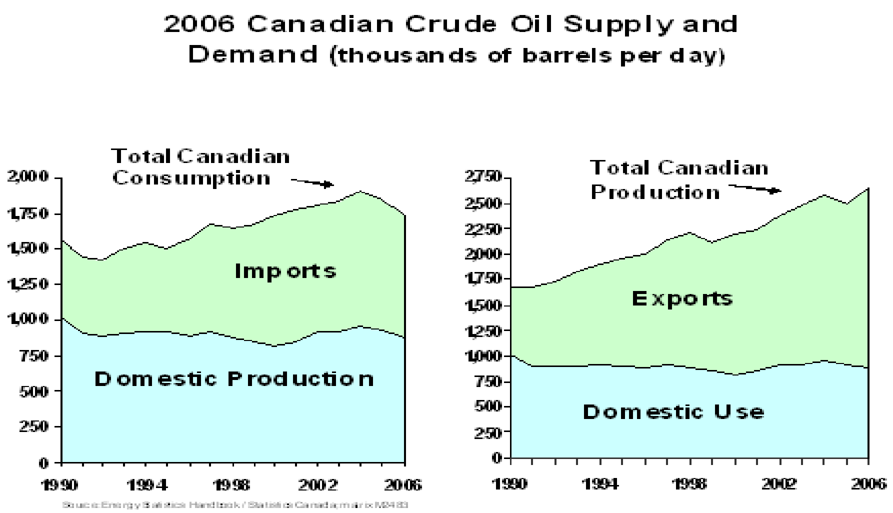

Fig. 1 2006 Canadian Crude Oil Supply and Demand (thousands of barrels per day)

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1 Statistics Canada, "Transportation," http://www.statcan.gc.ca/pub/11-402-x/2010000/chap/tran/trans-eng.htm

2 Natural Resources Canada, "Canadian Oil Market Review of 2006 & Outlook to 2020," http://www.nrcan.gc.ca/eneene/sources/crubru/outape-eng.php

Biofuels — or fuels from renewable sources — are a growing form of bioenergy in Canada. The principal agriculture feedstock for producing ethanol, a gasoline substitute, includes corn and wheat. Canada is a major world producer and exporter of these grains. As well, vegetable oils and animal fats can be used to produce biodiesel, a diesel substitute.[3]

In 2010, the domestic production capacity of biofuels in Canada was approximately 1.5 billion litres of ethanol and 200 million litres of biodiesel. The federal and provincial governments have announced several measures that should lead to the increased production and use of biofuels in the coming years, including the *Renewable Fuels Regulations*, published on September 1, 2010, in the Canada Gazette, Part II, requiring an average renewable fuel content of 5% in gasoline starting December 15, 2010.

Policies and Legislation[4]

The Government of Canada is committed to expanding the production and use of cleaner, renewable biofuels (such as ethanol and biodiesel) and has developed an integrated Renewable Fuels Strategy.

The strategy has several drivers, including the diversification of transportation energy use beyond conventional fossil fuels, which thereby enhances economic opportunities available to Canada's agricultural communities and reduces GHG emissions. The four key elements of the strategy include:

- **Establish minimum biofuels content through regulation**

The *Renewable Fuels Regulations* were published on September 1, 2010, in the *Canada Gazette*, Part II, and required an average renewable fuel content of 5% in gasoline starting December 15, 2010. The Government of Canada also announced its intention to regulate a 2% requirement for renewable content in diesel fuel and heating oil by 2011, subject to successful demonstration of technical feasibility under the range of Canadian conditions.

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3 Natural Resources Canada, "Renewable Energy," http://nrcan.gc.ca/eneene/renren/aboaprren-eng.php#bio

4 Government of Canada, "ecoACTION," http://www.ecoaction.gc.ca/ecoenergyecoenergie/renewablefuels-carburantsrenouvelables-eng.cfm
Government of Canada, Canada Gazette, "Regulations Amending the Renewable Fuels Regulations," http://canadagazette.gc.ca/rp-pr/p1/2011/2011-02-26/html/reg3-eng.html

In February 2011, after the successful demonstration of technical feasibility, the Government of Canada announced that it would be moving forward with the requirement for an average 2% renewable content in the national diesel fuel and heating oil pool. On February 26, 2011, the proposed regulatory amendment was published in the *Canada Gazette*, Part I, for a 60-day public comment period, with a proposed effective date of July 1, 2011.

These new regulations will require enough renewable fuel to reduce GHGs by about 4 megatonnes per year, which is the GHG equivalent of taking almost one million vehicles off the road.

- **Support the expansion of Canadian production of renewable fuels**

The Natural Resources Canada (NRCan) -led ecoENERGY for Biofuels Program will invest up to $1.5 billion over 9 years to boost Canada's production of renewable fuels, such as ethanol and biodiesel. The Program targets volume 2 billion litres of renewable alternatives to gasoline and 500 million litres of renewable alternatives to diesel.

The initiative will provide operating incentives to producers of renewable alternatives to gasoline and diesel on the basis of production/sales volume.

- **Assisting farmers to maximize new opportunities in this sector**

The ecoAgriculture Biofuels Capital Initiative (ecoABC), led by Agriculture and Agri-Food Canada (AAFC), is a federal $200 million program that provides repayable contributions for the construction or expansion of biofuel production facilities in which farmers invest.

The $20M for Biofuels Opportunities for Producers Initiative (BOPI), led by AAFC, assisted farmers in hiring technical, financial, and business planning advisors to help develop sound business proposals and undertake feasibility and other supporting studies.

- **Accelerating the commercialization of new technologies**

The NextGen Biofuels Fund™, administered by Sustainable Technology Development Canada, will invest $500 million with the private sector in establishing large-scale demonstration-scale facilities for the production of next-generation renewable fuels.

- **Actions in other Canadian jurisdictions**

Some provinces have established minimum renewable diesel content requirements for distillates. Tables 1 and 2 summarize the provincial requirements for distillates that have been announced or implemented to date.

Table 1 Provincial Ethanol Regulations

Province	Mandate	Date Effective
British Columbia	Provincial annual average 5.0% renewable content in gasoline	January 01, 2010
Alberta	5.0% average renewable alcohol content in gasoline	April 01, 2011
Saskatchewan	Blend average 7.5% ethanol in gasoline	November 01, 2005
Manitoba	Blend average 8.5% ethanol in gasoline [Blend average 5% for first quarter of 2008]	January 01, 2008
Ontario	Blend average 5.0% ethanol in gasoline	January 01, 2007
Québec	*Target*: average 5.0% ethanol in gasoline	2012

Table 2 Provincial Biodiesel Regulations

Province	Mandate	Date Effective
British Columbia	Provincial annual average 3.0% renewable content in diesel and heating oil [Phased-in approach: 4.0% in 2011 and 5.0% in 2012]	January 01, 2010
Alberta	2.0% renewable diesel content in diesel	April 01 2011
Manitoba	2.0% biodiesel in diesel pool	November 01, 2009

Implementation: the Use of Advanced Motor Fuels[5]

In 2006, renewable fuels used in the transportation sector represented less than 0.5% of fuel used, as shown in Figure 2. The renewable fuel consumed was predominately ethanol blended with gasoline in lower-level ethanol blends.

5 http://oee.nrcan.gc.ca/publications/statistics/parliament08-09/chapter1.cfm?attr=0

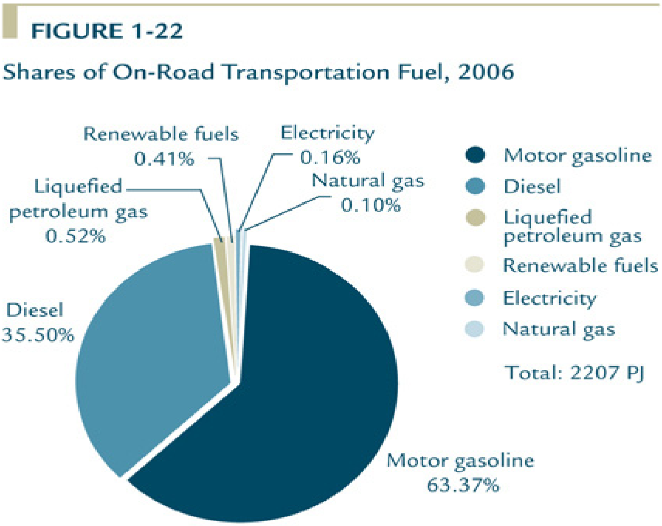

Fig. 2 Shares of On-Road Transportation Fuel, 2006

Fuel consumption

Table 3 lists the number of vehicles according to fuel type consumed in 2008. Virtually all vehicles (more than 99%) consumed either gasoline (including up to 10% ethanol blends) or diesel. Light vehicles primarily used gasoline (about 97%), while heavy vehicles primarily used diesel (also about 97%). Meanwhile, medium trucks were more varied in their fuel consumption, with about 75% running on diesel and the remainder running on gasoline.

Other types of fuel used by Canadians included electricity, propane, natural gas, and 85% ethanol/gasoline blends. These fuels were used by less than 1% of all vehicles.

Table 3 Vehicles in Canada by vehicle type and fuel type, 2008

	Vehicles			
Fuel	Light vehicles	Medium trucks	Heavy trucks	Total
Gasoline	18 808 773	107 160		18 923 790
Diesel	542 224	299 648	318 528	1 160 400
Other				
Total	19 426 504	412 811	327 106	20 166 421

Figure 3 shows gasoline and diesel consumption rates in 2005 and 2008 for each vehicle type. Fuel consumption remained constant for light vehicles (10.6 and 11.4 L/100 km for gasoline and diesel, respectively). Fuel consumption rates decreased for medium trucks (from 26.6 to 23.0 L/100 km for gasoline-powered trucks and 26.4 to 23.3 L/100 km for diesel-powered trucks). However, fuel consumption rates for heavy trucks fluctuated between 2005 and 2008 and ended the period at 35.3 L/100 km, up marginally from 35.1 L/100 km in 2005.

Figure 3 – Fuel consumption rate by vehicle type and fuel type, 2005 and 2008

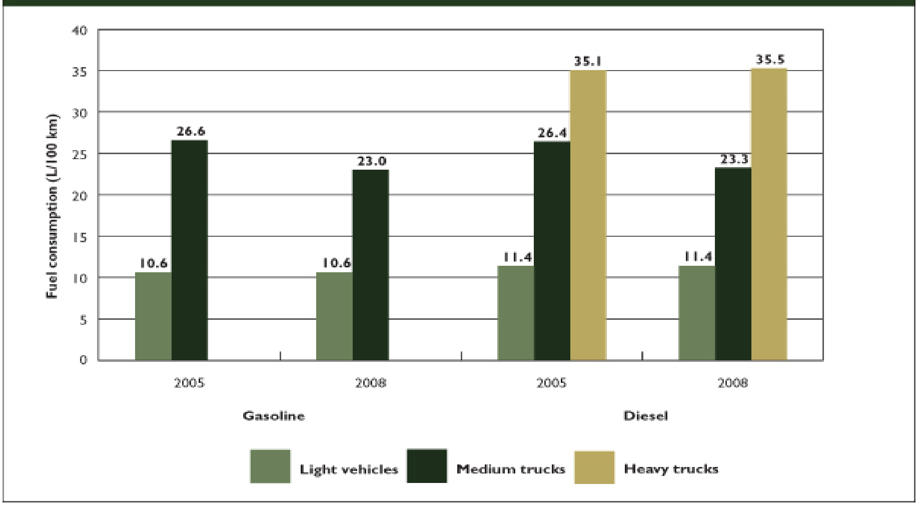

Fig. 3 Fuel Consumption Rate by Vehicle Type and Fuel Type, 2005 and 2008

Outlook

The recently enacted average renewable fuel content of 5% in gasoline requirement, as well as the proposed 2% requirement for renewable content in diesel fuel and heating oil, should stimulate the demand and use of renewable fuels in the transportation sector. The recently published *Natural Gas Use in the Canadian Transportation Sector Deployment Roadmap* focused on expanding the use of natural gas across the transportation sector and represents an important contribution to deliberations toward a broader strategy to reducing greenhouse gas (GHG) emissions. Further changes in transportation energy are expected to come from improvements in motor vehicle fuel efficiency.

Benefits of Participation in AMF

Canada has a long-lasting history of collaborative work, both domestically and internationally. Through its 25 years of participation in the IEA-AMF, Canada has been able to access and provide input to a worldwide recognised and unbiased source of data and recommendations, as well as leverage resources by either initiating or participating in a multitude of Annexes. To date, Canada has participated in 34 of the 41 IEA-AMF Annexes and initiated 6 of those Annexes, and vast amounts of the leveraged resources were reinvested domestically. Canada participates in all 10 Annexes that are currently active and leads Annex 40 on Life Cycle Analysis of Transportation Fuel Pathways. In addition to the usual cooperative interactions between the AMF member parties, AMF participation also provides opportunities to liaise with top experts and institutions from host countries, such as national R&D laboratories, universities, and fueling and transportation technology industries, and to create links with representatives from non-member countries who are invited to attend as observers to the IEA-AMF, with a potential for future participation.

Additional References

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The Natural Gas Use in the Canadian Transportation Sector Deployment Roadmap
http://oee.nrcan.gc.ca/transportation/alternative-fuels/resources/pdf/roadmap.pdf

Guiding Principles for Sustainable Biofuels in Canada
http://oee.nrcan.gc.ca/transportation/alternative-fuels/resources/principles.cfm?attr=16

National Renewable Diesel Demonstration Initiative
http://oee.nrcan.gc.ca/transportation/alternative-fuels/programs/nrddi/report-2010/toc.cfm?attr=16

Alternative Fuels Directory
http://oee.nrcan.gc.ca/transportation/alternative-fuels/resources/directory.cfm?attr=16

Alternative Fuels in Canada: Making Choices Today for a Better Tomorrow
http://oee.nrcan.gc.ca/publications/infosource/pub/transportation/fuels-in-canada.pdf

China

Introduction

Over the past two decades, the total number of vehicles in China has increased at an average rate of 12–14% annually. By the end of 2009, the motor vehicle population in China reached 62 million, and it will probably reach 200 million in 2020. With the growth of the vehicle population, fuel consumption in China increased rapidly. From 2000 to 2009, fuel consumption by vehicles increased from 55 million tons to 138 million tons. China's dependence on foreign oil is increasing year by year. Current imports of crude oil account for 45% of the total consumption, which is expected to reach to 75% by 2050.

Excluding gasoline and diesel, natural gas is another main energy source for vehicles in China. The others accounted for a small market share. By the end of 2009, vehicles powered by natural gas were promoted in 80 cities of China. There were 0.5 million natural gas vehicles with 1,300 refueling stations for them. Gasoline and diesel are predicted to continue to be the main fuels for automobiles in the next 20 years in China.

Policies and Legislation

In China, numerous national development strategies take the development of alternative fuels into consideration as an important green strategy, such as:

- The 11th Five-Year Plan of National Economic and Social Development,
- The 11th Five-Year Plan for Energy Development,
- National Long-term Scientific and Technological Development guidelines, and
- National Programs in Response to Climate Change.

In 2006, the 11th Five-Year Plan specified that China will largely develop renewable energy, accelerate the development and utilization of biomass energy, and expand the production of ethanol and biodiesel. In 2007, the National Development and Reform Commission issued the 11th Five-Year Plan for Energy Development to support the development of CNG and LPG vehicles, including city buses, taxis, and other public traffic vehicles. In 2007, the National Development and Reform Commission issued the 11th Five-Year Plan for Bio-industry Development, supporting the development of bio-liquid fuel.

In August 2007, the National Renewable Energy Long-term Development Plan specified the focus on the development of ethanol fuel technology by using cassava, cane, and sweet sorghum, as well as the development of biodiesel production technology that takes jatropha, pistache, tung, cottonseed, and other oil crops as raw material, which gradually establishes a waste-oil-recycling system in catering and other industries. In the long term, the focus should be on biofuel technologies with cellulosic biomass as the raw material. Moreover, the annual consumption of ethanol fuel is projected to reach 10 million tons in 2020, and the annual consumption of biodiesel is projected to be 2 million tons that same year. Consequently, 10 million tons of refined oil products will be substituted every year.

Implementation: the Use of Advanced Motor Fuels

Research into the use of natural gas as a vehicle fuel has a long history. At present, more than 80 cities in China are promoting the natural gas vehicles. The population of natural gas vehicles has reached 500,000, including buses, taxis, trucks, official vehicles, and private vehicles. The diversity of vehicles powered by natural gas by means of reliable technology and a more accessible infrastructure created favorable conditions for regional promotion.

LPG vehicles were greatly popularized in Beijing, Shanghai, Guangzhou, and Northeast China during the implementation of the Clean Vehicle Action. There were 40,000 LPG vehicles and more than 100 LPG refueling stations in Beijing by the year of 2000. In 2001, there were 103 LPG stations and 40,000 LPG taxis as a result of a subsidy by the Shanghai government. The annual consumption of LPG for vehicle usage was over 200,000 tons in 2001. Shanghai also implemented policies to keep the price of oil higher than that of LPG in order to support the development of LPG vehicles. During the 10th Five-Year Plan, Northeast China (including Harbin, Changchun, Shenyang, and Dandong) implemented a pilot project to promote LPG vehicles. The population of the LPG vehicles was over 30,000. Guangzhou carried out the promotion of LPG vehicles in 2003. The subsidy provided by the local government of Guangzhou for refitting an LPG taxi was 2,000 RMB, and the government subsidy for refitting an LPG bus was 20,000 RMB. With the support of local government, Guangzhou established 30 LPG refueling stations and had 12,000 LPG taxis (over 70% of the total taxis) and 6,799 LPG buses (over 81% of the total buses). In 2007, the consumption of LPG by vehicles was 300,000 tons.

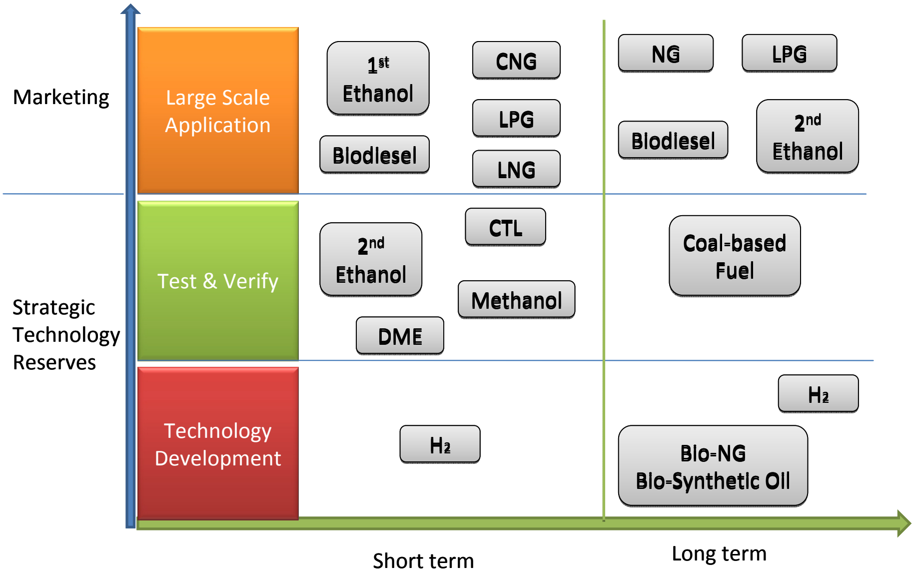
The Chinese government has established a series of development plans for ethanol fuel in 2001 and decided to build, rebuild, and enlarge the pilot project of ethanol fuel in Jilin, Henan, and Heilongjiang Provinces, respectively. Moreover, two national standards of ethanol fuel were set to promote the popularization of vehicles fueled with E10 fuel (a blend of 10% ethanol and 90% gasoline). The Chinese government made the cities of Zhengzhou, Luoyang, and Nanyang of Henan Province and Harbin and Zhaodong of Heilongjiang Province the first five cities to use E10 fuel and established a probation of 12 months, which symbolized the start of an ongoing plan that popularized the application of ethanol-gasoline blended fuel in China. Since 2004, China has made the closed operation of E10 ethanol gasoline in 9 provinces. The information supplied by the State Development and Reform Commission indicates that, at present, China has operated E10 vehicles in the whole of Henan, Jilin, Liaoning, Heilongjiang, and Anhui, Guangxi Province, and part of Hubei, Shandong, and Hebei, Jiangsu Province, and the E10 vehicles have performed well.

Shanxi Province is the first region to utilize methanol fuel from M15 to M100 in China. At the end of 2007, more than 700 refueling stations for the methanol have been established in Shanxi Province, which have been used for refueling over 40 million times. At the same time, taxis and buses had been refitted for methanol usage. Now, there are 2,000 M100 taxis and 260 M100 buses. More than 60% of the buses in Changzhou City use methanol as fuel.

Outlook

For the short-term plan, China will focus on the large-scale application of NG, LPG, 1st ethanol, and biodiesel. The fuel of CTL, DME, methanol, and 2nd ethanol produced from cassava, cane, and sweet sorghum will be at the testing and verification stage. Hydrogen fuel is at the technology development stage. China will continue to promote the low-proportion-ethanol gasoline and increase the pace of research and development into second-generation biofuels technology, the goal of which is to establish an international competitive bio-fuel industry.

The future technological roadmap for the alternative fuel vehicles in China as below:



Benefits of Participation in AMF

The China Automotive and Research Center (CATARC) participated in the IEA-AMF ExCo meeting as an observer in 2007 and gained the formal membership on July 30, 2008. For CATARC, participating in IEA-AMF has played a positive role in enhancing the cooperation with the International Energy Agency, communicating with experts all over the world, understanding advanced vehicle technology, and upgrading technological competence.

Denmark

Introduction

This report is based on information that can be found on the homepage of The Danish Energy Agency. For further information, please refer to www.ens.dk.

Policies and Legislation

The energy policy agreement from 2008 sets out ambitious goals for energy-saving initiatives. Total annual energy savings must be raised to 1.5% of the final energy consumption for 2006 (10.3 PJ per year), which corresponds to the combined energy consumption by about 110,000 homes. Furthermore, Denmark must reduce gross energy consumption by 4% by 2020 relative to 2006. At the same time, it has been decided that the energy-savings requirements of energy companies will be increased by about 85% from 2010, and that the requirements for the energy performance of buildings will be tightened by at least 25% in 2010, 2015, and 2020.

Related to transportation, the following initiatives were agreed upon:

- Electric vehicles are exempted from registration tax until 2012.
- Hydrogen vehicles are also exempted from registration tax.
- 35 mio DKK are set aside for the demonstration of electric vehicles in 2008–2012.
- The Danish government's goal is that biofuels should represent 5,75% of gasoline and diesel in 2010 and 10% in 2020, and that the biofuels should fulfill the EU's ambitions for sustainability – economically, environmentally, and socially.

Implementation: the Use of Advanced Motor Fuels

Information on this topic is in the previous section.

Outlook

This information presents the results of the Danish Energy Agency's annual outlook on energy consumption and emissions of greenhouse gases. The outlook is based on a so-called "frozen policy" scenario, which provides an assessment of future trends in energy consumption, energy production, and greenhouse gas emissions in the absence of new policies and measures. As the actual trends will be continuously influenced by new political initiatives, the scenario should not be regarded as a long-term prognosis, but rather as an approach that defines the challenges of future energy policy in relation to a set of established objectives. The "frozen policy" concept does not contain broad quantitative objectives. Only already-enacted energy-related policies, measures, and subsidies are considered. The scenario is underpinned by a number of assumptions about future economic conditions, technology specific conditions, and actions of different players in the energy market. Scenarios of this type are sensitive to many central but uncertain assumptions. Actual outcomes are, thus, likely to fluctuate upward or downward from those projected by the scenario. This year’s scenario is particularly sensitive to underlying assumptions about economic growth. The global economic downturn caused by the financial crisis has made current assumptions and previous expectations about short-term and long-term economic development extraordinarily uncertain, particularly regarding the extent of lasting negative effects from the downturn. This uncertainty affects the scenario directly as economic activity and energy consumption are closely linked.

The final energy consumption describes the use of energy in the industry, transport, household, and service sectors. The composition of the final energy consumption depends on the demand for energy services and the efficiency in the performance of these services. Figure 1 shows the final energy consumption for 1990–2025. In 2008 and 2009, energy consumption dropped significantly. The decrease is primarily explained by the economic crisis.

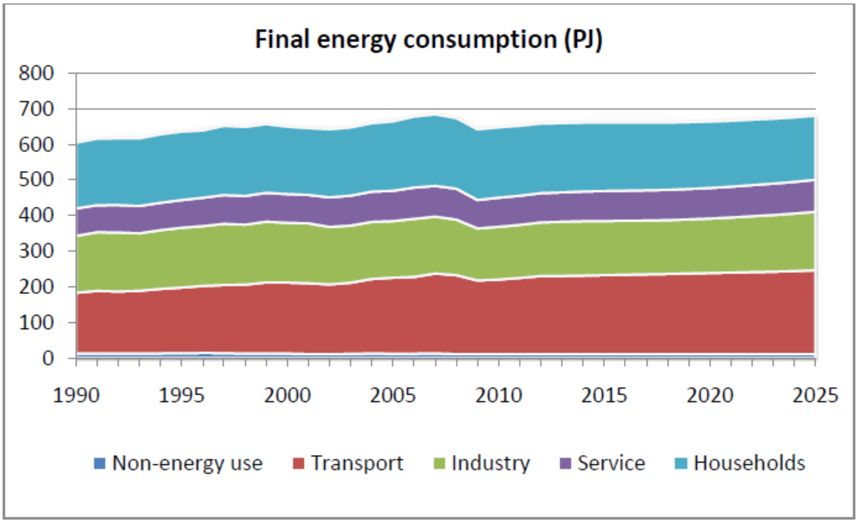


Fig. 1: Final energy demand by sector

The transport sector's energy consumption constitutes about a one-third of the final energy consumption and consists almost exclusively of fossil fuels. At the same time, the transport sector is not covered by the EU Emission Trading Scheme (also referred to as a non-traded sector) and is, thus, not under any sector-wide obligations to reduce CO_2 emissions. The transport sector includes road, rail and maritime transport, aviation, and transport-related energy consumption by the national defense. Road transport represents the largest part of energy consumption in the transport sector. This is followed by aviation, where the main part is international aviation, which is not included in Denmark's climate objectives.

The scenario for energy consumption by means of transportation is shown in Figure 2. In 2009, a fall in road transport is expected as result of the economic crisis. Overall, the demand for transport energy is projected to grow at about 0.8% annually in the period 2009–2025. The subdued future growth in energy demand reflects expectations for greater and faster technological improvements, particularly in the energy efficiency of passenger cars and a lower rate of increase in road transport.

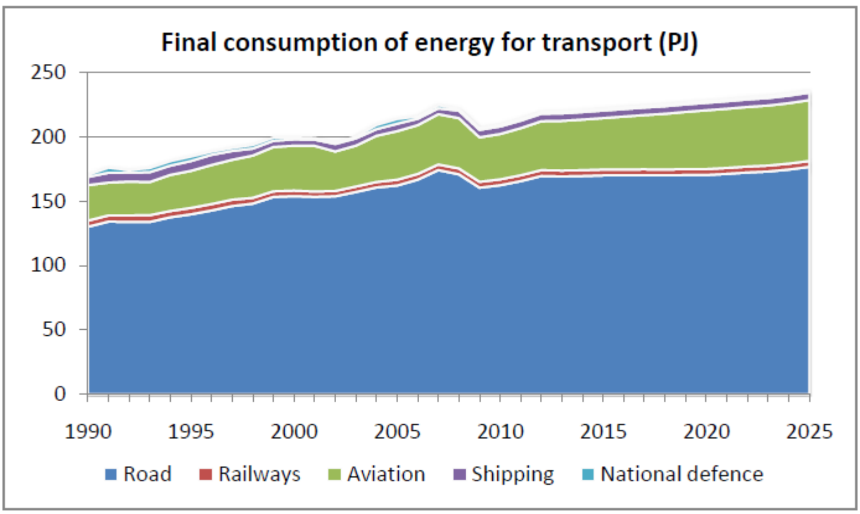


Fig. 2 Energy consumption by means of transportation

There is considerable uncertainty about the future trends in driven kilometres and average energy efficiency, which is of particular importance in relation to road transport and, thus, in achieving the objectives for CO_2 emission reductions in the non-traded EU ETS sectors (NETS).

At the EU level, enacted objectives for reduction in CO_2-emissions are imposed on the automobile industry. It is assumed that these objectives are achieved, but this is still uncertain. It is also unclear whether the objectives will have the same effect in Denmark as in the EU on average.

A continued switch from petrol to diesel for both passenger and commercial vehicles is expected.

Furthermore, the share of biofuels is assumed to increase gradually to 5.75% in 2012 in accordance with political objectives. It is also assumed that only first-generation biofuels will be of concern and that the use of electric cars will not be widespread. These assumptions are based on the assessment that additional political initiatives are required to drive such developments. The total energy demand for road transport by fuel type is shown in Figure 3.

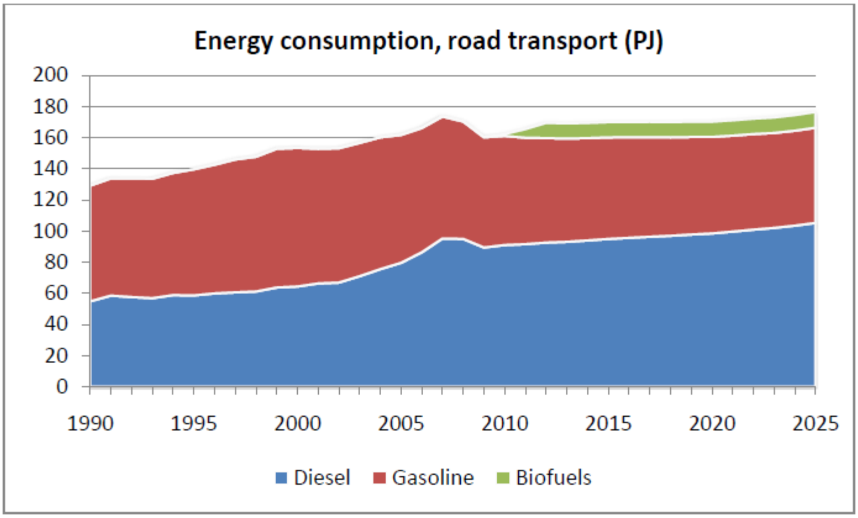


Fig. 3 Energy consumption of road transport by fuel type

Finland

Introduction

The primary energy consumption in Finland was 1420 PJ (~32 Mtoe) in 2009. The energy mix is well balanced, including contributions from oil, coal, nuclear energy, and hydropower (Figure 1). The share of renewable energy is exceptionally high — a total of 25.6% in 2009. The pulp and paper industry uses process side streams for power and heat generation, and this accounts for the greater part of the bioenergy share. In addition, peat is used for energy purposes, and wood is used for the heating of small houses. Directive 2009/28/EC sets a target of a 20% for renewable energy in the EU by 2020. A national target of 38% is set for Finland. Figure 1 shows the share of energy consumption in 2009.

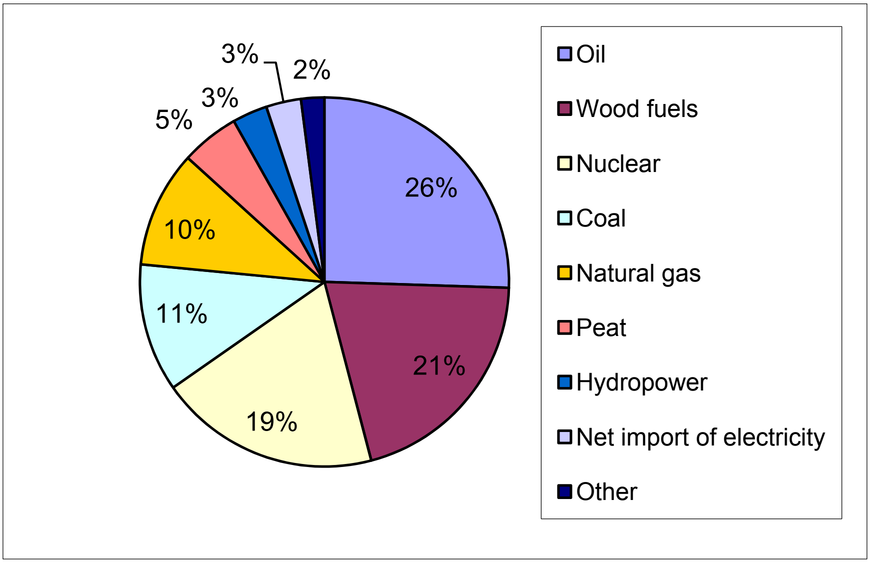


Fig. 1 Energy consumption in Finland in 2009 (Statistics Finland, www.stat.fi)

Finland is a sparsely populated country with long distances. Transportation work per capita, both for people and goods, is among the highest in the world. Transportation consumed 16.4% of total energy in 2009 (lipasto.vtt.fi). Table 1 presents the vehicle population (four of more wheels) in 2008. The total number of vehicles in 2010 was approximately 2,9 million. High-concentration ethanol fuel (E85) and FFV cars were introduced to the Finnish market in the spring of 2009. The number of FFVs at the end of 2010 is in the range of 100–1500 units.

The dominating fuels are petrol and diesel. For work machinery, it is allowed to use fuel oil with low taxation. Table 2 presents the use of transportation fuels in Finland.

