

Business from technology



Photo: VW



Vehicle energy efficiencies

IEA EGRD Workshop
“Mobility: Technology Priorities and Strategic Urban Planning
Nils-Olof Nylund
VTT Technical Research Centre of Finland

Outline

- General introduction
- Ways to reduce fuel consumption
 - engine technology
 - reduced need for power
 - electrification
- Trends for
 - passenger cars
 - buses
 - heavy-duty trucks
- ICE vs. EV
- Summary



Elements determining the environmental impacts of traffic

Community structure



Traffic volumes & choice of transport mode



Energy for transport



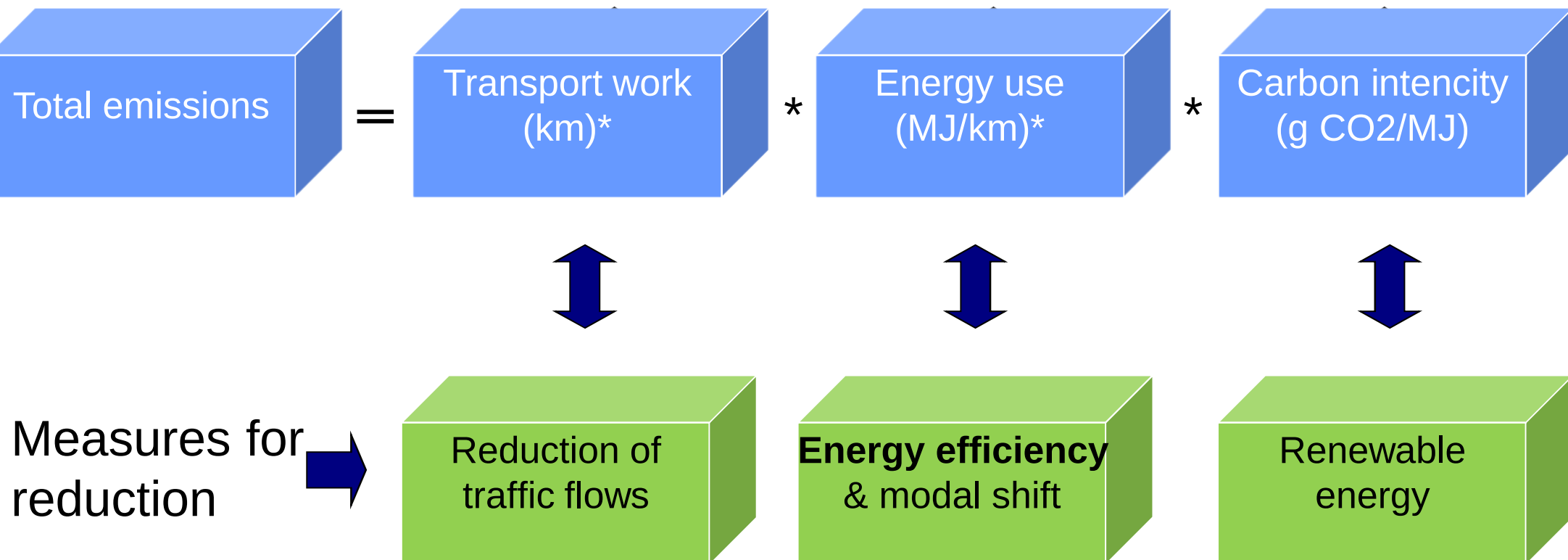
Vehicles and user behaviour



Policy orientation

Technology orientation

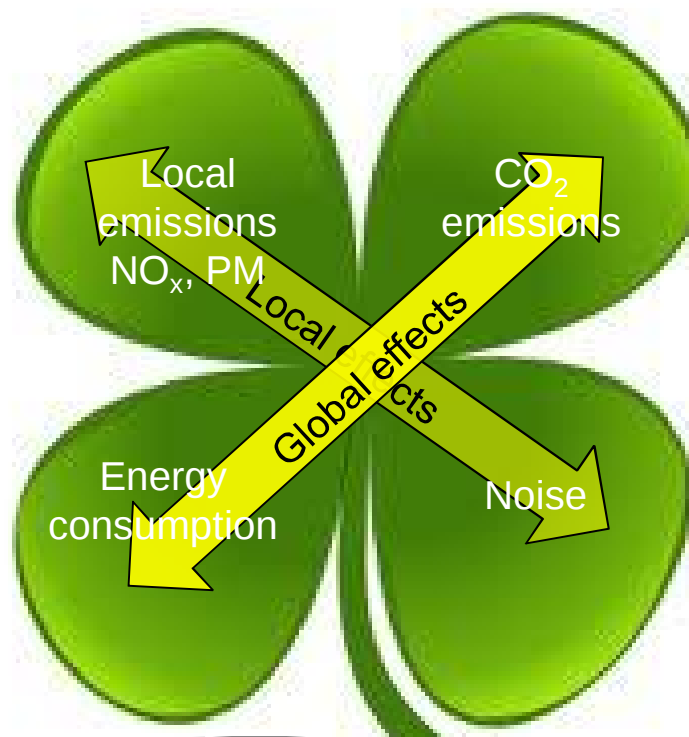
Formation and control of CO₂ emissions



*passenger/tonkilometre

Environmental friendliness

Multi-dimensional contemplation



A fluent intelligent transport system
Service and safety

Current status of vehicles

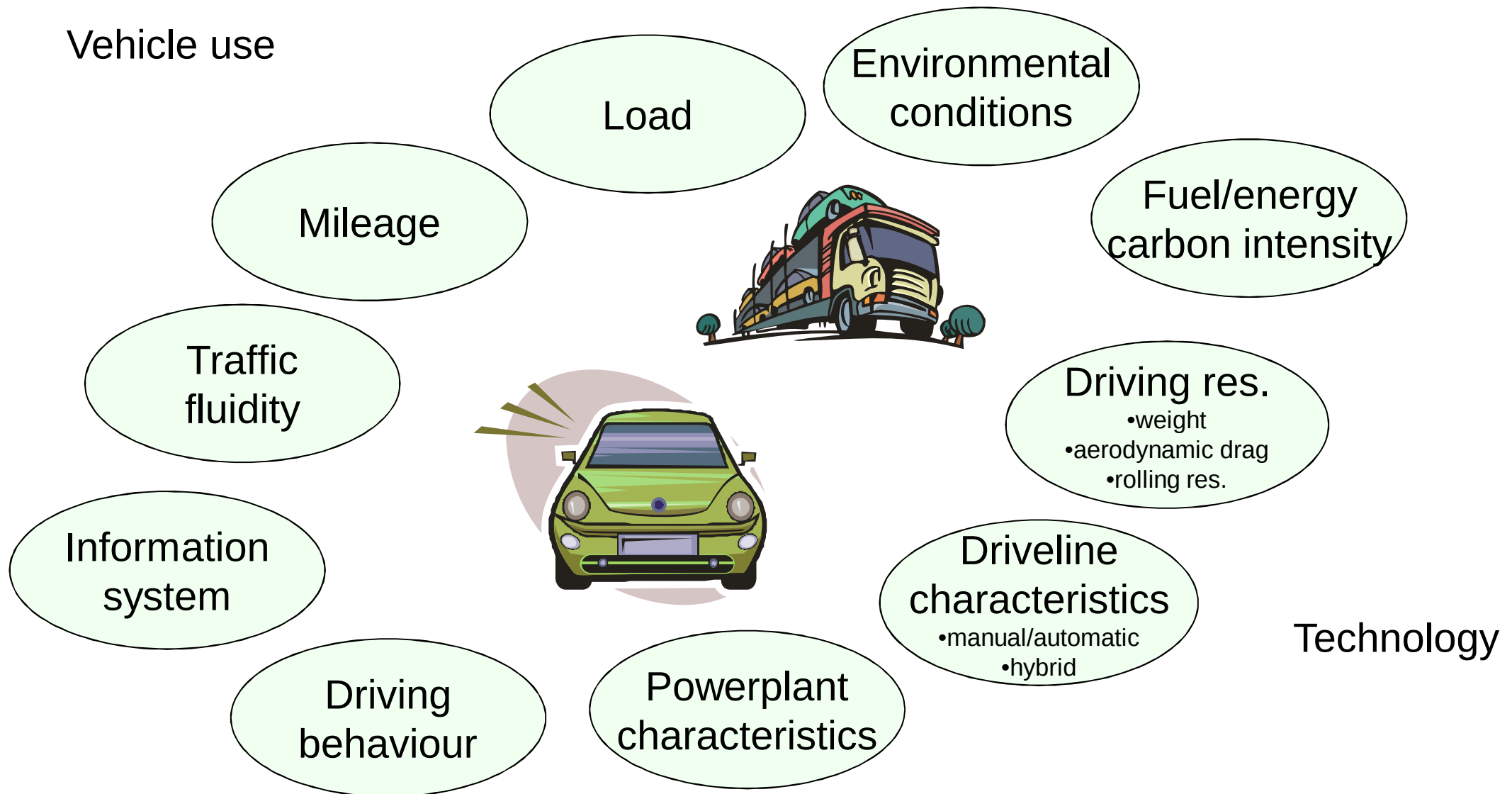
- The current passenger car is:
 - reliable
 - comfortable
 - relatively safe
 - environmentally friendly regarding regulated emissions
 - in most cases a "high-performance" vehicle
- What should be improved?
 - fuel efficiency
 - the ability to use renewable or CO₂-neutral energy
 - rational use of cars
- Traditionally heavy-duty vehicles have been fuel efficient but dirty, but with the JPN 2009, US2010 and Euro VI emission regulations the situation will change



