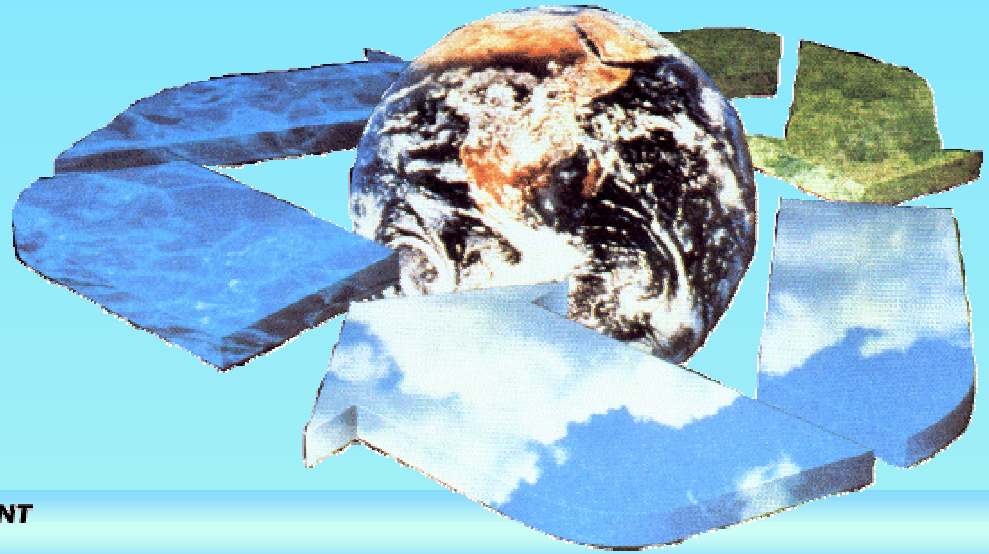
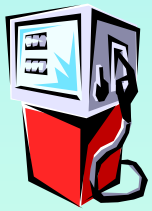


Ecotraffic

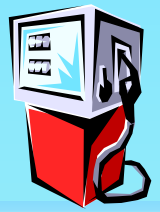
ENERGY RESEARCH, DEVELOPMENT, DEMONSTRATION, AND DEPLOYMENT
ENVIRONMENTAL CONSULTANTS

Well-to-wheel efficiency for fuels from natural gas and biomass

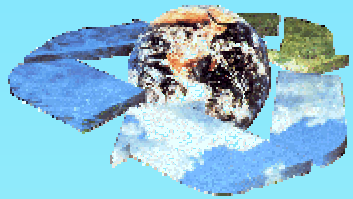


Meeting in Stockholm 2003-06-17

Peter Ahlvik, Ecotraffic ERD[3]



Outline

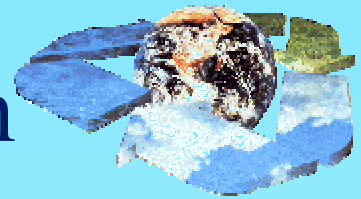


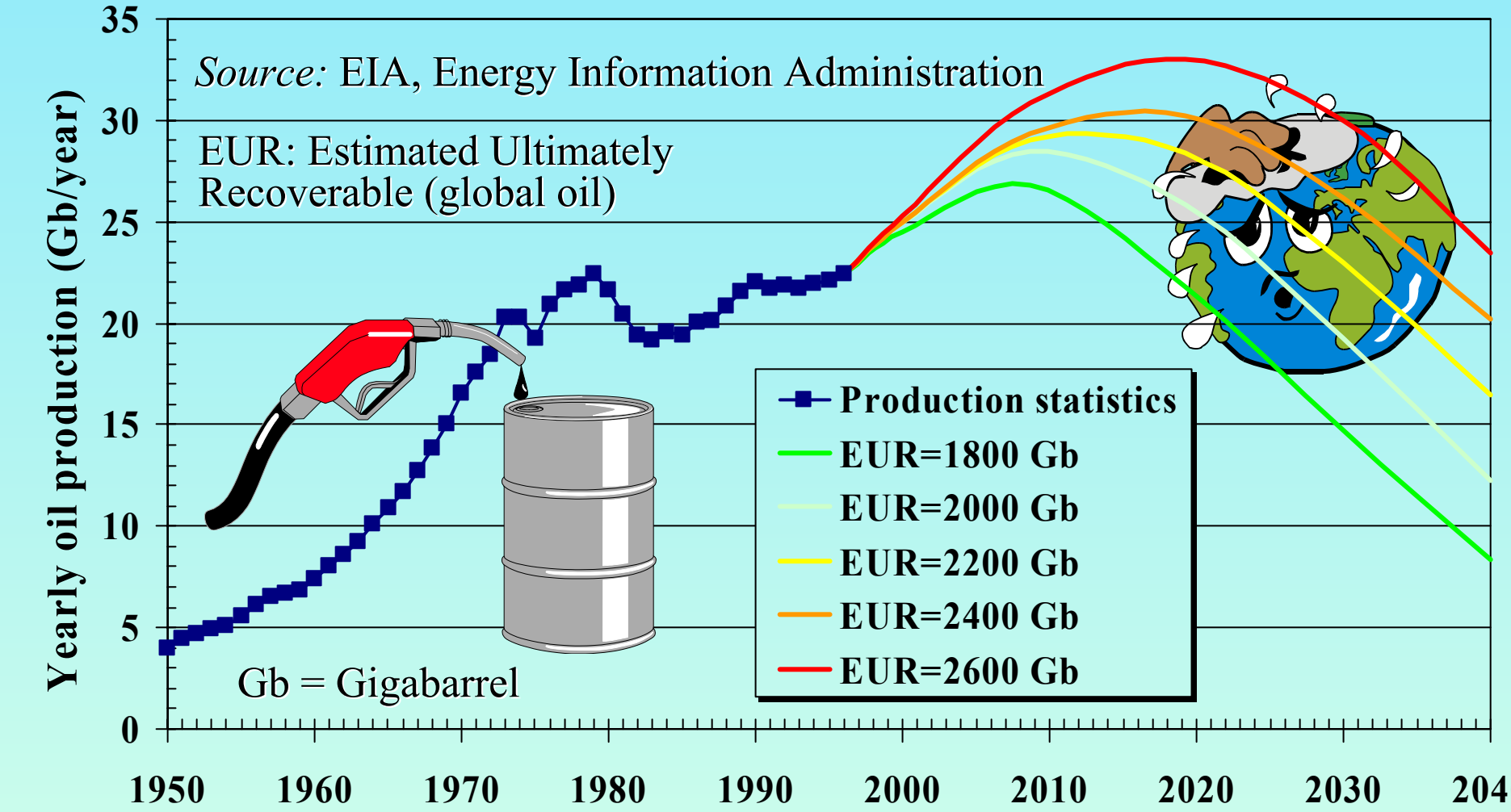
- Introduction and background
- Methodology
- Assumptions and conditions
- Vehicles, energy converters and drivetrain
- Fuel production and fuel supply (well-to-tank)
- Vehicle efficiency (tank-to-wheel)
- Full fuel cycle efficiency (well-to-wheel)
- Summary and conclusions

Some finalized and on-going Ecotraffic projects in this area

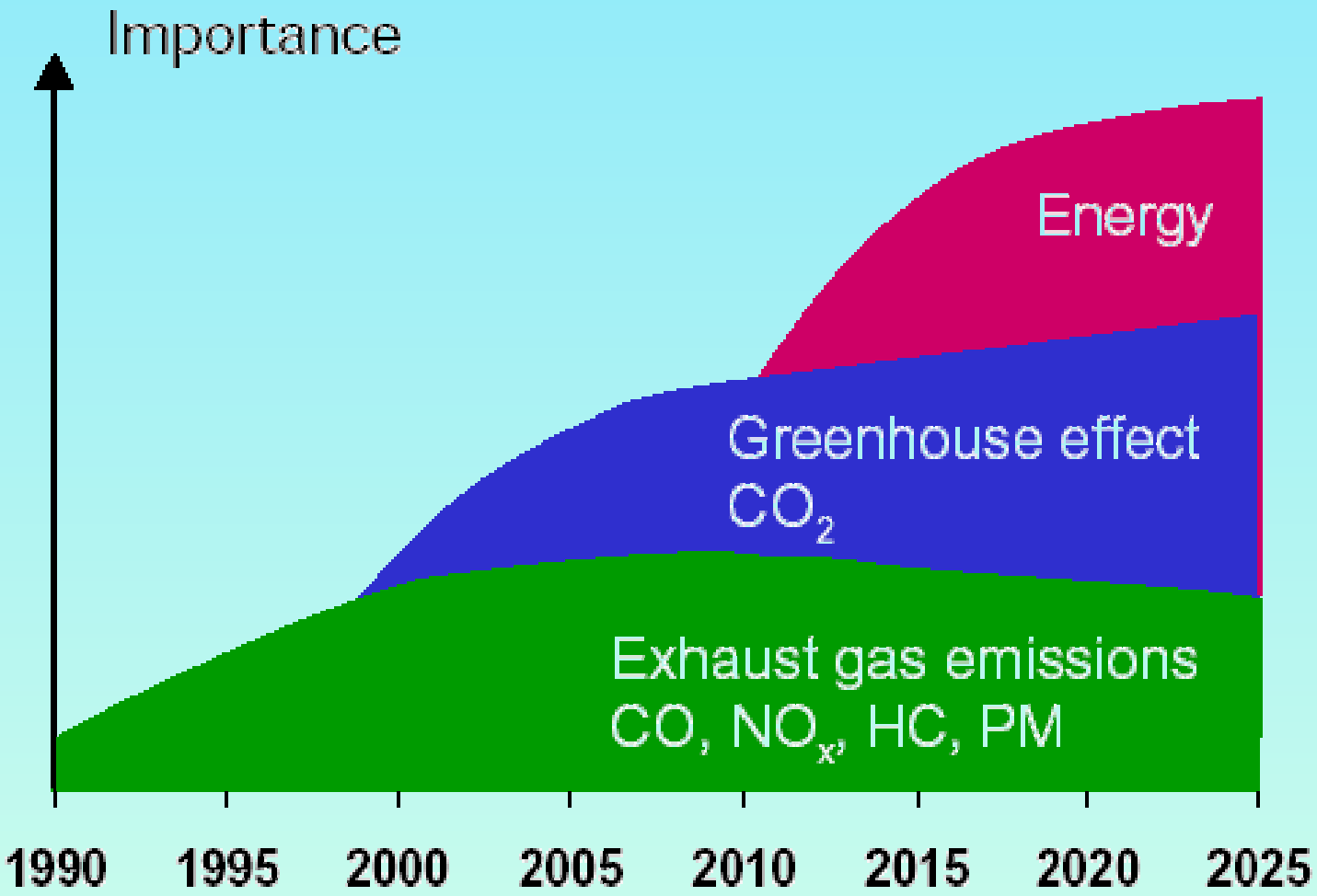
- BAL: Etanol, methanol from cellulosic m. — Compl
- BioMeeT I: Energy combine in Trollhättan — Compl
- Well-to-wheel efficiency — Compl
- Sustainable fuels: Introduction of biofuels — Compl
- BioMeeT II: ”Stakeholders” (incl. DME) — Compl
- BLGMF: Methanol/DME from black liquor
  Preliminary results: very low cost (!)
- RENEWA: Methanol/DME from waste

