IEA-Advanced Motor Fuels

ANNUAL REPORT 2011

Energy Technology Network

ADVANCED MOTOR FUELS

IEA-AMF

IEA-Advanced Motor Fuels
Annual Report 2011

Cover Photo: A B20 biodiesel (20% biodiesel, 80% conventional diesel) bus at the University of Colorado at Boulder (USA) used in research to analyze the performance and reliability of B20 in transit bus use.

Credit: Patrick Corkery, Staff Photographer, National Renewable Energy Laboratory (NREL; United States)

International Energy Agency

Advanced Motor Fuels Annual Report 2011

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

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

Country reports were delivered by the Contracting Parties or Observers:

Austria	Austrian Agency for Alternative Propulsion Systems (A3PS)
Canada	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)
Spain	Instituto para la Diversificación y Ahorro de la Energía (IDAE)
Sweden	Swedish Transport Administration (STA)
Switzerland	Swiss Federal Office of Energy (SFOE) Laboratory for IC Engines and Exhaust Emissions Control (AFHB)
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
Annex 35-2	Particulate Measurements: Ethanol and Butanol in DISI Engines	Jean-Francois Gagné
Annex 37	Fuel and Technology Alternatives for Buses – Overall Energy Efficiency and Emission Performance	Nils-Olof Nylund
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 Hådell
Annex 40	Life Cycle Analysis of Transportation Fuel Pathways	Peter Reilly-Roe
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 Powerplant Options	Jukka Nuottimäki

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

Jean-Francois Gagné	CanmetENERGY	Chairman 2011
Dina Bacovsky	BIOENERGY 2020+	Secretary

Contents

1 The IEA Advanced Motor Fuels Implementing Agreement

1.a Chairman's Message

With the end of another exciting year for the Advanced Motor Fuels (AMF) Implementing Agreement, I would like to take this opportunity to express my sincere thanks to everyone for their continued support and participation, and to re-iterate my conviction of the importance of the work the AMF is pursuing.

Despite the slow recovery from the worldwide economic crisis, overall energy demand has increased by 5%, according to the latest International Energy Agency (IEA) Energy Outlook, reinforcing the need for lower carbon energy sources. Transportation energy demand has followed a similar trend, and even with the introduction of ever more stringent efficiency regulations, there remains a need to find alternatives to oil-derived fuels and to de-carbonize the world's transportation energy systems. Notwithstanding the importance given to the electrification and weight reduction of the vehicles in the transportation sector recently, work needs to continue on the internal combustion engine to ensure that the transition to other energy sources is done without detrimental impacts. Therefore, the importance and relevance of the work performed by the AMF have been re-confirmed, and many new projects have been developed.

There is a growing realization, as noted in the IEA's Technology Perspectives, that for the foreseeable future and up to 2050, all energy resources, energy carriers, and conversion/propulsion systems will be part of the transportation mix. Technology will play a critical role in converting resources into energy carriers, and in transforming energy carriers into personal mobility. Consideration needs to be placed on the role of international policies and global resource quality in altering transportation fuel properties and vehicle propulsion options. The complex interrelationships between energy carriers and end-use technologies, if not recognized and coordinated, could lead to a reduction in the effectiveness of policy instruments.

This past year presented a number of challenges, especially as governments had to review their expenditures and make some difficult decisions, most notably in the realm of research and development programs. As a result we have revisited the operational principles of the AMF, and many new Annexes have been started under a Task sharing model to provide flexibility for participation under fiscal constraints. Cost-sharing Annexes still are the preferred AMF cooperation mechanism, due to their effectiveness in delivering results in a timely manner, but the main goal of information sharing and cooperation needs to be upheld even in periods of financial duress.

The combination of a need to identify low-carbon transportation energy solutions and the pressures exercised on government spending has made 2011 a dynamic year in terms of membership. At the same time as some countries have had to re-consider their participation in IEA Implementation Agreements due to domestic fiscal constraints, interest was raised from a number of non-member countries, in a large part due to the efforts of the Sub-Committee for Membership and Outreach, headed by Dr. Larry Johnson, of Argonne National Laboratory. As such, while we regretfully accepted the notice of Thailand and Australia to retract from the AMF, we are encouraged by the progress made by Turkey, South Korea, and Israel in their efforts to become new members. Further, efforts to increase the linkages between AMF and Latin American countries continue and are raising the awareness and interest of AMF activities in this region.

The AMF has also undergone some administrative changes, with the arrival of both a new chairman and a new secretary in 2011. I believe that I speak on behalf of myself and that of our new secretary when I express my sincere thanks to Dr. Nils-Olof Nylund of the VTT research center in Finland and to Lic. Eng. Claës Pilo of SDAB for their outstanding work as Chairman and secretary over the past years. Their efforts have placed the AMF in a great position to face the challenges of its next work term. Dr. Nylund also generously agreed to take on the role of Vice-Chairman for Europe, which has been very useful in allowing for a smooth transition. The AMF Executive Committee also welcomed a new Vice-Chair for Asia, Dr. Shinichi Goto of AIST, and would like to thank our departing Vice-chairman, Kazunori Nagai of NEDO. I would finally like to take the opportunity to welcome our new Secretary, Dina Bacovsky from Bioenergy 2020+, and to thank her for the amazing way she has taken ownership of the AMF secretariat role. Her support and dedication have been invaluable in achieving the success we have known in this year of transition, and her links with the Bioenergy Implementing Agreement have also helped us pursue our goals of better cooperation within the IEA.

In addition to the collaborative mechanisms and administrative changes that were initiated, the AMF is also reviewing the way it strategically identifies opportunities for collaborations. To support these efforts, a new Sub-Committee on Strategy was created under the leadership of Olle Hadell, from the Swedish Transportation Administration. This committee will focus on identifying key areas of interest to AMF participating countries where the AMF can play an active role and can provide valuable information and advice. This new committee will be joining the special Sub-Committee for Membership and Outreach in supporting the Executive Committee's efforts to increase the relevance and impact of the AMF work on the international community.

In summary, the AMF remains an amazingly active Implementing Agreement, with projects touching all spheres of the transportation sector. It provides relevant and detailed fuel and technology performance data and knowledge on the potential for current and future fuels and technologies to achieve the IEA transportation energy goals, and on potential regulatory barriers that could impact the performance of the various transportation energy options. Interest and participation are ever increasing, and we are revisiting both the way we identify our work priorities and how we disseminate our information to ensure it is provided in a format that is useful to policy makers, regulators, industry, and the public to help them identify the most effective ways to reduce the environmental impact of the transportation system on a life cycle basis. The redesign of our website, the primary tool used for information dissemination, will be one of our primary undertakings this year, and should help us further the impact of our work.

I look forward to another great year of AMF collaborative work in 2012.

Jean-François Gagné
AMF Chairman

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 emissions that contribute to climate change.
- Improve 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 non-member 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) supported by the IEA are a flexible and effective framework for IEA member and non-member countries, businesses, industries, international organizations and non-government organizations to research breakthrough technologies, fill existing research gaps, build pilot plants, and carry out deployment or demonstration program – 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 (IAs) are working in the areas of:

- Cross-Cutting Activities (information exchange, modeling, technology transfer)

- End-Use (buildings, electricity, industry, transport)
- Fossil Fuels (greenhouse-gas mitigation, supply, transformation)
- Fusion Power (international experiments)
- Renewable Energies and Hydrogen (technologies and deployment)

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

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

1.c Implementing Agreement on Advanced Motor Fuels

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

At the same time, new possibilities are opening up. The array of options is broadening, not narrowing. This is true for both fuel and vehicle technology options. We are closer than ever to a wide-scale use of alternative fuels. However, the increasing number of options makes decision making harder. This is true for the private consumer, fleet operator, communities, and governments. One of most important tasks at Advanced Motor Fuels (AMF) is to provide decision makers at all levels with unbiased and solid data on the performance and potential of various options.

We should note that AMF must always take note of the fact that the properties of commercial fuel and the sophistication of vehicles varies significantly between different regions of the world. All candidate future fuels face obstacles and barriers (bottlenecks) that might be either unique to a given fuel or shared with other fuels (Figure 1).

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

Expertise represented within AMF by the national delegates and experts helps to point out the obstacles and identify the types of R&D necessary to eliminate and/or overcome the obstacles. Making policy for alternative fuel implementation requires a prioritization of desirable attributes for the fuels and a balancing of the priorities with practical realities with regard to costs and benefits. Figure 1 illustrates the process of defining the priorities, along with the barriers (or bottlenecks).

Therefore, 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.

The mission of AMF is:

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

It will continue to provide a fuel-neutral platform for 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 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 greenhouse-gas 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:

- Alcohols (ethanol, methanol), ethers (e.g., DME, ETBE, MTBE), esters (e.g., RME), gaseous fuels (e.g., natural gas, biogas, hydrogen, LPG)
- Reformulated gasoline and diesel fuels, including oxygenated versions
- Synthetic fuels, such as Fischer-Tropsch fuels
- Fuels for new types of engines and fuel cells

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

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

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

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

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

Financial obligations of membership will include:

- An annual membership due; currently 9,500 EUR (as of June 6, 2012, 1 EUR = 1.2499 USD)
- 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 EUR to 100,000 EUR

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

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

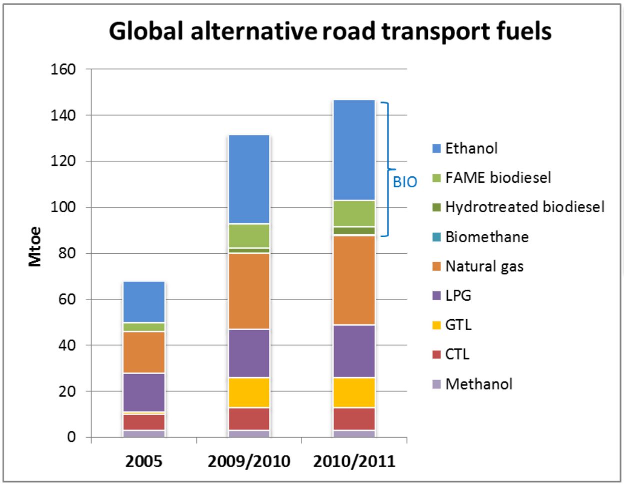
2 The Global Situation for Advanced Motor Fuels

2.a Overview of Advanced Motor Fuels

2.a.i Statistical Information on Fuels and Fleets

Alternative fuels for transportation have gained importance globally. The use of fossil-derived alternatives, such as Methanol, Coal-to-Liquid (CTL), Gas-to-Liquid (GTL), Liquified Petroleum Gas (LPG), and Natural Gas — as well as the use of biofuels, such as Biomethane, Hydrotreated biodiesel, FAME biodiesel and Ethanol — has considerably increased over the past years.

Figure 1 shows the global consumption of alternative road transport fuels and their development over the last five years. In 2009, transport energy consumed globally was around 2,300 Mtoe. A major part of that, approximately 73%, was consumed in the road transport sector. The consumption has doubled from approximately 70 Mtoe in 2005 to approximately 140 Mtoe in 2010/2011. This consumption represents a share of approximately 8.8% of road transport fuels in 2010. The share of biofuels is estimated to be 3.5%. Ethanol and natural gas are the dominant alternative fuels, although LPG, biodiesel, and synthetic fuels (GTL and CTL) are significant contributors as well.



Energy demand of transport sector is appr. 2300 Mtoe. Major part of that, appr. 73% (~ 1700 Mtoe), is consumed in road transport sector.

Alternative fuels are estimated to represent max. 8.8% share of road transport fuels in 2010. Share of biofuels is estimated to be 3.5%, respectively.

Sources: Ethanol 2010 (REN21, 2011); FAME and hydrotreated biodiesel 2010/2011 (EurObserv'ER, 2011; Press releases); CNG, biomethane 2010/2011 calculated from vehicle population (NGVA Europe and GVR, 2011); GTL and CTL capacities (IEA ETSAP, 2010); Methanol 2010 (Methanol Institute); World transport fuels 2009 (IEA WEO, 2011).

Figure by IEA-AMF (A-S 2012)

Fig. 1 Estimate of Global Consumption of Alternative Fuels in Road Transport Sector

Global consumption of transport fuels varies significantly by region (Figure 2). The largest consumer is OECD Americas, with a total of 29 Mio TJ (million terajoules), followed by OECD Europe (14 Mio TJ). The main fuels consumed are gasoline and diesel. Significant amounts of marine and aviation fuels are stored in bunkers.

Split by transport mode, light-duty vehicles consume around 53% of transport energy demand, whereas trucks and buses consume around 21% (Figure 3). Other main sectors are the marine and the aviation sectors, each consuming around 10%.

The main fuels are gasoline and diesel fuels, which are primarily used in road transport, followed by residual oil (marine fuel) and jet fuel (aviation). LPG, CNG, biofuels, and electricity together constitute only a minor share of 4%. Most biofuels are used in road transport, but driven by recent changes in regulations, the marine and aviation sectors are now also searching for alternatives.

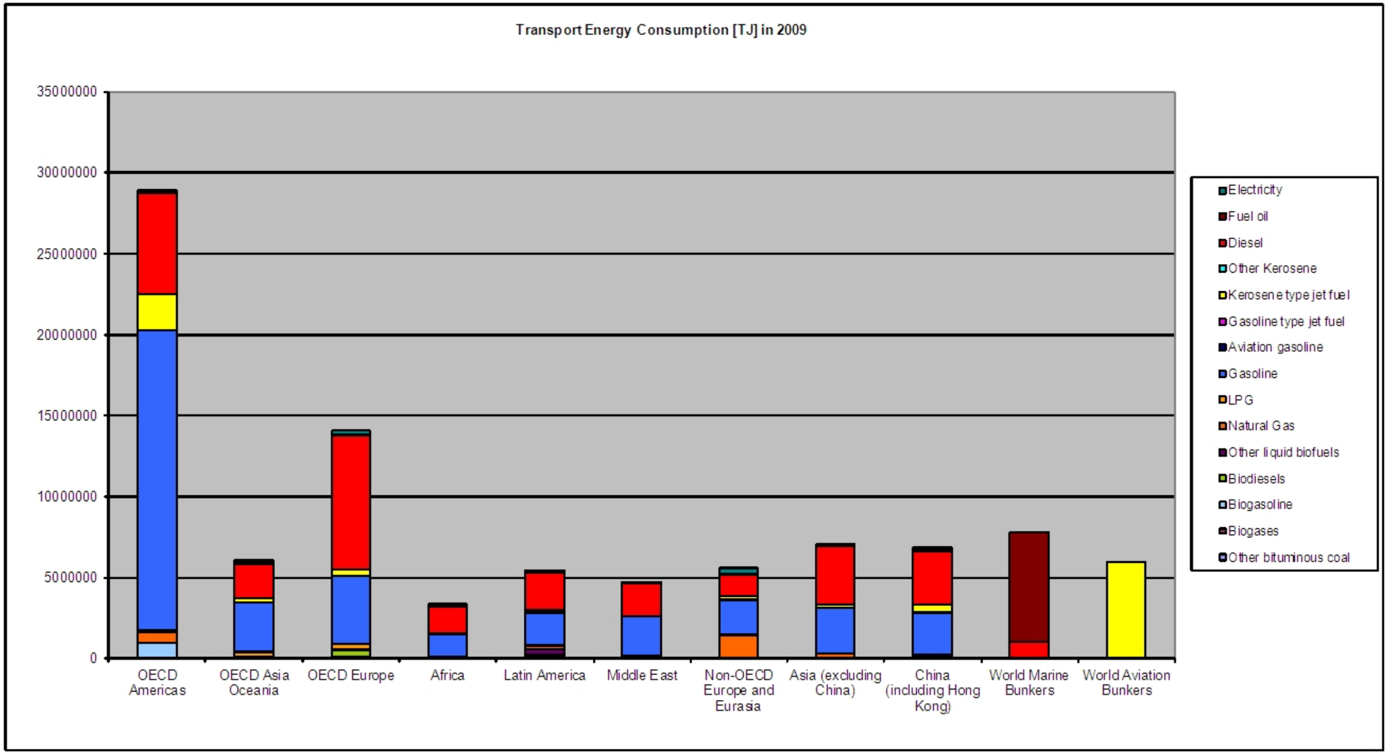


Fig. 2 Energy Use of the Transport Sector by Country and by Fuel Type in 2009 (Source: IEA [2011]; World Energy Balances)

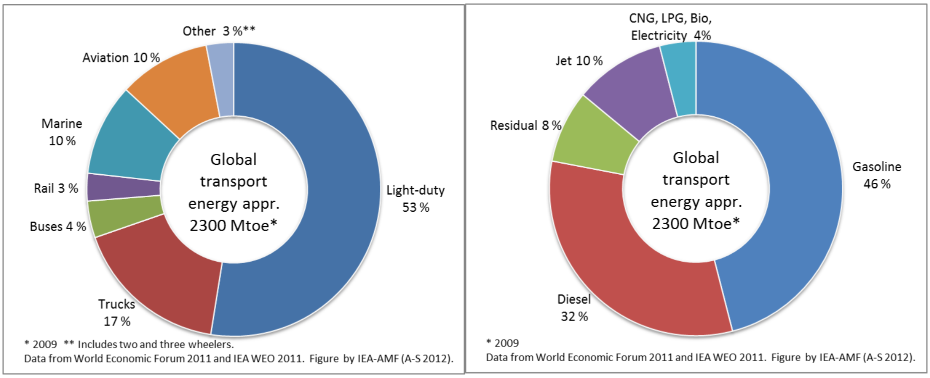


Fig. 3 Global View on Transport Modes and Fuels

Uptake of alternative fuels is challenging. Infrastructure needs to be built up, and alternative fuel vehicles are just entering the market. Few countries have more than a 30% share of alternative fuel vehicles, and only a handful have a significant share of more than one alternative vehicle technology in the total stock. Details are shown in Figure 4.

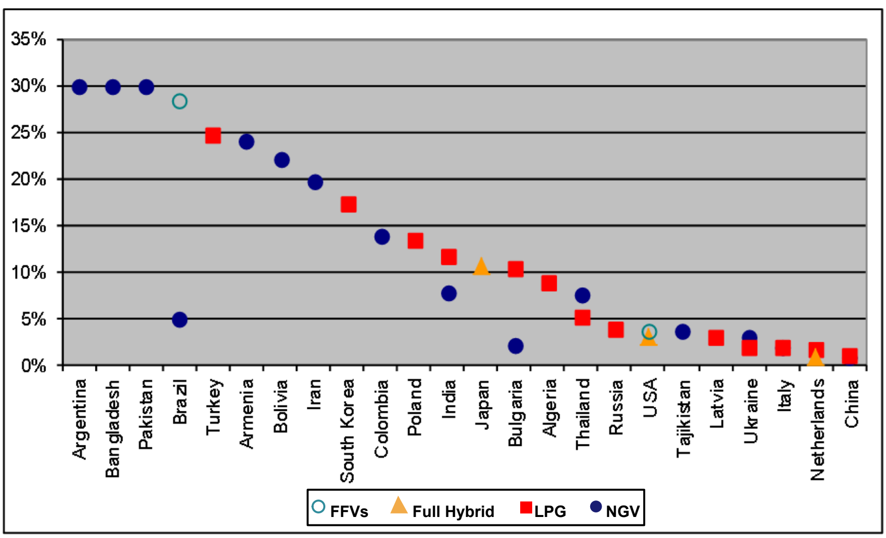


Fig. 4 Stock Share of Non-Gasoline and Non-Diesel Technology for Passenger LDVs, 2010 (Source: IEA (2012), Energy Technologies Perspectives 2012, OECD/IEA, Paris)

2.a.ii
National Goals for Advanced Motor Fuels

The market introduction of alternative fuels and vehicles depends heavily on the respective policies. Many countries have adopted national goals for the use of biofuels or alternative motor fuels. Measures applied include biofuel production subsidies, biofuel mandates, tax reduction, and vehicle purchase incentives. Most countries rely on biofuels mandates, often combined with tax reduction. National goals for advanced motor fuels are listed below; the information given is based on data from the IEA WEO 2010 and information from the country reports of IEA AMF participants.

Country/ Region	Current Mandate/Target	Future Mandate/Target	Current Status (mandate [M]/ target [T])
Argentina	E5, B7	n.a.	M
Australia (New South Wales (NSW), Queensland (QL))	NSW: E4, B2	NSW: E6 (2011); QL: E5 (recently put on hold until autumn 2011)	M
Brazil	E20-25, B5	n.a.	M
Canada	E5 (up to E8.5 in 4 provinces), B2-B3 (in 3 provinces)	B2 (nationwide) (2012)	M
Chile	E5, B5	n.a.	T
China (9 provinces)	E10 (9 provinces)	n.a.	M
European Union	5.75% biofuels	10% renewable energy in transport	T
India	E5	E20, B20 (2017)	M
Japan	500 million L/y (oil equivalent)	800 million L/y (2018)	T
Korea	B2	B2.5 (2011); B3 (2012)	M
Mexico	E2 (in Guadalajara)	E2 (in Moterrey & Mexico City)	M
Norway	3.5% biofuels	Possible alignment with EU mandate	M
Nigeria	E10	n.a.	T
Paraguay	E24, B1	n.a.	M
Peru	E7.8, B2	B5 (2011)	M

Country/ Region	Current Mandate/Target	Future Mandate/Target	Current Status (mandate [M]/ target [T])
Thailand	B3	3 million L/d ethanol, B5 (2011); 9 million L/d ethanol (2017)	M
Uruguay	B2	E5 (2015), B5 (2012)	M
United States	48 billion L, of which 0.02 L are cellulosic-ethanol	136 billion L, of which 60 L are cellulosic-ethanol (2022)	M

2.b
Country Reports of AMF Member Countries

Most of the countries participating in the IEA-AMF Implementing Agreement and one of the observing countries have prepared reports to highlight the production and use and the existing policies of advanced motor fuels in their respective countries.

Austria

(Prepared by A3PS)

Introduction

The transport sector in Austria has the highest share of final energy consumption; the corresponding distribution for 2010 was 32.9% for transport, followed by the production sector with 28.4% (see Figure 2). Data on mineral oil and energy consumption appear in Figures 1 and 2.

With a total of 22.5 million tons CO_2 eq. (0.6 million tons higher than the previous year), transport is the second highest emission source after the production sector. The increase in the emissions from the transport sector is less pronounced than in the case of the transport volume as a result of the implementation of biofuels, which prevented in 2010 the emission of 1.7 million tons in CO_2-eq. emissions.

Austria should reduce greenhouse gas (GHG) emissions by 13% in the period 2008–2012, with 1990 as the reference year, in order to achieve the targets set by the Kyoto Protocol (see Figure 3).

To reach this target, as well as the goals set by the European Climate and Energy Package, which include a share of 10% of renewables in the transport sector by 2020, the National Energy Strategy of 2010 (Energiestrategie) identified several measures, including higher mineral fuels and vehicle taxation based on CO_2 emissions, as well as different support schemes for the replacement of vehicles targeted at increasing the energy efficiency and reducing emissions for both commercial and communal fleets and private users. Further information on these measures will be provided in the following sections.

Source:
http://www.lebensministerium.at/presse/umwelt/treibhausgas_012012.html.

Table 1 Mineral Oil Consumption by Type of Fuel

Mineral oil consumption 1970–2010 (tons)									
End product	**1970**	**1980**	**1990**	**2000**	**2005**	**2007**	**2008**	**2009**	**2010**
LPG	88.746	156.363	179.145	150.300	171.530	157.895	151.521	142.877	161.071
Aviation fuel	1.645	2.896	2.910	2.039	2.787	2.856	2.938	3.268	2.920
Gasoline ÖNORM conform	589.521	791.130	794.504	622.820	545.331	474.145	310.500	149.523	158.041
Premium gasoline ÖNORM conform	984.308	1.645.176	1.757.750	1.357.577	1.528.108	1.491.941	1.524.494	1.692.339	1.662.392
Diesel	1.135.658	1.503.096	2.084.047	4.262.146	6.267.778	6.320.011	6.147.472	5.952.125	6.227.484
Extra light fuel oil	479.226	1.216.627	1.247.283	1.592.144	1.848.956	1.327.628	1.642.158	1.457.413	1.448.784
Kerosine	12.006	17.373	8.820	1.121	1.012	998	680	423	369
Turbine fuel	41.895	132.602	314.638	570.229	653.176	724.153	725.280	632.565	674.896

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

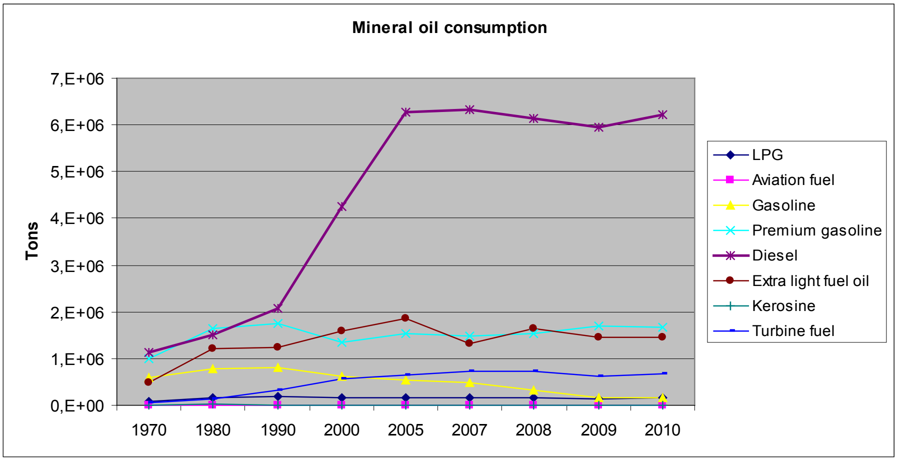


Fig. 1 Consumption of Mineral Oil Products for the Period 1970–2009 (Source: Statistik Austria)

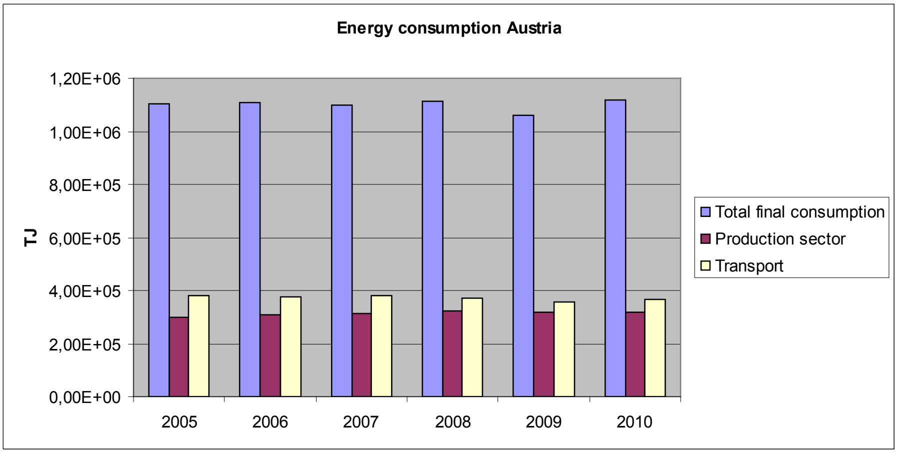


Fig. 2 Energy Final Consumption for the Period 2005–2010 (Source: Statistik Austria)

Emissionen von Treibhausgasen [1)2)]

Österreich, in Mio Tonnen CO2-Äquivalent

	Basisjahr 1990	2007	2008	2009	2010	Ziel 2008-2012
Kohlendioxid (CO2)	62,1	74,2	73,7	67,6	72,3	
Methan (CH4)	8,3	7,0	5,7	5,7	5,6	
Lachgas (N20)	6,1	5,4	5,6	5,4	5,1	
F-Gase	1,6	1,5	1,6	1,4	1,6	
Gesamt	**78,1**	**88,1**	**86,6**	**80,1**	**84,6**	
Ziel						68,8

Quelle: Umweltbundesamt 2012

Fig. 3 Greenhouse Gas Emissions (tons CO_2 eq.) and Target Set for Austria by the Kyoto Protocol for the Period 2008–2012 (Source: Umweltbundesamt)

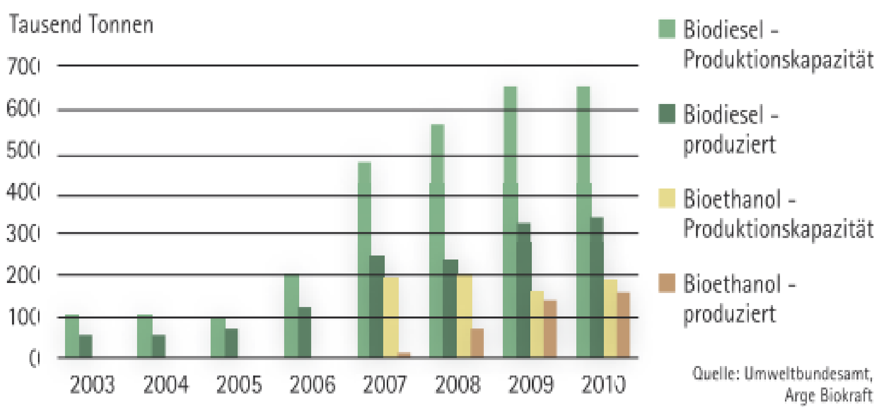


Fig. 4 Biofuel Production Capacities and Actual Production in Austria (Source: Basisdaten 2011 Bioenergie, Österreichischer Biomasse-Verband)

Regarding the national production of biofuels (see Figure 4), 14 plants for the production of biodiesel were in operation in 2010. Total production in 2010 was 650,000 tons, which met the demand for the biofuel substitution of diesel fuel.

In addition, the total demand of bioethanol for biofuel substitution can be met by the output of the production plant in Lower Austria (Pischelsdorf). Feedstock in this case is regional (central and eastern Europe) wheat and corn surplus, as well as other grains, which because of their low quality, are not suitable for food production.

Policies and Legislation

Fiscal Measures

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

An increase of the mineral oil tax applies since the beginning of 2011: + 0,04 €/L[1] for gasoline and + 0,05 €/L for diesel.

The tax rates for 1000 L of fuel are shown in Table 2.

Table 2 Tax Rates for 1000 L Fuel (€)

Gasoline	Tax rate
After December 2009	
Max. sulphur content: 10 mg/kg and biofuel content at least 46 L	442
Else	475
After December 2010	
Max. sulphur content: 10mg/kg and biofuel content at least 46 L	482
Else	515
Diesel	**Tax rate**
After December 2009	
Max. sulphur content: 10 mg/kg and biofuel content at least 66 L	347
Else	375
After December 2010	
Max. sulphur content: 10 mg/kg and biofuel content at least 66 L	397
Else	425

Source: Umw eltbundesamt. 100% biofuel is tax exempt.

Biofuel Substitution

The biofuel substitution goal set by the Fuel Regulation (Kraftstoffverordnung) approved on January 1, 2009, sets a share of 5.75% (energy content) of the total Otto and diesel fuels consumption in Austria.

[1] As of June 6, 2012, 1 EUR = 1.2499 USD

For 2010, the 5.75% goal was exceeded, reaching a share of biofuels of 6.58%, although in 2009 the share reached 7%. The reason for this decrease is a lower demand for biodiesel in commercial fleets.
Source: Umweltbundesamt "Biokraftstoffe im Verkehrssektor 2011."

Tax Modifications
Starting in July 2008, a new bonus-malus system for CO_2, NO_x, and particle emissions was introduced for the taxation on the acquisition of new vehicles (NoVA - Normverbrauchsabgabe).

An increase of the NoVA-Malus applies from January 1, 2011, through December 31, 2012:

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

With a further increase planned beginning January 1, 2013:

- Over 150 g/km 25€/g CO_2
- Over 170 g CO_2/km increased to 50€/g CO_2
- Over 210 g CO_2/km increased to 75 €/g CO_2

Regarding NO_x emissions, gasoline vehicles with emissions not higher than 60 mg/km (in the case of diesel vehicles not higher than 80 mg/km) and particle emissions not higher than 0.005 g/km receive a tax reduction of maximum 200 €.

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

Implementation: Use of Advanced Motor Fuels

Tables 3–5 present data on use of advanced fuels in Austria.

Table 3 Fleet Distribution by Drive Train in Passenger Cars as of 31.12.2010

Drive train	Total
Gasoline	1.983.936
Diesel	2.445.506
Electric	353
LPG	1
Natural gas	1.312
Bivalent Gasoline/Ethanol (E85)	4.143
Bivalent Gasoline/LPG	87
Bivalent Gasoline/Natural Gas	897
Hybrid Gasoline/Electric	4.792
Total	**4.441.027**

Table 4 New Registrations of Passenger Cars, January–December 2011, by Drive Train (absolute share in % and change against January–December 2010 in %)

Drive train	Passenger cars				Change in %
	2011	Share in %	2010	Share in %	
Gasoline[1]	159.027	44,7	159.740	48,6	-0,4
Diesel	194.721	54,7	167.130	50,9	16,5
Electro	631	0,2	112	0,0	463,4
Natural gas	262	0,1	171	0,1	53,2
Dual Fuel Gasoline/LPG	12	0,0	-	-	-
Dual Fuel Gasoline/Natural Gas	182	0,1	162	0,0	12,3
Hybrid: Gasoline/Electric	1.306	0,4	1.248	0,4	4,6
Hybrid Diesel/Electric	4	0,0	-	-	-
Total	**356.145**	**100,0**	**328.563**	**100,0**	**8,4**

Source: Statistik Austria
[1] *Includes Gasoline/Ethanol (E85).*

Table 5 Filling Stations for Alternative Fuels – Status 2011

Fuel	Total
CNG	146
Biogas	1
E85	28
Vegetable oil	19

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

Relevant Research Programs

A3plus

This program, funded by the Federal Ministry for Transport, Innovation and Technology, supports the development of innovative propulsion technologies and alternative fuels in order to secure the competitiveness of the Austrian automotive industry, achieve reductions in the energy consumed for transport, and reduce emissions from this sector.

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

A3plus core areas (5th call — 2011)

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

In the framework of this program, cooperative research projects involving industry, universities, and research centers are funded.

Neue Energien 2020

This program is funded by the Climate and Energy Fund, and its focus is the promotion of research activities on all aspects of the energy supply system, from energy conversion through its transport and end use.

The relevant areas for transport in the 2011 call with a total budget of 30 million € include energy efficiency and renewable energy carriers.

Klima:aktiv mobil
This initiative was launched in 2004 by the Federal Ministry of Agriculture, Forestry, Environment and Water Management in the context of the Austrian Federal Climate Strategy.