The Next Prius.
89
g/km CO₂

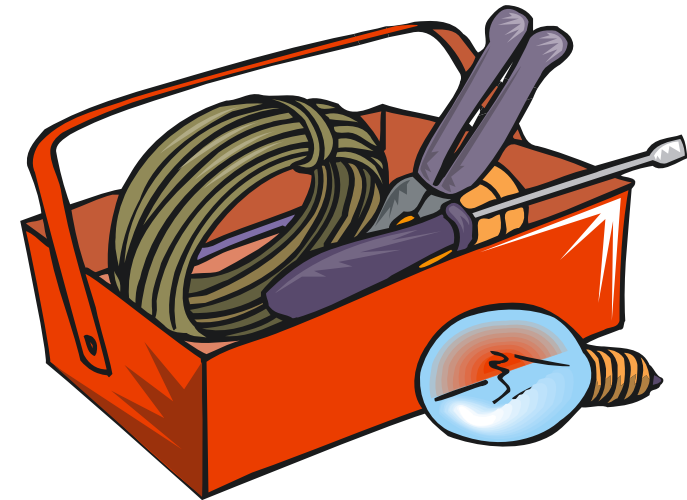
Factors affecting energy consumption/CO₂ emissions

Vehicle use



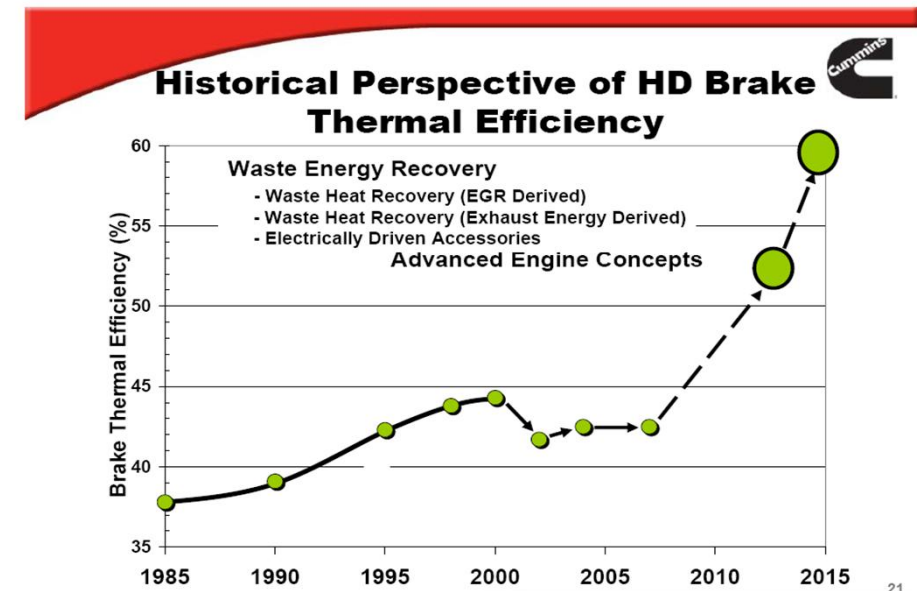
Technical tool box for a cleaner future

- Improved engine technologies
 - Combustion, AMT
- Reduced need for power
 - AMT
- Hybridisation
 - HEV
- Electrification
 - HEV, AFC
- Fuel cell technology
 - AFC, HEV, Hydrogen
- Alternative fuels
 - AMF, Bioenergy, Combustion, Hydrogen

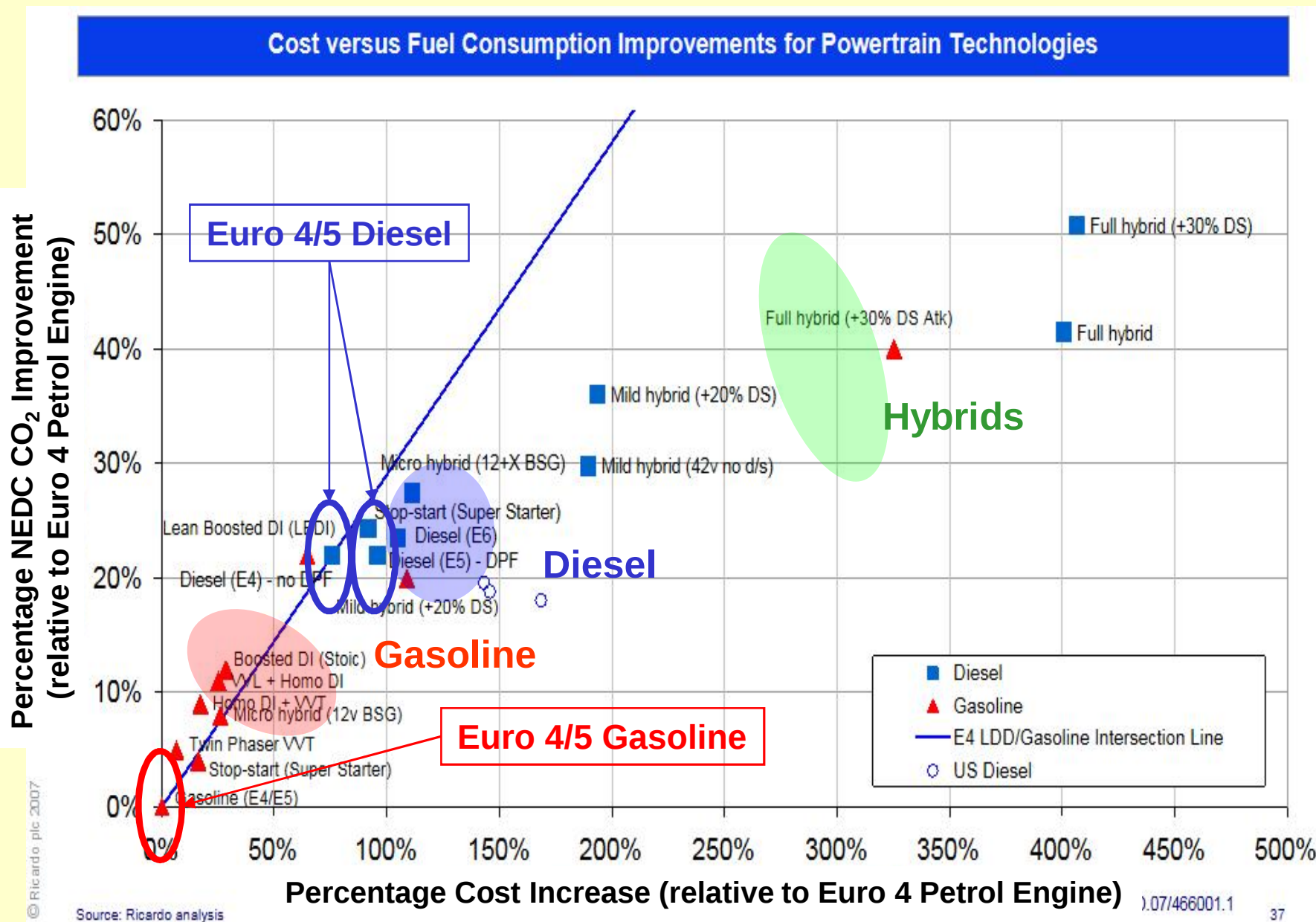


Improving engine efficiency

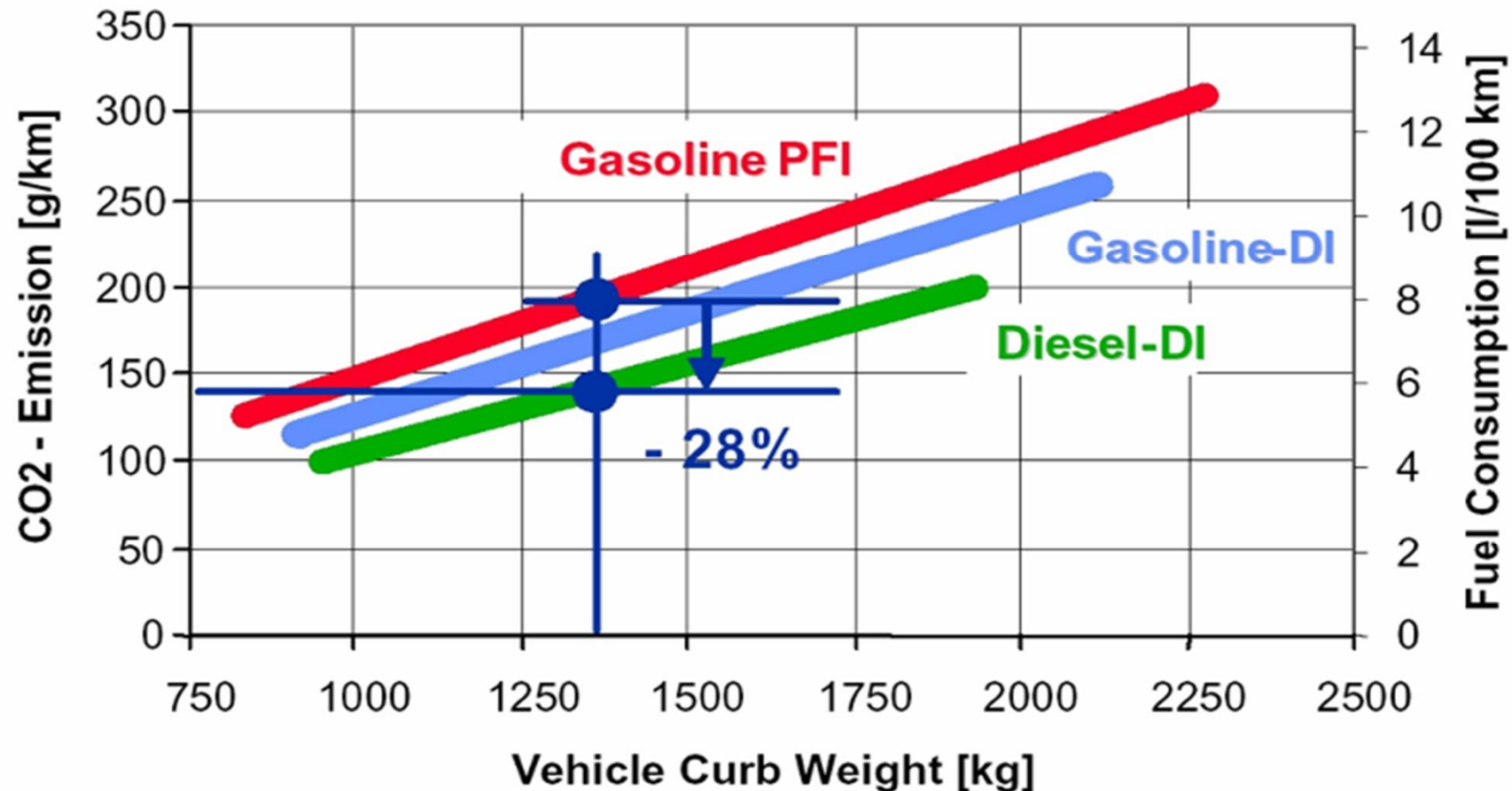
- For all ICE types the pathway into the future includes :
 - reducing the physical size of the engine and increasing relative load ("downsizing")
 - improving boosting technologies
 - implementation of direct fuel injection
 - reduction of friction
 - increase in control parameters
 - powerful control systems
 - electrification of auxiliaries
- The main challenge
 - simultaneous reduction of fuel consumption and regulated exhaust emissions
- Future possibilities
 - combining the best features of Diesel and Otto (spark-ignited) engines
 - waste heat recovery (with a focus on heavy-duty engines)



