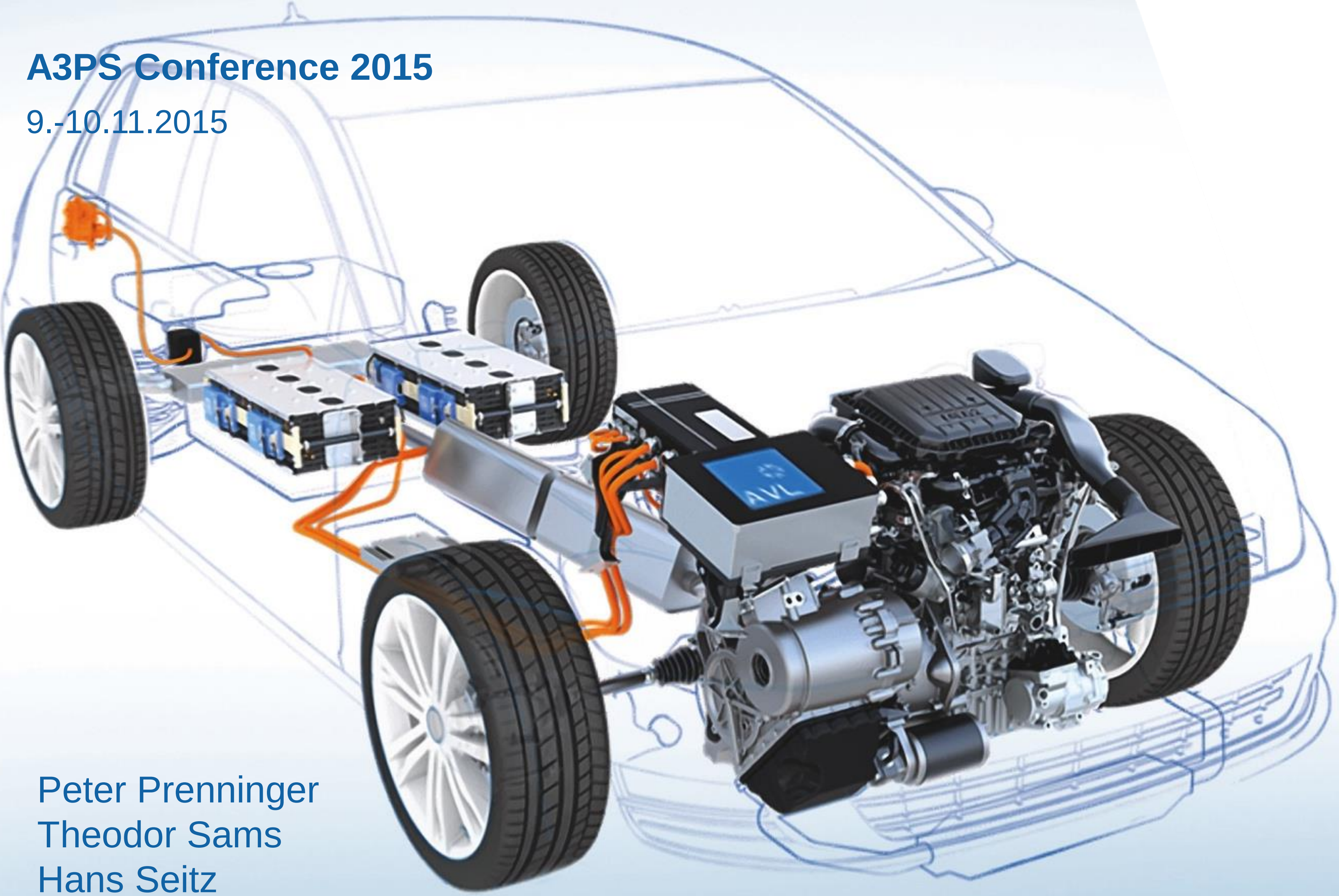
EFFICIENCY TOWARDS 50% AND EMISSIONS TOWARDS ZERO: FUTURE ICE TECHNOLOGY

AVL

A3PS Conference 2015

9.-10.11.2015



Peter Prenninger
Theodor Sams
Hans Seitz
Helmut Theissl

FUTURE POWERTRAIN TECHNOLOGY ZERO IMPACT EMISSIONS

EU1 ➔ EU6:

Gasoline:
NO_x+HC: –86 %

Diesel:
NO_x+HC: –85 %
PM: –98 %

Fuel Cell:
All: –100%

Source: Daimler

FUTURE POWERTRAIN TECHNOLOGY BENEFIT OF CONNECTIVITY

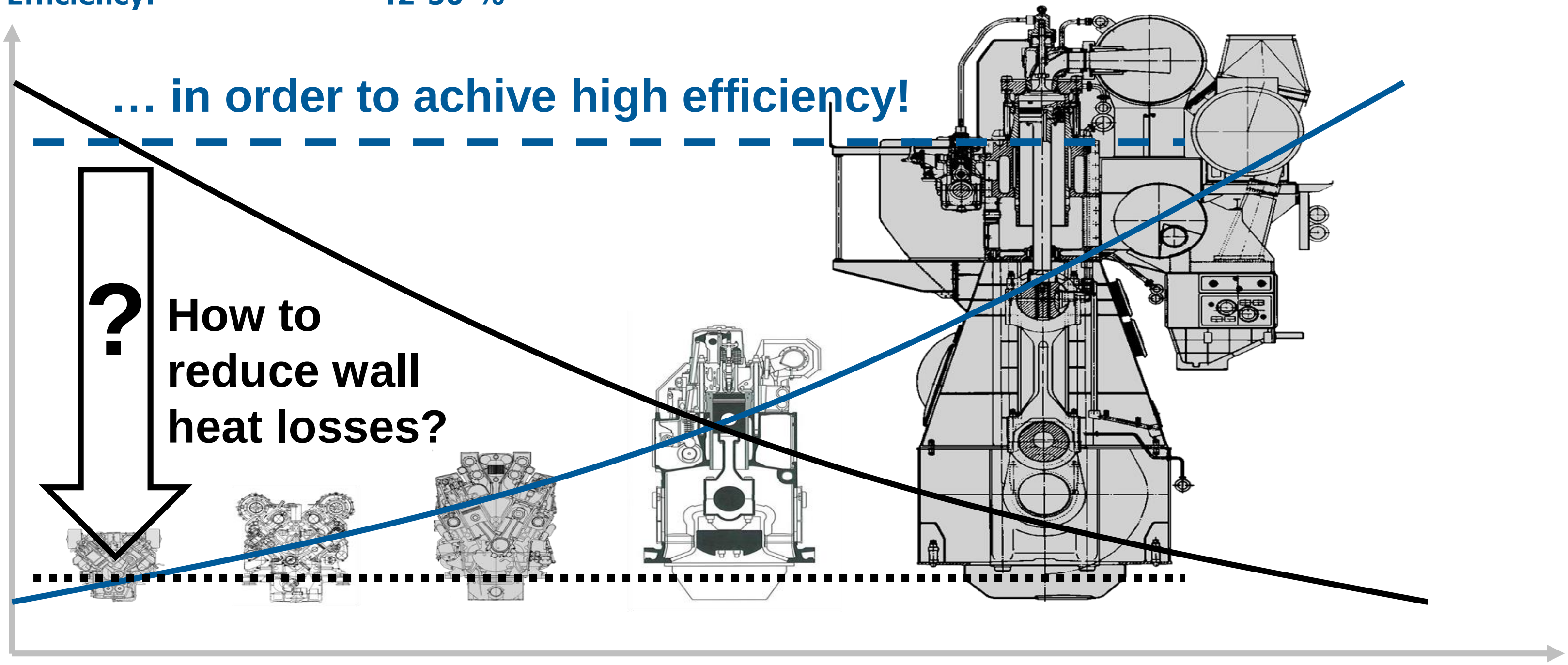
Fuel Consumption: 0,9 l/100 km (combined)
CO_2-Emissions: 21 g/km (combined)

Source: VW - XL1 Hybrid Electric Vehicle (catalogue)

