

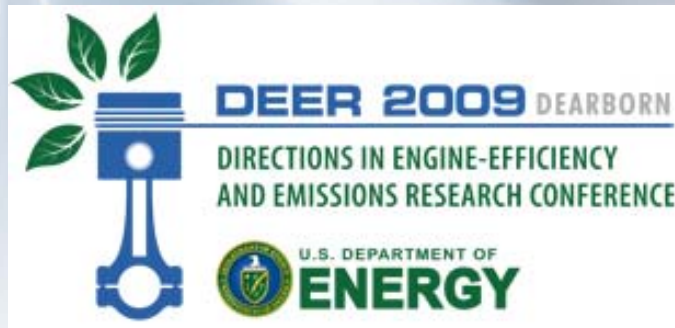


Diesel Combustion Control with Closed-Loop Control of the Injection Strategy

Marek Tatur, Dean Tomazic, FEV Inc.

Matthias Lamping, Thomas Koerfer, FEV Motorentchnik

Thorsten Schnorbus, Jan Hinkelbein, Stefan Pischinger, RWTH Aachen



Presentation Contents

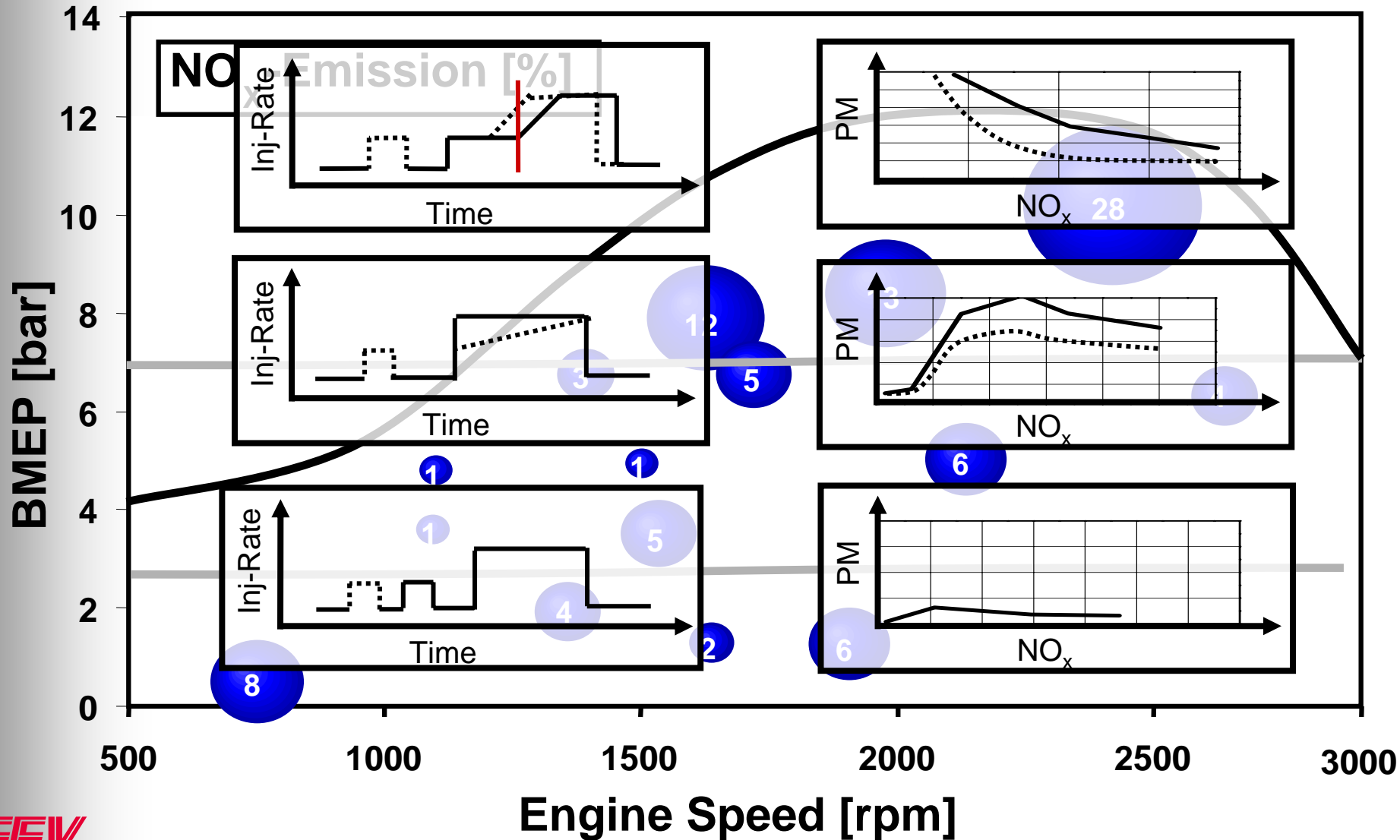
- Motivation
- System Specifications
 - Layout of Closed-Loop Combustion Control
 - Benefits of Closed-Loop Combustion Control
- Real Time Combustion Control
- Test Results
- Summary

Presentation Contents

- Motivation
- System Specifications
 - Layout of Closed-Loop Combustion Control
 - Benefits of Closed-Loop Combustion Control
- Real Time Combustion Control
- Test Results
- Summary

Diesel Combustion with Closed-Loop Control

Rate Shaping – Definition of Injection Characteristics



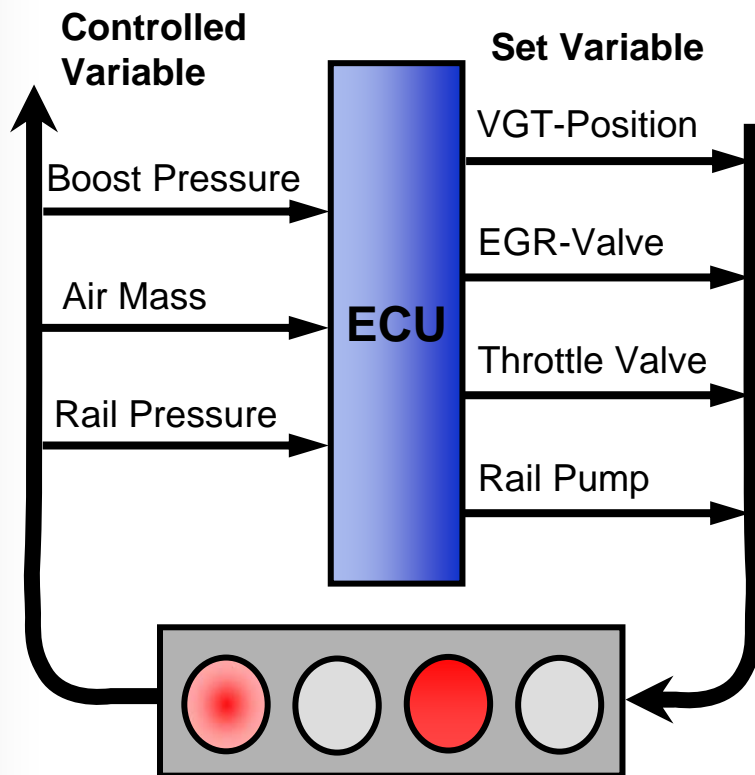
Presentation Contents

- Motivation
- System Specifications
 - Layout of Closed-Loop Combustion Control
 - Benefits of Closed-Loop Combustion Control
- Real Time Combustion Control
- Test Results
- Summary

