Business from technology

Biofuels end-use aspects: Maximizing impact and performance

Future Biomass-based Transport Fuels

IEA Bioenergy Workshop 10.5.2011

Nils-Olof Nylund

VTT Technical Research Centre of Finland

Outline

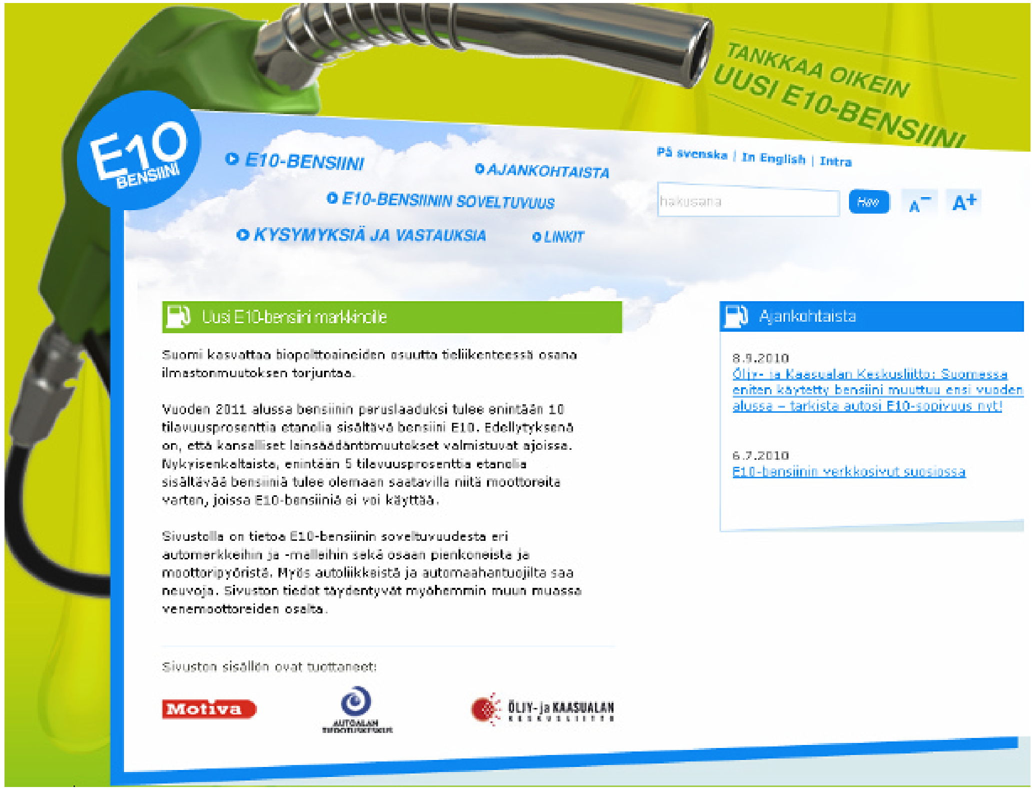
- Definitions and alternative ways to use biofuels
- Implementing biofuels in Finland
- Presentation of 3 research/demo projects
  - E85 optimised for cold conditions
  - Paraffinic renewable diesel for buses
  - the tripartite IEA Bus project
- Summary

Definitions

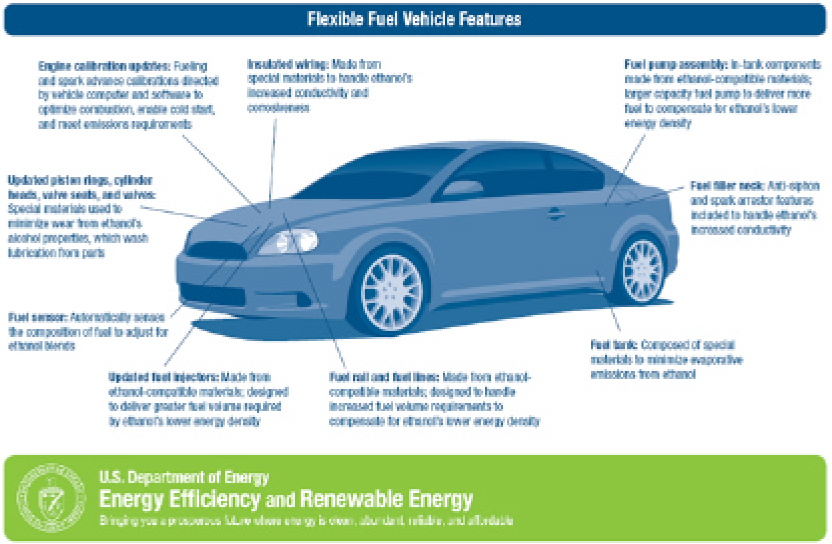
- ”Blending wall”
  - technical limitations for component concentrations
  - the Fuel Quality Directive 2009/30/EC:
    - maximum 10 % (vol.) of ethanol in petrol (E10)
    - maximum 7 % (vol.) of FAME biodiesel in diesel fuel (B7)
    - both these options render only 6.5 % of renewable energy
    - how to achieve 10 % or even higher energy substitution?

- ”Drop-in” fuel
  - a fuel that is compatible with the existing refuelling structure and existing vehicles even at high concentrations without any need for modifications (e.g. BTL and HVO)
- ”Dedicated vehicle”
  - a vehicle that has been adapted to high concentration alternative fuels
  - monofuel, bi-fuel or flex-fuel

E10 not compatible with all vehicles
Finnish motorists dislike E10



A century of FFV technology



In 1908, the Ford Model T was designed with a carburetor adjustment that could allow the vehicle to run on ethanol fuel produced by American farmers. Ford's vision was to "build a vehicle affordable to the working family and powered by a fuel that would boost the rural farm economy."