Klima:aktiv mobil supports measures focusing on mobility management, including alternative vehicles and renewable energy, intelligent multimodal mobility, ecodriving, cycling, walking, demand-oriented public transport, and awareness raising.

Areas of the Mobility Management Program include the following:

- 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

Outlook

A new climate protection law was approved in November 2011 (Klimaschutzgesetz) that sets the emission targets for the period 2008–2012 in those sectors not included in the European Union Emission Trading System (EU ETS) (i.e., road transport, among others). It also designates the coordination groups in charge of the national climate protection policy and sets the framework for the preparation of measures to achieve the emission goals. For the transport sector, these goals would include increasing energy efficiency and share of renewable energy sources, as well as improving mobility management. Source: https://www.help.gv.at/Portal.Node/hlpd/public/module?gentics.am=Content&p.contentid=10007.64188#Inh.

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.

Upcoming measures according to the National Energy Strategy of 2009 (Energiestrategie) include the introduction of E10 and B10 following the approval of the corresponding European Standard for these fuels.

There is still no consensus regarding the obligatory introduction of E10 for 2012, which will be most probably delayed and replaced by a voluntary decision made by each filling station.

There is still no consensus regarding the obligatory introduction of E10 for 2012, which will be most probably delayed and replaced by a voluntary decision made by each filling station.

Additional References

Information on alternative fuels:

1. Natural gas vehicles: www.erdgasautos.at.
2. Filling stations for alternative fuels, http://www.raiffeisen-leasing.at/tankstellen.html
3. Biogas filling stations, www.methapur.com.
4. Austrian Biomass Association, http://www.biomasseverband.at/.

Relevant institutions and programs:

1. Austrian Federal Ministry for Transport, Innovation and Technology (bmvit), http://www.bmvit.gv.at/
2. Austrian Research Promotion Agency (FFG), http://www.ffg.at/en
3. Klima:Aktiv Initiative, http://www.klimaaktiv.at/
4. Austrian Economic Chambers, http://portal.wko.at/wk/startseite.wk
5. Statistik Austria, http://www.statistik.at
6. Environment Agency Austria, http://www.umweltbundesamt.at
7. Austrian Federal Ministry of Finance (taxation), http://www.bmf.gv.at/Steuern/Brgerinformation/AutoundSteuern/NormverbrauchsabgabeNOVA/_start.
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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 158 million m^3, or 433.1 thousand m^3 per day, in 2009. Conventional sources provided 51% of total production, while oil sands production, which has been growing in recent years, accounted for the remainder. About two-thirds of Canada's 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.

Canada also has great potential supplies of alternative transportation fuels. It is the world's third-largest producer and exporter of natural gas. Canadian supplies have grown substantially in recent years due to the advent of technological advances in areas such as horizontal drilling and multi-stage hydraulic fracturing. Biofuels – or fuels from renewable sources – are a growing form of bioenergy in Canada. In 2011, the domestic production capacity of biofuels was approximately 1.8 billion liters of ethanol and 200 million liters of biodiesel.

Transportation plays a crucial role in the social, economic, and political activities of all Canadians. By moving both people and goods in a country as vast as Canada, transportation has a significant impact on where people choose to live, vacation, shop, and work. In 2009, the transportation sector consumed 2,576.6 PJ of energy, accounting for 30% of Canada's total secondary energy use (which is the energy used by final consumers in various sectors of the economy and, therefore, excludes exports, energy consumed by energy producers, and non-energy uses).

The 2009 Canadian Vehicle Survey, which describes the characteristics of Canada's vehicle fleet, including patterns in vehicle use and fuel consumption, reported that, overall, the number of vehicles grew an average of 2.0% per year over the period of 2000 to 2009, reaching 20.5 million vehicles in 2009. The number of vehicles per household increased from 1.43 to 1.47 for the same period. Additional findings were that the fuel consumption rate remained relatively constant between 2005 and 2009 for light vehicles that use gasoline, but that fuel consumption rates decreased for medium and heavy trucks (Figure 1). This decrease in consumption rates was offset by the significant change in the composition of the light vehicle fleet, the light truck category (vans, sport utility vehicles [SUVs], and pickup trucks) increasing substantially relative to the share of cars.

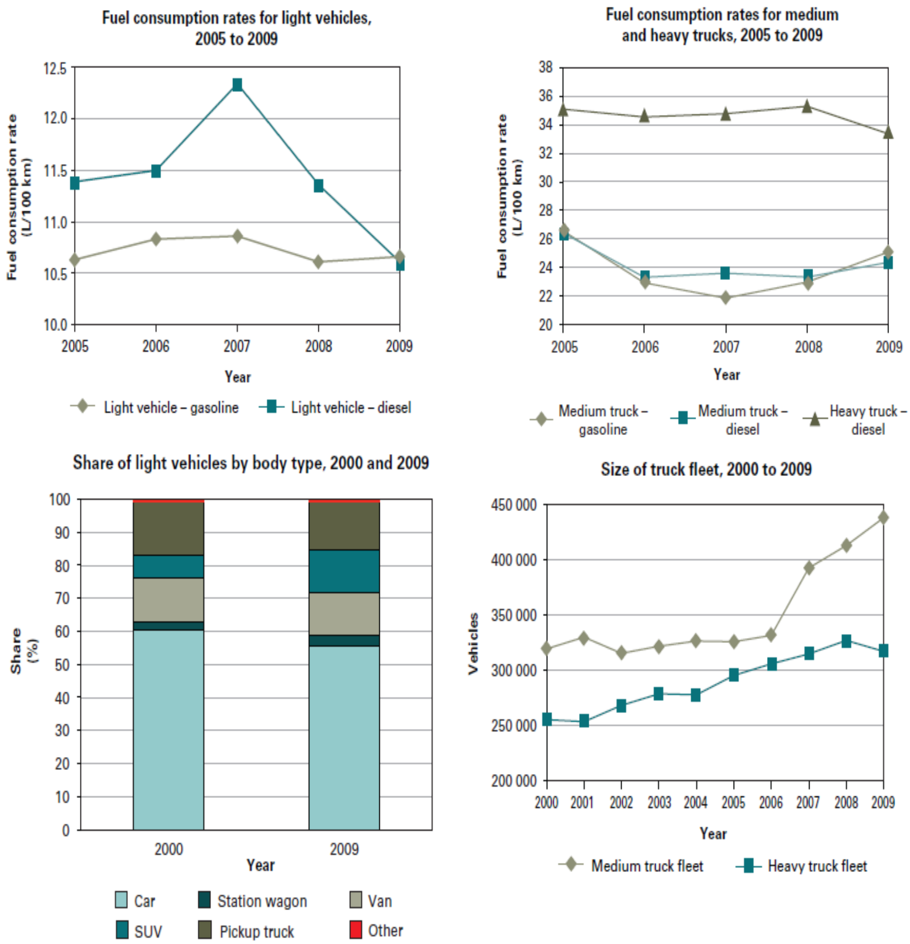

Fig. 1 Fuel Consumption and Composition of Canada's Vehicle Fleet in 2009 (Source: 2009 Canadian Vehicle Survey (CVS) Fact Sheet (http://oee.nrcan.gc.ca/publications/statistics/cvs09/factsheet/factsheet.pdf))

Policies and Legislation

The Government of Canada is committed to advancing clean energy technologies and to building a transportation system that responds to Canada's 21st-century needs. As such, many initiatives are under way to help Canada achieve its economy-wide target of reducing greenhouse gas emissions by 17% from 2005 levels by 2020.

As the transportation sector is the largest single source of emissions in Canada and is fully integrated across North America, Canada has worked collaboratively with the U.S. toward common standards for greenhouse gas emissions from vehicles, and has published final regulations for light duty vehicles for the 2011–2016 model years. The U.S. and Canada are also working together to do the same for heavy-duty vehicles, and to develop tighter standards for new passenger automobiles and light trucks of the 2017 and later model years.

In the area of renewable fuels, Environment Canada’s Renewable Fuels Regulations require an average renewable fuel content of 5% in gasoline and mandate 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 distillates that they produce and import. These regulations are one pillar of the Government’s broader Renewable Fuels Strategy. Additional components include the ecoAgriculture Biofuels Capital Initiative, which supports the construction or expansion of transportation biofuel production facilities; the ecoENERGY for Biofuels Program, which supports the production of renewable alternatives to gasoline and diesel and encourages the development of a competitive domestic industry for renewable fuels; and the Sustainable Development Technology Canada (SDTC) Next Gen Biofuels Fund™, aimed at supporting the establishment of first-of-its-kind commercial-scale demonstration facilities for the production of advanced renewable fuels and co-products.

The Natural Gas Use in the Canadian Transportation Sector Deployment Roadmap, published in January 2011, concluded that Canada’s transportation sector could benefit from expanding the use of lower emission technologies and fuels such as natural gas. As a follow-up, government and industry representatives created a senior-level Implementation Committee to guide joint efforts to implement the Roadmap recommendations. These joint efforts will be supported by Federal funding from the ecoEnergy for Alternative Fuels Program and by industry contributions. The Province of British Columbia has also strongly signalled its intent to encourage the use of natural gas for heavy vehicles in its recently released Natural Gas Strategy – Fuelling BC’s Economy for the Next Decade and Beyond. A

Heavy Natural Gas Vehicle Program (5 years, $62 million) is proposed to reduce emissions from transportation.

On the energy efficiency front, the Government of Canada is planning to update the content of vehicle fuel consumption labels to better align with information contained on labels recently introduced in the United States for model year 2013 vehicles. The Government of Canada expects to have updated labels in 2014 for new model year 2015 vehicles sold in Canada. This new label is one aspect of the ecoENERGY Efficiency for Vehicles Program, part of Natural Resources Canada's suite of energy efficiency initiatives.

To support efficient, safe, and secure transportation systems, Transport Canada's ecoTECHNOLOGY for Vehicles Program (eTV) 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. Results will help to inform the development of environmental and safety regulations to ensure that these technologies are introduced in Canada in a safe and timely manner, and will also support the Canada-U.S. Regulatory Cooperation Council in aligning vehicle regulations in North America to reduce and prevent barriers to cross-border trade.

In terms of research and development, 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 area of research is to address the key technical challenges associated with the following: advanced materials for high performance engines and vehicle weight reduction, highly efficient clean combustion technologies, and advanced exhaust after-treatment systems. Also being addressed are determination of vehicle system impacts associated with the use of fossil, renewable, and unconventional fuels; analysis of associated codes and standards; and the development of computational capabilities to predict the performance of vehicle components and systems. The ecoEII program complements the Program of Energy Research and Development (PERD) Clean Transportation Systems R&D work on advanced fuels and technologies for emissions reduction. This effort aims to conduct R&D to develop knowledge and technology relating to advanced transportation fuels, engine designs, after-treatment technologies, and technologies that reduce 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 fuel used, as shown in Figure 2. The renewable fuel consumed was predominately ethanol blended with gasoline in lower-level ethanol blends.

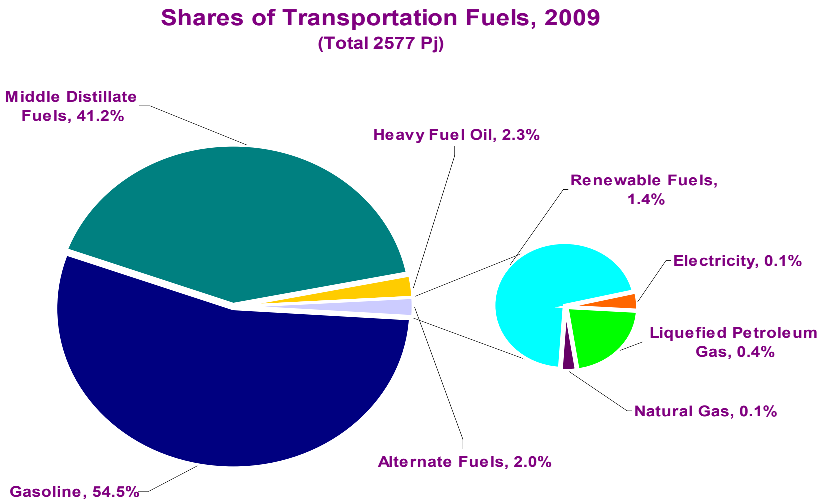

Fig. 2 Distribution of Fuel Types in Transportation Sector

Projects demonstrating the use of alternative fuels in various transportation sectors continued in 2011, with natural gas trucks in both corridor and return-to-base applications showing the most marked increase and aviation biofuel demonstration planning continuing with the goal of setting up demo flights in the coming year.

Canada's first two major projects for liquefied natural gas (LNG) highway trucks 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. Non-road sectors also began looking at LNG as a fuel source, with the announcement of the construction of two new ferries for the Tadoussac–Baie-Sainte-Catherine crossing, to be built in Quebec, and to be powered by LNG. Vancouver-based Westport Innovations Inc., developer of natural gas engines, entered into an agreement with Electro-Motive Diesel (EMD), an original equipment manufacturer (OEM) of diesel-electric locomotives, to integrate Westport's high pressure direct injection (HPDI) technology and natural gas fuel system technologies into an EMD locomotive provided by Canadian National Railways (CN). The consortium is expecting to demonstrate the natural gas locomotive as part of an SDTC project with CN and Gaz Metro.

Outlook

With average renewable fuel content requirements of 5% in gasoline and 2% in diesel fuel and heating oil, it is expected that the demand and use of renewable fuels in the transportation sector will grow substantially. Similarly, actions by both governments and industry following the launch of the Natural Gas Roadmap Implementation Committee are expected to yield tangible increases in the use of natural gas across the transportation sector. Additional reductions in fossil fuel consumption are expected to come from motor vehicle fuel efficiency improvements driven by increasingly stringent greenhouse gas emission regulations.

Additional References

- Natural Resources Canada, Office of Energy Efficiency, Alternative Fuels homepage, http://oee.nrcan.gc.ca/transportation/alternative-fuels/780.
- Natural Resources Canada, Office of Energy Efficiency, Cars and Light Trucks homepage, http://oee.nrcan.gc.ca/transportation/ personal/17604.
- Natural Resources Canada, Office of Energy Efficiency, Commercial Vehicles homepage, http://oee.nrcan.gc.ca/transportation/business/17935.
- Natural Resources Canada, Energy Science and Technology homepage, http://www.nrcan.gc.ca/energy/science/1232.
- Important Facts on Canada's Natural Resources, http://www.nrcan.gc.ca/statistics-facts/energy/895.
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Benefits of Participation in the IEA-AMF

Canada has a long-standing history of collaborative work, both domestically and internationally. Through its more than 25 years of participation in the IEA-AMF, Canada has been able to access and input into a world-wide recognized unbiased source of data and recommendations, as well as leverage resources by either initiating or participating in multitude Annexes. To date, Canada has participated in 34 of the 41 IEA-AMF Annexes, having initiated 6 of those Annexes, and a vast amount of the leveraged resources were reinvested domestically. Canada participates in all 9 Annexes that are currently active, and leads sub-task 2 of Annex 35 on Ethanol and Butanol in DISI Engines and Annex 40 on Life Cycle Analysis of Transportation Fuel Pathways. In addition to the usual cooperative interactions between the AMF member parties, AMF participation also provides opportunities to liaise with top experts and institutions from host countries, such as national R&D labs, universities, and fueling and transportation technology industries, and to create links with representatives from non-member countries who are invited to attend as observers to the IEA-AMF, with a potential for future participation.

China

Introduction

The total diesel and gasoline fuel consumption in China amounted to 205 million tons in 2010. Of this, 147 million tons was due to vehicles, as shown in Figure 1. Note that fuel consumption by road transportation vehicles has become the main vehicle segment of total consumption of gasoline and diesel in China.

China's vehicle production and sales number reached 18.26 million and 18.06 million, and the total population reached 78 million in 2010, as shown in Figure 2 and Figure 3. At present, China has the world's fastest-growing vehicle market, and is facing the dual challenges of lowering oil consumption and greenhouse gas emissions.

Natural gas (NG) is another main energy source for the vehicles in China. By the end of 2010, vehicles powered by NG were promoted in 80 cities of China. There were more than 1 million NG vehicles with 1,500 refuel stations for them.

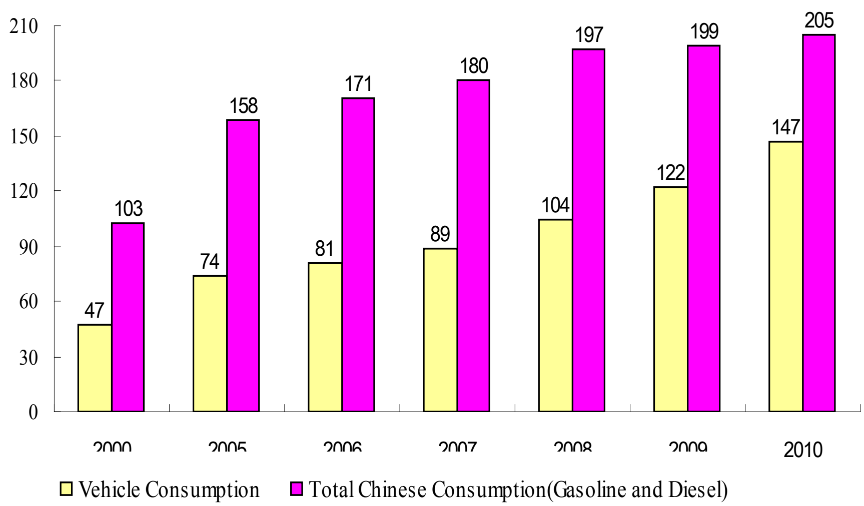

Fig. 1 Fuel Consumption in China (million tons)

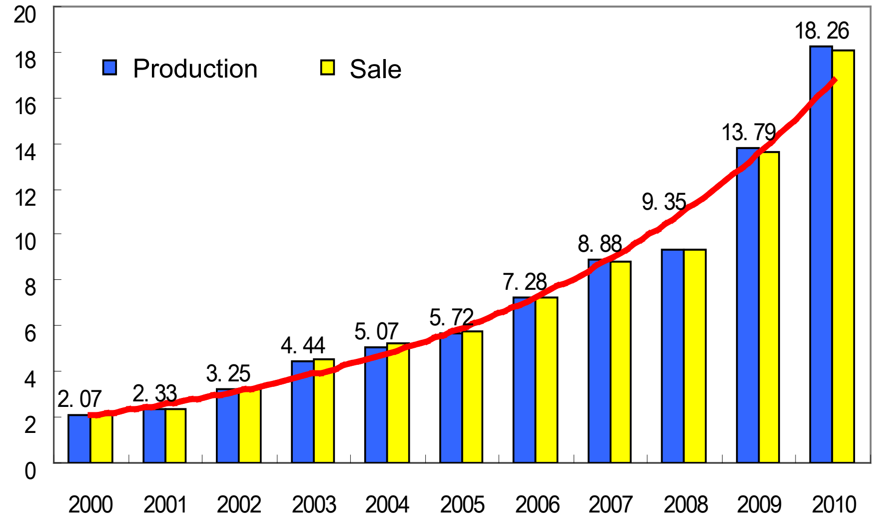

Fig. 2 Chinese Vehicle Production and Sales Numbers (millions)

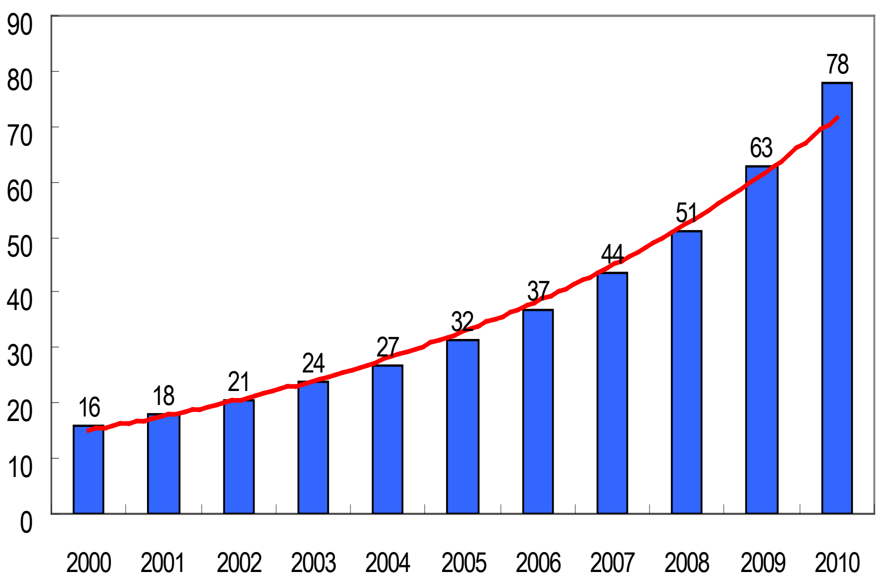

Fig. 3 Chinese Vehicle Population (millions)

Policies and Legislation

In 2011, the Chinese Government encouraged the development of several advanced technologies in the auto industry.

In June 2011 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 jointly issued guidelines for the preferential development of advanced technologies. The definition of “preferential” encompasses information, biology, aviation and aerospace, energy-saving and environmental protection, resources use, and advanced manufacturing, which cover 137 detailed industries.

Dozens of high-tech approaches for autos are covered in the guidelines. The basic auto technologies covered include lightweight thermo-composites for autos, fiberglass for auto covers, metallic pigment for high-end cars, and molds for auto covers. Traditional vehicle technologies and new energy technologies are encouraged in the guidelines.

Traditional vehicle technologies include high-efficiency-vehicle diesel engine, gasoline engine, continuous variable transmission, automatic transmission, electric steering equipment, active (semi-active) suspension system, brake systems (ABS/TCS/ESP), environmental protection thin-film airbag, aluminum body and parts, intelligent headlamp, and central lighting system. The new energy technologies include inverter and driving equipment for electric vehicles (EVs), charging facilities, and coordinated operation system with the grid. In addition, the power assembly technology for hybrid electric vehicles (HEVs) is contained in the key parts technologies.

The guidelines recommend the development of the 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

The China State Council issued the “Implementing Regulations of Vehicles and Vessel Tax” in June 2011. Battery electric vehicles (BEVs), fuel cell electric vehicles (FCVs), and plug-in HEVs are free from the vehicle and vessel tax, while the tax on other hybrid vehicles is reduced by half, compared with the tax 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 ￥660 to ￥60.[2] Industry experts expect that the vehicle and vessel tax exemption and reduction will not have a direct promotional effect on the market for new-energy vehicles.

Implementation: Use of Advanced Motor Fuels

China "10 Cities, 1000 Units" Energy-Saving and New Energy Vehicle Demonstration

In 2009, the four ministries under the State Council jointly started the operation pilot project "10 cities, 1000 units, " which is an energy-saving and new energy vehicle demonstration. Both BEV and HEV vehicles were promoted in the field of public bus, taxis, postal cars, and service cars through a government financial subsidy. By the end of 2010, the demonstration cities had been enlarged from 13 in 2009 to 25 in 2011. Of this, 6 cities were selected to provide a subsidy for private buyers. Now there are 190 models from 54 vehicle manufactures listed in the "Catalogue of Recommended Vehicle Models of the Project of Energy Saving and New Energy Vehicles." Table 1 provides statistical data for 2009 and 2010.

Table 1 Statistical Data on Demonstration City, 2009–2010

Type		2009	2010	Total
Passenger car	BEV	480	972	1452
	HEV	935	1642	2577
	FCV	90	80	170
Commercial vehicle, Special purpose vehicle	BEV	365	442	807
	HEV	5	0	5
	FCV	100	160	260
Bus	BEV	464	528	992
	HEV	2935	2390	5325
	FCV	84	80	164
Total		5458	6356	11,814

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

2 As of June 7, 2012, 1 ¥ = 0.16 USD

Action Commission and carried out the "Air Purification Project - Clean Vehicle Action." The aim of this project was to promote the natural gas vehicle (NGV) and accelerate the construction of an NGV filling station infrastructure. The project encouraged the development of natural gas, increased the proportion in the primary energy structure, and clearly defined NGVs as "first class" gas project. By the end of 2010, a total of 450 NGV models (including chassis) were listed on the national motor vehicle announcement; the annual sales number reached 60 thousand, including buses, passenger cars, trucks, special municipal cars, and other types. The number of NGV manufacturers also increased to more than 60. The numbers of NGVs in the top 10 demonstration cities are given in Table 2.

Table 2 Numbers of NGVs in Top 10 Demonstration Cities

City	Type			Subtotal
	Taxi	Bus	Other	
Sichuan	33,000	29,000	190,000	252,000
Xi'an	17,098	13,780	35,000	65,878
Chongqing	17,098	13,780	20,122	51,000
Urumchi	7960	3980	34,127	46,067
Tianjin	32,000	7000	0	39,000
Yinchuan	5141	1492	24,829	31,462
Guangzhou	18,000	7497	0	25,497
Shenyang	14,600	2500	1100	18,200
Ji'nan	8043	1130	7250	16,423
Changchun	9800	2300	0	12,100
Total	162,740	82,459	312,428	557,627

Outlook

"The National 12th Five-Year Science and Technology Development Plan (2011-2015)" was issued in 2011. This plan is intended to foster a strategic new rising industry, boost key technology breakthroughs, foster technology creation bases and platforms, and train creative talents.

The plan points out that science and technology can provide solutions to ensure the harmonious development of an automobile-based society. As for BEVs, the plan points out that their promotion would be fostered by research leading to breakthroughs in key parts (battery, electric motor and control, etc.), development of complete-vehicle integration technologies (hybrid, battery electric, and next-generation battery electric), and development of public platform technologies (technical standards and regulations, infrastructure, and testing and assessment technologies). The "10 cities, 1000 units" project should be continually implemented to form a batch of world-famous key parts with complete vehicle manufacturers having self-owned intellectual property rights. By 2015, the plan is to have breakthroughs in 23 key technical directions, large-scale demonstration in over 30 cities, and new-type business-model pilot implementation in over 5 cities. By that time, the EV stock will reach 1 million units, and the output value is expected to exceed 100 billion ¥.

The biomass energy section of the 12th Five-Year Development Plan states that the biomass power generation capacity will reach 13 million kW and 30 million kW by the end of 2015 and 2020, respectively, increasing by 1.36 fold and 4.45 fold from 5.5 million kW at the end of 2010. Also, by the end of the 12th Five-Year Development Plan, agriculture and forestry biomass power generation will reach 800 million kW, methane power generation will reach 200 million kW, and the waste-incineration power generation will reach 300 million kW. Furthermore, the utilization of biomass molding fuel, biomass ethanol, biodiesel fuel, and aviation biofuel will reach 10 million tons, 3.5-4 million tons, 1 million tons, and 100,000 tons, respectively.

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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 two decades. In 2010 the Danish Commission on Climate Change Policy concluded that the 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 stable energy supply. The strategy is also fully financed, taking full account of Danish competitiveness.

Policies and Legislation

The strategy presents a wide spectrum of new energy policy initiatives. These initiatives will in the short term considerably reduce fossil fuel dependence. Just in the period up to 2020, the strategy will reduce the use of fossil fuels in the energy sector by 33% compared with 2009. In addition, the strategy will increase the share of renewable energy to 33% by 2020, and it will reduce primary energy consumption by 6% by 2020 compared with 2006 due to a strong focus on energy efficiency improvements.

The government's goal of making Denmark independent of fossil fuels by 2050 is based on the realization that the world is facing a new era for energy policy. The 20th century was largely driven by access to cheap and plentiful coal, oil, and gas. In the 21st century we will have to find other means of satisfying our energy needs.

Within the next 25 years, the world's total energy consumption is expected to increase by one-third. At the global level, the increasing pressure on fossil energy resources has contributed to an energy race, in which the influence and growth opportunities of regions largely depend on their access to fossil fuels, with increasing prices and uncertainty as a consequence.

The Danish government does not wish to be part of this race. The government's resolve is only strengthened by the fact that much of the world's fossil energy reserves are concentrated in just a few, often politically unstable, countries. This combination can have negative consequences, with increased dependence on producing countries. Therefore, the transition to green energy is also a foreign policy requirement.

In addition to addressing the challenges in a new era of energy policy, Energy Strategy 2050 is Denmark's contribution to curbing global warming. The international community has committed to drastic reductions in greenhouse gas emissions at international climate change conferences in Copenhagen and Cancún. The world – and Denmark – can only do this by becoming less dependent on fossil fuels.

Finally, the strategy will bolster Danish growth and wealth. The transition will strengthen companies' opportunities for innovation and demonstration of new green solutions. This will improve the opportunities of Danish companies in a rapidly growing global market for energy solutions.
The transition to fossil fuel independence is a huge task that will fundamentally change Danish society. Fortunately, Denmark can draw on many years of solid experience. Denmark has a successful track record of securing economic growth without energy consumption growth. Since 1980, the Danish economy has grown by 78%, while energy consumption has remained more or less constant, and greenhouse gas emissions have been reduced.

Implementation

It is important to emphasize that the Danish transition cannot be realized in isolation, independent of the world around us. Denmark is not an island – not geographically and not in the field of energy policy. We need other countries – and our European neighbors in particular – to move in the same direction. Therefore, the Danish government will continue to work for ambitious global reduction targets. The government will strive for a European Union (EU) commitment of 30% carbon emission reductions by 2020. Furthermore, the Danish government is committed to working against green protectionism.

The Danish government's strategy ensures a responsible transition to a new era of energy policy. A transition that safeguards affordable, stable energy supply, is fiscally responsible, supports the growth potential of Danish companies, and protects the leeway in our foreign policy.

