



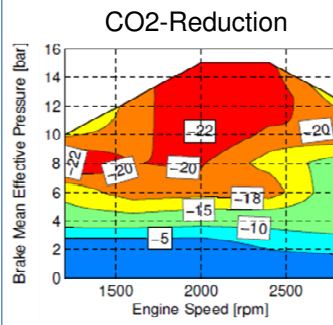
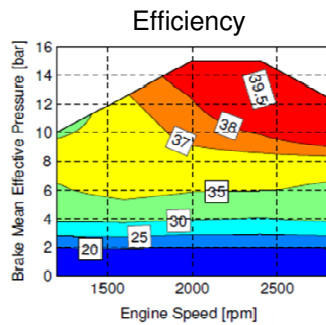
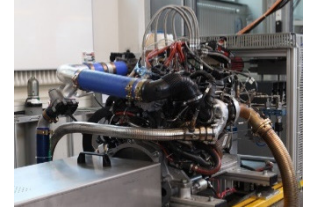
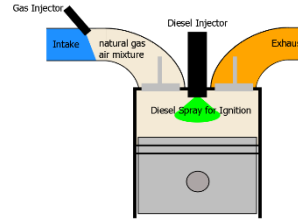
# Natural Gas-Diesel Engine

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## Introduction

The natural gas-diesel engine is a gas engine where the premixed air-gas mixture is ignited by a small amount of directly injected diesel fuel. The concept can be realized by modifying a production type diesel engine slightly through the addition of natural gas port injectors.

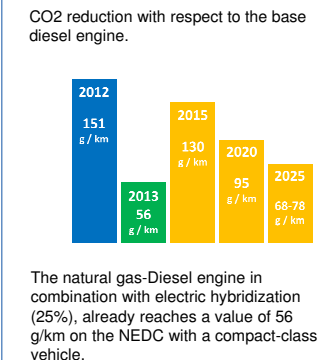
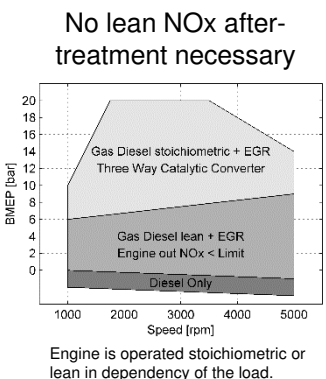
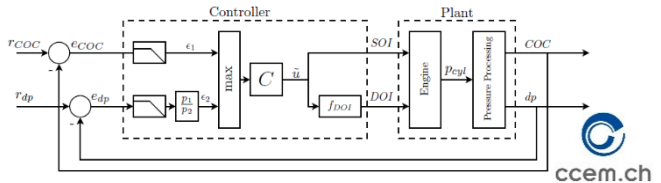
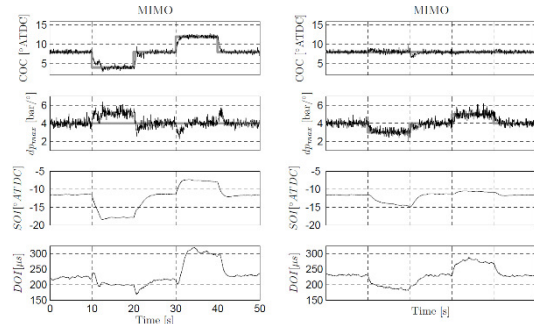
The natural gas-diesel engine has proven its potential of highly efficient operation with low CO<sub>2</sub> emissions on the test-bench of the Institute for Dynamic Systems and Control.



## Combustion Control

The combustion timing in the natural gas-diesel engine depends on the chemical reaction kinetics of the injected diesel fuel. The process is therefore prone to disturbances in temperature and composition. To overcome this problem, cylinder individual feedback control is applied based on the measured cylinder pressure.

The center of combustion and maximum pressure rise rate are controlled by manipulating the start and duration of the diesel injection.



## Thermal Management & HC Avoidance

### Challenges

- Efficient, lean combustion leads to low exhaust gas temperature
- Stability of Methane requires high catalyst temperatures for oxidation
- Reaching and maintaining the operating temperature in the three way catalytic converter is the critical task of the exhaust gas abatement system of the natural gas-diesel engine.

### Goals

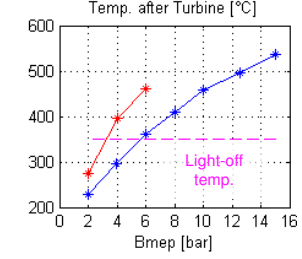
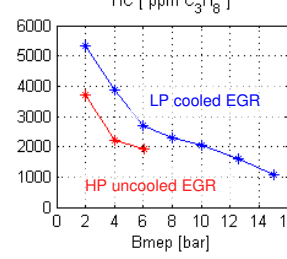
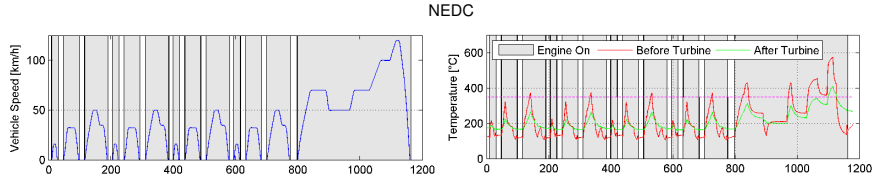
- Increase exhaust temperature
- Reduce HC emissions
- Avoid CH<sub>4</sub> emissions if catalyst temperature is below light-off temperature

### Methods

- Increase intake temperature
- Late injection/ post injection
- Increase engine load (Hybrid)
- Combustion control
- Pure diesel operation

### Optimal control of all degrees of freedom

- Type of fuel
- Type of EGR
- EGR cooling
- Lambda
- Combustion phasing
- Hybridization



Stationary HC engine-out emissions for two different types of Exhaust gas recirculation (high and low pressure).