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Ethanol as future fuel for optimized combustion engines

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Engines and Biofuels: Moving the World
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- CO2 emissions of Ethanol Fueled Engines
- Some current tribological Issues with Flex Fueled Vehicles
- Trends to optimize Otto combustion engines
- Conclusions

Which will be the future car?

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Electrical?

Hybrid?

Hydrogen fuel cell?

“Low Cost?” “Downsizing”?

Bio-Fuel ou “PetroSal”?

We can only be sure that different solutions will exist!

GreenHouse gas (GHG) emissions Predictions to 2035

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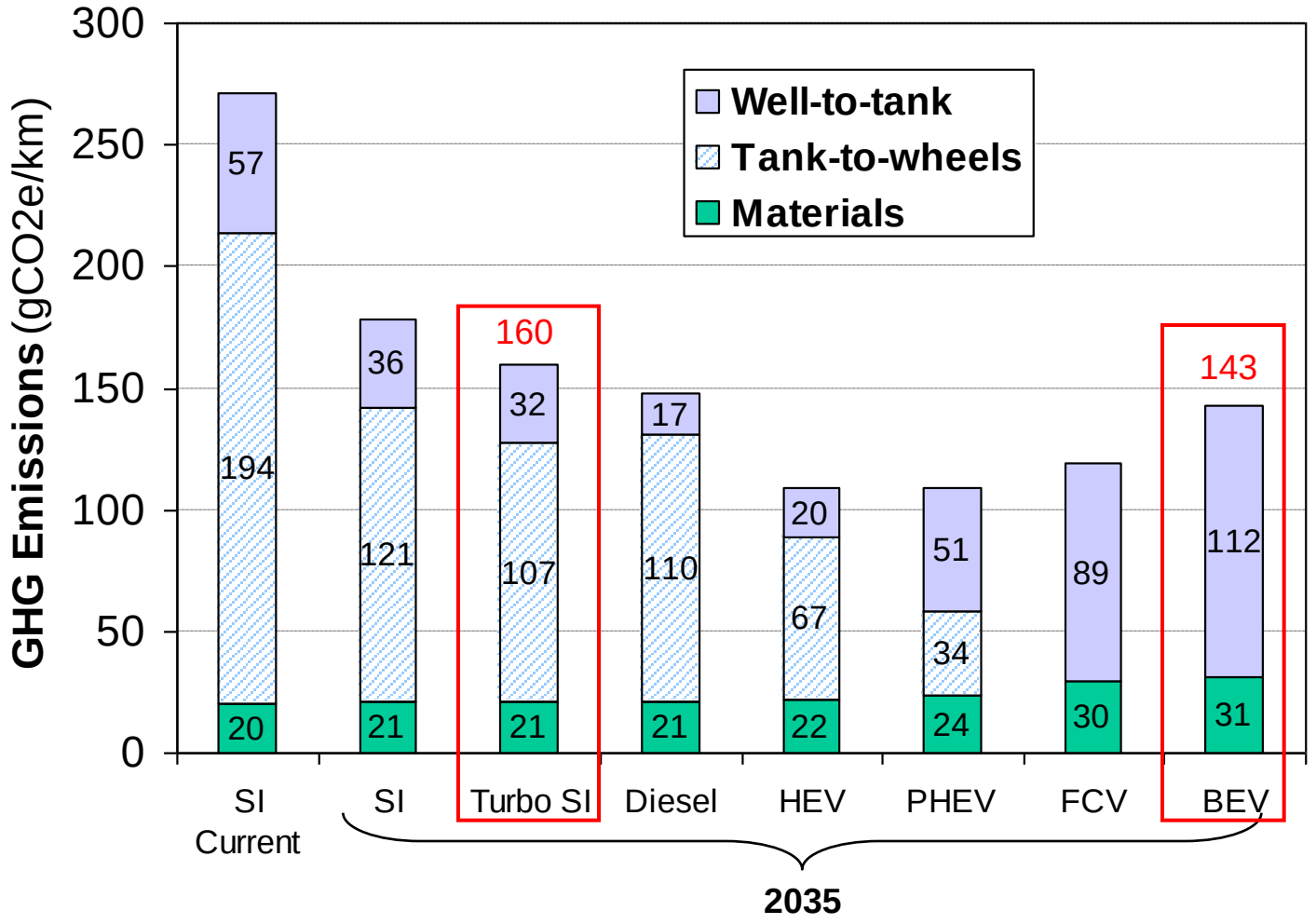

