Fuels and Lubricants in the Future

NVF Energieffectivitet för tunga fordon

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NESTE OIL

refining the future

Drivers behind fuel specifications

Requirements for fuel

Operabililty — **Correlation** ⟷ — **Fuel specification**

Immediate, e.g.
- cold start
- cold operability

Durability, e.g.
- fuel injection system
- catalyst, particulate filter
- deposits, corrosion

EN 590, e.g.
- cetane number
- CFPP
- lubricity (HFRR)
- ash, sulfur
- voluntary additive

Vehicle & engine tests — **Correlation** ⟷ — **Laboratory tests**

Vehicle & engine tests
- take time (weeks, months)
- expensive
- accuracy?
- often ”in-house” or only in R&D

Laboratory tests
- fast (hours)
- cheap
- accurate
- EN xxx, ISO xxx routine duties for fuel quality control

Requirements for fuel

Emissions — **Correlation** ⟷ — **Legislation**

Emissions

Environment, health

- SO_x
- NO_x
- particulates

Fossil CO_2, life cycle GHG

Legislation

- dir. 2009/30/EC, 2009/28/EC
  - sulfur
  - cetane, aromatics
  - sulfur, distillation, density
- bioenergy-%, GHG reduction

Safety

- fire
- health, leakages to nature

- flash point
- REACH, safety data sheet

Political

- sustainability, social needs

- dir. 2009/28/EC

Correlations

<u>Not perfect</u>

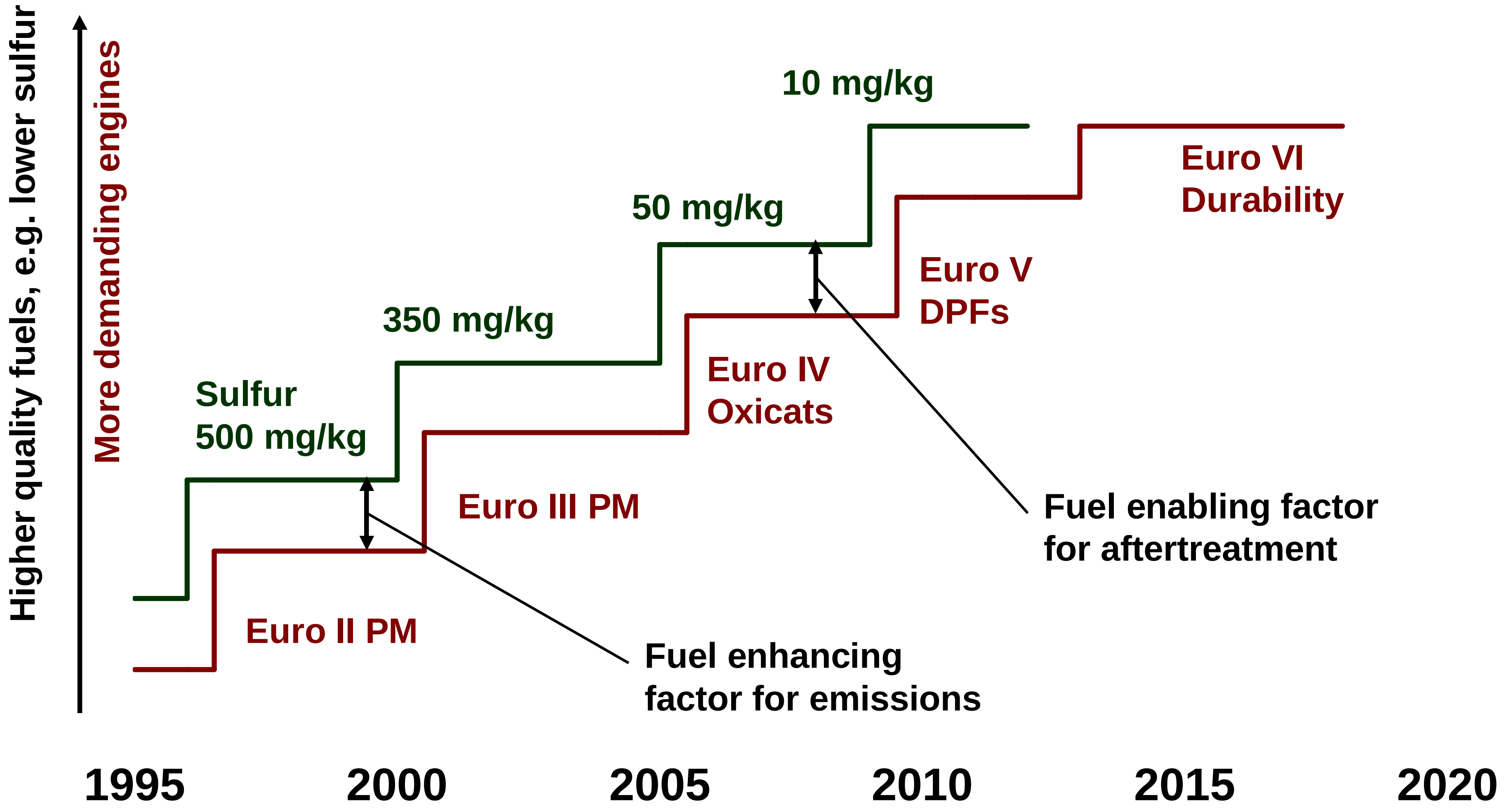
- **evolving vehicle designs, different driving conditions**
- **new fuel chemistries**
- **slow and laborious to develop, standardization process compromise**

