Bosch Diesel Systems beyond Fuel Injection & Exhaust Gas Treatment: Air System and Hybridization

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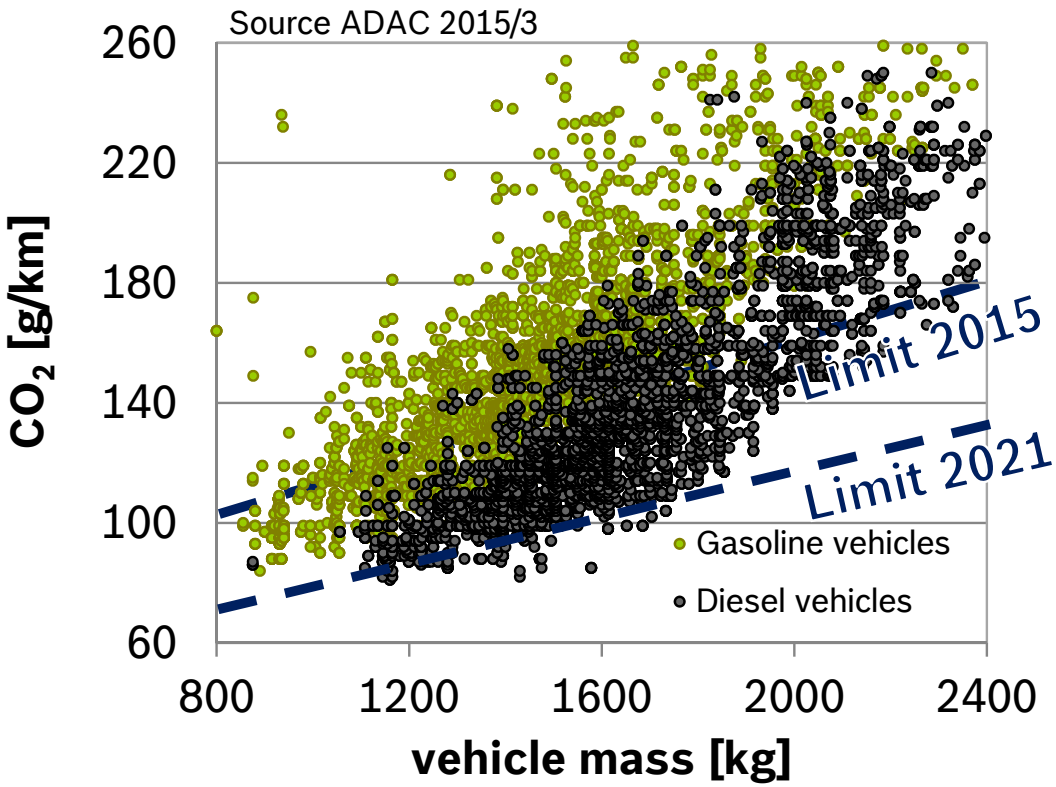
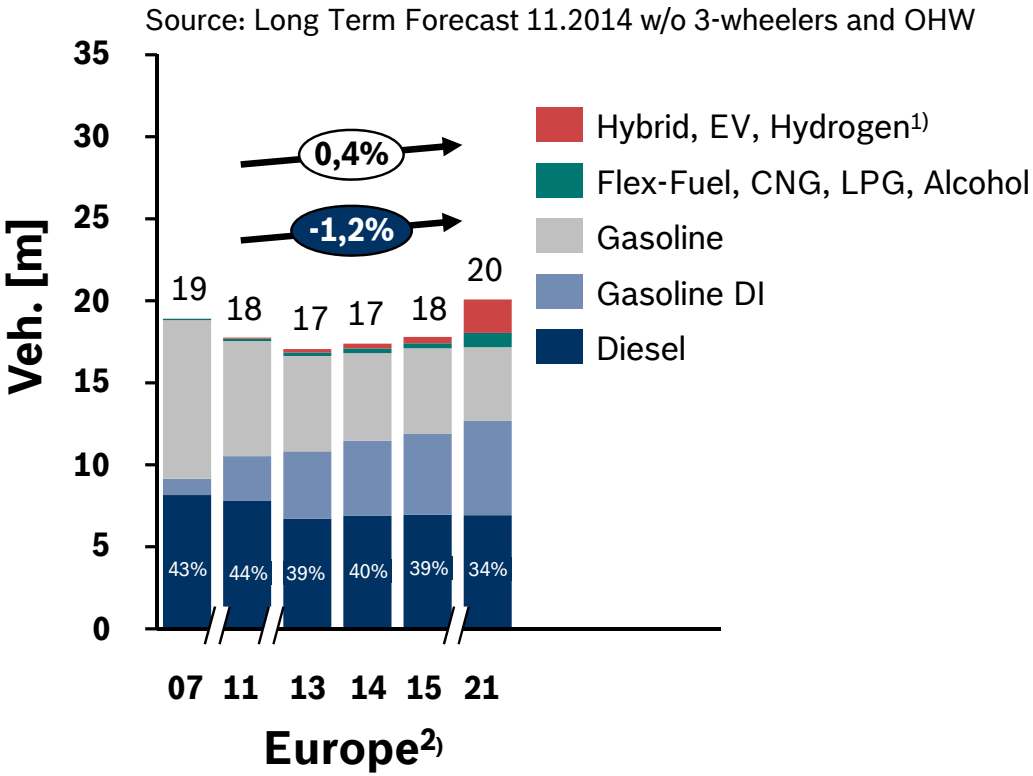
Bosch Diesel Systems beyond FIE & EGT

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
emission	EU 5	EU 6						post-EU 6					
CO_2		130 g/km 100% fleet					95%	95 g/km 100% fleet, proposals			Next step?		
cycle	MNEDC-based testing							WLTP-based testing					
RDE	Development phase						limit ≤ cf • criteria emission limit						





1) includes Gasoline / Diesel Hybrid and 48V
2) includes EU27 + other countries (non-EU, RU, TR, ...)

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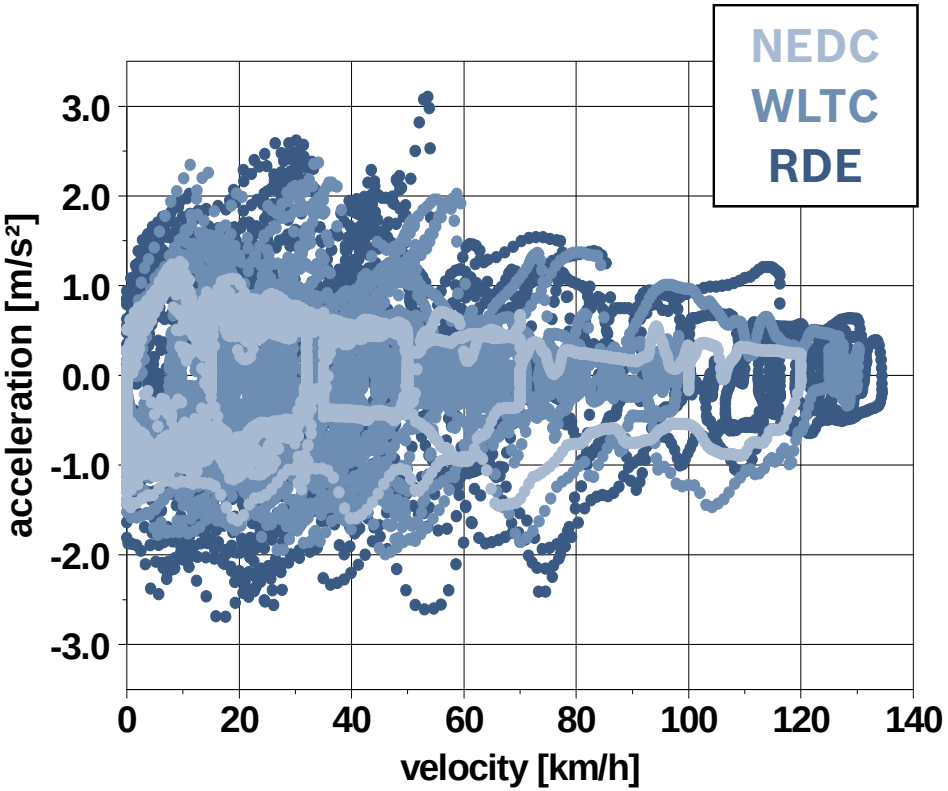
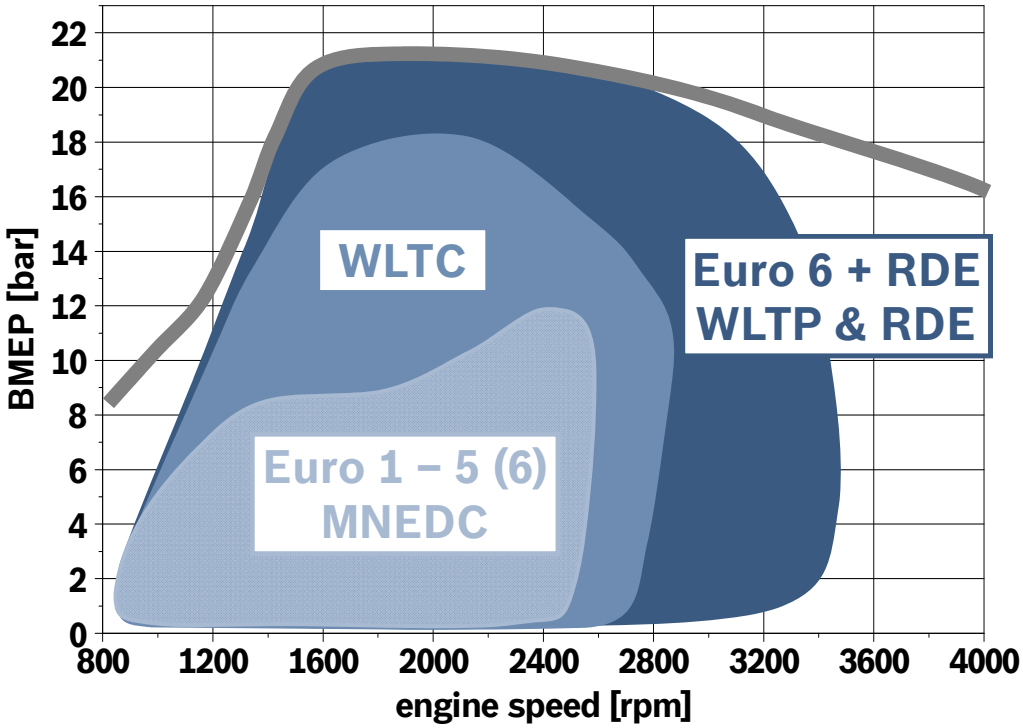
WLTC and Real Driving Emissions

