Diesel Engine-Efficiency and Emissions Research Conference
20th–24th August 2006

Injection System and Engine Strategies for Advanced Emission Standards

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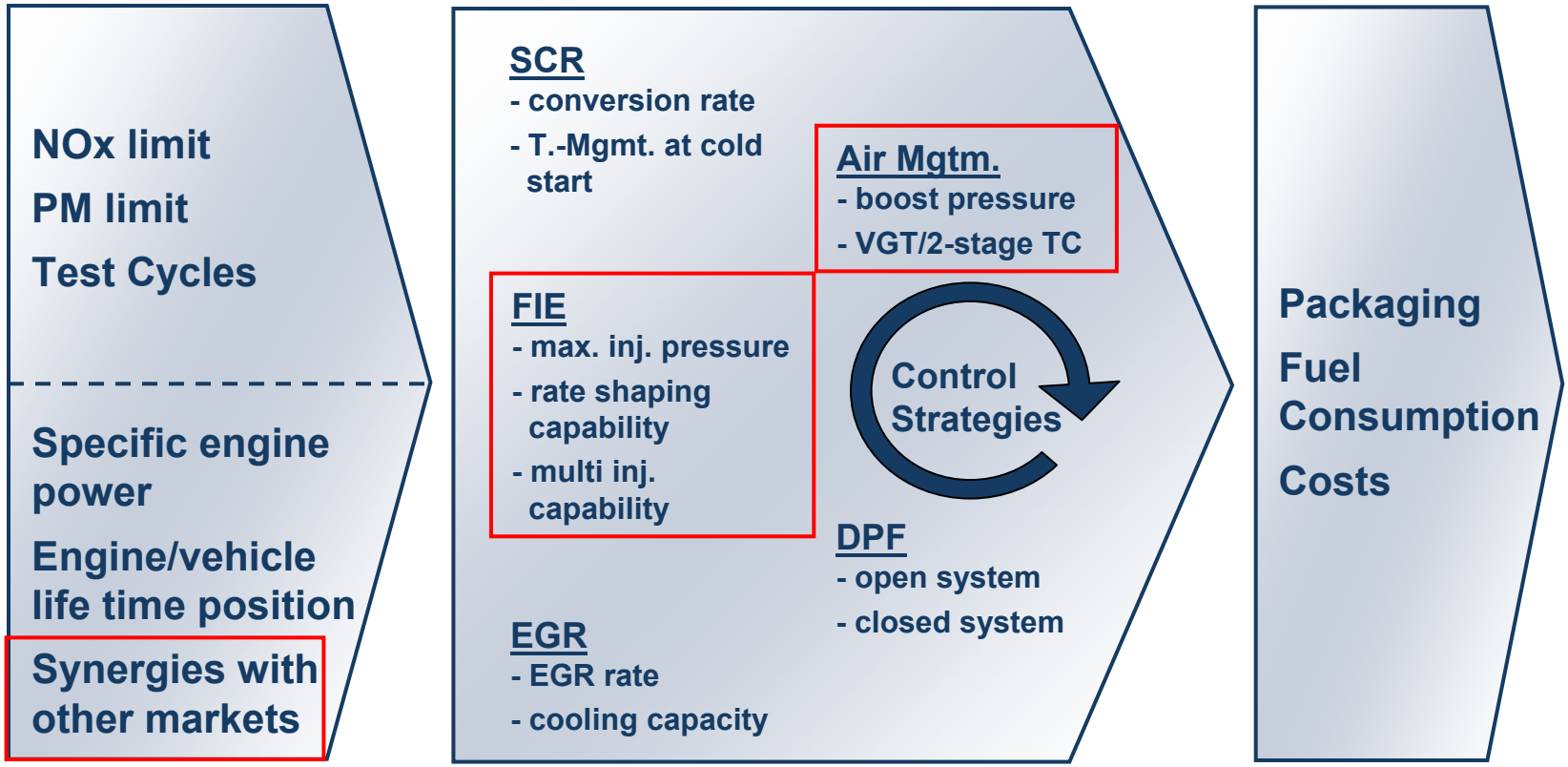
Content

- Emission Legislation
- Strategies for US 2010 Engine Certification
- Consequences for FIE
- Summary

Main Modules for US 2010 Strategies



SCR = Selective Catalytic Reduction
FIE = Fuel Injection Equipment
EGR = Exhaust Gas Recirculation

DPF = Diesel Particulate Filter
VTG = Variable Turbine Geometry
TC = Turbo Charger