U.S. DOE EERE 2007

http://www.nesea.org/greencarclub/factsheets_ethanol.pdf

Alternative technologies - buses

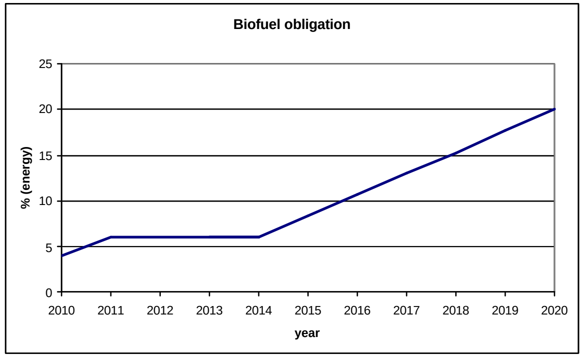
Biogas

Biodiesel, synthetic biodiesel

Hybrid technology, EVs and fuel cells

Ethanol

Special characteristics of Finland



- Cold climate
- Sparsely populated country and long driving distances
- Biofuels:
  - ambitious obligation law meaning that we have to prepare for high volumes of biofuels
  - cold winters meaning that we have to secure operability in cold conditions
  - we have to evaluate every option and think how and where to best implement biofuels

Arctic Circle

”Snapshot” of three projects

E85 optimised for cold conditions

Paraffinic renewable diesel for buses

The tripartite IEA Bus project

Business from technology

Optimising REFuel (RE85) composition for use in cold ambient conditions

Juhani Laurikko & Nils-Olof Nylund

10.05.2011

Target setting

- Main objective: to choose best option from different RE85 formulations available regarding cold startablity and emissions
- Method: exhaust emission tests from +23°C to -25°C
- Scope of analysis:
  - regulated species (CO, THC, NOx), as well as CO_2 (for fuel consumption) and
  - unregulated species like aldehydes and unburned ethanol
- Additional emphasis on:
  - *Startability* in low ambient temperatures
  - Effect of *electric block heater* (a standard feature for FFV's)

Tested fuels

- **”the basic” E85**
  - EtOH 85%
  - 95 RON petrol 15%
- **8 different blends**, with
  - 70-85 % bioethanol
  - 15-30% varying contents of ETBE, MTBE, petrol and some specific hydrocarbon species
- **”the reference”**
  - 95E10 petrol
- volatility (RVP) adjusted separately for normal and low temperatures

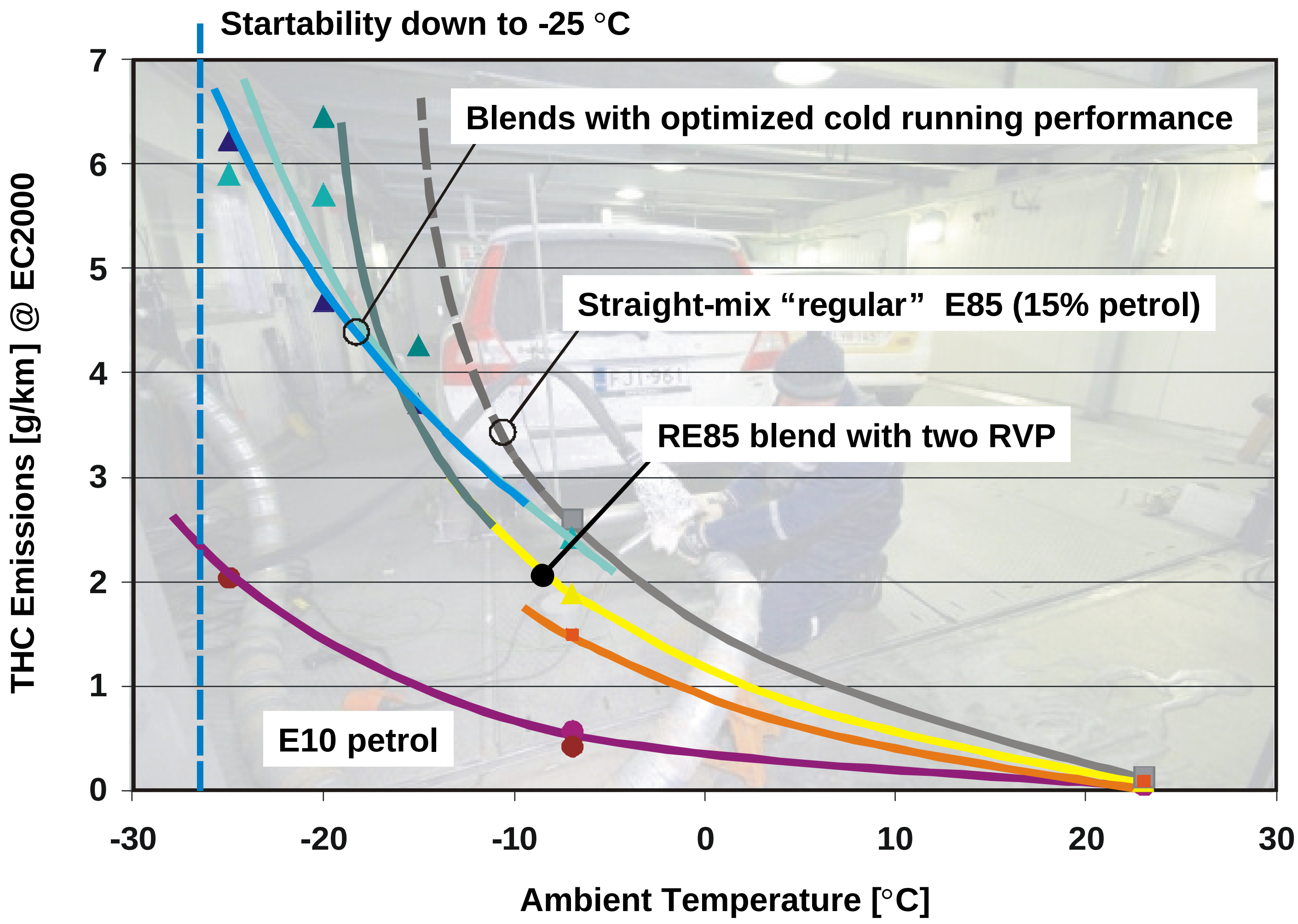
Test matrix

fuel	Ambient temperature					
Pa1	+23	-7				
Pa2	+23	-7				
Pa3	+23	-7				
Pa1T			-15	-20	-25	-25BH
Pa5			-15	-20	-25	
Pa7		-7		-20	-25	-25BH
Pa8	+23	-7				
Pa1wt	+23	-7				
E10K	+23	-7				
E10T		-7			-25	

wt=5% water

BH= electric block heater 2 hours

- In total about 120 tests...
- ...each producing more than 50 “results”, means...
- ...over 6000 data points to analyse!