Worldwide yearly oil production



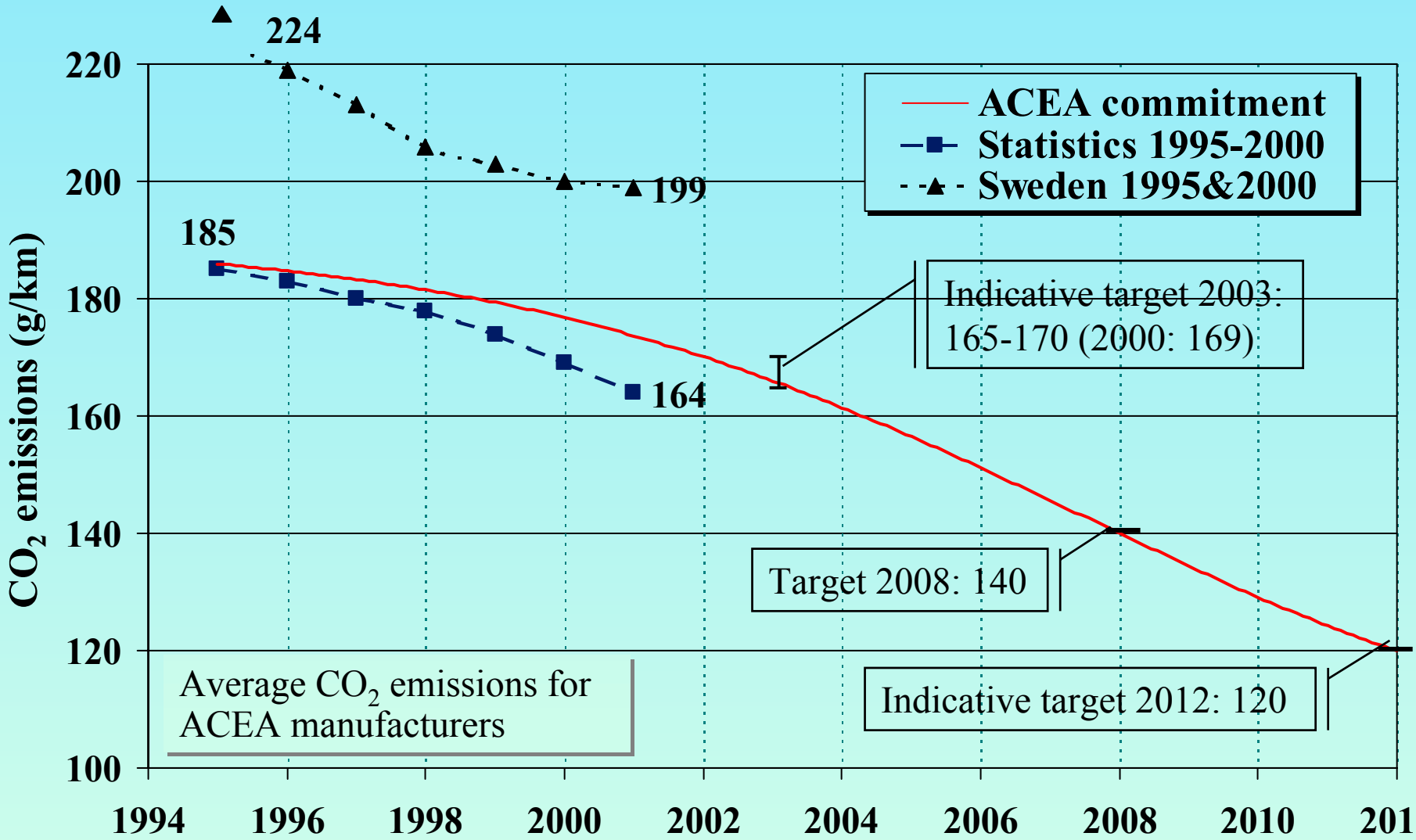


Environmental driving forces for vehicle development



Source: Schindler et al. (VW), DEER 2002 Workshop

Voluntary CO_2 reduction by EU car manufacturers (ACEA)



EU "biofuels" directive 2003/30/EC, targets

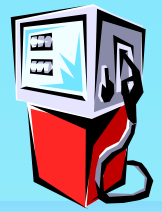
Reference value for targets for proportion of all sold gasoline and diesel fuel (energy equiv.) in a member state. Cancellations compared to original proposal are shown.

Year	*Biofuel (%)*	*Share of low-blending (%)*
2005	2	-
~~***2006***~~	~~2,75~~	-
~~***2007***~~	~~3,5~~	-
~~***2008***~~	~~4,25~~	-
~~***2009***~~	~~5~~	~~1~~
2010	5,75	~~1,75~~

Optimistic scenario in the EU

Assessment of alternative fuel potential if an active policy is decided to promote them (does not exclude other possibilities, e.g. DME). Note that this is an optimistic scenario and not part of the directive.

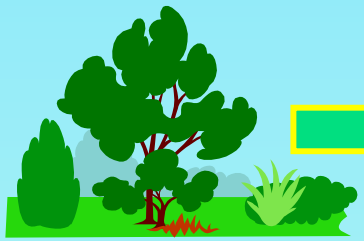
Year	Biofuel (%)	Natural gas (%)	Hydrogen (%)	Total (%)
2005	2			2
2010	6	2		8
2015	(7)	5	2	14
2020	(8)	10	5	(23)

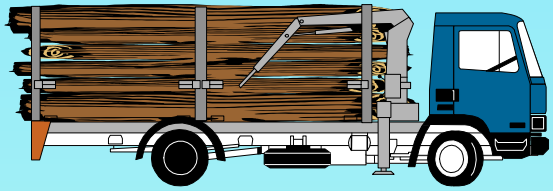


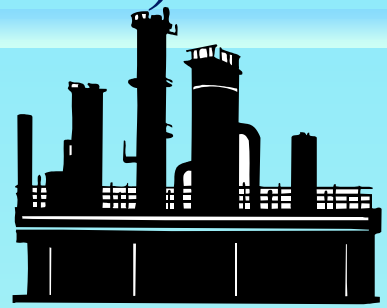
Methodology

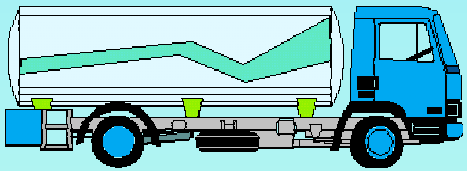
- Assumptions and conditions for period 2010 to 2015 (2012). Fuel efficiency scenario according to EU & car industry indicative target for 2012
- Well-to-tank efficiency based on previous Ecotraffic WTW study “Life of Fuels” but with extensive update using new input data.
- Vehicle simulations: Advisor® (by NREL)
- Some comparisons with studies by GM USA and MIT (2000) are shown (later studies by GM Europa and addendum by MIT are now available...)

