IEA-Advanced Motor Fuels

ANNUAL REPORT 2012

iea Energy Technology Network

ADVANCED MOTOR FUELS

IEA-AMF

IEA Implementing Agreement for Advanced Motor Fuels

Annual Report 2012

The AMF IA, also known as the Implementing Agreement for Advanced Motor Fuels, functions within a framework created by the International Energy Agency (IEA). Views, findings and publications of AMF IA do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries.

Rainbow Spine: The color of the spine of AMF Annual Reports follows the colors of the rainbow. This allows to easily distinguish yearly editions from one another. The 2010 edition of the AMF Annual Report had a blue cover, the 2011 edition a green one. This year´s edition uses a very light green and will be followed by a yellow and a red edition for 2013 and 2014. The next working period of AMF, which will start in 2015, will then start again with the first color of the rainbow: violet.

This year´s light green color stands for the environment, which AMF wishes to protect by avoiding GHG emissions and local pollutants through the use of advanced motor fuels in modern engines.

Cover Photo: Triple biofuels dispenser at Baca Street Biofuels Stations

Credit: Charles Bensinger, NREL
(http://images.nrel.gov/search.php?searchField=ALL&searchstring=biofuels+dispenser)

International Energy Agency

Advanced Motor Fuels
Annual Report 2012

This Annual Report was produced by Kevin A. Brown (project coordination/management, editing), Linda Conlin (document production), Florence Henning (editing), Patricia Hollopeter (editing), Andrea Manning (editing), Marita Moniger (editing), and Gary Weidner (printing) of Argonne National Laboratory. The cover was designed by Sana Sandler, also of Argonne National Laboratory.

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Country reports were delivered by the Contracting Parties:

Austria	Ministry of Transport, Infrastructure and Technology (BMVIT)
Canada	CanmetENERGY
China	China Automotive Technology and Research Center (CATARC)
Denmark	Technical University of Denmark (DTU)
Finland	The Technical Research Centre of Finland (VTT)
France	ADEME
Germany	Fachagentur Nachwachsende Rohsoffe (FNR)
Israel	Ministry of Energy and Water Resources
Italy	ENI S.p.A.
Japan	• National Institute of Advanced Industrial Science and Technology (AIST) • Organization for the Promotion of Low Emission Vehicles (LEVO)
Republic of Korea	Korea Institute of Energy Technology Evaluation and Planning (KETEP)
Spain	Instituto para la Diversificación y Ahorro de la Energía (IDAE)
Sweden	Swedish Transport Administration (STA)
Switzerland	Swiss Federal Office of Energy (SFOE)
United States of America	United States Department of Energy (DOE)

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

Annex 28	Information Service & AMF Website	Dina Bacovsky Päivi Aakko-Saksa
Annex 35-2	Particulate Measurements: Ethanol and Butanol in DISI Engines	Debbie Rosenblatt
Annex 38	Environmental Impact of Biodiesel Vehicles in Real Traffic Conditions	Norifumi Mizushima
Annex 39-2	Enhanced Emission Performance of HD Methane Engines (Phase 2)	Olle Hadell
Annex 41	Alternative Fuels for Marine Applications	Ralph McGill
Annex 42	Toxicity of Exhaust Gases and Particles from IC-Engines — International Activities Survey (EngToxIn)	Jan Czerwinski
Annex 43	Performance Evaluation of Passenger Car, Fuel, and Power Plant Options	Jukka Nuottimäki
Annex 44	Research on Unregulated Pollutant Emissions of Vehicles Fueled with Alcohol Alternative Fuels	Kewei You
Annex 45	Synthesis, Characterization, and Use of Algae-HVO and eFAME for Engine Operation	Benjamin Stengel
Annex 46	Alcohol Application in CI Engines	Jesper Schramm

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

Sandra Hermle	Swiss Federal Office of Energy (SFOE)	ExCo Chair
Dina Bacovsky	BIOENERGY 2020+	Secretary

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1

Advanced Motor Fuels Implementing Agreement

1.a Chairperson's Message

In 2009, the transport sector accounted for approximately one-fifth of global primary energy use and one-quarter of energy-related carbon dioxide emissions (IEA Energy Technology Perspectives [ETP] 2012). Today, the sector still relies on oil for more than 93% of the energy it uses. And energy demand in the transport sector has increased steadily over the past years. In order to reach climate targets, immediate solutions to fuel use problems have to be found.

The transport section of IEA ETP 2012 states that "the transport sector remains dependent on oil because it has high energy density and remains cost-competitive compared with most alternative fuels." Therefore, on one hand, new policies that support alternative fuels are needed, and on the other hand, new technologies and fuels need to be further developed. This work is exactly the core business of the Advanced Motor Fuels Implementing Agreement (AMF IA); in an international context, the AMF is important with regard to highlighting new solutions for the transport sector.

The AMF, currently with 10 active annexes, covers a broad expanse of issues, including investigations of the environmental performance of the different fuels (e.g., alcohols, biodiesel, hydrotreated vegetable oils [HVOs], methane) used in passenger cars and their particulate matter emissions; studies of alternative fuel use in marine applications; and performance evaluations of fuel and power plant options for passenger cars. The AMF's current work demonstrates that it is trying to contribute to sustainable solutions, as it takes the entire fuel chain (from resource development to end use) into account — a feat that is possible only through collaborations with other thematically associated Implementing Agreements. The initiation of relevant new fuel topics as well as the sharing of knowledge worldwide are important factors that will make the AMF Implementing Agreement vital and successful.

The year 2012 was very fruitful, with the kick-off of three new annexes, the entry of the Republic of Korea into the AMF IA, and the participation of several countries (e.g., Norway and Turkey, among others) as observers in the meetings. Furthermore, there was progress in developing AMF's strategy; at a brainstorming session, the top priorities for the different contracting parties were determined. Another area of progress has been the fact that the timing of the annex meetings has become more established; they are held one day before the official meeting days, which enables better exchanges among the annexes. As the Implementing Agreement has grown, the need for the formation of a technology subcommittee has been recognized, with the objectives of providing an overview of technology gaps, conducting in-depth discussions on technology, developing foresight regarding future issues, and possibly establishing links with other Implementing Agreements.

The AMF is very well integrated in different international fuel-related expert groups (End Use Working Party of the IEA, Transport Contact Group, Transportation Technologies and Fuels Forum, IEA Combustion, IEA Bioenergy, etc.). These relationships are important so that areas of mutual interest can be discovered and worked on and so the new findings and ideas can be brought forward in a political context.

The success of an Implementing Agreement is driven by its motivated members. I would like to express my special thanks to Dina Bacovsky for running the Secretariat in a very professional and encouraging manner. Furthermore, I would like to thank my predecessor, Jean-François Gagné, for continuously paving the way so that the output of the Implementing Agreement is relevant with regard to developing future solutions. I welcome the newly elected Vice-Chairmen: Dr. Shinichi Goto, Dr. Nils-Olof Nylund, and Mr. Kevin Stork. I also very much appreciate the work that has been done by the different subcommittees. The Outreach Committee has been of indispensable help in supporting new contracting parties interested in joining AMF. Also indispensable has been the Strategy Committee, which has brought forward new ideas, especially with regard to extending the Implementing Agreement every 5 years. A new subcommittee on technology has recently been formed and will no doubt help in identifying relevant research topics. And I would like to say a big "thank you" to all Executive Committee members for their commitment to the AMF IA, because "the whole is more than the sum of its parts" (Aristotle).

As already mentioned, the transport sector has represented the largest share of oil use since the early 2000s, and most of the energy use has been by road vehicles. This trend will continue in the future, with transport energy use rising much faster in non-OECD (Organisation for Economic Co-operation and Development) countries than in OECD countries. According to IEA ETP 2012, gasoline has remained the predominant type of transport fuel, and it accounts for almost half of energy use in North America. In Europe, however, diesel fuel accounts for half of energy use. Our current transport systems are very inefficient in transforming primary energy into mechanical energy (average conversion efficiency of 25%). Besides finding alternative modes of transportation, it is also crucial that transport users change their mobility habits.

Although new vehicle technologies will contribute to lower oil use and to a diversification of energy sources in the road transport sector, the fastest measure with the highest potential is improved fuel economy. Assumptions about the evolution of the technological composition of the world's transport fleet indicate that the share of conventional gasoline light-duty vehicles will decrease from 85% in 2010 to only 51% in 2050. The share of conventional diesel vehicles will increase until 2020, when it will reach 16%, and then it will decrease until it is 11% of the fleet in 2050 (*Transport Outlook* 2012). Models project that the highest increase in share will occur in the gasoline hybrid vehicle and plug-in hybrid vehicle share, which will have increased from 0% to reach 30% in 2050. All other technologies (natural gas, diesel hybrid, electric vehicles) will remain a marginal part of the share (*Transport Outlook* 2012). For commercial vehicles, there will be less diversification with regard to the utilized fuel. Gasoline and diesel will still remain the predominant fuel in the future. Diesel fuel will also remain predominant for medium- and heavy-duty trucks (*Transport Outlook* 2012).

In any case, with respect to future legislation, a much bigger focus should be placed on fuel economy. Improving the efficiency of today's propulsion systems and fuels has the most potential for achieving the desired results in the near future. The AMF IA can make a significant contribution toward both increasing the efficiency of vehicles and making them cleaner. As N.-O. Nylund, the former chairman of the AMF IA, stated: "The development of engines, exhaust after-treatment and fuels must go hand in hand." I would like to stress this statement, and I'll even go a step further by saying the integration of transport-related and fuel-related Implementing Agreements is a necessity; we must join forces to have the impact needed to move toward a more decarbonized transport sector. In my opinion, in the future, it is very important for us to not only make important technical data available but also to provide policy-relevant key messages that can be drawn from leading research. A good step toward achieving this is by working more closely with other Implementing Agreements (IEA Combustion, IEA Bioenergy, IEA HEV, etc.). I personally want to strengthen these collaborations, which should, in the long term, result in consolidated recommendations from experts to policymakers. They will then be able to set the framework to promote the conditions needed to achieve a sustainable, low-carbon transport sector.

Dr. Sandra Hermle
AMF Chair

1.b Introduction to the International Energy Agency

The International Energy Agency (IEA) is an autonomous agency that was established in 1974. The IEA carries out a comprehensive program of energy cooperation 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 the access of member countries to reliable and ample supplies of all forms of energy; in particular, maintain 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 (GHG) emissions that contribute to climate change.
- Improve the transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, through improved energy efficiency and the development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with nonmember countries, industry, international organizations, and other stakeholders.

To attain these goals, increased cooperation among industries, businesses, and governments engaged in energy technology research is indispensable. The public and private sectors must work together and share burdens and resources while, at the same time, multiplying results and outcomes.

The multilateral technology initiatives (Implementing Agreements, sometimes abbreviated IAs) supported by the IEA are a flexible and effective framework for IEA member and nonmember countries, businesses, industries, international organizations, and nongovernment organizations to conduct research on breakthrough technologies, fill existing research gaps, build pilot plants, and carry out deployment or demonstration programs — 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 are working in these five areas or categories:

- Cross-cutting Activities (information exchange, modeling, technology transfer)
- End-Use (buildings, electricity, industry, transport)
- Fossil Fuels (GHG 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 belongs to the End-Use category.

The Implementing Agreements 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 Implementing Agreements to shape work programs that address current energy issues productively, regularly reviewing their accomplishments, and suggesting reinforced efforts where needed. For further information on the IEA, CERT, and Implementing Agreements, please consult www.iea.org/techagr.

1.c
Implementing Agreement for Advanced Motor Fuels

The transport sector is facing many challenges. Today it is almost totally dependent on fuels derived from crude oil. The number of vehicles around the world is increasing rapidly — and so are their environmental impacts and the use of energy for transport. Whereas many other sectors of society have been able to stabilize or cut carbon dioxide (CO_2) emissions, transport-related CO_2 emissions have tended to increase in both relative and absolute terms.

At the same time, new possibilities are opening up. The array of options is broadening, not narrowing. 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 harder. This is true for private consumers, fleet operators, communities, and governments. One of most important tasks of AMF is to provide decision makers at all levels with unbiased and solid data on the performance and potential of various options.

The AMF must always account for the fact that the properties of commercial fuels and the sophistication of various vehicles vary significantly among the different regions of the world. All candidate future fuels face obstacles and barriers (bottlenecks) that might be either unique to a given fuel or shared with other fuels (Figure 1).

The knowledge represented in AMF by the national delegates and experts helps to point out the obstacles and to identify the types of research and development (R&D) needed to eliminate and/or overcome them. Making a policy for alternative fuel implementation requires prioritizing the desirable attributes of the fuels and balancing the priorities with practical cost and benefit realities. Figure 1 illustrates how the process of defining the priorities must consider the barriers (or bottlenecks).

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	●		

Fig. 1 Bottlenecks to Alternative Fuel Implementation

AMF Vision

The vision of 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.

AMF Mission

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

It will continue to provide a fuel-neutral platform for cooperative 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 an 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” fulfill one or more of the following criteria:

- Low toxic emissions
- Improved life-cycle efficiency
- Reduced GHG emissions
- Renewable energy sources
- Fuels for new propulsion systems
- Sustainability in transportation
- Security of supply

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

- Alcohols (ethanol, methanol), ethers (e.g., DME, ETBE, MTBE), esters (e.g., rapeseed 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 AMF IA is based on the mutual benefit it would bring to the IA and the Interested Newcomer.

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

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

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

Financial obligations of membership include:

- An annual membership fee, currently 9,500 EUR ($12,433 US)
- Funding for participation of an ExCo Delegate at two annual meetings
- Cost-sharing contributions to Annexes in which you wish to participate (cost shares range from 10,000 to 100,000 EUR ($13,088 to 130,088 US).

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 AMF Secretary and IEA Secretariat will guide you through the formalities of joining the AMF IA.

2 The Global Situation for Advanced Motor Fuels

2.a Overview of Advanced Motor Fuels[1]

Since 2010, 842 million passenger light-duty vehicles have been on the road worldwide. EU-27 countries hold 28% of the world´s passenger vehicle stock; the United States holds 25%; and Japan, Korea, China, and India together hold 16%. The increase in passenger vehicle stock has been highest in China, India, the Middle East, Brazil, and Mexico, with China´s vehicle stock more than doubling between 2005 and 2010 (Figure 1).

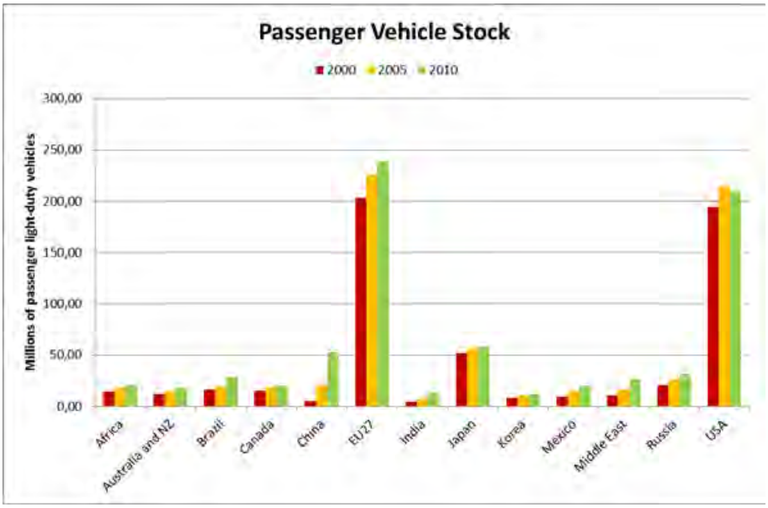

Fig. 1 Increase in Passenger Vehicle Stock, 2000–2010

Vehicle ownership per 1000 persons is highest in Australia and New Zealand (680 vehicles per 100 persons), followed closely by the United States (666), Canada (590), the EU-27 (479), and Japan (455) (Figure 2). The forecast is that by 2050, Korea and Russia will also have reached these levels, China and India will be the fastest developers (but

[1] Data taken from “International Energy Agency, Energy Technology Perspectives 2012 - www.iea.org/etp”.

starting from a lower level), and Africa will be the only region with only a very moderate increase in vehicle ownership.

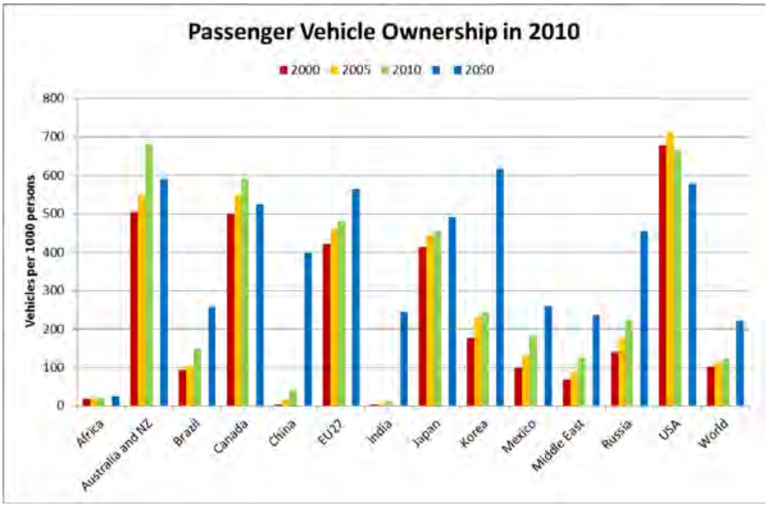

Fig. 2 Vehicle Ownership per 1000 Persons, 2000–2010

In 2010, the worldwide annual road energy consumption was 1,698 million oil-equivalent tonnes — the largest consumers were the United States (511), EU-27 (311), and China (132) (Figure 3). The forecast is that while the United States and EU-27 will be able to reduce their road energy consumption by 2050, China and India will become the largest consumers.

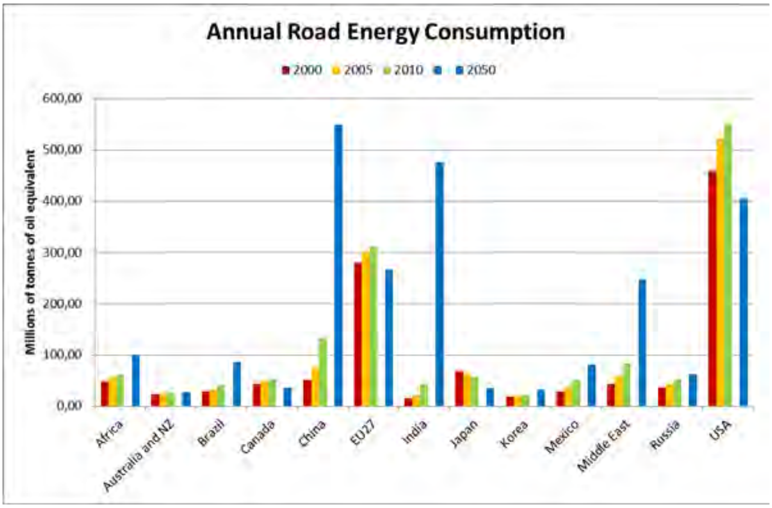

Fig. 3 Annual Road Energy Consumption, 2000–2010

Average fuel efficiency (calculated as the ratio of annual road energy consumption over annual roadway travel for each region/country) is highest in China, EU-27, India, and Japan, and Japan is expected to lead in terms of efficiency by 2050 (Figure 4).

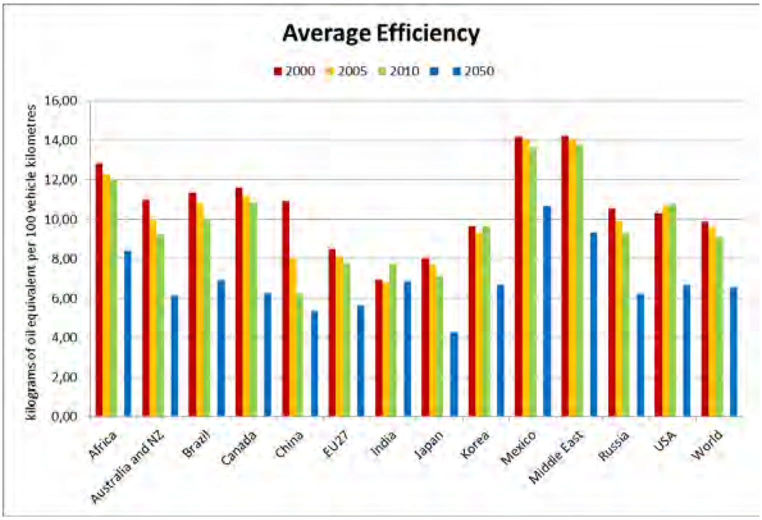

Fig. 4 Average Fuel Efficiency, 2000–2050 (Projected)

The transport sector consumed 93 EJ (exajoules) of final energy in 2009, which represents 18% of the total final energy consumption of 508 EJ (Figure 5). (1 EJ = 23.88 million tonnes of oil equivalent; 93 EJ = 2,221 million tonnes of oil equivalent)

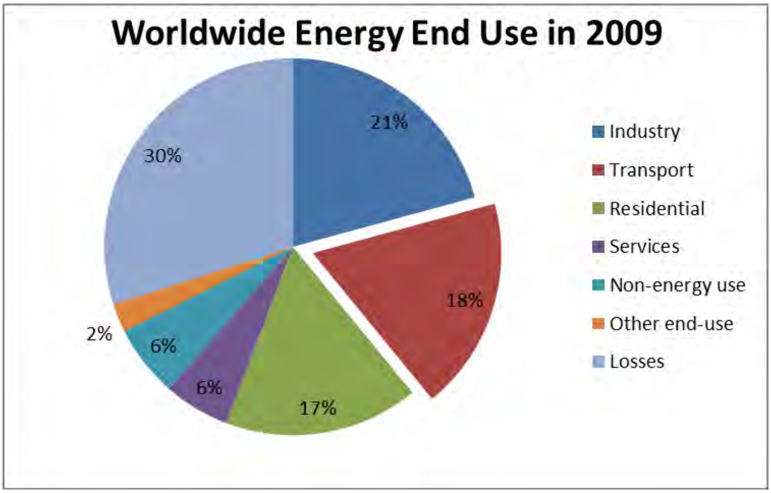

Fig. 5 Worldwide Energy End Use in 2009

The transport sector is almost entirely based on fossil oil products, as illustrated in Figure 6.

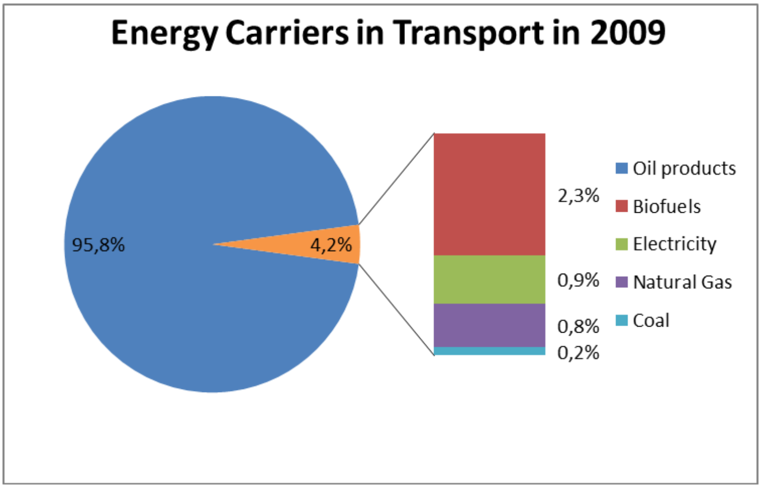

Fig. 6 Energy Carriers in Transport in 2009

In 2009, oil products were used in all transport modes (road, rail, air, sea), biofuels (as well as natural gas) were used in road transport only, and electricity and coal were used for rail transport. The worldwide modal split is represented in Figure 7.

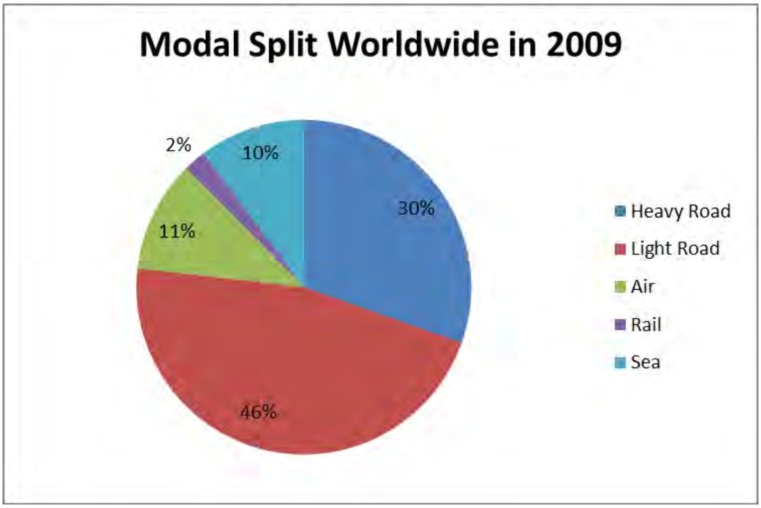

Fig. 7 Modal Split Worldwide in 2009

2.b Country Reports of AMF Member Countries

Most of the countries participating in the AMF IA 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, with a 32,9% share, still accounts for the highest share of final energy consumption in Austria (Figure 1). It is followed by the production sector, with a 28,7% share. This distribution did not change much since 2005. From 2010 to 2011, energy consumption for transport decreased by 2,3%. The consumption of mineral oil by type of fuel (1970–2011) is shown in Figure 2.

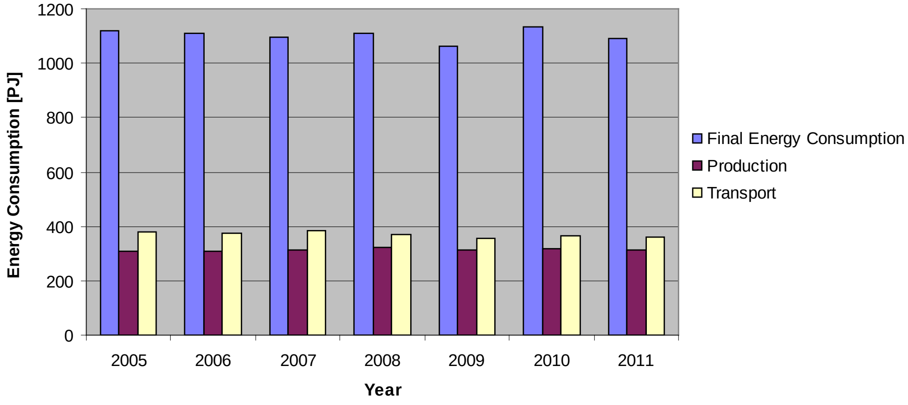

Fig. 1 Energy Consumption for the Period 2005–2011 (Source: Statistik Austria)

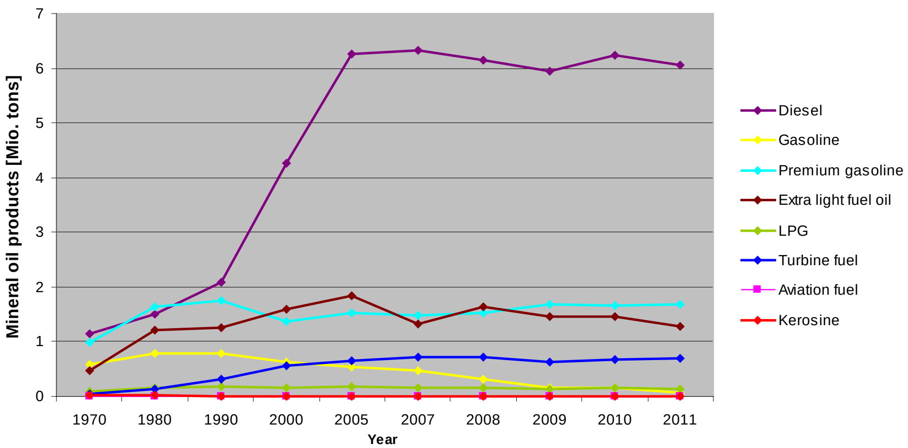

Fig. 2 Consumption of Mineral Oil by Type of Fuel, 1970–2011 (Source: Statistik Austria, Statistisches Jahrbuch 2013)

With a total of 22.5 million tons of carbon dioxide-equivalent (CO_2 eq.) in 2010, the transport sector was also the second-highest emission source after the production sector (Figure 3). In 2010, the use of biofuels prevented the emission of 1.7 million tons of CO_2 eq.

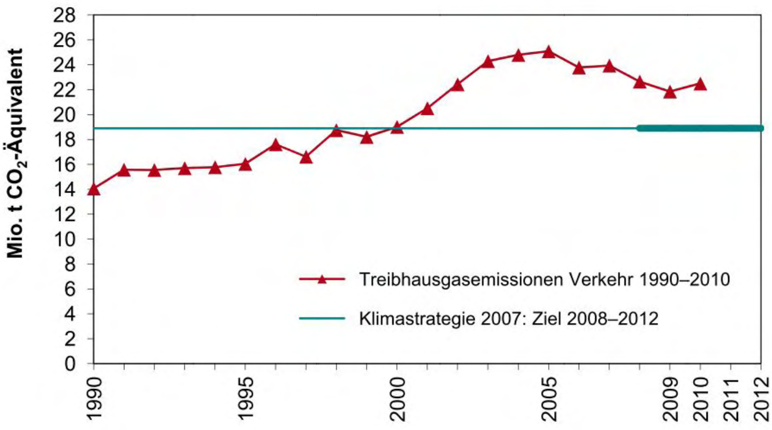

Fig. 3 GHG Emissions from the Transport Sector, 1990–2010, versus the 2007 Climate Strategy Target (see http://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0391.pdf [page 117])

Austria needed to reduce greenhouse (GHG) emissions by 13% in the period 2008–2012 (with 1990 being the reference year) to achieve the targets set by the Kyoto Protocol. To reach these targets as well as the goals set by the European Climate and Energy Package, which include a share of 10% for renewables in the transport sector by 2020, the National Energy Strategy of 2010 (Energiestrategie) identified several measures. They included higher-mineral fuels, vehicle taxation based on CO_2 emissions, and different support schemes for the replacement of vehicles. The goals were to increase energy efficiency and reduce emissions for both commercial and communal fleets and private users.

The biofuel substitution goal set by the Fuel Regulation (Bundesgesetzblatt Kraftstoffverordnung 2012 II 398) that was approved on January 1, 2009, is that biofuels should represent a share of 5,75% (energy content) of the total fuel consumed in Austria. As of October 1, 2020, the substitution goal will be 8,45%.

According to “ARGE Biokraft,” Austria’s capacity for producing biodiesel was 645.000 tons in 14 biodiesel production facilities. Of that capacity, 309.598 tons were actually produced, resulting in a capacity utilization of 48%. The total demand for bioethanol for biofuel substitution could be covered by using the output from the production plant in Lower Austria (Pischelsdorf). The feedstock in this case is regional (i.e., Central and Eastern European) wheat and corn surplus as well as other grains, which, due to their low quality, are not suitable for use in food products. The predicted extension of production capacity in 2011 did not occur (Figure 4).

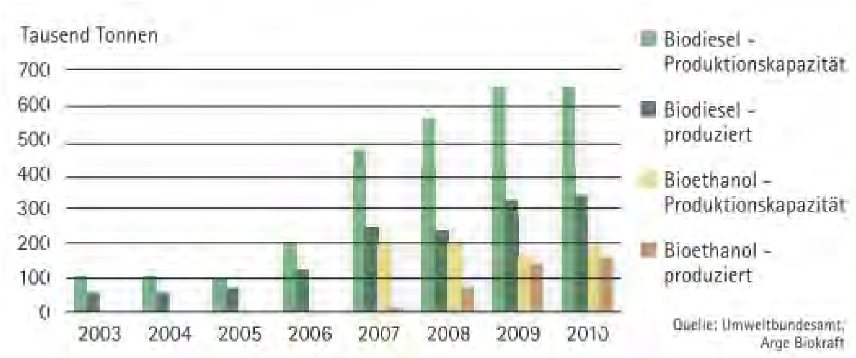

Fig. 4 Biofuel Production Capacities and Actual Production in Austria (Source: Österreichischer Biomasse Verband, Basisdaten 2011 Bioenergie)

In 2011, 6.064.893 tons of diesel were sold, of which 5.944.040 tons (98%) were blended with 6,72 volume percent (vol%) biodiesel (Table 1). Thus, a total of 506.770 tons of biodiesel was placed in the Austrian market in 2011.

The blending of gasoline with bioethanol began in the last quarter of 2007. In the 2011 reporting year, a total of 1.755.459 tons of gasoline was sold. To all gasoline fuels at least 4,60 vol% of bioethanol was added (Table 1). Therefore, with the addition of the quantities marketed as “superethanol,” 103.149 tons of bioethanol were sold during the reporting year.

In 2011, the 5,75% goal was exceeded, with the share of biofuels reaching 6,75% (Table 1), which is a small increase compared to 2010.

In addition to blending fuels, municipal and business fleets have been obliged to migrate to using pure biofuels or to increase their use of biofuels by more than 40% under the “Klima:Activ Mobil” Program implemented by the Ministry of Agriculture, Forestry, Environment and Water Management.

Table 1 Share of Biofuels in Austria

Share	2009	2010	2011
Share of bioethanol in gasoline	–	5,53 vol%	4,6 vol%
Share of biodiesel in diesel	–	6,68 vol%	6,72 vol%
Share of biofuels	**7%**	**6,58%**	**6,75%**

Source: Umweltbundesamt (Biokraftstoffe im Verkehrssektor 2012)

Policies and Legislation

The mineral oil fiscal law of 1995 was adjusted in December 2009 to establish the minimum biofuel content requirement in order for fuels to be applicable for lower tax rates.

An increase in the mineral oil tax has applied since the beginning of 2011. It is +0,04 € ($0,052) per liter (L) for gasoline and +0,05 €/L ($0,065) for diesel (Table 2). As compensation for drivers, the commuting allowance increased by 10%. Pure biofuel is exempted from this tax.

Table 2 Tax Rates for 1,000 Liters of Fuel

Gasoline	Tax Rate
After December 2009	
Content: sulfur max. 10 mg/kg, biofuel min. 46l	€ 442
Else (gasoline exceeding th7e sulfur content)	€ 475
After December 2010	
Content: sulfur max. 10 mg/kg, biofuel min. 46l	€ 482
Else (gasoline exceeding the sulfur content)	€ 515
Diesel	**Tax Rate**
After December 2009	
Content: sulfur max. 10 mg/kg, biofuel min. 66l	€ 347
Else (gasoline exceeding the sulfur content)	€ 375
After December 2010	
Content: sulfur max. 10 mg/kg, biofuel min. 66l	€ 397
Else (gasoline exceeding the sulfur content)	€ 425

Source: Umweltbundesamt (Biokraftstoffe im Verkehrssektor 2012)

Also important has been the change in the emission taxation system. Starting in July 2008, the NoVA (Normverbrauchsabgabe), a bonus/malus system for emissions of CO_2 and nitrogen oxides (NO_x) as well as particulate matter (PM), was introduced for taxation on the acquisition of new vehicles. Since January 1, 2013, the NoVA has been calculated for each additional gram of CO_2, as shown in Table 3.

Table 3 Emission Taxation System

Emission Level	Tax Increase Per g CO_2
Emissions over 150 g CO_2/km	€ 25 ($33)
Emissions over 170 g CO_2/km	additional € 25 ($33)
Emissions over 210 g CO_2/km	additional € 25 ($33)

Source: Federal Ministry of Finance (http://www.bmf.gv.at)

Regarding NO_x emissions, gasoline vehicles with emissions no higher than 60 mg/km (or, in the case of diesel vehicles, no higher than 80 mg/km) and PM emissions no higher than 0,005 g/km (refers to all particles that are catched in the measurement with the 0,3-µm DOP [di-octylphthalate] filter) receive a tax reduction of a maximum of € 200 ($259). Until August 31, 2012, vehicles running on alternative fuels such as E85, compressed natural gas (CNG), liquefied petroleum gas (LPG), biogas, or hydrogen obtained a reduction of a maximum of € 500 ($646).

Several federal programs fund and support the implementation of alternative fuels and propulsion systems in Austria. Of note is the Neue Energien 2020 Program, which is funded by the Climate and Energy Fund. Its focus is on promoting research on all aspects of the energy supply system, from energy conversion through energy transport and end use. Since 2012, it has continued under the e!MISSION.at Program.

Relevant areas with respect to transport found in the 2011 call for proposals within the "Neue Energien 2020" programme included energy efficiency and renewable energy carriers. Neue Energien 2020, which has a total budget of € 30 million ($38,7 million), is funded by the Federal Ministry for Transport, Innovation and Technology; the programme supports RD&D for the development of innovative propulsion technologies and alternative fuels to secure the competitiveness of the Austrian automotive industry. Some examples of projects that were funded in 2011 follow here:

- BioLNG-Snow Groomer: Bio-liquefied natural gas (LNG) propulsion for heavy groomed-trail vehicles
- LDS: LNG drives for the Danube inland waterway
- New Diesel: For increasing the efficiency of commercial vehicle diesel engines
- BioCrack: Pilot plant for combined conversion of solid biomass and heavy mineral oil to diesel-like fuels
- BIOGAS MOBIL: Feasibility study for fermenting organic wastes and feeding them into the grid for use in public bus transport

In 2012, the research program IV2Splus (Intelligent Transport Systems and Services Plus) of the Federal Ministry of Transport, Innovation, and Technology (BMVIT) that began in 2007 was replaced by the Mobility of the Future Program. Its focus is on personal mobility, freight mobility, transportation infrastructure, and vehicle technologies. In the first call for projects that could be founded within this research funding program, which lasted until February 14, 2013, € 4 Mio ($5.42 million) was reserved for vehicle technologies, including fuel cell technologies, hybrid and battery electric propulsion systems, and alternative fuels.

Another initiative is Klima:Aktiv Mobil, which was launched in 2004 by the Federal Ministry of Agriculture, Forestry, Environment and Water Management in the context of the Austrian Federal Climate Strategy. It supports measures focusing on mobility management, including alternative vehicles and renewable energy, intelligent multimodal mobility, ecodriving, cycling, walking, demand-oriented public transport, and raising the public's awareness. Some focuses of the mobility management program follow here:

- Cities, municipalities, and regions
- Companies, real estate developers, and public administrations
- Leisure, tourism, and youth
- Children, parents, and schools
- Eco-driving initiative for fleet operators

Implementation: Use of Advanced Motor Fuels

Since 2009, the Climate and Energy Fund (Klima und Energiefonds; see http://www.klimafonds.gv.at) has supported the development of climate and energy model regions. In 2011, there were already 66 regions with a total of 1.7 million people (20% of the Austrian population) who were very engaged in creating a more sustainable future. The Climate and Energy Fund mostly funds mobility projects that are related to electromobility.

The implementation of advanced motor fuels is best described by comparing used drivetrain configurations in past years. Table 4 shows the development of the fleet distribution over the last three years in Austria. In 2012, 336.010 passenger vehicles became road legal, which is 5,7% fewer vehicles than in 2011. Alternative drivetrains are continuously increasing their market share. Of note is the market entrance of hybrid/diesel cars in 2011.

Table 5 shows the number of filling stations for alternative fuel and conventional gas. The number of alternative filling stations did not change compared to last year. The number of conventional filling stations has dropped from 2,810 in 2007 (data not shown) to 2,575 in 2011.

Table 4 Fleet Distribution by Drivetrain, Passenger Cars (Kl. M1)[a]

Drivetrain	Dec. 31, 2010	Dec. 31, 2011	Dec. 31, 2012
Gasoline	1.983.936	1.997.066b	1.994.839
Diesel	2.445.506	2.506.511	2.570.124
Electric	353	989	1.389
LPG	1	–	1
CNG	1.312	1.572	1.826
H_2	0	0	0
Bivalent gasoline/ethanol (E85)	4.143	–	6.456
Bivalent gasoline/LPG	87	125	184
Bivalent gasoline/CNG	897	1.098	1.283
Hybrid gasoline/electric	4.792	6.056	7.762
Hybrid diesel/electric	0	4	338
Total	4.441.027	4.513.421	4.584.202

a *Vehicle category Kl. M1 is a passenger car with minimum of 4 wheels and a capacity of up to 8 passengers, not including the driver.*
b *Includes gasoline/ethanol (E85).*

Source: Statistik Austria, KFZ Bestand 2012

Table 5 Number of Filling Stations for Alternative Fuel and Conventional Gas in Austria

Fuel	Total
CNG	146
Biogas	1
E85	28
Vegetable oil	19
Conventional	2.575

Source: Fachverband der Mineralölindustrie, Mineralölbericht 2011 and http://www.raiffeisen-leasing.at/tankstellen.html

Outlook

A new climate protection law (Klimaschutzgesetz)[1] that sets the emission targets for the period 2008–2012 in the sectors that are not included in the European Union Emission Trading System (EU ETS), such as road transport, was approved in November 2011. It also designates the coordination groups in charge of the national climate protection policy and sets the framework for preparing measures to achieve the emission goals. For the transport sector, these goals would include increasing energy efficiency and the share of renewable energy sources and improving mobility management.

The goal set for the transport sector by the European Climate and Energy Package is a 10% share of renewable energy sources in transport fuels by 2020. According to the National Energy Strategy (Energiestrategie),[2] the most effective measure is the introduction of E10 and B10 following the approval of the corresponding European Standard for these fuels. There is still no consensus regarding the introduction of biofuels within the EU. In Austria, the introduction of E10 was stopped in September 2012.

1 106. Bundesgesetz: Klimaschutzgesetz – KSG, 21. Nov. 2011, https://www.help.gv.at/Portal.Node/hlpd/public/module?gentics.am=Content&p.contentid=10007.64188#Ver

2 Energie Strategie Österreich – Maßnahmenvorschläge, March 2012, http://www.energiestrategie.at/

Additional References

These sources have information about alternative fuels and filling stations in Austria:

- www.erdgasautos.at
- http://www.raiffeisen-leasing.at/tankstellen.html
- www.methapur.com

The following are relevant institutions and programs:

- Statistic Austria (www.statistik.at)
- Federal Environment Agency (www.umweltbundesamt.at)
- Ministry of Life (www.lebensministerium.at)
- Austrian Biomass Association (www.biomasseverband.at)
- Austrian Economic Chambers (http://portal.wko.at/)
- Ministry of Finance (www.bmf.gv.at/)
- Klima:Aktiv Initiative (www.klimaaktiv.at)
- Austrian Research Promotion Agency (FFG) (http://www.ffg.at)

Benefits of Participation in the AMF IA

Working in this Implementing Agreement gives you broad insights on the development of fuels and vehicles in different countries. The most important benefits it provides are the contacts with international experts that you will make and the information and results you will exchange, which should provide support needed for decision-making by domestic authorities.