Table 1 The vehicle population in Finland in 2010 (vehicles in use, www.trafi.fi)

Passenger cars*	Vans	Trucks	Buses		Total
2,520,995	292,234	97,203	11,484		2,921,916
Vehicles/1000 inhabitants					600

** Share of diesel vehicles ~19 %*

Table 2 The use of fossil transportation fuels (road transport) in Finland in 2009 (Finnish Oil and Gas Association) and biofuels in 2008 (EU Member State report 2009, ec.europa.eu)

Petrol [a] (Mt)	Diesel [b] (Mt)	Bioethanol (Mtoe)	Bioethers (Mtoe)	NExBTL, FAME (Mtoe)	Natural gas [c] (MNm^3)	LPG [d] (Mt)
1.7	2.2	0.03	0.04	0.01	5.5	0

[a] From 1.1.2011 — contains max. 10% ethanol; E85 at 7 filling stations in metropolitan area of Helsinki.
[b] May contain HVO or FAME.
[c] Value for 2008; source: Gasum.
[d] None at the moment; in 1990s, some 300 vehicles existed.

Policies and Legislation

Finland has no incentives for biofuels for transport. However, as of 1 January 2008, a national law has required fuel distributors to provide biofuels to the market (Law 446/2007). A mandate was deemed more cost-effective than a system based on incentives. The obligation is flexible (for regions, season, concentrations, etc.), and the fuel distributors can decide on how they best meet the targets. Distributors may transfer all or part of their obligation to another company. The national targets were 2% in 2008 and 4% in 2009 and in 2010 (target should have been 5.75% in 2010, according to Directive 2003/30/EC). In 2010, with the 4% obligation for biofuels, the amount of biofuels is some 160,000 toe.

The biofuels obligation law was amended in December (1420/2010). The new scheme is very progressive: 6% for 2011–2014, and then a linear increase from 8% in 2015 to 20% in 2020 (values as share of energy). The preamble states that the 20% obligation in 2020 will predominantly be met by fuels eligible for double counting according to the Directive 2009/28/EC, thus reducing the factual share to 10%. In 2020, the 20% target for biofuel use would mean some 730,000 toe of biofuels, or 365,000 toe when using "double-counted" biofuels, such as waste and residue-based biofuels. An estimated 365,000 tons of "double-counted" biofuels could be produced in Finland from wood residues in 2–3 biofuel plants. These second-generation biofuels would not require any changes to vehicles or infrastructure.

To enable 6% biofuels in 2011, E10 petrol (petrol containing 10 vol.% ethanol) was launched in the market in the beginning of 2011. This corresponds to some 110,000 toe ethanol, meaning that some 125,000 toe of biocomponents for diesel will also be needed.

The Ministry of Transport and Communications presented its 2020 climate policy for the transport sector in March 2009. It assumes that the use of biofuels will yield a 10% reduction in greenhouse gas emissions by 2020 and states that the most efficient way to cut GHG emissions is the renewal of the passenger car fleet with fuel-efficient vehicles. The target is to achieve average CO_2 emissions of 137.9 g/km by 2020 (currently 180 g/km). The Government presented its long-term (2050) energy and climate policy in October 2009. The policy calls for energy efficiency, biofuels, and electrification of transport. The target for the average fossil CO_2 emissions of the passenger car fleet is set at 20–30 g/km for 2050.

<u>Taxes</u>

In Finland, incentives have not been used to promote alternative fuels. A fuel tax reform, based on environmental aspects, came into force on 1 January 2011, and full implementation is expected in 2012 and 2013. Figure 2 shows taxes before and after reform. A new taxation system takes into account volumetric heat value, carbon dioxide emissions, and local emissions (such as nitrogen oxides and particulate matter). The low volumetric heating value of biofuels, such as ethanol, is compensated for in the calculation. Biofuels are exempted from the carbon component tax, depending on their ability to reduce well-to-wheel greenhouse gas emissions. A bonus for low local emissions is given for paraffinic diesel fuel and methane. Natural gas was almost totally exempted from taxes before tax reform.

On 1 January 1 2008, a purchase tax based on tailpipe CO_2 emissions was introduced for new passenger cars. The minimum tax is 12.2% (60 g CO_2/km or less), and the maximum tax is 48.8% (360 g CO_2/km or more). Starting in 2011, the annual vehicle tax will be linked to CO_2 emissions, and the range in taxes will be 20–600 €/a (CO_2 66–400 g/km). The CO_2-based purchase tax has been an effective instrument in reducing CO_2 emissions of new passenger cars: the average value dropped from 180 g/km in 2007 to below 150 g/km in 2010. Fuel-efficient diesels benefit from the new system.

Tax exemptions have been granted for demonstration projects on biofuels. This is the case for the bus fleet demonstration with HVO (NExBTL), as well as for the first stage of introducing high-concentration ethanol for FFVs.

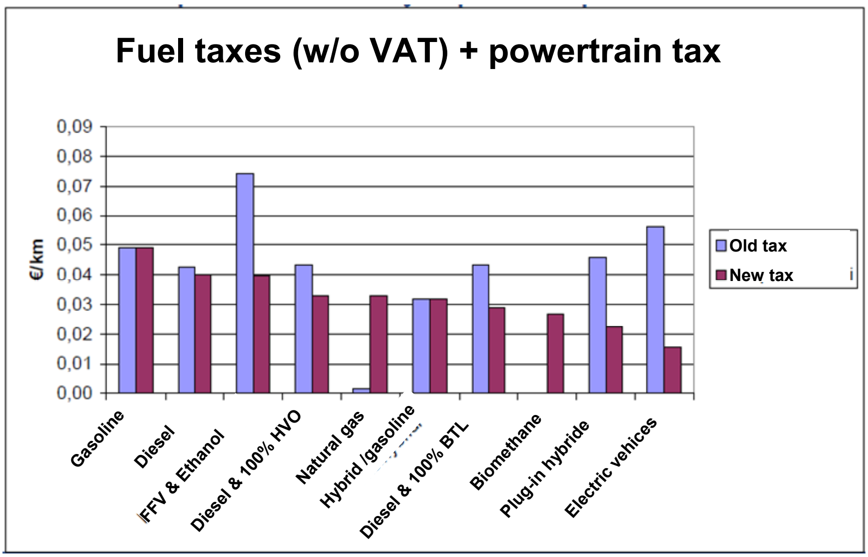


Fig. 2 Taxes before and after 1.1.2011. Calculated as accumulated taxes per vehicle kilometer. (Jyrki Katainen, *www.vm.fi*)

Research Programs

As a means of stimulating next-generation biofuels, special funds have been made available to encourage research and demonstration of next-generation biofuels. Biofuels are also part of the national research programme BioRefine (http://www.tekes.fi/ohjelmat/biorefine), financed by the Tekes, the Finnish Funding Agency for Technology and Innovation. Within this framework, the pulp and paper company Stora Enso, the national oil company Neste Oil, and VTT Technical Research are cooperating to develop wood-based BTL fuels. There are also other consortia on BTL fuels.

The TransEco research programme, spanning 2009 to 2013, focuses on energy efficiency and renewable energy in the road transport sector (www.transco.fi). The activities encompass research and development, demonstrations, commercialization of the results, and policy support. This programme is coordinated by VTT Technical Research Centre of Finland. The majority of the funding comes from Tekes, the Ministry of Employment and the Economy (TEM), the Ministry of Transport and Communications (LVM), and the Ministry of Finance (VM). In addition, a number of companies and research organisations contribute in funding. Neste Oil and St1 work together on a fuel project as part of TransEco, focusing on the development of cost-efficient solutions tailored to Finnish conditions. These projects are described in this document.

Implementation: the Use of Advanced Motor Fuels

Hydrotreated oils and fats (NExBTL)

Neste Oil's proprietary NExBTL[6] technology is a refinery-based hydrotreatment process using vegetable oils and animal fats as raw material. Neste Oil is producing NExBTL at its Porvoo refinery, which is close to Helsinki and has a capacity of 340,000 t/a. Neste Oil opened an 800,000-t/a NExBTL plant in Singapore in 2010, and a plant of that same size is expected to be opened in Rotterdam in 2011. Production of NExBTL is mainly based on palm oil, but rape seed oil and animal fats are also used. Non-food feedstocks could be used in future. Neste Oil is marketing diesel with 10–20% NExBTL under the name Green Diesel in southern Finland.

A demonstration project using NExBTL in some 300 buses in the Helsinki Metropolitan area started in 2007 together with Neste Oil, Helsinki City Transport, Helsinki Metropolitan Area Council, and Proventia (exhaust after-treatment manufacturer). Test fuels are a 30% blend of NExBTL and neat (100%) NExBTL. Neat NExBTL can reduce NO_x emissions by 10% and particulates by 30% when compared to conventional diesel fuel. This

[6] NExBTL is paraffinic fuel, which has a high cetane number; excellent ignition properties; and no sulfur, nitrogen, aromatics, or oxygen. No modifications are required in the fuel distribution infrastructure or existing vehicle fleet. The EN590 specification for diesel fuel can be met with blends containing up to about 30% NExBTL. Paraffinic diesel fuel is covered by a CEN pre-standard (CWA 15940).

fuel used in the demonstration project is released from the fuel tax, which means a tax incentive of 7.2 million Euros.

FAME
Some fuel distributors are blending in conventional esterified biodiesel (FAME). RME has been produced at a small scale, mainly on farms. In 2005, production was approximately 1 000 tons.

Bio-ethers
Neste Oil has processed ETBE since 2004. The production capacity of ETBE is 100 000 tonnes per year. The ethanol contained in ETBE is imported from Brazil, and the end product is mixed with petrol for export.

Bio-alcohols
In 2006, the energy company St1 began blending ethanol into gasoline in Finland. St1 is focusing on the decentralized production of fuel ethanol. At present, five decentralized ethanol units are running with a production capacity of 750–2000 t/a per unit. The total production in 2009 was around 5000 t. St1 also has invested in a centralized dehydration facility in Hamina with a capacity of 88 000 m^3/a. Start-up has been with side streams from the food industry (bakeries, confectionery factories, etc.) with a process called Etanolix. Waste is converted into an ethanol (85%) -water mixture at the sites of the food industry and then concentrated to 99.8% purity. About 20 small Etanolix stations are planned to be set up in Finland, and up 20 will be set up in Sweden. St1 is looking for partners both in Europe and in Asia. St1 is also importing hydrous ethanol and dehydrating it for blending into petrol.

St1 is selling a high-concentration ethanol, Refuel RE85, at seven refueling stations in the greater Helsinki area. The hydrocarbon part of the RE85 is a special mix targeted to operate well at low ambient temperature. FFV cars were introduced to the Finnish market in spring 2009, at the same time when St1 launched its RE85 ethanol fuel on the market.

Within the TransEco development programme, St1 with the VTT Technical Research Centre of Finland will develop optimized high-blend bioethanol designed to replace fossil petrol for Finnish conditions and minimize the environmental impact of its use (www.transeco.fi). In 2011, a demonstration project on ethanol use in heavy-duty diesel vehicles was begun.

Natural gas
The first natural gas buses were introduced in 1996 in Helsinki. Currently, some 100 natural gas buses and 10 heavy-duty vehicles are running on

natural gas. In addition, some 500 cars and vans are running on natural gas in southern Finland. There are 16 public natural-gas refueling stations, and construction of new stations is continuing. Gasum Oy, the national gas company, is marketing, selling, and servicing the “FuelMaker” home refueling appliance.

Natural gas is imported to Finland from Russia. Gasum Oy has announced its intention to start providing biogas for transportation in 2011.

Liquefied petroleum gas - LPG

In the 1990s, there was also some interest in LPG for heavy-duty vehicles. The number of vehicles peaked at some 15 vehicles, but interest has faded and no vehicles are running on LPG in Finland today.

Hydrogen

In Finland, there are no significant activities on hydrogen at present. Demonstration of fuel-cell-powered working machinery will commence in the harbour of Helsinki in 2013.

Electric and hybrid vehicles

HEVs have not made a major breakthrough in Finland. The new CO_2-based purchase tax has increased the competitiveness of hybrids. At present, no additional incentives are available for EVs or HEVs, although the taxation system in general favors low-emission, energy-efficient vehicles.

In 2009, Helsinki Metropolia University of Applied Sciences modified a Toyota Prius to a plug-in FFV car in cooperation with St1 and VTT within a TransEco research programme in Finland. The fossil CO_2 emission of this vehicle is approximately 15 g/km. Metropolia has also constructed a battery electric sports car caller ERA (Electric Race About). In 2010, Metropolia participated in the X-PRIZE competition in the United States and ended up in second place in this prestigious competition.

The Finnish car manufacturer Valmet Automotive, currently assembling Porsche sports cars, has announced a strategy for EVs. In 2009, Valmet Automotive started manufacturing the small Think City car and a luxury golf cart called Garia. In 2010, Valmet Automotive began producing the luxury Fisker Karma plug-in hybrid.

The Finnish company European Batteries will be the first company manufacturing large automotive lithium-ion batteries in Europe. A new production facility has been built in the city of Varkaus, and production started in the autumn of 2010. Initially, production capacity was 500,000 battery cells per annum.

At the end of 2010, Tekes announced the launch of a research programme dedicated to electric vehicles. The programme, called EVE, will run from 2011 to 2015. The total volume is some 80 M€, with a contribution of 37 M€ from Tekes.

Outlook

Ethanol and HVO diesel will be increasingly used as biofuels in Finland. The capacity of HVO (NExBTL) production is already significant: 340,000 t/a in Finland and 800,000 t/a in Singapore, and soon an additional 800.000 t/a is expected in Rotterdam.

Ethanol production from the side streams from the food industry by St1 in Finland is increasing. In addition, St1 is aiming to broaden the feedstock to separately collected biowaste, municipal solid waste, and eventually waste with straw and paper. The target for 2014 is to produce 300 000 m^3 ethanol per annum. St1 also plans to enlarge the Refuel RE85 distribution chain in Finland.

Interest in biomethane for transport is increasing. The primary method for introducing biogas would be injection of cleaned biogas into the natural gas grid. There is one small LNG plant in Finland, and there are plans to increase LNG production. The LNG is targeted for industrial use, not for transport. Gasum expects that biomethane could be used in Finland as transport fuel sometime in 2011.

In terms of long-term plans, cellulosic BTL is expected to cover a significant share of the diesel pool in Finland. Neste Oil and the forest industry company Stora Enso have announced a joint venture for the development of technology to produce next-generation biofuels. These companies are constructing a jointly owned pilot plant at Stora Enso's Varkaus factory. The pilot plant was commissioned in 2008.

Another Finnish forest industry company, UPM-Kymmene Oyj, has announced that it will focus strongly on second-generation biodiesels. Also, VAPO has announced the development of technology to produce next-generation biofuels. According to the press releases, investment decisions on the first commercial-scale production plants can be expected in the next few years.

Benefits of Participation in AMF

The IEA Advanced Motor Fuels Implementing Agreement is a unique collaborative forum covering simultaneously the whole spectrum of the end-use aspects of advanced motor fuels. A network of world-class experts representing different types of organizations and expertise enables multidisciplinary synthesis and analysis of a complex field of different technologies and policies on the transport sector.

The IEA-AMF organization is a flexible platform with effective tools to start and implement immediate actions to generate new data to fill in gaps in knowledge without heavy bureaucracy. The Executive Committee's working principles, combined with different possibilities to contribute by cost-sharing or task-sharing routes, offer suitable options for different purposes. IEA-AMF generates and synthesizes issues, which are of primary importance for research and development, as well as for decision-making bodies.

Germany

Introduction

Fuel consumption by road transportation vehicles in Germany amounted to 52.1 mt, including biofuels (Figure 1). Of this, 19.6 mt were petrol-type fuels and 32.5 mt were diesel-type fuels. Biofuels consumption amounted to 3.8 mt, with the majority as low-level blends of biodiesel (2.3 mt) and bioethanol (1 mt). Other biofuels consumed were pure biodiesel (293 kt), ethyl tert-butyl ether (ETBE) (125 kt ethanol share), pure vegetable oils (61 kt), and E85 (13 kt).

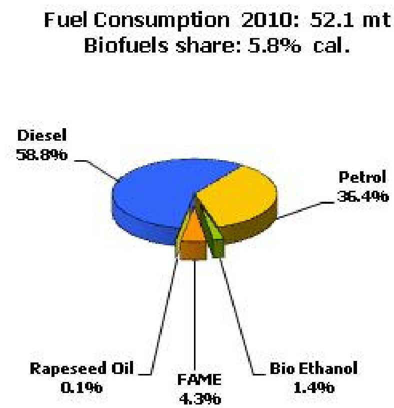


Fig. 1. Fuel Consumption by Vehicles in Germany, 2010

In Germany, 50.9 million vehicles are registered, 83% of which are passenger cars. Of those 42 million passenger cars (Table 1), 30 million are fueled by petrol, and 11 million are diesel cars. Additionally, some liquefied petroleum gas (LPG), compressed natural gas (CNG), hybrid, and electric vehicles are registered.

Table 1 Registered Passenger Cars in Germany

Year	Petrol	Diesel	LPG	CNG	Electro	Hybrid	Total
2006	35.918.697	10.091.290	40.585	30.554	1.931	5.971	46.090.303
2007	35.594.333	10.819.760	98.370	42.759	1.790	11.275	46.569.657
2008[1]	30.905.204	10.045.903	162.041	50.614	1.436	17.307	41.183.594
2009	30.639.015	10.290.288	306.402	60.744	1.452	22.330	41.321.171
2010	30.449.617	10.817.769	369.430	68.515	1.588	28.862	41.737.627

Source: Kraftfahrtbundesamt 2011

Policies and Legislation

Since 2007, firms marketing petrol and diesel are obliged to market a legally prescribed minimum percentage of such fuels in the form of biofuels. The level of this quota in relation to the energy content of the fossil fuel concerned, plus that of the biofuel replacing it, is 4.4% for diesel and 2.8% for petrol. Since 2009, there also has been an overall quota for petrol and diesel combined. Through the Biofuels Promotion Restructuring Act (Gesetz zur Änderung der Förderung von Biokraftstoffen) and the Act on the Acceleration of Growth (Wachstumsbeschleunigungsgesetz), the existing rules of the Federal Immission Control Act (Bundes-Immissionsschutzgesetz) on the biofuel quota and those of the Energy Tax Act (Energiesteuergesetz) on tax incentives in favor of biofuels have been adapted. The main features are:

- The overall quota was set at 5.25% for 2009 and at 6.25% for the years from 2010 to 2014.
- The tax relief for pure vegetable oil and pure biodiesel (B100) outside the quota has been reduced to a tax rate of 18 cents per liter.
- Biomethane may from now on count toward the petrol quota and the overall quota, provided that the requirements of the Fuel Quality Regulation (Kraftstoffqualitätsverordnung) are met.
- Beginning in 2015, the benchmark for biofuel quotas will be converted from the present energetic evaluation to the net greenhouse gas reduction. The net quota will increase from a rate of 3% in 2015 to 7% in 2020.
- The sustainability criteria for biofuels agreed upon at the European level under the Renewable Energy Directive and the Fuel Directive were translated into national law in 2009. Transitional periods apply until the end of 2010, so that the sustainability criteria have become applicable as of 2011.

In addition to ensuring an appropriate, consistent tax and regulatory business environment, research and development must be promoted across the various biofuel sectors to create conditions conducive to boosting the use of biofuels. In view of this effort, the German Federal Government supports *inter alia* projects for the further development of existing biofuel technologies, as well as the development of new biofuel technologies. This activity includes the provision of raw materials (breeding, cultivation, logistics), biomass conversion, quality assurance, and the use of biofuel in vehicles (emissions, material compatibility, etc.). Under the “renewable resources” funding scheme of the Federal Ministry for Food, Agriculture and Consumer Protection (BMELV), a total of 90 research and development projects relating to biofuels received funding totaling approximately

€ 60 million between the launch of the scheme in 1993 and the date of this report. The aid is granted through the Ministry's project promoter, the Renewable Resources Agency (Fachagentur Nachwachsende Rohstoffe e.V).

In the 2009 financial year, R&D support was strongly focused on biomass-to-liquid (BTL) fuels, in line with the assessment of promising fuel options in the national fuel strategy. Yet, growing market relevance and the requirements with regard to sustainability also led to increased funding of R&D projects on other biofuels introduced to the market. A total of 40 biofuels-related projects (including the provision of raw materials) received funding in 2009 for a total of around € 25 million. For vegetable oil (which is likely to remain a niche fuel because of its characteristics), particular priorities include establishing quality assurance and making improvements at the level of decentralized production and adapting engine concepts to run on vegetable oil. With the completion in summer 2010 of the national standardization of rape-seed oil as fuel, as well as the resulting more-stringent limit values, decentralized producers face new challenges in view of which intensive R&D aid has been made available. An equivalence clause in the Fuel Quality Regulation ensures the marketing on equal conditions of equivalent fuels from other Member States.

Biodiesel projects receiving support were aimed at evaluating the performance of diesel and biodiesel mixtures and the feasibility of using the coupled product glycerol as a source of energy. Further research projects related to biodiesel are in the pipeline. With respect to bioethanol, the emphasis has been on regional concepts for its production and exploitation as a fuel, with particular focus on boosting the efficiency of bioethanol production in distilleries. Further projects aimed at enhancing the efficiency of bioethanol manufacturing methods have been conducted in 2010. Under the project "Emissions from the engine combustion of biofuels and fuel mixtures," all marketable biofuels and fuel mixtures were examined for their impact on the environment through combustion in motor vehicles. On the basis of the results, a federal initiative aimed at standardizing sampling has been launched. The performance of various fuel mixtures is currently being examined under a project known as GOBio. The overall aim of these projects is to contribute to increasing the biogenic component of sustainable biofuels.

With regard to liquid energy sources, project support was focused on BTL fuels that have not yet been introduced on the market but are considered a promising option because of their broad raw materials base and chemical composition. BTL fuels are liquid synthetic bioenergy sources that can be obtained from agricultural and forestry biomass through thermo-chemical gasification. In the 2009 financial year, aid totaling € 22 million was granted mainly to two BTL projects, the emphasis of which was the planning and setting up of stages 3 and 4 of the "bioliq process" of the Karlsruhe Institute of Technology. The Renewable Resources Agency also supports the implementation of the "International Sustainability and Carbon Certification" (ISCC) system for sustainable biofuels and liquid biomass used in electricity generation.

In addition to the above, there are a large number of other research projects in Germany related to the sustainability of biofuels. These include, for example, ongoing projects:

- "Nature conservation standards for biomass cultivation" (a systematic overview, quantification, and modeling of the previous and future impact of biomass cultivation on nature conservation interests in Germany),
- "Acreage-effective bioenergy use from a conservation point of view" (an analysis of the impact of the extended and more intensive cultivation of energy crops on the environment and the landscape), and
- "Developing strategies and sustainability standards for certifying biomass for international trade" (development of sustainability standards for bioenergy to prevent conflicts with climate-protection and nature conservation objectives).

Further research is needed, especially into suitable methods of recording and minimizing the impact on food security of the cultivation of biomass for biofuels, in particular in developing countries, and on global biodiversity, especially in highly biodiverse areas, such as tropical rainforests or species-rich grasslands.

Implementation: the Use of Advanced Motor Fuels

In 2010, 2.9 million new passenger cars were registered in Germany, with nearly 60% petrol cars and 40% diesel cars. Other fuels (LPG, NPG, electricity, hybrid) accounted for less the 1% of total registrations. Incentives for advanced motor fuels are a full detaxation for specific biofuels (BtL, ethanol from lignocellulosics, biomethane, E85) until the end of 2015 and a partial detaxation for natural gas as transport fuel until 2018. The switch in the biofuels quota legislation in 2015 from quantitative shares to GHG reduction quotas (7% from 2020 on) will provide further impetus for advanced biofuels.

Outlook

The German national Renewable Energy Action Plan, submitted to the EC in summer 2010, stipulates a RES target in transport of 13.2% by 2020, which is above the 10% target in the EU Renewable Energy Directive. Advanced biofuels are estimated to contribute 155 kt oil equivalent in 2020, compared to 98 kt in 2010. However, their perspective will depend not only on the technical success of ongoing R&D activities but also on the success of scaling up these technologies to the industrial scale, which is a major challenge for public and private financing. The EU SET-Plan addresses this issue. In addition, the economic feasibility of advanced motor fuels will also depend on the regulatory framework and incentives for use.

Benefits of Participation in AMF

The German biofuels market is one of the biggest worldwide. As a result of changing framework conditions, advanced motor fuels will become more and more important in the short term. FNR, as a national funding organization, addresses many different issues regarding advanced motor fuels. We feel that AMF addresses most of the issues that are important in our country. Most of the sponsored research projects under the IEA AMF umbrella are relevant to our funding activities, and the common project sponsorship enables cost-efficient participation.

Furthermore, the participation in AMF gives our country the opportunity to become part of a scientific network with excellent researchers from across the world.

Additional References

A listing of key websites and/or significant reports for further reference or reading.

www.bio-kraftstoffe.info

http://www.tfz.bayern.de/biokraftstoffe/

http://ec.europa.eu/energy/renewables/transparency_platform/doc/national_renewable_energy_action_plan_germany_en.pdf

http://www.kba.de/cln_016/nn_125398/DE/Statistik/Fahrzeuge/fahrzeuge__node.html?__nnn=true

Italy

Introduction

In 2009, consumption of primary energy in Italy ran around 180.343 million-ton equivalent of petroleum (Mtep).

Oil still remains the main energy source (at 42% of all sources), with natural gas (NG) following at 35% and renewable sources at 7% of the whole (Fig. 1).

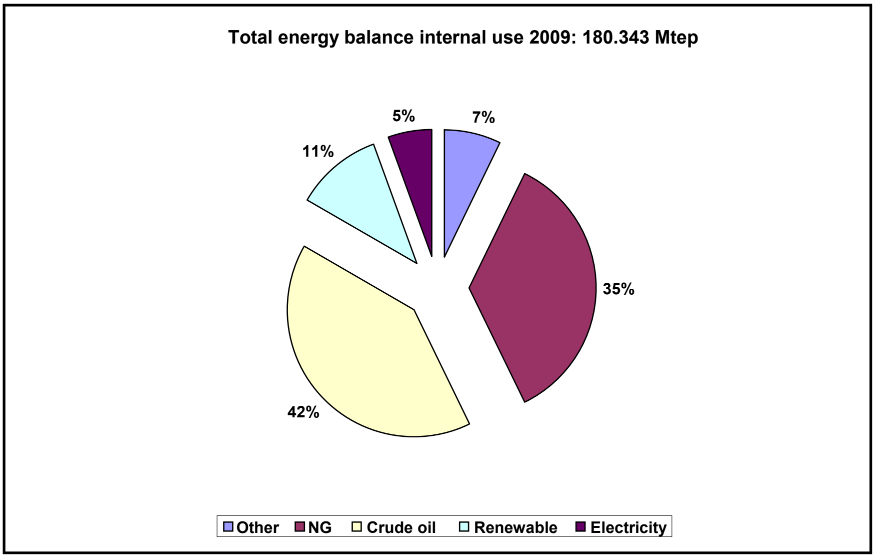


Fig. 1 Total Energy Balance Year 2009 (Source: Ministry for Economical Development, National Energy Balance 2009)

Italy depends heavily on imported oil, having imported about 94 Mtep of crude oil in 2009 (Fig. 2).

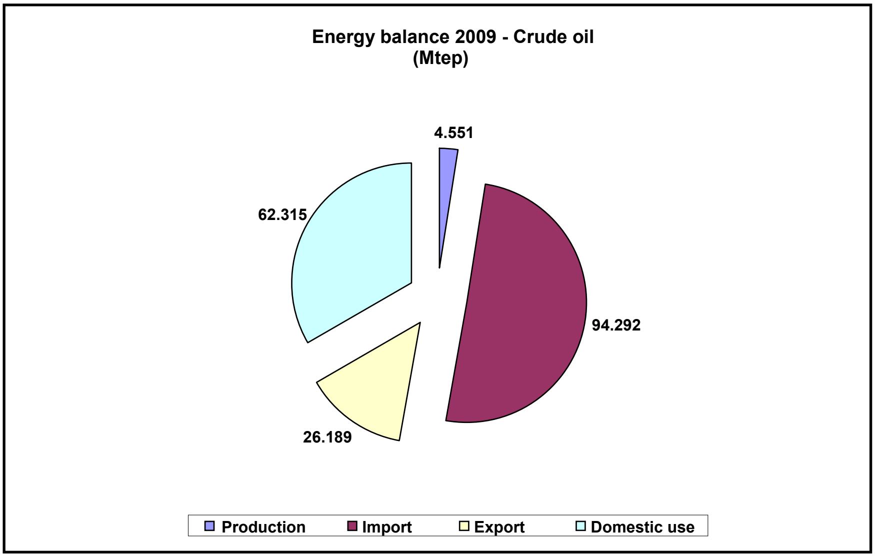


Fig. 2 Energy Balance 2009 – Crude Oil (Source: Ministry for Economical Development. National Energy Balance 2009)

The destination of a majority (about 64%) of derived oil is the transportation industry (Fig. 3).

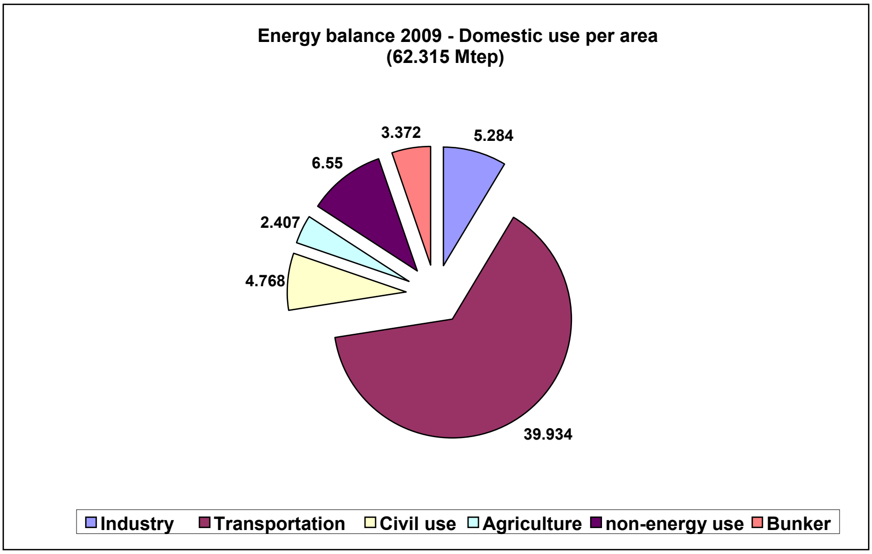


Fig. 3 Energy Balance 2009 – Domestic Use per Area (Source: Ministry for Economical Development. National Energy Balance 2009)

The main fuel that passengers rely on for transportation by far is diesel fuel (65%), followed by gasoline (30%). The same sector also uses a significant amount of liquefied petroleum gas (LPG) (3%) and NG (2%) (Fig. 4).

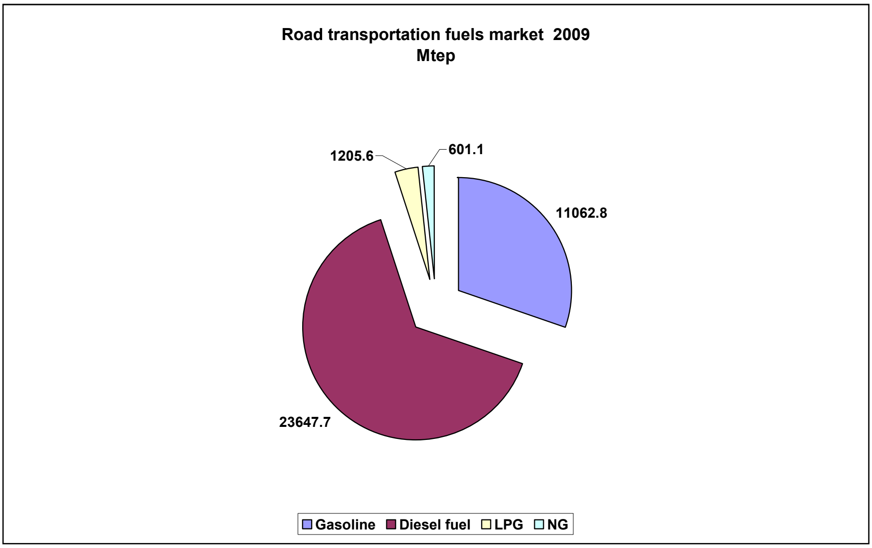


Fig. 4 Road Transportation Fuels Market 2009 (Source: Ministry for Economical Development. National Energy Balance 2009)

In terms of the vehicle fleet, the leading type is represented by gasoline vehicles (45% of all vehicles), followed by diesel-fueled vehicles —which include passenger cars (28%) and medium-/heavy-duty trucks (10%).

A not insubstantial percentage of vehicles is represented by those using NG (1%) and LPG (3%) (Fig. 5).

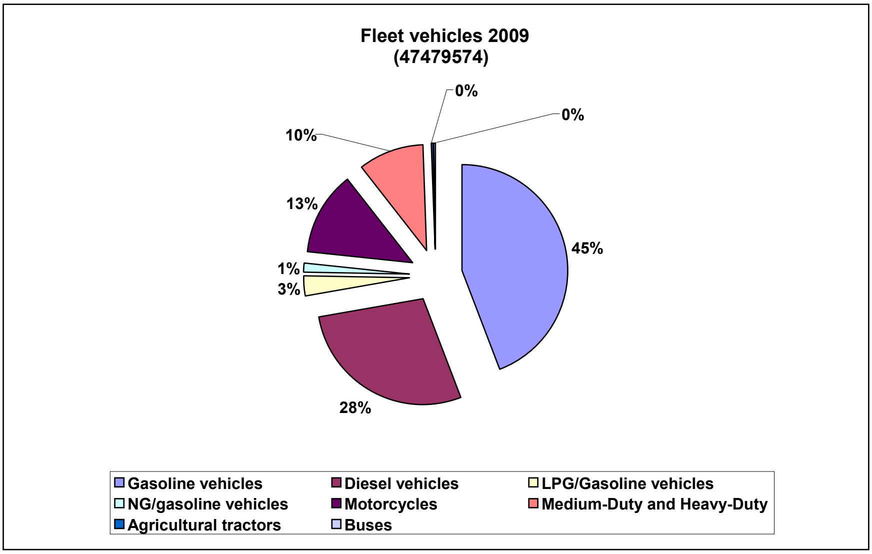


Fig. 5 Fleet Vehicles 2009 (Source: ACI – Statistics 2010)

Diesel-fueled vehicles can operate on up to 7% biodiesel; gasoline-fueled vehicles can run on gasoline containing oxygenated biofuels, which may contain 2.7% oxygen.