SI: Spark-Ignition

HEV: Hybrid Electric Vehicle

PHEV: Plug-in Hybrid with 30-mile all electric range

FCV: Hydrogen Fuel Cell vehicle

BEV: Battery Electric Vehicle

Price Increment relative to Gasoline SIE (USD):

Turbo Gasoline	**700**
Diesel	1,700
Hybrid	2,500
Plug-in Hybrid	5,900
Fuel Cell	5,300
Battery Electric	**14,400**

Source: On the road in 2035 – MIT report Jul/2008

Well to Wheel
The complete cycle of emissions

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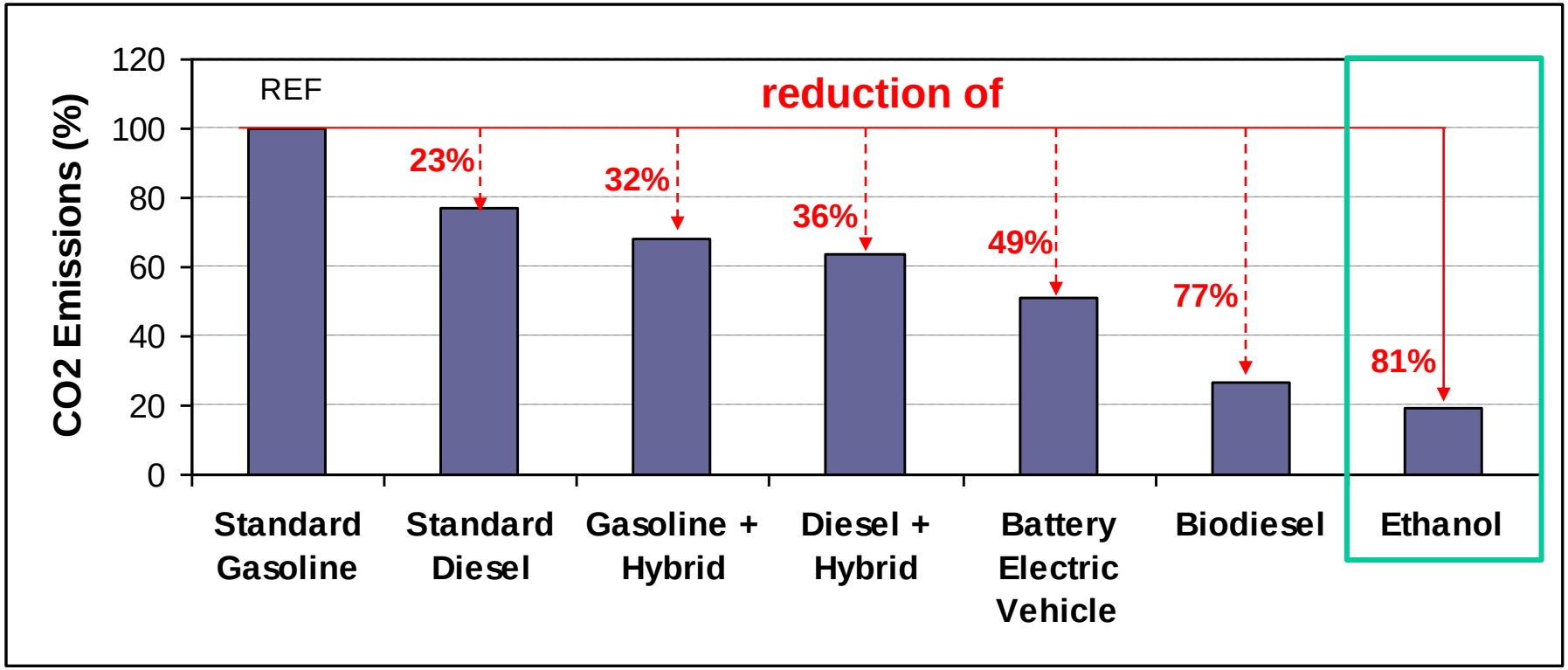
Considering the emissions to produce the fuel, use of bio-fuels brings more CO2 reduction than battery electric vehicles.