FUTURE POWERTRAIN TECHNOLOGY
CHALLENGE HEAT LOSSES

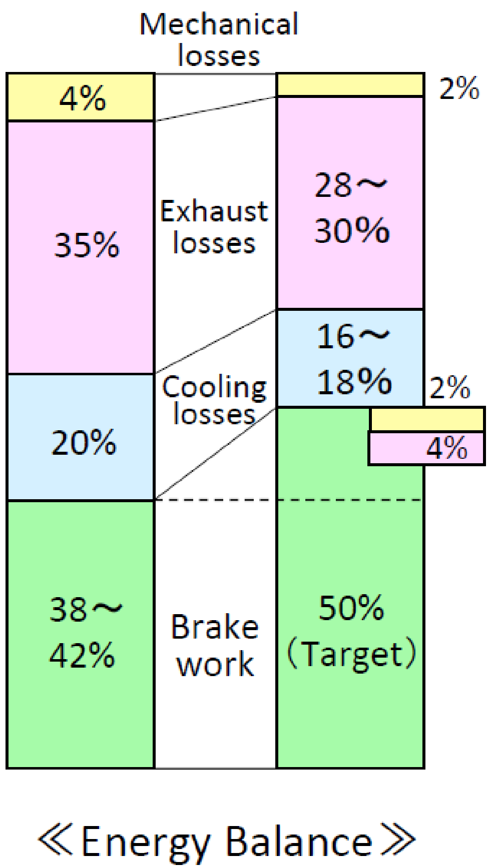
SYSTEM TYPE: INTERNAL COMBUSTION DIESEL ENGINE

Wall Heat Losses: **35-15 %**
Efficiency: **42-50 %**



JAPANESE "AICE" RESEARCH PROGRAMME

Solutions Exemplified to Achieve a 50% Brake Thermal Efficiency in ICEs



- ✓ Reducing mechanical losses by 50%

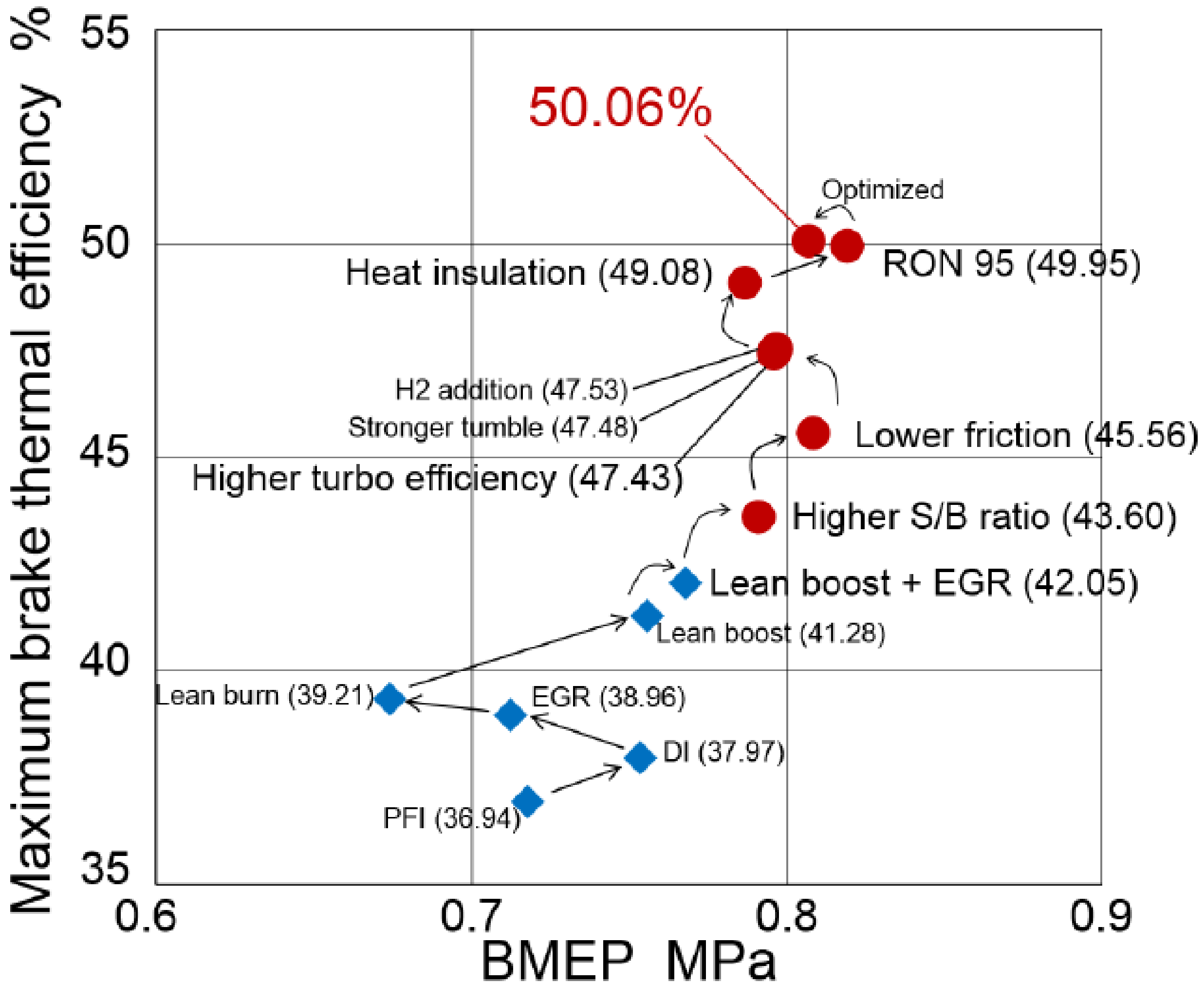
- ✓ Utilizing exhaust gas energy
  - Increasing turbocharging efficiency
    - Exhaust gas turbine efficiency: 80%
    - Air compressor efficiency: 80%
  - Waste heat recovery by fuel reforming
- ✓ Reducing heat losses by improving combustion

- ✓ Enhancing indicated work by improving combustion

★ Brake Thermal Efficiency Baseline:
- Gasoline engines ⇒ 38%
- Diesel engines ⇒ 42%