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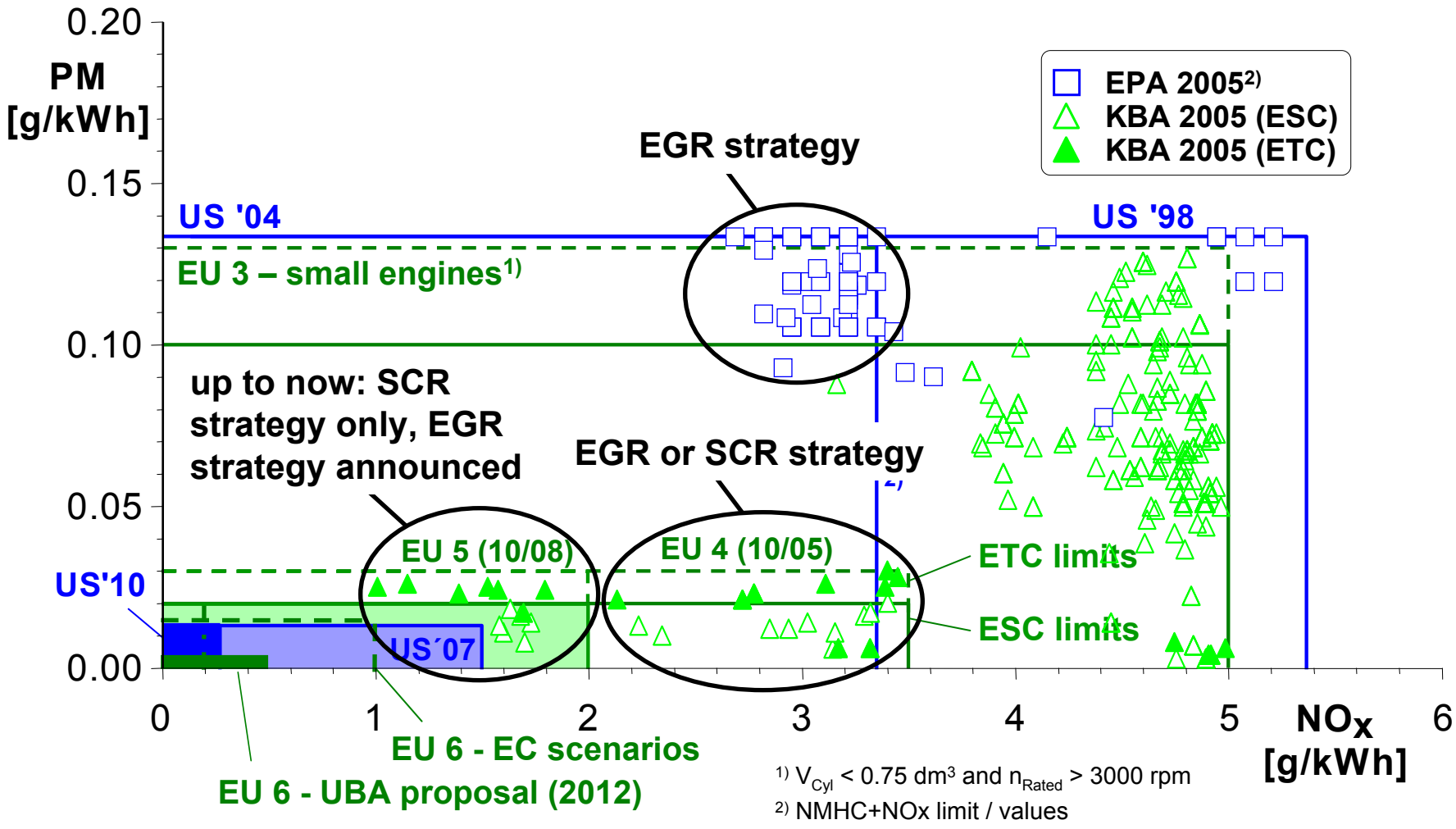
HD Engines - Emission Standards & Cert. data