Adapted from "Mobility 2030: Meeting the challenges to sustainability"
World Business Council for Sustainable Development - http://www.wbcsd.org/web/mobilitypubs.htm

Fuel Properties and Effects on Powertrain

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Property	Unit	Gasoline E0	E85	Ethanol E100
Air-fuel ratio		14.7	9,8	9,0
Specific calorific value	kcal/kg	12300		7090
Latent heat of vaporization	KJ/kg	350-450	~800	904
Ignition temperature	°C	280 / 430		392
Burning speed	cm/ms	33 / 47		44
Evaporation curve/value	°C	35 °C – 200 °C	78 °C	78 °C
Octane number	RON	> 91	≥108*	108

Ethanol differences:

– higher injection timing

– more fuel film

\+ higher torque due to cooling of air

– cold start difficulties

\+ lower knocking

Source: Bosch

Flex fuel engines– Increased loads on components

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Engines

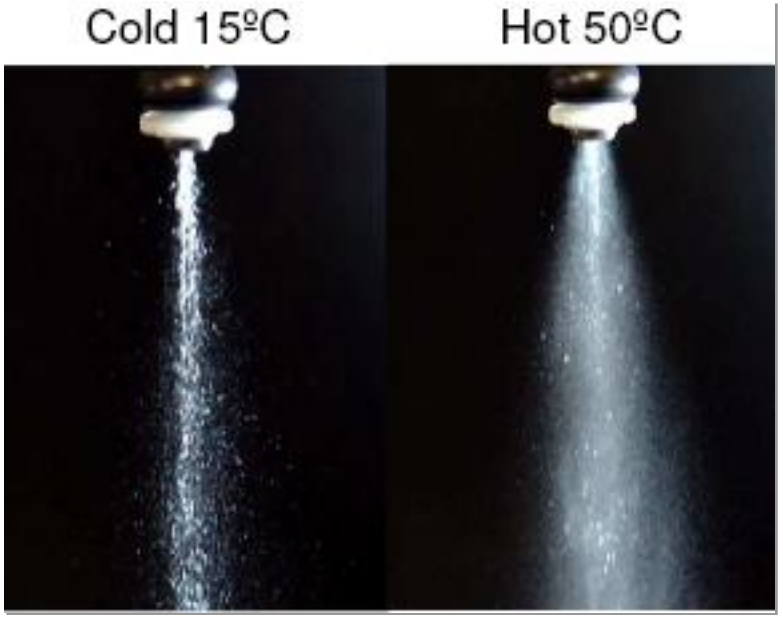
Higher efficiency
More compact engines
CO2 Emissions reduction
Lower fuel consumption

FFE Technology

PCP increase (20 to 30%)
More fuel injection (+30%)
Spark time changed

PCU

Higher Loads
Less lubrication (fuel dilution)
Tribological Severity Increased



Some current Tribological issues on FFE

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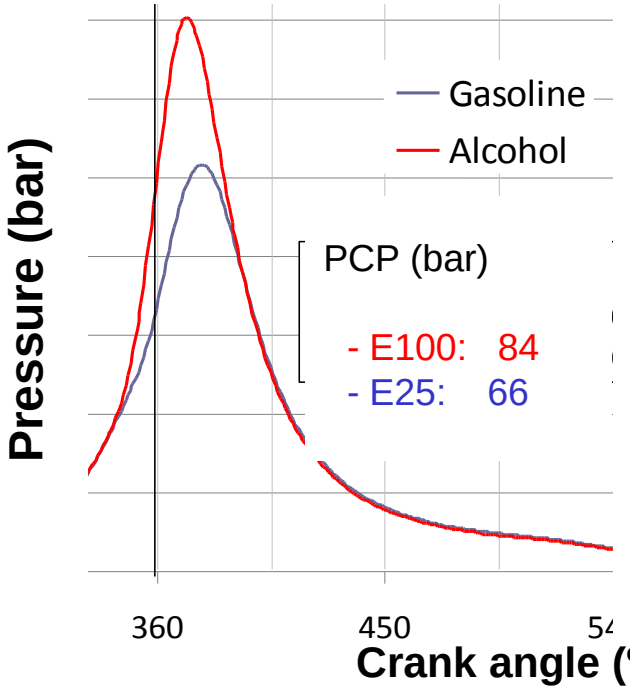
- **Ethanol lower lubricity**
- **Fuel dilution on cold start**
- **PCP is higher and closer to TDC**



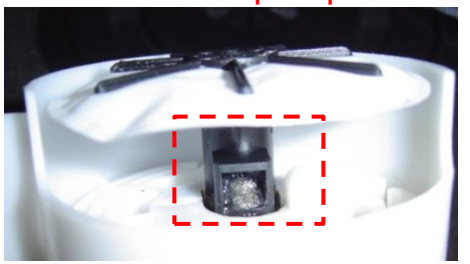
Spalling on top rings

Valve Issues

From 4 Rodas magazine

Corrosion on Bearings

Gel in the fuel pump



SAE 2011-36-0217 (to be published)