Source: Prof. Y. Daisho, ERTRAC Workshop, 2015-06-02, Brussels

JAPANESE "AICE" RESEARCH PROGRAMME



A. Kikusato,
J. Kusaka and
Y. Daisho,
Waseda Univ.
2014

THERMODYNAMIC IMPROVEMENT POTENTIALS

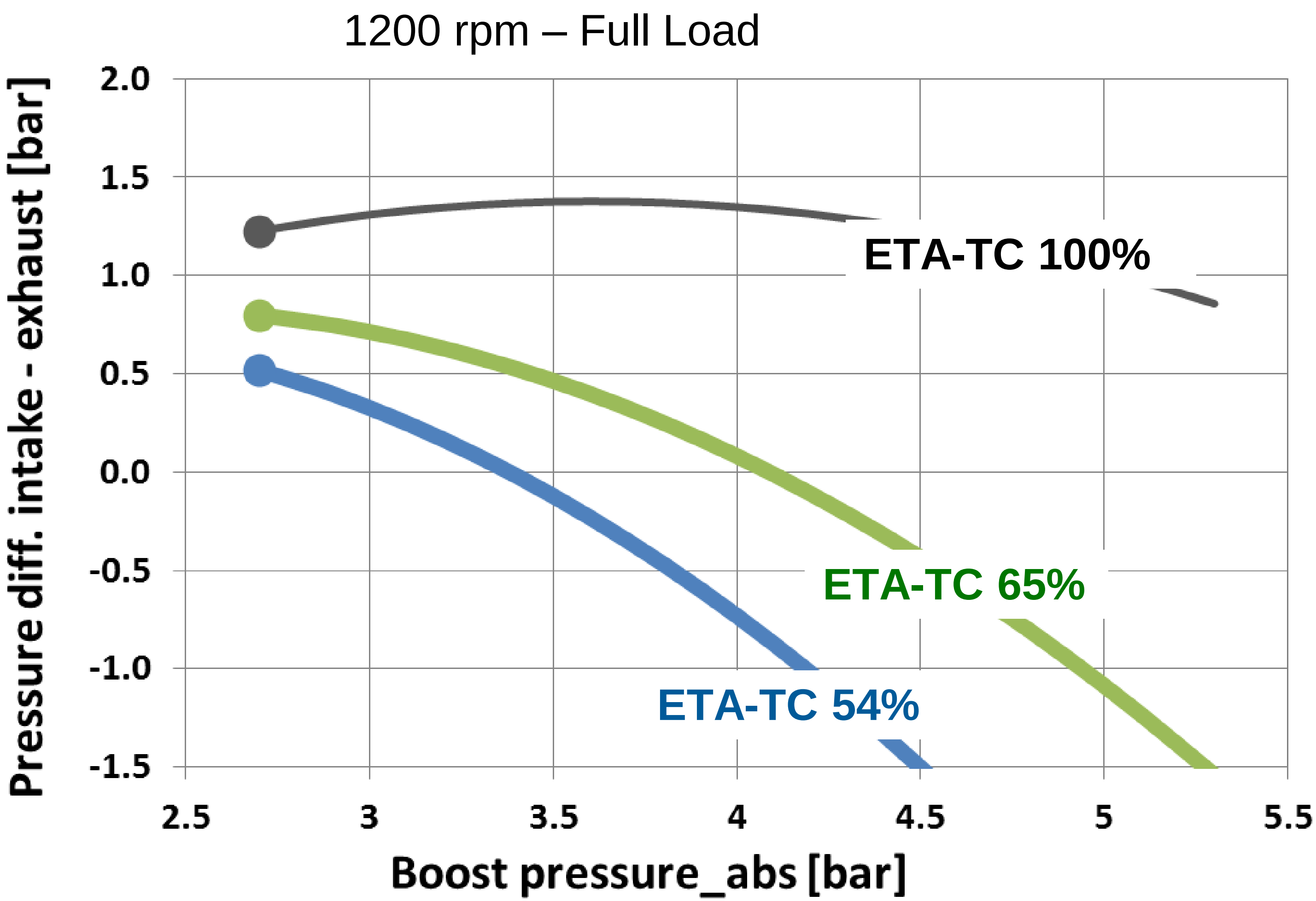
High pressure cycle:

- **Cylinder mass**
  - *w/o EGR → Excess air ratio*
  - *with EGR → Cylinder mass ratio*
- **Valve timing** (Miller, Atkinson)
- **Compression ratio**
- **Combustion process**
  - Center of combustion
  - Shape & duration of combustion
- **Reduction of cylinder wall heat losses**

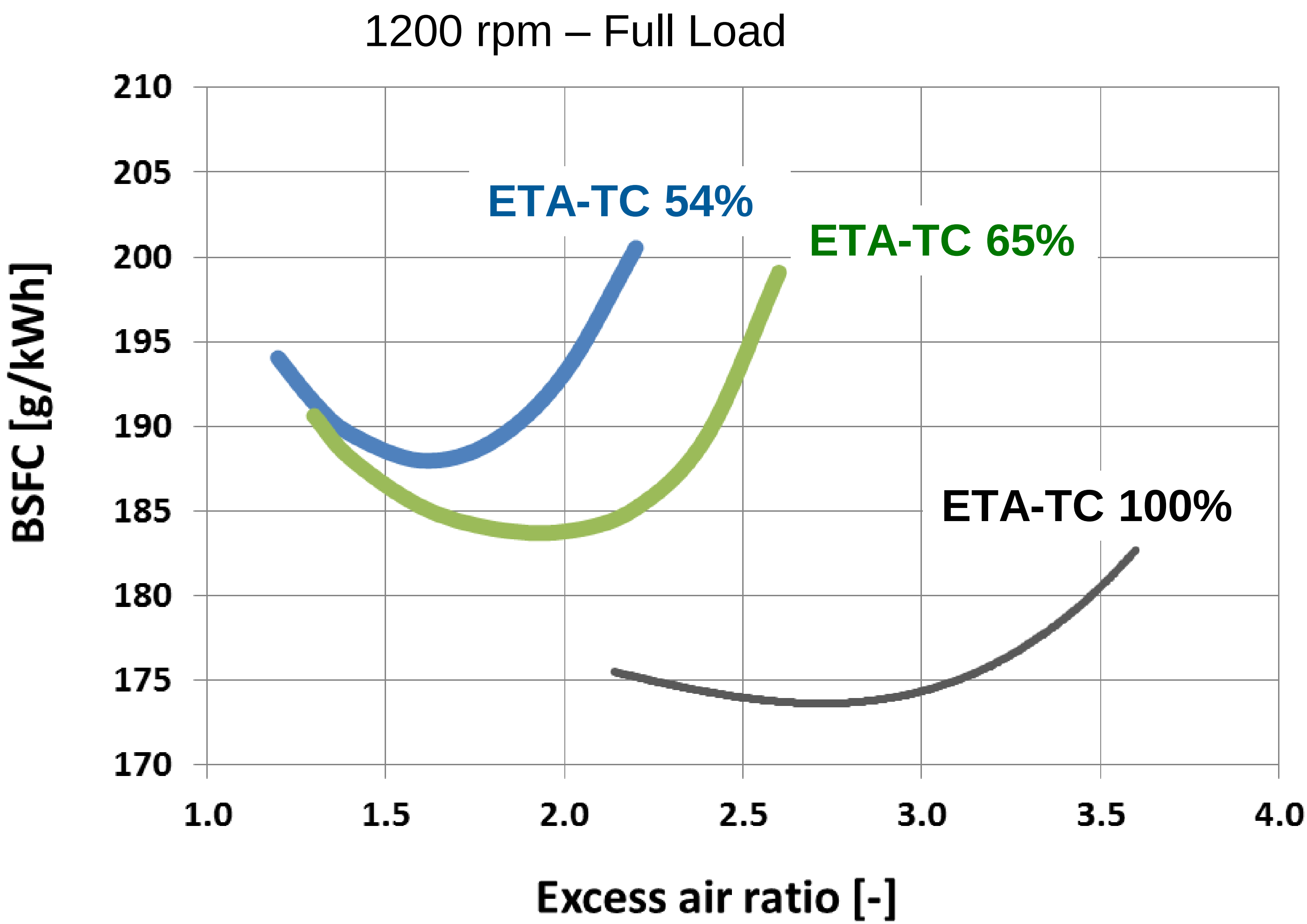
Low pressure cycle:

- **Turbocharging efficiency**
- **Pressure losses**
- **Reduction of exhaust wall heat losses before TC**

