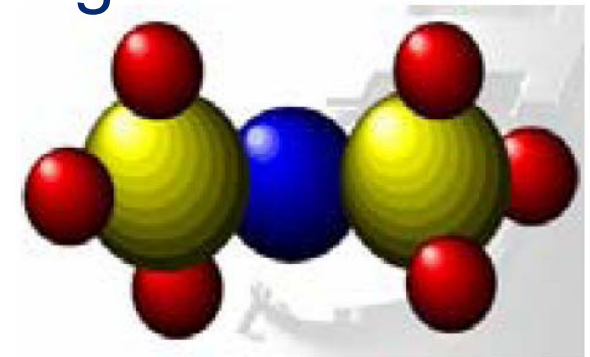


Aftertreatment and fuel upgrading system for DME-fuelled diesel engines

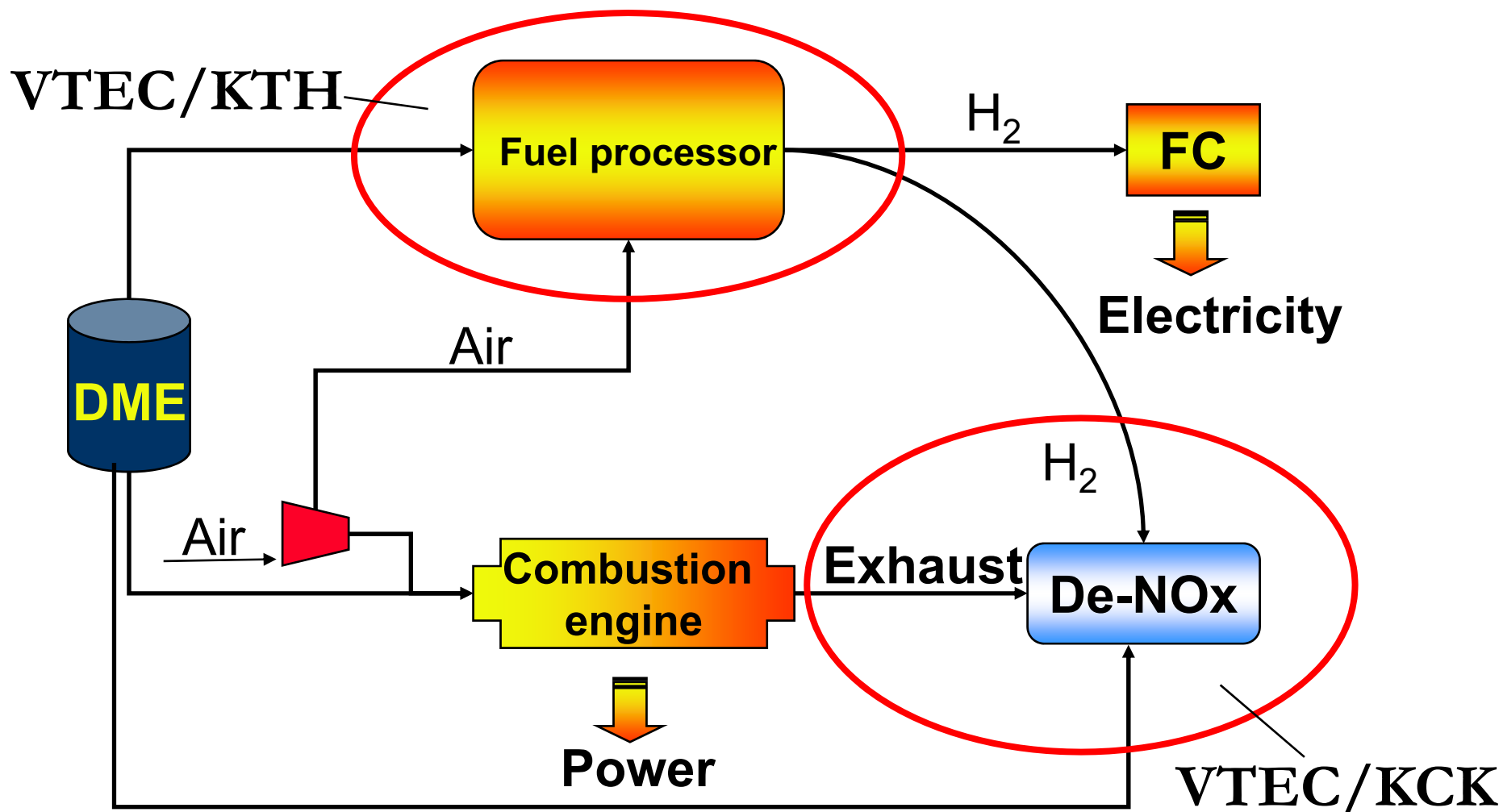
- Anders Palmqvist, Stefanie Tamm and Hanna Härelind-Ingelsten – KCK at CTH
- Lars Pettersson and Marita Nilsson - KTH
- Sara Erkfeldt, Peter Jozsa, Lennart Andersson and Per Ekdunge - VTEC
- Henrik Landälv and Henrik Salsing - VPT



Purpose of project

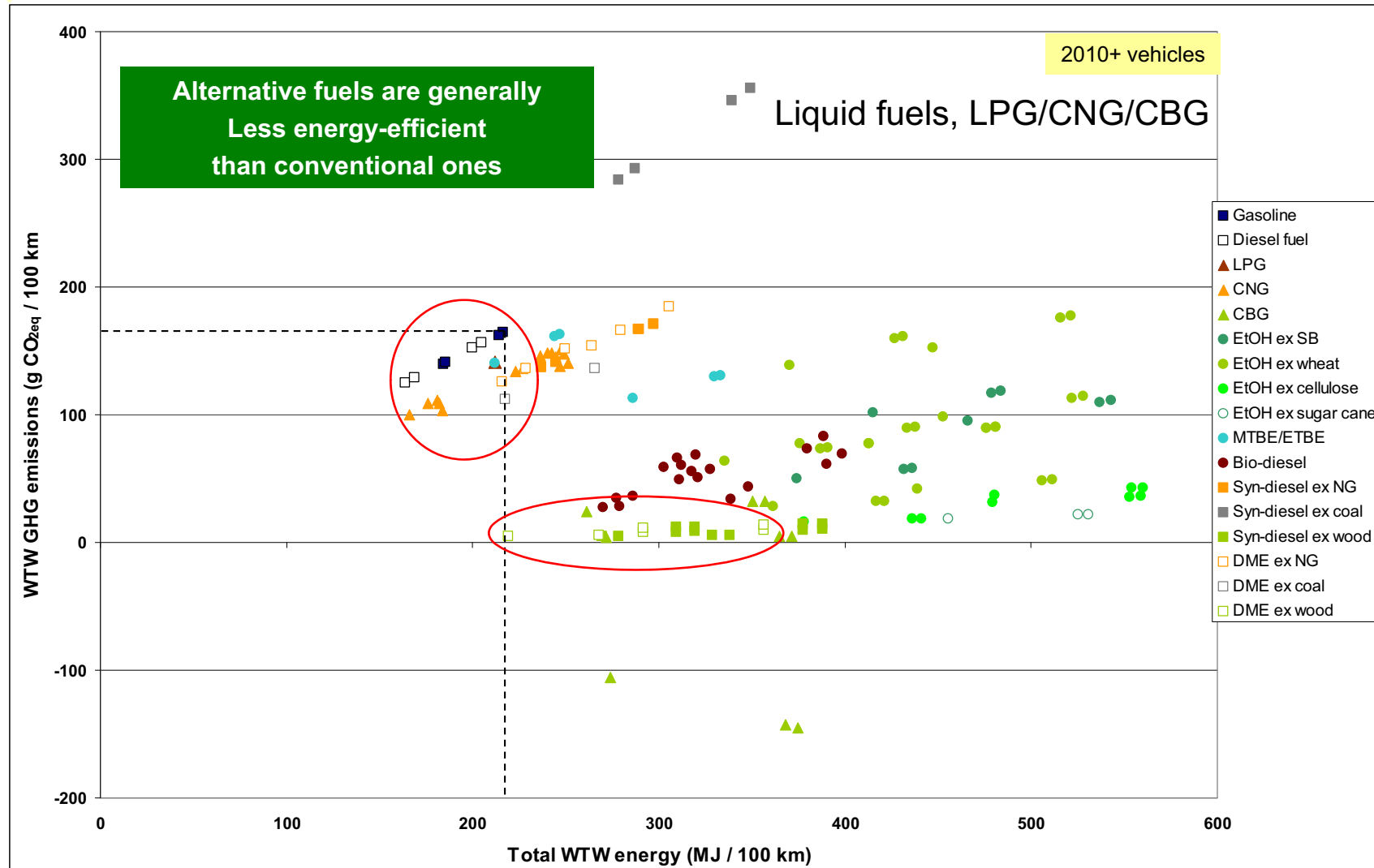
- Investigate technologies for lean aftertreatment of NO_x using DME as reducing agent
- Investigate reforming of DME to hydrogen for the use in fuel cell auxiliary power unit and for use as NO_x reducing agent
- Establish a national competence platform for research related to DME as alternative fuel

Project overview



DRAFT

Overall picture for alternative fuels: GHG versus total WTW energy

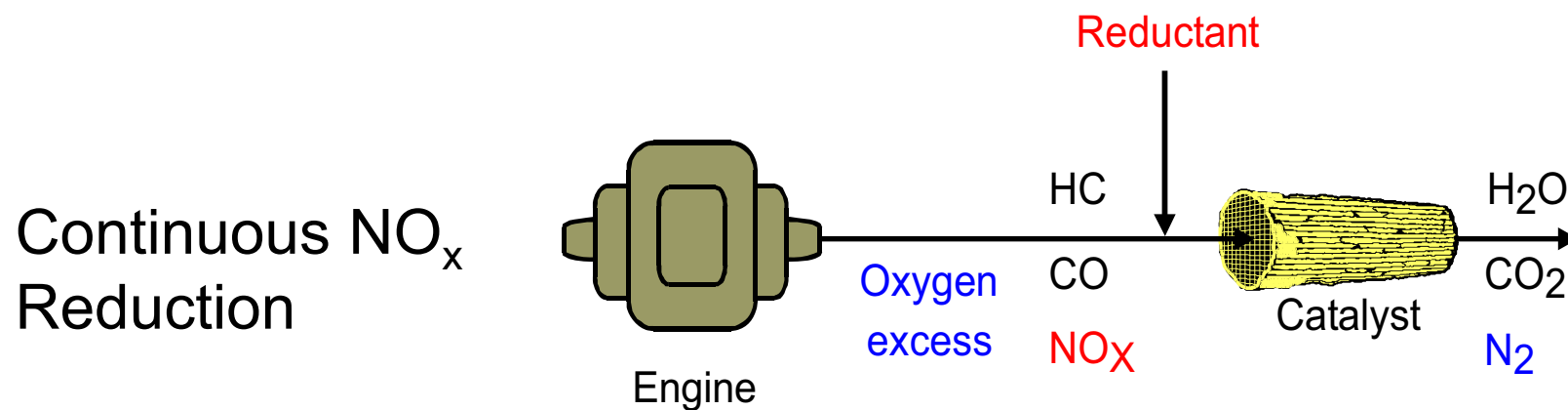


EUCAR/JRC/CONCAWE report available on: <http://ies.jrc.cec.eu.int/WTW>

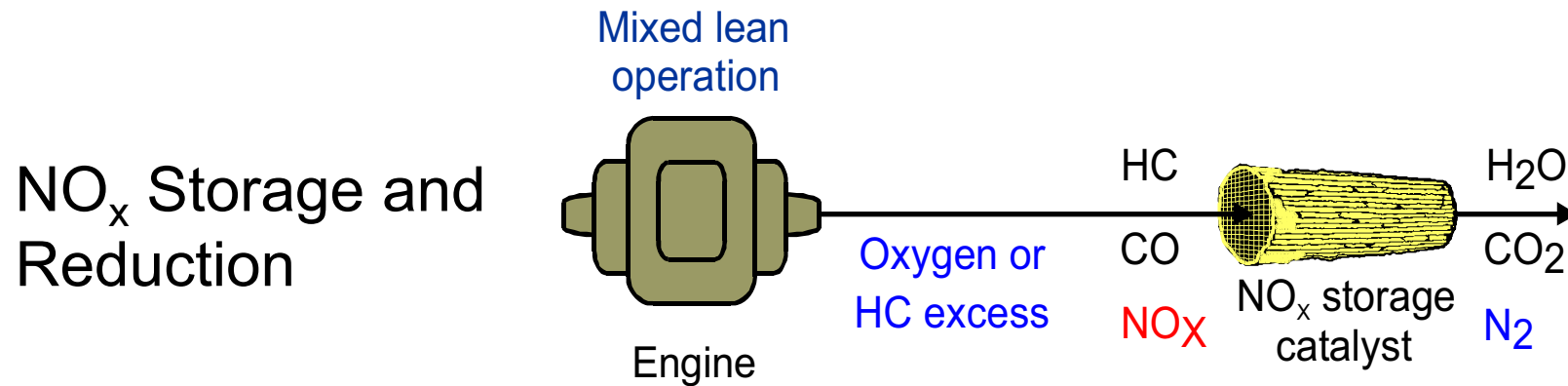
Euro 5 emissions (NO_x , CO, HC, PM) met with an oxidation catalyst and diesel baseline fuel consumption.