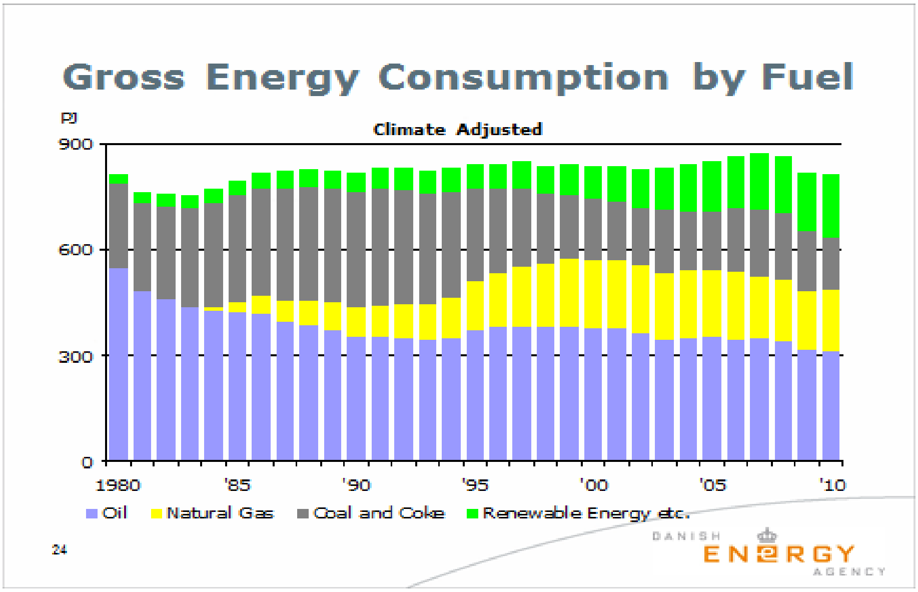

Fig. 1 Gross Energy Consumption in Denmark by Fuel Type

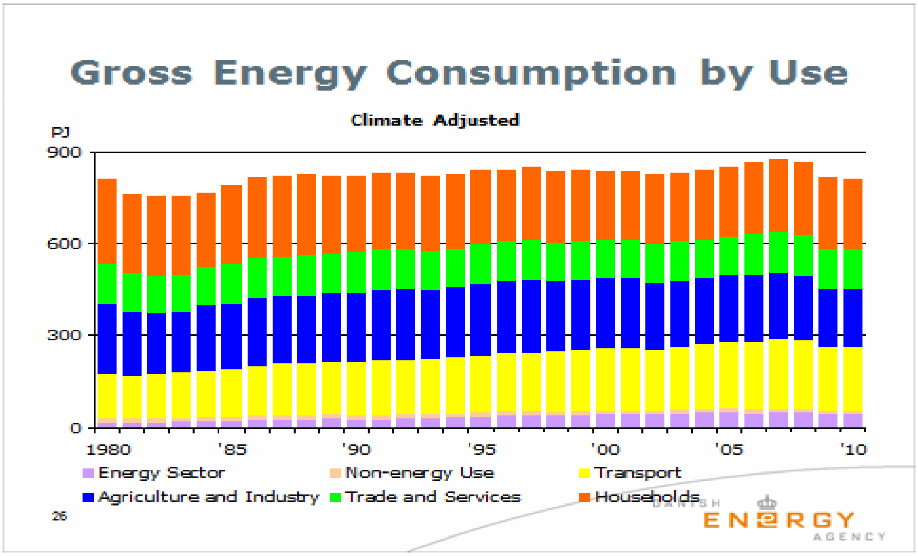

Fig. 2 Gross Energy Consumption in Denmark by Fuel Use

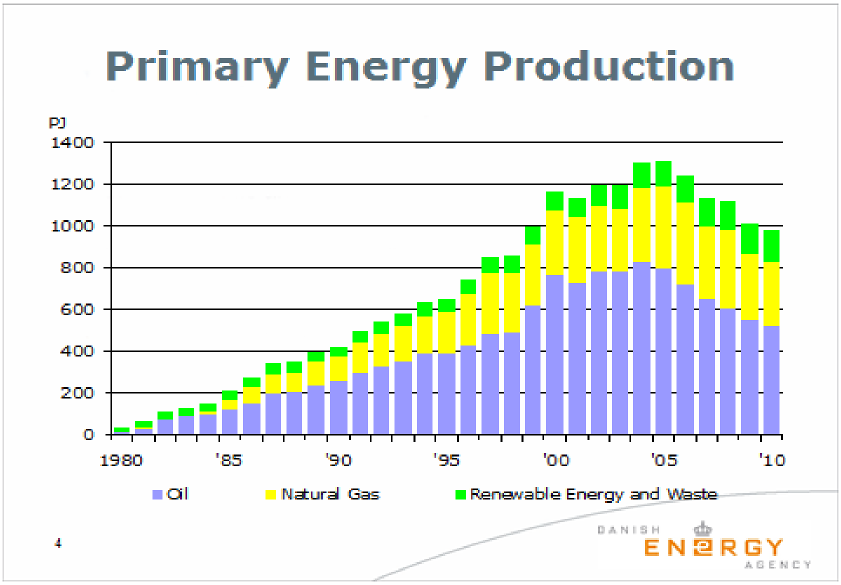

Fig. 3 Energy Production in Denmark by Fuel Type

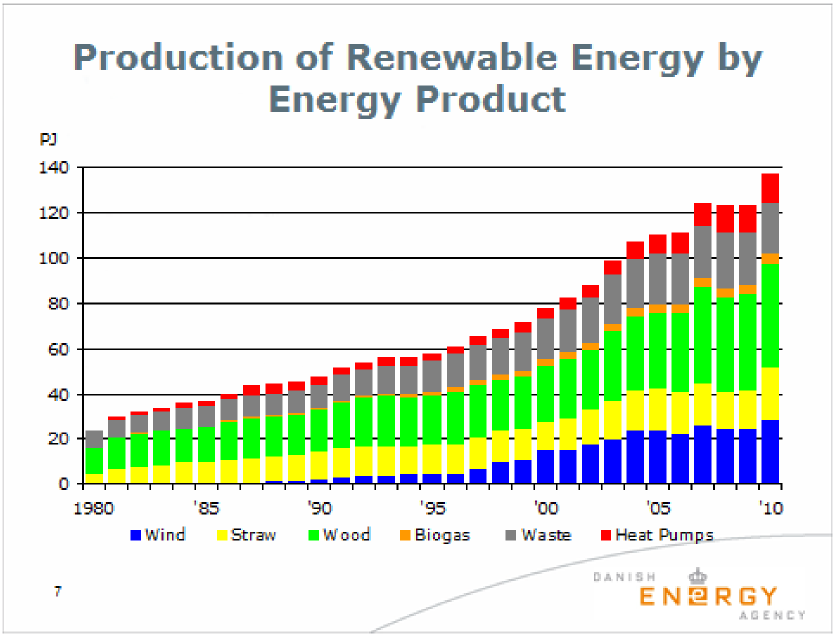

Fig. 4 Production of Renewable Energy in Denmark by Fuel Type

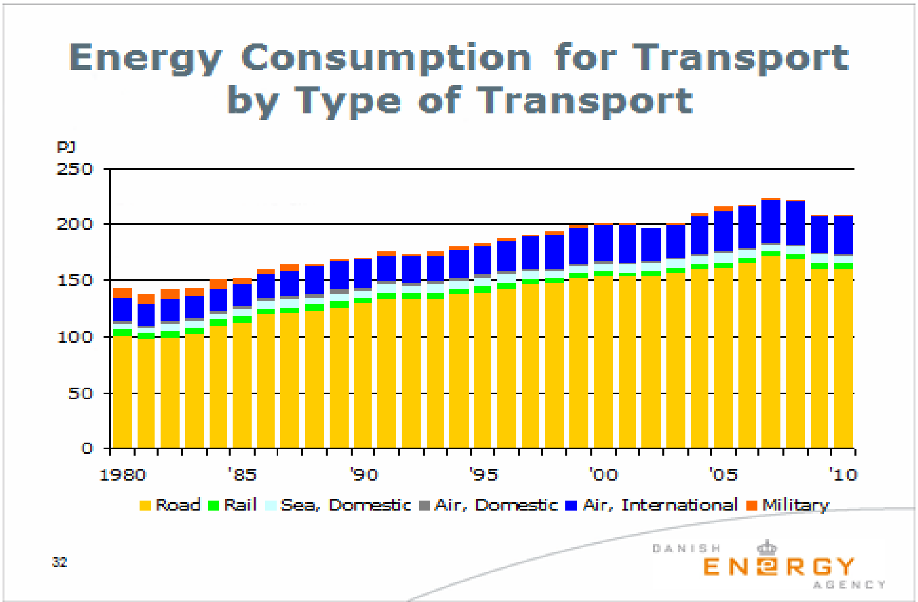

Fig. 5 Energy Consumption in Denmark by Type of Transportation

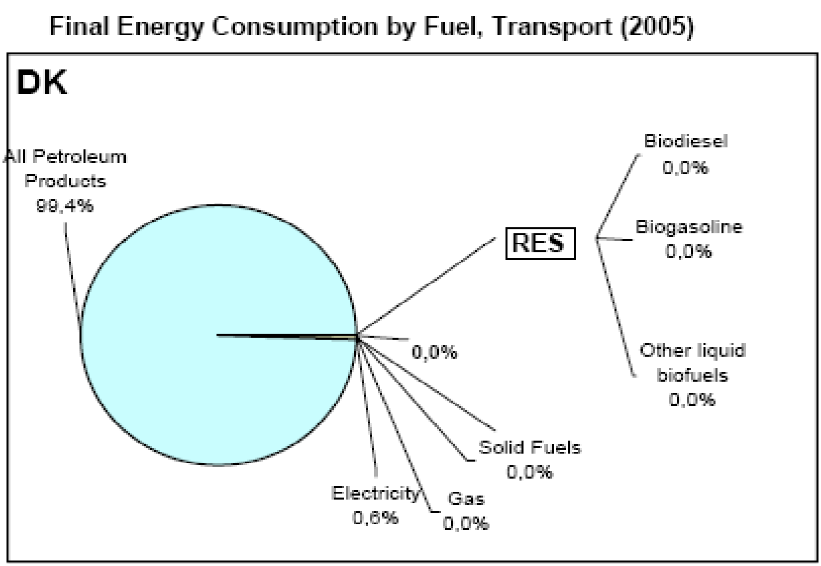

Fig. 6 Energy Consumption in Denmark by Fuel Type for Transportation

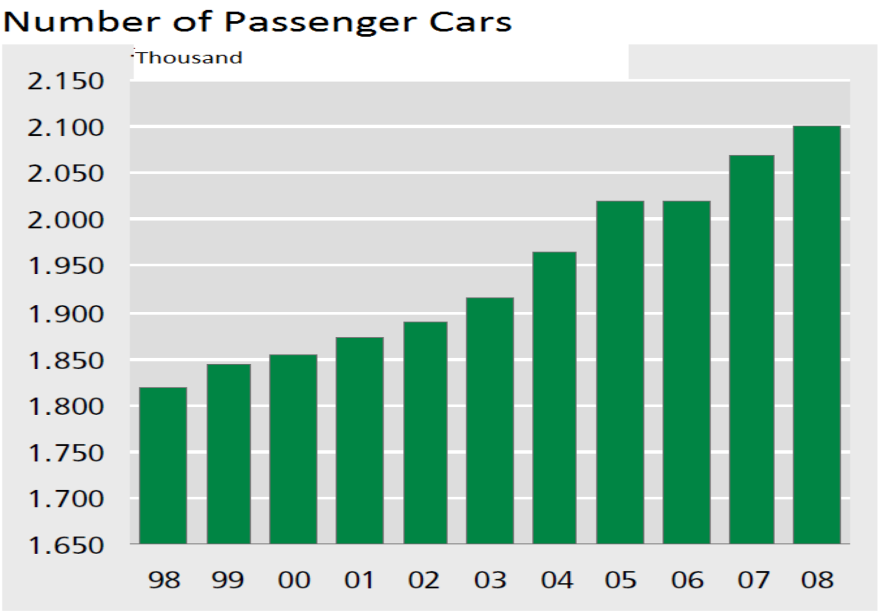

Fig. 7 Number of Passenger Cars in Denmark

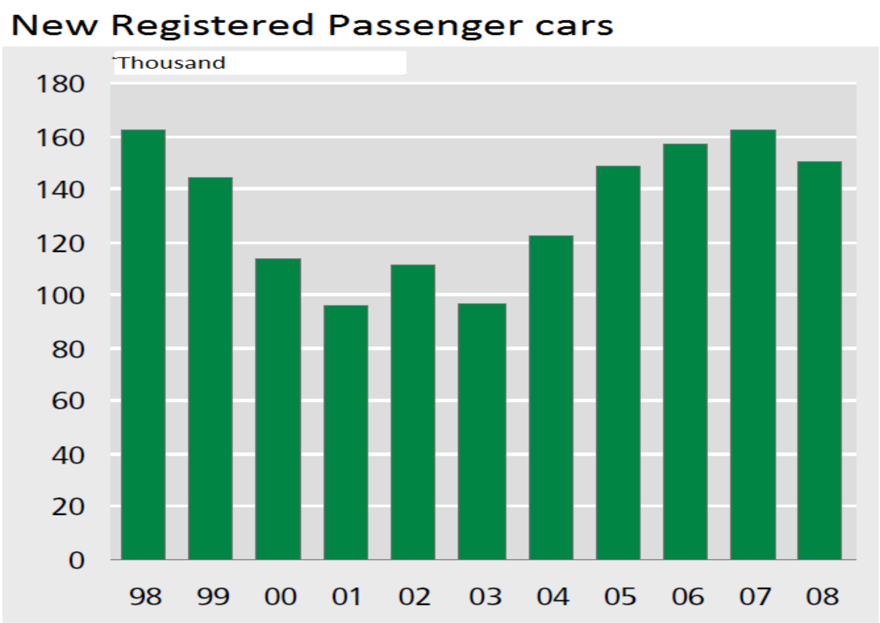

Fig. 8 Number of New Passenger Cars in Denmark

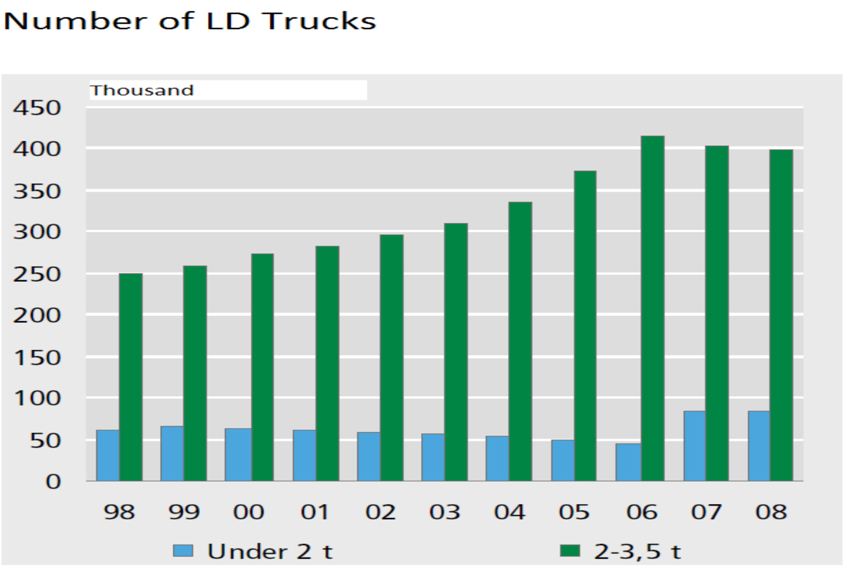

Fig. 9 Number of Heavy-Duty Trucks of Different Sizes in Denmark, 1998–2008

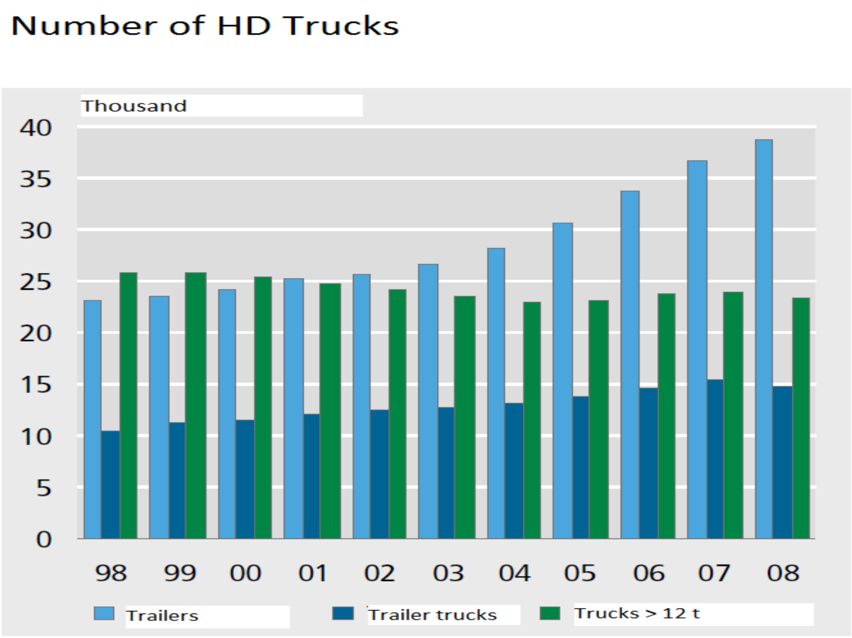

Fig. 10 Number of Heavy-Duty Trucks of Different Types in Denmark, 1998–2008

Outlook

- **Targets in the government's work plan:**
  - Denmark is to be a green and sustainable society.
  - Denmark is to be among the three countries in the world to raise its renewable energy share most by 2020.
  - Denmark is to be among the three most energy efficient countries in the Organisation for Economic Co-operation and Development (OECD) by 2020.

- **Danish targets arising from the EU climate and energy package:**
  - The share of renewable energy will be increased to 30% of final energy consumption by 2020 as part of an overall EU target of 20% renewable energy by 2020.
  - The share of renewable energy in the transport sector will be 10% by 2020.
  - Emissions in the sectors that are not part of the emissions trading scheme (ETS) will be reduced gradually in 2013-2020, reaching 20% by 2020 relative to 2005 as part of an overall EU target to reduce emissions by 20% by 2020 relative to 1990.

- **Targets in the national energy agreement for the period 2008-2011:**
  - In 2020, primary energy consumption will be 4% less than in 2006.

- **Danish objectives for EU climate and energy policy:**
  - The government is working for an EU commitment to reduce overall emissions of greenhouse gases by 30% by 2020 relative to the 1990 level.

- **Transport initiatives in the strategy:**
  - Initiate efforts to reach a 10% biofuels obligation in the transport sector by 2020.
  - Initiate technology assessment to support the right framework conditions for new transportation technologies.
  - Create fund to promote the establishment of recharging stations for electric cars.
  - Continue efforts to tighten EU standards on vehicle energy efficiency and CO_2 emissions.
  - Push for EU harmonization and standardization of technologies for electric cars.

Finland

Introduction

The primary energy consumption in Finland was 1460 PJ (~35 Mtoe) in 2010. The energy mix is well balanced, including contributions from oil, coal, nuclear energy, and hydropower (Figure 1). The share of renewable energy is exceptionally high, a total of 27% in 2010. Wood fuels represented nearly 80% of renewable energy. 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 the heating of small houses. Directive 2009/28/EC sets a target of 20% usage for renewable energy in the EU by 2020. A national target of 38% is set for Finland.

Finland is a sparsely populated country with long distances. Transportation work per capita, both for people and goods, is among the highest in the world. Transportation consumed about 18% of total final energy in 2010 (Figure 2, lipasto.vtt.fi, Statistics Finland).

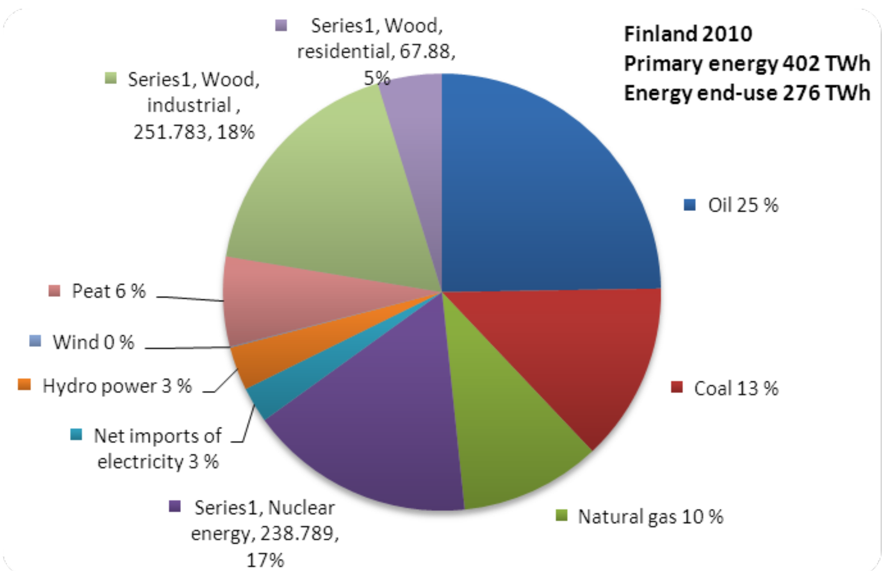

Fig. 1 Energy Consumption in Finland in 2010 (Source: Fig. by Aakko-Saksa; data by Statistics Finland, www.stat.fi)

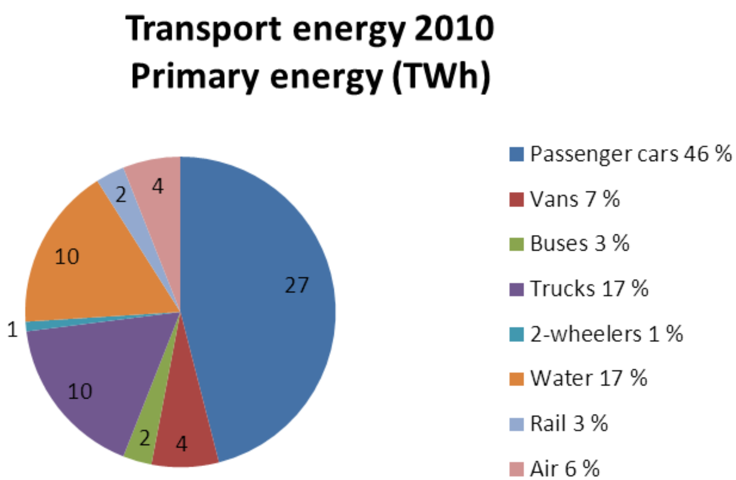

Fig. 2 Energy End-Use in Transport Sectors in 2010 in Finland (Source: Fig. by Aakko-Saksa; data by lipasto.vtt.fi, Statistics Finland)

Table 1 presents the vehicle population in 2011. The total number of vehicles was approximately 2.96 million in 2011. High concentration ethanol fuel (E85) and flexible fuel vehicles (FFVs) were introduced to the Finnish market in 2009. The number of FFVs at the end of 2011 was more than 1500 units.[3] There are around 30 refueling stations for E85 fuel.

The dominating fuels are petrol and diesel with consumption of approximately 4.0 Mt and a 40/60 gasoline/diesel share in 2011. In total, alternative fuels consumed 209 ktoe in 2010/2011 (non-road excluded). For work machinery, it is allowed to use fuel oil with low taxation. Table 2 presents the use of road transportation fuels in Finland.

3 FFV classification was not systematically registered for the Euro 4 car models.

Table 1 The Vehicle Population in Finland in 2011 (Vehicles in Use, www.trafi.fi).

Passenger cars[a]	Vans	Trucks	Buses	2-wheelers	Other vehicles	Non-road
2,958,568	361,499	122,673	14,185	512,427	13,313	584,045
Passenger cars/1000 inhabitants						550

[a] *Share of diesel vehicles, ~19 %; more than 1500 FFVs1[4]; ~800 natural gas vehicles (~100 buses and ~700 cars and vans). Source: vehicles in use, www.trafi.fi.*

Table 2 The Use of Road Transportation Fuels in Finland[c]

Petrol[a] 2011 (Mton)	Diesel[b] 2011 (Mton)	Bioethanol[a] 2010 (Mtoe)	Bioethers/ biocontent[a] 2010 (Mtoe/Mtoe)	Biodiesel[b] (w/o non-road) 2010 (Mtoe)	Natural gas 2011 (Mtoe)	Bio-methane 2010 (Mtoe)
1.6	2.3	0.038	0.103/0.034	0.063	0.005	0.000058

[a] *95 octane petrol (0.78 Mton) incl. max. 10% ethanol; 98 octane petrol (0.84 Mton), max. 5% ethanol. E85 ~30 filling stations.*
[b] *Diesel contains mainly HVO as bio-component. Non-road biofuels not included.*
[c] *Sources: Petrol, diesel: Finnish Oil and Gas Association; Biofuels: Finnish Customs, Biofuels Barometer 2011; Natural gas (6Mm3): Suomen Kaasuyhdistys ry, Biomethane: Biofuels Barometer 2011.*

Policies and Legislation

Finland has no incentives for use of biofuels in transport. However, as of January 1, 2008, a national law has required fuel distributors to provide biofuels to the market (Law 446/2007). A mandate was deemed more cost effective than implementation of a system based on incentives. The obligation is flexible (for regions, season, concentrations, etc.), and the fuel distributors can decide how they best meet the targets. Distributors may transfer all or part of their obligation to another company. The national targets were 2% in 2008, and 4% in 2009 and in 2010 (5.75 % in 2010 according to Directive 2003/30/EC). In 2010, preliminary information indicated approximately 135 ktoe consumption of road biofuels, and approximately 160 ktoe with non-road biofuels (Table 2). These values are close to the biofuel target of 4%.

[4] FFV classification was not systematically registered for the Euro 4 car models.

The biofuels obligation law was amended in December 2010 (1420/2010). The new scheme is very progressive: 6% for 2011 – 2014, and then a linear increase from 8% in 2015 to 20% in 2020 (values as share of energy). The preamble states that the 20% obligation in 2020 will predominantly be met by fuels eligible for double counting according to the Directive 2009/28/EC, thus reducing the actual share to 15% (10% traditional biofuels and 5% double-counted fuels). In 2020, 20% biofuels would mean about 730 ktoe of biofuels, or 365 ktoe when using "double counted" biofuels, such as waste and residue-based biofuels. It is estimated that "double-counted" biofuels could be produced in Finland from wood residues in 2-3 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 greenhouse gas emissions by 2020, and states that the most efficient measure to cut greenhouse gas emissions is the renewal of the passenger car fleet with fuel efficient vehicles. The target in Finland is to achieve average CO_2 emissions of 143 g/km for all cars and 95 g/km for new cars by 2020. The Government presented its long term (2050) energy and climate policy in 2009. This calls for improvements in energy efficiency, greater use of biofuels, and electrification of transport. The target for the average fossil CO_2 emissions of the passenger car fleet is set at 20–30 g/km for 2050.

Taxes

In Finland, incentives have not been used to promote alternative fuels. A fuel tax reform came into force on January 1, 2011, and it is being fully implemented in 2012 and in 2013. This new taxation system takes into account volumetric heat value, carbon dioxide emissions, and local emissions, such as nitrogen oxides and particulate matter. Compensations are made for the low volumetric heating value of biofuels, such as ethanol. Biofuels are exempted from the carbon component tax, depending on their ability to reduce well-to-wheel greenhouse gas emissions. A bonus for low local emissions is given for paraffinic diesel fuel and methane. Natural gas was almost totally tax exempted before tax reform.

As of April 1, 2012, a new purchase tax based on tailpipe CO_2 emissions was introduced for passenger cars and vans. The minimum tax is 5% (0 g CO_2/km), and the maximum is 50% (360 g CO_2/km or more). Also the annual vehicle tax is linked to CO_2 emissions, the new range being 43–606 €/a (CO_2 0-400 g/km)[5]. The CO_2-based purchase tax has been an effective instrument in reducing the CO_2 emissions of new passenger cars:

[5] As of June 6, 2012, 1 EUR = 1.2499 USD

the average value dropped from 180 g/km in 2007 to below 145 g/km in 2011.

Tax exemptions have been granted for demonstration projects on biofuels. This is the case for the bus fleet demonstration with hydrotreated vegetable oil used as diesel fuel (NExBTL).

Research Programs

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

The TransEco research program, spanning 2009–2013, focuses on energy efficiency and renewable energy in the road transport sector (www.transco.fi). The activities encompass research and development, demonstrations, and commercialization of the results as well as policy support. This program is coordinated by VTT Technical Research Centre of Finland. The majority of the funding comes from Tekes, 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 funding. Neste Oil and St1 are working 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.

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

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

Implementation: Use of Advanced Motor Fuels

Hydrotreated Oils and Fats

Hydrotreated oils and fats, HVO, are dominating the biocomponent industry in Finland. Neste Oil's proprietary NExBTL[6] technology is a refinery-based hydrotreatment process using, e.g., vegetable oils and animal fats, as a raw material. Neste Oil's NExBTL production capacity in total is close to 2 Mton (~380 kton/a in Finland, and ~800 kton/a in Singapore and Rotterdam each). Production of NExBTL is mainly based on palm oil, but also rape seed oil and animal fats are used. Non-food feedstocks could be used in the future.

Neste Oil is marketing diesel with 10-20% NExBTL under the name Green Diesel in southern Finland. A demonstration project using NExBTL in some 300 buses in the Helsinki metropolitan area started in 2007. Test fuels are a 30% blend of NExBTL and neat (100 %) NExBTL. Neat NExBTL can reduce NO_x emissions by 10% and particulates by 30% when compared to conventional diesel fuel. The fuel used in demonstration projects is released from the fuel tax, which means a tax incentive of 7.2 million €. A final report is available at http://www.vtt.fi/inf/pdf/tiedotteet/2011/T2604.pdf .

FAME

Some fuel distributors are blending in conventional esterified biodiesel (FAME). Rapeseed methyl ester (RME) has been produced in small scale, mainly on farms. In 2005, production was approximately 1000 tons.

Bioethers

Neste Oil has processed ethyl tertiary butyl ether (ETBE) since 2004. In 2010, 103 ktoe bioethers, mainly ETBE and tertiary amyl ethyl ether (TAEE), were blended in petrol in Finland. The bioenergy portion of these bioethers represented 34 ktoe. The ethanol contained in ETBE is imported, and the end-product is mixed with petrol for export.

Bioalcohols

E10 petrol (petrol containing 10 vol% ethanol) was launched in the beginning of 2011 in Finland. However, sales of E10 petrol represented only 48% of petrol sales, even though some 70% of the Finnish petrol car population is E10 compatible. This difference was due to lack of consumer's

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

acceptance of E10 petrol. The energy company St1 is also selling a high concentration ethanol, Refuel RE85, at some 30 refueling stations in Finland. The hydrocarbon part of the RE85 is a special mix targeted to operate well at low ambient temperature. FFV cars were introduced to the Finnish market in spring 2009, at the same time when St1 launched its RE85 ethanol fuel on the market. At the moment, more than 1500 FFVs are running in Finland.[7]

The energy company St1 is focusing on de-centralized production of fuel ethanol from side streams in the food industry with 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 is also importing hydrous ethanol and dehydrating it for blending into petrol. St1 also has invested in a centralized dehydration facility in Hamina with a capacity of 88,000 m^3/a (~45 ktoe). Currently, seven decentralized ethanol units are running with a production capacity of 750-2000 t/a per unit. The total production of bioethanol with Etanolix units in Finland is 7 ktoe. The major part of the 38 ktoe bioethanol portion consumed in Finland is imported.

Within the TransEco development program, St1 with VTT Technical Research Centre of Finland will develop optimized high-blend bioethanol designed to replace fossil petrol for Finnish conditions, thereby minimizing the environmental impact of its use (www.transeco.fi). A demonstration project on ethanol use in heavy-duty diesel vehicles is ongoing.

Natural Gas and Biomethane

The first natural gas buses were introduced in 1996 in Helsinki. Currently, around 800 vehicles, consisting of some 100 natural gas buses, 10 heavy-duty vehicles, and some 700 cars and vans are running on natural gas in Finland. There are sixteen public natural gas refueling stations, and construction of new stations is continuing. Gasum Oy, the national gas company, is marketing, selling, and servicing a home refueling appliance made by FuelMaker Corp. Natural gas is imported to Finland from Russia.

In 2011 injection of biomethane into the natural gas transmission network was started in Finland by Gasum. Biogas is manufactured at the Kymen Bioenergia Oy biogas facility in Kouvola, and upgraded by KSS Energia Oy. At this facility 19,000 tonnes of wastewater sludge, biowaste, and biomass will produce around 15 GWh of biogas energy for electricity, heat, and digestion residue to make agricultural fertilizer and biomethane for use

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

in vehicles. Biomethane, approximately 7 GWh, is sold at Gasum's filling stations in southern and south-eastern Finland.

Liquefied Petroleum Gas (LPG)

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

Electric and Hybrid Vehicles

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

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

The Finnish car manufacturer Valmet Automotive, earlier assembling Porsche sports cars, has announced a strategy for EVs. Already in 2009, Valmet Automotive 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 manufacturing large automotive lithium-ion batteries in Europe. A new production facility has been built in the city of Varkaus, and production started in the autumn of 2010. To begin with the production capacity will be 500,000 battery cells per annum.

The Research program of Tekes called EVE is dedicated to electric vehicles (http://www.tekes.fi/programmes/EVE). Within the next four years a test bed of estimated 400 electric vehicles and 850 charging points will be created in Helsinki, Espoo, Kauniainen, Lahti, and Vantaa (http://sahkoinenliikenne.fi/). The first Finnish demonstration with fully electric buses will start in Espoo in 2012.

Hydrogen

In Finland, there are no significant activities on hydrogen at the moment. 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. Production capacity of Neste Oil's NExBTL (HVO) is in total already close to 2 Mt/a (Finland, Singapore, and Rotterdam).

The Finnish forest company, UPM, has announced investment in a biorefinery producing biofuels from crude tall oil by hydrotreatment in Lappeenranta. The biorefinery will produce annually approximately 100 kton/a of advanced hydrotreated biodiesel for transport. Construction of the biorefinery will begin in the summer of 2012, and will be completed in 2014.

In the long-term plans, cellulosic BTL is expected to cover a significant share of the diesel pool in Finland. Three applications for NER300 funding to the European Commission were submitted in 2011 by the three consortia, led by UPM-Kymmene Oyj, NSE Biofuels Oy Ltd., and Forest Btl Oy. Three large-scale production units of renewable biofuels from wood biomasses via synthesis gas route are planned, each around 100,000–200,000 ton/a. NSE Biofuels Oy demonstrated its technology at the Stora Enso Varkaus Mill. The pilot plant was commissioned in 2008.

Ethanol production from the side streams in the food industry by St1 in Finland is increasing from the current 7 ktoe. In addition, St1 is broadening the feedstock to separately collect biowaste (utilized already in Hämeenlinna), municipal solid waste, and later on straw and paper. The target for 2014 is 150 ktoe bioethanol (300,000 m^3). St1 also plans to enlarge the Refuel RE85 distribution chain in Finland.

There is increasing interest in biomethane for transport. Biomethane is currently injected into the natural gas grid. Gasum and the Helsinki Region Environmental Services Authority (HSY) will cooperate to produce biomethane for use as a public transport fuel. In 2012 up to 50 local buses will have access to biomethane produced locally from wastewater by the Suomenoja wastewater treatment plant. Biogas will be upgraded to biomethane and fed into the gas network. The new upgraded facility is planned to produce 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. Gasum also has other biomethane-related projects, including plans to produce wood-based synthetic natural gas. In total, production of biogas could be around 150 ktoe in 2016. There are some plans to increase LNG production, which is, however, not targeted for road transport use.

Benefits of Participation in the IEA-AMF

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

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

France

(Prepared by ADEME [Agence de l'Environnement et de la Maîtrise de l'Energie])

Introduction

Incentives to Promote Use of Renewable Energy in Transport

Under the "National Action Plan for Renewable Energy,"[8] following the "Grenelle de l'environnement," France has introduced a number of incentives to promote the use of energy generated from renewable resources in the transportation sector. These incentives are described briefly below.

- The objectives for biofuel blends include an incorporation rate of 7% by volume in 2010 (the European objective is 5.75%) and 10% in 2013. To meet these objectives, France has taken the following actions:
  - On April 1, 2009, France launched a new **SP95-E10** product in the gasoline sector that corresponds to an incorporation rate of 10% ethanol in gasoline. This product has been approved for sale in service stations since 2009, but it will be the standard from 2013 onwards. The deployment of E10 was progressive, with sales of 1.55 million cubic meters (m^3) in 2010 (0.7 in 2009), for global gasoline sales of 10.9 millions m^3. In mid-June 2011, fewer than 300 service stations (25% of the French network) sold E10; today, about 1,300 stations are equipped to sell the blended fuel.
  - France authorized the use of fuels containing high levels of biofuels, including **E85** in the gasoline sector and **B30** in diesel fuel production. Deployment of E85 has been low, despite fiscal incentives, because marketing of flex-fuel vehicles has been removed from the bonus/malus (i.e., reward/penalty) system, and the number of stations that offer E85 is limited. However, because sales of E85 fuel are recorded in sales of biofuels, they are crucial to achieve the target of 10% by 2013.
  - The maximum rate of incorporation for biodiesel and ethanol provided by the texts on fuel quality in volume amounted to 7% and 10%, respectively.
- France has implemented fiscal incentive schemes, such as those described below, to encourage the use of biofuels.
  - A general tax on polluting activities (taxe générale sur les activités polluantes [**TGAP**]) has been promulgated to advance biofuel objectives. The TGAP must be paid by operators-distributors

[8] The European Union's Directive 2009/28/EC, dated April 23, 2009, requires member states to implement a "National Action Plan for Renewable Energy," which establishes objectives in terms of "renewable energy mix" in 2020 and annual trajectories by energy (e.g., biomass, hydro, wind, solar).

(e.g., refiners, supermarkets, and independent) that sell fuel containing a lower proportion of biofuels than the national goals of incorporation. The TGAP rate increased from 1.75% in 2006, to 3.5% in 2007, 5.75% in 2008, and 6.25% in 2009. It is set at 7% in 2010, and it remains unchanged for 2012.

  - A domestic tax on consumption (taxe intérieure sur la consommation [**TIC**]) aims to reduce the extra cost of manufacturing biofuels compared with fossil fuels. The TIC offers a partial exemption for biodiesel and bioethanol and a total exemption for pure vegetable oil used as fuel for agriculture and fishing. The 2010 and 2011 financial laws establish a progressive reduction of the tax exemption for biofuels: the 2009 tax exemption rates — 21 €/hl[9] for the bioethanol and 15 €/hl for the biodiesel industry — decreased to 18 €/hl and 11 €/hl in 2010 and 14 €/hl and 8 €/hl in 2011, respectively. Also, the tax applicable to super ethanol (E85) was reduced from 23.24 €/hl in 2009, to 20.69 €/hl in 2010, to 17.29 €/hl in 2011. This rate is being maintained for 2012 and 2013.