Canada

Introduction

Canada has a vast and diversified portfolio of energy resources. Taking advantage of this endowment, Canada produces large quantities of energy for both domestic consumption and export. It is also an energy-intensive country, given its northern climate, vast territory, industrial base, and high standard of living.

Production of crude oil in Canada totalled 167.4 million m^3 in 2010. Oil sands accounted for 51.9% of production, exceeding conventional sources for the first time. About two thirds of crude oil production is exported, while the balance is processed by Canadian refineries into refined petroleum products, such as gasoline, diesel, and heating oil. Canadian refineries — especially those far from major domestic production areas — also process imported crude oil purchased on the international market.

Natural gas proven reserves at the end of 2010 totalled 1 727.5 billion cubic meters (bcm). Of this amount, about 95% was from conventional sources, and the remainder was from unconventional sources (such as coal-bed methane and shale gas). The total potential from conventional resources is estimated to be 10.1 trillion cubic meters (tcm), while recent estimates suggest that the potential from unconventional resources is in the range of 10.7 to 26.8 tcm. Marketable production of natural gas in Canada amounted to 144.4 bcm in 2010. Close to two-thirds of this production was exported to the United States, and the balance was sold to Canadian consumers (see http://www.nrcan.gc.ca/statistics-facts/energy/895).

Biofuels — or fuels from renewable sources — are a growing form of bioenergy in Canada. In 2010, Canada accounted for 2% of world ethanol production (fifth-highest in the world, after the United States, Brazil, the European Union [EU], and China) and 1% of world biodiesel production. The principal agriculture feedstock for producing ethanol, a gasoline substitute, includes corn, wheat, and barley. Canada is a major world producer and exporter of these grains. Vegetable oils and animal fats can be used to produce biodiesel, a diesel substitute.

In 2010, the domestic production capacity of biofuels in Canada was about 1,400 million liters (L) of ethanol and about 139 million L of biodiesel. The federal and provincial governments have introduced regulations on the content of renewable fuels that will further lead to the increased production and use of biofuels in the coming years (see http://www.nrcan.gc.ca/energy/renewable/1297).

Emissions from transportation (including passenger, freight, and off-road emissions) are the largest contributor to Canada's greenhouse gas (GHG) emissions, representing 24% of overall GHG emissions in 2010. Between 1990 and 2005, emissions in the transportation sector increased 33%, from 128 million metric tons (i.e., megatonnes or Mt) in 1990 to 170 Mt in 2005. This increase was largely driven by a strong period of economic growth as well as a shift from cars to light-duty trucks.

Since 2005, transportation emissions have decreased by 4 Mt. Light-duty vehicles (LDVs) have become increasingly more fuel efficient. For example, between 2005 and 2010, the sales-weighted on-road fuel economy for new cars improved from 8.5 to 6.8 L per 100 km, while the sales-weighted on-road fuel economy for new light trucks improved from 12.7 to 8.5 L per 100 km. Offsetting factors included increases in the number of vehicles on the road and kilometers driven (see http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=253AE6E6-5E73-4AFC-81B7-9CF440D5D2C5).

Table 1 shows the number of vehicles in Canada from 2000 to 2009, as well as the growth rate for each category during this period. Vehicles are divided into three categories according to weight:

1. Light vehicles — gross vehicle weight of less than 4.5 t
2. Medium trucks — gross vehicle weight between 4.5 and 15 t
3. Heavy trucks — gross vehicle weight of 15 t or more

Table 1 Vehicles in Canada by Vehicle Type, 2000–2009

Year	Light Vehicles	Medium Trucks	Heavy Trucks	Total
2000	16,642,140	319,500	255,503	17,217,143
2001	16,790,536	330,043	253,648	17,374,227
2002	17,299,423	315,424	268,411	17,883,258
2003	17,547,499	321,878	278,848	18,148,225
2004	17,782,719	326,525	277,942	18,387,185
2005	18,134,739	325,939	295,463	18,756,141
2006	18,536,955	331,667	305,947	19,174,569
2007	19,007,572	392,608	314,877	19,715,057
2008	19,426,504	412,811	327,106	20,166,421
2009	19,755,945	437,997	317,219	20,511,161
2000–2009 Growth	18.70%	37.10%	24.20%	19.10%
2000–2009 CAGR[a]	1.9%	3.6%	2.4%	2.0%

[a] *CAGR = compound annual growth rate.*
Source: http://oee.nrcan.gc.ca/publications/statistics/cvs09/index.cfm

Figure 1 reveals that the rapid increase in the number of medium and heavy trucks is not as pronounced when the focus is the on-road transportation sector in general, because medium trucks and heavy trucks account for only 2.1% and 1.5% of vehicles on the road, respectively. The age distribution of vehicles in 2009 is illustrated in Figure 2. In the light vehicle fleet, 18.7% of vehicles were less than 3 years old, while half were between 3 and 9 years old.

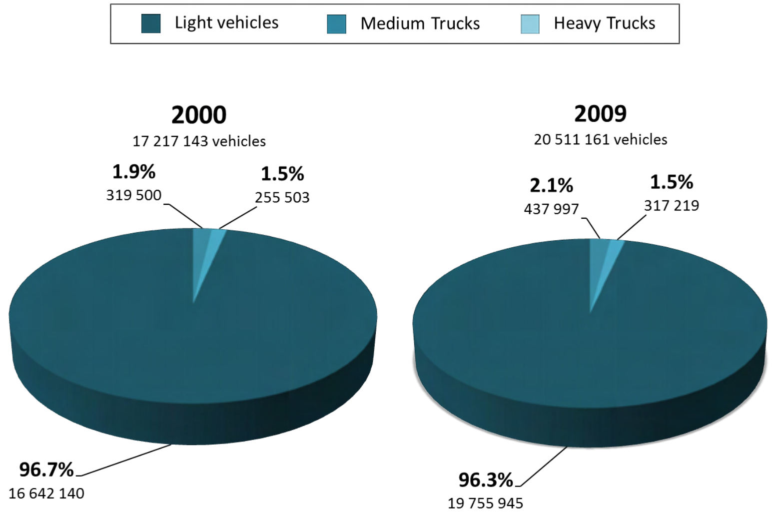

Fig. 1 Share of Vehicles in Canada by Vehicle Type, 2000 and 2009
(Source: http://oee.nrcan.gc.ca/publications/statistics/cvs09/index.cfm)

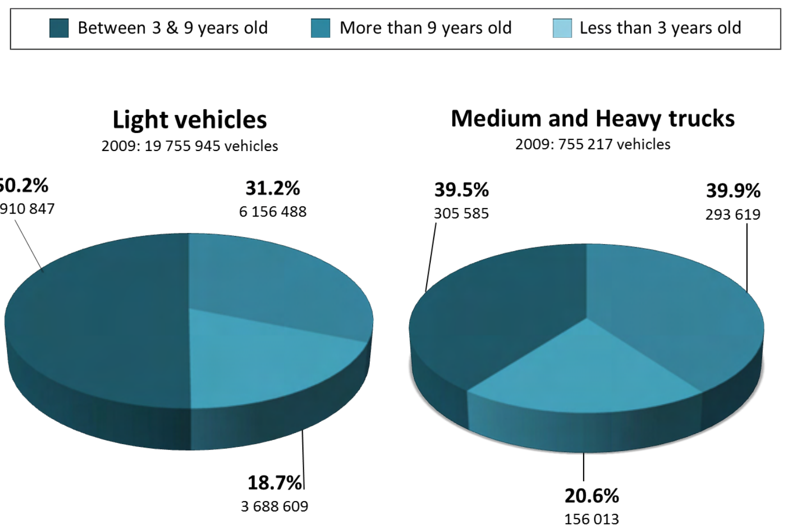

Fig. 2 Age of Vehicle Fleets by Vehicle Type, 2009
(Source: (http://oee.nrcan.gc.ca/publications/statistics/cvs09/pdf/cvs09.pdf; page 5)

Figure 3 highlights the changes in the composition of the light vehicle fleet (change in the share of body type) that occurred between 2000 and 2009. During this period, the share of the entire light truck category (vans, sport utility vehicles [SUVs], and pickup trucks) increased substantially relative to the share of cars. Most notably, the number of SUVs almost doubled its share of the light vehicle fleet (increasing from 6.9% to 12.8%). Meanwhile, the share of cars decreased from 60.5% to 55.4%, and the share of station wagons increased by 1 percentage point to reach 3.5%.

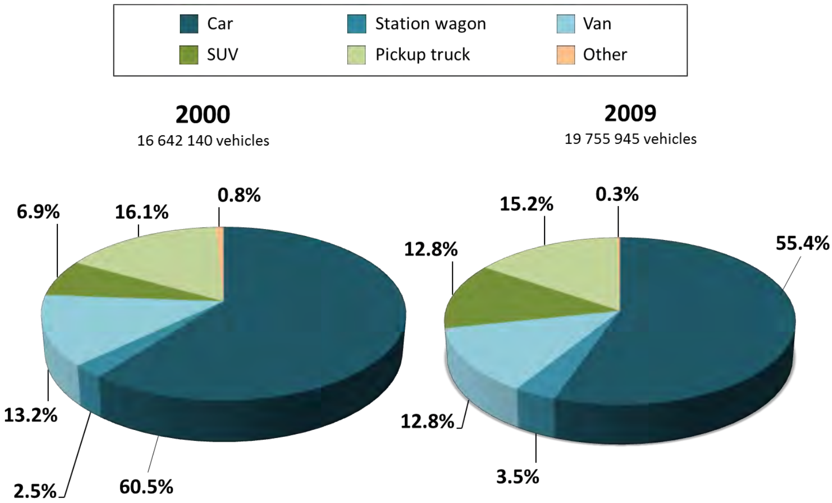

Fig. 3 Light Vehicles by Body Type, 2000 and 2009
(Source: http://oee.nrcan.gc.ca/publications/statistics/cvs09/index.cfm)

Transportation is a significant source of GHG emissions in Canada. In 2010, transportation sources accounted for 24% of total Canadian GHG emissions, of which 55% were emissions from LDVs (i.e., cars and small trucks). This led the Government of Canada to target LDVs as a high priority for regulation.

In recognition of the integrated North American economies and transportation industry, the governments of both Canada and the United States established aligned policies for national regulations to reduce emissions from the transportation sector (see http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=253AE6E6-5E73-4AFC-81B7-9CF440D5D2C5).

Policies and Legislation

The Renewable Fuels Regulations, published on September 1, 2010, in the Canada Gazette, Part II, require fuel producers and importers to have an average renewable content of at least 5% based on the volume of gasoline that they produce or import starting on December 15, 2010. These regulations include provisions that govern the creation of compliance units, allow trading of these units among participants, and require recordkeeping and reporting to ensure compliance. The regulations also require fuel producers and importers of diesel fuel and heating distillate oil to have an average annual renewable fuel content equal to at least 2% of the volume of diesel fuel and heating distillate oil that they produce and import. The Regulations Amending the Renewable Fuels Regulations set a coming-into-force date of July 1, 2011, for this requirement (see http://www.ec.gc.ca/energie-energy/default.asp?lang=En&n=0AA71ED2-1).

In October 2010, the Government of Canada released the final *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations* (LDV1). LDV1 prescribes progressively more stringent annual emission standards for new model-year 2011–2016 LDVs. The Canadian Government also published a Notice of Intent for Phase 2 of the regulations to develop more stringent GHG emission standards for model-year 2017–2025 LDVs (LDV2).

These regulations will achieve significant and sustained GHG emission reductions and fuel savings. By 2020, preliminary estimates suggest that Canadian regulations for model-year 2011–2016 LDVs will lead to annual reductions of between 9 and 10 Mt in Canada. Preliminary estimates also suggest that the proposed regulations for model-year 2017–2025 LDVs will contribute to achieving the Copenhagen 2020 target by reducing GHG emissions by an additional 2 to 3 Mt in 2020. GHG emissions are expected to be reduced even more after 2020, as the 2021 to 2025 reductions come into effect.

Under Phase 1 of the regulations, it is projected that the average fuel efficiency of new vehicles will increase by 15% between 2010 and 2016. The regulations will continue to establish progressively stringent annual fleet average emission standards. Under Phase 2 of the regulations, it is projected that the average fuel efficiency of new vehicles will increase by 37% between 2016 and 2025. Overall, it is projected that the cumulative improvement from LDV1 and LDV2 will increase the average fuel efficiency of new vehicles by 57% over the 2010–2025 period.

It is projected that unconventional vehicles (those that use diesel, alternative fuels, and/or hybrid electric systems) will play a significant role in meeting more stringent fuel economy standards. This means that companies will continue to offer a full range of vehicle types to meet the transportation needs of Canadians, but that consumers can also expect to see a greater choice of alternative vehicles available for sale. As a result, it is anticipated that the market penetration of existing advanced technology vehicles — such as hybrid-electric vehicles (e.g., Toyota Prius), plug-in hybrid-electric vehicles (e.g., Chevrolet Volt), and fully electric vehicles (e.g., Nissan Leaf) — will increase in Canada. These vehicles would not only allow for significant changes in driving habits but also significantly reduce CO_2 emissions. Moreover, electric vehicles have zero tailpipe emissions since electricity is generated at centralized utilities; use of these vehicles would thus significantly reduce localized smog and emissions of other air pollutants.

Under these regulations, it is projected that GHG emissions from LDVs will decrease by 16% between 2005 and 2020. Moreover, these regulations will have a significant impact on total transportation emissions. Canadian average annual transport GHG emissions increased 1.9% per year over the 1990–2000 period but are projected to increase by only 0.4% on average over the 2010–2020 period. As Phase 2 of the regulations takes hold, and regulations for heavy-duty vehicles (HDVs) increasingly affect other transport subsectors, the average annual transport GHG emissions will decrease by 4% from 2020 to 2030.

The objective of the HDV and Engine GHG Emission Regulations is to reduce GHG emissions by establishing mandatory GHG emission standards for new on-road HDVs and engines that are aligned with U.S. national standards. The development of common North American standards will provide a level playing field that will lead North American manufacturers to produce more advanced vehicles, thereby enhancing their competitiveness. These regulations will establish progressively more stringent standards for model-year 2014–2018 HDVs (e.g., full-size pickup trucks, semi-trucks, garbage trucks, and buses). The regulations will remain in full effect for all subsequent-model-year vehicles, which will be required to adhere to the 2018 standard, and they will result in GHG emission reductions of 19.1 Mt over the lifetimes of the model-year 2014–2018 vehicles.

Transport Canada’s ecoTECHNOLOGY for Vehicles (eTV) Program conducts in-depth safety, environmental, and performance testing on a range of new and emerging advanced vehicle technologies for passenger cars and heavy-duty trucks. The Government of Canada has committed to developing increasingly stringent GHG emission regulations for passenger cars and trucks, in alignment with U.S. regulations. To meet these standards, manufacturers will introduce a wide range of technology innovations to improve vehicle efficiency over the next several years. Transport Canada's eTV Program will help ensure that Canada is ready and that Canadians can benefit from these new innovations. To achieve this, eTV is proactively testing and evaluating a range of new advanced vehicle technologies. Results are helping to inform the development of environmental and safety regulations to ensure that these technologies are introduced in Canada in a safe and timely manner. The program also supports the Canada–U.S. Regulatory Cooperation Council. Test results will help align vehicle regulations in North America to reduce and prevent barriers to cross-border trade, thereby lowering costs for businesses and consumers and supporting jobs and growth (see http://www.tc.gc.ca/eng/programs/environment-etv-menu-eng-118.htm).

In terms of research and development (R&D), the ecoENERGY Innovation Initiative (ecoEII) aims to support energy technology innovation to produce and use energy in a cleaner and more efficient manner. One key research area is addressing the major technical challenges associated with (1) advanced materials used for high-performance engines and used to reduce vehicle weight; (2) highly efficient clean combustion technologies; (3) advanced exhaust after-treatment systems; and (4) impacts on vehicle systems from the use of fossil, renewable, and unconventional fuels, from associated codes and standards, and from the development of computational capabilities to predict the performance of components and systems. ecoEII complements the work being done under the Program of Energy Research and Development, Clean Transportation Systems, on advanced fuels and technologies for emission reduction. The R&D work aims to develop knowledge and technology related to advanced transportation fuels, engine designs, after-treatment technologies, and human health effects from the transportation sector.

Implementation: Use of Advanced Motor Fuels

In 2009, alternative fuels used in the transportation sector represented approximately 2% of the fuel used, as shown in Figure 4. The predominant renewable fuel consumed was ethanol blended with gasoline in lower-level ethanol blends.

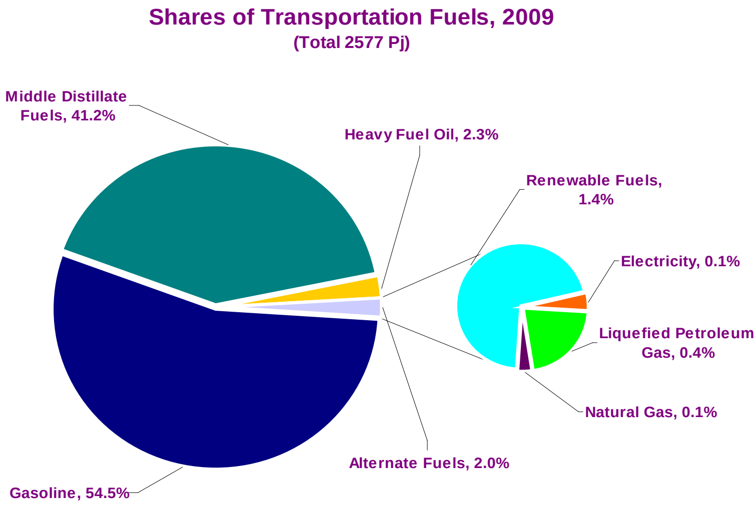

Fig. 4 Shares of Transportation Fuels, 2009

Canada's first two major liquefied natural gas (LNG) highway truck projects began in 2011, with Robert Trucking operating LNG trucks in Québec and Ontario, and Vedder Transport operating in British Columbia. Canada's first natural gas refuse truck fleet was put into service by Waste Management in British Columbia, while the City of Surrey, British Columbia, became Canada's first municipality to require the use of lower-emission natural gas refuse trucks for residential collection services.

Outlook

Total transportation emissions are projected to increase by about 1 Mt in 15 years (from 170 Mt in 2005 to 171 Mt by 2020), which represents a marked deceleration of growth from the historical long-term trend. This deceleration is expected to occur as a result of higher gasoline and refined petroleum prices and greater fuel efficiency in vehicles that will be accelerated by federal vehicle emission regulations.

As depicted in Table 2, the transportation sector is composed of several distinct subsectors: passenger, freight, air, and others (e.g., rail and marine). Each subsector exhibits different trends and responds to a very different mix of technological options. For example, it is projected that emissions from passenger transportation will decrease by 11 Mt between 2005 and 2020, while ground freight and off-road emissions will grow by 11 Mt.

Under LDV regulations, which span model-years 2011 to 2025, the fuel efficiency of passenger vehicles will increase by 35%. It is projected that the sales-weighted fuel economy of new passenger vehicles will improve from 7.9 to 6.0 L to 5.0 L per 100 km in 2010, 2020, and 2025. Likewise, it is expected that emissions from freight will decrease as a result of various federal, provincial, and territorial programs.

The recently announced HDV regulations will improve the average fuel efficiency of trucks from 2.5 to 2.1 L per 100 t-km by 2020.

Table 2 Transportation: Emissions (Mt CO_2 equivalent)

Subsector	2005	2010	2020
Passenger transport	97	96	86
Cars, trucks, and motorcycles	87	88	74
Bus, rail, and domestic aviation	9	8	12
Freight transport	56	60	67
Heavy-duty trucks, rail	49	52	58
Domestic aviation and marine	8	8	9
Other: Recreational, commercial and residential	17	10	18
Total emissions (Mt)	170	166	171

Source: http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=253AE6E6-5E73-4AFC-81B7-9CF440D5D2C5

One of the chief challenges in coming years will be to decouple economic growth from energy use and GHG emissions: reducing not only the amount of energy spent to move one passenger or one metric ton over one kilometer but also the total amount of energy used despite growing demand. Across all modes, operators have to reduce their dependency on fossil fuels and leverage new fleets of vehicles that integrate new technologies, advanced materials, and emerging fuel sources.

In the future, the transportation industry will continue to adjust to changes in global and domestic market conditions and competition. Alternative and innovative models of transportation service and infrastructure will showcase technological breakthroughs designed to support transportation sector efficiency, reliability, sustainability, safety, security, and integration across modes and boundaries. New technologies and ongoing adjustments to programs, policies, and regulatory frameworks will allow the sector to address new pressures on Canada's transportation system (see http://www.tc.gc.ca/eng/policy/anre-menu-3025.htm).

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Benefits of Participation in the AMF IA

Canada has a long-lasting history of collaborative work, both domestically and internationally. Through its 25 years of participation in the AMF IA, Canada has been able to access and input into a worldwide, recognized, 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 35 of the AMF Annexes, initiated 6 of those Annexes, and reinvested a vast amount of the leveraged resources domestically. Canada participates in 7 of the 10 Annexes that are currently active and leads Subtask 2 of Annex 35 on Ethanol and Butanol in DISI (Direct Injection, Spark Ignition) Engines. In addition to the usual cooperative interactions among 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 nonmember countries who are invited to attend as observers to the AMF IA, with a potential for future participation.

China

Introduction

In 2012, total diesel and gasoline fuel consumption in China amounted to 256 million tons. Of this, 186 million tons were consumed by vehicles, as shown in Figure 1. The figure also shows that road transportation vehicles have become the main consumers of gasoline and diesel in China.

Natural gas (NG) is another main energy source for vehicles in China. Natural gas consumption has reached 147 billion cubic meters, an increase of 13% over 2011. By the end of 2012, vehicles powered by NG were promoted in 80 cities in China. There were more than 1.2 million NG vehicles with 1,600 dedicated refueling stations.

In 2012, 470,000 tons of M15 methanol gasoline and 64,000 tons of M85–M100 methanol fuel were consumed in Shanxi province, China. A total of 33,271 vehicles (including taxis and cars) were refitted, of which 11,513 vehicles were inside the province and 21,758 vehicles were outside the province in this year. From 2000 through 2012, a total of 69,400 vehicles were refitted, of which 27,000 vehicles were inside the province and 42,400 vehicles were outside the province. Income from sales of methanol fuel and methanol-fueled vehicles was 6 billion RMB (Ren Min Bi), and industrialization has initially been realized. By 2015, the use of methanol gasoline is expected to increase to 3 million tons, and the numbers of refitted vehicles and new methanol-fueled vehicles will reach 200,000 and 50,000 vehicles, respectively.

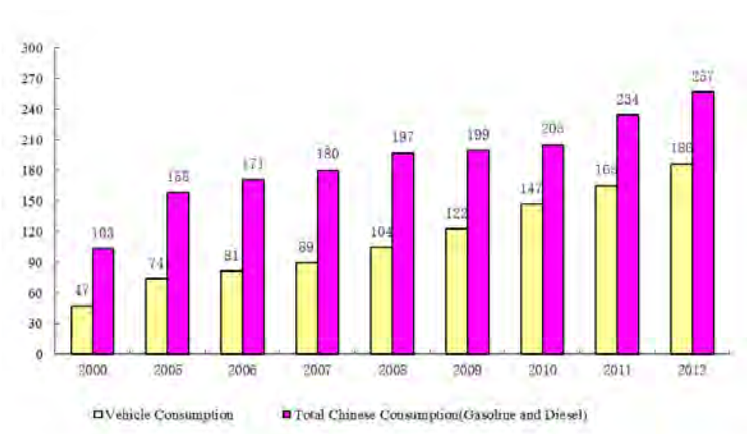

Fig. 1 Fuel Consumption in China (million tons)

Policies and Legislation

Auto Industry's High-Tech Innovations Encouraged by the Chinese Government in 2011

In June 2011, guidance called "The Guidelines for the Important Sections of High-tech Industry to Be Preferentially Developed" were jointly issued by the China National Development and Reform Commission, the Ministry of Science and Technology, the Ministry of Industry and Information Technology, the Ministry of Commerce, and the State Intellectual Property Office in June 2011. Focus areas defined as preferential include information, biology, aviation and aerospace, energy-saving and environmental protection, use of resources, and advanced manufacturing, and these areas represent 137 industries.

Dozens of high-tech automobile technologies are covered in the Guidelines. The basic automobile technologies the Guidelines support contain lightweight automotive thermo-composites, fiberglass for auto covers, metallic pigment for high-end cars, and molds/designs of auto covers. Technologies for both traditional vehicles and new energy vehicles are encouraged in the Guidelines.

The traditional vehicle technologies include diesel engines for high-efficiency vehicles, gasoline engines, controlled variable timing, automatic transmission, electric steering equipment, active (semi-active) suspension system, ABS/TCS/ESP (anti-lock brake system/traction control system/electronic stability program), environmental protection thin-film airbag, aluminum body and parts, intelligent headlamp, and central lighting system. The new energy technologies include electric vehicle (EV) inverter and driving equipment, EV charging facilities, and coordinated operation system with the grid. In addition, the hybrid EV (HEV) power assembly technology is covered in the key parts technologies.

The Guidelines mention the aim to develop vehicle environmental protection technology, including auto reproduction technology, degradable inner trim material technology, and high-efficiency honeycomb carrier for tail gas emission-control technology.

Tax Modification for Vehicles with New Energy

China's State Council issued the "Implementing Regulations of Vehicles and Vessel Tax" in June 2011. Battery EVs (BEVs), fuel cell EVs, and plug-in hybrid vehicles can avoid the vehicle and vessel tax, while taxes on other hybrid vehicles can be reduced by half compared with taxes on similar traditional vehicles. According to the Regulations, the standard annual vehicle and vessel tax for passenger vehicles with 2.0-L displacement and below is ￥60–660. Industry experts expect that the vehicle and vessel tax exemption and reduction will have a limited, direct promotional effect on the market for new-energy vehicles.

Implementation: Use of Advanced Motor Fuels

China's "10 cities, 1,000 units" Energy-Saving and New Energy Vehicle Demonstration

In 2009, the four ministries under the State Council jointly launched "10 cities, 1,000 units" — a pilot project to demonstrate energy-saving and new-energy vehicle operations. Both BEVs and HEVs were promoted in the categories of public buses, taxis, postal cars, and service cars through government financial subsidies. According to the statistics, as of the end of 2011, there have been about 16,800 units of the energy-saving and new-energy cars promoted in 25 pilot cities across China, including a few car models that failed to enter the demonstration and recommendation list or are about to enter the market, according to contracts. Table 1 and Figure 2 provide statistical data on the 11,423 cars enlisted in the Category of Recommended Car Models for the Demonstration and Promotion of Energy-Saving and New-Energy Cars.

The statistics indicate that the 11,423 energy-saving and new-energy cars are not allocated equally in the 25 pilot cities. Actually, 7 cities have less than 100 cars; 11 cities have 100–500 cars; 4 cities have 500–1,000 cars, which have all reached a certain scale; and only 3 cities have more than 1,000 cars. More than 70% of the pilot cities have promoted less than 500 units, and therefore the project failed to reach the effect of a large-scale demonstration.

Table 1 Statics of Demonstrated and Promoted Cars (by Vehicle Type)

Vehicle Type	Units	Percentage	Remarks
Hybrid buses	6,449	56	Includes a small number of plug-in hybrid buses
All-electric buses	990	9	Includes a small number of fuel cell and super capacitor buses
Hybrid passenger cars	1,766	15	
All-electric passenger cars	2025	18	Includes fuel cell all-electric cars and plug-in sedans and business cars
Other pure all-electric cars	193	2	Covers the post service, logistics, and sanitation area
Total	**11,423**	**100**	

Fig. 2 Total Number and Allocation of Demonstrated Cars as of Early December 2011

Air Purification Project – Clean Vehicle Action

In early 1999, the Ministry of Science and Technology and the Ministry of Environmental Protection jointly established the National Clean Vehicle Action Commission and carried out the "Air Purification Project – Clean Vehicle Action." The aim of this project is to promote natural gas (NG) vehicles (NGVs) and accelerate the construction of infrastructure for NGV filling stations. The project encouraged the development of natural gas, increased its portion in the primary energy structure, and clearly defined NGVs as "first class" gas projects. A total of 450 NGV models (including chassis) were listed on the national motor vehicle announcement; annual sales reached 60,000 units, including buses, passenger cars, trucks, special municipal cars, and others. The number of NGVs reached 75,106 by the end of 2012. Numbers of alternative fuel vehicles in the top 10 demonstration cities are shown in Table 2.

Table 2 Numbers of Alternative Fuel Vehicles in Top 10 Demonstration Cities

City	Type				Subtotal
	LPG[a]	LNG[a]	CNG[a]	Alcohol	
Sichuan	240	204	314,200	0	314,644
Shanghai	281,200	0	2,570	0	283,770
Urumqi	0	0	124,550	0	124,550
Shandong	0	2,470	51,454	0	53,924
Chongqing	0	0	51,700	0	51,700
Yinchuan	0	0	41,350	0	41,350
Shanxi	0	0	0	27,080	27,080
Guangzhou	25,570	100	0	0	25,670
Xi'an	0	0	20,950	0	20,950
Shijiazhuang	0	0	19,709	0	19,709
Subtotal in Top 10 Demonstration Cities	307,010	2,774	626,483	27,080	963,347
Total in China	**328,375**	**8,984**	**742,102**	**27,080**	**1,106,541**

[a] *LPG = liquefied petroleum gas; LNG = liquefied natural gas; CNG = compressed natural gas.*

Outlook

"The National 12th Five-Year Science and Technology Development Plan (2011–2015)," which was initiated in 2011, seeks to foster strategic developments within the rising new industry intensively, boost key technology breakthroughs in important fields, stimulate the construction of technology creation bases and platforms, and train people with creative talents.

The plan points out that science and technology are important elements of the solution to sustaining the harmonious development of automobiles in society. As for BEVs, the plan points out that promotional efforts should be engaged in research leading to breakthroughs for key parts technologies (battery, electric motor, and control), complete vehicle integration technologies (hybrid, battery electric, and next-generation battery electric), and public platform technologies (technical standards and regulations, infrastructure, and testing and assessing technologies). The "10 cities, 1,000 units" project should be continuously implemented to form a portfolio of world-famous key parts, complete with vehicle manufacturers having self-owned intellectual property rights. By 2015, the plan will have led to breakthroughs in 23 key technical directions, will have promoted large-scale demonstrations in more than 30 cities, and will have conducted a new type of business-model pilot implementation in more than 5 cities. The EV stock will reach 1 million units, and the output value is expected to exceed 100 billion RMB.

The biomass energy section of the "12th Five-Year Development Plan (2011–2015) for Renewable Energy" points out that the biomass power generation capacity will reach 13 million kW and 30 million kW, respectively, by the end of 2015 and 2020, effecting 1.36-fold and 4.45-fold increases from a 5.5-million-kW level at the end of 2010. Whereas agriculture and forestry biomass power generation will reach 800 million kW by the end of the 12th Five-Year, methane power generation will reach 200 million kW, and waste-incineration power generation will reach 300 million kW. During the 12th Five-Year period, the utilization of biomass molding fuel pellets, biomass ethanol, biodiesel, and aviation biofuel will reach, respectively, 10 million tons, 3.5–4 million tons, 1 million tons, and 100,000 tons.

Additional References

The following may be consulted for additional information:

- http://www.catarc.ac.cn/ac_en/index.htm
- http://www.chinaev.org/
- *2012 Yearbook of Energy-saving and New Energy Vehicles*, 2012, China

Denmark

Introduction

Energy Strategy 2050 is a huge step toward realizing the Danish government’s vision of becoming independent of coal, oil, and gas.

Figures 1–10 present data on energy consumption and production in Denmark over the past decades. In 2010, the Danish Commission on Climate Change Policy concluded that transition to a fossil-fuel-independent society is a real possibility. Energy Strategy 2050 builds on this work.

This strategy is the first of its kind in Denmark and in the rest of the world. The strategy outlines the energy policy instruments to transform Denmark into a green sustainable society with a stable energy supply. The strategy is also fully financed, taking full account of Danish competitiveness.

In March 2012, a historic new Energy Agreement was reached in Denmark. The Agreement contains a wide range of ambitious initiatives, bringing Denmark a good step closer to the target of 100% renewable energy in the energy and transport sectors by 2050.

In many ways, Denmark has started the green transition well. The Agreement calls for achieving goals more rapidly, with large investments expected in energy efficiency, renewable energy, and the energy system by 2020. In 2020, we expect approximately 50% of electricity consumption to be supplied by wind power and more than 35% of final energy consumption to be supplied from renewable energy sources.

No energy agreement has ever been reached by a larger and broader majority in the Danish Parliament than this one, and no Danish energy agreement has previously covered such a long time horizon. In other words, a solid framework has been established to enable the huge private and public investment to be made in the years to come.

Policies and Legislation

Climate Policy

Denmark has committed to meeting an ambitious and binding target for reducing greenhouse gases by 2020. This target is the most ambitious in the EU: By 2020, Denmark must have reduced greenhouse gas emissions from

Danish non-ETS (Emissions Trading System) sectors by 20% relative to 2005.

Denmark's international commitment to a significant reduction in greenhouse gas emissions not covered by the ETS in 2013–2020 poses a special challenge. The government's climate target is to cut greenhouse gas emissions by 40% by 2020 relative to those in 1990. To reach both the total target for 2013–2020 and the target of 40%, the government presented a climate plan in 2012. The Danish government's ambitious goals underscore the need for a Danish policy that will give Denmark the highest return on climate and energy investments. A good example of such a climate and energy policy is investing in wind turbines.

Another good example is the electric car. The current investments in expanding the infrastructure to accommodate electric cars are a relatively inexpensive way to reduce CO_2 emissions from the transport sector. The electric car solves three problems in one, since it also provides energy savings and opportunities for increasing the share of renewable energy in our energy system.

Energy Savings – The Road Forward

Energy savings and energy efficiency are important components of Danish energy policy and contribute to limiting energy consumption. We need significant and cost-effective energy savings within all areas. We need to use less energy in our homes, enterprises need to be made more energy-efficient, and we need to focus special efforts on conserving energy in public institutions.

The initiatives agreed on in the Energy Agreement will result in a reduction of energy costs by almost 7.6% in 2020 relative to 2010.

Renewable Energy in Denmark

Along with security of supply, energy savings, and green growth, expanding the use of renewable energy in Denmark is at the core of Danish energy policy.

As a result of the Energy Agreement, renewable energy in Denmark is expected to represent more than 35% of final energy consumption in 2020. This is a major step toward achieving the long-term goal of establishing a green-growth economy with 100% renewable energy in the energy and transport sectors.

The binding target in the EU is that by 2020, at least 30% of final energy consumption will be renewable energy in Denmark. This target is stated in the EU climate and energy package from 2008. In addition, there is a binding target that 10% of total energy consumption in the transport sector is represented by renewable energy by 2020.

Security of Supply

The best strategy to ensure the long-term security of energy supply is to reduce energy consumption through energy savings, increased use of renewables, and closer collaboration among countries in Europe.

Implementation: Use of Advanced Motor Fuels

Transport

In Denmark, the transport sector is still almost entirely dependent on oil. The government has a goal that by 2050 all Danish energy supply will be met by renewable energy, including that required by the transport sector. In February 2012, the Danish Energy Agency finalized a report on alternative fuels for the transport sector, including socio-economic aspects, energy efficiency, and environmental impact. The analysis indicates that by 2020 and beyond, electricity, biogas, and natural gas could become especially attractive as alternatives to petrol and diesel in the transport sector. Electricity is the most energy-efficient alternative because of high efficiency in the engine and an increase in the share of wind-generated electricity supply.

Funding Priorities

The Energy Agreement includes a decision to establish a pool of DKK (Danish Krone) 70 million in the years 2013–2015 to provide funding for the establishment of more recharging stations for electric cars, infrastructure for hydrogen, and facilities for gas in heavy transport. Furthermore, an overall strategy will be prepared for the promotion of energy-efficient vehicles, such as electric cars. In addition, DKK 15 million has been earmarked for the continuation of the electric-car pilot scheme in 2013–2015. The government is also giving priority to joint efforts in the EU to promote electric cars, with focus on harmonization and rollout of a car recharging infrastructure.