<u>What has happened, e.g.</u>

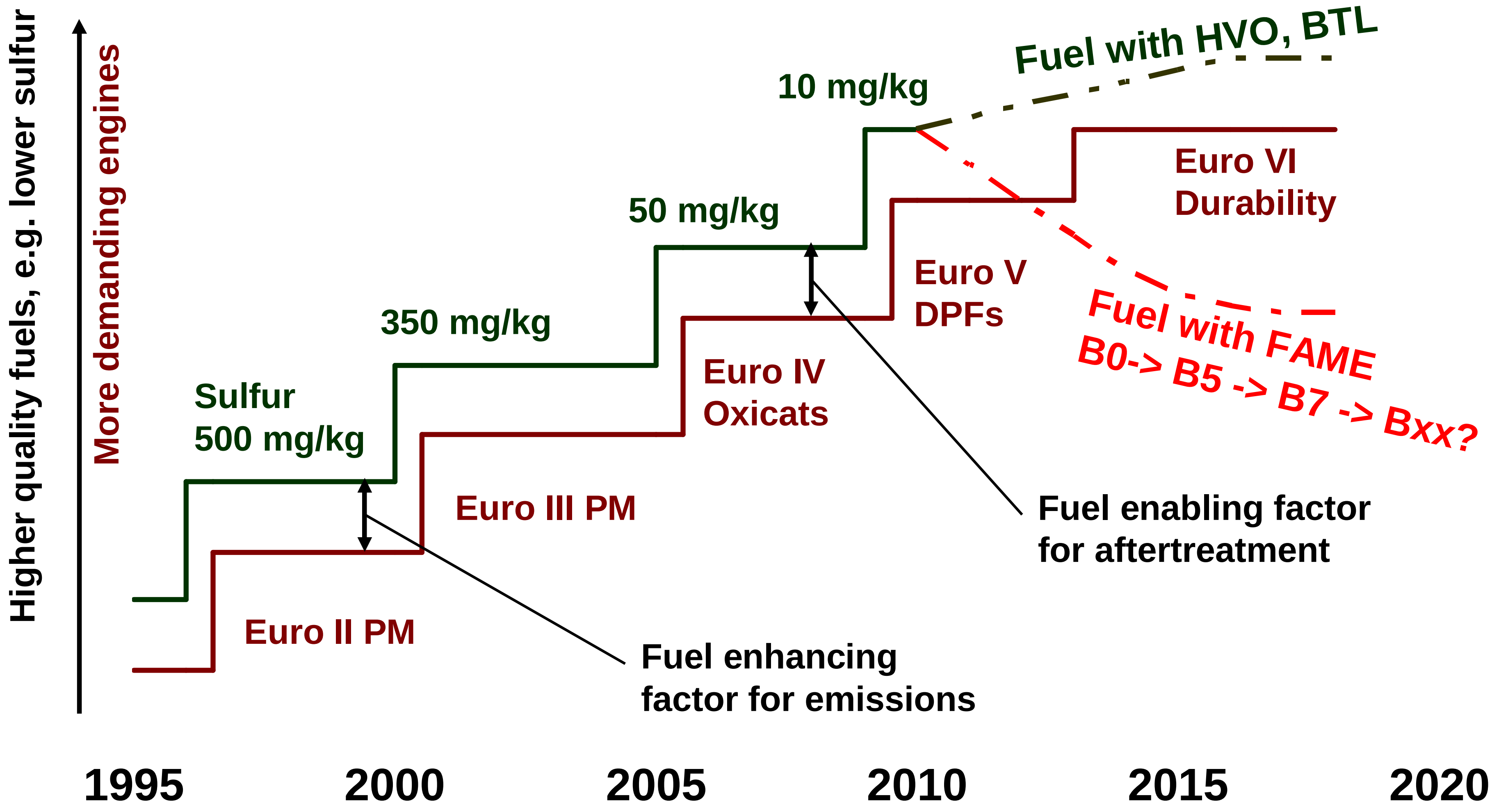
- **cold operability <=> CFPP –correlation from 1960 ... 1970’s**
- **fuel filter lifetime <=> total contamination specification for fuel**
  - **new vehicle designs**
  - **new fuel chemistries, biocomponents (FAME), new additives**
  - **laboratory tests fast, do not correlate with real life**

=> correlation may be history, but <u>fuel has to be fit-for-purpose</u>

Evolution of diesel fuels and engine requirements



Evolution of diesel fuels and engine requirements



Properties of future fuels

Properties of diesel fuels

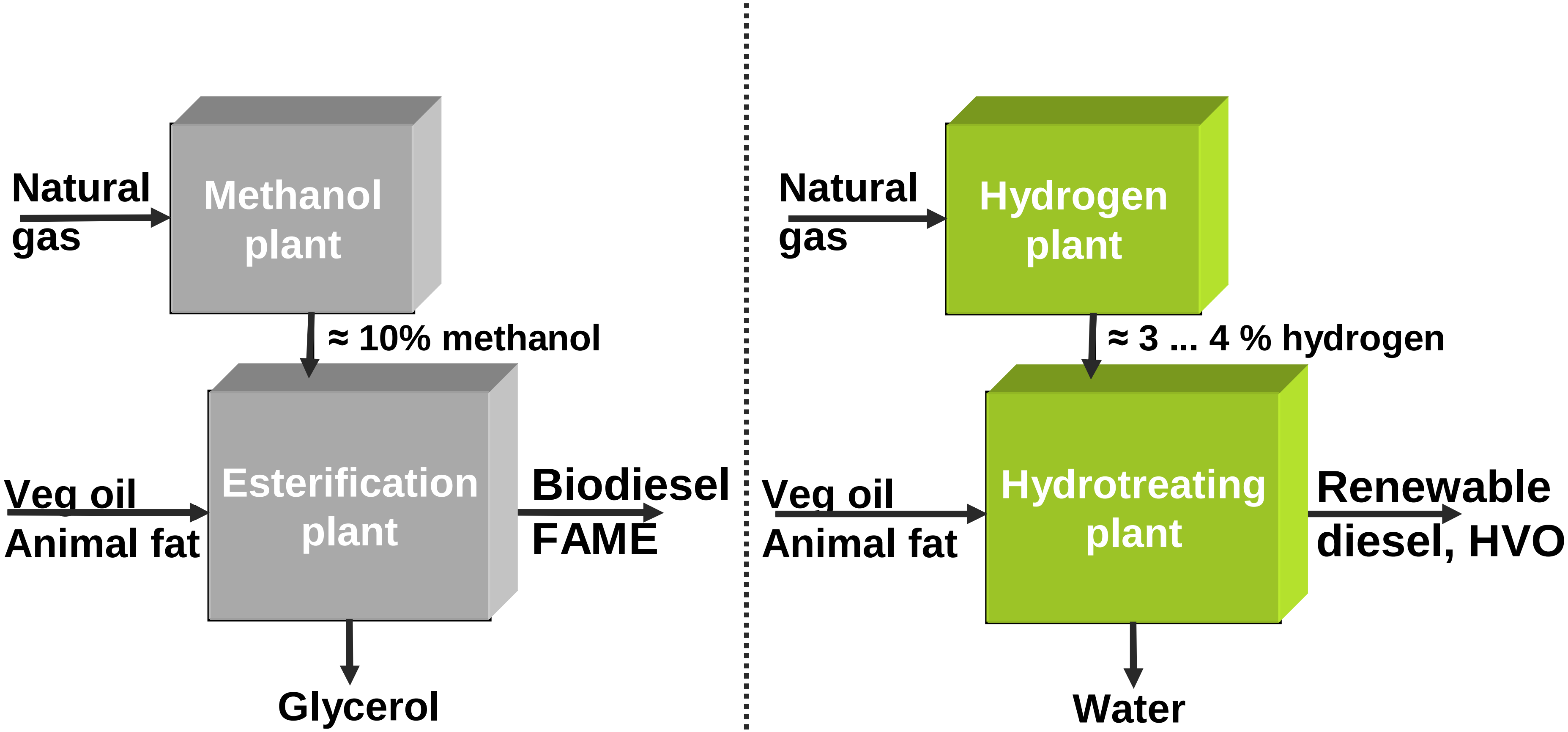
	S-free EN590 diesel fuel	HVO BTL GTL (even 100 %)	If not ok
Sulfur content	OK	OK	Aftertreatment operation
Distillation range	OK	OK	Engine oil dilution
Stability	OK	OK	Deposits in fuel system
Ash, metals	OK	OK	Aftertreatment durability
Cold properties	OK	OK	Fit for purpose all the year round