- Measures to encourage fleet renewal have been implemented, including the following.
  - Under a **bonus-malus system**, the objectives of which are to promote the purchase of low-consumption vehicles and reduce pollutant emissions, a premium is granted for the purchase of a new car that generates 105 g/km or less of CO_2 emissions. The maximum premium is € 5,000, granted for vehicles that emit CO_2 at 50 g/km or less. This incentive may change. For such vehicles, the amount of the incentive cannot exceed 20% of the vehicle purchase price (including value-added tax, or VAT, increased with the cost of the battery if the vehicle is rented. Hybrid vehicles emitting 110 g/km or less receive an incentive of € 2000. This system also includes a fee (penalty) charged to those who purchase a vehicle that emits more than 140 g CO_2/km. The maximum penalty is € 3,600, which applies to vehicles emitting 230 g/km or more.
    - o The bonus-malus system involves changing scales, as illustrated by the 2009 rates listed below.
      - ▪ Bonus of
        - € 5,000 for vehicles emitting less than 60 g CO_2/km
        - € 1,000 for vehicles emitting less than 100 g CO_2/km
        - € 700 for vehicles emitting between 101 and 120 g CO_2/km
        - € 200 or vehicles emitting between 121 and 130 g CO_2/km

[9] As of June 6, 2012, 1 EUR = 1.2499 USD

- Malus of
  - € 200 for vehicles emitting between 161 and 165 g CO_2/km
  - € 750 for vehicles emitting between 166 and 200 g CO_2/km
  - € 1,600 for vehicles emitting between 201 and 250 g CO_2/km
  - € 2,600 for vehicles emitting more than 250 g CO_2/km

The PLF 2010[10] accelerated the increase of the automobile penalty. According to original plans, the trigger point of the bonus/malus would be reduced by 5 g CO_2/km every 2 years starting on January 1, 2010, and the threshold for triggering the malus would be 156 g CO_2/km as of January 1, 2010, and 151 g CO_2/km as of January 1, 2012. But the PLF 2010 amended this threshold, and the scale originally planned for 2012 was applied in 2011. Thus, beginning on January 1, 2011, the tax threshold was lowered to 151 g CO_2/km. Overall, the trigger point of the penalty decreases significantly over time, from 161 g CO_2/km in 2009 to 141 g CO_2/km in 2012. The progression of the applicable scale is as follows:

- Scale 2011
  - Less than 60 g CO_2 – € 5.000 bonus
  - 61 to 90 g CO_2 – € 800 bonus
  - 91 to 110 g CO_2 – € 400 bonus
  - Hybrid vehicles emitting less than 110g CO_2 per km receive a bonus of € 2.000.
  - Neutral zone from 111 to 150g of CO_2 – € 0
  - 151 to 155 g of CO_2 – € 200 malus
  - 156 to 190 g of CO_2 – € 750 malus
  - 191 to 240 g of CO_2 – € 1.600 malus
  - Above 241 g of CO_2 – € 2.600 malus
- Scale 2012
  - Less than 50 g CO_2 – € 5.000 bonus
  - 51 to 60 g CO_2 – € 3.500 bonus
  - 61 to 90 g CO_2 – € 400 bonus
  - 91 to 105 g CO_2 – € 100 bonus
  - Hybrid vehicles emitting less than 110 g CO_2 per km receive a bonus of € 2.000.
  - Neutral zone from 106 to 140 g of CO_2 – € 0
  - 141 to 150 g of CO_2 – € 200 malus

[10] Projet de Loi de Finances

- 151 to 155 g of CO_2 – € 500 malus
- 156 to 180 g of CO_2 – € 750 malus
- 181 to 190 g of CO_2 – € 1.300 malus
- 191 to 230 g of CO_2 – € 2.300 malus
- Above 231 g of CO_2 – € 3.600 malus

- The government offers an environmental bonus for purchasing or leasing **hybrid vehicles**.

  Bonuses given for hybrid vehicles are maintained in 2012 to continue supporting the transportation sector. For the acquisition or lease of a hybrid electric/gasoline or electric/diesel in 2011 and 2012, an award is paid to any person, during the first registration for the purchase or lease (with option to purchase or long-term lease of at least 2 years) of a new vehicle that combines electricity and gasoline or diesel. The invoice for the vehicle must be dated March 13, 2013, or before.

  The amounts of the bonuses are as follows:
  - € 3,500 for vehicles emitting between 50 and 60 g of CO_2/km,
  - € 2,000 for vehicles emitting between 61 and 110 g of CO_2/km.
- The government also offers an environmental bonus for purchasing or leasing **LPG or NG vehicles**.

  Vehicles running on liquefied petroleum gas (LPG) or natural gas (NG) (as in electric hybrids) and emitting less than 135 g /km CO_2 benefit from a 2009 bonus of € 2,000. Since January 1, 2011, the government stopped the special bonus of € 2,000 for LPG vehicles and introduced these vehicles in the traditional scale. They are therefore subject to the conditions of allocation of general environmental bonus.
  - Support for the purchase of **electric vehicles** emitting less than 50 g of CO_2/km is € 5,000 in 2011 and 2012.
  - A **scrapping premium** was established in late 2008. The premium was € 1,000 in 2009, revised downward in 2010 to € 700 in the first half and € 500 from July 1 for every purchase of a vehicle emitting less than 160 g CO_2/km, against the abandonment of a vehicle over 10 years. The premium was abolished in 2011.

Market Developments

Since its establishment, the bonus/malus system has proven to be extremely effective in influencing purchasing decisions.[11] Overall, the proportion of vehicles subject to penalties has been declining, while the proportion of those receiving bonuses increased.

Analysis of 2011 figures confirms this trend. Over the full year, the share of vehicles benefiting from the bonus (those that had CO_2 emissions below 110 g) nearly doubled, to 32% of registrations. The key is still the combustion-engine vehicles (the 91–110-g bracket with € 400 bonus, representing 31% market share), thanks in part to the adjustment of supply by manufacturers to get off just below the threshold of 110 g.

Gradually during the year, sales of hybrid vehicles (61–90 g of CO_2) or electric vehicles (less than 60 g CO_2) (still supported by the bonuses of € 2,000 and € 5,000, respectively) began to be significant. Thus, registrations of vehicles with emissions below 90 g (essentially, hybrids and electric vehicles) accounted for 1.7% of the market in December compared with 0.84% for the full year.

The decline in sales of vehicles with a penalty continued in 2011, but with an exception for vehicles in the 156–190-g bracket (penalty of € 750), which increased at year end with the resumption of corporate sales. In December, we also noted registrations related to anticipation of higher penalties in 2012. Finally, vehicles subject to penalties (CO_2 emissions over 151 g) represented 11.3% of registrations in 2011 — 2 percentage points less than in 2010.

For LPG and NG vehicles, a year after the withdrawal of the bonus (€ 2000 for the purchase of an LPG or NG vehicle), these two types of vehicles virtually disappear from the market: no registrations of NG vehicles and just over 200 registrations of LPG vehicles were recorded in January, according to data on car registrations by type of energy.

In terms of reducing CO_2 emissions, the system worked: emissions were reduced on average in France from 149.2 g/km per vehicle to 127.4 g/km per vehicle between 2008 and 2011.

[11] According to data gathered by "Auto News."

R&D in Transportation Sector

Public support for innovation and research and development (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 Agence nationale de la recherché (ANR) (see Carnot device), OSEO (the French state innovation agency), or Caisse des Dépôts (French financial organization under the control of the Parliament) — participating in project financing and
- Tax exemptions for companies with a cluster involved in an R&D project financed by the government.

Public support is also exerted by the Demonstrator Fund research on new energy technologies (NET), which aims to fund research demonstrations.

Some examples of advanced biofuels research and R&D of electric vehicles and plug-in hybrids are provided below.

- **Advanced Biofuels**

  All biofuels currently used in France are produced by using processes known as "first generation." These processes target the storage organ of the plant (e.g., grain, fruits, tubers). Second-generation processes are designed to produce "sustainable" biofuels; they use the entire plant tissues of a wide range of agricultural- and forestry-related plants or the waste and residues associated with these industries. They also make use of dedicated crops and waste organics. Other processes could benefit from microalgae or microorganisms capable of producing high-percentage biomass or oil converted into biodiesel; such processes offer improved energy and environmental balance. In France, benefits related to the development of biofuel industrial sectors are considerable. They include reduction of greenhouse gas (GHG) emissions during transport, limiting our energy dependence, creating new economic activities.

  Projects in France that are aimed at removing a number of scientific and technical hurdles are summarized below.

  - Futurol is a lignocellulosic ethanol produced by using a thermochemical process. In the Futurol project, we are seeking to develop and market processes and technologies for producing second-generation bioethanol, not only from dedicated energy crops, but also agricultural and forestry by-products, green waste, and other lignocelluloses-containing biomass. Funding (€ 7.6 million) comes from OSEO. The 8-year project timeline is centered on the implementation of a laboratory-scale pilot and then an industrial pilot, in parallel with the ongoing R&D work.

- BioTfuel involves biodiesel production by means of a thermochemical process. The process comprises 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 Demonstrators Fund "biofuels 2nd generation" — which is supported by ADEME and the Regional Council of Picardy — BioTfuel brings together R&D organizations (IFP Energies nouvelles and CEA) and industrial partners (Axens Sofiprotéol, Total and Uhde) to create a complete, integrated chain of production for kerosene and synthetic diesel BtL (Biomass to Liquid). The project should result in the development, by 2017, of an integrated, competitive, and sustainable process that can be used with other biomass resources such as petroleum or coal residues. The cost for the project is € 112.7 million, including € 33.2 million in public funding (ADEME Demonstrator Fund and region Picardie).
- The Gaya project is aimed at producing bio synthetic natural gas (bioSNG) by using a thermochemical process. This research demonstrator, selected under the Demonstrator Fund "second-generation biofuels," explores the full chain of bioSNG production via a thermochemical process (bio methane fuel by gasification followed by a methanation step). The project, scheduled to last 7 years, began in June 2010. It brings together 14 partners. Public support amounts to $18.9 million. The GDF SUEZ group will coordinate this project, which will involve subject matter experts and public research organizations.
- The Salinalgue project targets seaweed growth and processing. The objective is to structure a sustainable business culture and process for microalgae by controlling the growth and harvesting of microalgae that are highly recoverable on a massive scale in an open environment on untapped salts. In addition, the project integrates bio refinery activities in order to manufacture and commercialize bio products (biodiesel, biogas, and molecules with high added value, such as beta-carotene, omega 3, etc.) and protein for aquaculture. A demonstrator will validate the pre-industrial technical and economic feasibility of the production chain. The project is funded by the FUI (Single Interdepartemental Fund) and labelled by the Trimatec, Mer PACA, Derbi, and Capénergies clusters.

- **Electric Vehicles and Plug-in Hybrids**
  Vehicle electrification has great potential to reduce fuel consumption, limit the impact on the environment, and diversify energy sources. France is involved in many projects to eliminate the existing technical barriers; some examples are provided below.
  - The HyHIL (hybrid hardware-in-the-loop) project is part of overall research on hybrid vehicles. It is aimed at developing 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. This project is supported by the FUI and the Mov'eo competitiveness cluster. Partners include IFP New energies, D2T, the Electrical Engineering Laboratory of Grenoble, LMS, and Renault. The overall budget is € 2.2 million, of which € 0.9 million is public funding.
  - The objective of the SYNERGY project is to simultaneously reduce CO_2 emissions and pollutant emissions from diesel vehicles. IFP Energies nouvelles, Renault, Faurecia, Valeo, Delphi, Ecole Centrale Nantes, Mechadyne, and Honeywell are associated with this project. The project is approved by the competitiveness clusters Mov'eo and Vehicles of the Future. The overall budget is € 3.8 million, of which € 1.6 million is public funding (ANR).
  - Mov'eo and other competitiveness clusters receive public funds as LUTB (Lyon Urban Truck & Bus) in the truck sector in the Lyon region.
  - The IEED Institute project (Institutes of Excellence in Low-carbon Energies) VeDeCoM is supported by the competitiveness cluster Mov'eo and local government (Council of Yvelines). Participants work in the field of land transport and eco-mobility. The center will receive an allocation of € 54.1 million. The ANR is the public operator in charge of IEED centers.

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

Concerning the **Fund Demonstrators**, the following must be emphasized:

- VELROUE (Véhicule Utilitaire Léger hybride bi mode), a project developed by Michelin, Renault, and IFP Energies nouvelles, has arranged with a research demonstrator to test the concept of a commercial vehicle equipped with dual-mode engine wheels on the rear. The Velroue is a hybrid based on the Renault Kangoo with electric motors driving the rear wheels to give an all-electric mode for city use. This program is accredited by ADEME as part of the Grenelle Environment.
- The Hydole (HYbride à DOminante éLEctrique) project, developed by PSA, EDF, Freescale, Leroy Somer, CEA and IFP Energies, seeks to evaluate the potential of a new concept of dual-mode, plug-in hybrid electric vehicle (pure electric and hybrid)
- The TIGRE (Technologies Innovantes pour Grands Routiers Économes) project, developed by Renault Trucks, seeks to simultaneously develop innovative technologies in the following areas: kinematic chain (e.g., engine, gearbox, bridge), aerodynamics, low rolling resistance, and driving aids. These technologies will be adapted to all types of vehicles (e.g., road, urban, hybrid) to promote the growing integration of electricity.

Germany

Introduction

German fuel consumption in road transport in 2011 amounted to 2237 PJ, including biofuels. Thereof, 806 PJ was motor gasoline, and 1305 PJ was diesel. Biofuels consumption amounted to 125 PJ, with the majority as low level blends of biodiesel (87 PJ) and bioethanol (28 PJ). Other biofuel quantities were pure biodiesel (3 PJ), ETBE (6 PJ ethanol share), pure vegetable oils (0.7 PJ), and E85 (0.3 PJ).

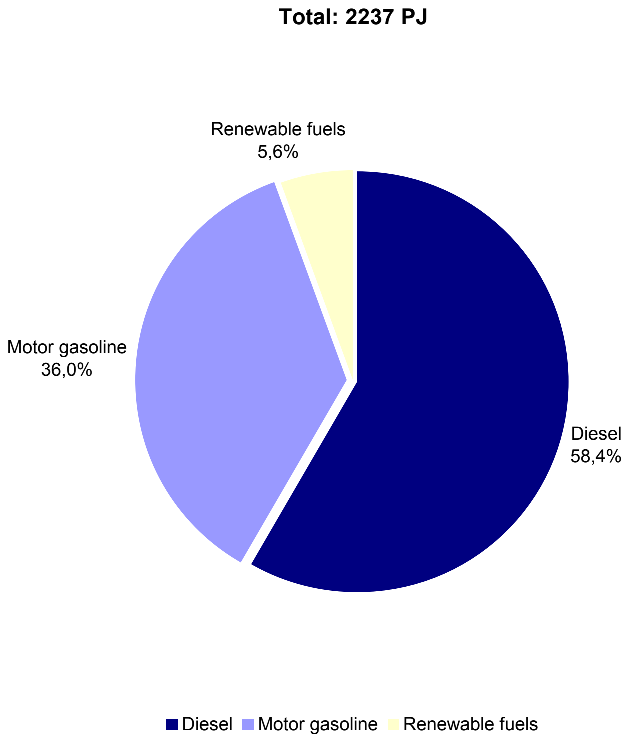

Fig. 1 Shares of On-Road Transportation Fuel in Germany, 2011

In Germany 51.7 million vehicles are registered; 83% are passenger cars. Of the 43 million passenger cars 30.5 million are petrol fueled and 12 million are diesel fueled. Additionally, some LPG, compressed natural gas (CNG), hybrid, and electric vehicles are registered. Hybrid and electric vehicles show strong increases in relative terms; their share in total vehicles is still below 1 thousandth.

Table 1 Passenger Cars in Germany by Fuel Type (Source: KBA 2012)

Year	Gasoline	Diesel	LPG	NG	Hybrid	EV
2006	35,918,697	10,091,290	40,585	30,554	1931	5971
2007	35,594,333	10,819,760	98,370	42,759	1790	11,275
2008	30,905,204	10,045,903	162,041	50,614	1436	17,307
2009	30,639,015	10,290,288	306,402	60,744	1452	22,330
2010	30,449,617	10,817,769	369,430	68,515	1588	28,862
2011	30,487,578	11,266,644	418,659	71,519	2307	37,256
2012	30,452,019	11,891,375	456,252	74,853	4541	47,642

Table 2 Vehicle Population in Germany 2011 (Source: KBA 2012)

Motorcycles	Passenger cars	Buses	Trucks	Others	Total
3,908,072	42,927,647	75,988	2,528,656	2,294,814	51,735,177

Policies and Legislation

Since 2007 firms marketing petrol and diesel are obliged to market a legally prescribed minimum percentage of such fuels in the form of biofuels. The level of this quota in relation to the energy content of the fossil fuel concerned, plus that of the biofuel replacing it, is 4.4% for diesel and 2.8% for petrol. Since 2009 there is also an overall quota for petrol and diesel combined. The overall quota was set at 5.25% for 2009 and at 6.25% for the years from 2010 to 2014. From 2015 the benchmark for biofuel quotas will be converted from the present energetic evaluation to the net greenhouse gas reduction. The net quota will increase from a rate of 3% in 2015 to 7% in 2020.

The tax rate for pure vegetable oils and pure biodiesel (B100) outside the quota is at 18.5 cents per liter. From 2013 on, these pure biofuels taxed on the same basis as diesel fuel. Tax relief still exists for biofuels used in agriculture, for bioethanol (E85, lignocellulosic), for synthetic fuels, and for biomethane.

The sustainability criteria for biofuels agreed at the European level under the Renewable Energy Directive (RED) and the Fuel Directive were transposed into national law in 2009. Transitional periods applied until the end of 2010, so that the sustainability criteria have become applicable as of 2011.

In 2011, the German Government launched the 36th Federal Immission Control Ordinance (36. BImSchV), which allows “double counting” of particular biofuels in accordance with article 21(2) of the RED.

In addition to ensuring an appropriate, consistent tax and regulatory business environment, research and development must be promoted across the various biofuel sectors to create conditions conducive to boosting the use of biofuels. In view of this, the Federal Government supports inter alia projects for the further development of existing, and the development of new, biofuel technologies. These technologies include the provision of raw materials (breeding, cultivation, and logistics), biomass conversion, quality assurance, and the use of biofuel in vehicles (emissions, material compatibility, etc.).

Under the “Renewable Resources” funding scheme of the Federal Ministry for Food, Agriculture and Consumer Protection (BMELV), 63 ongoing R&D projects relating to biofuels are receiving a total funding of approximately € 34 million[12] at the date of this report. The aid is granted through the Ministry's project promoter, the Renewable Resources Agency (Fachagentur Nachwachsende Rohstoffe e.V.). In the 2011 fiscal year, R&D support was focused on BTL fuels. Yet, growing market relevance and the requirements with regard to sustainability also led to increased funding of R&D projects on other biofuels introduced on the market. For vegetable oil, which due to its characteristics is likely to remain a niche fuel, particular priorities include adapting engine concepts (TIER 4) to running on vegetable oil. With the release of the national rapeseed oil fuel standard in 2011, and the resulting more stringent limit values, decentralized producers will face new challenges, in view of which intensive R&D aid has been made available. An equivalence clause in the Fuel Quality Regulation ensures the marketing on equal conditions of equivalent fuels from other Member States.

Biodiesel projects receiving support were aimed at evaluating the engine performance and the emissions of diesel and biodiesel mixtures. Further research projects related to biodiesel are in the pipeline. With respect to bioethanol, the emphasis has been on regional concepts for its production and exploitation as a fuel, with particular focus on boosting the efficiency of bioethanol production in distilleries. Further projects aimed at enhancing the efficiency of bioethanol manufacturing methods have been conducted in 2011.

[12] As of June 6, 2012, 1 EUR = 1.2499 USD

With regard to liquid energy sources, project support was focused on BTL fuels, which have not yet been introduced on the market but are considered a promising option due to their broad raw materials base and chemical composition. BTL fuels are liquid synthetic bioenergy sources, which can be obtained from agricultural and forestry biomass through thermo-chemical gasification. In the 2011 fiscal year, aid was granted mainly to stages 3 and 4 of the "bioliq process" of the Karlsruhe Institute of Technology. First BTL production is scheduled for mid 2012.

The Renewable Resources Agency also supports the implementation of the certification system, International Sustainability and Carbon Certification (ISCC), for sustainable biofuels and liquid biomass used in electricity generation. Further research is needed, especially into suitable methods of recording and, where possible, minimizing the impact on food security of the cultivation of biomass for biofuels, in particular, in developing countries, and on global biodiversity, especially in highly biodiverse areas such as tropical rainforests or species-rich grasslands. Against this background, BMELV published a new funding priority on the sustainability aspects of biofuels.

Implementation: Use of Advanced Motor Fuels

In 2011, 3.7 million new passenger cars were registered in Germany, with 57 % petrol cars and 42 % diesel cars. Other fuels (LPG, NPG, electricity, hybrid) counted for ca. 1 % of total registrations. More than half of these cars were commercially registered.

Incentives for advanced motor fuels are full detaxation for specific biofuels (BTL, ethanol from lignocellulosics, biomethane, E85, etc.) until the end of 2015 and a partial detaxation for natural gas as transport fuel until 2018. The switch in the biofuels quota legislation in 2015 from quantitative shares to greenhouse gas reduction quotas (7% from 2020 on) will provide further impetus for advanced biofuels.

The German government set an ambitious target to introduce 1 million electric vehicles on the German market by 2020. To reach the target, the government is providing 1 billion € of support for R&D. According to the National E-Mobility Roadmap, research and development is focused on energy storage, automotive engineering, infrastructure, and system integration. German industry is deeply involved in the e-mobility activities, e.g., as a part of the German E-Mobility Platform.

Outlook

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

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

Additional References

- Biokraftstoffe, www.bio-kraftstoffe.info.
- Kraftfahrt-Bundesamt, http://www.kba.de.
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Benefits of Participation in the IEA-AMF

Due to changing framework conditions, advanced motor fuels will become more and more important in the short term. Fachagentur Nachwachsende Rohstoffe, 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 IEA-AMF umbrella are relevant to our funding activities, and the common project sponsoring offers cost efficient participation. Furthermore, the participation in AMF gives the opportunity to become part of a scientific network with excellent researchers from across the world.

Israel

Introduction

Israel is an oil poor country. The Government of Israel wishes to reduce its dependence on imported oil for reasons that stem from high and volatile oil prices, political instability in oil-producing regions, and economic and environmental benefits.

In 2011, the Israeli transport sector consumed approximately 2.7 million ton of gasoline and a similar amount of diesel. The vehicle fleet has grown at 5.4% since 2009 and currently consists of around 2.7 million vehicles, of which 85% are gasoline fueled, and the rest are mainly diesel-fueled heavy-duty vehicles, buses, and trucks.

Policies and Legislation

In January 2011, the government of Israel announced a national program to expand the development and implementation of technologies that will decrease global dependence on oil in transportation. The adaptation of new oil substitutes will be feasible only by international acceptance. Therefore, the resolution seeks to position Israel among the global leaders in research and development in the field and as a catalyst for a worldwide adoption of oil alternatives. The resolution is backed by an ambitious 10-year plan and a budget of $400 million. The initiative includes programs on both the supply and the demand aspects of the market.

The main alternatives to oil fuels categorized by the Israeli government are:

- **Long term:**
  - Electrical vehicles ("e-mobility") –including plug-in EV and hybrid EV. Emphasis is given to the development of novel batteries and fuel cells (operated on hydrogen or methanol).
  - Biofuels (liquids-BTL), mainly from the second and third generation.

- **Technology bridge (medium and short term):**
  - Synthetic fuels from natural gas (GTL).
  - Methane and biomethane such as CNG and LNG.
  - Complementary fuels – blending/dual fuel with ethanol and methanol.

The framework program supports the following activities:

- **Academic and Applied Research**
  Two inter-university research centers with new laboratories and research teams were established in early 2012. One center focuses on solar biofuel research and the other on batteries and fuel cells. The centers were granted $16 million and $12 million, respectively. In addition, a new research fund was established, awarding grants of up to $450,000 to research groups in the field.
- **Industrial Research and Development**
  The Oil-Free Initiative operates a number of programs for applied research within companies, research institutes, and universities. It includes a large research consortium in the field of batteries and fuel cells.
- **Venture Capital Investments**
  A new governmental co-investment fund is being established in order to promote large investment in venture-capital-backed companies. The government share in each investment will be up to 30%, with a maximum of $6 million. Besides industry, eligible private co-investors include investment funds and corporations, both Israeli and foreign.
- **"One-Stop" Center**
  The initiative has commenced the operation of a governmental one-stop center that supports companies conducting innovative technological demonstrations, by tailoring Israeli regulations to facilitate each case.

Green Taxation

Israel's Green Tax reform went into effect on August 2, 2009. The reform sets tax incentives aimed at reducing vehicular air pollution. The tax reform largely relates to changes in purchase taxes imposed on new motor vehicles weighing less than 3.5 tons. The rate of benefit ranges from 15,000 shekels[13] for relatively clean vehicles to 0 shekels for the most polluting group.

The proposed reform includes:

- Taxing vehicles according to pollution levels they emit
- Matching taxation of fuel types to external cost
- Creating incentives for electric and hybrid vehicles
- Fostering completion by not offering focused encouragement of a certain type of engine or fuel
- Creating a ranking of vehicles according to pollution level
- Sorting vehicles into groups according to rank

[13] As of June 7, 2012, 1 shekel = 0.26 USD

What happened after the implementation of green taxation? Increase of "green" vehicles imports. The proportion of vehicles in the lower groups (2–6 increased from 32% in 2008 to 47% in 2010. The emission levels of all pollutants decreased significantly, by 2% for hydrocarbons to 24% for particulate matter.

Implementation: Use of Advanced Motor Fuels

Currently there are 87 start-ups and commercial spin-offs relating to oil alternatives that need to raise finance.[14] The companies' activities are in the fields of:

- Feedstock – range of raw materials to be converted into fuel – 21% of companies.
- Fuel Production – conversion of feedstock into fuel (applied to biomass or non-biomass feedstock – 34% of companies.
- Vehicles – platforms or critical elements that make transport efficient and cheaper compared to standard oil fueled vehicles – 34% of companies.
- Infrastructure – critical technologies which enable realization of oil independence – 11% of companies.

The Ministry of Energy and Water Resources decided to focus primarily on fuels based on natural gas. A special administration, consisting of experts from all relevant institutions and regulatory bodies, was formed in order to be enable to conduct "from well to wheel" projects including all technical, regulatory, economic, and political aspects. Natural gas is currently turning out to be an abundant worldwide resource, with large reserves in the United States, Israel, and elsewhere. Several commercially available technologies already exist and are commercially available such as CNG, GTL (drop in fuels), methanol, dimethyl ether, etc.

The selected technologies will also be compatible with biogas or syngas (a mixture of CO and H_2) production from any organic matter and especially wastes, opening up the option for use of a massive new source of feedstock which is both sustainable and renewable, and which has a low carbon footprint. Thus, oil replacements based on natural gas are a gateway to promising future fuels.

The Ministry of Energy and Water Resources promotes small- and medium-scale demonstration projects under a new technology-demonstration

[14] IEP Database of Oil Alternative Companies initiated in Dec 2009 by the Israeli Institute for Economic Planning , last updated fully 2011 Q3.

program. The financial support includes grants at the level of 50% of a project's expected cost with a limit of $0.5 million. Examples of such demonstration programs:

- **Dor Chemicals**
  Project: Motor Vehicle Field Trial Run Using a Mixture Containing 85% Gasoline and 15% Methanol - M15. The project's objective is to examine methanol as an additive to petroleum-derived fuels in existing gasoline-operated vehicles. The tests include:

  - Laboratory test to examine the mixture's qualities and stability.
  - Engine performance tests on a test bench.
  - Road tests with operating vehicles.
  - Examination of the logistics system that exists in the fuel market
  - Assessment of vehicle-generated evaporative emissions.

  The purpose of this pilot project is to provide a full characterization of M15 implications that is required for standardization in Israel as a motor fuel. This can later facilitate the introduction of methanol as a transportation fuel in other countries, diversify their energy resources, and reduce the global oil dependency for transportation.

- **Company: Engineuity**
  Project: Production of Diesel (Syngas) from Natural Gas (CH_4) and CO_2. Engineuity is developing an innovative process to produce standard diesel fuel from natural gas and carbon dioxide. This is a considerably less expensive alternative to production of diesel fuel from crude oil. The program objectives are to demonstrate a novel process to produce a synthetic diesel fuel with less than 15 ppm sulfur, by operating an innovative prototype reactor producing 100 kg/h of syngas. The process is more modular, more efficient, and less expensive than existing ones.

Outlook

The implementation of the Government's resolution will advance additional government programs and business activity in Israel and abroad, with an emphasis on international cooperation.

Benefits of Participation in the IEA-AMF

The Israeli government effort to decrease the country dependency on oil coincides with the global need to find oil alternatives due to their economic and environmental benefits and their important impact on energy security. Israel wishes to learn from the knowledge gained by the IEA-AMF and to bring in new ideas and technologies. We further propose to serve as an international test bed for technologies and systems.

Italy

Introduction

In 2010, consumption of primary energy in Italy ran around 187.785 Mtep. Oil remains the main energy source (39%) followed by natural gas (36%) and renewable sources (12%).

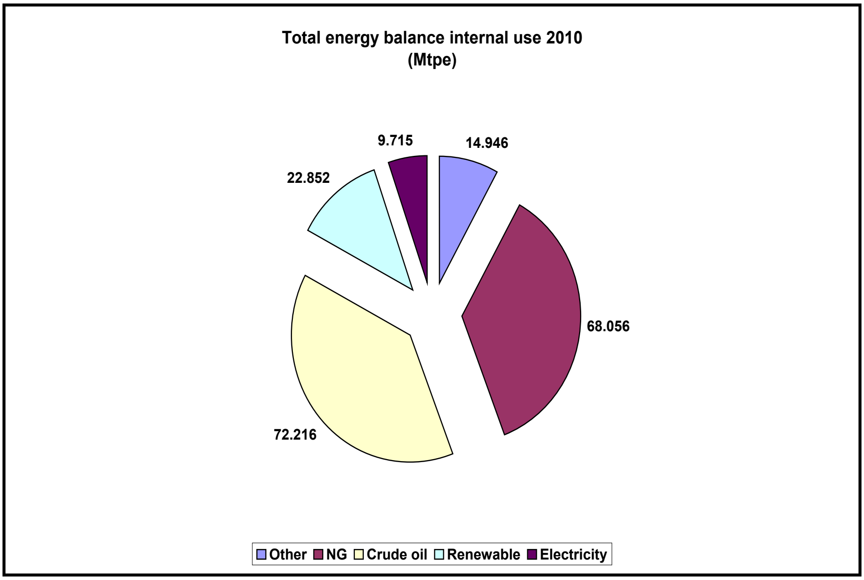

Fig. 1 Total Energy Balance in 2010 (Source: Ministry for Economic Development, *2010 National Energy Balance*)

Italy is largely dependent on imported oil, about 97 Mtpe in 2010.

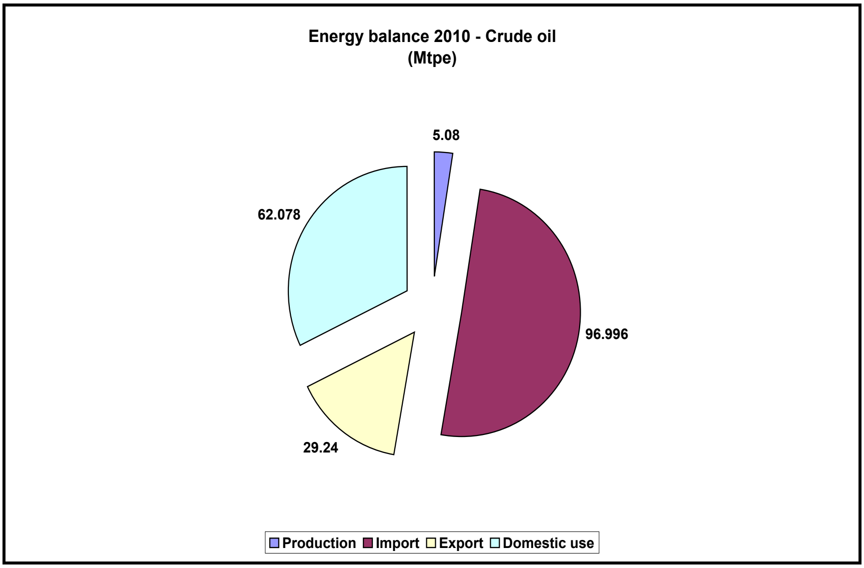

Fig. 2 Energy Balance in 2010 – Crude Oil (Source: Ministry for Economic Development, *2010 National Energy Balance*)

The major destination (about 64%) of derived oil is transportation.

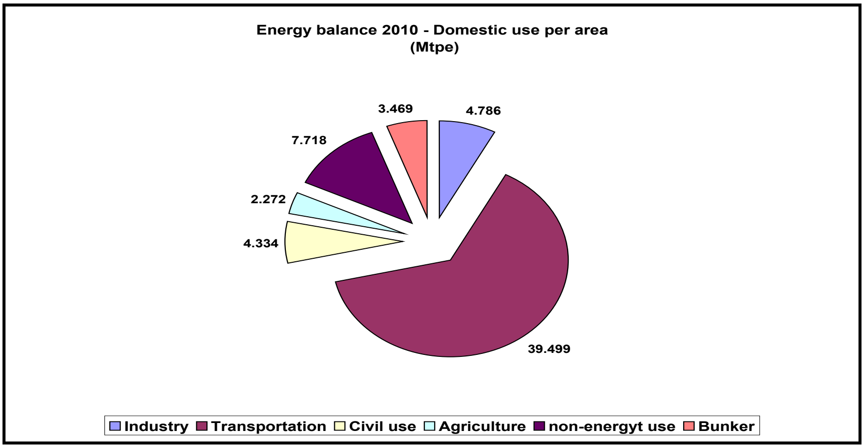

Fig. 3 Energy Balance in 2010 – Domestic Use per Area (Source: Ministry of Economic Development, *2010 National Energy Balance*)

The main transportation fuel is diesel fuel (66%) followed by gasoline (29%). Within the same sector a significant amount of natural gas (1.9%) and liquefied petroleum gas (3.7%) can be found.