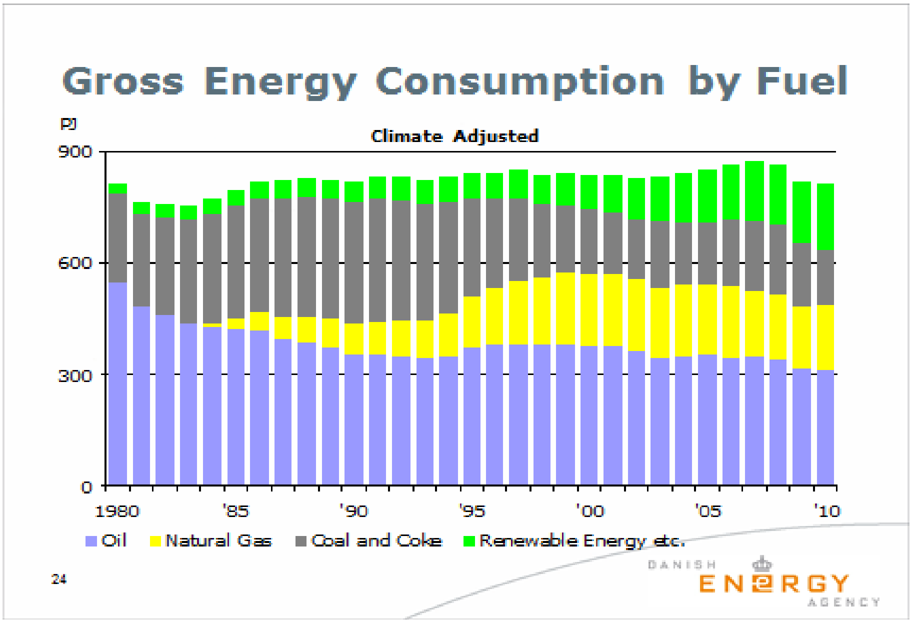

Fig. 1 Gross Energy Consumption by Fuel

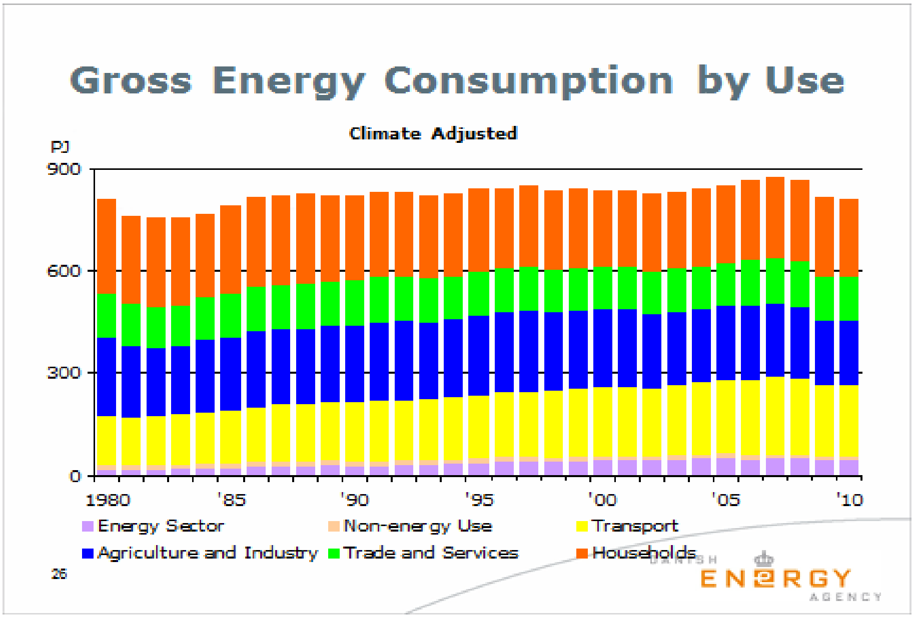

Fig. 2 Gross Energy Consumption by Use

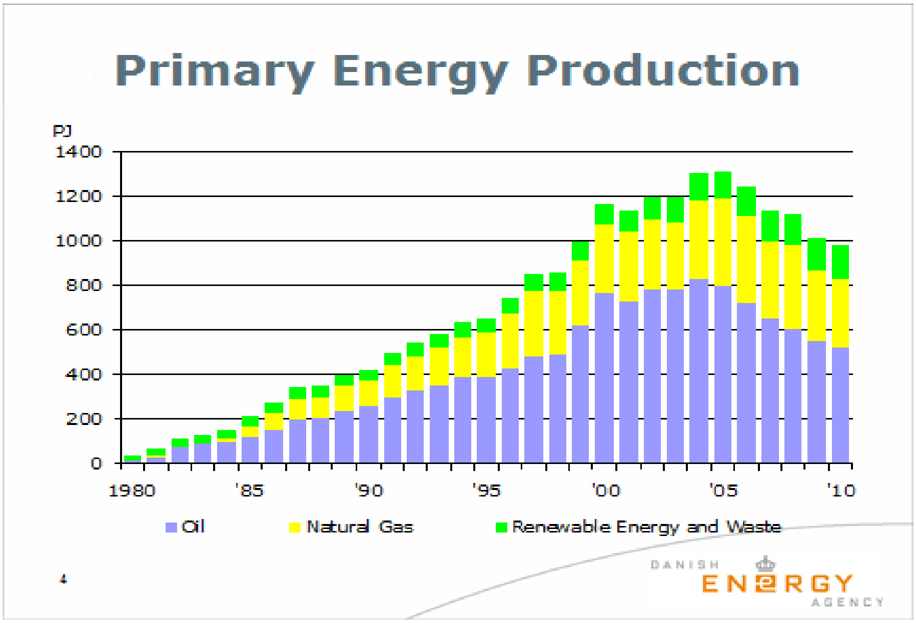

Fig. 3 Primary Energy Production

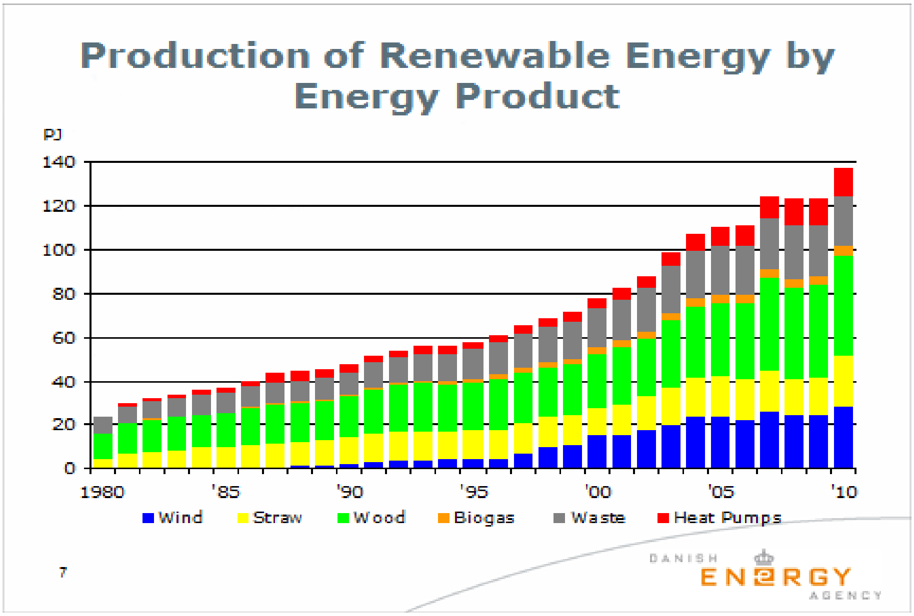

Fig. 4 Primary Energy Production by Energy Product

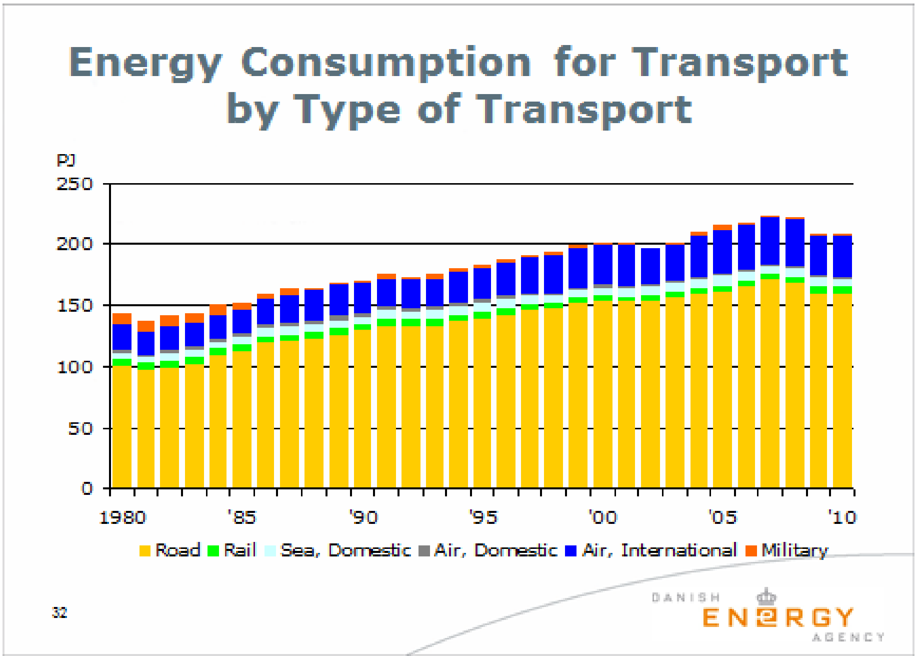

Fig. 5 Energy Consumption for Transport by Type of Transport

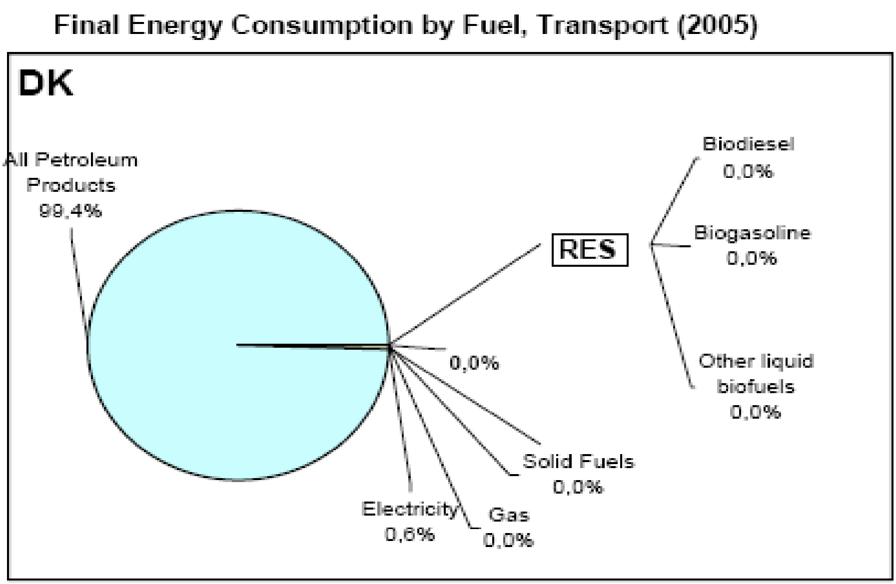

Fig. 6 Final Energy Consumption by Fuel, Transport (2005)

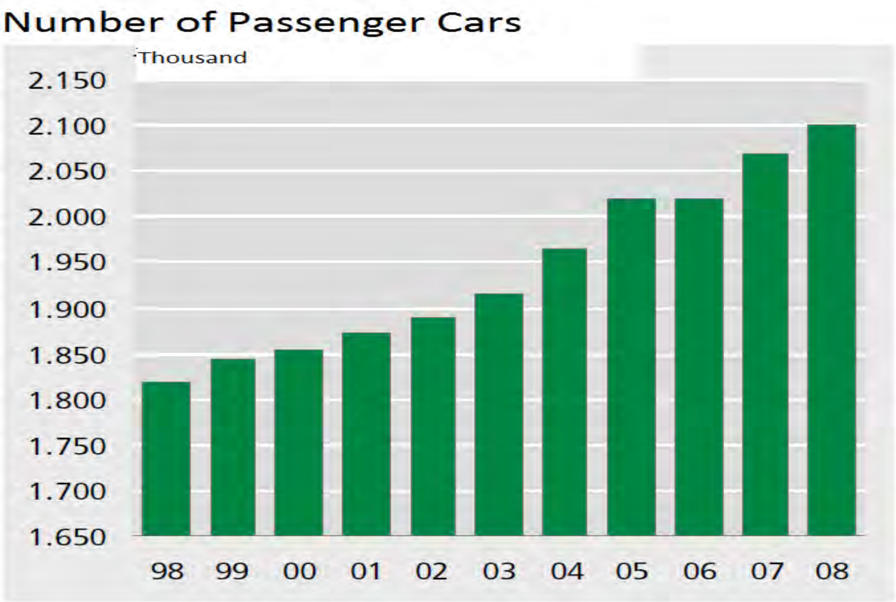

Fig. 7 Number of Passenger Cars in Denmark

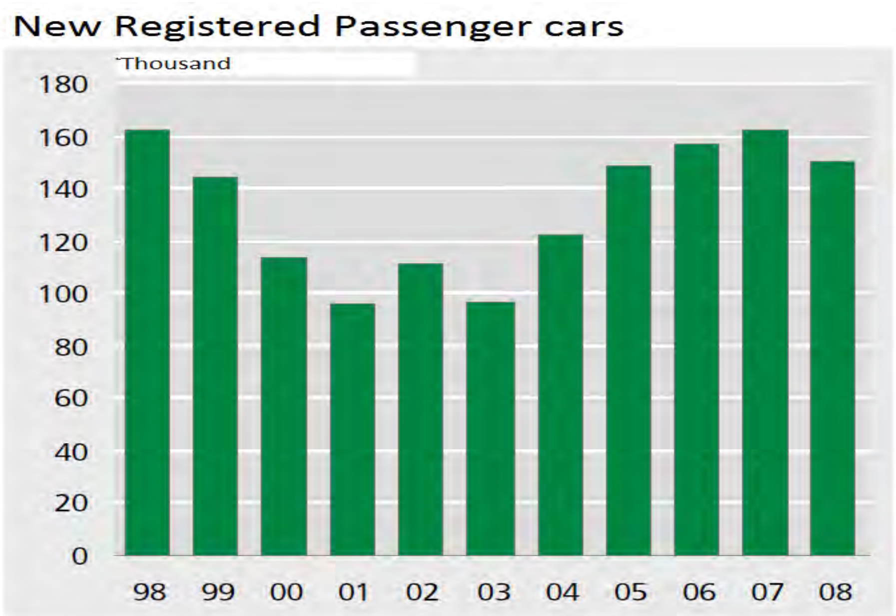

Fig. 8 Number of New Registered Passenger Cars in Denmark

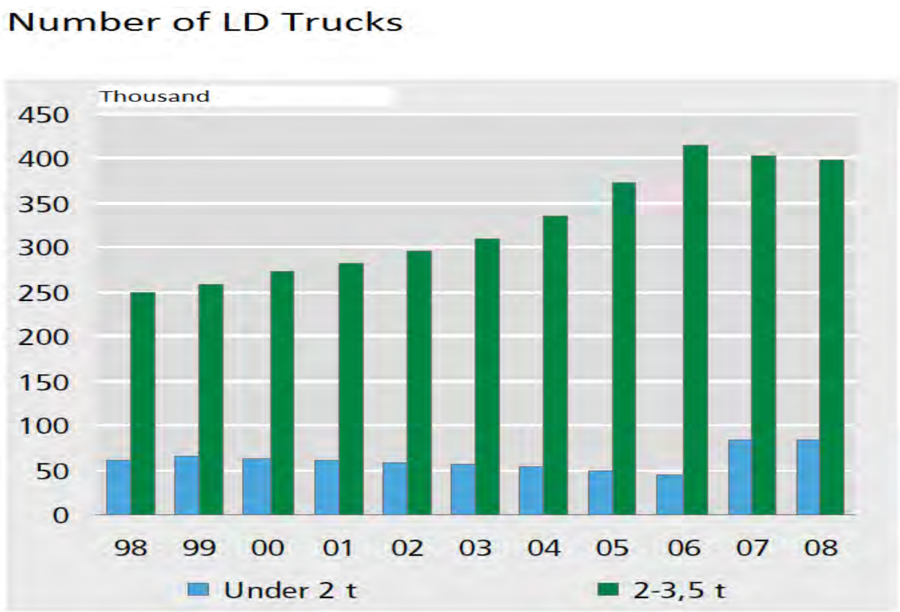

Fig. 9 Number of LD Trucks in Denmark

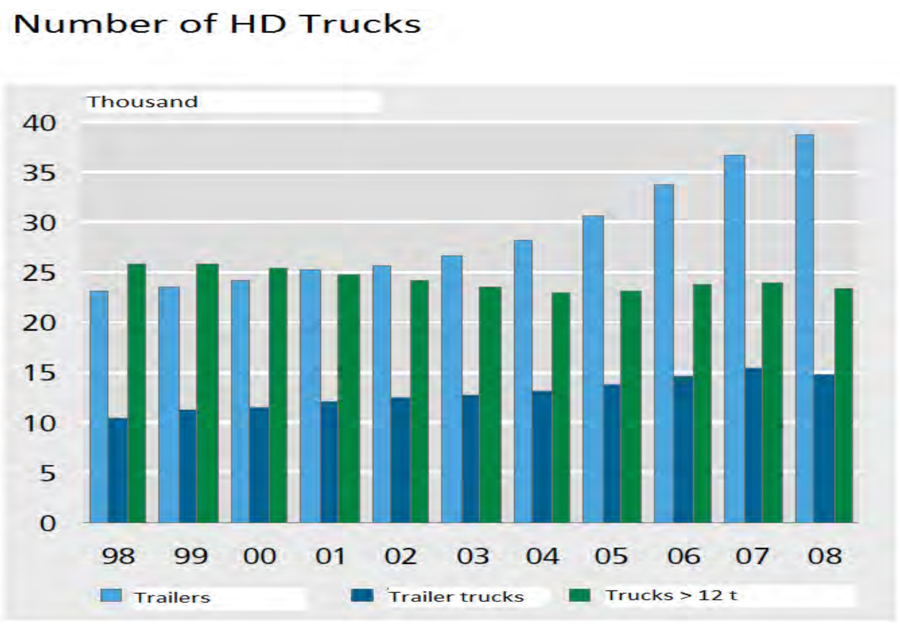

Fig. 10 Number of HD Trucks in Denmark

Outlook

The general trend in transport technologies will depend considerably on international efforts. However, the government will set in motion now what *can be* set in motion now, given that the transport sector must contribute to the government's goal of a 40% reduction in Denmark's emissions of greenhouse gases by 2020 compared with the 1990 level. As stated in the government coalition agreement, the government will present a proposal for a revenue-neutral reform of taxes on passenger cars, which underpins a holistic approach to the Danish transport sector's infrastructure and environmental challenges. The government will, moreover, present a proposal for a kilometer-based tax on lorries, part of the revenues from which will be used to invest in public transport, including making public transport less expensive. Furthermore, there is the Ministry of Transport's pool for initiatives to reduce energy consumption and carbon emissions in the transport sector.

In addition, a Danish Renewable Energy Directive includes an EU target of using 10% renewables in the transport sector by 2020. The Directive was implemented as part of Danish legislation in December 2010. Furthermore, an EU Fuel Quality Directive requires that cradle-to-grave emissions of CO_2 per energy unit must be reduced by 6% in 2020 compared with those in 2010.

The Energy Agreement includes a decision to amend the current Biofuels Act to ensure a mix that includes 10% biofuels by 2020. This is, however, pending analysis of alternatives that can help Denmark live up to its EU commitment. This analysis must be finalized in 2015.

Additional References

- http://www.ens.dk/en-US/policy/danish-climate-and-energy-policy/Sider/danish-climate-and-energy-policy.aspx

Finland

Introduction

In 2011, total consumption of energy in Finland amounted to 1 390 PJ (~33.2 Mtoe; ~386 terawatt hours [TWh]), which was 5% less than in 2010. 84.2 TWh of electricity was used. 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, with a total of 28% in 2011. Wood fuels represented around 80% of the renewable energy used. Bioenergy is used for heat and power production for industry and municipalities in general. In addition, peat is used for energy purposes, and wood is used for heating small houses. Directive 2009/28/EC sets a target of 20% renewable energy in the European Union (EU) by 2020. A national target of 38% is set for Finland. Carbon dioxide (CO_2) emissions from the production and use of energy totaled 51.7 tonnes of CO_2 in 2011 (Statistics Finland, www.stat.fi[1]).

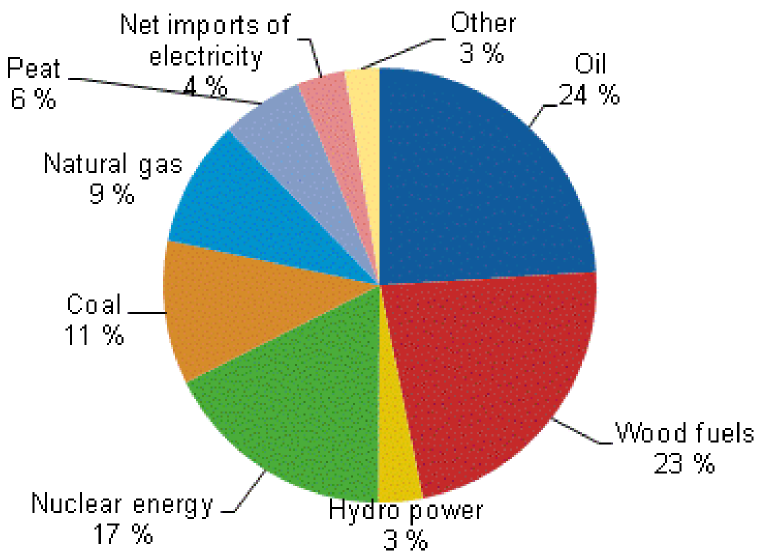

Fig. 1 Total Energy Consumption in Finland in 2011 (www.stat.fi[1])

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[1] Official Statistics of Finland (OSF): Energy supply and consumption [e-publication]. ISSN=1799-7976. 2011, Appendix figure 1. Total energy consumption 2011. Helsinki: Statistics Finland [referred: 4.6.2013].

Access method: http://www.stat.fi/til/ehk/2011/ehk_2011_2012-12-13_kuv_001_en.html. http://www.stat.fi/til/ehk/2011/ehk_2011_2012-12-13_tie_001_en.html.

Finland is a sparsely populated country with long distances. Transportation work per capita, for both people and goods, is among the highest in the world. Transportation consumed about 222 PJ of Finland's primary energy, which is around 16% of total energy consumption in Finland in 2011 (Figure 2; lipasto.vtt.fi, Statistics Finland).

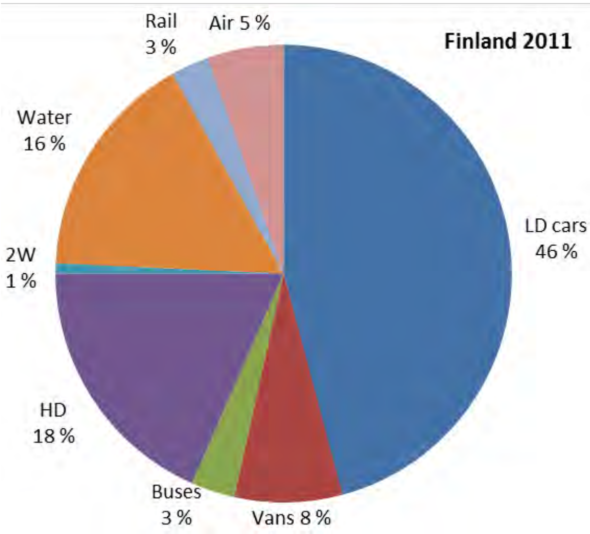

Fig. 2 Energy Consumption in Transport Sectors in 2011 in Finland (Figure by Aakko-Saksa; data by lipasto.vtt.fi)

Table 1 presents the types and numbers of vehicles in Finland in 2011. The total number of vehicles was approximately 3.48 million in 2011. At the end of 2011, around 1,500 flex-fuel vehicle (FFV) cars were capable of using high-concentration ethanol fuel (E85), and approximately 40 refueling stations carried E85. Also in 2011, there were around 850 natural gas vehicles (NGVs), and 18 refueling stations that carried methane (natural gas and biomethane).

Table 1 Types and Numbers of Vehicles in Finland in 2011[a,b]

Passenger Cars	Vans	Trucks	Buses	Two-Wheelers	Other Vehicles	Non-road
2,978,729	365,568	123,371	14,226	515,517	12,463	561,440
~2500 FFV passenger cars ~850 NGVs, of which 100 are buses and the rest are cars and vans ~131 electric vehicles ~550 passenger cars per 1000 inhabitants						

a *Share of diesel cars ~19%.*
b *Source: vehicles in use, www.stat.fi; NGVs Suomen Kaasuyhdistys ry.*

The dominant fuels are petrol and diesel. In 2012, of the total consumption of approximately 4.0 Mt, 40% was gasoline and 60% diesel. In total, the contribution from alternative fuels, including fossil fuel options, was around 250 ktoe in 2011. Ethanol is used both by itself and as fuel ethers (ethyl *tert*-butyl ether [ETBE] and ethyl *tert*-amyl ether [TAEE]). As for diesel, the bio portion consists mainly of hydrotreated vegetable oil (HVO) -type paraffinic renewable diesel fuel. The contribution to on-road fuels from biofuels fulfilling sustainability criteria was around 200 kilotons of oil equivalent (ktoe) in 2011 (non-road excluded). Table 2 presents the use of road transportation fuels in Finland.

Table 2 Use of Road Transportation Fuels in Finland[e]

Petrol[a] 2012 (Mt)	Diesel[b] 2012 (Mt)	Bioethanol & ethers (total/bio-portion)[c] 2011 (Mtoe)	Bio-origin diesel[b] (w/o non-road) 2011 (Mtoe)	Natural gas 2011 (Mtoe)	Bio-methane 2011 (Mtoe)
1.6	2.4	0.131/0.090[d]	0.109/0.107[d]	0.005	0.00027

a *95 octane petrol 0.86 Mt (E10); 98 octane petrol 0.71 Mt (E5) and 0.0049 Mt E85.*
b *Diesel contains mainly HVO as bio-component. Non-road biofuels not included.*
c *Ethanol is used partly as fuel ethers in Finland.*
d *Fulfills EU's sustainability criteria.*
e *Sources: Petrol, diesel: Finnish Oil and Gas Association; Biofuels: Finnish Customs, Biofuels Barometer 2011; Natural gas: Suomen Kaasuyhdistys ry; Biomethane: Suomen biokaasurekisteri n:o 15.*

Policies and Legislation

Finland has no financial incentives for biofuels for transport. However, as of the January 1, 2008, a national law requires 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 how best to 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 2010.

In 2010, biofuel consumption in the transport sector was close to the target of 4%.[2] The biofuels obligation law was amended in 2010 (1420/2010) to target 6% for 2011–2014 and then incrementally increase from 8% in 2015 to 20% in 2020 (values as share of energy). The preamble of the mandate stated that the 20% obligation in 2020 will partly be met by fuels eligible for double counting according to Directive 2009/28/EC, thus reducing the actual share to 15% (assuming a 50/50 split between conventional biofuels and biofuels eligible for double counting).

The EC (European Commission) proposed an update of the regulations for biofuels and new counting principles in October 2012 (COM [2012] 595), and the Finnish approach will be updated accordingly. In Finland, meeting a 20% biofuel target would mean some 730 ktoe of biofuels, or a lower amount when using “multiple-counted” biofuels. It is estimated that “double-counted” and/or “fourfold-counted” biofuels could be produced in Finland from wood residues in two to three large biofuel plants.

The Ministry of Transport and Communications presented its 2020 climate policy for the transport sector in 2009. This policy assumes that the use of biofuels will yield a 10% reduction in GHG emissions by 2020 and states that the most efficient measure to cut GHG emissions is the renewal of the passenger car fleet with fuel-efficient vehicles. Finland’s goal is to achieve average CO_2 emissions of 143 g/km for all cars and of 95 g/km for new cars by 2020. The long-term (2050) energy and climate policy, presented in 2009, calls for energy efficiency, use of biofuels, and electrification of transport. The target for the average fossil CO_2 emission of the passenger car fleet is set at 20–30 g/km for 2050.

[2] TEM/1104/08.10.02/2012, 3 May 2012.

Taxes

In Finland, financial incentives have not been used to promote alternative fuels. A fuel tax reform came into force on January 1, 2011, and was fully implemented in 2012 and 2013. The new taxation system takes into account volumetric heat value, CO_2 emissions, and local emissions (such as nitrogen oxides and particulate matter). The low volumetric heating value of biofuels, such as ethanol, is compensated. Biofuels are exempted from the carbon component tax, depending on their ability to reduce well-to-wheel GHG emissions. A bonus is given for paraffinic diesel fuel and methane because of their low local emissions. Before the tax reform, natural gas was almost totally tax-exempt.

Since 2008, the passenger car purchase tax has been based on tailpipe CO_2 emissions. On April 1, 2012, the system was slightly revised. The minimum tax is now 5% (0 g CO_2/kilometer [km], meaning battery electric vehicles), and the maximum is 50% (360 g CO_2/km or more). In addition, the annual vehicle tax is linked to CO_2 emissions; the new range is 43–606 €/a (CO_2 0–400 g/km). The CO_2-based purchase tax has been an effective instrument in reducing the CO_2 emission of new passenger cars: the average value dropped from some 180 g/km in 2007 to below 145 g/km in 2011.

The annual vehicle tax comprises a base tax and a “fuel-fee” tax, depending on the energy source. The fuel-fee tax is imposed on vehicles that are propelled by an energy source other than a fully taxed gasoline motor. This tax changed in January 2013 so that the annual fuel-fee tax for a 1500-kg car would be 301 € for diesel, 82 € for electricity, and 170 € for methane.

Tax exemptions have been granted for demonstration projects on biofuels. This is the case for the large bus fleet demonstration with HVO.

Research Programs

Special funds have been made available to stimulate research and demonstration of next-generation biofuels.

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

In 2013, a new research program called TransSmart was started by VTT. TransSmart (Smart Mobility Integrated with Low-carbon Energy) will focus on four core areas: low-carbon energy, advanced vehicles, smart transport services, and transport systems. VTT's new program combines energy-efficient solutions, advanced vehicle options, information technologies, and consumer aspects to build up sustainable transport systems for the future. Demonstrations on new low-carbon fuels and advanced vehicles will continue within this new framework. The "BioVerno," which is wood-based biofuel manufactured by the Finnish pulp and paper company UPM, will be demonstrated. The "BioVerno" biofuel is produced from crude tall oil by hydrotreatment. A dual-fuel concept, in which methane (natural gas or biomethane) is used in diesel engine with pilot injection of diesel fuel, is optimized for a combination of biomethane and renewable diesel as a pilot fuel. Biomethane from the national gas company Gasum and NExBTL renewable diesel from national oil company Neste Oil will be demonstrated. Ethanol from national energy company, St1, will be demonstrated as fuel for heavy-duty transport in special vehicles. Demonstrations will involve a large number of companies, end-users, and public bodies.

Tekes has launched a research program dedicated to electric vehicles. The program, called EVE, will run from 2011 to 2015. The total volume of EVE program is some 80 M€, with a contribution of 37 M€ from Tekes.

Biofuels were part of the national research program BioRefine, which was financed by the Tekes (http://www.tekes.fi/ohjelmat/biorefine). Within this framework, the pulp and paper company Stora Enso, the national oil company Neste Oil, and VTT Technical Research cooperated to develop wood-based biomass-to liquid (BTL) fuels. There are also other consortia on BTL fuels.

Tekes has a research program on fuel cells, but this program is mainly devoted to sectors other than transport.

Implementation: Use of Advanced Motor Fuels

Hydrotreated Oils and Fats

Hydrotreated oils and fats, or HVO, is a dominating biocomponent in Finland. Neste Oil's proprietary NExBTL[3] technology is a refinery-based hydrotreatment process that uses, for example, vegetable oils and animal fats as a raw material. Neste Oil's total NExBTL production capacity is close to 2 Mt/a (in Finland ~380 kt/a, in Singapore and in Rotterdam ~800 kt/a each). Production of NExBTL is mainly based on palm oil and animal fats. In 2011, the percentage of waste and residues in NExBTL production was 40.3%, and the percentage of non-food feedstocks is expected to increase in the future. Neste Oil's pilot plant for producing microbial oil (see the "Outlook" section) exemplifies one approach to reaching this goal.

Neste Oil markets diesel with a minimum of 15% NExBTL under the name "Neste Pro Diesel" in Finland. A demonstration project using NExBTL in some 300 buses in the Helsinki metropolitan area was organized in 2007–2010. Test fuels consisted of a 30% blend of NExBTL and neat (100%) NExBTL. Neat NExBTL reduced NO_x emissions by 10% and particulates by 30% compared to conventional diesel fuel. The fuel used in this demonstration project was exempt from fuel tax, which amounted to a tax incentive of 7.2 million Euros.

FAME

Minor amount of conventional esterified biodiesel (FAME) is used. RME (rape methyl ester) has been produced on small scales, mainly on farms. In 2005, approximately 1 000 tons were produced.

Bio-ethers

Neste Oil has processed ETBE since 2004. In 2011, 59 ktoe of bioethers, mainly ETBE and TAEE, were blended in petrol in Finland. The ethanol contained in ETBE is imported and the end product is mixed with petrol; the bioenergy portion of these ethers represented 20 ktoe.

Bio-alcohols

Petrol containing 10 vol-% ethanol (E10) was launched in 2011 in Finland. In the beginning, sales of E10 were low because of a lack of consumer acceptance. Now, E10 sales are around 55%, whereas 70% of petrol cars are

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[3] 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 specifications for diesel fuel can be met with blends containing up to about 30% NExBTL. Paraffinic diesel fuel is covered by a European pre-standard (CWA 15940).

E10 compatible. St1 also sells a high-concentration ethanol, RE85, at 36 refueling stations in Finland. The hydrocarbon part of the RE85 is a special mix targeted to operate well at low ambient temperatures. FFV cars and St1's RE85 were introduced to the Finnish market in the spring of 2009. At present, around 2500 FFVs are operating in Finland.[4]

The energy company St1 is focusing on decentralized production of fuel ethanol from side streams from the food industry, by using a process called Etanolix. Waste is converted into an ethanol (85%) -water mixture at food industry sites and then concentrated to 99.8% purity. St1 also has a centralized dehydration facility in Hamina that has a capacity of 88 000 m^3/a (~45 ktoe). Five decentralized ethanol units are running with production capacity of 750–2000 t/a per unit. In 2012, a Bionolix™ unit in Hämeenlinna was combined with a biogas production plant to convert side products of ethanol into green energy, by using biowaste from households. The total production of fuel bioethanol in Finland was some 7 ktoe in 2011.

The majority of bioethanol consumed in Finland is imported.

Natural Gas and Biomethane

The first natural gas buses were introduced to Helsinki in 1996. Currently, a total of about 800 vehicles — consisting of some 100 natural gas buses, 10 heavy-duty vehicles, and 700 cars and vans — are running on natural gas in Finland. However, a bus company, Helsingin Bussiliikenne, that owns 47 natural gas buses announced that it was considering giving up natural gas buses because of high operating costs. There are 18 public natural gas refueling stations, and construction of new stations is continuing. In addition, Gasum Oy, the national gas company, markets, sells, and services the "FuelMaker," a home refueling appliance. Natural gas is imported to Finland from Russia.

In 2011, biomethane was introduced into the natural gas transmission network in Finland by Gasum. Biogas is manufactured at the Kymen Bioenergia Oy biogas facility in Kouvola and upgraded by KSS Energia Oy. Nineteen thousand tonnes of wastewater sludge, biowaste, and biomass will produce around 15 gigawatt-hours (GWh) of biogas energy for electricity, heat, digestion residue to make agricultural fertilizer and biomethane for use in vehicles. Biomethane is sold at Gasum's filling stations in southern and southeastern Finland. Gasum and the Helsinki Region Environmental Services Authority (HSY) cooperate to produce biomethane for use as a

[4] FFV classification was not systematically registered for the Euro 4 car models, which may lead to underestimation of FFV car population.

public transport fuel. In 2012, up to 50 local buses had access to biomethane produced locally from wastewater by the Suomenoja wastewater treatment plant. The new upgrading facility produces up to 20 GWh (1.7 ktoe) of biomethane. So far, the sludge produced as a wastewater treatment plant by-product has been used to generate electricity and heat used by the plant.

Liquefied Petroleum Gas – LPG

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

Electric and Hybrid Vehicles

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

One of Tekes' research programs, EVE, is dedicated to electric vehicles (http://www.tekes.fi/programmes/EVE). Over the next few years, a test bed consisting of an estimated 400 EVs and 850 charging points will be created in Helsinki, Espoo, Kauniainen, Lahti, and Vantaa (http://sahkoinenliikenne.fi). The first Finnish demonstration of fully electric buses started in Espoo in 2012. The electric bus fleet of Veolia Transport Finland is expanding with rented buses from Portugal, China, Sweden, and the Netherlands. In addition, manufacturers will test electric buses in Finnish weather conditions (meaning there will be a 50°C difference between summer and winter temperatures).

VTT and Helsinki Metropolia University of Applied Sciences have built an electric test bus based on Kabus Oy's lightweight bus chassis, to accelerate the development of Finnish components for future EVs and machinery, battery systems, and components of various types.

The Finnish car manufacturer Valmet Automotive, which formerly assembled Porsche sports cars and has now begun manufacturing the new Mercedes-Benz A Class, has announced a strategy for EVs. In 2009, Valmet Automotive had already started manufacturing the small Think City car and a luxury golf cart called Garia. In 2011, Valmet Automotive started producing the luxury Fisker Karma plug-in hybrid.

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

Hydrogen

At present, there are no significant activities on hydrogen in Finland. Demonstration of fuel cell–powered working machinery will commence in the harbor of Helsinki in 2013.

Outlook

Bioethanol and HVO renewable diesel will be increasingly used as biofuels in Finland.

Ethanol produced by St1 from the side streams of the food industry and from separately collected biowaste in Finland is increasing from its current 7 ktoe/a. In addition, St1 is broadening its feedstock sources to include straw and waste fibers. St1 is planning to construct an ethanol plant in Kajaani that will use sawdust by 2015. This plant would produce around 5 ktoe/a ethanol. The target for 2020 is to produce some 150 ktoe bioethanol (300 000 m^3) per year. St1 also plans to expand its RE85 distribution chain in Finland.

The total production capacity of Neste Oil's NExBTL (HVO) is already close to 2 Mt/a (Finland, Singapore, and Rotterdam). In 2012, Neste Oil built a pilot plant for producing microbial oil. The goal is to develop the technology to the point where it is capable of yielding commercial volumes of microbial oil for use as a feedstock for NExBTL renewable diesel. A wide range of different waste and residue materials can be used, such as straw and sidestreams from the pulp and paper industry, which makes feedstock optimization possible. Commercial-scale production is expected by 2015 at the earliest.

The Finnish pulp and paper company, UPM, is building a biorefinery in Lappeenranta that will use hydrotreatment to produce biofuels from crude tall oil. The biorefinery will annually produce approximately 100 kt/a of advanced hydrotreated biodiesel for transport. Construction of the biorefinery started in 2012 and is expected to be complete in 2014.

In the long term, cellulosic BTL is expected to cover a significant share of the diesel pool in Finland. Three consortia in Finland applied for NER300 funding from the European Commission in 2011. Finland's state-owned energy company, Vapo, was awarded 88.5 million euros for a wood-based biodiesel plant in northern Finland (Kemi) that would produce renewable fuels around 100,000 t/a. In addition, UPM was awarded 170 million euros for a solid wood-based biorefinery project in Strasbourg, France. Vapo and UPM will make investment decisions within the next 18 months. NSE Biofuels Oy demonstrated its technology in the pilot plant from 2008 at the Stora Enso Varkaus Mill.

There is increasing interest in the use of biomethane for transport. Biomethane is currently injected into the natural gas grid, and up to 50 local buses have access to biomethane produced in the Suomenoja wastewater treatment plant. Gasum also has other biomethane-related projects, including plans to produce large-scale wood-based bio-SNG. In total, production of biogas could be around 150 ktoe in 2016. LNG infrastructure is currently being built up in Finland for marine transport as a result of upcoming sulphur regulations. This offers an opportunity to consider LNG options for long-haul and heavy-duty transport.

Benefits of Participation in the AMF IA

Finland has been involved in a number of projects and studies within the AMF IA. The 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. Executive Committee working principles, when combined with diverse cost-sharing or task-sharing routes, offer suitable options for a variety of purposes. AMF generates and synthesizes information, which is of primary importance for research and development, as well as for decision-making bodies. Finland, with its ambitious targets for biofuels in transport, really needs solid data for decision-making.

The IEA Advanced Motor Fuels Implementing Agreement is a unique collaboration forum covering simultaneously the whole spectrum of advanced motor fuels, from fuel production to end-use. A network of world-class experts representing different types of organizations and expertise allows for multidisciplinary synthesis and analysis of a complex field of different technologies and policies in the transport sector.

In December 2012, in conjunction with the annual seminar of the TransEco research programme, VTT arranged a special session on international cooperation. In this session, activities of the AMF IA, Bioenergy, Combustion, and Hybrid and Electric Vehicles were presented. In addition, Co-Nordic cooperation was discussed.

France

Introduction

France, like the rest of the world, faces the twin challenges of climate change and excessive dependence on fossil fuels. Transport is responsible for close to one-quarter of greenhouse gas (GHG) emissions in France and in Europe. It is therefore vital to find ways to reduce these emissions.
To define the key points of public policy that are required to reduce these emissions, the French government initiated the Grenelle Environment Round Table, which is a very ambitious plan for the transportation sector. A key objective is to reduce average carbon dioxide (CO_2) emissions per kilometer from 170 g to 130 g by 2020 from total vehicle park.

Policies and Legislation

Incentives to promote use of renewable energy in transport
Under the National Action Plan for Renewable Energy, following the Grenelle de l'environnement, a number of incentives have been introduced to promote the use of energy from renewable resources in the transport sector.

At a conference on the environment in September 2013, the government confirmed that it would phase out subsidies for first-generation biofuels by 2015 instead of 2018, as promulgated by European regulations. The incorporation rate of first-generation biofuels will be limited to 7% (on a LHV-equivalent basis) in gasoline and diesel, compared to the 10% in force since 2005. This slight reduction does not include the financial support for the sector until 2015, and the process of granting biofuels a tax exemption will continue. However, the threshold of 10% renewable energy in transport by 2020 set by the climate and energy package adopted in 2008 remains valid.

Objectives for biofuel blends:

- On April 1, 2009, the new SP95-E10 fuel was launched in the gasoline sector; the corresponding ethanol incorporation rate is 10% maximum in gasoline. This product has been approved for sale in service stations since 2009; from 2013 onward, it will be the standard. The deployment of E10 was progressive. In 2012, sales of SP95-E10 were greater than those of SP98, with a market share of 24% of gasoline sold. The increase in 2012 was 35%. This fuel, more and more present on the market today, is distributed in almost 35% of service stations and has been confirmed as the European standard gasoline. Currently, more than

80% of the French fleet is compatible with SP95-E10, as are almost all petrol vehicles registered since 2000.

- Fuels with high levels of biofuels have been authorized, including E85 in the gasoline sector and B30 in diesel fuel production. In 2012, E85 experienced sales growth of 41%. With a pump price of 0.93 €, E85 saves about € 20 per tank of gas produced. This economy is an advantage and promotes interest in flex-fuel vehicles (FFVs) available on the market. Even though sales of flex-fuel vehicles have increased by 12%, with more than 7,000 vehicles sold, and the car market as a whole fell 18% over the same period, this sector remains marginal.
- At present, texts on fuel quality state that the maximum rate of incorporation for biodiesel and ethanol is 7% and 10% by volume, respectively.
- According to RED (Renewable Energy Directive), the biofuels produced from used vegetable oils or from animal greases (capped at up to 75 kt [kilotons] per year) have doubled their LHV value since 2009.

Fiscal incentive schemes:

- A tax exemption is granted to biofuels. It complies with European Directive 2003/96/EC on the taxation of energy, which allows Member States to have a special tax for biofuels to ensure their development and promotion.
- There is a general tax on polluting activities—taxe générale sur les activités polluantes (TGAP)—the purpose of which is to enable the government to achieve its objectives for biofuel. This is an additional levy of TGAP that must be paid by the operator-distributors (refiners, supermarkets, and independents) that sell fuel containing a proportion of biofuels (LHV-based) that is lower than that stated in the national incorporation goals. This tax rate goal increased every year: from 1.75% in 2006 to 3.5% in 2007, 5.75% in 2008, and 6.25% in 2009. It was set at 7% in 2010 and remains unchanged for 2012. The 9 March 2012 circular precisely calculated the mode of the TGAP due by the distributor.
- There is a domestic tax on consumption—taxe intérieure sur la consommation (TIC)—that aims to reduce the extra cost of manufacturing biofuels compared to fossil fuels. This is a partial tax exemption of TIC for biodiesel and bioethanol and a total exemption for pure vegetable oil used as fuel for agriculture and fishing. The Financial Laws of 2010 and 2011 establish a progressive reduction of the tax exemption for biofuels: the rate of tax exemption of 21 €/hl (US $277/$m^3$) for bioethanol industry and 15 €/hl (US $198/$m^3$) for the biodiesel industry in 2009 decreased to, respectively, 18 €/hl and 11 €/hl (US $237/$m^3$ and $145/$m^3$) in 2010 and 14 €/hl and 8 €/hl in 2011

(US \$185/m^3 and \$106/m^3). In addition, the tax applicable to super-ethanol E85 is lowered: from 29 €/hl (\$US 383/m^3) to 23.24 €/hl (US \$307/m^3) in 2011. These rates will be maintained in 2012 and 2013.

Measures to encourage fleet renewal:
The ecological tax for the purchase of new vehicles will change by expanding its scale, beginning January 1, 2013. The maximum bonus increased to 7000 Euros (US \$9174), beginning on August 1, 2012, and continues in 2013. Beginning January 1, 2013, the purchase of a new vehicle will always be subject to the principle of bonus-malus, but with a modified scale. Among the major changes, the threshold for passage of bonus to malus is set at 140 g instead of 135 g of CO_2 per kilometer (Table 1). The objective of the bonus-malus system is to begin the ecological transition through measures to encourage individuals to acquire low-emission vehicles and to stimulate technological innovation builders, as stipulated in the Finance Act 2013.

Table 1 Changing Scales

CO_2 Emissions/km	Bonus from 1 January to 31 July 2012	Bonus since August 1, 2012	CO_2 Emissions/km	Malus in 2012	Malus in 2013
Less than or equal to 20 gCO_2/km	5000 €	7000 €	Less than or equal to 135 g	0 €	0 €
			Between 136 and 140 g	0 €	100 €
Between 21 and 50 gCO_2/km	5000 €	5000 €	Between 141 and 145 g	200 €	300 €
			Between 146 and 150 g	200 €	400 €
Between 51 and 60 gCO_2/km	3500 €	4500 €	Between 151 and 155 g	500 €	1000 €
			Between 156 and 175 g	750 €	1500 €
Between 61 and 90 gCO_2/km	400 €	550 €	Between 176 and 180 g	750 €	2000 €
			Between 181 and 185 g	1300 €	2600 €
Between 91 and 105 gCO_2/km	100 €	200 €	Between 186 and 190 g	1300 €	3000 €
			Between 191 and 200 g	2300 €	5000 €

CO_2 Emissions/km	Bonus from 1 January to 31 July 2012	Bonus since August 1, 2012
Between 106 and 110 gCO_2/km	0 €	0 €
More than 110 gCO_2/km	0 €	0 €

CO_2 Emissions/km	Malus in 2012	Malus in 2013
Between 201 and 230 g	2300 €	6000 €
More than 230 g	3600 €	6000 €

Environmental bonus for hybrid vehicles:
The aid applies only to hybrid vehicles with CO_2 emissions below 110 g/km. Since July 25, 2012, the maximum amount of aid is € 4,000 (US $5242), limited to 10% of the cost with a minimum guarantee of € 2,000 (US $2621). Thus, the buyer of a hybrid car with a selling price of € 18,500 (TTC) (US $24,245) will still be entitled to a bonus of € 2,000 (US $2621). Buyers of plug-in hybrid cars with CO_2 emissions less than or equal to 60 g receive assistance of € 4,500 (US $5897).