HVO = hydrotreated vegetable oil
BTL = bio-to-liquids from biomass by Fischer-Tropsch
GTL = gas-to-liquids from natural gas by Fischer-Tropsch

Typical fuel properties

	EN 590 diesel (summer)	HVO	Biodiesel FAME (rape seed)
Density (kg/m^3)	≈ 835	≈ 785	≈ 885
Cetane number	≈ 53	75 ... 99	≈ 51
Distillation range (°C)	180 ... 360	180 ... 320	350 ... 370
Heating value (MJ/l)	≈ 35.7	≈ 34.4	≈ 33.2
Total aromatics (wt-%)	≈ 30	0	0
Oxygen (wt-%)	0	0	≈ 11
Stability	Ok	Ok	Challenge
Ash, metals	Ok	Ok	Challenge
Cold operability	Ok	Ok	Challenge
In diesel fuel (vol-%)		... 30 ... 100	... 7 (... 10?)

Esterification (FAME) & hydrotreating (HVO) processes



Natural gas input about the same in both routes

The same feedstocks but superior product quality with HVO

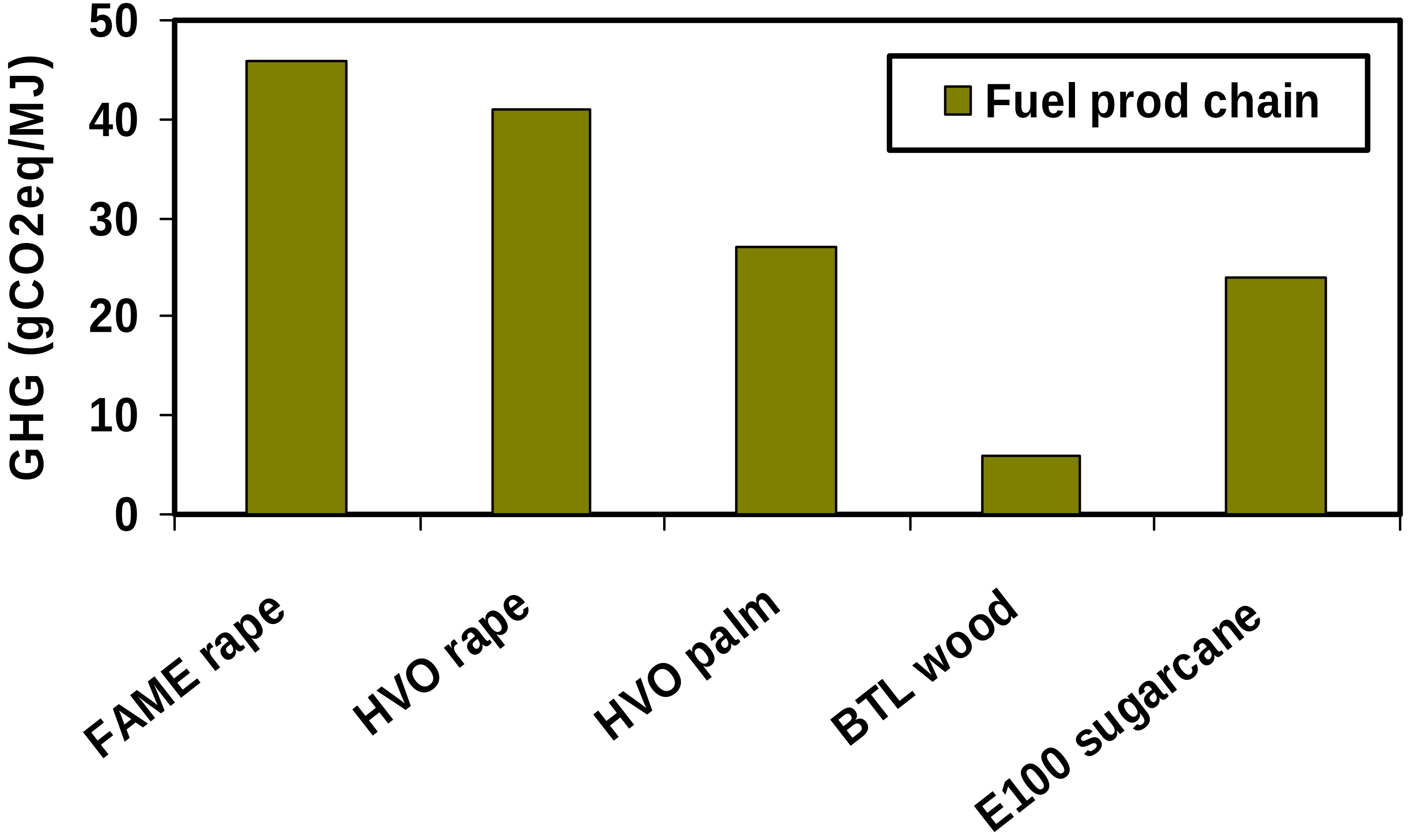
Technologies for biobased diesel fuels

Commer-cial scale	Process	Product	Feedstock availability	Product quality *Chemistry*	Process plant capital cost
≈ 1995 ...	Esterifi-cation	FAME	- Some veg oils	- *Ester*	+
2007 ...	Hydro-treating	HVO	+ All veg oils	+ + + *Paraffin*	-
≈ 2017 ?	Gasification + Fischer-Tropsch	BTL	+ + + Biomass	+ + + *Paraffin*	- - -