"Carmakers rethink sustainability approach amid E10 fuel fiasco"

Carmakers rethink sustainability ap

Trends in Engine Development – Future Otto Engines

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Downsizing with Charging

- Downsizing
- Direct Injection
- Increased peak cylinder pressures
- Charging / Variable Geometry Turbines

Friction / Weight Optimisation

- Friction reduction
- Lightweight design

De-throttling / Variable Valvetrain

- De-Throttling
- Variable valve-control
- Variable capacity / Cylinder de-activation

Combustion Process

- Spark Ignition: Combustion process (lean, stratified, homogeneous)
- Self Ignition (CAI, HCCI)
- EGR / increased EGR-rates

Hybridisation

Bild: Audi

High EGR rates - Motivation

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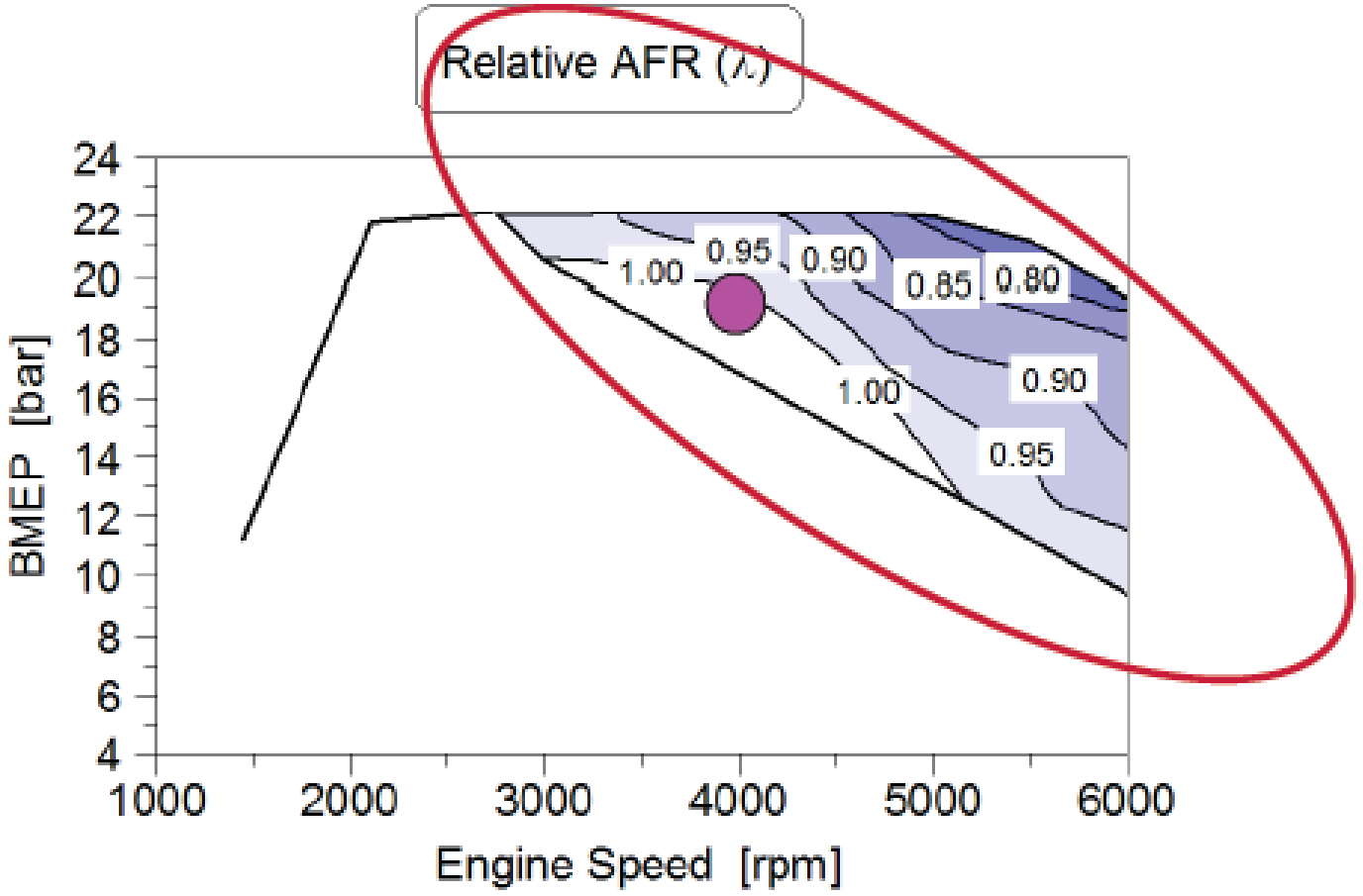

