

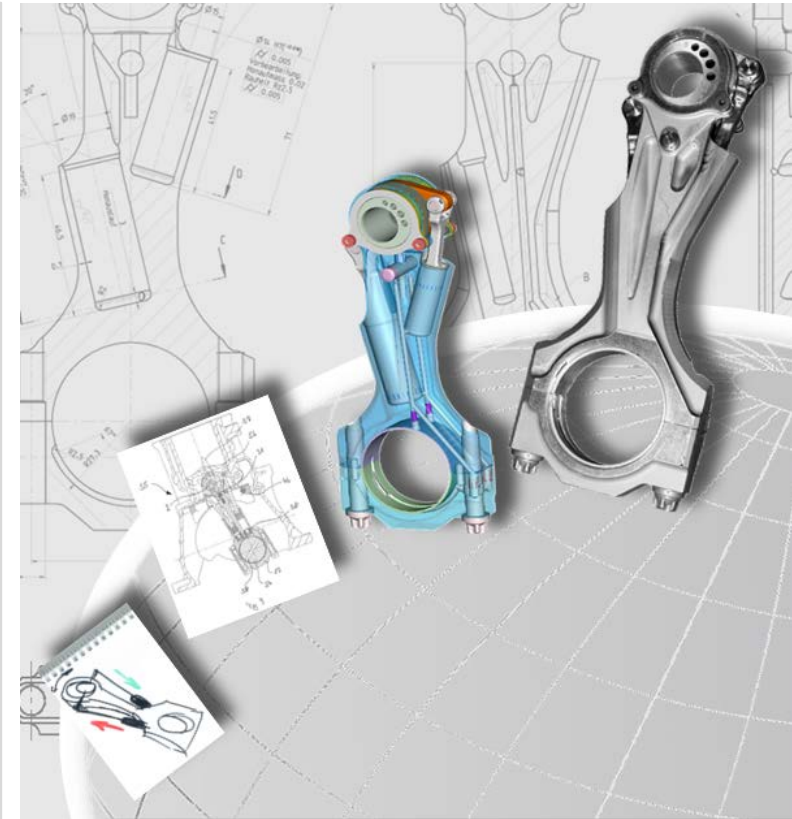
# Two-Stage Variable Compression Ratio (VCR) System to Increase Efficiency in Gasoline Powertrains

DEER Conference 2012

D. Tomazic, H. Kleeberg, S. Bowyer, FEV Inc.

J. Dohmen, K. Wittek, B. Haake, FEV GmbH

Dearborn, October 16<sup>th</sup>, 2012



# Content

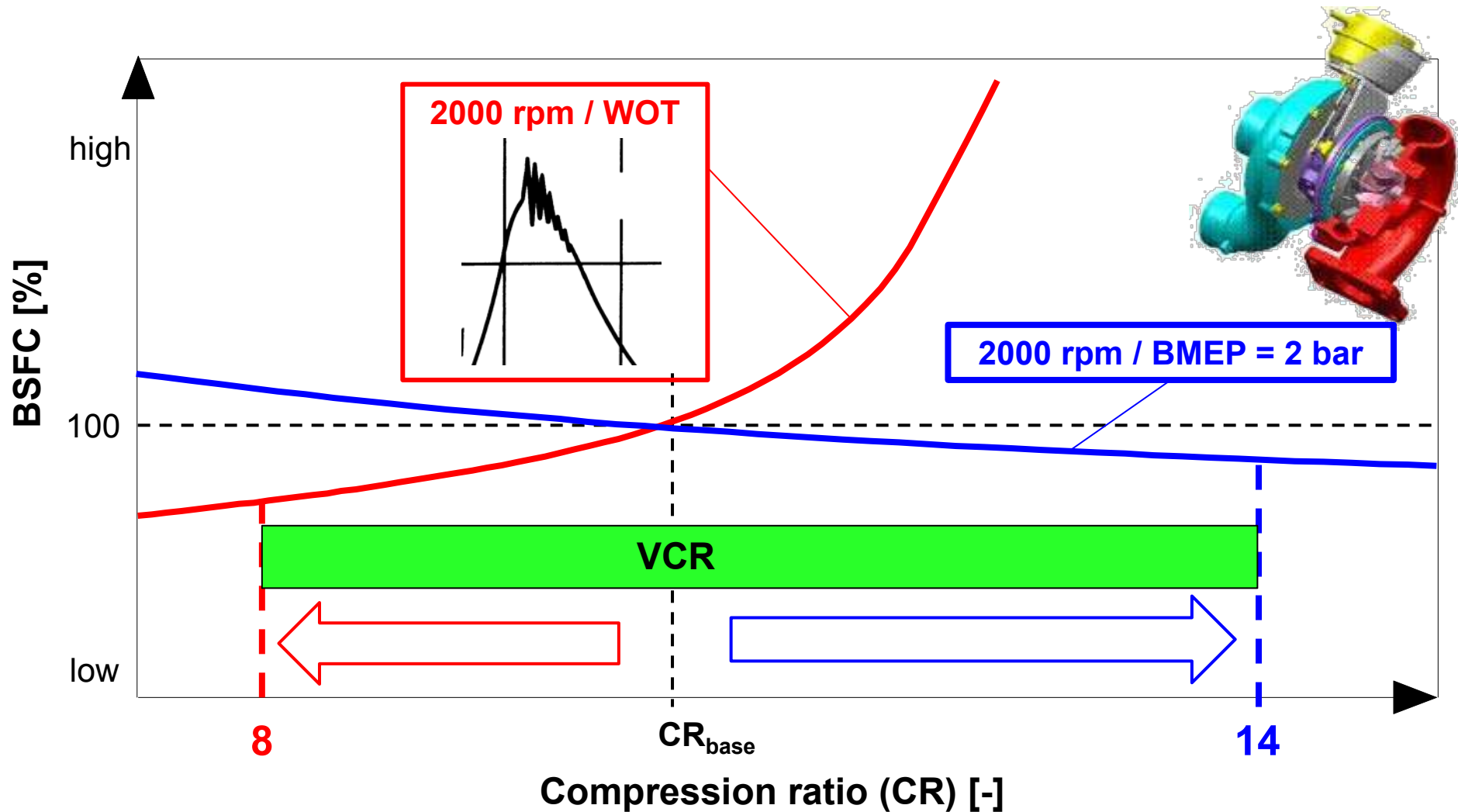
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- **Introduction and motivation**
- **Layout of FEV's two-stage VCR system**
- **CO<sub>2</sub> reduction potential**
- **Combination with future technologies**
- **Summary and conclusion**