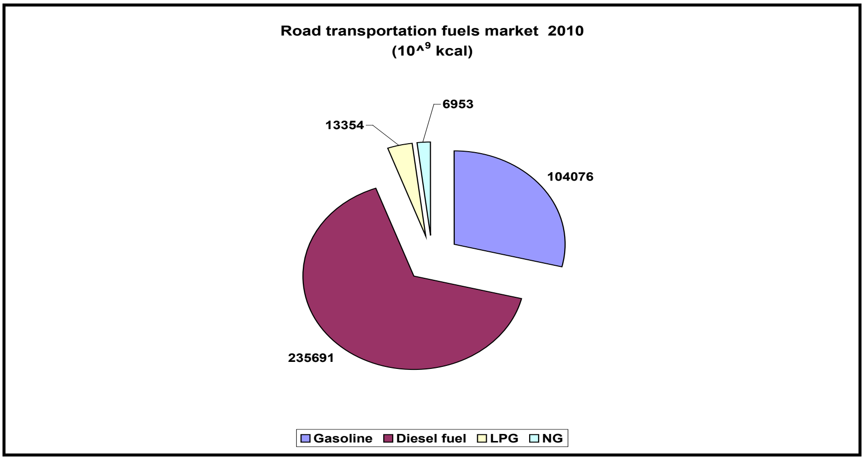

Fig. 4 Road Transportation Fuels Market in 2010 (Source: Ministry for Economic Development, *2010 National Energy Balance*)

As for vehicles, the first category is represented by passenger cars (76%) followed by motorcycles (13%) and lorry (8%).

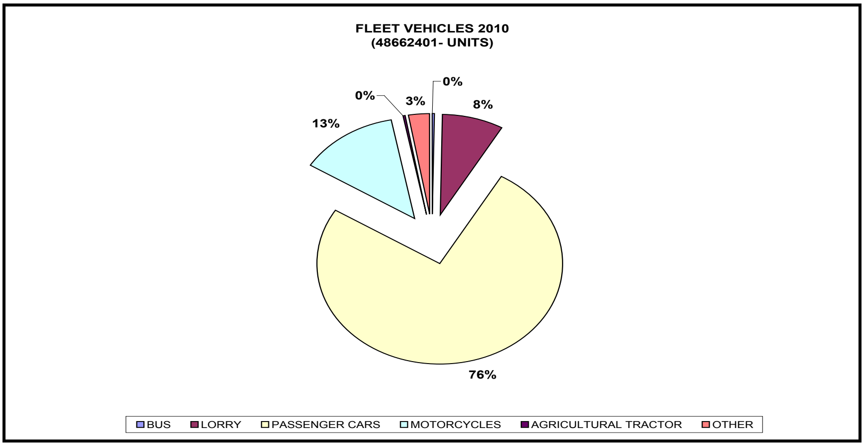

Fig. 5 Fleet Vehicles in 2010 (Source: ACI – *Autoritratto 2010*)

As for passenger cars, the first category is represented by gasoline vehicles (55%) followed by diesel fueled vehicles (38%). A significant percentage is represented by natural gas (2%) and liquefied petroleum gas (5%) vehicles.

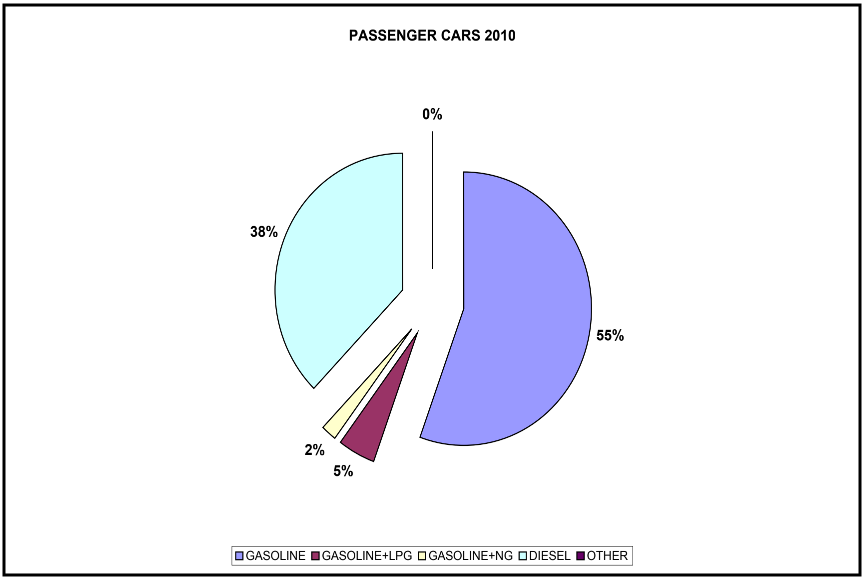

Fig. 6 Passenger Cars in 2010 (Source: ACI, *Autoritratto 2010*)

Diesel fueled vehicles can employ up to 7% of biodiesel; gasoline fueled vehicles can employ gasoline containing oxygenated bio-fuels where oxygen may amount to 2.7%.

Policies and Legislation

The Italian Law has adopted the European Renewable Energy Directive (2009/28/EC) and the Fuel Quality Directive (2009/30/EC). By the Law 2009/99 of July 23, 2009 and along the European Specification EN590:2009, the Italian Government has given permission to use biodiesel in diesel fuel up to 7%. The Decree 2011-28 acknowledges all European Directives promoting the use of fuels or any other renewable source. Energy incentives are granted for renewable sources fuels derived from wood cellulose or plant and animal residues. Moreover, municipalities have taken important local measures impacting transportation. To improve air quality, reduce PM10 emissions, improve the road system, and lower noise in the cities, traffic blocks to urban areas have been introduced. Milan has established a tax for entering the city center, whereas access is kept free to electric vehicles, motorbikes, and mopeds; free access for hybrid as well as NG and LPG bi-fueled vehicles will be allowed until December 31, 2012.

In its 2007 fiscal budget, the Italian Government planned the Industry 2015 Program, which encompassed two new funding mechanisms and a call for projects to promote innovation in Italian industry. Selected projects, involving a variety of private sector enterprises of various sizes as well as research institutions, received co-financing from the Government.

Two of the project streams, launched in 2008, target sustainable mobility and industrial energy efficiency and use of renewable energy. In December 2008, 26 selected Sustainable Mobility projects received a total of EUR 180 million, generating a total investment of EUR 450 million.[15] Nearly a third involved the development of ecological, efficient, and economic road vehicles or production processes.

In January 2009, the Industrial Energy Efficiency stream selected 30 projects, mobilizing an investment of EUR 500 million in research and development targeting both efficiency and the use of renewable energy technologies. Approximately 65% of the investment funding (and 56% of company proposals) targeted bioenergy, energy production from waste, and solar photovoltaics. The remaining 35% of investments targeted high-efficiency building materials, improved efficiency in end-use systems and sub-systems, and wind energy. Another 7 projects received funding in the areas of bioenergy and production of energy from waste, efficient appliances, and technologies for increasing energy efficiency of industrial processes.

As regulations have taken the direction of promoting the use of bio-components, some private organizations are researching new fuels to preserve land and water resources destined to agriculture as second-generation sources of fuels; others are examining algae and plant and animal residues for producing biodiesel or HVO.

In 2006, Chemtex-M&G began R&D activities devoted to demonstrate technological and environmental sustainability of second-generation bioethanol production from lignocellulosic feedstock (PROESATM technology). In particular, Chemtex-M&G has conducted research into cellulosic crop optimization and agronomics; has designed, engineered, developed, and tested at the laboratory- and pilot-scale proprietary

[15] As of June 6, 2012, 1 EUR = 1.2499 USD

technology and components for key aspects of the biomass to fuel conversion process; and has partnered with leading technology providers 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, Italy, is planned to start production in 2012. The M&G PROESA® process allows this plant 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 was developed 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 was invented. Unlike traditional oil processes, the EST technology can produce gasoline and gasoil without generating coke or fuel oil, whose market is constantly declining.

Implementation: Use of Advanced Motor Fuels

Biodiesel is the primary source for the renewable advanced motor fuel in Italy. From 2009 to the present, biodiesel has been blended up to 7 vol.% in diesel fuel. The renewable fuel currently used in gasoline is bio-ETBE, derived from bio-ethanol. The amount of bio-ETBE used in gasoline is 242,000 tons.

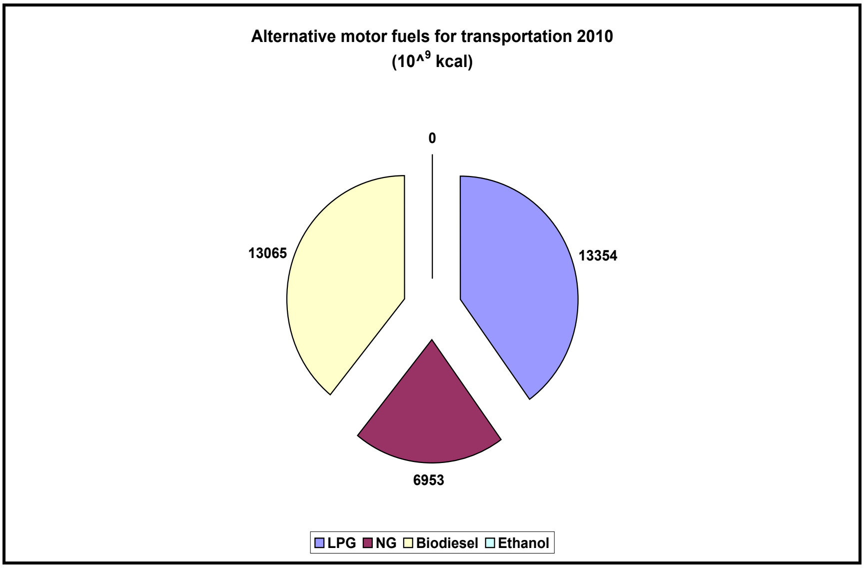

Fig. 7 Alternative Motor Fuels for Transportation (Source: Ministry for Economic Development, *2010 National Energy Balance*)

At the end of 2011, more than 803 NG stations existed in the country with a fleet of more than 600,000 cars. The network is mostly located in Northern Italy, whereas Central and Southern Italy are not homogeneously represented. In the Region of Sardinia Island, no NG service station is to be found.

At the beginning of 2010, the LPG filling station network amounted to 1490 stations, with a fleet of about 1.7 millions cars (Source: http://www.unionepetrolifera.it/it/CMS/pubblicazioni/get/2011/UP%20Relazione%20Annuale%202011.pdf).

Outlook

With the aim of reaching 10% biofuels in 2020, out of the total energy destined to transportation, the following yearly minimum increase of energy derived from bio-components is targeted:

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%

Additional References

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- AEGPL, www.aegpl.eu

Benefits of Participation in the IEA-AMF
Transportation is a crucial aspect in a country's economic development. Sharing choices of high value for the environment and participating to the ongoing debate on energy are vital for accomplishing a common viewpoint. For example, the global debate can help in building a world outlook on renewable sources to control CO_2 emissions.

Japan

Introduction

Since crude oil price fluctuations are intimately related to various world events, reduction of oil price fluctuations is a very important driver for research and development of petroleum-substitute fuels and new fuels. Figure 1 shows the variation of Japan's crude oil import volume [1]. Due to crude oil price increases and energy conservation policies, crude oil cutbacks are observed, and in 2009 the volume decreased by about 20% from its peak. However, crude oil demand is increasing on a worldwide scale, and the maximum output is being extracted from each field; thus higher crude oil prices are expected to continue in the future. With regard to this world situation, it is important to note that the price depends not only on consumption volume, but also on the research and development of new alternative fuels for the middle and long term.

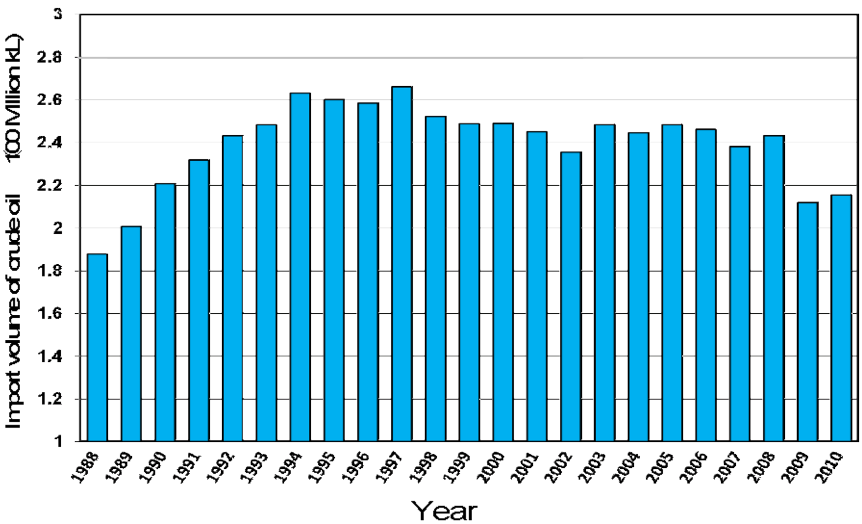

Fig. 1 Japan's Crude Oil Import Volume

Policies and Legislation

In May 2006, a new national energy strategy was developed by the Ministry of Economy, Trade and Industry (METI), in which two major targets were set for the transportation sector. In order to reduce the energy constraints, the strategy focuses on taking various energy policy measures. One was reduction of oil dependence in the transportation sector to 80% by fiscal year 2030. The other was improvement of energy efficiency by 30% by fiscal year 2030.

Improvement of fuel economy is the most effective short term strategy to reduce energy consumption and increase energy security by introduction of more stringent fuel economy standards. As a long term strategy, METI will take a comprehensive approach to significantly reduce energy consumption and reduce oil dependence. To reduce energy consumption and oil dependence, in December 2006 the Minister announced the Next-Generation Vehicle Fuel Initiative, which focuses on further development and introduction of three technologies, including biofuels, clean diesel, and next-generation battery, and the Fuel Cell & Hydrogen Society.

The "Basic Energy Plan for Japan" was revised in June 2010. But because of the Great East Japan Earthquake on March 11, 2011, major discussions are going toward the establishment of a new "Basic Energy Plan for Japan" [2]. This discussion is based on deep reflection on the enormous damage caused to the national livelihood, regional economies, and the environment due to the accident at the Fukushima Daiichi Nuclear Power Station, which occurred in the wake of the Great East Japan Earthquake.

Implementation: Use of Advanced Motor Fuels

LPG

In Japan there were about 276,000 LPG vehicles as of June 2010, and more than about 79% of those were taxis. Figure 2 shows the variation of LPG automobile count [3]. In Japan the number of LPG vehicles like taxis and freight rail cars decreased slightly, but at the same time the required energy resource units decreased due to improved fuel consumption; thus the amount of LPG demand also decreased.

Several grants were awarded under the program entitled "Enterprises for LPG Vehicle Promotion" by the Japan Energy Resource Agency, Petroleum Circulation Section, Grant System, under the auspices of the Japan LP Gas Association. A 197,000,000 yen[16] (1,015 automobiles) grant was awarded in 2010 for advanced LPG automobiles with next-generation clean exhaust emissions, and a 61,000,000 yen grant consisting of establishment of 13 locations for LPG stations. Proliferation and promotion of advanced LPG automobiles have been accelerated. Considering that obstacles were raised in distribution due to lack of gasoline and diesel fuel after the Great

[16] As of June 7, 2012, 1 yen = 0.01 USD

East Japan Earthquake, the Japan LP Gas Association has published guidelines indicating the necessity for promoting multiple fuel options (not only gasoline) for automobiles, beginning with increasing numbers of LPG vehicles at this time.

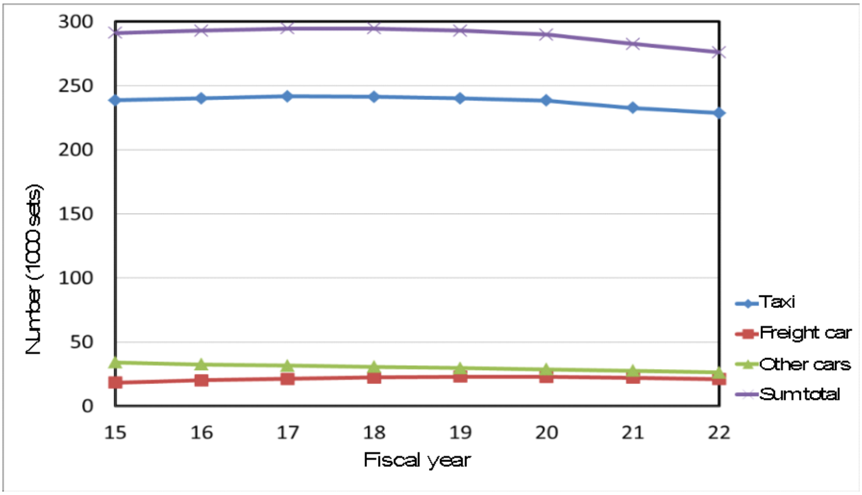

Fig. 2 Trend of Number of LPG Automobile

Natural Gas

The number of natural gas vehicles in Japan rose to 40,429 at the end of March 2011. Figure 3 shows trends in the number of natural gas vehicles and refueling stations in Japan. Some natural gas vehicles have replaced heavy duty trucks so far, because they would normally have a diesel engine. Kyodo Co., Ltd., which installs natural gas power plant retrofits, converted a Isuzu Giga that is post new-long-term emissions (similar emission level to “Tier 4” in the U.S.) compliant as a demonstration unit. The base engine was a 9.8 liter diesel, producing 380 PS, while running on natural gas, the output was 350 PS. This is over 90% of the baseline value, while emissions measurements showed reduction by 35.7% (NO_x) and 74.3% (CO) of the maximum values for post new-long-term emissions [4].

Researchers at Kyoto University and the Energy Technology Research Division of Osaka Gas Co., Ltd., are working with dual fuel engines, with natural gas as the main fuel and diesel fuel as the auxiliary fuel. In this strategy, the diesel fuel is used for ignition, and injected by a common rail injection system [5].

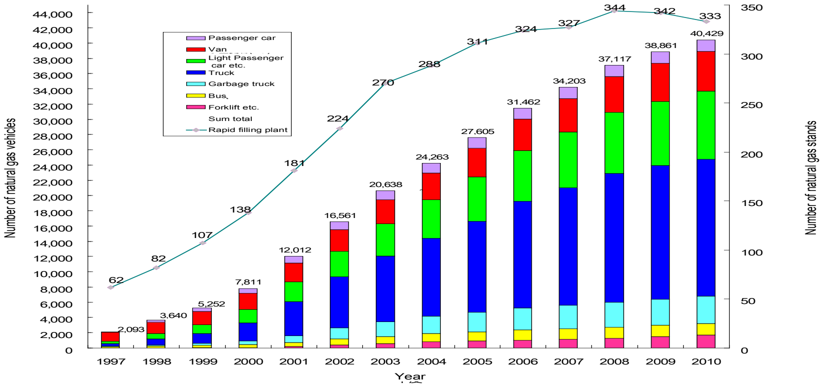

Fig. 3 Trends of Natural Gas Vehicles and Gas Stations in Japan

Biofuels

Bioethanol. In Japan, regulations entitled “Sophisticated Methods of Energy Supply Structures” took effect in November 2010. Petroleum companies were obliged to use biofuels by this law, and at the same time “Evaluation Standards for Petroleum Refiners on Utilization of non-Fossil Energy Sources” maintains targets for the primary energy source, such as global warming gas reduction of over 50% compared to gasoline, via life-cycle assessment (LCA) [6]. One way to meet this standard is through the use of sugarcane ethanol cultivated by existing farms in Brazil; however, it is necessary to continue our investigations.

A number of biofuel projects, such as “Local Bio-fuel Utilization Models for Actual Model Businesses” by the Ministry of Agriculture, Forestry and Fisheries, and “Eco-fuel Utilization by Local Enterprises” by the Ministry of Environment, are being carried out in Japan.

The report entitled “What Future Automobile Emissions Reduction Countermeasures Ought to Be” was prepared, and reports about “Exhaust Gas Reduction Countermeasures for E10 Compatible Gasoline Automobiles and Fuel Standards for E10” have been forwarded to the Ministry of Environment [7].

The Japan Automobile Standards Organization (JASO) has developed ethanol fuel quality standards based on JASO M361. The Japan Institute of Standards (JIS) standardization has been consulted by many organizations, such as Petroleum Association of Japan, Japan Automobile Manufacturers

Association, Inc., and National Institute of Advanced Industrial Science and Technology.

Biodiesel Fuel. With support of the Ministry of Economy Trade and Industry, a three-year interim report on the five-year JATOP (Japan Auto-Oil Program) biodiesel test plan has been prepared. This test plan involves biofuel application to diesel vehicles, including utilization of high biodiesel blend ratios (over 5%), measurements taken at both the fuel producer and vehicle side, and establishment of relevant standards. Results have shown that it is undesirable to characterize FAME ignition quality by the cetane index: it has undesirable acid stability and can have a large influence on certain types of rubbers and polymers, it can form precipitates during room temperature storage above the cloud point, and both manual and automatic diesel particulate filter regeneration fails at high blend ratios [8].

Di-Methyl Ether (DME)

At the Ministry of Land, Infrastructure, Transport, and Tourism, an operating test program of DME vehicles was approved by the minister under the leadership of the National Traffic Safety and Environment Laboratory, and this program is ongoing [9]. A 2-ton truck manufactured by Isuzu Advanced Engineering Center, Ltd. (IAEC) for a total distance of 100,000 km, after which the fuel supply system and fuel injection system were dismantled, and a piece-by-piece evaluation of each part was carried out. Important data on durability and wear of critical engine parts of DME vehicles were obtained [10]. Later on, two 3.5-ton trucks with a wing box bodies began actual service, during which measurements of fuel consumption showed no difference of diesel fuel. These trucks, shown in Figure 4, were registered and licensed by a special enterprise registration (green plates) in November 2009. The latest data showed that no major operator inconveniences related to DME occurred, and the total trouble-free distance operated continues to ratchet upward [11]. Operating test results such as these are used to create technology guidelines of DME vehicles.

The DME Vehicle Promotion Committee recently created the Technology Standards Plan Investigation Committee for High Pressure Gaseous Fuel Filling Equipment for DME Vehicles, and has been actively updating and revamping codes and regulations. Some examples include revamping the high-pressure gas safety laws to reduce the safety distance of automotive DME filling stations, and creating new fuel tank regulations for DME vehicles.

For fuel standardization, in the International Standards Organization Technical Committee 28 ISO/TC-28/SC4, a proposal for a new standard

(NWIP) controlling vehicular DME fuel quality was turned in and registered in November 2010 (ISO NP16861). Following that, the usual activities for ISO publication within three years have continued. Also, work to update and/or eliminate certain related laws and to establish standardization that is indispensable to promote DME vehicles has been in progress.

Fig. 4 DME Truck Developed by IAEC

Hydrogen

The most notable groups that carried out hydrogen engine research in Japan were Tokyo City University and the National Traffic Safety and Environment Laboratory. To control backfire in pre-mixed hydrogen engines, the following key points were identified: use a capacitive discharge ignition (CDI) system and reduce the size of the spark gap by an appropriate amount [12]. Moreover, the same teams carried out development on direct injection hydrogen engines. Using a novel method called plume combustion concept (PCC), a high-pressure heterogeneous fuel plume was initiated by ignition of the tail-end near the injector hole, right after injection ended. Even with this direct injection method and hydrogen fuel, low NO_x was realized, and with only exhaust gas recirculation (EGR), this method is expected to reduce NO_x enough to meet the 2009 regulated value for large size engines [13].

Outlook

The following lists future activities, including outlook regarding advanced 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. This can be done by speeding up the improvements of the biomass-derived fuel supply infrastructure through the environmental and safety countermeasures of gas stations, and by 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 gasoline cars. Such vehicles are also important for the utilization of GTL and promote the use of GTL.

- Promote the supply of new fuels such as biomass-derived fuels and improve economic efficiency by promoting the development of high-efficiency ethanol production technology and GTL technology.
- Promote the dissemination of electric vehicle and fuel cell vehicles, which are already about 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 have been in progress toward the establishment of a new "Basic Energy Plan for Japan." It is expected that the new plan will come out in 2012.

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[12] H. Shirakura, et al., Proc. JSAE, No. 29-10, pp. 23-28 (in Japanese).
[13] Y. Ogasawara, et al., Proc. JSAE, No. 29-10, pp. 11-16 (in Japanese).

Benefits of Participation in the IEA-AMF

It is possible to obtain the latest information on Advanced Motor Fuels in the world through the activities of the IEA Advanced Motor Fuels Implementing Agreement. Access to information in the field of motor fuels in various countries is important for stakeholders, such as policy makers and industry.

Spain

Introduction

The total Spanish market for transportation fuels in the last 12 months (until November 2011, last available data) was 25.631 ktons. Figure 1 shows this fuels market and the evolution of fuel consumption.

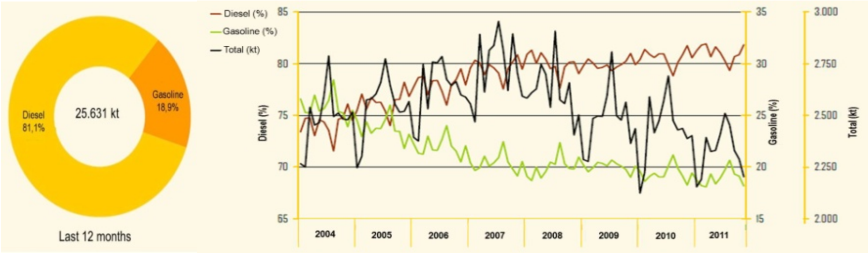

Fig. 1 Evolution of Fuel Consumption (diesel and gasoline) in Spain, 2004–2011 (Source: CORES)

Spain has very little domestic oil and gas production and relies heavily on imports, the sources of which are Africa, the Middle East, and OECD countries. Figure 2 shows the total amount of oil imports and the countries where it is produced.

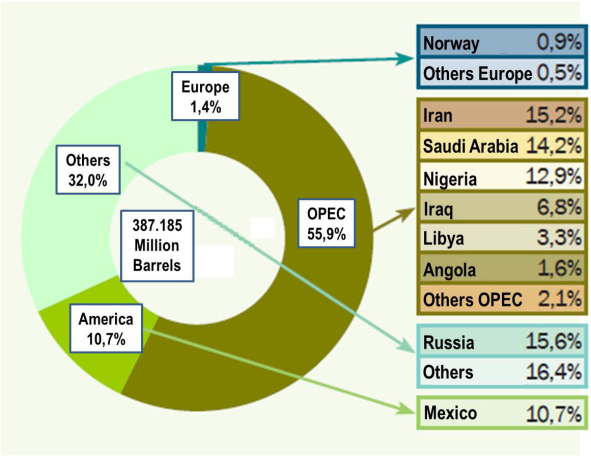

Fig. 2 Total Amount of Oil Imports in Spain by Country (Source: CORES)

Policies and Legislation

New mandatory objectives for biofuels for the period 2011–2013 have been set by means of Royal Decree 459/2011:

	2011	2012	2013
Total Biofuels	6,2%	6,5%	6,5%
Biofuels in Diesel	6,0%	7,0%	7,0%
Biofuels in Gasoline	3,9%	4,1%	4,1%

Implementation: Use of Advanced Motor Fuels

Biofuels represent the largest share of alternative transportation fuels while the market penetration of LPG and natural gas is very low. Figure 3 shows the biofuel sales up to July 2011 (last consolidated data).

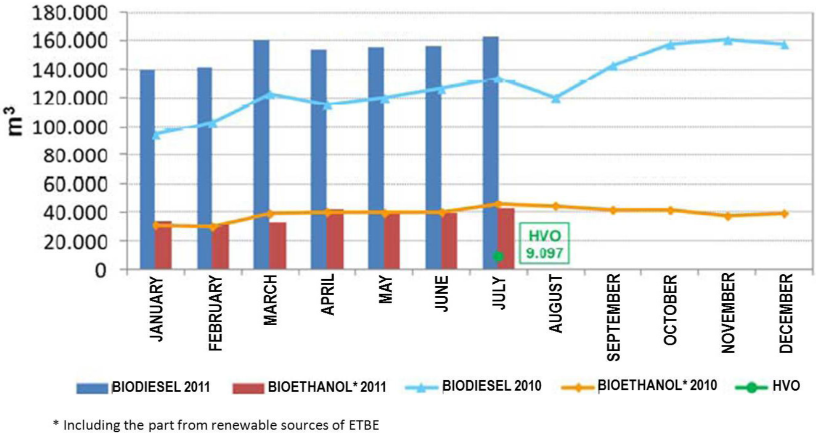

Fig. 3 Biofuel Sales in Spain from January to July 2011 (Source: CNE)

The evolution of biodiesel and bioethanol production, consumption, and imports and exports during last 12 months are given in Figure 4.

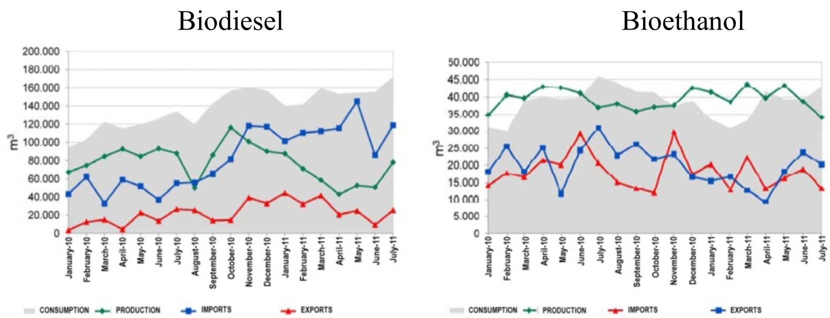

Fig. 4 Biodiesel and Bioethanol Data in Spain for 2010–2011 (Source: CNE)

The current number of vehicles capable of using other alternative fuels (LPG and natural gas) is shown in Figure 5.

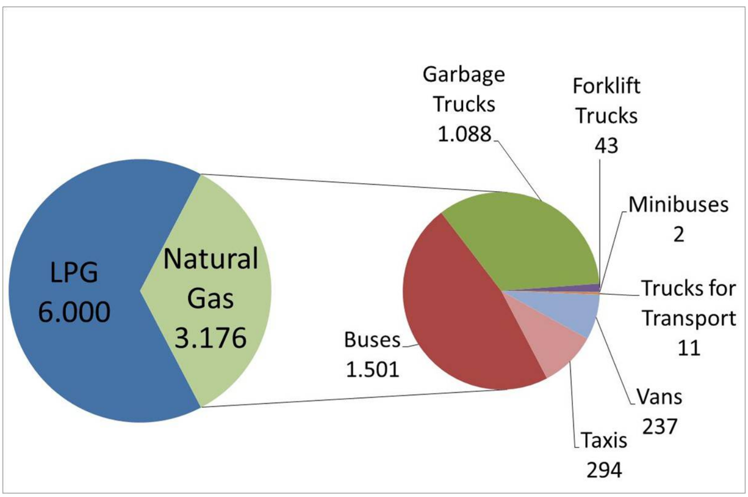

Fig. 5 Number of Vehicles in Spain Capable to Using Alternative Fuels (Source: IDEA)

There are also a few pilot fuel cell vehicles (not commercialized today).

As for the number of fuel stations, currently there are 57 fuel stations on natural gas, mainly located in fleet sites, and 140 LPG stations (80 public and 60 private).

Outlook

Bioethanol and bio-ETBE consumption is expected to grow from 232 ktoe in 2011 to 400 ktoe in 2020 (Figure 6). Biodiesel consumption is also expected to increase from 1.816 ktoe in 2011 to 2.313 ktoe in 2020.

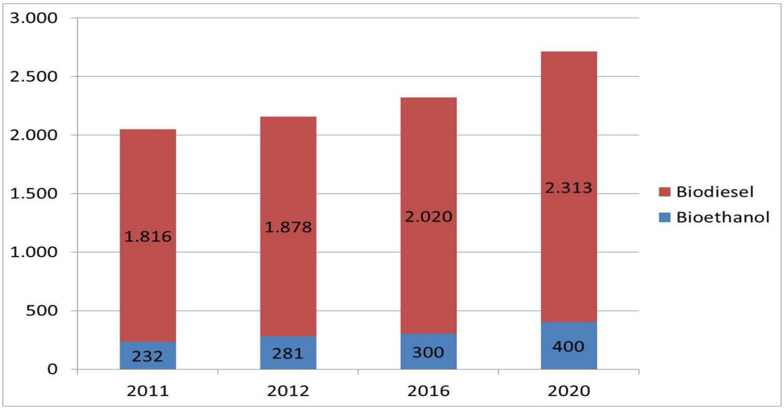

Fig. 6 Biodiesel and Bioethanol Growth in 2011–2020 (Source: IDEA)

Consumption of HVO has already started in 2011 and is likely to have a relevant growth during the next decade.

Additional References

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

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

Sweden

Introduction

Total energy use in the transport sector, including foreign transport, amounted to 128 TWh. Bunkering for foreign maritime traffic amounted to 23 TWh, and fuel for nondomestic aviation accounted for 8 TWh. Swedish domestic transport used 96 TWh in 2010, 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 2010, and net-exported 5.1 million tonnes of refinery products. Around 50% of Sweden's total crude oil imports was from the North Sea – mainly from Denmark and Norway.

Between 2000 and 2010, the use of diesel fuel increased by almost 70%, while that of petrol fell by 14% over the same period. One reason is the change in the mix of type of vehicles on the road.

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 5.7. Biofuels presently used for vehicles are mainly ethanol, biogas, FAME, and a small portion HVO as a 15% admixture.

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

Use of biogas has increased rapidly during the last couple of years. Currently, almost all petrol has a 5% blend of ethanol, while about 80% of the diesel contains a 5% blend of biodiesel.

Only about 30% of the ethanol and 50% of the biodiesel used in Sweden were produced within the country in 2010. Biodiesel capacity is about 160 million tonnes per year. All of the biogas was domestically produced.

Policies and Legislation

Sweden is using a relatively high proportion of biofuels in relation to most other countries in the EU. The main drivers for biofuels policy are to decrease the emissions of CO_2 from the transport sector. Another aim, not directly related to biofuels, is to increase the overall energy efficiency in the transport system.

The motor vehicle tax was changed in October 2006 to be based on the vehicle's carbon dioxide emissions instead of, as was previously the case, on the vehicle's weight. The purpose of this change was to encourage the sales of more low-carbon vehicles. Some relief is being 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 was also subject to the carbon dioxide tax charge. The vehicle tax for heavy goods vehicles does not include a carbon dioxide element, but depends on the vehicle's weight and levels of regulated emissions.

Bio-based motor fuels pay no energy or carbon dioxide tax, which affects the profitability of using such fuels. 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. As this requirement resulted mainly in an increase in the number of E85 pumps, a grant was also introduced for investment in other pumps. This grant is no longer available.