Increase of Transient Operations



Wider engine operating area



Significant increase of transient operations and wider operation area for new driving cycles

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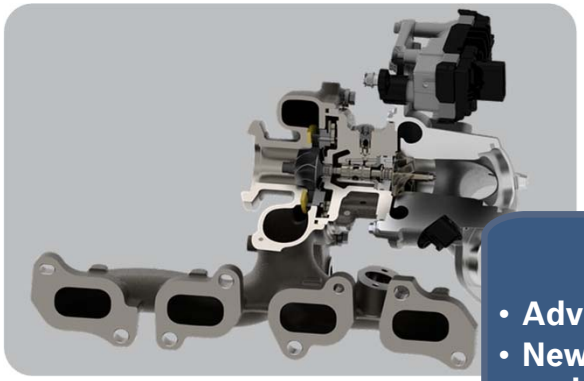

Air System
- Advanced T/C HW
- New SW functions (transient and model based engine control)

Diesel Hybridization
- Boost recuperation system
- Operating mode strategy (stationary and transient conditions)

innovative concepts

future legislation

exhaust gas after treatment

FIE benchmark

injection strategy

single cylinder engine

platform demonstrator

incl. demo-vehicle

- optimized emission potential
- hardware upgrade
- software development

Complete testing platform for future technologies

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Bosch Diesel Systems beyond FIE & EGT

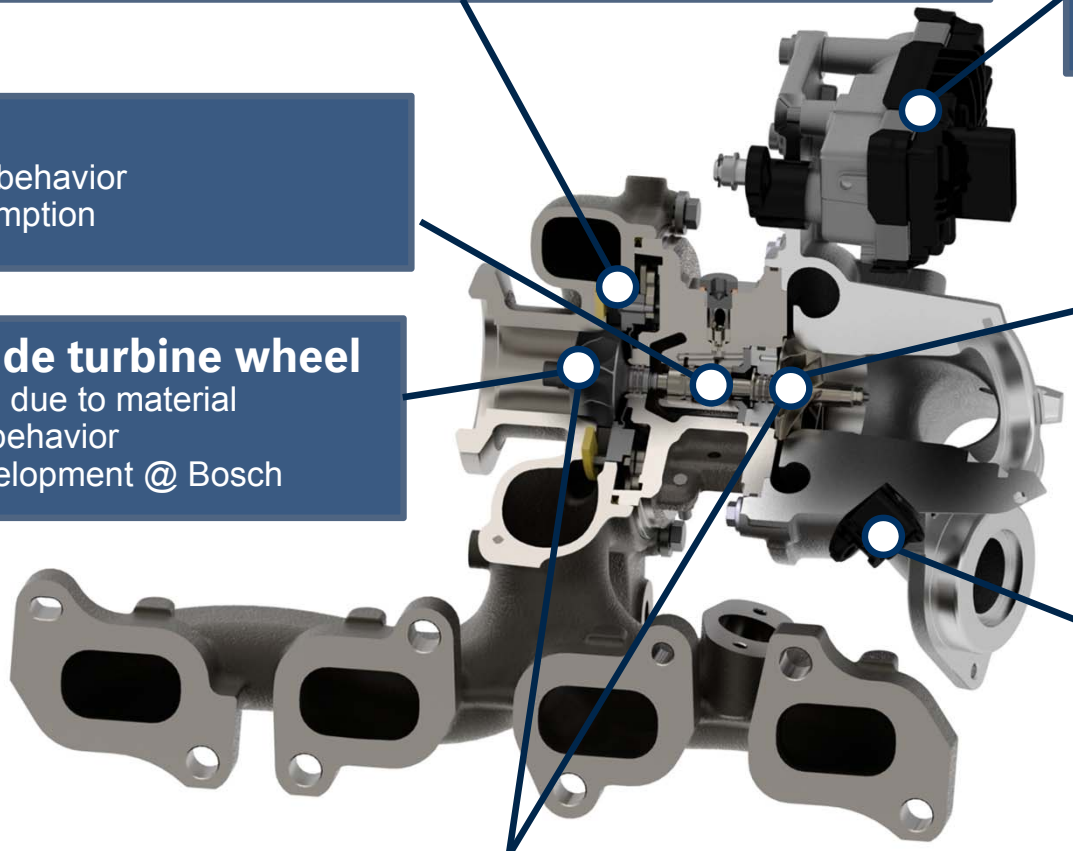
VTG 2nd gen
- reduced axial vane clearance
- minimal hysteresis

electrical actuator
- minimal hysteresis
- high actuating speed and force

ball bearing
- improved transient behavior
- reduced fuel consumption

compressor wheel
- hard anodized compressor wheel to prevent damages due to low pressure EGR

titanium aluminide turbine wheel
- 50% reduced inertia due to material
- improved transient behavior
- MIM process in development @ Bosch



Bosch speed sensor
- no over speed damages
- use of whole compressor map
- additional OBD functions

new aero design
- High flow turbine and compressor wheel

Deriving turbocharger requirements within Bosch's overall system approach

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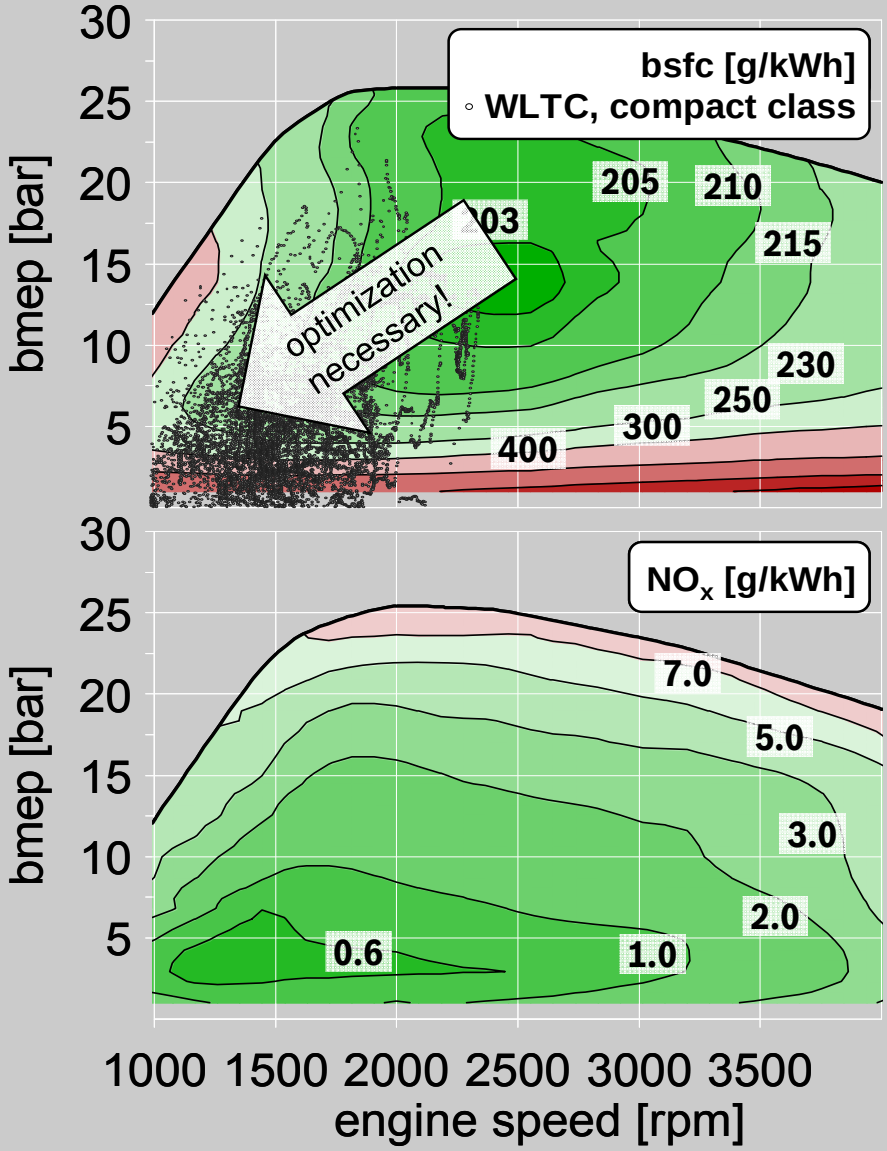
basic configuration

displacement	1.65 l
rated power	110kW@4000rpm
max. torque	340Nm@1700rpm
compr. ratio	16
bore	81mm
stroke	80.5mm
EGR	low pressure + high pressure