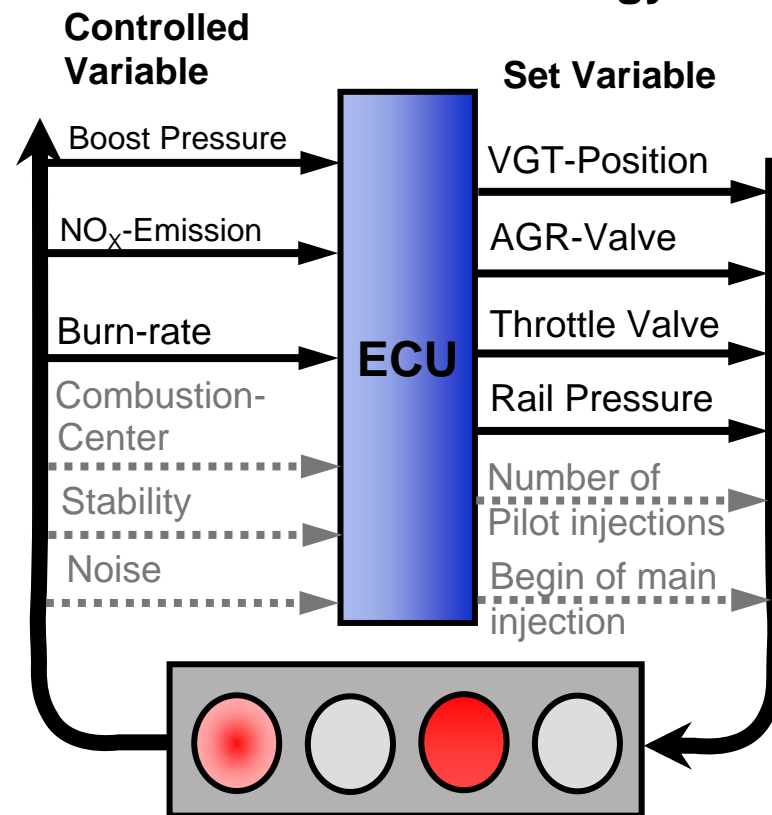
Diesel Combustion with Closed-Loop Control