1) V_{Cyl} < 0.75 dm³ and n_{Rated} > 3000 rpm

2) NMHC+NOx limit / values

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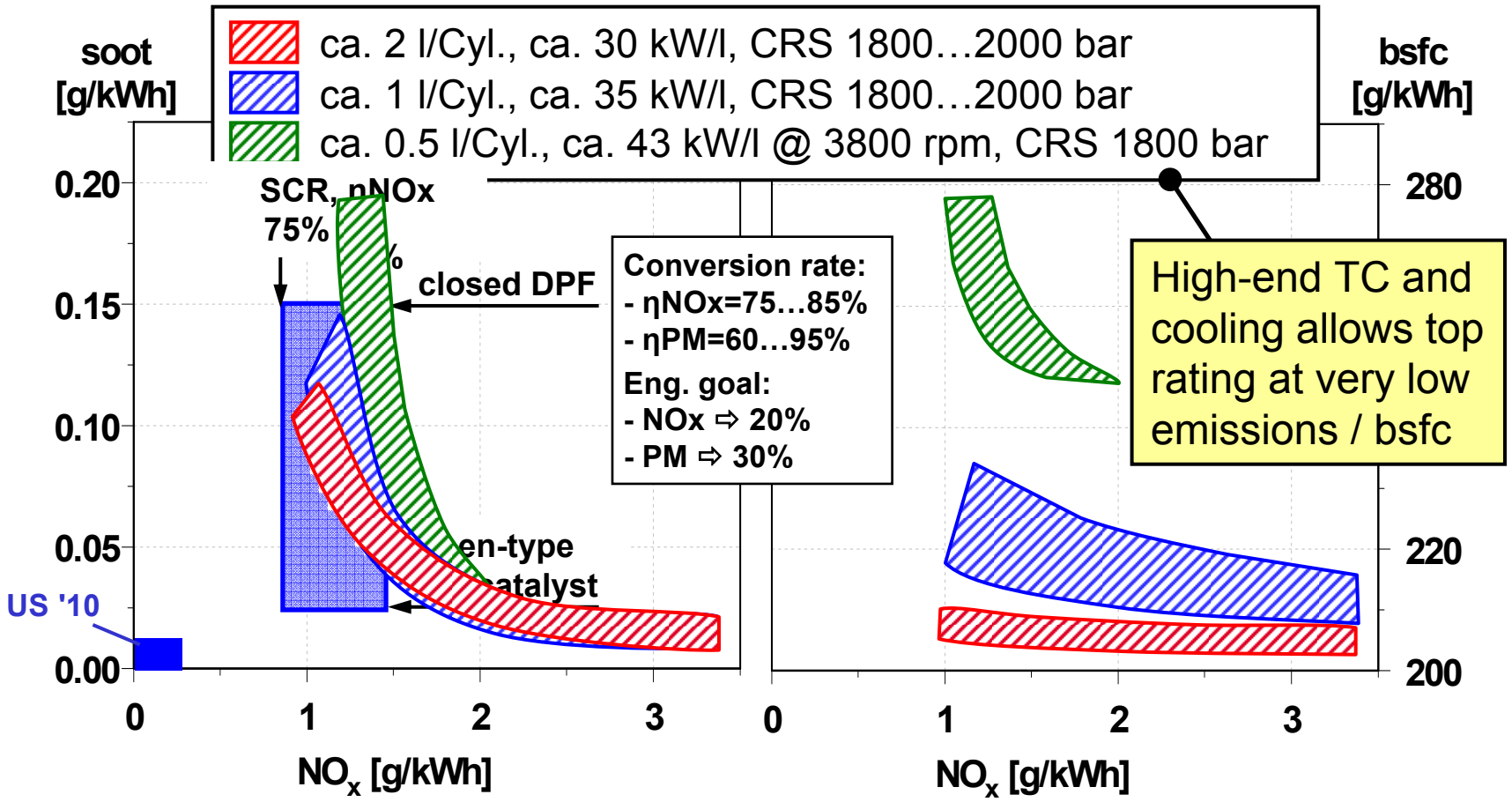
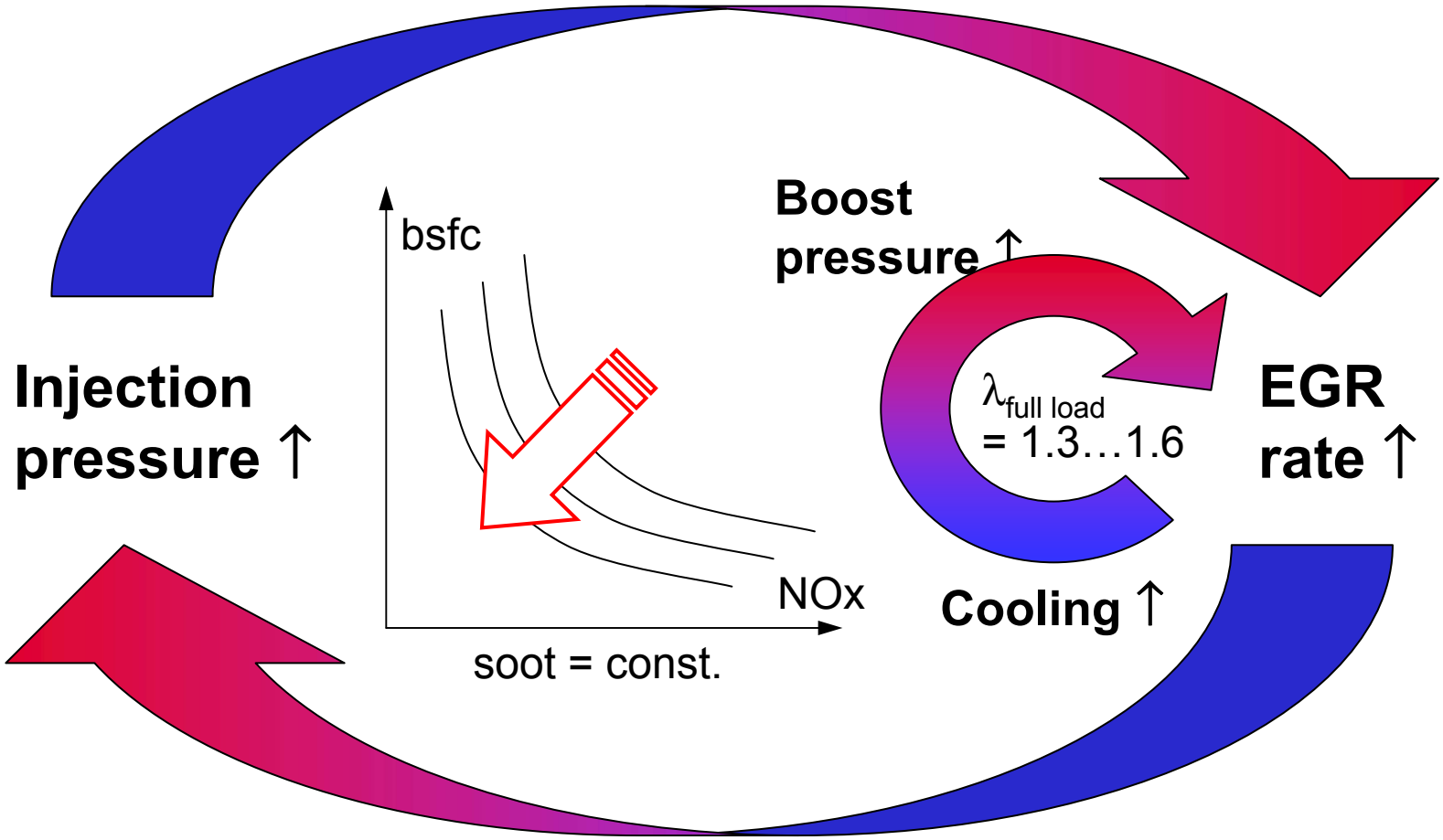
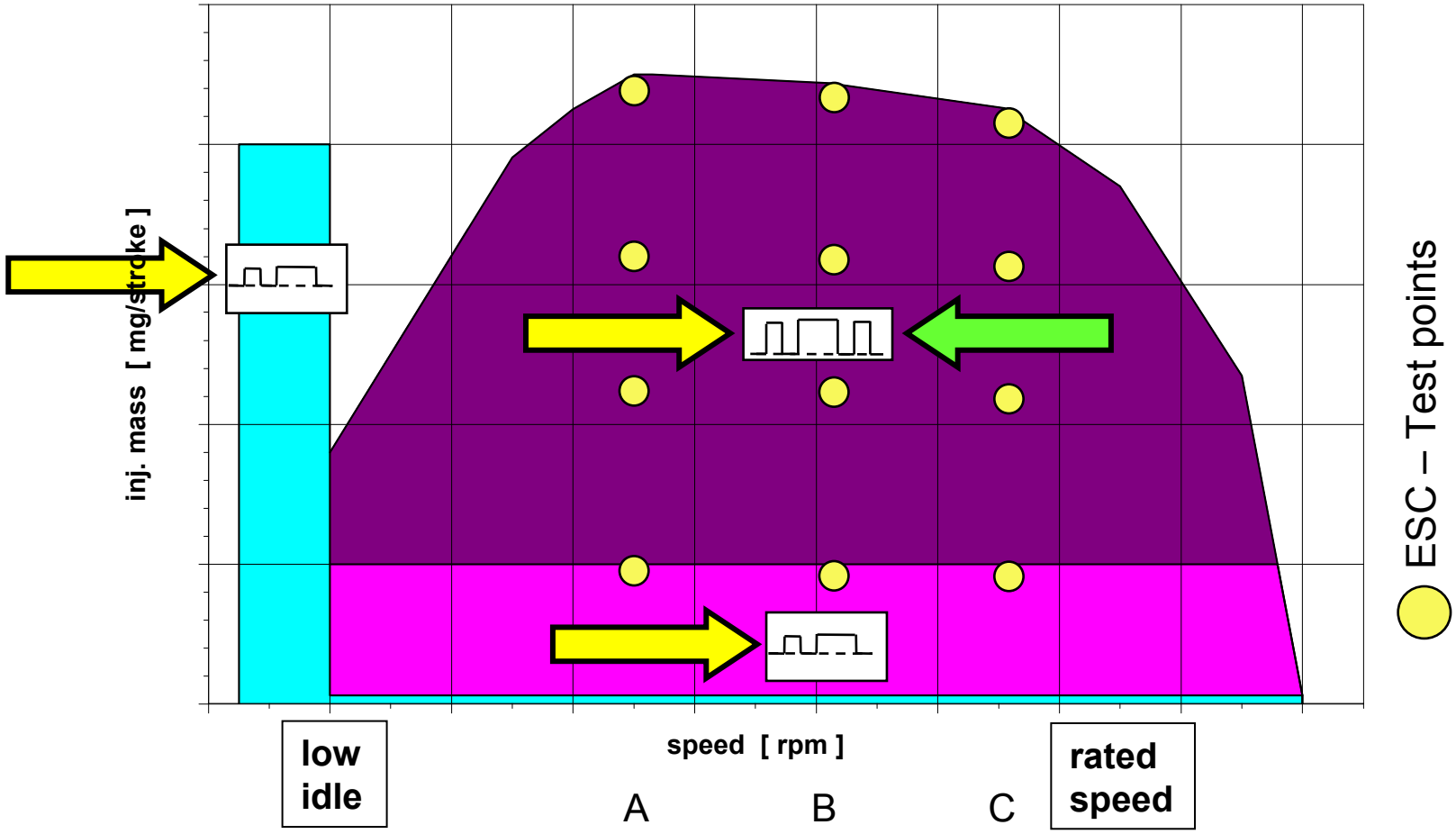
ESC test results