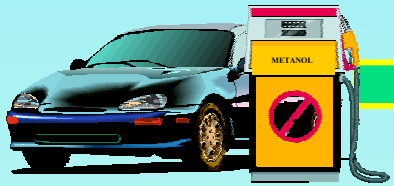
Systems that have been assessed (well-to-wheel)


Feedstock production

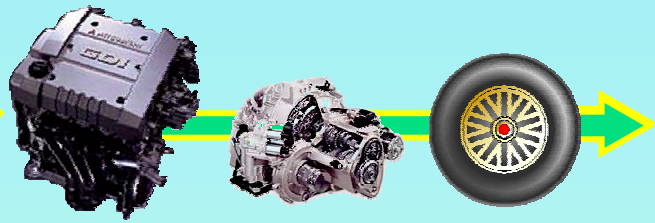

Feedstock transport


Fuel production


Fuel transport



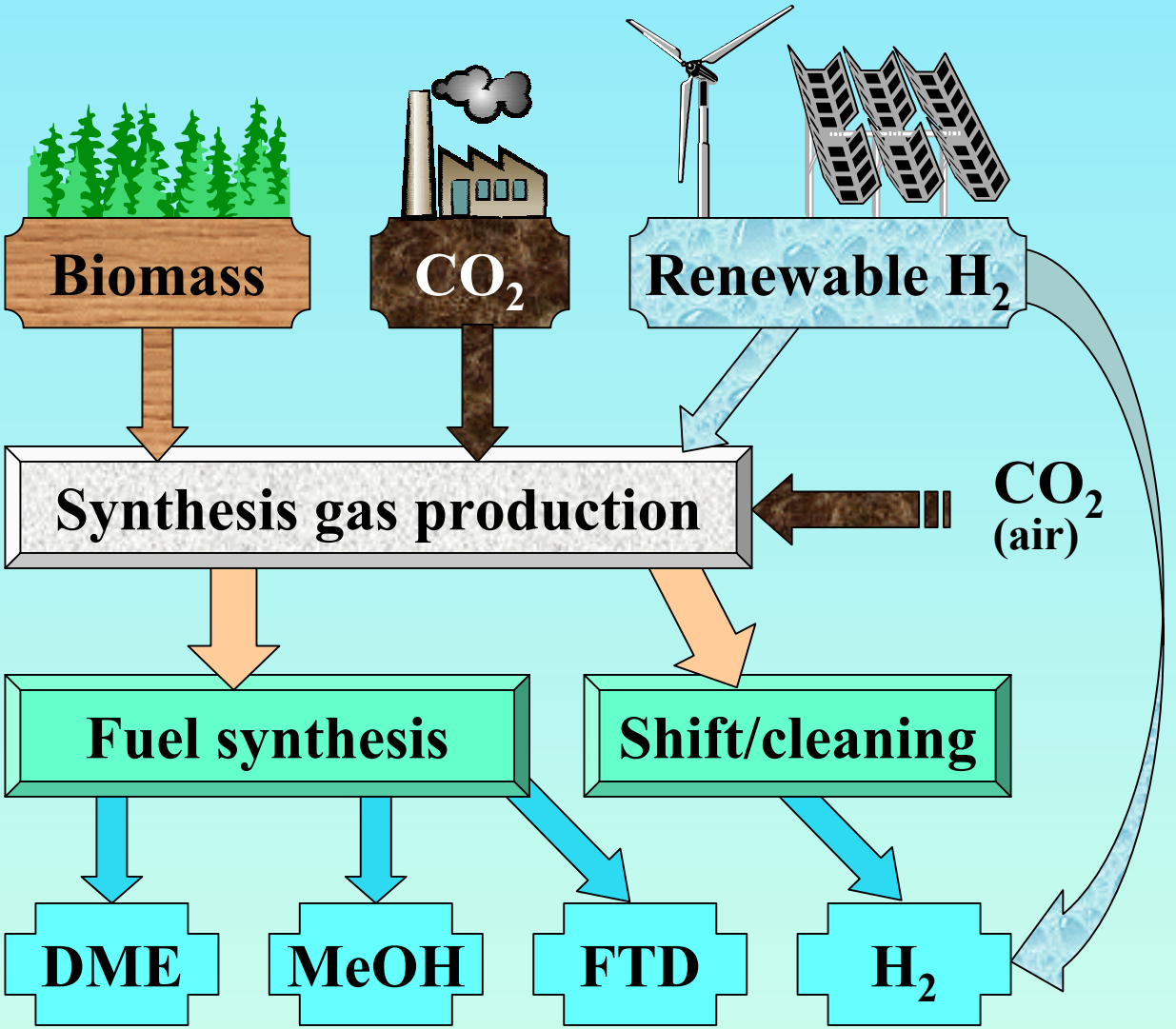
Refuelling (+conversion)


Energy conversion in the vehicle

Some examples of pathways

Motor fuel	*Energy converters (EC)*	*Drivetrains (DT)*
Ethanol (EtOH)	Otto engine (otto)	Conventional (conv.)
Hydrogen, gaseous (GH_2)	Fuel cell (FC)	Electric hybrid (hyb)
Methanol (MeOH)	Diesel engine (diesel)	Electric hybrid (hyb)
In total: 98 different combinations of feedstocks, fuels and drivetrains		

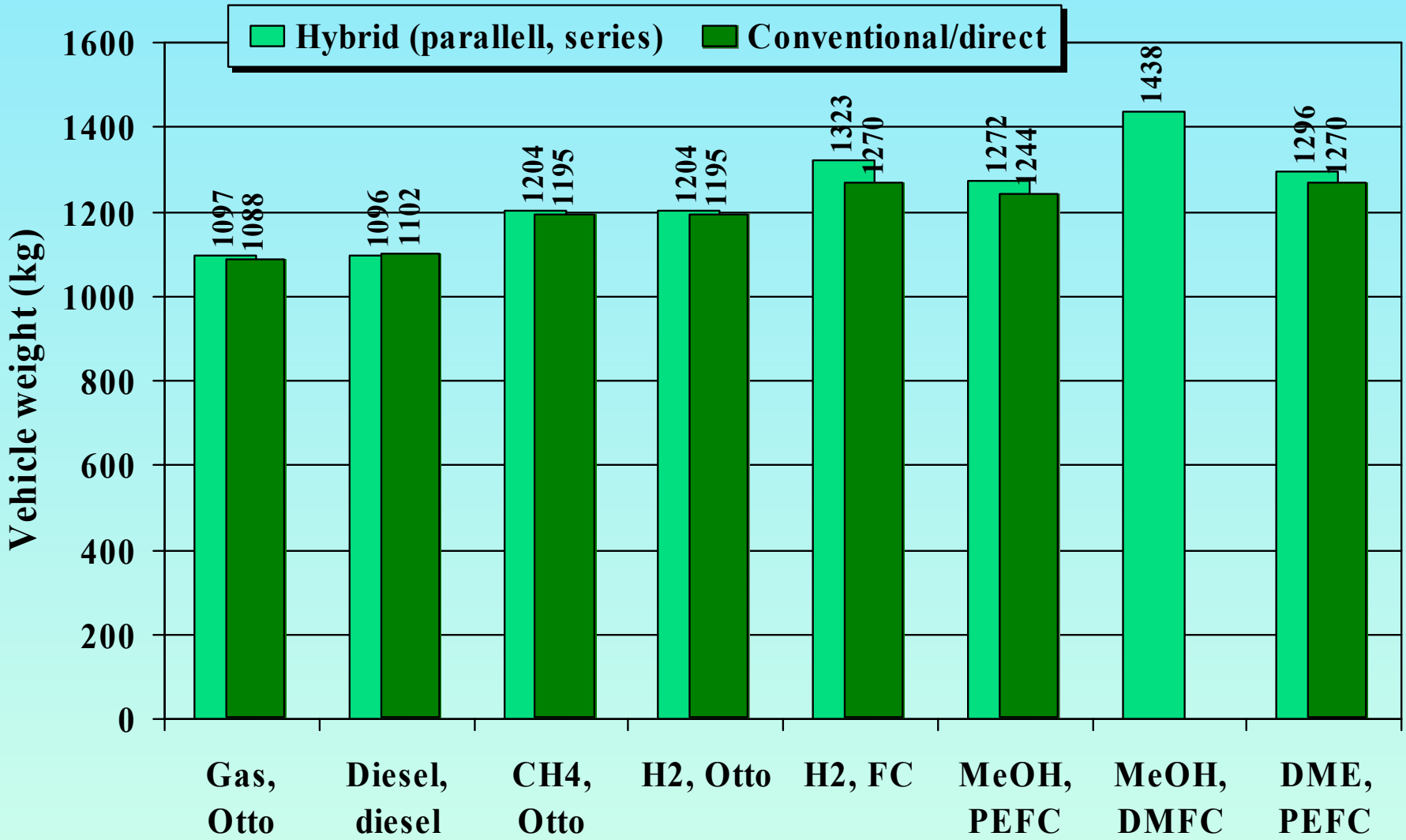
Production of biofuels via the synthesis gas route