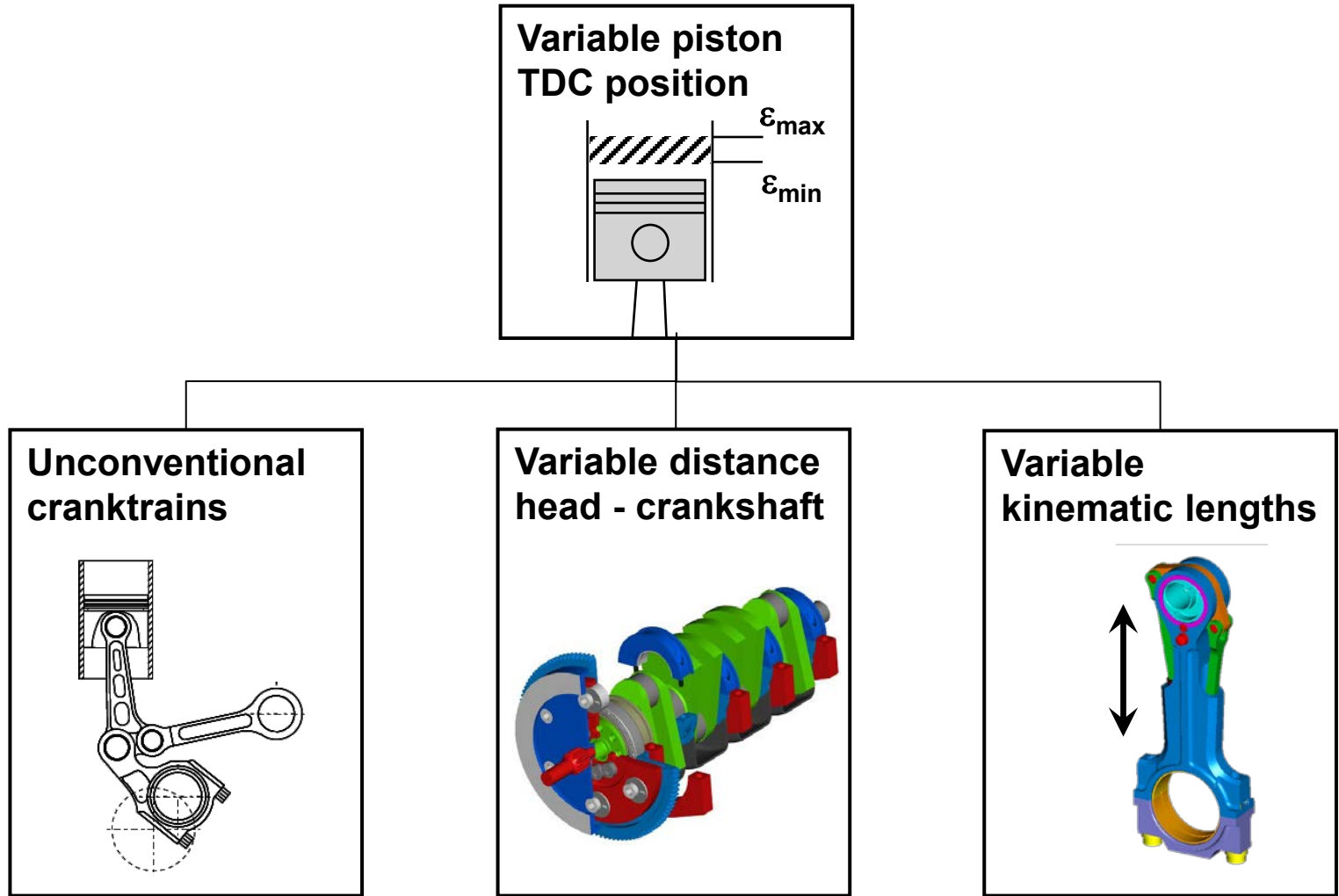
# Introduction and Motivation

## Principle Influence of Compression Ratio on Fuel Consumption



# Introduction and