Reducing CO₂ Adds Cost to Vehicle Powertrain



Effect of engine type and curb weight on passenger car fuel consumption



Reducing the need for power

- We should reduce curb weight, rolling resistance and aerodynamic drag
- Weight reduction can be achieved through reduction of size (passenger cars) and by utilizing lighter materials (all types of vehicles):
 - high-strength steels
 - aluminium and aluminium alloys
 - magnesium and magnesium alloys
 - titanium and titanium alloys
 - carbon fiber composites
 - nanocomposites
- The effect of weight:
 - For passenger cars a weight reduction of 10 % reduces fuel consumption some 6 – 7 %.
 - For buses 1,000 kg of added weight as curb weight or passengers increases fuel consumption some 2.5 l/100 km (6 %) in city driving (e.g. Helsinki)
- Aerodynamic drag becomes significant at higher speeds



More small cars needed?

smorsche



smerrari



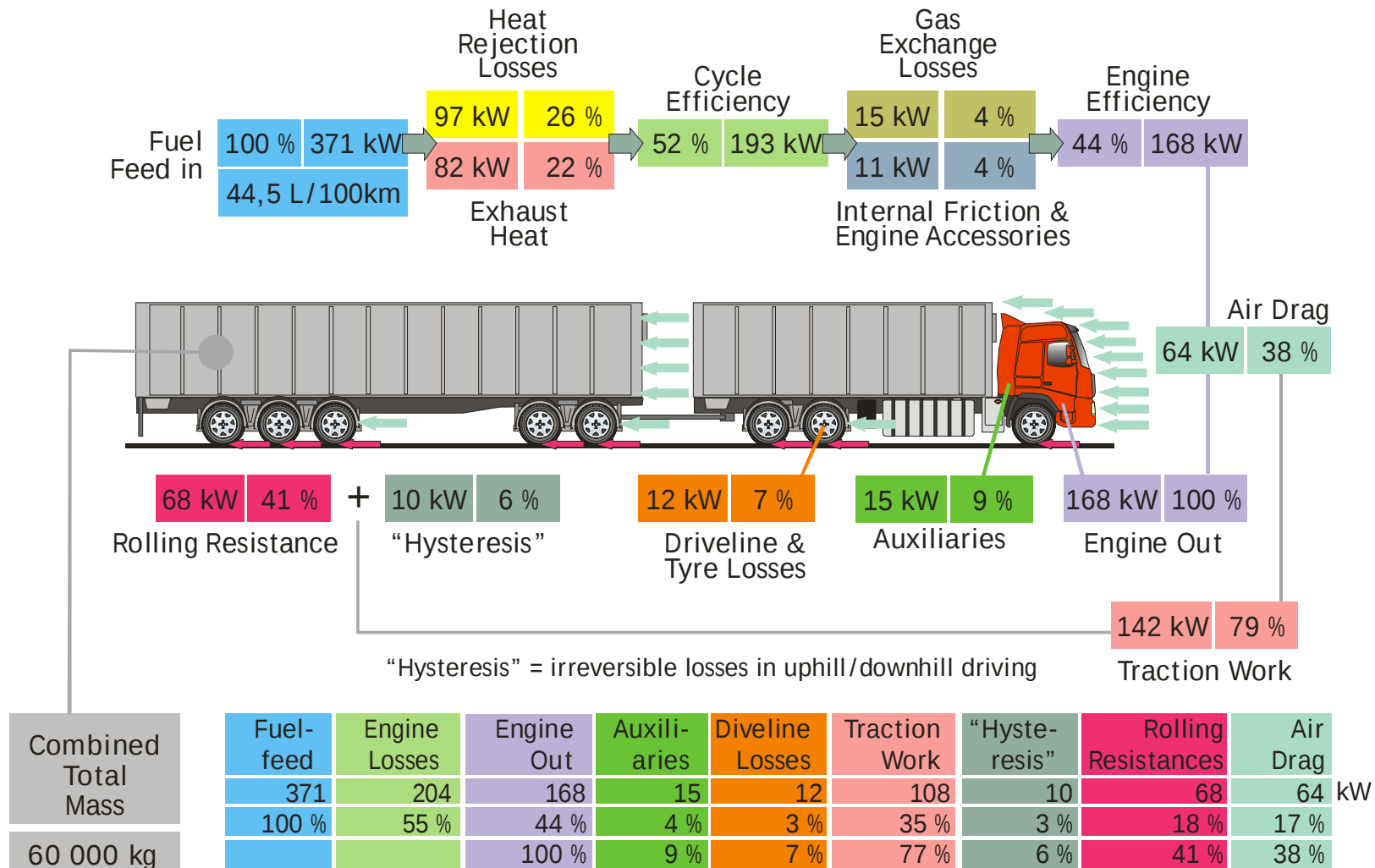
smorvette



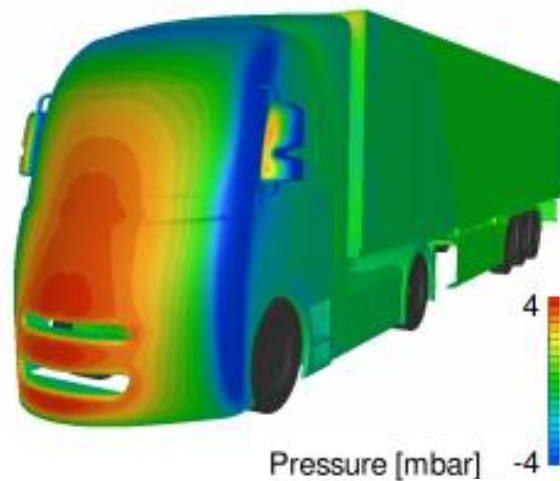
smamborgini



60 ton Tractor & Trailer, Full Payload, Freeway at 80 km/h

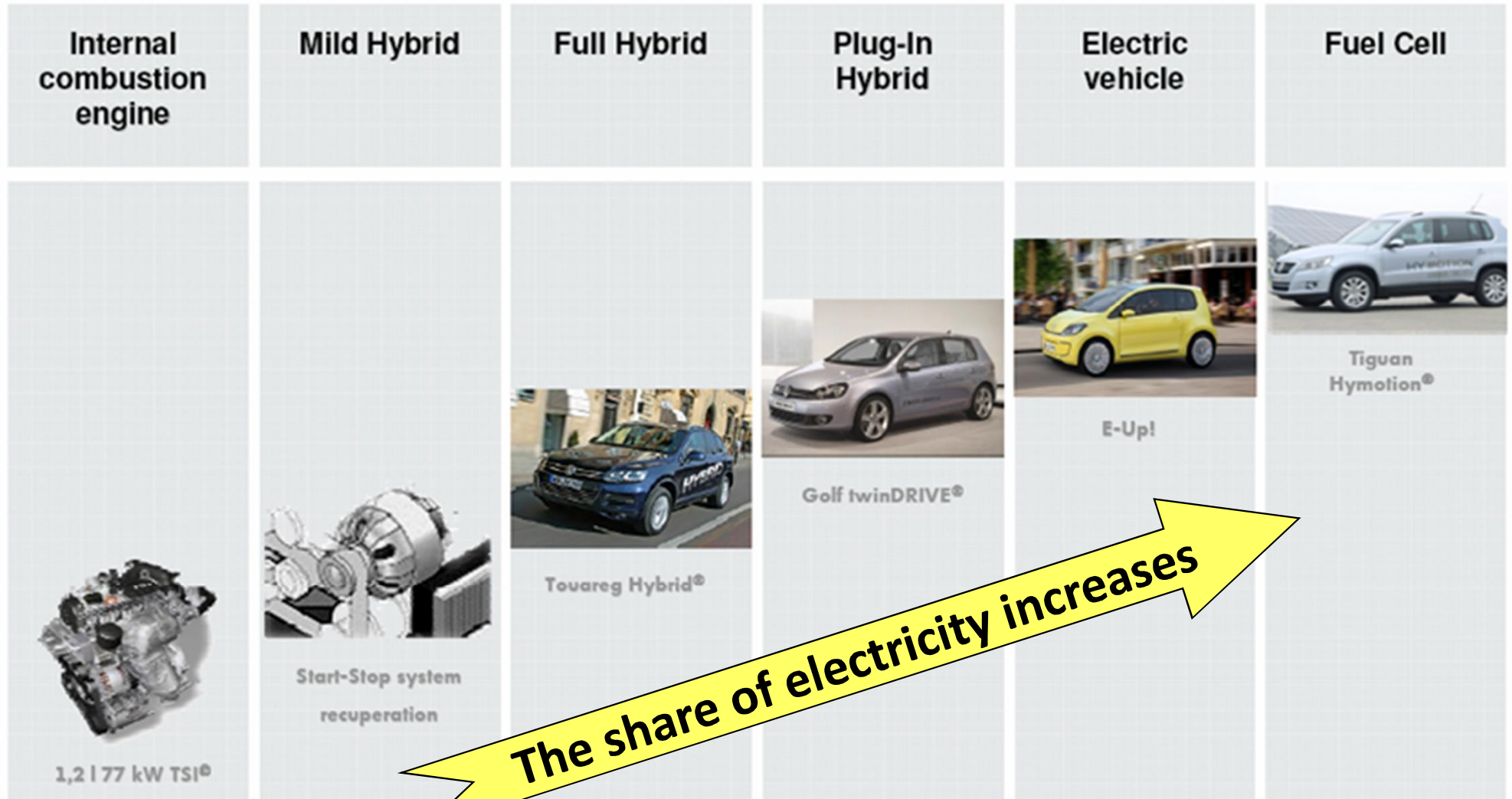


Improving aerodynamics of HD vehicles



30 % smaller drag: fuel savings 10 – 15 %

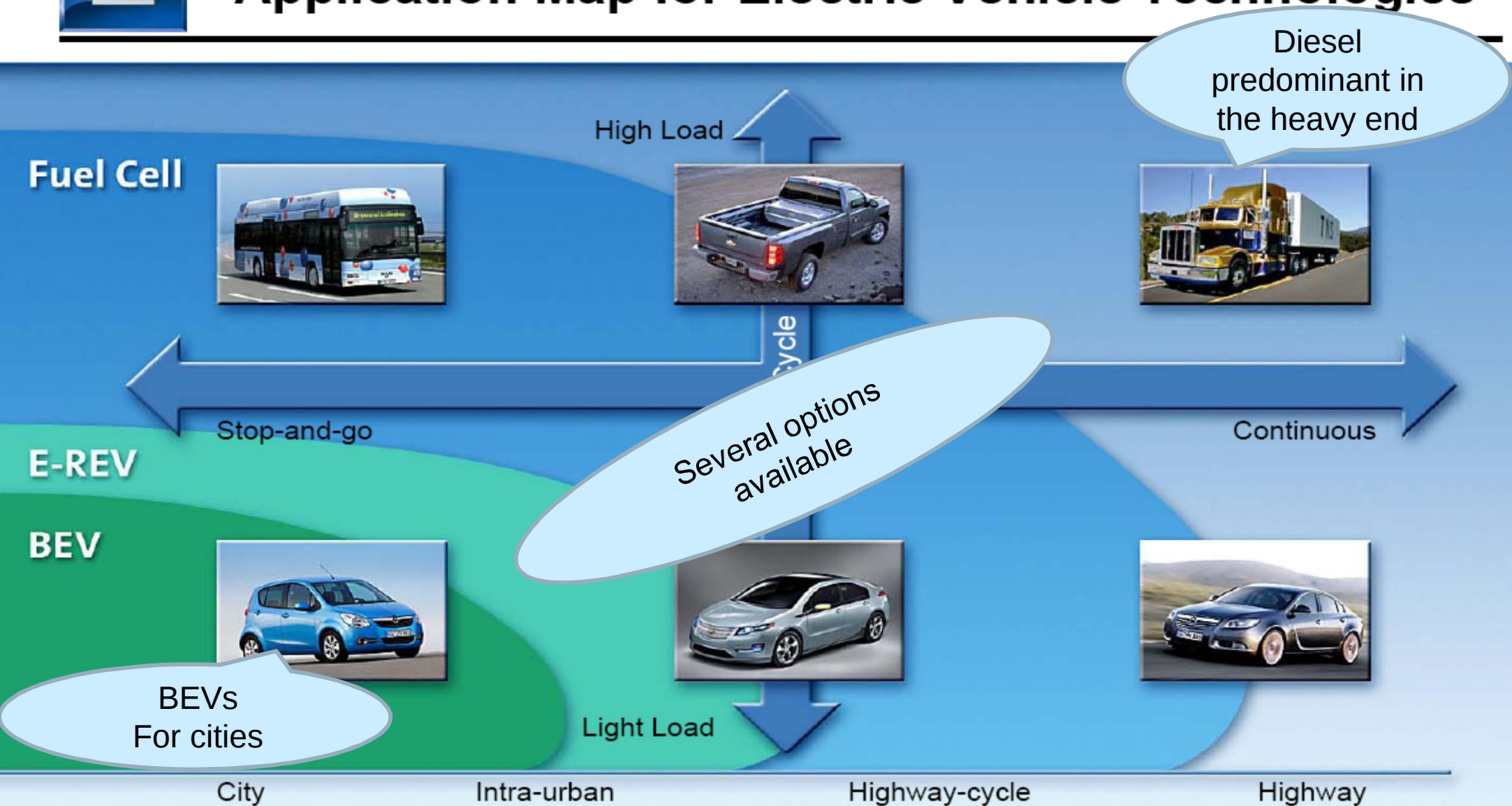
Steps in Electrification



The share of electricity increases



Application Map for Electric Vehicle Technologies



No Silver Bullet !!!

Source: GM

Key technical measures to promote energy efficiency for various vehicle classes

Passenger cars:

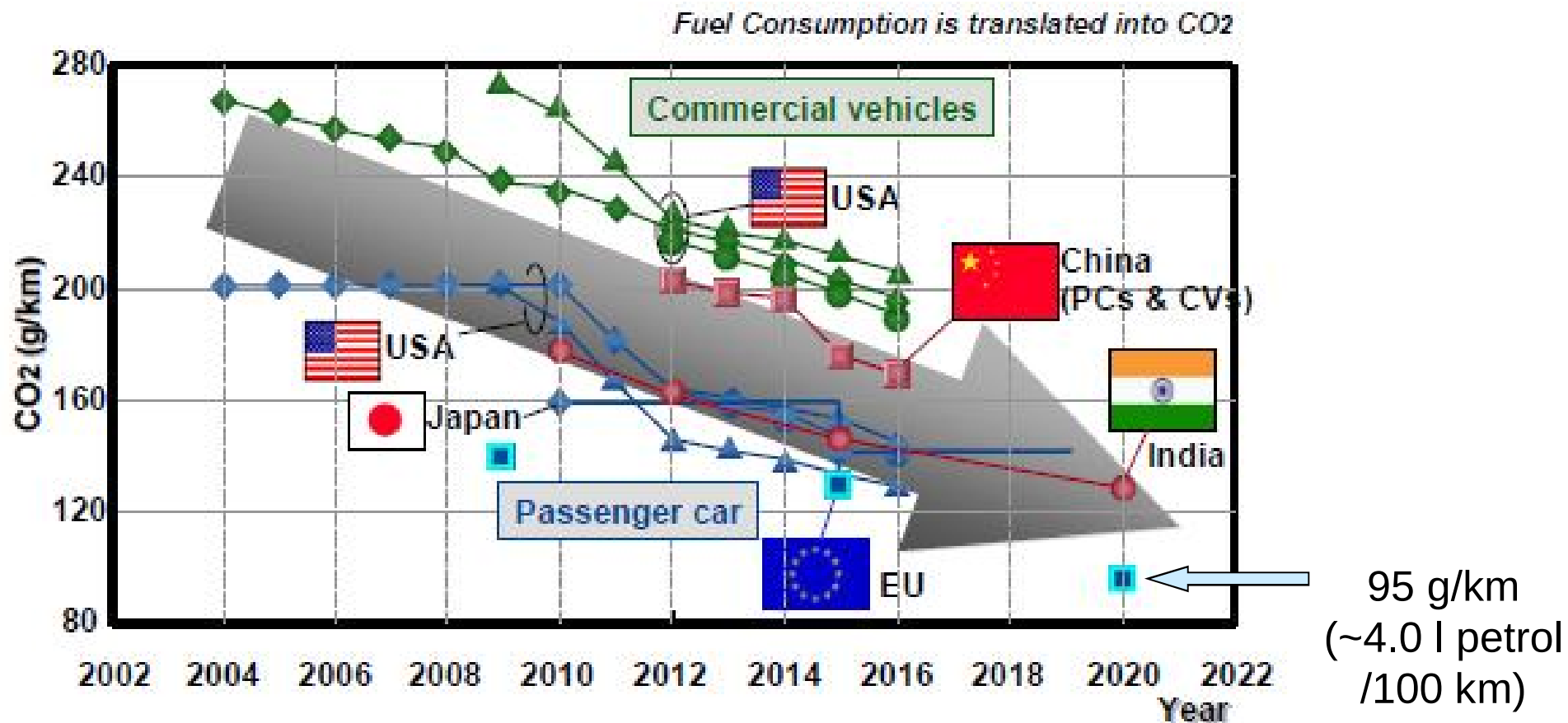
- smaller and lighter vehicles
- reduced performance
- hybridization, electrification