Dedicated optimization of main driving area necessary

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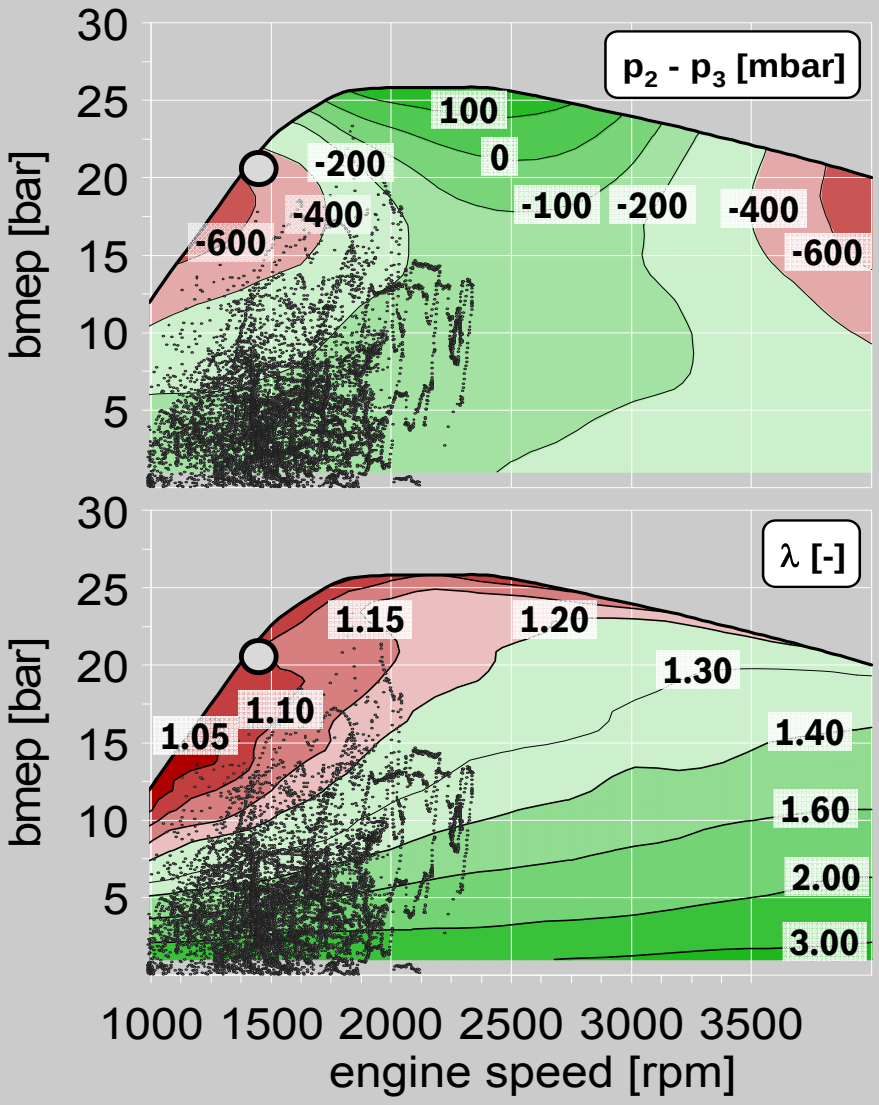

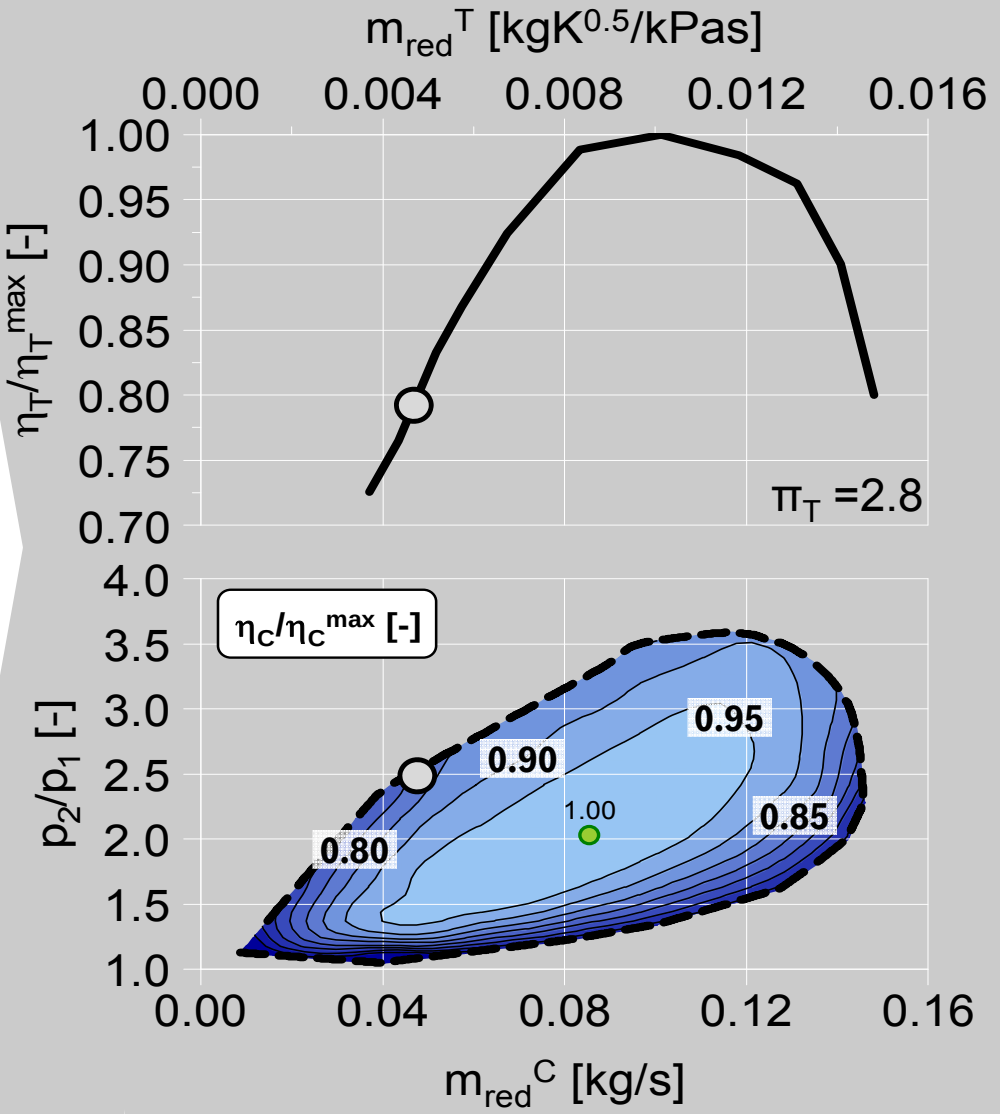

Increased bsfc caused by low air-fuel ratio and high gas exchange work at low engine speed

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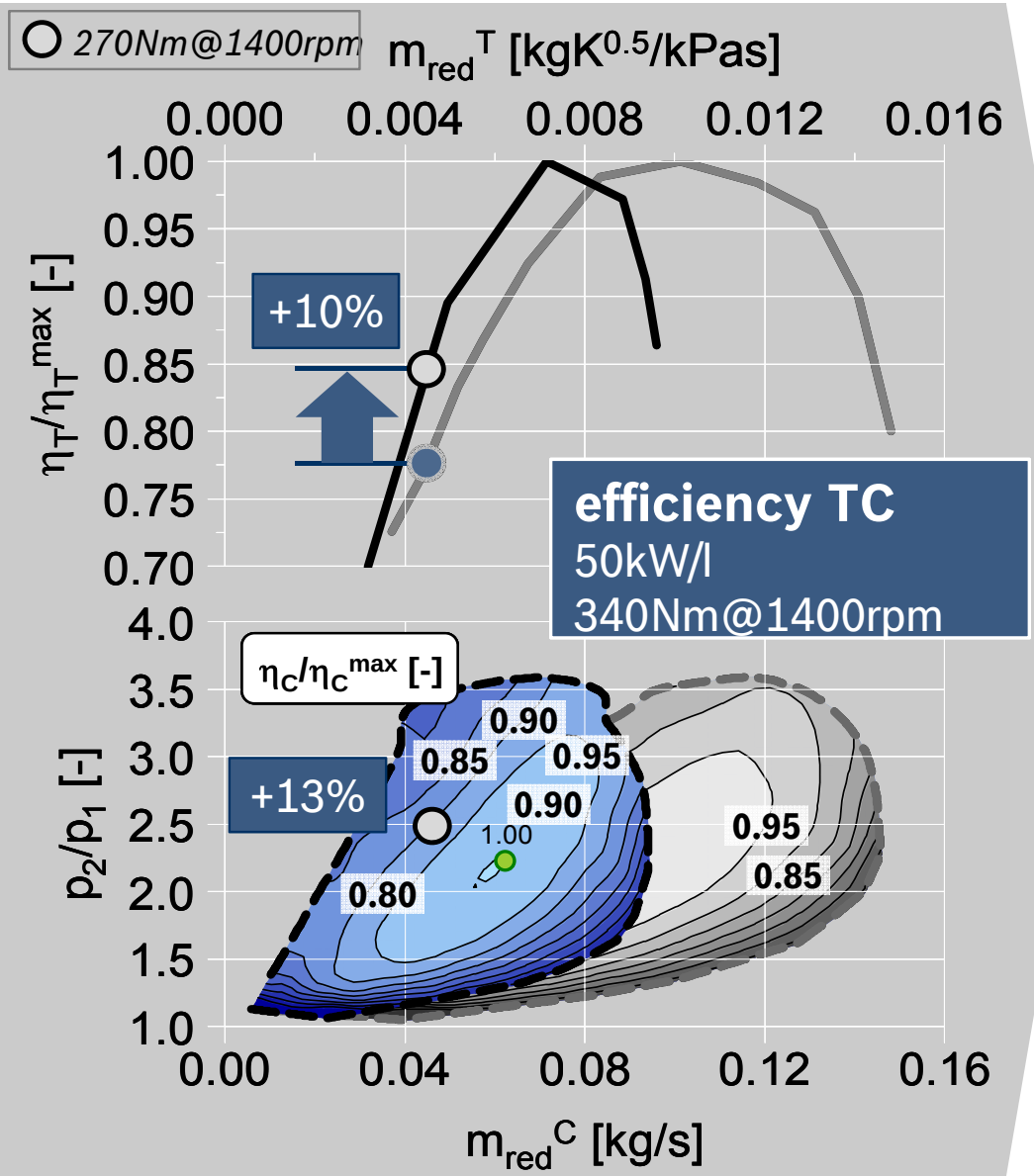

