Environment Canada Environnement Canada

Canada

International Energy Agency

AMF Annex XXXVII: Fuel and Technology Alternatives for Buses

Debbie Rosenblatt

Environment Canada

September 23, 2009

Outline

- AMF: Fuel and Technology Alternatives for Buses
  - Project Objectives, Plans, Test Details
- Evolution of Bus Tailpipe Exhaust Emissions
- Questions

Fuel and Technology Alternatives for Buses: Objectives

- To characterize the life-cycle performance of technology options either currently available or available in the near future
- To assess overall energy efficiency, emissions, and costs of various technology options for buses
- The outcome of the task will be unbiased and solid IEA sanctioned data for policy- and decision-makers responsible public transport
- The project will bring together various international expertises (Canada, Finland, France, USA)

Approach

- Well-to-tank analysis **(ANL, NRCan, VTT)**
  - based on existing data for various fuel options
  - ranges depending on feedstock and process
- Tank-to-wheel analysis **(EC,VTT,AVL)**
  - actual testing of the most relevant technology and fuel options
  - fuel efficiency and exhaust emissions
  - effects of driving conditions, powertrains, and fuels
- Well-to-wheel analysis
  - synthesis of WTT and TTW
- Cost estimates **(ADEME)**
  - direct costs (infrastructure, fuel and vehicle)
  - external costs (valuation of exhaust emissions)
- Overall Assessment **(ADEME, ANL, EC, NRCan, VTT)**

WTT: Fuels

- Diesel Options:
  - conventional diesel, including oil-sand derived diesel fuels
  - Biodiesel from various feedstocks
  - Hydrotreated vegetable oil from various feedstocks
  - Synthetic Diesels:
    - BTL synthetic diesel from various feedstocks
    - CTL from coal without and with carbon capturing
    - GTL from various natural gas sources without and with carbon capturing
- Ethanol:
  - conventional ethanol from sugarcane, corn and wheat
  - ethanol based on waste
  - lignocellulosic ethanol
- Methane:
  - natural gas from various sources, end use as CNG or LNG
  - biogas from various sources
  - synthetic natural gas
- DME from natural gas and renewable sources
- Hydrogen from fossil and renewable energy sources

Fuel Pathways

Table 2: Heavy-Duty Vehicle and Fuel Pathways

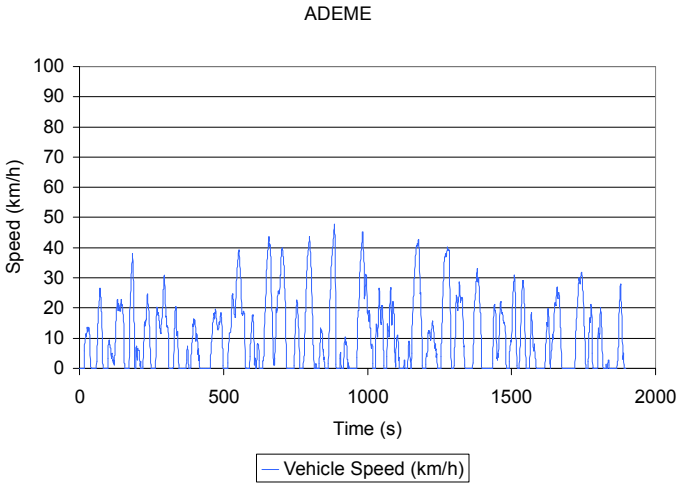
	Gasoline	Diesel or Blends	FTD	DME	Methanol	Ethanol	Butanol	Mixed Alcohols	Biodiesel	Super Cetane	Natural Gas	LPG	Hydrogen	Hythane
Crude oil	ICE FC	ICE										ICE	FC	
Coal			ICE		ICE FC						ICE			
Natural gas			ICE	ICE	ICE FC			ICE			ICE	ICE	ICE FC	ICE
Landfill gas					ICE FC						ICE		FC	
Wood or grass			ICE		ICE	ICE		ICE			ICE		FC	
Corn						ICE	ICE						FC	
Sugar cane						ICE								
Sugar beets						ICE								
Wheat						ICE							FC	
Barley						ICE								
Peas						ICE								
Soybeans									ICE					
Canola									ICE	ICE				
Palm									ICE					
Tallow									ICE	ICE				
RDF			ICE					ICE						
Yellow grease									ICE					
Marine oils									ICE					
Electricity													ICE FC	ICE
Nuclear													FC	

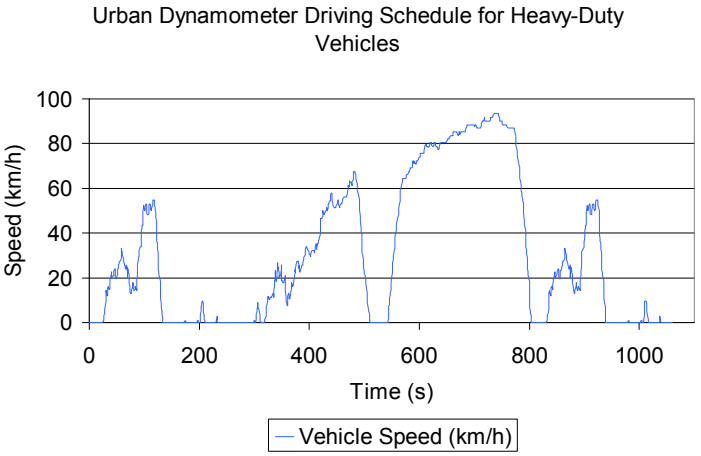
ICE = internal combustion engine
FC = fuel cell

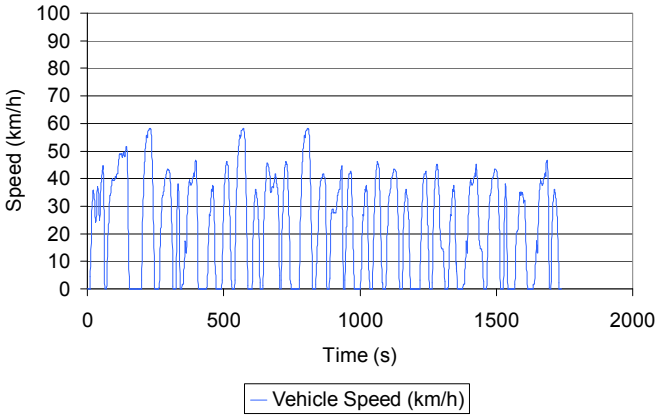
Chassis Dyno Measurements: Technologies and Fuels

- Conventional Diesel Powertrains
  - Current and next tier emissions certified
- Hybrid Diesel Powertrains
- Conventional Natural Gas Powertrains
- EEV certified Scania Ethanol Bus
- Fuel Cell Bus
- Diesel Fuel Options
  - Traditional biodiesels, hydrotreated vegetable oils, synthetic diesel (CTL, BTL,GTL), oilsands derived
- Non-commercial/Emerging Fuels