Policies and Legislation

Italian law has adopted the following European Directives, the “Renewable Energy Directive” (2009/28/EC) and the “Fuel Quality Directive” (2009/30/EC).

Through Law 2009/99 of July 23, 2009, and along with the European Specification EN590:2009, the Italian government has authorized the percentage of biodiesel used in diesel fuel to reach as high as 7%.

Furthermore, according to the Decree 5/2009 of February 10, 2009, which was converted into Law 33/2009 made official on April 11, 2009, an incentive of € 1,500 is granted to the passenger of use for cars that were (1) destined to demolition; (2) belonging to categories Euro 0, Euro 1, or Euro 2; (3) registered by December 31, 1999; and (4) to be traded for vehicles of category Euro 4 or Euro 5 emitting no more than 140 grams (g) of carbon dioxide (CO_2) per kilometer (km) or — if diesel fueled — no more than 130 g of CO_2 per km.

A higher contribution was granted for new cars or cars certified by the manufacturer as complying with natural gas or hydrogen fueling standards and electric (hybrid) vehicles, as follows:

- € 3,500 for vehicles emitting no more than 120 g of CO_2 per km.
- € 1,500 for remaining cases.
- € 4,000 for new trucks up to 3,500 kilograms (kg) of weight belonging to categories Euro 4 or Euro 5 and complying with natural gas fueling standards.

A further contribution was granted for new cars or cars and trucks weighing up to 3,500 kg that were certified by the manufacturer as complying with LPG or hydrogen fueling standards and electric (hybrid) vehicles, as follows:

- € 2,500 for vehicles emitting no more than 120 g of CO_2 per km.
- € 1,500 for remaining cases.

An additional provision of € 500 was established for mopeds and motorcycles belonging to categories Euro 0 or Euro 1 that are to be traded for a new motorcycle in the Euro 3 category and having up to 400 cc (cubic centimetres) or with power up to 60 kilowatts (kW).

Implementation: Use of Advanced Motor Fuels

Biodiesel is the primary source for renewable advanced motor fuel in Italy (Fig. 6). From 2009 to present, biodiesel has been blended in at up to 7% of the diesel fuel's volume.

The renewable fuel currently used in gasoline is bio-ETBE (ethyl tertiary butyl ether), which is derived from bioethanol.

The amount of bio-ETBE used in gasoline in 2009 was 183 kilotons (kt).

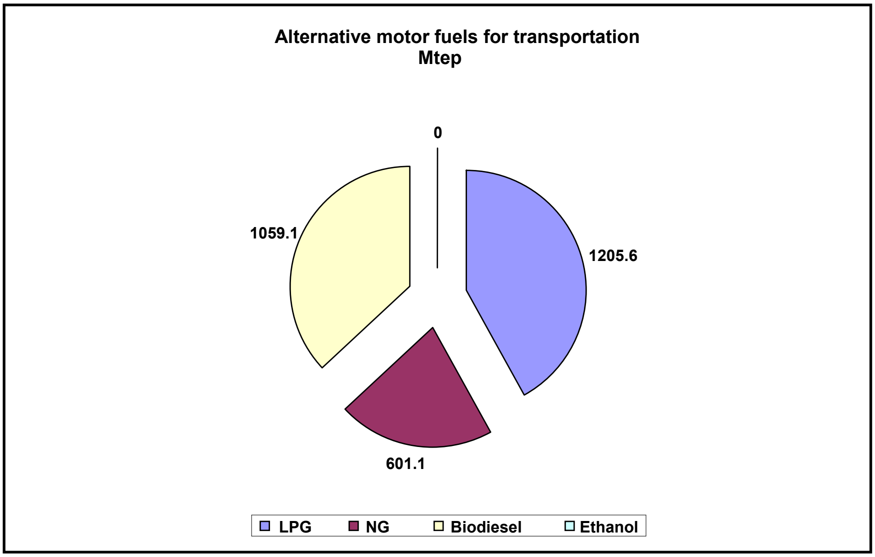


Fig. 6 Alternative Motor Fuels for Transportation (Source: Ministry for Economical Development. National Energy Balance 2009)

At the end of 2010, more than 700 NG stations could be counted in the country serving a fleet of about 600,000 cars.

The network is mostly located in northern Italy, whereas central and southern Italy are not homogenously represented. In addition, no NG service stations are to be found on Sardinia Island.

In 2007, the LPG filling station network amounted to 2,350 stations serving a fleet of about 1.5 millions cars.

Outlook

Italy aims to reach the goal of having (by 2020) 10% of the fuels in its fuels portfolio come from biofuels out of the total energy destined for use by the transportation sector. With that goal in mind, the following yearly minimum increases in energy derived from bio-components have been targeted as follows:

From January 1, 2007: 1%
From January 1, 2008: 2%
From January 1, 2009: 3%
From January 1, 2010: 3.5%

From January 1, 2011: 4%
From January 1, 2012: 4.5%
From January 1, 2013: 5%
From January 1, 2014: 5.5%

Benefits of Participation in AMF
Transportation is a crucial aspect in a country's economic development. Sharing choices of high value for the environment and participating in the ongoing debate on energy is vital to realizing common perspectives. For example, the global debate can help in building an outlook shared around the globe on seeking to incorporate renewable sources to control CO_2 emissions.

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Japan

Introduction

Figure 1 shows the crude oil cost in yens/liter (¥/L), which takes exchange rate effects into account. The plot also shows Japan's gasoline price (including the current tax rate of ¥53.8/L) and diesel fuel price (which includes a current tax rate of ¥32.1/L). The second oil shock from 1979 to 1986 was so fierce that crude oil prices shot up to ¥50 per liter. The government has increased the gasoline tax rate since 1974, and in 1979, the gasoline price rocketed to about 100 ¥/L. But after 1987, crude oil prices fell precipitously to under 20 ¥/L, and fuel prices also fell dramatically. Because the taxation on gasoline and diesel fuels usually exceeds the actual crude oil cost, the effect of fluctuations in crude oil prices is lessened, and gasoline and diesel fuel prices had remained fairly stable up until around 2005. However, there has been an increase in demand in recent years, and a trend by the Organization of the Petroleum Exporting Countries (OPEC) of maintaining higher prices; thus, it seems important that research and development (R&D) of new fuels should be carried out over the mid to long term.

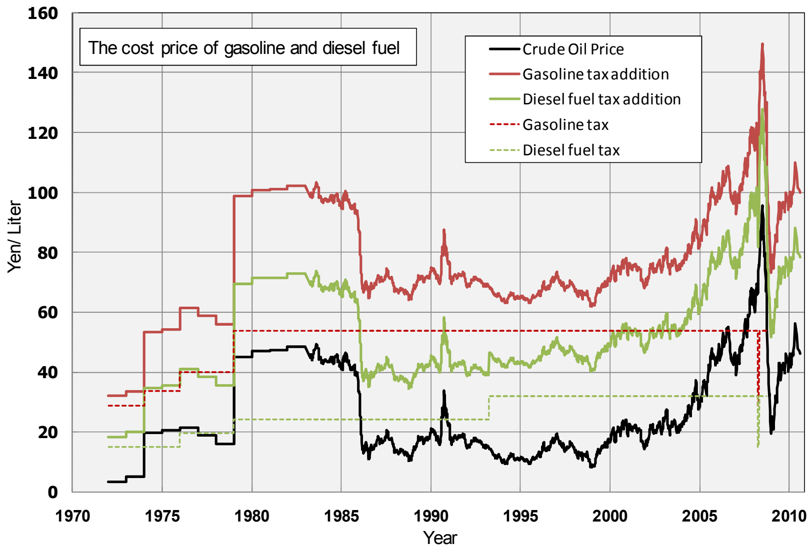

Fig. 1 Prices of Gasoline and Diesel Fuel in Japan with or without Tax

Policies and Legislation

In May 2006, the New National Energy Strategy (the Strategy) was developed by the Ministry of Economy, Trade, and Industry (METI), in which two major targets were set for the transportation sector. In order to reduce the energy constraints, the Strategy focuses on taking various measures to support the energy policy. One was to reduce the oil dependence of the transportation sector to 80% of current usage totals by fiscal year 2030. The other was to improve energy efficiency by 30% by fiscal year 2030.

Realizing improvements in fuel economy is the most effective short-term strategy to reduce energy consumption and increase energy security by introduction of more stringent fuel economy standards. As a long-term strategy, METI will take a comprehensive approach to identify ways to significantly reduce energy consumption and reduce oil dependence. To reduce energy consumption and oil dependence, in December 2006, the Next-Generation Vehicle Fuel Initiative was announced, which focused on furthering the development and introduction of four technologies, including biofuels, clean diesel fuel, next-generation batteries, and promotion of the Fuel Cell & Hydrogen Society. Following are outlines of proposed objectives for the four technologies.

- Biofuels
    - Introduced goal of using 500,000 kiloliters (kl) of biofuels by 2010 (part of the plan to meet the Kyoto Target).
    - As part of the long-term strategy, focused on the development of second-generation biofuels (namely, cellulosic ethanol).
- Clean Diesel
    - Promoted the introduction of clean diesel passenger cars into the Japanese market (via incentives and promotional events).
- Next-generation Battery
    - Launched a next-generation battery development project that started in Japan's fiscal year (JPFY) 2007 for the commercialization of electric vehicles (EVs), plug-in hybrid vehicles, and fuel cell vehicles (FCVs).
- Fuel Cell & Hydrogen Society
    - Tasked with continuing current development of fuel cell and hydrogen technologies for the commercialization of FCVs.

Implementation: the Use of Advanced Motor Fuels

Natural Gas Engines

Natural gas vehicles (NGVs) are not only known as clean energy vehicles but also as the only nonpetroleum-fueled cars that are currently in practical use, which underscores the fact that natural gas (NG) is not obtained from crude oil. Figure 2 shows a timeline plot of domestic (Japan) NGV and natural gas stations. As of the end of March 2009, the total number of NGVs in Japan was 37,117. Of this number, 15,507 are passenger cars, vans, and light passenger cars (including forklifts), while 20,155 are trucks and garbage trucks, and 1,455 are buses. Natural gas stations currently number 344 locations.

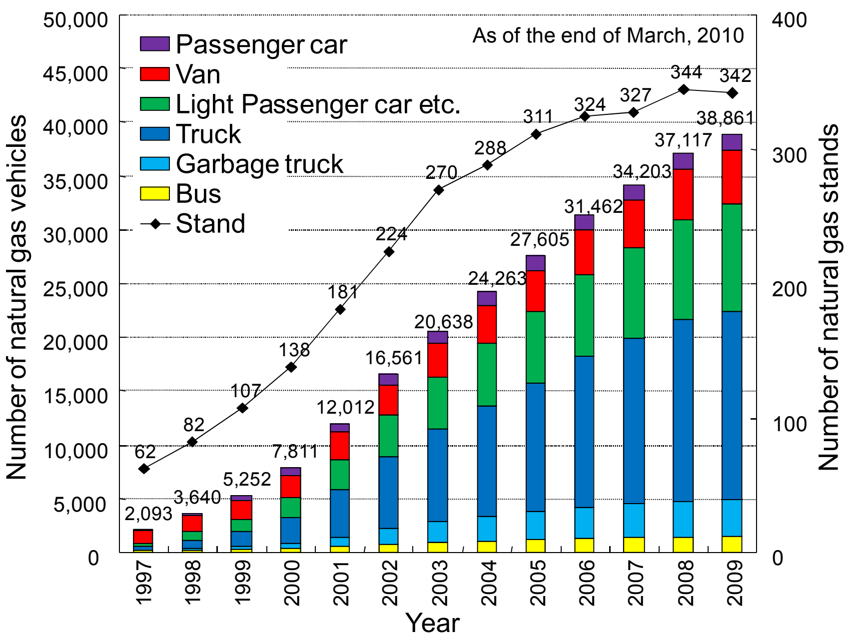

Fig. 2 Timeline Plot of Natural Gas Vehicles and NG Stations in Japan

On the other hand, the total number of natural gas vehicles in the world as of March 2009 is 10,050,000.[1] This total has increased by more than 2,000,000 as compared to 2008, and in particular, the total number of NGVs in Pakistan, Argentina, Brazil, and Iran account for about 65% of the worldwide total. Also notable is the fact that countries like Italy have recently shown a remarkable increase in NGVs, which now has 580,000 such vehicles. Compared to petroleum-based fuels, about 25% less carbon dioxide (CO_2) is exhausted by the combustion of natural gas. In addition, because there is no soot emission with NGVs, numerous engine development efforts have been carried out in the past several years.

Toyota Motor Co., Ltd., has developed an NGV with a multi-point fuel injection (MPI) system, which was developed for gasoline-substitute vehicles. To improve the NGV with MPI, a compressed natural gas (CNG) direct-injection strategy was applied.[2] Researchers have confirmed that direct injection is able to help improve fuel efficiency through use of stratified charge combustion and by increasing volumetric efficiency by injecting CNG during a compression stroke.

Gunma University and Yamato Motor Co., Ltd., carried out a joint project that aimed to improve the thermal efficiency and power output of two-stroke, spark-ignition NG engines and to reduce fuel-air mixture blowing. This effort found positive results with intermittent fuel injection at the scavenging port.[3]

The National Traffic Safety and Environment Laboratory (NTSEL) has established the "Next Generation Low-Emission Vehicle Development Promotion Program," which started in JPFY 2002, and NTSEL also established the "Next Generation Low-Emission Vehicle Development and Practical Use Promotion Program," which started in JPFY 2005. These programs involved development, public road testing, and other experimental testing of ultra-low emission, heavy-duty CNG trucks equipped with the world's largest size class (13L) engine. Related work was carried out involving heavy-duty liquefied natural gas (LNG) trucks that are capable of operating over larger ranges.[4]

In response to the Japan New Long Term Emissions Regulations, Isuzu Motors, Ltd., adopted the MPI method for light- and medium-duty CNG trucks and medium- and heavy-duty route buses currently in production. With detailed combustion control, exhaust emissions characteristics were improved to less than one-fourth of the Japan New Long-Term Emissions NO_x regulated value (i.e., for heavy-duty vehicles: 0.3 grams per kilowatt-hour [g/kWh]). Moreover, this vehicle has already conformed to the Japan Post New Long-Term Emissions Regulations that took effect in October 2010.[5] In addition, Mitsubishi Motors Corporation has performed R&D on CNG vehicle fuel supply and storage systems. In order to improve practical use of NGVs, bi-fuel vehicles operating on both CNG and gasoline have been developed for light-duty commercial vehicles.[6]

Biofuels

Bio-Ethanol

According to an article published in May 2007[7], relying on imported petroleum is unavoidable, to some extent, as a transitional measure to cover for shortfalls in the domestic supply of petroleum. However, over the long term, we look to controlling fluctuations in the global pricing climate, where the strategy is "*domestic production for domestic consumption,*" and where ethanol is produced from nonfood feedstocks. In its "Next Generation Vehicle and Fuel Initiative" officially announced in 2007, METI placed strong emphasis on technology, development, and production of cellulosic-type ethanol, which does not compete with food. This METI initiative is a joint effort in close cooperation with industry circles, universities, and government. In November 2007, the "Bio-Fuel Technology Innovation Council" was established. In March 2008, the "New Bio-Fuel Technology Innovation Plan" was drawn up in which specific objectives, technologies, development areas, and a road map were clearly outlined. The goal of this plan is to produce ethanol from nonfood biomass feedstocks, such as herbaceous plants (grasses) and ligneous plants (woody plants) with a cost target of 100 ¥/L. Furthermore, 40 ¥/L was proposed in case a production technology were to be innovated.[8]

There are also projects under way in various parts of Japan. The Ministry of Agricultural Forestry and Fisheries (MAFF)[9] gave no additional initiatives in JPFY 2008. Instead, two joint ventures involving soft cellulose utilization technology were established in Japan, one in the north and one in the south. In Hokkaido, the Taisei Construction Co., Ltd., and Sapporo Beer Co., Ltd., joined forces, and in Hyogo Prefecture, Mitsubishi Heavy Industries, Ltd., and Hyogo Environmental Advancement Association established a joint effort.[9] Both ventures are developing technologies related to production of ethanol from wheat chaff/hulls, rice straw, and wheat straw.[10] These efforts make it apparent that transitioning to nonfood ethanol feedstocks is an urgent matter.

METI has established a public/private initiative with partners in the petroleum industry with its Biomass Origin Fuel Validation and Introduction Venture. On April 27, 2007, test sales of 3% bio-ETBE (ethyl tertiary butyl ether) blended gasoline, popularly known as "bio-gasoline," began at 50 gas stations in Tokyo area gas stations with pricing set equal to regular gasoline.[11] The number of gas stations was to be increased to 100 as of April 2008, underscoring that full-scale introduction had begun.[12] About 22,000 kl of bio-ETBE had been imported from the Lyondell-Bassell Chemical Company in the United States as of July 2008. It was transported to the Negishi Refinery operated by Shin Nippon Petroleum Refining Co., Ltd.[13]

Biodiesel Fuel

Along with the bio-ethanol initiatives mentioned above, there remains debate on the “food vs. fuel” trade-off, and on Japan’s overall dependency on imports, which are a result of its dependency on Middle East petroleum. In METI’s “Next Generation Vehicle and Fuel Initiative” discussed above, it is further reported that only the waste by-products of vegetable oil and industrial rice oil should be used as the raw materials for FAME (fatty acid methyl ester) in Japan.[14] Jatropha is a nonfood oilseed that has drawn recent attention; however, there is little information on its toxicity and carcinogenic effects, and we are still in the situation in which caution must be exercised.

An initiative similar to the bio-ethanol regional initiative mentioned above exists for biodiesel. The five-year project was launched in 2007 in cooperation with MAFF.[9] In addition to five areas adopted in JPFY 2007, a total of nine areas were chosen in JPFY 2008.[15,16] In all areas, vegetable oil waste is used as the primary feedstock, along with sunflower oil, rape seed (canola) oil, and real tea oil. Local production for local consumption can be a reasonable initiative. Thus, a total of 14 biodiesel fuel projects were launched in Japan.

A working group has been established under the auspices of the Economic Research Institute for ASEAN (Association of Southeast Asian Nations) and East Asia (ERIA). This committee is focused on standardization of biodiesel fuels in the East Asian regions and has two goals: (1) support of each country’s standardization efforts in order to achieve distribution of high-quality biodiesel fuel across the entire region, and (2) harmonization of basic standards and specifications among the member countries. In JPFY 2007, recommended quality standards for low-concentration biodiesel blends (B5 is the current limit in Japan) were established[17], and in the second East Asia Summit Energy Ministry Meeting (held in Bangkok in August 2008), this recommended standard was clearly identified in the joint statement as “EAS-ERIA BDF Standard (EEBS):2008” (BDF stands for biodiesel fuel). The International Organization of Motor Vehicle Manufacturers is developing a “World Wide Fuel Charter” to establish international guidelines for alternative fuels, including biodiesel and bio ethanol. A draft document was released in July 2008 and was open for public comment.[18] The guidelines cover E10, B5, E100, and B100. Review of input was carried out, and the updated guidelines were released in March 2009.

Dimethylether (DME)
Although the most recent crude oil price spikes have settled down and stabilized, maintaining energy security is still very much a required objective. In Japan there are also strong municipal restrictions on environmental pollution, an overriding movement to reduce the country's dependency on the Middle East for petroleum, and an effort to improve the "well-to-wheel" energy efficiency of biofuels — a quality for which DME has been attracting attention as a second-generation biodiesel fuel.

A DME technology demonstration plant with an annual 80,000-ton capacity was commissioned in August 2008 by the joint company, Fuel DME Production Co. Ltd., in Niigata, Japan.[19] With assistance from the Agency of Natural Resources and Energy (belonging to METI) to promote the introduction and utilization of DME, a boiler in Niigata was refueled to run on DME by Issei Kamaboko Co., Ltd.[20] As of December 2008, DME circulation was started as fuel.

The Ministry of Land, Infrastructure, and Transport has conducted operating tests of DME vehicles at NTSEL.[21] The 2-ton truck was manufactured by Isuzu Advanced Engineering Center, Ltd. (IAEC) and is shown in Figure 4. As of the end of 2008, it had put on more than 80,000 kilometers. Results from these road tests will be compiled and used to provide technological guidance in preparation for technology standards planned for DME vehicles, so that they can be widely utilized by all types of customers.

Fig. 4 DME Truck Developed by IAEC.

DME vehicle development and activities have been actively continued by the DME Vehicle Proliferation Promotion Committee, which is supported by private companies (IAEC; Iwatani Industry Co., Ltd.; Totaru DME Japan, Co. Ltd.; Toyota Transportation Business Co. Ltd.; and Idemitsu Kousan Co. Ltd.) that are associated with fuels, plants, parts, and infrastructure systems.[22]

For standardization trends regarding fuel, DME vehicular fuel quality standards are covered in the International Standard Organization's ISO/TC28/SC4, and sampling is covered in ISO/TC28/SC5; moreover, steady progress has been made on engineering standards, international standardization of specifications, and associated measurement methods. Furthermore, in order to provide a backup technology and development plan regarding standardization of DME fuel, the National Institute of AIST's Research Center for New Fuels and Vehicle Technology (NVT) has received a grant to perform basic R&D for application to dedicated DME vehicles, as well as to diesel fuel vehicles. In cooperation with the ISO, NVT has initiated a three-year plan for standardization R&D on DME fuel utilization. A DME fuel specifications committee was established to help meet these goals. Given all of the expected laws,·specifications, and infrastructure design and construction efforts, DME vehicles are steadily "climbing the stairs" toward their practical application and use.

Outlook

The following specific activities, including the outlook regarding progress in the use of advanced fuels, were detailed in the New National Energy Strategy developed by METI in May 2006 and included objectives to:

- Reexamine the upper blending limit regulation of oxygenated compounds that contain ethanol by around 2020 by speeding up improvements to the biomass-derived fuel supply infrastructure through gas stations' environmental and safety countermeasures and by prompting the automobile industry to accept 10% ethanol-mixed gasoline. Moreover, METI would strive to spread the use of diesel cars that have exhaust gas performance equal to that of gasoline cars (a measure that is also important in the utilization of gas-to-liquid [GTL] technology), and the organization promoted the use of GTL by the middle of 2010.
- Examine the support for regional efforts to expand domestic bio-ethanol production and the modalities of development of support of the

importing of biomass-derived fuels, such as bio-ethanol. METI would also promote the supply of new fuels (such as biomass-derived fuels) and improve economic efficiency by promoting the development of high-efficiency ethanol production technology and GTL technology.

- In addition to promoting the adoption of EVs and FCVs, which are already close to being put to practical use, work on the intensive technical development of next-generation batteries and FCVs; establish a safe, simple, efficient, and low-cost hydrogen storage technology; and promote the development and practical application of next-generation vehicles.

Benefits of Participation in AMF

It is possible to obtain the latest information available on developments in advanced motor fuels from around the world through the activities of the International Energy Agency's (IEA's) Advanced Motor Fuels Implementing Agreement. It is important for stakeholders, such as policy makers, and industries, to learn what is occurring in the field of motor fuels in various countries.

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Norway

Transportation fuels and the alternative fuels market — including the number of vehicles (total and those capable of using alternative fuels) in Norway — are presented for biofuels, hydrogen (H_2), and electric vehicles (EVs).

Biofuels: Biodiesel

Consumption
A total of 104 million liters of biodiesel was consumed in 2008, or 4% of total diesel use. Ninety-six percent (96%) of the biodiesel was sold as low-ratio blended fuel (£ B7), first-generation RME/FAME (rape methyl ester/fatty acid methyl ester).

On January 1, 2010, the diesel tax was also applied to biodiesel.

Production
The only producer is Uniol (est. June 2009), which mainly produces first-generation RME/FAME with a capacity of 125 million liters/year.

The components of the retail costs of diesel and biodiesel in Norway are shown in Figure 1 (on following page).

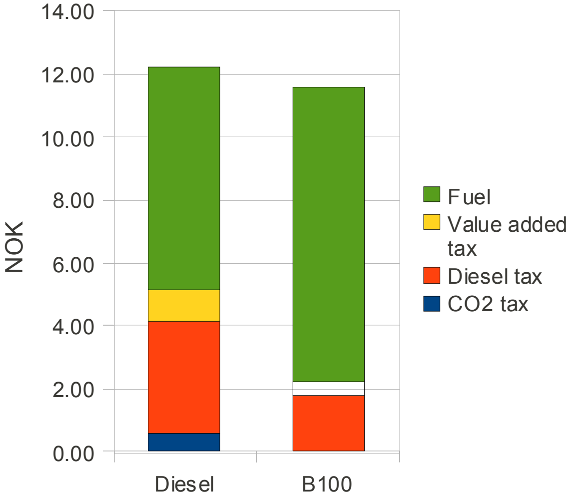


Fig. 1 Components of the Retail Costs of Diesel (left) and Biodiesel (right)

Figure 2 shows the share of each source for biodiesel produced in Norway.

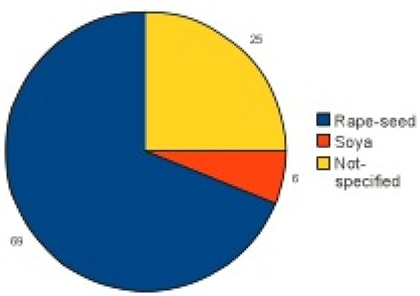


Fig. 2 Share of Each Source of Biodiesel Fuel Produced in Norway

Biofuels: Bioethanol

Consumption

Before 2010, there was virtually no use of ethyl alcohol (EtOH) as a transport fuel in Norway. However, in 2010, both E95 and E85 were on the market (sold by Statoil).

Its formulation was based on grains from the European Union (EU) and Brazilian ethanol. Statoil also started selling E5 based on Brazilian ethanol.

Production

Borregaard produced EtOH as a forestry-based industry product. It has a second-generation biorefinery with a 20 million-liter capacity. Production totaled 6 million liters of E5, E85, and E95 in 2010. Elements of Borregaard's fuel production are highlighted in Figure 3.

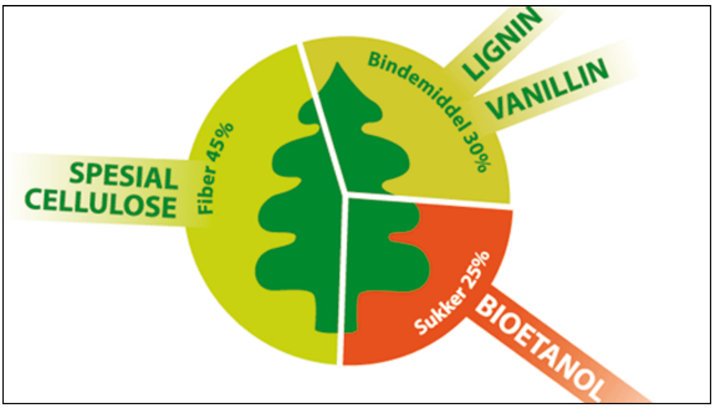


Fig. 3 Components of Borregaard's Bioethanol Fuel

Biofuels: Biogas

Consumption

Biogas is used to fuel public transport (buses) in Fredrikstad, Oslo, and Trondheim (Figure 4). There are 170 EtOH-buses altogether in Norway.

Fig. 4 EtOH-fueled Bus in Oslo

Production
Two production sites exist: Fredrikstad Biogass AS, which has a capacity of 273,000 Nm^3 (normal cubic meters), and EGE Oslo. The EGE EtOH system is depicted in Figure 5.

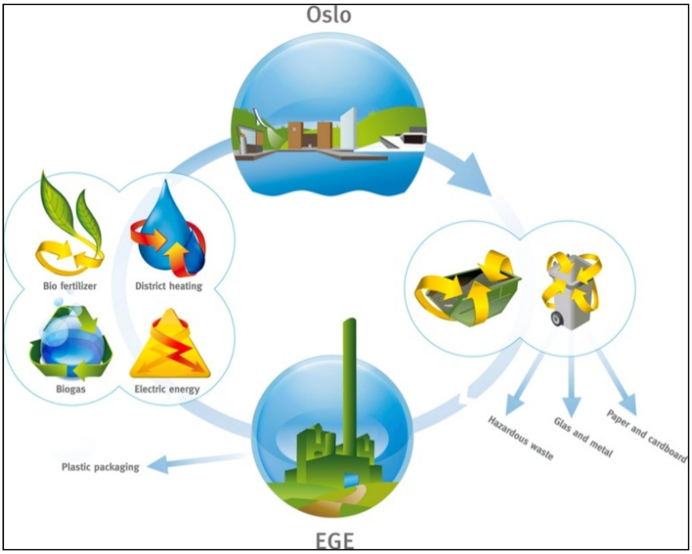


Fig. 5 EGE's EtOH System

Figure 6 is a flow chart of EGE's production.

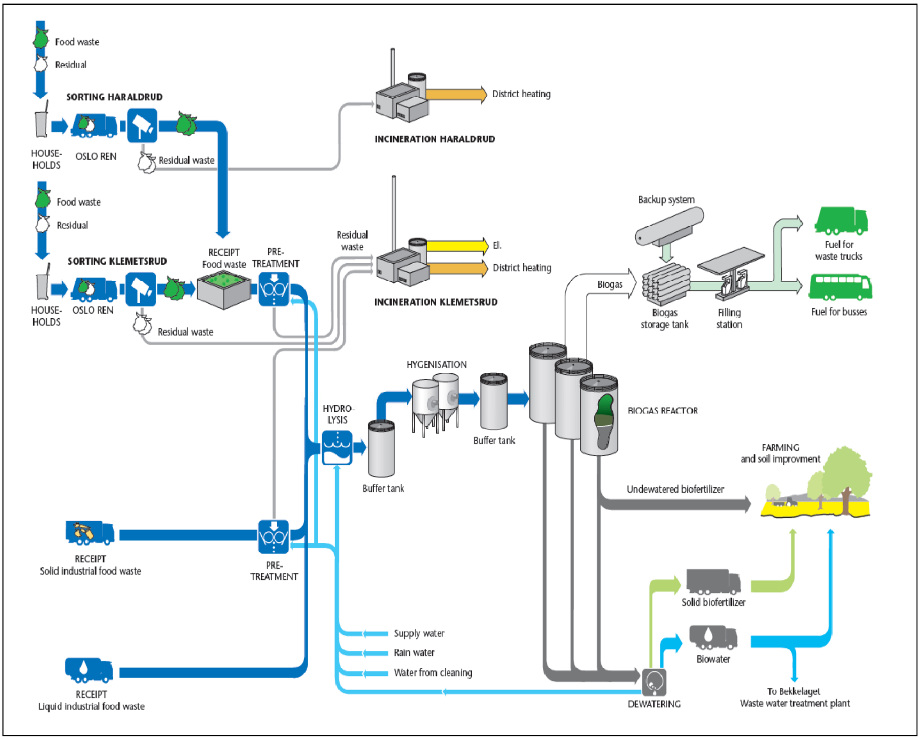


Fig. 6 Flow Chart of Steps in EGE's Biogas Production

Biofuels: Research and Development (R&D)

Industry Projects

Industry-driven projects include that of Xynergo, Weyland, and Borregaard. These companies are co-developing second-generation bioethanol.

Research

The Norwegian University of Science and Technology (NTNU) is investigating the following:

- N-Inner efficient production of fuels from biomass.
- Biomass-to-liquids fuels.

The University of Environment and Bio Science is researching second-generation biofuel in terms of technology development and impacts on biomass markets.

The Paper and Fibre Research Institute is exploring lignocellulosics as a basis for second-generation biofuels and the future biorefinery.

Hydrogen Projects
Norway's Hydrogen Road — HyNor — was established in 2003. Goals for HyNor have been to:

- Complete a network of filling stations from Oslo to Stavanger by 2009, enabling mobility with H_2 cars.
- Provide a carbon dioxide (CO_2)-neutral H_2 supply in 2011 that will enable extending the use of H_2 cars and buses in the local projects, expanding the H_2 road to other cities, and increasing capacity in existing projects.
- Develop the H_2 road link to the hydrogen infrastructure in Sweden and Denmark by 2015 in cooperation with the Scandinavian H_2 Highway Partnership.

In terms of current status, there are four fueling stations for H_2 (as shown in Figure 7). There are 14 refitted Toyota Prius H_2 vehicles, 4 Mazda RX8s, 10 Mercedes B-class fuel cell vehicles, and 5 Th!nk hydrogen cars; 2 Alfa Romeo MiTo fuel cell vehicles are to be phased in during 2011.

Fig. 7 Norway's Hydrogen Road, HyNor

Utsira — The First "Hydrogen Society"

The Utsira hydrogen facility was established in 2004 by Hydro and Enercon. The project aims to promote a stable energy supply. The primary energy source is wind generation (Figure 8). With an H_2 generator (electrolysis), H_2 storage and H_2 fuel cell electricity are both produced for the community. The Utsira project received Platt's award for Renewable Project of the Year in New York in 2004.

Fig. 8 Views of Utsira: Model Depiction (left) and Wind Generation (right)

Hydrogen R&D

Two main hydrogen R&D centers exist in Norway:

1. The NTNU and SINTEF (The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology). Primary research areas include the following:

- H_2 production (natural gas, methanol, electrolysis),
- Proton exchange membrane and solid oxide fuel cell development, and
- Vehicle technology.

2. Institute for Energy Research. Its research areas of focus include:

- H_2 storage (metal hydrides),
- Liquefaction, and
- Infrastructure.