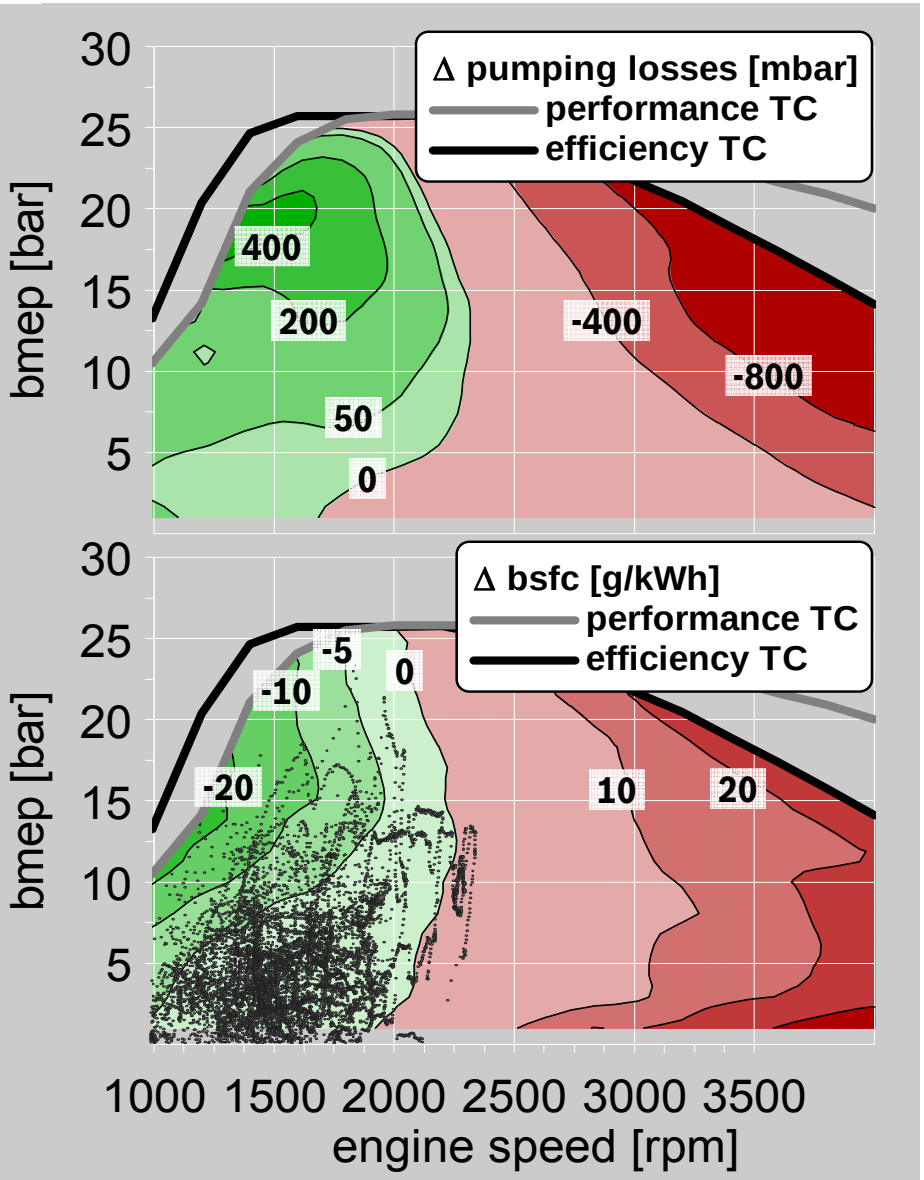

High fuel consumption benefit in main driving area with the efficiency TC

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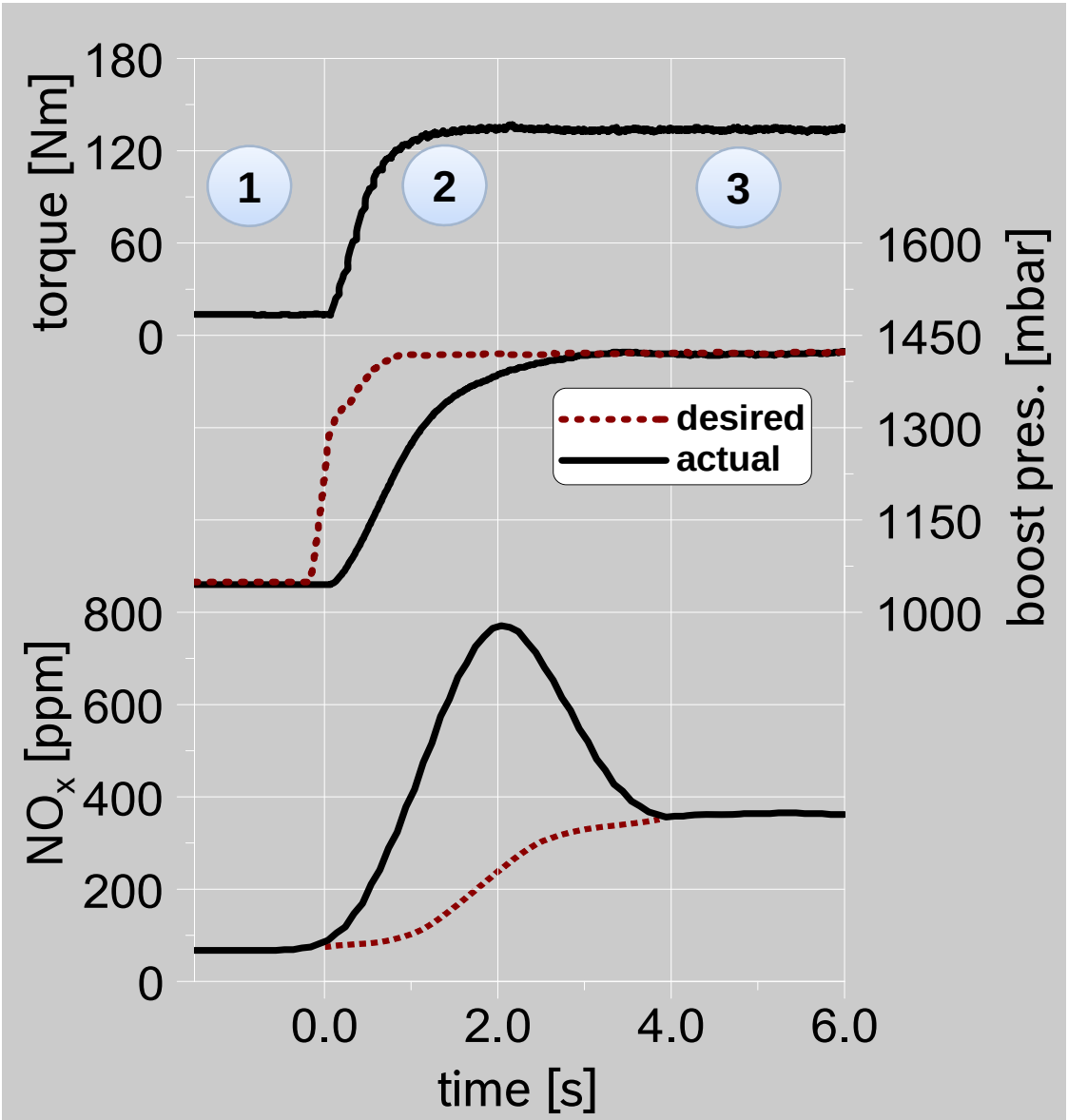
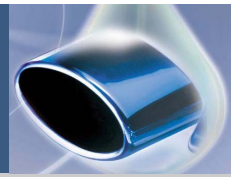


Transient ECU strategy load step 1200rpm



stationary low load operating point

1

transient: temporary lack of boost pressure

2T torque forced control

2E emission forced control*

*EGR + fuel injection system control

stationary high load operating point

3 AIR EGR fuel

Transient turbocharger performance as essential key parameter

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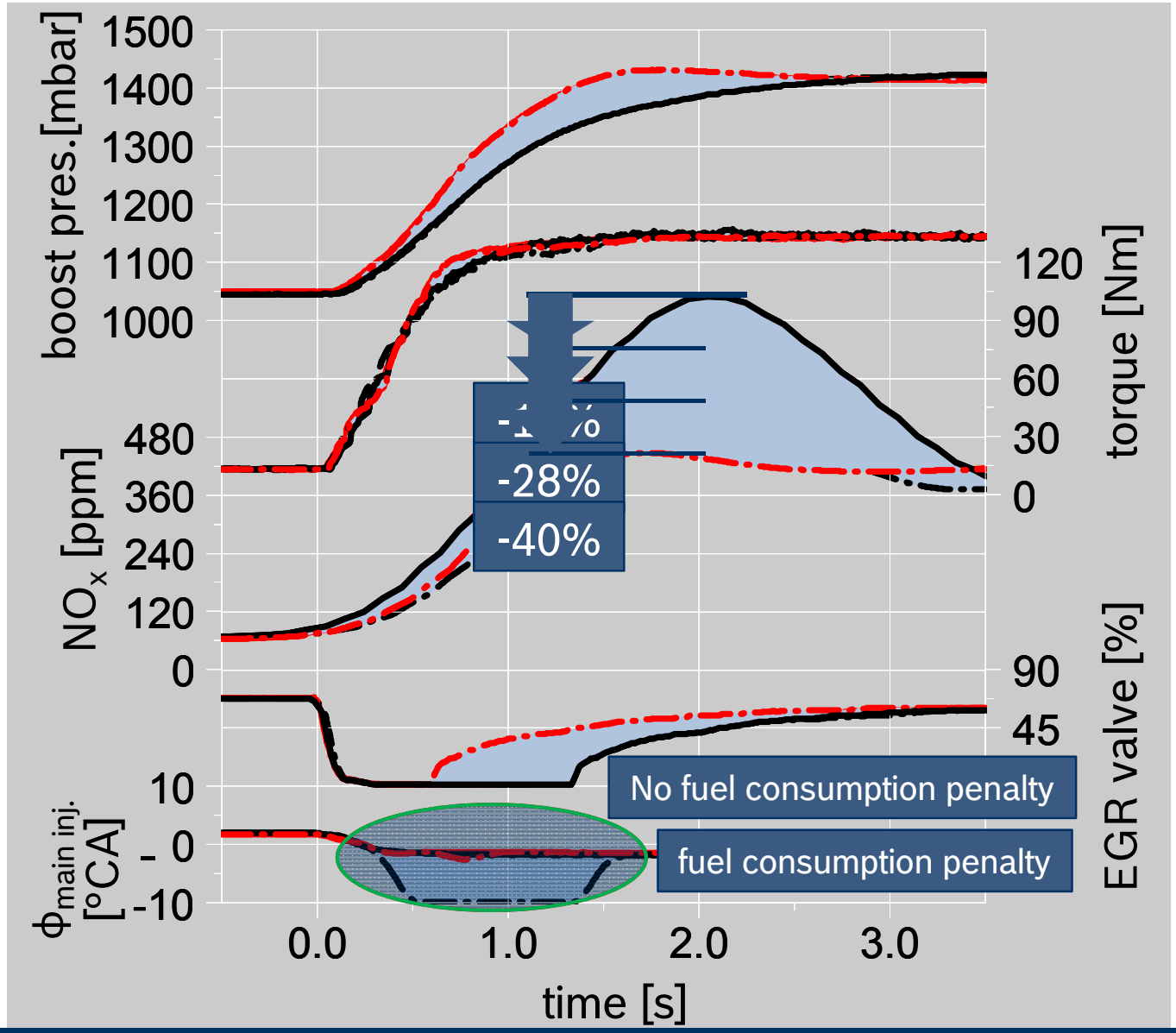