Lean NO_x Catalyst - LNC



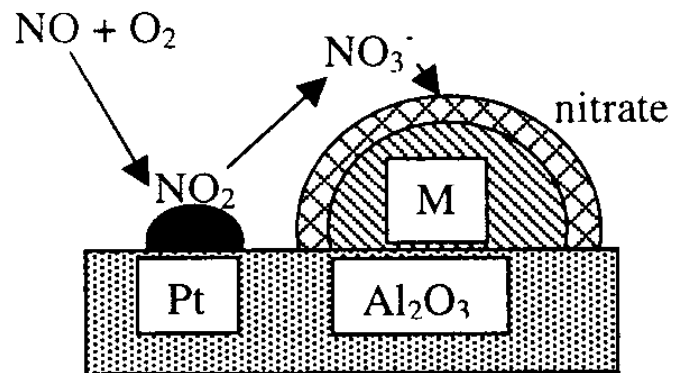
Lean NO_x Adsorber – LNA



NO_x Storage and Reduction

Lean Exhaust, ~1 min

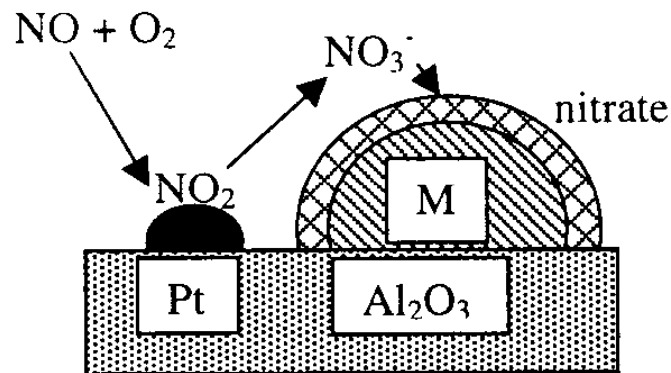
- 1) Oxidation of NO to NO₂
over precious metals
- 2) Formation of nitrates
on storage sites



NO_x Storage and Reduction

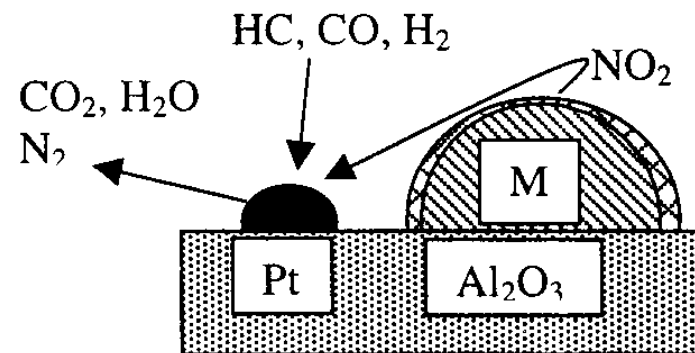
Lean Exhaust, ~1 min

- 1) Oxidation of NO to NO₂ over precious metals
- 2) Formation of nitrates on storage sites



Rich or Stoichiometric Exhaust, ~1 s

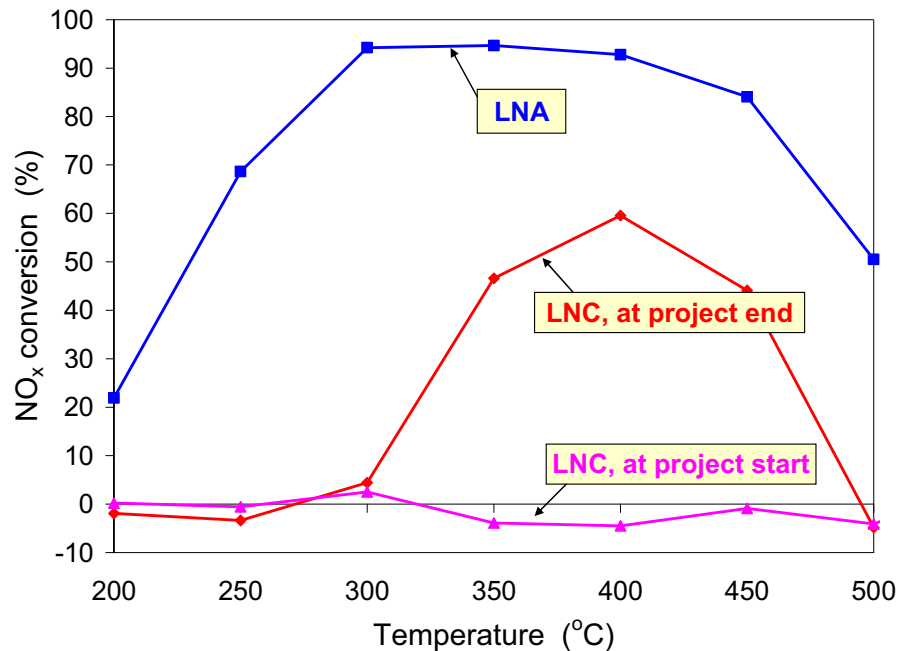
- 3) Nitrate decomposition and release
- 4) NO_x reduction to N₂ over noble metal sites