Motivation

## Classification of VCR Systems



# Content

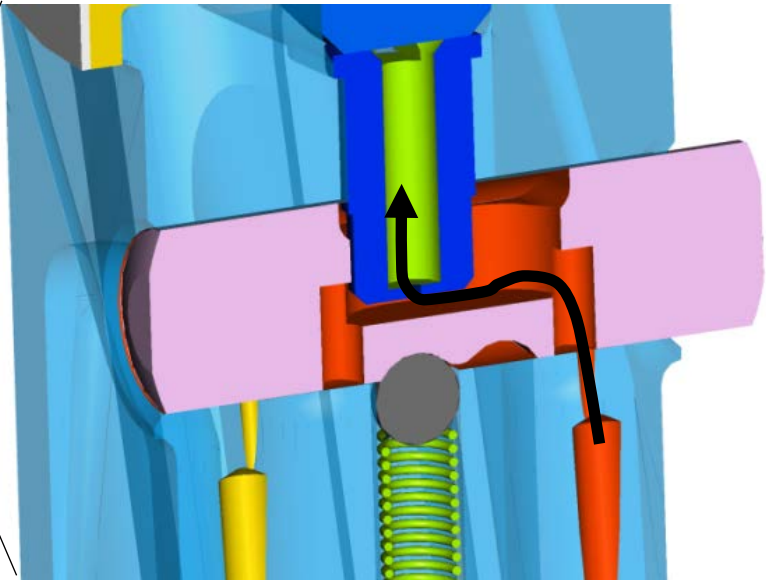
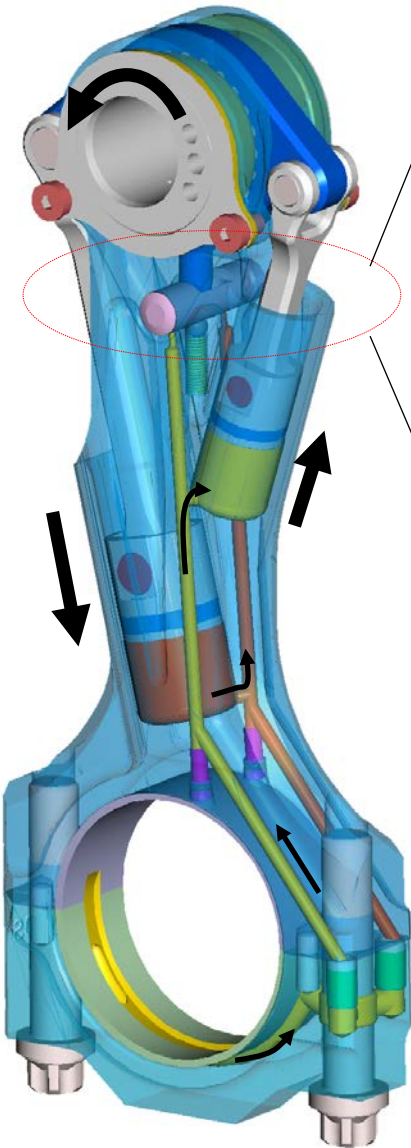