Inj. Pressure demand = f (air system parameters)



Multiple Injection



Summary – US 2010 requirements

Injection System

- Injection pressure CRS ≥ 1800 bar (depending on quality of air system)
- Advanced injection timing for optimum fuel consumption
- Multiple injection
  - coupled post injection for soot reduction
  - pilot injection for NOx reduction at upper loads, for combustion noise reduction at part load

Air system

- cooled high-pressure EGR, EGR rates up to 30% at full load
- Advanced turbocharger (high-end VGT or 2-stage TC with IC)
- High-end charge-air and EGR cooling for best performance / emissions

Exhaust Gas Treatment

- Combination of SCR ($\eta_{NOx} \geq 75\%$) and DPF with active regen. strategy

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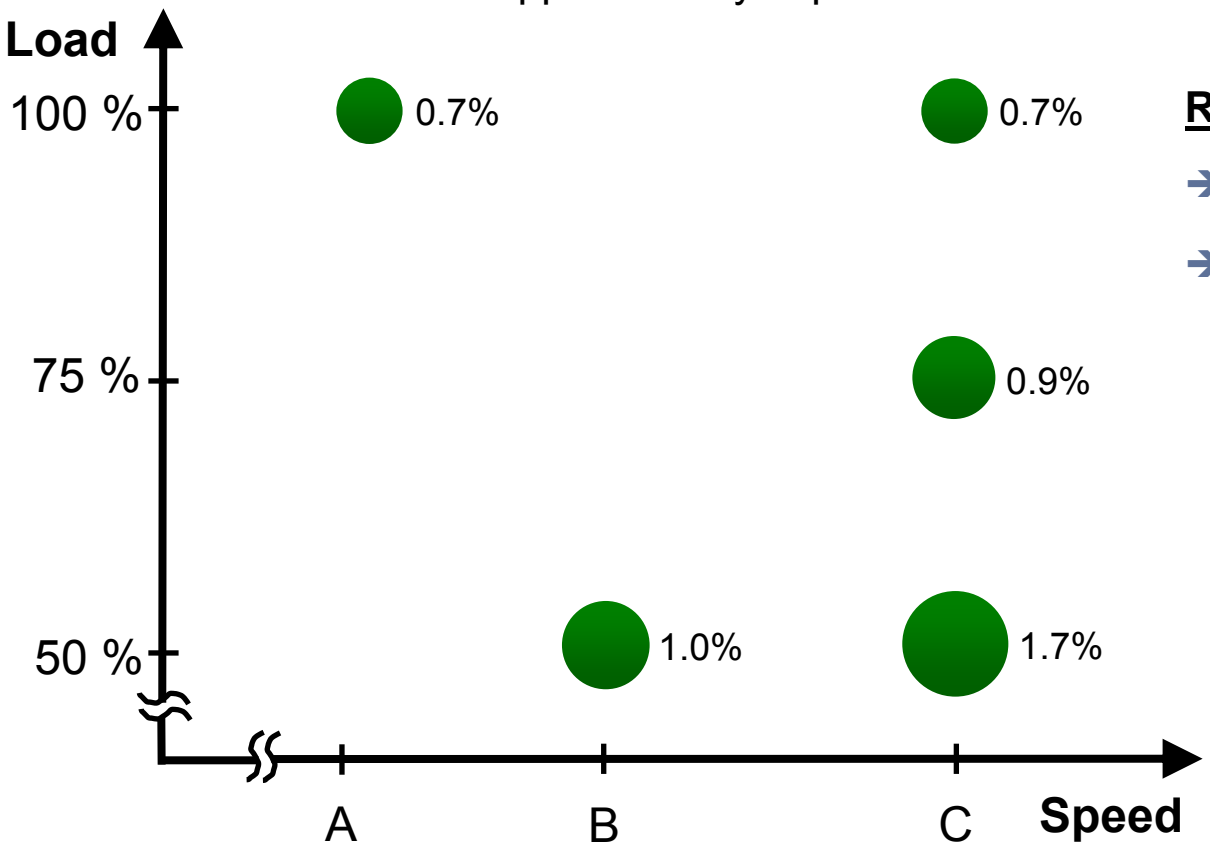
Improvement of spec. fuel consumption of engine