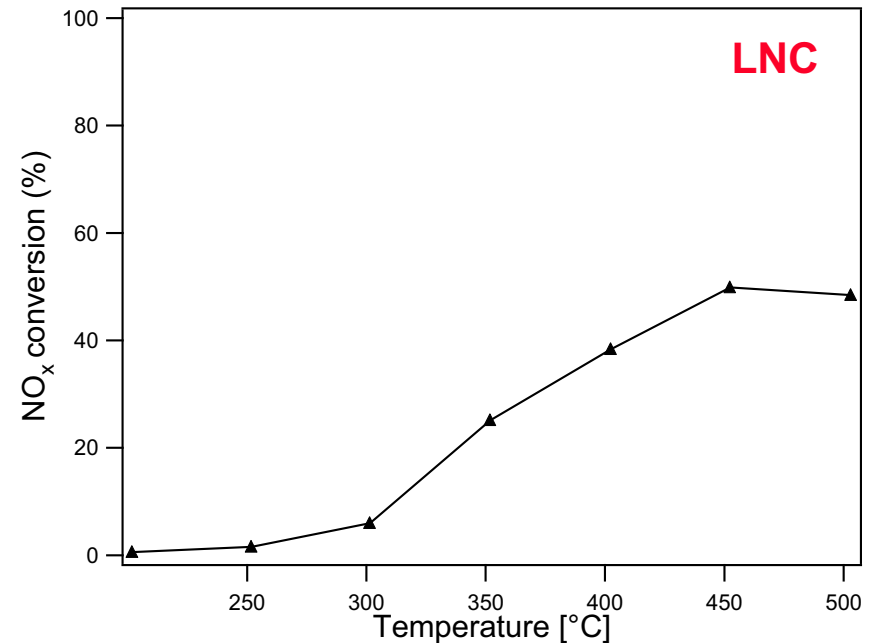
DME-deNO_x catalyst development results

Extra DME added for reduction of
NO_x in simulated exhaust gas

Commercial developer



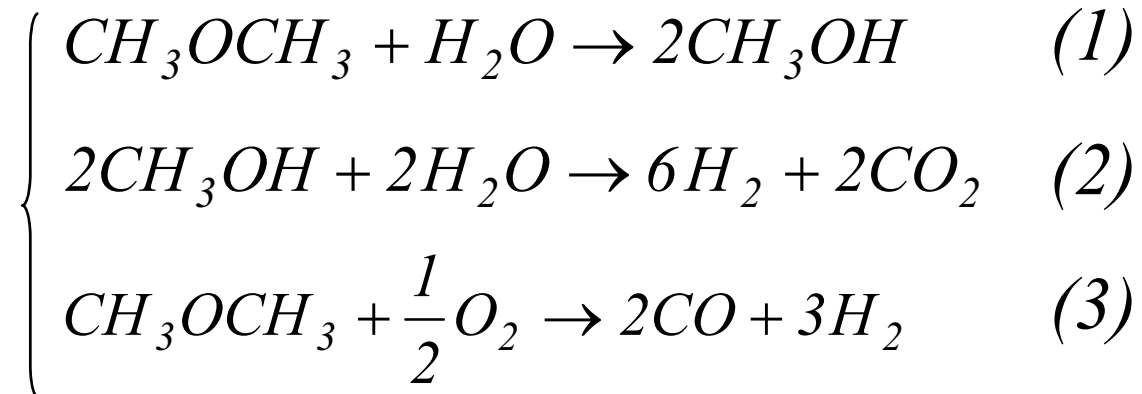
Developed at KCK



Reforming reactions



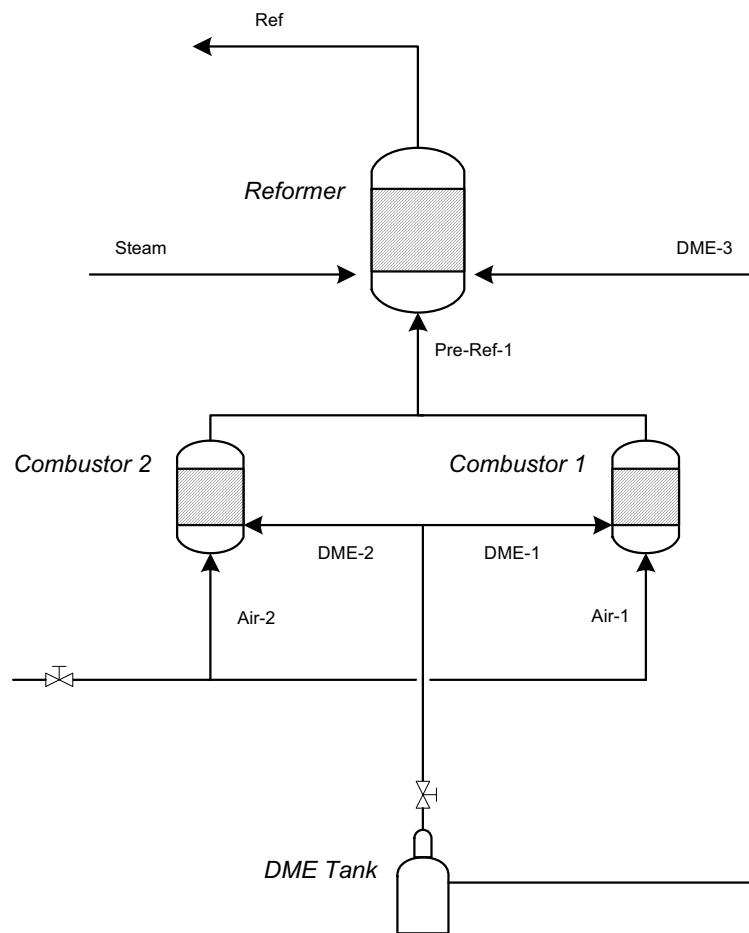
ROYAL INSTITUTE
OF TECHNOLOGY



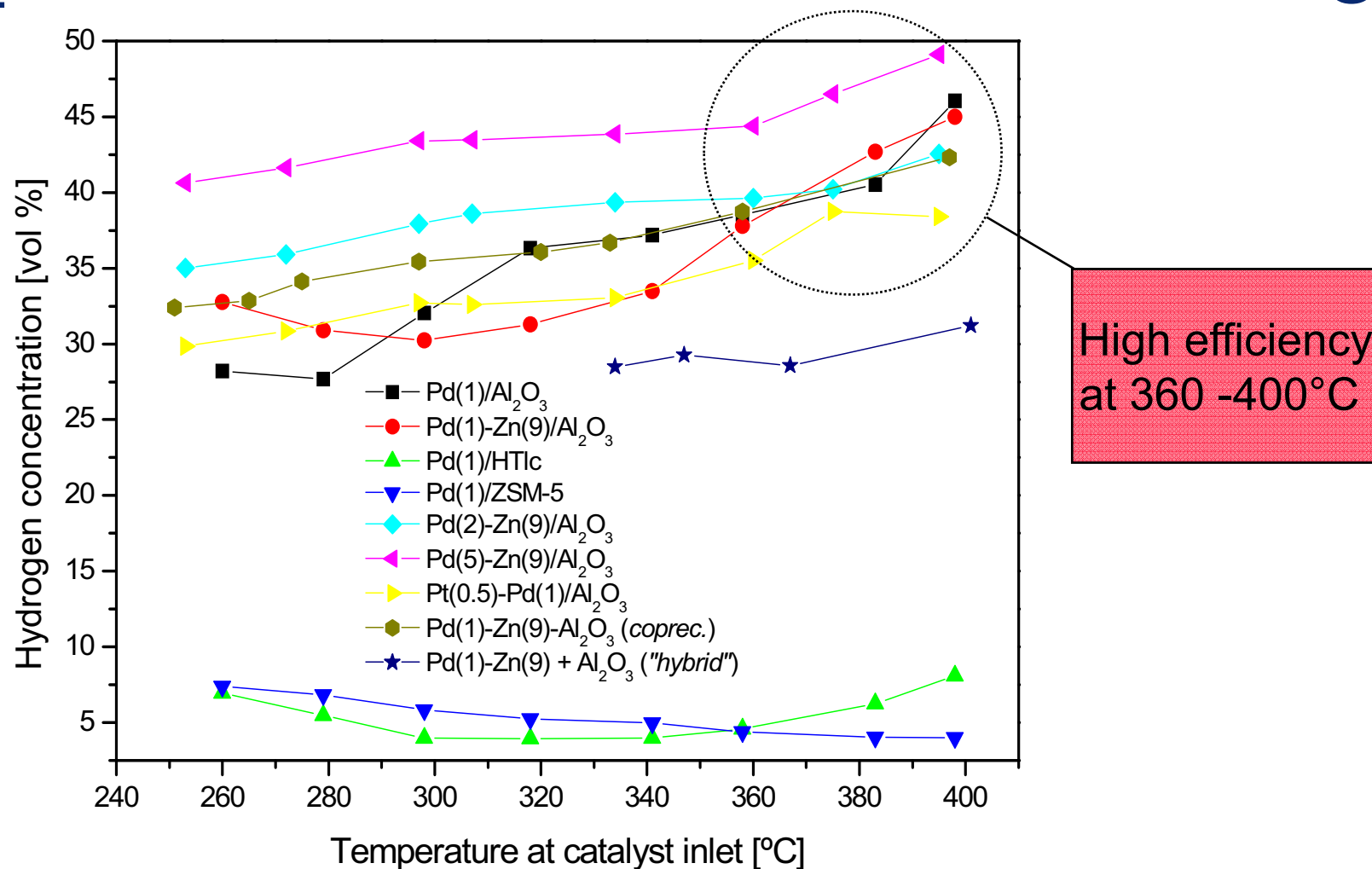
Reformer system overview



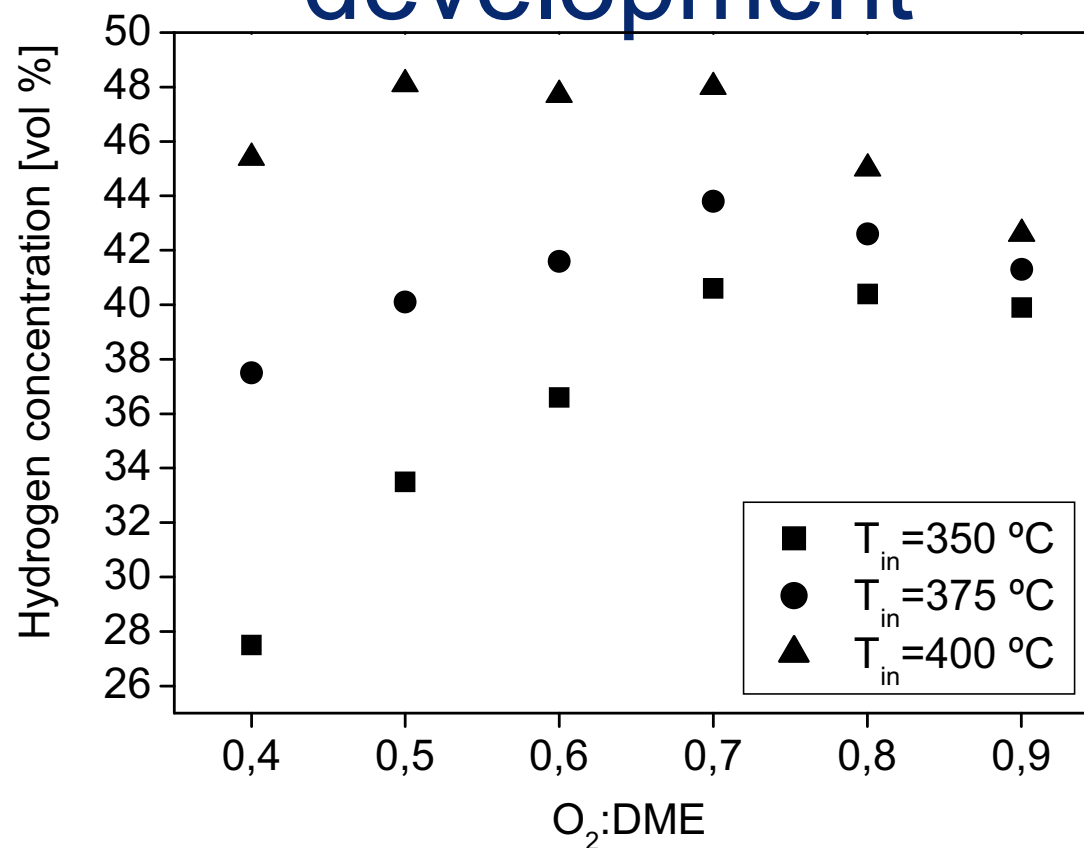
ROYAL INSTITUTE OF TECHNOLOGY



H₂ formation from DME reforming



DME reforming catalyst development



Close to 100 % conversion of DME to H₂ with Pd-Zn/Al₂O₃ catalyst developed at KTH

Conclusions

- All project targets have been met
- 4 graduate students have been educated at Chalmers, KTH and Volvo.
- A national competence platform for research related to DME as fuel has been established.
- A commercial diesel-LNA catalyst was found very efficient for NO_x reduction with DME and reformat.
- New LNC catalysts show promising activity for NO_x reduction with DME.
- High conversion of DME to H₂ with new reformer catalyst.

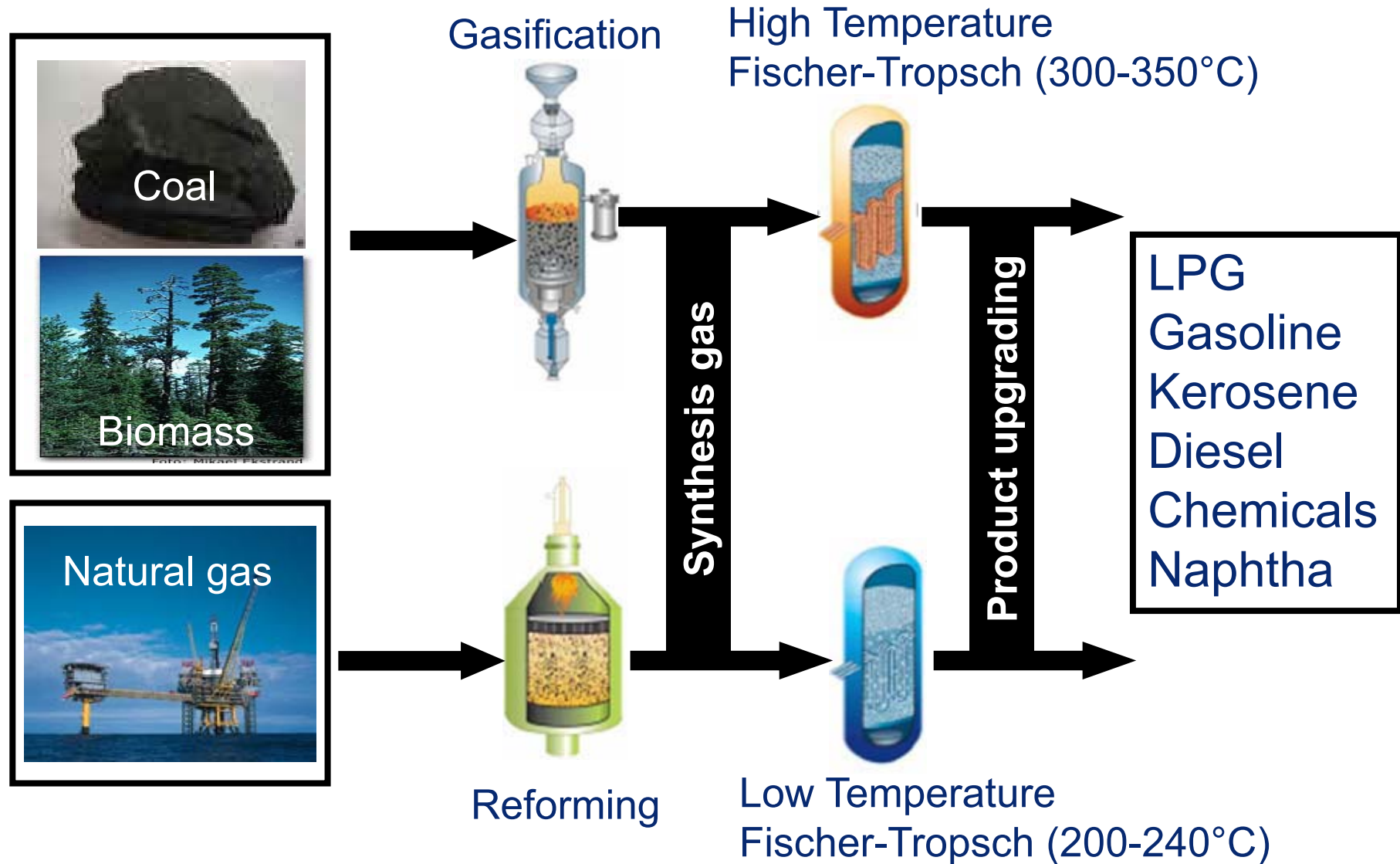
Fischer-Tropsch Fuels for Low Emissions in Diesel Engines