Environmental bonus for liquefied petroleum gas (LPG) vehicles:
Aid for the acquisition or transformation of a LPG vehicle was abolished in 2011. Aid for the purchase of this vehicle is subject to the same conditions as aid for the purchase of clean vehicles running on gasoline or diesel.

- Support for electric vehicles:
  - *Electric cars and vans:* Buyers of electric cars are eligible for the highest levels of environmental bonus, if the vehicle emits less than 20 g of CO_2; electric cars (M1) and light trucks are eligible under the super bonus offers for € 7,000 (US $9174), but the amount cannot exceed 30% of the purchase price (including vehicle tax plus the cost of the battery if it is rented). The bonus will be set at € 5,000 (US $6553) if the vehicle emits less than 50 g of CO_2.
  - *Tricycles and quadricycles:* In 2012, the ADEME aid given to buyers of quadricycles corresponds to 18% of the purchase price, up to a maximum of € 1800 (US $2359) for the first 50 vehicles produced. For the purchase of 150 vehicles, the aid is reduced to 9% of the purchase cost and limited to a € 900 (US $1180) maximum before aid is 0% after the purchase of 200th vehicle.
- The scrapping premium was set up in late 2008 and abolished in 2011. A new device is being studied in the government that is similar to a conversion premium. Its objective is to encourage people to dispose of the old diesel cars, which are considered hazardous to health. They represent 27% of the existing fleet.

- Bonus-malus budget: According to figures released by the Ministry of Ecology, the bonus-malus policy on the purchase of automobiles had reached equilibrium in 2012, for the first time since its inception in 2008.

Research and Development (R&D) in transport sector

Public support for innovation and R&D deployed within competitiveness clusters results in the following:

- Financial support via the single interdepartmental fund (Fond Unique Interministériel, FUI), involving various partners, such as the L'Agence Nationale de la Recherche ANR (see Carnot device), OSEO, or Caisse des Dépôts participating in project financing and ADEME.
- Tax exemptions for companies with a group involved in an R&D project financed by the government.

Public support is also enabled by the Demonstrator Fund for research on new energy technologies (NET), which aims to fund research demonstrators, and by the important program "véhicule du futur des investissements d'avenir," which is managed by ADEME for the government (CGI). Some examples can be cited in the areas of advanced biofuels and the development of electric vehicles and plug-in hybrids.

Advanced biofuels:

All biofuels currently consumed are produced by first-generation processes, which value the storage organ of the plant (grain, fruits, and tubers). Second-generation processes are designed to produce "sustainable" biofuels, which are made from the whole plant tissues of a wide range of agricultural and forestry materials, or from the waste and residues of these industries, dedicated crops, and waste organic materials. Other processes could benefit from microalgae or microorganisms capable of producing high biomass, or from oil converted into biodiesel, with improved energy and environmental balance. In France, challenges in the development of these industrial sectors are considerable—they include reducing GHG emissions in transport, limiting energy dependence, and creating new economic activities.

Several projects in France that aim to remove a number of scientific and technical bottlenecks are summarized below.

- *Futurol: lignocellulosic ethanol production through the thermochemical process.* This project seeks to develop and market processes, technologies, and products for producing second-generation bioethanol—not only from dedicated energy crops, but also from agricultural and forestry by-products, green waste, and other lignocellulose-containing biomass. Approved by the competitiveness cluster with global reach, Industries and Agro-Resources (IAR), the Futurol Project requires a total investment of 74 million euros (US $97) and has received support from OSEO (the French state innovation agency) for an amount of € 29.9 million (US $39). The 8-year project timeline is centred on the implementation of a lab-scale pilot, followed by an industrial pilot, in parallel with ongoing R&D work.

- *BioTfueL: project that aims to develop and bring to market by 2020 a chain of processes for producing second-generation biodiesel and biokerosene through thermochemical processes.* These processes will be used, alone or in combination, in all types of diesel engines and turbojet aircraft. The project involves a sequence of individual steps: gasification of the biomass, purification of the syngas produced, Fischer-Tropsch synthesis, and hydro-isomerisation to produce hydrocarbons. Selected under the "biofuels 2nd generation" Demonstrators Fund and supported by ADEME and the Regional Council of Picardy, BioTfueL brings together R&D organizations (IFP Energies nouvelles and CEA) and industry (Axens Sofiprotéol, Total, and ThyssenKrupp Uhde) around a complete chain of production for kerosene and synthetic diesel biomass-to-liquid (BTL). The project integrates all of these steps. By 2017, it should result in the development of an integrated, competitive, and sustainable process that enables project participants to deal with other biomass resources, such as petroleum or coal residues. The budget of this project is 112.7 million Euros (US $148), with 33.2 million (US $44) of public funding (ADEME Demonstrator Fund and region Picardie).
- *Gaya: bioSNG (synthetic natural gas made of renewable resources) production through a thermochemical process (biomethane fuel by gasification followed by methanation).* This research demonstrator, selected under the "second generation biofuels" Demonstrator Fund, explores the full chain of bioSNG production. This project, which is supported by the EC, aims to demonstrate a commercial pathway for gasification and methanation of residues (e.g., wood, straw) to produce synthetic biomethane at the industrial scale. This 7-year project began in June 2010 and brings together 14 partners. Public support amounts to $18.9 million (total budget 46,5 M€ [US $61 million]). The GDF SUEZ group will coordinate this project and will involve subject matter experts (SMEs) and public research organizations.
- *Salinalgue: culture and seaweed processing.* The objective is to structure a sustainable business culture and microalgae recovery. The project aims to control the culture and harvesting of microalgae that is highly recoverable on a massive scale in an open environment (open tank) on untapped salts. In addition, the project integrates biorefinery activity in order to manufacture and commercialize bioproducts

(biodiesel, biogas, molecules with high added value: beta-carotene, omega 3, etc.) and protein for aquaculture. A demonstrator will validate the pre-industrial technical and economic feasibility of production chain. This project is funded by the FUI (France-UK-Ireland) and Collectivités Territoriales. The project is managed by Compagnie du Vent, groupe GDF-Suez; research partners include IFREMER (Institut français de recherche pour l'exploitation de la mer), INSA Toulouse (Institut National des Sciences Appliquées of Toulouse), Green University, CEA Marcoule (Commissariat à l'Energie Atomique et aux Energies Alternatives), SupAgro, Inria, and Tour du Valat; industrial partners include IDEE Aquaculture, Air Liquide, and Naskeoand. The project budget is 6 800 k€.

Electric vehicles and plug-in hybrids:
Vehicle electrification has great potential to reduce fuel consumption, limit environmental impacts, and diversify energy sources. Many projects aim to eliminate existing technical barriers. Some examples are listed below.

- *The project HyHIL (Hybrid Hardware-in-the-loop), part of the research on hybrid vehicles.* This project is supported by the FUI and the Mov'eo worldwide competitiveness cluster and is being developed by a range of partners, including IFP New Energies, D2T, the Electrical Engineering Laboratory of Grenoble, LMS (learning management system), and Renault. This project's goal is to develop a suite of software tools that can be used to predict and optimize the performance of a hybrid power train and validate it in advance on a high-dynamic engine test bench before any testing is performed on a vehicle. It is thus a future test platform dedicated to the development of hybrid vehicles. The overall budget is 2.2 M €, of which 0.9 k € comes from public funding.
- *The ANR e-MECA project.* This project — launched in 2011 and coordinated by Valeo — is aimed at developing innovative solutions for ultracompact electric powertrains with a high specific power. This type of machine offers significant potential for mass production at affordable prices. The industrial partners involved in the project are Valeo and SKF (Svenska Kullagerfabriken); research laboratories include Satie, Dynfluid, and Tempo together with IPFEn. ANR funding is 1,5 M €.
- *The SYNERGY project.* How can CO_2 emissions and pollutants from diesel engine cars be reduced simultaneously? Answering this question is the goal of the SYNERGY project. Currently, experimental studies are being conducted to optimize the system and its settings to achieve the ambitious target of reducing CO_2 emissions by 20%. IFP Energies nouvelles (coordinator), Renault, Faurecia, Valeo, Delphi, Ecole Centrale Nantes, Mechadyne, and Honeywell are associated with this ANR project. The project has been approved by the competitiveness

clusters Mov'eo and Vehicles of the Future. Its overall budget is 3.8 M €, of which 1.6 M € comes from public funding (ANR).

- *Competitiveness clusters.* The role of competitiveness clusters is central in the field of transport. It is an important tool to support that sector, which consists of companies such as Mov'eo (automobile) and Lyon Urban Trucks and Bus (LUTB) (heavy trucks).
- *The IEED Institute project (institutes of excellence in low-carbon energies); Institute for Communicative Carbon-free Vehicles and their Mobility (VeDeCoM).* This project is supported by the Mov'eo worldwide competitiveness cluster and the local government (Council of Yvelines) and is in the field of land transport and ecomobility. The center will receive an allocation of 54.1 million euros. The ANR is the public operator in charge of IEED centers.

In the field of IEED, we must also mention the Picardie Innovations Végétales, Enseignements et Recherches Technologiques (PIVERT) project, a collaborative platform dedicated to vegetable chemistry based on oleaginous biomass (rapeseed, sunflower, etc.). This future refinery will use local agriculture and forest resources of the Picardie region. The budget will be 220 M € over 10 years.

Concerning the Fund demonstrators, the following must be emphasized:

- *VELROUE (Véhicule Utilitaire Léger hybride bi mode).* This project was developed by Michelin, Renault, and IFP New energies. In support of the project developers, a research demonstrator tested a commercial vehicle concept equipped with dual-mode rear engine-wheels. The VELROUE is a hybrid based on the Renault Kangoo with electric motors driving the rear wheels to provide an all-electric mode for city use. This program is accredited by ADEME as part of the Grenelle Environment.
- *Hydole (hybride à dominante électrique).* This project was developed by PSA (Peugeot S.A.), EDF (Electricite de France SA), Freescale, Leroy Somer, CEA (French Alternative Energies and Atomic Energy Commission), and IFP Energies nouvelles. Participants seek to evaluate the potential of a new concept of a dual-mode plug-in hybrid electric vehicle (pure electric and hybrid).
- *TIGRE (Technologies Innovantes pour Grands Routiers Économes).* This project was developed by Renault Trucks. Partners include Plastic Omnium, Michelin, Tenesol, Renault, IFP Énergies nouvelles, CEP, CETHIL (The Center for Thermal Sciences of Lyon), and LMFA (Laboratoire de Mécanique des Fluides et d'Acoustique). Project participants seek to develop innovative technologies in several areas simultaneously (e.g., kinematic chain [engine, gearbox, bridge],

aerodynamics, low rolling resistance, and driving aids) to be adapted to all types of vehicles (road, urban, and hybrid) and promote the growing integration of electricity.

Other

In the field of air transport, additional R&D is conducted in cooperation with European partners, particularly research on alternative powertrains, combustion, and low-carbon fuels. Examples of projects in the aviation sector include Alfa-Bird, SWAFEA (Sustainable Way for Alternative Fuels and Energy for Aviation), Timecop, and Kiai, among others.

Germany

Introduction

Figure 1 shows Germany's 2012 consumption levels (in percentages by weight), with the following ranking: diesel, gasoline, renewables, LPG and natural gas.

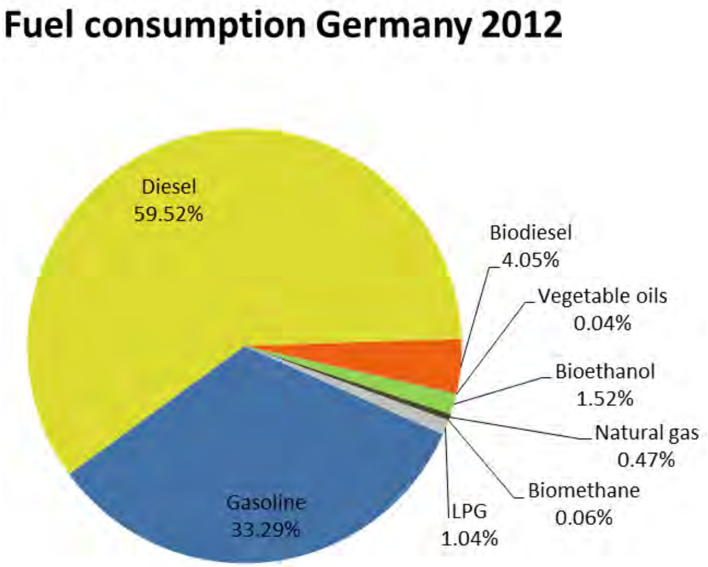

Fig. 1 2012 Consumption Levels of On-Road Transportation Fuels (%-weight) in Germany (Source: BAFA/erdgas mobil/ DVFG/ FNR [Fachagentur Nachwachsende Rohstoffe])

In 2012, German fuel consumption for use in road transport amounted to 53.1 million tons (mt), including biofuels. Of this amount, 17.2 mt of gasoline and 31.3 mt of diesel were consumed (excluding biofuels incorporated). The consumption of biofuels amounted to 3.8 mt (5.67% (energy content) of German fuel consumption), with the majority being low-level blends of biodiesel (2.3 mt) and bioethanol (1.1 mt). Quantities of other biofuels consumed in 2012 were pure biodiesel (131 kilotons [kt]); ethyl tertiary butyl ether (ETBE), the additive for motor gasoline (142 kt); pure vegetable oils (25 kt); and E85 (21 kt). Although biomethane consumption is still low (22 kt), it is increasing quickly (constituting 15% of natural gas consumption in transport 2012, up from 6% in 2011). Biofuels consumption levels in 2012 were quite similar to those of 2011.

Table 1 shows the number of passenger cars on the road in Germany by fuel type for the years 2006 through 2013.

Table 1 Passenger Cars in Germany by Fuel (on January 1 of given year)

Year	Gasoline	Diesel	LPG	NG	EV	Hybrid
2006	35,918,697	10,091,290	40,585	30,554	1,931	5,971
2007	35,594,333	10,819,760	98,370	42,759	1,790	11,275
2008	30,905,204	10,045,903	162,041	50,614	1,436	17,307
2009	30,639,015	10,290,288	306,402	60,744	1,452	22,330
2010	30,449,617	10,817,769	369,430	68,515	1,588	28,862
2011	30,487,578	11,266,644	418,659	71,519	2,307	37,256
2012	30,452,019	11,891,375	456,252	74,853	4,541	47,642
2013	30,206,472	12,578,950	494,777	76,284	7,114	64,995

Source: KBA 2013

A total of 52.4 million vehicles are registered in Germany as of January 1, 2013 (+1.3% compared with 2011), with 43.4 million (82.9%) passenger cars. Of registered vehicles, 4 million (7.6%) are motorcycles and 2.6 million (4.9%) are trucks. The rest are buses, tractors, and other vehicles. Of passenger cars, 12.6 million (29.0%) are diesel fueled (compared to 27.7% in 2011). A total of 69.6% of the passenger cars are petrol fueled. Vehicles with alternative powertrains numbered 645,702 (1.5%). This total includes 7,114 electric vehicles (EVs) (+56.7% compared with 2011), 64,995 hybrid vehicles (+36.4%), 494,777 vehicles using liquefied petroleum gas (LPG) (+8.4%), and 76,284 vehicles using natural gas (NG) (+1.9 %).

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% (from 2010 to 2014) for petrol. Since 2009, there is also an overall quota for diesel and petrol combined. This overall quota was set at 5.25% for 2009 and at 6.25% for 2010 to 2014. From 2015, the benchmark for biofuels quotas will be converted from the present energetic evaluation to the net greenhouse gas (GHG) reduction. The net quota will increase from a rate of

3% in 2015 to 4.5% in 2017 and to 7% in 2020. Biomethane mixed in natural gas can also be used to fulfill the quota.

The tax rate for pure vegetable oils outside the quota started at 18.5 cents per liter and at 18.6 cents per liter for biodiesel (B100). These have increased step by step, and from January 2013, pure biofuels have the same tax rate as fossil diesel fuel (45.03 cents per liter). Tax relief still exists until 2015 for the following: pure biofuels used in agriculture, bioethanol (e.g., bioethanol in high blends between 70% and 90%, lignocellulosic ethanol), synthetic biofuels, and biomethane. Tax relief for natural and liquefied natural gas used for fuel exists until 2018.

The sustainable criteria for biofuels agreed to at the European level under the Renewable Energy Directive (RED; 2209/28/EG) and the Fuel Quality Directive (FQD; 98/70/EC) were transposed into German law in 2009. On October 17, 2012, the European Commission published a proposal for an amendment of the RED and FQD (COM [2012] 595 final). The main new stipulations are to:

- Set a limit of 5% for food-based biofuels to meet the binding target of using 10% renewable energies in the transport sector and to phase out state aid for these fuels after 2020.
- Include the indirect land use change (ILUC) in the reporting when assessing the GHG performance of biofuels.
- Increase the minimum GHG–saving threshold for new installations to 60%.

The proposal is now under discussion in the European Parliament and Council, and a decision is expected by early 2014 at the latest.

In 2011, the German government launched the 36th Federal Emission Control Ordinance (36. BImSchV), which allows “double counting” of particular biofuels (e.g., biofuels based on waste and residues) in accordance with article 21(2) of the RED.

In addition to ensuring an appropriate, consistent tax and regulatory business environment, research and development (R&D) must be promoted across the various biofuel sectors to create conditions conducive to boosting the use of biofuels. In view of this objective, Germany’s federal government supports inter alia projects for the further development of existing and the development of new biofuel technologies. This support encompasses the full value chain, including the provision of raw materials (breeding, etc.), biomass conversion, quality assurance, and the use of biofuels in vehicles (emissions, material compatibility, etc.).

Under the “Renewable Resources” funding scheme of the Federal Ministry for Food, Agriculture, and Consumer Protection (BMELV), 126 R&D projects relating to biofuels received total funding of more than €57 million ($US 75 million) over the last six years. This support includes funding for projects related to bioethanol, biodiesel, vegetable oil, biomethane, and biomass-to-liquid (BTL) fuels, as well as on topics such as the sustainability of biofuels. The aid is granted through the Ministry’s project sponsor, the Agency for Renewable Resources (Fachagentur Nachwachsende Rohstoffe e.V., FNR).

For vegetable oil, which is likely to remain a niche fuel because of its various characteristics or properties, particular priorities include adapting engine concepts (Tier 4 Interim/Stage IIIB since January 2012) to running on vegetable oil. With respect to biodiesel, the emphasis is on engine performance and critical emissions (e.g., nitrogen oxides [$NO_{x]}$) of pure biodiesel and diesel and biodiesel mixtures. With regard to advanced biofuels, project support was focused on BTL fuels, which have not yet been introduced to the market but are considered a promising option because of their broad raw materials base and chemical composition. At the moment, the Karlsruhe Institute of Technology’s “bioliq process” is receiving financial support.

Fachagentur Nachwachsende Rohstoffe (FNR) has also supported implementation of “International Sustainability and Carbon Certification” (ISCC), the certification system for sustainable biofuels and liquid biomass used in electricity generation. ISCC is the world’s first state-approved certification system applicable to all agricultural resources (i.e., biofuels) and also contains social aspects to be reported on a voluntary basis.

The Federal Ministry of Transport, Building, and Urban Development launched the “Mobility and Fuel Strategy” in June 2011 with a major public event in Berlin aimed at creating environment- and climate-friendly, socially responsible, and economically efficient modes of mobility for the future. It is based on the strategy launched in 2004, and outreach and promotion will continue until spring 2013. The comprehensive workshop program started in April 2012 with around 400 stakeholders. The strategy does not favor a specific technology but includes all important transport modes (road, aviation, railway, and waterborne transport) and all relevant drivetrains and energy sources (fossil and biofuels, electric mobility, and fuel cells). It is organized as a consistent and adaptive process, and stakeholders from government, industry, academia, society, and nongovernmental organizations (NGOs) participate. This breadth of participation helps to ensure that the dialogue is broad based and transparent. The main target is to find medium- and long-term prospects for substitution of fossil fuels; develop fuels based on renewable sources of energy; and identify promising drivetrain technologies and the supply infrastructures required for their support. With respect to electric mobility, for example, the target of the German government remains that there will be at least 1 million electric vehicles on German roads by 2020.

Implementation: Use of Advanced Motor Fuels

In 2012, 3.08 million new passenger cars were registered in Germany, of which 50.5% were petrol-fueled cars, 48.2% were diesel-fueled cars, and 1.3% were cars with alternative drivetrain technologies. Of these cars, 38.2% were privately registered, and the average CO_2-emission was 141.8 g/km.

Incentives for using advanced motor fuels are to receive a full tax exemption for specific biofuels (i.e., BTL, bioethanol from lignocellulose, biomethane, E85) until the end of 2015 and a partial tax exemption for natural gas as transport fuel until the end of 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.

During the program “burnFAIR,” the German airline Lufthansa tested biokerosene mixed with 50% regular jet fuel, or “Jet A-1,” used in one engine on 1,187 flights that took place in 2011 with an Airbus A 321 D-AIDG from Hamburg to Frankfurt and back. The biokerosene is made of 80% camelina (*Camelia sativa*), 15% jatropha (*Jatropha curcas*), and 5% animal fat and is produced by the Finnish company Neste Oil. A final flight took place between Frankfurt and Washington, D.C., in January 2012 with a Boeing 747-400. The practical trial was successful and proves that advanced fuel can be used in aviation.

Outlook

At the moment, it is very difficult to provide a reliable outlook for the use of advanced motor fuels over both a short-term and long-term basis. The EU 2020 target is still 10% use of renewable energy sources in transport. The biggest uncertainty is how the RED/FQD amendment proposal of the European Commission from October 2012 will materialize (i.e., cap on food crop–based biofuels, multiple counting, ILUC factor). Discussions are expected to last until June 2014. On a national level, the replacement of the biofuels quota in terms of its energy equivalent by the CO_2 reduction quota will need to be implemented from 2015 onward on a large-scale and actionable basis. Further R&D activities (e.g., on reducing the GHG emissions of biofuels to make them compatible with the amended RED/FQD, upscaling advanced biofuel production processes to an industrial scale) will be other important challenges.

From a process technology perspective, ethanol from lignocellulose material, biomethane, and synthetic diesel may become promising mid-term options to replace fossil fuels in Germany.

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Benefits of Participation in the AMF IA

The German biofuels market is one of the largest worldwide. Because of changing framework conditions, advanced motor fuels will become more important over the short and long term in Germany. FNR, as a national funding organization, addresses many different issues regarding advanced motor fuels. AMF addresses most of the issues that are important in our country. Most of the sponsored research projects under the AMF umbrella are relevant to our funding activities and the common project sponsoring offers a cost-efficient participation. Furthermore, participation in the AMF IA provides German researchers and stakeholders with the opportunity to become part of a scientific network with excellent researchers from around the world. For example, Germany participates in the research project ANNEX 45, “Synthesis, Characterization, and Use of Hydro Treated Oils and Fats for Engine Operation,” with partners from Denmark, Turkey, and the United States.

Israel

Introduction

Israel is a fuel-poor country and is forced either to refine most of the fuel products it requires by using imported raw petroleum or to import ready-made fuel products. The Israeli government wants to decrease its dependency on petroleum to improve its energy supply security, especially in light of geopolitical issues, and because of the economic and environmental benefits that would result.

From 2011 to 2012, the consumption of fuels for transportation in Israel had grown 2%, and the country consumed approximately 2.7 million tons of gasoline and a similar amount of diesel for transportation. Israel's vehicle fleet consists of 85% gasoline-fueled vehicles; the rest of the vehicles are fueled by diesel, and they are mainly heavy-duty vehicles, buses, and trucks.

On January 13, 2013, the cabinet of the Government of Israel approved a program to encourage lowering the country's dependence on crude oil for transportation. The program sets ambitious targets: to cut the use of oil for transportation by 30% by 2020 and by 60% by 2025, as compared to currently projected "business as usual" oil consumption.

The government resolution is an extension of the Alternative Fuels Initiative Program from 2011. The original initiative aimed to serve as a catalyst for reducing global dependence on crude oil, thereby fostering geopolitical stability, economic security, and environmental protection, while establishing Israel as a center of knowledge and industry in the field of oil alternatives for transportation.

The targets (30% reduction by 2020 and 60% by 2025) are based on a bottom-up analysis of the various Israeli transportation market sectors and the assumption that any solution must be economically viable to the end user as well as the economy.

Among the alternatives considered are compressed natural gas, mainly for heavy-duty trucks and buses; methanol for cars, starting with a 15% blend and advancing later to higher blends; and electricity, mainly for buses, mass transit, and inner-city use.

The Alternative Fuels Initiative also aims and projects in the longer term to use biofuels from second- and third-generation nonedible crops developed in Israel and a process that converts waste to energy.

The latest resolution focuses on activities that will help build the alternative fuel ecosystem. It covers pilots for new technologies, regulations and standardization for fuels and vehicles, infrastructure, and an alternative fuel-friendly tax policy (in addition to the current progressive tax policy for fuel efficiency). Together, these efforts, as well as others, aim to accelerate the adoption of alternative fuels in Israel and throughout the world. A forecast of the economic viability of the fuels and market needs is presented in Figure 1.

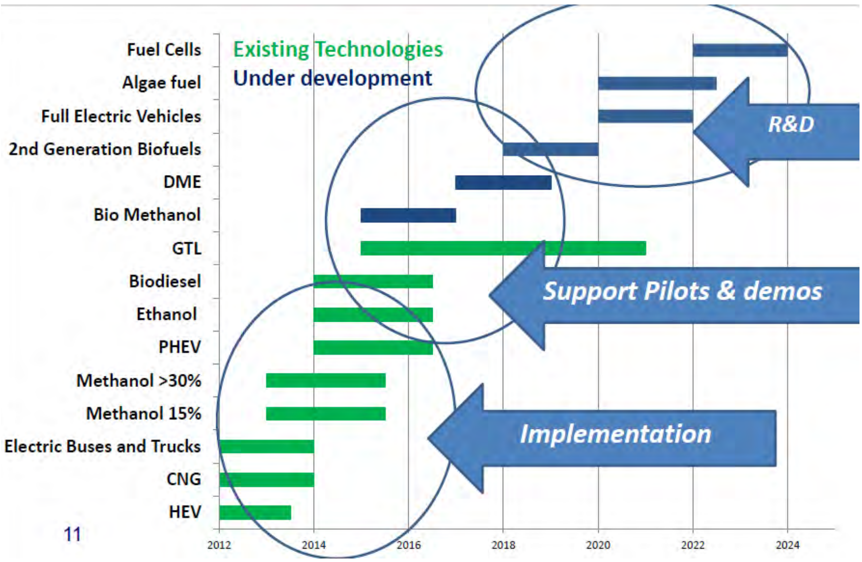

Fig. 1 Israel Alternative Fuel Timeline (Source: Israel Alternative Fuel Initiative website)

Government Activity

- One Stop Center (part of the Israel Alternative Fuels Initiative)
- Academic centers and grants
- Clusters of academia-industry pilot programs and test beds
- Unified regulation process
- Chief Scientist + Co-investment fund New global price
- Seminars
- Bilateral agreements

Implementation

Currently there are 87 start-ups and commercial spin-offs related to oil alternatives that need to raise funds (see the Israeli Institute for Economic Planning database of oil alternative companies [IEP OAC database] that was initiated in December 2009 and last fully updated in the third quarter of 2011). These companies conduct activities in the following areas:

- Feedstock: 21% of companies deal with raw materials that are eventually converted into fuel.
- Fuel production: 34% of companies convert biomass feedstock and/or nonbiomass feedstock into fuel.
- Vehicles: 34% of companies deal with making the cost of transport (per kilometer driven) cheaper than it is when done by standard oil-dependent vehicles.
- Infrastructure: 11% of companies deal with critical technologies that enable the oil-independent paradigm.

The Ministry of Energy and Water Resources is acting to implement fuels based on natural gas — namely, CNG, natural gas-to-liquid (GTL) fuels (i.e., drop-in fuels), and methanol. It is conducting “well to wheel” projects, covering all technical, regulatory, and economic aspects. This task is being supported by a number of pilot and demonstration projects in this field, as well as a techno-economic study of these fuels and their relevance to the Israeli market. This extensive analysis considered all relevant segments of the supply chain (including the production, transportation, and consumption of the fuels by end users) and the required infrastructure.

Italy

Introduction

In 2011, consumption of primary energy in Italy was around 184.204 megatonnes of petroleum equivalent (Mtpe). Oil remained the main energy source at 38%; natural gas followed at 35%, and renewable sources represented 13% of consumption (Figure 1).

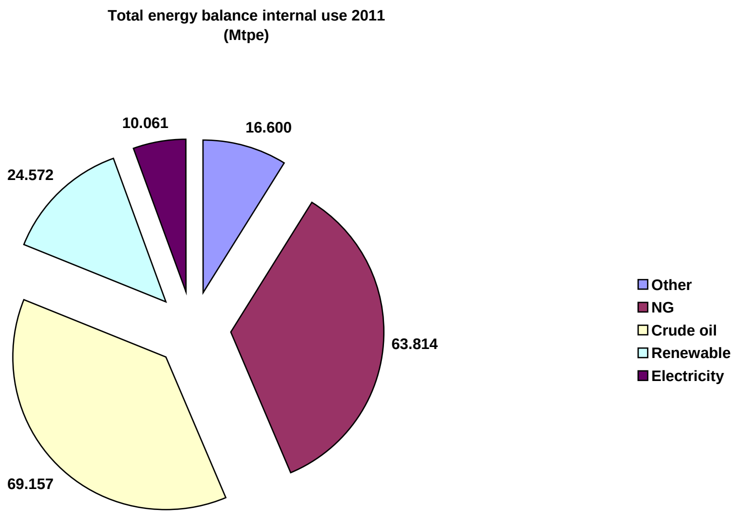

Fig. 1 Total Energy Balance by Type of Source in 2011 (Source: Ministry for Economic Development, 2011, *National Energy Balance*)

Italy is very dependent on imported oil; it imported 89.943 Mtpe in 2011 (see Figure 2).

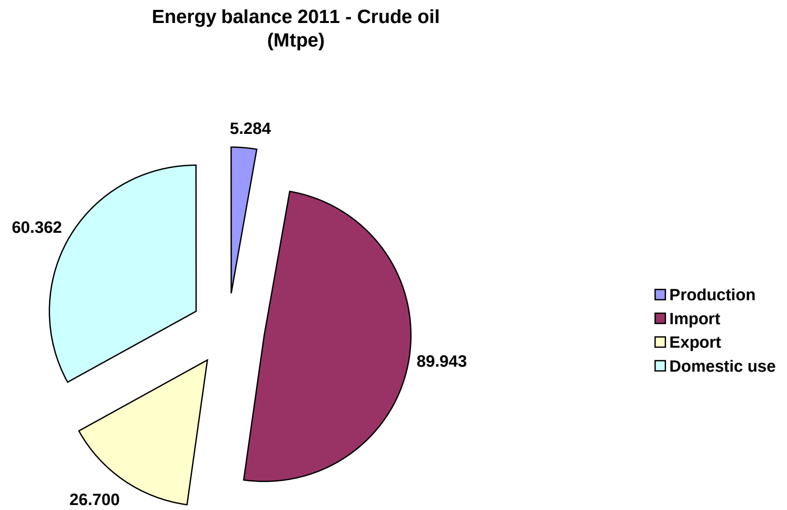

Fig. 2 Crude Oil Energy Balance in 2011 (Source: Ministry for Economic Development, 2011, *National Energy Balance*)

The major destination (about 66%) for derived oil in Italy is the transportation sector (see Figure 3).

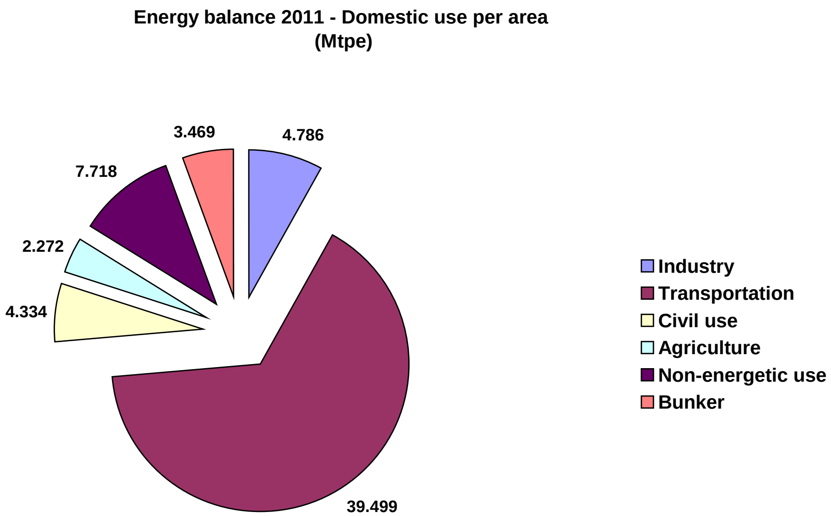

Fig. 3 Domestic Use per Sector in 2011 (Source: Ministry of Economic Development, 2011, National Energy Balance)

The main transportation fuel is diesel fuel (66%); this is followed by gasoline (28%). Within the same sector, significant amounts of natural gas (2%) and liquefied petroleum gas (LPG) (3.9%) are used (see Figure 4).

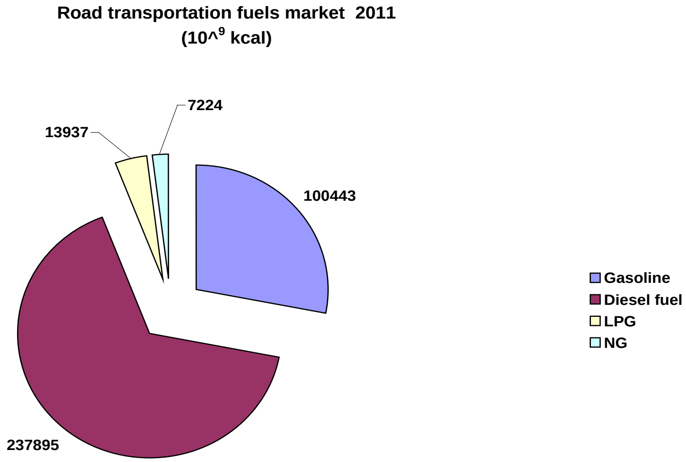

Fig. 4 Market for Road Transportation Fuels in 2011 (Source: Ministry for Economic Development, 2011, *National Energy Balance*)

With regard to vehicle fleet, the largest category (in terms of number of vehicles) is passenger cars (75.5%); this is followed by motorcycles (13.1%) and lorries (8.2%) (see Figure 5).

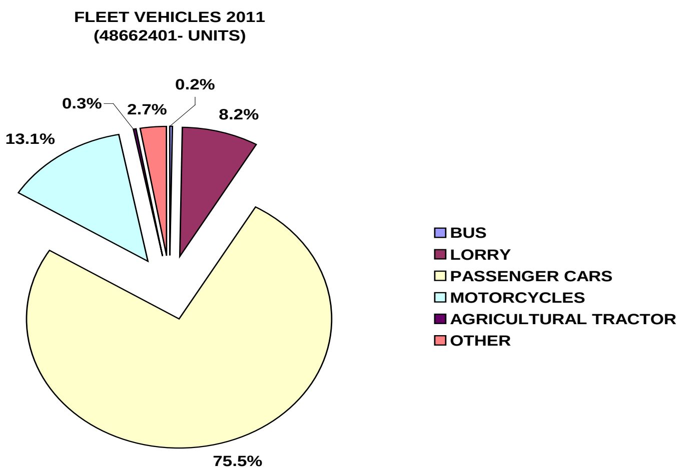

Fig. 5 Types of Fleet Vehicles in 2011 (Source: ACI, 2011, *Autoritratto*)

Regarding the type of passenger cars, the biggest category is gasoline-fueled vehicles (54.33%), followed by diesel-fueled vehicles (39.03%). A significant percentage of vehicles uses natural gas (1.83%) and LPG (4.79%) (see Figure 6). Diesel-fueled vehicles can use fuel blends up to 7% v/v (volume/volume percent) biodiesel; gasoline-fueled vehicles can use gasoline containing oxygenated biofuels in which the oxygen content may amount to 2.7% m/m (mass percent).

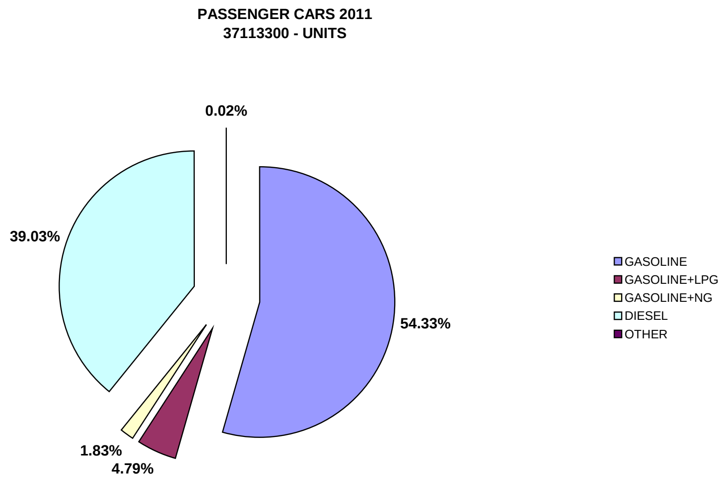

Fig. 6 Passenger Cars – Engine Types in 2011 (Source: ACI, 2011, *Autoritratto*)

Policies and Legislation

In both the long term and the very long term (2030–2050), Italy subscribes to the spirit of European Roadmap 2050, aiming toward a low-carbon economy in which emissions would be reduced by up to 80%. In recent decades, however, it has been difficult to predict developments in technology and the markets, especially for the long term.

Italy therefore intends to adopt a flexible and efficient long-term strategy for pursuing its key low-carbon policy. The country will focus on and exploit (especially through research and technological developments) any pursuits that could produce significant changes; examples might include more rapid cost reductions in renewable and storage technologies, the use of biofuels, or the capture and storage of carbon dioxide (CO_2).

Italian Law has adopted the European Renewable Energy Directive (2009/28/EC) and the Fuel Quality Directive (2009/30/EC). Through

Law 2009/99 of July 23, 2009, the Italian government has given permission to use up to 7% biodiesel in diesel fuel, in accordance with European Specification EN590:2009.

Decree 2011-28 acknowledges all European Directives (RED and FQD) that promote the use of biomass for fuels or any other renewable source to produce energy. Energy incentives are granted for fuels from renewable sources derived from wood cellulose or plant and animal residues.

Decree 2012-83 of June 22, 2012, establishes a limit for assigning energy double-counting to second-generation renewable sources for transport fuels. This advantage is recognized up to the 20% of the total biomass used for transport.

Moreover, municipalities have implemented important local measures that affect transportation. In order to improve air quality, reduce emissions of particulate matter of 10 μm or less (PM_{10}), smooth the road system, and lower noise in the cities, they have introduced traffic blocks in urban areas.

Implementation: Use of Advanced Motor Fuels

Biodiesel is the primary source for renewable advanced motor fuels in Italy. From 2009 until the present biodiesel has been blended with up to 7 vol% diesel fuel. The renewable fuel currently used in gasoline is bio-ethyl *tert*-butyl ether (ETBE) derived from bio-ethanol. The amount of bio ETBE used in gasoline was 225 kilotons (kt) in 2011.

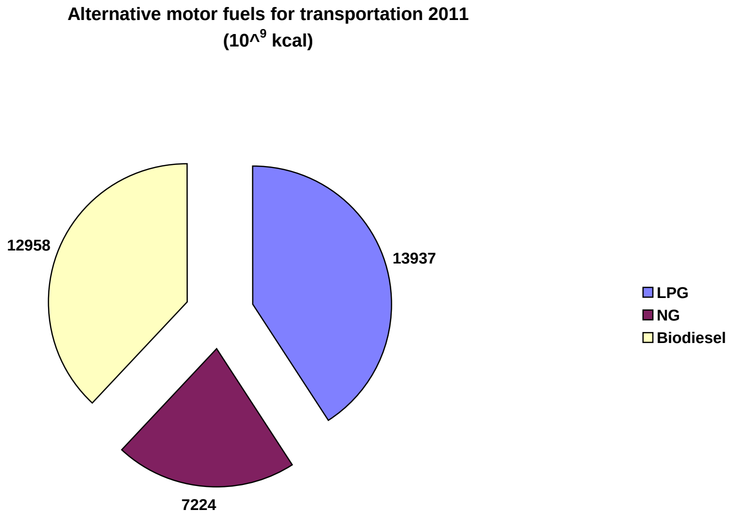

Fig. 7 Alternative Motor Fuels Used for Transportation in 2011 (Source: Ministry for Economic Development, 2011, *National Energy Balance*)

At the end of 2012, there were 999 natural gas filling stations in Italy. More than 680,000 cars use natural gas in Italy. The natural gas filling stations network is mostly located in Northern Italy, whereas Central and Southern Italy are not homogenously represented. In the Sardinia Island region, there are no natural gas service stations. At the end of 2010, the LPG filling station network amounted to 1,537 stations. The LPG car fleet in Italy amounted to more than 1.7 million cars.

Eni launched the Green Refinery process, which will lead to the conversion of the Venice Refinery into a "bio-refinery," producing innovative and high-quality bio-fuels. The project is the first in the world to convert a conventional refinery into bio-refinery and is based on Ecofining technology developed and patented by Eni. The Green Refinery process will start with an initial conversion of existing facilities, which will be launched in the second quarter of 2013 and completed by the end of that year. Biofuel production will start January 1, 2014, and will grow progressively as the new facilities enter into operation. The new facilities to be built under the project will be completed in the first half of 2015. The new green plant will maintain the Venice site in an economically sustainable industrial operation over the long term, with low environmental impact. The activities of the Green Refinery will be associated with the construction of a new Logistics Centre.

The Green Refinery process is based on distinctive environmental technologies, which are highly compatible with Eni's continued commitment to research and innovation.

In 2006, Chemtex-M&G began R&D activities devoted to demonstrating technological and environmental sustainability of second-generation bioethanol production from lignocellulosic feedstock (PROESA^{TM} technology). In particular, Chemtex-M&G has conducted research into cellulosic crop optimisation and agronomics; has designed, engineered, developed, and tested at lab- and pilot-scale proprietary technology and components for key aspects of the biomass to fuel conversion process; and has partnered with leading technology providers for the key biological process components. Building a bioethanol facility to demonstrate this technology in Europe is the next incremental step in development of the M&G/Chemtex technology. The world's largest cellulosic ethanol plant, in Crescentino - VC - Italy, has just started up with a 40-ktpa ethanol capacity. The plant is in the course of debugging and optimization, and we expect continuous production at target capacity by the end of Q2. The PROESA^{TM} process technology allows it to deliver superior economics in converting non-food biomass to sugars for the production of bio-ethanol.