- Poor Fuel Economy
- High Hydrocarbons, CO
- Poor three-way catalyst efficiency

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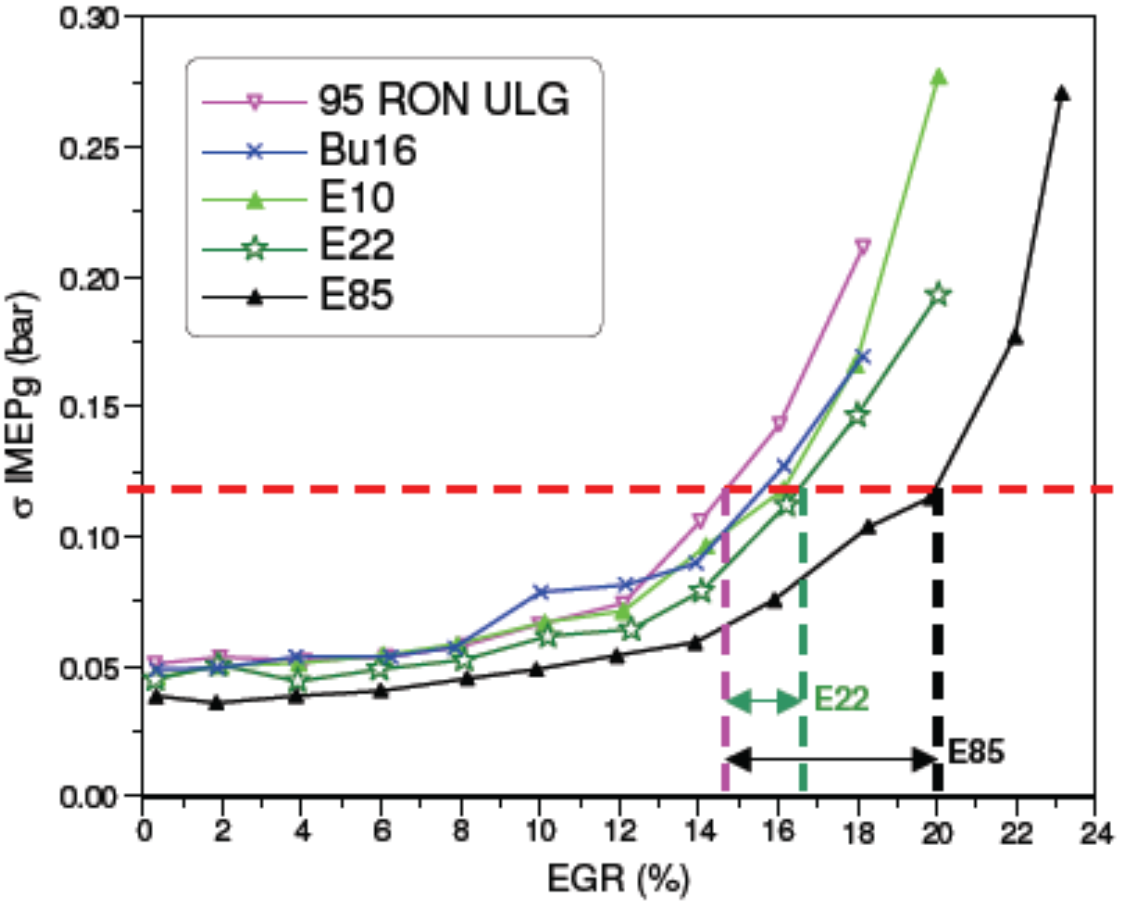
Dilution Tolerance

Ethanol is more tolerant to Higher EGR rates predicted in the next engine generations



