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Swiss Competence Center for Energy Research
Efficient Technologies and Systems for Mobility

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Optimal and Universal Calibration of a Heavy-Duty Diesel Engine and Aftertreatment System

The aim of this research project is the development of a so-called universal optimal calibration methodology for the engine control unit. The key idea is to calculate and store the multitude of all possible optimal emission-strategies and choose them freely depending on the engine model, application and environmental conditions. Thus, the calibration process is streamlined for the various engines and applications, thereby greatly reducing the development time and cost. Moreover, the method ensures that the maximum potential of the engine is used, thus minimizing the environmental impact. In a final step, the optimization is to be performed for the engine and aftertreatment system combined, which could reduce fuel consumption and pollutant emissions even further. The project is supported by Liebherr Machines Bulle SA.

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1. Introduction

Modern Diesel engine systems: various engine sizes, applications and operating conditions + increase in number and variety of actuators:

➞ **Large calibration efforts**

Optimized separately: Diesel engine raw emissions (NOx, soot) and exhaust gas aftertreatment system (SCR [1]):

➞ **Full potential not reached**

2. Universal Engine Calibration

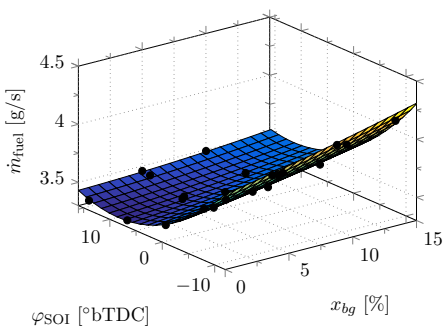
Goal: Development of a systematic model-based method to optimize the reference values for the feedforward and feedback controllers of the engine actuators.

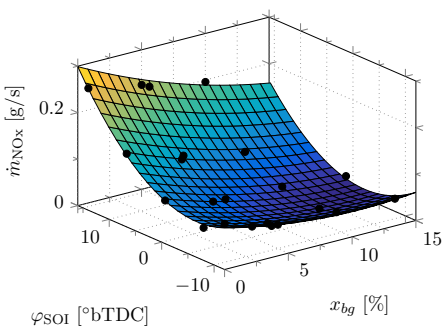
Method: Flexible optimization of fuel consumption and pollutant emissions [2]:

$$H(\boldsymbol{u}, \mu_{NOx}) = (1 - \mu_{\mathrm{NOx}})\, \dot{m}_{\mathrm{fuel}} + \mu_{\mathrm{NOx}}\, \dot{m}_{\mathrm{NOx}}(\boldsymbol{u})$$

$$\boldsymbol{u}^*(\mu_{NOx}) = \arg\min_{\boldsymbol{u}} H(\boldsymbol{u}, \mu_{NOx})$$

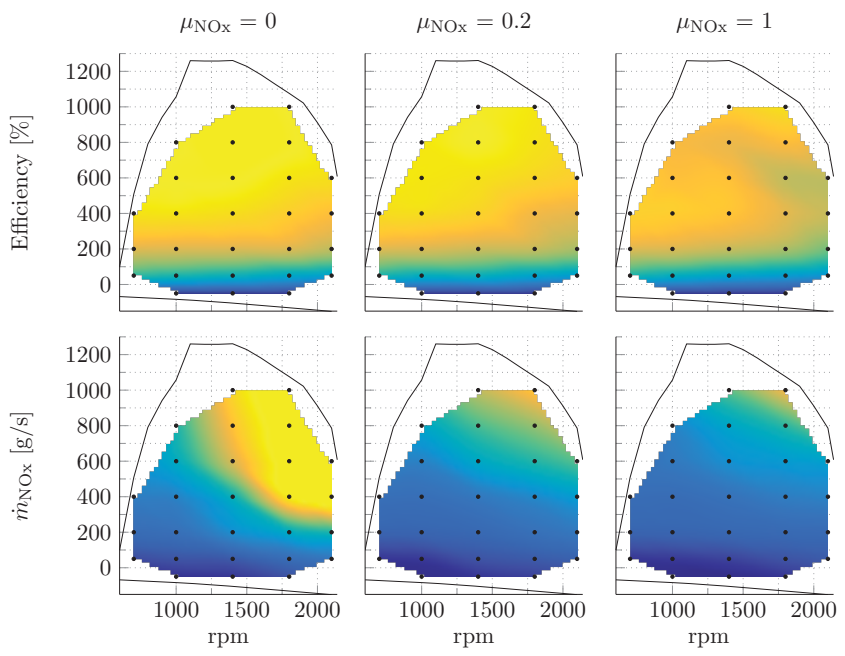
Weighting or "strategy" $\mu_{\mathrm{NOx}} \in [0,1]$ not fixed a priori, but kept as a tuning variable during and after calibration. All choices for μ_{NOx} (strategies) are Pareto optimal.

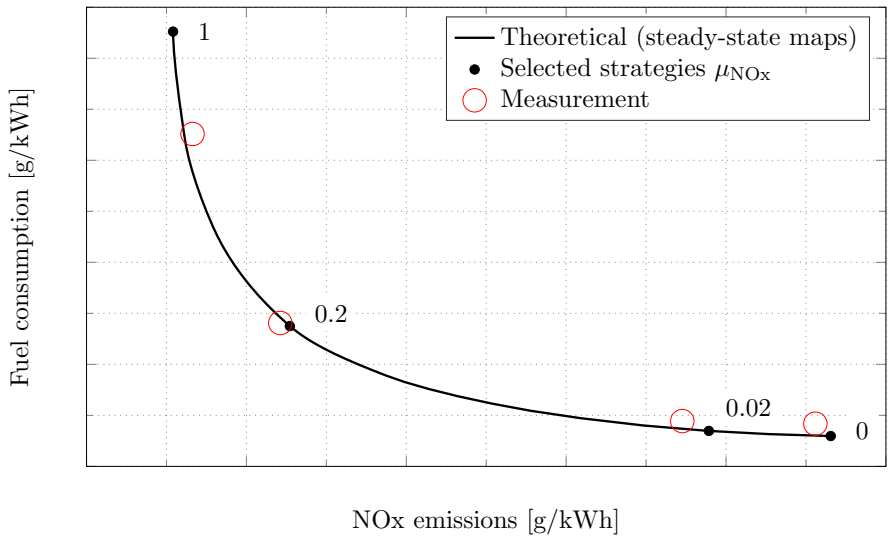




3. First Results

- Flexible calibration of engine maps.
- Validation of steady-state assumption for Nonroad Transient Cycle (NRTC)





References

[1] M. Wang, Model-Based Control of Selective Catalytic Reduction Systems, PhD Thesis No. 22829, ETH Zurich, 2015.

[2] P. Elbert, C. Barro, A. Amstutz, C. Onder and K. Boulouchos, Emissionsoptimierter Dieselmotor, Informationstagung Motoren R572, Pages 4-45, Frankfurt, 2015.

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