Regarding the optimization of the fossil fuel refining process, we report that Eni is building a plant for the total conversion of fossil fuels crudes (the EST plant in Sannazzaro). Eni has invented the new oil process EST (Eni Slurry Technology), which is able to completely convert waste oil, heavy crude, and tar sands in high-quality and performance fuels. Technically, this hydroconversion process is developed by using a special catalyst and self-starting hydrogen from natural gas.

In the history of scientific discoveries in the oil sector, this is the first Italian invention, which comes 40 years after the last manufacturing process of oil invented. Unlike traditional oil processes, the EST technology can produce gasoline and gasoil without generating coke or fuel oil, the market for which is constantly declining.

Outlook

Italy has confirmed the 2020 target of 10% energy content by biofuels as a percentage of total transportation fuel use, which, in terms of the costs to the system, could reach about €1 billion (1.10^9 Euro) annually (estimate of extra-cost compared to the use of fossil fuels). On the basis of this 2020 target, here are the yearly minimum increases in energy to be derived from biocomponents:

- 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, 2014: 5%

At the same time, Italy intends to play an active part in reviewing the European Directive, with a goal of promoting second- and third-generation biofuels. The review should leave open the possibility for a European assessment on whether to postpone the target if more time is needed to adequately develop these technologies.

In the short run, the Italian government has already adopted a number of tactical measures to steer the transportation sector toward second-generation biofuel production (in which Italy has reached levels of excellence). These measures are also designed to foster the development of the domestic and European Union (EU) system throughout the production sector.

In the transportation sector, biofuel development is the subject of a wide-ranging international debate, in view of doubts regarding the real sustainability of traditional biofuels. This is why European Directive 28/2009 on this matter will be reviewed in 2014. The key decision will be whether to transition to second- and third-generation biofuels. For now, they are not able to completely replace traditional sources.

It will also be important to carefully evaluate the prospects for developing the domestic production of biomethane for transport use.

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Benefits of Participation in the AMF IA

Transportation is a crucial aspect of a country's economic development. Sharing information about energy choices that place a high value on the environment and participating in the ongoing debate on energy are vital components toward achieving a common viewpoint. For example, participants in the global debate on controlling CO_2 emissions can help build a world outlook on renewable sources. This information is important for stakeholders, policymakers, and industry.

Japan

Introduction

Since fluctuations in crude oil price are intimately related to research and the development of substitute petroleum and other new fuels, oil prices are very important.

Figure 1 shows the price variation of Arabian light crude oil [1]. After 2000, the price tended to increase, and in 2008 it reached a record peak value of $136.02 per barrel (values are USD). After that, the price declined. However, as a result of the Great East Japan Earthquake on March 11, 2011, prices for fuels used for power generation, like LNG (liquefied natural gas), spiked. Following a new round of crude oil price increases, prices ultimately reached $120 per barrel.

Figure 2 shows the variation of Japan's crude oil import volume [2–4]. Because of increases in crude oil prices and policies on energy conservation, crude oil cutbacks are observed: in 2011, the import volume decreased by about 20% from its peak of 2.5 billion kL to 2 billion kL. However, crude oil demand is generally increasing on a worldwide scale, along with peak output of crude oil, as indicated from each oilfield. There is also a trend away from nuclear power plants; thus, crude oil prices are expected to continue to rise in the future as well. From this global situation, it is important to note that the price depends not only on consumption volume, but also on research and development of new alternative fuels for the middle and long term.

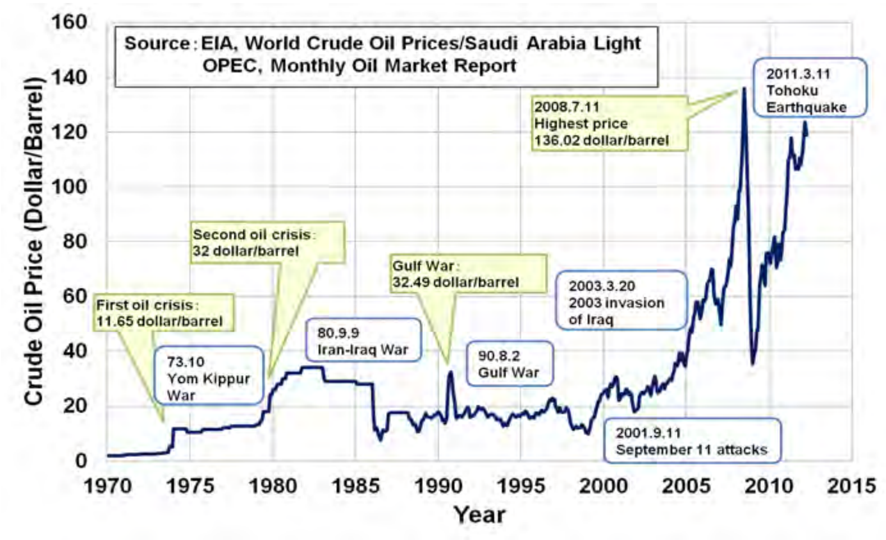

Fig. 1　Japan's Crude Oil Import Volume

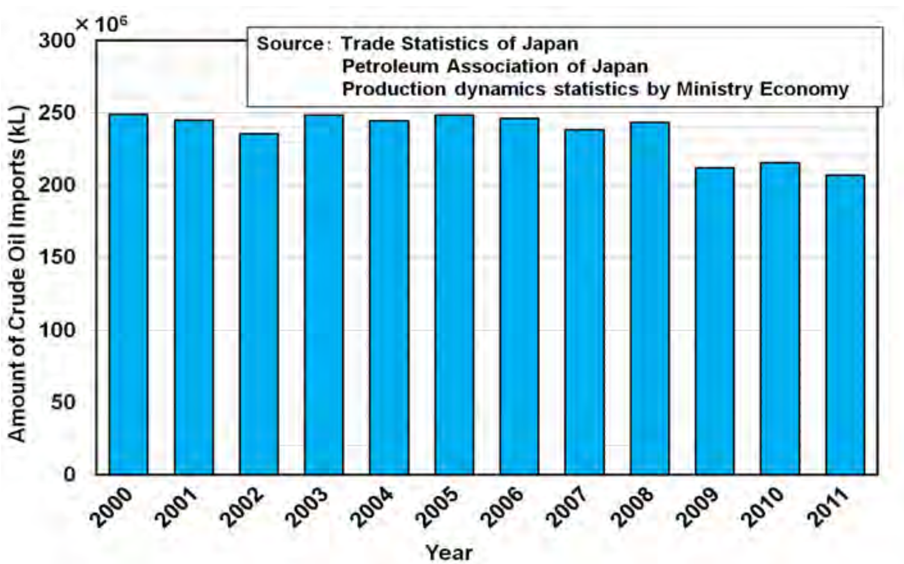

Fig. 2　Transition of Crude Oil Imports in Japan

Policies and Legislation

In May 2006, the Ministry of Economy, Trade and Industry (METI) developed a New National Energy Strategy in which two major targets were set for the transportation sector. One was to reduce the oil dependence of the transportation sector to 80% by fiscal year 2030. The other was to improve energy efficiency by 30% by fiscal year 2030.

The improvement of fuel economy is the most effective short-term strategy to reduce energy consumption and increase energy security through the introduction of more stringent fuel economy standards. As a long-term strategy, METI will take a comprehensive approach to significantly reduce energy consumption and reduce oil dependence. In December 2006, the Minister of METI announced the Next-Generation Vehicle Fuel Initiative, which focuses on further development and introduction of four technologies, including biofuels, clean diesel, next-generation batteries, fuel cells, and hydrogen.

The current Basic Energy Plan for Japan was revised in June 2010. However, after the Great East Japan Earthquake on March 11, 2011, major discussions are going forward for the establishment of a new Basic Energy Plan for Japan [5]. This discussion is based on deep reflection about the enormous damage caused to the national livelihood, regional economies, and the environment as a result of the accident at the Fukushima Daiichi Nuclear Power Station that occurred in the wake of the Great East Japan Earthquake.

Implementation: Use of Advanced Motor Fuels

(1) LPG

Currently there are about 17,500,000 LPG vehicles [5] in the world (2010), which is about 2.4 times greater than the 7,300,000 vehicles in 2000.

It is said that the tax policy in each country, which depends on the demand for propane for homes and surplus butane, greatly affects the promotion of LPG vehicles. In Japan, the taxation of gasoline is 53.8 yen/L ($0.56/L US), light oil (diesel fuel) is 32.1 yen/L ($0.33/L US), and LP gas is 9.8 yen/L ($0.10/L US). Natural gas has no tax.

In Japan, there are about 288,000 LPG vehicles, of which more than 80% are taxis. However, the numbers of LPG taxis and other LPG vehicles (such as) trucks have slightly decreased.

Toyota Motor Corporation will halt production for LPG-fueled taxis in 2017 [6] and concentrate on gasoline hybrid automobiles. Conversely, Mazda Engineering & Technology Co., Ltd., started selling passenger vehicles powered by LPG in September of 2011 [7]. Nissan Motor Company concentrated on universal designs (UDs) of taxis that have excellent ingress/egress designs and better usability. Nissan plans to add LPG models and electric models, in addition to gasoline vehicles [8].

(2) Natural Gas

The number of NGVs (natural gas vehicles) in Japan had risen to 41,463 by the end of March 2012. For NGVs in Japan, the introduction of large trucks has begun, in addition to trucks and buses used for conventional local transport. The Japan Gas Association has sent three heavy-duty CNG truck models to be tested by the Organization for the Promotion of Low Emission Vehicles (LEVO). On-road demonstration started with driving tests by 15 companies, including Sagawa Express and Yamato Transport (package delivery companies) and Suntory Logistics (beverage distributor). These tests will run for 3 years (until fiscal year 2013) and will focus on evaluating fuel consumption, CO_2 emissions, and operating performance, among other parameters [9].

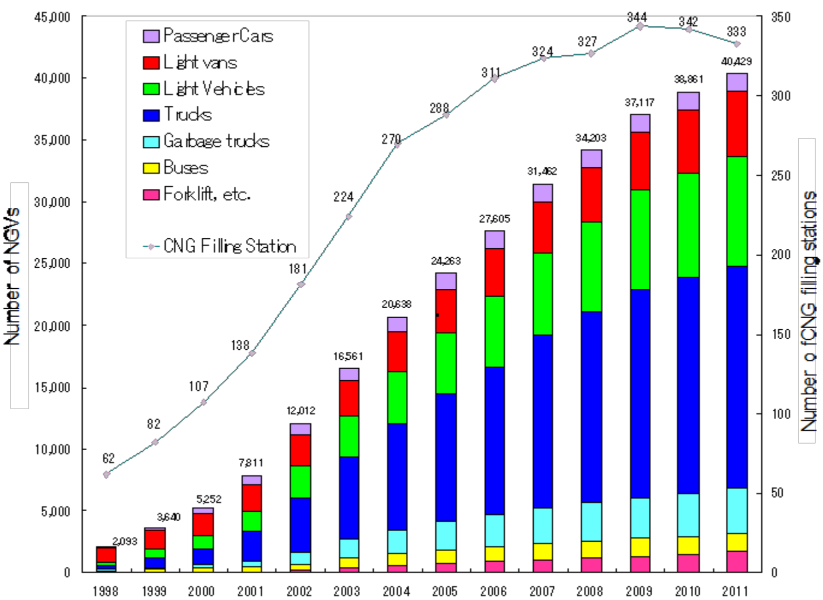

Fig. 3 Trends of Natural Gas Vehicles and Gas Stations in Japan

Fig. 4 CNG Truck for Demonstration Tests

Basic research of DDF (Diesel Duel-Fuel) engines has been previously carried out in Japan. A group at Kyoto University, Osaka Gas Co., Ltd., and Central Research Institute of Electric Power Industry's Energy Engineering Research Laboratory investigated the effects and influence of such parameters as injection quantity, injection timing, single or split injection of light oil, and variations of combustion chamber shape on performance and exhaust characteristics [10]. Okayama University performed spectroscopic measurements to clarify the two-stage heat release combustion phenomenon that occurs in DDF engines, to and investigate the differences between conventional and DDF combustion processes [11].

(3) Bio-fuels

(3)-1 Bio Ethanol

Bio-gasoline in the form of an ETBE (ethyl tert-butyl ether) blend is being sold at 3050 filling stations in Japan (as of April 2012). Nationwide, this is about three times the number of stations selling it the previous year [12]. Activities of the Central Environment Council include a report entitled "Methods and Countermeasures for Future Automobile Exhaust Emission Gas Reduction (10th Report)," and a response, "Automobile Exhaust Emissions Reduction Countermeasures with E10 and Fuel Specifications of E10." The required revisions were made to relevant Ministerial ordinances related to the Air Pollution Control Act so that E10 can be used in Japan [13].

Standardization of bio-ethanol quality and relevant test methods for ethanol automotive fuel has been promoted. Aiming to maintain the quality and to promote widespread use, JIS K 2190 (ethanol fuel) was enacted and publicly announced on November 21, 2011 [14].

(3)-2 Bio-Diesel Fuel

In March 2012, the second report of JATOP's (Japan Auto-Oil Program's) diesel bio-fuel vehicle working group was presented. This work was carried out under a 5-year plan, beginning in 2007 [15]. The first report (June 2010) pointed out several technical issues related to a new long-term use of 5%, 10%, and 20% biodiesel blends (in light oil) and discussed new long-term exhaust regulations for corresponding biodiesel fueled vehicles. In addition to these topics, such issues as effects of biodiesel on materials, biodiesel storage stability, and low-temperature biodiesel operability were clarified. One group reported on the effects that metal species in biodiesel fuel have on deposit formation inside the fuel injector. Results showed that deposit formation was particularly promoted with copper contamination, and this caused the injection quantity to be lowered.

(4) Di-Methyl Ether (DME)

The seventh Asian DME Conference was held in November of 2011 in Niigata, Japan, where DME has been introduced to the market as vehicular fuel. The location of this conference alternates among China, Korea, and Japan every other year.

The DME Vehicle Promotion Committee, or DMEVPC [16], established and managed two new committees — the Structure Handling Standards Development Investigation Committee and the Technology Standards Draft Investigation Committee for High Pressure Gaseous Fuel Filling Equipment for DME Vehicles — as part of the Asian standards promotion in the International Standards Innovation Technology Research Association. The former committee created a revised draft of a notice to determine new safety standards, worked out details of these safety standards for road transport vehicles, and created a new draft standard with a proposal addendum. Revised drafts of the High Pressure Gas Safety Act, General High Pressure Gas Safety Regulations, and example illustrative criteria were summarized by the latter committee.

Fuel standardization activities involved quantification of DME quality as a base fuel (including for automobiles) have been covered in ISO/TC28/SC4/WG13. In January of 2012, the legislation progressed from WD (working draft) to CD (committee draft) in ISO CD16861. Moreover, discussion has been under way on CD16861 (DME Fuel Quality) in WG14-covered analysis of five methods for the determination of DME quality:

1. NP17198 (sulfur content via ultraviolet fluorescence),

2. NP17199 (sulfur content via coulometric titration with very small sample size),
3. NP17786 (evaporation residue),
4. NP17197 (moisture), and
5. NP17196 (other impurities via gas chromatograph).

Discussion on subsequent DME automotive fuel quality standards is planned as well.

Fig. 5　3.5-ton Wing Van DME Vehicle

(5) Hydrogen

Tokyo City University and the National Traffic Safety and Environment Laboratory (NTSEL) are the most active organizations in hydrogen research. Their results have shown that high-pressure hydrogen can be used to form an over-rich fuel air mixture, which is then ignited with a spark plug. When combined with EGR (exhaust gas recirculation), this prevents the high NO_x production at high loads usually observed with hydrogen engines. Results showed that it was possible to pass the Japan 2009 regulations (0.7g/kWh) for large buses and trucks. However, countermeasures designed to increase thermal efficiency are a future challenge [17].

Researchers at Toyota Motor Company utilized hydrogen with CNG and achieved 0.48g/kWh NO_x emissions. Further work was carried out, seeking to improve thermal efficiency and realize control of carbon dioxide emissions. Results showed that by adding hydrogen to extend the lean combustion limit (while optimizing the tumble ratio), it was possible to improve the thermal efficiency by 9% and reduce tank-to-wheel CO_2 emissions by11%. Note that this was accomplished without decreasing vehicle range and by retaining the same fuel tank capacity [18].

Outlook

After the nuclear power plant accident, consumption of LNG began to increase in Japan. This results in the import of expensive LNG. Recently, the national strategy to import less-expensive LNG has been discussed. One way to reduce costs is to diversify the countries from which Japan imports LNG.

The following are ongoing activities and the outlook regarding advanced motor fuels in the New National Energy Strategy developed by METI in May 2006:

- Reexamine the upper blending limit regulation of oxygenated compounds that contain ethanol by around 2020 by (1) speeding up the improvements of the biomass-derived fuel supply infrastructure through the environmental and safety countermeasures of gas stations and (2) prompting the automobile industry to accept 10% ethanol mixed gasoline. Moreover, strive to spread the use of diesel cars that have exhaust gas performance equal to that of gasoline cars, which is also important for the utilization of GTL (gas-to-liquids) technologies, and promote the use of GTL technologies by the middle of 2010.
- Examine the support for regional efforts toward the expansion of domestic bioethanol production and examine ways to support the development of the import of biomass-derived fuels, such as bioethanol. Promote the supply of new fuels, such as biomass-derived fuels, and improve economic efficiency by promoting the development of high-efficiency ethanol production technologies and GTL technologies.
- As well as promoting the dissemination of electric vehicle and fuel cell vehicles, which are almost ready to be put to practical use, work on the intensive technical development of next-generation batteries and fuel cell vehicles; establish a safe, simple, efficient, and low-cost hydrogen storage technology; and promote the development and practical application of next-generation vehicles.

After the Great East Japan Earthquake on March 11, 2011 major discussions are going forward regarding the establishment of a new Basic Energy Plan for Japan. The new plan is expected to be released in 2013.

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[3] http://www.paj.gr.jp/statis/ (in Japanese)

[4] http://www.meti.go.jp/statistics/tyo/seidou/result/ichiran/07_shigen.html#menu2 (in Japanese)

[5] http://www.j-lpgas.gr.jp/ (in Japanese)

[6] http://www.j-cast.com/2012/05/11131712.html?p=all (in Japanese)

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[11] Eiji Tomita et al., Characteristics of Auto-ignition in the End-gas Region and Combustion Spectroscopy in a Gas Engine Ignited with a Pilot Injection of Gas Oil, JSAE Proceedings, NO.120-11, p. 19–22 (2011)

[12] http://www.paj.gr.jp/eco/biogasoline/

[13] http://www.env.go.jp/press_r/15039.html

[14] http://www.jisc.go.jp/newstopics/2011/20111121_fuel_ethanol.pdf

[15] http://www.pecj.or.jp/japanese/jcap/jatop/pdf02/004.pdf

[16] http://www.dme-vehicle.org/

[17] Yasuo Takagi, Reduction in NOx Formation by Diffusion Burning of Rich Mixture Plume in Direct Injection Hydrogen Engines, Journal of JSAE, Vol. 66, No.4, p. 92–98

[18] Mutsumi Kanda et al., Combustion Improvement of CNG Engines by Hydrogen Addition, PFL2011Proceedings (JSAE201109044, SAE2011-01-2011), p. 1888–1896

Republic of Korea

Introduction

In Korea, all city buses (>35,000) use natural gas and all taxis use liquefied petroleum gas (LPG). However, all diesel fuel mixed with 2% biodiesel (BD2) is mandatory, and there is no policy for BE (bioethanol).

The Korean government is discussing future scenarios for the introduction of BD2.5 (blending of 2.5% BD to diesel fuel) and is in the process of creating a long-term road map for the introduction of BE. This discussion will be finalized in April 2013.

Fig. 1 LNG (Liquefied Natural Gas) Bus (Courtesy Hyundai Motor Company)

Policies and Legislation

The current running mandate for the biofuel consists only of BD2 legislation, and until now, there has been no official policy. The Korean government is working for the new RFS (Renewable Fuel Standard). This work will be finalized in April 2013.

Implementation: Use of Advanced Motor Fuels

More than 35,000 NGVs and 164 compressed natural gas (CNG) or liquefied natural gas (LNG) stations are being operated in Korea. Since

2000, the Ministry of Environment has promoted NGVs, mainly city buses, by using subsidies and low-priced natural gas to reduce air pollution in urban areas and cut greenhouse gas (GHG) emissions. About 80% of NGVs are original equipment manufacturer (OEM) transit buses, and the rest are OEM trucks and bi-fuel retrofit passenger cars. Dedicated CNG buses and trucks are supplied by Korean automakers, such as Hyundai, Daewoo bus, and Tata Daewoo. NGVs are mainly operated by CNG. However, dedicated buses recently developed by Hyundai, which also developed a CNG hybrid bus in 2010, and some LNG-diesel dual-fuel trucks with retrofit technology are in use. Hydrogen-enriched natural gas (HCNG) engine technology is currently being developed by a government project.

Biodiesel has been used as an automotive fuel in Korea since 2002. After a few years of demonstration, the Ministry of Commerce, Industry and Energy (now the Ministry of Knowledge Economy) decided to introduce BD 0.5 nationwide. After that, the blending ratio of BD in diesel oil has been increased gradually, and BD2 has been fixed since 2010. Major feedstocks of BD are waste cooking oil and imported soybean and palm oil. At present, there are 16 biodiesel production companies, and production capacity is more than 1 million tons.

Other alternative fuels, such as BE (bioethanol), dimethyl ether (DME), and xTL (synthetic liquid transportation fuels, collectively known as xTL fuels, are produced through specialized conversion processes)[1], have been developed or demonstrated by government institutes and some companies. However, it is not clear when these fuels will be introduced.

Outlook

For the Korean RFS under discussion, there are two-scenarios: one is the 7% scenario, which takes into account the reduction of carbon dioxide (CO_2) in the transportation sector, and the other is the 5% scenario, which takes into account the supply and demand of raw materials. We are discussing a three-step long-term plan for 2014 to 2023 that would introduce BD3 in 2017 and BD7 in 2020.

[1] Source: http://www.afdc.energy.gov/fuels/emerging_xtl_fuels.html (accessed June 6, 2013)

The first step, from 2014 to 2016, would review the introduction of BE and increase the BD up to 3–3.5%. The second step would take place from 2017 to 2020, and the final step would take place from 2021 to 2023. In this discussion, we also consider the introduction of biogas (BG) beginning in 2017.

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Spain

Introduction

The total market in Spain for transportation fuels in 2012 was 26.137 kt (kilotonnes). Figure 1 shows this fuel market and the evolution of fuel consumption.

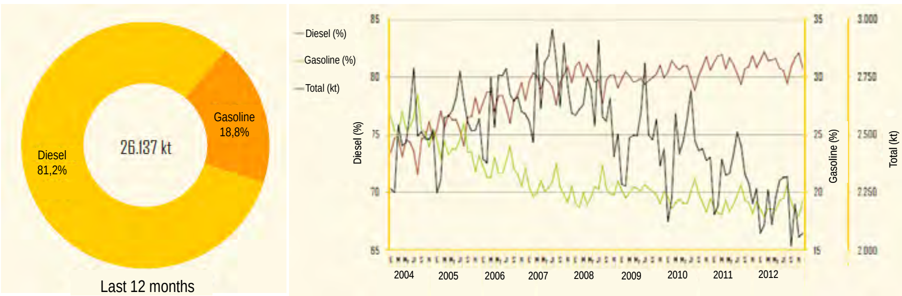

Fig. 1 Total Market in Spain for Transportation Fuel (2012) and Evolution of Fuel Consumption (Source: CORES)

Spain has very little domestic oil and gas production and relies heavily on imports, the main sources of which are the Middle East, Africa, and OECD (Organisation for Economic Co-operation and Development) countries. Figure 2 shows the total amount of oil imports and the countries where oil is produced.

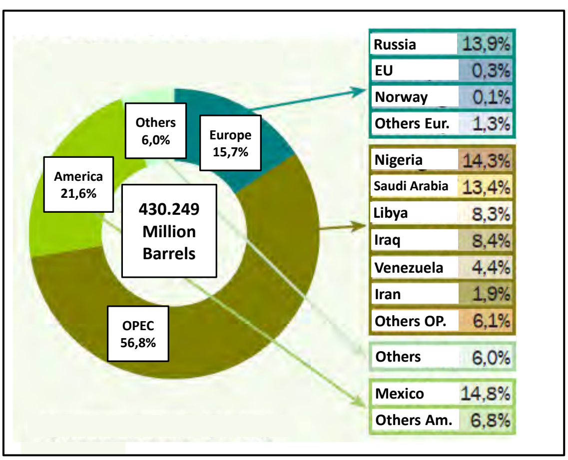

Fig. 2 Total Amount of Oil Imports and Countries of Oil Production (Source: CORES)

Policies and Legislation

A Ministerial Order to establish a biodiesel production quota system has been published (Order IET 822/2012). Biodiesel companies can request a quota up to the limit of their authorized capacity; only production under quotas will be eligible to meet the consumption mandates.

Implementation: Use of Advanced Motor Fuels

Biofuels represent the largest share of alternative transportation fuels in Spain. LPG (liquefied petroleum gas) and natural gas constitute a small part of the total market.

Figure 3 shows the biofuels sales up to November 2012 (most recent consolidated data).

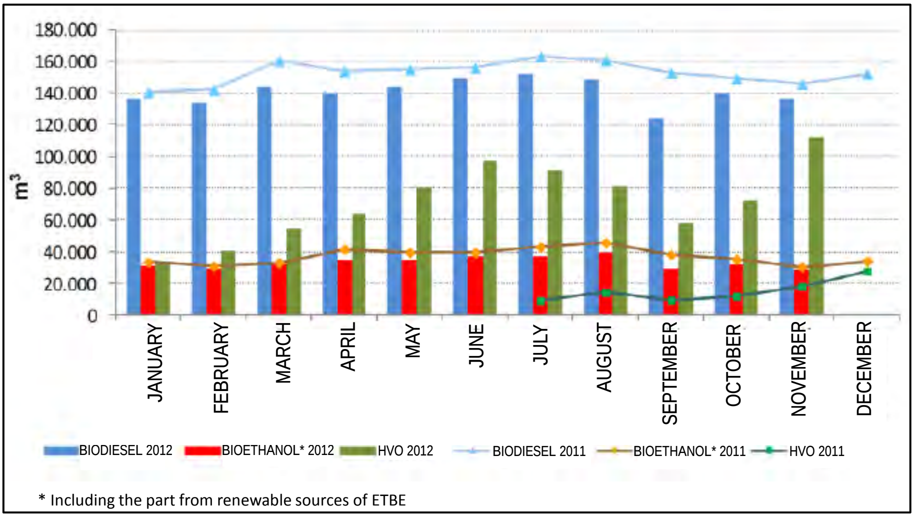

Fig. 3 Sales of Biofuels as of November 2012 (Source: CNE)

Figure 4 shows the current number of vehicles capable of using other alternative fuels (LPG, natural gas).

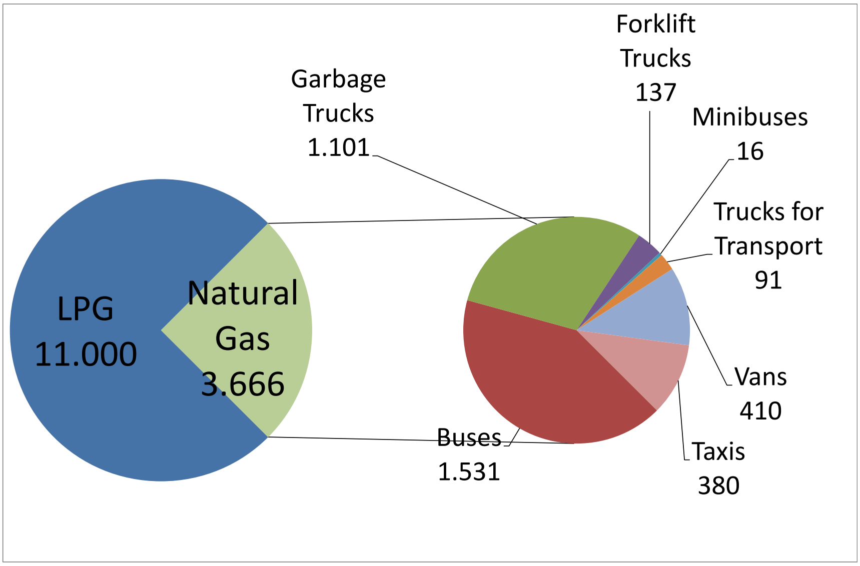

Fig. 4 Current Number of Vehicles Capable of Using Other Alternative Fuels (LPG, natural gas) (Source: idea)

In Spain, 73 fuel stations providing natural gas (26 public and 47 private) and 184 LPG stations have already been put into operation.

Outlook

According to the National Renewable Energy Action Plan, in order to fulfill the committed targets, biofuels consumption is expected to reach 2.713 ktoe (kilotonnes of oil equivalent) in 2020. On the one hand, 400 ktoe would correspond to biofuels in gasoline (bioethanol and bio-ETBE [ethyl tert-butyl ether]). On the other hand, 2.313 ktoe would correspond to biofuels in diesel (mainly FAME [Fatty Acid Methyl Ester] and HVO [Hydrotreated Vegetable Oil], which has achieved significant market penetration in 2012).

Additional References

- CNE: Comisión Nacional de Energía, www.cne.es
- CORES: Corporación de Reservas Estratégicas, www.cores.es
- IDAE: Instituto para la Diversificación y Ahorro de la Energía, www.idae.es

Benefits of Participation in the AMF IA

Membership in the AMF IA provides wider and easier access to information and helpful analysis to guide national policies and programs. It also helps to raise awareness on the advanced motor fuels issues, ongoing research, and the need for future development.

Sweden

Introduction

Total energy use in the transport sector, including foreign transport, amounted to 123 TWh. Figure 1 shows the share of energy use among different transport modes. Bunkering for foreign maritime traffic amounted to 20 TWh, and fuel for non-domestic aviation accounted for 9 TWh. Swedish domestic transport used 94 TWh in 2011, or 23% of the country's total energy use. Petrol and diesel oil met 87% of the country's energy requirements for domestic transport.

Sweden imported almost 19 million tonnes of crude oil in 2011 and net-exported 3.9 million tonnes of refinery products. Around 50% of Sweden's total crude oil imports come from the North Sea — mainly from Denmark and Norway.

Between 2003 and 2011, the use of diesel fuel increased by 38%, while the use of petrol fell by 25% over the same period. A change in the mix of vehicle types on the road is one reason for these variations.

The proportion of renewable motor fuels used by road vehicles has increased in recent years. In 2010, the proportion of renewable motor fuels amounted to 6.8%. The biofuels currently used for vehicles are mainly ethanol, biogas, FAME (fatty acid methyl ester), and a small portion of HVO (hydrogenated vegetable oil) as a 15% admixture.

Ethanol is blended with gasoline, but it is also the main constituent in fuels, such as E85 and ED95. FAME is blended with regular diesel fuel and used to a limited extent as 100% FAME.

The use of biogas has increased rapidly over the last few years. Currently, almost all petrol has a 5% blend of ethanol, and about 80% of diesel fuel contains a 5% blend of biodiesel.

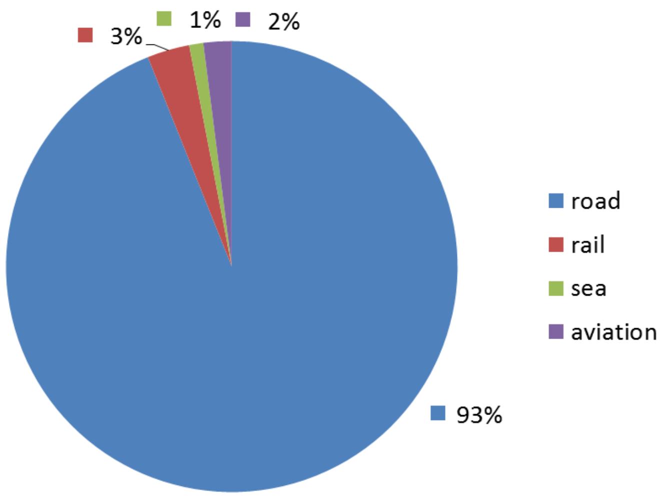

Fig. 1 Share of Energy Use among Different Transport Modes

Policies and Legislation

Sweden is using a relatively high proportion of biofuels compared to most other countries in the EU. A main goal of biofuels policy is to decrease the emissions of CO_2 from the transport sector. Another goal, not directly related to biofuels, is to increase overall energy efficiency in the transport system.

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 is to encourage the sale of more low-carbon vehicles. 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 element, but it depends on the vehicle's weight and levels of regulated emissions.

The fuel tax consists of two parts: energy tax and carbon dioxide tax. Bio-based motor fuels (such as biogas and E85) are not subject to energy or carbon dioxide tax, which affects the profitability of using such fuels. In low blends, there is a reduced energy tax on the bio component. The availability of bio-based motor fuels has been supported by the requirement that filling stations selling more than a certain volume of fuel must also sell a renewable-based alternative. Because this requirement resulted mainly in an increase in the number of E85 pumps, a grant was also introduced for investment in other pumps. However, this grant is no longer available.

Beginning on July 1, 2009, new "Clean Vehicles" were exempted from the vehicle tax for 5 years. A Clean Vehicle is defined as follows:

- It is equipped with technology that allows it to operate entirely or partially on electricity, alcohol, or gas or
- A fuel-efficient petrol or diesel car with carbon emissions below 120 g/km.

The market share of diesel cars is increasing rapidly. Sixty-two percent of new vehicles were diesel-powered in 2011, as compared to 20% in 2006. The shift to diesel can be attributed to new, attractive, efficient diesel cars on the market combined with the fiscal incentives for cars emitting less than 120 g CO_2/km. In 2010 and 2011, sales of cars with large, low-efficiency engines fueled with petrol, E-85, or methane declined rapidly.

Implementation: Use of Advanced Motor Fuels

The sustainability criteria for biofuels and bioliquids aim to reduce greenhouse gas (GHG) emissions and ensure that no areas with high biological values have been damaged as a consequence of renewable fuels production. During the spring of 2012, economic operators with a reporting obligation concerning biofuels and bioliquids in Sweden submitted their annual reports for the first time. The reports described the quantities of sustainable biofuels and bioliquids used in Sweden in 2011.

Emission Reduction of 940 000 Tonnes

Biofuels used in 2011 include ethanol, FAME, biogas, HVO, ETBE (ethyl tert-butyl ether), and DME (dimethyl ether). The total amount of sustainable biofuels is equivalent to 5.5 TWh (Table 1). Of the feedstock used for the production of biofuels, none was cultivated in Africa or Oceania, almost none in Asia, and very little in Latin America other than in Brazil, in order to supply the Swedish biofuel market. Most of the feedstock was cultivated in Europe. The current requirement on emission reductions is set at 35% compared to a fossil comparator; however, half of the reported biofuels in Sweden already fulfill the 50% reduction requirement that comes into force in 2017.

Table 1 Biofuel Use, Production of Sustainable Quantity, and Association Reductions in Emissions

Fuel Category	Energy Amount (GWh)	Sustainable Quantity Produced (m^3)	Emission Reduction (ton CO_2)
Ethanol	2 274	388 423	416 887
FAME	2 183	237 320	296 348
Gaseous Biogas	724	74 526 328	138 812
HVO	320	34 902	85 351
ETBE	19	2 830	3 089
DME	**>0**	**>0**	
Verified sustainable	**5 520**	–	**940 487**
Non-verified sustainable	**540**	–	–
Total sum	**6 061**	–	–

Feedstock and Emissions Reduction
The most common biofuels are ethanol and FAME. Emissions from the cultivation of biomass often constitute a large proportion of the total emissions from biofuels from a lifecycle perspective. Depending on the feedstock, the average emission reduction from ethanol varies between 50% and 80%. The ethanol delivered in 2011 was derived from 11 different types of feedstock, one-third of which originated in Sweden (Figure 2). Europe is the main area of origin for the remaining part (Figure 3).

Nearly all sustainable FAME used in Sweden has been produced from rapeseed, with a total emission reduction of 38%. Europe is the dominant area of origin for this feedstock (Figure 4).

HVO is mainly based on tall oil, which is a residue from the forest industry, and its average emission reduction is 88%. Only 8% of biofuels, other than biogas, have been produced from residues, which mainly come from the forest industry. These include, for example, brown liquor, black liquor, and crude tall oil, which are used to produce ethanol, DME, and HVO, respectively; also included are vegetable and animal waste oil and molasses from sugar beets, which have been used to produce FAME and ethanol, respectively.

Biogas intended for transport is subject to sustainability criteria. Swedish feedstock contributed to 89% of the biogas for transport in 2011. The biogas is produced from a variety of feedstock, which in most cases consists of waste or residues. The biogas produced from manure yields the best reduction in emissions — more than 80%. Cultivated biomass (such as barley, rye, corn, and ley crops) give the lowest reductions in emissions (40–60%). Approximately 25% of biofuel quantities also meet certain requirements for social and economic sustainability by having been certified under one of the EU-Commission's eight approved voluntary certification schemes.

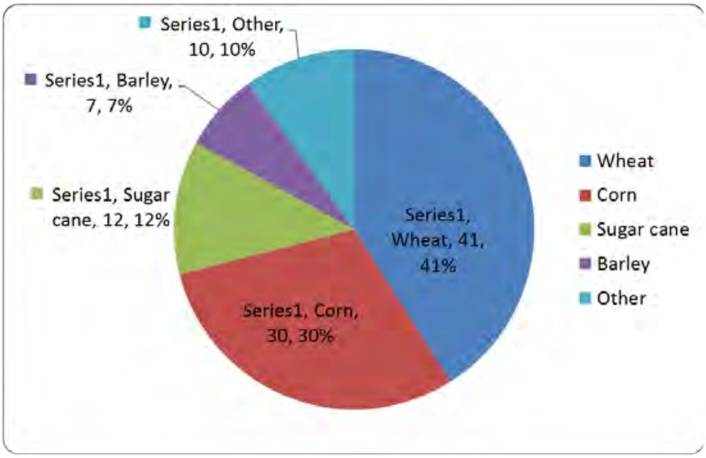

Fig. 2 Feedstock for Ethanol (%0

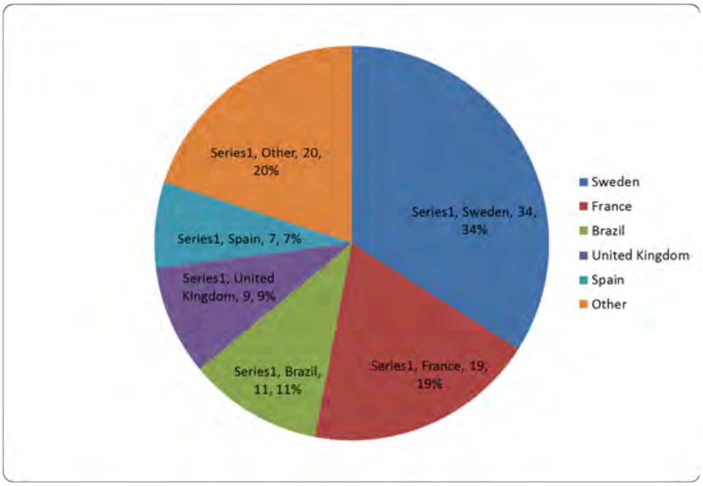

Fig. 3 Country of Origin for Ethanol Feedstock (%)

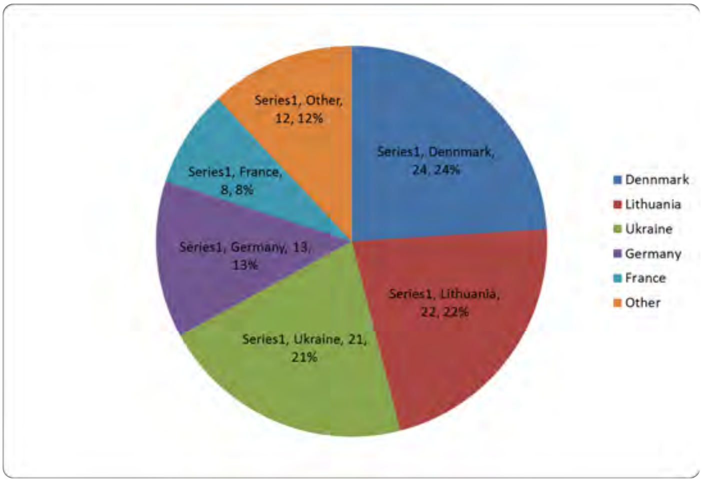

Fig. 4 Country of Origin for FAME Feedstock (%)

Outlook

The new policy sets a target for the transport sector: at least 10% of its energy use must be met from renewable sources by 2020. Parliament has approved a target for improving the efficiency of energy use, with an overall reduction of 20% in energy intensity between 2008 and 2020.

The Swedish Energy Agency's forecast predicts Sweden will nearly reach the EU target of 10% renewable energy for transport in 2020. Furthermore, renewable electricity use for railway traffic is expected to contribute to an additional 2 TWh in 2020; altogether, a total of around 8 TWh of renewable energy for transport is expected in 2020.

The existing tax exemption is working in the sense that it stimulates the use of biofuels; to a lesser degree, it also stimulates investment in production plants in Sweden. The tax exemption is renewed on a yearly basis, which makes it difficult to make an investment decision for a production plant but a lot less risky to import biofuels from abroad. This explains, in part, why about 70% of ethanol and 50% of biodiesel used in Sweden is imported.

Sweden has a vision that its car fleet of 2030 will be "fossil independent." The distinctions and the details will be clarified by a governmental investigation. The ultimate target is to describe how energy can be supplied to road transport without use of fossil fuels by 2050. Furthermore, a comprehensive set of incentives will be proposed. The final report will be delivered before the end of 2013.

Benefits of Participation in the AMF IA

AMF offers excellent opportunities for all participating countries to learn from the experiences of others. Cooperation in annexes makes it possible to carry out project that otherwise might have been too expensive for a single country.

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

Switzerland

Introduction

The final total energy consumption in Switzerland in 2011 was 852,330 terajoules (TJ), 35% of which came from transport fuels [1]. Compared to 2010, there was a 1.1% increase in the utilization of transport fuels (Figures 1 and 2). The highest levels of increase were for diesel (+2.6%) and aviation fuels (+9.6%). Most fossil fuels are imported. The energetic share of biofuels is very little (0.24%), only 720 TJ in 2011 [2].