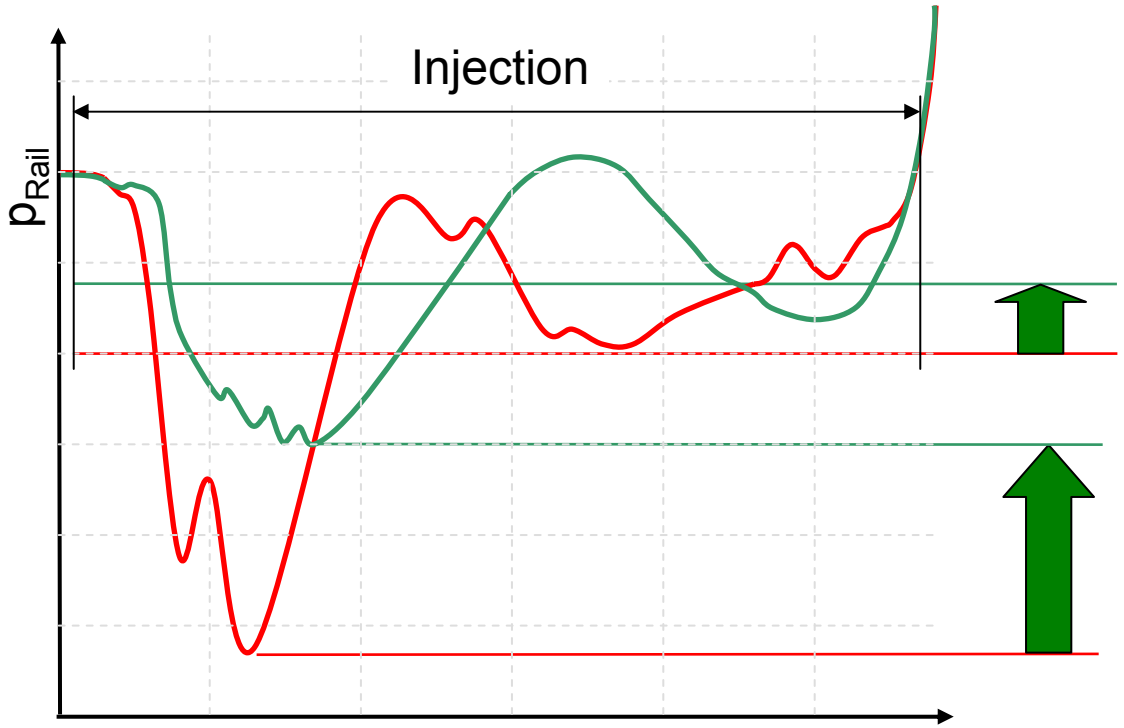
Measured benefit of specific fuel consumption
for a MD application by improved FIE



Reduced driving power by:

- optimized injector
- dethrottled system

Measures to increase injection pressure



with measures
w/o measures

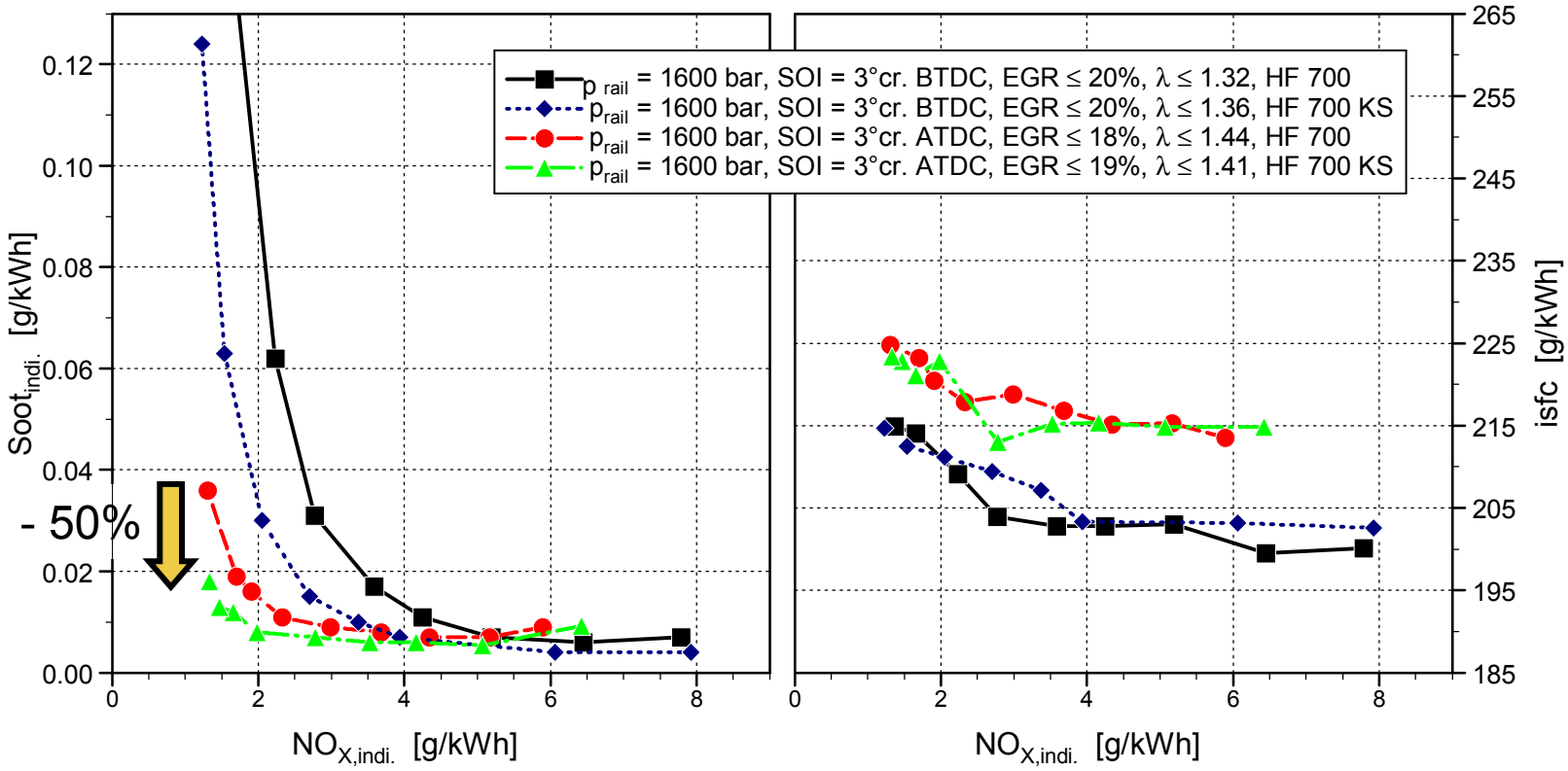
Benefit:

Average injection pressure

Minimum injection pressure

Efficiency of injection nozzle

HD Engine (ca. 2 l/Cyl.) with CRS: C100



ks nozzles with significant soot reduction potential

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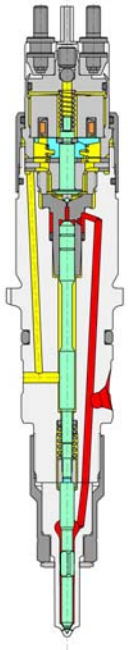
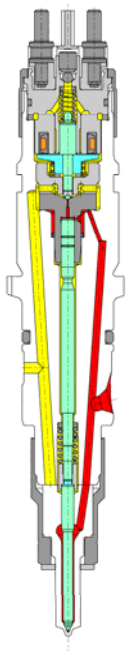
LD/MD/HD Engine Common Rail Injector - Evolution