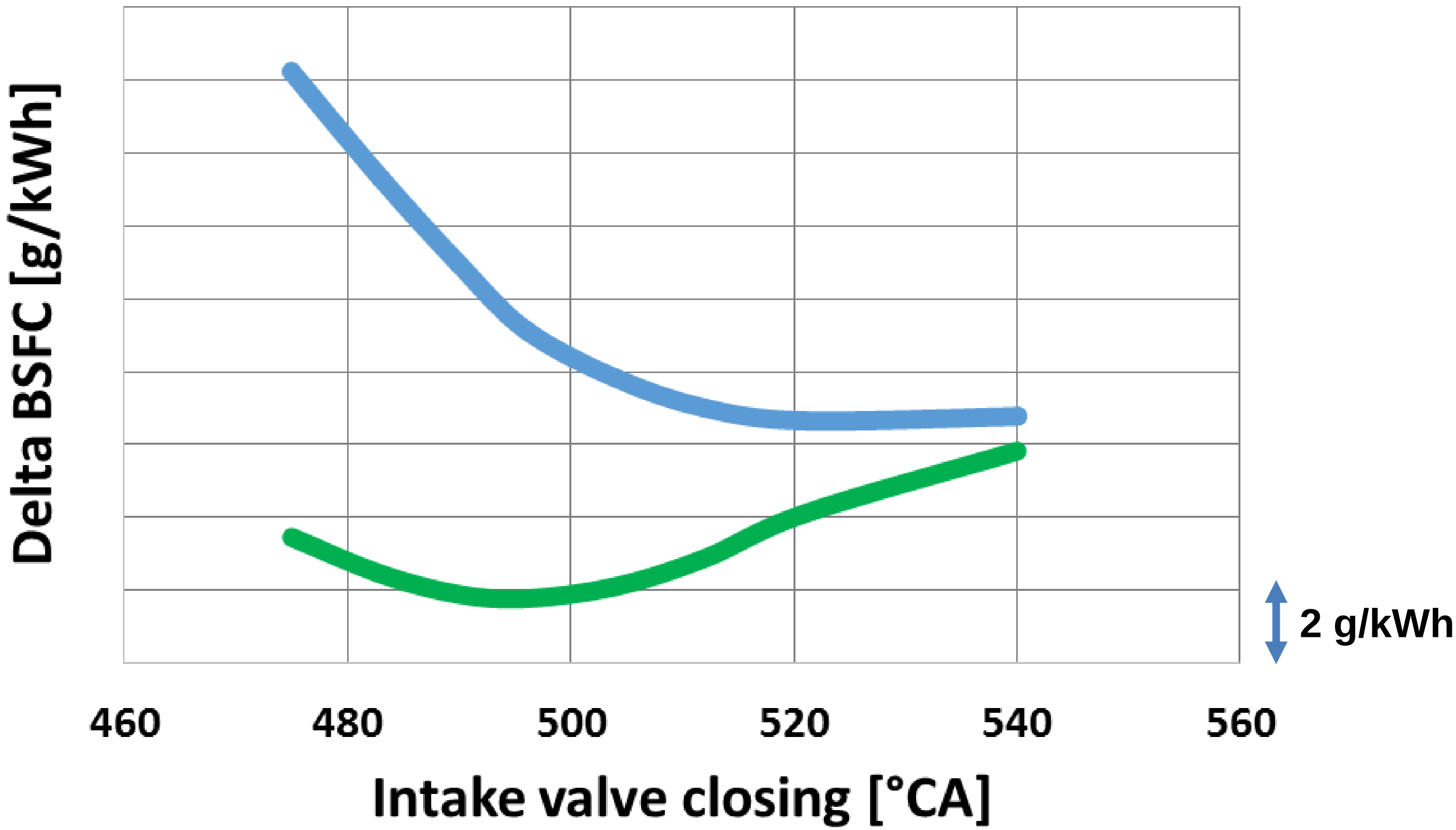
INFLUENCE OF TURBOCHARGER EFFICIENCY ON PUMPING WORK



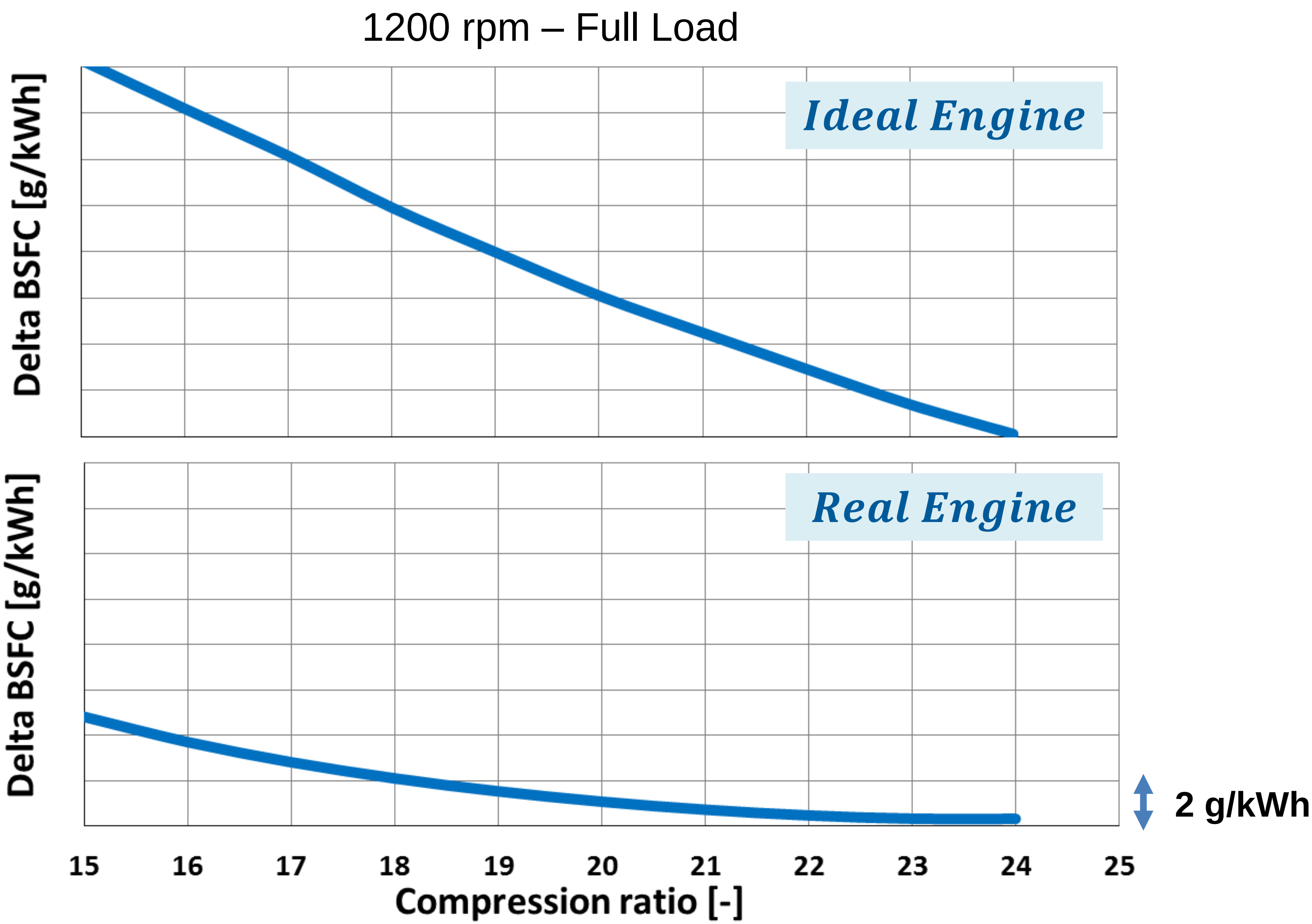
OPTIMUM EFFICIENCY DEPENDING ON EXCESS AIR RATIO



OPTIMAL INTAKE VALVE TIMING DEPENDING ON TURBOCHARGER EFFICIENCY