Diesel Engine Control Strategies

Diesel Control Strategies Today

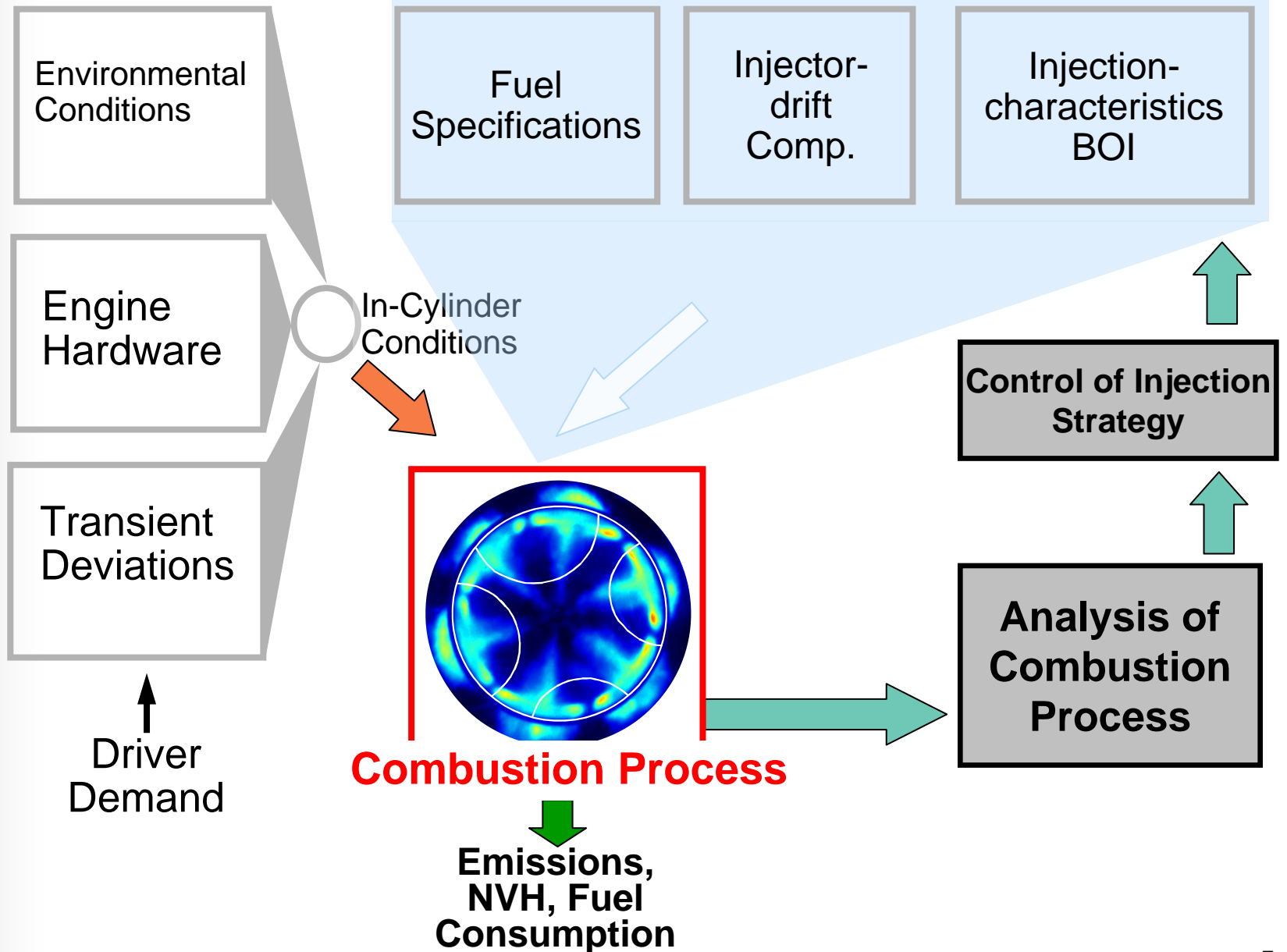


Future Control Strategy



Diesel Combustion with Closed-Loop Control

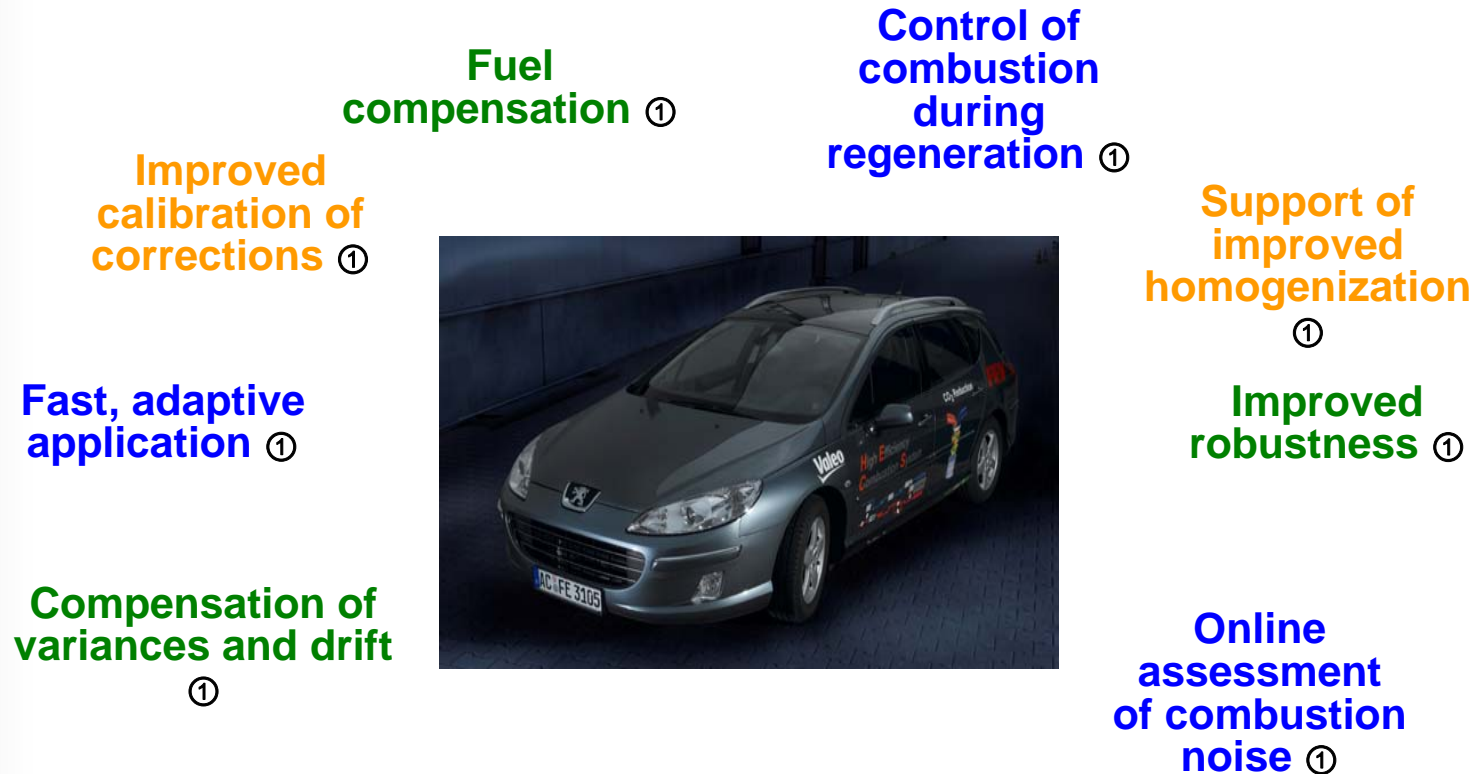
Diesel Engine Control Strategies



Diesel Combustion with Closed-Loop Control

Diesel Engine Control Strategies

Expectations for Closed-Loop Combustion Control



- ① Patent pending