+ Benefit **- Challenge**

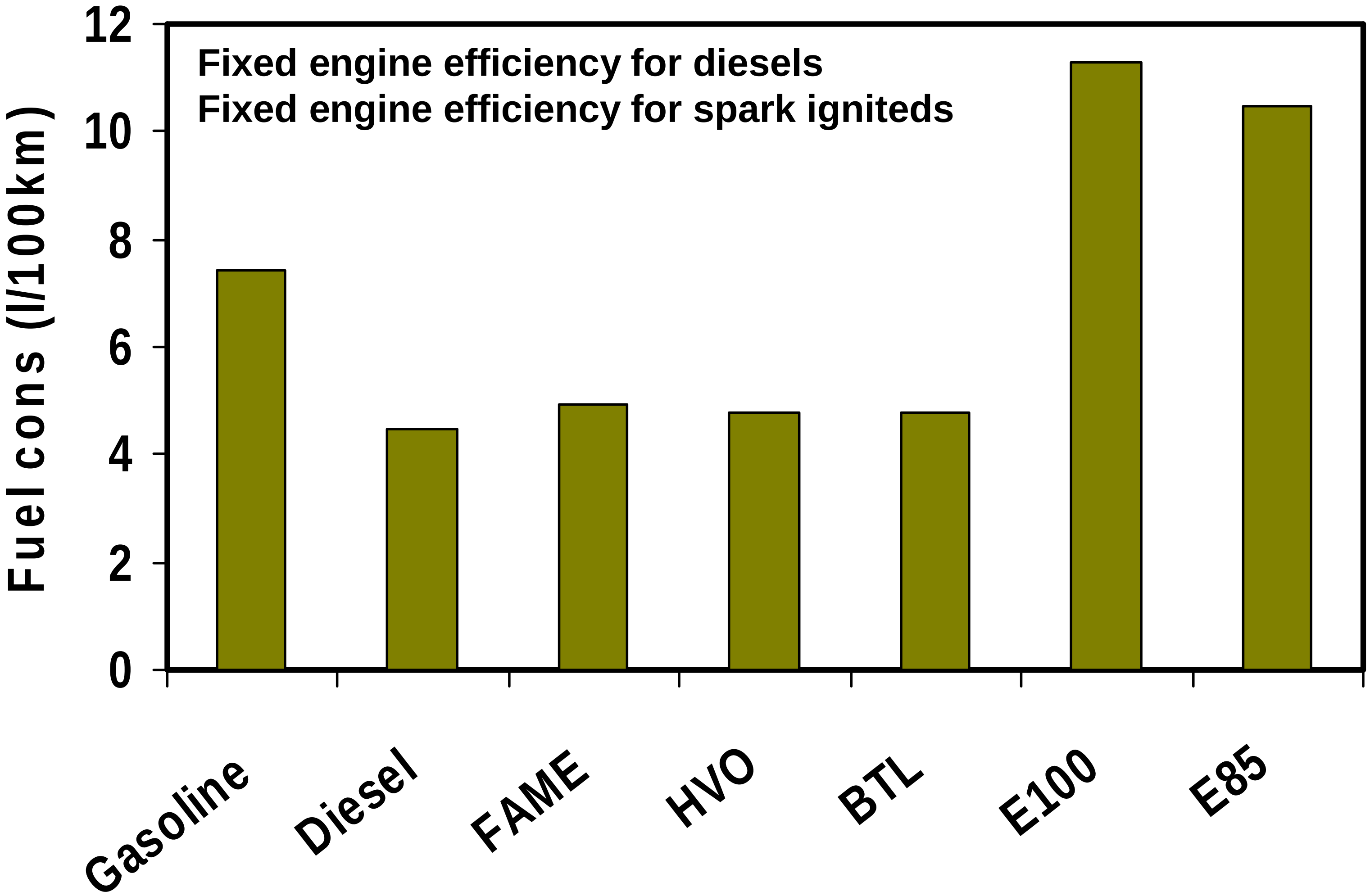
Think well-to-wheels in fuel life-cycle

Directives think well-to-tank (calorific combustion)