CRIN1
LD - HD
1400 bar



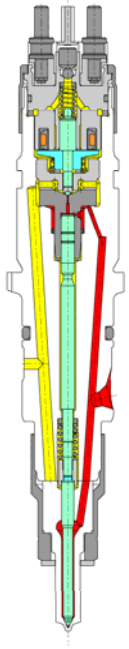
CRIN1.6
LD - MD
1600 bar

CRIN2
LD - HD
1600 bar



EU3/4/5
US04

CRIN3
LD - HD
1800 bar

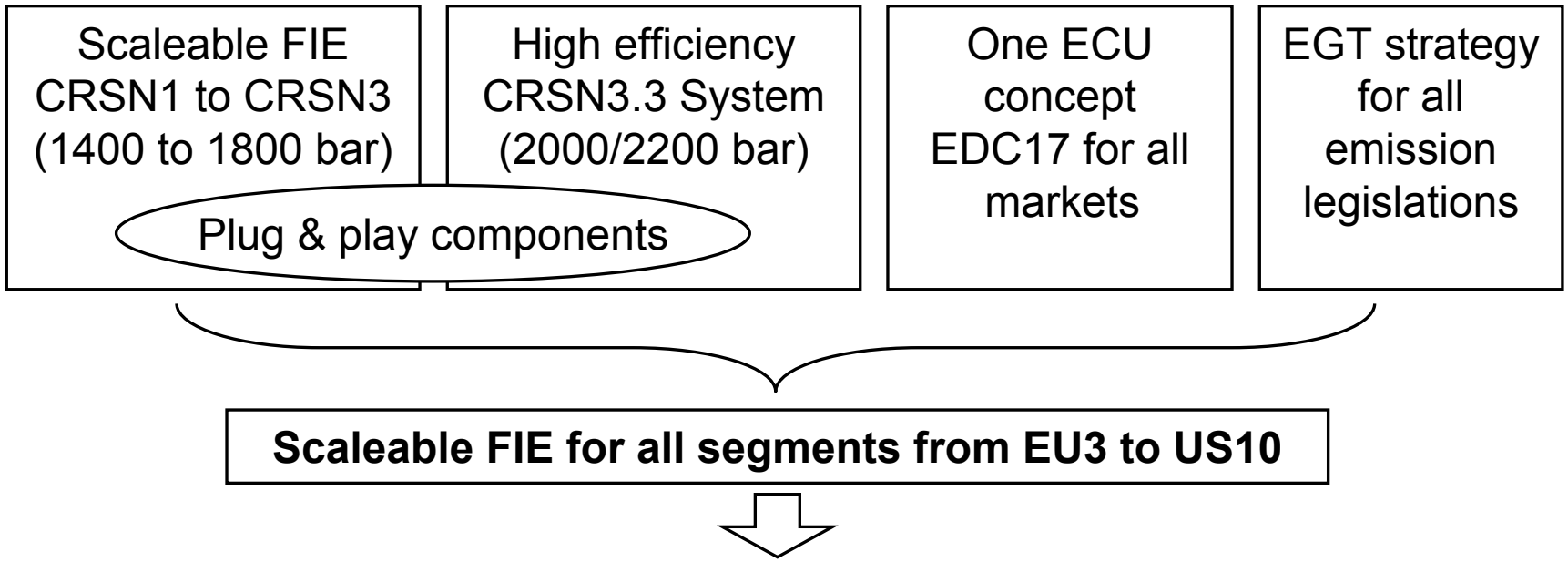


EU4/5
US07

CRIN3.3
LD - HD
2000/2200 bar

“High efficiency”
EU6
US10

Summary – Consequences for FIE



High efficiency as important as injection pressure

- **Pump driving power**
- **Rail to nozzle efficiency**
- **Nozzle bore efficiency**

High efficiency components have potential for >>2200 bar

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Summary & Outlook

- Engine test results @ Bosch show US 2010 engine-out emissions with CRS 1800…2000 bar for an engine range of 0,5 l/cyl. to 2 l/cyl.
- Best engine performance – in terms of soot/NO_X emissions and fuel consumption – is achievable in combination with high-end turbocharger and high-end charge-air resp. EGR cooling.
- Additional fuel consumption benefit can be achieved by improved FIE efficiency (system, injector, nozzle) and increased injection pressure.
- Scaleable injection system with ECU supporting all EGT strategies supports world engines with applications from EURO3 to US10.
- In 2010 Bosch is offering CRS 1400 bar to 2200 bar high efficiency. FIE pre-development focuses on CRS injection pressures >>2200 bar based on high efficiency 2200 bar CRS.

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Thank you for your attention

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