Electric Vehicles

In 2008, there were 1,750 EVs in use; in 2010, that number had climbed to approximately 3,000 EVs. The Green Vehicle (Grønn Bil) project has a goal of having 200,000 EVs and hybrid EVs (HEVs) in use by 2020 and of having more than 5,000 charging stations in operation to support these vehicles.

Several incentives are being applied, which include:

- Making a collective traffic lane free for use by electric and H_2 vehicles,
- Offering free reserved public parking,
- Offering free charging at public charging points (Figures 9 and 10), and
- Waiving the yearly vehicle tax and vehicle registration tax.

Fig. 9 The Minister of Transport and Communication Opens an EV Charging Station

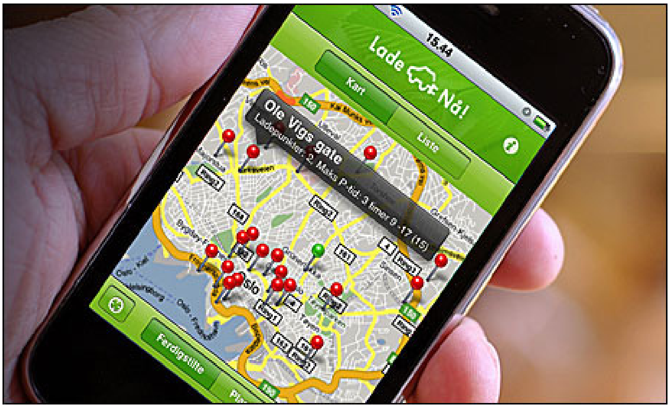


Fig. 10 Applications to Show Locations of Charging Stations

EV Production

There are two producers of EVs in Norway:

1. Th!nk. Th!nk has been in series production since 1999. The vehicle's administration is based at Think Nordic AS (2006), Norway, and production is by Valmet Automotive, Finland. The EVs have a range of 180 kilometers (km).
2. Kewet Buddy. This EV is produced by Elbil Norge AS (1999). Series production began in 1991 in Denmark; production has occurred in Norway since 2005. Called an electric urban vehicle or an EUV, yearly production totals 500 vehicles with a range of between 80–120 km.

Each vehicle is shown in Figure 11.

Fig. 11 The Th!nk EV (left) and Kewet Buddy EV (right)

National Public Funding

The following sources provide national public funding:

1. Norwegian Research Council. Projects and funding totals (in U.S. dollars) include the following:
   - Research Center for Environmentally Friendly Energy, $170 million;
   - RENERGI – clean energy, $60 million;
   - Nature and industry – biogas and micro-algae production for bioenergy and CO_2 sequestration, $2.2 million;
   - Center for Innovation, $23 million; and
   - MAROF – the maritime and offshore sector, $23 million.
2. Innovation Norway. Projects and funding totals (in U.S. dollars) include $17 million for various commercialization funding options. Innovation Norway has offices in 32 countries outside of Norway.

3. Transnova. Transnova will spend $25 million (in U.S. dollars) over three years (a preliminary amount) to develop long-term policy measures aimed at reducing CO_2 emissions from transport.
4. Confederation of Norwegian Enterprise (NHO). The NHO's proposed climate-fund was established January 17, 2008. The preliminary project is funded at $25 million (U.S. dollars) over three years.
5. The Norwegian Public Roads Administration – technology section. This organization develops long-term policy and measures aimed at reducing CO_2 emissions from transport. Its focuses are as follows:
   - Pilot and demonstration projects.
   - Market-ready technology.
   - Incentive programs.
   - Charging stations for electric vehicles ($5,000 USD).
   - Projects aimed at replacing fossil fuel (demonstration 40%, development 50%).

Renewable Energy in Transport Directive

The EU Renewable Energy Directive applies to Norway. According to this directive, the target is to be using 10% renewable fuels out of total fuel use by 2020; renewables are to include biofuels, hydrogen, and electricity. This directive was to be implemented by January 1, 2011.
The directive specifies these minimum biofuel standards:

- 2.5% as of January 4, 2009.
- 3.5% from 2010.
- 5.0% from 2011 (to reach 10% by 2020, as noted above).

Table 1 shows taxation rates for various fuels as of 2010.

Table 1 Taxation Rates for Various Fuels

Taxation 2010	Fuel Tax (USD)	CO_2 Tax (USD)
Gasoline	0.72 0.56	0.14 0.35
Gasoline w. low-blend ethanol	0.72 × (1 – gasoline %) 0.56	0.14 × (1 – gasoline %) 0.35 × (1 – gasoline %)
E85	0.00 0.00	0.00 0.00
Diesel	0.56 0.60	0.09 0.10

Table 1 Taxation Rates for Various Fuels (Cont.)

Taxation 2010	Fuel Tax (USD)	CO_2 Tax (USD)
Diesel w. low-blend biodiesel	0.56 × (1 – biodiesel %) 0.60 × (1 – biodiesel %) + 0.30 × biodiesel %	0.09 × (1 – biodiesel %) 0.10 × (1 – biodiesel %)
Biodiesel	0.00 0.30	0.00 0.00
Compressed Natural Gas	0.00 energy tax (proposed)	0.00 energy tax (proposed)
Biogas	0.00	0.00
Liquefied Petroleum Gas	0.00 energy tax (proposed)	0.00 energy tax (proposed)
Hydrogen	0.00	0.00
Hytan	0.00 energy tax (proposed)	0.00 energy tax (proposed)
Electricity	0.02/kilowatt-hour	0.00

Educational Institutions for Renewable Energy (Alternative Fuels)
The following Norwegian educational institutions support study of renewable energy and/or alternative fuels:

- Norwegian University of Life Sciences
- University of Agder
- University of Stavanger
- University College of Sogn and Fjordane

Energy (General)
The following support general energy programs:

- Norwegian University of Science and Technology
- University of Oslo
- University College of Oslo
- University of Tromsø
- University of Bergen
- University College of Bergen
- University College of Telemark
- University College of Southern Trondelag
- University College of Bodø

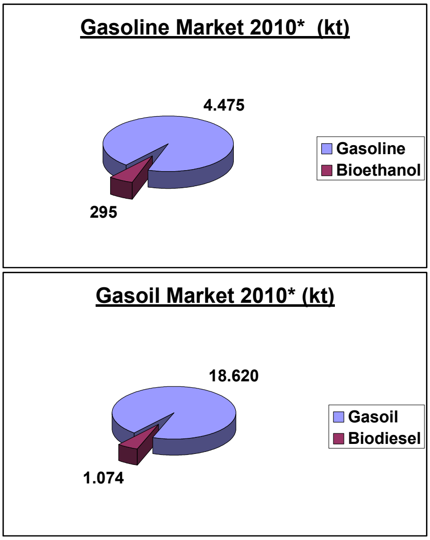
Spain

Introduction

The total market for transportation fuels in Spain in 2010 (through October, when data were last available) was almost 24.5 kilotons (kt). According to estimates, by the end of 2010, this market total liked reached more than 29 kt.

Biofuels represent the largest share of alternative transportation fuels, whereas the market penetration levels of liquefied petroleum gas (LPG) and natural gas (NG) are very low.

The charts in Figure 1 show totals for the gasoline and gasoil markets. The amounts for bioethanol and biodiesel within these markets are also depicted.



** From January to October (when data were last available).*

Fig. 1 Gasoline and Gasoil Markets in 2010

The progress in the consumption levels of biofuels in recent years can be found in Figure 2 below. The chart at right is also included to show consumption levels of fossil fuels over the same period (i.e., 2005–2010). As the charts show, the total amount of transportation fuels has decreased during the last six years as a consequence of the global crisis, whereas biofuels consumption has increased over this same time period as a result of blending mandates.

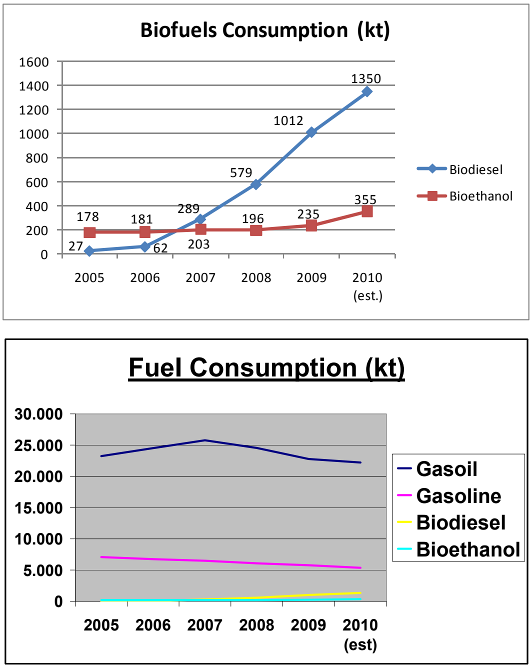


Fig. 2 Consumption of Biofuels as Compared to Fossil Fuels, 2005–2010

Policies and Legislation

Biofuels consumption in Spain is incentivized by means of Law 53/2002, on Tax, Administrative, and Social Measures, which modifies the Special Taxes Law 38/1992. This law established that until the end of 2012, biofuels will be practically be exempted from the Hydrocarbons Special Tax.

Law 12/2007, which modifies Law 34/1998 of the Hydrocarbon Sector, extended the list of products that could be considered to be biofuels and set annual objectives for the commercialization of biofuels and other renewable fuels for the period 2008–2010 (i.e., compulsory 5.83% of energy content by 2010). This law also enabled the Ministry of Industry, Tourism, and Trade to enact the necessary resolutions to regulate a mechanism of promotion of biofuels in order to meet the annual objectives. This mechanism was established by means of Ministerial Order ITC/2877/2008.

New mandatory objectives for the period 2011–2013 have been set by means of Royal Decree 1738/2010, as follows:

2011	2012	2013
5.9%	6.0%	6.1%

In the frame of Action Plans 2005–2007 and 2008–2012 of the Spanish Energy Efficiency and Saving Strategy, the Instituto para la Diversificación y Ahorro de la Energía is currently supporting, in collaboration with regional governments, the acquisition of alternative vehicles (e.g., hybrid, electric, LPG, NG, hydrogen, and fuel cell) and the implementation of charging points/fuel stations for each technology. The financial support covers up to 15% of the market price of these vehicles and 30% of the implementation costs of the charging points/fuel stations.

Implementation: The Use of Advanced Motor Fuels

Biofuels production capacity in Spain has experienced a sharp growth throughout this decade and, in particular, during the last three years. As a consequence of this growth, the current installed production capacity as of 2010 has reached 4,170 million tons of oil equivalent (toe), as shown in Figure 3.

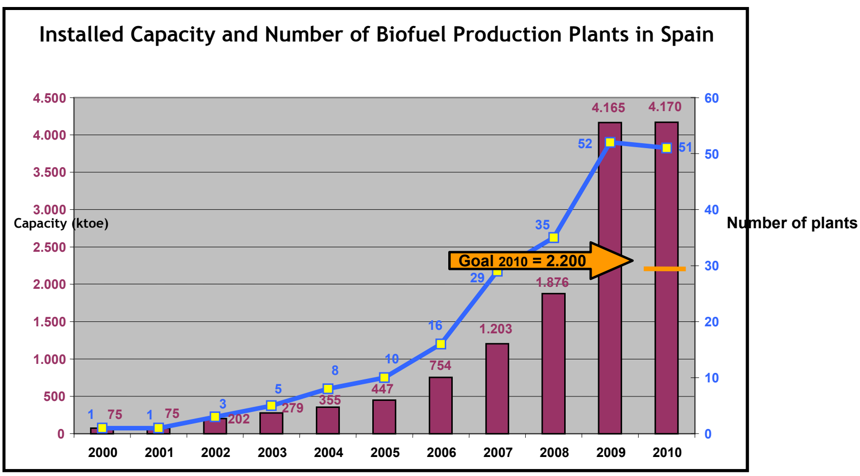


Fig. 3 Installed Capacity and Number of Biofuel Production Plants in Spain

The Spanish Renewable Energy Plan, which was issued in 2005, established the national strategy to develop renewable energy sources. Several measures intended to support the biofuels industry were included in this plan. As Figure 3 shows, the biofuels consumption goal included in the Renewable Energy Plan for 2010 was 2,200 kilotons of oil equivalent (the actual production capacity nearly doubles this target).

This 4,170 million toe capacity is generated by 51 production plants all over Spanish territory. The geographical distribution of these plants is shown in the map in Figure 4.

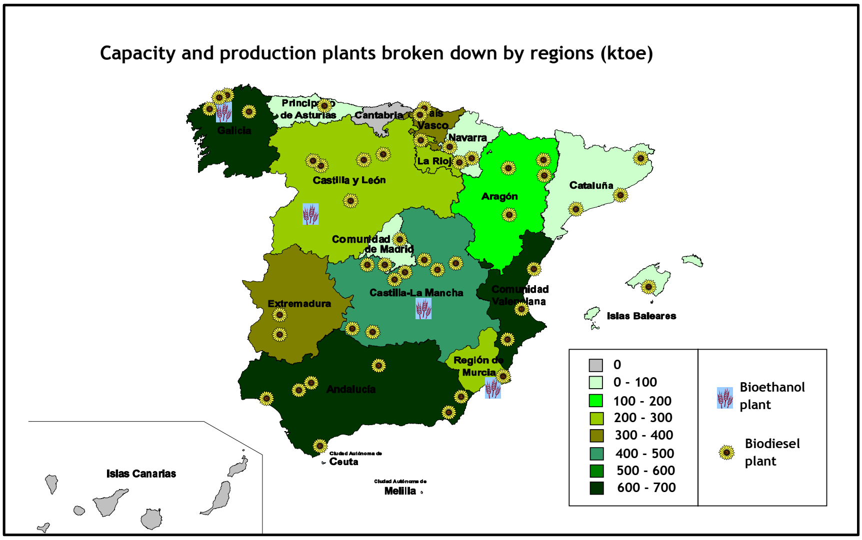


Fig. 4 Locations of Biofuel production Plants in Spain

The current number of vehicles capable of using other alternative fuels (i.e., LPG, natural gas, and hydrogen/fuel cell) is shown in Table 1.

Table 1 Numbers of Vehicles Using Other Alternative Fuels and Associated Fuel Stations

Alternative Fuel	Current Number of Vehicles	Number of Fuel Stations
LPG Financial support (up to €2,000 for cars and €12,000 for trucks and buses) for the acquisition and transformation of industrial vehicles and cars/vans with a maximum CO_2 emission of 150 grams/kilometer (km) in 2010.		CURRENT NUMBER OF FUEL STATIONS: Public Fuel Stations: 70 (most of them are Repsol fuel stations). Private Fuel Stations: 60.
Natural Gas Financial support (up to €2,000 for cars and €12,000 for trucks and buses) to the acquisition of industrial vehicles and cars/vans with a maximum CO_2 emission of 160 g/km.		CURRENT NUMBER OF FUEL STATIONS: 45 (Fuel stations on NG are mainly located in fleet sites.)
Hydrogen/Fuel Cell Financial support for the acquisition of cars (up to €7,000) and industrial vehicles (up to €50,000).		TOTAL FUEL STATIONS: 2 (as part of the CUTE project). Currently not in operation. 1 in Zaragoza (operating until 2016 in the Expo zone). 1 in Albacete (Ajusa; has operated since 2009). 1 in Andalucía (as part of the Hércules Project).

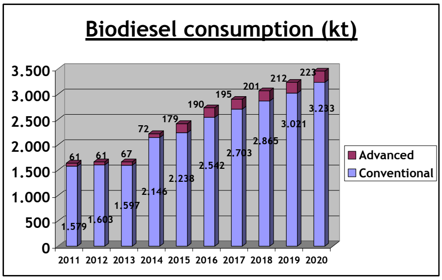
Outlook

Consumption of bioethanol and bio-ETBE (ethyl tertiary butyl ether)is expected to nearly double, from 363 kt in 2011 to 707 kt in 2020 as a consequence of the general addition of a bioethanol/ETBE mix to gasoline (see the chart on the right in Figure 5).

Regarding the consumption of advanced bioethanol and bio-ETBE, the figures suggest that by the end of the 2011–2020 period, one or more of Spain's bioethanol production projects using ligno-cellulosic or waste material will be at the commercial stage.

Biodiesel consumption is also expected to double during the next decade, from 1,640 kt in 2011 to 3,456 kt in 2020 (see chart on the left in Figure 5). However, the rate of growth is not expected to be uniform: from now until 2013, growth will be very slow and then will pick up as a result of the development of specifications for labeled blends and the foreseeable success of B10 standardisation. Regarding advanced biodiesel consumption, the figures support the expectation that biodiesel from waste material will reach 223 kt by the end of the 2011–2020 period.

Consumption of biofuels between 2011 and 2020 will also include a small contribution from biofuels other than bioethanol and biodiesel, which will be incorporated during the second half of the period. Of these, the most likely to develop independently in the future are biogas for transport and hydrotreated vegetable oil and Bio-SPK (Bio-Derived Synthetic Paraffinic Kerosene) for the aviation market, although all are now at very early stages of development.



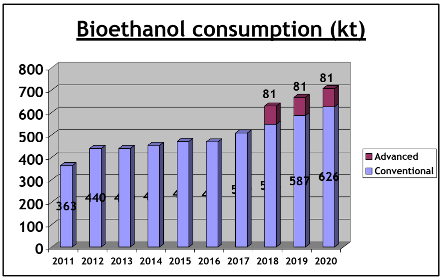


Fig. 5 Projected Levels (through 2020) of Biodiesel and Bioethanol Consumption in Spain

Benefits of Participation in AMF
Membership within IEA-AMF provides wider and easier access to information and helpful analysis to guide national policies and programs. It also helps to raise awareness concerning advanced motor fuels issues, ongoing research, and the need for future research.

Additional Reference

The following may be consulted for additional information: http://www.idae.es.

Sweden

Introduction

Swedish domestic transport consumed 93 terawatt-hours' (TWh) worth of energy in 2009, or 25% of the country's total energy use.

Bunkering for foreign maritime traffic amounted to 25 TWh, and fuel for nondomestic aviation accounted for 8 TWh. Total energy use in the transport sector, including foreign transport, amounted to 127 TWh. Petrol and diesel oil met 88% of the country's energy requirements for domestic transport.

Sweden imported almost 19 million tons of crude oil in 2009, and net-exported 4.4 million tons of refinery products. More than 50% of Sweden's total crude oil imports come from the North Sea — mainly from Denmark and Norway.

The portion of renewable motor fuels used by road vehicles has increased substantially in recent years. In 2009, the portion of renewable motor fuels amounted to 5.4%: in comparison, the corresponding portion for 2008 was 4.9%. In this context, the portion of renewable motor fuels is calculated as the quantity of bio-based motor fuels divided by the quantity of bio-based motor fuels, petrol, and diesel fuel. The renewable motor fuels that vehicles use at present are biogas, ethanol, and fatty acid methyl ester (FAME).

Between 2000 and 2008, the use of diesel fuel increased by 56%, while that of petrol has fallen by 10% over the same period. One reason for this development is the change in the mix of the types of vehicles on the road, both private cars and light goods vehicles. For instance, the portion of new vehicles that were diesel-powered amounted to 51% in 2010, as compared with 20% in 2006.

The number of passenger cars in Sweden in 2009 amounted to 4.3 million vehicles. A total of 4.5% of the passenger cars are able to run on renewable fuels (biogas or ethanol [E85, which is 85% ethanol and 15% gasoline]) (Figure 1). Figure 2 shows the fuel efficiency levels of vehicles sold in Sweden in 2009 as compared to 2007.

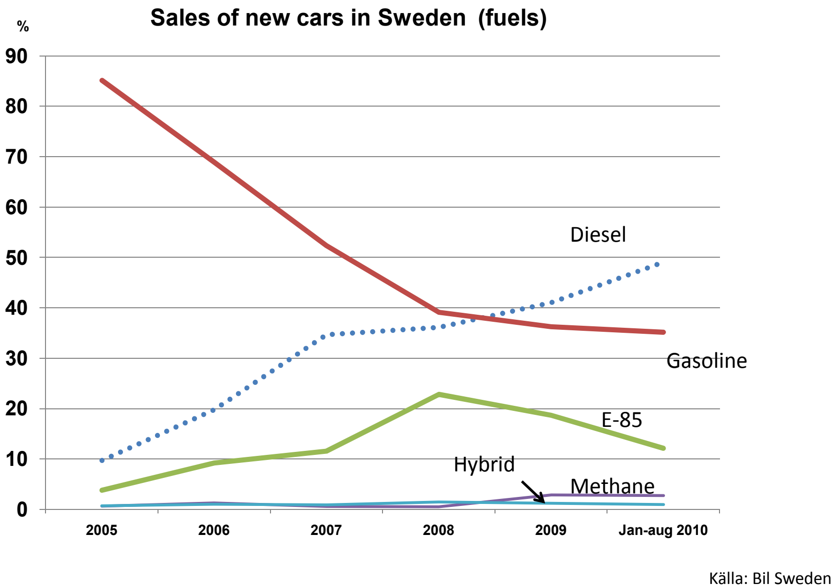


Fig. 1 Percent Sales of New Cars in Sweden by Type of Fuel, 2006–August 2010

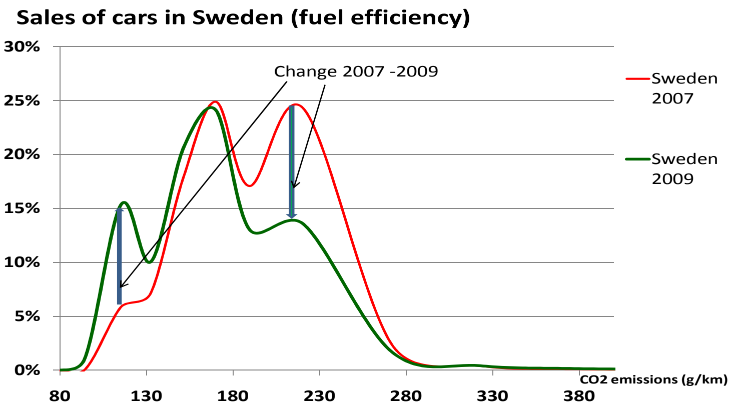


Fig. 2 Comparison of Fuel Efficiency Levels of New Cars Sold in Sweden in 2007 and 2009

Policies and Legislation

The motor vehicle tax was changed in October 2006 to be based on a vehicle's carbon dioxide emissions instead of, as was previously the case, on the vehicle's weight. The purpose of this change was to encourage the sales of more low-carbon vehicles. In new legislation going into effect in 2011, the carbon dioxide multiplier will be increased. Some relief will be provided for vehicles capable of running on bio-based motor fuels. Starting in 2011, the vehicle tax for newly registered light-goods vehicles, buses, and motor caravans will also be subject to the carbon dioxide tax charge. The vehicle tax for heavy-goods vehicles does not include a carbon dioxide multiplier element, as it depends instead on the vehicle's weight and exhaust levels. The lack of harmonized and accepted methods of measuring fuel consumption of heavy-duty (HD) vehicles is an obstacle to linking taxation to their carbon dioxide (CO_2) emissions.

The notional benefit of a free vehicle is subject to income tax and the social insurance and related tax paid by employers. Free fuel may also be included and is also subject to tax. The actual tax levels for these benefits affect the sales and use of vehicles. The present structure of notional value tends to even out the effect of price differences among cars, with the result that cars provided as a benefit to employees are larger, heavier, and emit more CO_2 per kilometre (km) as compared to the averages of these measures for new cars.

Heavy-goods vehicles and trailers weighing more than 12 tons are subject to a toll charge. The charge is based on the vehicle's exhaust emissions category and its number of axles and is payable for one year at a time. Some offset relief is provided by a reduction in the vehicle tax.

Bio-based motor fuels pay no energy or CO_2 tax, which affects the profitability of using such fuels. The availability of bio-based motor fuels has been affected by the requirement that filling stations selling more than a certain volume of fuel must also sell a renewable-based alternative. As this requirement resulted mainly in an increase in the number of E85 pumps, a grant was also introduced for investment in other pumps. This grant is no longer available.

Thanks to legislation that went into effect on July 1, 2009, clean vehicles are exempt from paying the vehicle tax for five years: in addition, their notional taxable value is also reduced. Public authorities are also required to ensure that the passenger cars they purchase or lease must be clean vehicles

(SFS 2009:1) and that their light goods vehicles must have emissions levels lower than 230 grams of CO_2/km.

During 2010, the city of Stockholm, in conjunction with Vattenfall AB, planned to carry out Sweden's largest technology procurement project for electric vehicles (EVs), with support from the Swedish Energy Agency. The purpose of the procurement is to launch a market in Sweden for electric vehicles, and thus assist the country in its changeover to a system of sustainable energy use. The procurement project's target is to have 1,050 EVs in operation in Sweden by the end of 2012.

Research is being carried out on the production of alternative motor fuels. The Bio-DME (dimethylether) project started in September 2008. As part of the project, Chemrec and its partners are building a second-generation biofuels demonstration plant in Piteå in northern Sweden. Volvo will by then have the first of 10 DME-fueled trucks ready, and Preem will have built filling stations. This project will demonstrate the entire chain from biomass to trucks running on DME. Chemrec will build and operate the plant where DME will be produced through the gasification of black liquor, which is an internal stream in pulp mills. A full-scale plant will be built at the Domsjö pulp factory in Örnsköldsvik.

A demonstration project with three Volvo HD trucks fueled with liquid methane (CH_4) started in October 2010. Liquid methane combined with dual-fuel technology offers four times the driving range as compared to the range available when trucks are fueled by traditional methane alone. One part of the project involves building a refueling station for liquid methane in Gothenburg.

Implementation: the Use of Advanced Motor Fuels

The alternative motor fuels that vehicles use at present are natural gas (NG), biogas, ethanol, and FAME. Natural gas and biogas go under the common name of motor fuel gas and are used mainly as a fuel for buses and private cars. Ethanol finds uses as a low‑admixture constituent of petrol and as a constituent in such fuels as E85 and ED95 (an ethanol diesel fuel mix of 95% ethanol and 5% ignition improver). FAME is used both as 100% FAME and as an admixture constituent in diesel fuel. A small portion of vehicles using hydrotreated vegetable oil (HVO) are going to be introduced in Sweden. The feedstock comes from the pulp industry.

Low admixture ratios of ethanol and petrol increased progressively at the beginning of the 2000s, reaching the 5% admixture level in 2005 in almost all petrol on the Swedish market. A low admixture of FAME in diesel fuel began to be permitted as of August 1, 2006, and since then its percentages have steadily increased: statistics for 2009 show that an admixture of 5% FAME was mixed into 80% of all diesel fuel delivered to the Swedish market.

Motor fuel gas consists either of straight biogas, straight natural gas, or a mixture of the two. The proportion of natural gas in motor fuel gas varies by location in Sweden and is generally higher in those parts of the country covered by the NG grid. In terms of the total use of motor fuel gas in 2009, the constituent proportion of biogas was almost 65%. Figure 3 shows how Sweden's use of renewable motor fuels has grown from 2000 to 2009.

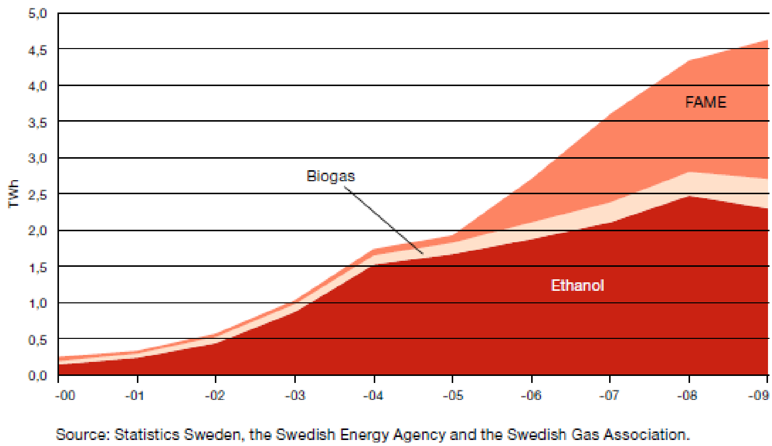


Fig. 3 Use of Renewable Motor Fuels, 2000–2009

Outlook

The Swedish Energy Agency produces both short-term and long-term forecasts. In the latest forecast, the Agency expects the use of ethanol as an admixture constituent to increase through 2015. According to legislation going into in 2011, admixtures of 6.5% in petrol and 5% in diesel will be tax exempt. If a higher admixture (e.g., 10% ethanol as allowed within the European Union [EU]) is chosen, the remaining part of the ethanol is subject to both an energy and carbon dioxide tax. The agency expects the admixture levels to correspond with the level of tax exemption (i.e., 6.5% ethanol in petrol and 5% FAME in diesel). In 2015, the ethanol used for admixtures is expected to decrease, which corresponds to the expectation that the use of petrol will decrease.

When considering ethanol in the form of higher blends, its levels are expected to remain around the 2010 level. The use of biogas is expected to increase, because of higher expected use of biogas in both light and heavy vehicles.

The use of HVO will probably increase to a few TWh until 2030.

The Swedish Energy Agency's forecast expects that Sweden will just about reach the EU target of using 10% renewable energy for transport purposes by 2020. In addition to the renewable energy shown in Figure 3, the use of renewable electricity for railway traffic is expected to contribute an additional 2 TWh by 2020, which yields a projection of a total of around 8 TWh of renewable energy used for transport purposes in 2020.

While it is hoped that there will be bio-methanol and bio-DME used as fuel in 2020, the plants must first develop production.

Benefits of Participation in AMF

IEA-AMF offers excellent opportunities to take part in different countries' experiences. Cooperation through annexes makes it possible to carry out a project that otherwise might have been too expensive for individual countries.

The most important benefit is that the participation of multiple countries in the annexes leads to a common view of the challenges, as well as of the possible solutions.

Additional References

The following may be consulted for additional information:

Swedish Energy Agency, *Energy in Sweden 2010*.

Swedish Energy Agency, *Långsiktsprognos 2010* [long-term forecast] (was to be published in February 2011).

Switzerland

Introduction

The final total energy consumption level in Switzerland in 2009 was 877,560 terajoules (TJ), with 55% of that use attributed to transport fuels.[1] All fossil fuels are imported. The share of biofuels is very small (< 1%).

In 2008, 5,448 passenger cars with environmentally friendly propulsion systems were sold (3,000 of these with E5). The share of total sales was 1.9%. In addition, in 2008 more small vehicles with lower rates of fuel consumption were sold.

Different cantons have mandated a vehicle tax reduction or even a tax exemption for environmentally friendly and energy efficient vehicles (see http://www.bio-sprit.ch).

In 2008, there were 89 fueling stations for E5 fuel, and 22 fueling stations providing E85 (85% ethanol and 15% gasoline). Furthermore, 216 fueling stations provide B5, and 17 stations provide B100 (see http://www.biofuels-platform.ch).

Policies and Legislation

In February 2007, the Federal Council decided to focus its energy policy on four main areas.[2] (1) energy efficiency, (2) renewable energy, (3) replacement of existing large-scale power plants and construction of new ones, and (4) foreign energy policy. In order to implement this strategy, the Federal Department of the Environment, Transport, Energy, and Communications (DETEC) prepared draft action plans for promoting energy efficiency and the use of renewable energy, which were approved by the Federal Council on February 20, 2008.

These action plans set out to reduce the consumption of fossil fuels by 20 percent by 2020 in line with the declared climate objectives, to increase the proportion of renewable energy to overall energy consumption by 50 percent, and to limit the increase in electricity consumption to a maximum of 5 percent between 2010 and 2020. From 2020 onward, the objective will be to stabilize electricity consumption.

The action plans comprise a carefully conceived package of measures that complement and supplement one another. The package combines incentives (e.g., a bonus/penalty scheme for the vehicle tax on new cars), direct promotional measures (e.g., a national program to promote the renovation of buildings), and regulations and minimum standards (e.g., introduction of a ban on conventional light bulbs in 2012). The action plans include measures for which either the federal government, Parliament, or the cantons are responsible. The action plan for increasing energy efficiency encompasses 15 measures in the areas of buildings, mobility, appliances, training and further education, research, and technology transfer.

With regard to the signed Kyoto Protocol, Switzerland is obliged to reduce its greenhouse gas (GHG) emissions. The CO_2 Act asks for an emissions reduction of 10% by 2010 and of 20% by 2020 compared with 1990. The CO_2 Law requires that by 2010, carbon dioxide (CO_2) emissions resulting from fossil fuels should be reduced by 10% as compared to 1990. The emissions from fossil fuels for heating purposes must be reduced by 15%, while the emissions from fossil fuels for transportation purposes (except kerosene used for international flights) must be reduced by 8%. From a political perspective, the focus is on freely agreed-upon measures.

To reach this goal, the government allows for different measures like the CO_2 levy, “Climate Cent,” and the fiscal promotion of environmentally friendly fuels. The goal of the CO_2 levy is to reduce CO_2 emissions by levying a regulatory tax on all fossil combustibles like natural gas (NG), heating oil, and coal. Petrol and diesel are not affected from the CO_2 levy. The “Climate Cent” is a voluntary measure of the mineral oil industry and has been in effect since 2005. With a price surcharge of 1.5 centimes per litre of petrol or diesel, reduction measures are financed. Since July 2008, Switzerland has allowed a partial or total tax exemption on fuels from renewable sources like biogas, bio-ethanol, biodiesel, vegetable, and animal oils, as long as they meet ecological and social minimum requirements (according to the Act of Mineral Oil Taxation).

Regarding biofuels, the SFOE has published a position paper.[3] The main messages within this document are the following: (1) the production of biofuels from waste has to be preferred for ecological reasons; (2) new technologies and cropping systems can improve the initial position of biofuels; (3) quotas for blending are not regarded as reasonable because they are in opposition to a more rational use (e.g., heat-dimensioned combined-heat-and-power plants); and (4) food production has priority.

Implementation: the Use of Advanced Motor Fuels

Biodiesel & Fuel Pure Vegetable Oil
Table 1 shows how consumption of biodiesel and fuel PVO has developed in Switzerland over the period 1997–2009.