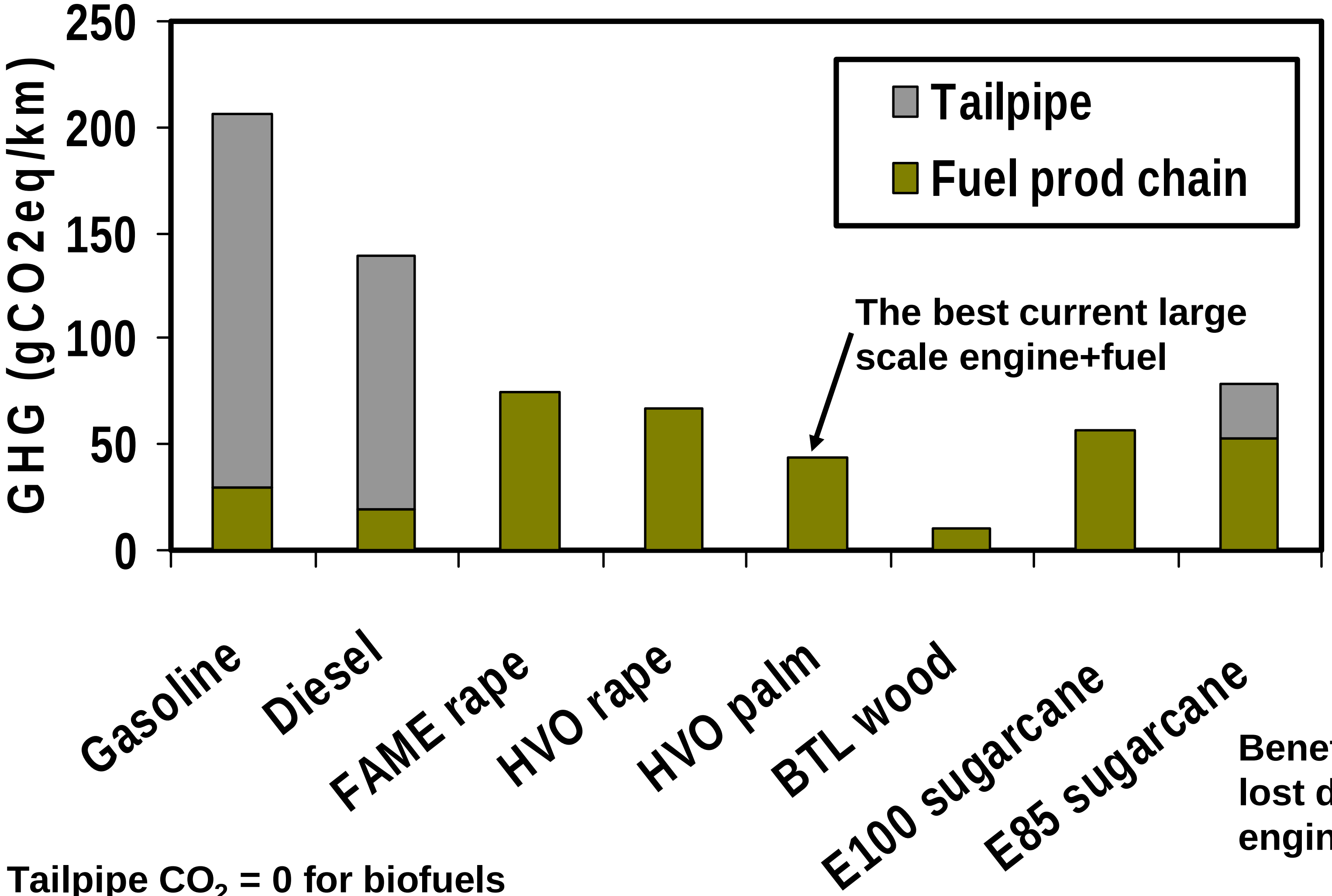
Palm with methane capture at oil mill **Source: Dir2009/28/EC typical values**

Drivers think tank-to-wheels in liters



Example: Medium size passenger car **FAME100 and E100 only theory for current cars**