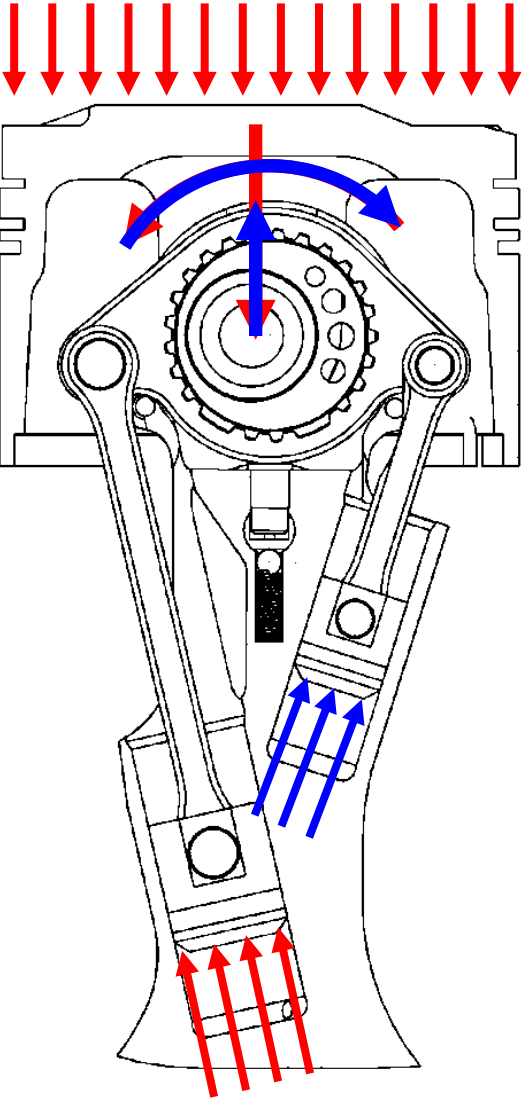
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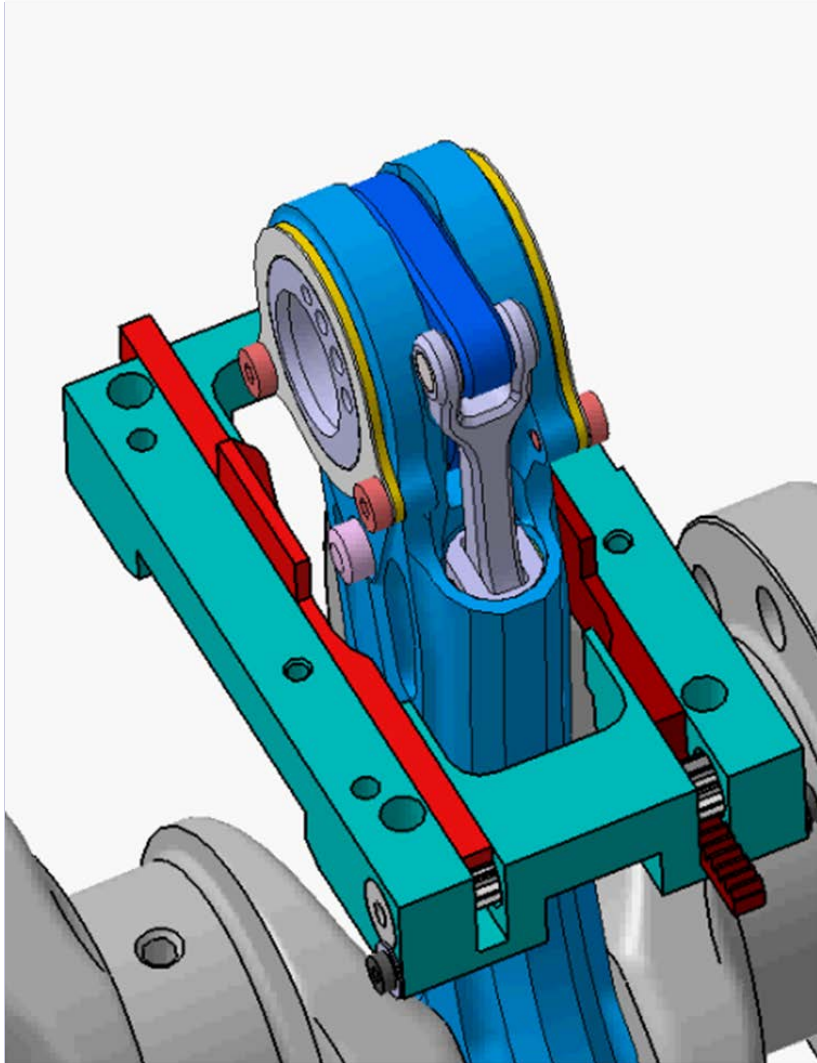
# Layout of FEV's Two-stage VCR System