Table 1 How Consumption of Biodiesel and Fuel PVO Has Developed in Switzerland over the Period 1997–2009 (in kiloliters [kl]/year)[4]

Year	Biodiesel (in kl)			Fuel-PVO (in kl)		
	National Production	Imports	Total	National Production	Imports	Total
1997	1,851	-	1,851	-	-	-
1998	1,664	-	1,664	-	-	-
1999	1,563	-	1,563	-	-	-
2000	1,825	-	1,825	-	-	-
2001	1,937	-	1,937	-	-	-
2002	1,774	-	1,774	-	-	-
2003	2,342	-	2,342	-	-	-
2004	3,262	-	3,262	313	-	313
2005	6,361	-	6,361	529	-	529
2006	8,833	-	8,833	845	-	845
2007	9,756	113	9,869	1,846	-	1,846
2008	11,915	12	11,927	849	158	1,007
2009	6,821	694	7,515	796	1,430	2,226

The consumption of biodiesel in Switzerland amounted to just over 7.5 million liters in 2009, that is, a drop of 37% with respect to 2008. The consumption of fuel PVO, however, showed a significant increase in 2009, namely, of 121% with respect to 2008.[4] Biodiesel and pure vegetable oils are applied only in some local diesel fleets (mostly in agriculture).[5]

Bioethanol
Table 2 shows the progression of fuel bioethanol consumption from 2005–2009.

Table 2 Development of Fuel Bioethanol Consumption in Switzerland over the Period 2005–2009 (in kl/y)[4]

Year	Production	Imports	Total
2005	901	-	901
2006	1,060	-	1,060
2007	3,188	-	3,188
2008	3,284	-	3,284
2009	-	1,483	1,483

In 2008, Alcosuisse (The Profit Centre of the Swiss Alcohol board) placed about 25% of the production of Borregaard Schweiz (i.e., about 3.3 million liters) on the vehicle fuel market. The closing down of Borregaard's production facility in Switzerland in November 2008, however, forced Alcosuisse to find new suppliers of fuel-bioethanol that meets the ecological and social minimum requirements according to the Act of Mineral Oil Taxation. It is fuel bioethanol produced from wood waste (using a process very similar to the one Borregaard Swiss employed) by the companies SEKAB in Sweden and Borregaard in Norway which today provides the supply in Switzerland. In compliance with the requirements according to the Act of Mineral Oil Taxation, this bioethanol has benefitted from tax exemption since March 2009, which extends to 2013.[4]

Biogas

Table 3 shows the progression in consumption rates of fuel biogas (obtained either from the gas grid or fueling stations) in Switzerland from 1998–2009.

Table 3 Development of Consumption (Taxed Amounts) of Fuel Biogas (via Gas Grid and Directly at Fueling Station Responsible for Electricity Production) in Switzerland over the Period 1998–2009 (in kl/y)[6]

Year	Biogas via gas grid	Share of biogas in gas grid (%)	Biogas direct usage for electricity production or as fuel	Total biogas production
1998	63	33.87	964	1,027
1999	90	51.72	1,068	1,158
2000	294	44.82	1,017	1,311
2001	366	47.10	1,486	1,852
2002	470	36.95	1,524	1,994
2003	542	37.35	1,635	2,177
2004	681	37.79	2,696	3,377
2005	890	36.88	2,461	3,351
2006	927	26.25	3,356	4,283
2007	1,334	20.24	1,329	2,663
2008	2,493	23.95	482	2,975
2009	3,152	23.30	0	3,152

In 2009, biogas production was at 2,878 TJ (800 gigawatt-hours [GWh]), of which 3,152,000 kilograms (kg) (37 GWh, 2.6million cubic meters (m^3), or 4.6%) were used as fuel.[7]

Total consumption of liquid biogas fuel (excluding aviation fuels) in Switzerland was 7,054 million liters in 2009, of which 0.1% (7.5 million liters) was biodiesel, 0.03% (2.2 million liters) was pure vegetable oil, and 0.02% (1.5 million liters) was bioethanol.

The total gaseous fuel consumption in Switzerland (NG + biogas) was 13,525,000 kg (which equals 18.74 million liters of Petrol 95) in 2009, of which 23% (3,152,000 kg) was biogas.[6]

Figure 1 shows Switzerland's use of biofuels as a percentage of total energy use: in 2009, fossil fuels provided 99.8% of Switzerland's energy, and biofuels provided 0.2%.

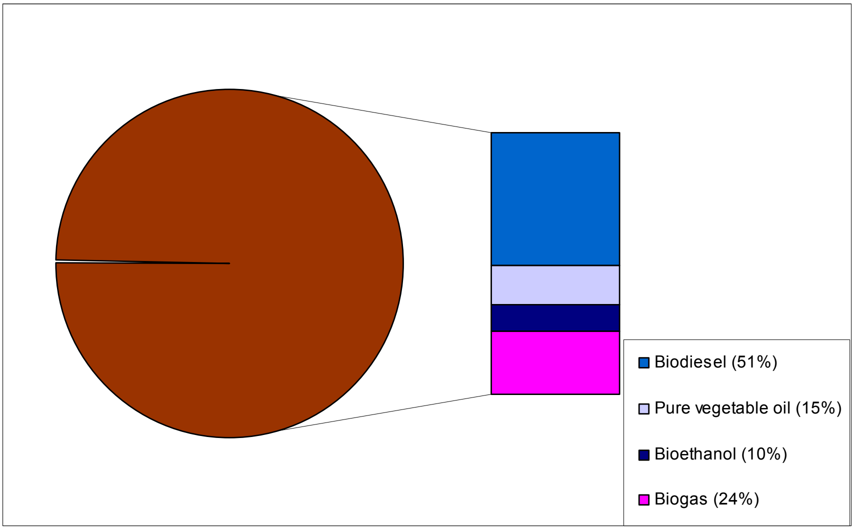


Fig. 1 Share of Biofuels out of Total Fuel Consumption in Switzerland in 2009 (fossil fuels, 99.8%; biofuels,0.2%)

Outlook

The medium-term production potential for biofuels is estimated by the federal council at 76 million liters. This projected amount equals 1% of Swiss annual fuel consumption.[8]

If policy measures were to heavily encourage local energy production from biomass, it would be possible for biomass to reach a share of 8% of biofuels until 2020. Therefore, all biomass fractions, including the produced by-products, have to be used energetically.[9]

Regarding research and development, the focus is on optimizing the use of first-generation biofuels and developing new technologies for second-generation biofuels.

Recently completed and ongoing research projects are highlighted below.

One project that aims to optimize use of first-generation biofuels studies the influences of rape methyl ester (RME) on emissions using the different exhaust gas aftertreatment systems of diesel engines (Bern University of Applied Sciences; research project, ongoing).

Second-generation biofuels projects (completed and/or ongoing) include the following:

- Future perspectives of 2nd generation biofuels (Centre for Technology Assessment – TA Swiss; study; finished).
- Sulphur-resistant methanation (Paul Scherrer Institute; research project; ongoing).
- Hydrothermal gasification (Paul Scherrer Institute; research project; ongoing).
- New pathways to efficient use of biomass for power and transportation (2nd generation biogas) (Paul Scherrer Institute, Swiss Federal Institute of Technology Zurich & Lausanne, Swiss Federal Institute for Forest, Snow, and Landscape Research, Swiss Federal Institute for Aquatic Research, Swiss Federal Laboratories for Materials Science and Technology; research project; finished).
- Pilot plant – Hydrothermal gasification of wet biomass (Hydromethan AG, KASAG, Brand Anlagenbau AG, AVUT Consulting, EPR Lüthy & Co; research project; ongoing).
- The Roundtable on Sustainable Biofuels (International initiative coordinated by the Energy Center at the Swiss Federal Institute of Technology Lausanne; ongoing).
- Harmonization and extension of environmental life cycle assessment also regarding biofuels (Swiss Federal Laboratories for Materials Science and Technology; study; ongoing).

Benefits of Participation in AMF

Some of the major benefits of participating in the IEA-AMF include:

- International contacts and knowledge exchange,
- Information services,
- Project collaborations and shared funding,
- Research of specialists and consultants,
- Promotion of domestic projects and research, and
- Support for domestic authorities.

Additional References

The following may be consulted for additional information:

1 http://www.bfe.admin.ch/themen/00486/index.html?lang=en.

2 http://www.bfe.admin.ch & http://www.bafu.admin.ch.

3 BFE, 2008, *Positionspapier biogene Treibstoffe*, http://www.bfe.admin.ch/themen/00490/00496/index.html?lang=en&dossier_id=00726.

4 http://www.biofuels-platform.ch.

5 EV Annual Report, 2009, http://www.swissoil.ch.

6 http://www.ezv.admin.ch.

7 BFE, 2010, *Schweizerische Statistik der erneuerbaren Energien 2009*, http://www.bfe.admin.ch/themen/00526/00541/00543/index.html?lang=en&dossier_id=00772.

8 http://www.bio-sprit.ch.

9 Erneuerbare Energien, 2006, Sondernummer.

Thailand

Introduction

In 2010, the growth rate of the economy of Thailand was 7.8% and estimated at US$36 billion. Its average energy consumption as a percentage of gross domestic product (at current prices) was 17.7%. Thailand imports most of its energy from abroad. Oil and natural gas (NG) are the major imported items. Imports of crude oil equivalent are at the level of 803,000 barrels per day and valued at US$24.43 billion. These are mostly used in the field of transportation, which uses 24,907 tons of oil equivalent or 46.12%. The transportation sector consumes gasoline at an average of 20.4 million liters per day and diesel at an average of 50.8 million liters per day. The major part of transportation gasoline is gasohol (E10–E85) at 59% of the total or 11.9 million liters per day.

Currently, there are 28,484,829 vehicles in Thailand. Among these units, gasoline engine vehicles account for 20,467,417 units, diesel engine vehicles for 6,967,320 units, liquefied petroleum gas (LPG) for 23,511 units, LPG and gasoline or diesel for 642,644 units, compressed natural gas (CNG) for 32,416 units, CNG and gasoline or diesel for 156,714 units, with the rest being electric vehicles (EVs), hybrids, etc. A total of 2,623,327 new vehicles were registered last year in which passenger cars represented 43.5%. The total amount of fuel consumed by these vehicles is 61.4 million liters per day.

Policies and Legislation

The use of bioethanol increased as a result of government policies that encouraged the use of gasohol 91 by reducing the levy for the energy funds; as a result, the retail prices of gasohol 91 and 95 (i.e., E10) became lower than that of than ordinary gasoline. The government also aims to promote mixing ethanol at a high level, such as E20 and E85, by encouraging car manufacturers to add a production line for flexible fuel vehicles (FFVs); this measure is coupled with the reduction of excise tax to 3% for 1,780–3,000 CC of FFVs, using E85 fuel, and increasing the number of E20 and E85 oil filling stations.

Similar to gasoline, a pricing strategy is also applied to promote the consumption of biodiesel (B2, B3, and/or B5) through reducing the levy for the energy fund. Quality control and assurance are also applied to biodiesel production to increase consumers' confidence. There is also enforcement of the compulsory biodiesel B3 since June 1, 2010, with biodiesel B5 as an alternative fuel. Currently, the production of oil palm — the main raw material used in the production of biodiesel (B100) — has been affected by flooding in many areas, which has resulted in shortages of biodiesel. In response, the Ministry of Energy has permitted the reduction of biodiesel blended in diesel oil from 3% to 2% and requested that the refinery plant stop production of biodiesel B5 from February to March 2011.

Molasses and cassava are considered to be the most viable feedstocks for ethanol production to mix with gasoline as gasohol (e.g., E10, 20, 85). The supply would be enough to produce 10 million liters per day of ethanol through use of surplus sugar cane from sugar production and would not require more plantation areas to obtain the needed amounts of sugar cane and cassava.

The strategies and guidelines to enhance the use of ethanol as fuel are as follows:

1. Promote research and development (R&D) of alternative crops.
2. Provide sufficient raw materials and increase production of ethanol.
3. Reduce the production cost of ethanol and promote its use/marketing.
4. Increase gasohol consumption as an alternative to gasoline.

Currently, oil palm, sunflower, castor bean, and jatropha are various feedstocks for biodiesel production. Palm oil and palm stearin from a refinery plant are considered to be two economically viable feedstocks. On the other hand, used vegetable oil and animal fats are used to produce biodiesel at the community level in the agricultural sector.

The strategies and approaches to drive the development of production and commercialization of biodiesel in Thailand are as follows:

- Promote oil palm cultivation.
- Promote R&D of water management techniques to increase yield of energy crop per area.
- Promote R&D of biodiesel production from alternative crops.
- Increase proportion of biodiesel from B2 to B5 and B10, respectively, to achieve the trust of consumers.
- Develop continuous process in industries, increase efficiency, and reduce the cost of biodiesel production.
- Promote development and design of the oil extraction system, waste water treatment, and power plant systems.
- Establish a biofuel management center (Public Organization).

- Build a database of potential production and consumption sources of biomass energy, especially all aspects of oil palm — from its cultivation to biodiesel production.

Implementation: the Use of Advanced Motor Fuels

The 15-year Alternative Energy Development Plan (2008–2022) of the Ministry of Energy specifies the promotion of alternative energy applications, with aims to proportionally increase the proportion of alternative energy from 6% to 20% of total primary energy consumption by 2022. The plan specifies a alternative-energy goal of 10.35% for the transportation sector (biofuel vehicles at 4.1%, natural gas vehicles [NGVs] at 6.25%) and 10% for the stationary sector (heat at 7.6%, power at 2.4%).

Thailand's government policy on alternative energy as a national agenda encourages the production and use of alternative fuels for vehicles and the use of LPG, CNG, biofuels such as gasohol (E10, E20, and E85) and biodiesel (B2, B5) to enhance energy security and to reduce pollution, greenhouse gases, and other pollutants.

Table 1 shows alternative fuels for driving the development of alternative energy in the transportation sector in 2010.

Table 1 Impacts of Biofuel Use on Key NGV Metrics

Biofuels	2009 (million liters per day)	2010 (million liters per day)	Difference (%)
1. Ethanol	1.25	1.23	−1.3
2. Biodiesel	1.66	1.73	+4.1
NGVs	**2009**	**2010**	**Difference (%)**
- Consumption (tons/day)	4,000	4,900	+22.5
- Vehicles	162,023	211,368	+30.46
- Stations	386	420	+8.0
% Substitution	6.24%	7.25%	1.01%

Outlook

Potential and Target in Transportation Sector

Table 2 exhibits the potential and existing alternative fuels in the transportation sector in Thailand from 2008 and projected through 2022.

Table 2 Projected Use of Alternative Fuels in Thailand in the Transportation Sector, 2008 to 2022

	Potential	Existing	2008–2011		2012–2016		2017–2022	
Biofuels	mlpd	mlpd	mlpd	ktoe	mlpd	ktoe	mlpd	ktoe
1. Ethanol	3.0		3.0	805	6.20	1,686	9.0	2,447
2. Biodiesel	4.2		3.0	950	3.64	1,145	4.5	1,415
3. Hydrogen (million kg)							0.1	124
Total			6.0	1,755	9.84	2,831	13.50	3,986
NGV (mmscfd)		108.1	393.0	3,469	596	5,260	690	6,090
(ktoe)				10,961		15,579		19,799

Note: mlpd = million liters per day.
kg = kilogram.
ktoe = kiloton of oil equivalent.
mmscfd = Million Standard Cubic Feet per Day of gas.

Benefits of Participation in AMF

Thailand has had the opportunity to participate as a member of the IA-AMF since 2008. This initial step is important to developing the domestic biofuel industry that will be recognized in subsequent years at the global level. The NSTDA, as the leading science and technology R&D organization in Thailand, is representing the country in IA/AMF.

In Thailand, the Ministry of Energy has a 15-year development plan for promoting and increasing the use of alternative energy, with the goal of developing renewable energy in the thermal, electricity, and transportation sectors. The energy research plan of the NSTDA is developed in response to national policy. The opportunity for NSTDA to join the IA/AMF has been particularly helpful in tracking and monitoring information and advances in R&D from the member countries and in providing an opportunity to develop research and network with professionals from other countries. R&D collaboration helps Thailand to understand the policies and standards on alternative fuels that are acceptable and will be announced and globally applied in the near future.

Thailand has a vision of becoming a leader in the export of biofuels in Association of Southeast Asian Nations/Asia. Participation as a member is a strategic step toward developing biofuels from Thailand that will be accepted on a global basis, in addition to participating in R&D with experts from the member states. The learning potential provided by the technology and policy guidelines on biofuel development as issued by different countries affords the opportunity to develop the staff's capacity, as well as to reduce the cost of imported measurement instruments that are expensive and require experts to monitor and analyze the results.

In January, NSTDA organized the IA/AMF Share Forum to disseminate the information gained from the 40th ExCo Meeting and also to open a forum for sharing R&D on biofuels. The participants include stakeholders from the government, the private sector (oil traders, automobile manufacturers), associations, and researchers from different universities. This forum is the starting point in development of the country's research group that will conduct the research/research support of IA/AMF and create the most benefit of being a member of the IA/AMF for Thailand.

Additional References

The following may be consulted for additional information:
http://www.dede.go.th.
http://www.eppo.go.th.
http://www.dlt.go.th/.

United States

Introduction

The U.S. government has many active research programs evaluating advanced motor fuels, including biofuels from multiple feedstocks. In the near term, the U.S. government is pursuing ethanol for direct displacement of gasoline in the light-duty transportation fleet, and to a lesser degree it is pursuing biodiesel for displacement of conventional diesel. Longer-term research projects are investigating fungible biofuels for displacement of gasoline and diesel.

Policies and Legislation

Light-Duty Vehicles

The greatest change in light-duty transportation policy since President Obama was elected in 2008 has been increased funding and legislation to promote vehicle electrification. The current vehicle electrification efforts are focused primarily on full electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs). Research efforts on advanced combustion engines and advanced motor fuels continue at a substantial level; however, research into hydrogen fuel-cell vehicles is decreasing.

The use of ethanol may continue to expand in the following years, although it is not likely to result in expanded E85 use. Because of laws enacted in 2007 that require the use of 36 billion gallons' worth of renewable fuels by 2022, research and testing programs are being conducted by the U.S. government and private industry to assess routes that will dramatically expand ethanol use. The largest effort is an evaluation of the impacts of increasing the legal blend limit for non-FFVs from 10% ethanol to something higher, such as 15% or 20% (i.e., E15, E20). The ongoing program is focusing on issues including, but not limited to, emissions, durability, and infrastructure. The U.S. Department of Energy (DOE) committed significant additional resources to this program in 2009 and expects to continue funding it through 2011.

In May 2009, a newly formed ethanol trade group, Growth Energy, filed for a waiver submitted under section 211(f)(4) of the Clean Air Act. The U.S. Environmental Protection Agency (EPA) took initial action in October 2010. EPA granted a partial waiver for E15 for use in model year (MY) 2007 and newer light-duty motor vehicle. EPA took additional action in January 2011 and approved E15 for use in MY 2001 and newer light-duty vehicles. The partial waiver allows fuel and fuel additive manufacturers to introduce into commerce gasoline that contains greater than 10 volume percent ethanol and no more than 15 volume percent ethanol (E15) if certain conditions are fulfilled. Additional state and local legislation is necessary in the majority of the United States because of restrictions on ethanol blends greater than 10%.

Heavy-Duty Vehicles

The EPA and the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) have announced a first-ever program to reduce greenhouse gas (GHG) emissions and improve the fuel efficiency of medium- and heavy-duty vehicles, such as the largest pickup trucks and vans, semi trucks, and all types and sizes of work trucks and buses in between.

For purposes of the proposal, the heavy-duty fleet incorporates all on-road vehicles rated at a gross vehicle weight at or above 8,500 pounds and the engines that power them, except those covered by the current GHG emissions and Corporate Average Fuel Economy standards for model years 2012–2016. The current 2012–2016 standards cover some vehicles above 8,500 pounds. For example, this proposal excludes sport-utility vehicles, vans with less than a 13-person capacity, and ½-ton pickups.

The agencies are each proposing complementary standards under their respective authorities covering model years 2014–2018, which together would form a comprehensive HD National Program. EPA and NHTSA are proposing emissions standards for carbon dioxide (CO_2) and fuel consumption standards, respectively, tailored to each of three main regulatory categories: (1) combination tractors, (2) heavy-duty pickup trucks and vans, and (3) vocational vehicles. EPA is additionally proposing standards for air conditioning-related emissions of hydro-fluorocarbons from pickups, vans, and tractors; as well as dinitrogen oxide (N_2O) and CH_4 standards applicable to all heavy-duty engines, pickups, and vans.

Implementation: The Use of Advanced Motor Fuels

Figure 1 shows the relative number of different types of alternatively fueled vehicles in the United States through 2008. Vehicles capable of using E85 represent the largest share, followed by vehicles that use propane and compressed natural gas.

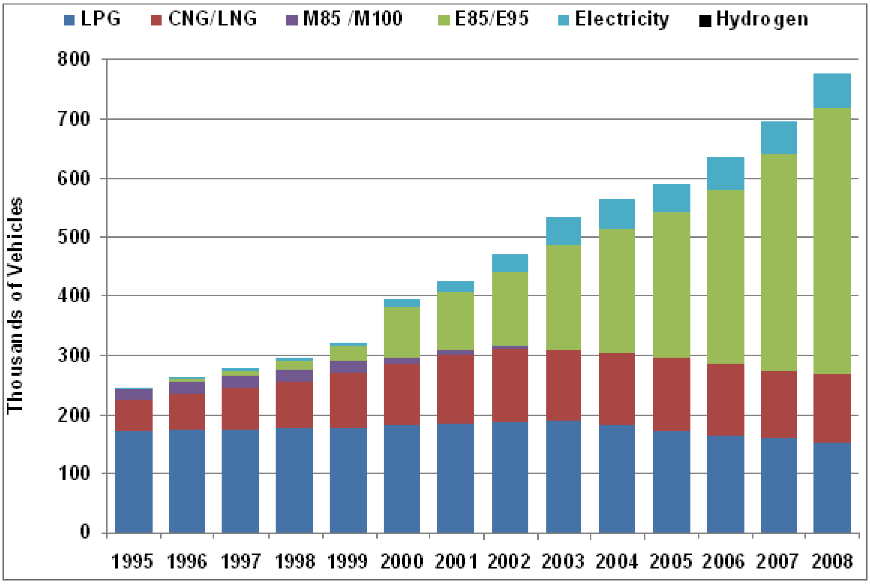


Fig. 1 Relative Numbers of Vehicles using Alternative Fuels, 1995 through 2008

Ethanol

Ethanol is the most common alternative fuel in the United States by a large margin, although the vast majority (>99%) of ethanol currently sold in the United States is in the form of gasoline blends containing up to 10% ethanol (E10). E10 is legal for sale and use in all regions of the United States as a direct replacement for gasoline. The use of ethanol in gasoline blended with 10% ethanol has increased drastically in the past five years, from approximately 3.5 billion gallons in 2004 to an estimated 13 billion gallons in 2010.[1] Blends containing up to 85% ethanol (E85) are only legal for sale in FFVs. On an energy content basis, ethanol currently displaces more than 6% of U.S. gasoline demand. Currently, more than 90% of the United States uses E10.

Although the vast majority of increased ethanol use in the United States has been attributable to the expansion of E10, E85 use continues to increase as have the number of available FFVs and fueling stations. There were approximately 8.35 million E85 FFVs in the U.S. light-duty fleet in 2010, although the number using E85 is significantly smaller. Chrysler, Ford, and General Motors each offered several FFV models in 2010. Mercedes, Nissan, and Toyota each offered one FFV engine package (2 vehicle models for Toyota and Nissan). In total, there were 34 different E85 FFV models for sale in 2010 as compared to 37 in 2009, 19 models in 2004, and just 2 models in 1998. In addition, there were 2,318 E85 stations as of December 2010 as compared to fewer than 200 stations in 2003.[2] Because of the increasing availability and use of E85, DOE commenced with nationwide E85 quality surveys in 2008 that were still ongoing in 2010. Also, because volumetric fuel consumption increases with ethanol as compared to gasoline, DOE conducted and recently concluded a research and development (R&D) program aimed at increasing engine efficiency when operating on ethanol. Funded research projects mainly exploited ethanol's octane, which is higher than that of gasoline, to improve engine thermal efficiency. Final reports from the projects are expected sometime in 2011.

In an effort to increase the use of ethanol, industry stakeholders have focused considerable attention on blender pumps, which are capable of dispensing any mixture between E0 and E85 (Figure 2), by splash blending the two fuels. Such pumps are marketed to consumers who want to use ethanol fuels but seek a greater driving range than can be attained with E85. Unsubstantiated claims of optimal blends for fuel efficiency occasionally accompany the marketing of such pumps, although research by the U.S. government shows fuel consumption to be proportional to the energy content of the fuel (i.e., it increases linearly with increasing ethanol content). Several ethanol trade organizations have announced plans to install up to 5,000 blender pumps in the coming years. The estimated number of blender pumps in current operation in the United States during 2010 was less than 250.[3] Such pumps are currently only legal for use in FFVs if the blends exceed 10% ethanol (E10) in MY 2000 and older vehicles and 15% ethanol (E15) for MY 2001 and newer vehicles. There is concern that consumers will intentionally "misfuel" conventional vehicles if the price of ethanol blends is lower than that of gasoline. Anecdotal evidence strongly suggests that a significant amount of deliberate misfueling of non-FFVs with >10% ethanol is occurring from blending pumps. The U.S. government does not have any active research activities into blender pumps. There are concerns with fuel quality and volatility characteristics of splash-blended fuels, and DOE does have a fuel sampling program currently active. DOE also maintains consumer education documents on ethanol blended fuels, which includes discussion of blender pumps.[4]

Fig. 2 Ethanol Pump

Biodiesel

Biodiesel production in the United States dropped from 678 million gallons in 2008 to 532 million gallons in 2009[2] resulting from a reduction in exports, which may, in turn, be attributable to anti-dumping tariffs imposed by the European Union in March 2009. Net exports fell from 362 million gallons in 2008 to 166 million gallons in 2009. Although domestic consumption has increased from approximately 26.9 million gallons per year in 2004[5] to 339 million gallons per year in 2009 according to the Alternative Fuels and Advanced Vehicles Data Center, it has been fairly flat for the past three years. Blends of up to 20% biodiesel (B20) are currently legal for sale in all regions of the United States, and 612 B20 fueling stations were available throughout the United States as of December 2010.[2] Blends containing up to 5% biodiesel can be marketed as regular diesel fuel instead of biodiesel and may use the existing infrastructure. An increasing number of B20 Original Equipment Manufacturer (OEM)-approved vehicles and engines are becoming available, thereby contributing to increased biodiesel use in the coming years. A notable example is the 2011 Ford F-Series pickup truck. Ford has dominated the light-duty diesel marketplace in the United States with nearly 46% of all diesel registrations, making the approval of B20 for the F-Series truck significant.

Algae-derived Fuels

In late 2009, DOE's Biomass Program commissioned a large research program for algae-derived fuels studying cultivation, oil extraction, conversion, and deployment. Uses of by-products from algae fuel production are also being investigated for other applications, such as biopower, to lessen the overall GHG impact. Algae-derived fuels are not currently available at commercial volumes in the United States.

Compressed Natural Gas (CNG)

CNG (methane) prices have dropped dramatically in the past few years as advanced recovery techniques, such as horizontal drilling combined with hydraulic fracturing, have become widespread. CNG continues to be one of the more common alternative fuels used in the United States, and its use for transportation has become more attractive as prices have dropped. In addition, the U.S. government has been actively promoting the use of natural gas (NG) in appropriate niche applications, such as urban mass transit. Nearly 20% of the transit bus fleet is currently CNG powered. The light-duty sector has not responded with as much enthusiasm to the use of CNG in passenger vehicles. The number of models available for sale from OEMs has dropped from 16 in 2004 to just 1 in 2010. Currently, the only CNG vehicle for sale in the United States through an OEM is the Honda Civic GX (which is sold packaged with a home-based refueling system). Even with the lack of available OEM vehicles, there were approximately 865 fueling stations available in the United States as of December 2010 and an estimated 113,973 CNG vehicles in service (Figure 3) in 2008.[2]

The U.S. government did not have any active research programs studying CNG in light-duty vehicles in 2009, but related gaseous fuel storage activities are being conducted by the DOE's Hydrogen Fuel Cell and Infrastructure Technologies Program. However, the DOE Vehicle Technologies Program committed to begin research activities for CNG in medium-duty applications in 2010 and issued a solicitation for research projects through its National Renewable Energy Laboratory (NREL). Final selection of the research projects is expected to be completed in 2011.

Fig. 3 CNG More Popular for Transportation Use

Liquefied Natural Gas (LNG)

While LNG does increase the volumetric energy density of methane compared to CNG, it is not commonly used or available in the United States for transportation use. There were only 40 fueling stations in the United States as of December 2010. LNG fueling stations are not publicly accessible, and 27 were concentrated in the State of California. There were 3,101 LNG vehicles in use in 2008.[2] Furthermore, the perception in most of the United States is that LNG is exclusively a fuel for fleets because of the safety issues and complexity involved in dispensing and using cryogenic liquid fuel. The U.S. government did not have any active R&D programs studying LNG as a replacement for petroleum fuels in 2010. DOE's Vehicle Technologies Program issued a solicitation for research projects through its NREL. Final selection of the research projects is expected to be completed in 2011and may include heavy-duty LNG engine development and vehicle platform integration.

Liquefied Petroleum Gas

Liquefied petroleum gas (LPG, i.e., propane) has the largest refueling infrastructure of all of the alternative fuels in the United States with 2,601 fueling stations as of December 2010, and it is one of the more common alternative fuels in use. A number of companies provide certified conversions for dedicated or bi-fuel use, and there were an estimated 151,049 vehicles in use (Figure 4) in 2008.[2] LPG is most commonly used in off-road and non-transportation applications, such as hi-lo lift trucks (forklift trucks) and agricultural equipment. Because of the maturity of the market, the United States government does not have active LPG-related R&D programs.

Fig. 4 Propane-Fueled Vehicle

Hydrogen

The U.S. government has a large research program studying hydrogen for the transportation sector; however, funding has been decreasing for the past several years. The work is primarily being done in DOE's Hydrogen Fuel Cell and Infrastructure Technologies Program. Research funding for hydrogen as a direct replacement for gasoline in internal combustion engines has been declining in recent years, and hydrogen is primarily expected to be used in fuel cells. Some research into the use of hydrogen in internal combustion engines continues, which could become a transition to the use of hydrogen in fuel cells. Hydrogen refueling stations are rare, with only 58 in the United States as of December 2010. Nineteen states have at least one hydrogen refueling facility (although most are not publicly accessible), with California having the most with 22 stations.[2] At present, hydrogen is still considered to be a fuel of the future to a greater extent as compared to other alternative fuels.

Other Fuels

Higher alcohols, such as butanol, are receiving more attention, and the U.S. government is studying them for their use as transportation fuels through several smaller research projects. The U.S. government also has several research programs studying Biomass to Liquids (BtL). Methanol is currently not under study by the U.S. government as a direct replacement for gasoline, but there are still research programs studying it for use in fuel cells. Worth mentioning but not widespread is use of hydro-treated waste fats for fuel use. While such fuels are eligible for tax credits and are being studied by several private companies, they are not currently being studied by the U.S. government. Dimethylether is another notable fuel without current government research projects but is of interest because of its compatibility with existing equipment.

Outlook

Trends in Research and Development

With the passage of the Energy Independence and Security Act (EISA) in December 2007, the United States has dramatically increased its renewable fuel targets. While EISA does not specifically call for ethanol to be the major renewable fuel to meet a 36 billion-gallon-per-year mandate by 2022, it is being pursued as the most likely choice. EISA also limits the renewable credits available for corn ethanol. This has raised the bar for research into advanced biofuels, such as cellulosic ethanol and algae-derived fuel, and the U.S. government has substantially increased funding in those areas in recent years. The FAME (fatty acid methyl ester) types for biodiesel use are also mandated by EISA, but biodiesel production capacity in the United States is significantly lower than ethanol capacity, and diesel is not expected to significantly replace gasoline as a transportation fuel for passenger vehicles. Another recent trend is that research into the various steps of biofuel production ranging from feedstock cultivation through end usage is becoming more tightly integrated. Various non-process oriented impacts are also becoming increasingly critical to strategic decisions, such as land usage changes and lifecycle GHG emissions.

Diesel is expected to remain the fuel of choice for over-the-road freight transport, and research into the effects of increasing biodiesel levels in heavy-duty vehicles is ongoing. Significant research projects for dramatically increased efficiency of heavy-duty applications, including engine efficiency improvements as well as trailer design, were begun in 2010 under the DOE Supertruck awards.[6]

Although the United States Congress introduced legislation for a cap and trade system of controlling carbon emissions, it was not passed into a law in 2009. Several states, most notably California, are in the process of passing their own legislation to limit GHGs, as well. Such proposed laws have sparked increased interest in consistent and accurate modeling of the GHG contribution of biofuels (well-to-wheel). This modeling has prompted the U.S. government, as well as many state governments, to expand research programs in preparation for such legislation becoming law.

Conclusion

The United States has significantly expanded its goals for renewable fuel use and is exploring several strategies to meet its aggressive targets, including the EPA's approval for use of E15 in the light-duty vehicle fleet. Expansion of the E85 market is still being aggressively pursued in two main areas: infrastructure expansion and engine efficiency improvements aimed to lessen the fuel economy penalty of ethanol. Blender pumps that can dispense ethanol fuel blends between E0 and E85 are being pursued by ethanol industry groups, but the U.S. government does not have any activities promoting their use. Along with efforts to expand ethanol usage, significant efforts are being made to derive ethanol from cellulosic sources. Hydrogen is still being pursued as a transportation fuel but is considered a longer-term solution to petroleum dependency and will be primarily used in fuel cells rather than internal combustion engines. Research into natural gas for transportation is expected to commence again in 2011 as NG is being considered for displacement of petroleum products in the medium-duty vehicle market as CNG and in the heavy-duty vehicle market as LNG. In addition, significant efforts were initiated in 2010 to research algae as a feedstock for biofuel production, including biodiesel and ethanol, and expanded programs are expected to continue throughout 2011.