Energia- merkinnän päästöluokka	Raja-arvot CO2-päästöille g/km	CO2-päästöä vast. polttoaineenkulutus (pyöristettynä 0,1 l/100 km tarkkuuteen)	
		Bensiini (l/100 km)	Diesel (l/100 km)
A	max. 100	max. 4,3	max. 3,8
B	101 - 120	4,3 - 5,1	3,8 - 4,5
C	121 - 130	5,1 - 5,5	4,5 - 4,9
D	131 - 150	5,6 - 6,4	4,9 - 5,6
E	151 - 175	6,4 - 7,4	5,7 - 6,6
F	176 - 200	7,4 - 8,5	6,6 - 7,5
G	201 -	8,6 -	7,6 -

City buses:

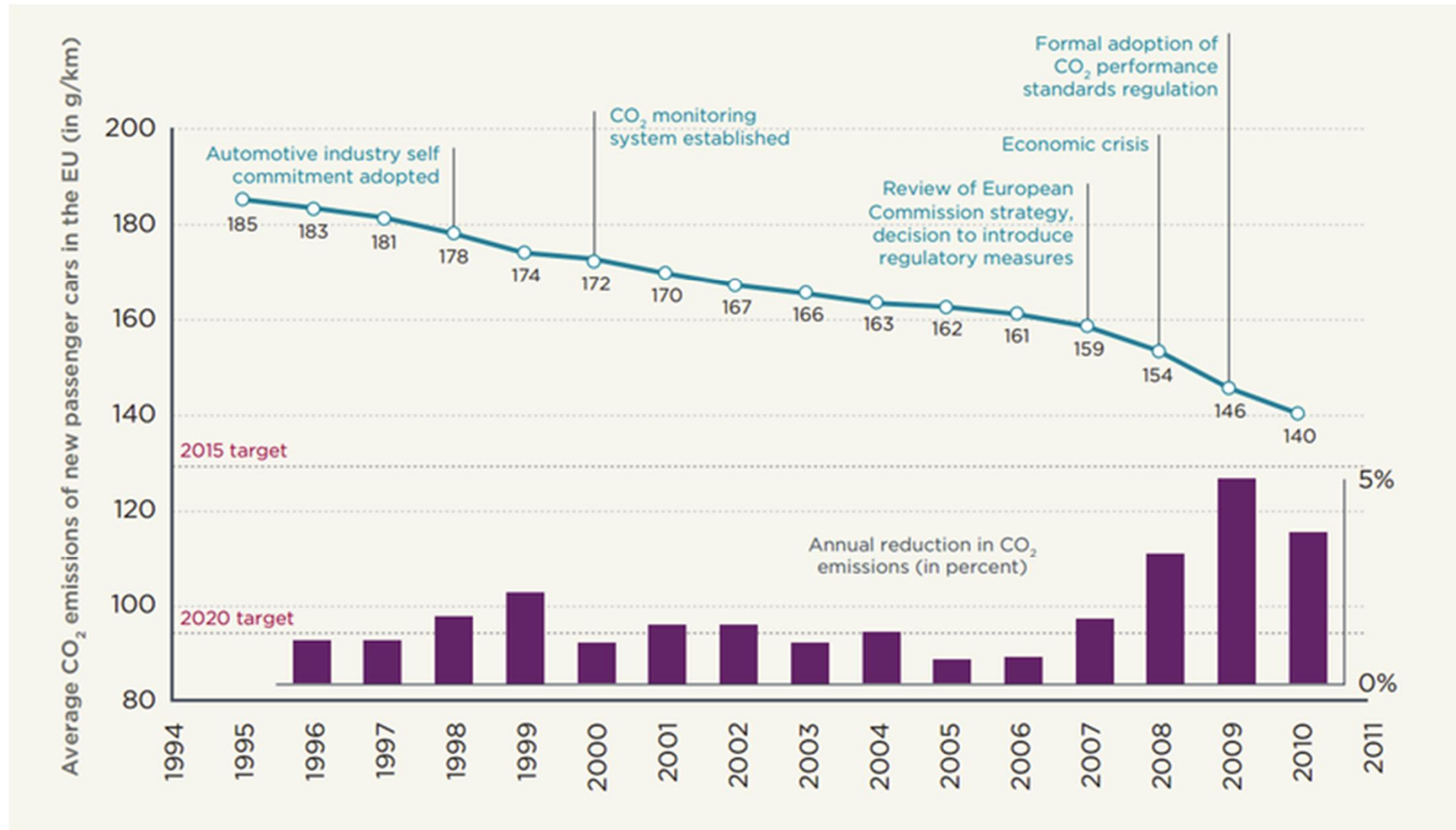
- reduced weight
 - hybridization, electrification
-
- HD trucks for highway use
 - improved aerodynamics

Development of CO₂ limit values for passenger cars



Both developed and emerging countries have similar tendencies to enhance CO₂ regulations.

Development of passenger car CO₂ emissions in Europe



185 g CO₂ ~ 7.9 l petrol/100 km

140 g CO₂ ~ 6.0 l petrol/100 km

What is the fuel consumption of a Volvo V40 ?
It depends!.....

Pick the
low-hanging
fruit first!



**Volvo V40 T5 automatic
8,1 l/100 km**

185 g CO₂/km



**Volvo V40 D2
3,6 l/100 km**

94 g CO₂/km

I.e. a reduction of 49 %!

Technical progress

VW Golf VII diesel 2013 VW Golf I diesel 1976 Audi A6 Avant 2013



Displacement (l)	1.6	1.5	3.0 twin-turbo
Max output (kW)	77	37	230
Torque (Nm)	250	84	650
Max speed (km/h)	192	144	250 (limited)
Acceleration 0 – 100 km/h (s)	10.7	18	5.3
Curb weight	1295	780	1930
Fuel consumption (EU comb. l/100 km)	3.8	6.4	6.4
CO ₂ emission (g/km)	99	169	169
Particulate filter	yes	no	yes

What would have happened if the technical potential would have been used for fuel efficiency only (keeping performance and weight constant)?

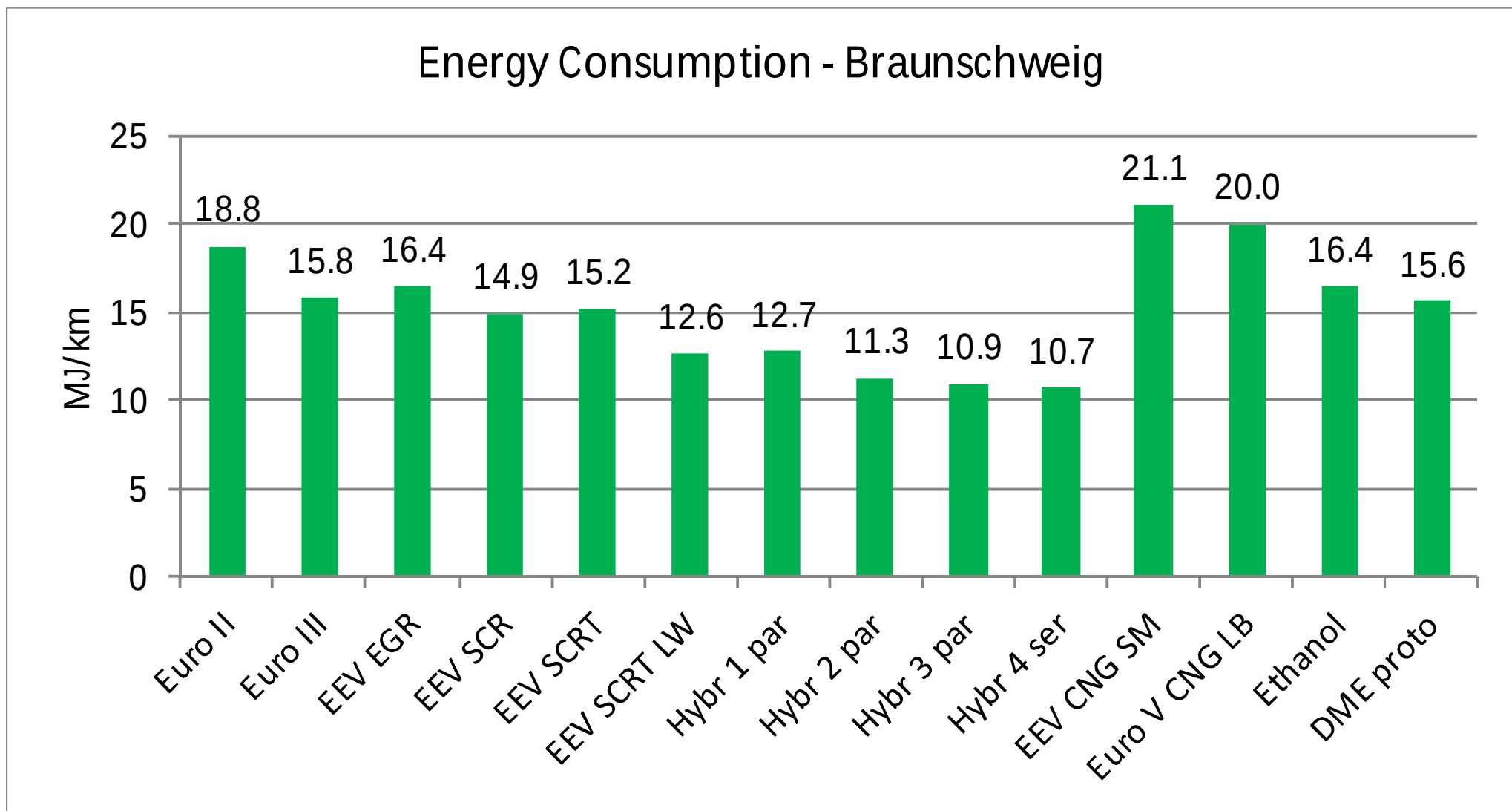
IEA Technology Network Cooperation: Fuel and Technology Alternatives for Buses Overall energy efficiency and emission performance