## Working Principle: Conrod

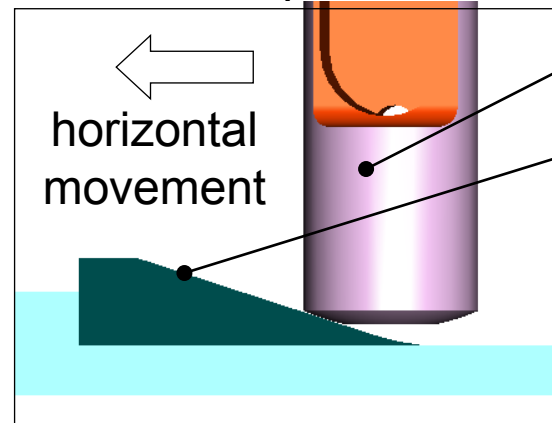


# Layout of FEV's Two-stage VCR System

## Working Principle: Mechanical Actuation

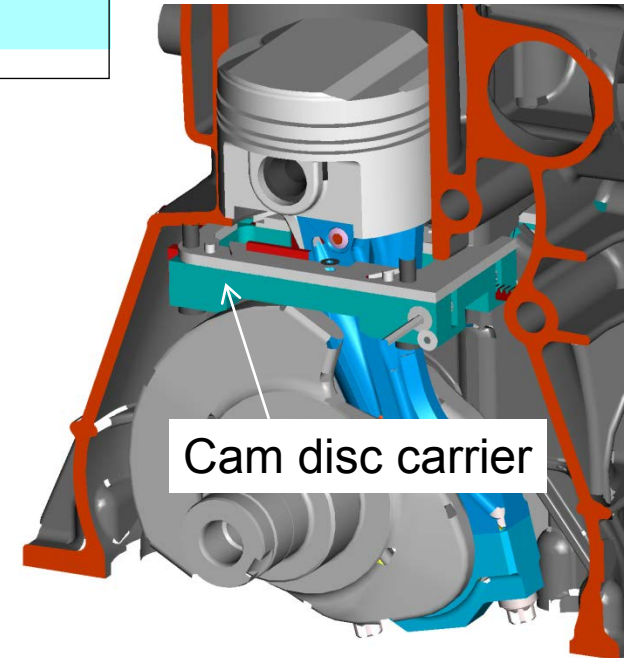


View from top