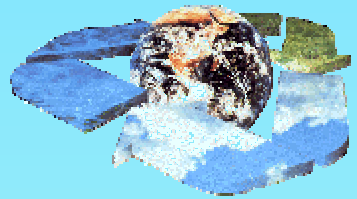
Some vehicle parameters

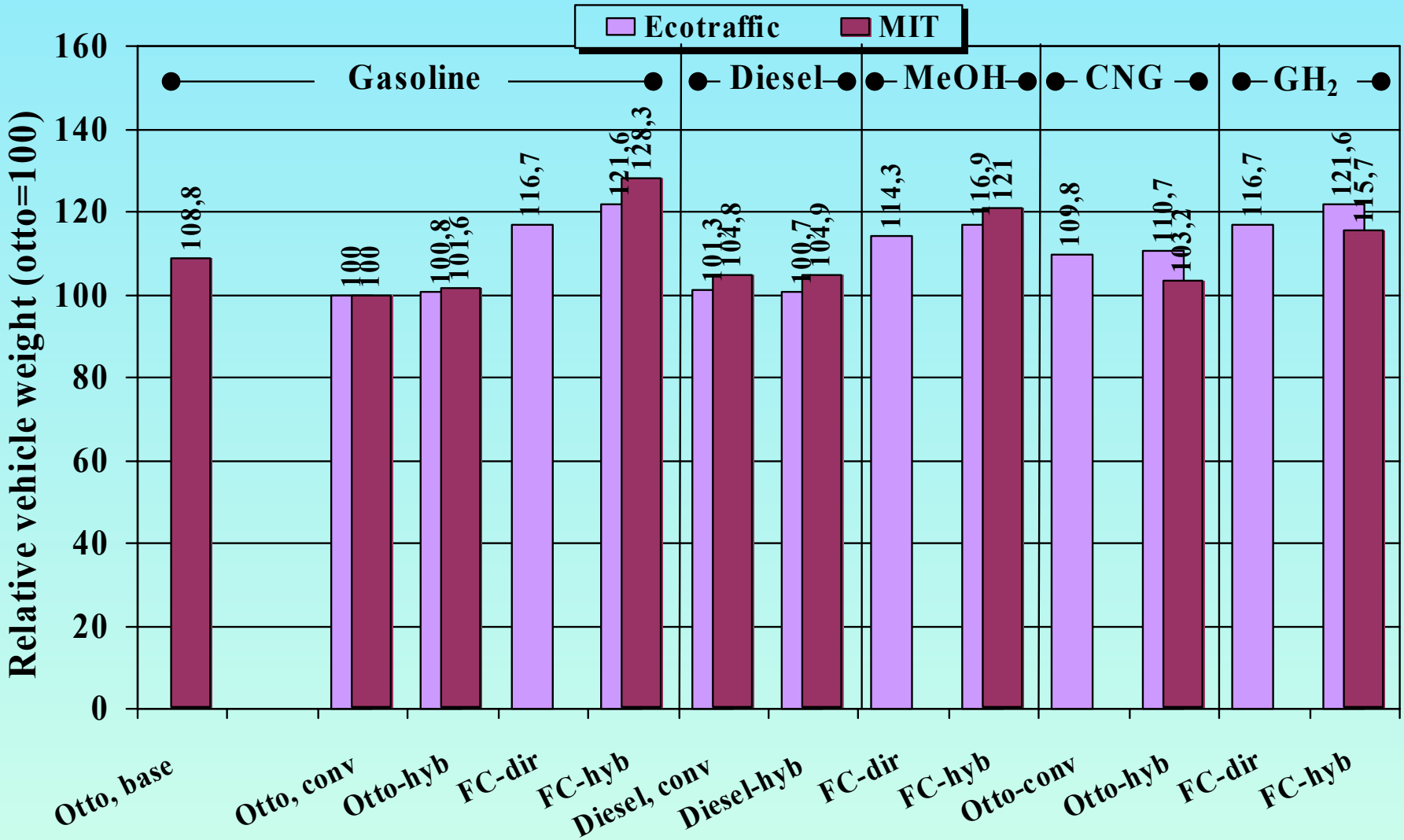
- Model year: 2010 – 2015 (2012)
- Vehicle size: between VW Golf and Passat
- Aerodyn.: A=2,1 m^3, C_d=0,25, C_d•A=0,525 m^3
- Rolling resistance: 0,007
- Vehicle weight (conventional): 1088 kg (plus fuel and driver)
- Performance: acc. 0-100 km/h: 11,0 s ± 0,1 s. The powertrains were scaled to match the performance criterion

Vehicle weight for some fuel and powertrain combinations

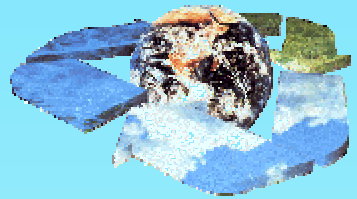


Relative vehicle weight Ecotraffic vs. MIT



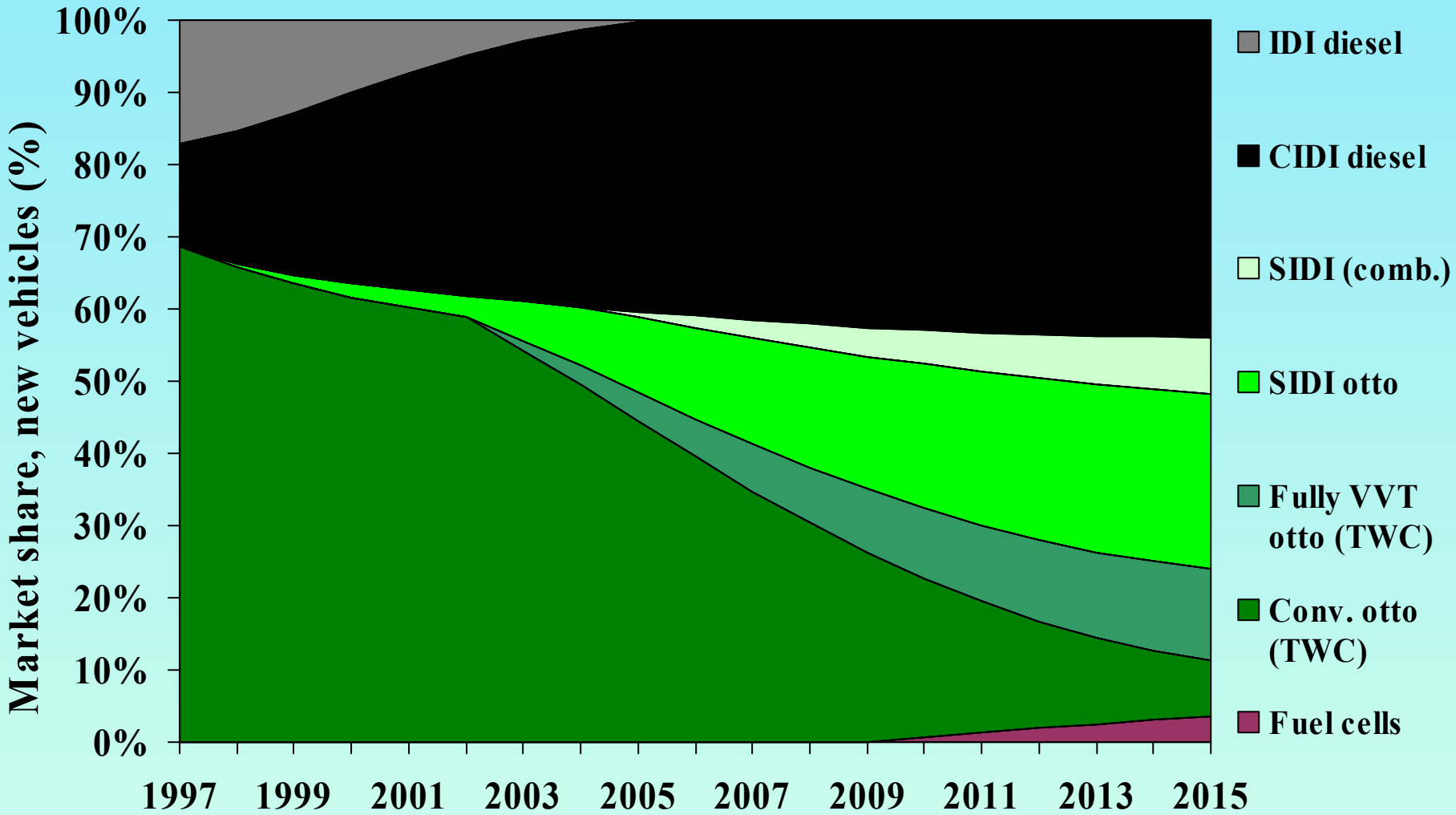


Powertrain

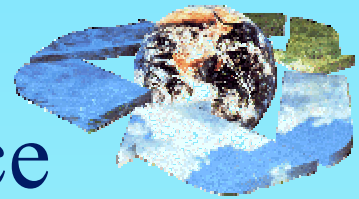


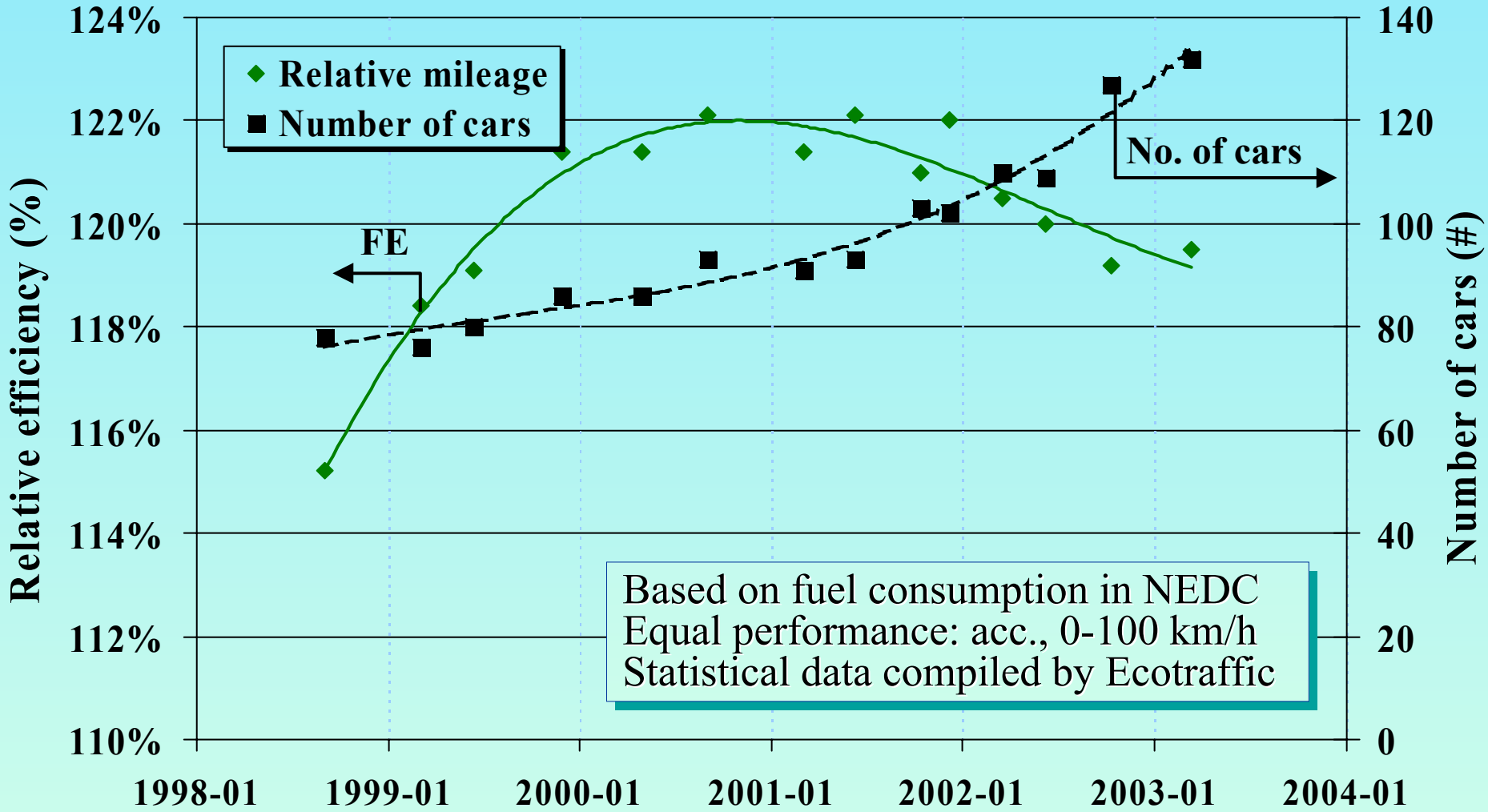
- Energy converters
  - Otto engine: direct injection (”GDI”), N/A
  - Diesel engine: direct injection, turbocharged (”TDI”) and downsized
  - Fuel cell: PEFC, DMFC (MeOH)
- Drivetrain
  - Otto & diesel: Automated manual transmission (5 & 6 speed), conventional and parallel hybrid
  - FC: direct drive and series hybrid
- Battery: 2x performance of NiMh in Advisor