- ② FEV Patent

Rate-Shaping
Realtime ② / Cycle to Cycle ①

transient load control ①

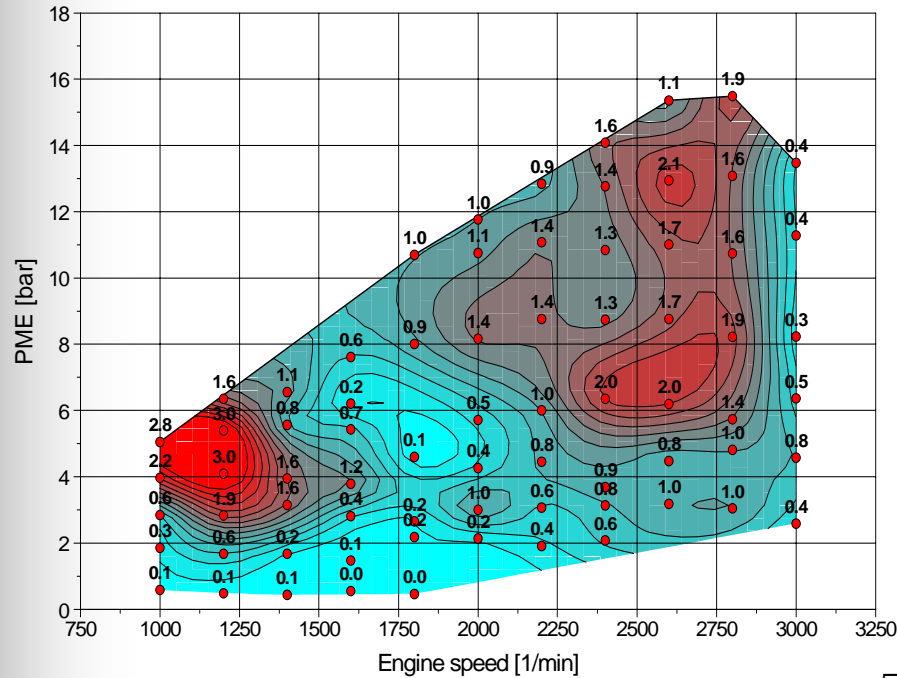
**short term
mid term
long term**

Presentation Contents

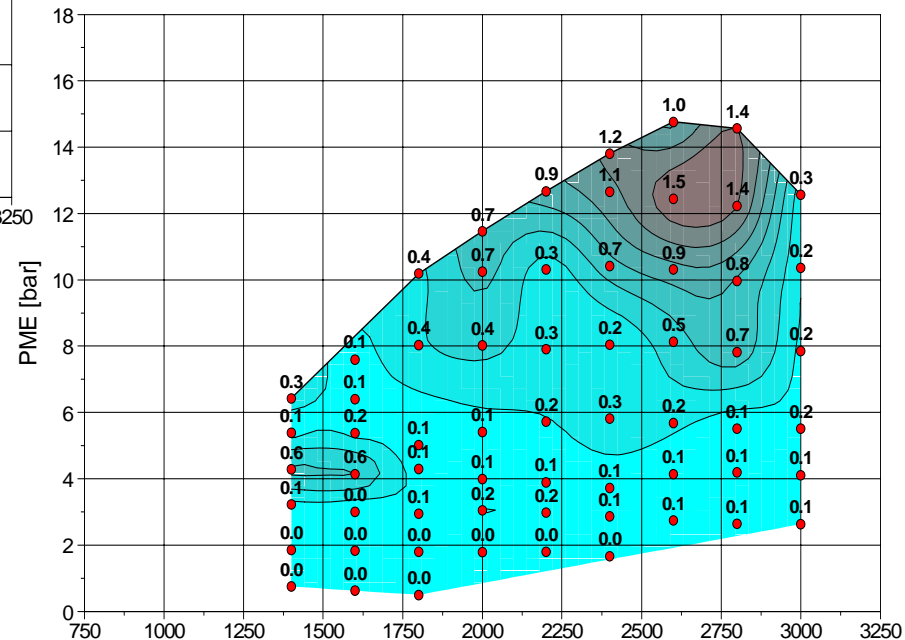
- Motivation
- System Specifications
 - Layout of Closed-Loop Combustion Control
 - Benefits of Closed-Loop Combustion Control
- Real Time Combustion Control
- Test Results
- Summary