Load step 1200rpm
Emission forced

- performance TC
- efficiency TC
- performance TC + transient control
- efficiency TC + transient control

NO$_x$ peak reduction	
performance TC	base

Significant reduction of NO$_x$ peaks w/o reduced engine efficiency possible

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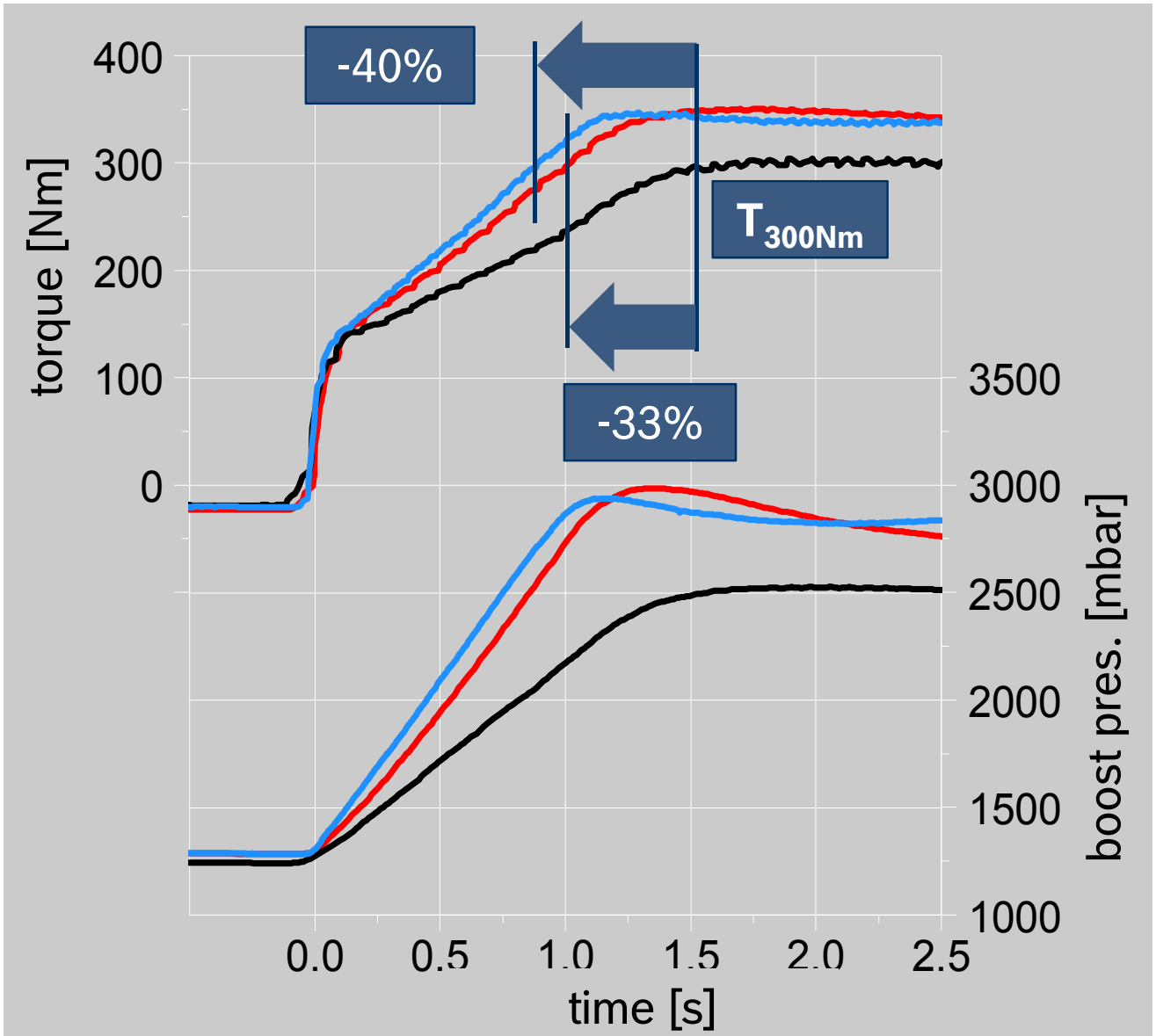

Load step 1500 rpm
Torque forced

- performance TC
- efficiency TC
- 2-stage TC (simulation)

Transient behavior	
performance TC	base

Significant increase of transient performance due to efficiency turbocharger

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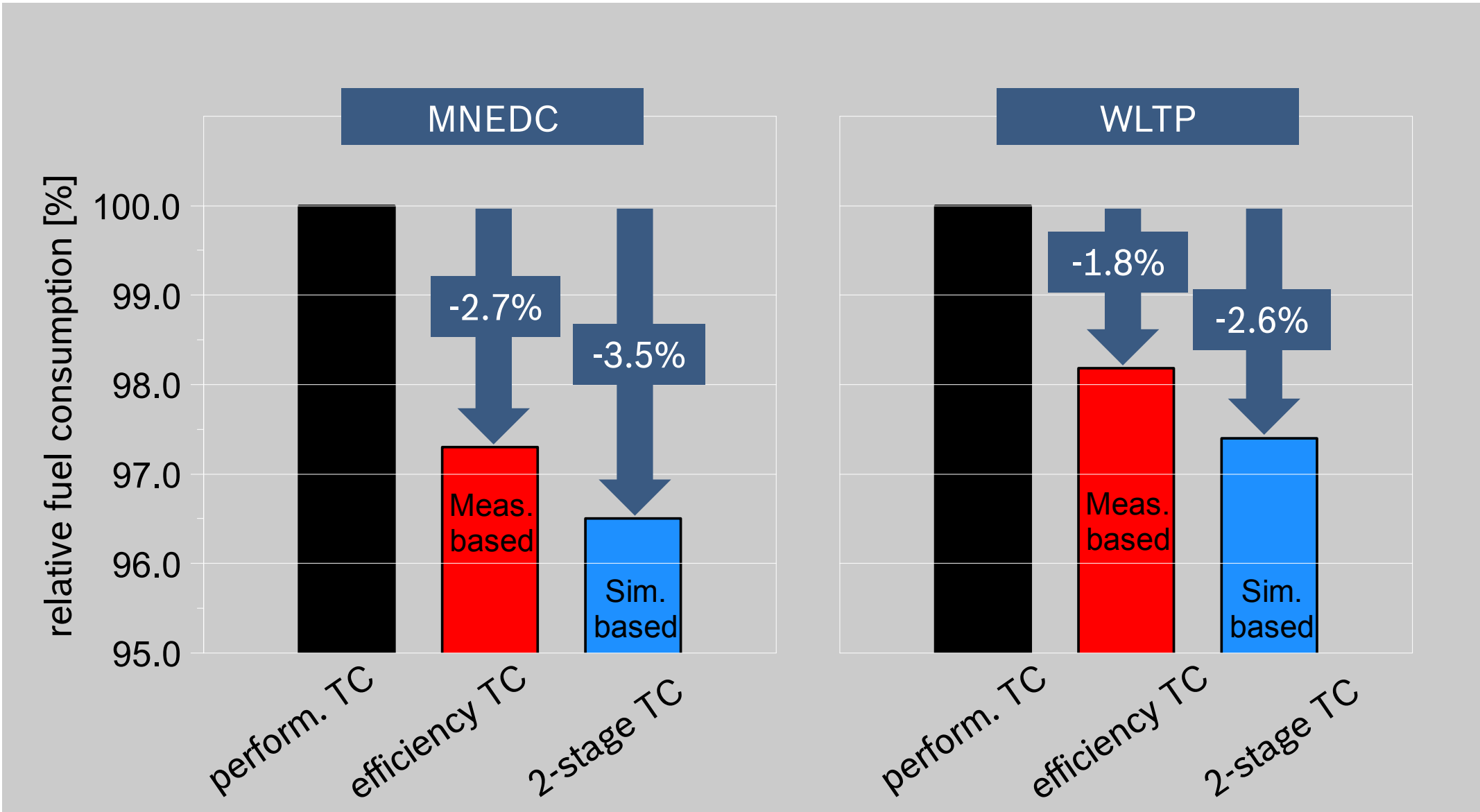

Fuel consumption benefit up to 2-3% due to efficiency turbocharger

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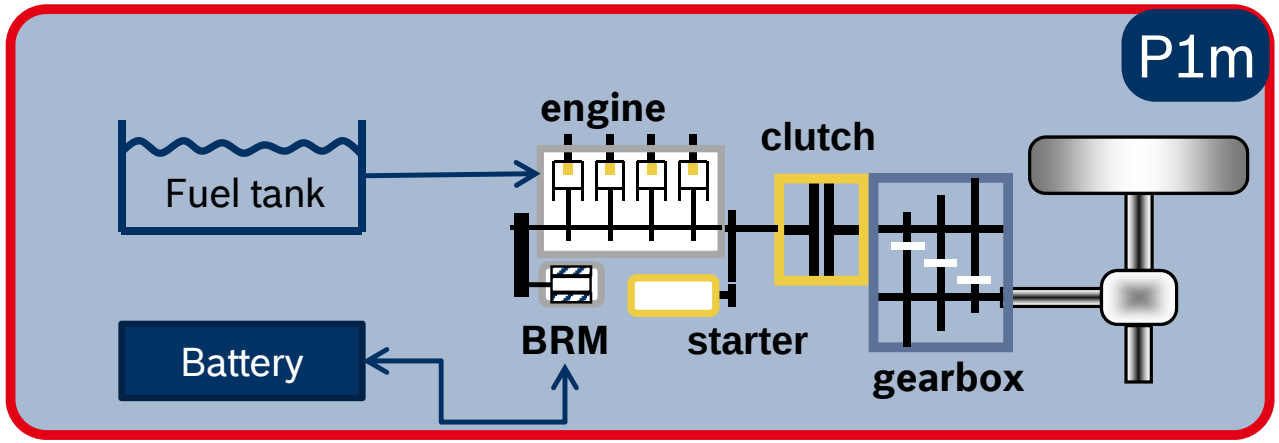
Content