SAE 2012 Commercial Vehicle Engineering Congress
October 2-3, 2012

Rosemont, Illinois USA
Kati Koponen & Nils-Olof Nylund
VTT Technical Research Centre of Finland

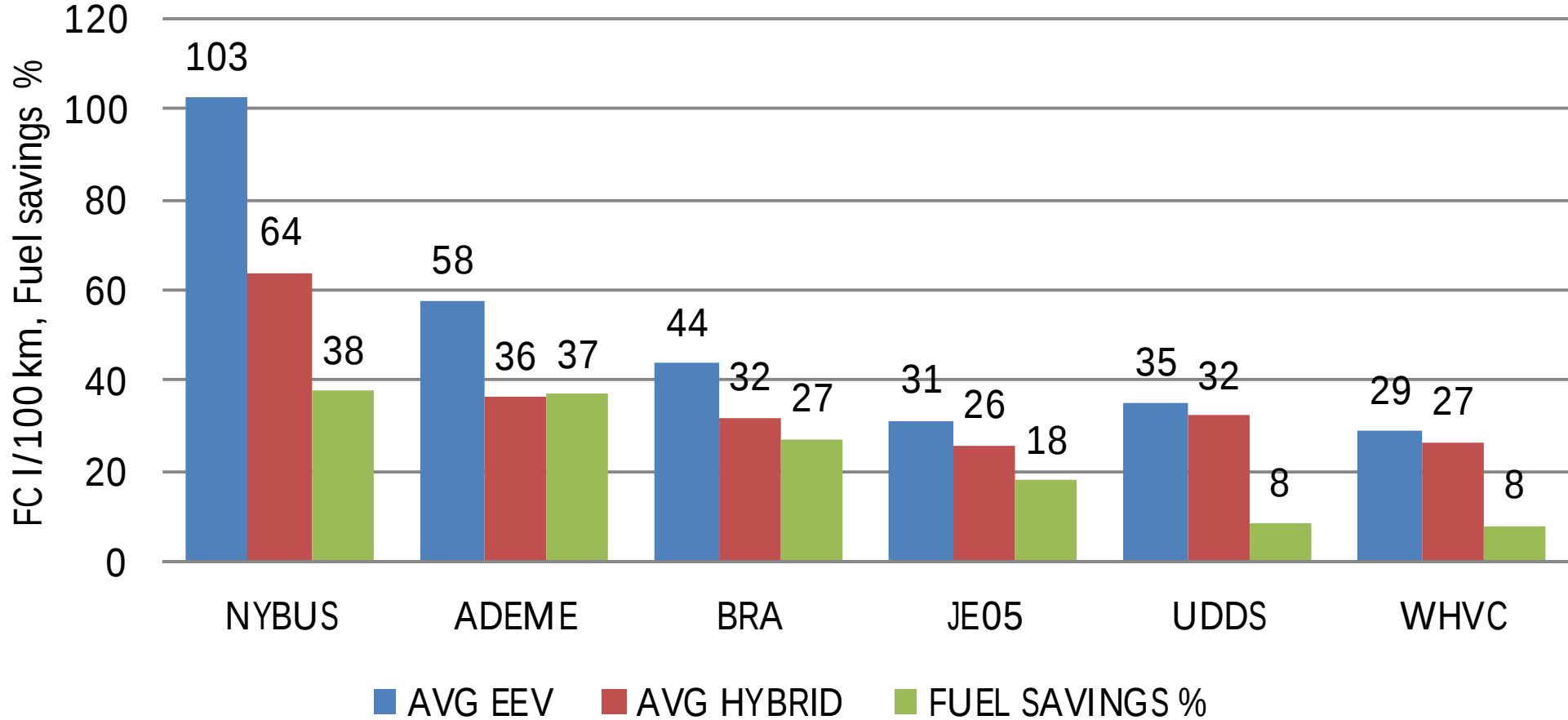
Energy consumption of European vehicles Braunschweig cycle