Startability down to -25 °C
Blends with optimized cold running performance
Straight-mix “regular” E85 (15% petrol)
RE85 blend with two RVP
E10 petrol
THC Emissions [g/km] @ EC2000
Ambient Temperature [°C]
0
1
2
3
4
5
6
7
-30
-20
-10
0
10
20
30

Business from technology

OPTIBIO – HVO fuels for urban buses

Nils-Olof Nylund
VTT Technical Research Centre of Finland

The OPTIBIO project…

The objective was to demonstrate the use of high quality renewable diesel fuel in buses in metropolitan Helsinki for:

- reduced toxic emissions
- increased share of renewable fuels

- The first project in the world involving use of high quality renewable diesel in high concentration
  - 30 % and 100 % renewable paraffinic diesel (HVO) made through hydrotreatment of vegetable oils and animal fats
  - original initiative from the municipal organisations responsible for procurement of bus services
  - example of a public-private partnership
- Testing within a research project spanning more than three years (September 2007 – December 2010)
  - a comprehensive test programme to verify performance as well as actual reductions in emissions levels over time

(NExBTL is the trade mark of Neste Oil's HVO)

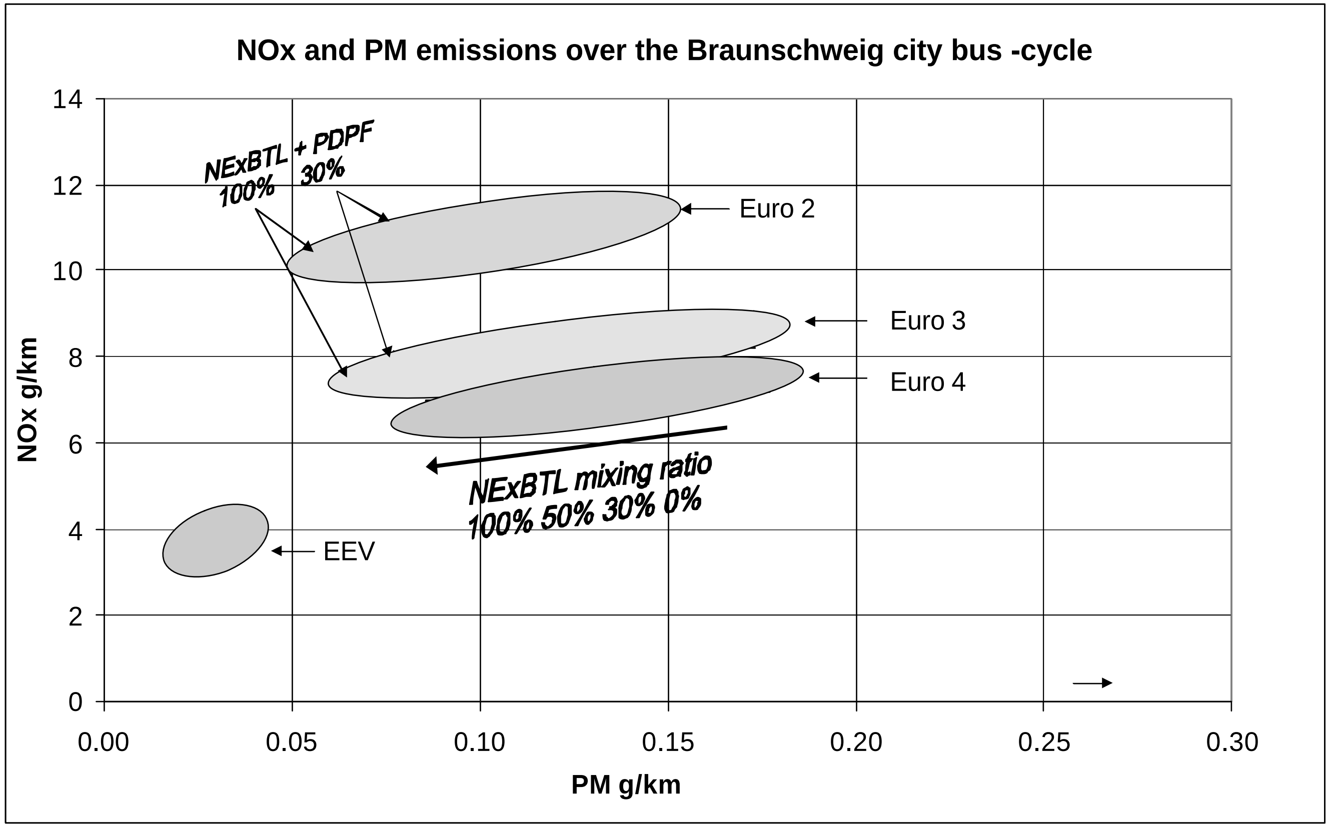
..The OBTIBIO project

- Some 300 buses running on HVO fuels
  - the bulk of the fleet on a 30 % blend
  - 10 vehicles on 100 % HVO
- Paraffinic HVO also depicts the end-use performance of future BTL qualities
- The project was part of the BioRefine technology programme by TEKES, – the Finnish Funding Agency for Technology and Innovation, and the initiative for development of 2nd generation biofuels by the Ministry of Employment and the Economy