Ecotraffic's forecast for future energy converters i the EU



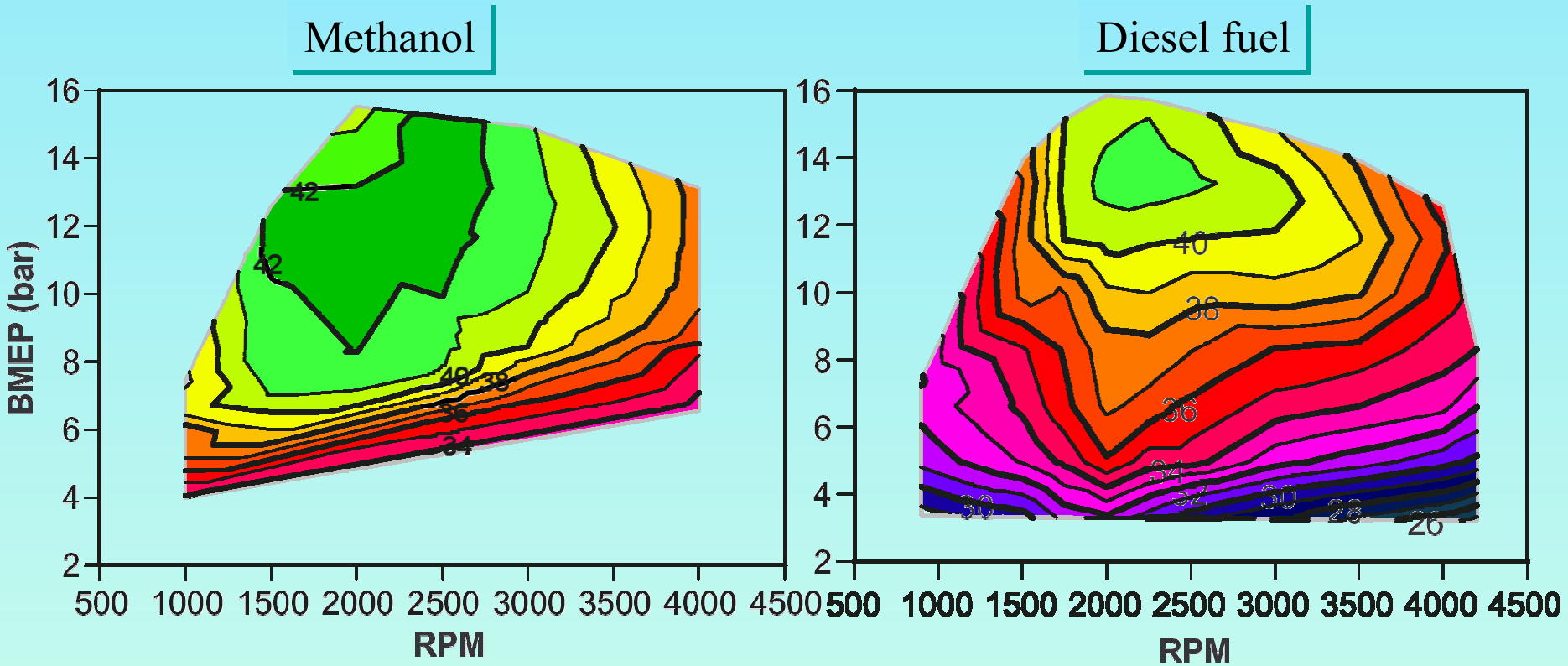
Relative efficiency, gasoline and diesel cars with similar performance





Comparison of efficiencies for CI diesel and SI methanol engines

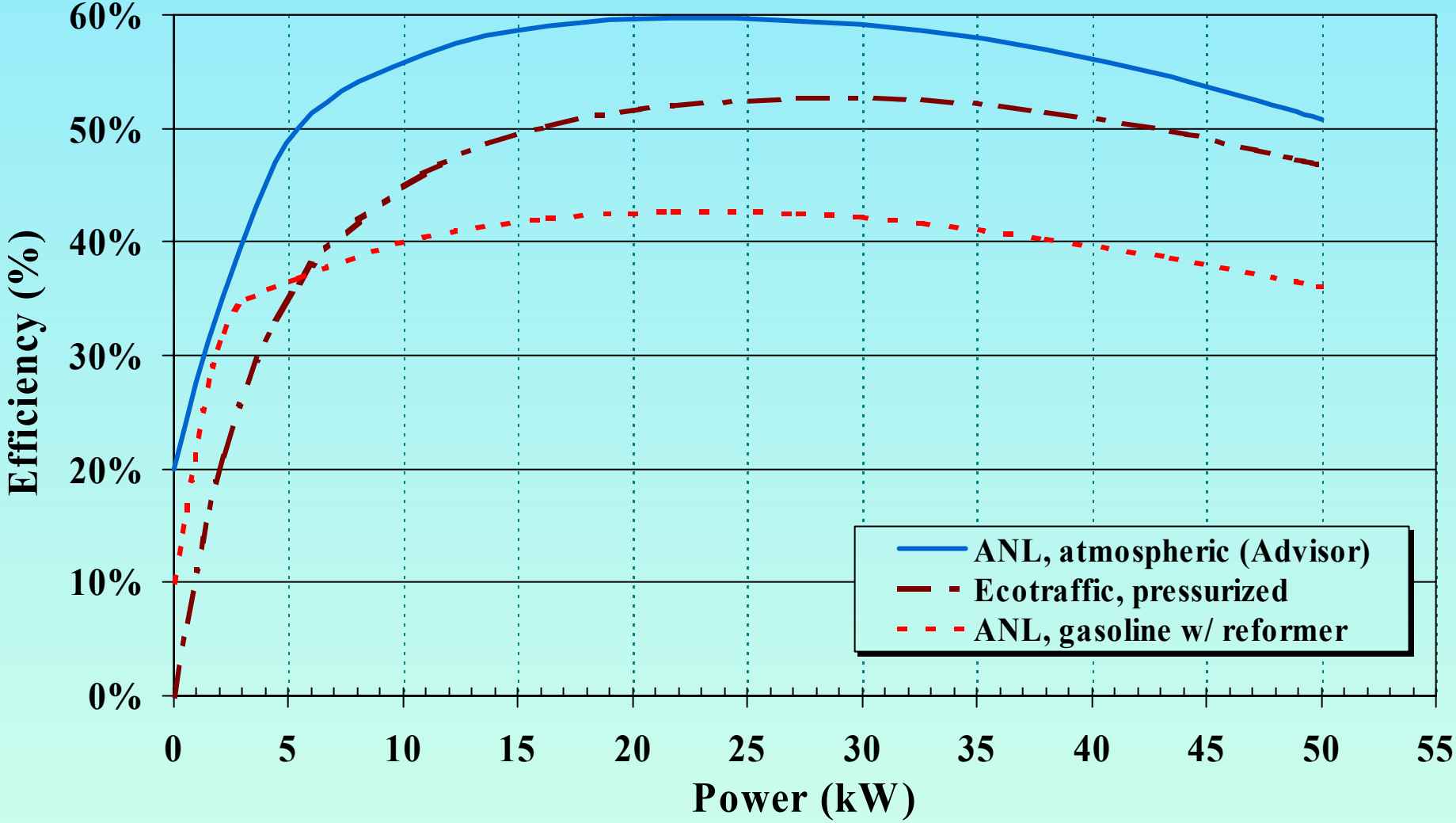
Is it possible to improve ICEs, i.e. achieve a higher efficiency than the diesel engine?