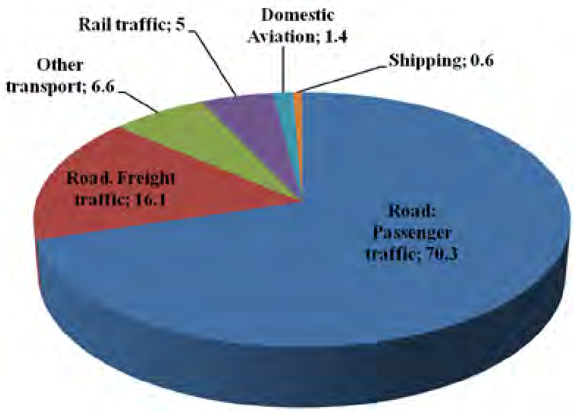

Fig. 1 Transport Sector: Percentages of Modes of Transport in Terms of Energy Consumption (2011) [3]

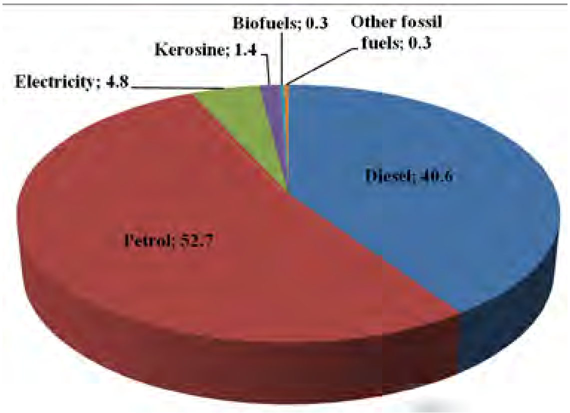

Fig. 2 Transportation Sector: Shares of Energy Sources in Energy Consumption (2011) [3]

In 2011, there were 4.2 m (million) registered passenger cars [4]. On average, 280,000 passenger cars per year are newly registered, of which only 2.3% have alternative propulsion systems (first half of 2012) [5]. Different cantons have vehicle tax reductions or even tax exemptions for environmentally friendly and energy-efficient vehicles, but there is still skepticism regarding alternative propulsion systems. However, car sharing is very popular in Switzerland compared to other European countries [5].

Policies and Legislation

Energy Strategy 2050

The Federal Council intends to continue to maintain Switzerland's high level of electricity supply security even without nuclear energy in the medium term. This decision was made at its special meeting on May 25, 2011. Existing nuclear power plants are to be decommissioned when they reach the end of their service life and will not be replaced by new ones. In order to guarantee supply security in the future, within the scope of its new Energy Strategy 2050, the Federal Council is focusing on increased energy efficiency, the expansion of hydropower and use of new renewable energy, and, where necessary, on fossil-fuel-based electricity production (combined heat and power plants, gas-fired combined cycle power plants) and imports. Furthermore, Switzerland's electricity networks are to be expanded without delay and energy research is to be intensified.

Carbon Dioxide (CO_2) Emissions Regulations for Cars

An international comparison showed that newly registered passenger cars in Switzerland are relatively heavy and powerful. This results in higher specific CO_2 emissions. The average CO_2 emissions of new passenger cars in Switzerland amounts on average to 155 g CO_2/km (2011); in comparison, in the European Union (EU) these amount to 136 g CO_2/km (2011) [6]. The potential to reduce fossil energy consumption as well as CO_2 emissions through CO_2 emission regulations is considerable.

On March 18, 2011, the Parliament had already adopted a partial revision of the CO_2 Act, which covers the emission standards for passenger cars [7]. Like the EU, Switzerland has introduced CO_2 emission regulations for new cars. These regulations went into effect July 1, 2012. Swiss importers are required to reduce the level of CO_2 emissions from cars registered for the first time in Switzerland to an average of 130 g CO_2/km by 2015. If the CO_2 emissions per kilometer exceed the target level, a penalty applies as of the above date. In 2012, 65% of the passenger cars already had to reach the above-mentioned target value of 130 g CO_2/km. This percentage increases to 75% in 2013, 80% in 2014, and 100% in 2015.

The CO_2 regulations apply to all importers of new cars. Here a distinction is made between large-scale importers (registration of 50 or more new vehicles per annum) and small importers (registration of fewer than 50 new vehicles per annum). Private individuals who directly import new cars are also classified as small importers.

With this partial revision of the CO_2 Act, the legal basis for emission standards for passenger cars was created [8].

Mineral Oil Tax Exemption for Biofuels

The amendment of the Mineral Oil Tax Act came into force July 1, 2008. This enabled the fiscal promotion of environmentally friendly and socially acceptable fuels. Switzerland is the only country worldwide to introduce mandatory ecological and social minimum requirements for biofuels on the market.

Biofuels (e.g., biogas, bioethanol, biodiesel, and vegetable and animal oils) are completely or partially relieved from the mineral oil tax if they comply with ecological and social minimum criteria. This can make up to 72 Swiss cents per liter ($0.75 US) for imported biofuels. The fiscal measures shall be neutral for the federal budget, which is why the reduction of revenues is compensated with a higher taxation of petrol [8].

For a tax exemption, the following criteria, which are valid for cultivation and utilization of fuels, have to be fulfilled:

- The emissions of greenhouse (GHG) gases must be at least 40% lower than those of fossil fuels;
- The environmental impact may not be much greater than that from fossil fuels;
- The protection of the rainforest and biodiversity may not be endangered.
- In addition, biofuels must be obtained from raw materials produced in accordance with the local social standards.

Implementation: Use of Advanced Motor Fuels

Biodiesel and Pure Vegetable Oil Fuel

Table 1 Evolution of the Consumption of Biodiesel and Fuel Pure Vegetable Oil (PVO) in Switzerland over the Period 1999–2012 (in kL/yr) [2,9]

Year	Biodiesel [1,000 L]			Fuel–PVO [1,000 L]		
	National Production	Imports	Total	National Production	Imports	Total
1999	1,563	–	1,563	–	–	–
2000	1,825	1	1,826	–	–	–
2001	1,937	18	1,955	12	–	12
2002	1,774	8	1,782	59	–	59
2003	2,324	18	2,342	145	–	145
2004	3,158	104	3,262	313	–	313
2005	6,180	181	6,361	529	–	529
2006	8,717	116	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	6,837	679	7,516	808	1,418	2,226
2010	6,945	2,380	9,325	869	950	1,819
2011	7,161	3,101	10,262	641	229	870
2012	n.a.	n.a.[a]	12,391	n.a.	n.a.	506

[a] *n.a. = not available.*

The consumption of biodiesel in Switzerland amounted to just over 12.4 million liters (ML) in 2012 (i.e., an increase of 21% with respect to 2011). The consumption of fuel-PVO, however, showed a significant decrease in 2011 (i.e., -42% with respect to 2011). Biodiesel and pure vegetable oils are applied only in some local diesel fleets (mostly in agriculture) [9].

There are 216 fueling stations that provide B5, and 12 fueling stations that provide B100 (2010).

Bioethanol

Table 2 Evolution of Fuel Bioethanol Consumption in Switzerland over the Period 2005–2011 (in kL/y) (dash = 0) [9]

Year	Production	Imports	Total
2005	901	–	901
2006	1,060	–	1,060
2007	3,188	–	3,188
2008	3,284	–	3,284
2009	–	1,438	1,438
2010	–	2,593	2,593
2011	–	4,047	4,047

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 Ml) 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 meet the ecological and social minimum requirements according to the act of mineral oil taxation. 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 provides the supply today in Switzerland. In compliance with the requirements according to the act of mineral oil taxation, this bioethanol benefits from the tax exemption from March 2009 until 2013.

In 2011, there were 50 fueling stations with E85 and 90 fueling stations with E5.

Biogas

Table 3 Evolution of Fuel Biogas (via gas grid and used at a fueling station or for electricity production in a CHP [combined heat and power plant]) Consumption (taxed amounts) in Switzerland over the Period 1999–2012 (in kL/yr) [9]

Year	Biogas via Gas Grid	Share of Biogas in Gas Grid (%)	Biogas Direct Usage for Electricity Production or as Fuel	Total Biogas Production
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
2010	4,505	27.56	0	4,505
2011	6,350	34.51	0	6,350
2012	6,995	37.06	0	6,965

The gas industry guarantees a minimum percentage of 10% biogas within the national gas grid (effectively it amounts to 37%).

In 2011, biogas production was 3,421 TJ (950 GWh), of which 41.8 GWh [11] (4.4%) was used as fuel [2]. In total, 13 biogas plants are upgrading the biogas and feeding it into the natural gas grid (2012).

The total gaseous fuel consumption in Switzerland (natural gas + biogas) was 18,795 000 kg (equal to 27.6 Ml Petrol 95) in 2012, of which 37% (6,965 000 kg) was biogas [9].

Outlook

The medium-term production potential for biofuels is estimated by the federal council at 76 M liters. This is equal to 1% of the Swiss annual fuel consumption.

If policy heavily encouraged local energy production from biomass, a share of 8% of biofuels would be possible until 2020. Therefore, all biomass fractions including the produced by-products have to be used for energy [12].

There is no strong political support for biofuels at the moment. In 2008, the Swiss Federal Office of Energy published a position paper [13]. The main messages within this document are as follows:

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 head and power [CHP] plants); and
4. Food production has priority.

These messages were also supported by a recently published study [14] showing that many biofuels based on agricultural products help to reduce GHG emissions but lead to other environmental pollution, such as too much acid in the soil and polluted (over-fertilized) lakes and rivers. Most biofuels therefore just deflect environmental impact: they result in fewer GHGs, but more growth-related pollution for land used for agriculture. This results in only a few biofuels having an overall better ecobalance than petrol, especially biogas from residues and waste materials, which — depending on the source material — impact the environment up to half as much as petrol. Within the biofuel group, ethanol-based fuels tend to have a better ecobalance than those with an oil base; however, the results are very much dependent on the individual method of manufacture and the technology.

Additional References

[1] BFE (2012): Gesamtenergiestatistik 2011 (http://www.bfe.admin.ch/themen/00526/00541/00542/00631/index.html?lang=de)

[2] BFE (2012): Schweizerische Statistik der erneuerbaren Energien 2011

[3] BFE (2012): Analyse des schweizerischen Energieverbrauchs 2000–2011 nach Verwendungszwecken

[4] BFS (2011): Mobilität und Verkehr, Verkehrsinfrastruktur und Fahrzeuge.
[5] http://www.nachhaltigleben.ch/themen/mobilitaet/auto/ (Download from 04.03.2013)
[6] http://ec.europa.eu/clima/news/articles/news_2012062002_en.htm
[7] BBl (2011): Bundesgesetz über die Reduktion der CO2-Emissionen, Änderung vom 18. März 2011, BBl 2011 5483
[8] BFE (2012): Energiestrategie 2050 – erstes Massnahmenpaket
[9] FCA (Swiss Federal Customs Administration) 2011: Mineralölsteuerstatistik (http://www.ezv.admin.ch/zollinfo_firmen/steuern_abgaben/00382/00632/01468/index.html?lang=de)
[10] http://www.swissoil.ch (EV Annual Report 2011)
[11] VSG (2012): Erdgas in der Schweiz; VSG Jahresstatistik
[12] Erneuerbare Energien (2006); Sondernummer, BFE (see [1])
[13] BFE (2008): Positionspapier biogene Treibstoffe
[14] BFE (2012): Harmonisation and extension of the bioenergy inventories and assessment (http://www.bfe.admin.ch/forschungbiomasse/02390/02720/03175/03197/index.html?lang=de&dossier_id=05663)

Benefits of Participation in the AMF IA

Membership offers great opportunities with regard to international contacts and knowledge exchange. The provided information is always up-to-date, which is valuable. Furthermore, the membership within the AMF IA facilitates international project collaborations with mutual benefits. It helps to promote national projects and provides support for national authorities.

United States of America

Introduction

The U.S. Energy Information Agency (EIA) estimates that total transportation-related energy consumption in the United States in 2011 was approximately 27,000 trillion British thermal units (Btu) (a level that has changed little since 2008[1]), and it projects that the 2012 total will be just under this level at 26.73 trillion.[2],[3] More than 90% of this amount was of petroleum-based fuels, gasoline, and diesel (some 12 million barrels per day), with almost the entire remainder being ethanol blended into gasoline at 10% (roughly 95% of U.S. gasoline currently consists of such blends).[4]

U.S. net dependence on foreign oil has dropped from approximately 60% of U.S. petroleum use in 2005 to around 45% at the end of 2011, with 2012 imports preliminarily estimated at 41%[5] and 2013 projections for 39%.[6] These reductions are due mainly to increased domestic production of "tight oil," including shale deposits and enhanced recovery at mature conventional fields; increases in use of biofuels and other renewables; increases in vehicle efficiency; and increased numbers of consumers switching to smaller vehicles.[7]

A significant development in U.S. motor fuels markets in recent years has been the shutdown of two less efficient refineries that had been serving the East Coast of the United States, such that the East Coast will rely more on refined product shipments from the Gulf Coast and Europe, which has increased its motor fuel prices in that region. A third refinery that had been shut down was sold to an investor group, which is now restarting it, although at reduced production levels.

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1 http://www.eia.gov/totalenergy/data/annual/showtext.cfm ?t=ptb0201e.

2 http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2013ER&subject=15-AEO2013ER&table=46-AEO2013ER&region=0-0&cases=early2013-d102312a,full2012-d020112c.

3 All EIA projections in this report, unless otherwise noted, are from the "Sneak Preview 2013" and its "Reference Case."

4 Ibid.

5 http://energy.aol.com/2012/10/23/eia-chief-us-could-reduce-oil-imports-to-zero-but-might-not-wa/.

6 http://www.marketwatch.com/story/eia-us-oil-use-seen-dropping-to-15-year-low-2012-09-11.

7 http://www.eia.gov/energy_in_brief/foreign_oil_dependence.cfm.

Policies and Legislation

The federal government and state governments provide many incentives for development, deployment, and use of alternative fuels and alternative fuel vehicles (AVFs). Although these are too numerous to catalog here, some of the more important ones are described below.

The Energy Policy Act of 1992 (EPAct 92) requires that certain centrally fueled fleets (federal, state, and alternative fuel provider fleets, such as those of utility companies) acquire light-duty alternative fuel vehicles as most of their new vehicle acquisitions. Fleets of alternative fuel providers must also use alternative fuels in the vehicles where available for use.

The U.S. Department of Energy (DOE) Clean Cities Program is a government-industry partnership program that supports local decisions to reduce petroleum use in the transportation sector. To accomplish this goal, the program encourages the public and private sectors to reduce petroleum consumption by making use of alternative fuels and increasing vehicle efficiency through technologies such as alternative-fueled vehicles, hybrid and electric-drive vehicles, fuel blends, idle reduction technologies, and fuel economy measures. Clean Cities carries out its mission working in cooperation with nearly 100 geographically diverse, community-based coalitions nationwide. Coalitions form partnerships within their communities to design projects to suit their area's needs, resources, and strengths. At the national level, Clean Cities provides manufacturers, trade associations, national fleets, government agencies, and other stakeholders with coordinated strategies and resources they can leverage to implement effective petroleum reduction practices. Clean Cities also provides coalitions with access to information and incentives from DOE, other federal and state agencies, and industry partners that can help fund significant high-impact projects.

As shown in Figure 1, use of advanced motor fuels through the Clean Cities program displaced 348 million gallons of gasoline equivalent (MGGEs) in 2011, an increase of 35% relative to the petroleum saved by alternative fuels in 2010. Results for 2012 are expected to be even greater.

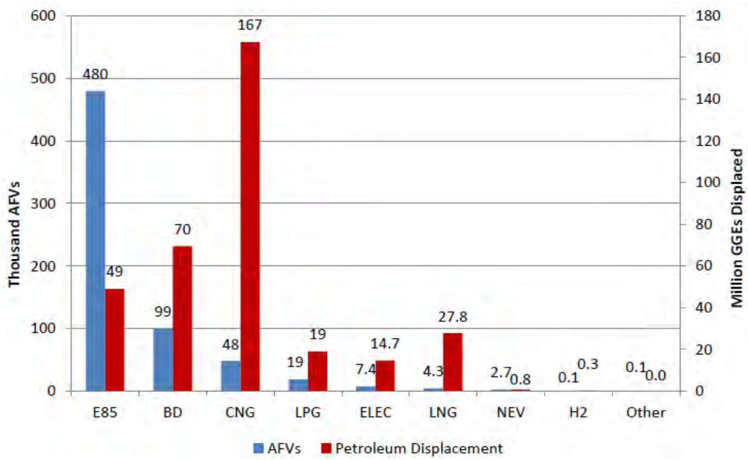

Fig. 1 Clean Cities 2011 AFV Numbers and Petroleum Displacement[8]

More information on the Clean Cities program can be found at: www.cleancities.energy.gov.

The primary driver of biofuel use in the United States is currently the Renewable Fuel Standard (RFS), adopted in 2005 and expanded in 2007 (RFS2), which requires that renewable fuels be sold as motor fuels in increasing volumes each year. For 2011, the requirement was 13.95 billion gallons.

Year-end 2011 also saw the expiration of excise tax credits associated with blending of biofuels. Late in 2012, tax credits were reinstated for cellulosic ethanol, other advanced biofuels, and biodiesel — but not for corn-based ethanol.

The RFS2 statute also requires that minimum amounts of cellulosic biofuel, advanced biofuels, and biomass-based diesel fuel be sold annually (if available) from 2010 on. Anticipating that production would fall well short of the statutory target, the U.S. Environmental Protection Agency (EPA) used its waiver authority to lower the cellulosic ethanol requirement for 2012 to 10.45 million gallons. However, less than 1 million gallons was actually produced in 2012. The EPA is now proposing to lower the required volume of cellulosic biofuel from the statutory 1 billion gallons for 2013 to 14 million gallons.[9]

8 http://www.afdc.energy.gov/uploads/publication/56091.pdf.
9 http://www.gpo.gov/fdsys/pkg/FR-2013-02-07/pdf/2013-02794.pdf, p. 9294.

The EPA has not reduced the requirements for biomass-based diesel or advanced biofuels, almost all of which is biodiesel. For 2012, the total advanced biofuel requirement was for 1 billion gallons and for 2013 is 2.75 billion gallons. These requirements have been met almost wholly with biodiesel and some other bio-based diesel blending components.

Various federal and state programs are also creating incentives to promote use of other alternative and advanced motor fuels. Lists of these are available at http://ethanol.cttstest.nrel.gov/afdc/laws/. Perhaps foremost among the remaining federal tax credits are those for alternative fuel refueling infrastructure.

Implementation: Use of Advanced Motor Fuels

Although actual data for 2012 are not yet available, the EPA currently projects[10] that nearly the entire required amount of 13.8 billion gallons of RFS2 will have been blended; the EPA further reports that ethanol production capacity in 2012 was 14.9 billion gallons.[11] Approximately 95% of U.S. gasoline is believed to contain 10% ethanol. Another milestone of 2012 was that the sale of E15 became fully legal in a number of places: however, thus far, few stations have chosen to offer it, and sales have not been substantial. Thus, ethanol blending in 2012 was bumping up against the 10% “blend wall,” and the total amount blended in 2013 is not expected to be dramatically greater than that blended in 2012.

In 2012, commercial production of cellulosic ethanol in the United States came online for the first time. Although the volume — less than 1 million gallons — was still very small, it appears more likely than ever before that a number of larger facilities will come on-line in 2013. The EPA projects production of 14 million gallons of cellulosic ethanol in 2013,[12] although its

[10] The EPA is required under the Energy Independence and Security Act (EISA) to determine the volume of ethanol that will be required to be blended in a calendar year as part of the RFS. While they are required to publish this information by November 30 of each year for the following year, in 2012 only “preliminary” numbers were published. These volumes have yet to be finalized as of the date of this writing (February 28, 2013).
The EPA’s determination of the amount of ethanol (and other renewable fuels) to be required for use is based on EIA estimates of available volumes of such fuels under EISA.

[11] *Ibid*., p. 9286. A number of ethanol plants were idled in 2012 due to excess capacity and low operating margins. These are apparently still considered part of production capacity, and a few have resumed operation in early 2013.

[12] Ibid., p. 9294.

prior projections (based largely on what aspiring producers predicted they would produce) have proven to be overly optimistic. The EPA identifies four commercial-scale cellulosic biofuel plants, three of which will produce ethanol and one of which will produce gasoline, along with numerous pilot-scale plants that are structurally complete and in the process of start-up.[13]

At this time, blends of greater than 15% ethanol are marketed in the United States at special dispensers for use only in flexible-fuel vehicles (FFVs) designed to run on blended fuels up to the E85 level. There were an estimated 2,596 stations selling FFV fuel in the United States by the end of January 2013, including in “blender pumps,” which sell blends for conventional vehicles as well as a range of blends for FFVs (e.g., E20, E30, and E85). It should be noted that FFVs using high-ethanol blends have experienced problems with starting and drivability in winter months in some regions. In 2011, ASTM International (ASTM) revised its specification, D5798-11 Standard Specification for Ethanol Fuel Blends for Flexible-Fuel Automotive Spark-Ignition Engines, to allow for blends of down to 51% ethanol to be used as FFV fuel.[14] There is, however, no legal barrier to marketing blends of even lower than the 51% for use in FFVs. As noted above, some marketers are offering lower blends year-around through blender pumps.

The impetus to expand use of high-level ethanol FFV fuel was probably greater in 2012 than ever in the past thanks to a number of factors. These include the requirement to comply with the RFS with other ethanol sales facing the blend wall, excess supply of ethanol and low prices, high gasoline prices, greater number of stations, greater FFV vehicle population, and the new ASTM specification to address cold start issues. Despite more favorable conditions, sales of FFV fuel have not taken off, for a variety of reasons that probably include lack of fuel stations passing on savings related to ethanol to consumers, the lack of awareness among many consumers that they are driving FFVs, a lack of consumer awareness of the availability of E85 in the areas in which it is available, the reduced range per tank for those consumers who try E85, and the low percentage represented by fuel costs of the total cost of automobile ownership relative to most of the world.

For biomass-based diesel, the EPA projects that 1.28 billion gallons will be sold in the United States in 2013.[15]

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[13] Ibid.
[14] http://ethanol.cttstest.nrel.gov/afdc/fuels/ethanol_e85_specs.html.
[15] http://www.gpo.gov/fdsys/pkg/FR-2013-02-07/pdf/2013-02794.pdf, p. 9297.

In 2011, the EPA revised its regulations governing conversion of conventional vehicles' systems to those able to run on alternative fuels, making it easier — particularly for conversion systems to natural gas and propane — to obtain approval for vehicles more than two years old. As a result, many more AFV conversion systems are being registered with the EPA. However, data on the impact that this change has had on actual numbers of natural gas and propane vehicles, or vehicle use of natural gas and propane, are not yet available.

The record on the penetration of electric vehicles into the market in 2013 continues to be mixed, as the industry experienced various setbacks, such as equipment suppliers going out of business and monthly vehicle sales numbers fluctuating up and down. But the trend of total numbers of electric vehicles on U.S. roads continues to be upward, with battery electric, plug-in hybrids, and extended-range electric vehicles topping 75,000 in January 2013 (up from nearly zero in January 2011), and with monthly sales reaching about 8,000 vehicles in December 2012.[16]

Figure 2 provides the numbers of alternative fuel refueling stations in the United States in 2011 and 2012 according to DOE's Alternative Fuels Data Center (AFDC). Updated information, with a breakdown by state, can also be accessed at http://www.afdc.energy.gov/data/tab/fuels-infrastructure/data_set/10332.

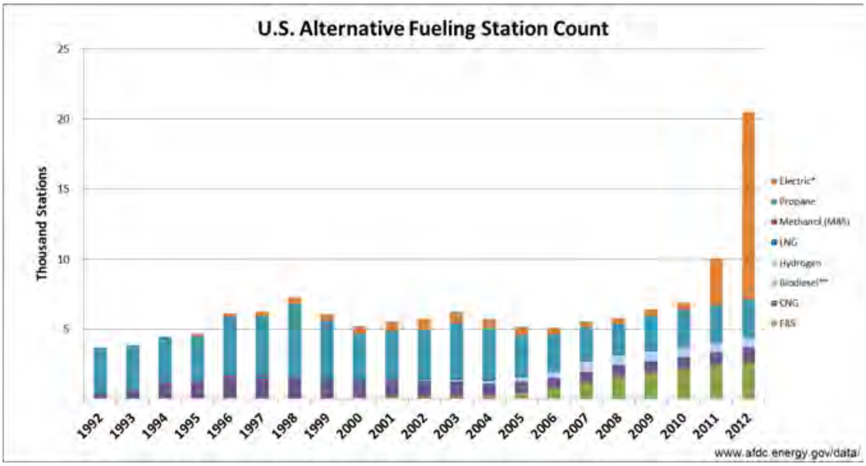


Fig. 2 Number of Alternative Fuel Refueling Stations

16 http://www.electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952.

As Figure 2 shows, the total number of alternative fueling stations in the United States nearly doubled in 2012 over 2011's total, mainly reflecting an increase of more than 250% in the number of recharging stations for electric vehicles.[17]

Outlook

The EIA projects that U.S. petroleum imports and the import dependence ratio will continue to decline to about 36% in 2035 for the same reasons that account for the decline since 2005 (as noted in the Introduction).[18]

High oil prices provide a continuing impetus for switching to alternative fuels, particularly natural gas–based fuels, as U.S. gas prices have been dropping as a result of new supplies from shale gas and enhanced recovery at conventional fields. The EIA projects steady increases in the use of compressed natural gas (CNG) in both freight trucks and transit buses from the present through 2035 (although it projects CNG use in light-duty vehicles to remain at between 11.5 trillion Btu/year and 12.5 trillion Btu/year through 2035).[19] Although the EIA has not included liquefied natural gas (LNG) in its projections as its use has been limited to date, the private sector is investing substantial resources on the expectation that a market will develop.

In addition, as noted above, changes to EPA regulations governing conversions of vehicle systems to those running on natural gas or propane are likely to result in substantial increases in use of these fuels. Moreover, the California Air Resources Board has initiated a similar rulemaking effort — likely to take effect in late 2013 or 2014 — to reform its regulations to facilitate such conversions.

A number of companies have introduced advances in technology for LPG use in light-, medium-, and some heavy-duty applications and are offering additional models incorporating the advances. EIA projects that the

[17] This growth in the total number of refueling sites is somewhat misleading because the electric recharging numbers generally reflect an individual charger outlet for a single auto — in most cases, a Level 2 charger that requires some 1–2 hours to recharge. The other types of stations shown may include multiple dispensers and can refuel many more vehicles in shorter time periods.

[18] http://www.eia.gov/forecasts/aeo/MT_liquidfuels.cfm#net-imports.

[19] http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2011&subject=0-AEO2011&table=46-AEO2011&region=0-0&cases=ref2011-d020911a.

transportation use of LPG will remain fairly steady in the future, a change from previous years when declines had been projected.[20]

However, use of the principal U.S. advanced fuel, ethanol, is expected to continue being constrained in 2013 by the challenges associated with blending more than 10% in gasoline and over concerns about misfueling, compatible systems, etc. In fact, the EIA projects that domestic ethanol production will be unchanged in 2013 at 0.87 million barrels per day to increase slightly by 2020 to 1.01 million barrels per day and to level off thereafter.[21]

While use of FFV fuel has not taken off to date, the next few years could be “make or break” because of a combination of high gasoline prices, RFS2 requirements, and constraints on meeting those requirements posed by additional low-level blends. At the same time, however, station owners have expressed some reluctance to install new FFV refueling systems because of the loss of the excise tax credit, which has made the FFV fuel more expensive than it has been previously and has led to disappointing sales where FFV dispensing has been installed in the past, often leaving such investments unrecoverable. The EIA projects that FFV fuel use (based on the average blend of 74% ethanol) will grow from about 10 trillion Btus in 2012 to nearly 100 trillion in 2014 and to continue growing to 146 trillion in 2024.[22]

An interesting development in 2012 has been the expressed interest of automakers in offering FFVs optimized to use an E20 blend. These vehicles could take advantage of both the higher octane and the higher thermal efficiency of ethanol so as to essentially offset the lower energy content of the ethanol.

U.S. companies are also investing significantly in development of butanol as an alternative to ethanol, as well as in hydrocarbon “drop-in fuels” for both gasoline and diesel fuel based on renewable feedstocks. Butanol offers a number of advantages over ethanol, including materials compatibility, volatility, and water tolerance. It can be blended in higher volumes than ethanol can for use in older vehicles as well as small and marine engines, motorcycles, etc., and has higher energy density, enabling greater progress

[20] http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2011&subject=0-AEO2011&table=46-AEO2011&region=0-0&cases=ref2011-d020911a.
[21] http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2013ER&subject=0-AEO2013ER&table=11-AEO2013ER&region=0-0&cases=early2013-d102312a.
[22] Ibid.

toward the goals of RFS2. It also can be shipped through existing multi-product pipelines. A few ethanol plants have expressed interest in possibly converting to butanol production. Initial products, however, may have greater value in chemical than fuel markets. The conversion of ethanol plants to butanol production in 2012 appears to have lagged behind announced schedules. Apparently, unforeseen problems have surfaced, and at least one of the major butanol development companies has scaled back its operations.

Another interesting development with potential for advanced motor fuel production is to combine natural gas and coal to liquids. A number of the areas where shale gas is plentiful in the United States are also major sources of coal. By combining natural gas and coal, the most efficient ratio of hydrogen to carbon monoxide can be generated. An 800-ton-per-day plant is scheduled to come online in southwestern Pennsylvania with a projected efficiency of 80%, well beyond that of even the latest world-scale plants using natural gas alone. Other plants may follow soon.

Additional References

- Alternative Fuels and Advanced Vehicle Data Center, http://www.afdc.energy.gov.
- Bioenergy Feedstock Information Network, http://bioenergy.ornl.gov/.
- Biomass R&D Initiative, http://www.biomass.govtools.us.
- 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.
- EIA International Energy Outlook, http://www.eia.doe.gov/oiaf/ieo/index.html.

Benefits of Participation in the AMF IA

The U.S. Department of Energy Vehicle Technologies Program is an active participant in the AMF IA 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 IA are facing the same fuel issues as those faced in the United States, and mutual cooperation has proven beneficial in the past and should continue to do so in the future.

3 Ongoing AMF Annexes

3.a
Overview of Annexes

Ongoing Annexes

Annex Number	Title	Operating Agent
28	Information Service & AMF Website (AMFI)	Dina Bacovsky
35-2	Particulate Measurements: Ethanol and Butanol in DISI Engines	Debbie Rosenblatt
38-2	Environmental Impact of Biodiesel Vehicles in Real Traffic Conditions	Norifumi Mizushima
39-2	Enhanced Emission Performance of HD Methane Engines (Phase 2)	Olle Hadell
41	Alternative Fuels for Marine Applications	Ralph McGill
42	Toxicity of Exhaust Gases and Particles from IC-Engines — International Activities Survey (EngToxIn)	Jan Czerwinski
43	Performance Evaluation of Passenger Car, Fuel, and Power Plant Options	Jukka Nuottimäki
44	Research on Unregulated Pollutant Emissions of Vehicles Fueled with Alcohol Alternative Fuels	Kewei You
45	Synthesis, Characterization, and Use of Algae-HVO and eFAME for Engine Operation	Benjamin Stengel
46	Alcohol Application in CI Engines	Jesper Schramm

Recently Completed Annexes

Annex Number	Title	Operating Agent
37	Fuel and Technology Alternatives for Buses	Nils-Olof Nylund
40	Life Cycle Analysis of Transportation Fuel Pathways	Peter Reilly-Roe

The final reports of all recently completed annexes are published on the Advanced Motor Fuels (AMF) website. In addition, Annex 37 was presented at the SAE 2012 Commercial Vehicle Engineering Congress, October 2–3, 2012, Rosemont, Illinois, United States of America.

3.b
Annex Reports

Annex 28: Information Service & AMF Website

Project Duration	January 28, 2004 (continuous)
Participants	All Contracting Parties
Task Sharing	No task sharing
Cost Sharing	Austria, Canada, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Republic of Korea, Spain, Sweden, Switzerland, Thailand, United States
Total Budget	52,000 € for 2012 ($68,057 US) 43,000 € for 2013 ($56,278 US)
Operating Agent	Dina Bacovsky, BIOENERGY 2020+ dina.bacovsky@bioenergy2020.eu

Background

Today, a wealth of information on hundreds of topics is easily available through the worldwide web. With so much information available, filtering out the relevant information has become very time-consuming. In theory, everyone has access to publications from all over the world. However, one may not know where to look for a particular publication or may be in need of a translation.

Purpose and Objectives

The purpose of Annex 28 is to collate information in the field of advanced motor fuels and to make it available to a targeted audience of experts in a concise manner.

Activities

- Reviewing the relevant sources of news regarding advanced motor fuels, vehicles, energy, and environmental issues in general. News articles are provided by experts in North America, Asia, and Europe.
- Publishing four electronic newsletters yearly (on an average) on the AMF website. An e-mail alert system is used to disseminate information for the latest issues.
- Preparing an Alternative Fuels Information System. This effort seeks to collate relevant information on alternative fuels and their use for transport. The performance of cars, the effect of fuels on exhaust emissions, and fuel compatibility with infrastructure are covered. However, resources, production, and greenhouse gas (GHG) emissions are excluded. In close cooperation with different organizations, efforts are under way to build a guidebook on advanced motor fuels that will be accessible electronically on the AMF website.
- Updating the AMF website to provide information on issues related to transportation fuel — 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. This internal information includes strategy, proposals, and decisions, as well as details about the Executive Committee (ExCo) meetings of the AMF IA.
- Refreshing the AMF website and moving it to www.iea-amf.org. Based on the current content and on suggestions for improvement by AMF delegates, a new structure has been created along with a new design. The purpose is to improve the AMF outreach to stakeholders.

Results and Reports/Deliverables

In 2012, electronic newsletters were published in March, June, October, and December (Figure 1).

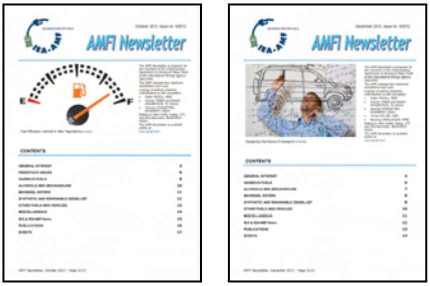


Fig. 1 AMF Newsletters Published in 2012

The Alternative Fuels Information System was completed for all fuels, and the review process was started.

The AMF website was updated frequently with information from Annexes and ExCo meetings. A new design and structure for the AMF website was developed and implemented (Figure 2). The website was moved to www.iea-amf.org.

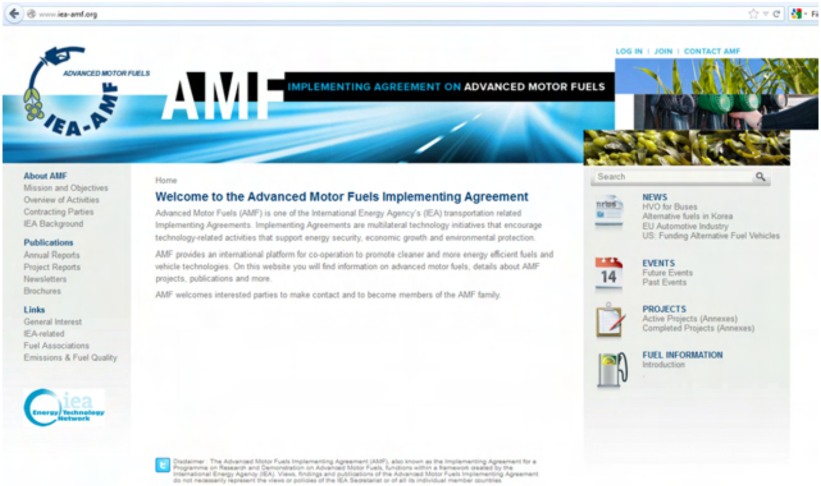


Fig. 2 Screenshot of the New AMF Website

Future Plans

Future plans include making the Alternative Fuels Information System available on the AMF website, continuing to publish four electronic newsletters per year, and frequently updating the website.

Annex 35: Ethanol as Motor Fuel
Sub-task 2: Particulate Measurements: Ethanol and Butanol in DISI Engines

Project Duration	November 2010 – May 2014
Participants **Task Sharing** **Cost Sharing**	 Canada, China, Finland, United States No cost sharing
Total Budget	~225,000 € ($300,000 US)
Operating Agent	Debbie Rosenblatt Environment Canada Email: Debbie.Rosenblatt@ec.gc.ca

Background

As renewable fuel mandates become enacted in North America, and as fuel economy standards get 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 sixfold since the year 2000. Market growth is expected to continue for the next decade at least.

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. Also, 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

As a result of 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 due to the interaction of ethanol-gasoline blends in DISI engines. Initial research has shown that low-level ethanol blends decrease PM formation. However, further confirmation is needed. Particulate formation is basically unknown in the cases of butanol blends. This sub-task to Annex 35 is designed to investigate these issues.

Activities

The project involves comparing direct injection of ethanol-blended fuels to direct injection of gasoline-injected fuels. Steady-state engine dynamometer tests, as well as transient chassis dynamometer vehicle tests, will be performed with gasoline direct-injection engines, and emissions, power, and fuel economy will be compared. It is suspected that ethanol may have a larger advantage for brake-specific power as a result of the high octane of the fuel and the increased in-cylinder cooling of the intake air charge.

Canada Project Activities

Environment Canada — Emissions Research and Measurement Section conducted chassis dynamometer tests on a model year 2011 light-duty vehicle with a 2.4-L DISI engine that meets Tier 2 Bin 5 North American Emissions standards. This emissions profile was compared to that of a model year 2010 light-duty vehicle with a 2.4-L PFI (port fuel injection) engine that also meets Tier 2 Bin 5. Tests were performed with gasoline, E10, and E20. Two transient drive cycles were used (FTP-75 and US06) at 22°C, -7°C, and -18°C. Emissions tests were also performed by using iso-butanol-16 (iB16) at 22°C and -18°C. The DISI vehicle, in addition to being tested in its original stock configuration, was equipped with a prototype noncatalyzed gasoline particulate filter. *In situ* particle measurements were conducted by using both the European Union Particle Measurement Programme solid particle system and an engine exhaust particle sizer directly to monitor particle number distributions.

China Project Activities

The China Automotive Technology and Research Center (CATARC) has tested five DISI vehicles with gasoline to date. It plans to compare two of these DISI vehicles with gasoline, M15, and E10.

The University of Toronto has initiated tests on a Ford 4-cylinder 2-L *gasoline direct injection* (GDI) engine. The test plan includes engine operation on four types of engine test cycles: cold start, hot start, steady-state simulated highway cruise, and simulated passing maneuver. During the tests, the engine exhaust will be continually sampled by using a mini-dilution system. The PM samples will be collected on 47-mm filters and quartz-fired filters for gravimetric determination and organic and elemental carbon split. Particle size distribution will be measured on a continuous basis by using a differential mobility spectrometer. Test fuels include gasoline and varying blends of ethanol.

Finland Project Activities

The Finnish portion of the project builds on work carried out under Annex 43: Performance Evaluation of Passenger Car, Fuel, and Power Plant Options. Chassis dynamometer tests were made within the VTT Technical Research Centre of Finland's facilities on a passenger vehicle (model year 2011) with a 1.4-L turbocharged DISI engine that meets Euro 5a European Union emissions standards. The tested fuels were E10 and E85, and tests were performed in two ambient temperatures, namely 23°C and -7°C. Measurements were made on the transient New European Driving Cycles (NEDC). Particulate measurements included size distributions (through an electrical low-pressure impactor) and soot mass (on 47-mm filters).

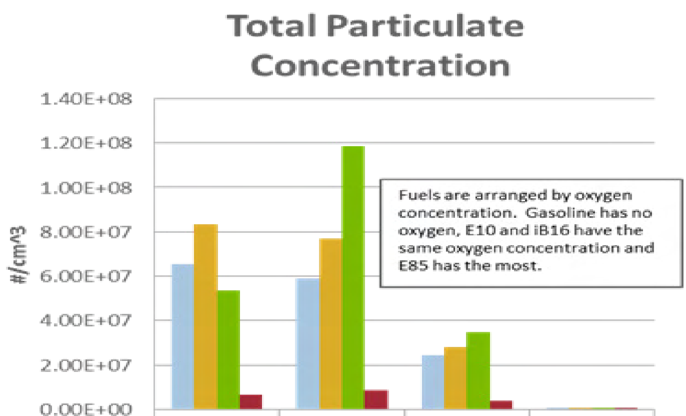
U.S. Project Activities

The U.S. portion of the project was performed at Argonne National Laboratory (Argonne) by using a GM 2.2-L, in-line 4-cylinder, 16-valve DISI engine at idle conditions, as well as at 25%, 50%, and 75% load at 2,000 rpm. The spark timing was advanced to the point just prior to the occurrence of knocking for the purpose of testing. No optimization was made for exhaust gas recirculation (EGR) levels. The EGR was maintained at 4% for all idle test points with all fuels and was held at 14% for all other test points. The fuels tested were gasoline, E10, E85, and iso-butanol-16 (iB16). Particulate measurements included size and number distribution through a scanning mobility particulate sizer, as well as soot morphology (primary and aggregate particle size).

Results and Reports/Deliverables

Results

As illustrated in Figure 1, results from the Argonne work showed significant differences in the levels of particulates produced for the fuels and for the different load/speed combinations. The E85 produced significantly lower particulate levels than did any of the other fuels tested. Gasoline produced lower levels, by 10% to 30%, throughout the testing matrix than did E10. The iB16 produced levels slightly above the other fuels for 75% load conditions and slightly below them for the 25% load case. At 50% load, iB16 produced significantly higher levels than did the other fuels. These results suggest that fuel properties, including viscosity and latent heat of vaporization, may influence combustion behavior, thereby leading to increased particulate emissions.



	25%	50%	75%	idle
Gasoline	6.52E+07	5.90E+07	2.43E+07	2.40E+05
E10	8.32E+07	7.68E+07	2.78E+07	2.54E+04
ib16	5.36E+07	1.19E+08	3.49E+07	6.97E+04
E85	6.36E+06	8.61E+06	3.85E+06	2.92E+04

Fig. 1 Total Particulate Concentration (#/cm^3): 2.2-L DISI Engine

At Environment Canada, particle size distributions from a 2.4-L DISI vehicle (Figure 2) and a comparable PFI vehicle were quantified, as illustrated in Figure 3. The GDI vehicle clearly emitted more particles than the PFI vehicle at all ambient temperatures. However, both vehicles exhibited increased particle emissions with decreasing ambient temperature. At standard temperature, the changes in particle emissions on E10 were small on both vehicles.