Supervisor: Prof. Ingemar Denbratt

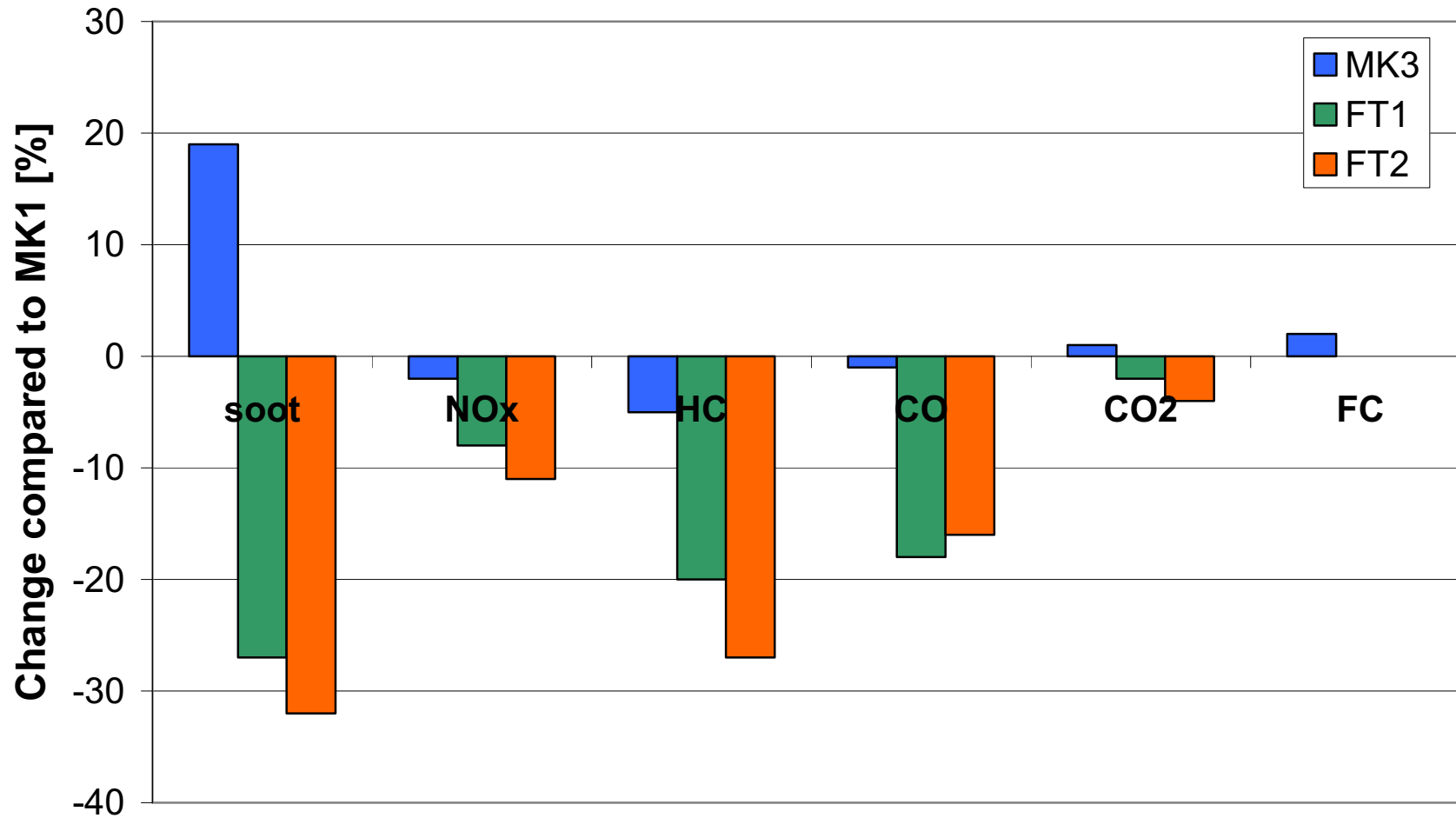
Objectives

- Evaluate F-T Diesel (L-D, H-D single cyl engines)
 - HCCI
 - Diesel
- Fuel parameters
 - Density
 - Cetane number
 - Boiling intervals
- Engine setting
 - Pilot + main injection
 - Start of injection
 - EGR
- Spray studies

Fischer-Tropsch Technology

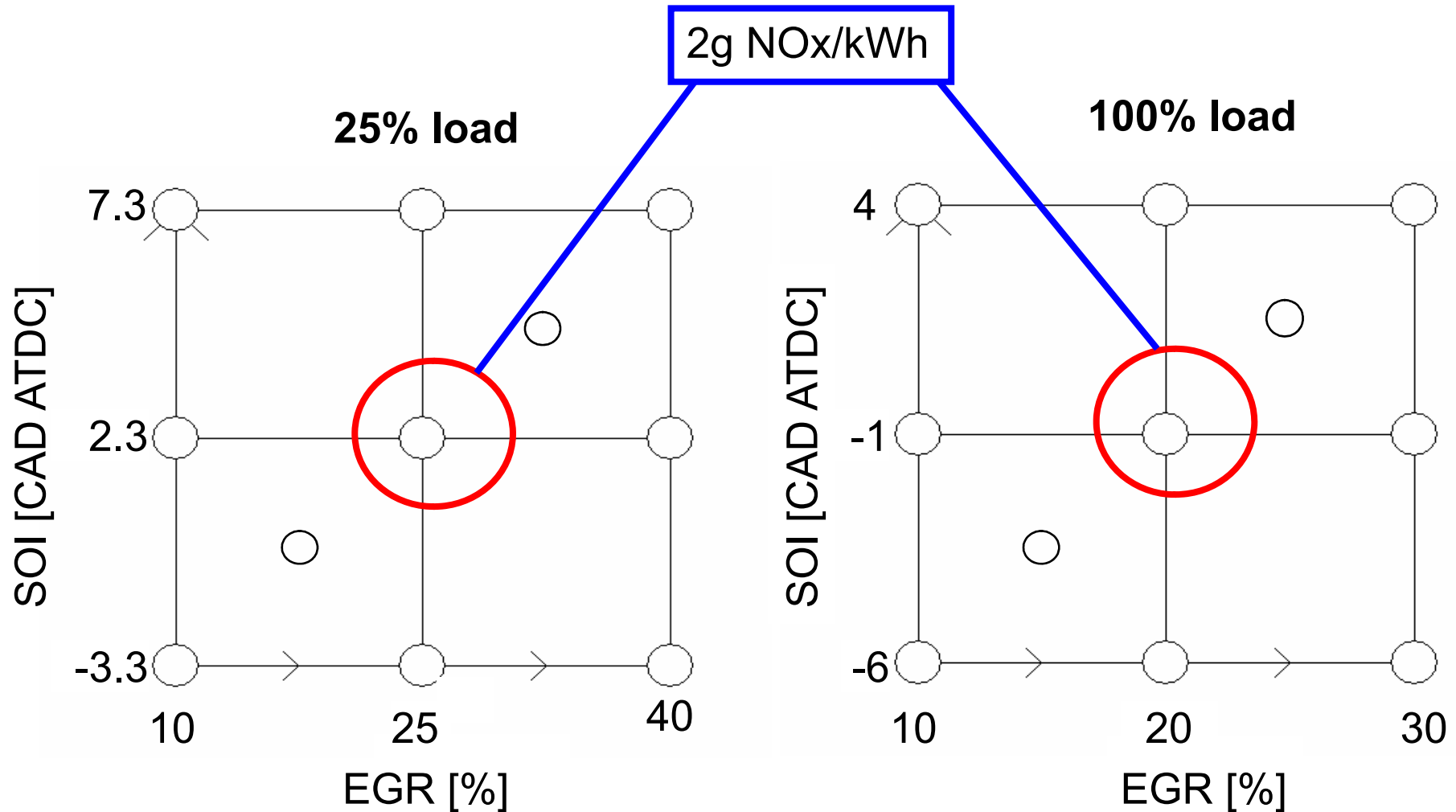


Emissions compared to MK1 for low load



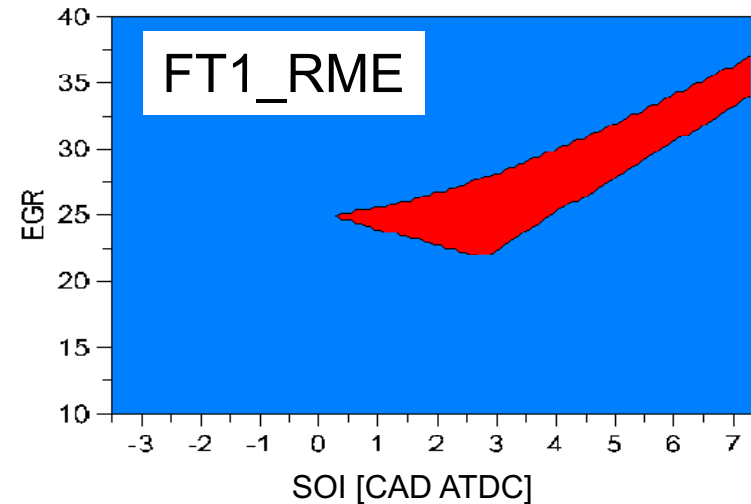
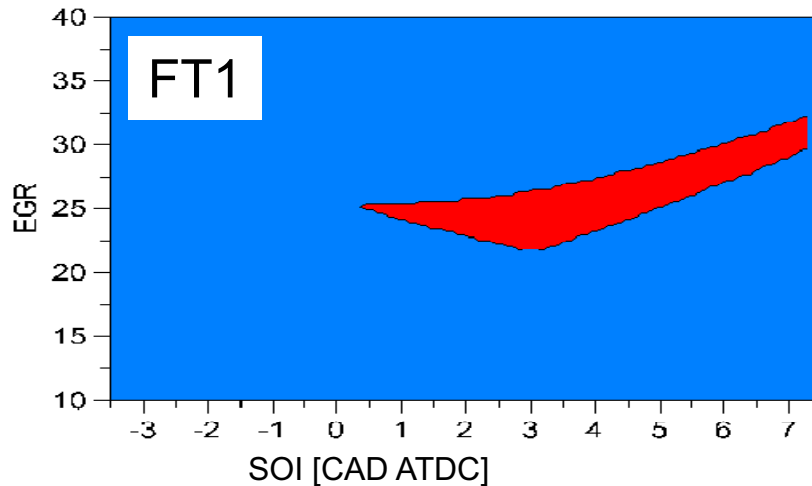
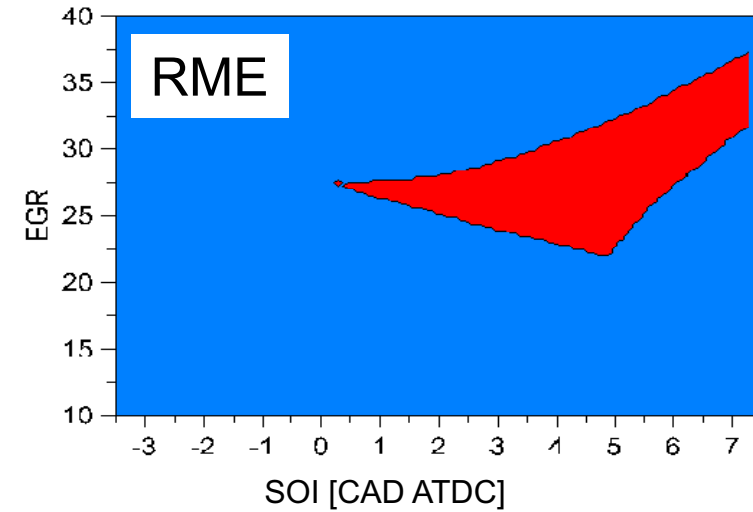
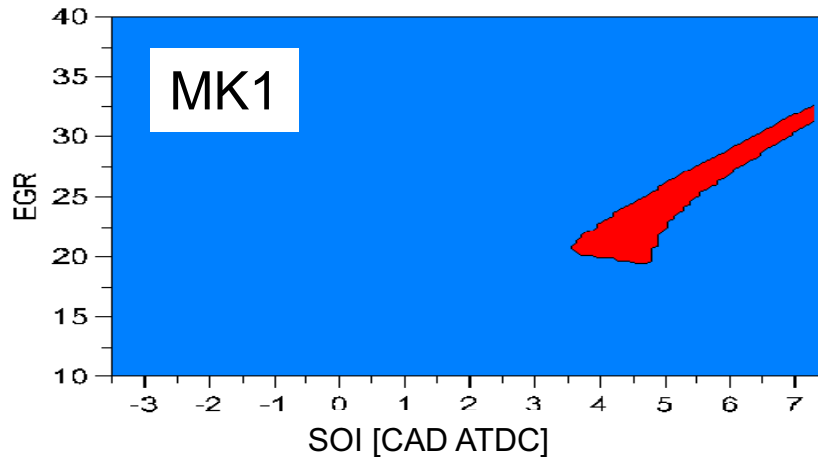
Design of experiments