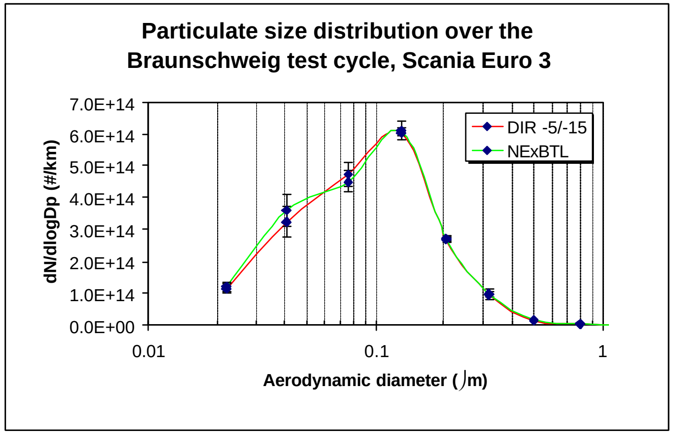
Measurement programme

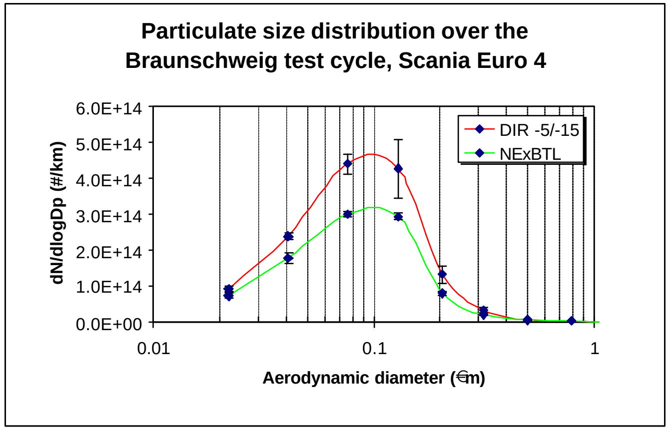
- Screening
  - 13 vehicle types (11 buses, 2 refuse trucks)
  - Euro II – EEV
  - summer and winter grade diesel fuel
  - 0, 30, 50 and 100 % HVO
- Follow-up emission testing
  - 22 vehicles
  - Euro II – EEV emission classification
  - annual measurements
- Catalyst testing
  - 4 vehicle types
  - 3 fuel blends
  - wide range of catalytic converters and filters
- Non-regulated emissions testing
  - 3 vehicle types
  - 2 fuel types

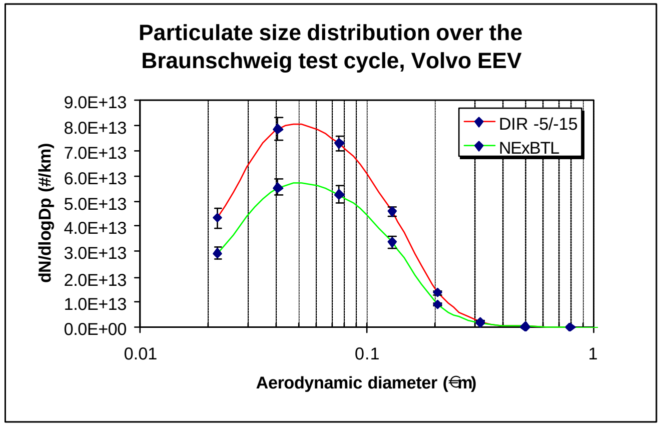
Screening results - Summary



Particulate numbers





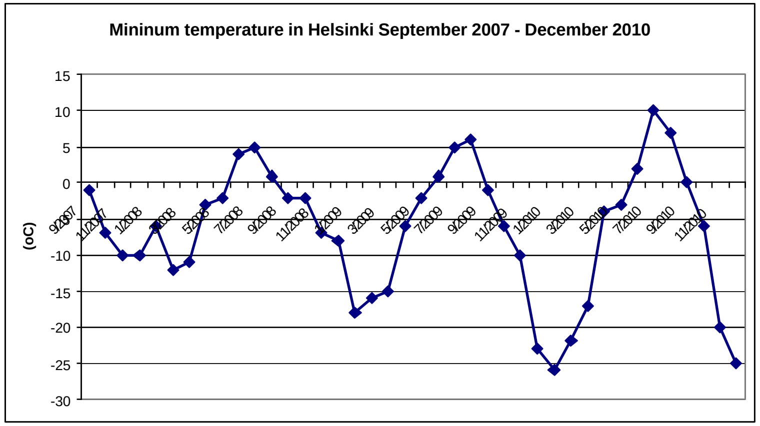


Field test..

- Commenced with some 50 buses on a 30 % HVO blend in September 2007
- 4 new Scania EEV vehicles on 100 % HVO entered the test in March 2008 (in addition 2 new reference vehicles on conventional diesel)
- Expansion to full scale (300 buses) in the autumn of 2008, most of them on a 30 % blend fulfilling the EN590 specifications
- 3 older Euro III level Scania vehicles started operation on 100 % HVO in April 2009
- 3 EEV level Irisbus vehicles started operation on 100 % HVO in February 2010

..Field test

- All in all, the vehicles accumulated some 50 million kilometres, of which some 1.5 million kilometres on 100 % HVO.
- The amounts of fuel were some 22 million litres of blended fuel and 1 million litres of straight HVO.
- No problems whatsoever in the field, not even during the extremely cold 2009/2010 and 2010/2011 winters
- Some indications that more work is needed to enhance the lubricity of neat paraffinic diesel in engines with extremely high injections pressures



Reports coming up

- Final report in English (VTT’s series of publications)

- Conference papers, e.g., SAE 20119172 and 20119239

(2011 JSAE/SAE International Powertarins, Fuels & Lubricants, Kyoto 30.8 – 2.9.2011)

Business from technology

FUEL AND TECNOLOGY ALTERNATIVES FOR BUSES

Overall energy efficiency and emission performance

Update on AMF Annex XXXVII/HEV Annex XVI/Bioenergy Task 41/Project 3

5.5.2011
Nils-Olof Nylund
VTT Technical Research Centre of Finland

Bus project objective

- To produce data on the overall energy efficiency, emissions and costs, both direct and indirect costs, of various technology options for buses
- Provide solid IEA sanctioned data for policy- and decision-makers
- Bring together the expertise of various IEA Implementing Agreements:
  - **Bioenergy: fuel production**
  - AFC & Hydrogen: automotive fuel cells
  - **AMF: fuel end-use**
  - AMT: light-weight materials
  - Combustion: new combustion systems
  - **HEV: hybrid power-trains**

Well-to-tank
- AMF
- Bioenergy Task 39
- ANL
- NRCan
- VTT

Tank-to-wheel
- EC
- VTT
- AVL MTC (on-board)
- VTI (engine tests)

Overall assessment of energy, emissions, externalities and costs
- ADEME
- ANL
- EC
- NRCan
- VTT

Task and cost sharing

Outlook AFC

Outlook AMF

Outlook AMT

Outlook Biofuels

Outlook Combustion

Outlook HEV

Outlook Hydrogen

Task sharing

WTT values analyzed for the following fuels:

GREET (USA)	GHGenius (Canada)	EU Renewable energy directive (RED)
low-sulfur diesel from conventional petroleum	low-sulfur diesel from conventional petroleum	fossil fuel comparator (EU average)
natural gas to Shell GTL and SASOL FT diesel	oil sands crude to low-sulfur diesel	remote NG to synthetic diesel (remote plant)
natural gas to CNG (SI engine)	canola/rapeseed to biodiesel	rapeseed to HVO
sugar cane and/or grain to ethanol	tallow to biodiesel	rapeseed to FAME
soybeans to biodiesel (FAME)	soybeans to biodiesel	palm oil to HVO (process not specified)
soybeans to renewable diesel (NExBTL/HVO)	soybeans to HRD	palm oil to HVO (process with methane capture at oil mill)
	canola/rapeseed to HRD	palm oil to FAME (process not specified)
	natural gas to CNG	palm oil to FAME (process with methane capture at oil mill)
	natural gas to LNG	sugarcane to ethanol
	landfill gas to CNG	wheat to ethanol (natural gas as process fuel in conventional boiler)
	landfill gas to LNG	wood to FT-diesel (farmed wood)
	anaerobic digestor to CNG	wood to FT-diesel (waste wood)
	anaerobic digestor to LNG	wood to DME (farmed wood)
	natural gas to FT diesel	wood to DME (waste wood)
	coal to FT diesel	jatropha to FAME
	biomass (wood) to FT diesel	biogas from wet manure
		biogas from organic waste

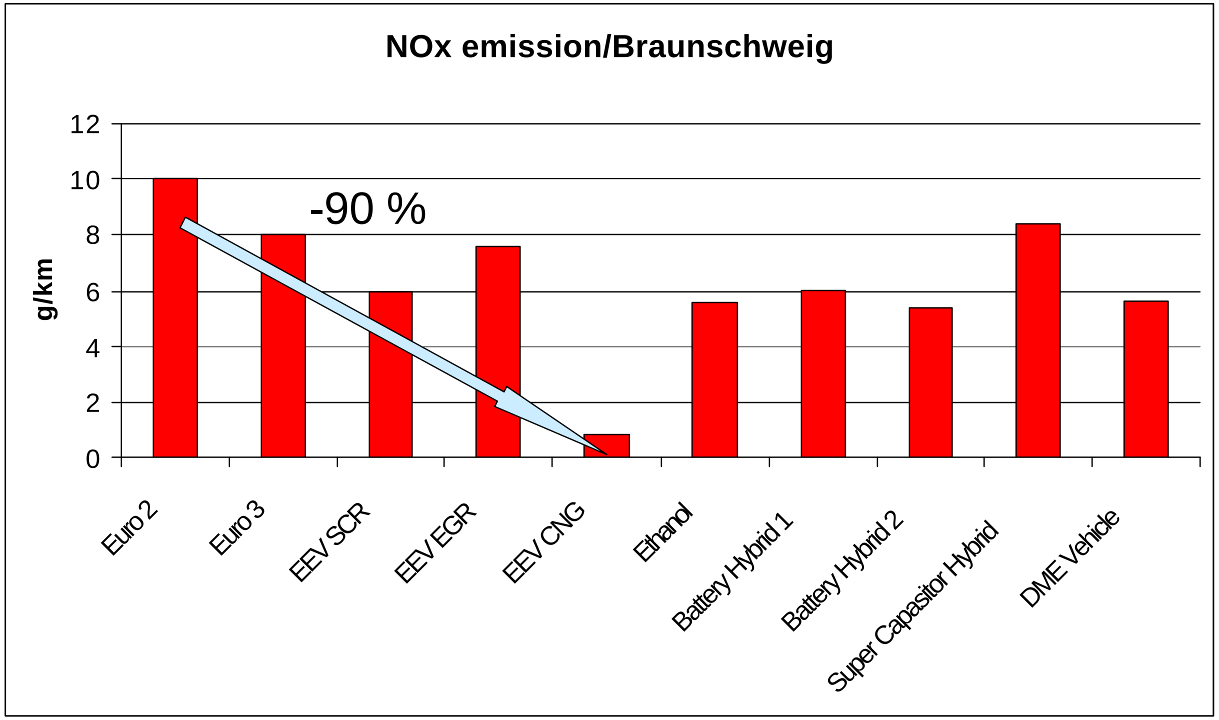
Vehicles measured so far

- Diesel
  - Volvo Euro 2
  - Scania Euro 3
  - Volvo SCR EEV
  - Scania EGR EEV
  - Solaris/Eaton parallel hybrid
  - Volvo parallel hybrid
  - Golden Dragon hybrid (supercaps, Cummins engine)
- CNG
  - MAN EEV
- Ethanol
  - Scania EEV
- DME
  - Volvo (truck, simulated as a bus)

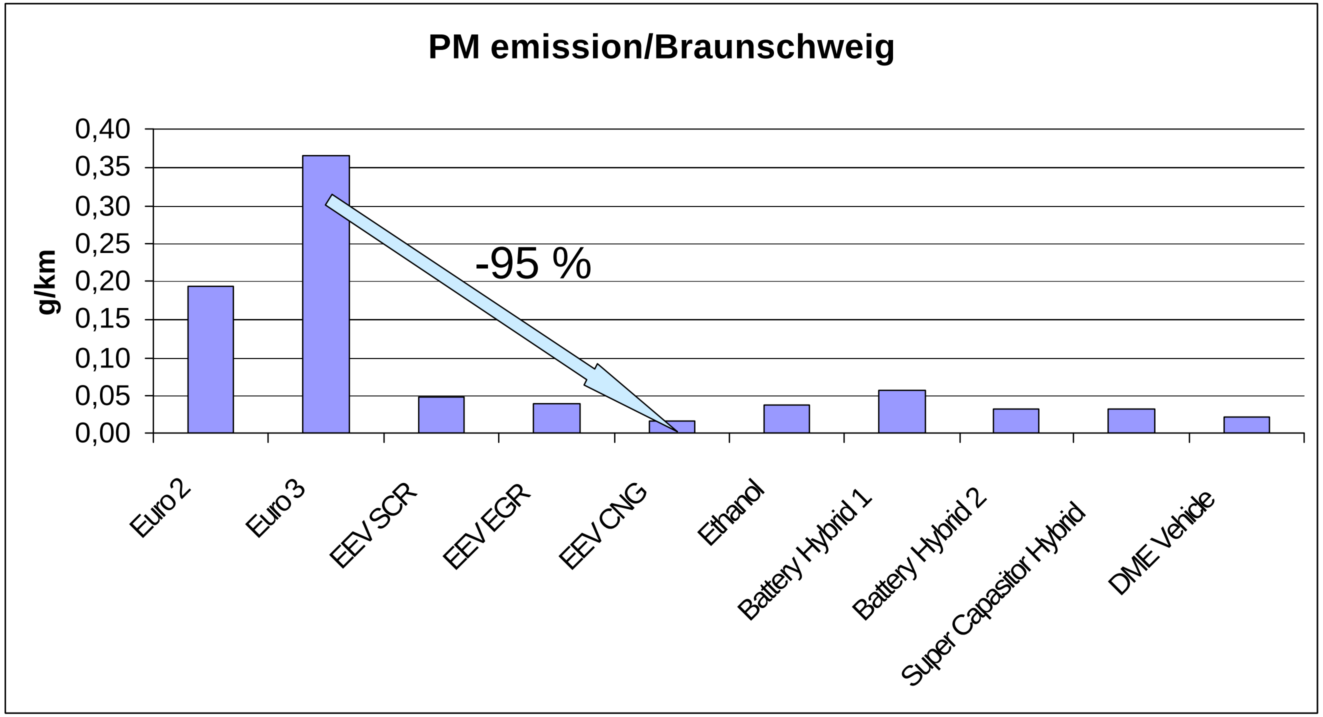
- Still to be measured:
  - CNG Iveco Euro 6
  - Iveco hybrid