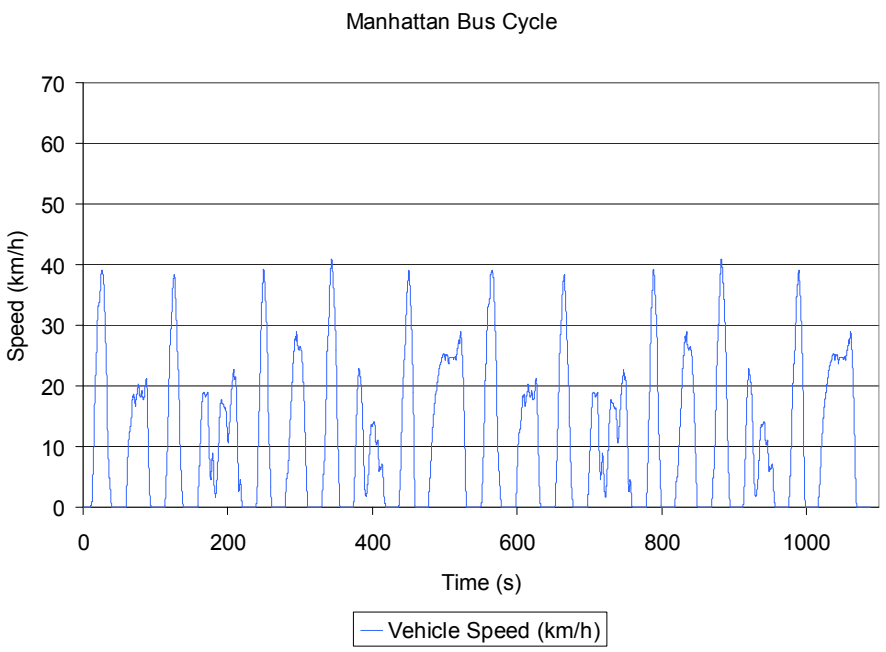
Drive Cycles - Common

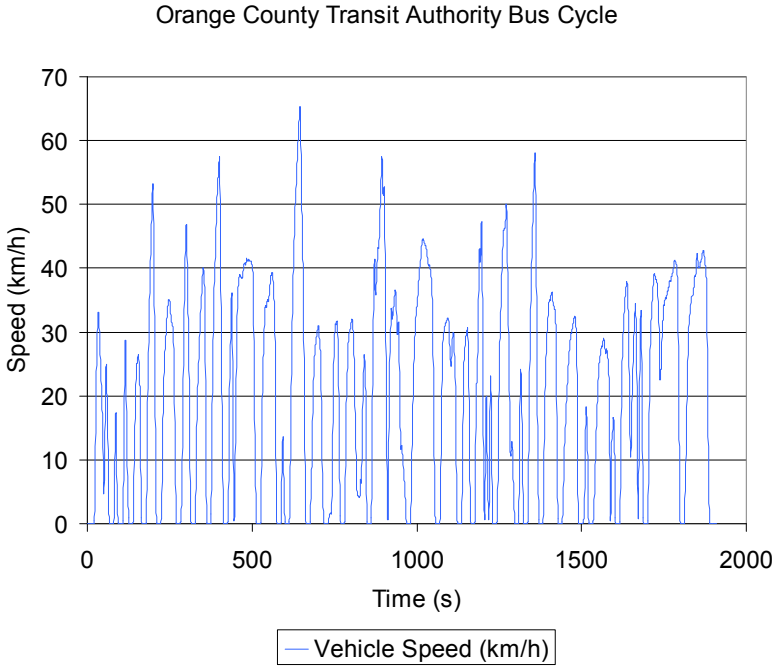




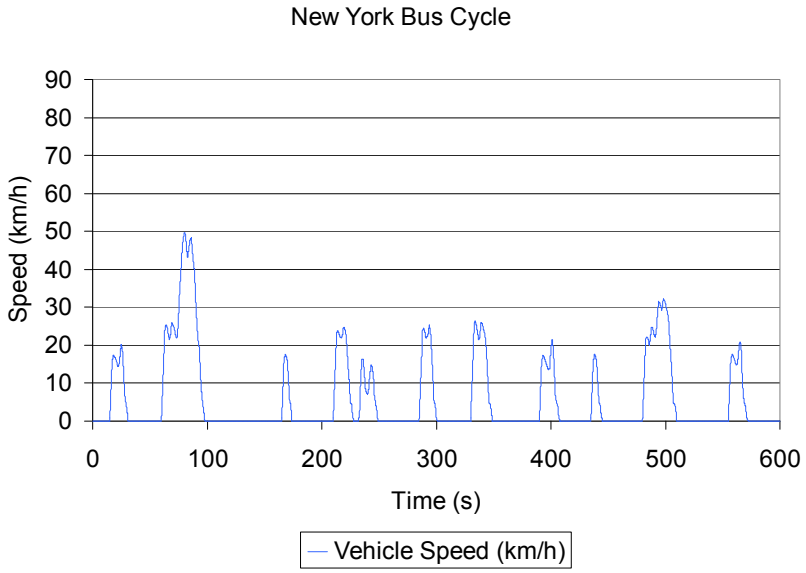


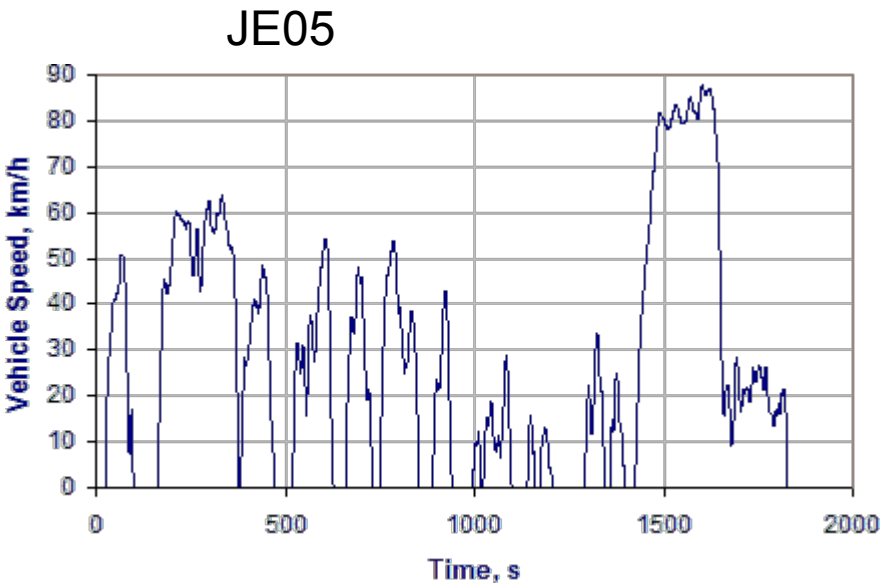
Additional Drive Cycles – NA





Additional Drive Cycles- EU

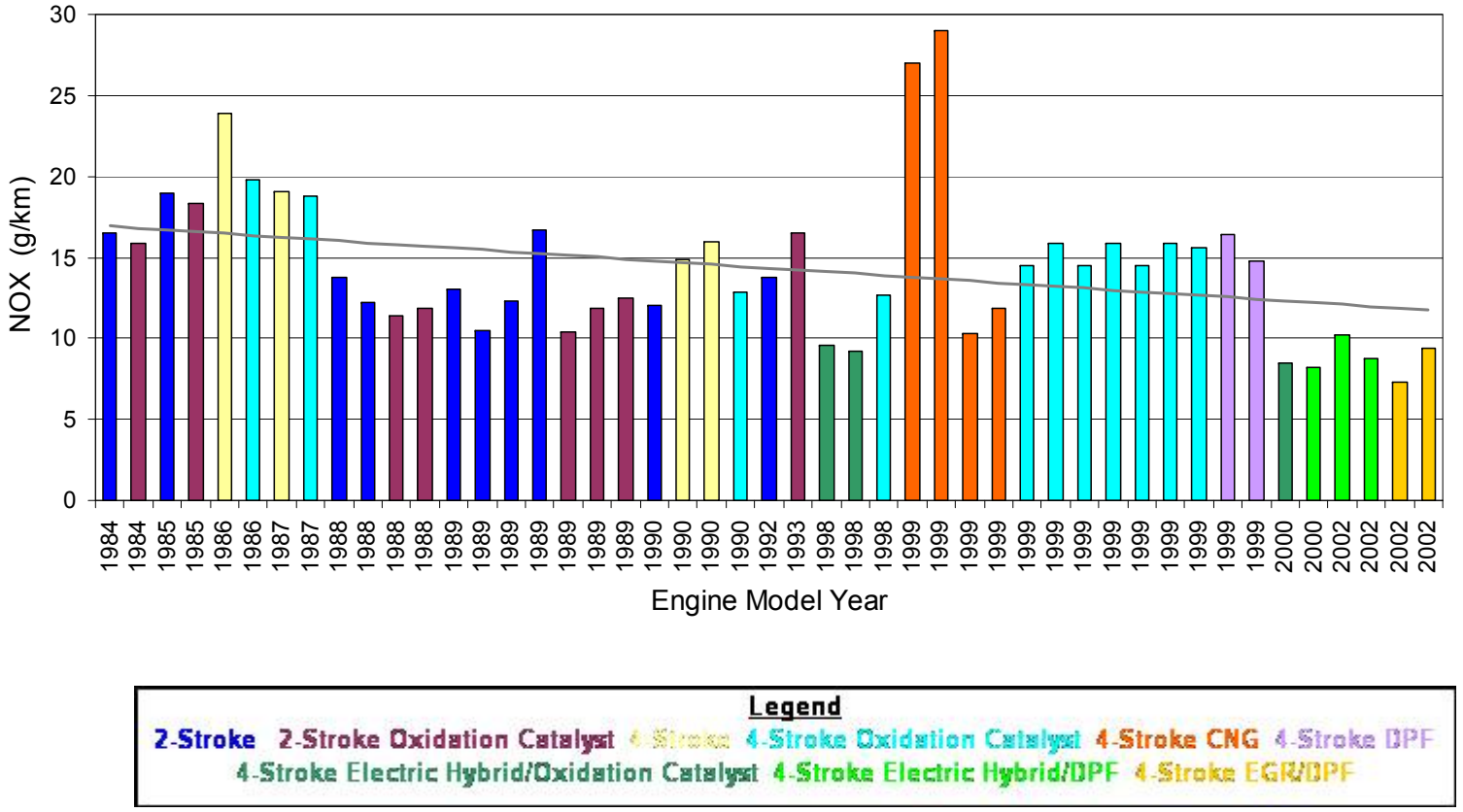




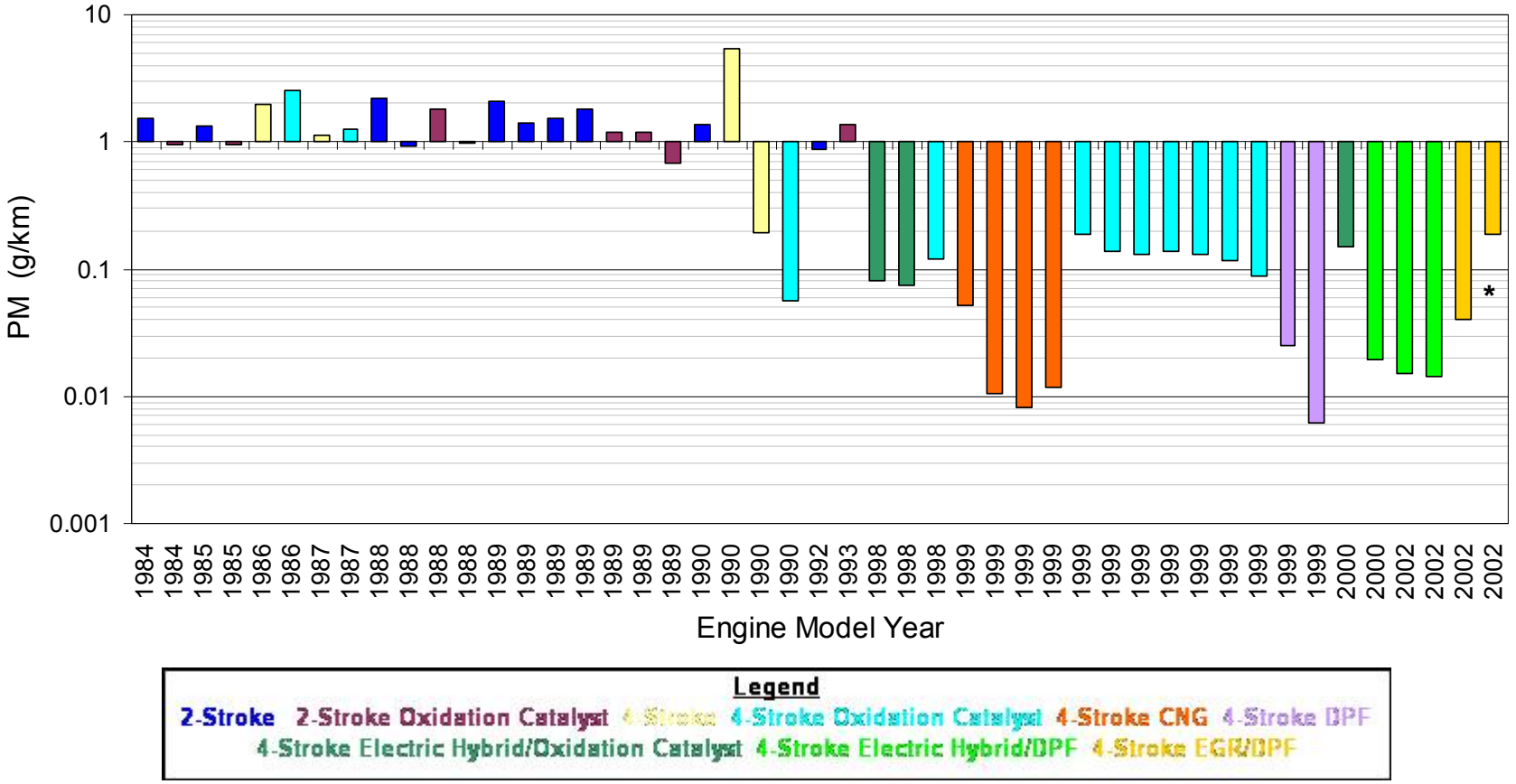
Environmental Science & Technology Centre – Environment Canada

- Conformity Program for New Light Duty Vehicles
- Quantifying the emission contribution of mobile & stationary sources
- Support the development of technologies, fuels, & strategies to reduce emissions
- Providing technical assistance and expertise to government divisions, industry, and other countries
- In-lab test facility – Chassis & Engine test cells
- In-field test capabilities
- Characterisation of unregulated emissions
- Characterised emissions from a variety of buses