Constant engine speed at 1200 rpm



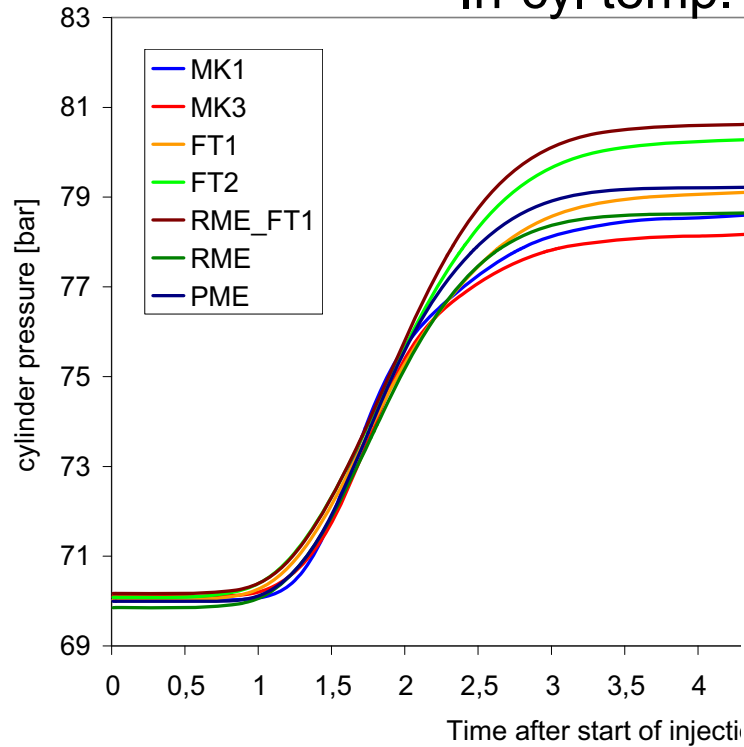
Operating windows (25% load)

2g NO_x/kWh
0.02g soot/kWh

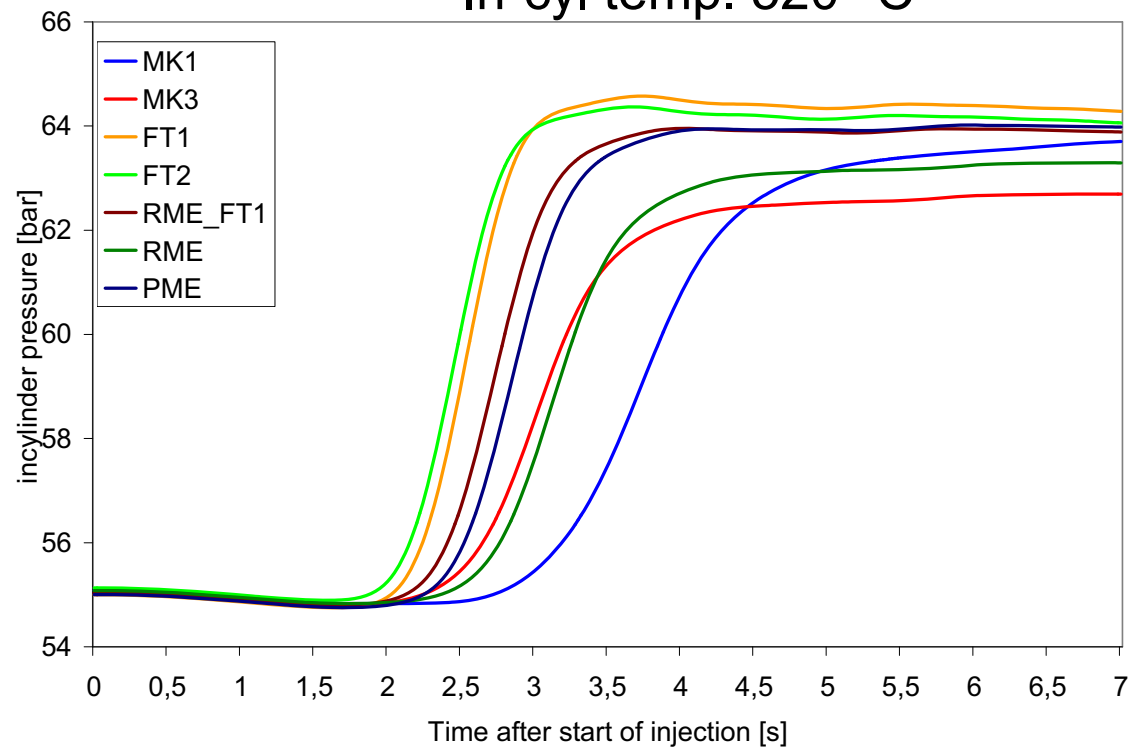


Ignition delay measurements

In-cyl temp. 590° C



In-cyl temp. 520° C



Conclusions

- Possible to operate the engine in HCCI mode with FT fuels
- Soot emissions are lower with FT fuels
- HC and CO levels are lower with FT fuels
- FT fuels have shorter ignition delay at low load, similar at high load
- Low sulfur content benefits use of catalyst

Publications

“Comparison of Conventional Diesel and Fischer-Tropsch Diesel Fuels for HCCI Combustion”

Monica Larsson and Ingemar Denbratt, Chalmers University of Technology

JSAE paper no 20065422

Presenterades vid JSAE Annual Spring Congress 24-26 May 2006

“An Experimental Investigation of Fischer-Tropsch Fuels in a Light-Duty Diesel Engine”

Monica Larsson and Ingemar Denbratt, Chalmers University of Technology

SAE paper no 2007-01-0030

Presenterades vid SAE Fuel and Emissions Conference 23-25 January 2007

“Combustion of Fischer-Tropsch, RME and Conventional Fuels in a Heavy-Duty Diesel Engine”

Monica Larsson and Ingemar Denbratt, Chalmers University of Technology

SAE paper no 2007-01-4009

Presenterades vid SAE Powertrain & Fluid Systems Conference 29-31 October 2007

“Optical studies of spray development and combustion characterization of oxygenated and Fischer-Tropsch fuels”

R. Ochoterena, M. Larsson, S. Andersson and I. Denbratt, Chalmers University of Technology

Presenterades vid SAE World congress April 2008

Acknowledgement

- EMFO for financial support
- GM, Scania, Statoil, Volvo AB, Volvo Cars, Volvo Technology for technical support

Fischer-Tropsch fuels

Börje Gevert

Our research

We have successfully integrate the Fischer Tropsch synthesis with the Shift reaction

Shift:



Fischer Tropsch



Approach

1. Prepare catalyst with high activity cobalt for FT and Iron for shift
2. Prepare new high activity catalyst based on iron
3. Prepare separate FT catalyst and shift catalyst and mix the catalysts in the reactor.

Only the third route works well

Heat recovery in reactor

Both the Fischer Tropsch process and the Shift process are exothermic. This means that large quantities of heat have to be taken out of the reactor at about 240 degrees C. In this Emfo project we assumed that the Statoil ebulated reactor should be used.

Research students in the Fischer Tropsch project

- Dewi Tristantini PhD, Energimyndigheten
- Stylianos Nassoth PhD, Emfo
- Sara Lögdberg student for a PhD at KTH, Energimyndigheten

Students that have worked in the Fischer Tropsch project

- Aamir Raza Khokhar
- Olivier Ansseau
- Rickard Dalman
- Rose Fassihi Karimi
- Zandra George
- Simon Lundevall
- Olov Mattsson
- David Samuelsson
- Salud Seguí Zaragoza
- Gregori Liotard

Conclusions

- It is possible to integrate shift and the Fischer Tropsch reaction.
- A low cost alternative would than be a plant with high conversion and no recycle.
- This is a big advantage for the Fischer Tropsch over methanol synthesis.

- SYNBIOS III -

**The third International Conference on the
Introduction of Second Generation Automotive Biofuels and Hybrid Vehicles**

At Chalmers University of Technology, May 28 – 29, 2009

Effekter av transienta belastningar på energieffektivitet och emissionsbildning från arbetsmaskiner vid användning av alternativa bränslen