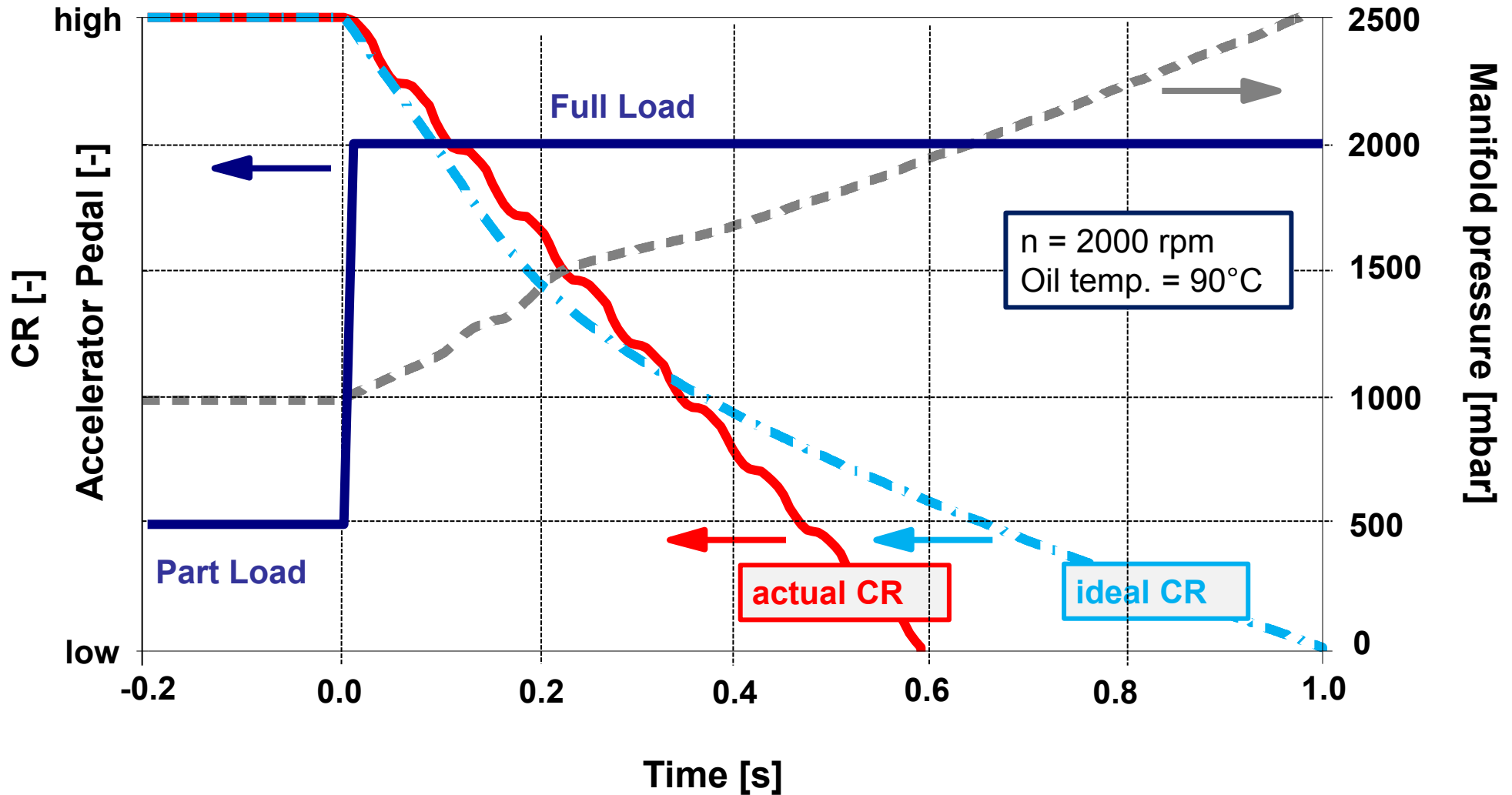
valve body

functional surface



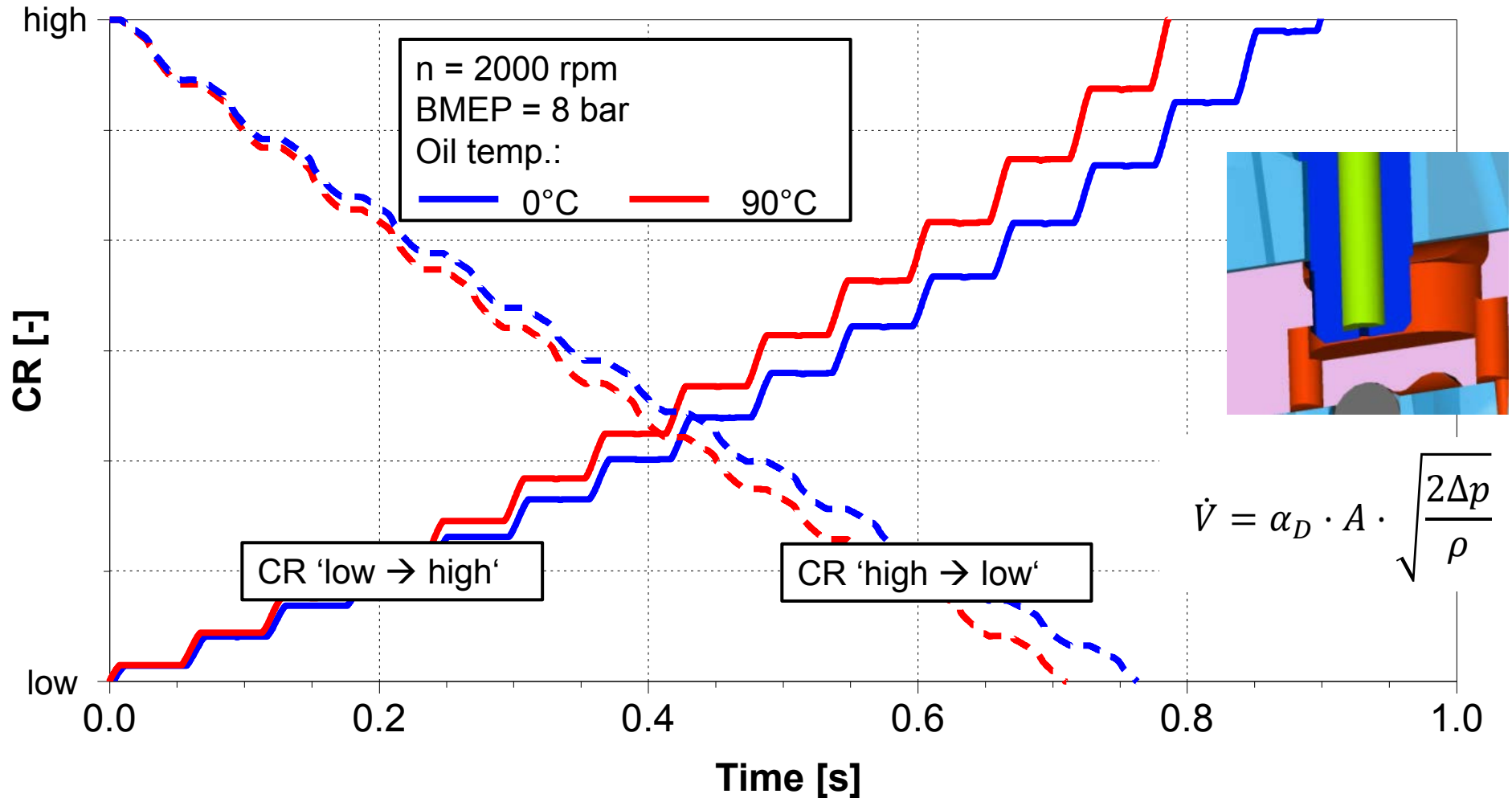
Cam disc carrier

# Layout of FEV's Two-stage VCR System Transition Time During Load Step





# Layout of FEV's