Diesel Combustion with Closed-Loop Control Particulate Matter Benefits

Smoke Number with Pilot Injection



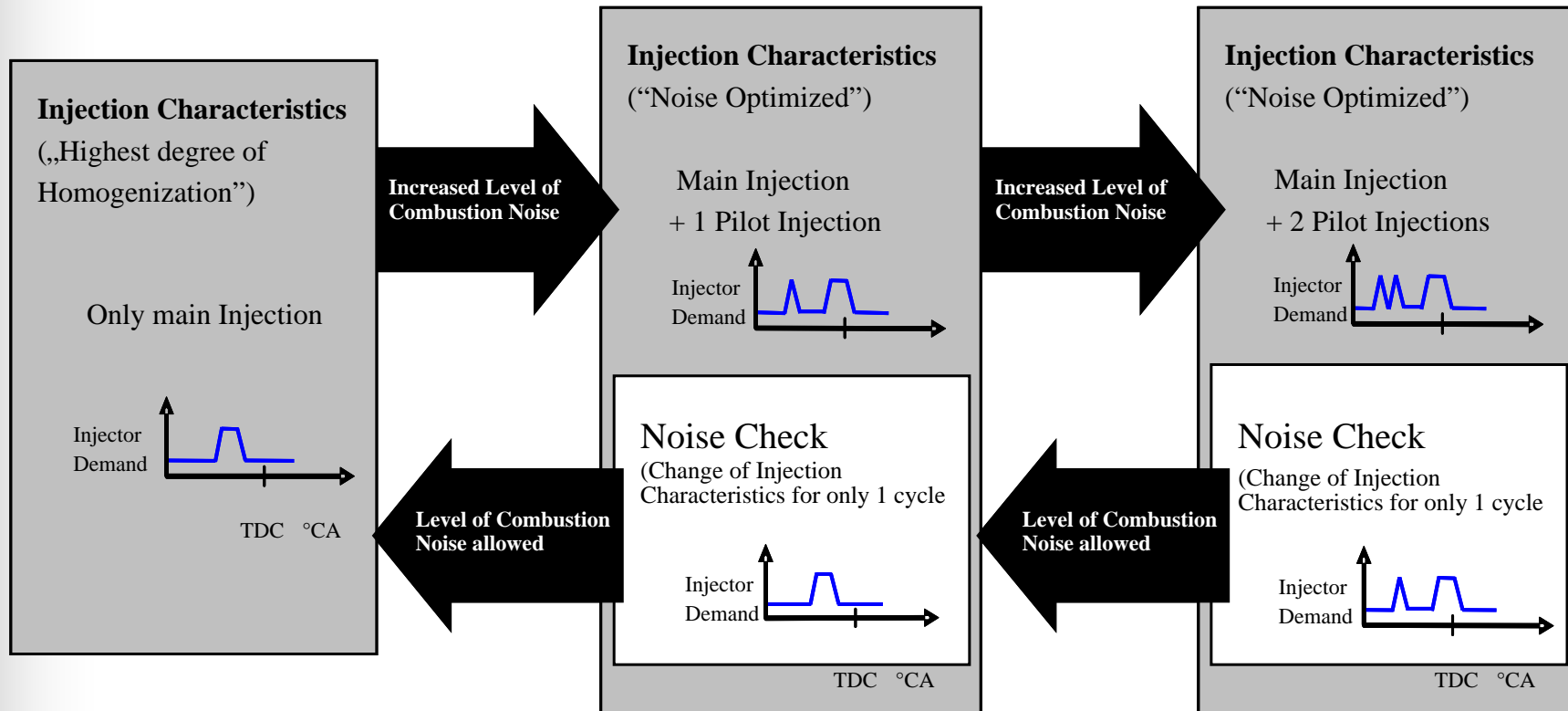
Smoke Number without Pilot Injection



Diesel Combustion with Closed-Loop Control

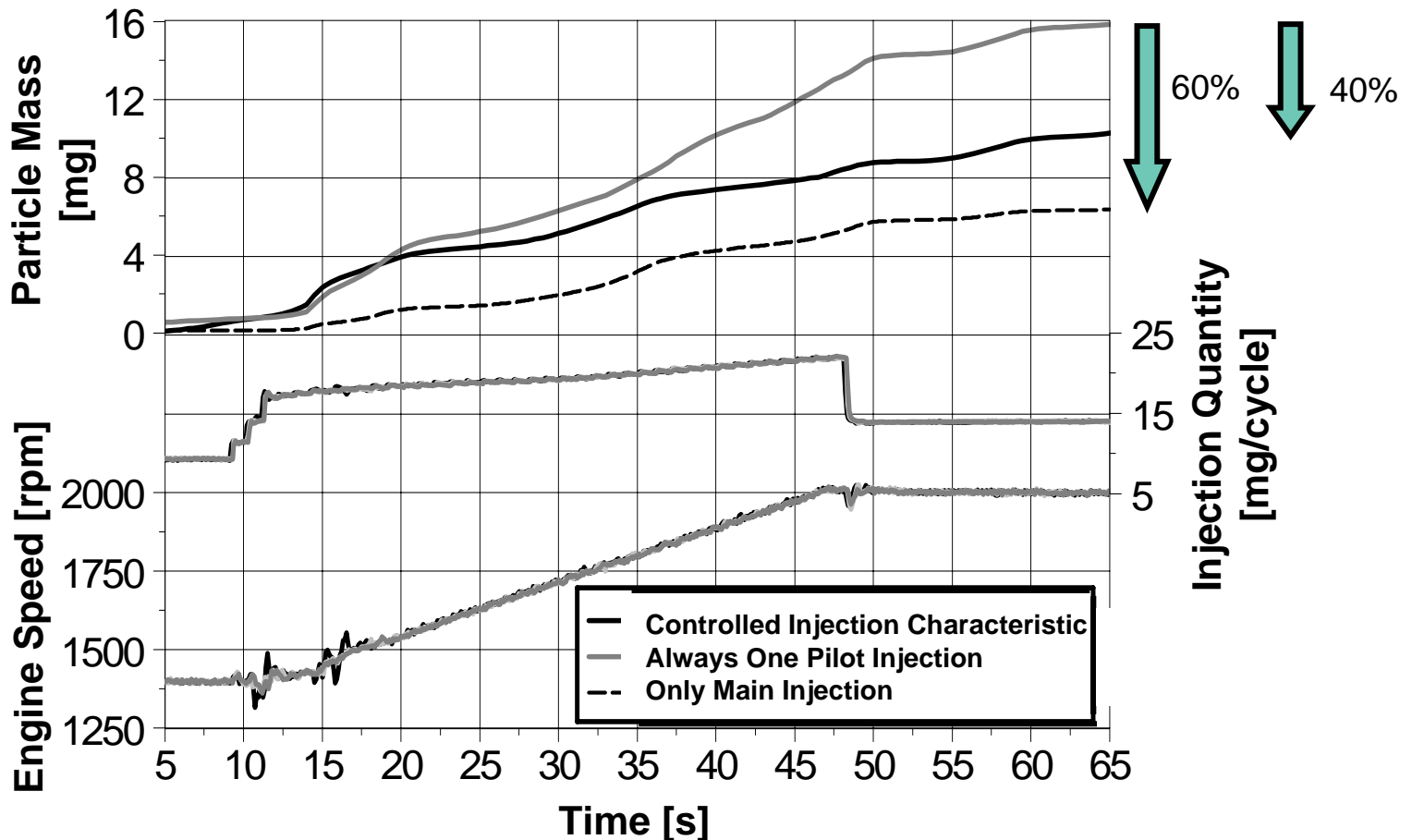
Pilot Strategy Adjustment

Control of Combustion Noise Through Number of Pilot Injections



Diesel Combustion with Closed-Loop Control Pilot Strategy Adjustment

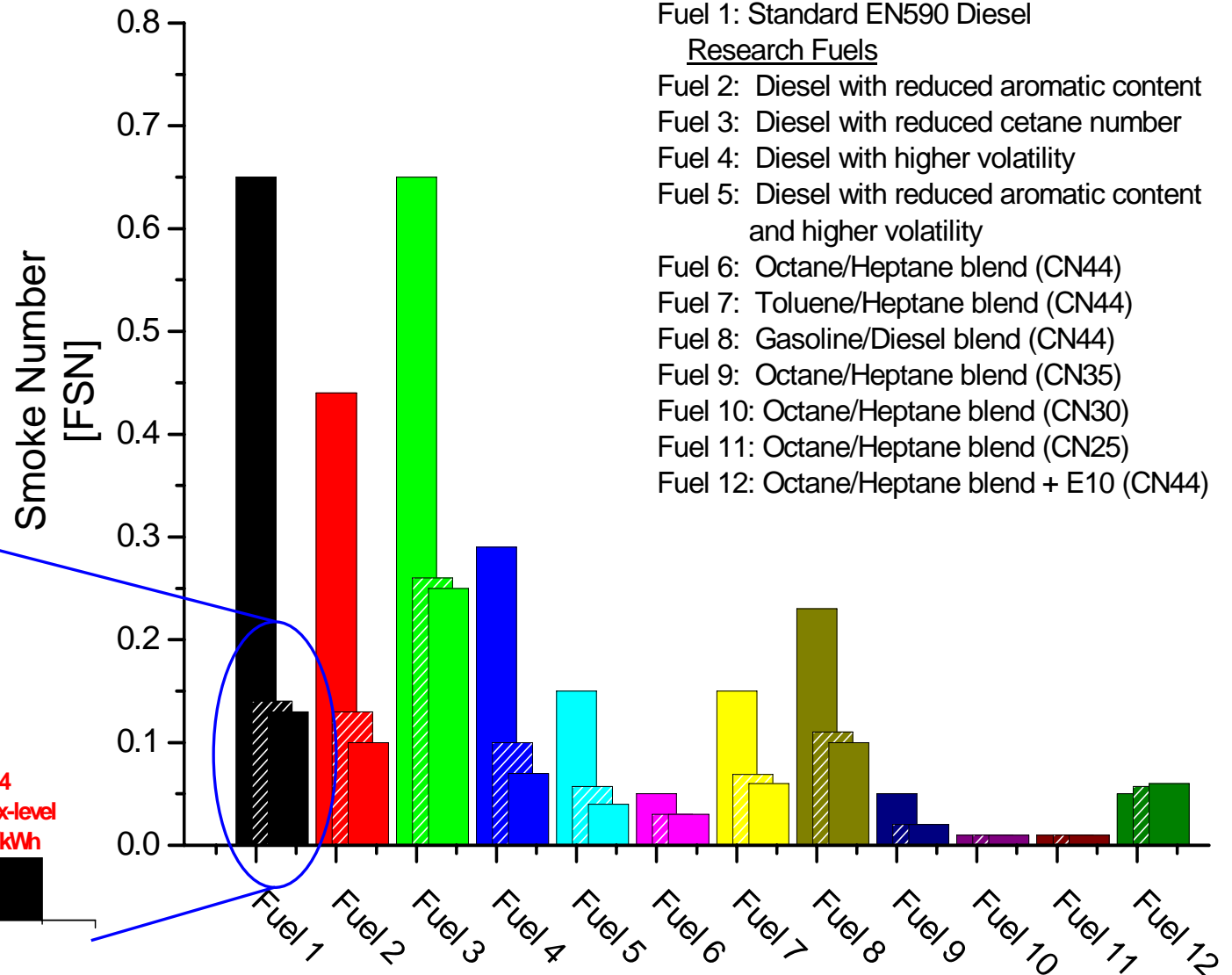
Control of Combustion Noise Through Number of Pilot Injections