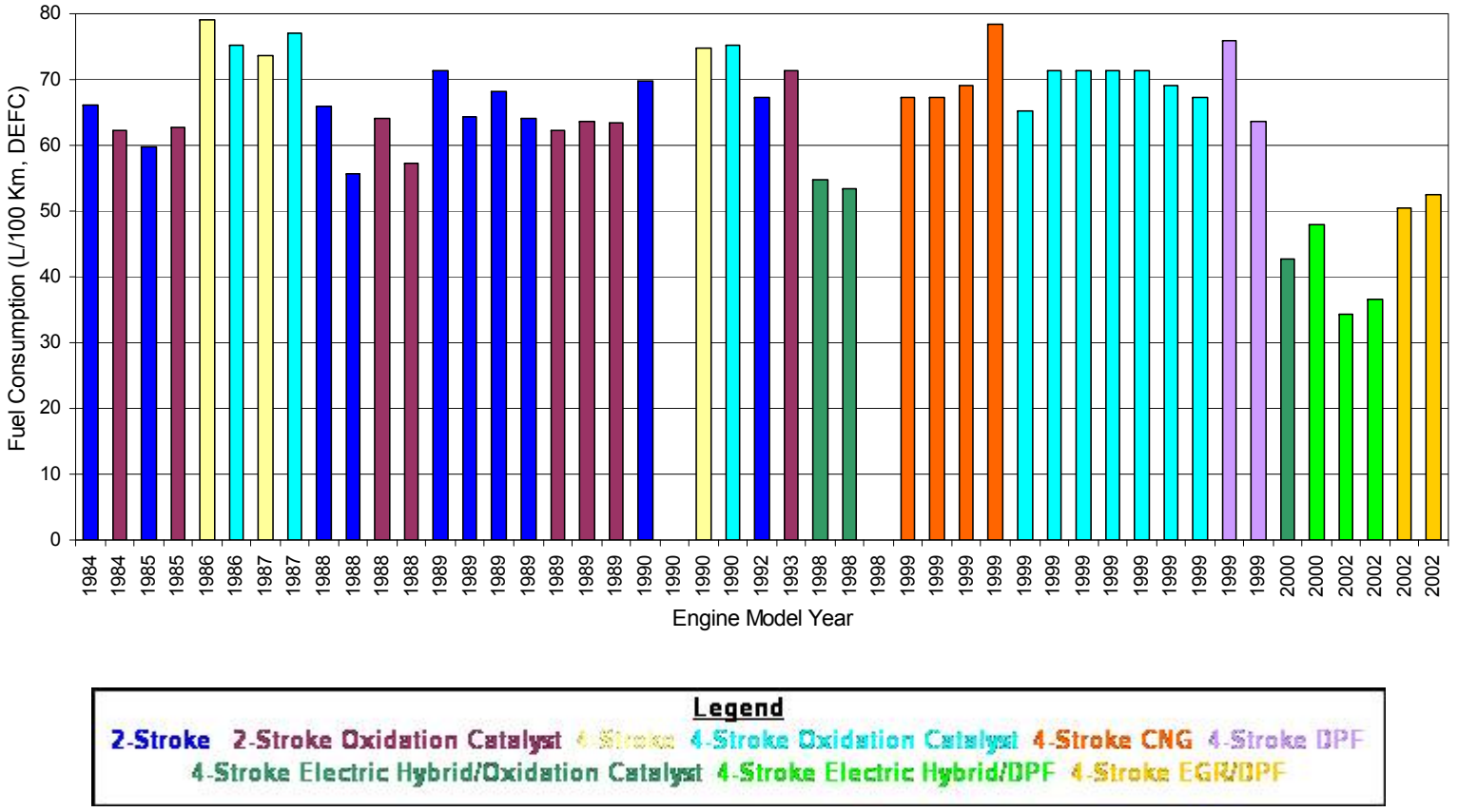
Evolution of Bus Emissions - NO_X



Evolution of Bus Emissions - PM



Evolution of Bus Emissions – Fuel Consumption



Collaboration

- AMF and links to other Implementing Agreements
- 7 AMF countries
- VTT along with other Finnish Participation
- Canadian Support:
  - Natural Resources Canada, Environment Canada, Transport Canada
  - Canadian Urban Transit Association, Municipal Transit Authorities
  - Bus, Engine and Transmission Manufacturers
- Canadian Funding Support:
  - PERD – Panel on Energy Research and Development
  - AFTER – Advanced Fuels and Technologies for Emissions Reductions
  - P&E - Particles and Related Emissions
- *POSTER " Characterization of Exhaust Emissions from Varying Mobile Sources"*

Contact

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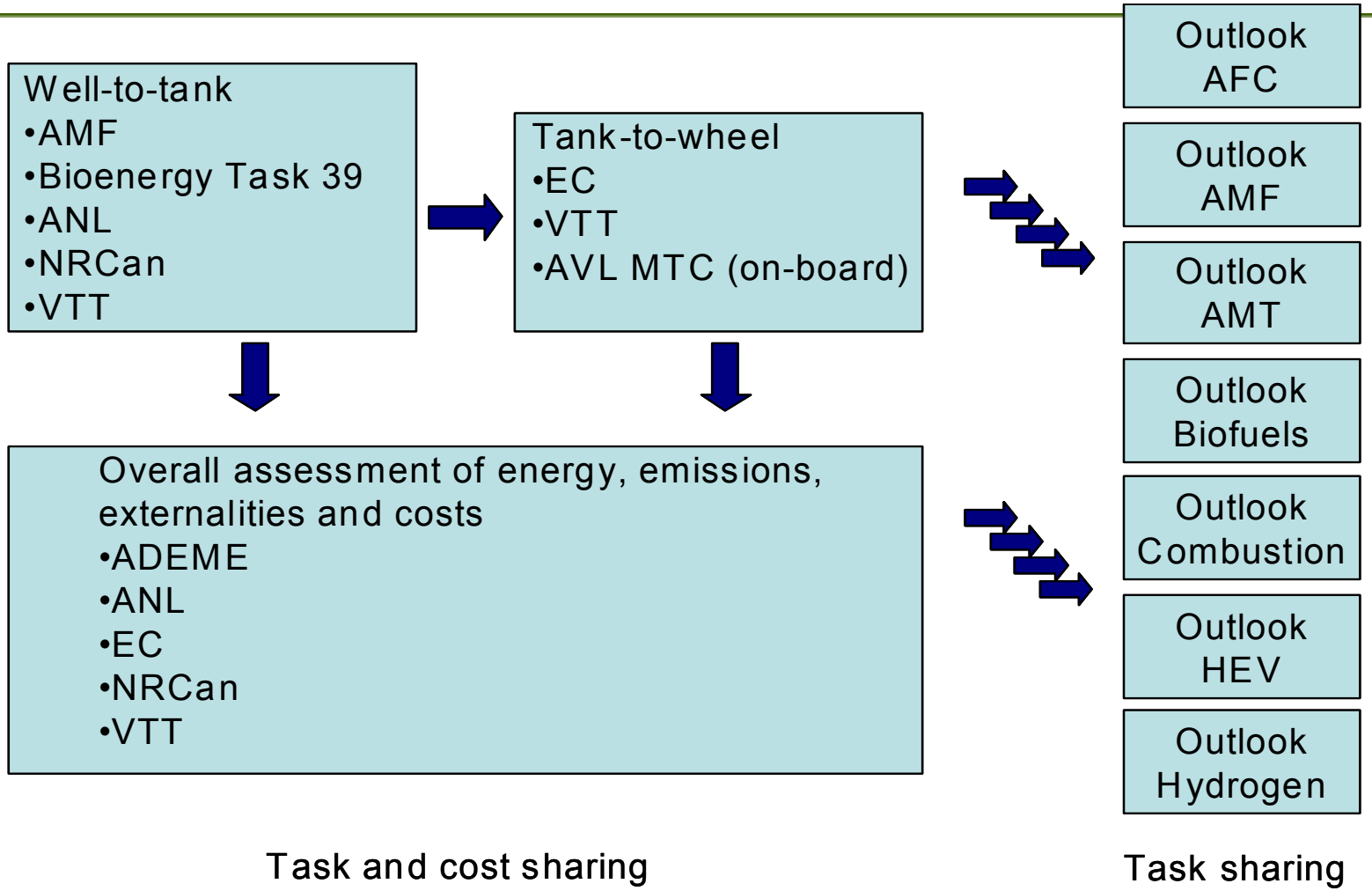
Back up