Fig. 2 DISI Vehicle Emissions Tested on Environment Canada's Chassis Dynamometer

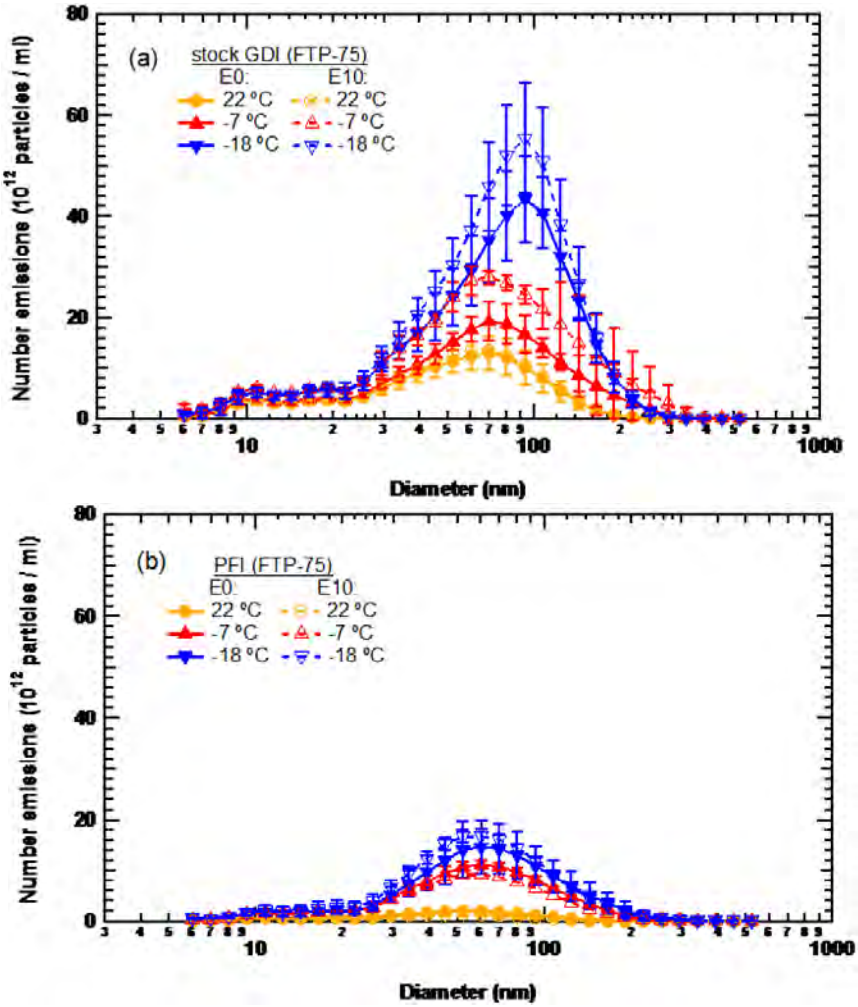


Fig. 3 Particle Size Distributions (number emission rate: 10^{12} particles/mile) for DISI (stock GDI) and PFI Vehicles over the FTP-75 at Various Ambient Temperatures Operated on E0 and E10[31] (SAE 2013-01-0527)

At the University of Toronto, much effort was taken to develop sampling procedures and to ensure instrumentation quality control. The main focus has been to determine particle losses in the sampling/dilution systems. To

[31] Chan, T., Meloche, E., Kubsh, J., Brezny, R., et al., "Impact of Ambient Temperature on Gaseous and Particle Emissions from a Direct Injection Gasoline Vehicle and Its Implications on Particle Filtration," SAE Int. doi:10.4271/2013-01-0527.

date, the cold start and hot start tests have been performed with E0. Cold start and hot start tests with ethanol blends are ongoing and will be followed by tests with the simulated highway cruise and simulated passing maneuver test cycles.

The VTT test results showed that at both temperatures, 23°C and -7°C, light-duty vehicle particle concentrations with E85 were significantly lower than those with E10. With both fuels, the particle concentrations were higher at lower ambient test temperatures (see Figure 4).

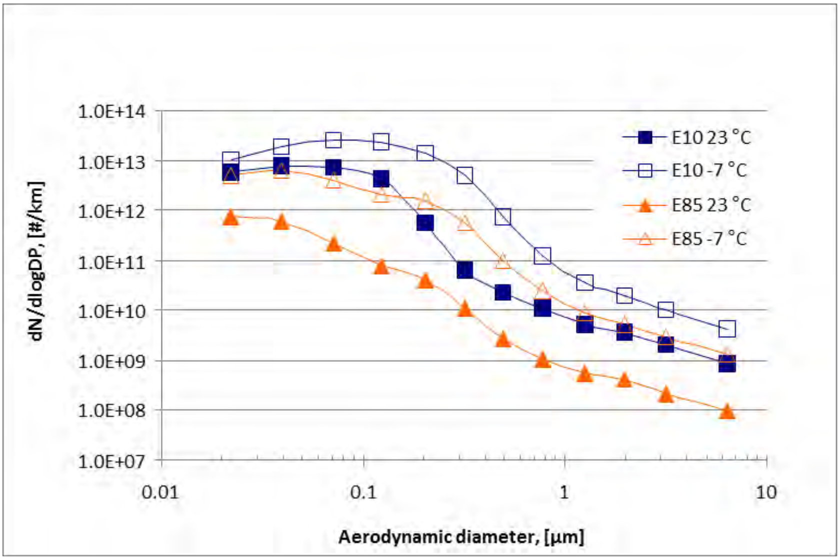


Fig. 4 Particle Size Distributions (number/km) for DISI Vehicles over the NEDC at Various Ambient Temperatures Operated on E10 and E85

The preliminary findings on CATARC tests showed that for the five DISI vehicles, the PM emissions in the first urban cycle make the greatest contribution of the total PM emissions in the entire NEDC, and that PM emissions are directly related to engine temperature. The PM emissions at hot start are significantly reduced compared with the cold start mode. Regardless of the cold start or hot start, the transient acceleration can significantly increase PM emissions. From the current test results, PM emissions are about 2~3.4 mg/km, which can meet the emission regulations limits of 4.5 mg/km, while the particulate number emission is about 3.5~6.59 × 10^{12}/km — generally higher than the Euro 5 and 6 limits (6 × 10^{11}/km).

Reports/Deliverables

Environment Canada has drafted two publications in the Society of Automotive Engineers that detail the results of DISI and PFI vehicles operating with ethanol blends and particle filtration:

- Evaluation of a Gasoline Particulate Filter to Reduce Particle Emissions from a Gasoline Direct Injection Vehicle [32] and
- Impact of Ambient Temperature on Gaseous and Particle Emissions from a Direct Injection Gasoline Vehicle and Its Implications on Particle Filtration.[33]

Time Schedule

Testing is currently continuing in Canada and China. A Draft Report is scheduled to be circulated to project partners for review by May 2013.

Future Plans

There is a potential to include additional testing in the coming year. This issue will be presented at the upcoming AMF ExCo 45 in Gothenburg, Sweden, with the option of extending Annex 35-2 to 2014.

[32] Chan, T., Meloche, E., Kubsh, J., Rosenblatt, D., et al., "Evaluation of a Gasoline Particulate Filter to Reduce Particle Emissions from a Gasoline Direct Injection Vehicle," SAE Int. J. Fuels Lubr. 5(3):1277–1290, 2012, doi:10.4271/2012-01-1727.

[33] Chan, T., Meloche, E., Kubsh, J., Brezny, R., et al., "Impact of Ambient Temperature on Gaseous and Particle Emissions from a Direct Injection Gasoline Vehicle and Its Implications on Particle Filtration," SAE Int. doi:10.4271/2013-01-0527.

Annex 38: Environmental Impact of Biodiesel Vehicles in Real Traffic Conditions

Project Duration	January 2012 – June 2014
Participants **Task Sharing** **Cost Sharing**	 Canada, Japan (LEVO) Denmark, Finland, Sweden, United States
Total Budget	95,000 € ($124,450 US)
Operating Agent	Norifumi Mizushima, Dr. Eng. National Traffic Safety and Environment Laboratory (NTSEL) E-mail: mizusima@ntsel.go.jp

Background

From the standpoint of seeking to lower greenhouse gas (GHG) emissions and to pursue “carbon-neutral” strategies, biodiesel fuel (BDF) is receiving attention because of its potential to contribute significantly to environmental protection on a global basis. The BDF made from waste cooking oil also is expected for recycling. As a result of this potential, efforts to promote the production and use of BDF have increased all over the world.

On the other hand, diesel vehicles adapted to the latest emissions regulations have leading-edge technologies with the precise electronic control system to reduce exhaust emissions. However, these technologies have been optimized for vehicles fueled with light oil. Therefore, if the latest diesel vehicles are fueled with BDF, whose emission properties are much different from those of light oil, exhaust emissions might get worse.

The promotion of BDF is highly effective for the reduction of GHG emissions. Thus, the possibility of affecting the increase of harmful exhaust emissions is of concern if BDF is used for diesel vehicles with the latest technologies. In this context, the emissions characteristics of the latest diesel vehicles fueled with BDF must be researched.

Purpose and Objectives

The use of BDF vehicles has increased in many countries. For example, in Kyoto City, Japan, route buses and refuse trucks are fueled with “neat” waste cooking-oil BDF. Thus, it is important to determine not only the emissions levels in certification tests, but also the real-world emissions.

In this research, on-road driving tests that use the Portable Emission Measurement System (PEMS) are conducted on new diesel vehicles adapted to the latest emissions regulations, where the emissions level is equivalent to EURO V (Phase 1 of this Annex) and EURO VI (Phase 2 of this Annex). The test diesel vehicle is not customized for BDF operation. This study aims to clarify the real-world emissions between the case of light oil and that of BDF, which includes first-generation and next-generation fuels.

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

Activities

The main activities for this project are as follows:

- Tasks are carried out by the National Traffic Safety and Environment Laboratory (NTSEL) and the Organization for the Promotion of Low Emission Vehicles (LEVO). The NTSEL and LEVO have meetings to confirm the progress.
- Tests are performed by using the latest heavy-duty diesel vehicle that applies to the Japanese 2009 regulation (Figure 1).
- Chassis dynamometer tests are conducted to assess the latest heavy-duty diesel vehicle fueled with light oil, first-generation BDF (waste cooking-oil BDF) and next-generation BDF (hydrotreated vegetable oil [HVO] and biomass to liquid [BTL]).
- On-road driving tests are conducted to examine the latest heavy-duty diesel vehicle fueled with light oil, first-generation BDF (waste cooking-oil BDF) and next-generation BDF (HVO and BTL).
- A task-sharing effort with Canada includes testing with its test vehicles and equipment.

Fig. 1 Test Vehicle (applies to the Japanese 2009 regulation)

Results and Reports/Deliverables

The results and deliverables for this project are as follows:

- Chassis dynamometer tests with light oil, first-generation BDF (waste cooking-oil BDF) and next-generation BDF (HVO) were completed.
- The PEMS was installed on the test vehicle.
- On-road driving tests (normal and eco-driving) with light oil, first-generation BDF (waste cooking-oil BDF) and next generation BDF (HVO) were completed.
- The analysis of test data for on-road driving (Figure 2) has been under way since February 2013.

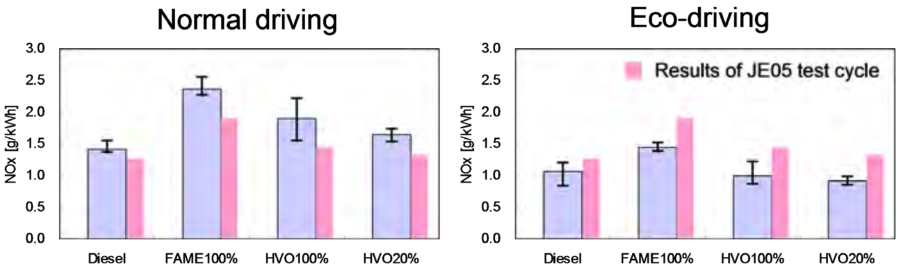


Fig. 2 Example of On-road Driving Test Results

Time Schedule

The time schedule for this project is presented in Table 1.

Table 1 Time Schedule: January 2012 – December 2013

Year	2012												2013											
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chassis dynamometer test (Diesel)																								
Chassis dynamometer test (FAME)																								
Chassis dynamometer test (HVO)																								
Setup of on-road driving test																								
On-road driving test (Diesel)																								
On-road driving test (FAME)									B100		B5													
On-road driving test (HVO)									B100, B20		B5, B7, B50													
Chassis dynamometer test (BTL)																								
On-road driving test (BTL)																	B5, B7, B20, B50, B100							
On-road eco-driving test (Diesel)																								
On-road eco-driving test (FAME)									B100		B5													
On-road eco-driving test (HVO)									B100, B20		B5, B7, B50													
On-road eco-driving test (BTL)																	B5, B7, B20, B50, B100							
Preparation of the final report																								

Future Plans

Future work will include chassis dynamometer tests with next-generation BDF (BTL) and on-road driving tests with next-generation BDF (BTL).

Annex 39: Enhanced Emission Performance of HD Methane Engines (Phase 2)

Project Duration	November 2010 – July 2014
Participants **Task Sharing** **Cost Sharing**	 ANGVA, Canada, Denmark, Finland Germany, Japan, Sweden, IEA Bioenergy (EC DG Energy)
Total Budget	365,000 € ($484,793 US)
Operating Agent	Magnus Lindgren Swedish Transport Administration (STA) Email: Magnus.Lindgren@trafikverket.se

Background

Climate change and the shortage of crude oil are serious challenges. As such, the use of fossil fuels must be reduced to a fraction of the volume that is consumed today. Figure 1 illustrates this issue.

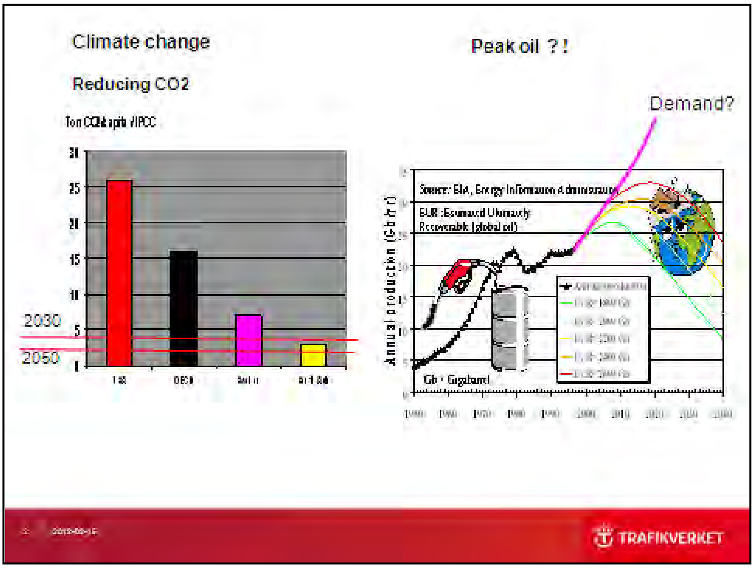


Fig. 1 Impact of Climate Change on Oil Use

To achieve that level of reduction in road transport, vehicles need to become much more efficient, and renewable energy must be commercialized.

Because of legislation mandating that future vehicle concepts consume less energy, ordinary cars will rapidly become 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 reduced need for gasoline and a growing demand for diesel oil — especially for heavy-duty vehicles (HDVs). Furthermore, jet fuels for aviation also depend on the same components as diesel, and heavy oils in marine applications will soon be substituted by lighter fractions. The current imbalance 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, such as Fischer-Tropsch diesel or hydrotreated vegetable oils. Another route is to modify the heavy, still compression-ignited engine to enable the 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 the development of highly efficient methane engines.

The most interesting use of biomethane occurs in HDVs. The volumes are predictable and even higher than light-duty vehicle volumes, and installation of the infrastructure is relatively simple and inexpensive. However, more importantly, in HDVs biomethane always substitutes for diesel oil. Liquefied methane can be a cost-effective solution in long-haul transportation.

Purpose and Objectives

It is important to realize that conforming to the latest emission regulations (limits) requires significant efforts from engine manufacturers during the development phase of the engine. These efforts will involve huge considerations when an engine is converted afterwards to operate on a different fuel, yet still must conform to the requirements of the emission regulations. Therefore, future work within the project will mainly deal with original equipment manufacturer (OEM) applications (i.e., when the manufacturer of the engine takes full responsibility for emission performance and warranty). Highlights of the recommended road map for future work are listed below.

- Continue the dialogue with suppliers of diesel dual-fuel (DDF) concepts and interested OEMs.

- Verify the present status of fuel efficiency, diesel replacement, and emission performance for commercially available DDF concepts that meet the latest emission requirements.
- Conduct benchmarking of available concepts (DDF and spark ignition [SI]) for methane-fueled heavy-duty (HD) engines.
- Contribute to the development of a certification scheme and in-service conformity program for HD dual-fuel engines. (Work is carried out in the Gaseous Fueled Vehicles [GFV] informal work group within the United Nations Economic Commission for Europe [UNECE] Working Party on Pollution and Energy [GRPE]).
- Consider methods for verification of emission performance for methane-fueled HD engines in normal operation (i.e., an inspection and maintenance program).

Activities

Phase 2 of the project involves the benchmarking of commercially available methane fuel concepts. Sweden, as the operating agent, will compile test results and experiences from emission laboratories in the member countries that participate on a task-sharing basis. Sweden also will conduct emission testing of state-of-the-art methane concepts for HDVs. A sophisticated test program has been provided to participating member countries. Details of the test program can be found in the IEA-Advanced Motor Fuels Annual Report for 2010. During 2012, four vehicles were tested in Sweden, both in a laboratory environment and on the road during real-life operation. These vehicles ranged from commercially available dedicated gas engines to newly developed methane diesel or dual-fuel vehicles. The tests of the dual-fuel vehicles were conducted in close cooperation with the vehicle manufacturers in order to verify the emission potential from methane-fueled HDVs.

The activities in the project are summarized as follows:

- Plan the overall test campaign,
- Conduct emission testing in the laboratory and on the road,
- Compile emission test results from other laboratories,
- Analyze the test results,
- Present an interim report for the Annex members at ExCo 45,
- Elaborate and present a technical report for AMF, and
- Present the results at seminars/workshops.

Results and Reports/Deliverables

Phase 1 of the project was finalized in May 2010. The result from Phase 1 was a report: “Enhanced Emission Performance and Fuel Efficiency for HD Methane Engines.” The report is a literature study that focuses on DDF concepts and highlights the potential to reach low exhaust emissions and improved engine efficiency (compared with SI-methane engines). The report is available at www.iea-amf.org.

The second part of the project consists of emission and performance measurements of dedicated methane engines and dual-fuel engines. In addition to the measurements conducted in Sweden, cost share participants Germany, Japan (Organization for the Promotion of Low Emission Vehicles [LEVO] and Japan Gas Association [JGA]), and IEA Bioenergy (DG Energy) contributed information. The task share contributions from Canada, Denmark, and Finland have not yet been reported. Also, the final report will contain information from the Asia Pacific Natural Gas Vehicles Association (ANGVA) about the gas consumption and post-conversion of petrol/diesel engines to gas/DDF engines in Asian countries.

Time Schedule

The time schedule for this project is presented in Table 1.

Table 1 Time Schedule for Annex 39

	2010	2011				2012				2013				2014	
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Vehicle 1 (DDF #I)	X														
Vehicle 2 (SI #I)							X								
Vehicle 3 (SI #2)								X							
Vehicle 4 (DDF #2)									X						
Interim Report											X				
Input Canada												?	?		
Input Denmark												?	?		
Input Finland												?	?		
Final Report															X

Future Plans

During the planning phase, stakeholders expressed an interest in identifying ways to present the potential of emission performance for methane-fueled engines and to compare energy consumption and emissions performance in an uncomplicated manner. However, the focus of the different stakeholders varies, and diverse questions must be addressed. From a strict technical point of view, modifications to the test program will cause some minor problems, and the time line to finalize the report might change. Examples of additional issues to be included in the final report are as follows:

- Unregulated emissions from methane-fueled HD engines,
- Emission performance for converted engines/vehicles in use that meet Euro III standards,
- Durability performance for methane-fueled engines,
- Differences in emission performance between compressed natural gas and biogas, and
- Use of liquefied natural gas/biogas.

So far, financing has been partly arranged for the measurement of unregulated components. These components will be measured and analyzed by Fourier transform infrared, mass spectrometry, and DNPH (2,4-Dinitrophenylhydrazine) cartridges. We intend to expand the scope of the project to also include this type of measurement.

The DG JRC has expressed an interest in participating in the task share. However, the details have not been confirmed.

Annex 41: Alternative Fuels for Marine Applications

Project Duration	November 2011 – June 2013
Participants **Task Sharing** **Cost Sharing**	 Denmark Denmark, Finland, Germany
Total Budget	80,000 € ($106,256 US)
Operating Agent	Ralph McGill Fuels, Engines, and Emissions Consulting (United States) Email: rnmcgill@chartertn.net

Background

The marine shipping industry is facing challenges to reduce engine exhaust emissions and greenhouse gases (GHG) in particular carbon dioxide (CO_2) from their ships. International regulatory bodies, such as the International Maritime Organization (IMO) and national environmental agencies of many countries, have issued rules and regulations that drastically reduce GHG and emissions emanating from marine sources. These new rules are impacting ships that engage in international and coastal shipping trade, the cruise industry, and ship owners and operators.

Of particular note are regulations in Emissions Control Areas (ECAs), such as the North American ECA, which came into effect in 2012, and the SO_x Emission Control Areas (SECA), which have been in effect in the Baltic Sea and North Sea and English Channel since 2006 and 2007, respectively. Ships operating in the ECAs and SECAs are required to use lower-sulfur fuels or add SO_x exhaust scrubbers. Future ECAs will be coming into effect in countries that see heavy ship traffic. Short-term local (SECA/ECA) NO_x and SO_x reductions are the most pressing issues as a result of these regulations. In the longer term, GHG and particulate matter (PM) emissions will provide further environmental challenges.

Many ship operators, with current propulsion plants and marine fuels, cannot meet these new regulations without installing expensive exhaust aftertreatment equipment or switching to alternative fuels with properties that 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 has grown dramatically for both liquid and gaseous fuels. Each of these alternative fuels has advantages and disadvantages from a shipping industry standpoint.

Purpose and Objectives

The overall objective of Annex 41 is to compile an extensive volume of information relative to the implementation of various alternative fuels within the European maritime sector. This information will enable us to determine and recommend the most fiscally sound policies to achieve the goals of environmental compliance, seamless integration of alternative fuels within existing infrastructures, unfettered maritime trade practices, and minimal impediments to ship owners and operators.

Activities

PART ONE (Alternative Fuels Evaluation)

- Task 1 (Literature Survey)
- Task 2 (Alternative Fuel Propulsion System Evaluation)
- Task 3 (Economic Evaluation)
- Task 4 (Alternative Fuel Infrastructure)

PART TWO (Ship Operators Challenges)

- Task 1 (Operating in Emission Control Areas)
- Task 2 (Alternative Fuels Cost and Availability)

PARTNERS

- Fuels, Engines, and Emissions Consulting (Ralph McGill)
- Alion Science and Technology (Bill Remley)
- Danish Technical Institute (in kind) (Kim Winther, et al.)

Results and Reports/Deliverables

The final report will be distributed at ExCo 45 (May 2013).

Time Schedule

The project duration (Parts 1 and 2) is estimated to take about 18 months. An interim report will be issued at the conclusion of Part 1 (at about 7 or 8 months), and a final report will be issued at the completion of Part 2.

Future Plans

Currently, there are no future plans. However, as possible topics are identified during the course of the study, they will be discussed with the ExCo participants.

Annex 42: Toxicity of Exhaust Gases and Particles from IC-Engines — International Activities Survey (EngToxIn)

Project Duration	November 2010 – December 2014
Participants **Cost Sharing**	All Contracting Parties: Austria, Canada, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Republic of Korea, Spain, Sweden, Switzerland, Thailand, United States
Total Budget	48,000 € ($62,784 US) • AMF: 30,000 € • Switzerland: 18,000 €
Operating Agent **Co-Operating Agents**	Jan Czerwinski (jan.czerwinski@bfh.ch) AFHB (Laboratory for IC-Engines & Exhaust Emissions Control, Berne), University of Applied Sciences, BFH-TI, Biel, Switzerland Ronny Winkelmann, FNR, Germany Jean-Paul Morin, University Rouen, France

Background

Exhaust gases from engines, as well as from other combustion and industrial processes, contain different gaseous, semi-volatile, and solid compounds that are toxic. In addition, some new substances may appear as a result of progressing technical developments and new systems of exhaust gas aftertreatment. Some of these compounds are not regarded by the respective legislations.

Purpose and Objectives

This Annex offers an information and knowledge exchange among specialists with an expertise on engines, vehicles, and toxicology. To enable potential common projects with European and overseas partners, it is beneficial to participate in interdisciplinary and international network activities, such as the Engine Toxicity Network (EngToxNet). This Annex also provides valuable material for decision-making authorities.

Activities

The toxical effects of exhaust gases as whole aerosols (i.e., all gaseous components together with particle matter and nanoparticles) can be investigated in a global way by exposing the living cells, or cell cultures, to the aerosol. When this occurs, the result is a simultaneous superposition of all toxic effects from all active components.

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

This new methodology can be applied to all types of emission sources. It bears the potential of giving new contributions to the present state of knowledge in this domain. In some cases, it could lead to a change of paradigm.

Results and Reports/Deliverables

Worldwide, a number of research activities to address the health effects of exhaust gases are under way. Because these activities have different objectives, approaches, and methodologies, the results rarely can be directly compared to each other. Nevertheless, since some common lines do exist, appropriate efforts could result in possible ways to establish harmonized biological test procedures.

To obtain a common validated bio-toxicological testing procedure, more test activities are needed on a worldwide basis. Several European countries have expressed an interest in participating in a common European Union project with EngToxNet to establish a round-robin validation program of toxicological procedures.

Annex 43: Performance Evaluation of Passenger Car, Fuel, and Power Plant Options

Project Duration	January 2011 – December 2013
Participants **Task Sharing** **Cost Sharing**	 Canada, China, Finland, Japan, Sweden, United States No cost sharing
Total Budget	~450,000 € ($594,135 US)
Operating Agent	Jukka Nuottimäki VTT Technical Research Centre of Finland Email: jukka.nuottimaki@vtt.fi

Background

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

Passenger cars are a major vehicle class among road-going vehicles. Since the number of individual vehicle types, makes, and models is very large, the evaluation of future options is quite challenging. The goal of this research project is to deliver first-hand primary data for this type of evaluation, which could improve the possibilities for making appropriate choices among the many available options. The available technology options are increasing for both power train and fuel alternatives. Therefore, unbiased data sanctioned by the International Energy Agency (IEA) on the performance (energy use and emissions) of new technologies is needed for decision makers at all levels.

Purpose and Objectives

The core of the evaluation consists of benchmarking a set of makes and models of passenger cars that offer multiple options for power plants and fuels (i.e., gasoline, flex-fuel [E85], diesel, compressed natural gas/liquid petroleum gas [CNG/LPG], and hybrid and electric vehicle [EV] variations). Since the beginning of this project, the offering of suitable vehicles has increased, including vehicle platforms that offer hybrid or EV versions. The project also will demonstrate the differences in efficiency that arise from engine type and size by testing engines of different power output offered to the same vehicle platform.

The test matrix allows for modulation of the duty cycle and ambient temperature in order to obtain more application/environment-specific data. To make the assessment as realistic as possible, the evaluation is based on a set of different operating conditions and applications (duty cycles). For example, using only standard type-approval cycles and normal ambient temperature could yield misleading information. This varying of conditions is important, since previous experience has shown that cars tend to be optimized to type-approval conditions and common driving cycles.

The primary objective of the project is to produce comparable information about different power plant options for fuel efficiency, energy efficiency, and tailpipe emissions. By using selected vehicle platforms and basically performing “internal” comparisons between power plant options, the vehicles themselves can be “nullified.” This approach will emphasize the differences between alternative engine technologies, rather than the differences between car makes and models. The project also provides a way to compare and develop different fuel options.

Activities

The project consists of a comparison of power trains and alternative fuels, firstly within a vehicle model family and secondly between different vehicle model families. Chassis dynamometer testing will provide data on the end-use performance of alternative vehicles. Full fuel-cycle performance will be calculated by (1) combining well-to-tank data for various fuels generated in the current IEA Bus Project and then (2) combining that data with the end-use performance for various light-duty vehicle and fuel technologies. These data will provide information on the complete fuel cycle.

Canada Project Activities

Canada was able to participate in this Annex when the duration of the project was prolonged. However, most of the measurement activities will occur in 2013.

Several alternative fuel variants of an individual vehicle/model will be tested on Environment Canada’s in-laboratory chassis dynamometer. The test vehicle platform is a large pick-up truck, which is typical for the Canadian vehicle market. The model and fuel variants include:

1. A diesel vehicle tested with ultra-low-sulfur diesel, B20 fatty acid methyl ester, hydrogenation-derived renewable diesel (HDRD), and B20HDRD and
2. A hybrid version tested with gasoline, E15, and E85.

The test cycles will include FTP 75, Highway, Aggressive US06, and New European Driving Cycle (NEDC). The test temperature will be +25°C for all tests. On FTP 75, the measurements also will be performed in temperatures of -7°C and -18°C.

China Project Activities

The China Automotive Technology and Research Center (CATARC) and Beijing Institute of Technology (BIT) have tested two Chinese-brand passenger vehicles. The test fuels included regular gasoline, diesel, E10, M15, and M100. Some tests also were conducted with M20, M30, and M50. The tests occurred in an ambient temperature of +25°C. Measurements were made on the transient China's certification driving cycle (GB18352.3-2005) for light-duty vehicles, which corresponds to NEDC.

Finland Project Activities

The VTT Technical Research Centre of Finland has conducted measurements with a European-based mid-sized passenger car with different power trains. The test fuels included E10, E10 with 15% renewable gasoline, diesel (EN 590 B7), 100% hydrotreated vegetable oil (HVO; secondgeneration biodiesel), CNG, electricity, and a high-concentration ethanol fuel blend (E85). The effects of engine power on exhaust emissions and energy consumption were tested with two diesel and gasoline vehicles. The engine power was 77 kW for the low-power diesel vehicle and 125 kW for the high-power diesel vehicle. The engine power was 90 kW for the low-power gasoline vehicle and 155 kW for the high-power version. The tests were conducted in ambient temperatures of -7°C and +23°C. Exhaust emission measurements also were performed in an ambient temperature of +5°C. The tests were performed with the transient drive cycle NEDC. Additional tests were conducted by using the Artemis Urban Cold and the Rural Road and Highway 130 Cycles, which depict better driving in realistic conditions.

Japan Project Activities

Japan's National Traffic Safety and Environment Laboratory (NTSEL) has provided data on a mid-sized Japanese vehicle that was converted to use LPG. The vehicle was tested while running on both conventional gasoline and LPG. The tests were performed using Japanese transient certification driving cycles for light-duty vehicles. The drive cycles included the 11 mode cycle (cold start), the 10.15 mode cycle (hot start), and the JC08 mode cycle with both hot and cold engine starting conditions.

Sweden Project Activities

Swedish AVL Motor Test Center has performed testing on three vehicles with different power train concepts, but with a common platform from the C-segment. The three different power train concepts included (1) an E85-fueled Otto-cycle engine, 5-gear manual transmission; (2) a diesel-fueled diesel-cycle engine, 6-gear manual transmission; and (3) a battery-electric power train, one-gear “automatic” transmission.

Vehicles equipped with internal combustion engines were tested with several duty cycles. The duty cycles included NEDC, Artemis Urban Cold, Artemis Urban, Artemis Rural Road, and Artemis Motorway 130. For the NEDC cycle, the ambient temperature was +23 °C and -7 °C. The Common Artemis Driving Cycles (CADC) were performed in an ambient temperature of +23°C.

A vehicle with an electric power train was tested for energy consumption according to United Nations Economic Commission for Europe (UNECE) R101 in an ambient temperature of +23 °C. Combined range and energy consumption tests were conducted with CADC in ambient temperatures of +23°C and -7°C.

U.S. Project Activities

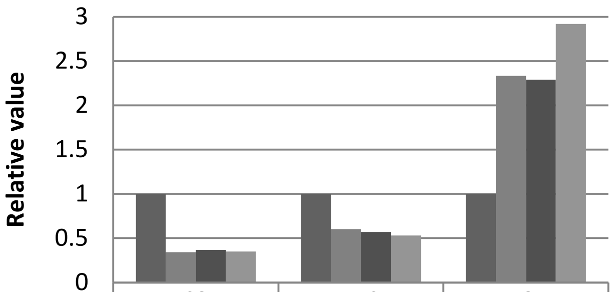
Argonne National Laboratory is providing test data on vehicles that are suitable for this project. The test cycles include the Urban Dynamometer Driving Schedule (FTP 75) and Highway and Aggressive US06. The tests were performed in an ambient temperature of +23°C.

Results and Reports/Deliverables

Results

Sub-reports are still under way. Therefore, all the results in this section are preliminary.

Figures 1 and 2 show some preliminary results from the China Automotive Technology & Research Center (CATARC) and Beijing Institute of Technology (BIT) work that display the emission trade-off between gasoline and methanol blends. In these tests, carbon monoxide (CO) levels dropped by 16%, to almost 71%, when the methanol content increased. Also, total hydrocarbon (THC) levels dropped by 4%, to 47 %, when the methanol content increased. On the other hand, the M20, M30, and M50 blends increased nitrogen oxides (NO_x) emissions significantly compared to gasoline. These preliminary results indicate that the test vehicle was not able to correct the mixture ratio according to the changes of test fuels energy content.The M100 blend also increased NO_x emissions, although to a lesser degree. The best compromise solution to decrease all these emissions has been obtained with an ethanol blend (E10).



	CO	THC	NOx
gasoline	1	1	1
M20	0.3425	0.6014	2.3318
M30	0.3684	0.5694	2.2891
M50	0.3488	0.5302	2.9194

Fig. 1 Relative Exhaust Emissions on the Chinese Certification Cycle in an Ambient Temperature of +25°C, Comparison between Gasoline and Methanol Blends

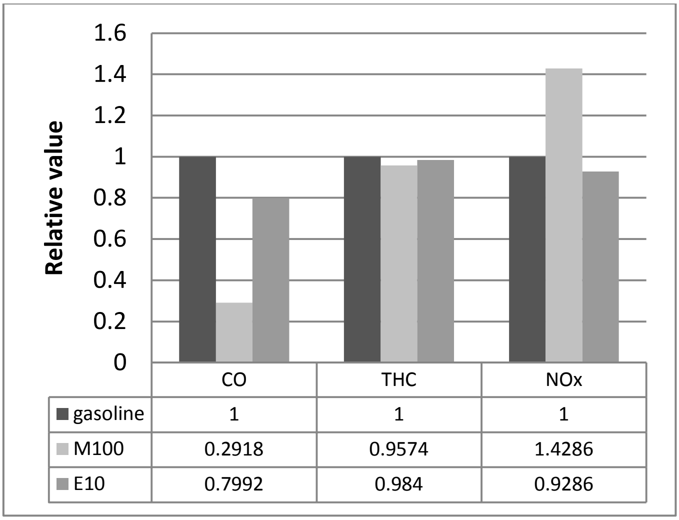


Fig. 2 Relative Exhaust Emissions on the Chinese Certification Cycle in an Ambient Temperature of +25°C, Comparison among Gasoline, M100, and E10

The tank-to-wheel results measured by VTT in Finland are shown in Figure 3. On NEDC, the ambient temperature change from +23°C to -7°C increased energy consumption by 19% on average. On this drive cycle, the energy need of the powerful gasoline engine version is roughly 4.3 times bigger than the energy need of the battery-electric version.

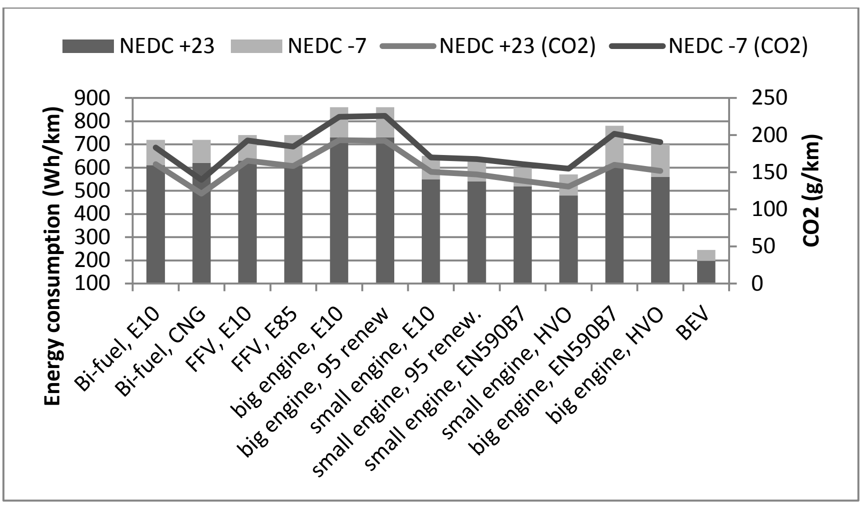


Fig. 3 Tank-to-Wheel Energy Consumption and CO_2 Emissions on NEDC in Ambient Temperatures of +23°C and -7°C

The preliminary results of well-to-wheels carbon dioxide ($CO_{2)}$-equivalent emissions are shown in Figure 4. Although battery-electric vehicles dominate tank-to-wheel energy efficiency, the overall CO_2-equivalent emissions depend on the well-to-wheel efficiency of an energy source. (Well-to-wheel results are calculated according to RED methodology.) It also is apparent that so-called biofuels help to reduce well-to-wheel CO_2-equivalent emissions significantly.

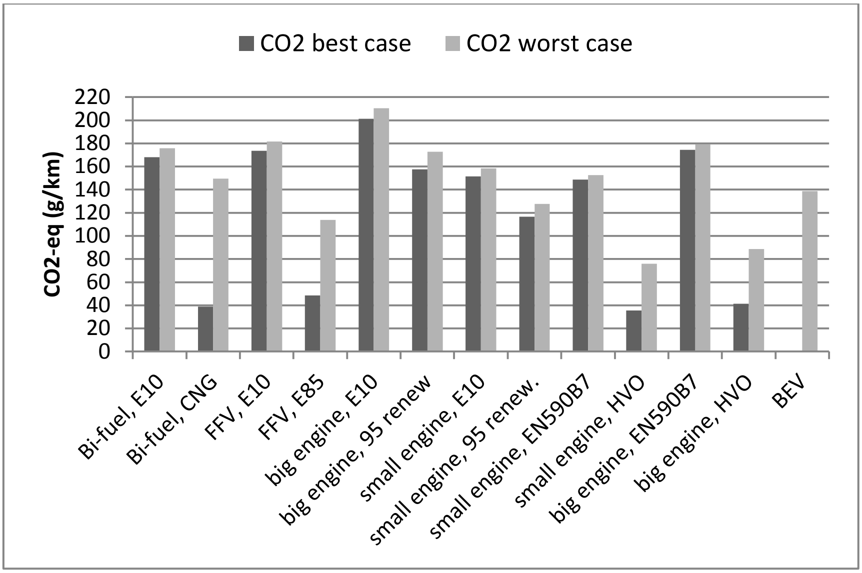
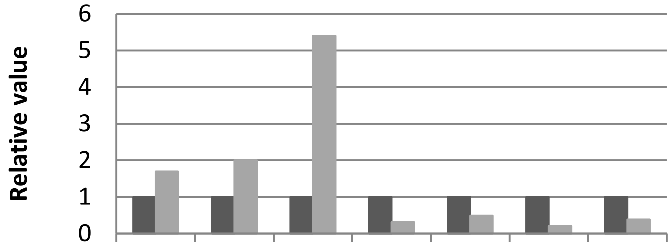


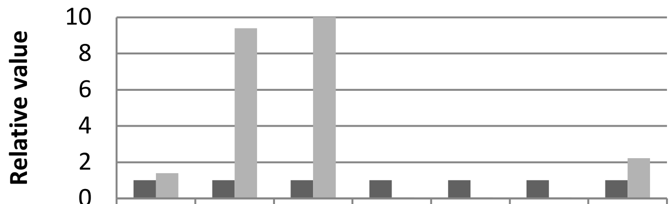
Fig. 4 Well-to-Wheel CO_2-Equivalent Emissions on NEDC in an Ambient Temperature of +23°C

Tank-to-wheel emission results from the Swedish participant AVL MTC are shown in Figures 5 and 6. These results were obtained by using the reference cycle (NEDC) in ambient temperatures of +23°C and -7°C.



	CO2	CO	THC	NOX	NO	NO2	PM
Diesel	1	1	1	1	1	1	1
E85	1.7	2	5.4	0.32	0.49	0.21	0.39

Fig. 5 Relative Tank-to-wheel Exhaust Emissions on NEDC in an Ambient Temperature of +23°C



	CO2	CO	THC	NOX	NO	NO2	PM
Diesel	1	1	1	1	1	1	1
E85	1.4	9.4	55.8	0.05	0.05	0.05	2.23

Fig. 6 Relative Tank-to-Wheel Exhaust Emissions on NEDC in an Ambient Temperature of -7°C

The choice of fuel is a trade-off among CO_2, CO, THC, and NO_x emissions (tank-to-wheel). The NO_x emissions of the E85 version are 68% lower in room temperature and 95% lower in freezing conditions than the NO_x emissions of the diesel version. On the other hand, the diesel version produces 40–70% less CO_2, 100–840% less CO, and 440–5,480% less THC emissions. The E85 version's particulate matter emissions are heavily dependent on ambient temperature.

Reports/Deliverables

The general outcome will be IEA sanctioned, unbiased 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:

- Performance and comparison of various technology options within the same vehicle family (primary objective);
- Performance and comparison of different vehicle families (secondary objective);
- Information and methodology on how to test and compare new power train and vehicle technologies and universal test protocols;
- Full fuel-cycle data for different passenger vehicles; and
- A data bank of different vehicle types and propulsion systems that will provide an opportunity to match vehicle/fuel/power train characteristics (both strengths and weaknesses) to a unique and specific applications and environments, because no single system can be applied to all operating parameters.