Diesel Combustion with Closed-Loop Control

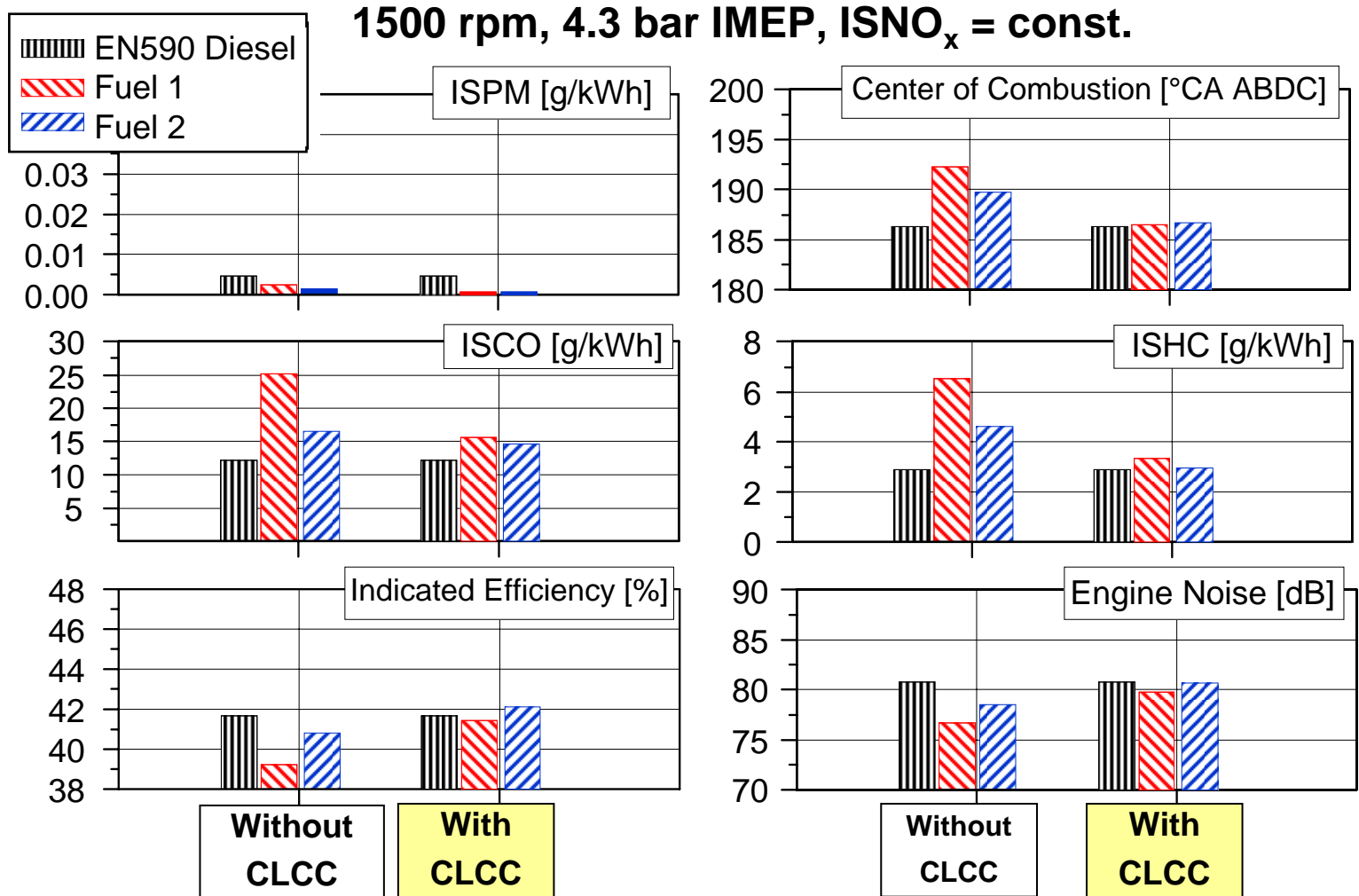
Emission Potential of Advanced Fuel Compositions

Part Load Operation Point: 2300 rpm, high load (HECS)



Diesel Combustion with Closed-Loop Control

Performance Effect of Closed-Loop Combustion Control



Maintain high engine efficiency

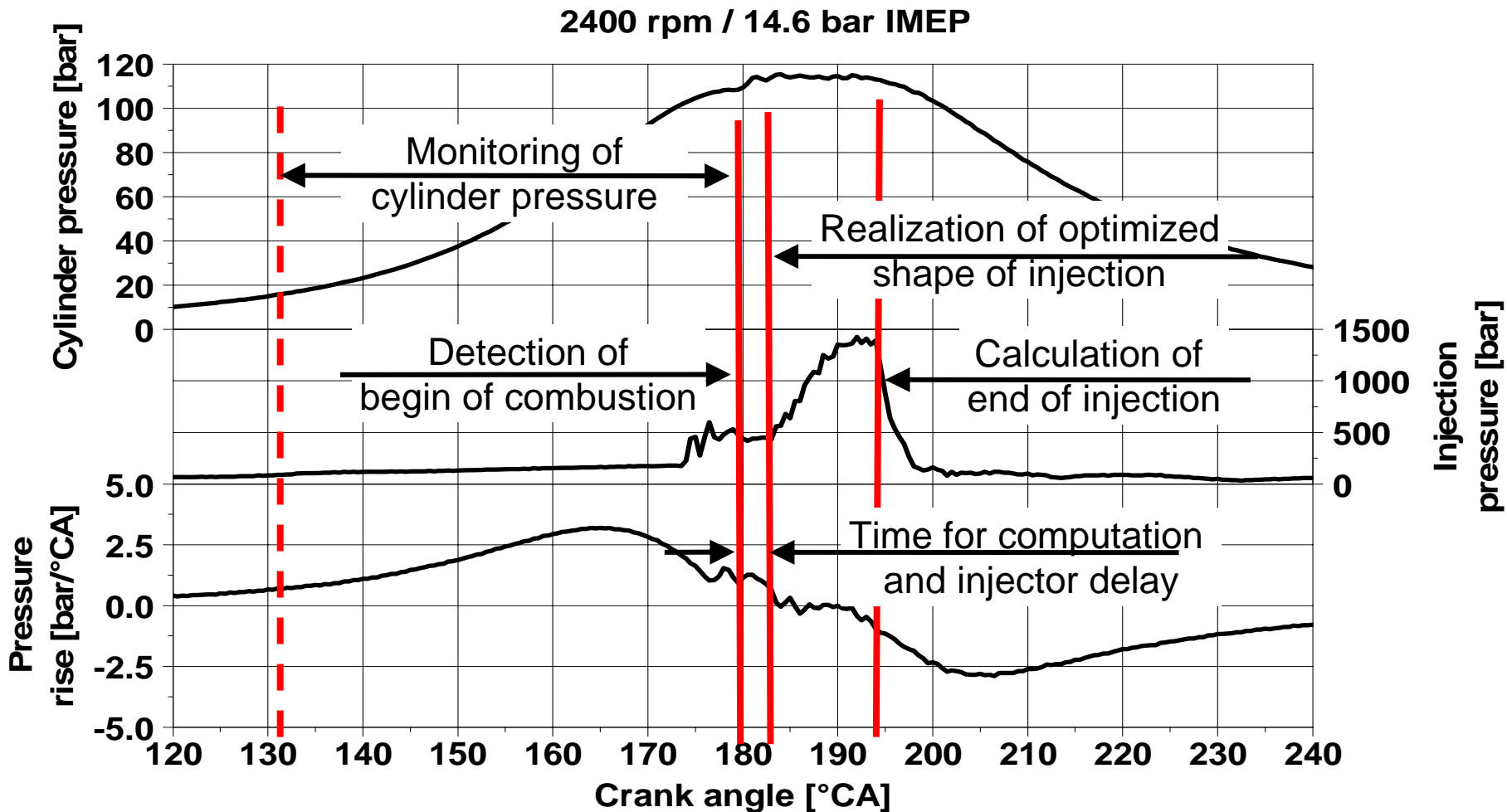
Compensate HC & CO drawbacks and noise impact

Presentation Contents

- Motivation
- System Specifications
 - Layout of Closed-Loop Combustion Control
 - Benefits of Closed-Loop Combustion Control
- Real Time Combustion Control
- Test Results
- Summary

Diesel Combustion with Closed-Loop Control RTC² (Real-Time Combustion Control)