Task Sharing



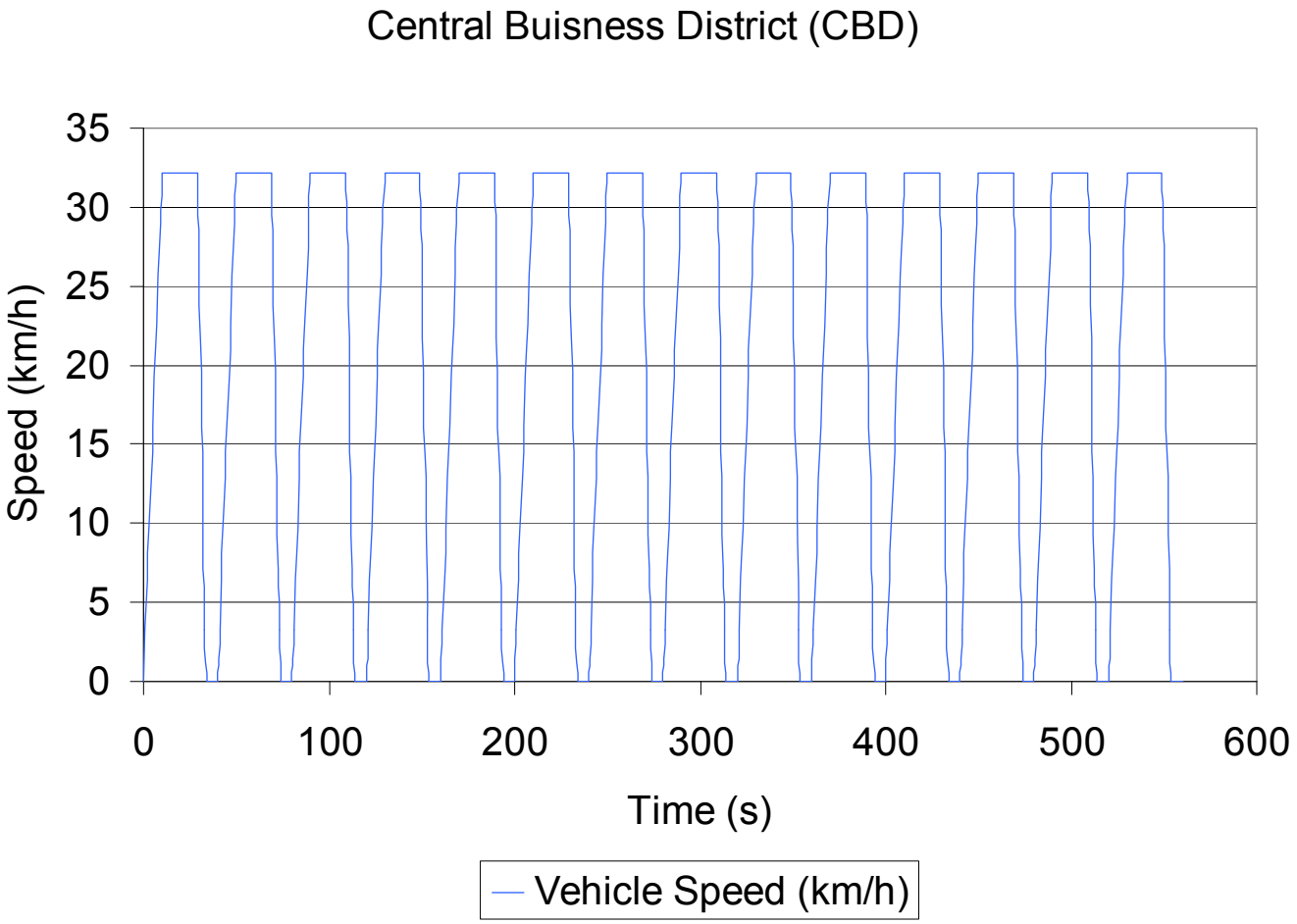
Previous Collaboration

Evaluation of duty cycles for
Heavy duty
urban vehicles
Final report of IEA AMF Annex XXIX

Schedule

- Preparations June 2008 –March 2009
- Actual testing April 2009 –July 2010
- Collecting WTW and WTT data April 2009 –July 2010
- Estimating direct and indirect costs March 2010 –Sep 2010
- Modeling environmental performance March 2010 – Sep 2010
- Synthesis of results September 2010 – June 2011
- Final report July 2011

CBD


Central Buisness District (CBD)
Speed (km/h)
35
30
25
20
15
10
5
0
0
100
200
300
400
500
600
Time (s)
Vehicle Speed (km/h)

IEA IMPLEMENTING AGREEMENT ON ADVANCED MOTOR FUELS

Presentation to IEA Combustion

September 23, 2009

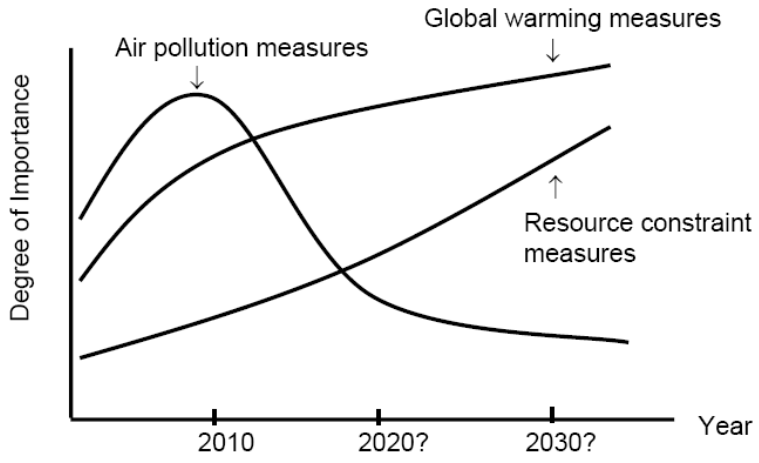
Jean-François Gagné
Natural Resources Canada CanmetENERGY

Outline

- Background
- AMF profile
- Strategic Plan 2009 - 2014
- Strategic Plan Implementation
- Cooperative Work and Contacts

Major Challenges in Transport

- Local pollution
  - technology will solve this problem on developed markets
  - still a problem for many years to come in emerging countries
- Greenhouse gas emissions
  - GHG emissions from transport are increasing
  - energy savings is the most efficient measure to reduce GHG
- Resource constraints
  - road transport 96 % dependent on oil
  - lately huge variations in oil price
- Congestion
  - we have to start discussing reduction of traffic flows, spatial planning, public transport and modal shift



Tabata 2005

Advanced motor fuels can address all challenges except congestion!

ADVANCED MOTOR FUELS

IEA-AMF

IEA Implementing Agreement on Advanced Motor Fuels

History of IEA AMF "Fuel Flexibility"

- 1984-1989 — Alcohols as Motor Fuels
- 1990-1998 — Alternative Motor Fuels
- 1999- — Advanced Motor Fuels

- End-of-Term Report and a new Strategic Plan 2009 – 2014 produced
- AMF extension approved for 5 years (September 9, 2009)

Status of AMF

- The Advanced Motor Fuels Program (AMF) continues to be a very active and successful program.

- The number of participating countries has grown from a beginning of four countries in 1984 to fifteen countries in 2009.

- 37 annexes (projects) have been initiated by the Program over the years.

IEA AMF Participation

Australia	Environment, Water, Heritage and the Arts (as of 25.5.2009)
Austria	BMVIT (starting 2008)
Canada	NRCan
China	CATARC (starting 2008)
Denmark	DTU
Finland	VTT
France	ADEME
Italy	ENI
Japan	LEVO, NEDO
Spain	IDAE
Sweden	SRA
Thailand	NSTDA (starting 2008)
UK	DTLR
USA	DOE
Switzerland	Univ. of Appl. Sciences

Strategic Plan 2009 - 2014

- **Scope of AMF:**

- "Advanced Motor Fuels" encompasses alternative fuels as well as advanced petroleum-based fuels, and the scope of the AMF Implementing Agreement includes all such fuels.