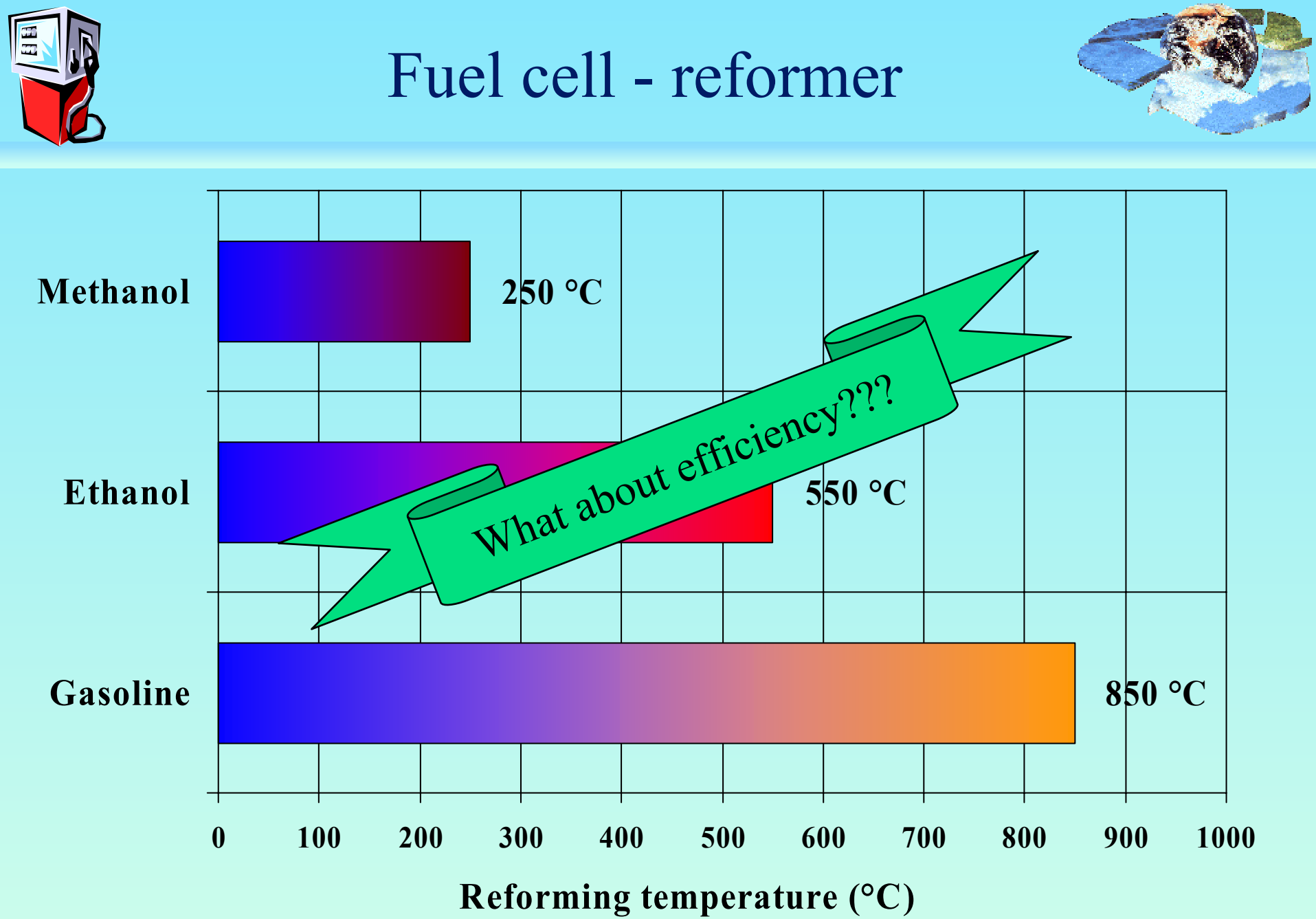
Adapted from SAE 2002-01-2743

The efficiency achieved in SAE 2002-01-2743 was significantly higher than in the Ecotraffic WTW study

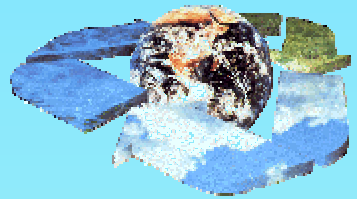
Efficiency for various fuel cell systems (fuel cell "engine")