Well-to-wheels GHG

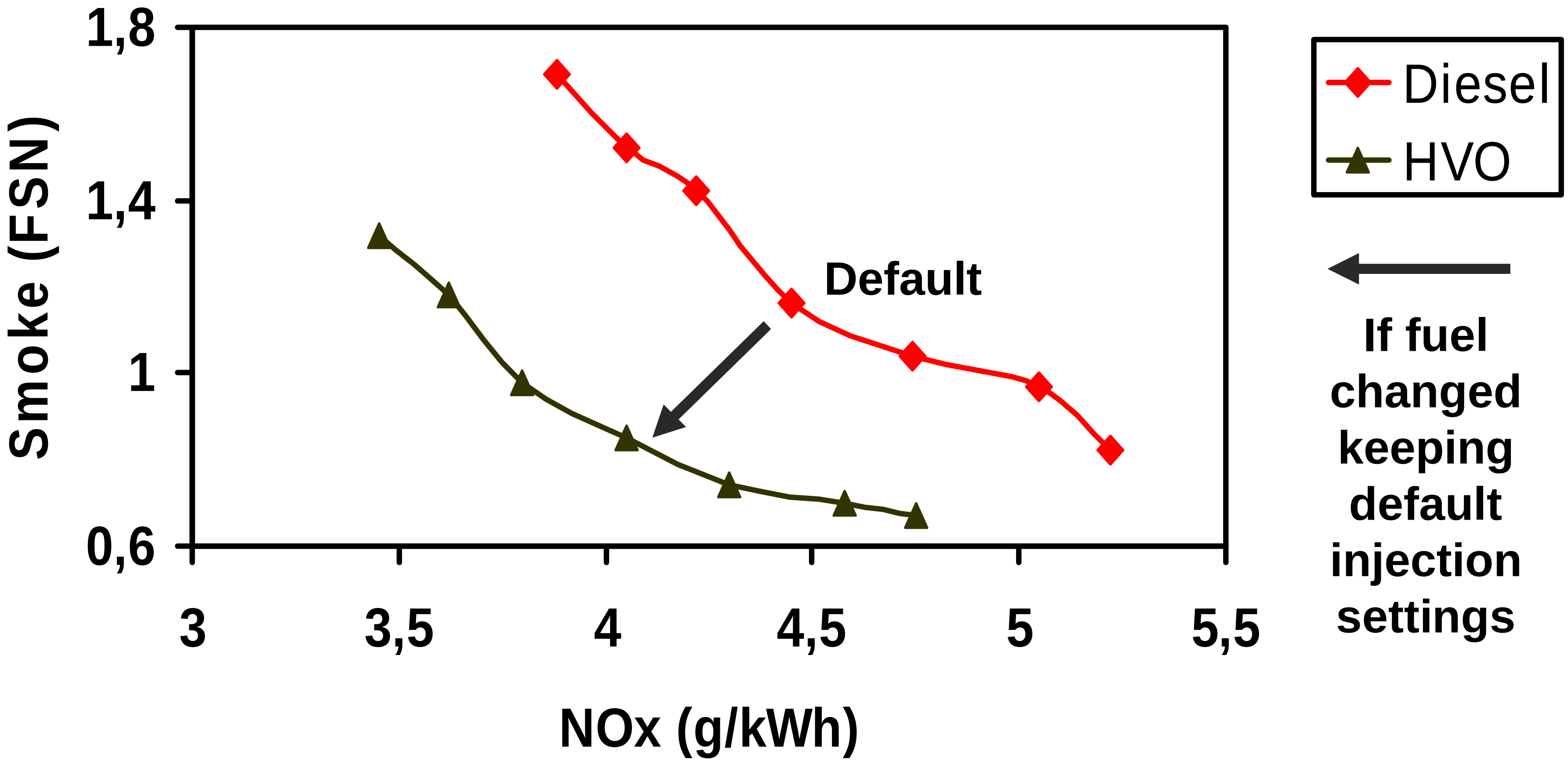


Benefit of ethanol lost due to lower engine efficiency

Tailpipe CO_2 = 0 for biofuels

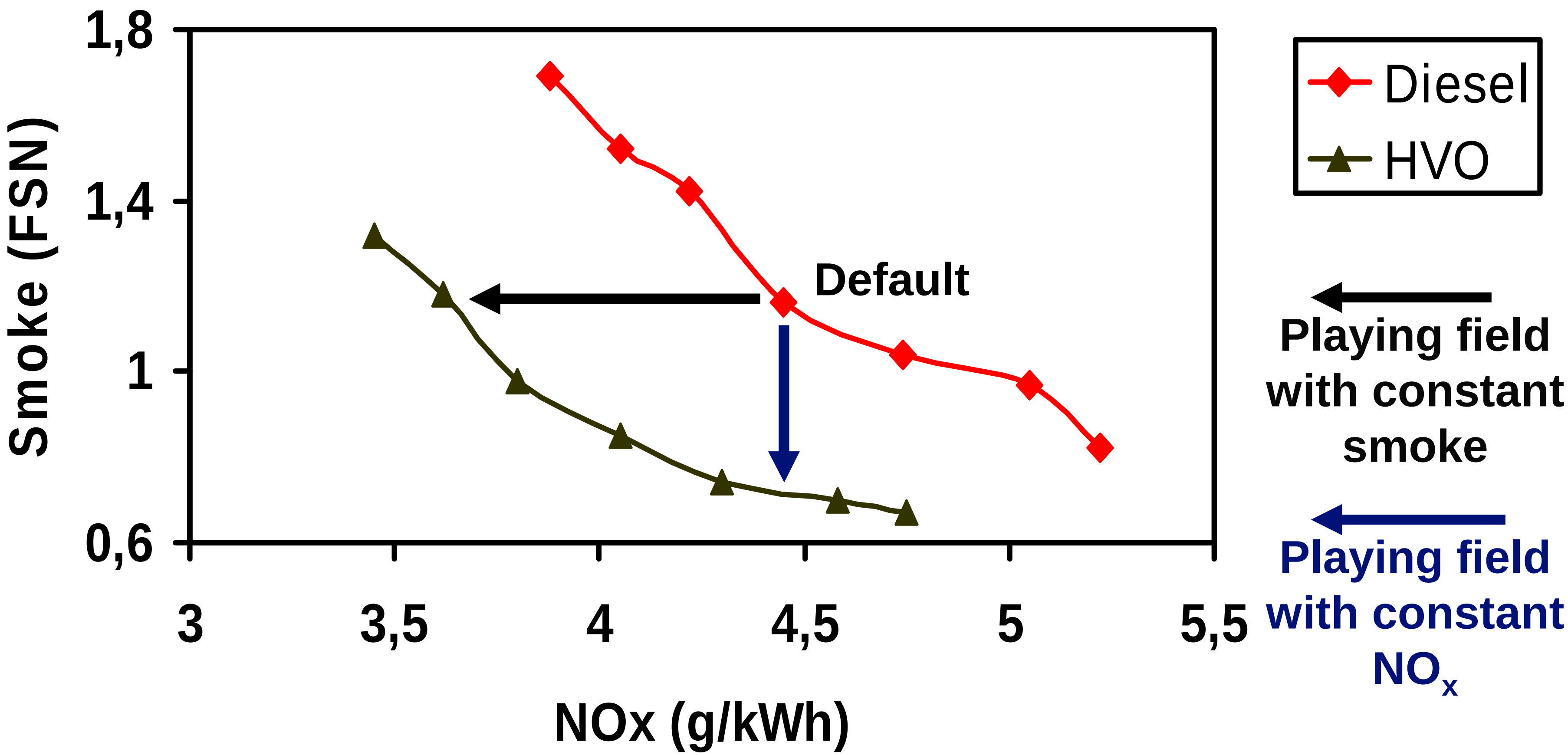
Optimizing engine + diesel fuel

Trade-off NO_x – particulates in a HD engine



Only smoke measured, device for particulates not available

Playing field with changing injection timing



Similar trade off with fuel consumption: The lower NO_x, the higher consumption

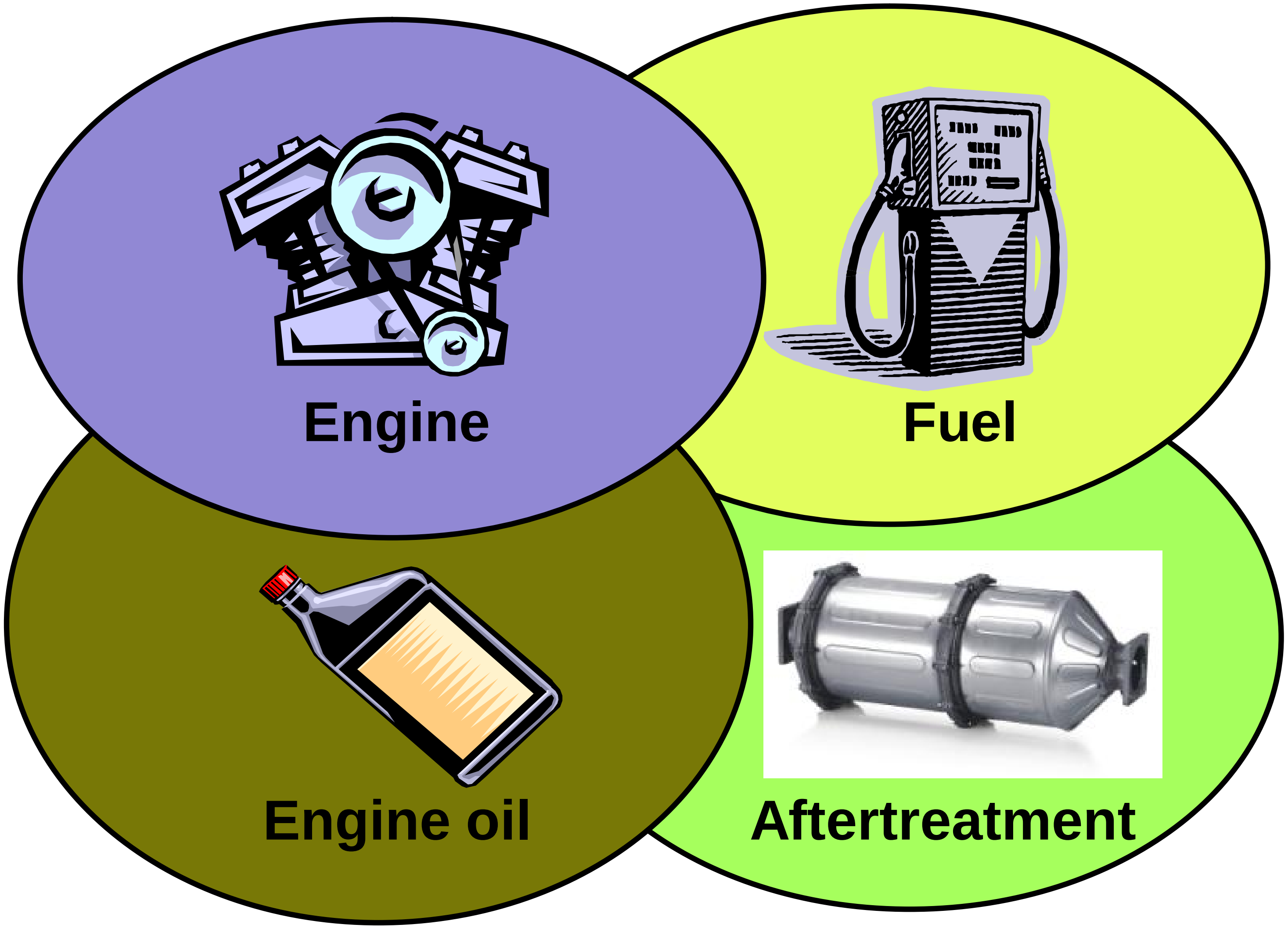
Optimizing a HD engine for 100 % HVO

Injection timing ➔	Default	Advanced	Remarkably advanced	Retarted
NO_x	- 6 %	+/- 0 %	+ 4 %	- 16 %
Smoke	- 35 %	- 37 %	- 32 %	- 32 %
Fuel cons (mass)	- 3 %	- 6 %	- 8 %	+/- 0
Fuel cons (volume)	+ 5 %	+ 2 %	+/- 0 %	+ 8 %
	Fuel cons (vol) increased due to lower fuel density	Lower mass fuel cons => well-to-wheels GHG down	Lower mass fuel cons => well-to-wheels GHG down	

% = change compared to S-free EN590 diesel fuel

Details: SAE 2008-01-2500

Compatibility essential: All need to work together



Lubricants for Commercial Vehicles

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Lubricant Development for Busses, Coaches, Lorries and Trucks

- Lube development work has focused on Engine Oils.
- All new engine oil formulations in Europe must fulfil **European Automobile Manufacturers Association ACEA-08** requirements as of 22nd Dec 2010.
- E-category for Heavy Duty Engine Oils contains new European engine tests from Daimler