- Additionally, AMF has the license to work on the entire spectrum of fuels from feedstock, through fuel processing, distribution, and, finally, end use in vehicles.

- Directly and indirectly AMF is also promoting fuel efficiency of vehicles.

- AMF works closely with other related Implementing Agreements either through the End Use Working Party or by way of direct interaction.

Strategic Plan 2009 - 2014

Vision of AMF:

- The need for mobility is increasing on a global basis, but the transport sector is facing challenges from local pollution, climate threats, and resource constraints.

- AMF is well-positioned to contribute to solutions to these challenges by way of its multinational makeup of representatives familiar with the challenges, from well to wheel, and potential solutions. 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.***

Strategic Plan 2009 - 2014

Mission of AMF:

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

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

- We also work actively for energy conservation in transport.

Strategic Plan 2009 - 2014

Objectives:

- Objective 1 (Information, Dissemination and Membership):
  - to gather, evaluate and disseminate information on advanced motor fuels and to act as a clearing-house on related information
  - provide an easy-access platform for interested parties to become member of AMF

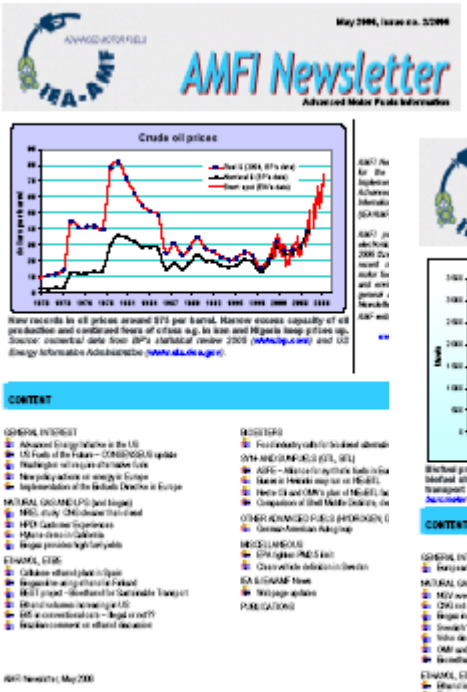
- Objective 2 (Cooperative R&D):
  - to create, maintain and make use of networks among partners involved in research, development, and demonstration related to advanced motor fuels

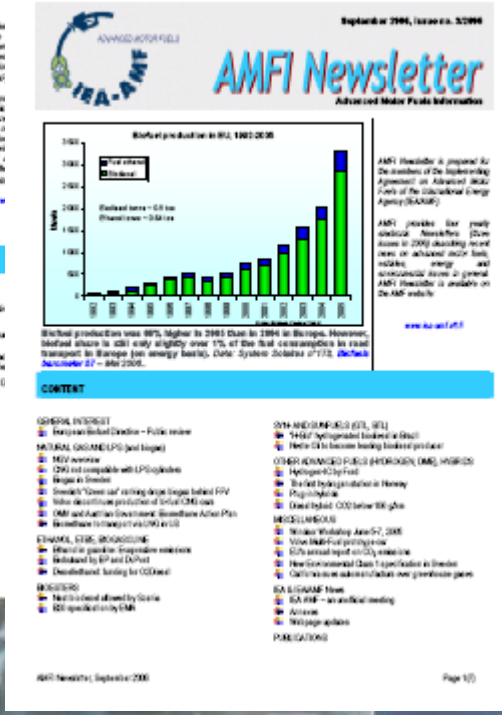
- Objective 3 (Markets and Deployment):
  - to encourage large-scale market deployment of advanced motor fuels by contributing to the identification of technical and economic barriers and by providing solid data to decision makers.

Objective 1: Dissemination

Newsletter (quarterly) plus several documents and reports available for downloading!

www.iea-amf.vtt.fi





www.iea-amf.vtt.fi

IEA Implementing Agreement on Advanced Motor Fuels

About AMF
- General
- Activities
- Strategy
- Annual reports

Organisation
- Participants
- Contact

Technical Annexes
- Annex Info
- Public reports

Downloadables
- Annual reports
- Technical reports
- Newsletters

Events and links
- Events
- Links

MEMBER AREA

Welcome to IEA Advanced Motor Fuels site

Advanced Motor Fuels (AMF) is one of the International Energy Agency's (IEA) transportation related Implementing Agreements. Information on IEA's structure for energy technology related R&D and IEA's Technology Agreements can be found at www.iea.org.

Transportation in itself is a function with significant impacts on energy, emissions and even on economy. The share of energy used in transportation is high, ranging typically from some 20 to 30 % of the total energy consumption. The share of harmful emissions from the transport sector is in general even higher than its share of energy usage.

The transport sector is facing many challenges. Today this sector is practically totally dependent on crude oil derived fuels. 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 stabilise 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 widening, not closing in. This is true for both fuel and vehicle technology options. We are closer than ever to a wide-scale use of alternative fuels. Today we have biofuels and natural gas on the agenda, for tomorrow there might be synfuels and even hydrogen. We already have hybrid and natural gas vehicles in the market, as well as the first experimental series of fuel cell vehicles. At the same time, the internal combustion engine is improving, with features like direct injection, flexible engine controls and new combustion systems.

AMF provides an international platform for co-operation to promote cleaner and more energy efficient fuels and vehicle technologies. AMF welcomes interested parties to make contact and to become members of the AMF family.

News

Report on Standardisation...

Next IEA/AMF ExCo May 2009, Finland...

More news...

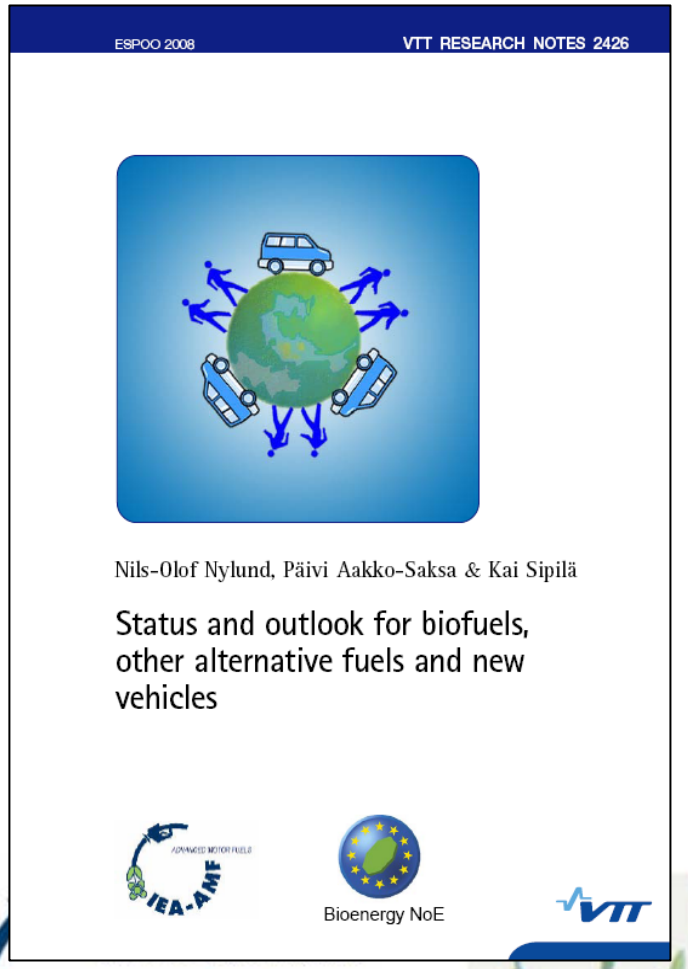
Broschure

IEA/AMF Flyer

updated 23.2.2009
website info

Public Reports

www.iea-amf.vtt.fi



- Status and outlook for biofuels, other alternative fuels and new vehicles
  - released in March 2008
  - more than 50 000 downloads!