Ethanol has also great potential for Diesel engines

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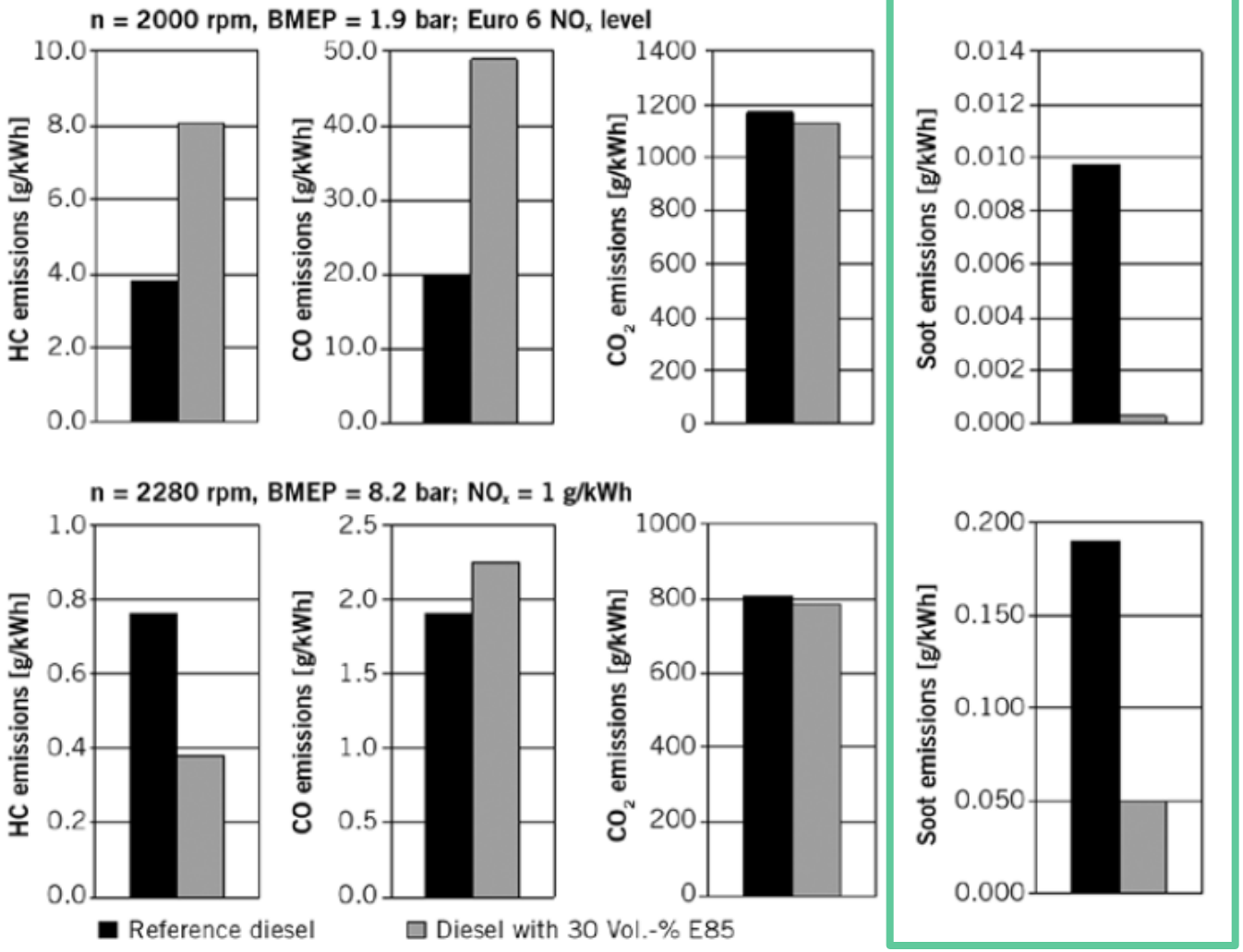

From “Chances and challenges of the admixture of ethanol to diesel fuel MTZ 08I2011 Volume 72

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Conclusions

- A variety of vehicle/engine technologies is expected on the future. While developed countries will demand high efficiency/tech solutions, the growing market will be on developing countries.

- Considering well to wheel, advanced engines burning bio-fuels have the lowest CO2 emissions. Lower even than full electric vehicles.

- Ethanol fuel brings both advantages and disadvantages in terms of combustion and tribology. So far, engines are mostly adapted from gasoline engines, not ethanol optimized.

- More concentrated efforts on R&D are needed to fully explore the ethanol potential as engine fuel. Although pioneer in ethanol, Brazil scientific studies of ethanol as combustion engine fuel are relatively few.

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Thanks for the attention

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