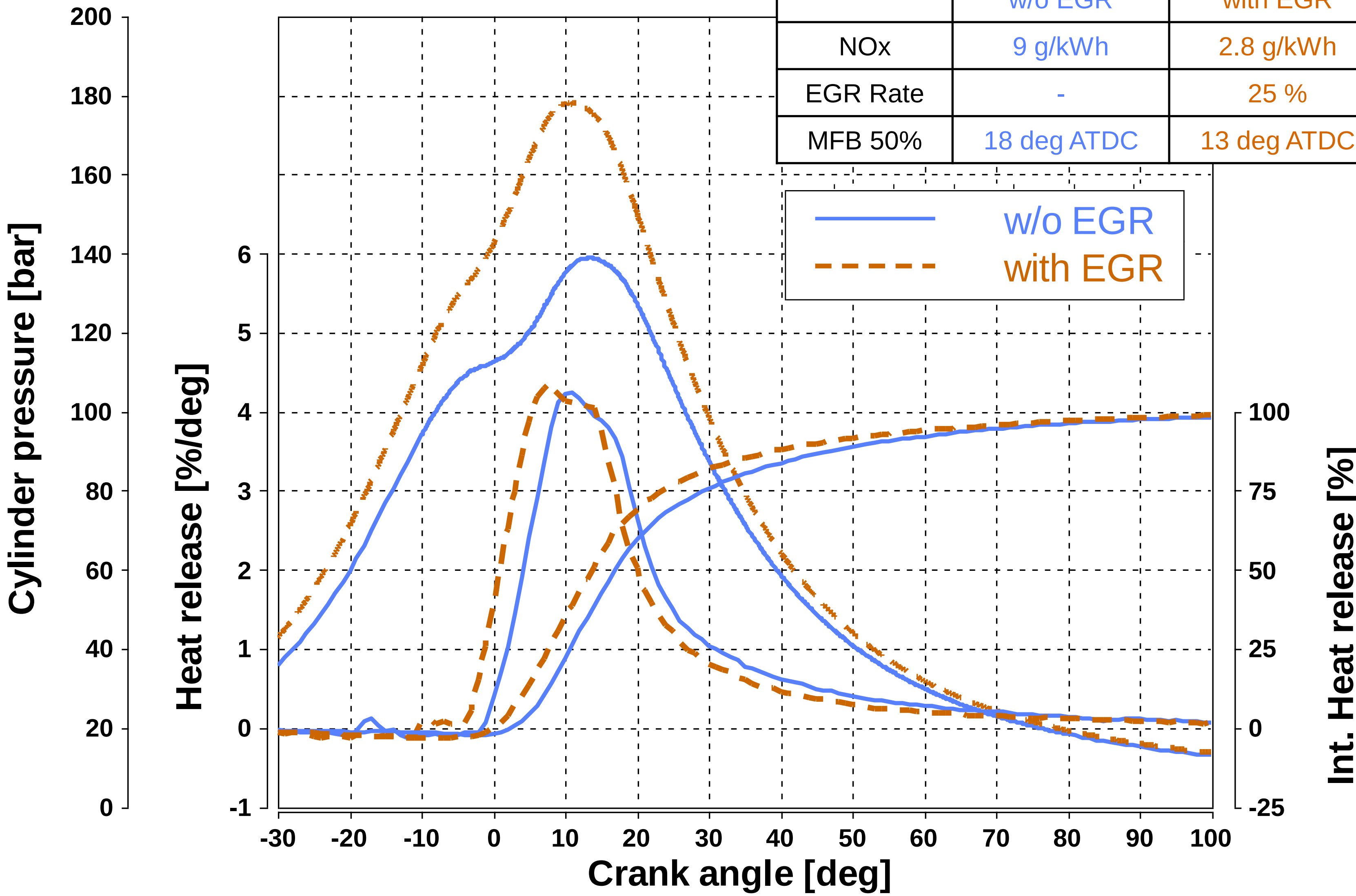


INFLUENCE OF COMPRESSION RATIO ON FUEL CONSUMPTION

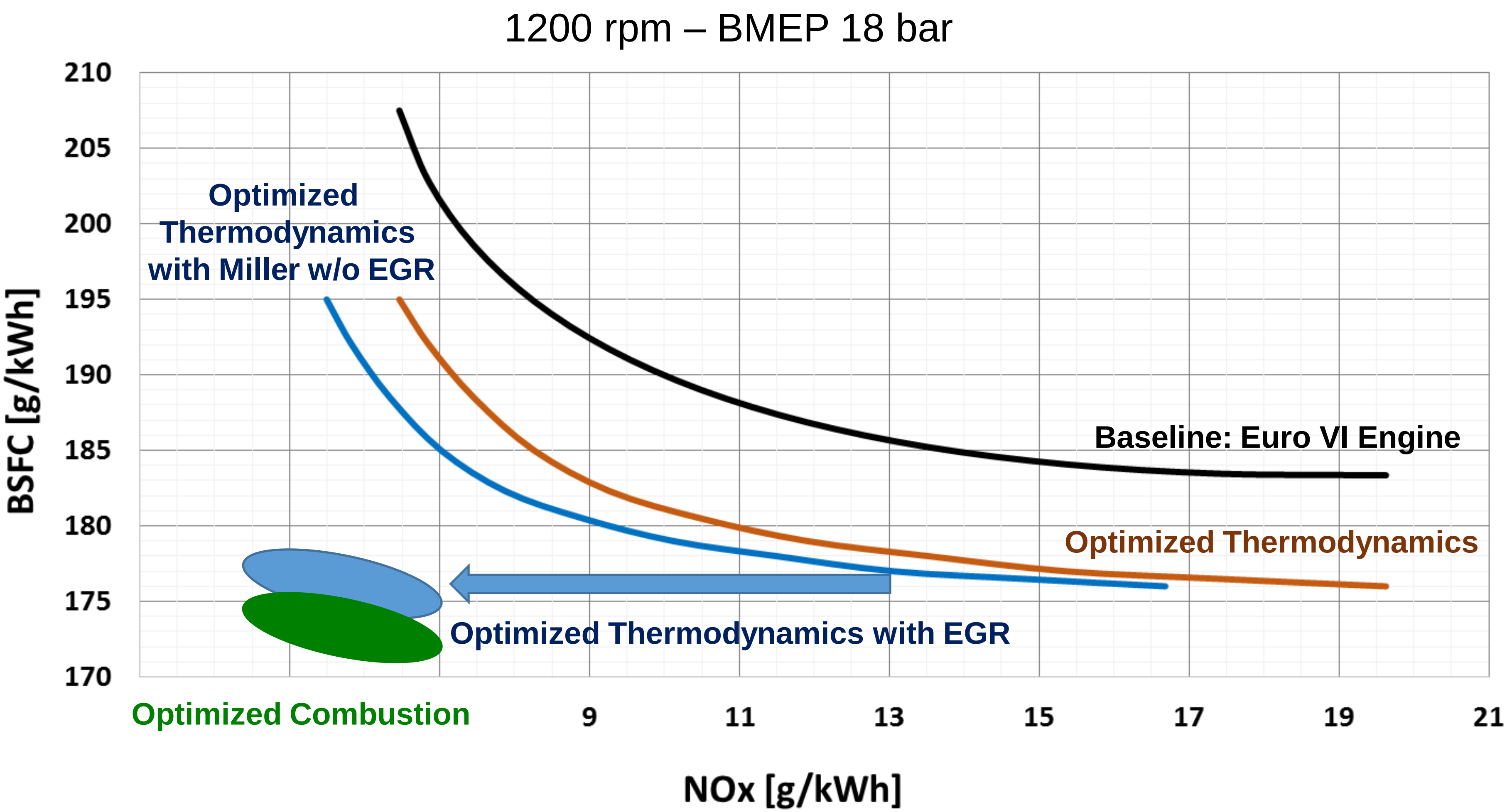


HIGH EFFICIENT COMBUSTION WITH AND W/O EGR (EURO VI)

	w/o EGR	with EGR
NOx	9 g/kWh	2.8 g/kWh
EGR Rate	-	25 %
MFB 50%	18 deg ATDC	13 deg ATDC