http://www.vtt.fi/inf/pdf/tiedotteet/2008/T2426.pdf or www.iea-amf.vtt.fi

- Summary of alternative fuel standardization
  - released in October 2008
- Analysis of biodiesel options
  - released in April 2009
- Ethanol as a motor fuel
  - released in May 2009

IEA-AMF

IEA Implementing Agreement on Advanced Motor Fuels

Objective 2: Cooperative R&D - AMF Annexes

- 29 Annexes (projects) completed
  - 2 Annexes never started (Annex XXIII & Annex XXXII)
- 8 active Annexes
- Average budget USD 200.000 per Annex
- Average 6 participants per Annex
- Mostly cost shared work
  - cost sharing means that the ExCo actively directs the work carried out
  - recent examples of combination of cost and task sharing

Active Annexes

- Annex XXVIII: Information Service
  - VTT Technical Research Centre of Finland, Finland
  - all countries participate, paid from the Common Fund
  - continuous activity
  - www.iea-amf.vtt.fi

- Annex XXXIII: Particle Emissions of 2-S Scooters
  - University of Applied Sciences, Switzerland
  - task shared activity
  - ends 2009

Active Annexes

- Annex XXXIV: Biomass Derived Diesel Fuels
  - Fuels, Engines and Emissions Consultant (FEEC) & Sentech, USA
  - cost shared activity
  - Task 1, Analysis of Biodiesel Options, completed in 2008, report publicly available
  - Task 2, Algae as a Feedstock for Biofuels, active, cooperation with IEA Bioenergy

- Annex XXXV: Ethanol as a Motor Fuel
  - Technical University of Denmark (DTU)
  - task shared activity
  - report publicly available
  - ends 2009

Active Annexes

- Annex XXXVI: Measurement Technologies for Emissions from Ethanol Fuelled Vehicles
  - Swedish Road Administration
  - cost shared activity
  - 2008 - 2009

- Annex XXXVII: Fuel and Technology Alternatives for Buses
  - VTT Technical Research Centre of Finland
  - combination of cost and task sharing
  - Bioenergy and HEV participating through cost and task sharing
  - 2008 - 2011

Active Annexes

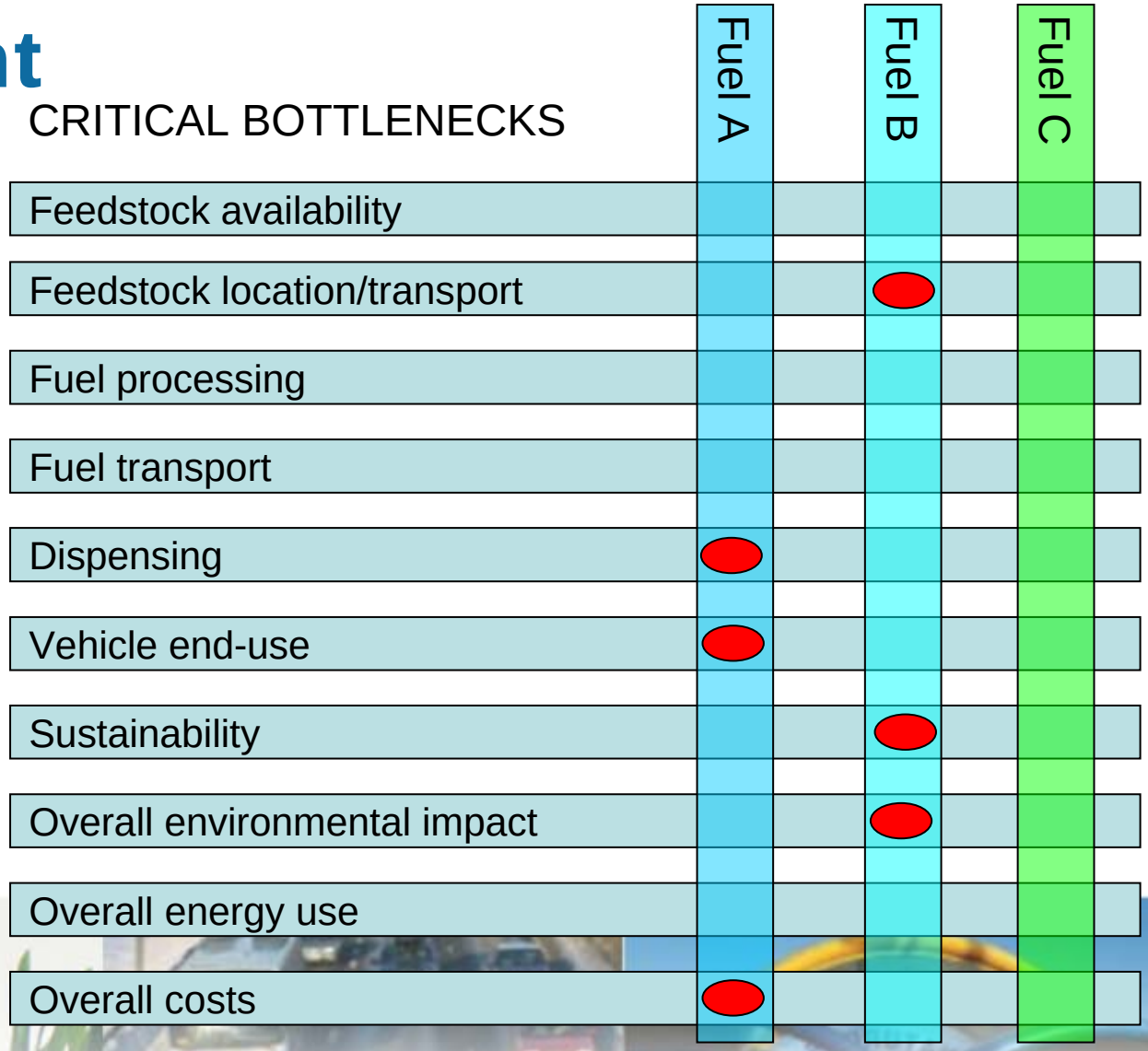
- Annex XXXVIII: Evaluation of Environmental Impact of Biodiesel Vehicle in Real Traffic Conditions
  - NTSEL & LEVO, Japan
  - combination of cost and task sharing
  - first phase 2009 – 2011
  - the first Japanese Annex ever

- Annex XXXIX: Durability and fuel efficiency of heavy-duty gas engines
  - Swedish Road Administration
  - combination of cost and task sharing
  - first phase 2009 – 2010