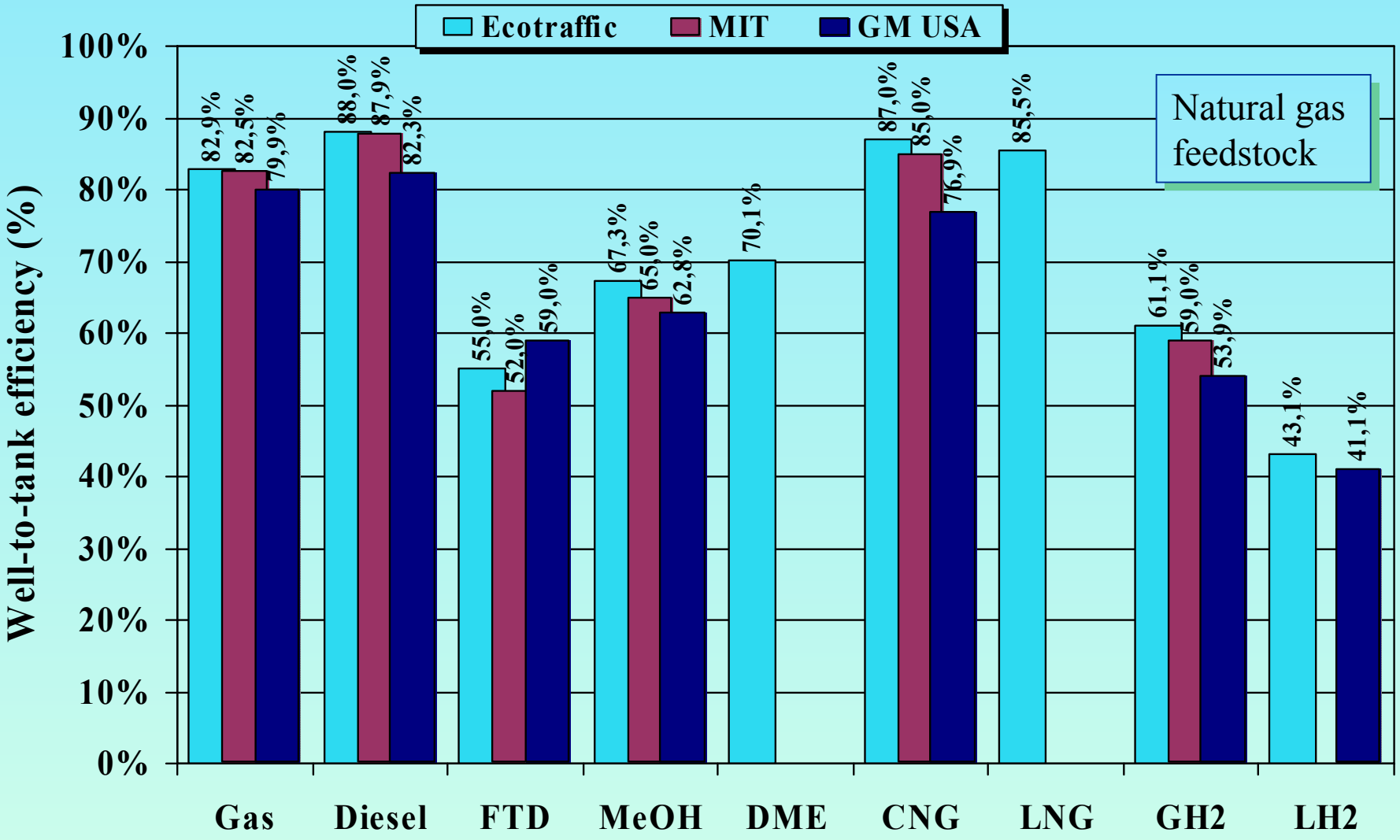


Fuel cell - reformer

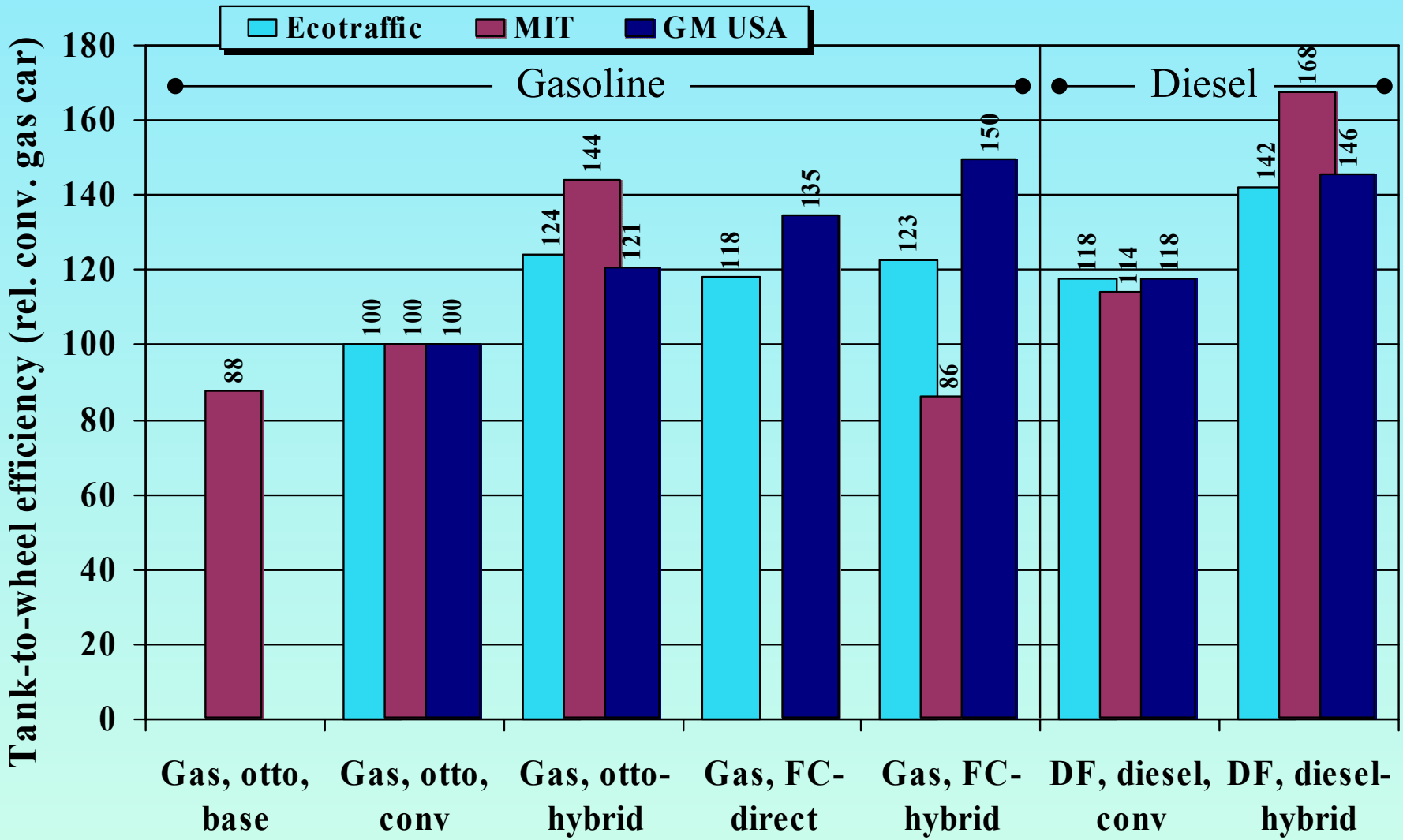


Well-to-tank (WTT) efficiency Ecotraffic, MIT and GM USA

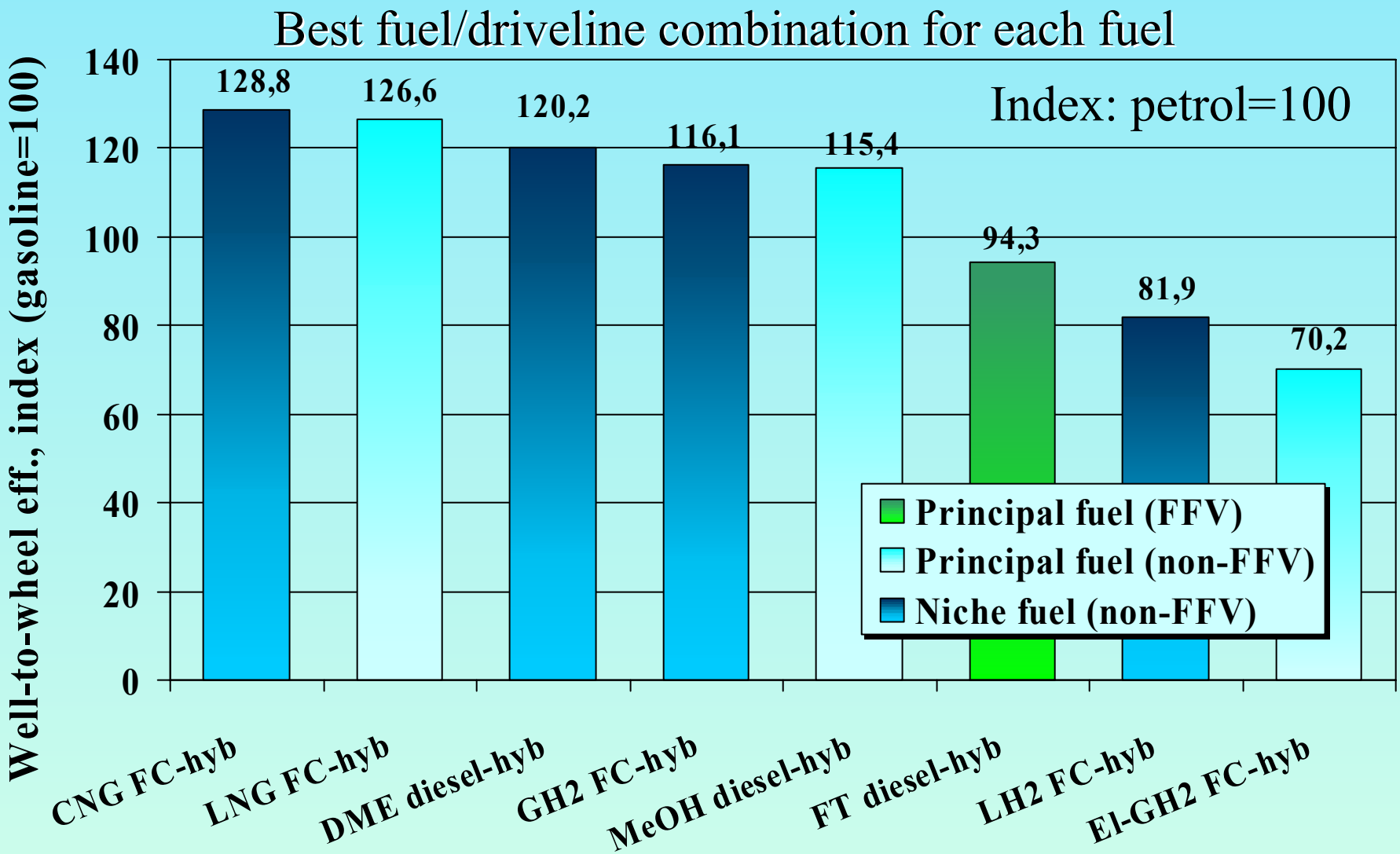




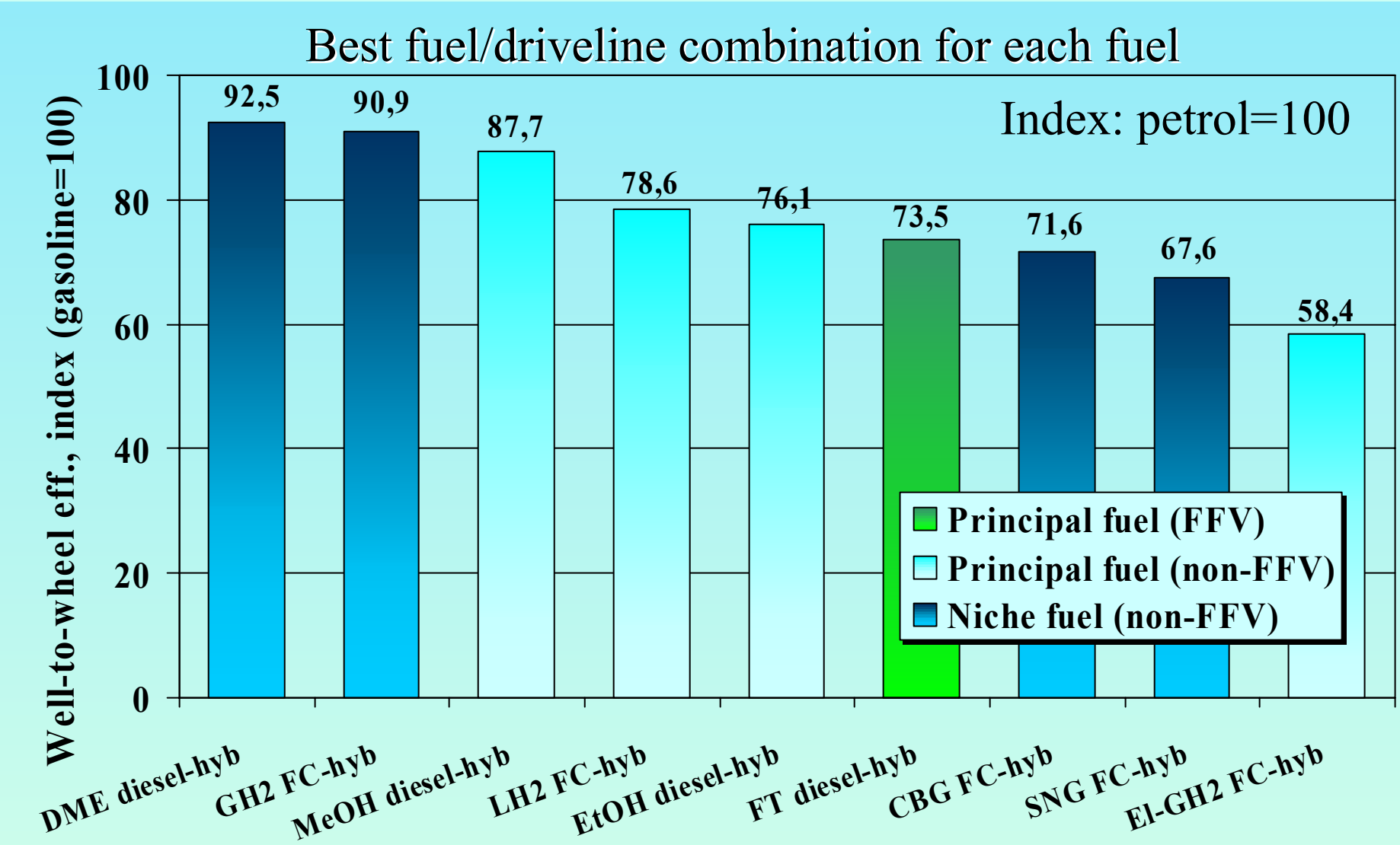
Tank-to-wheel (TTW) efficiency Ecotraffic, MIT and GM USA