Two-stage VCR System Influence of Oil Temperature





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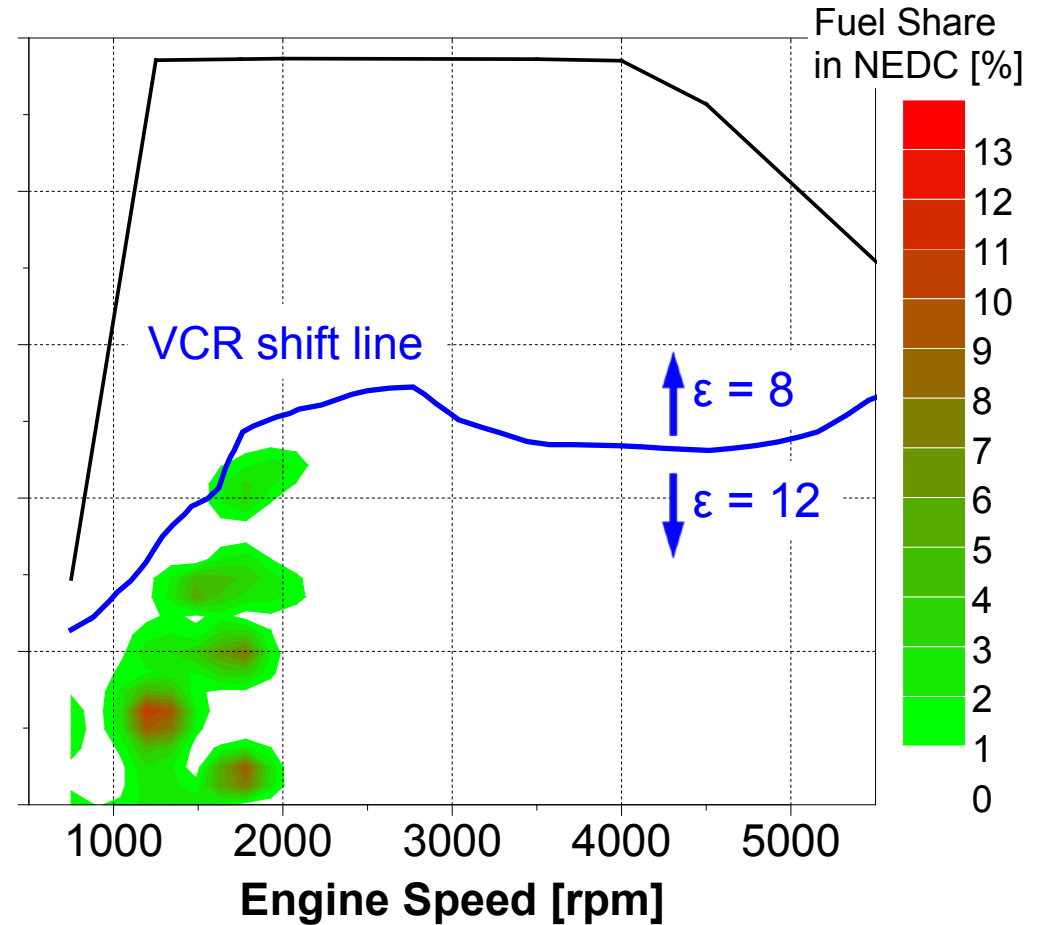
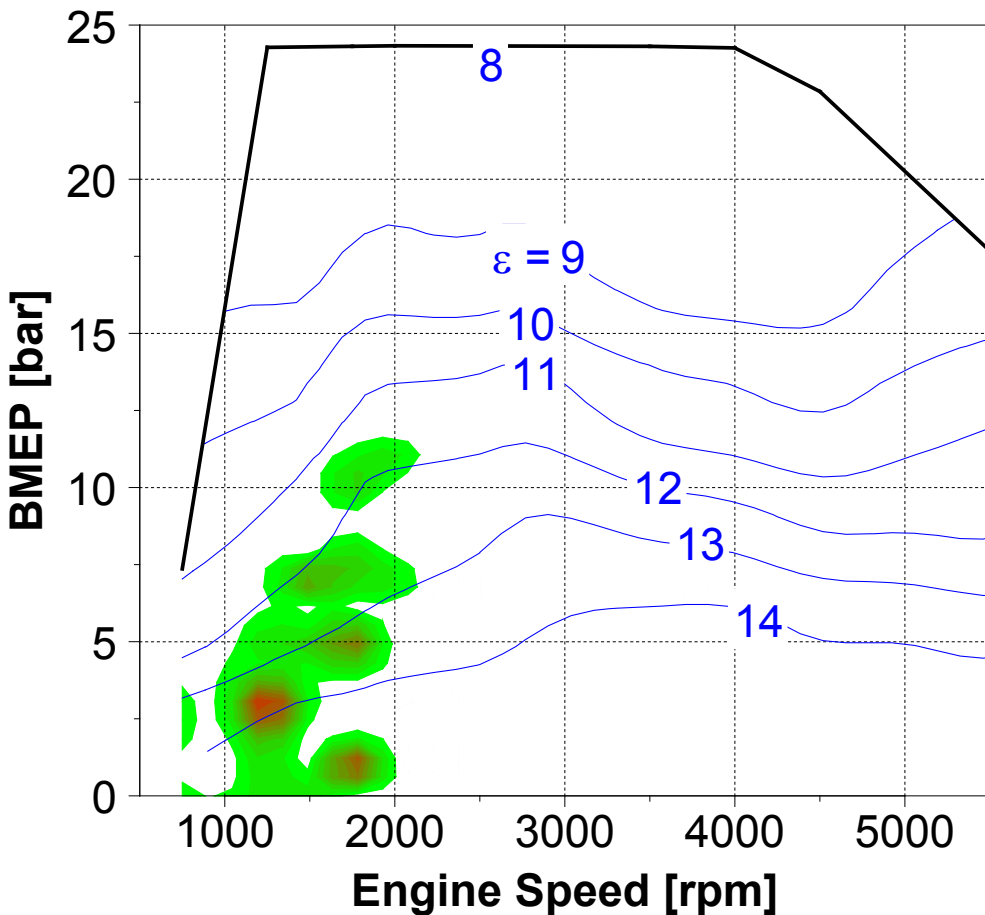
# CO<sub>2</sub> Reduction Potential