OPTIMIZED NO_x / BSFC TRADE-OFF



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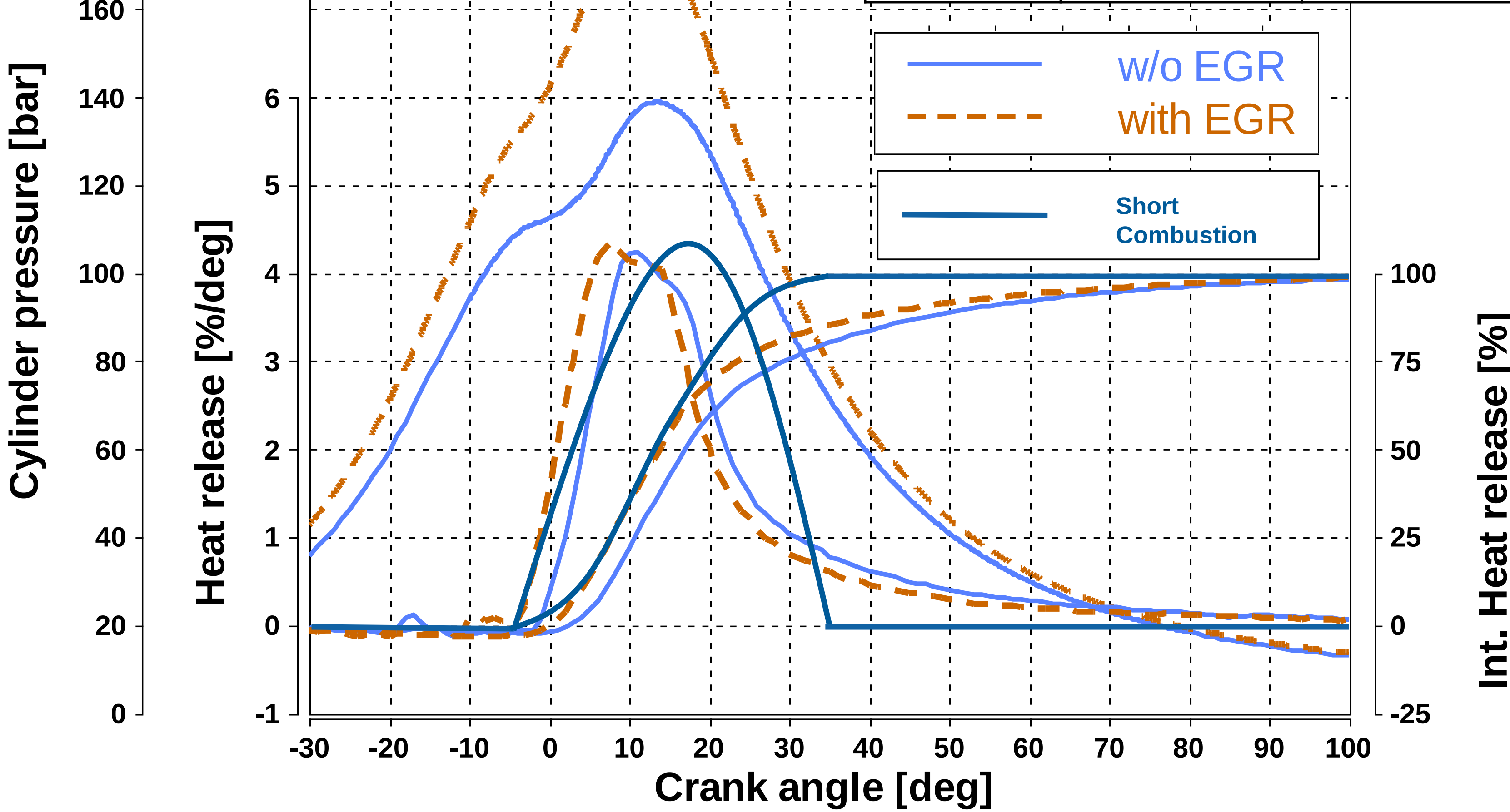
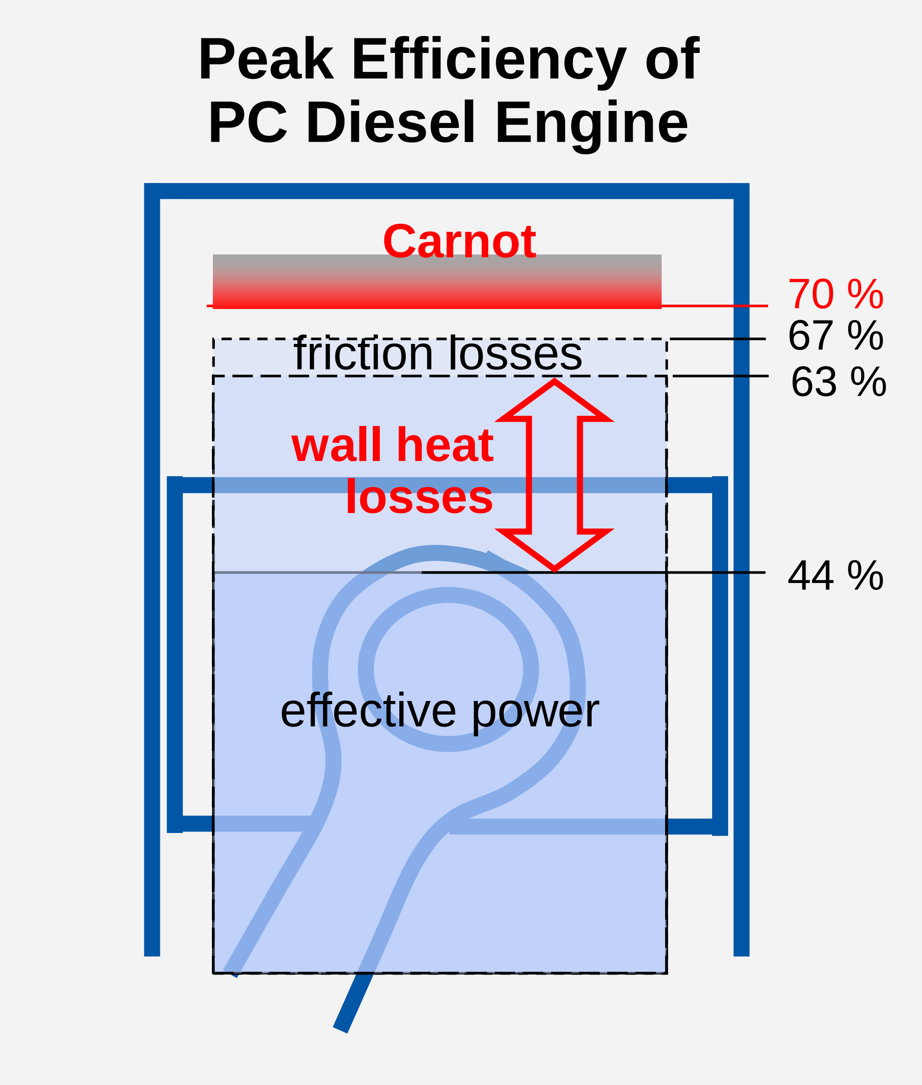


CHALLENGE: REDUCTION WALL HEAT LOSSES



Target:
Reduction of Wall Heat Losses

Technology Hurdles

- Low Heat Capacity & Low Thermal Conductivity of Materials
- Oilfree Contact of Piston and Liner

FUTURE POWERTRAIN TECHNOLOGY
WHAT CAN WE LEARN FROM NATURE?