Proposed Annexes

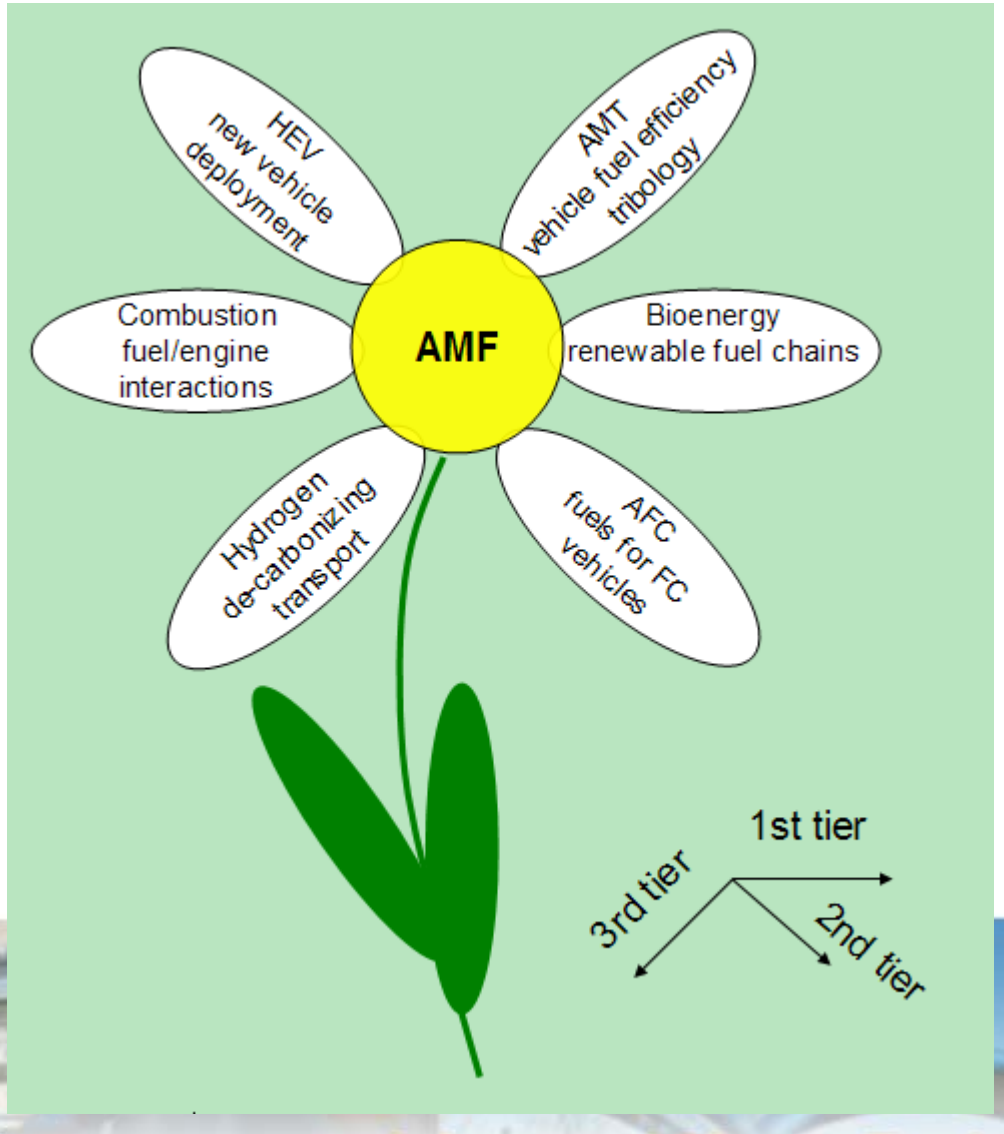
- Pending (started as a pre-study): Toxicity of Combined Aerosols from Diesel Engines
  - Univ. of Applied Sciences, Switzerland
- Proposed Annex on Ammonia as a Transportation Fuel
  - Technical University of Denmark (DTU)
- Proposed Annex on Advanced Marine Fuels
  - Technical University of Denmark (DTU)
  - Natural Resources Canada

Objective 3: Markets and Deployment



Links to Other Implementing Agreements

- Collaboration allows better communication of scientific advice to policy-makers
  - This will help in creating policies that allow potential solutions to be brought to market
- Need to define proper reporting mechanisms to ensure IA's are properly heard and understood
  - CERT
  - EUWP
  - TWG



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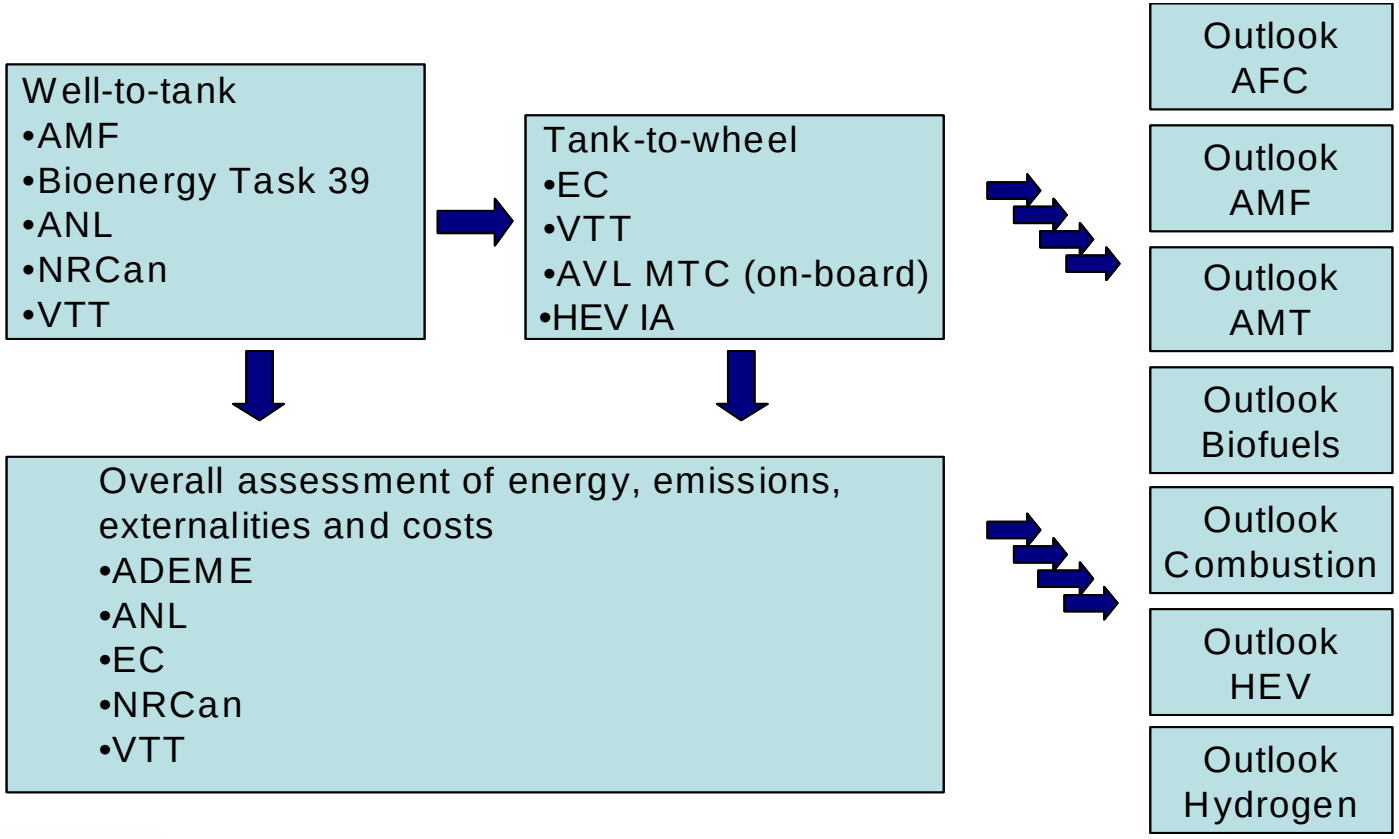

ADVANCED MOTOR FUELS

IEA-AMF

IEA Implementing Agreement on Advanced Motor Fuels

Contacts

- Chairman
  - Dr. Nils-Olof Nylund, VTT, Finland
- Vice Chairmen
  - Mr. Jean-Francois Gagné, NRCan, Canada
  - Mr. Kazuneri Nagai, NEDO, Japan
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  - including a quarterly newsletter “AMFI”

ADVANCED MOTOR FUELS

IEA-AMF

IEA Implementing Agreement on Advanced Motor Fuels

Thank You

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