Benefits of Participation in AMF

DOE's Vehicle Technologies Program is an active participant in the IA-AMF annex through the Fuels and Lubricants subprogram. The U.S. government benefits from participation through several means. One major benefit is the ability to leverage finances and technical expertise on research programs of mutual interest. U.S. government researchers also benefit from the ability to maintain contact with international experts and interact in research and policy discussions. Many of the countries participating in the AMF are facing the same fuel issues as the United States, and mutual cooperation has proven beneficial in the past and should continue to be so in the future.

Additional References

[1] Renewable Fuels Association, http://www.ethanolrfa.org/page/-/2011%20RFA%20Ethanol%20Industry%20Outlook.pdf?nocdn=1.

[2] DOE Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/.

[3] October 2010, Growth Energy, http://www.growthenergy.org/news-media-center/releases/growth-energy-blender-pumps-effort-by-usda-the-right-step-forward/.

[4] DOE Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/ethanol/index.html.
[5] EIA Short Term Energy Outlook supplement, table 5, April 1, 2009.
[6] Energy.gov, http://www.energy.gov/8506.htm.

The following may also be consulted for additional information:
Alternative Fuels & Advanced Vehicle Data Center, http://www.afdc.energy.gov.
Energy Information Administration, Annual Energy Outlook, http://www.eia.doe.gov/oiaf/ieo/index.html.
DOE Office of Vehicle Technologies, http://www1.eere.energy.gov/vehiclesandfuels/.
DOE Office of Biomass Program, http://www1.eere.energy.gov/biomass/.
EERE Info Center, http://www1.eere.energy.gov/informationcenter.
Bioenergy Feedstock Information Network, http://bioenergy.ornl.gov/.
Biomass R&D Initiative, http://www.biomass.govtools.us.

3 Ongoing AMF Annexes

3.a
Overview of Current Annexes

#	Annex	Title	Operating Agent
28	Annex XXVIII	Information Service & AMF Website (AMFI) and Fuel Information	Dina Bacovsky
34-2	Annex XXXIV-2	Algae as Feedstock for Biofuels	Ralph McGill
35-2	Annex XXXV-2	Particulate Measurements: Ethanol and Butanol in DISI Engines	Jean-Francois Gagné
37	Annex XXXVII	Fuel and Technology Alternatives for Buses	Nils-Olof Nylund
38	Annex XXXVIII	Environmental Impact of Biodiesel Vehicles	Susumu Sato
39-2	Annex XXXIX-2	Emission Performance of HD Methane Engines Phase 2	Olle Hadell
40	Annex XL	Life Cycle Analysis of Transportation Fuel Pathways	Peter Reilly-Roe
41	Annex XLI	Alternative Fuels for Marine Applications	Ralph McGill
42	Annex XLII	Toxicity of Exhaust Gases and Particles from IC-Engines	Jan Czerwinski
43	Annex XLIII	Performance Evaluation of Passenger Car, Fuel, and Powerplant Options	Jukka Nuottimäki

3.b
Annex XXVIII: Information Service & AMF Website

Operating Agent	BIOENERGY 2020+ as of 1.1.2011; VTT Technical Research Centre Finland in 2010
Started	January 28, 2004 (ExCo 29)
Project Duration	Continuous
Participants	All contracting parties: Australia, Austria, Canada, China, Denmark, Finland, France, Germany, Italy, Japan (AIST), Japan (LEVO), Spain, Sweden, Switzerland, Thailand, USA
Total Budget	€35,000 for 2010
Responsible	Dina Bacovsky BIOENERGY 2020+ Gewerbepark Haag 3 3250 Wieselburg-Land, Austria Phone: +43 7416 52238 35 Fax: +43 7416 52238 99 E-mail: dina.bacovsky@bioenergy2020.eu

Background

The International Energy Agency (IEA) Advanced Motor Fuels (AMF) Agreement has been running an Information Service called IEA AMF/AFIS (Automotive Fuels Information Service) under two previous annexes, Annex IX and Annex XXIV. Annex IX produced, among other things, five volumes of the "Automotive Fuels Survey" for AMF. In 2000–2004, Annex XXIV produced three yearly newsletters on the subject of automotive fuels and related issues. Both annexes were handled by Innas BV of Holland. Since 1999, VTT Technical Research Centre of Finland has been maintaining a Web site for AMF.

AFIS was replaced in 2004 by a new information system, AMFI (Advanced Motor Fuels Information, Annex XXVIII), which combines an electronic newsletter service and maintaining the AMF web site. TEC TransEnergy Consulting Ltd. (Finland) was Operating Agent from 2004 to 2009. VTT Technical Research Centre of Finland was Operating Agent for 2010. BIOENERGY 2020+ GmbH of Austria was designated as Operating Agent of Annex XXVIII starting in 2011.

Annex XXVIII has two subtasks:
Subtask 1: Fuel Standardization was active in 2007 and is closed.
Subtask 2: Fuel Information System is active since 2010 and is ongoing.

The information service shall provide information on transport fuels and related issues and on the IEA.

The AMF implementing agreement is discussed below.

Purpose and Objectives

Sharing and providing information are very important elements in IEA cooperation. The AMFI information system makes use of electronic communication. AMFI activities include production of four yearly electronic newsletters and maintenance of the AMF web site.

AMFI/Annex XXVIII is a low-budget annex, and its costs are shared by all participants in the AMF Implementing Agreement.

Activities

Relevant sources of news regarding advanced motor fuels, vehicles, energy, and environmental issues in general are reviewed. News articles are provided by experts in North America, Asia, and Europe.

Four electronic newsletters are published yearly (on average) at the AMF Web site using an e-mail alert system to disseminate information on the latest issues.

In 2010, work on the new Alternative Fuels Information System was started. This effort seeks to collate relevant information on alternative fuels and their use for transport. The results of AMF annexes shall be presented and ordered by type of fuel. Efforts are being made in close cooperation with, for example, the United States' Alternative Fuels and Advanced Vehicles Data Center, to build a guidebook on advanced motor fuels that will be accessible electronically on the AMF web site.

The AMF web site is updated frequently to provide information on transportation fuel-related issues, especially those related to the work of the Implementing Agreement of Advanced Motor Fuels. In addition to public information, a special password-protected area is provided to distribute and store internal information for delegates, alternates, and operating agents on, for example, strategy, proposals, decisions, and Executive Committee (ExCo) meetings of the AMF Agreement.

Results and Reports/Deliverables

In 2010, four electronic newsletters were published in January, April, July, and October, respectively.

The Alternative Fuels Information System, through which users can obtain general fuel information for gasoline replacements and for ethanol use as E10, has been completed.

The AMF Web site has been updated frequently with information from annexes and ExCo meetings.

Time Schedule and Future Plans

In 2011, four more electronic newsletters will be published.

The Alternative Fuels Information System is scheduled to be completed by December 2011 and moved to the public area of the AMF Web site. The AMF Web site will continue to be updated frequently.

3.c
Annex XXXIV: Biomass-Derived Diesel Fuels Sub-task 2: Algae as a Feedstock for Biofuels

Operating Agent	Sentech, Inc.
Started	September 2009
Project Duration	9/09 – 12/10
Participants	United States, Canada, Finland, and Japan (LEVO)
Total Budget	€150,000
Responsible	Dr. Ralph McGill Fuels, Engines, and Emissions Consulting 305 Sugarwood Drive Knoxville, Tennessee, 37934, USA Phone: +1 (865) 207 9137 Fax: +1 (865) 675-2866 E-mail: rnmcgill@chartertn.net

Background

There has been a recent worldwide reemergence of interest in pursuing research and development (R&D) of algae as a feedstock for biofuels, and many R&D initiatives are under way around the world as researchers, governments, and policy makers become aware of the considerable potential that algae possess. It can be expected that these various initiatives will take a number of different approaches as researchers search for answers to the challenges that algae-derived fuels face. Some pathways will be deemed unsuccessful for large-scale production, whereas others will produce high-quality results. It is important at this point to take inventory and assess the many various activities and also to try to develop recommendations about the most promising pathways to success in producing large quantities of transportation fuels from algae, which may help policy makers reach wise decisions about which areas of effort to support.

Purpose and Objectives

The project team has been tasked with conducting a study that assesses the state of the technology and opportunities associated with algal fuels. Since the International Energy Agency-Advanced Motor Fuels (IEA-AMF) focuses on end-use fuels, the focal point of this report will be on the downstream activities (e.g., dewatering, oil/biomass extraction, and conversion of algae and algal components to energy products). However, limited investigation of upstream activities (e.g., strain selection, cultivation) was also conducted to help identify promising lifecycle pathways.

Activities

This study was broken down into six primary phases:

- Literature Review/Data Collection. Considerable time was spent gathering information on the major components of the algae-to-biofuels production process, ranging from algae strain selection to end-use fuel conversion techniques. Some of this information was gathered from attending the "Algae Commercialization, Research, and Business Networking Forum," which took place in Houston, Texas, in the United States.
- Industry Mapping. Once all of the major components of the algae-to-biofuels production process were established, the project team identified all major players worldwide that conduct activities within each market segment.
- Market Feasibility Assessment. A feasibility assessment was conducted on algal biofuels as part of this study that addressed production capacity, total energy balance, total greenhouse gas emissions, competition with food supply, biodiversity and ecosystems, production cost, and adaptability among markets.
- Collection and Analysis of National Research Council (NRC) Canada Data. For a Special Focus portion of the report, the project team chose to investigate how oil properties from different species may affect the properties of end-use algal biofuels. In July 2010, a team member visited researchers at NRC Canada's research facilities in Halifax, Nova Scotia, to learn about the testing procedures it uses to characterize the oil extracted from various algal strains. This visit initiated exchange of oil property data that was analyzed and documented in the final report.
- Report Preparation. All industry information, assessments, and results were compiled into a draft report, which was completed and delivered in December 2010.
- Presentation of Results. Preliminary results of this study have been shared at the 40th AMF Executive Committee Meeting. To date, results from this study have not been published in any journals or newsletters. However, the committee has chosen this report to be published in book format.

Results and Reports/Deliverables

The information presented in this study strongly supports that algae have potential as a feedstock for biofuels. Depending on their composition, different algae species may be suitable for a range of biofuels. For example, lipids in microalgae may be a source for production of biodiesel and other oil-based transportation fuels. Macroalgae (seaweeds) may be fermented to produce ethanol, or anaerobically digested to create methane. In these processes, algae take up carbon dioxide (CO_2) from the atmosphere during their growth, and the same amount of CO_2 is released when the biofuel is used in vehicles. Other microalgae and cyanobacteria are able to produce hydrogen in a process called biophotolysis where the algae are not consumed. All options show the potential for closed CO_2 cycles, excluding the fossil energy consumed in the total (well-to-wheel) fuel chain. Another advantage of these fuels is their compatibility with existing vehicles. For instance:

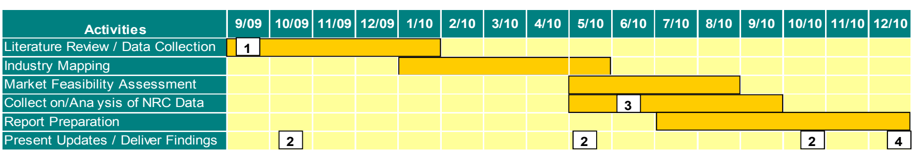
- Biodiesel can be used in diesel vehicles;
- Ethanol can be blended with gasoline (to an extent) for use in internal combustion engine (ICE) vehicles;
- Methane can be used in compressed natural gas (CNG) vehicles;
- Renewable gasoline, diesel, and jet fuel can fuel traditional ICE vehicles, diesel vehicles, and jets, respectively; and
- Hydrogen can be used in fuel cell vehicles or hydrogen ICE vehicles.

In addition, rates of algal biomass productivity per hectare can be more than ten times higher than are rates for terrestrial energy crops. Last but not least, algae can be cultivated at sea or on nonarable land, so there is no competition with current food production.

The final draft report, entitled *Algae as a Feedstock for Biofuels: An Assessment of the State of the Technology and Opportunities,* was completed and delivered to the contributing member countries in December 2010. Feedback was received and incorporated in January 2011, and the report is now being prepared for publication.

Time Schedule

Below is a breakdown of this project schedule by activity.



Milestones / Deliverables

National Algae Association Conf.	1
Project Updates at ExCo Meetings	2
Visit to NRC Canada Facilities	3
Draft Report Delivered	4

Note: NRC = Natural Resources Canada

Future Plans

Currently, three items are being considered for follow-on work as a result of this study.

The Committee has selected this report to be published in book form. The draft has been sent to Argonne National Laboratory (Argonne) in the United States where the editing/publishing process is to occur.

Additional in-depth analysis of end-use fuel property characteristics using data on NRC Canada's algal oil data may be conducted. The analysis documented in the draft report was limited by the equipment available at NRC facilities during the study period; however, more advanced equipment has since been installed and is available for use.

Industry information collected during the literature review portion of this study may be used to help populate a database on worldwide biorefineries. The goal of this database is to boost transparency in the emerging algae sector, and it would be updated on an annual basis. Specific tasks may include the following:

- Constructing the database and bringing it online;
- Collecting and inserting information into database; and
- Contacting research institutions and companies with the information to verify data, send more information, and agree to publish.

3.d
Annex XXXV: Ethanol as Motor Fuel
Sub-task 2: Particulate Measurements: Ethanol and Butanol in DISI Engines

Operating Agent	Technical University of Denmark (DTU)
Started	November 2010 (ExCo 40)
Project Duration	TBD
Participants	Canada, China, Denmark, Finland, Germany, United States
Total Budget	Task shared (estimated at $45,000 [USD] per participating country)
Responsible	Jean-Francois Gagné Natural Resources Canada Ottawa, Canada K1A 0E4 Phone: +1 (613) 947-1963 E-mail: jegagne@NRCan.gc.ca

Background

As renewable fuel mandates are enacted in North America and as fuel economy standards become more demanding, there is a need to better understand the synergies between the proposed fuels that meet cleaner domestic renewable energy production goals and the technologies that allow better fuel economy to ensure that the interactions between these solutions do not produce undesirable effects. As an example, the use of ethanol in gasoline has increased dramatically in a number of countries, such as in the United States, where ethanol use has expanded six-fold since the year 2000. Market growth is expected to continue for at least the next decade.

Globally, vehicle manufacturers are pursuing a number of ways to improve engine efficiency. Two notable strategies include downsizing engines and using direct injection (DI) with turbocharged spark ignition (SI) engines. Emissions of particulate matter (PM) are not currently a problem in gasoline engines, but PM emissions regulations are becoming more stringent. Plus, the particle number concentrations in DISI engines have been shown to be greater than that for port fuel-injected gasoline engines and greater than that for compression-ignition engines with diesel particulate filters.

Purpose and Objectives

Because of such factors as the increasing use of ethanol, the growing number of DISI engines available from vehicle manufacturers, and the impact on the design and effectiveness of aftertreatment systems, there is a need to understand particulate formation resulting from the interactions of ethanol-gasoline blends in DISI engines. Initial research has shown that low-level ethanol blends reduce PM formation; however, further confirmation is needed. Particulate formation is basically unknown in the cases of butanol blends. This subtask to Annex XXXV is designed to shed light on these issues.

Project Scope

The project involves comparing direct injection of ethanol-blended fuels to direct injection of gasoline-injected fuels. It is proposed to perform steady-state engine dynamometer tests with a common gasoline DI engine and compare emissions, power, and fuel economy. It is suspected that ethanol may have a larger advantage for brake-specific power because of the high octane of the fuel and increased in-cylinder cooling of the intake air charge.

Studying transient operation and simulated drive cycles is not considered practical for the scope of this project because of the complexity and effort involved in engine calibration. Total hydrocarbons will be measured via a flame ionization detection method in lieu of speciated hydrocarbon measurements to limit the overall program cost. Dual-fuel operation with split injection is not considered part of the scope of the project. An optional, but desired, component would be to use the same engine converted to port fuel injection to perform the same tests.

Activities to Date

The U.S. portion of the project builds on an existing project at Argonne National Laboratory (Argonne) using a General Motors 2.2-liter, inline 4-cylinder, 16-valve DISI engine and involving the following test matrix:

- Engine conditions
  - Idling speed
  - 2,000 rotations per minute (rpm) and three different engine loads (25%, 50%, 75%)
- Fuels
  - Baseline certification fuel
  - E10
  - E85
  - BU16

- Particulate measurement
  - Size and number
  - Morphology
    - Primary and aggregate particle size
    - Fractal geometry

Particulate matter mass, size distribution, and morphology (aerodynamic diameter, fractal geometry, etc.) are being measured and correlated to engine speed, load, and fuel.

Continuing Activities

The results from the Argonne project will be compared to results from other laboratories.

Environment Canada – Emissions Research and Measurement Section will conduct chassis dynamometer tests on a model year 2011 light-duty vehicle with a 2.4-liter DISI engine meeting Tier 2 Bin 5 North American Emissions standards. Tests will be performed with baseline certification fuel and E10. Transient tests along with steady states will be conducted. The transient emissions results will be used as baseline tests that can be replicated in European test cells with European models. The steady-state tests will be used to compare the differences in gaseous and particulate emission rates between the baseline fuel and E10, with the emission changes noted with the engine tests performed at Argonne.

For calendar year 2012, Environment Canada will investigate the option of emissions testing of a 2.4-liter DISI engine with ethanol blends.

Results

Work on this subtask is just getting under way. Engine test results should become available over the course of this calendar year.

3.e
Annex XXXVI: Measurement Technologies for Hydrocarbons, Ethanol, and Aldehyde Emissions from Ethanol-Powered Vehicles

Operating Agent	Swedish Transport Administration (STA), Sweden
Started	Started 2007-11-15 (ExCo 34, Decision #5)
Project Duration	November 2007 – May 2010 (2.5 years)
Participants	Canada, Finland, Sweden, and United States (four countries)
Total Budget	Total cost of €150,000 + contributions from industry
Responsible	Mr. Olle Hådell Swedish Transport Administration (STA) SE-781 87 Borlänge Phone: +46 243 753 98 Mobile: +46 70 372 43 93 Fax: +46 243 757 26 E-mail: olof.hadell@trafikverket.se
Assistant	Mr. Lennart Erlandsson, AVL MTC, Sweden

Background

In recent years, hydrocarbon, aldehyde, and alcohol tailpipe emissions from flexible fuel vehicles (FFVs) fueled by alcohols have received increased attention in Europe together with an increased and expanding interest in alternative fuels for vehicle propulsion.

Because alcohol fuel blends have different fuel properties as compared to conventional fuels (such as gasoline/diesel), it is important to study factors that affect the reproducibility and repeatability of the hydrocarbon (HC) measurements from such vehicles.

Aldehyde and alcohol tailpipe emission measurements need to be further evaluated (i.e., by comparing different measurement methods).

Objectives

The aim of the project is to provide crucial information for developing the methodology for measuring HC, aldehyde, and alcohol tailpipe emissions from ethanol-powered vehicles. The project also aims to find a simplified method by using today's advanced measurement technology that can account for differences in harmfulness between exhausts from gasoline and ethanol-powered vehicles.

Content of Work

The project is divided into three different tasks:

Task 1: Fact finding (literature and interviews)

Regulation (including European Union [EU])
Measurement specification (level, sensitivity, cost indication, time, etc.)
Lab experience
Question area

Task 2: Measurement and correlation study of HC and ethanol

- Flame ionization detector (FID) measurement of ethanol, propane calibration gases with different concentrations, and oxygen content in carrying gas.
- Measurement of ethanol and propane calibration gases in bags with different waiting times.
- Use of different type of FID and individuals for measuring ethanol, propane calibration gases.
- Use of FID at different sampling and detector temperatures for measuring ethanol, propane calibration gases.
- Comparison of MS (mass spectroscopy), photo acoustic, and Fourier transform infrared radiation (FTIR) for measuring ethanol calibration gas.
- Bomb test of ethanol and propane in a constant volume sampling (CVS) system.
- Measurement of an unknown gas bottle with ethanol and propane mixture in different labs.
- Analysis of ethanol solutions at different labs.

Task 3: Vehicle tests

- Emissions tests at different temperatures (22°C, −7°C, −15°C).
- Emissions tests with different CVS flow.
- Federal Test Procedure tests and New European Driving Cycle tests.
- Emissions tests with different fuels.
- Comparison of FTIR with MS for ethanol measurement.
- Comparison of photoacoustic with MS for ethanol measurement.
- Comparison of two MS tests for ethanol measurement.
- Comparison of FTIR and cartridge for aldehyde measurement.
- Comparison of different cartridge setup and sampling flow rate for aldehyde measurement.

The tasks were performed at different test laboratories. Some tasks were combined and performed simultaneously.

Financial Status

The financing of the project is arranged according to the initial plan. Participating countries have fulfilled their obligations. Input from the vehicle industry has not been as forthcoming as expected because of the turbulence in the automotive business. The output of the project is in line with the originally approved project plan.

Results and Reports

A draft report was presented November 2009, and comments were received from Annex participants. A final report was presented on the Public Domain of the International Energy Agency-Advanced Motor Fuels (IEA-AMF) Web site in April 2010.

The results of the Annex have been published further in a Society of Automotive Engineers (SAE) report (2010-01-1557) and presented at the SAE International Powertrains, Fuels, and Lubricants meeting in May 2010.

In addition, the European Union Directorate General (DG) for Enterprise (DG Enterprise) has been informed about the results of the Annex and has commissioned DG Joint Research Center to further investigate:

- Specification for “E85 Winter Quality” reference fuel,
- Method for calculation of total hydrocarbon (THC) for FFV vehicles,
- Possibility of introducing requirements for Type 6 test (−7°C), and
- Suitability for introduction of new requirements for evaporative emissions.

The Annex participants decided to close the Annex.

3.f
Annex XXXVII: Fuels and Technology Alternatives for Buses

Operating Agent	VTT Technical Research Centre of Finland
Started	May 2008 (ExCo 35)
Project Duration	June 2008 – November 2011 (3 years, modified)
Participants	AMF: Canada, Finland, France, Japan, Sweden, Thailand, United States Bioenergy: European Commission, Finland, Germany HEV: Switzerland
Total Budget	€1.2 million
Responsible	Dr. Nils-Olof Nylund VTT Technical Research Centre of Finland P.O.Box 1000 FIN-02044 VTT, Finland Phone: +358 20 722 5518 Mobile: +358 400 703 715 Fax: +358 20 722 7048 E-mail: nils-olof.nylund@vtt.fi

Background

Buses are the backbone of many public transport systems around the world. Until now, the baseline bus in most parts of the world has been a diesel-powered 12-meter or 40-foot-long bus. Now the spectrum of technology options for buses is increasing, both regarding vehicle technology (advanced diesel technology, hybridization, lightweight designs, etc.) and fuels (sulphur-free diesel, biofuels, synthetic fuels, gaseous fuels, etc.). Some manufacturers are already offering hybrid buses, while others are just in the phase of launching hybrids. The procurement or delivery of bus services is often handled by municipalities or states in a centralized manner. As the service life of buses is as long as 20 years, solid data are needed on the performance of the new technologies.

Purpose and Objectives

The objective of the project is to bring together the expertise of International Energy Agency's (IEA's) transport-related implementing agreements (seven in all) to generate information on the overall energy efficiency, emissions, and costs of various technology options for buses. Here technology options cover variations in engine technology, power train technology (including hybridization), and fuels.

The outcome of the task will be to produce unbiased and solid IEA-sanctioned data for policy- and decision-makers responsible for public transport using buses.

Three of the Implementing Agreements — Advanced Motor Fuels, Bioenergy, and Hybrid and Electric Vehicles — contribute with actual funding to the project. All transport-related Implementing Agreements are expected to contribute by producing condensed technology outlooks for their respective technologies.

Activities

The project encompasses a combination of desk studies and actual measurements on conventional and new types of buses. Thus the project is divided into two main parts, WTT (well-to-tank) fuel pathway analysis and TTW (tank-to-wheel) vehicle performance. For the well-to-tank studies, experts at Argonne National Laboratory (Argonne), Natural Resources Canada (NRCan), and VTT Technical Research Centre of Finland are cooperating to evaluate and filter data for the chosen fuel alternatives.

Environment Canada (EC) and VTT are carrying out chassis dynamometer emissions testing on buses to establish TTW performance. The testing is carried out using dynamic driving cycles representative for buses. EC covers North American vehicle technology and VTT European vehicle technology. In addition, there are two supplementary experimental activities. The consulting company AVL MTC of Sweden has conducted on-board emissions measurements on buses. von Thünen Institute in Germany has carried out detailed analysis of fuel effects on emissions, including unregulated emission components, by using a test engine installed in an engine dynamometer.

The WTT data and the TTW for the various fuel/powertrain combinations will be combined into overall well-to-wheel (WTW) data. The French energy agency ADEME (Agency for Environment and Energy Management) is responsible for cost assessments of the alternative pathways and will address both direct as well as indirect (environmental) costs.

The work on fuel pathways, as well as the vehicle measurements, are approaching completion. Analysis of the total WTW pathways (as well as costs) has commenced.

Results

Fuel Pathways

For the WTT analysis, three different methodologies were applied: the GREET model (developed by Argonne National Laboratory), the GHGenius model (developed by Natural Resources Canada), and the methodology presented in the European Union Renewable Energy Directive 2009/28/EC (developed by VTT). The simulation results using the GREET model and the values according to the European Union Renewable Energy Directive (RED) are already available. A description of these two methodologies has been written. Both the GREET model the RED methodology yield results for greenhouse gas emissions, and in addition, the GREET model also accounts for six criteria pollutants. The work based on use of the GHGenius model is in the final phase.

A description of the general principles of the WTT analysis based on life cycle assessment (LCA) has been written, in which the GREET and the GHGenius models and the European Union RED methodology are compared to each other, with an emphasis on highlighting the most important differences between these calculation methods. Some challenges and open questions related to the WTT assessment of biofuels (e.g., indirect land use change issues) also are addressed in the text. To provide some perspective regarding the uncertainty and the variation of the WTT results, a literature review of 25 LCA studies of 14 different biofuel chains has been conducted. This review shows significant variations in the WTT results.

Vehicle and Engine Testing

Both EC and VTT have carried out a significant number of vehicle tests. The variables include the following:

- Type of drive train (conventional vs. hybrid).
- Emissions certification class (three sets of regulations for North America as well as Europe, from the late 1990s to current emissions regulations).
- Diesel vehicles and alternative fuel vehicles (natural gas, ethanol, dimethylether [DME]).
- Alternative diesel fuels (conventional diesel fuel, various biofuel options and synthetic fuels from natural gas and oil sands).
- Test cycle (North American, European, and Japanese test cycles).

So far, EC has tested six vehicle platforms: four conventional diesel vehicles and two diesel hybrids. The fuel matrix comprises 13 different fuels (including ultra-low sulphur diesel, oilsands-derived diesel fuel, canola methyl ester, soy methyl ester, tallow/waste fry oil methyl ester, and hydrotreated vegetable oil [HVO]). More than 60 vehicle/fuel/test cycle combinations have been run.

VTT has tested nine vehicles: four conventional diesel vehicles, two diesel hybrids, and three alternative fuel vehicles (natural gas, ethanol, DME). The DME vehicle was a prototype truck that was simulated as a bus on the chassis dynamometer. At VTT, the full diesel fuel test matrix covers 11 different fuels (including ultra-low sulphur diesel, gas-to-liquid [GTL], rapeseed methyl ester, Jatropha methyl ester, and hydrotreated vegetable oil). Some 100 combinations have been tested already. Figures 1 (fuel consumption) and 2 (particulate emission) show the spread in performance for European vehicles.

von Thünen Institute carried out an in-depth emissions analysis using a Euro III certified heavy-duty diesel engine. The test fuels were diesel, 100% rapeseed methyl ester, 100% Jatropha methyl ester, and 100% HVO. Among otherobjectives, particulate mutagenicity was analyzed.

Time Schedule

All testing will be completed by June 2011. A final report is scheduled for November 2011.

Future Plans

The work on fuel pathways within the bus project gave a launching point for the new Advanced Motor Fuel (AMF) activity on life cycle analysis, Annex XL (40), “LCA of Transportation Fuel Pathways.” In addition, the WTT data of the bus project will be used in another AMF activity, Annex XLIII (43), “Performance Evaluation of Passenger Car Fuel and Powerplant Options.”

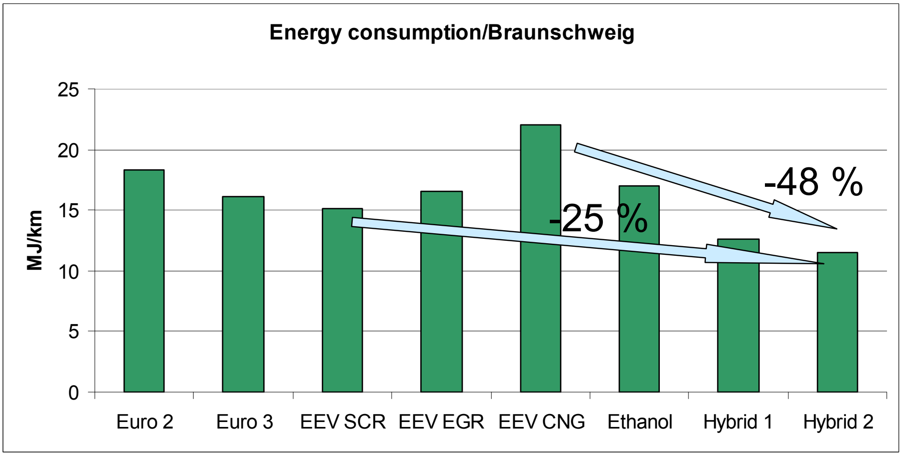


Fig. 1 The Energy Consumption of Different European Buses (Braunschweig bus cycle)

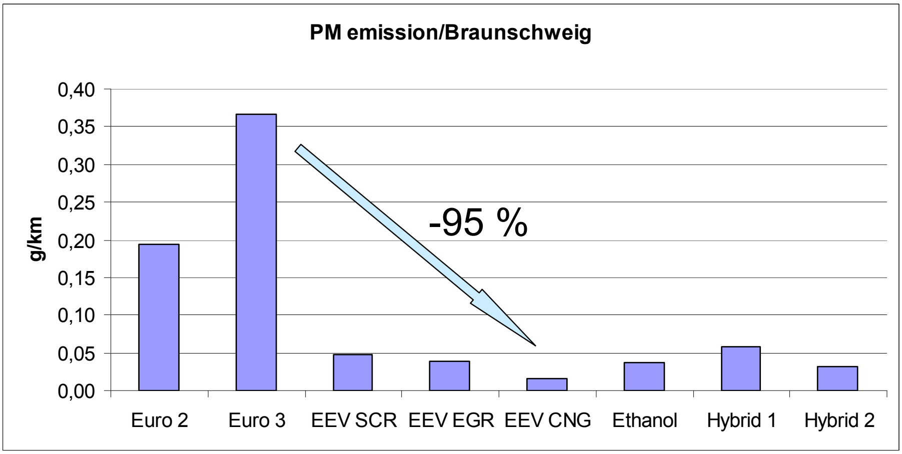


Fig. 2 The Particulate Emissions of Different European Buses (Braunschweig bus cycle)

3.g
Annex XXXVIII: Environmental Impact of Biodiesel Vehicles

Operating Agent	National Traffic Safety and Environment Laboratory (NTSEL), Japan
Started	May 28, 2009
Project Duration	June 2009 – May 2011 (2 years)
Participants	Finland, Japan (LEVO), Sweden, Thailand, and the United States (five confirmed participants)
Total Budget	US $170,000 (€118,830) confirmed plus US $30,000 (€20,970) pending
Responsible	Susumu Sato, Ph.D. Environment Research Department National Traffic Safety and Environment Laboratory (NTSEL) 7-42-27 Jindaiji-higashimachi, Chofu, Tokyo, 182-0012, Japan Phone: +81-422-41-3220 Fax: +81-422-76-8604 E-mail: su-sato@ntsel.go.jp

Background

From the standpoint of seeking to lower greenhouse gas (GHG) emissions and pursue "carbon-neutral" strategies, biodiesel fuel (BDF) is receiving attention because of its potential to contribute significantly to environmental protection on a global basis. As a result of this potential, efforts to promote the production and use of BDF have proceeded all over the world.

On the other hand, the diesel vehicles adapted to the latest emissions regulations have the most recent elemental technologies and the precise electronic control of these technologies to reduce exhaust emissions. However, these technologies have been optimized for vehicles fueled with light oil. Therefore, when the latest diesel vehicles are fueled with BDF, whose properties are much different from those of light oil, emissions characteristics will grow worse.

Thus, the promotion of BDF is highly effective for the reduction of GHG emissions and recycling; at the same time, the possibility of affecting the atmospheric environment is of concern. To address these sources of concern that inhibit BDF promotion, the emissions characteristics of the latest vehicles fueled with BDF must be researched.

Purpose and Objectives

In Japan in Kyoto City, for example, route buses and refuse trucks fueled with "neat" waste cooking oil BDF are running. Because use of BDF vehicles has progressed in many countries, it is thus important to determine not only the emissions levels in type approval mode testing but also the real-world emissions.

In this research, the on-road driving test using PEMS (Portable Emission Measurement System) will be conducted on new diesel vehicles adapted to the latest emissions regulations, of which the emissions level is equivalent to EURO V. For the test, these diesel vehicles are applied to BDF without special customization, and this study aimed to clarify the real-world emissions between the case of light oil and that of BDF, which includes first-generation and second-generation fuels.