For example:

OM501LA (11.9 l, V6, 350 kW power)

- Piston cleanliness,
- bore polish,
- oil consumption

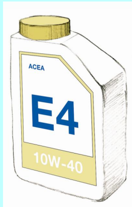
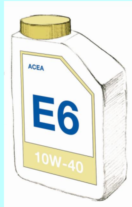
Modern Euro V hardware running on a modern diesel fuel

– B5 (<10ppm ULSD + 5% FAME)

Market Tiers

Four distinct market tiers for Euro V

Sulphated Ash, Phosphorus, Sulphur

	High SAPS	Low/Mid SAPS	
UHPD (Ultra High Performance Diesel Engine Oil)	 Some EGR engines some SCR units	 EGR engines SCR units with/without DPF with low S diesel	**Extended drain performance** (up to ~90-120tkm)
SHPD (Super High Performance Diesel Engine Oil)	 most EGR engines most SCR units	 most EGR engines most SCR units with/without DPF with low S diesel	**Mid drain performance** (~30-60tkm)
	SCR/EGR (Euro V)	DPF (Euro V/VI)	

Performance Driven Categories

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Source: The Lubrizol Corporation

Market Tiers

Four distinct market tiers for Euro V

Sulphated Ash, Phosphorus, Sulphur

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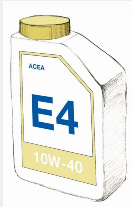
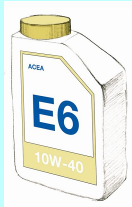
UHPD (Ultra High Performance Diesel Engine Oil)	 Some EGR engines some SCR units	 EGR engines SCR units with/without DPF with low S diesel	Extended drain performance
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Suitability for different Engine and After Treatment Technologies