As of July 1, 2009, new "clean vehicles" were exempted from the vehicle tax for five years. A clean vehicle is defined as:

- Vehicle equipped with technology for operation on alcohol or methane and with a fuel consumption below 9,2l/100 km and
- Fuel-efficient petrol or diesel car with carbon emissions below 120 g/km.

Diesel cars are increasing their market share rapidly. The proportion of new vehicles that were diesel-powered amounted to 62% in 2011, as compared with 20% in 2006. The shift to diesel is caused by new efficient diesel cars on the market combined with the fiscal incentives for cars emitting less than 120 g CO_2 /km. Sales of cars with high and low efficient engines fueled with petrol, E-85, or methane have declined rapidly in 2010 and 2011. See Figure 1.

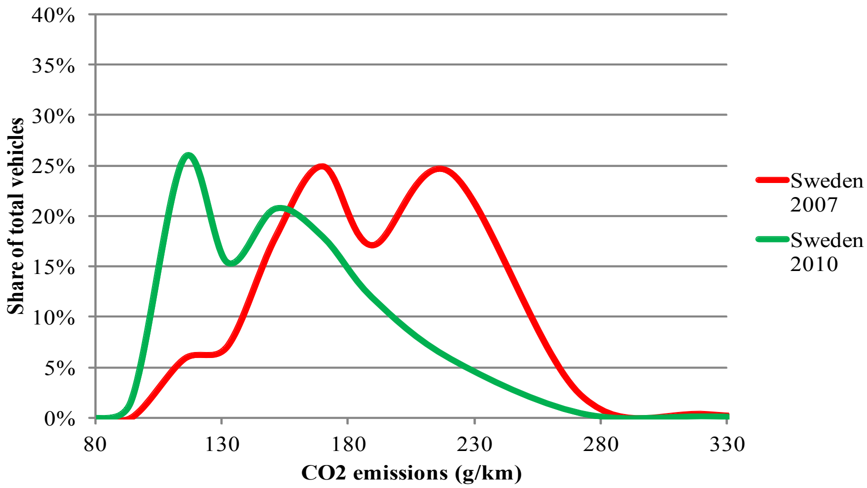

Fig. 1 Sales of New Cars in Sweden 2007 and 2010

The “benefit value” of a company car is subject to income tax. The present structure of benefit value tends to even out the effect of price differences between cars, with the result that company cars emit more carbon dioxide per kilometer than the average for new cars. Vehicles that can be fueled with methane have reduced benefit taxation. Until the end of 2011 ethanol cars and hybrid cars were subject to reduced benefit taxation.

As of January 1, 2012, a super-green car rebate (cars with emissions below 50 g/km) was introduced. The size of the premium is €4000 for individuals and 35% of the additional cost of producing a super-green car or a maximum of €4000[17] for legal entities.

In September 2009, the Swedish Energy Agency announced €87 million in support of three demonstration facilities. A review was performed by the European Union Commission, and support for the projects was approved at the beginning of 2011. The two largest projects funded in the program focus on biofuel production via the synthetic gas route.

The company Chemrec AB was granted €54 million for a project with a total budget of around €300 million. The project aims to extract biofuels from black liquor via gasification at a facility in Domsjö, Örnsköldsvik. The

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[17] As of June 6, 2012, 1 EUR = 1.2499 USD

plant will have the capacity to produce 100,000 tons of biomethanol and bio-DME motor fuels [8].

Another company, Göteborg Energi AB, was granted €24 million to build and run a facility for the transformation of low-quality forestry materials into biomethane via gasification. The methane will be distributed on the existing natural gas grid and, according to Göteborg Energi AB, in 2020 the plant will produce approximately 1 TWh/year, which is the equivalent amount of fuel for 100,000 cars.

In 2010, the company Sunpine in Piteå started production of renewable diesel from crude tall oil, a by-product from the pulp and paper industry. The nominal capacity of the plant is about 80 000 tonnes of raw tall diesel per year. The raw tall diesel is shipped to the oil refinery in Gothenburg on the Swedish west coast, where it is further upgraded via a hydrogen treatment (HVO) and is then mixed with fossil diesel. In 2011 the product called "evolution diesel" was introduced on the market. It contains 15% tall diesel and 5% RME and is distributed throughout most of Sweden. According to a well-to-wheel study, the fuel achieves 16% CO_2 emissions reductions relative to its fossil-based diesel counterpart.

Implementation: Use of Advanced Motor Fuels

On April 1, 2006, a law on the obligation to make renewable fuels available came into place. Filling stations above a certain sales volume must offer a renewable motor fuel in addition to petrol and diesel. Many local incentives for clean cars exist, such as free parking and exemption from congestion charges. Procurement rules for state authorities also include the demand for a certain proportion of clean cars. From July 1, 2011, a new Act requires that the procurement or leasing of cars and public transport services takes into account a vehicle's energy consumption and emissions during the entire period of use.

The alternative motor fuels that are presently used for vehicles are natural gas, biogas, ethanol, biodiesel, and HVO. Ethanol is used as a low-admixture constituent of petrol, and as a main part in fuels such as E85 and ED95. Biodiesel in the form of FAME is used as 100% FAME and as an admixture constituent in diesel fuel.

Low admixture ratios of ethanol and petrol increased progressively at the beginning of the 2000s, reaching 5% admixture in 2005 in almost all petrol on the Swedish market. A low admixture of FAME in diesel fuel was permitted as of August 1, 2006, and its use has steadily increased. Statistics for 2010 show that 5% FAME was mixed into 80% of all diesel fuel delivered to the Swedish market.

Motor fuel gas consists either of pure biogas, pure natural gas, or a mixture of the two. The ratio of natural gas in motor fuel gas varies with location, with the proportion of gaseous fuel vehicles tending to be higher in the parts of Sweden that are more extensively covered by the natural gas grid. In 2010, the proportion of biogas in gaseous motor fuels reached almost 65%. Motor fuel gas is used mainly as a fuel for buses and private cars.

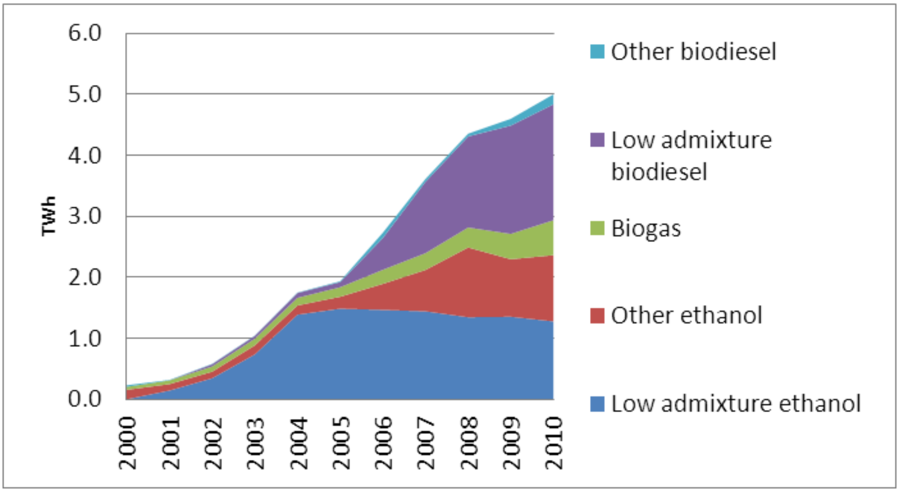

Fig. 2 Use of Renewable Motor Fuels, 2000–2010

Outlook

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

The Swedish Energy Agency’s forecast expects that the EU target of 10% renewable energy for transportation in 2020 will be just about reached for Sweden. Furthermore, the use of renewable electricity for railway traffic is expected to contribute to an additional 2 TWh in 2020, which makes a total of around 8 TWh of renewable energy for transportation in 2020.

The existing tax exemption is working in the sense that is stimulates the use of biofuels, but to a lesser degree 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 situation at least partially explains why about 70% of the ethanol and 50% of the biodiesel used in Sweden are imported. Sweden has a vision that the car fleet in 2030 will be "fossil independent." The distinctions and the details still have to be clarified.

Additional References

- Swedish Energy Agency, *Energy in Sweden, 2011*, http://www.energimyndigheten.se/en/Press/News/New-publication-Energy-in-Sweden-2011.
- Swedish Energy Agency, *Långsiktsprognos* [long-term forecast], *2010* (published in February 2011), http://webbshop.cm.se/System/DownloadResource.ashx?p=Energimyndigheten&rl=default:/Resources/Permanent/Static/a5f894444155405fbb1d1a063cf43ea4/ER2011%2003w.pdf.

Benefits of Participation in the IEA-AMF

IEA-AMF offers excellent opportunities to learn from different countries' experiences. Cooperation in annexes makes it possible to carry out a project that otherwise would have been too expensive for single countries. The most important benefit is that the participation of multiple countries in annexes leads to a common view of the challenges, as well of the possible solutions.

Switzerland

(Prepared by Swiss Federal Office of Energy SFOE and AFHB)

Introduction

The final total energy consumption in Switzerland in 2010 was 991,550 TJ, 54.2% of which was for transport fuels [1]. Most of the fossil fuels were imported. The energetic share of biofuels was very low (< 0.1%). In 2008, 5,448 passenger cars with environmental friendly propulsion systems were sold (3,000 with E5). The share of the total sales was 1.9%. In addition, in 2008 more small vehicles with less fuel consumption were sold. Different cantons have a vehicle tax reduction or even a tax exemption for environmental friendly and energy efficient vehicles [2]. In 2008, there were 89 fueling stations with E5, and 22 fueling stations with E85. Furthermore, 216 fueling stations provide B5, and 17, B100 [3].

Policies and Legislation

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

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

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

With regard to the signed Kyoto Protocol, Switzerland is obliged to reduce its greenhouse gas emissions. The CO2 Act asks for an emissions reduction of 10% by 2010 and 20% by 2020 compared with 1990. The CO2 Law requires that, by 2010, CO_2 emissions due to fossil fuels be reduced by 10% compared to 1990. The emissions from fossil fuels for heating purposes must be reduced by 15%, while the emissions from fossil fuels for transportation purposes (except kerosene used for international flights) must be reduced by 8%. The political orientation focuses on freely agreed measures.

For reaching this goal the government allows for different measures like the CO2 levy, "Climate Cent," and the fiscal promotion of environmentally friendly fuels. The goal of the CO2 levy is the reduction of CO_2 emissions by a regulatory tax on all fossil combustibles like natural gas, heating oil, and coal. Petrol and diesel are not affected by the CO2 levy. Climate Cent is a voluntary measure of the mineral oil industry and has been in effect since 2005. With a price increase of 1.5 centimes[18] per liter of petrol or diesel CO_2-reduction measures are financed. Since July 2008 Switzerland has had a partial or total tax exemption on fuels from renewable sources like biogas, bioethanol, biodiesel, and vegetable and animal oils as long as they meet ecological and social minimum requirements (according to the act of mineral oil taxation).

Regarding biofuels the Swiss Federal Office of Energy has published a position paper [5]. The main messages within this document are: (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) quota for blending are not regarded as reasonable because there is a more rational approach, e.g., heat dimensioned-combined heat and power plants; and (4) food production has priority.

Implementation: Use of Advanced Motor Fuels

The consumption of biodiesel in Switzerland amounted to just over 10.4 million liters in 2011, an increase of 13% with respect to 2010 (Table 1). The consumption of fuel-PVO, however, showed a significant decrease in 2011 (i.e., -53%) with respect to 2010 [3]. Biodiesel and pure vegetable oils are applied only in some local diesel fleets (mostly in agriculture) [6].

[18] As of June 7, 2012, 95.61 Swiss centimes = 1 USD

Table 1 Evolution of the Consumption of Biodiesel and Fuel Pure Vegetable Oil (PVO) in Switzerland over the Period 1999–2011 (in kL/yr) [3]

Year	Biodiesel [1000 L]			Fuel-PVO [1000 L]		
	National production	Imports	Total	National production	Imports	Total
1999	1563	-	1563	-	-	-
2000	1825	-	1825	-	-	-
2001	1937	-	1937	-	-	-
2002	1774	-	1774	-	-	-
2003	2342	-	2342	-	-	-
2004	3262	-	3262	313	-	313
2005	6361	-	6361	529	-	529
2006	8833	-	8833	845	-	845
2007	9756	113	9,869	1846	-	1846
2008	11,915	12	11,927	849	158	1007
2009	6821	694	7515	796	1430	2226
2010	6805	2380	9185	890	950	1840
2011	7307	3101	10,408	633	229	862

Table 2 shows bioethanol consumption in Switzerland from 2005 to 2011. 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 which meet the ecological and social minimum requirements according to the Act of Mineral Oil Taxation. In Switzerland, the companies SEKAB in Sweden and Borregaard in Norway provide the bioethanol supply, which is produced from wood waste (using a process very similar to the one Borregaard Swiss employed). 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 [3].

Table 2 Evolution of Fuel Bioethanol Consumption in Switzerland over the Period 2005–2009 (in kL/y) [3]

Year	Production	Imports	Total
2005	901	-	901
2006	1060	-	1060
2007	3188	-	3188
2008	3284	-	3284
2009	-	1483	1483
2010	-	3513	3513
2011	-	3790	3790

Table 3 shows biogas production in Switzerland between 1999 and 2011. In 2009 the biogas production was 2,878 TJ (800 GWh), whereof 3,152,000 kg (37 GWh; 2.6 Mm^3; 4.6%) was used as fuel [7]. The total liquid fuel consumption (except aviation fuels) in Switzerland was 7,054 Ml in 2009, whereof 0.1% (7.5 Ml) was biodiesel, 0.03% (2.2 Ml) was pure vegetable oil, and 0.02% (1.5 Ml) was bioethanol. The total gaseous fuel consumption in Switzerland (natural gas + biogas) was 13,525,000 kg (equals 18.74 Ml Petrol 95) in 2009, whereof 23% (3,152,000 kg) was biogas [7].

Table 3 Evolution of Fuel Biogas (via gas grid and directly at fueling station for electricity production) Consumption (taxed amounts) in Switzerland over the Period 1999–2011 (in kL/y) [5]

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	1068	1158
2000	294	44.82	1017	1311
2001	366	47.10	1486	1852
2002	470	36.95	1524	1994
2003	542	37.35	1635	2177
2004	681	37.79	2696	3377
2005	890	36.88	2461	3351
2006	927	26.25	3356	4283
2007	1334	20.24	1329	2663
2008	2493	23.95	482	2975
2009	3152	23.30	0	3152
2010	4505	-	-	4505
2011	6350	-	-	6350

Outlook

Figure 1 shows the share of biofuels as of 2010. The medium-term production potential for biofuels is estimated by the federal council at 76 million liters. This equals 1% of the Swiss annual fuel consumption [8]. If policy would heavily encourage local energy production from biomass, a share of 8% of biofuels until 2020 would be possible. Therefore, all biomass fractions, including the produced by-products, have to be energetically used [9].

The following research and development is in progress or recently completed:

- 1st generation biofuels: Bern University of Applied Sciences (research project; finished 2011): Influences of RME on emissions with different exhaust gas after-treatment systems of diesel engines.
- 2nd generation biofuels: Centre for Technology Assessment - TA Swiss (2010): Future perspectives of 2nd generation biofuels (Study) [10, 11].
- Paul Scherrer Institute (research project; ongoing): Sulphur-resistant methanation. Projects on gaseous fuels [12].

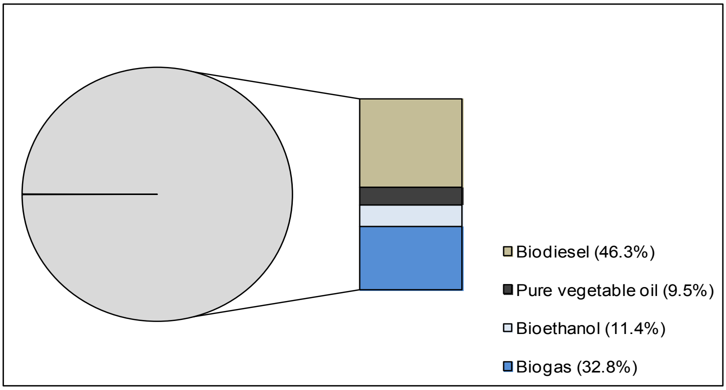

Fig. 1 Share of Biofuels Relative to the Total Consumption of Fuels in Switzerland (2010). (99.9% fossil fuels; 0.1% biofuels)

References

[1] BFE Energy Statistics, http://www.bfe.admin.ch/themen.
[2] Die Plattform für biogene Triebstoffe, http://www.bio-sprit.ch.
[3] Biofuels Platform, http://www.biofuels-platform.ch.
[4] Bundesamt für Energie (BFE), http://www.bfe.admin.ch; Bundesamt für Umwelt, http://www.bafu.admin.ch.
[5] Positionspapier biogene Treibstoffe, BFE [1].
[6] EV/UP Annual Report 2009, http://www.swissoil.ch.
[7] Eidgenössische Zollverwaltung (EZV), http://www.ezv.admin.ch.
[8] Schweizerische Statistik der erneuerbaren Energien 2009, http://www.bfe.admin.ch/php/modules/publikationen.
[9] Erneuerbare Energien, Sondernummer 2006, http://www.biomasseenergie.ch/Portals/0/1_de/01_Wie_produzieren/Pdf/biogas-sondernummeree.pdf.
[10] Competence Center for Energy and Mobility, http://www.ccem.ch.
[11] Paul Scherrer Institute, www.psi.ch.
[12] Federal Laboratories for Testing Materials, www.empa.ch.

Benefits of Participation in the IEA-AMF

- International contacts and knowledge exchange
- Information services
- Project collaborations and associated findings
- Research by specialists and consultants
- Promotion of domestic projects and research
- Support for domestic authorities

United States of America

Introduction

The U.S. government has active research programs evaluating advanced motor fuels. In the near term, the United States government is pursuing renewable fuels, such as ethanol and biodiesel, for direct displacement of gasoline in the transportation fleet. Natural gas in liquid and compressed forms has become of interest for transportation due to advances in recovery techniques. Longer-term research projects are also investigating fungible (drop-in) fuels produced from biomass.

Total U.S. transportation energy consumption in 2011 was approximately 27 quadrillion Btu (4.7 billion gallons of crude a year, 12.7 million barrels per day), a level that has remained little changed since 2008.[19] Over 90% of this was petroleum-based fuels,[20] with most of the remainder being ethanol blended into gasoline at 10%. Over 95% of U.S. gasoline currently contains 10% ethanol.

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, due mainly to increases in vehicle efficiency, consumers having switched from light trucks and sport-utility vehicles to smaller vehicles, increased domestic production of "tight oil" from shale deposits, and increases in the use of biofuels and other renewables.[21]

A significant development in U.S. motor fuels markets in recent years has been the emergence of substantial excess capacity in the U.S. refining industry. This excess has cut refining margins significantly despite substantial net U.S. exports of refined products for the first time in decades. As a result, several less efficient eastern U.S. refineries, which were up for sale, were in the process of being shut down near the end of 2011. The expectation is that the east coast will rely more on refined product shipments from the U.S. Gulf coast region and Europe.

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

20 http://www.eia.gov/oiaf/aeo/tablebrowser/#release=EARLY2012&subject=0-EARLY2012&table=11-EARLY2012&region=0-0&cases=early2012-d121011b.

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

Policies and Legislation

The federal and state governments provide many regulations and incentives for development, deployment, and use of alternative fuels and alternative fuel vehicles. While 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 acquire alternative fuel vehicles for most of their vehicle acquisitions. Fleets of alternative fuel providers must also use alternative fuels in the vehicles where practical.

The primary driver of alternative fuel use in the U.S. is currently the Renewable Fuel Standard (RFS) adopted in 2005 and expanded in 2007 (RFS2), which requires that increasing volumes of renewable fuel be sold as motor fuels. 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. Although there are moves to renew credits for sale of E85, biodiesel, and other advanced biofuels, there is a consensus for not renewing the credits for low level corn ethanol blending due to the maturity of the industry and the RFS.

In December 2010 the Environmental Protection Agency (EPA) approved a waiver allowing up to 15% ethanol to be blended in gasoline for use in 2001 and later model year vehicles. However, the fuel is not currently available for sale, except to flex-fuel vehicles, because other regulatory barriers have yet to be addressed. In February 2012, EPA approved a submission of health effects data that will allow blenders to register up to 15% ethanol/gasoline blends. The fuel must be registered with EPA before it is legal for sale by EPA requirements, but it still may not be legal by other regulatory requirements.

Many states have their own regulations restricting ethanol to 10% blends. Additionally, most existing retail dispensers are not listed by Underwriters Laboratory as compatible with blends above E10. This situation creates issues with both the Federal Occupational Safety and Health Administration and state regulations. EPA fuel volatility regulations, which are more stringent than for E10, could also cause impediments based on commercially available blend stocks.

The RFS2 statute also requires that minimum amounts of cellulosic ethanol, advanced biofuels, and biomass-based diesel fuel be sold annually from 2010 on, if available. For 2011, the statutory minimum for cellulosic ethanol was 250 million gallons. Anticipating that production would fall well short of this number, EPA used its waiver authority to lower that requirement for 2011 to 6.5 million gallons. From July 2010 to June 2011, however, there was no cellulosic ethanol produced in the U.S.[22] By January 2012, a single facility, K.L. Energy Corp., was producing cellulosic ethanol (at a rate of 100,000 gal/year), but the EPA projects production capacity for 2012 is at 10.45 million gallons, thus lowering the requirement to that amount from the statutory target of 500 million gallons.[23]

EPA has not reduced the requirements for biomass-based diesel or advanced biofuels, almost all of which is biodiesel. For 2011, the requirement was for 800 million ethanol equivalent gallons of biodiesel and for 2012, the requirement is 1 billion gallons.

Other alternative and advanced motor fuels are incentivized by various federal and state programs. 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.

New regulations extend beyond renewable and alternative fuels. EPA announced in 2011 that it intends to propose a rulemaking (Tier 3 emissions levels) that includes a provision to reduce sulfur content in U.S. gasoline from a maximum of 30 ppm to 10 ppm. U.S. automakers have generally supported this move and have stated that major reductions in tailpipe pollutants could be possible with enhanced exhaust after-treatment made possible through the reduction in sulfur.

One of the larger incentive programs is the U.S. Department of Energy's Clean Cities Program. Clean Cities is a government-industry partnership program that supports local decisions to reduce petroleum use in the transportation sector. 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 access to information and incentives from DOE, other federal and state

[22] 77 *Fed. Reg.* 1323, Jan. 9, 2012, http://www.gpo.gov/fdsys/pkg/FR-2012-01-09/pdf/2011-33451.pdf.

[23] *Ibid.*, p. 1322.

agencies, and industry partners that can help fund significant high impact projects.

Clean Cities coalitions have reduced petroleum consumption by more than 2.4 billion gasoline gallon equivalents (GGE) since 1993 through alternative fuel use and other petroleum reduction strategies. Annual petroleum displacement increased from 15 million GGE in 1994 to 412 million GGE in 2010 — an impressive 28% average annual growth rate. At the same time, Clean Cities efforts accounted for 600,000 new alternative fuel vehicles on the road and helped build 73% of alternative fueling stations nationwide.[24] Clean Cities primary goal is to reduce U.S. petroleum use by 2.5 billion gallons per year by 2020. To achieve this overall goal, Clean Cities identified three petroleum-reduction strategies: 1) replace petroleum with nonpetroleum by promoting smarter driving practices, idle reduction, and the use of more fuel-efficient vehicles and advanced technologies, 2) eliminate petroleum use by encouraging the use of mass transit and trip elimination measures, and 3) develop other congestion mitigation approaches. More information on the Clean Cities program can be found at www.cleancities.energy.gov.

Implementation: Use of Advanced Motor Fuels

Although actual data for 2011 are not yet available, EPA projects that the 13.95 billion RFS2 volume will likely have been blended, having reported that 14.05 billion gallons of biofuel was produced from July 2010 to June 2011, of which all but 0.47 billion gallons was corn-based ethanol and 0.42 billion gallons was biodiesel.[25] (The 14.05 billion figure, however, includes significant exports of ethanol to Brazil.) Over 95% of U.S. gasoline is believed to contain 10% ethanol. It was not yet legal in the U.S. in 2011 to blend greater than 10% for use in vehicles other than flexible fuel vehicles (FFVs). Thus, ethanol blending in 2011 was butting up against the 10% "blend wall," and the total amount blended in 2011 is not expected to be dramatically greater than that for 2010. Both the regulatory barriers discussed above and concerns for liability over misfueling of older vehicles have caused a number of major fuels marketers to decide against marketing 15% blends for the foreseeable future.

Blends of greater than 15% ethanol are marketed in the U.S. at special dispensers for use only in FFVs designed for use with up to E85. There were an estimated 2512 stations selling E85 in the U.S. by end 2011, including

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[24] http://www1.eere.energy.gov/cleancities/pdfs/48231.pdf.
[25] *Ibid.*, p. 1323.

"blender pumps," which sell both blends for conventional vehicles and a range of blends for FFVs (e.g., E20, E30, and E85). FFVs using high ethanol blends have experienced problems with starting and driveability in winter months in some regions. In response, ASTM International 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 in 2011.[26] 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, presumably for FFVs only, although some use in non-FFVs is likely.

The table below provides the current count of alternative fuel refueling stations in the U.S. according to the U.S. DOE's Alternative Fuels Data Center (AFDC).[27]

B20	CNG	E85	Electricity	H2	LNG	LPG	Total
637	1056	2512	6033	56	50	2680	12,927

Although current data are not available on actual fuel use, the following chart (Figure 1) from the AFDC shows estimated alternative fuel use from 1995 to 2009.

[26] http://ethanol.cttstest.nrel.gov/afdc/fuels/ethanol_e85_specs.html.

[27] Updated information, breakdown by state, can also be accessed at http://www.afdc.energy.gov/afdc/fuels/stations_counts.html. Individual station locations can also be accessed on the AFDC site.

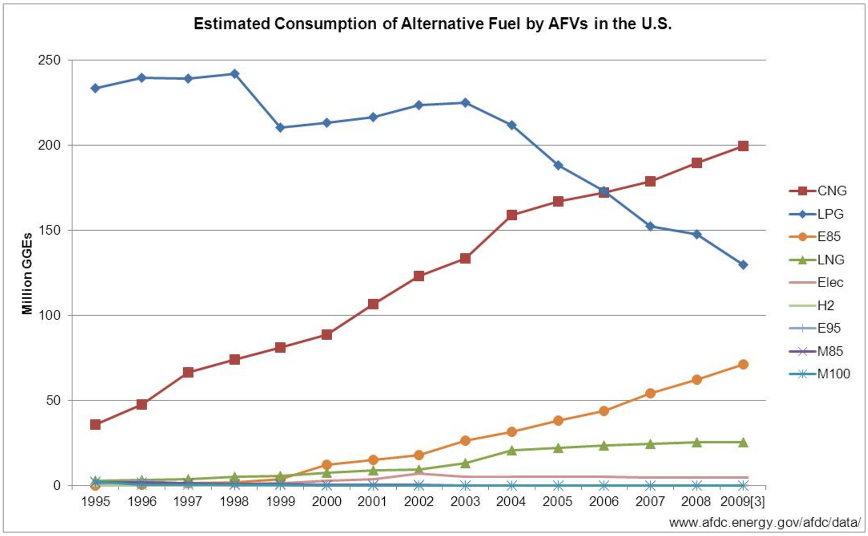

Fig. 1 Consumption of Alternative Fuel by Advanced Fuel Vehicles in the United States, 1995–2009[28]

For biodiesel fuel, which is not shown on Figure 1, EPA estimated that 640 million ethanol equivalent gallons (430 million actual biodiesel gallons) was sold in the U.S. from July 2010 to June 2011. The total for calendar 2011 will undoubtedly be greater than that as biodiesel sales in 2011 by all accounts far exceeded all prior records.[29]

The LNG refueling infrastructure has been growing rapidly in the 2nd half of 2011. Chesapeake Energy and Clean Energy have a joint project to install 150 LNG stations; the two companies, along with a group of international investors, have committed $450 million to the project. Four or five stations have already been completed, with the remainder expected in 2012 and 2013. Some natural gas production companies are also getting involved in LNG infrastructure. New heavy-duty engines are being made available to run on LNG, and there are some LNG to CNG stations being built. These stations are commonly referred to as “LCNG” stations. A number of companies are also investing in CNG infrastructure, and DOE’s Clean Cities program is providing some grant funding for both CNG and LNG stations.

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28 Updated information, breakdown by state, can also be accessed at http://www.afdc.energy.gov/afdc/fuels/stations_counts.html. Individual station locations can also be accessed on the AFDC site.

29 http://biodieselmagazine.com/articles/8288/a-record-year-for-americaundefineds-advanced-biofuel.

Several initial stations are in California, but there are others going in at various places around the U.S. This infrastructure will be installed primarily along interstate trucking corridors. LNG is typically trucked into these stations from liquefaction facilities, three of which have been built dedicated for transportation LNG; others have been built by utilities for storage and peak load shaving.

Outlook

Energy Information Administration (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 identified in the introduction for the decline since 2005.[30]

High oil prices, expected to climb further in 2012, provide a continuing impetus for switching to alternative fuels, particularly natural gas-based fuels, as U.S. gas prices have been dropping due to new supply from shale gas. EIA projects steady increases in use of CNG in both freight trucks and transit buses from the present through 2035 (though it projects CNG use in light duty vehicles to remain at 11.5–12.5 trillion Btu/year through 2035).[31] The EIA has not included LNG in its projections as its use has been limited to date, but, as shown above, the private sector is investing substantial resources on the expectation that a market will develop.

Although 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 transportation use of LPG to decline steadily in the future.[32] This presumably reflects continuing decline in LPG use for farm transportation.

The principal U.S. advanced fuel, ethanol, however, is expected to be constrained in 2012 by the challenges with blending over 10% in gasoline, concerns about misfueling and compatible systems, etc. In fact, EIA projects domestic ethanol production to be nearly flat through 2016, when it is projected to resume brisk growth, although it also expects domestic use to

30 http://www.eia.gov/forecasts/aeo/source_oil.cfm. EIA Annual Energy Outlook 2012. See early release version at http://www.eia.gov/oiaf/aeo/tablebrowser/#release=EARLY2012&subject=0-EARLY2012&table=11-EARLY2012&region=0-0&cases=early2012-d121011b.

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

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

absorb a switch from net exports of 50,000 barrels per day in 2011 to a slight net import position by 2013 and thereafter.[33]

While FFV fuel has not been readily accepted to date, the next few years could be “make or break” years for it due to the combination of high gasoline prices, RFS2 requirements, and constraints on meeting those requirements by additional low level blends. At the same time, however, station owners have expressed some reluctance to install new FFV refueling systems due to the loss of the excise tax credit, making the FFV fuel more expensive than previously, and disappointing sales where FFV dispensing has been installed in the past, often leaving such investments unrecouped. The EIA projects FFV fuel use (based on average blend of 74% ethanol) to reach 10,000 barrels per day in 2014 and to grow briskly from then on (reaching 90,000 barrels per day in 2035, a growth rate of 27.5%/year from 2010 to 2035).[34]

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 toward the goals of RFS2. It is, however, more toxic, which could significantly impair its economics due to loss of by-product value as animal feeds. A few ethanol plants have expressed interest in possibly converting to butanol production. The initial product, however, may have greater value in chemical than fuel markets.

Another significant development in the near and medium term could be a substantial increase in the light-duty diesel market in the U.S. Historically, diesel vehicles have been a very small part of the U.S. light-duty market, particularly the passenger car market. Technology advances and renewed consumer interest in fuel economy, however, have prompted a number of automakers to announce that they plan to introduce additional light-duty diesel vehicles in the next few years.

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[33] http://www.eia.gov/oiaf/aeo/tablebrowser/#release=EARLY2012&subject=0-EARLY2012&table=11-EARLY2012&region=0-0&cases=early2012-d121011b.

[34] *Ibid.*

Additional References

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

Benefits of Participation in the IEA-AMF

The United States Department of Energy’s Vehicle Technologies Program is an active participant in the IEA-AMF annex through the Fuels and Lubricants subprogram. The United States 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. United States Government researchers also benefit from the ability to maintain contact with international experts and interact in research and policy discussions. Many of the countries participating in the AMF are facing the same fuel issues as the United States, and mutual cooperation has proven beneficial in the past and should continue to do so in the future.

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3 Ongoing AMF Annexes

3.a
Overview of Current Annexes

Annex number	Title	Operating Agent
28	Information Service & AMF Website	Dina Bacovsky
35-2	Ethanol as Motor Fuel Sub-task 2: Particulate Measurements: Ethanol and Butanol in DISI Engines	Jean-Francois Gagné
37	Fuel and Technology Alternatives for Buses – Overall Energy Efficiency and Emission Performance	Nils-Olof Nylund
38	Environmental Impact of Biodiesel Vehicles in Real Traffic Conditions	Norifumi Mizushima
39-2	Enhanced Emission Performance of HD Methane Engines (Phase 2)	Olle Hådell
40	Life Cycle Analysis of Transportation Fuel Pathways	Peter Reilly-Roe
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 Powerplant Options	Jukka Nuottimäki

3.b
Annex Reports

Annex 28: Information Service & AMF Website

Operating Agent	BIOENERGY 2020+
Started	28.1.2004 (ExCo 29)
Project Duration	Continuous
Participants	All contracting parties: Australia, Austria, Canada, China, Denmark, France, Finland, Germany, Italy, Japan, Spain, Sweden, Switzerland, Thailand, United States of America
Total Budget	• EUR 65,000 for 2011 • EUR 52,000 for 2012 (as of June 6, 2012, 1 EUR = 1.2499 USD)
Responsible	Dina Bacovsky BIOENERGY 2020+ Gewerbepark Haag 3 3250 Wieselburg-Land, Austria Phone: +43 7416 52238 35 Fax: +43 7416 52238 99 Email: dina.bacovsky@bioenergy2020.eu

Background

The IEA Advanced Motor Fuels Agreement (AMF) has been running an Information Service called IEA AMF/AFIS (Automotive Fuels Information Service) under two previous Annexes, Annex 9 and Annex 24.

AFIS was replaced in 2004 by a new information system, AMFI (Advanced Motor Fuels Information, Annex 28), which combines an electronic newsletter service and maintains the AMF website.