  - Full fuel matrix measured with some of the vehicles

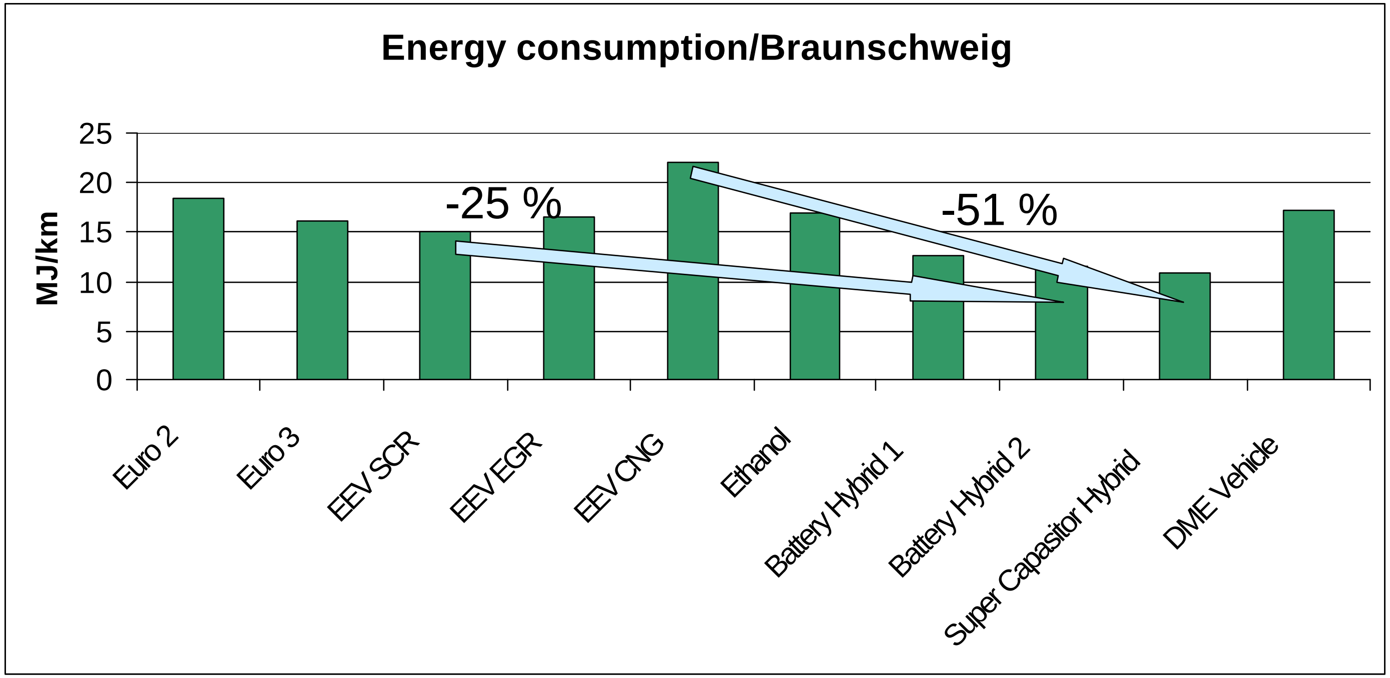
Effect of vehicle technology - NOx



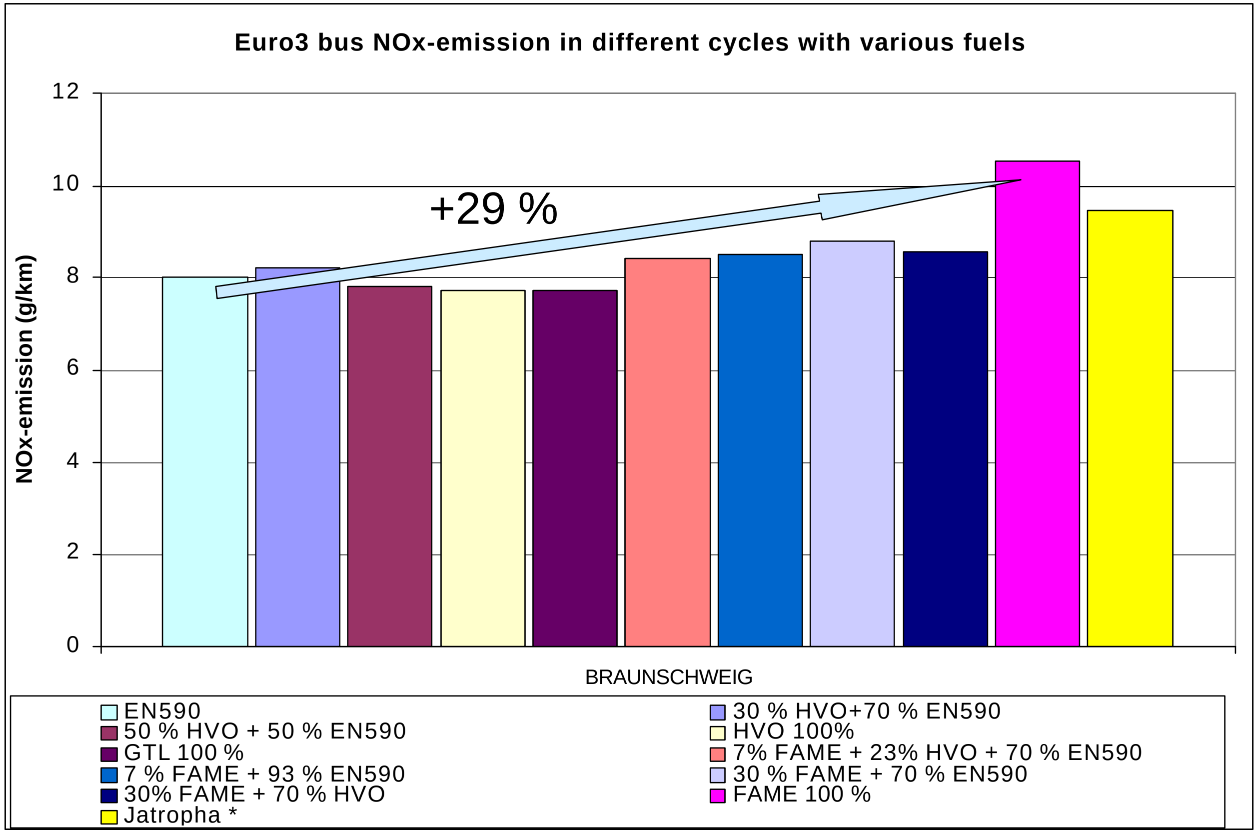
Effect of vehicle technology - PM



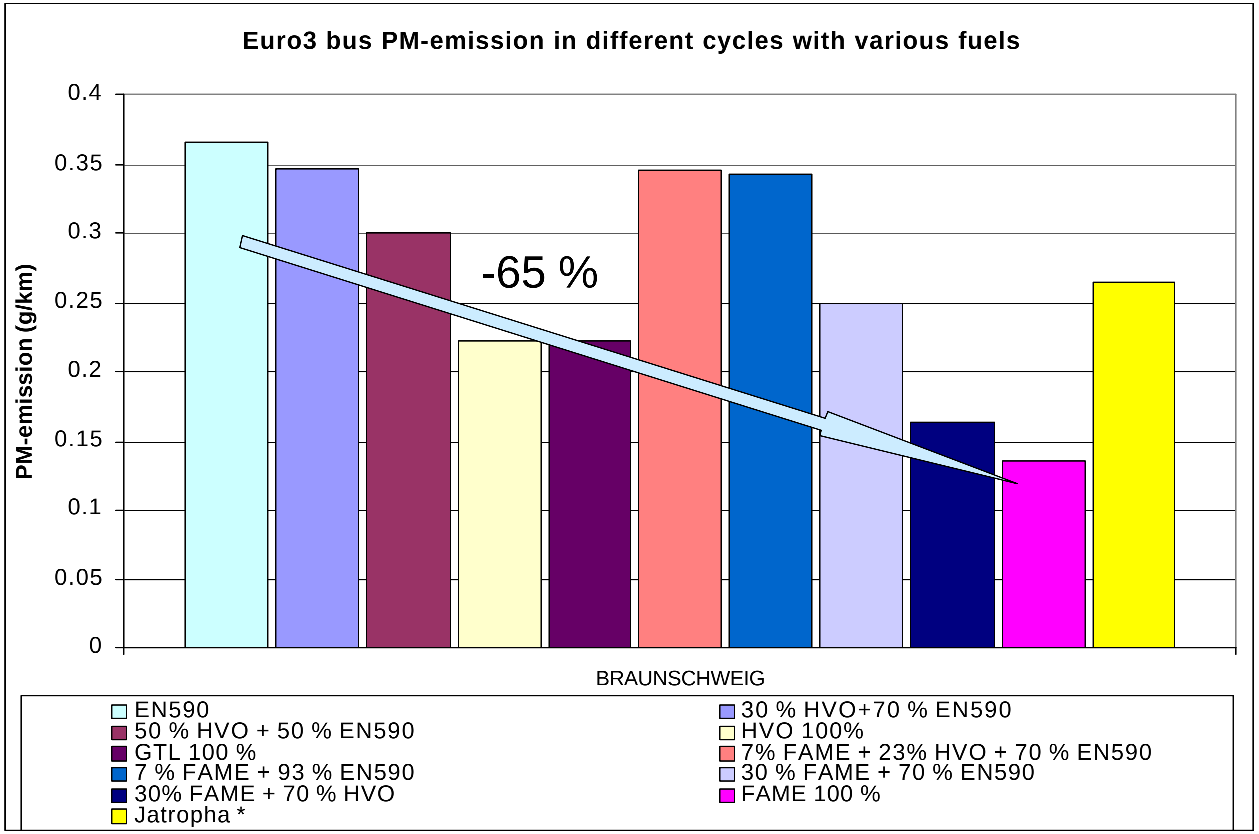
Effect of vehicle technology – energy consumption



Fuel effects on NOx, Euro 3 technology



Fuel effects on PM, Euro 3 technology



Environment Canada | Environnement Canada

Canada

Fuel and Technology Alternatives for Buses

Overall energy efficiency and emission performance

AMF Annex XXXVII

Environment Canada

Debbie Rosenblatt

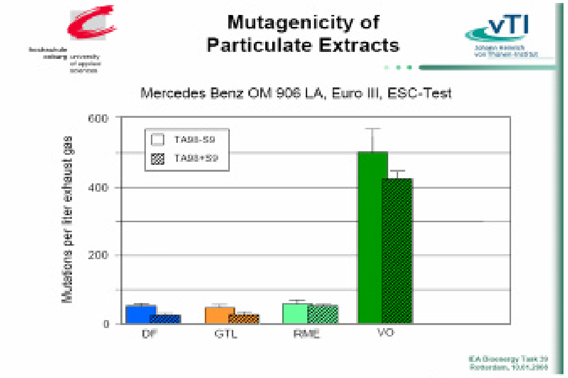
Environment Canada (EC) - Update

- To date EC has completed measurements on 6 buses
- Buses were tested with a combination of drive cycles and fuel types:
  - Primary cycles: HD UDDS & Manhattan
  - Additional cycles: Braunschweig & ADEME/RATP
  - Fuel types: commercial Canadian ULSD (ultra low sulphur diesel); oilsands derived commercial ULSD, HVO, and low level blends of FAME (varying feedstocks)
- A MY 2002 bus was tested in November 2010 to serve as an average baseline reference
- Additional tests will be performed on a second conventional driveline bus meeting US EPA 2010 equipped with SCR technology
- All tests included measurement of NO_X, Total PM, CO, HC, CO_2, CH_4, N_2O; particle size distributions were performed on selected tests
- Data analysis on-going