EMMA 5

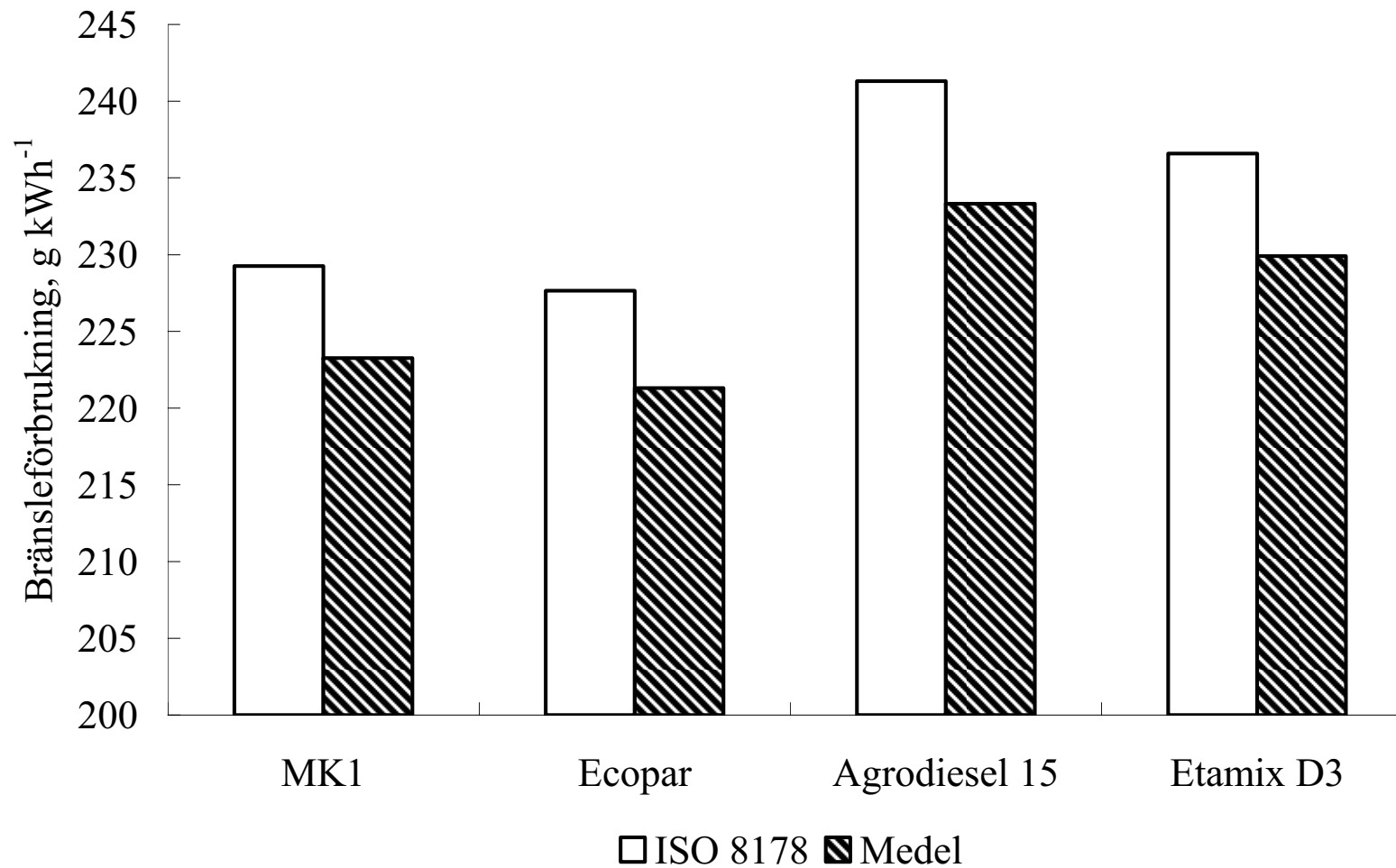


Bränslen

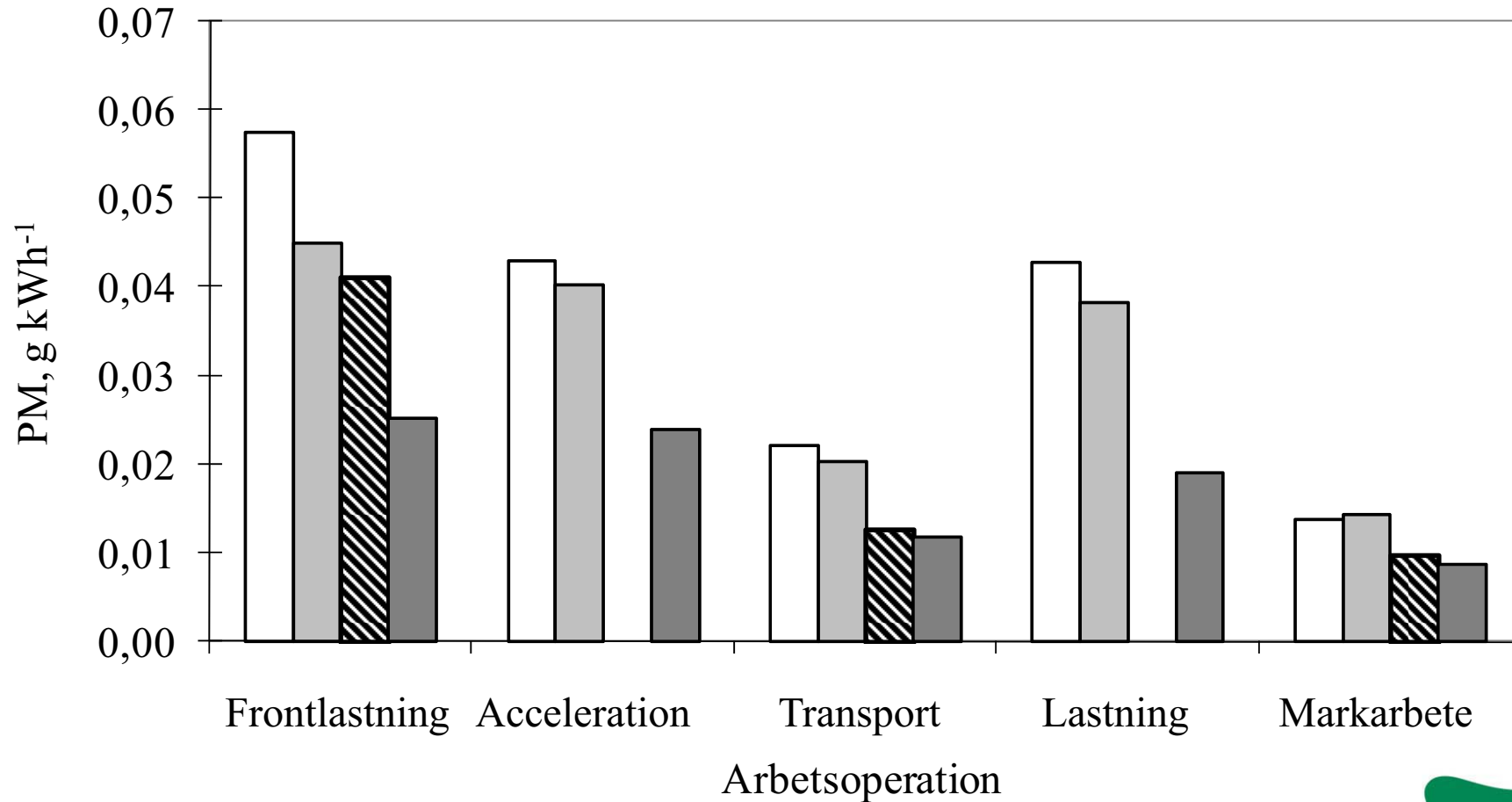
- **MK1**
 - Konventionell diesel
- **Ecopar®**
 - Fischer-Tropsch diesel
- **Agrodiesel 15**
 - Blandbränsle mellan
 - MK1 – 85%
 - Högre alkohol – 10%
 - RME – 5%
- **Etamix D3**
 - Blandbränsle mellan
 - MK1 – 90%
 - Etanolderivat – 10%



Bränsleförbrukning, statisk belastning



Partiklar, transient belastning

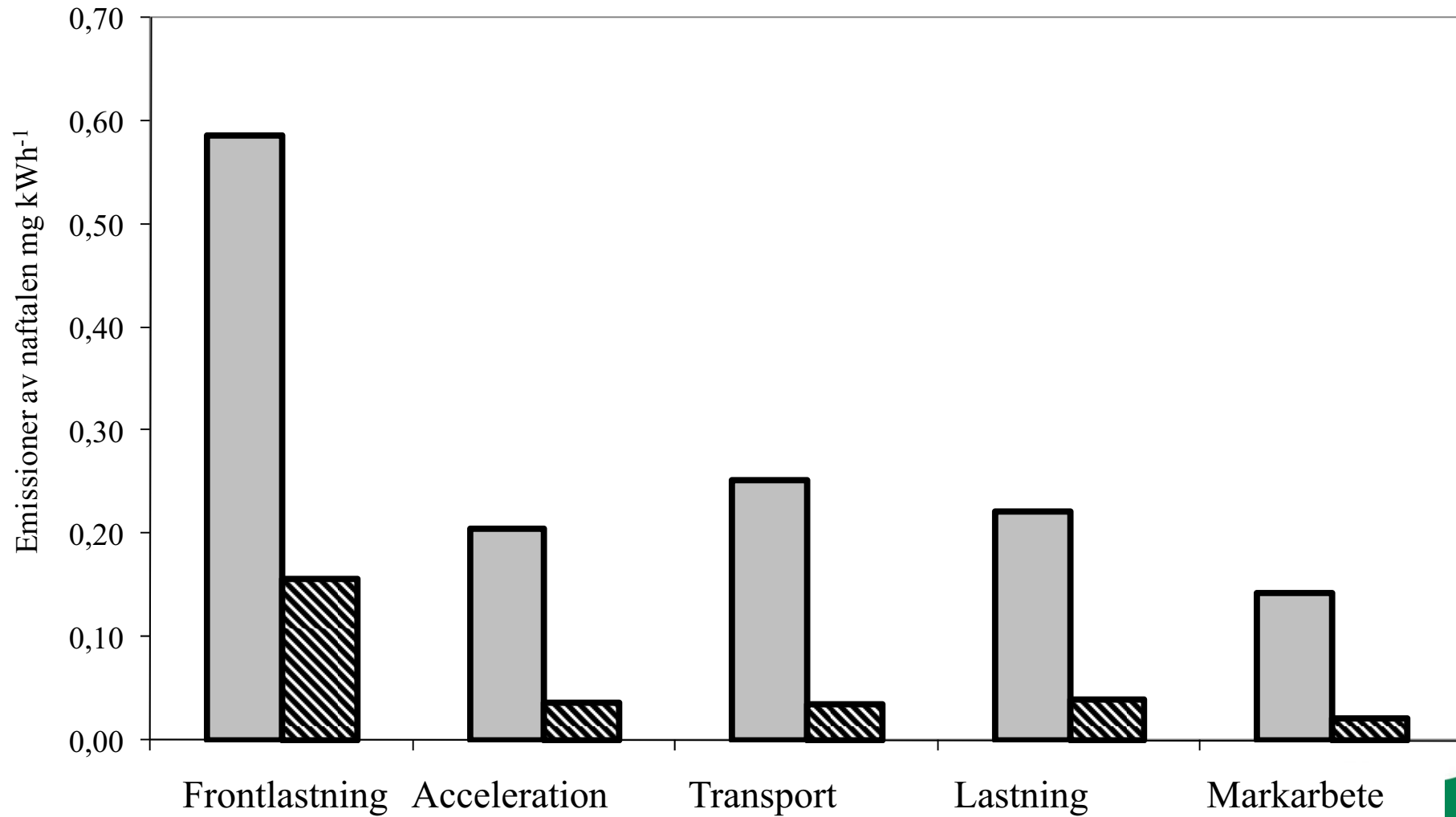


□ MK1 □ Ecopar ■ Agrodiesel 15 ■ Etamix D3

svenskt lantbruksuniversitet
www.slu.se



Naftalen, transient belastning

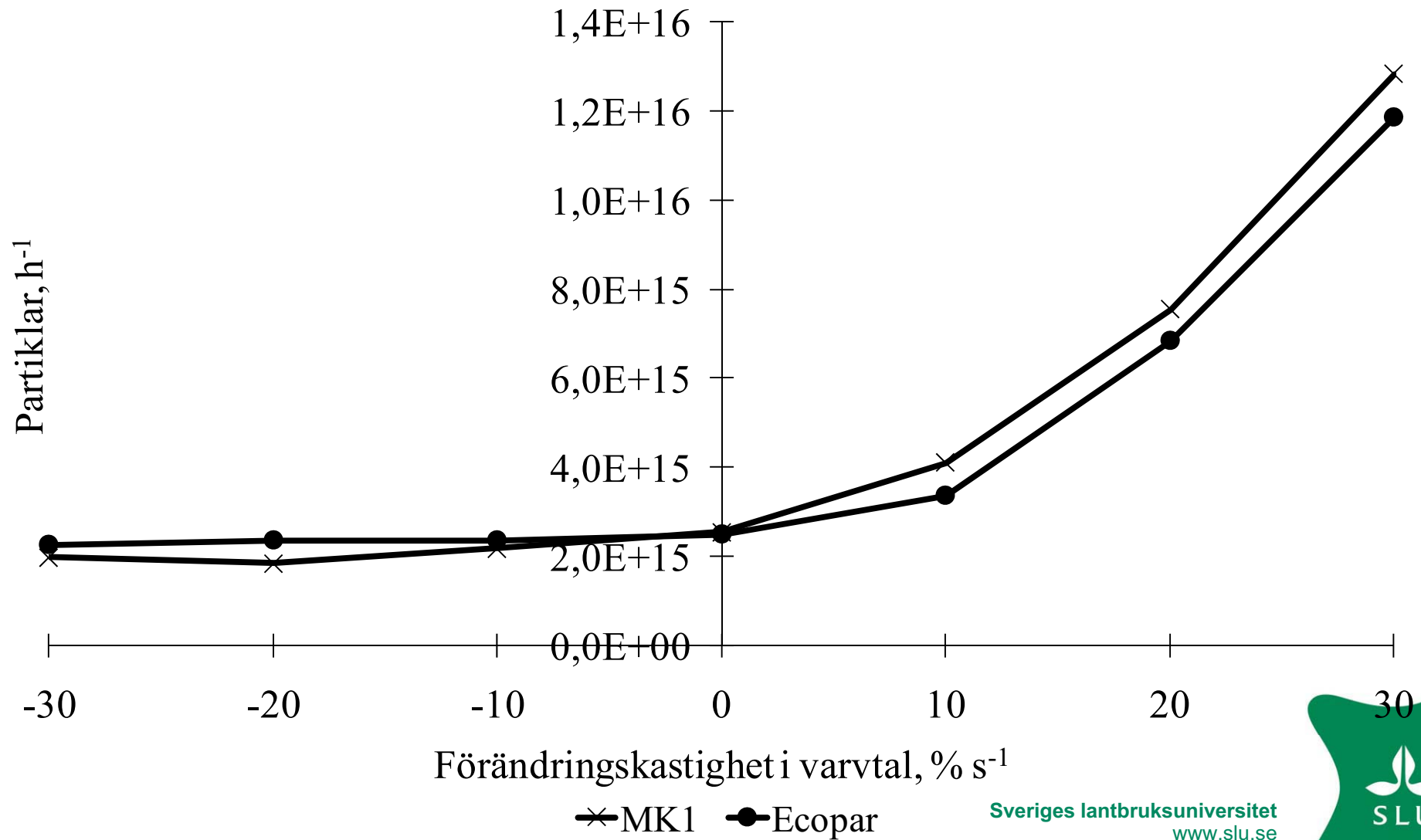


■ MK1 ■ Ecopar

Sveriges lantbruksuniversitet
www.slu.se



Partikelantal och storleksfördelning



Slutsatser

- Stor påverkan av transienta belastningar
- Tydliga skillnader mellan bränslen
- Lägre utsläpp av partiklar från Etamix D3 och Agrodiesel 15 – oxygena bränseln?
- Höga utsläpp syns inte i bränsleförbrukning