Real Time Control of Injection Rate Within one Cycle



Presentation Contents

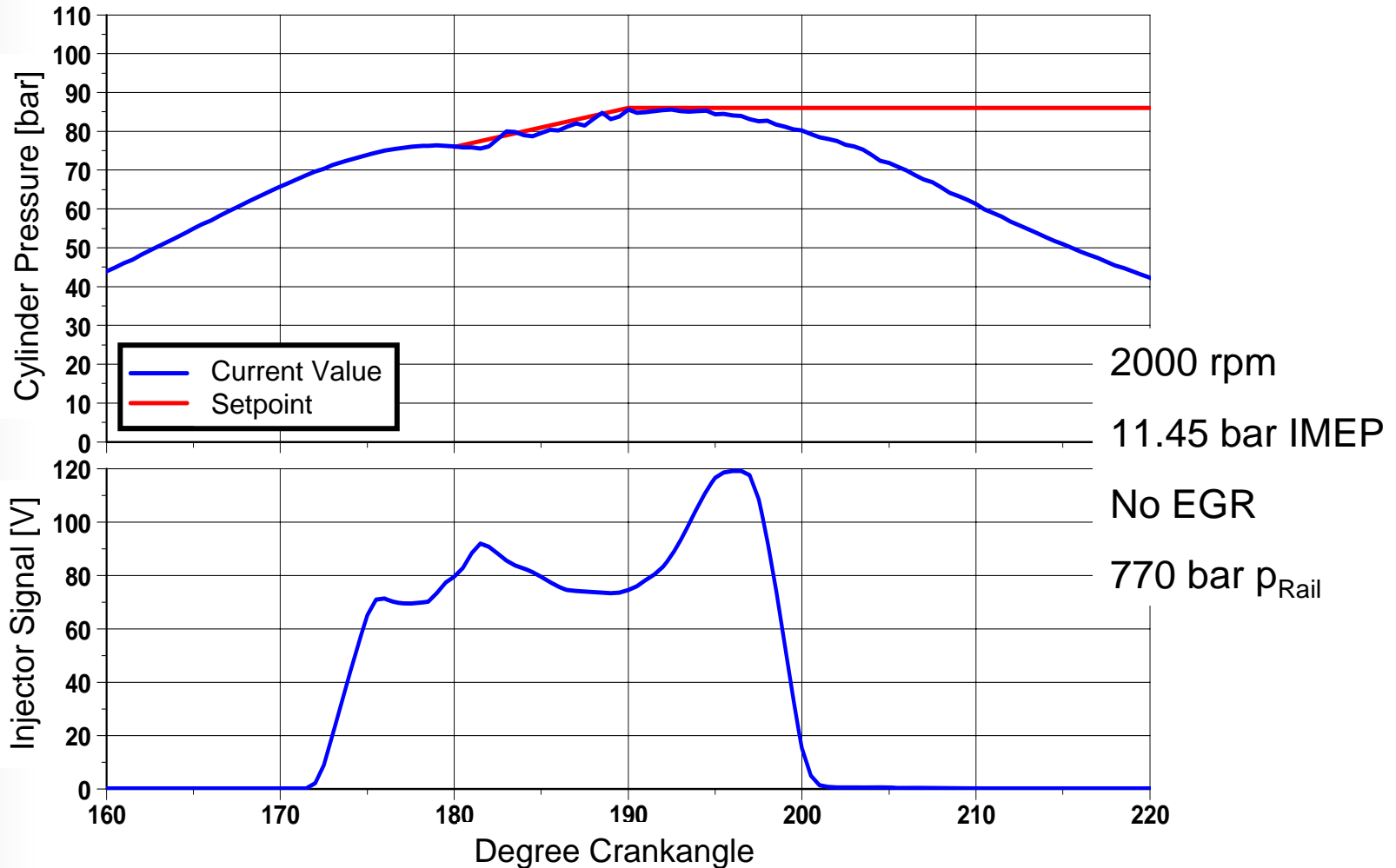
- Motivation
- System Specifications
 - Layout of Closed-Loop Combustion Control
 - Benefits of Closed-Loop Combustion Control
- Real Time Combustion Control
- Test Results
- Summary

Diesel Combustion with Closed-Loop Control

Rate-Shaping

Controlled Cylinder Pressure Shape CNL Optimized

Constant Pressure Rise ($1^{\circ}\text{CA}/\text{degree}$) with Peak Pressure Limitation