The main task of Annex 28 is to produce four electronic newsletters per year and to maintain the AMF website. In addition, Annex 28 has three subtasks, which are limited in time and budget:

- Subtask 1: Fuel Standardization was active in 2007 and is closed
- Subtask 2: Fuel Information System has been active since 2010 and is ongoing
- Subtask 3: Website Refresh started in 2012

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

Purpose and Objectives

Sharing and providing information are very important elements in IEA cooperation. The AMFI information system makes use of electronic communication. AMFI comprises the production of four yearly electronic newsletters and the maintenance of the AMF website. AMFI/Annex 28 is a low budget Annex, and its costs are shared by all participants of the AMF Agreement.

Activities

- Relevant sources of news are reviewed regarding advanced motor fuels, vehicles, and energy and environmental issues in general. News articles are provided by experts in North America, Asia, and Europe.
- Four electronic newsletters are published yearly (on an average) in the AMF website using the e-mail alert system to disseminate information of the latest issues.
- In 2011, work on the new Alternative Fuels Information System continued. This effort seeks to collate relevant information on alternative fuels and their use for transport. Performance of cars, effect of fuels on the exhaust emissions, and fuel compatibility with infrastructure are covered, whereas resources, production, and

greenhouse gas emissions are excluded. Efforts are being made in close cooperation with different organizations to build a guidebook on advanced motor fuels that will be accessible electronically on the AMF web site.

- The AMF website is updated frequently to provide information on transportation fuel-related issues, especially those related to the Implementing Agreement of Advanced Motor Fuels. In addition to public information, a special password-protected area is provided to distribute and store internal information for Delegates, Alternates, and Operating Agents on strategy, proposals, decisions, and Executive Committee meetings of the AMF Agreement.
- The AMF website shall be refreshed in 2012. Based on the current content and on suggestions for improvement by AMF delegates, a new structure shall be created along with a new design. The purpose is to improve AMF's outreach to stakeholders.

Results and Reports/Deliverables

In 2011, four electronic newsletters were published in April, July, September, and December. The Alternative Fuels Information System was completed for general fuel information for gasoline replacements and for ethanol use as E10. The AMF website was updated frequently with information from Annexes and ExCo meetings.

Future Plans

In 2012, four electronic newsletters shall be published. The Alternative Fuels Information System shall be completed and moved to the public area of the AMF website. The AMF website shall be refreshed.

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

Operating Agent	Canada
Started	November 2010 (ExCo 40)
Project Duration	November 2010 – May 2013 (2.5 years)
Participants	Canada, China, Finland, USA
Total Budget	Task shared
Responsible	Jean-Francois Gagné Natural Resources Canada Ottawa, Canada K1A 0E4 Phone: +1 (613) 947-1963 Email: jegagne@NRCan.gc.ca

Background

As renewable fuel mandates get 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 goals for cleaner domestic renewable energy production 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 U.S., where ethanol use has expanded six-fold 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 emission regulations are becoming more stringent. In addition, the particle number concentrations in DISI engines have been shown to be greater than those for port fuel-injected (PFI) gasoline engines and greater than that for compression-ignition engines with diesel particulate filters.

Purpose and Objectives

Because of the increasing use of ethanol, the growing number of DISI engines available from vehicle manufacturers, and of the impact on the design and effectiveness of aftertreatment systems, there is a need to understand particulate formation due to 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 shed light on 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 tests will be performed with gasoline direct-injection engines, then emissions, power, and fuel economy will be compared. It is suspected that ethanol may have a larger advantage for brake-specific power due to the high octane of the fuel and increased in-cylinder cooling of the intake air charge.

USA Project Activities

The U.S. portion of the project builds on an existing project at Argonne National Laboratory (ANL) using a General Motors DISI engine (2.2 liter, inline 4 cylinder, 16 valve) at idle conditions, as well as at 25%, 50%, and 75% load at 2,000 rpm. The engine control unit controlled spark timing by advancing to the point of knock and then backing the timing off slightly. No optimization was made for exhaust gas recirculation (EGR) levels. 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).

Canada Project Activities

Environment Canada - Emissions Research and Measurement Section (EC/ERMS) conducted chassis dynamometer tests on a light duty vehicle (model year 2011) with a 2.4 L DISI engine meeting the standards of the Tier 2 Bin 5 North American Emissions. This emissions profile was compared to that of a light duty vehicle (model year 2010) with a 2.4 L PFI engine meeting Tier 2 Bin 5. Tests were performed with E0–Tier 2 certification gasoline, E10–10% ethanol by volume, and E20–20% ethanol by volume. Two transient drive cycles were used (FTP-75 and US06) at standard temperature conditions and -7°C and -18°C. The DISI vehicle, in addition to being tested in its original stock configuration, was equipped with a prototype uncatalyzed gasoline particulate filter (GPF). In-situ particle measurements were conducted using both the European Union Particle Measurement Programme (PMP) solid particle system and an Engine Exhaust Particle Sizer (EEPS) to monitor particle number distributions (5-600 nm) in real time. Additional testing and analysis are ongoing to collect particulate matter for metallic ash analysis and to characterize black carbon emissions.

The University of Toronto has taken delivery of a new Ford gas-fueled injection (GDI) engine (4 cylinder, 2 liter) that they will be running on four types of engine test cycles: cold start; hot start; steady-state simulated highway cruise (load and speed representative of a highway cruise operating condition); and simulated passing maneuver. (For the latter, starting from the simulated highway cruise operating condition, wide-open throttle is applied, and the engine speed is allowed to rise for 10 seconds. After the 10 seconds the engine is returned to the simulated highway cruise condition.) During the tests, the engine exhaust will be continually sampled using a mini-dilution system. PM samples will be collected on 47 mm filters, and the particle size distribution will be measured on a continuous basis using a differential mobility spectrometer. Gravimetric determination of PM samples will be carried out in a temperature- and humidity-controlled clean room equipped with a 0.1µg resolution microbalance that enables gravimetric PM measurements to the latest EPA standards. Regulated gaseous emissions (carbon monoxide, total hydrocarbons, and nitrogen oxides) as well as carbon dioxide and oxygen will be measured using a standard emissions bench. A Fourier transform infrared system will also be used to measure gaseous species, including various hydrocarbon species.

Finland Project Activities

The Finnish portion of the project builds on work carried out under Annex 43: Performance Evaluation of Passenger Car, Fuel and Powerplant 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 meeting Euro 5a European Union emission standards. Tested fuels were E10 and E85, and tests were performed in two ambient temperatures, namely, -7°C and +23°C. Measurements were made on a transient New European Driving Cycle (NEDC). Particulate measurements included size distribution (through an Electrical Low Pressure Impactor) and soot mass (on 47 mm filters). Regulated gaseous emissions and fuel consumption were measured with standard emission measurement equipment. Fuel consumption was measured also gravimetrically.

China Project Activities

The China Automotive Technology and Research Center (CATARC) has tested five GDI vehicles with gasoline to date, and plan to test two GDI vehicles with gasoline, M15 and E10 in May. Beijing Institute of Technology (BIT) Laboratory engine testing is still planned, depending on whether a suitable GDI engine can be found.

Results to Date

Results from the ANL work showed significant differences in the levels of particulates produced for the fuels and for the different load/speed combinations. 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. This leads to the conclusion that fuel properties, including viscosity and latent heat of vaporization, may influence combustion behavior, leading to increased particulate emissions. Additionally, late 50% mass fraction burn timing did not lead to larger or higher PM emissions at idle. The ANL results from Annex 35 Subtask 2 will be published as an ASME paper, to be presented at the ASME Internal Combustion Engine Fall Technical Conference in Vancouver, B.C., in September.

The EC/ERMS particle emission results have been analyzed and presented to the Manufactures of Emissions Control Association. In general, the solid particle number emission rates for the DISI stock configuration were higher than those of the PFI vehicle by 10 and 31 times for the FTP-75 and US06 drive cycles, respectively. However, when the uncatalyzed prototype GPF was installed, the solid particle number emission rates were reduced to 2 and 8 times higher than those from the PFI vehicle. For the DISI vehicle, the number-weighted geometric mean diameters over both FTP-75 and US06 were about 50-70 nm. The situation was similar for the PFI vehicle over FTP-75. For the US06, most of the emitted particles from the PFI vehicle were ultrafine particles with a diameter of about 10 nm. E10 fuel had little impact on particle size for both DISI and PFI vehicles. The use of E10 fuel generally led to a reduction in particle number emissions on the PFI vehicle over both cycles. For the DISI, the use of E10 led to a reduction in particle emissions over the FTP-75, but the opposite was observed for the

US06 drive cycle. Based on the test results, the unconditioned GPF had a particle filtration efficiency of 82% and 76% for the FTP-75 and US06 cycles, respectively. Results also revealed that the GPF filtration efficiency was strongly linked to the exhaust temperature, and continued soot regenerations were the reason for the lower filtration efficiency being observed for the US06 drive cycle. Two technical papers on these results are under development.

The preliminary findings on CATARC tests show that for the five GDI vehicles already tested, the PM emission in the first urban cycle makes the greatest contribution of the total PM emission in the entire NEDC cycle, and that the PM emission is directly related with engine temperature. The PM emission at hot start is significantly reduced compared with cold start mode. Regardless of the cold start or hot start, the transient acceleration can significantly increase the PM emission. Finally, according to the current test results, the PM emission is about 2~3.4 mg/km, which can meet the emission regulation 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).

The University of Toronto and VTT's test results should become available over the course of this calendar year.

Time Schedule

All currently planned testing will be completed by June 2012. A draft report is scheduled to be circulated to project partners for review by November 2012. Final report approval is expected in May 2013.

There is a potential to pursue additional testing in the coming two years. This will be presented at the upcoming AMF ExCo 43 in Zürich, Switzerland, and the option of either extending Annex 35-2 to 2014 or to start a new annex on DISI engine technologies will be brought forward for decision by the Executive Committee (ExCo) members.

Annex 37: Fuel and Technology Alternatives for Buses – Overall Energy Efficiency and Emission Performance

Operating Agent	VTT Technical Research Centre of Finland
Started	May 2008 (ExCo 35)
Project Duration	June 2008 – January 2012, to be closed at ExCo 43
Participants	• AMF: Canada, Finland, France, Japan, Sweden, Switzerland, Thailand, United States • Bioenergy: European Commission, Finland, Germany
Total Budget	~€ 1 million (as of June 6, 2012, 1 EUR = 1.2499 USD)
Responsible	Dr. Nils-Olof Nylund VTT Technical Research Centre of Finland P.O. Box 1000 FIN-02044 VTT, Finland Phone: +358 400 703715 Fax: 350 20 722 7048 Email: nils-olof.nylund@vtt.fi

Background

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

Purpose and Objectives

It is obvious that the spectrum of vehicle and fuel technologies is widening, not closing in. This poses a challenge to decision makers at all levels of decision making: governments, local authorities, and fleet operators. Both when setting policies and when procuring new vehicles, the following questions must be confronted:

- Which technology or fuel/technology combination gives the best *overall* energy efficiency?

- Which technology or combination yields the lowest *overall* greenhouse gas (GHG) emissions?
- Which technology or combination is best for reduced *local* emissions and improved urban air quality?
- Which option provides the best overall cost efficiency for reduction of GHG emissions as well as local emissions?
- Which clean fuel options can be implemented for existing vehicle fleets?

The objective of the task was to bring together the expertise of IEA's transport-related implementing agreements to access reliable information on overall energy efficiency, emissions, and costs (both direct and indirect) of various technology options for buses. The technology options vary with respect to engine technology, powertrain technology, and fuels. The outcome of the task will be unbiased and provide solid IEA-sanctioned data for use by policy- and decision-makers responsible for public transport using buses.

Activities

Two Implementing Agreements, namely, AMF and Bioenergy, were the lead partners in this exercise. These two Implementing Agreements formed projects (Annex of Tasks) to carry out the overall project:

- AMF: Annex 37
- Bioenergy: Task 41/Project 3

In addition, all IEA transport-related Implementing Agreements were asked to submit outlook reports (timeline 2020) of their respective technologies.

The project comprised four major parts: well-to-tank (WTT) assessment of alternative fuel pathways, assessment of bus end-use (tank-to-wheel, TTW) performance, and combination of WTT and TTW data into well-to-wheel (WTW) data and cost assessment, including indirect as well as direct costs. The project was a combination of cost and task sharing.

Experts at Argonne National Laboratory, Natural Resources Canada, and VTT worked on the WTT part. Different fuel options were evaluated using RED (EU), GHGenius (Canada), and GREET (U.S.) methodology. In the TTW part Environment Canada and VTT generated emission and fuel consumption data by running 21 different buses on chassis dynamometers, generating data for some 180 combinations of vehicle, fuel, and driving cycle. The TTW work was topped up by on-road measurements

(AVL MTC) as well as some engine dynamometer work (von Thünen Institute).

In vehicle and engine testing, the following fuels diesel and diesel substitutes were covered:

- conventional diesel fuel
- diesel fuels from unconventional fossil sources (natural gas, oil sand-derived fuels)
- biodiesel fuels (methyl esters as well as hydrotreated vegetable oils)

The alternative fuels requiring dedicated vehicles covered were:

- methane (biogas/natural gas)
- additive treated ethanol
- di-methyl-ether (DME)

To ensure real international significance, the vehicle matrix consisted of older as well as top-of-the-line new buses, and also some prototype vehicles. The driveline configurations included conventional as well as hybrid drivetrains. The emission certification of the vehicles varied from requirements of the late 1990s (U.S. 1998 and Euro II) to current regulations (U.S. 2010, Euro V/EEV). The U.S. 2010 requirements are roughly equivalent to Japan 2009 and the oncoming Euro VI regulation for Europe.

As for the WTT part, the spectrum of fuels evaluated was broader than the fuel matrix for actual vehicle and engine testing. The WTT part covered, e.g., several options for actual BTL (biomass-to-liquids) type fuels. GTL (gas-to-liquids) and HVO (hydrotreated vegetable oil) are already in the commercial phase, whereas actual BTL and DME are still in the development phase.

Results and Reports

A draft final report was completed in January 2011. Based on the findings of the project, it is possible to establish the effects of various parameters on bus performance. The largest variations and also uncertainties can be found for WTW 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 GHG emissions is to switch from fossil fuels to efficient biofuels.

The findings can be summarized and quantified as follows (see also Figures 1–3):

Vehicle Level

- Old vs. new diesel vehicles
  - 10:1 and even more for regulated emissions
  - 100:1 for particulate numbers
  - close to neutral for fuel efficiency
- Hybridization and light-weighting
  - 20-30% reduction in fuel consumption
  - not automatically beneficial for regulated emissions
  - energy consumption ratio between the least fuel efficient vehicle with conventional power train and the most efficient hybrid 2:1
- Effect of driving cycle
  - 5:1 for fuel consumption and regulated emissions
- Fuel effects on tailpipe emissions (when replacing regular diesel)
  - 2.5:1 at maximum (particulates)
- Alternative fuels (in dedicated vehicles)
  - low PM emissions but not automatically low NO_x emissions
  - fuel efficiency depends on combustion system (compression or spark-ignition)
  - diesel vs. spark-ignited CNG roughly equivalent for tailpipe CO_2

Well-to-Wheel Level

- Conventional fossil diesel CO_{2eqv}
  - WTT some 20% and TTW some 80% of total WTW
  - 2:1 for WTW for a given fuel (least fuel efficient vehicle with conventional power train and the most efficient hybrid)
- Coal-to-liquid (CTL) diesel CO_{2eqv}
  - WTT some 60% and TTW some 40% of total WTW
- CTL vs. conventional diesel for CO_{2eqv}
  - 2:1
- CNG, DME, and GTL vs. conventional diesel for CO_{2eqv} (average)
  - ~ +10 %
  - CNG equivalent to diesel at its best (local gas)
- Biofuels vs. conventional diesel for CO_{2eqv}
  - relative reduction ~ 30…70% (biofuels from traditional feedstocks)
  - relative reduction ~ 85…95% (biofuels from lignocellulosic feedstocks or waste in vehicles using diesel combustion)
- Conventional biogas vs. CNG for CO_{2eqv}
  - relative reduction ~ 65…90%

- CTL vs. best biofuel for CO_{2eqv}
  - 120:1 (fuel only)
  - 240:1 (fuel and vehicle combined)
- Biofuels vs. conventional diesel for overall energy
  - 2.5:1…1.75:1
- CNG and DME from remote natural gas and GTL vs. conventional diesel for overall energy
  - ~1.5:1

Costs

- External costs for NO_x and PM
  - 12:1 variation in unit prices depending on country and region
  - 200:1 in calculated external costs (including effects of country, region and vehicle, range 0.24…0.001 €/km)
- External costs for CO_{2eqv} (at a price of 40 €/ton of CO_2)
  - 2:1 for vehicle (least fuel efficient vehicle with conventional power train and the most efficient hybrid)
  - 120:1 for fuel (CTL vs. FAME from tallow)
  - 240:1 (fuel and vehicle combined)
- Direct costs (investment, fuel and maintenance calculated as €/km), lowest vs. highest
  - ~ +15% (baseline)
  - ~ +20% (high diesel price)

Time Schedule

The project is in principle completed, and will be closed at ExCo 43 in May 2012.

Future Plans

After approval by the participants, the full final report will be brought into the public domain in the spring of 2012. In addition, the results of the project will be presented in workshops, conferences, and technical papers. The first workshop for the Finnish audience will be held already in February 2012.

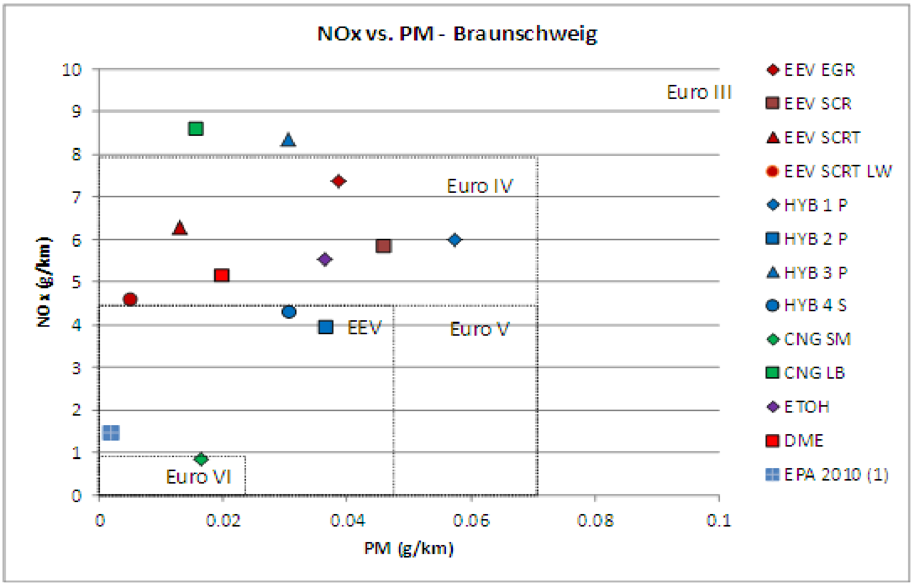


Fig. 1 NO_x vs. PM for European EEV Diesels, Hybrids, and Alternative Fuel Vehicles. Included is also the data point for a North-American EPA 2010 vehicle.

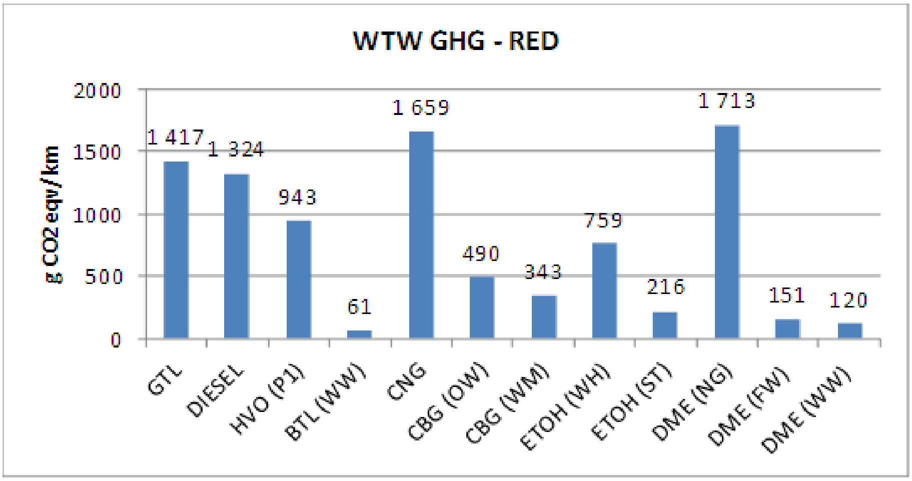


Fig. 2 WTW GHG Emissions for Diesel and Alternative Fuel Vehicles. RED Methodology. Braunschweig Cycle.

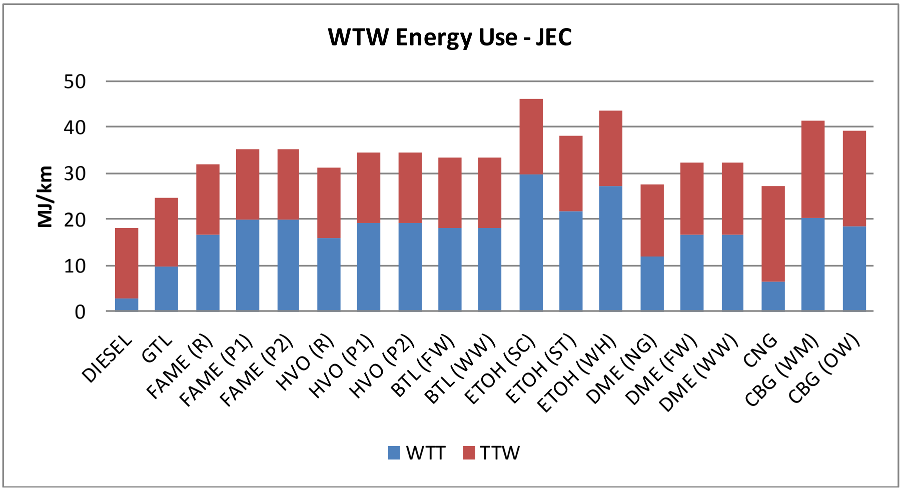


Fig. 3 WTW Energy Using JEC Values (Europe). Braunschweig Cycle.

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

Operating Agent	National Traffic Safety and Environment Laboratory (NTSEL), Japan
Started	28 May 2009
Project Duration	• Phase 1: June 2009 – August 2011 (2 years) • Phase 2: January 2012 – December 2013 (2 years)
Participants	• Phase 1: FI, JP (LEVO), SE, TH and US (5 confirmed participants) • Phase 2: CA, DE, FI, JP (LEVO), SE and US (6 confirmed participants)
Total Budget	• Phase 1: US $ 200,000 (€ 139,800) • Phase 2: € 95,000 (as of June 6, 2012, 1 EUR = 1.2499 USD)
Responsible	Norifumi Mizushima, Dr. Eng. Traffic System Research Department National Traffic Safety and Environment Laboratory (NTSEL) 7-42-27 Jindaiji-higashimachi, Chofu, Tokyo, 182-0012, Japan Phone: +81-422-41-3393 Fax: +81-422-76-8602 Email: mizusima@ntsel.go.jp

Background

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

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

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

Purpose and Objectives

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

In this research, the on-road driving test using PEMS (Portable Emission Measurement System) will be conducted on new diesel vehicles adapted to the latest emissions regulations, of which the emissions level is equivalent to EURO V (Phase 1) and EURO VI (Phase 2). For the test, these diesel vehicles are applied to BDF without special customization, and this study aimed to clarify the real-world emissions between the case of light oil and that of BDF, which includes first-generation and next-generation fuels.

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

Activities

Tasks in this annex are carried out by the National Traffic Safety and Environment Laboratory (NTSEL) and Organization for the Promotion of Low Emission Vehicles (LEVO). NTSEL and LEVO will have meetings to confirm the progress situation of this annex. Annex 38 phase 2 was proposed in the 41st and 42nd Executive Committee (ExCo) meeting and approved by the delegates.

Main activities included the following:

- Procuring a latest heavy-duty diesel vehicle which complied with Japanese 2009 regulation for phase 2 of this annex.

- Conducting chassis dynamometer tests of the latest heavy-duty diesel vehicle fueled with light oil, first-generation BDF (waste cooking oil BDF), and next-generation BDF (HVO and BTL).
- Conducting on-road driving tests of the latest heavy-duty diesel vehicle fueled with light oil, first-generation BDF (waste cooking oil BDF), and next-generation BDF (HVO and BTL).
- Task sharing in the phase 2 with Canada, which includes next-generation BDF (BTL) tests with their test vehicles and equipments.

Results and Reports/Deliverables

The chassis dynamometer tests of the latest heavy-duty diesel vehicle that complied with a Japanese 2009 regulation fueled with light oil and first-generation BDF have been performed (Figure 1). In the case of this test vehicle, NO_x emissions were increased compared with light oil with an increase in BDF mixing ratio, and the results were compared with the case of a diesel vehicle that complied with a Japanese 2005 regulation.
PM emissions were sufficiently low when using BDF as well as light oil.

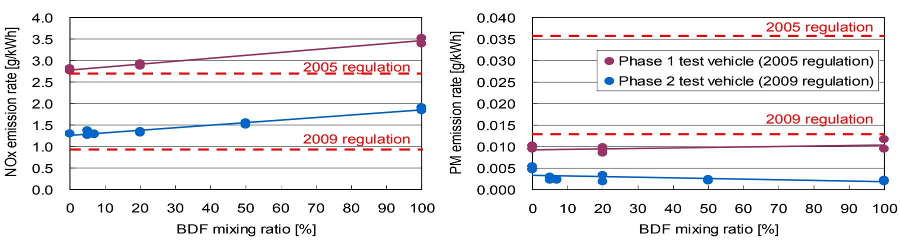


Fig. 1 Emissions Test Results of the JE05 Driving Cycle with First-Generation BDF

Time Schedule

Future activities include chassis dynamometer tests with next generation BDF (HVO and BTL) and on-road driving tests with light oil, first-generation BDF (waste cooking oil BDF), and next-generation BDF (HVO and BTL). See Table 1.

Table 1 Time Schedule, January 2012 – December 2013

Year	2012											
Month	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)										→		
On-road driving test (HVO)											→	

Year	2013											
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chassis dynamometer test (BTL)	→	→										
On-road driving test (BTL)			→									
On-road eco-driving test (Diesel)				→								
On-road eco-driving test (FAME)					→							
On-road eco-driving test (HVO)						→						
On-road eco-driving test (BTL)							→					
Preparation of the final report								→	→	→	→	→

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

Operating Agent	Swedish Transport Administration
Started	November 2010
Project Duration	November 2010 – July 2013
Participants	Canada, Denmark, Finland, Germany, Japan, Sweden
Total Budget	€ 240 000 (as of June 6, 2012, 1 EUR = 1.2499 USD)
Responsible	Olle Hådell Senior Advisor Swedish Transport Administration (STA) Röda Vägen 1 S-781 89 Borlänge, Sweden Email: olle.hadell@trafikverket.se Phone: +46 70 372 43 93

Background

Climate change and a shortage of crude oil are real threats. Because of these threats, the use of fossil fuels has to be reduced to a fraction of the volumes consumed today. This can be illustrated with Figure 1. The left side illustrates carbon dioxide per capita in relation to proposed sustainable levels 2030 and 2050; the right side illustrates different assumptions about peak oil in relation to forecast about rising oil demand. To achieve that level of reduction in road transport, vehicles need to become much more efficient, and renewable energy must be commercialized.

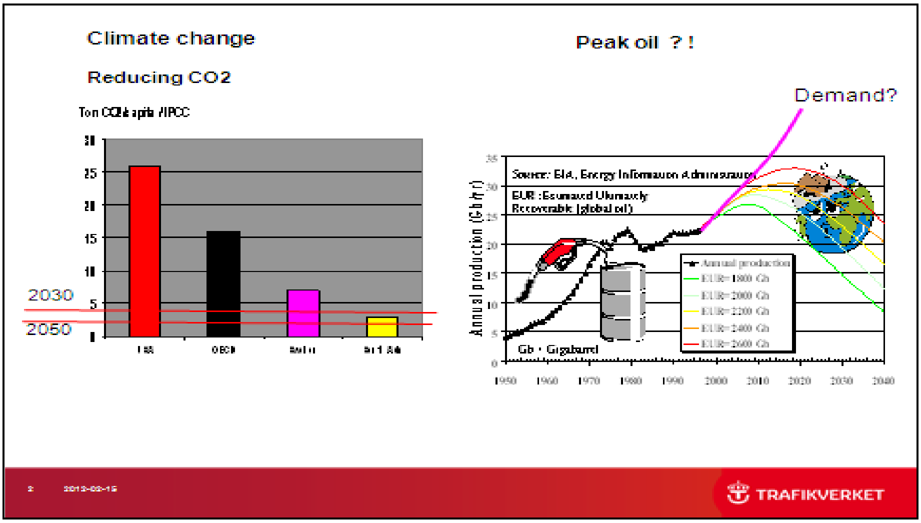


Fig. 1 Climate Change and Oil Demand

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

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

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

Purpose and Objectives

It is important to bear in mind that conforming to the latest emission regulations (limits) requires significant efforts from manufacturers of engines during the development phase of the engine. This implies huge considerations when an engine is converted afterwards to operate on another fuel and still have to 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 the 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 present status of fuel efficiency, diesel replacement, and emission performance for commercially available DDF concepts meeting 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 for a certification scheme and in-service conformity program for HD dual-fuel engines. [Work is carried out in the informal group Gaseous Fueled Vehicles (GFV) within the UNECE Working Party on Pollution and Energy.]
- Consider methods for verification of emissions performance for methane-fueled HD engines in normal operation (i.e., an inspection and maintenance program).

Activities

Phase two of the project is the benchmarking of commercially available methane fueled concepts. Sweden, as the operating agent, will compile test results and experiences from emission laboratories in member countries participating on a task-sharing basis and carry out emission tests of state-of-the-art methane concepts for HDVs. A sophisticated test program has been communicated with participating member countries, and details of the test program can be found in the IEA-Advanced Motor Fuels Annual Report for 2010. Limited testing (on prototype vehicles) has already been carried out both in laboratory environment and on-road during real life operation. The next step will be to carry out emission tests on commercially available vehicles in close cooperation with vehicle manufacturers to verify the emission potential from methane-fueled HDVs. Emission tests in Sweden will be carried out on vehicles with dedicated SI methane engines as well as with vehicles equipped with dual fuel concepts.

The activities in the project can be summarized as follows:

- Plan the overall test campaign
- Carry out emission testing in laboratory and on road
- Compile emission test results from other laboratories
- Analyze test results
- Elaborate and present a technical report for IEA-AMF
- Present the results at seminars/workshop

Results and Reports/Deliverables

The deliverable from phase one of the project was a report, "Enhanced Emission Performance and Fuel Efficiency for HD Methane Engines," a literature study focusing on DDF concepts and highlighting the potential to reach low exhaust emissions and improved engine efficiency (compared to SI-methane engines). The first phase of the project was finalized May 2010.

The report can found at http://www.iea-amf.vtt.fi/annex/annex39.html.

Results from the test program will be presented in a technical report.

Time Schedule

Activity	Time slot
Initial preparatory testing of DDF concepts	April – December 2010
Planning of test program	March – October 2011
Test of first vehicle	March 2012
Presentation of initial results and progress	ExCo meeting May 2012
Test of second vehicle	June 2012
Test of third vehicle	August 2013
Compiling test results from other laboratories	April – September 2012

Activity	Time slot
Analyses of test results	October – December 2012
Presentation of preliminary results	ExCo meeting Nov. 2012
Draft Final Report	February 2013
Final Report	ExCo meeting May 2013
Presentation	

Future Plans

During the planning phase, discussions with stakeholders exposed an interest of the idea to document the potential of emission performance for methane fueled engines and to be able to compare energy consumption and emissions performance in an easy way. However, different stakeholders have different focus, and different questions have to be dealt with. From a strictly technical point of view there will be minor problems to modify the test program, but the timeline to finalize the report might have to be changed. As examples of additional issues to be included in a final report, the following could be mentioned:

- Unregulated emissions from methane fueled HD engines
- Emission performance for converted engines/vehicles in use meeting Euro III standards
- Durability performance for methane-fueled engines
- Difference in emission performance between compressed natural gas and biogas
- Use of liquefied natural gas/biogas (LNG/LBG)

So far, financing is partly arranged for measurement of unregulated components by Fourier transform infrared spectroscopy, mass spectrometry and dinitrophenylhydrazine cartridges. It is the intention to expand the scope of the project to also include this kind of measurement. Further, the European Commission (DG Energy) has expressed the ambition to participate in the project on a cost-sharing basis; at this stage the details are not yet settled.

Annex 40: Life Cycle Analysis of Transportation Fuel Pathways

Operating Agent	Reilly-Roe & Associates Ltd.
Started	November 11, 2010
Project Duration	January 31, 2011 – January 31, 2012
Participants	• Cost Sharing: Canada, Finland, Germany, Japan (AIST), Austria. • Task Sharing: USA, France, Norway, Switzerland, Thailand
Total Budget	50,000 € (as of June 6, 2012, 1 EUR = 1.2499 USD)
Responsible	Peter Reilly-Roe, Operating Agent for Annex 40 President, Reilly-Roe & Associates Ltd. 163 Bell St N, #57060 Ottawa ON, K1R7E1, Canada Tel: 613-862-8336 US Tel: 646-233-4018 Fax: 866-472-8569 Email: peterrr1@mac.com

Background

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

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

Purpose and Objectives

The purpose of this work is to improve the understanding of the concept of LCA of transportation fuels and some of its pertinent issues among non-technical people, senior managers, and policy makers. This work should provide some guidance to nations considering LCA-based policies and to people who are affected by existing or in-development policies.

Activities

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

Communications between countries and the Operating Agent are mainly by conference calls and email, as well as limited meeting opportunities at ExCo venues.

Results and Reports/Deliverables

The project has produced a written report that:

- Provides a general overview of LCA principles (ISO methodologies, multiple approaches, etc.).