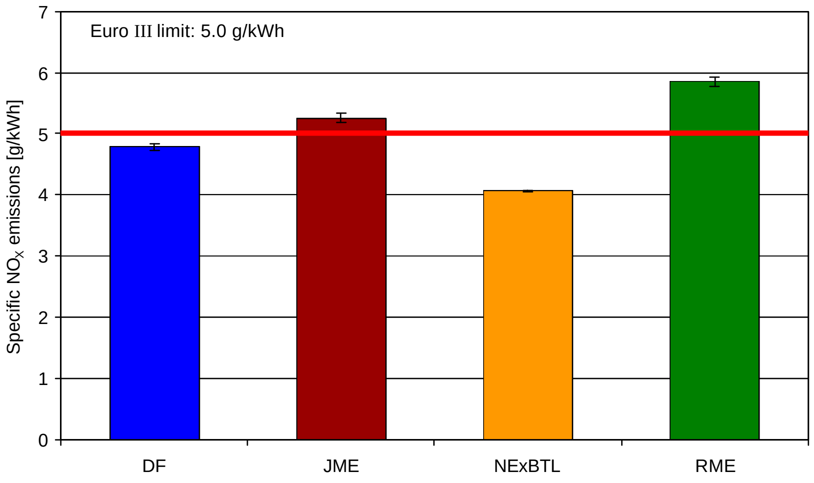
Research Project Report

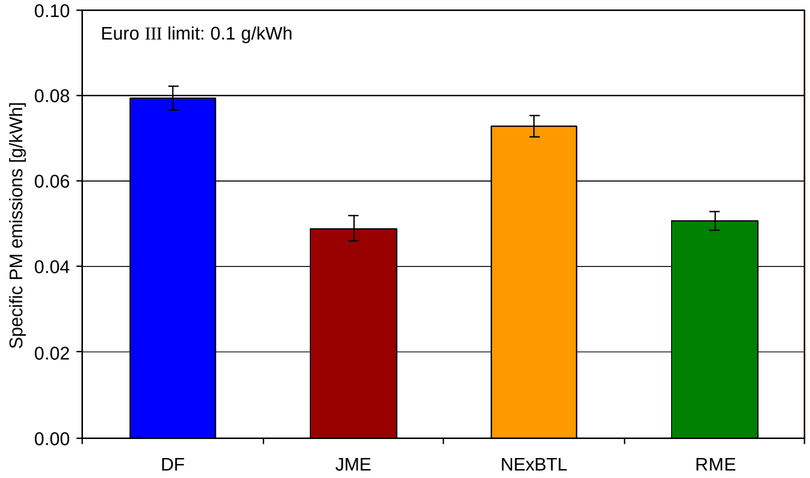
Fuel and Technology Alternatives for Buses – Measurements with NExBTL and Jatropha Oil Methyl Ester in a Euro III Heavy Duty Engine

Project Director: Prof. Dr.-Ing. A. Munack

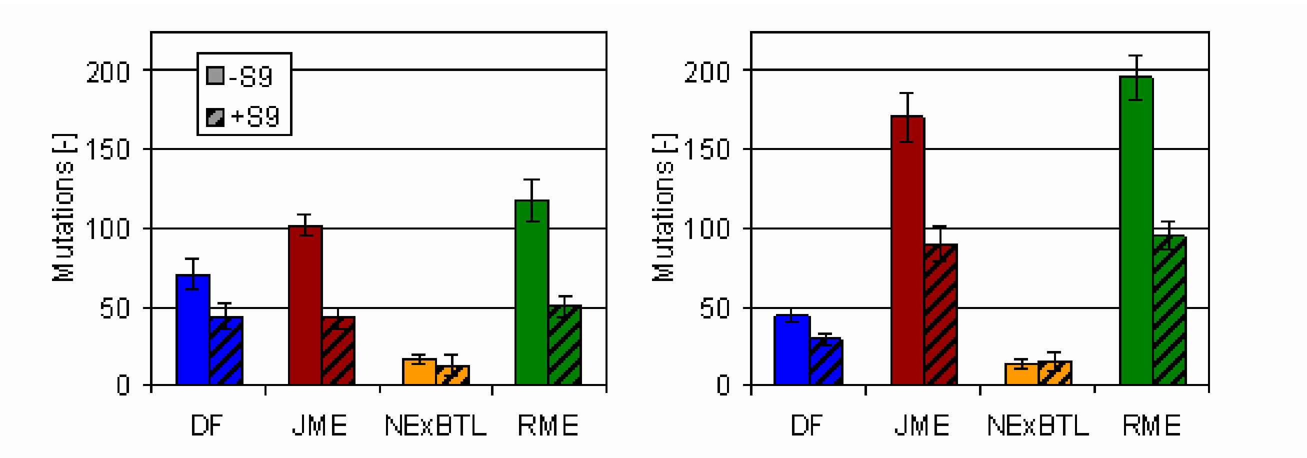


NOx & PM emissions





PM mutagenicity – TA98



Extracts (left) Condensates (right)

Summary

- There are challenges in producing sufficient amounts of sustainable and cost-effective biofuels
- However, do not forget end-use requirements
- Blending of conventional biocomponents only provide limited substitution
- ”Drop-in” fuels or alternative dedicated vehicles are needed to really make an impact
- In biofuels development, VTT is looking at production as well end-use, in good cooperation with industry as well as the public sector
- When developing alternative fuels, check all aspects of end-use performance, including unregulated exhaust emissions!