Fuel savings through hybridization

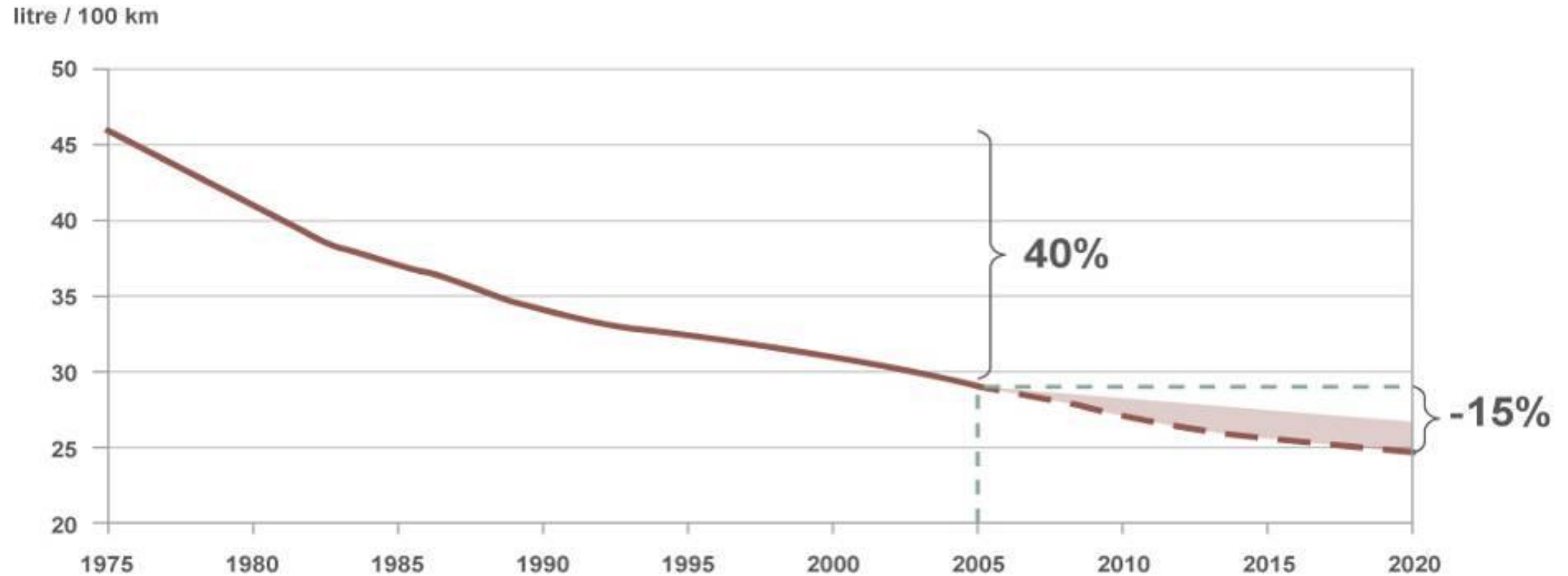
European vehicles

Conventional Vehicles vs. Hybrids

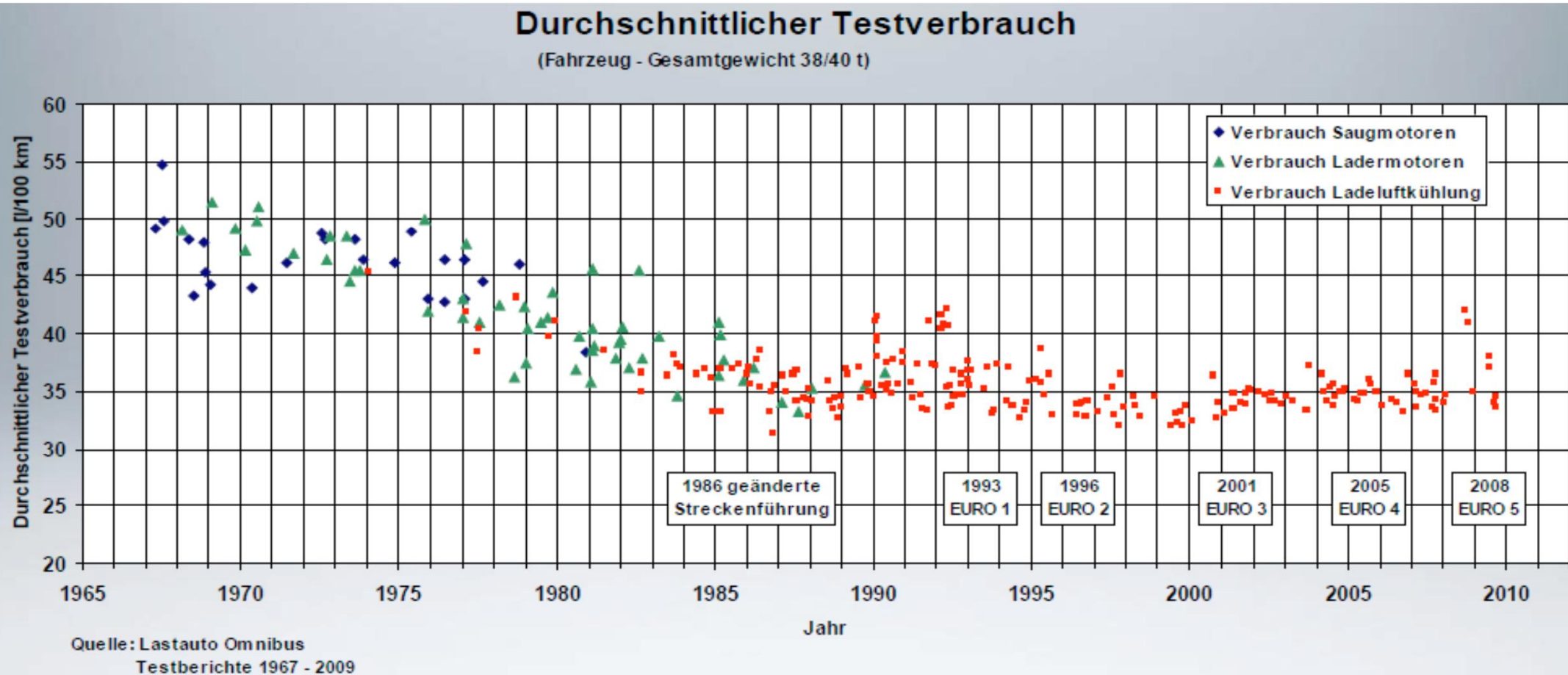


Reduced fuel consumption

Volvo FH12, 40 ton in traffic

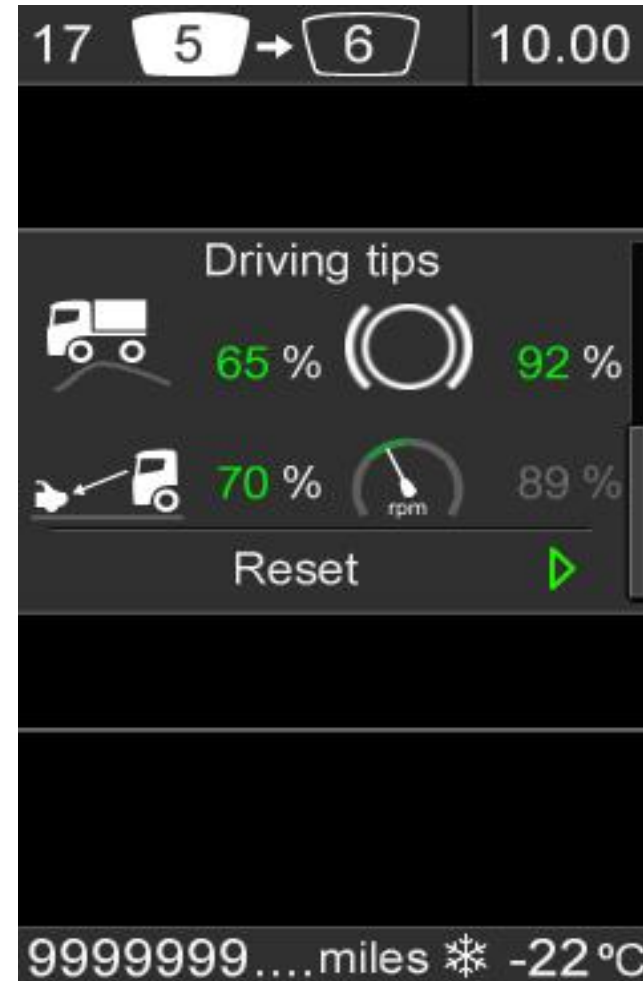


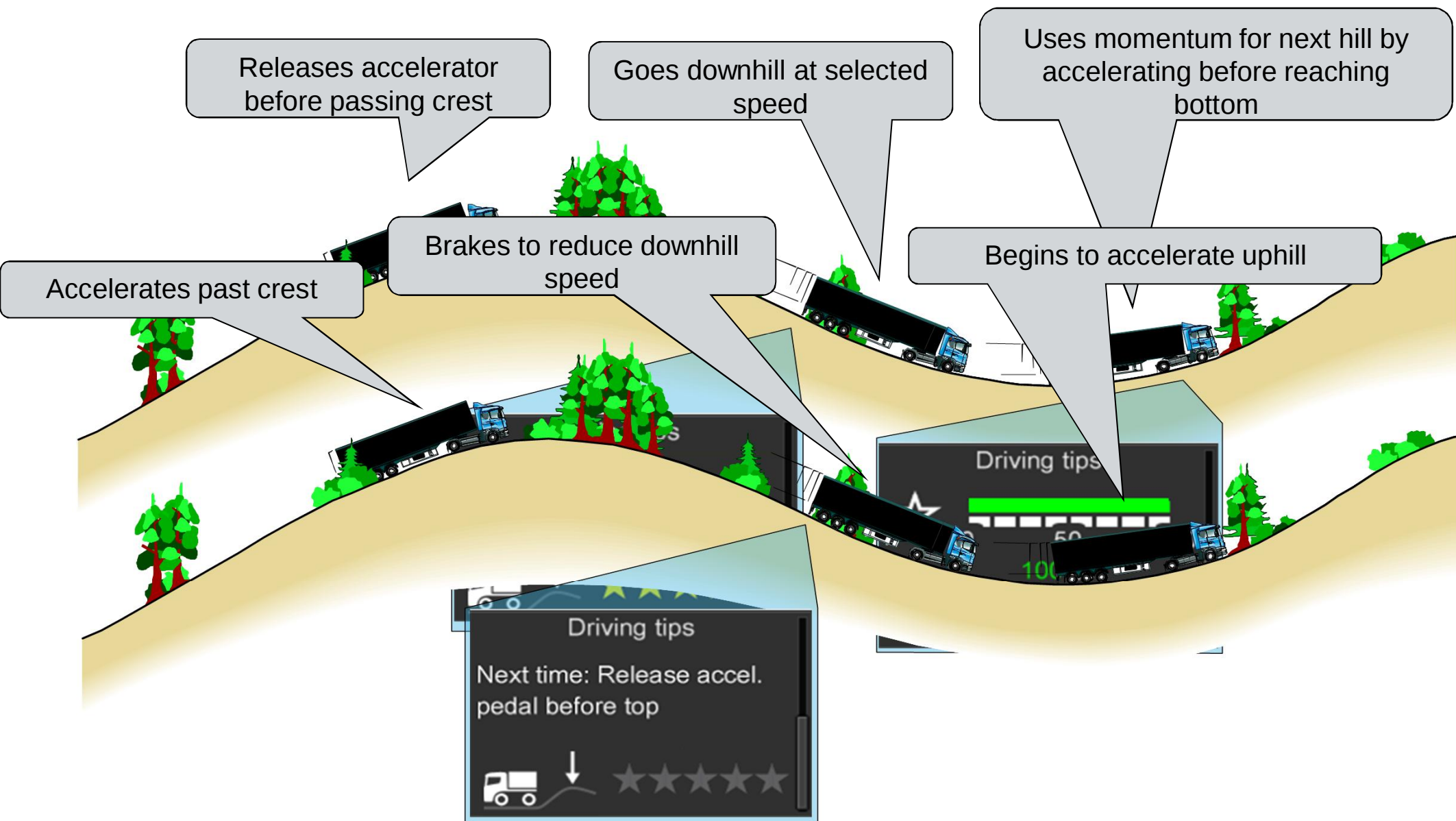
Tested fuel consumption of 38/40 t truck combinations



Summary mode

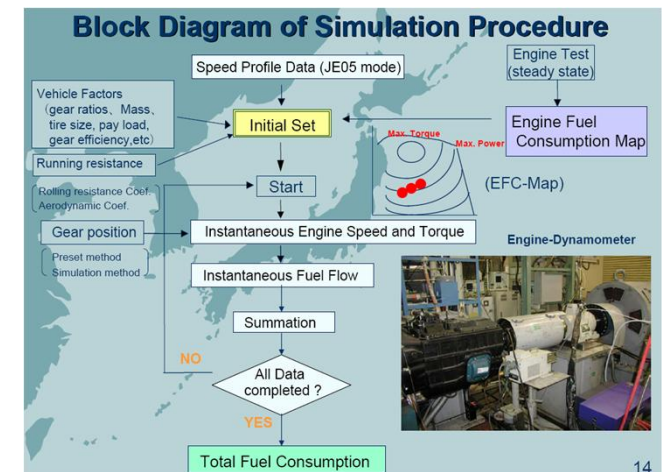
- Instant feed-back on driving behaviour in the instrument cluster
- Tips given when good and bad events have been detected
- Evaluated situations
 - Hill-driving
 - Brake use
 - Anticipation
 - Gear selection





Energy efficiency/CO₂ regulations for HD vehicles

- Japan has been the forerunner
 - fuel efficiency standards for heavy vehicles above 3.5 t as of 2006
- USA
 - the first US GHG emission and fuel consumption standards for heavy- and medium-duty vehicles were adopted on August 9, 2011
- EU
 - methodology and regulations under development



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PERFORMANCE EVALUATION OF PASSENGER CAR, FUEL AND POWERPLANT OPTIONS