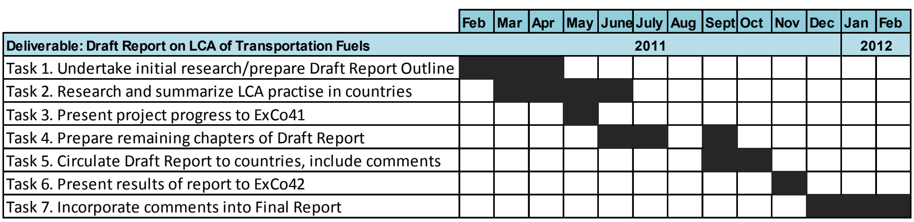
- Characterizes LCA specific sensitivities for transportation fuels (such as scope and system boundaries, data sources, and geo-physical differences).
- Puts sensitivities into context using specific examples and potential impacts of fuel compatibility needs.

As of February 16, 2012, progress included:

- All chapters of the draft final report were completed, including incorporation of written contributions from the USA, Thailand, and Austria.
- The report is in the final stage of preparation. Comments on the draft report received from some countries have been included in the draft final report as of January 31, 2012. Remaining country comments are being incorporated during February 2012, with a view to completing a publication-ready version of the final report before the end of February.

Time Schedule

Annex 40: Draft Report on LCA of Transportation Fuels GANTT Chart
Version: February 16, 2012



Future Plans

It is planned to circulate the pre-publication version of the final report, incorporating all comments, to AMF member countries during March 2012.

As the final report completes the planned tasks on this Annex, a decision will sought at the next ExCo meeting in May 2012, on how broadly and in what form, the report should be distributed.

Annex 41: Alternative Fuels for Marine Applications

Operating Agent	Fuels, Engines, and Emissions Consulting (USA)
Started	November 2011
Project Duration	December 2011 – June 2013
Participants	Denmark, Finland, Germany
Total Budget	80,000 € (as of June 6, 2012, 1 EUR = 1.2499 USD)
Responsible	Ralph McGill, FEEC

Background 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 (AF) within the European maritime sector 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 fewest 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

No results to report yet.

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

No future plans at the moment. However, as possible topics are identified during the course of the study, they will be discussed with the ExCo members.

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

Operating Agent	Jan Czerwinski, AFHB (Laboratory for IC-Engines & Exhaust Emissions Control, Berne, University of Applied Sciences, BFH-TI, Biel, Switzerland
Cooperating Agents	Ronny Winkelmann, FNR, Germany Jean-Paul Morin, University Rouen, France
Started	Nov. 2010, ExCo Thessaloniki
Project Duration	Nov. 2010 – Dec. 2012
Participants	AMF members: • Task sharing: Austria, Canada, China, Denmark, Finland, France, Germany, Japan, Sweden, Switzerland, USA • Cost sharing: all AMF members through the common fund AMF non members: Czech Republic, Greece, Netherlands, Norway
Total Budget	Euro 20,000 • Task sharing, AMF budget 10 kEuro, • Swiss contribution 10 kEuro (as of June 6, 2012, 1 EUR = 1.2499 USD)
Responsible	Jan Czerwinski Univ. of Applied Sciences Bern, BFH-TI, Biel Laboratory for Exhaust Emissions Control (AFHB) Gwerdtstrasse 5 CH-2560 Nidau Switzerland Phone: +41 32 321 66 80 Fax: +41 32 321 66 81 Email: jan.czerwinski@bfh.ch

Background

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

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

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

Purpose and Objectives

The purpose of Annex 42 is as follows: offer information services and knowledge transfer, use the finding at EC and other potential sponsors for the activities of the Engine Toxicity Network (EngToxNet) and help to make these activities known worldwide, inform and encourage the overseas partners/members for activities in the domain of toxicology and health risks, and help several non-member states to become AMF members.

Activities

International

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

The NL-Ministry of Environment (VROM) charged the National Institute of Public Health and Environment (RIVM) to deliver basic propositions for new legal prescriptions. This activity of RIVM, which tries to coordinate the knowledge of toxicologists by organizing and evaluating different international meetings, is called SETPOINT. To obtain a common validated bio-toxicological testing procedure, more test activities worldwide are necessary. Several European countries declared interest to participate in EngToxNet (Engine Toxicity Network) and perform a round-robin validation program of toxicological procedures.

Present Annex

- Contacts with different research groups
- Collection of information
- Preparation of annual information report
- Coordination with cooperating agents
- Sending of report to AMF

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

Operating Agent	VTT Technical Research Centre of Finland
Started	November 11, 2010 (ExCo 40, Decision #9)
Project Duration	January 2011 – December 2012
Participants	China, Finland, Japan, Sweden, United States
Total Budget	~ 400,000 € (as of June 6, 2012, 1 EUR = 1.2499 USD)
Responsible	Jukka Nuottimäki VTT Technical Research Centre of Finland P.O BOX 1000 FIN-02044 VTT, Finland Mobile: +358 40 166 2615 Fax: +358 20 722 7048 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 need to entertain use of multiple technologies to find the best-suited alternatives for each given set of boundary conditions. Fuel efficiency's importance is seen to be growing. Engine downsizing, switching to diesel, and opting for hybridization contribute to fuel efficiency. Renewable energy can be introduced either through biofuels or electricity from renewable sources.

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

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

Purpose and Objectives

The core of the evaluation consists of benchmarking a set of passenger cars of a make and model that offers multiple choices for power plant and fuel such as gasoline, flex-fuel (E85), diesel, CNG/LPG, and perhaps also hybrid and electric vehicle (EV) variations. Examples of European vehicles that offer a multitude of fuel options are the Ford Focus, Volkswagen Passat, and Volvo V70, to name a few. After this project has started, the offering of these kinds of vehicles has increased, and other similar examples can be found, including vehicle platforms that offer hybrid or even EV versions.

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

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

The primary objective of the project is to produce comparable information about different power plant options on 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 that differences between car models and makes. The project is also seen as a way to compare and develop different fuel options. Another objective is to enhance cooperation among research institutes.

Activities

a. Main Activities: Main activities include harmonization of test protocols between participating parties; testing of vehicles on a light-duty vehicle test facility, preferably with cooling equipment and ambient temperature control; and comparison and evaluation of passenger car power plant options.

Vehicle testing has begun in Finland. Sweden and China are expected to begin testing in 2012. Japan and the United States have promised to commit to this project by delivering data from their databases on suitable vehicle tests. Currently, the test matrix (Table 1) includes four vehicle model families and 11 different fuels.

Table 1 Current Fuel Matrix

	China	Finland	Japan	Sweden
Gasoline	1		1	
Diesel	1	1		1
100 % Hydrotreated Vegetable Oil (HVO)		1		
E10	1	1		
E10 + 15 % renewable gasoline		1		
E85		1		1
M15	1			
M100	1			
LPG			1	
CNG	1	1		
Electricity		1		1

b. Sub-activities: These include include coordination of the project and gathering of information on different fuels' well-to-tank (WTT) efficiency. Full fuel cycle performance will we calculated by combining well-to-tank data for various fuels generated in the current IEA Bus Project, and combining this data with the end-use performance for various light-duty vehicle and fuel technologies.

c. Participants and/or experts´ meetings: (Finnish part of the project): As a follow-up, VTT organized the second management group meeting regarding the Finnish part of the project in late September. These management group meetings will be held twice a year during this project.
In terms of the international part of the project, Sweden and China delivered their preliminary project plan and made a commitment to take part to this Annex. The work for harmonization of test protocols has been conducted mainly by email, although regarding to this subject, also a meeting was held in late September with the Swedish participant. The aim is to conduct project meetings within the context of IEA Advanced Motor Fuels (AMF) Executive Committee meetings.

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

Results and Reports/Deliverables

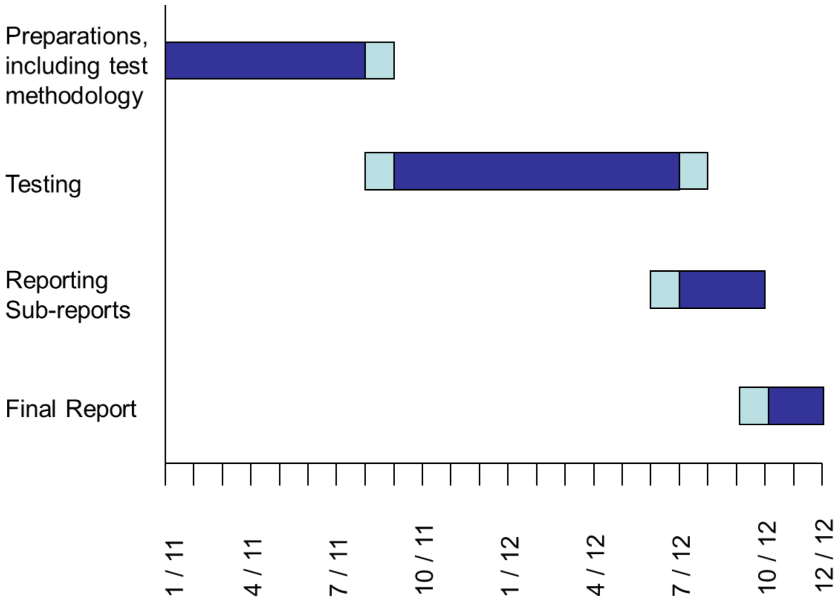
The general outcome will be IEA sanctioned, unbiased data on the performance (energy use and emissions) of new technologies. This type of information is needed for decision makers at all levels.

The expected results are:

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

Time Schedule

The project has started in January 2011, and the duration is originally planned for two years. The breakdown of the schedule is as follows:



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4

The Outlook for Advanced Motor Fuels

The image of standing at an energy crossroad has never been stronger than today. While the worldwide economic crisis seems to have had few effects on slowing the global demand for energy or inversing the increasing trend of emissions of greenhouse gases, concerns about energy security have been heightened by geo-political instability and uncertainty about energy prices. It is therefore critical that we transition to a mix of energy solutions that are clean, reliable, secure, and affordable.

This is also very true when looking at the transportation sector. While economic growth in emerging economies has declined somewhat, the demand for personal vehicles and moving freight by road is still growing. Energy demand in the transport sector has steadily increased in recent years and is projected to more than double by 2050. Currently, the transport sector accounts for 20% of the world's primary energy use and 25% of energy-related CO_2 emissions.

These conclusions have been reached by a multitude of stakeholders, and initiatives have been put forward to address this formidable challenge. As an example, the Global Fuel Economy Initiative (GFEI) partnership has been established, in which the IEA works with the United Nations Environment Programme (UNEP), the International Transport Forum (ITF), and the Fédération Internationale de l'Automobile (FIA) Foundation. This partnership asserts that by creating greater fuel economy, CO_2 emissions will be cut in half by 2050 and six billion barrels of oil a year could be saved by this date.

There is general agreement that the internal combustion engine will constitute the prime technology of choice for personal and freight mobility for many years, if not decades. This is especially true in the heavy-duty segment where the opportunities for electrification are limited. There is also general agreement that the transportation sector is on the verge of a major expansion in the range of environmentally friendly vehicle technologies available to consumers. Highly efficient clean-combustion engines and powertrains offer near-zero NO_x and particulate matter emissions and up to 25% higher efficiency (less CO_2), in comparison to conventional technologies. The evolution of transportation fuels from petroleum to alternative and renewable fuels (all with decreasing carbon footprint), in concert with advanced combustion, will fill an interim gap while the world transitions to a near-zero-emission transportation system in 2050.

Advanced combustion technologies are also improving the internal combustion engine in terms of criteria air contaminant emissions and efficiency (CO_2 emissions), and novel emissions-control technologies allow even further combustion optimization. In addition, various fuel types and chemistries are playing an increasingly important role in optimizing the fuel-engine-powertrain system. The combined effects of these improvement could result in vehicle efficiencies of around 65 mpg US (3.7 litres per 100 km), with emissions of 85 g CO_2/km and brake thermal efficiency (BTE) of about 56% — values that are comparable with those of hybrid technologies.

The increasing interest in reducing the concentrations of “short-lived climate forcers” — substances that contribute to global warming and also have relatively short lifetimes in the atmosphere (including methane, black carbon particles, tropospheric ozone and many hydrofluorocarbons) — will also have an impact on how fuels and engine technologies can be introduced to the marketplace. This reduction would not only enhance climate protection on the global scale, but it would also do so at the regional scale because reducing black carbon particles, in particular, will mitigate their current impact on regional climate processes. There is evidence to suggest that they are altering regional rainfall patterns and cloud formation and contributing to the accelerated melting of ice and snow in such regions such the Arctic and the Himalayas.

Increasing the penetration of both advanced transportation fuels and highly efficient clean combustion engines and powertrains into the marketplace in the near to medium term will require knowledge of the interactions among fuels, engines, emissions controls, and the refueling infrastructure. There is a need for research that evaluates the suitability and performance of potential advanced motor fuels for use in advanced and legacy transportation technologies. Some questions that need to be answered include:

- Can Alternative Fuel Vehicles match conventional vehicles in terms of practicality, general performance, and operational costs?
- Which alternative fuels can make the biggest impact when applied to existing vehicles (fungible fuels, drop-in fuels)?
- Will the regulatory framework be able to cope with the myriad of technology options?
  - Will regulations impede the adoption of new technologies?
  - Will the new technologies bring about new issues to be regulated?

- Can lessons learned in the on-road sector be applied to off-road applications?

Transportation fuels must function in today's vehicles and tomorrow's advanced technologies. The advancement of transportation technology will be enabled through the elucidation of the interactions among fuels, engines, emissions controls, and refueling infrastructure. Ensuring the smooth transition of lower-carbon-intensity fuels in our transportation system requires knowledge of the integration aspects of the whole system (see Figure 1). The interaction between the fuels that are being produced and the technologies that use them needs to be investigated to develop combustion technologies that are optimized for the intrinsic advantages of novel fuels, rather than relying on traditional technology adaptation.

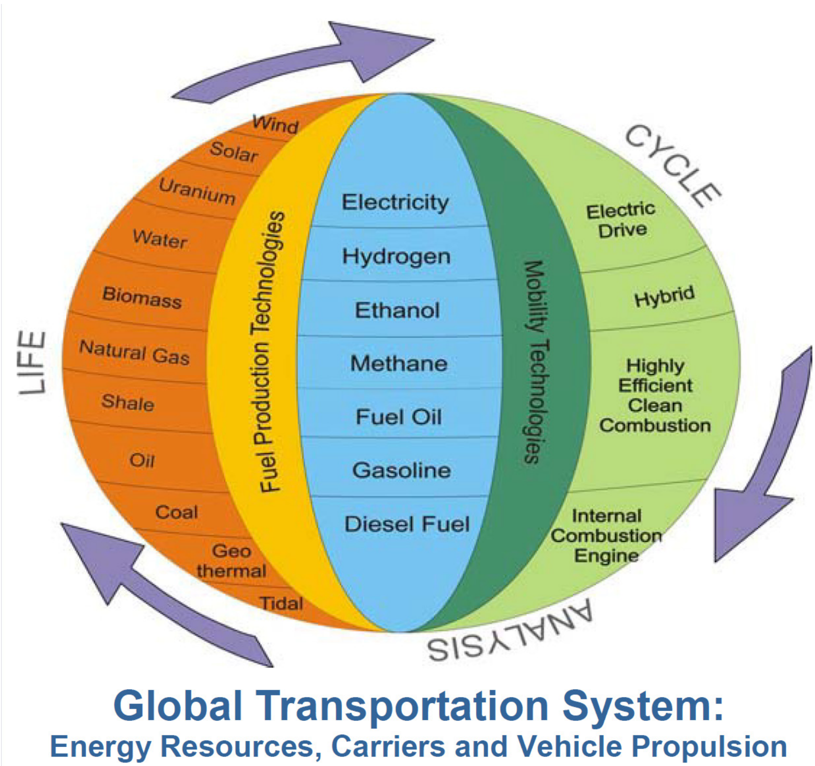

Fig. 1 The Integrated Nature of the Transportation Energy System (Source: CanmetENERGY)

The options for transportations fuels are changing and evolving at an unprecedented pace, and the science needed to support the deployment of innovative transportation fuels needs to evolve with them. As an example, the introduction of more fungible renewable liquid fuels will create a need to analyze potential new issues related to their safety or operability. Bringing in new fueling infrastructure to support alternatives requires data to ensure that these fuels can be distributed and used safely and reliably. Other issues stem from increasing the allowable blend ratios of currently available renewable fuels. The impact of those new requirements needs to be analyzed, and so do the data generated to support developing or modifying infrastructure and storage technologies. The rapid development of a new market place for natural gas in the heavy- and medium-duty transportation sector — spurred by an increasing supply of natural gas — and an increased interest in LNG as a supply option have meant that there is also an immediate need for R&D to evaluate the suitability and the potential for improvement of current distribution and storage technologies.

Governing bodies need to be able to rely on unbiased analysis of the potential for technology to enable the achievement of specific policy objectives. The insight obtained through involvement in R&D work helps provide information needed for (1) making policy decisions, (2) achieving policy goals, (3) identifying the potential risks associated with counteracting policy instruments, and (4) determining the real capacity to meet advertised technology potentials. R&D work provides access to open-source, detailed fuel and technology performance data and knowledge to policy makers, regulators, industry, and the public to help them identify the most effective ways to reduce the environmental impact of the transportation system on a life-cycle basis.

Additional efforts are needed to improve the communication between policy makers and scientists. There is a need for a policy vision that is well aware of technological capabilities and limits, so that goals are achievable and programs are available to develop optimal solutions to our energy challenges. There is an equal need for a strong innovation system that is targeted toward the development of solutions that are consistent with policy direction and needs. Solutions are needed to close the communication gaps between the long-term vision of scientists and the need for tangible solutions resulting from the policy decision-making process.

As information on environmental benefits of current and emerging transportation technologies and fuels is used as input to the policy-making process, those who are charged with analyzing options and formulating policies (regulations and others) that foster sustainable development and sustainable transportation must have ready access to the most recent information on the progress of transportation technologies that are emerging to meet current and future emission standards. Alternatively, understanding the key policy objectives allows R&D efforts to be focused on areas of greatest need, which will ensure the relevance of the information developed and knowledge gained.

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5 Further Information

5.a
Advanced Motor Fuel Executive Committee Meetings

In 2011, two Executive Committee (ExCo) meetings took place.

ExCo 41, May 24–26, 2011, Karlsruhe, Germany

Advanced motor fuels, whether from renewable feedstock or unconventional fossil sources, are going to keep playing a major role in the foreseeable future of transportation energy. No single fuel will emerge as the solution for all transportation modes – vehicle electrification, along with both liquid and gaseous fuels, will play a role in meeting the demand for sustainable transportation energy supply.

The interaction between fuel characteristics and vehicle technologies needs to be investigated before a solution can be embraced – there is a need to ensure that the new technologies being developed to increase vehicle efficiencies are compatible with, or even better optimized for, the current and emerging fuels.

The development of sustainability criteria that address the full life-cycle environmental and socio-economic impacts of transportation energy can act as both driver and challenge to the large-scale development and deployment of advanced transportation fuels.

For the 41st Meeting of the Executive Committee of the Advanced Motor Fuels Implementing Agreement, 42 participants from 17 countries gathered in Karlsruhe, Germany, May 24–26, 2011. The meeting program included regional overviews on advanced motor fuels, discussions on current annexes and annex proposals, outreach of AMF work, and AMF management issues. As usual, an informal meeting on day one was followed by a study tour on day two, and the meeting concluded with the formal meeting and voting on ExCo decisions on day 3. The study tour included visits to the Karlsruhe Institute of Technology (KIT) and the John-Deere-Factory Mannheim (JDF Mannheim).

Trends and Developments of Advanced Motor Fuels around the Globe

The meeting host, the AMF Chairman, and the two Vice-Chairmen gave regional overviews for Germany, Europe, Asia, and North America. Drivers to new fuels are quite similar across the globe: global warming, energy security, regional development, and air pollution. Policies as well as fuel standards are in place in Europe and North America and in place or under development in Asia.

Current Annexes

Currently, 10 annexes are active. Six of them kicked off at ExCo 40, and thus some are not yet fully established. In detail:

- **Annex 28: Information Service & AMF Website**
  This is a continuous annex which provides information to AMF members and motor fuel experts via the website and the quarterly newsletter. The Operating Agent changed from Päivi Aakko-Saksa to Dina Bacovsky. The website shall be refreshed in 2012. Päivi Aakko-Saksa continues to be responsible for the development of "Fuel Info," which shall provide information on advanced motor fuels and their end-use related aspects.
- **Annex 34-2: Algae as Feedstock for Biofuels**
  This is the second subtask under the umbrella of Annex 34: Biomass Derived Diesel Fuels. Work has been completed; the final report is already available to the annex participants. A joint executive summary with IEA Bioenergy Task 39 shall be made and published. Currently, no follow-on work is considered. Annex 34 shall remain open to facilitate new subtasks.
- **Annex 35-2: Particulate Measurements: Ethanol and Butanol in DISI Engines**
  This is the second subtask under the umbrella of Annex 35: Ethanol as Motor Fuel. It was kicked-off at ExCo 40. Work is based on task sharing. Five countries indicated their interest in participating. Chassis dynamometer and engine tests are planned.
- **Annex 37: Fuel and Technology Alternatives for Buses – Overall Energy Efficiency and Emission Performance**
  This project is a great opportunity to deliver policy advice on bus fleets. The annex is a collaborative effort between AMF, Bioenergy, and HEV. Consequently, formalizing the collaboration is a task in itself. In the meanwhile, most of the work has already been carried out, and first results shall be published in technical papers. The final report of Annex 37 shall be brought into the public domain without lead time.

- **Annex 38-1: Environmental Impact of Biodiesel Vehicles in Real Traffic Conditions**
  Most of the work under Annex 38 has already been carried out, but due to the earthquake in Japan, there has been some delay. The annex is extended by 3 months, and the final report shall be delivered at ExCo 42. Phase 2 of this annex was discussed. For details see below (proposals).
- **Annex 39-2: Enhanced Emission Performance of HD Methane Engines (Phase 2)**
  Phase 2 of Annex 39 was kicked-off at ExCo 40. It is a task-shared annex but includes a small coordination fee to facilitate producing a joint report. The Operating Agent is in the process of developing a detailed test program which shall be carried out in each of the participating countries.
- **Annex 40: Life Cycle Analysis of Transportation Fuel Pathways**
  This annex was kicked-off at ExCo 40. Work shall be carried out by the Operating Agent (Reilly-Roe & Associates); participants shall contribute through cost sharing. Discussion on the details of the work program is ongoing between the potential participants.
- **Annex 41: Alternative Fuels for Marine Applications**
  Annex 41 had difficulties getting started, but indications during the meeting were that it would meet sufficient interest to actually take off. It was decided that as soon as there is enough interest and funds, work can be started; if this has not happened until ExCo 42 the annex will be withdrawn.
- **Annex 42: Toxicity of Exhaust Gases and Particles from IC Engines – International Activities Survey (EngToxIn)**
  Work under this annex is carried out by the Operating Agent (University of Applied Sciences Bern) and financed from the common fund. All AMF members are asked to contribute information they may have available concerning toxicity issues. There is special interest in Asian work.
- **Annex 43: Performance Evaluation of Passenger Car, Fuel and Powerplant Options**
  This is a task shared annex with Finland additionally covering expenses for coordination. The platforms as well as the test matrix have been defined, and Finland has started working. The list of participants should be enlarged. Participants from Asia and North America are particularly interesting.

For all annexes, it was decided that they shall consider including a section with an acknowledgment of annex participants in the annex report.

Annex Proposals

Five pre-proposals were presented by the German institutes Deutsches Biomasseforschungszentrum (DBFZ), KIT, and Rostock University. In addition, phase 2 of Annex 38 was proposed. The five pre-proposals were:

- Advanced Motor Fuels in Small SI Engine Applications – Kai Beck/ Ulrich Spicher, KIT
- Influence of Fuel Blends on Soot and NO_x-Emissions in a Diesel Engine - Uwe Wagner, KIT
- Future Fuels for Modern Gasoline Engine Concepts - Heiko Kubach, KIT
- Synthesis, Characterization and Use of Hydrotreated Oils and Fats for Engine Operation - Christian Fink, Rostock University
- "Opportunities and Challenges for the Implementation of Biomethane as Alternative Motor Fuel" - Michael Seiffert, DBFZ

Feedback was provided to all five pre-proposals on how to better integrate the planned work into existing AMF annexes or other IEA Implementing Agreements. All were invited to present updated proposals at ExCo 42. (In the meanwhile, DBFZ has indicated to do so, the others have declined.)

A proposal for Phase 2 of Annex 38 was presented. It was decided that the annex shall be opened up to more participants, that potential participants shall raise funds for cost sharing, and that Phase 2 of Annex 38 shall be started as soon as the participants have raised the funding.

Outreach

AMF aims to disseminate the findings of its work within and outside the participating countries. Therefore, it was decided at ExCo 40 to put greater efforts in the Annual Report 2010. The result is nearly 200 pages, including country reports from 14 countries, 11 annex reports, a global overview of and an outlook for advanced motor fuels, and a section on IEA AMF in general. The Annual Report 2010 shall be printed as a book and used as an outreach document.

Additional outreach documents are a new flyer on AMF as well as upcoming Annex Reports. The report on Algae Biofuels of Annex 34-2 shall also be distributed in print.

AMF comprises 16 Contracting Parties, and four countries attend to AMF meetings as Observers: Czech Republic, Greece, Norway, and Turkey. All four of them are interested in becoming Contracting Parties in AMF and have started the respective procedures. Official invitations to attend as Observer were sent to Brazil, India, Korea, Poland, and Uruguay. A

Delegate of Korea actually participated in ExCo 41. Initial contacts were established with Portugal, Latin America Energy Organization (OLADE), and South Africa.

AMF Management Issues

Starting January 2011, Dina Bacovsky, BIOENERGY 2020+, replaces Claes Pilo as AMF Secretary. There was a transition period of four months in 2010 to facilitate a smooth transition.

Some progress was made in delivering the "Notification of Annex Participation" letters to the IEA Secretariat. With six annexes just kicked-off at ExCo 40, formal annex texts for most of the annexes are not yet available, but shall be completed as soon as possible.

Cooperation and information exchange within the IEA Energy Technology Network are good and further improving. AMF participates in the Transport Contact Group (TCG) and the End-Use Working Party (EUWP) and reports to the Committee on Energy Research and Technology (CERT). AMF has also participated in two Networking Workshops organized by the IEA Secretariat. Direct contacts with members from other transport-related Implementing Agreements are established, and they are invited to participate in meetings. AMF has participated in an IEA Bioenergy ExCo Meeting in May 2011, and the Technical Coordinator of IEA Bioenergy has participated in the IEA AMF ExCo 40 in May 2011. Through AMF Annex 37 and AMF Annex 34-2 direct cooperation is performed.

AMF receives funds from 15 countries (EUR 9,500 per country) and still holds ~ EUR 60,000 from 2010 funds. Expenses in 2011 (for the Secretariat, Annex 28 and Annex 42, the Annual Report and printing costs) shall amount to ~ EUR 180,000. The balance will be ~ EUR 20,000[35].

Next Meeting

The next meeting of the IEA AMF Executive Committee, ExCo42, was held October 25–27, 2011, in Istanbul, Turkey.

[35] As of June 6, 2012, 1 EUR = 1.2499 USD

ExCo 42, October 25–27, 2011, Istanbul, Turkey

The 42nd Executive Committee Meeting (ExCo 42) of the IEA-AMF Implementing Agreement was held in Istanbul, Turkey, October 25–27, 2011. In addition to the usual cooperative interactions between the AMF member parties, the meetings provided opportunities to liaise with the Tübitak Marmara Research Center (MAM), under the Scientific and Technological Research Council of Turkey, an advisory agency to the Turkish Government on science and research issues. This was enhanced through very interesting technical tours of the MAM facilities, as well as a tour of the Tüpras refinery, where Tüpras R&D activities were described.

During ExCo 42, discussions were undertaken to help AMF plan its activities in a more strategic way, and to encourage broader participation from member and potential member countries. The purpose of these discussions was to help AMF start new annexes while ensuring the work focuses on areas of importance to participating countries. The yearly country reports were seen as a good means to identify key areas, but a more visual tool could help in coordinating efforts. It was proposed that a matrix of fuels of interest and areas to be explored be prepared to help highlight where AMF currently is focusing its efforts, and to help identify areas that may need more work. This tool could then be used by member countries to report on their current and future research interests.

ExCo 42 also provided an opportunity to discuss current AMF annexes, as well as potential new projects. The IEA-AMF has ten annexes running at this time. These include:

Current Annexes

- **Annex 28: Information Service & AMF Website**
  - The work on Fuel Info to provide aggregated information on end-use aspects of all fuels was discussed, and it was agreed to extend the completion to Summer 2012.
  - It was decided to start work on refreshing and improving the structure and the layout of the AMF website.
- **Annex 34: Biomass Derived Diesel Fuels; through its sub-task 2 - Algae as Feedstock Biofuels**
  - The joint AMF-Bioenergy Executive Summary was approved by the annex participants.
  - The ExCo decided to close Annex 34.

- **Annex 35: Ethanol as a Fuel for Road Transportation; through its sub-task 2 - Particulate Measurements: Ethanol and Butanol in DISI Engines**
  - This task is on-going.
  - The annex participants agreed to results from testing at ANL to be published in a SAE or ASME paper.
- **Annex 37: Fuel and Technology Alternatives for Buses – Overall Energy Efficiency and Emission Performance**
  - The WTW calculations have been completed, and the report is being finalized.
  - The annex participants agreed to a reduced scope for the cost calculations if France cannot meet its obligations.
- **Annex 38: Evaluation of Environmental Impact of Biodiesel Vehicle in Real Traffic Conditions**
  - Phase 1 was completed and Phase 2 started.
  - Annex 39 - Enhanced Performance of Methane Engines
  - Phase 2 is now ongoing.
- **Annex 40: Life Cycle Analysis of Transportation Fuel Pathways**
  - All work is ongoing according to schedule.
  - Some additional funds may be required depending on the input received from task sharing participants.
- **Annex 41: Alternative Fuels for Marine Applications**
  - Official funding pledges from participating countries of this annex were resolved.
- **Annex 42: Toxicity of Exhaust Gases and Particles from IC Engines – International Activities Survey (EngToxIn)**
  - Input was received from participating countries.
  - The report is being prepared for submission at ExCo 42.
- **Annex 43: Performance Evaluation of Passenger Car, Fuel and Powerplant Options**
  - Activities for this annex have started.

Annex Proposals

Two new proposals were discussed during ExCo 42:

- Opportunities and Challenges for the Implementation of Biomethane as Alternative Motor Fuel: This proposal was discussed at ExCo 41 in Karlsruhe, and the proponents were asked to coordinate their proposal with other related efforts (e.g., IEA Bioenergy Task 37) and to come back with a scaled-down version looking at issues specific to the application of biomethane in the transportation sector. Although the scope of work was decreased to focus on transportation aspects, the overall budget did not reflect these changes, and the coordination aspects were deemed insufficient (e.g., no formal link with other groups). The ExCo re-iterated its interest in the work, albeit through a better coordinated effort with more detailed interactions and work packages definitions.

- Proposed Evaluation of Alcohols as Compression Ignition Engine Fuels: A new idea was discussed to identify and assess opportunities and barriers to the introduction of alcohols in compression ignition engines. This would originally focus on ethanol as a diesel substitute in heavy-duty vehicles, with a specific look at ignition improvement additives where combustion aspects might be assessed together with the Combustion IA. It was suggested that the range of engines might be extended to medium duty or even light duty vehicles.

Next Meeting

The next IEA-AMF Executive Committee Meeting was scheduled from May 30 to June 1, 2012, in Zürich, Switzerland. It was suggested to host the following meeting in Latin America, preferably in conjunction with an international conference to allow as many observers as possible to learn of AMF activities.

5.b
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5.c
IEA-AMF Publications in 2011

- **Annex 34-2: Biomass-Derived Diesel Fuels: Algae as a Feedstock for Future Fuels**
  - Algae as a Feedstock for Biofuels: An Assessment of the State of Technology and Opportunities. Final report, May 2011.

- **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). 1st Information Report for IEA Implementing Agreement AMF, September 2011.

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Glossary

Advanced Motor Fuels (AMF)

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

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 and 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.

Compressed Natural Gas (CNG)

CNG consists mostly of methane and is drawn from gas wells or in conjunction with crude oil production. CNG vehicles store natural gas in high-pressure fuel cylinders at 3,000 to 3,600 pounds per square inch. An odorant is normally added to CNG for safety reasons. In many cases, CNG vehicles generate fewer exhaust and greenhouse gas emissions than their gasoline- or diesel-powered counterparts. Two types of CNG fuel systems are on the market: dedicated vehicles, which operate exclusively on natural gas, and dual-fuel vehicles, which can use both natural gas and gasoline. CNG generally costs 15–40% percent less than gasoline or diesel. CNG requires more frequent refueling, however, because it contains only about a quarter of the energy by volume of gasoline. In addition, CNG vehicles cost between $3,500 and $6,000 more than their gasoline-powered counterparts, primarily because of the higher cost of the fuel cylinders. (Source: U.S. EPA, www.afdc.energy.gov/afdc/pdfs/epa_cng.pdf)

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 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 its 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 produced domestically, 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 to 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. With only minor adaptations to vehicles, B100 may also be used as a pure fuel.

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, because of 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 powers electric motors that drive the vehicle. Fuel cell vehicles have the potential to lower harmful emissions in comparison to internal combustion engines.

Green House Gas (GHG)

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

Hydrofluorocarbons (HFC)

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 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, as an alternative to gasoline to power current vehicles equipped with ICEs. 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 because it can potentially contaminate 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 conversion is a popular trend among fleet vehicles. The only new OEM NGV available in the U.S. market is the Honda Civic Natural Gas model — in years past, by comparison, multiple vehicles were available.

Countries in Europe and Asia offer a much wider selection of OEM NGVs.

NO_x

Nitrogen oxides are composed of nitric oxide (NO) and nitrogen dioxide (NO_2). NO_x is formed from the nitrogen and oxygen molecules in the air and are a product of high-combustion temperatures. NO_x is responsible for the formation of acid rain and smog. The three-way catalyst, which operates most efficiently at stoichiometric air-fuel ratios, has significantly 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 significantly 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)

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

Notation and Units of Measure

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

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

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

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

Units of Measure

cc	cubic centimeter
GWh	gigawatt-hour(s)
kg	kilogram(s)
kL	kiloliter(s)
km	kilometer(s)
kt	kiloton(s)
ktoe	kiloton of oil equivalent
kW	kilowatt(s)
L	liter(s)
Mtep	million-ton equivalent of petroleum
PJ	Peta-joules (1×10^{15} joules)
TJ	terajoule(s)
toe	tons of oil equivalent
¥/L	yen(s)/liter
€/L	Euro(s)/liter