In addition, the Japanese heavy-duty diesel vehicles that are adapted to the latest emissions regulations are also adapted to the fuel economy standards of heavy-duty vehicles — which Japan (as a pioneer) introduced. Given that an effect of BDF on fuel economy as well as on emissions levels cannot be ignored, the real-world fuel economy will be estimated.

Activities

(a) Main Activities

Main activities included the following:

- Procuring BDF Neste oil in Finland, which provided in-kind second-generation BDF, NExBTL for this study.
- Conducting chassis dynamometer tests (light oil, first- and second-generation BDF).
- Carrying out real-world driving tests for emissions and fuel economy measurements (light oil, first- and second-generation BDF).
- Performing real-world driving tests under the cold start condition.

(b) Participants and/or Experts' Meetings

Participants in this annex are the National Traffic Safety and Environment Laboratory (NTSEL) and Organization for the Promotion of Low Emission Vehicles (LEVO). NTSEL and LEVO will have meetings to confirm the progress situation of this annex.

Results and Reports/Deliverables

Among results of the study, the chassis dynamometer tests of light oil and first- and second-generation BDF have been performed (Figure 1). In the case of the first-generation BDF (waste cooking oil BDF), NO_x emissions increased with the rise in the mixing ratio of BDF. On the other hand, second-generation BDF (HVO, NExBTL of Neste Oil) did not worsen NO_x emissions. Figure 2 shows the emissions test results of the JE05 driving cycle with second-generation BDF. Table 1 shows the schedule of tests performed from June 2009 through May 2011.

The nitrogen oxide (NO_x) emissions characteristics of real-world driving tests were the same as those of the chassis dynamometer tests. In other words, first-generation BDF raised NO_x emissions, whereas second-generation BDF did *not* in the real-world tests.

Fig. 1 Chassis Dynamometer Test

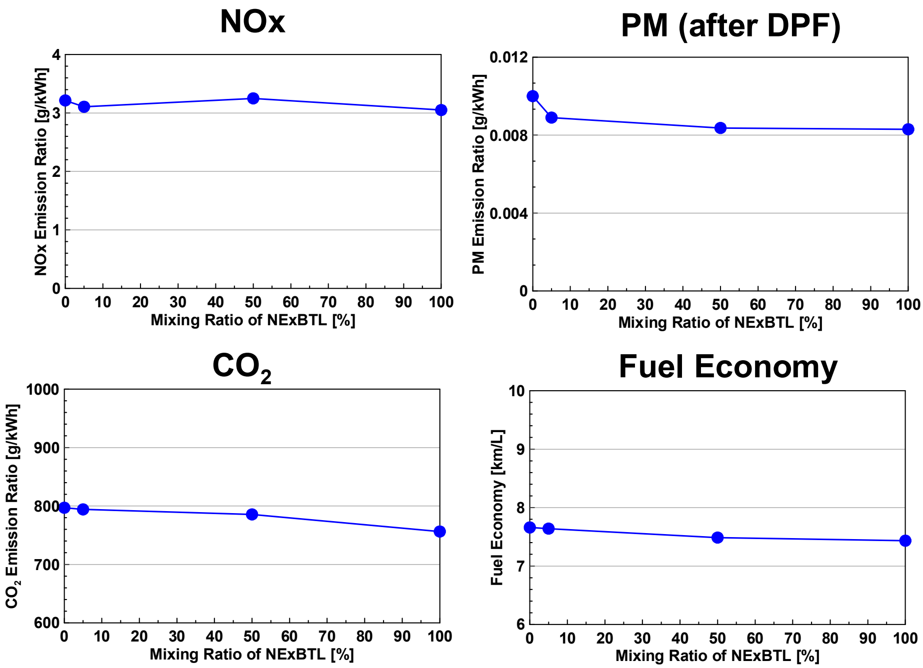


Fig. 2 Emissions Test Results of the JE05 Driving Cycle with Second-Generation BDF

Table 1 Time Schedule, June 2009–May 2011.

Year	2009							2010						
Month	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Light oil chassis dynamo tes														
1st generation BDF chassis dynamo test														
Transport of 2nd generation BDF (from Finland to Japan)														
2nd generation BDF chassis dynamo test														
Real-world emission test setup														
Light oil real-world driving test (hot)														
Light oil real-world eco-driving test (hot)														

Year	2010								2011				
Month	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Light oil real-world driving test (hot)													
Light oil real-world eco-driving test (hot)													
1st generation BDF real-world driving test (hot)													
1st generation BDF real-world eco-driving test (hot)													
2nd generation BDF real-world driving test (hot)													
2nd generation BDF real-world eco-driving test (hot)													
2nd generation BDF real-world driving test (cold)													
Preparation of the final report													○

3.h
Annex XXXIX: Enhanced Emission Performance of HD Methane Engines (phase 2)

Operating Agent	Swedish Transport Administration
Started	November 2010
Project Duration	November 2010 until July 2012
Participants	Canada, Denmark, Finland, Germany, Japan, Sweden
Total Budget	€240,000
Responsible	Olle Hådell Senior Advisor Swedish Transport Administration Röda Vägen 1 S-781 89 Sweden E-mail: olof.hadell@trafikverket.se Tel: +46 243 753 98

Background

Climate change and a shortage of crude oil are real threats. Because of these threats, the use of fossil fuels has to be reduced to a fraction of the volumes consumed today. To achieve that level of reduction in road transport, vehicles need to become much more efficient, and renewable energy must be commercialized.

Thanks to European Union efficiency legislation concerning light-duty vehicles (LDVs), ordinary cars are now rapidly becoming more fuel efficient. Cars in the small- and medium-class sizes will be equipped with direct-injected gasoline engines, and larger cars will be driven by rather small turbocharged diesel engines. Some manufacturers are launching plug-in hybrids, with batteries that can be charged from the grid. This ongoing development will result in a lowering need for gasoline and a growing demand for diesel oil, especially for heavy-duty vehicles (HDVs). Jet fuels depend on the same components as diesel, and, furthermore, heavy oils in marine applications will probably be substituted out for lighter fractions. The existing imbalance today between petrol and diesel in refineries will increase. Substitutes for fossil diesel oil are crucial. The shortage of diesel oil is perhaps the most significant near-term threat to the energy supply for road transportation.

Two optional routes offer viable solutions. One route is to substitute crude oil–based diesel oil with a synthetic fuel as Fischer-Tropsch diesel or HVOs (hydrotreated vegetable oils). Another route is to modify the heavy, still compression-ignited engine to enable use of other fuels. Biomethane can be such a fuel. Methane fuel is used on a global basis, which is a prerequisite for manufacturers to pursue development of highly efficient methane engines.

The most interesting use of biomethane is in HDVs. The volumes are predictable and even higher than LDV volumes, and installation of the infrastructure will be relatively simple and inexpensive. More important, however, is that in HDVs biomethane always substitutes for diesel oil. Liquefied methane can be a cost-effective solution in long haul transportation.

Purpose and Objectives

Highlights of the recommended road map for future work, or phase two of the project, are as follows:

- Continue the dialogue with suppliers of diesel dual fuel (DDF) concepts and interested original equipment manufacturers (OEMs).
- Verify present status of fuel efficiency and emission performance for commercially available DDF concepts.
- Conduct benchmarking of available concepts (DDF and spark ignition [SI]) for methane-fueled HD engines.
- Develop a first proposal for a certification scheme for heavy-duty (HD) dual-fuel engines.
- Consider methods for verification of emissions performance for methane-fueled HD engines in normal operation (i.e., an inspection and maintenance program).

Activities

In the period from January 2010 to the date for the next Executive Committee (ExCo) meeting, Sweden (AVL MTC, the world's largest privately owned and independent company for the development of powertrain systems with internal combustion engines, as well as instrumentation and test systems) will contact participating member countries in order to define a test program that will meet the major needs for each country. The main interest from financing member countries is in developing original equipment manufacturer (OEM) applications (or as close as is possible); therefore, retrofit solutions will receive only limited attention. The project will imply cost-sharing and/or task-sharing activities.

Methane-fueled engines used in HDVs could be classified in different main groups depending upon the working principle of the engine. Those groups are either dedicated gas engines (i.e., engines using only methane as fuel) or engines using a various mix of diesel fuel and methane gas simultaneously (i.e., DDF).

Based on experience from limited initial testing of DDF concepts, AVL MTC proposes that the following test program should be carried out:

- Start of warm engine, with a test cell temperature of between 20–30°C. Stationary testing using an internationally accepted test cycle (preferably WHSC [World Harmonized Stationary Cycle]) with measurement of at least carbon monoxide (CO), total hydrocarbon (THC), methane (CH_4), nitrogen oxide (NO_x) and particulate matter (PM_{mass}), as well as, if possible, the particle number and size distribution. In some of the selected measuring points, diesel replacement should also be measured. The calculation of emissions in grams per kilowatt-hour (g/kWh) is to be performed in accordance with recognized protocol.
- Transient testing using internationally accepted test cycle (preferably World Harmonized Test Cycle [WHTC], warm start) with measurement of at least CO, THC, CH_4, NO_x, and PM_{mass}. Test sequence should be carried out in duplicate (i.e., two tests). Calculation of emissions in g/kWh is to be performed in accordance with recognised protocol.
- Additional measurements of nitrogen dioxide (NO_2), dinitrogen oxide (N_2O), and ammonia (NH_3) should be carried out to obtain a complete picture of emitted greenhouse gas (GHG) emissions.
- Measurement of λ (lambda) and exhaust temperature before diesel oxidation catalyst (DOC) for possible identification of where improper operation of the complete system could occur.
- Testing of the vehicle over the course of one day under various operating conditions in order to verify real-world emissions. Driving pattern/schedule to be determined.

The test program should be designed to make it possible to calculate energy efficiency, diesel replacement, and consumption of energy (diesel and/or gas). The result from testing should show the potential for the different concepts.

To cover present commercially available concepts considered to be state of the art, the test program should preferably consist of the following technologies:

- DDF concept – Hardstaff oil ignition/gas injection
- DDF concept – Clean Air Power
- DDF concept – Cummins Westport high-pressure direct injection
- DDF concept – Bosch

- Dedicated gas concept – Stoichiometric combustion (various OEMs)
- Dedicated gas concept – Lean-burn combustion (limited OEMs)

The vehicles tested should preferably meet emissions standards according to Euro V/VI or corresponding requirements in the United States and Japan.

Results and Reports/Deliverables

As report will be developed as a result of the testing. In the case of task-sharing activities, the issue of reporting the result(s) must be the responsibility of the concerned laboratory/country. Sweden will, however, be responsible for the main report and coordination of all activities.

Time Schedule

The testing schedule is as follows:

- Start of test program: spring 2011.
- End of test program: spring 2012.
- Presentation of findings and results: summer 2012 (ExCo meeting).

3.i Annex XL: Life Cycle Analysis of Transportation Fuel Pathways

Operating Agent	Reilly-Roe & Associates, Ltd.
Started	November 11, 2010
Project Duration	January 31, 2011, to January 31, 2012
Participants	Cost Sharing: Canada, Finland, Germany, Japan (AIST), Sweden Task Sharing: France, Norway, Switzerland, Thailand, United States
Total Budget	€50,000
Responsible	Peter Reilly-Roe President, Reilly-Roe & Associates, Ltd. Suite 277, 1411A Carling Avenue Ottawa, Ontario, Canada K1Z 1A7 Tel: 613-862-8336 U.S. Tel: 646-233-4018 Fax: 866-472-8569 E-mail: peterrr1@mac.com

Background

Within the last decade, there has been increasing development of, and reliance upon, life cycle analysis (LCA) models to assess greenhouse gas (GHG) and other emissions from vehicle and fuel pathways. These models are designed to quantify emissions from the different stages of vehicle and fuel production and use. Because the production of fuels and vehicles involves many possible feedstocks and processes, these models are quite complex, rely on large and varied sets of input data, and contain assumptions that influence final results. LCA models were initially used to quantify, from a technical perspective, the emissions from new fuel pathways in comparison to the emissions of conventional fuel pathways such as gasoline or diesel. This deployment of LCA models provides useful guidance for the research and engineering communities involved in vehicles and fuels development. With the large increases in investments in new fuels development — initially for biofuels and potentially for electricity to power vehicles — it is important for researchers, vehicle manufacturers and fuels producers, and government agencies to understand the environmental and GHG emissions impacts of the various vehicle and fuels options. LCA models can be of great assistance in this endeavor.

The International Energy Agency Implementing Agreement (IA) on Advanced Motor Fuels (IEA-AMF) has recently discussed the need to further its involvement in the life cycle analysis of various technological options for transportation fuels and technologies. The IEA-AMF believes it can play a role in integrating and disseminating fact-based information on LCA as it relates to various transportation technology pathways. Members of the AMF have been exposed to some examples of the results of assessments of GHG emissions from LCA models in the past. However, while LCA modeling could be a useful tool for AMF members, its limitations and strengths need to be properly understood and explained. This project is intended to provide, as far as is possible in nontechnical language, a better understanding of LCA models and their appropriate uses.

Purpose and Objectives

The purpose of this work is to improve understanding of the concept of lifecycle analysis of transportation fuels and some of its pertinent issues among nontechnical people, senior managers, and policy makers. This work should provide some guidance to those countries considering LCA-based policies and to other industry professionals who are affected by existing or in-development policies.

Activities

The operating agent will provide the technical services of an LCA expert to draft the main report. Countries participating in task sharing will contribute knowledge about the LCA techniques used in their respective countries, as well as the main issues that they encountered and solutions they adopted in building LCA capability and using it for assessment purposes. These country contributions will be summarized and integrated into the report by the Operating Agent. Countries will be asked to comment on the draft report to ensure that their views are reflected and to ensure that the text is suited to its intended audience.

Communications between countries and the Operating Agent will be conducted mainly by conference calls and e-mail, as well as limited meeting opportunities at Executive Committee (ExCo) meeting venues in May and November 2011.

Results and Reports/Deliverables

The project will produce a written report that contains the following:

- Provides a general overview of LCA principles (International Organization for Standardization methodologies, multiple approaches, etc.).

- Characterizes LCA-specific sensitivities regarding transportation fuels (such as scope and system boundaries, data sources, geophysical differences).
- Puts sensitivities into context by using specific examples (e.g., Task 39, Annex 37) and potential impacts of fuel compatibility needs.

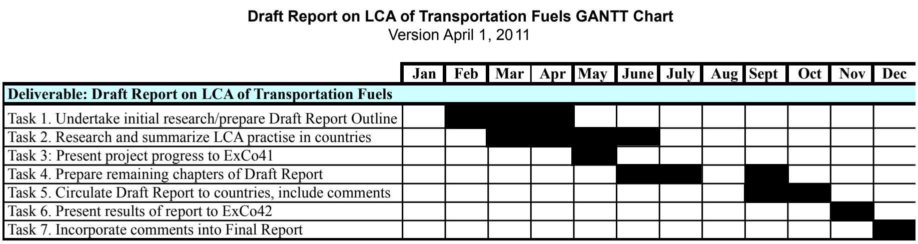
As of April 1, 2011, progress included:

- Completion of a detailed table of contents and structure for the final report, which has been drafted for discussion.
- Two chapters have been drafted as of March 31, 2011.
- The United States, Thailand, and France are working on their written contributions.

Time Schedule

The annex project will follow the schedule in Table 1 for the balance of 2011.

Table 1 Project Schedule through December 2011 (as of April 1, 2011).



3.j
Annex XLI: Alternative Fuels for Marine Applications – Future Marine Fuels Study

Operating Agent	FEEC, USA
Status/Schedule	Active, 2011–2012
Participants	Canada, Finland, Germany
Total Budget	Phase 1: 84,000 €; Phase 2: 63,000 €
Responsible	Ralph McGill FEEC 305 Sugarwood Drive Farragut, TN 37934 USA E-mail: rnmcgill(at)chartertn.net

Background

Recent domestic and international efforts to reduce the impact of greenhouse gases (GHG) on climate change and engine emissions that affect the health of many has led international regulatory bodies, such as the international maritime organization (IMO) and national environmental agencies, to issue new rules and regulations that drastically reduce GHG and emissions emanating from marine sources. These new rules have far-reaching implications for the international shipping trade, the cruise industry, and ship owners and operators in particular. Of particular note are impending regulations in emissions control areas (ECAs), such as the North American ECA scheduled to take effect in 2012. All ships operating in the ECA would be required to use lower-sulfur fuel beginning as early as 2010, when the fuel sulfur limit for ships operating in the ECA will be 10,000 ppm or 1% sulfur, and new engines will have to meet emission standards, which require the use of advanced emission-control technologies, beginning in 2016. The new rules will mandate reductions in emissions of sulphur and nitrogen oxides and particulate matter (PM).

Many ship operators with current propulsion plants and marine fuels cannot meet these new regulations without installing expensive exhaust after-treatment or switching to low-sulphur diesel or alternative fuels with properties that naturally reduce engine emissions below mandated limits, all of which impact the bottom-line profits. The impact of these new national and international regulations on the shipping industries worldwide has brought alternative fuels to the forefront as a means for compliance. The alternative fuels industry, spurred on by increased funding, has grown dramatically for both liquid and gaseous fuels. Each of these alternative fuels has advantages and disadvantages from a shipping industry standpoint. It is vitally important that nations recognize the impact the new marine regulations will have on their marine industries and implement policies that will minimize these impacts and pave the way for smooth transitions to alternative marine fuels and operating procedures that will meet GHG and emissions limits without jeopardizing international maritime trade.

This project will capitalize on the knowledge and experience of the subject matter that Alion and partners have gained in working on current alternative fuels project with Transport Canada, the U.S. Navy, and the U.S. Coast Guard. These projects have involved evaluating alternative fuels for implementation within the Canadian marine freight system and demonstration on U.S. Navy ships and U.S. Coast Guard boats. The goal is to expand the work on similar issues in the Asian and European regions so that a more global view of the future of marine fuels can be developed. Ultimately, all countries will be impacted directly or indirectly by the changes that will take place in marine fuels and ship propulsion systems if for no other reason than the implications of petroleum refining, which will be major.

Objective

The overall objective of the Task is to compile an extensive volume of information relative to the implementation of various alternative fuels (AF) within the Asian and European maritime sectors and recommend the most fiscally sound policy in order to achieve the goals of environmental compliance, seamless integration of alternative fuels within existing infrastructures, unfettered maritime trade practices, and fewest impediments to ship owners and operators.

This proposed study is separated into two parts. Parts 1 and 2 will focus on the following tasks:

PART ONE (Alternative Fuels Evaluation)

- Task 1 (Literature survey) — Assess the implementation of future fuels (alternative and conventional) and survey the energy requirements for the marine transportation sector, including alternative fuels penetration into global marine markets, with particular emphasis on the Asian and European markets. This assessment and survey will be conducted in concert with a thorough review of the current and proposed rules and regulations governing the use of current and alternative marine fuels.
- Task 2 (AF Propulsion System Evaluation) — Evaluate various engines and propulsion systems used in international shipping and how

alternative fuels will impact these systems in terms of operation, environmental impact, and performance . Options will include such alternative fuels as natural gas, biomass, biofuels, and engine exhaust after-treatment options.

- Task 3 (Economic Evaluation) — Examine alternative fuel availability and supply, price projections, and suitability for use onboard ship (weight, storage, and hazards) and the regulations that will impact the use of these alternative fuels on the global shipping sector. Also, assess the economic viability of new construction and modified vessels to use alternative fuels for both regional (Asian and European Community) and international maritime trade.
- Task 4 (Alternative Fuel Infrastructure) — Evaluate the impediments associated with implementing an alternative fuel infrastructure and how they will affect the technical and logistical challenges of domestic and international shipping that have adopted alternative fuels. Also evaluate the current supply of alternative fuel engines and vessels and how ship capacity and construction would be affected by a changing alternative fuel infrastructure in regards to the availability of coastal terminals and support operations. Finally, examine the costs in building an alternative fuel infrastructure, its minimum market requirements for acceptable economic returns, and the effect natural gas would have on profitability. These tasks will be conducted to identify impediments unique to the Asian countries and the European Community as infrastructure for alternative fuels may be at different stages, and impediments to building these infrastructures will probably be unique.

PART TWO (Ship Operators Challenges)

- Operating in Emission Control Areas (ECAs) — Develop strategies for ship owners to use in ECAs to meet the restrictive engine exhaust and GHG requirements while operating within ECA boundaries. The strategies will include using low-sulphur and alternative fuels, installing fuel-efficient and emission-compliant engines, using integrated power plants, and using exhaust after-treatment devices.
- Alternative Fuels Cost and Availability — Conduct a survey of the global alternative fueling facilities by identifying what fuels are commercially available and where, estimate costs of each alternative fuel, and compile a comprehensive listing.

3.k
Annex XLII: Toxicity of Exhaust Gases and Particles from IC-Engines International Activities Survey

Operating Agent	AFHB (Laboratory for IC Engines and Exhaust Emissions Control), Berne, University of Applied Sciences, BFH-TI [Berner Fachhochschule Technik und Informatic, Biel, Switzerland
Cooperating Agents	Ronny Winkelmann, FNR, Germany Jean-Paul Morin, University Rouen, France
Started	November 2010, ExCo Thessaloniki
Project Duration	November 2010 – December 2012
Participants	AMF members: Austria, Canada, China, Denmark, Finland, France, Japan, Switzerland, United States AMF nonmembers: Czech Republic, Greece, The Netherlands, Norway
Total Budget	€20,000 Task sharing, AMF budget: €10,000 Swiss contribution €10,000
Responsible	Jan Czerwinski Univ. of Applied Sciences Bern, BFH-TI, Biel Laboratory for IC Engines and Exhaust Emissions Control (AFHB) Gwerdtstrasse 5 CH-2560 Nidau Switzerland Phone: +41 32 321 66 80 Fax: +41 32 321 66 81 E-mail: jan.czerwinski@bfh.ch

Background

The toxic effects of exhaust gases as combined aerosols (i.e., all gaseous components together with particulate matter and nanoparticles) can be investigated in a "global" way by exposing the living cells or cell cultures to the aerosol, which means a simultaneous superposition of all toxic effects from all active components.

In several cases, researchers have shown that this method offers more objective results of validation of toxicity than do other methods used to date. It also enables relatively quick insight into the toxic effects with consideration of all superimposed influences of the aerosol.

The scientific question is to investigate the degree of correlation between the reduction of toxicity as expressed by biological parameters to the toxicity equivalence (TEQ) expressed by the chemical parameters and the reduction of particle number, surface, mass, and other physical parameters as evaluated by the aerosol analytics.

Purpose and Objectives

The present annex seeks to achieve the following objectives:

- The annex offers to support both information services and knowledge transfer.
- The annex will also help to identify opportunities for funding at the European Commission (EC) and with other potential sponsors for the activities of the Engine Toxicity Network (EngToxNet) and will help these activities to take place on a worldwide basis.
- The annex will inform and encourage the oversea partners/members to pursue projects and activities in the domain of toxicology and health risks.
- The annex will help several nonmember states become Advanced Motor Fuel (AMF) members.

Activities

International:

Several toxicologists, biologists, and medical doctors are working on the problem of the toxic influences of exhaust emissions from vehicles.

The Netherlands Ministry of Environment (VROM) charged the National Institute of Public Health and Environment (RIVM) to deliver basic propositions for new legal prescriptions.

This activity of RIVM, which seeks to coordinate knowledge sharing among toxicologists by organizing and evaluating different international meetings, is called SETPOINT.

To obtain a common and validated bio-toxicological testing procedure, more test activities occurring on a worldwide basis are necessary. Several European countries declared their interest in participating on a common European Union project of the EngToxNet to perform a round robin validation program of toxicological procedures.

Present Annex:

Activities in support of the present annex include the following:

- Contacts with different research groups have been established.
- Information is in the process of being collected.
- An annual information report is being prepared .
- Coordination with cooperating agents is taking place.
- The annual report will be sent to the AMF.

Results and Reports/Deliverables

This project will yield the results of information and knowledge exchange (including through two annual reports). Project efforts and activities will help us coordinate future activities.

Time Schedule

This project is running from November 2010 through December 2012.

3.I
Annex XLIII: Performance Evaluation of Passenger Car, Fuel, and Powerplant Options

Operating Agent	VTT Technical Research Centre of Finland
Started	November 11, 2010 (ExCo 40, Decision #9)
Project Duration	January 2011 – December 2012
Participants	Finland; other countries to confirm their participation
Total Budget	€325,000 (Finland)
Responsible	Jukka Nuottimäki, VTT Technical Research Centre of Finland, P.O Box1000, 02044 VTT, Finland. E-mail. jukka.nuottimaki@vtt.fi

Background

Road transport needs major de-carbonizing actions. However, there is no single solution that can solve this challenge. Therefore, we need to entertain multiple technologies in order to find the best-suited alternatives for each given set of boundary conditions. Fuel efficiency's importance is seen to be growing. Engine downsizing, switching to diesel, and opting for hybridization contribute to fuel efficiency. Renewable energy can be introduced either through biofuels or electricity from renewable sources.

Passenger cars are a major vehicle class among road-going vehicles. Globally, around 60% of transport energy is used by cars. As the numbers of individual vehicle types, makes, and models are very large, the evaluation of future options is also quite challenging. This project proposal describes a research action that could deliver first-hand primary data for this kind of evaluation and could greatly improve the possibilities for making the right kind of choices among available options.

The offering of technology options is increasing, both regarding powertrain and fuel alternatives. Therefore unbiased data sanctioned by the International Energy Agency (IEA)on the performance (energy use and emissions) of new technologies are needed for decision makers at all levels.

Purpose and Objectives

The core of the evaluation consists of benchmarking a set of passenger cars of such make and model that offer multiple choices for powerplant and fuel (i.e., gasoline, flex-fuel [E85], diesel, compressed natural gas/liquid petroleum gas [CNG/LPG]) and perhaps also hybrid and electric vehicle (EV) variations. Examples of European vehicles that offer a multitude of fuel options are, for example, the Ford Focus, Volkswagen Passat, and Volvo V70. Other similar examples can be found, too, including vehicle platforms that offer hybrid or even EV versions.

The project would also demonstrate the differences in efficiency arising from engine type and size by testing engines of different power output offered to the same vehicle platform. A common presumption is that a large and more powerful engine will in normal driving operate at very low load, leading to inferior fuel economy. In addition, a car that is underpowered can lead drivers to pursue an excessively aggressive driving style in which the driver will try to keep up with the pace of traffic even if, for example, the acceleration capability of the car is not sufficient.

The test matrix must allow modulation of duty-cycle and ambient temperature in order to give more application/environment-specific data. One task is to develop test protocols that depict the true performance of vehicles representing a large variety of technologies. The evaluation will be based on a set of different operating conditions and applications (duty-cycles) in order to make the assessment as realistic as possible. Using only, for example, standard-type approval cycles and normal ambient temperature could yield misleading information. This varying of conditions is seen to be crucial, as it is known from previous experience that cars tend to be optimized to the type of approval conditions and common driving cycles.

The primary objective of the project is to produce comparable information about different powerplant options on fuel efficiency, energy efficiency, and tailpipe emissions. By using selected vehicle platforms and basically performing “internal” comparisons between powerplant options, the vehicles themselves can be “nullified.” This approach will emphasize the differences between alternative engine technologies rather than differences between car models and makes. The project is also seen as a way to compare and develop different fuel options. Another objective is to enhance cooperation between research institutes, which in this case will include exchange of research personnel.

Activities

(a) Main activities: These include harmonization of test protocols between participating parties, testing of vehicles on light-duty vehicle test facility with cooling equipment and ambient temperature control and comparison, and evaluation of passenger car powerplant options.

(b) Sub-activities: This will involve coordination of the project and gathering of information on different fuels’ well-to-tank (WTT) efficiency.

Full fuel cycle performance will be calculated by combining WTT data for various fuels generated in the current IEA Bus Project and combining this data with the end-use performance for various light-duty vehicle and fuel technologies.

(c) Participants and/or experts' meetings (Finnish part of the project): As a kick-off, VTT organized the first management group meeting regarding the Finnish part of the project in early March. These management group meetings will be held twice a year during this project.

In terms of the international part of the project: The first meeting regarding all of the participants will be held as soon as all of the interested parties have delivered their preliminary project plans. The aim is to conduct these meetings within the context of IEA (Advanced Motor Fuel (AMF) Executive Committee meetings.

(d) Publications/Newsletters: Project results are expected to generate high international interest, and therefore, if approved by all participants, the results will be published and disseminated widely through IEA AMF, IEA, and national agencies.

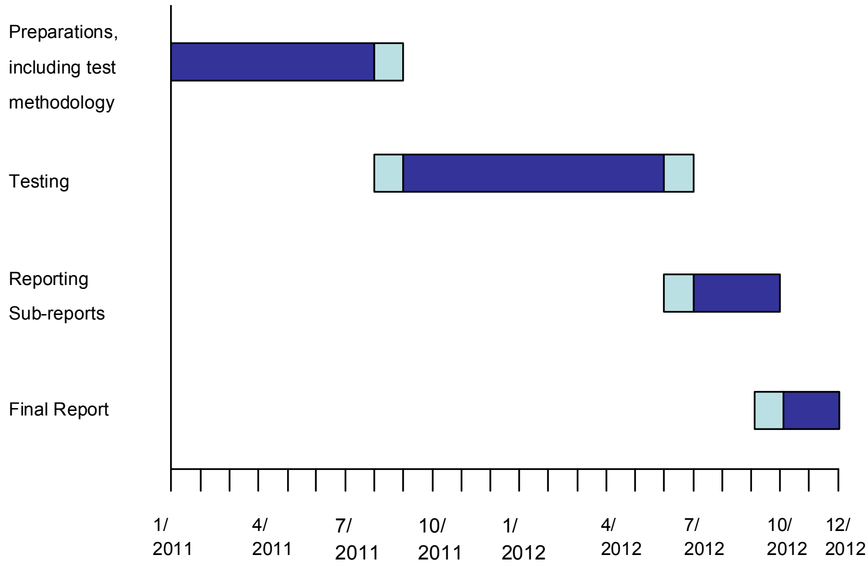
Results and Reports/Deliverables

The general outcome will be unbiased, IEA-sanctioned data on the performance (energy use and emissions) of new technologies. This type of information is needed for decision makers at all levels. The expected results are:

- Information and a methodology on how to test and compare new powertrain and vehicle technologies and universal test protocols.
- Performance and comparison of various technology options within the same vehicle family (primary objective).
- Performance and comparison of different vehicle families (secondary objective).
- Full fuel cycle data for different passenger vehicles.
- A data bank of different vehicle types and propulsion systems giving the opportunity to match vehicle/fuel/powertrain characteristics (both strengths and weaknesses) to the set of boundary conditions in application and the environment at hand to find a good match, as there in no "silver bullet" to fit all cases.
- Exchange of researchers.

Time Schedule

The project duration is planned for two years, starting in January 2011 and ending in December 2012. The breakdown of the schedule is as follows:



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4 The Outlook for Advanced Motor Fuels

The transportation sector is the largest energy consumer and represents close to 30% of total energy demand. Additionally, because this sector depends primarily on energy derived from petroleum sources, it is responsible for almost 60% of oil consumption in OECD countries, which, in turn, puts transportation near the top of global sources of GHG emissions, with 23% (globally) and 30% (OECD) of overall CO_2 emissions from fossil fuel combustion. Whereas many other sectors of society have been able to stabilise or cut CO_2 emissions, transportation-related CO_2 emissions tend to be increasing both in relative and absolute terms. Additionally, the economic progress of China and India, with their combined populations of over 2 billion people, is leading to rapid increases in their energy demand, more vehicles, and other amenities of a higher standard of living. This demand adds to the strain on current and future global energy resources.

Worldwide actions have been announced to counteract these trends. The United States is aiming to reduce oil imports by one-third over the next decade, although the United States does recognize that oil will retain its position in the U.S. energy portfolio. The European Commission's comprehensive strategy (Transport 2050) aims to dramatically reduce Europe's dependence on imported oil and cut carbon emissions in transportation to 60% below the 1990 baseline by 2050.

These energy policy drivers point toward the role that Advanced Motor Fuels, whether from renewable feedstock or unconventional fossil sources, are going to play in the future. This is recognized in many strategic papers — for example, U.S. President Barack Obama's "Blueprint for a Secure Energy Future" requires increases in the production of domestic resources while working toward diversifying the fuel mix in the U.S. vehicle fleet. The EU Transport 2050 roadmap sets different goals for different types of journey — within cities, between cities, and long distance. Among other goals, the roadmap proposes to cut the use of "conventionally fueled" cars in urban transport in half by 2030 and phase them out in cities by 2050 and to increase the share of low-carbon fuels used in aviation to 40% by 2050, as well as to reduce, by 2050, EU CO_2 emissions from maritime bunker fuels by 40%.

The European Commission stakeholder Expert Group on Future Transport Fuels, established in March 2010, concluded in their January 2011 report that alternative fuels could gradually replace fossil fuels and lead to sustainable transport by 2050. This report highlighted that "Single-fuel solutions covering all transport modes would be technically possible with liquid biofuels and synthetic fuels. But feedstock availability and sustainability considerations constrain their supply potential. Thus the expected future energy demand in transport can most likely not be met by one single fuel. Fuel demand and greenhouse gas challenges will require the use of a great variety of primary energies. There is rather widespread agreement that all sustainable fuels will be needed to resolve the expected supply-demand tensions." The report further argues that different modes of transportation will require different options of alternative fuels.