Time Schedule

The duration of the project was prolonged for a year to enable Canada to participate in this Annex. Canada is participating with new measurements, and testing is currently continuing in Canada. Sub-reports and results are scheduled to be ready by October 2013.

Annex 44: Research on Unregulated Pollutant Emissions of Vehicles Fueled with Alcohol Alternative Fuels

Project Duration	July 2012 – June 2014 (2 years)
Participants **Task Sharing** **Cost Sharing**	 China, Canada, Finland, Sweden, Israel, Switzerland China, Sweden, Finland
Total Budget	80,000 € ($103,000 US)
Operating Agent	Donglian Tian Beijing Auto Test Lab China Automotive Technology & Research Center (CATARC) Email: tiandonglian@catarc.ac.cn Phone: 86-10-67832310

Background

The gradual depletion of petroleum resources throughout the world generates an increased urgency to develop alternative energy sources. Alcohol fuels have the advantages of a wide range of sources. These fuels can be manufactured from biomass raw materials, agricultural raw materials (e.g., sugar cane, cereals, and rice), timber and urban waste, and fossil fuels (e.g., natural gas, petrochemical, and coal). A number of countries support the use of alcohol alternative fuels. For example, the United States, Brazil, and Sweden encourage the use of ethanol fuel made from biomass materials. In addition, several regions in China, including Shanxi Province and Shanghai, have initiated a pilot program to promote the use of methanol fuel.

As a result of the reduction of the limits of regulated pollutant emissions, interest in unregulated pollutant emissions in vehicle exhaust is increasing. Studies indicate that the use of alcohol fuels blended with gasoline in vehicles can reduce engine-out hydrocarbon (HC) and carbon monoxide (CO) emissions to some extent. The reduction occurs because the oxygen content in the fuel can promote the complete combustion of the fuel. However, more unregulated pollutants may be emitted, such as polycyclic aromatic hydrocarbons, aldehydes, and ketones. These substances have very strong stimulation and sensitization. They also have potential genetic toxicity and carcinogenic activity, which could significantly impact human health. This issue is an important factor that could hinder further development of alcohol alternative fuels.

Therefore, it is necessary to investigate the unregulated pollutant emissions from vehicles fueled with alcohol alternative fuels. This type of research would serve to promote the application of alcohol alternative fuels in a more expedient manner.

Purpose and Objectives

By measuring the unregulated pollutant emissions of vehicles fueled with alcohol fuels, the main purpose of this project is to obtain the unregulated pollutant emission levels of alcohol-fueled vehicles and to gradually establish the measurement methods and limits of unregulated pollutant emissions. Furthermore, our research will examine the influences that measurement methods, automotive technology, alcohol content in the fuel, ambient temperature, test cycles, and other relevant factors have on emissions of unregulated pollutants from vehicles.

Activities

Researchers in China conducted emissions tests on the chassis dynamometer by using port fuel injection vehicles fueled with gasoline, E10, E20, M15, and M30. The driving cycle was the New European Driving Cycle (NEDC). Fourier transform infrared (FTIR), high-performance liquid chromatography (HPLC), and gas chromatography-mass spectrometry (GC-MS) were utilized to synchronously measure regulated and unregulated emissions from the vehicles. The results of formaldehyde, benzene, and toluene emissions obtained through different measuring methods were comparatively analyzed. Furthermore, methanol, formaldehyde, acetaldehyde, acetone, benzene, toluene, xylene, and other unregulated emissions from vehicles fueled with different proportions of alcohol-gasoline blends at 25°C and -7°C ambient temperature were quantitatively determined.

Researchers in Israel conducted a test program where M15 fuel was used in four different car models. During this program, they measured regulated and unregulated (focusing on formaldehyde and acetaldehyde) emissions. All tests were performed in a closed climatic chamber on a chassis dynamometer, thereby controlling all parameters. Two driving cycles were used: NEDC and US06. The main objective was to compare the emissions of normal 95 octane gasoline and M15.

Researchers in Sweden conducted a literature review regarding low blending of alcohol fuels in passenger cars. The review considered both regulated and unregulated emissions, as well as other experiences related to the use of alcohol fuels. The focus was on methanol.

Researchers in Canada conducted chassis dynamometer tests on two vehicles (2011 Hyundai Sonata GDI and 2010 Volvo S40 PFI) with E0, E10, and E20 with the FTP75 at 25°C, -7°C, and -18°C. Also on the Sonata only they conducted NEDC tests with E0 and E10 at 25°C and E10 at -7°C. Unregulated Emissions were collected by HPLC for Carbonyl and GC-FID for VOC.

Results and Reports/Deliverables

Canada

Preliminary results are given as unregulated emissions data from vehicles fuelled with E0, E10, and E20 tested at Environment Canada. Formaldehyde, acetaldehyde, and BTEX are included. In general, acetaldehyde increases as the ethanol blend proportion increases. A high standard deviation was associated with some of the E20 values. Carbonyl emissions increased with the decrease in ambient test temperature. At 25°C, E20 decreases the emissions of BTEX. This result varies for the tests at the colder temperatures. For E10 fuel both at 25°C and -7°C, increases of VOC emissions at colder temperatures are evident.

China

The test results from China indicate that the methods of the integration of FTIR instantaneous values and the chemical analysis of bag sampling can accurately measure formaldehyde, acetaldehyde, benzene, and toluene emissions in the vehicle exhaust. A comparison of the instantaneous emissions and average emissions of major pollutants during the driving cycle verifies the good consistency of FTIR, HPLC, and GC-MS measuring methods. The emissions deviations of various measurement methods are in the range of ±10%. During the first acceleration condition, the instantaneous emissions of methanol, formaldehyde, acetaldehyde, benzene, propylene, and 1,3-butadiene have the highest peak. Then, with the three-way catalyst lights off, the emissions values gradually fall to nearly zero and remain so until the end of the driving cycle. As the alcohol proportion increases in the fuel, the carbon dioxide emissions in the exhaust remain basically the same; the HC, CO, and carbon tetroxide emissions decrease slightly; the nitrogen oxides emissions increase slightly; the unburned methanol, formaldehyde, and acetaldehyde emissions increase proportionally; and the benzene, toluene, ethylene, propylene, 1,3-butadiene, and isobutene emissions decrease.

Sweden

After a quick survey of projects carried out in Sweden with low-level blending of methanol, two projects of main interest in this context could be identified:

1. The Swedish M15 fleet test in the 1980s and
2. The "Intromet" project with M3E3 blending, which was carried out in 2003–2006.

As expected, the well-known impacts of methanol blending on emissions could also be found in the Swedish projects. For example, regarding regulated emission components (lower CO emissions), the marginal impact on HC and, in some cases, increased NO_X emissions documented in the Swedish projects have also been documented in many other studies. Among unregulated emission components, an increase in formaldehyde and a corresponding decrease in acetaldehyde emissions are trends that are seen with increasing methanol content. Some air toxics, such as light aromatics, are often somewhat lower for methanol-blended gasoline. A substantial decrease in particulate emissions was reported in one project, and the decrease was approximately linear with the methanol content. No clear trend has been documented for polycyclic aromatic hydrocarbons (PAH), but it should be noted that sampling and analysis of PAH was not very well developed in the earlier research. Several PAH compounds are either mutagenic or carcinogenic and thus pose a significant health hazard.

In a relatively recent project on E85 cars, very high PAH emissions were found during cold starts at low ambient conditions, whereas no increase was found at normal temperature. PAH increased with increasing ethanol content. Since no similar tests have been conducted on methanol blends on modern vehicles, it is difficult to say if methanol would have the same problem as ethanol. Nevertheless, a significant gap in knowledge is apparent here.

Time Schedule

The estimated project duration is two years, beginning in 2012.07. The main breakdown of the schedule is as follows:

- Preparation of the project: 2012.07~2012.09
- Literature survey: 2012.10~2012.12
- Measurement with methanol fuels: 2013.01~2013.12
- Measurement with ethanol fuels: 2013.03~2014.03
- Final report: 2014.04~2014.06

Future Plans

- China will continue taking measurements from GDI vehicles running on methanol and ethanol fuels synchronously in the next year.
- Finland will start the measurements of Annex 44 in Finland beginning in fall 2013.
- Canada will test a third vehicle (2012 Kia Soul GDI) with NEDC at 25°C with E10.
- Switzerland will begin a specific research effort and is confident that it will be able to share task information before the planned end of the annex in June 2014.

Annex 45: Synthesis, Characterization, and Use of Algae-HVO and eFAME for Engine Operation

Project Duration	March 2013 – February 2014
Participants **Task Sharing** **Cost Sharing**	 Denmark, Finland, Germany, Israel, Turkey, United States No cost sharing
Total Budget	186.000 € ($247,045 US)
Operating Agent	Dipl.-Ing. Benjamin Stengel University of Rostock, Germany Email: benjamin.stengel@uni-rostock.de

Background

The conventional use of fossil fuels for passenger car and ship engines will persist for the upcoming decades, even though the costs for oil will increase. However, as a result of the emissions from internal combustion engines and the limited oil stocks, it is necessary to conduct research on alternative fuels. One promising approach is to substitute fossil fuels with renewable fuels. The European Union has established the goal of reaching a 10% share of renewable energy in the transport sector by 2020. Currently, vegetable oils in connection with transesterification (fatty acid methyl ester [FAME]) are used mainly for blending fossil diesel with biofuel. However, increased FAME blends can lead to the dilution of lubrication oil, thereby resulting in shorter intervals between oil changes. Furthermore, fouling can occur, which leads to damage of high-pressure injection pumps.

One promising alternative is the use of hydrotreated vegetable oil (HVO) as a diesel substitute. The HVO shows very similar characteristics compared to conventional diesel and results in reduced exhaust emissions. Further research is needed in order to reduce the high production costs for HVO. Simultaneously, the production method for FAME must be improved to decrease biodiesel costs.

Purpose and Objectives

In the framework of this project, two alternative diesel fuels will be studied with respect to process costs, fuel characteristics, and usability in modern diesel engines. One fuel is an HVO based on algae as a raw material. The other fuel is a FAME that has been transesterified by special enzymes. The innovative production method that is used for enzymatic FAME (eFAME) is supposed to reduce the amount of chemicals and widen the range of raw materials, thereby decreasing the production costs. Algae have become an attractive alternative feedstock for fuels, mainly because of their high yield of fuel production per acre of land and non-consumable character. An algae-based HVO is expected to show similar emission advantages as other HVO fuels. Combined with its benefits in cultivation and production, an algae-HVO can facilitate the commercialization of HVO fuels.

The goal of the project is to analyze the process costs for both fuels and to evaluate their sustainability with regard to energy costs, catalysts, and other parameters. Both algae-HVO and eFAME will be analyzed intensively according to EN 590 (HVO) and EN 14214 (eFAME), with the main focus on their usability as fuel. Additionally, the project will examine the purity of the fuels in terms of methanol residue, free lipids, or glycerol content.

Through engine testing, the fuels will be tested to analyze engine performance, combustion behavior, and exhaust emissions, with the main focus on nitrogen oxides and particulate matter. Furthermore, fuel consumption and potential influences on exhaust aftertreatment systems will be evaluated. For this purpose, measurements will be taken for both the standard diesel engine application and the HVO/eFAME-adapted engine application.

The main objective of this project is to present results on the tested fuels as they relate to production costs, sustainability, and usability as fuel. The final outcome we wish to achieve for HVO/eFAME is to decrease the process costs by using alternative raw materials to facilitate the substitution of fossil fuels by biofuels.

Activities

Main Activities

The main activities will include benchmarking of eFAME and algae-HVO in terms of process cost, sustainability, and fuel characteristics. Furthermore, the fuels will be tested during engine tests to evaluate their use as diesel substitutes, with the main focus on exhaust emissions and fuel consumption.

Sub-Activities

The influences on exhaust aftertreatment systems will be investigated. Engine tests will be conducted for both standard and eFAME/HVO-adapted engine applications. After the application work, a systematization of determined data sets will be carried out to reduce upcoming application work.

Participants and/or Experts’ Meetings

Three participant meetings have been scheduled for the project. The starting event occurred in Denmark in March 2013. The primary focus of this meeting was to coordinate work packages and set internal and external deadlines. The second meeting will be held in Turkey in September 2013. This meeting will center on discussions about project status and upcoming tasks. A final project meeting will take place in January 2014. The achieved results will be presented and evaluated at this session. Moreover, this final meeting will involve discussions about the final report, problems that occurred during the project and subsequent improvements, and potential follow-up projects. In addition, further project meetings will be conducted within the framework of AMF Executive Committee meetings.

Publications/Newsletters

After six months and at the end of the project, an interim/final report will be prepared and sent to the AMF Executive Committee. Moreover, publications will be submitted to suitable journals.

Results and Reports/Deliverables

By using the cylinder pressure traces and exhaust emission measurements, it is possible to analyze the combustion behavior for the tested fuels. We are particularly interested in the influence of each fuel on the combustion process. Since we expect to find differences in the heat release rate, we will make comparisons to conventional diesel (EN 590). The analysis will include an evaluation of exhaust emissions, with the main focus on nitrogen oxides and particulate matter emissions. We expect to see significant emission improvements for the tested fuels. Furthermore, we will analyze influences on exhaust aftertreatment systems (i.e., diesel oxidation catalyst [DOC], *diesel particulate filter* [DPF], and s*elective catalytic reduction* [SCR]) in terms of DPF regeneration or ammonia slip.

Concerning the engine application, we expect to find slight shiftings in the engine characteristic maps as a result of different fuel characteristics — especially for eFAME. Adapting the engine application for each fuel should result in improvements in exhaust emissions and fuel consumption.

Moreover, through an intensive fuel analysis, the fuel characteristics will be determined and compared to conventional diesel. In addition, the process benchmark of the fuels will produce results that pertain to energy costs, catalysts, and sustainability. We will provide an assessment of the possibilities for substituting fossil fuels.

Time Schedule

The time schedule for this project is presented in Table 1.

Table 1 Time Schedule for Annex 45

Time schedule														
No.	Tasks	Partner	Months											
			1	2	3	4	5	6	7	8	9	10	11	12
1	Literature survey	all												
2	Obtainment of fuels	DK/USA												
3	Fuel purity (methanol residue, free lipids, ...)	DK												
4	Engine tests (benchmark)	GER												
5	Evaluation of measurement data (benchmark)	GER												
	Interim report	all												
6	E-FAME and HP/LP-HVO process cost	DK												
7	Engine tests (fuel adapted application)	GER												
8	Systematisation of parameter sets	GER												
9	Sustainability (energy cost, catalyst)	DK												
10	Final report	all												
11	Project coordination	GER												
12	Project meeting													

Annex 46: Alcohol Application in CI Engines

Project Duration	March 2013 – February 2015
Participants **Task Sharing** **Cost Sharing**	 Denmark, Finland, Sweden No cost sharing
Total Budget	~300 k€ ($398,460 US)
Operating Agent	Jesper Schramm DTU Technical University of Denmark Email: js@mek.dtu.dk

Background

In Europe, Directive 2009/28/EC on renewable energy sets the transport bioenergy obligation in 2020 at a minimum of 10% of the transport energy use. Modern spark-ignition (SI) vehicles are compatible with 10% ethanol in gasoline (E10), which represents 6% of the bioenergy content. Since a higher ethanol content can be used only with a limited car population, ethanol use is limited — even if higher amounts are commercially available (the so-called "blending wall").

Alcohols represent superior fuels for the SI engine with respect to key properties, such as octane number and latent heat of vaporization. Basically, alcohols can withstand high pressures and temperatures without igniting uncontrollably. In many parts of the world, ethanol is widely used in low-concentration blends with gasoline, and it has a more limited use in high-concentration blends. In the case of low-ethanol blends (E5−10), it is possible to produce fuels with a slightly higher or similar octane number compared to that for regular gasoline. Most modern cars are able to regulate the ignition timing and advance the timing to a degree that increases engine efficiency by a few percentage points. A high share of ethanol, up to 85%, can be used in special SI flexible-fuel vehicles.

Fuel economy is an increasingly important current issue. An obvious goal is to achieve efficiencies similar to diesel engines with the alcohol applications. However, the application of alcohols in a diesel engine requires a fuel additive to ignite the unburned mixture. An option is to use additised ethanol in heavy-duty ethanol diesel engines, which are now manufactured by Scania. These engines run with so-called Etamax D fuel that consists of 95% hydrous ethanol together with an ignition improver, a corrosion inhibitor, and denaturants (i.e., methyl tertiary-butyl ether and isobutanol).

This fuel is manufactured by SEKAB in Sweden. With this concept, relatively small modifications are required in the engine. The compression ratio is increased, and the fuel system is modified. The exhaust catalyst is developed to prevent excessive aldehyde emissions. This concept, for example, is used in buses in Stockholm. In total, around 1,000 heavy-duty vehicles are running with Scania's ethanol engines.

The most interesting option would be a "flex fuel" diesel engine that can run with both ethanol and diesel fuel without pilot injection technology. Engines that can use only ethanol would be suitable only in restricted areas, where availability of fuel can be controlled. Diesel engines and their control technologies have advanced considerably in recent years. For example, the common-rail system enables fine adjustments of injection. Ethanol diesel engines could be used in road transport, machinery, and the marine sector — especially in countries where ethanol is produced on a large scale.

Alcohols, particularly those produced from biomass, are the obvious fuels for more intense combustion engine applications in the near future. Therefore, it is relevant to initiate a general study on the best way to produce alcohols from biomass. The goal is to combine good fuel economy with low emissions. This type of project is suited for an AMF study, since many member countries are interested in fuel/additive development. For example, Brazil, Finland, and Thailand would like to consider alternative, locally produced additive packages. In addition, there are ideas for new combustion schemes (e.g., reactant controlled combustion), which could eliminate the need for the dedicated ignition improver additive. (Scania's current technology is based on an additive package that includes an ignition improver and a lubricity additive, as well as a high compression ratio of the engine.)

Purpose and Objectives

The goal is to report the best possibilities for the implementation of alcohols in diesel engines. One of the main objectives of the project is to secure the supply of fuels for diesel engines, in this way by focusing on sustainable biofuels in the form of alcohols. The project involves one of the main diesel engine producers in Europe, as well as some of the most powerful research institutions and universities in Europe. The project will therefore result in worldwide frontline experiences, and it will have a large influence on strategies for the implementation of alternative fuels in many countries. Thus, the project will contribute to the achievement of many relevant political goals, such as support of a sustainable energy policy, independency of fossil energy, and reduced emissions — including carbon dioxide.

Activities

The work is divided into the following work packages (WPs):

WP 1. Review of alcohol application in diesel engines

Fuels, additives, and engine concepts will be reviewed on the basis of existing literature, experimental data, and information from engine manufacturers. In this context, the focus will center on fuels with an alcohol content over 50%. The review of additives will be divided into ignition improvers, emulsifiers, and other additives. Special attention will be given to bio-origin additives.

WP 2. Ethanol application in a diesel engine

New ethanol fuel formulations and additive options will be studied with the VTT Scania ethanol engine, which is instrumented to study injection and combustion parameters. In the fuel development, priority will be given to bio-origin additives. Both additives and denaturants could be bio-components. In addition, vegetable oil esters and bio-oxygenates could be considered as fuel components. Physical properties can be changed, for example, with high-viscosity components. Commercial Etamax D fuel will be used as a reference.

The fuel matrix will cover approximately 15 fuel combinations by varying ethanol content, additives, and other components. The ethanol content will be a minimum of 50%. The basic fuel properties will be analyzed from samples.

In the engine tests, combustion parameters will be monitored, as well will regulated gaseous emissions. High emissions of unburned fuel and rough engine running indicate an inefficient combustion process. The best fuel candidates will be selected for more detailed analysis, including particulate matter emissions. This activity will be carried out in cooperation with Scania and the Finnish energy company, St1, which produces ethanol from waste.

WP 3. Analysis of the applicability of ethanol in a diesel engine

The project will include analyses of the obtained experimental data in order to optimize the fuel conversion with respect to fuel economy and emissions. To characterize the best possible operation area, it is essential to characterize and understand the spray formation and heat release pattern during engine operation for different fuels/additives.

This WP will result in an evaluation of the possibilities and limitations of operating a diesel engine on ethanol-based fuels. The evaluation will be based on emission and fuel consumption perspectives, as well as the potential to operate the engine as a normal diesel-fueled engine.

WP 4. Project organization and compilation of results
The project will be carried out under the umbrella of the Advanced Motor Fuels Implementing Agreement (AMF IA) and in collaboration with the IEA Combustion Agreement. The work will result in a final report that gathers information from the mentioned WPs. The report also will include information about related work from the IEA Combustion Agreement. In addition, the overall management of the project is part of this WP.

Results and Reports/Deliverables

The project is carried out through the AMF IA. Therefore, the specifics of the project will be detailed in an official IEA report. Furthermore, the results will be presented at international conferences that focus on transportation issues, such as the International Council on Combustion Engines, the Society of Automotive Engineers International, and the International Symposium of Alcohol Fuels.

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Further Information

4.a AMF ExCo Meetings

In 2012, two Executive Committee (ExCo) meetings took place.

ExCo 43, 30 May–01 June 2012, Zürich, Switzerland

The 43rd Meeting of the AMF Executive Committee attracted 44 participants. These included delegates from 12 of the 15 member countries, observers from 5 countries (Israel, Norway, Poland, Republic Korea, and Turkey) and guests from 3 transport related Implementing Agreements (Bioenergy; Bioenergy Task 39; and Combustion, Hybrid and Electric Vehicles). Israel and Republic Korea will be invited to join the Implementing Agreement. In December 2011, Australia and Thailand announced their withdrawals.

Annex Proposals

Out of the six proposals presented, two were kicked off as new annexes:

- Alcohol fuels, including methanol, by China Automotive Technology & Research Center (CATARC), China
- Hydrotreated vegetable oil, by Germany and Denmark

The other proposals will be revised and presented again at ExCo 44, except for the Biomethane proposal by DBFZ, Germany, which will only be reconsidered if IEA Bioenergy Task 37 covers part of the work.

Current Annexes

- ***Annex 28: Information Service & AMF Website***
  - The timetable for Fuel Info will continue until December 2012.
  - Step 2 of Website Refresh (programming) will be started.
- ***Annex 35 Subtask 2: Particulate Measurements: Ethanol and Butanol in DISI Engines***
  Annex work is progressing well, no decisions required.
- ***Annex 37: Fuel and Technology Alternatives for Buses***
  - The AMF participants of Annex 37 approve the final report and the budget. IEA Bioenergy Task. 41 participants will be asked by email.
  - The AMF participants of Annex 37 decide to close Annex 37.

- ***Annex 38: Phase 2: Environmental Impact of Biodiesel Vehicles in Real Traffic Conditions***
  Annex work is progressing well, no decisions required.
- ***Annex 39: Phase 2: Enhanced Emission Performance of HD Methane Engines (Phase 2)***
  Annex work is progressing well, no decisions required.
- ***Annex 40: Life Cycle Analysis of Transportation Fuel Pathways***
  - The final report will be made publicly available on the AMF website and distributed by email to AMF contacts.
  - Annex 40 will be closed.
- ***Annex 41: Alternative Fuels for Marine Applications***
  The project outline and the timeline are approved.
- ***Annex 42: Toxicity of Exhaust Gases and Particles from IC-Engines — International Activities Survey (EngToxIn)***
  Annex work is progressing well, no decisions required.
- ***Annex 43: Performance Evaluation of Passenger Car, Fuel, and Power Plant Options***
  - The project duration will be extended for 1 year (until 31.12.2013).
  - Canada will join on a task-sharing basis.
  - For the well-to-tank analysis, the same numbers as used in Annex 37 will be used.

Another two ideas for new annexes were mentioned and will be presented at ExCo 44.

Final Reports

Findings from Annex 37 (Bus Annex) are:

- The largest variations and uncertainties can be found for wheel-to-wheel (WTW) carbon dioxide equivalent (CO_{2eqv}) emissions, or in fact, the WTT part of the CO_{2eqv} emissions.
- The most effective way to reduce regulated emissions is to replace old vehicles with new ones.
- The most effective way to cut greenhouse gas (GHG) emissions is to switch from fossil fuels to efficient biofuels.

Advice to policy makers from Annex 40 (LCA) are:

- While the concept of employing life-cycle analysis (LCA) to evaluate fuel options is simple and straightforward, the act of putting the concept into practice is complex and fraught with issues. Policymakers need to understand the limitations inherent in carrying out LCA work for transportation fuel systems.
- Comparisons between systems should ideally be made using the same tool, so that differences caused by system boundaries, allocation

processes, and temporal issues can be minimized (although probably not eliminated).

- LCA will give more reliable estimates when it is used to examine small changes in transportation fuel pathways than when used to estimate large-scale changes that replace current pathways with completely new pathways.
- Some LCA tools have been developed recently, primarily for regulatory purposes. These tools may deviate from International Organization for Standardization (ISO) principles in order to facilitate simplicity and ease of use. The results of these tools should not be confused with, or compared to, the results that are obtained from a more complex and rigorous ISO compliant LCA.
- It should be fully understood that an LCA will not determine which product is the most cost effective or works best. No LCA can identify optima in the manner of, say, a linear program. This would still be true even if all inputs were specified with complete accuracy and precision, because no result would yield a simultaneous optimum for all outputs.

Both reports are available at the AMF website (www.iea-amf.org).

Terms and Conditions for Sponsors

The issue of sponsors was discussed, but no decision was taken yet because the positions were too heterogeneous. It is not yet clear whether the group wishes to include sponsors and what the purpose of doing so would be. Discussion will continue at the next meeting.

ExCo 43 was a very successful meeting, with the problem of running out of time due to the many activities of the IA. The next meetings will take place in the week of 22nd October 2012 in Beijing, China, and the week of 27th May 2013 in Gothenburg, Sweden. Having a meeting in fall 2013 in Latin America is still on the wish list, but not yet confirmed.

ExCo 44, 24–26 October 2012, Beijing, China

The 44th Meeting of the AMF ExCo was held 24–26 October 2012 in Beijing, China, kindly hosted by CATARC. There were 31 participants, including Israel and Asia Pacific Natural Gas Vehicles Association (ANGVA) as Observers. Republic of Korea was welcomed as a new Contracting Party, the project “Alcohol Application in CI Engines” was started as Annex 46 with the Technical University of Denmark (DTU) as Operating Agent, and Sandra Hermle, Swiss Federal Office of Energy, was elected ExCo Chair.

Cooperation with other Implementing Agreements includes joint work with IEA Bioenergy in Annex 39, possible joint work with the Combustion Implementing Agreement in Annex 46, and possible joint sessions with IEA Bioenergy Task 39 at ISAF 2013 and ISAF 2015.

Upcoming ExCo Meetings (tentative list)

Meeting	Date	Location
ExCo 45	28–30 May 2013	Gothenburg, Sweden
ExCo 46	Fall 2013	Latin America; United States or Israel as backup
ExCo 47	Spring 2014	Denmark
ExCo 48	Fall 2014	To be determined
ExCo 49	March 2015	Republic of Korea

Membership

Republic of Korea joined the AMF IA as a Contracting Party on 10 October 2012.

PTT (Petroleum Authority of Thailand; www.pttplc.com) was officially invited to join as a Contracting Party on behalf of the government of Thailand. The hope of AMF is that PTT can take over from the National Science and Technology Development Agency (NSTDA) without delay by December 2012.

Chile, as well as the company Sasol, will be invited as Observers. Because Sasol is more interested in joining as a Sponsor than as a Contracting Party, Terms and Conditions for Sponsors will be proposed by the Secretary and a decision on these will be taken by written procedure.

Work Program

Current Annexes

- ***Annex 28: Information Service & AMF Website***
  Fuel Info is ready for review; feedback on the draft new website is welcome. Details will be provided by the Secretary.
- ***Annex 35: Particulate Measurements: Ethanol and Butanol in DISI Engine***
  Work is progressing well, report due May 2013.

- ***Annex 38-2: Environmental Impact of Biodiesel Vehicles in Real Traffic Conditions***
  Work is progressing well, report due December 2013.
- ***Annex 39-2: Enhanced Emission Performance of HD Methane Engines (Phase 2)***
  The work scope will be expanded to include a literature survey of retrofit of vehicles in use meeting EURO III requirements. The Annex will be prolonged until May 2014. An interim report will be presented at ExCo 45. Contributions from ANGVA (data) and the European Commission through IEA Bioenergy (funds) are gratefully accepted.
- ***Annex 41: Alternative Fuels for Marine Applications***
  The Operating Agent has circulated a draft report among the Annex participants and asks for feedback.
- ***Annex 42: Toxicity of Diesel Exhaust—an In Vitro Study***
  A report is due in November 2012. Prolongation of the Annex will be discussed at ExCo 45.
- ***Annex 43: Performance Evaluation of Passenger Car, Fuel, and Power Plant Options***
  This Annex recently had to be prolonged in order to include testing done in Canada. VTT Technical Research Centre of Finland (VTT) was given permission to publish a summary report of VTT's test results in Finnish and publish it in Finland only, although Annex 43 is still ongoing. The final annex report is due December 2013.
- ***Annex 44: Research on Unregulated Pollutant Emissions of Vehicles Fueled with Alcohol Alternative Fuels***
  The work program has been set up among China, Canada, and Finland, and first tests have been performed at CATARC. Israel is interested in contributing through M15 tests.
- ***Annex 45: Synthesis, Characterization, and Use of Algae-HVO and eFAME for Engine Operation***
  The work program, the budget, and the timeline have been set up; the project will start in March 2013 with a duration of 1 year.

A new Annex was started:

- ***Annex 46: Alcohol Application in CI Engines***
  DTU will be the Operating Agent; confirmed participants are Denmark, Finland, and Sweden. The Annex is still open for more participants, and the Combustion IA might be contributing through Finland and Italy.

For ExCo 45, three proposals will be refined following a new timeline for circulating revised versions and feedback of delegates:

- Value Proposition Study on Natural Gas Pathways for Road Vehicles.

- Reconsideration of dimethyl ether (DME) fuel specifications for vehicles.
- Pre-proposal: Fuel and Technology Alternatives for Commercial Vehicles.

The process of deciding on the work program will furthermore be improved by identification of areas of interest for each country, fuels in use, and observed barriers to deployment.

Reporting on current annexes will be improved by encouraging annex meetings 1 day before each ExCo meeting and by the use of reporting templates.

The annex participation table will be updated and uploaded to the website.

Administration

The ExCo has elected a new team of chairpersons for a two-year period of service:

- ExCo Chair: Sandra Hermle
- Regional Vice-Chair for Asia: Shinichi Goto
- Regional Vice-Chair for North America: Kevin Stork
- Senior Vice-Chair: Nils-Olof Nylund

Subcommittees include Outreach and Membership, Strategy, and Technology.

The Secretary will work on a procedure book that will describe the usual procedures of work in the AMF IA; this will complement the AMF Legal Text.

Contracts with ASEE (handling of finances) and BIOENERGY 2020+ (secretary services) were extended until 28 February 2015. AMF is aware of the need to apply for extension of the Implementing Agreement. Some funds were reserved for additional work that might be needed during the application process.

Outreach

Outreach activities include production of a printed Annual Report, refreshing of the website (soon to be found at www.iea-amf.org) and distribution of USB drives with AMF reports and outreach documents. USB drives are available from the Secretary upon request.

Liaison with other IAs

As described above, IEA Bioenergy is cooperating with AMF in Annex 39, and the Combustion Implementing Agreement is interested in cooperation in Annex 46. IEA Bioenergy Task 39 has invited AMF to join its session at ISAF 2013 in South Africa, and Republic of Korea offered to host ExCo 49 in conjunction with ISAF 2015, which would hopefully allow for face-to-face meeting with IEA Bioenergy Task 39.

4.b
AMF Contact Information

4.b.i
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4.b.ii
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4.b.iii
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Dina	Bacovsky	Austria	Secretary	dina.bacovsky@bioenergy2020.eu

4.c
AMF Publications in 2012

Annex 37: Fuel and Technology Alternatives for Buses:

- Nylund, N.-O. and Koponen, K.: Fuel and Technology Alternatives for Buses. VTT Technology: 46. 2012

Annex 38: Environmental Impact of Biodiesel Vehicles:

- Evaluation of Environmental Impact of Biodiesel Vehicles in Real Traffic Conditions, S. Sato and N. Mizushima, National Traffic Safety and Environment Laboratory (NTSEL), A. Saito and Y. Takada, Organization for the Promotion of Low Emissions Vehicles (LEVO). January 2012.

Annex 40: Life Cycle Analysis of Transportation Fuel Pathways:

- Life cycle analysis of transportation fuel pathways. February 2012.

Annex 42: Toxicity of Exhaust Gases and Particles from IC Engines—International Activities Survey (EngToxIn):

- Toxicity of Exhaust Gases and Particles from IC-Engines — International Activities Survey (EngToxIn). Second Information Report for the AMF IA, Annex XLII, international activities. October/November 2012.
- Annexes to 2012 report.

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 IA 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.

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, ethyl ester or fatty acid alkyl ester are referred to as biodiesels.

Biomass to liquid (BTL) fuels

BTL fuel is 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)

DDF is 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, spark-ignited engine emission levels can be achieved along with the high thermal efficiencies of diesel engines.

Di-methyl ether (DME)

DME is 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)

DISI is a 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% ethanol and 15% gasoline by 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

ED95 is a blend of diesel fuel consisting of 95% bio-ethanol and 5% of an ignition improver for the fuel. Sweden’s transportation sector has adapted some of their heavy-duty diesel buses 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 engine and exhaust systems have to be made in order to run a higher ethanol blend. Ethanol is a popular alternative fuel, because of its propensity to 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)

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

Fatty acid methyl ester (FAME)

FAME is 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- 20% biodiesel. Manufacturers are now creating engines compatible with biodiesel blends up to B20. Under European standards, the terms Fame and biodiesel are used synonymously. B100 may as well be used as a pure fuel with only minor adaptations to 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 which 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 fuels 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 it is with 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 do see a loss in fuel economy when running alternative fuels, due to the lower energy content of ethanol.

Fuel Cell Vehicle (FCV)

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

Greenhouse Gas (GHG)

GHGs are emissions that increase the harmful greenhouse 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)

HFCs are GHG emissions that have no potential to deplete the ozone. HFCs are used as additives in aerosol, solvent, and coolant agents. HFCs are released into the atmosphere when they leak from air-conditioning units on cars. HFCs are implemented to replace harmful chlorofluorocarbons, which have the potential to deplete the ozone.

Hydrotreated vegetable oil (HVO)

HVO is a biobased diesel fuel that is derived through the 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)

An ICE is 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)

LNG is 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 tertiary-butyl ether (MTBE)

MTBE is an additive derived from methanol, which can be used to oxygenate and increase the octane rating of gasoline. MTBE is not commonly used anymore due to the risk of it contaminating ground water supplies.

Multi Port Fuel injection (MPI)

MPI is 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)

NG is 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 to lower GHG emissions and smog-forming pollutants. Current gasoline and diesel vehicles can be converted to run on natural gas.

Natural Gas Vehicle (NGV)

NGVs are alternative fuel vehicles that use compressed or liquid natural gas, which are much cleaner-burning 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.

NExBTL

NExBTL is a renewable diesel production process commercialized by the Finnish oil and refining company Neste Oil.

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.

xTL

Synthetic liquid transportation fuels, collectively known as xTL fuels, are produced through specialized conversion processes.

Notation and Units of Measure

ADEME	Agence de l'Environnement et de la Maîtrise de l'Energie (France)
AF	alternative fuels
AFDC	Alternative Fuels Data Center
AFHB	Lab for Exhaust Gas Control, Univ. of Applied 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
AMF IA	Advanced Motor Fuels Implementing Agreement
ANGVA	Asia Pacific Natural Gas Vehicles Association
Argonne	Argonne National Laboratory (United States)
ASEAN	Association of Southeast Asian Nations
AVL MTC	AVL Motor Test Center
BD	biodiesel
BD2	biodiesel 2%
BDF	biodiesel fuel
BE	bioethanol
BG	biogas
bioSNG	synthetic natural gas made of renewable resources
BIT	Beijing Institute of Technology
BMELV	Federal Ministry of Food, Agriculture, and Consumer Protection (Germany)
BTL fuel	biomass-to-liquid fuel
CAC	criteria air contaminants
CADC	Common Artemis Driving Cycles
CATARC	China Automotive Technology & Research Center
CD	committee draft
CEA	French Alternative Energies and Atomic Energy Commission (commissariat à l'énergie atomique et aux énergies alternatives)
CEN	European Committee for Standardization
CERT	Committee on Energy Research and Technology (IEA)
CETHIL	The Center for Thermal Sciences of Lyon
CHP	combined heat and power

CH_4	methane
CI	compression ignition
CNE	Comisión Nacional de Energía
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CORES	Corporación de Reservas Estratégicas
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
DMEVPC	DME Vehicle Promotion Committee (Japan)
DOC	diesel oxidation catalyst
DOE	Department of Energy (United States)
DPF	*diesel particulate filter*
E5	an ethanol fuel mix of 5% ethanol and 95% gasoline
E10	petrol containing 10 vol-% ethanol
E85	85% ethanol/15% gasoline fuel blend
EC	Environment Canada
ED95	an ethanol diesel fuel mix of 95% ethanol and 5% ignition improver
EDF	European Development Fund
eFAME	enzymatic fatty acid methyl ester
EGR	exhaust gas recirculation
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 *tert* butyl ether
ETS	emission trading scheme
EU	European Union
EUV	Electric Urban Vehicle
EV	electric vehicle
EVE	Electric Vehicles Systems Programme
ExCo	Executive Committee

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
FUI	Fond Unique Interministériel (France)
FY	fiscal year
GC-MS	gas chromatography-mass spectrometry
GFV	Gaseous Fueled Vehicles (work group within UNECE GRPE)
GHG	greenhouse gas
GRPE	Working Party on Pollution and Energy
GTL	gas-to-liquid
GWh	gigawatt-hour(s)
H_2	hydrogen
HC	hydrocarbon
HCNG	hydrogen-compressed natural gas
HD	heavy duty
HDV	heavy-duty vehicle
HEV	hybrid electric vehicle
HFC	hydrofluorocarbons
HPLC	high-performance liquid chromatography
HSY	Helsinki Region Environmental Services Authority
HV	hybrid vehicle
HVO	hydrotreated vegetable oil
Hydole	hybride à dominante électrique
HyHIL	Hybrid Hardware-in-the-loop
HyNor	Hydrogen Road (Norway)
IAEC	Isuzu Advanced Engineering Center Ltd. (Japan)
IAR	Industries and Agro-Resources
IC	internal combustion
ICE	internal combustion engine
IDAE	Instituto para la Diversificación y Ahorro de la Energía
IEA	International Energy Agency
IFE	Institute for Energy Research
IFP	French Institute of Petroleum (Institut français du pétrole)
IMO	International maritime organization
ISCC	International Sustainability and Carbon Certification

ISO	International Organization for Standardization
JATOP	Japan Auto-Oil Program
JGA	Japan Gas Association
JPFY	Japan's fiscal year
LCA	life-cycle analysis
LDV	light-duty vehicle
LEVO	Organization for the Promotion of Low-Emission Vehicles (Japan)
LMFA	Laboratoire de Mécanique des Fluides et d'Acoustique
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LUTB	Lyon Urban Trucks and Bus (France)
LVM	Ministry of Transport and Communications (Finland)
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 tertiary-butyl ether
MY	model year
NEDC	New European Driving Cycle
NET	new energy technology
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
OECD	Organisation for Economic Co-operation and Development
OEM	original equipment manufacturer
OICA	International Organization of Motor Vehicle Manufacturers
OPEC	Organization of the Petroleum Exporting Countries
OSF	Official Statistics of Finland
PEMS	Portable Emission Measurement System (Japan)
PFI	port fuel injection
PHEV	plug-in electric hybrid vehicle
PIVERT	Picardie Innovations Végétales, Enseignements et Recherches Technologiques (France)
PM	particulate matter
PVO	pure vegetable oil
R&D	research and development
RD&D	research development and deployment
RFS	Renewable Fuel Standard
RIVM	National Institute of Public Health and Environment (The Netherlands)
RE85	A high-concentration ethanol fuel (similar to E85), manufactured from biowaste (helps to reduce CO_2 emissions); sold by St1
RME	rape methyl ester
SAE	Society of Automotive Engineers
SCR	selective catalytic reduction
SFOE	Swiss Federal Office of Energy
SI	spark ignition
SINTEF	Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology
SME	subject matter expert
SPK	synthetic paraffin kerosene
STA	Swedish Transport Administration (Sweden)
SWAFEA	Sustainable Way for Alternative Fuels and Energy for Aviation
TAEE	tertiary amyl ethyl ether
Tekes	the Finnish Funding Agency for Technology and Innovation

TEM	Ministry of Employment and the Economy (Finland)
TEQ	toxicity equivalence
TGAP	taxe générale sur les activités polluantes (a French tax on polluting activities)
THC	total hydrocarbons
TIC	taxe intérieure sur la consommation (a French tax on consumption)
TIGRE	Technologies Innovantes pour Grands Routiers Économes (France)
TransSmart	Smart Mobility Integrated with Low-carbon Energy
TTC	Toronto Transit Commission
TTFF	Transportation Technologies & Fuels Forum
UD	universal design
UNECE	*United Nations Economic Commission for Europe*
USD	U.S. dollars
VeDeCoM	Institute for Communicative Carbon-free Vehicles and their Mobility (France)
VELROUE	Véhicule Utilitaire Léger hybride bi mode (France)
VM	Ministry of Finance (Finland)
VOC	volatile organic compounds
VTT	VTT Technical Research Centre of Finland
WD	working draft
WP	work package
WTT	well-to-tank
WTW	well-to-wheel

Units of Measure

cc	cubic centimeter
DKK	Danish krone (currency)
Euro(s)	EU currency
GWh	gigawatt-hour(s)
kg	kilogram(s)
kL	kiloliter(s)
km	kilometer(s)
kt	kiloton(s)
ktoe	kiloton of oil equivalent
kW	kilowatt(s)
kWh	kilowatt-hour(s)
L	liter(s)
m^3/a	cubic meters per year (annum)
Mktoe	mega-ktoe
Mt	mega-tonnes
Mtep	million-ton equivalent of petroleum
PJ	Peta-joules (1×10^{15} joules)
t/a	tons per year (annum)
TJ	terajoule(s)
toe	tons of oil equivalent
tonne	metric ton
TWh	terawatt-hour(s)
yen	Japanese currency
¥/L	yen(s)/liter
€/a	euro per year (annum)
€/hL	euro per harvest-liter
€/L	Euro(s)/liter