System description: P1m configuration



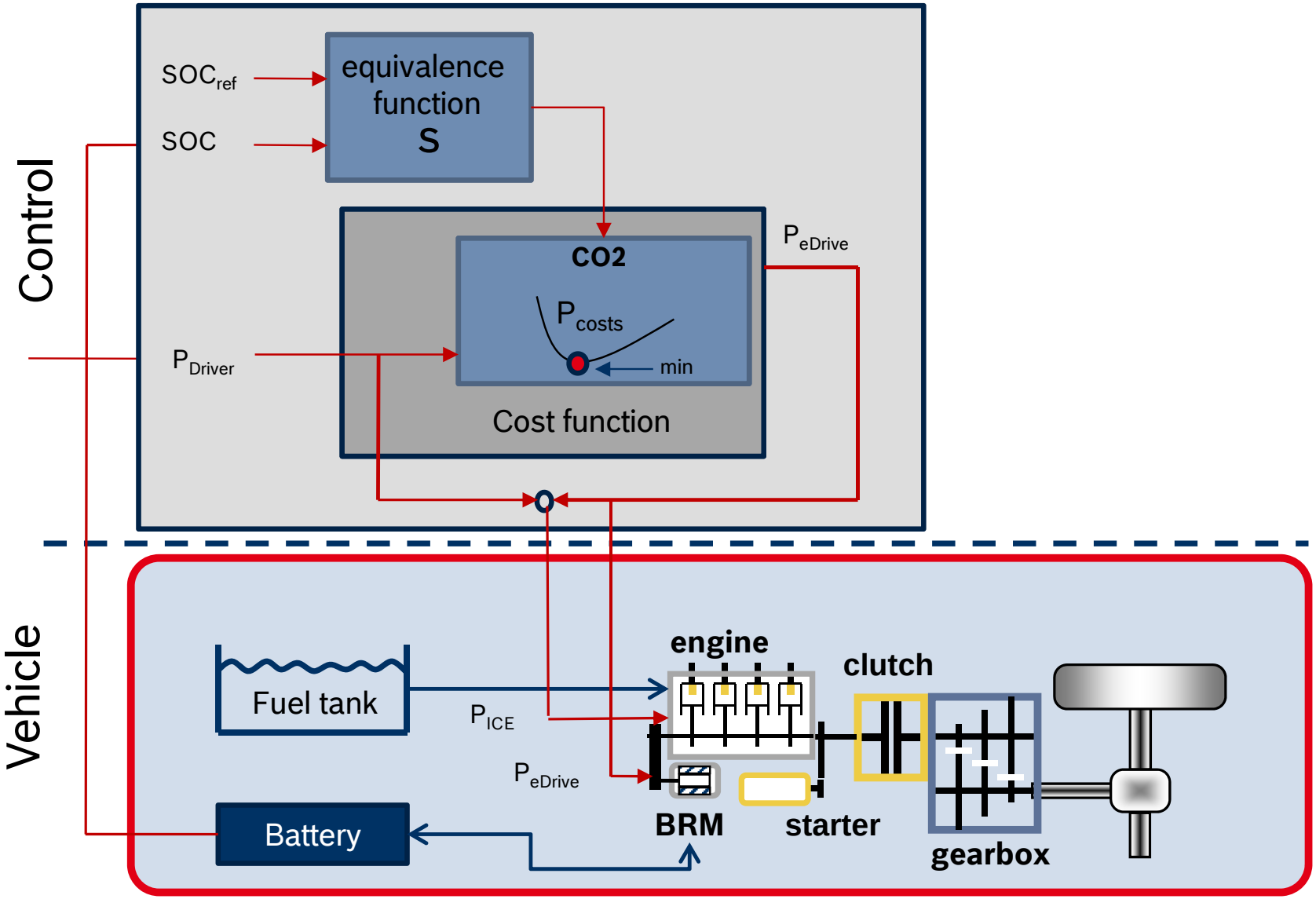
System description:	
Vehicle	1470 kg curb weight
ICE	Diesel
Swept volume	1,65 litre
Cylinders	4
Valves	4
CR	16
Power	90kW @ 4000 rpm
Torque	270 Nm @ 2000-2400 rpm
Emissions	EU6
Gearbox	MT5
Clutch	electrical actuated
E-Drive	48V
E-Motor (BRM)	11kW peak power, air cooled Ratio E-Motor/Crank shaft 3/1
Battery	Lithium Ion

Considered Degrees of Freedom:

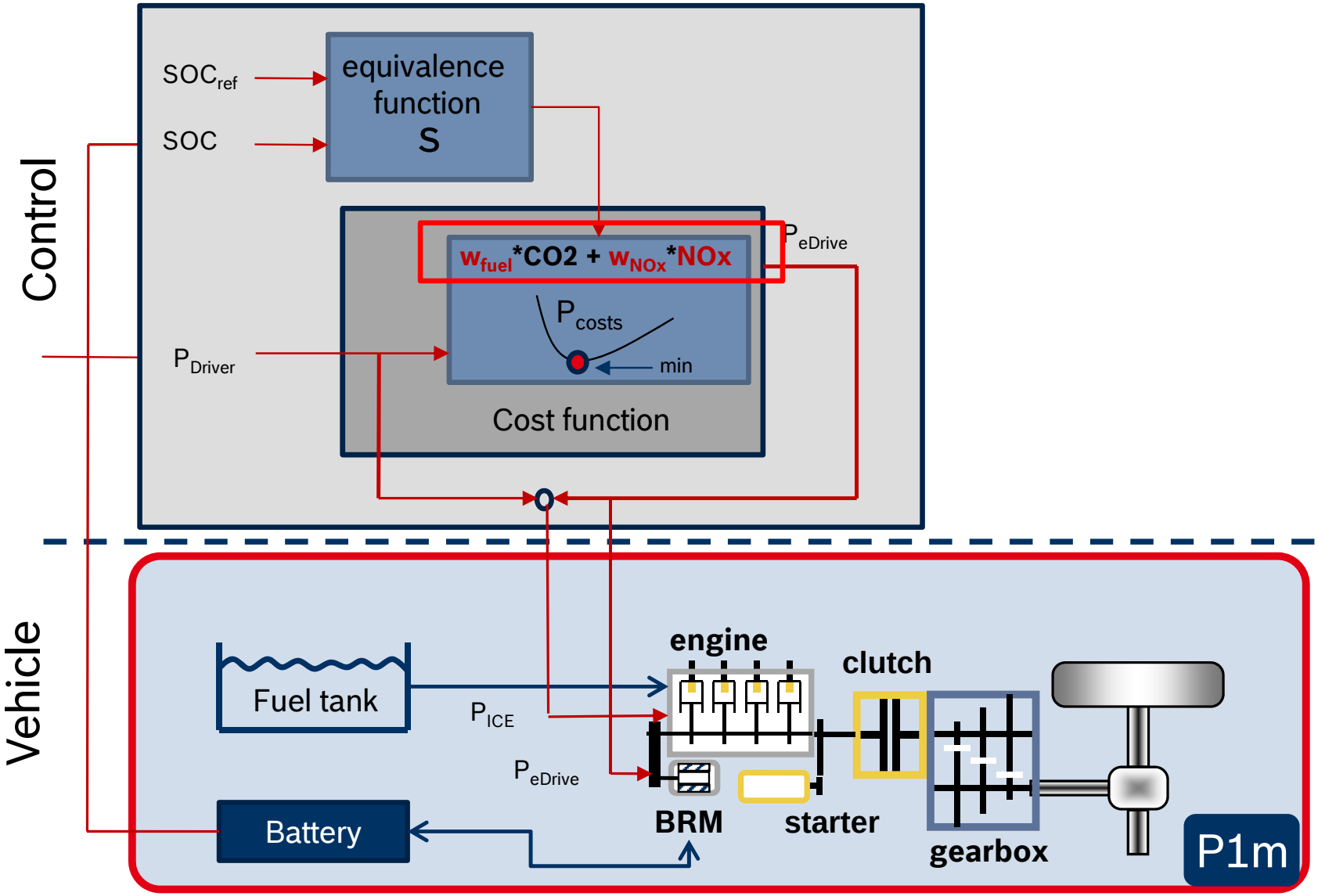
- Clutch open/closed
- **Torque distribution**
- Vehicle velocity

Torque distribution as major degree of freedom for P1m configuration

Basic ECMS controller structure:

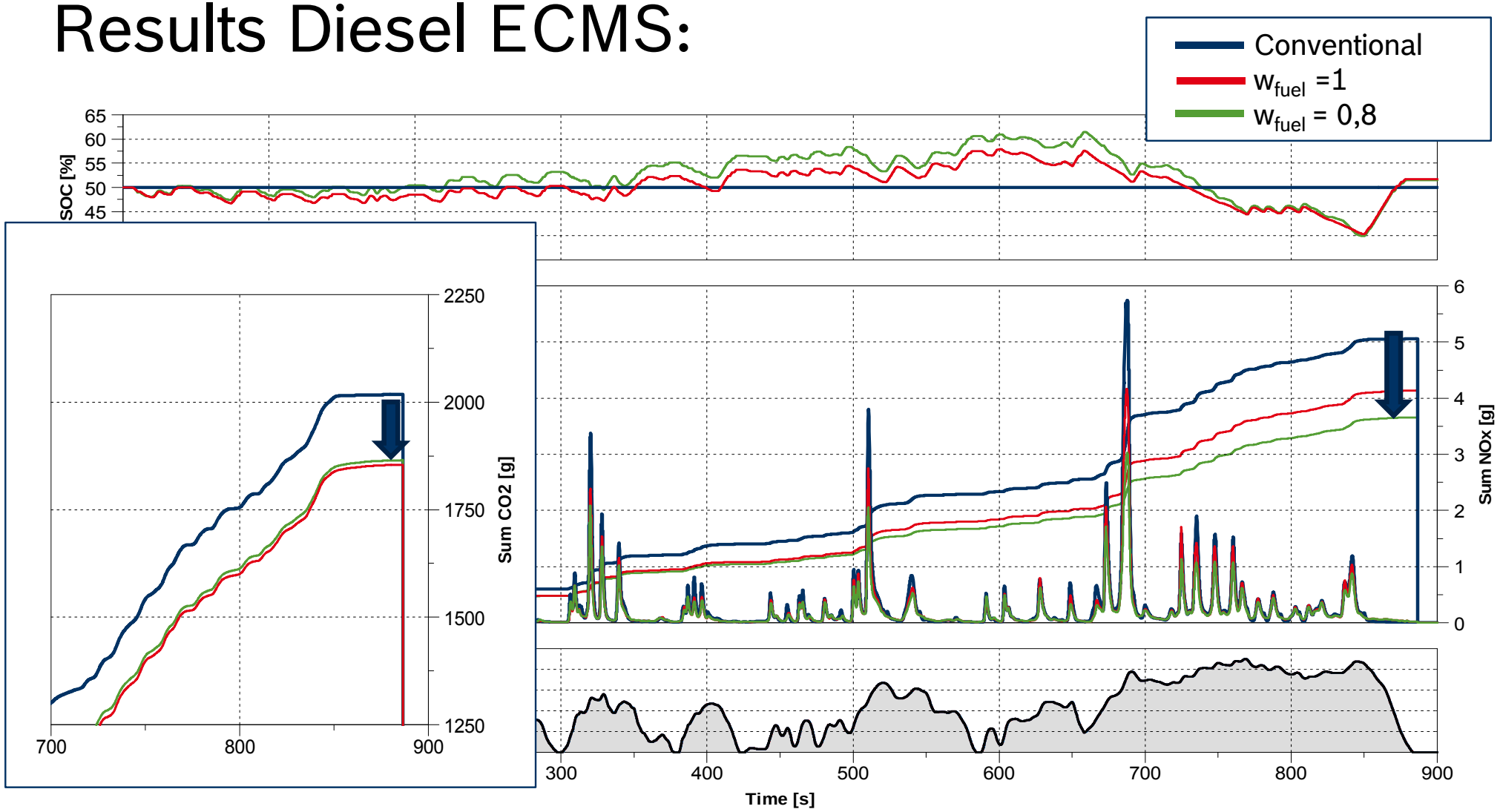


Diesel ECMS controller structure:



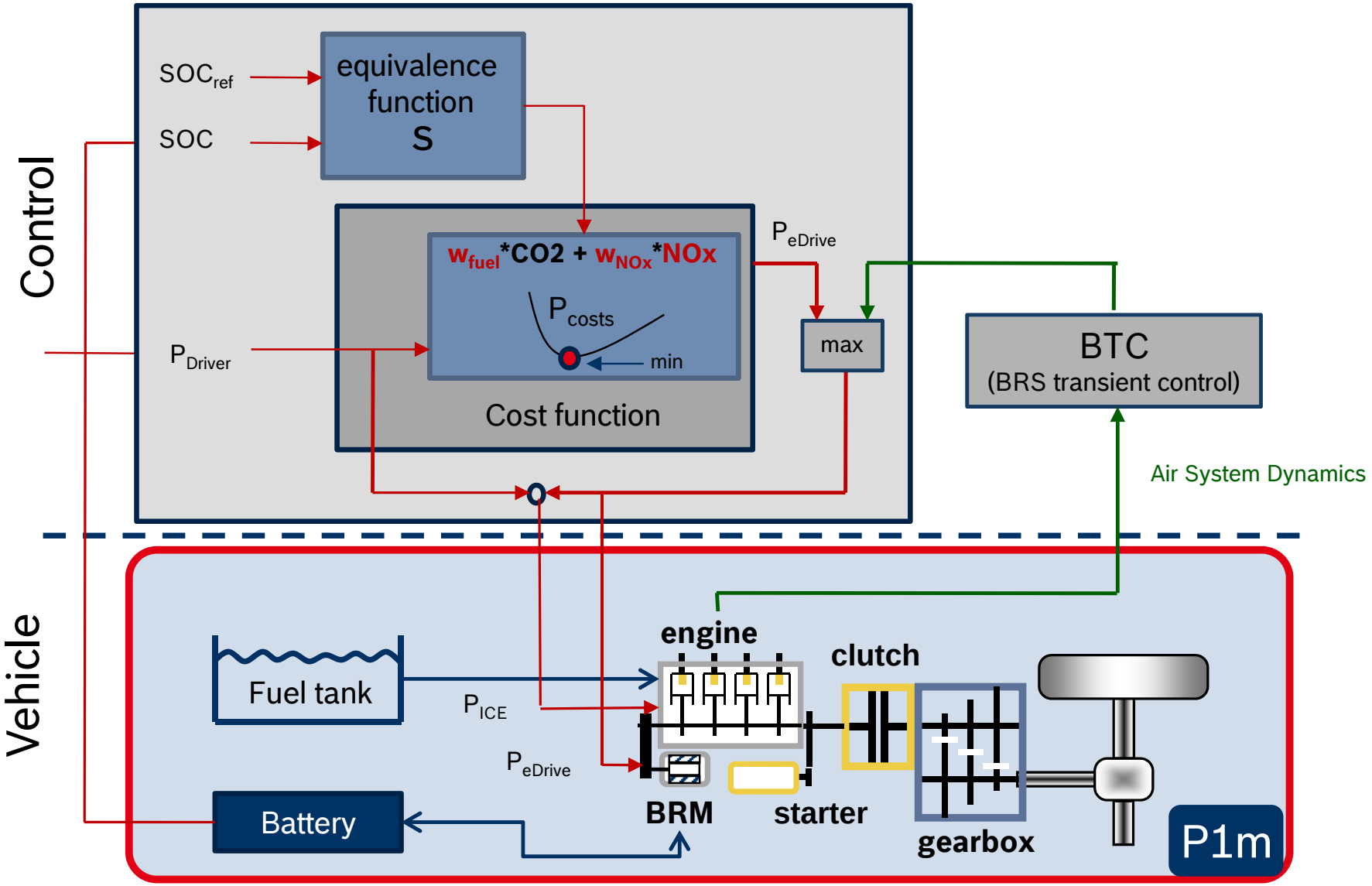
ECMS: Equivalent Consumption Minimization Strategy

Results Diesel ECMS:



Reduced NO_x-Emissions w/ comparable consumption improvement for w_{fuel} = 0,8

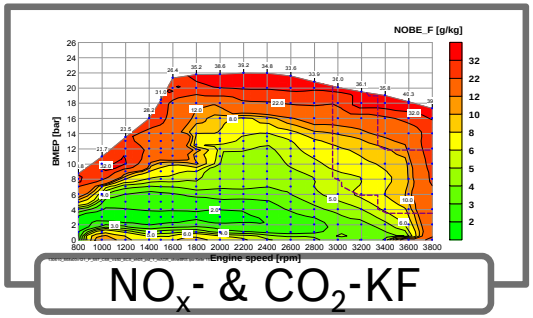
Transient Diesel ECMS controller structure:

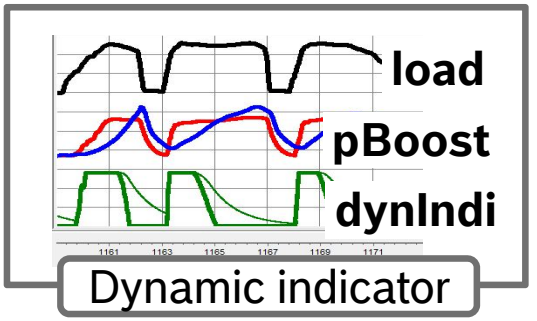


BRS transient control (BTC): Motivation

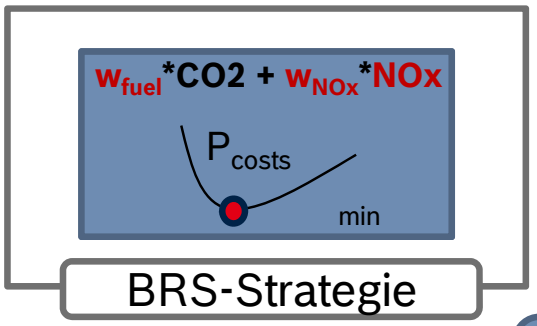
ECMS: Stationary Emissions → BTC: Transient Emissions

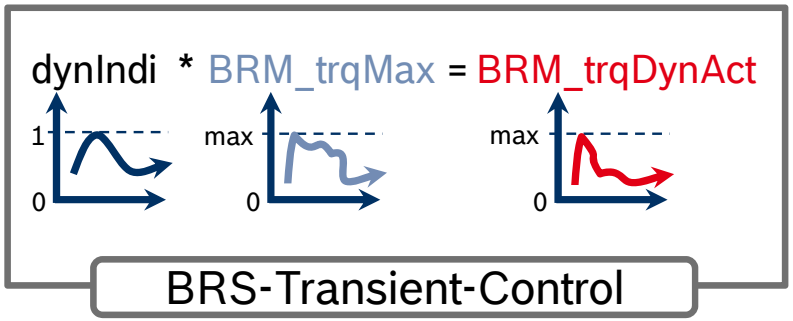
Diesel ECMS based on stationary NO_x-/CO_2-Maps

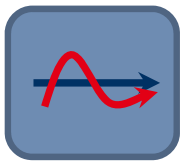




Dynamic indicator (rel. boost pressure deviation)