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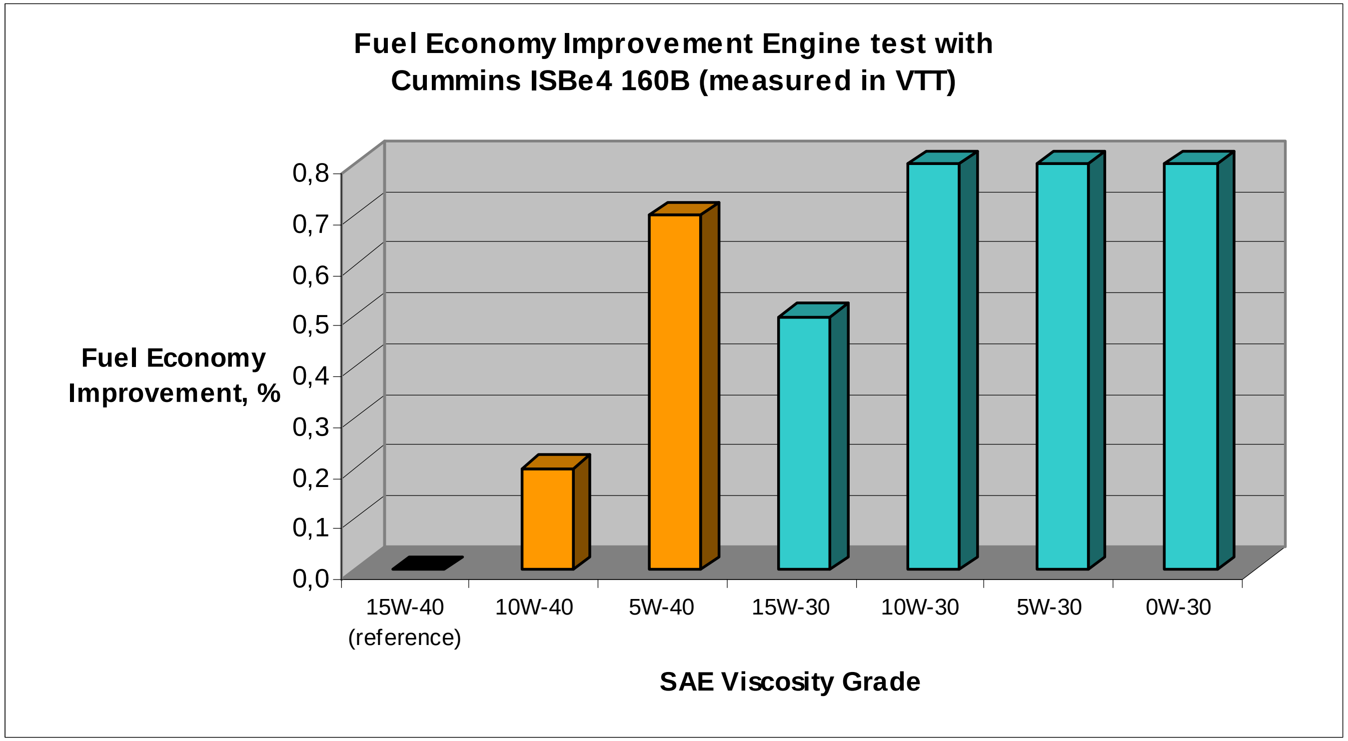
Source: The Lubrizol Corporation

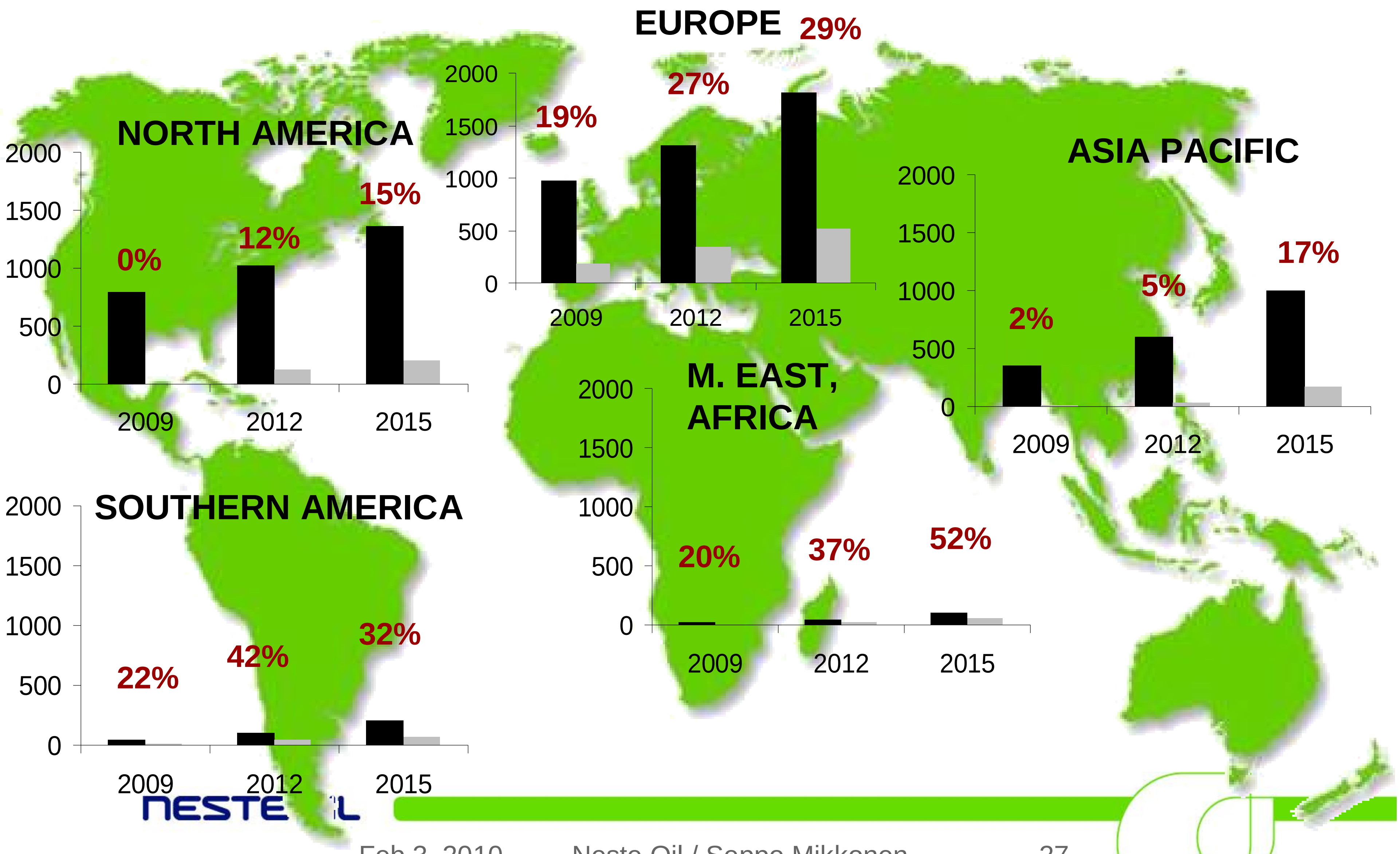
Focus areas for future Engine Oils

- Engine oil capability for **higher biodiesel (FAME) content**
- Engine Oil's effect on **ultrafine particulate number**
- **Fuel economy improvement** (FEI) and CO_2 reduction



- Only higher quality, **sulphur free base oils** suitable for Euro VI and beyond heavy duty engine oil development programmes

Group III base oil markets and Neste Oil's market share in 2015

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