IEA AMF Annex XLIII

IEA ExCo 44
Jukka Nuottimäki

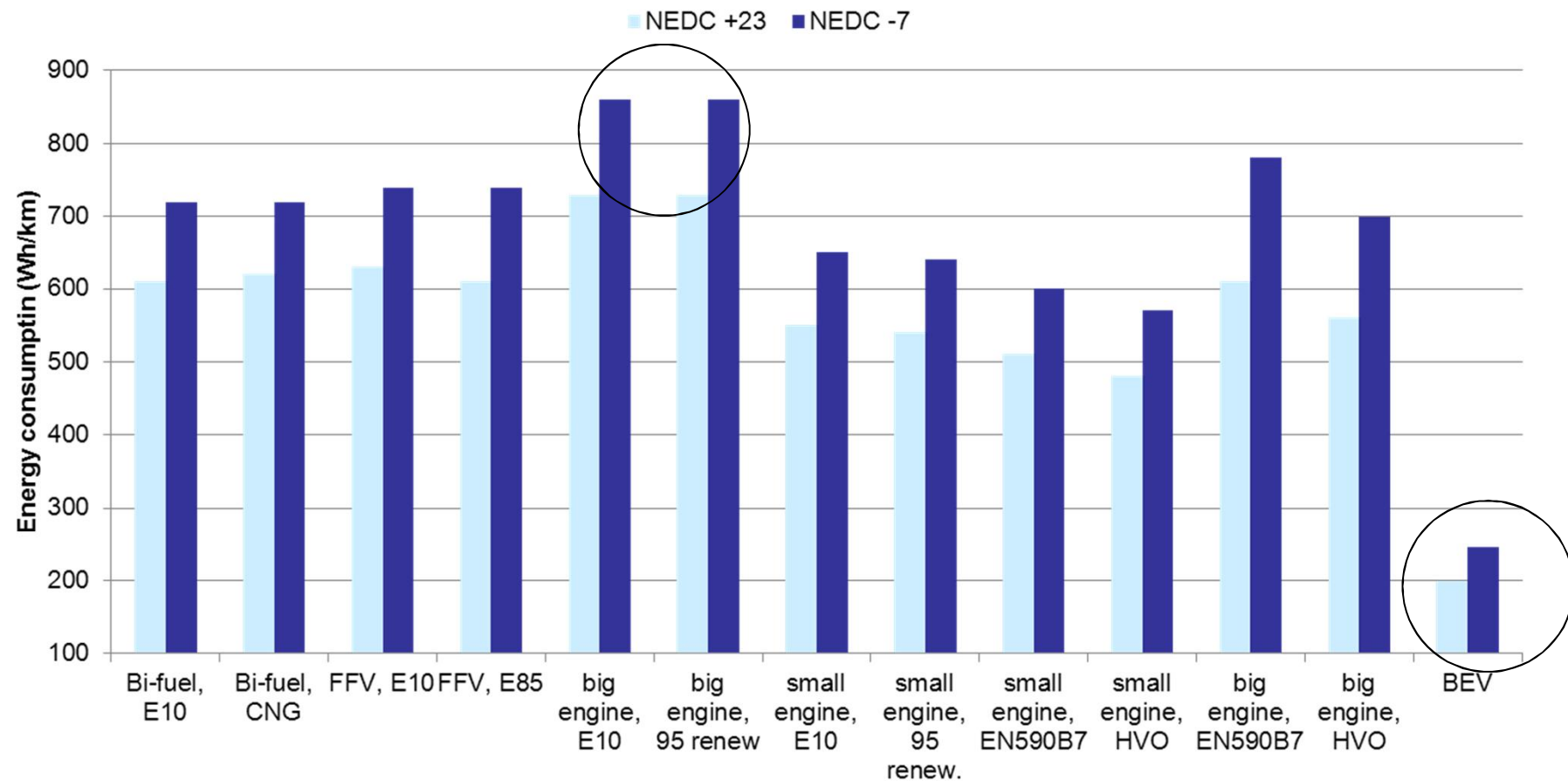
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Annex 43:

Content of the project

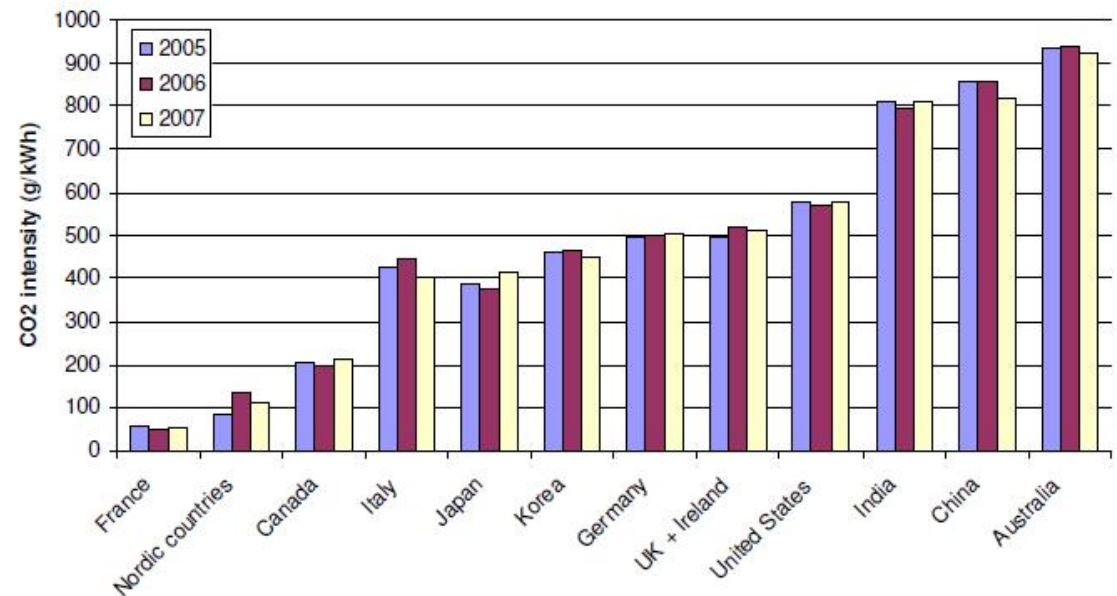
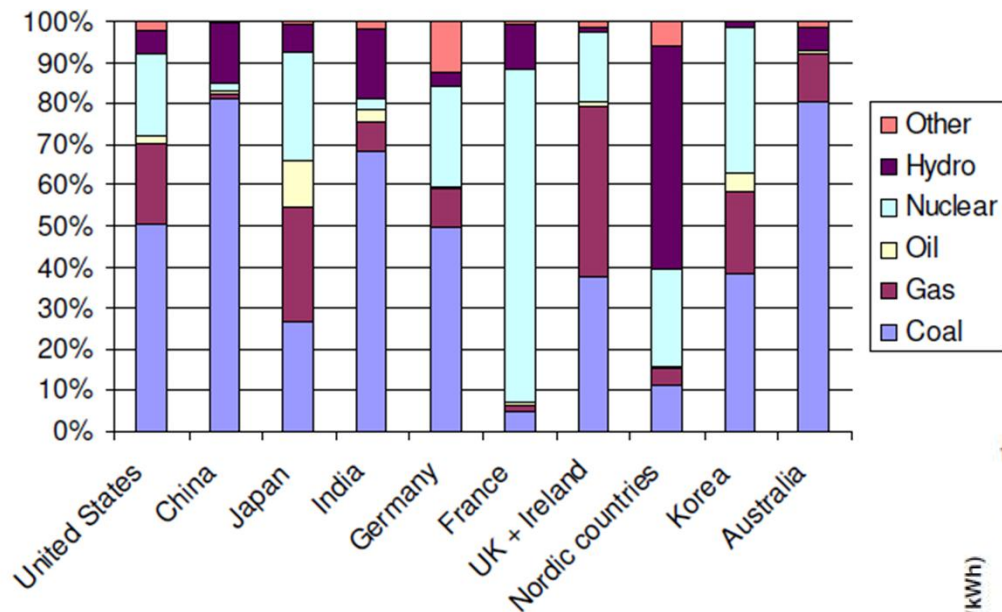
- The core of the comparison consists of benchmarking a set of passenger cars of such make & model that offer multiple choices for engine, i.e. gasoline, flex-fuel, diesel, CNG/LPG and perhaps also some hybrid and EV variations
- The project will also demonstrate the differences in efficiency arising from the engine type and size
- The test matrix will allow some modulation of duty-cycle and ambient temperature in order to give more application/environment specific data
- Making this kind of back-to-back comparison can "neutralize" the vehicle itself from the equation, thus highlighting the role of the propulsion system
- Combined to the results of the upstream fuel-cycle research conducted within the IEA Bus Project, this project can be enlarged to a comprehensive, full fuel-cycle evaluation

Finnish Results: Energy consumption of a medium sized vehicle on NEDC



Max 860 Wh/km (big gasoline engine), minimum 198 Wh/km (BEV)

Power generation profiles



Source: Ecofys 2010

Energy consumption EV vs. ICE

- Electric vehicle Nissan Leaf
 - energy consumption 0.21 kWh/km (motoring magazine TM 2012)
 - transmission losses 5 %
 - total energy consumption 0.22 kWh/km (well-to-wheel WTW, renewable electricity)
 - total energy consumption 0.55 kWh/km (well-to-wheel WTW, gas turbine power plant)
- Diesel car VW Golf 1.6 D Blue Motion Technology
 - factual fuel consumption 5.0 l/100 km (own experience)
 - energy consumption 1.80 MJ/km (0,50 kWh)
 - total energy consumption 0.60 kWh/km (WTW)

Sources: Ecofys 2010, Climate Counter 2012

Summary

- Independent of the energy source, energy efficiency must be prioritized
- Several technical measures are available for reducing energy consumption
- Emphasis of measures varies from one vehicle category to another
- Light-duty vehicles show greater potential for reduction of energy consumption than heavy-duty commercial vehicles
- Driving behaviour has a major impact on energy consumption and emissions



VTT creates business from technology