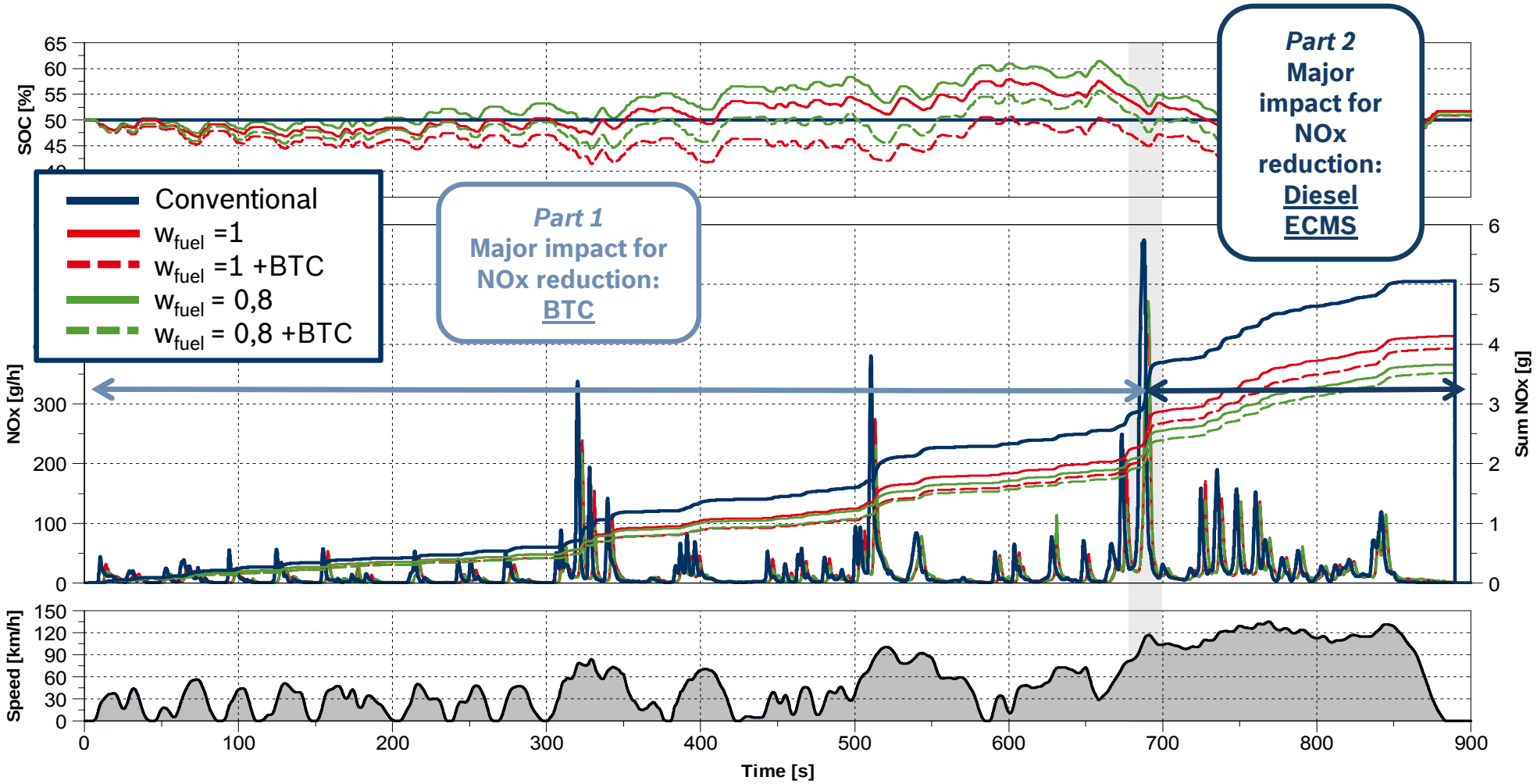






Additional transient torque intervention by BTC

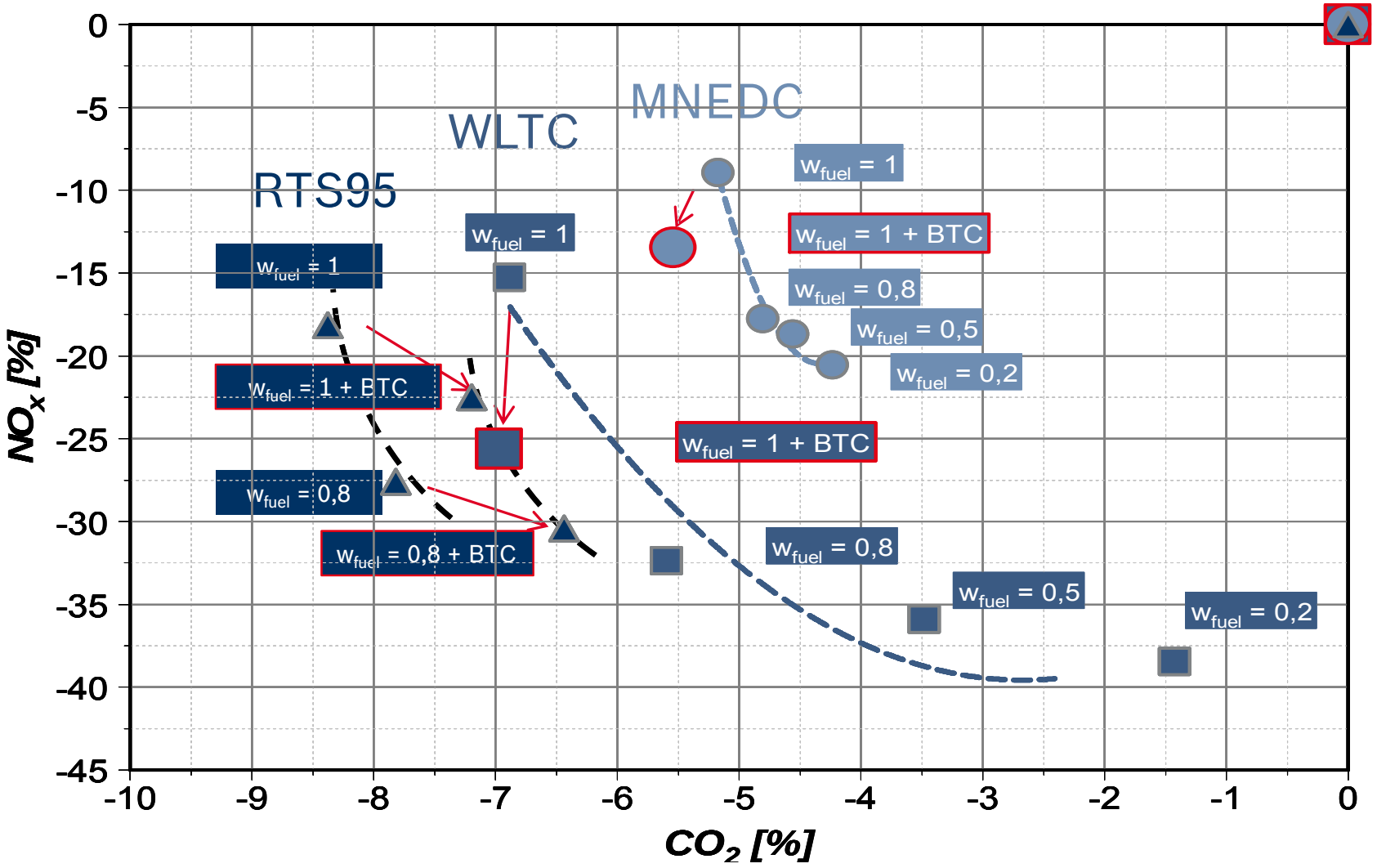
Results Diesel ECMS + BTC:



Minimal NO_x-emissions with 80%-CO_2+BTC

CO_2 and NO_x potential:

w/o BRS



Increasing CO2 and NOx potential for real driving conditions

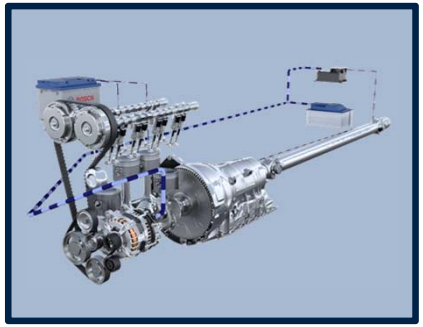
BOSCH HEV product portfolio:

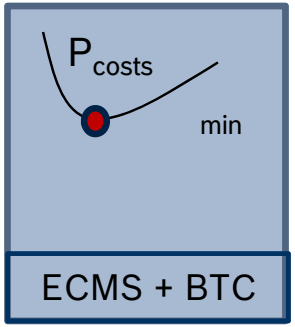
P-HEV

S-HEV

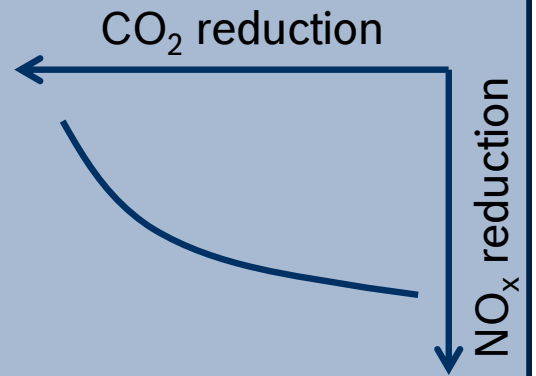
BRS 48V

Components Systems Functions

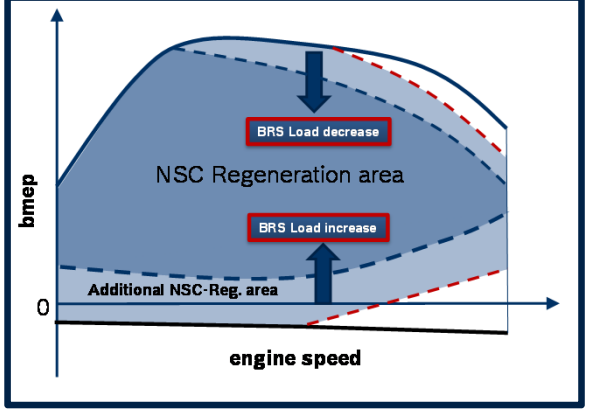




Engine



EGT



BOSCH enables optimized overall system w/ minimized CO_2 and NO_x emissions

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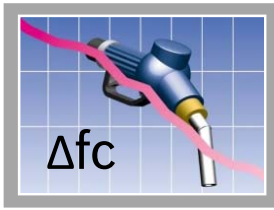
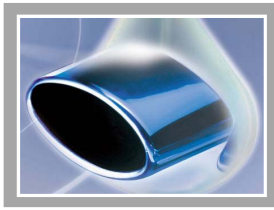
Air System Approach

	performance TC	efficiency TC	2-stage TC		efficiency TC + transient control
 time to torque	base line • TiAl turbine • ball bearing • RDE compliant	-33%	simulation only -40%		-33%
 MNEDC WLTP		-2.7% -1.8%	-3.5% -2.6%		-2.7% -1.8%
 NO_x peak reduction		-12%	not measured		-40%

- Optimized overall system including RDE compliance developed by Bosch and BMTS
- Reduced fuel consumption demonstrated with further potential for down speeding
- Significant reduction of transient NO_x emissions due to fast boost pressure built up and advanced transient control:
  → Reduction of costs for the EGT system possible + Fuel and cost efficient overall system

Diesel Hybridization Concept

- A holistic approach for Diesel Hybrid Operating strategy was **realized**
- Potential for CO_2 and NO_x reduction was demonstrated in three different driving cycles: MNEDC, WLTC, RTS95
- Increasing CO_2 and NO_x potential for realistic driving cycles compared to homologation cycles
- Diesel Hybrid Operating Strategy as one option for RDE fulfilment
- Available as platform ECU function
- Future development:
  - Enlarge to higher hybridisation degrees (S-HEV, P-HEV)
  - Adaptive closed loop operating strategy
  - Include short-, mid- and long range prediction

Bosch Diesel Systems beyond FIE & EGT

Thank you for your attention !
Questions ?

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