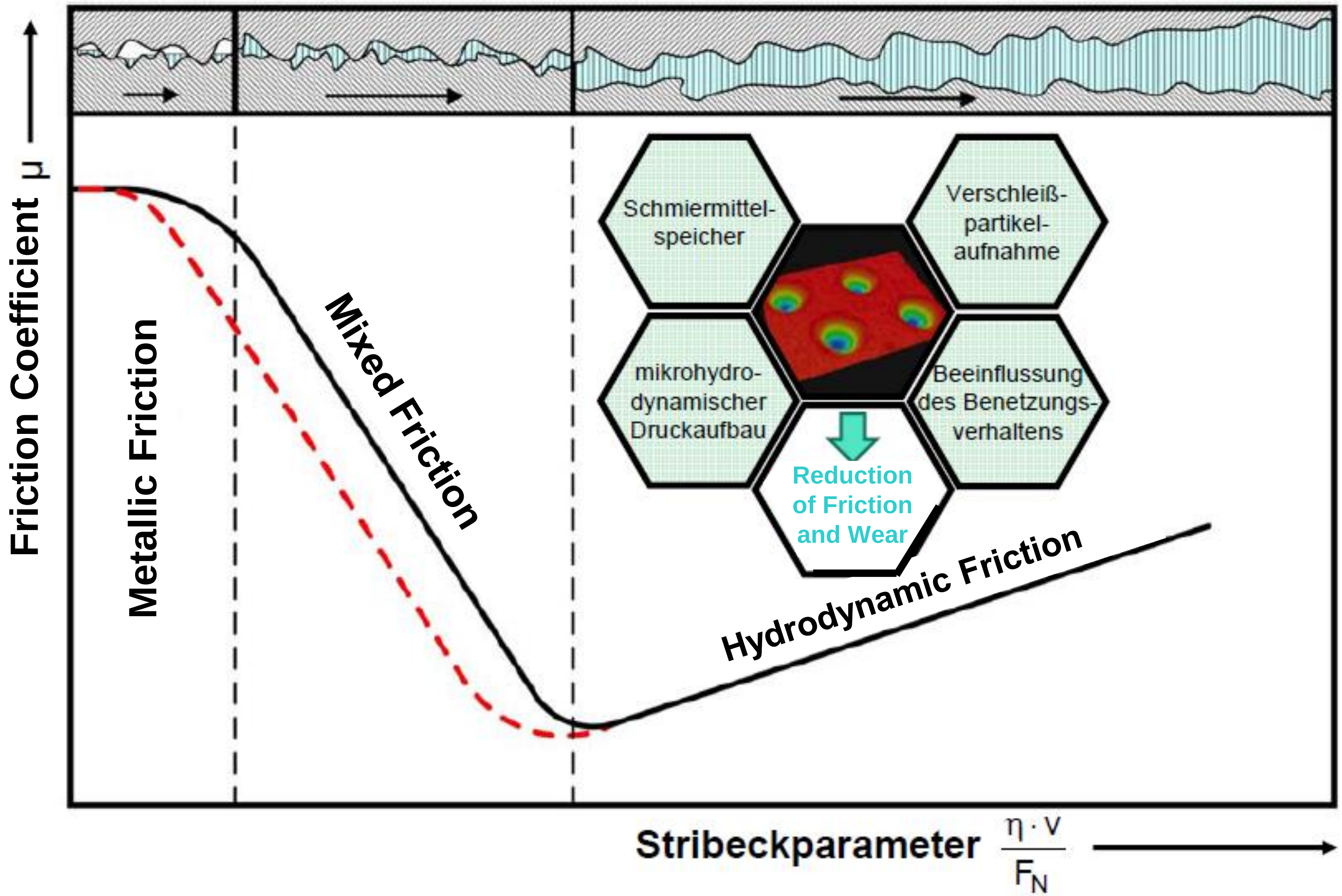
NEW MATERIALS

GENERIC TECHNOLOGIES

Species:	Snow Grouse
Heat losses:	approx. 0 $W/m^2/K$

FRICTION REDUCTION?

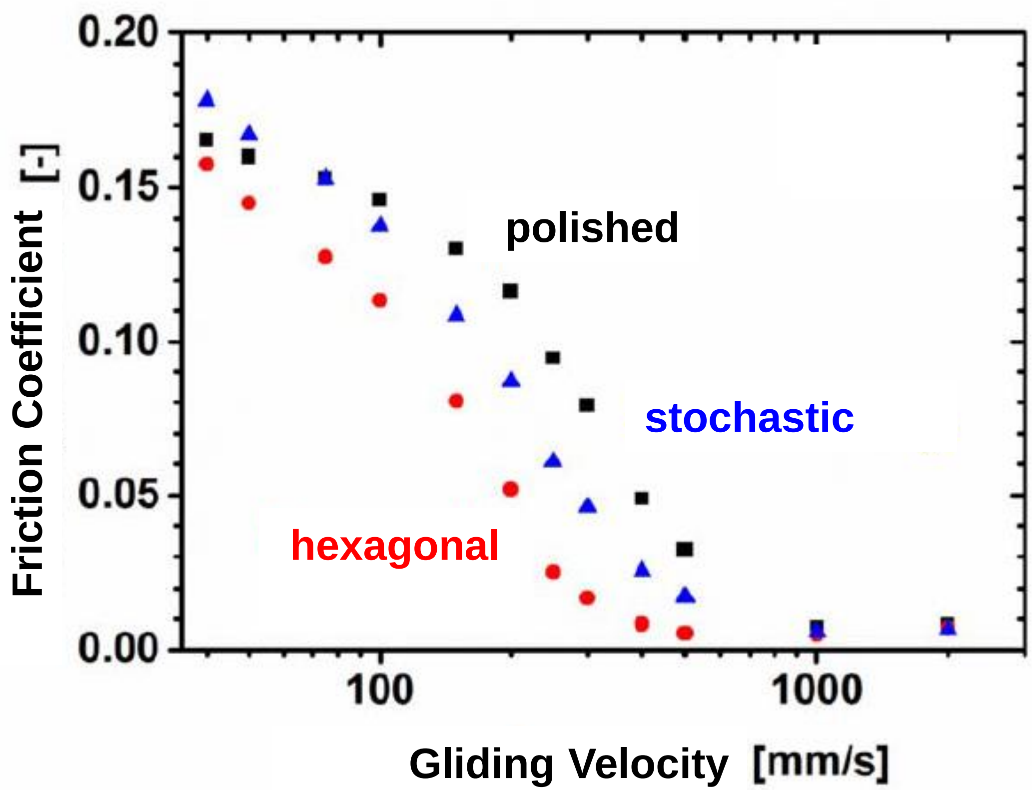
Micro-Structured Tribologic Surfaces for Metallic Contacts with Oil Lubrication

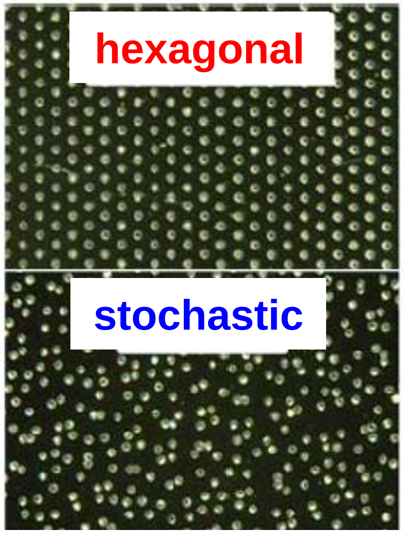


SPECIFIC SURFACE STRUCTURES

Micro-Structured Tribologic Surfaces for Metallic Contacts with Oil Lubrication

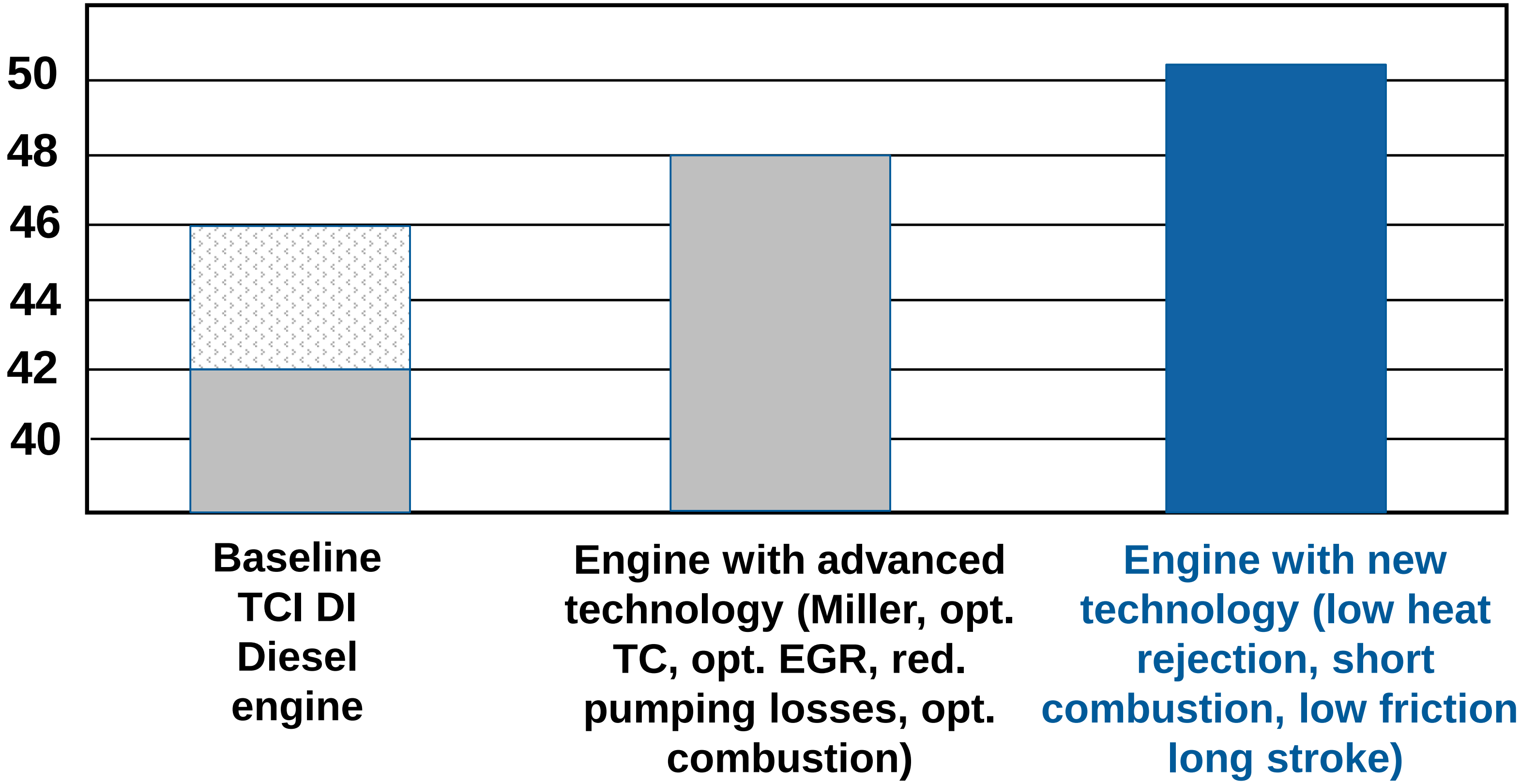
p = 3 MPa; r = 30 mm; PAO; v = 125 ml/h; T = 100° C; v = 0,04-2 m/s