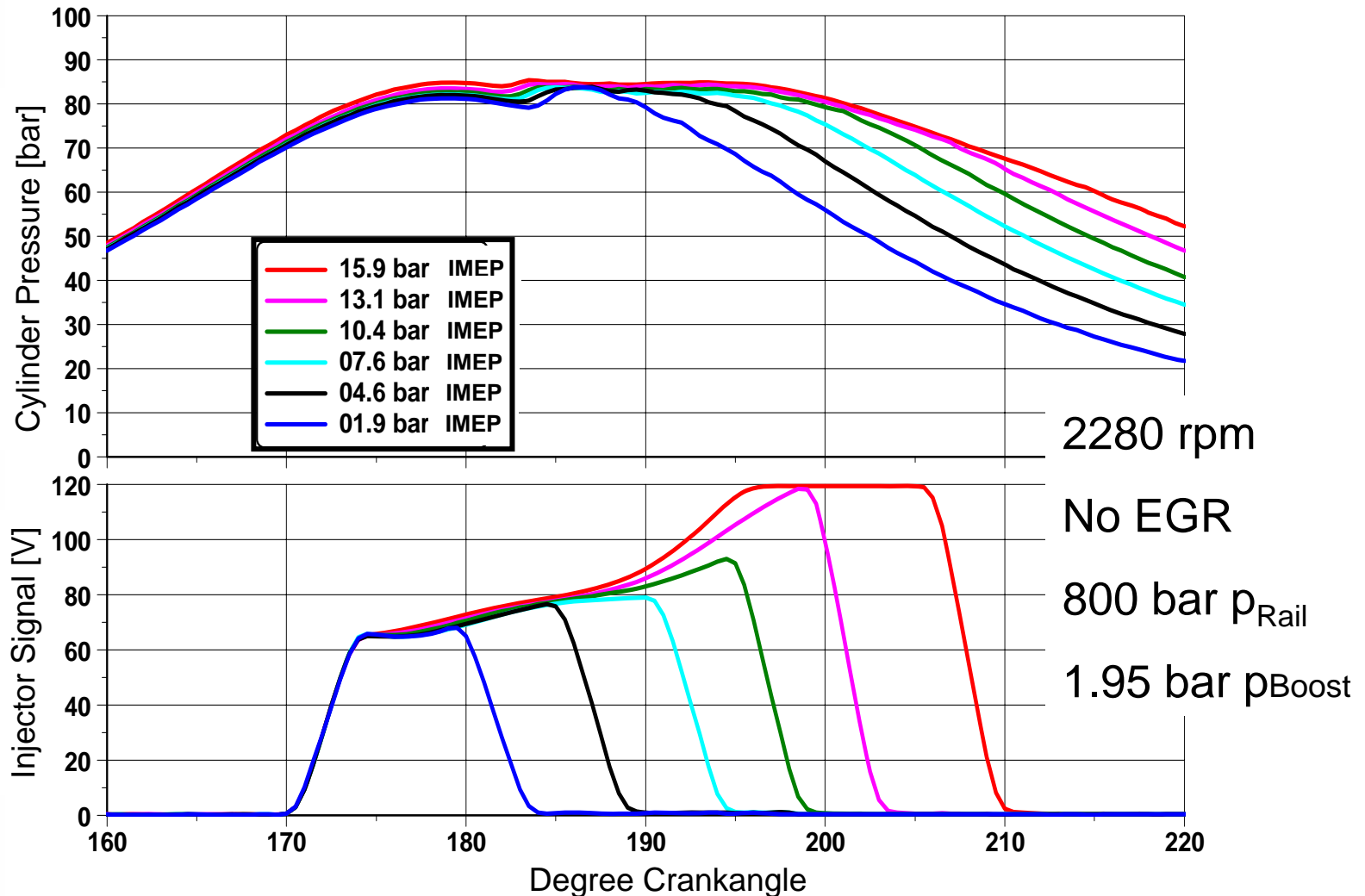


Diesel Combustion with Closed-Loop Control

Rate-Shaping

Load Variation with Constant Pressure Cycle

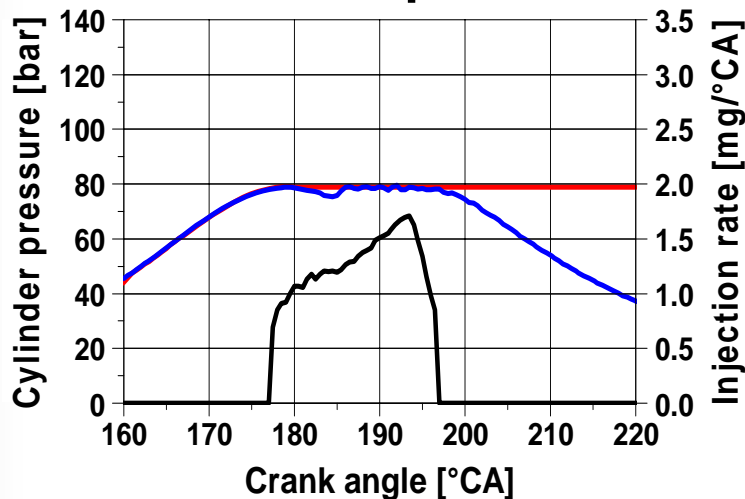
Adjustments only necessary to the last part of the injection trace



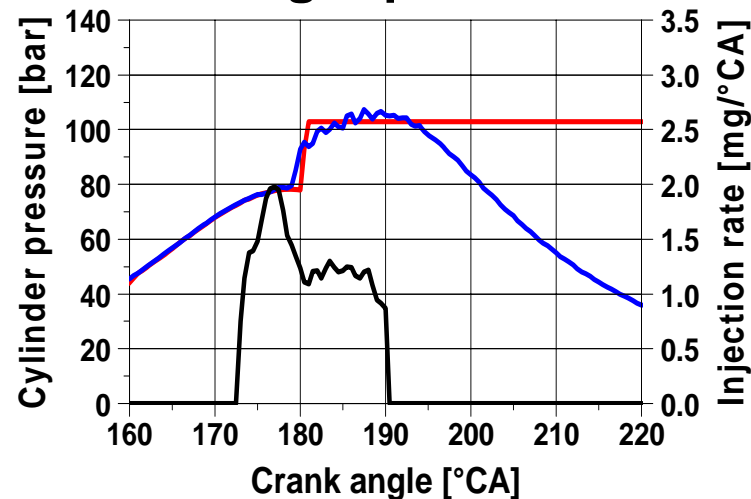
Diesel Combustion with Closed-Loop Control

CORS Combustion Rate Shaping

Isobaric process

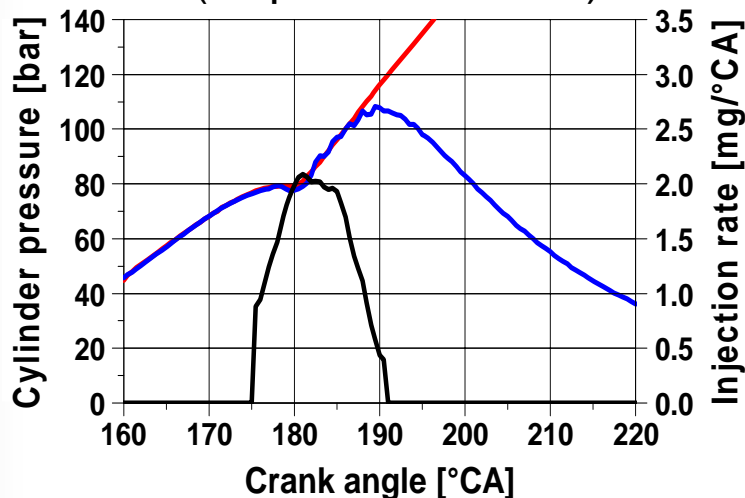


Seiliger process



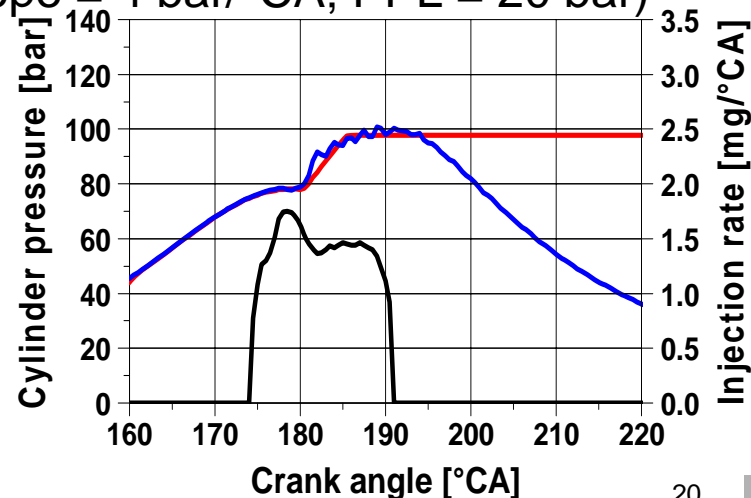
α -process

(slope = 4 bar/°CA)



α -process with peak pressure limitation

(slope = 4 bar/°CA; PPL = 20 bar)



Summary

- ❑ New control strategies are enabler for new combustion concepts for further reduction of engine out emission
- ❑ Engine operation with high degrees of homogenization is highly sensitive to transient driving profiles
- ❑ Adaptive injection characteristic is able to solve most challenges which occur in transient conditions
- ❑ The system is able to avoid torque drops and combustion noise peaks by adapting the number of pilot injections