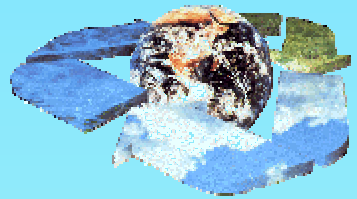
Natural gas feedstock (WTW) Efficiency ranking of fuels, index

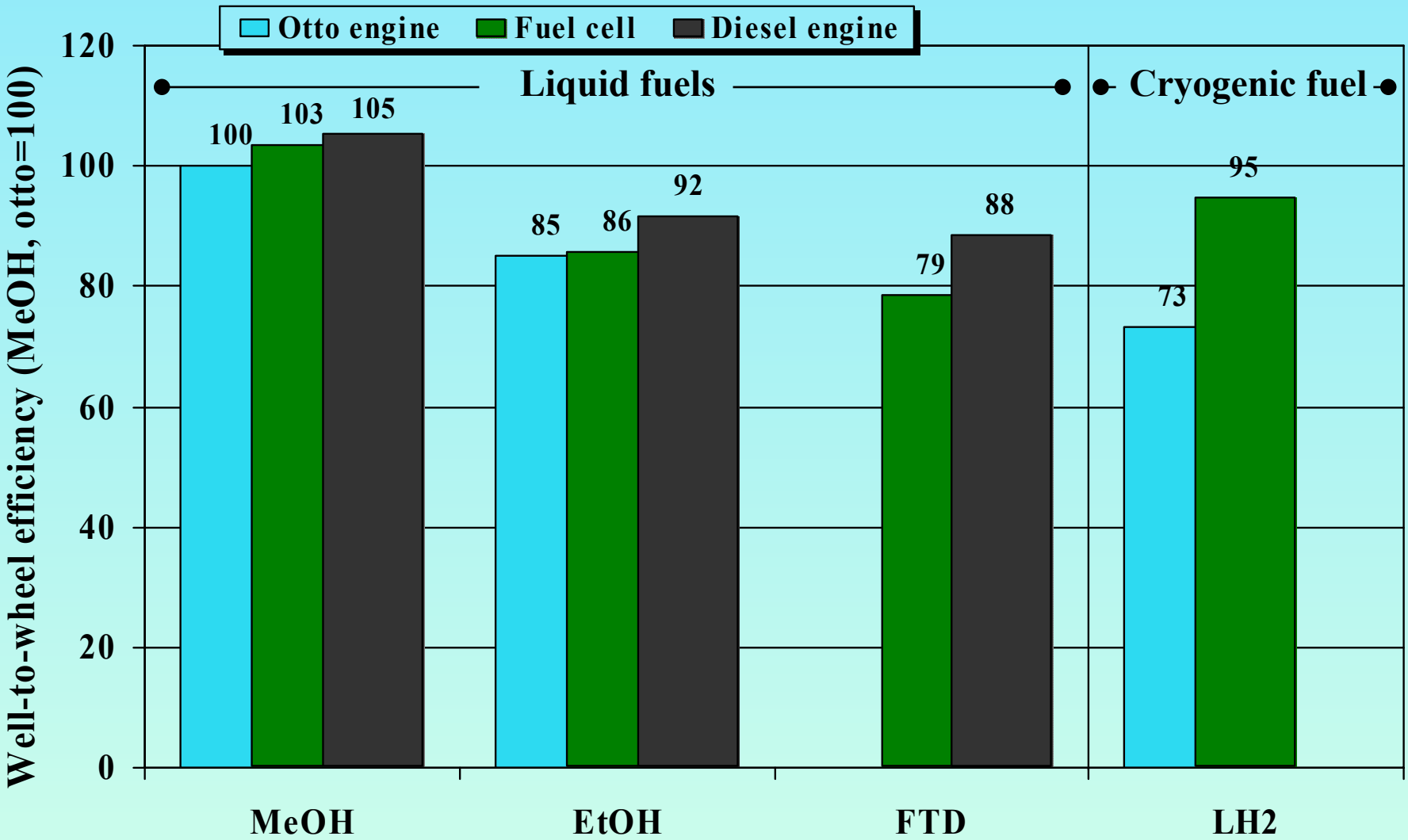


Biomass feedstock (WTW) Efficiency ranking of fuels, index

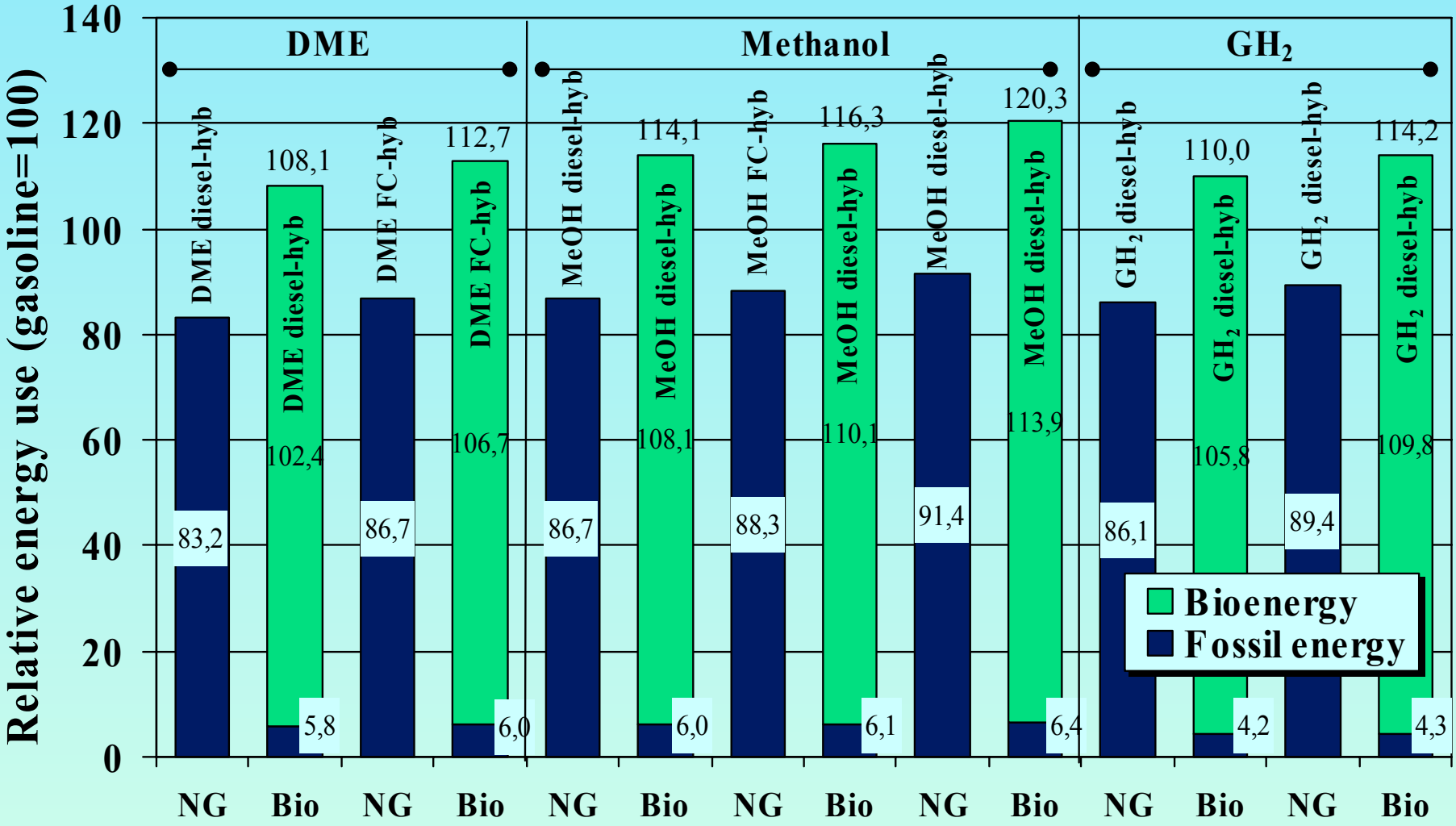


Relative efficiency (WTW) for liquid biofuels in hybrid cars





Fossil and non-fossil energy use
Conventional gasoline = 100



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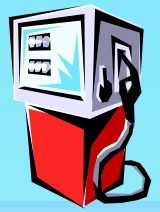
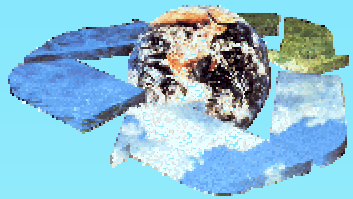


Summary and conclusions



- WTW in 2010 to 2015 timeframe (2012)
- Improved drivetrain is essential, i.e. hybrids. Diesel and fuel cells more efficient than otto.
- Performance criteria are important conditions.
- Biomass conversion has “low” efficiency.
- Fossil energy use can be kept low (i.e. ~5%)
- CNG/LNG rank high; low process energy.
- DME, GH_2 and MeOH are “best” biofuels
- Differences between studies can be explained in most cases
- Many issues and uncertainties still remain...

This concludes my presentation

- Thank you for your attention!
- Questions?

More information available at:
www.ecotraffic.se
(e.g. reports, presentations, etc.)