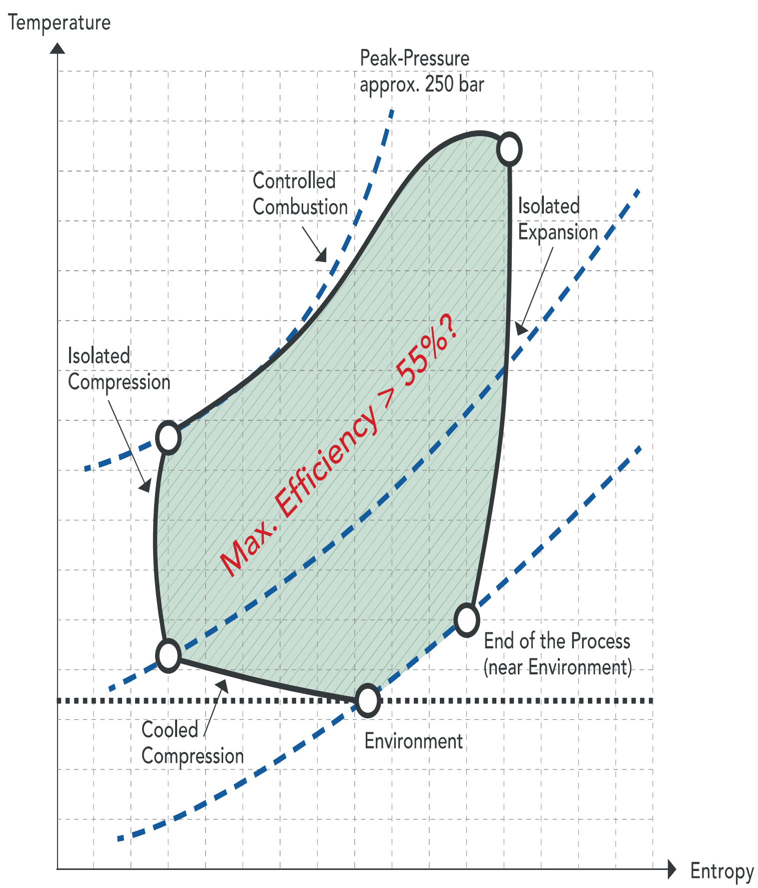


HOW TO ACHIEVE >50% EFFICIENCY?

Peak Thermodynamic Engine Efficiency [%]



TECHNOLOGY & PROCESS TO REACH OUT TO PHYSICAL LIMITS



- **Objectives**
  - Approaching the ideal process in single point operation
  - Usage of sustainable fuels
- **Technology hurdles**
  - New nano-structured materials
  - New thermodynamic process layout

SUMMAY & CONCLUSION

Need for further improved charging systems

Peak firing pressure potential of at least 250 bar prerequisite for highly efficient engine

EGR mandatory for ultra low NOx levels

Waste heat recovery via thermo-chemical processes

High potential in combustion process

New materials/coatings needed for low heat rejection

Dedicated surfaces for low friction systems

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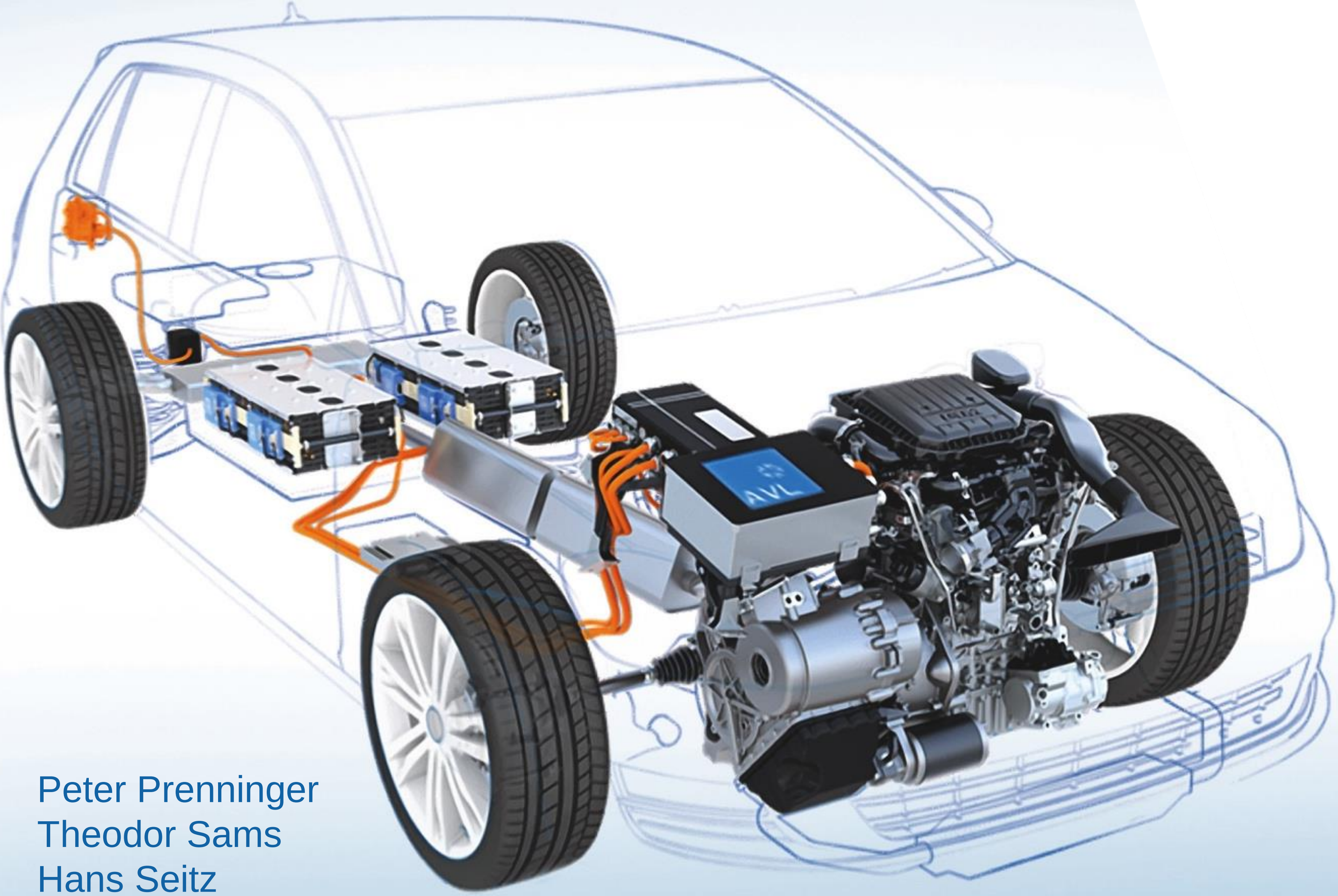

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