In the renewable fuel arena, the IEA Technology Roadmap *Biofuels for Transport* shows how "global biofuel consumption can increase in a sustainable way — one in which production of biofuels brings significant life cycle environmental benefits and does not compromise food security — from 55 million tonnes of oil equivalent (Mtoe) today to 750 Mtoe in 2050; this would mean that the global share of biofuel in total transport fuel would grow from 2% today to 27% in 2050." The report further details this potential as able to "contribute in particular to the replacement of diesel, kerosene and jet fuel." Current global biofuel production is estimated to have grown from 16 billion litres in 2000 to more than 100 billion litres in 2010 (Figure 1), and this production still mainly consists of conventional biofuel processes, which continue to improve in efficiency and economics. Advanced conversion routes are moving to the demonstration stage or are already there, and although total capacity for next-generation biofuels production is changing slowly, the improved GHG savings and lack of competition with food production makes for still strong support for these fuels. Next-generation facilities have started production but are generally of pre-commercial scale (except for hydro-treated renewable diesel), and future growth will depend on the capacity to move the technology from the demonstration to the commercial stage (Figure 2). Both thermo-chemical and bio-chemical conversion of ligno-cellulosic biomass and wastes to biofuels are still being pursued, with additional options being considered, such as marine biomass (algae) to produce biofuels for transportation activities. Niche applications (such as jet fuel from microalgae oils) help drive the research to solve the main issues of cost, energy consumption, and yield. The concept of bio-refineries including chemicals production from biomass may also help increase the value of these options, by emulating the model successfully used by the petroleum refining industry.

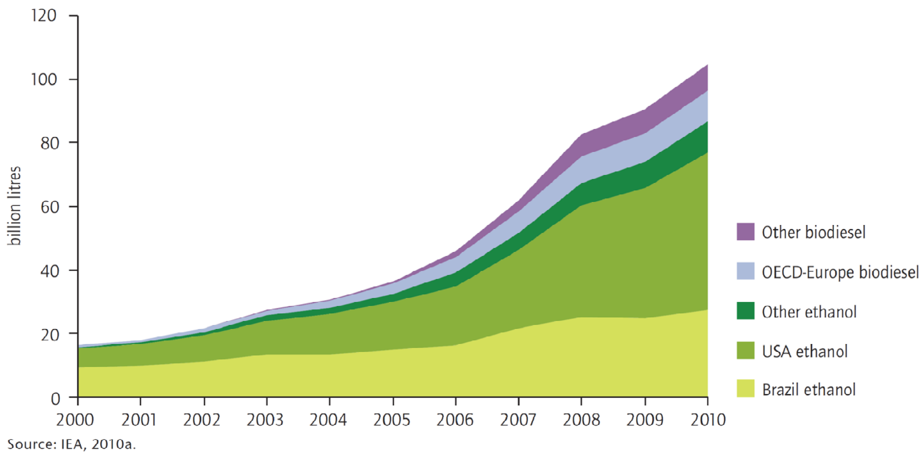

Fig. 1 Global biofuel production 2000–2010
Source: IEA Technology Roadmap "Biofuels for Transport," 2011

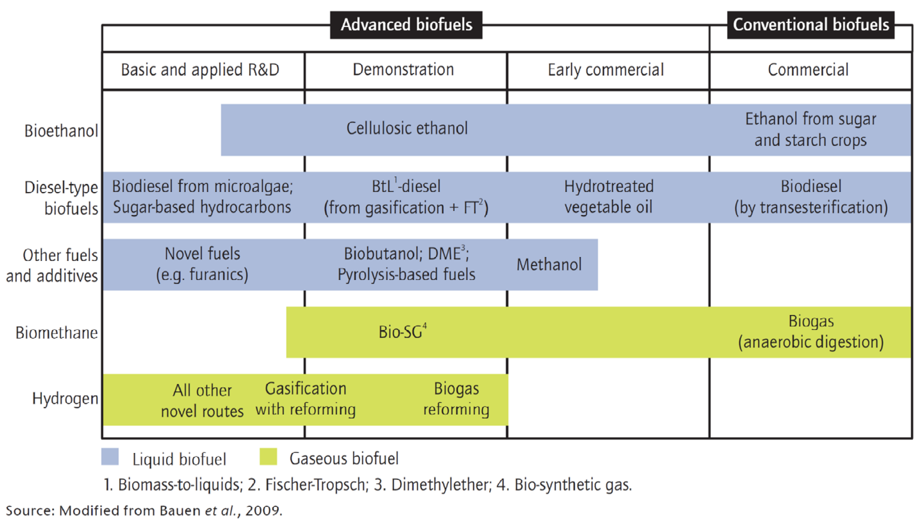

Fig. 2 Commercialisation status of main biofuel technologies
Source: IEA Technology Roadmap "Biofuels for Transport," 2011

Gaseous fuels are also receiving great attention in many areas of the globe. The deployment of natural gas vehicles (NGVs) has started to grow rapidly, particularly during the last decade, with an average annual growth rate of close to 25%, to a total of more than 12.5 million vehicles in 2010, according to the International Association for Natural Gas Vehicles (IANGV). Although the Asia-Pacific region and Latin America account for the majority of NGVs, the reevaluation of the potential North American reserves due to the deployment of horizontal drilling and hydraulic fracturing techniques has brought the potential of natural gas vehicles back to the forefront of the political agendas. In his speech for the launch of the "Blueprint for a Secure Energy Future," U.S. President Barack Obama asked congress members to pursue work on "proposed legislation providing incentives to use clean burning natural gas in our vehicles instead of oil." In addition to providing clean air and energy security benefits, NGVs can also be run on biomethane derived from anaerobic digestion or biomass gasification. To help access those benefits, a European project called GasHighWay has been established, aimed at promoting the uptake of gaseous vehicle fuels (namely biomethane and CNG) and especially establishing a comprehensive network of filling stations for these fuels spanning Europe from the north (Finland and Sweden) to the south (Italy).

One major consideration that could act as both driver and challenge to the large-scale development and deployment of advanced transportation fuels is the development of sustainability criteria that address all of the full life-cycle environmental and socio-economic impacts of the various options. Many policies referring to sustainability standards or regulations for transportation fuels are being proposed or even implemented. Notably, the United States and the European Commission have sustainability requirements requiring certain levels of greenhouse gas (GHG) reduction, as well as specific land-use criteria, embedded in their biofuels policies. A number of endeavors have been launched by international and domestic organizations to define schemes under which the sustainability of transportation fuels can be assessed. As an example, the Roundtable on Sustainable Biofuels (RSB), an international initiative coordinated by the Energy Center at EPFL in Lausanne, developed a "third-party certification system for biofuels sustainability standards, encompassing environmental, social and economic principles and criteria through an open, transparent, and multi-stakeholder process." The Global Bioenergy Partnership Task Force on Sustainability "is working to develop a set of relevant, practical, science-based, voluntary criteria and indicators as well as examples of best practice regarding the sustainability of bioenergy." Although all of these activities have the potential to help identify promising transportation pathways, one of the key risks they could pose to the widespread distribution and use of alternative fuels lies in the difference in targets and application mechanisms of the various methodologies being developed and implemented. This could create artificial barriers and pose onerous costs that would limit the competitiveness of certain alternatives.

Finally, one key element that needs to be kept to the forefront is the interaction between the fuels that are being produced and the technologies that use them. With an ongoing push by worldwide jurisdictions to bring forward ever-more stringent requirements for transportation energy efficiency, there is a need to ensure that the new technologies being developed to increase vehicle efficiencies are compatible with, or even better optimized for, the emerging fuels. The European Commission has a comprehensive strategy to reduce CO_2 emissions from new cars and vans sold in the European Union, to ensure that the EU meets its greenhouse gas emission targets under the Kyoto Protocol and beyond. This strategy, which was adopted in 2007, aims to tackle CO_2 emissions from both the production and consumer sides and is designed to help the EU reach its long-established objective of limiting average CO_2 emissions from new cars to 120 grams per kilometer by 2012 — a reduction of around 25% from 2006 levels. In addition to this 2007 strategy, the Commission considers, on the basis of a thorough impact assessment, proposing a target for passenger car emissions to be reached by 2025. Among other options, the Commission will assess the feasibility of the target suggested by the European Parliament of reaching 70 g CO_2/km by 2025. In North America, the EPA and NHTSA published on May 7, 2010, combined Light-Duty Vehicle Greenhouse Gas Emissions Standards and Corporate Average Fuel Economy Standards that require passenger cars, light-duty trucks, and medium-duty passenger vehicles, covering model years 2012 through 2016, to meet an estimated combined average emissions level of 250 grams of CO_2 per mile (Figure 3). The Canadian Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations were published on October 13, 2010, and target new “passenger automobiles” and “light trucks” of the 2011 and later model years, with an aim to achieve a new vehicle fleet in 2016 that will emit, on average, an estimated 246 g CO_2/mile (Figure 3). Additionally, both the United States and Canada published Notices of Intent to develop progressively stringent standards for model years 2017 and beyond.

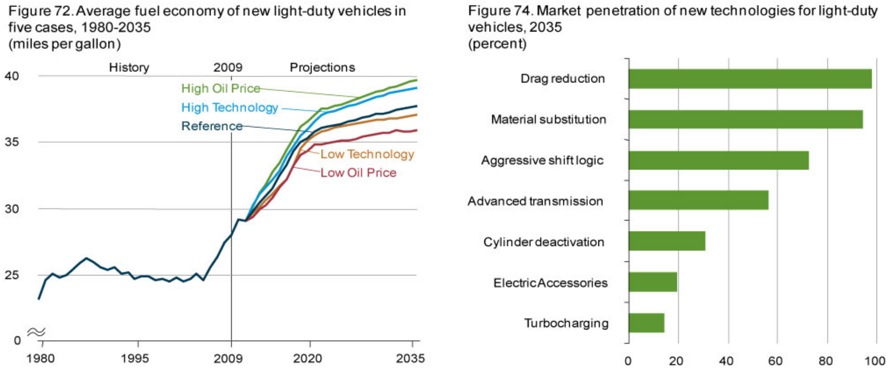

Fig. 3 Left: Average Fuel Economy of New Light-Duty Vehicles in Five Cases, 1980-2035; Right: Market Penetration of New Technologies for Light-Duty Vehicles, 2035
Source: EIA Annual Energy Outlook - 2011

In light of these increasingly more stringent fuel-efficiency requirements, it is important that fuels developed for transportation be designed to work properly with the higher-efficiency technologies and potentially play the role of enabling fuels, thereby providing routes to enhanced efficiency and reduced emission, such as through having physical and chemical properties beneficial to High Efficiency Clean Combustion (HECC) regimes like Low-Temperature Combustion and Homogeneous Charge Compression Ignition. Increased collaboration between fuel producers/providers and the vehicle/engine design and manufacturing community will result in further advances in technology.

In conclusion, the potential for Advanced Motor Fuels to play a leading role in the global efforts to reduce the negative impacts of our energy needs has never been so much at the forefront. Many options have tremendous potential, although there is much consensus worldwide that no single solution will be optimal for all transportation applications, and that the future will likely consist of a range of transportation energy sources. Biofuels — both liquid and gaseous — will likely be a key element of this portfolio, and efforts will continue to be expanded to increase their competitiveness, as well as to ensure and optimize the sustainability of all options. The pace at which the transportation scene is evolving is unprecedented, and as both new fuels and new vehicle technologies are rolled out simultaneously, care will need to be taken to help ensure they can work together and that they have the proper infrastructure to support them.

5 Further Information

5.a
Advanced Motor Fuel Executive Committee Meetings

In 2010, two Executive Committee (ExCo) meetings took place.

ExCo 39, May 12–14, 2010, Ottawa, Canada

Decisions taken in Ottawa included the following:

- The Executive Committee unanimously decided to elect Ms. Dina Bacovsky, Bioenergy 2020+, as International Energy Agency-Advanced Motor Fuel (IEA-AMF) Secretary for a period of two years from January 1, 2011, to December 31, 2012. The choice was first and foremost based on Ms. Bacovsky's qualifications and experience in the field of alternative fuels.
- The Executive Committee unanimously decided to elect Ralph McGill to replace Dina in case she would not be able to take over as Secretary.
- The Executive Committee unanimously decided to publish the final report under Annex XXVIII.
- The Executive Committee unanimously decided to keep Annex XXXV open so that a new Sub-task No. 2 can be started.
- The Annex participants unanimously decided to close Annex XXXVI.
- The Executive Committee unanimously decided to invite the Government of The Netherlands, or any entity it designates, to join the AMF Implementing Agreement for a Programme of Research and Demonstration on Advanced Motor Fuels as a Contracting Party.
- The Executive Committee unanimously decided to invite the Government of Norway, or any entity it designates, to join the AMF Implementing Agreement for a Programme of Research and Demonstration on Advanced Motor Fuels as a Contracting Party.

ExCo 40, November 9–11, 2010, Thessaloniki, Greece

Decisions taken in Thessaloniki included the following:

- The Executive Committee unanimously decided to continue with Annex XXVIII with BIOENERGY 2020+ as the new Operating Agent.
- The Executive Committee unanimously decided to continue with AMF Fuel Info as a Sub-task No. 2 with Päivi Aakko-Saksa as responsible.

- The Annex participants decided that the efforts to keep hybrid electric vehicles within the project should continue and welcomed the proposal from Jean-Francois Gagné.
- The Annex participants unanimously decided to modify the timeline so that the final report is submitted in autumn 2011 (one month ahead of ExCo 42 for review). This decision was taken so that VTT can obtain more test vehicles and Environment Canada can secure more test fuels.
- The Annex participants unanimously decided to start a Sub-task No. 2 of Annex XXXV, "Particulate Measurements: Ethanol and Butanol in DISI Engines" with Canada as Task Leader.
- The Executive Committee unanimously decided to start a new Annex XL, "Life Cycle Analysis of Transportation Fuel Pathways" with Peter Reilly-Roe from Canada as Operating Agent.
- The Executive Committee unanimously decided to start a new Annex XLI, "Alternative Fuels for Marine Applications – Future Marine Fuels Study" with at least three participating countries (Canada, Finland, and Germany) and with Ralph McGill as Operating Agent. Denmark and Sweden expressed their interest in cost sharing and will come back with a decision.
- The Executive Committee unanimously decided to start a new Annex XLII, "Toxicity of Exhaust Gases and Particles from IC-Engines – International Activities Survey (EngToxIn)" with the Laboratory For Exhaust Emissions Control, University of Applied Sciences Bern (AFHB) as Operating Agent.
- The Executive Committee unanimously decided to start a new Annex XLIII, "Performance Evaluation of Passenger Car-, Fuel-, and Powerplant Options" with VTT as Operating Agent.
- (On December 3, 2010, Nils-Olof Nylund informed that VTT had got a confirmed budget of €225,000 for measurements at VTT and €100,000 for coordination of Annex XLIII.)
- The Annex XXXIX participants unanimously decided to start Phase 2 of Annex XXXIX. A more detailed proposal will be presented at ExCo 41.
- At the request of the IEA's Committee on Energy Research and Technology (CERT) in order to implement the CERT's recommendations at its meeting of March 3–4, 2010, the Executive Committee of the Implementing Agreement for a Programme of Research and Demonstration on Advanced Motor Fuels, acting by unanimity, requested the CERT to extend the current term of the Implementing Agreement from August 31, 2014, to February 28, 2015.
- The Executive Committee unanimously decided to set up a special Sub-Committee on Strategy with Olle Hådell as Chairman.

- The Executive Committee once again unanimously decided to invite the Government of Greece, or any entity it designates, to join the AMF Implementing Agreement for a Programme of Research and Demonstration on Advanced Motor Fuels as a Contracting Party.
- The Executive Committee unanimously decided to allow the United Kingdom to withdraw as of January 1, 2011, without any financial obligations for 2011.
- The Executive Committee once again unanimously decided to invite the Government of the Czech Republic, or any entity it designates, to join the AMF Implementing Agreement for a Programme of Research and Demonstration on Advanced Motor Fuels as a Contracting Party.
- The Executive Committee unanimously decided to invite the Government of Turkey, or any entity it designates, to join the AMF Implementing Agreement for a Programme of Research and Demonstration on Advanced Motor Fuels as a Contracting Party.
- The Executive Committee unanimously decided to distribute one month after the ExCo spring meetings two copies of the Annual Report to each delegate and 10 copies to the IEA Secretariat.
- The Executive Committee unanimously decided to elect Jean-Francois Gagné as Chairman of the Executive Committee on Advanced Motor Fuels for a period of two years from January 1, 2011.
- The Executive Committee unanimously decided to elect Nils-Olof Nylund and Shinichi Goto as Vice Chairmen of the Executive Committee on Advanced Motor Fuels for a period of two years from January 1, 2011.
- The Executive Committee unanimously decided to set the Membership Fee for the year 2011 at €9,500.
- The Executive Committee unanimously decided to hold its 41st Executive Committee meeting May 24–26, 2011, in Karlsruhe, Germany.

5.b
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5.c
IEA-AMF Publications in 2010

Annex XXXIX: Enhanced Emission Performance and Fuel Efficiency for HD Methane Engines

- Broman, R., P. Stålhammar, L. Erlandsson. Report AVL MTC 9913. May 2010. Available at [http://www.iea-amf.vtt.fi/pdf/annex39_final.pdf].

Annex XXXVI: Measurement Technologies for Hydrocarbons, Ethanol, and Aldehyde Emissions from Ethanol Powered Vehicles

- Sandström-Dahl, C., L. Erlandsson, J. Gåsste, and M. Lindgren. Measurement Methodologies for Hydrocarbons, Ethanol, and Aldehyde Emissions from Ethanol Fuelled Vehicles. Society of Automotive Engineers, Warrendale. SAE Technical Paper 2010-01-1557.

Annex XXXIII: Particle Emissions of 2-S scooters:

- 5th Final report and Appendices, September 2010. (see http://www.iea-amf.vtt.fi/pdf/annex33_b290_2.pdf)

Annex XXVIII: Information Service & AMF Web site, AMFI

- AMFI Newsletters.
  - 2010/4 October (see http://www.iea-amf.vtt.fi/news/amfinewsletter2010_4october.pdf)
  - 2010/3 July (see http://www.iea-amf.vtt.fi/news/amfinewsletter2010_3july.pdf)
  - 2010/2 April (see http://www.iea-amf.vtt.fi/news/amfinewsletter2010_2april.pdf)
  - 2010/1 January (see http://www.iea-amf.vtt.fi/news/amfinewsletter2010_1january.pdf)

Glossary

Advanced Motor Fuels (AMF)

A part of the International Energy Agency (IEA), this transportation-related sector is also an Implementing Agreement of the IEA. The AMF promotes more advanced vehicle technologies, along with cleaner and more-efficient fuels. Transportation is responsible for approximately 20–30% of all the energy consumed and is considered to be the main producer of harmful emissions. Although the transportation sector is still highly dependent upon crude oil, advancements are being made to allow for domestically made biofuels and other forms of energy for transportation use.

Biodiesel Fuel (BDF)

A form of diesel fuel (methyl ether), derived from biomass. BDF has benefits over petroleum-derived diesel because it can be created from renewable and sustainable sources. Such blends of biodiesel include fatty acid methyl esters, soy methyl esters, and rapeseed methyl esters. In Brazil, biodiesel may as well be an ethyl ester or a fatty acid alkyl ester.

Biomass to liquid (BTL) fuels

A type of fuel derived from refining biomass, whether it is a renewable or waste material. Waste animal fats and vegetable oils can be used to create biodiesel. Ethanol can be derived from a vast array of renewable and sustainable sources, including switchgrass, corn, and even sugarcane. Switchgrass is a popular alternative to corn, because it does not affect food supplies. Brazil, for example, derives its ethanol from sugarcane. In Europe, BTL fuels are usually used to name synthetic fuels that are produced from lignocellulosic biomass (usually wood chips) via gasification.

Diesel Dual Fuel (DDF)

A fueling strategy currently being researched in diesel engines. A fuel resistant to auto-ignition, such as gasoline, is delivered to the combustion chamber through port fuel injection. A fuel that has a propensity to auto-ignite, such as diesel, is injected directly into the combustion chamber. This charge of diesel fuel is used to ignite the air-fuel mixture. Preliminary results show that by using diesel dual-fuel strategies, emission levels of spark-ignited engines can be achieved, with the high thermal efficiencies of diesel engines.

Di-methyl ether (DME)

A fuel created from natural gas, coal, or biomass, which is noted for producing low levels of NO_x emissions and low smoke levels, when compared to petroleum-derived diesel fuels. Di-methyl ether does not have some of the transportation issues associated with other alternative fuels, such as ethanol, which causes corrosion in pipelines. Because DME is a gas at room temperature, it must be put under pressure in large tanks for transportation and storage, unlike ethanol.

Direct Injection Spark Ignition (DISI)

Fueling strategy currently being implemented in light-duty vehicles on the road today. A fuel resistant to auto-ignition, such as gasoline, is injected directly into the combustion chamber of a spark-ignited internal combustion engine. This fuel delivery process is more efficient than its port fuel injection predecessor because it creates a charge cooling effect in the combustion chamber, allowing for higher compression ratios to be run.

E85

E85 is composed of 85 vol.% ethanol and 15 vol.% gasoline, per unit volume. This type of fuel is used in flex fuel vehicles, which are compatible with pump gasoline and available alternative fuels. Consequent fuels (such as E0, E5, and E20), contain a certain vol.% of ethanol, denoted by the number in their name, with the rest of the mixture gasoline.

ED95

A blend of diesel fuel, consisting of 95% bio-ethanol and 5% of an ignition improver for the fuel. Sweden has adapted some of their heavy-duty diesel buses in their transportation sector to run this biofuel blend.

Ethanol (C_2H_5OH)

An alcohol fuel derived from plant matter, commonly feed corn. Ethanol is blended into pump gasoline as an oxygenate. Changes to the engines and exhaust systems have to be made in order to run a higher ethanol blend. Ethanol is a popular alternative fuel, because of its advantages to help increase an engine's thermal efficiency. Ethanol is also popular because it can be domestically produced, despite discussions of its impact on food supplies. By law, ethanol must be denatured by using gasoline to prevent human consumption.

Ethyl tertiary butyl ether (ETBE)

An additive introduced into gasoline during the production process. As an additive, ETBE can be used to create some of the emissions benefits that are inherent with oxygenates. ETBE can be derived from ethanol, which allows its inclusion as a biofuel.

Fatty acid methyl ester (FAME)

A form of biodiesel derived from waste biomass, such as animal fats, recycled vegetable oils, and virgin oils. Pure biodiesel, B100, must meet standards before it can be blended into diesel fuels. In the United States, different blends of biodiesel can be found across the nation, ranging from 5 to 20% biodiesel, and manufacturers are now creating engines compatible with biodiesel blends up to B20. In Europe, FAME and biodiesel are used as synonyms in European standards. B100 may as well be used as a pure fuel with only minor adaptations of vehicles.

Fischer-Tropsch (F-T)

The Fischer-Tropsch process involves taking low-value refinery products, such as coal, and converting them into high-value fuels and can be produced from biomass gasification. The resulting F-T fuels, when compared to standard diesel fuels, can reduce NO_x, CO_2, and PM. F-T fuels can also be produced from biomass gasification. Again, the properties of the resulting fuel are better than those of conventional diesel fuels. The cetane number, a measure of diesel fuels propensity to auto ignite, is higher with F-T fuels than conventional petroleum-based diesels.

Flex Fuel Vehicle (FFV)

Flex fuel vehicles are capable of safely handling various fuels, ranging from gasoline to high-ethanol-content blends. The fuel system in a flex fuel vehicle is dedicated to handle the flow of ethanol, which would harm a normal vehicle. General Motors is a major producer of FFVs. These vehicles see a loss in fuel economy when running alternative fuels, due to the lower energy content of ethanol.

Fuel Cell Vehicle (FCV)

A type of hybrid that uses a hydrogen-powered fuel cell to produce electrical energy, to power electric motors that drive the vehicle. Fuel cell vehicles have the potential to lower harmful emissions in comparison to internal combustion engines.

Green House Gas (GHG)

Emissions that increase the harmful green house effect in our atmosphere. The emission of carbon dioxide, a common GHG, is a direct product of combustion. GHGs are responsible for trapping heat in the Earth's atmosphere. Methane, another powerful GHG, can remain in the atmosphere for longer than a decade and is at least 20 times more effective than carbon dioxide at trapping heat. GHGs have been a topic of great debate concerning global climate change in years past.

Hydrofluorocarbons (HFC)

A GHG emission that has no potential to deplete the ozone. HFCs are used as an additive in aerosols, solvents, and coolant agents. HFCs are released into the atmosphere as they leak from air-conditioning units on cars. HFCs are implemented to replace harmful cholorfluorocarbons, which have the potential to deplete the ozone.

Hydrotreated vegetable oils (HVO)

A biobased diesel fuel that is derived through hydrotreatment (a reaction with hydrogen) of vegetable oils. HVO can be used as a renewable diesel fuel and can also be blended with regular diesel, to create varying blends on a volume basis.

Internal combustion engine (ICE)

A device that uses stored chemical energy in a fuel to produce a mechanical work output. There are over 600 million ICEs in existence today, used for transportation and stationary purposes. Typical peak efficiencies for gasoline, diesel, and stationary engines are 37%, 42%, and 50%, respectively. Efficiencies of transportation gasoline and diesel engines are lower than their peak efficiencies, because they do not operate in the peak range.

Liquefied Natural Gas (LNG)

Produced through the liquefaction process of natural gas, which can be used to power heavy-duty vehicles, such as transit buses. LNG is composed primarily of methane (CH_4), with impurities being removed during the liquefaction process.

Liquefied Petroleum Gas (LPG)

LPG is composed of propane (C_3H_{10}) and butane (C_4H_{10}), with its exact composition varying by region. This clean-burning fossil fuel can be used with modification to power current vehicles equipped with ICEs, as an alternative to gasoline. Liquefied petroleum gas also can be produced domestically.

Methyl tert-butyl ether (MTBE)

An additive derived from methanol, which can be used to oxygenate and increase the octane rating of gasoline. MTBE is not as commonly used anymore because it contaminates ground water supplies.

Multi Port Fuel injection (MPI)

A type of fuel delivery system in which fuel is injected into the intake manifold before the intake value. This method of fuel injection is being replaced in newer vehicles by direct fuel injection. MPI is found typically in spark-ignited engines.

Natural Gas (NG)

A gas primarily consisting of methane (CH_4), which can be used as a fuel, after a refining process. This fossil fuel is extracted from the ground and burns relatively clean. Natural gas is not only less expensive than gasoline, but it also contributes lower GHG emissions and smog-forming pollutants. Current gasoline and diesel vehicles can be converted to run on natural gas.

Natural Gas Vehicle (NGV)

An alternative fuel vehicle that uses compressed or liquid natural gas as a cleaner-burning fuel, when compared to traditional fuels. Current vehicles can be converted to run on natural gas and is a popular trend among fleet vehicles. The only new OEM NGV available in the U.S. market is the Honda Civic GX CNG — in years past, by comparison, multiple vehicles were available. Countries in Europe and Asia offer a much wider selection of OEM NGVs.

NO_x

Nitrogen oxides are composed of nitric oxide (NO) and nitrogen dioxide (NO_2). NO_x is formed from the nitrogen and oxygen molecules in the air and are a product of high-combustion temperatures. NO_x is responsible for the formation of acid rain and smog. The three-way catalyst, which operates most efficiently at stoichiometric air-fuel ratios, has tremendously reduced NO_x emissions in spark-ignited engines. A lean-burn after-treatment system is needed for compression-ignition engines, because they do not operate at stoichiometric conditions.

Particulate Matter (PM)

Particulate matter is an emission produced through the combustion process. PM less than 10 micrometers can cause serious health issues, because it can be inhaled and trapped in a person’s lungs. With the advent of diesel particulate filters (DPF), PM emissions have been tremendously reduced.

Plug-in hybrid electric vehicle (PHEV)
A type of hybrid electric vehicle equipped with an internal battery pack, which can be charged by plugging the vehicle into an outlet and drawing power from the electrical grid. These vehicles are becoming popular, because the vehicle itself produces very low emission levels.

Rape methyl ester (RME)
A form of biodiesel, derived from rapeseed (canola) oil. This form of biodiesel is also renewable, allowing it to be produced domestically. RME can then be blended with petroleum-based diesel to produce varying blends of biodiesel.

Well-to-wheel (WTW)
The well-to-wheel concept takes into account all of the emissions created from the initial energy source to the end system for the desired mode of transport. For instance, an electric vehicle will create lower GHG emissions, when compared directly to a gasoline-powered vehicle. If the electricity used to charge the electric vehicle came from a combustion power plant and other transmissions of power were taken into account, it could, in fact, exceed the emissions of the gasoline counterpart.

Notation and Units of Measure

AF	alternative fuels
AFDC	Alternative Fuels Data Center
AFHB	Lab For Exhaust Gas Control, Univ. of Appl. Sciences, Biel-Bienne, Switzerland
AFIS	Automotive Fuels Information Service
AIST	Advanced Industrial Science and Technology (Japan)
AMF	Advanced Motor Fuels
AMFI	Advanced Motor Fuels Information
Argonne	Argonne National Laboratory (United States)
ASEAN	Association of Southeast Asian Nations
AVL MTC	AVL Motor Test Center
BDF	biodiesel fuel
BMELV	Federal Ministry for Food, Agriculture and Consumer Protection (Germany)
BTL fuel	biomass-to-liquid fuel
CAC	criteria air contaminants
CERT	Committee on Energy Research and Technology (IEA)
CHP	combined heat and power
CH_4	methane
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CVS	constant volume sampling
DDF	Diesel Dual Fuel
DETEC	Department of the Environment, Transport, Energy, and Communications (Switzerland)
DG	Directorate General (European Union)
DI	Direct injection
DISI	Direct Injection Spark Ignited
DME	di-methyl ether
DOE	Department of Energy (United States)
E5	an ethanol fuel mix of 5% ethanol and 95% gasoline
E85	an ethanol fuel mix of 85% ethanol and 15% gasoline
EC	Environment Canada

ED95	an ethanol diesel fuel mix of 95% ethanol and 5% ignition improver
EISA	Energy Independence and Security Act (United States)
EMAs	emissions control areas
EngToxNet	Engine Toxicity Network
EPA	U.S. Environmental Protection Agency (United States)
ERIA	Economic Research Institute for ASEAN and East Asia
EtOH	ethanol
ETBE	ethyl tertiary butyl ether
ETS	emission trading scheme
EU	European Union
EUV	Electric Urban Vehicle
EV	electric vehicle
F-T	Fischer-Tropsch
FAME	conventional esterified biodiesel; fatty acid methyl ester
FCV	fuel cell vehicle
FID	flame ionization detector
FFV	flex-fuel vehicles
FTIR	Fourier Transform Infrared Radiation
FY	fiscal year
GHG	green house gas
GTL	gas-to-liquid
GWh	gigawatt-hour(s)
H_2	hydrogen
HC	hydrocarbon
HD	heavy duty
HDV	heavy-duty vehicle
HFC	hydrofluorocarbons
HV	hybrid vehicle
HVO	hydrotreated vegetable oil
HyNor	Hydrogen Road (Norway)
IA-AMF	Implementing Agreement-Advanced Motor Fuels
IAEC	Isuzu Advanced Engineering Center Ltd. (Japan)
ICE	internal combustion engine
IDAE	Instituto para la Diversificación y Ahorro de la Energía
IEA	International Energy Agency
IFE	Institute for Energy Research
IMO	international maritime organization

ISCC	International Sustainability and Carbon Certification
ISO	International Organization for Standardization
JPFY	Japan's fiscal year
LCA	life-cycle analysis
LDV	light-duty vehicle
LEVO	Organization for the Promotion of Low-Emission Vehicles (Japan)
LNG	liquefied natural gas
LPG	liquefied petroleum gas
M5	fuel blend containing 5% methanol and 95% gasoline
MAFF	Ministry of Agricultural Forestry and Fisheries (Japan)
METI	Ministry of Economy, Trade, and Industry (Japan)
MOST	Ministry of Science and Technology (Thailand)
MPI	multi-port fuel injection
MS	mass spectroscopy
MTBE	methyl tert-butyl ether
MY	model year
NEDO	New Energy and Industrial Technology Development Organization (Japan)
NG	natural gas
NGV	natural gas vehicle
NHTSA	National Highway Traffic Safety Administration (United States)
NHO	Confederation of Norwegian Enterprise
NO_x	nitrogen oxides-composed of nitric oxide (NO) and nitrogen dioxide (NO_2)
NoVA	Normverbrauchsabgabe (Austria)
NRC, NRCan	National Resources Canada
NREL	National Renewable Energy Laboratory (United States)
NSTDA	National Science and Technology Development Agency (Thailand)
NTNU	Norwegian University of Science and Technology
NTSEL	National Traffic Safety and Environment Laboratory (Japan)
NVT	New Fuels and Vehicle Technology
OEM	original equipment manufacturer
OICA	International Organization of Motor Vehicle Manufacturers
OPEC	Organization of the Petroleum Exporting Countries

PEMS	Portable Emission Measurement System (Japan)
PHEV	plug-in electric hybrid vehicle
PM	particulate matter
PVO	pure vegetable oil
R&D	research and development
RD&D	research development and deployment
RIVM	National Institute of Public Health and Environment (The Netherlands)
RE85	Similar to E85, manufactured from biowaste (helps to reduce CO_2 emissions)
RME	rape methyl ester
SAE	Society of Automotive Engineers
SFOE	Swiss Federal Office of Energy
SI	spark ignition
SINTEF	The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology
SPK	Synthetic paraffin kerosene
STA	Swedish Transport Administration (Sweden)
TEQ	toxicity equivalence
THC	total hydrocarbons
TTFF	Transportation Technologies & Fuels Forum
VOC	volatile organic compounds
WTT	well-to-tank
WTW	well-to-wheel

Units of Measure

cc	cubic centimeter
GWh	gigawatt-hour(s)
kg	kilogram(s)
kL	kiloliter(s)
km	kilometer(s)
kt	kiloton(s)
ktoe	kiloton of oil equivalent
kW	kilowatt(s)
L, l	liter(s)

Mtep	million-ton equivalent of petroleum
TJ	terajoule
toe	tons of oil equivalent
TJ	terajoule
¥/L	yen(s)/liter
€/l	Euro(s)/liter
PJ	Peta-joules (1×10^{15} joules)