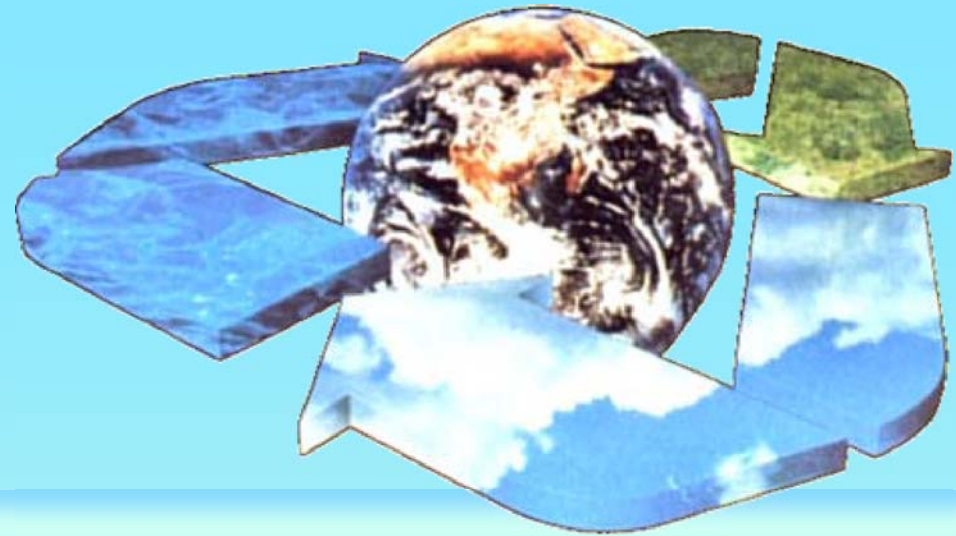
Deltagare

- **SLU Sveriges lantbruksuniversitet**
 - Per-Anders Hansson
 - Magnus Lindgren
- **SMP Svensk Maskinprovning**
 - Christian Wetterberg
 - Hans Arvidsson
- **VCE Volvo Construction Equipment**
 - Bengt Johansson
- **SP Sveriges Tekniska forskningsinstitut**
 - Lars Rosell
 - Linda Johansson
 - Karine Arrhenius
 - Anna Boss



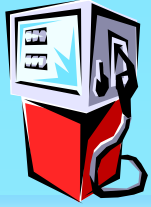
The logo for Ecotraffic, featuring the word "Ecotraffic" in a bold, green, sans-serif font.

ENERGY RESEARCH, DEVELOPMENT, DEMONSTRATION, AND DEPLOYMENT
ENVIRONMENTAL CONSULTANTS



Well-to-wheel, tunga fordon EMFO seminarium 2009-03-04

Patrik Klintbom, Volvo Technology
Peter Ahlvik, Ecotraffic ERD³



Kombinationer fordon/drivmedel



Fjärrbil

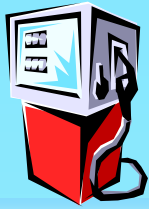
- ◆ Diesel
- ◆ FTD
- ◆ RME
- ◆ Etanol
- ◆ Metanol
- ◆ DME
- ◆ LNG/LBG/LSNG

- ◆ AdBlue (urea)

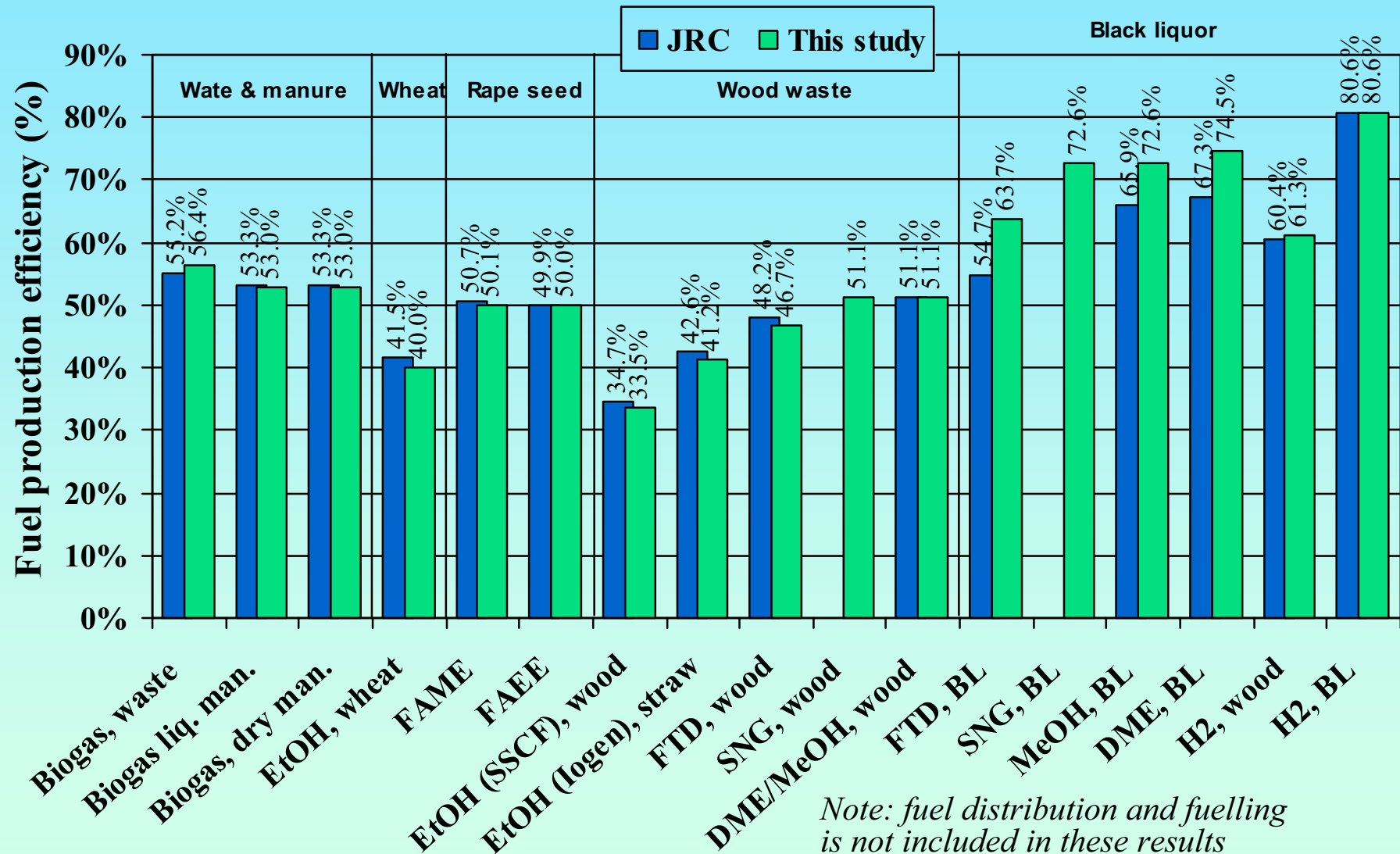
Stadsbuss

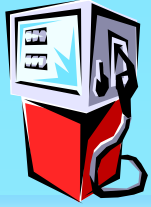
- ◆ Diesel
- ◆ FTD
- ◆ RME
- ◆ Etanol
- ◆ Metanol
- ◆ DME
- ◆ CNG/CBG/CSNG

- ◆ AdBlue (urea)



Verkningsgrad i drivmedelsproduktion

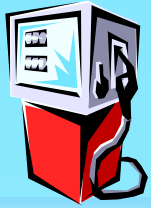




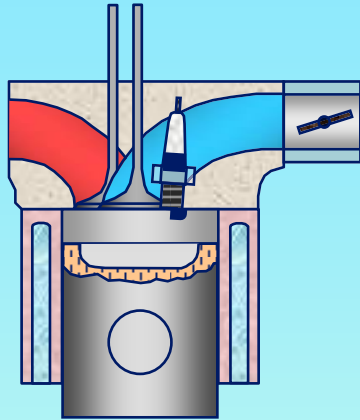
”Basmotor” och ”derivat”



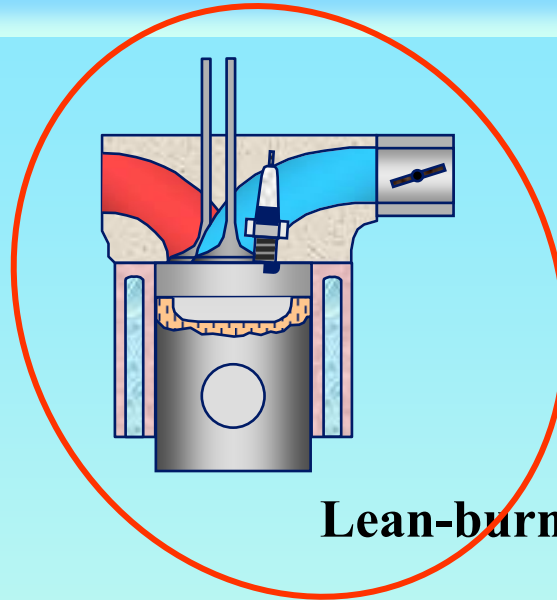
- ◆ Volvo 13-litersmotor = basmotor. Underlag från Volvo Technology
- ◆ Nedskalning till bussmotor \approx 9-liter (diesel)
- ◆ Skalning även för alkoholmotorer med tändförbättrare (lägre specifik effekt)
- ◆ Verkningsgrad vid skalning av motorer skalas enl. formler av Uyehara
- ◆ NO_x efterbehandling \rightarrow användning av urea



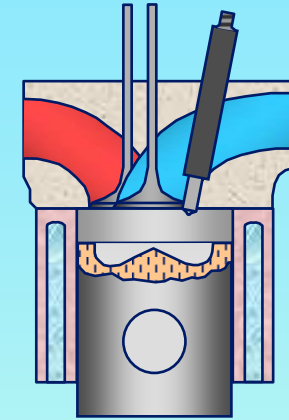
Gas- och alkoholoralternativ



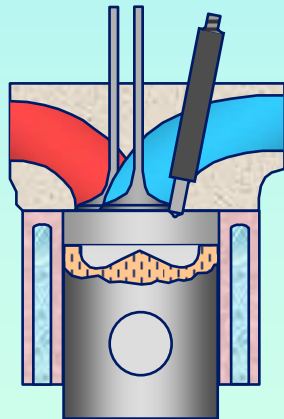
TWC



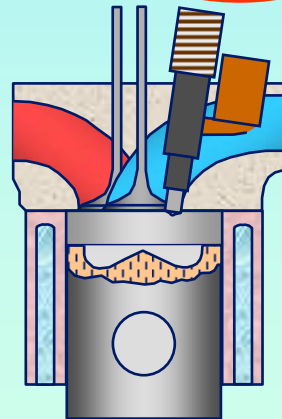
Lean-burn



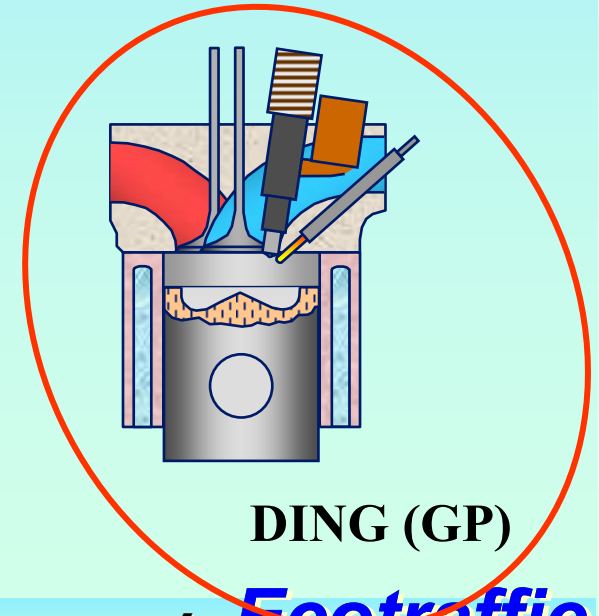
DFNG



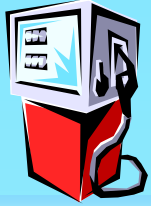
PING



DING (PI)



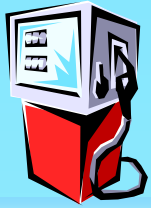
DING (GP)



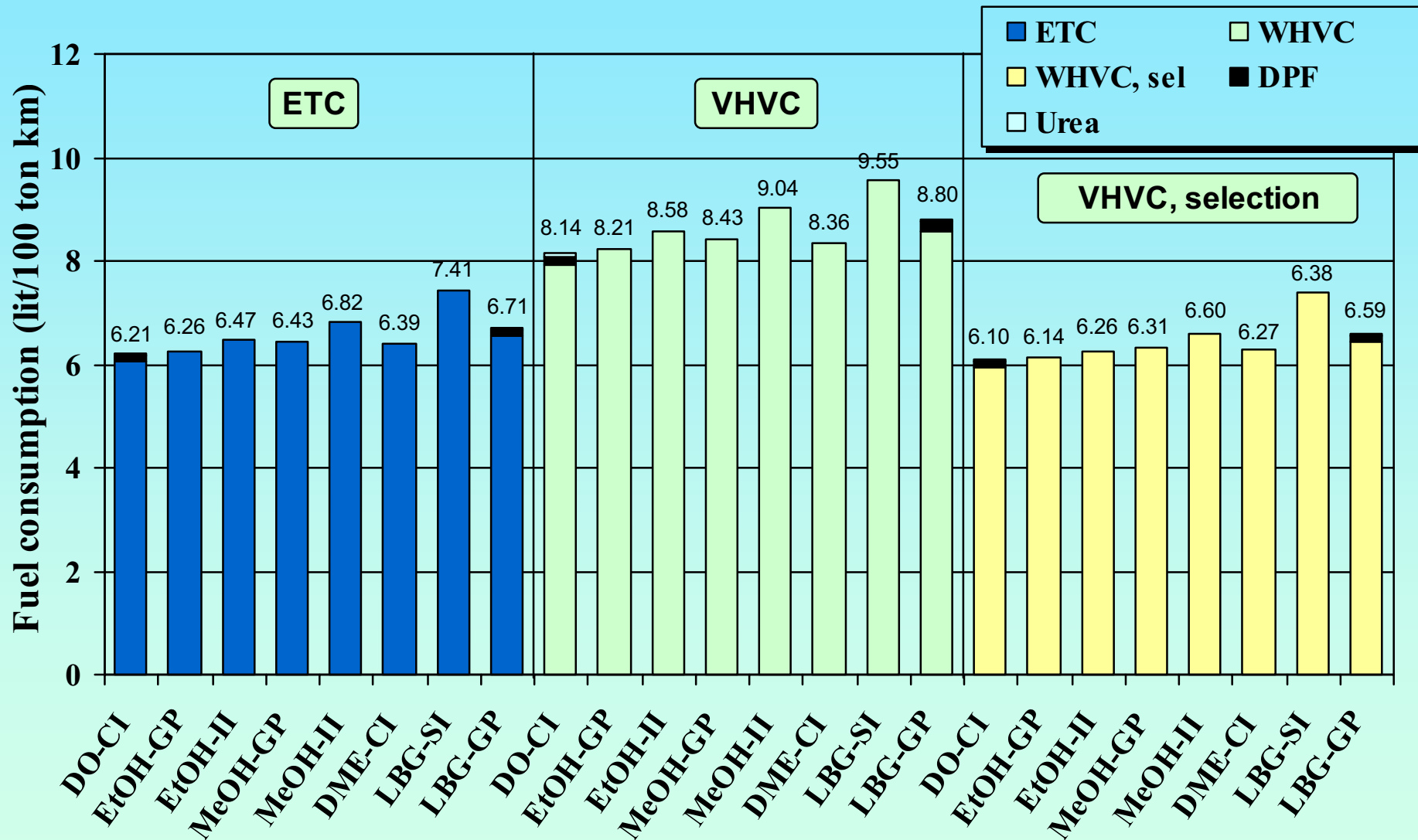
Förkortningar (i figurer)

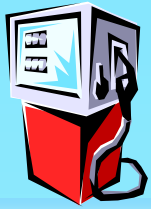


<i>Abbreviation</i>	<i>Fuel</i>	<i>Engine/combustion technology</i>
DO-CI	Diesel oil	Diesel cycle, compression ignition
EtOH-GP	Ethanol (neat with additives)	Diesel cycle, glow-plug ignition
EtOH-II	Ethanol w. ignition improver	Diesel cycle, compression ignition
MeOH-GP	Methanol (neat with additives)	Diesel cycle, glow-plug ignition
MeOH-II	Methanol w. ignition improver	Diesel cycle, compression ignition
DME-CI	DME	Diesel cycle, compression ignition
CBG-SI	Methane (CNG, CBG and SNG)	Otto cycle, spark plug ignition
CBG-GP	Methane (CNG, CBG and SNG)	Diesel cycle, glow-plug ignition

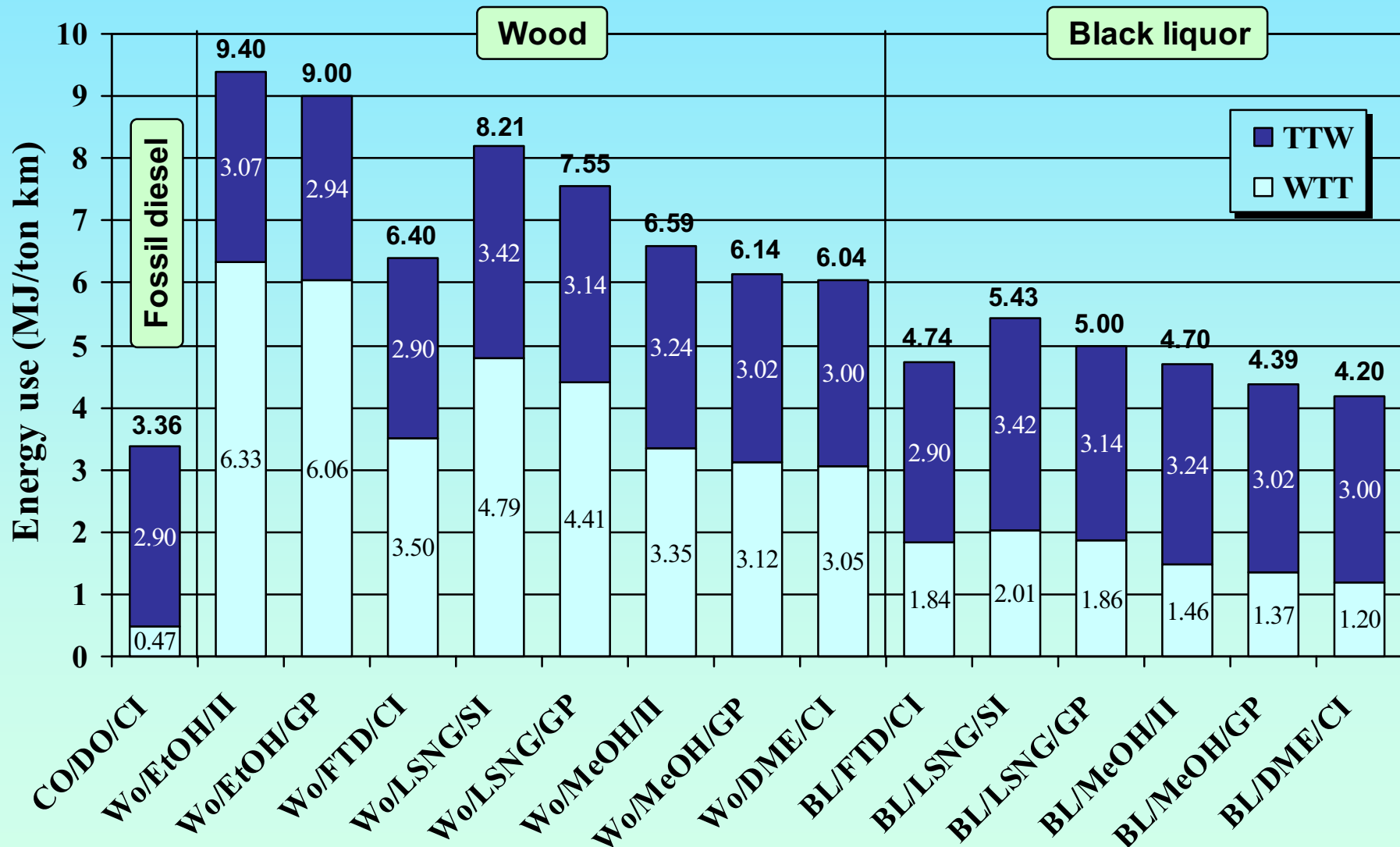


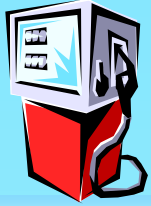
Bränsleförbrukning för lastbilen (i dieselev./tonkm) i olika körcykler





WTW energianvändning för lastbilen (MJ/tonkm) i VHVC körcykeln

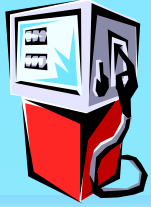




Sammanfattning och slutsatser



- ◆ Biobränsle-el med 48,2% verkningsgrad:
 - Liten inverkan: alt. med lågt elbehov, t.ex. biogas
 - Försämring: etanol från cellulosa
 - Förbättring: drivmedel fr. svartlut (spec. FTD)
- ◆ Stadsbuss och fjärrbil: relativt lika resultat
- ◆ Små skillnader mellan olika körcykler men de kan förklaras
- ◆ Bränslen med låg energitäthet generellt sämre
- ◆ Alkoholer: glödstift bättre än tändförbättrare
- ◆ Gas: diesel med glödstift bättre än otto (LB)
- ◆ DME från svartlut ”bäst” av biodrivmedel



Slut!



◆ Tack för visat intresse!

◆ Frågor?

Mer information finns på:

www.ecotraffic.se

(t.ex. rapporter, presentationer mm.)



Stockholms
universitet

Blending of Ethanol in Gasoline for Spark Ignition Engines

Problem inventory and evaporative measurements

Study performed 2004-2005

Roger Westerholm, Karl-Erik Egebäck, Björn Rehnlund,
Magnus Henke and Mats Wallin

Summary of report

- There is intense interest world-wide in using ethanol as an automotive fuel, especially in blending ethanol with gasoline.
- Ethanol has a lower heating value than gasoline, which will reduce the energy content of the fuel. However, this can be partly offset by the higher octane value of ethanol. There will be a slight increase ($\sim 2-3\%$) in fuel consumption when shifting from neat gasoline to a 10 percent ethanol-gasoline blend
- The main conclusion from using ethanol-gasoline blends in practice is that blends with up to 15 percent ethanol will not have any significant negative effects on the wear of the engine or vehicle performance.

Summary of report

- No significant difference can be seen in regulated emissions when comparing the use of blended fuel (with up to 10-15% ethanol) to the use of neat gasoline.
- Concerning unregulated emissions views differ. Regarding the emissions of light aromatics (BTEX) the main conclusion is that there is a slight decrease when using ethanol blends.
- For aldehydes there is a significant increase, especially of acetaldehyde and (to a lesser extent) formaldehyde emissions. However, there is a serious lack of data describing the effects under Swedish conditions.

Summary of report

- There is a need to generate data and experience by running tests and analysing the environmental effects of blending ethanol with gasoline. The lack of data is even more marked for blends with high ethanol contents ($\sim 20\%$). Such blends should be avoided before a thorough analysis has been carried out and more data are available.
- Running vehicles on blended fuels, a number of issues have to be addressed before the alcohol content of blends is increased.

Summary of report

- The problem that the RVP increases when ethanol is blended with gasoline since current gasoline standards impose limits on its RVP. Therefore, either there must be an exemption for ethanol blended fuels or the base gasoline RVP must be adjusted. Such adjustments are already made today to the base gasoline used in the 5 % ethanol gasoline blends.
- The concern about the performance and start-ability of vehicles at low temperatures, which commonly occur in wintertime, especially in the northern parts of Sweden.
- A issue is whether blends with 10 to 15 percent ethanol in gasoline will affect human health and the environment (both local and regional).

Full report available on request

Mail to:

Roger Westerholm, Stockholm University

roger.westerholm@anchem.su.se

or

Jan Gåste, AVL MTC AB

jan.gaste@avlmtc.com