## Compression Ratio Maps Continuous VCR vs. Two-stage VCR



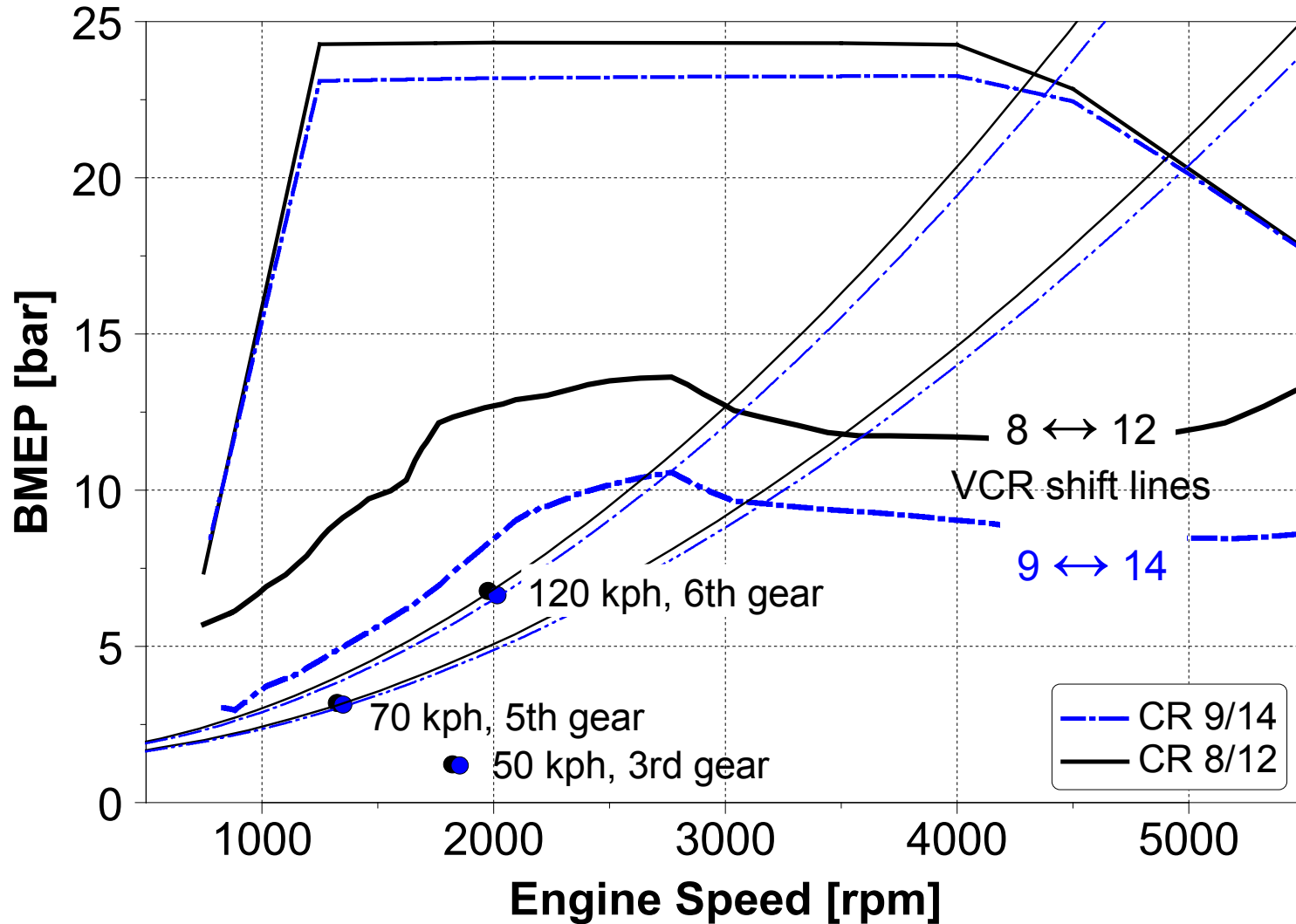
### Continuous VCR

### Two-stage VCR CR 8/12



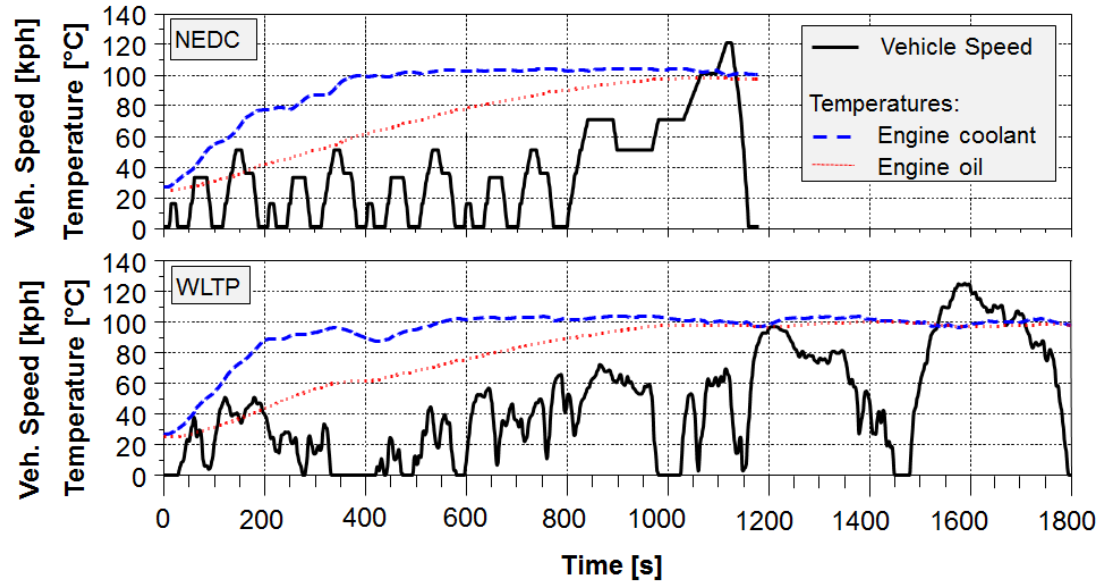
# CO<sub>2</sub> Reduction Potential

## Influence of CR-stages on the VCR Shift Line and BMEP at WOT



# CO<sub>2</sub> Reduction Potential

## Simulation Boundaries - Europe

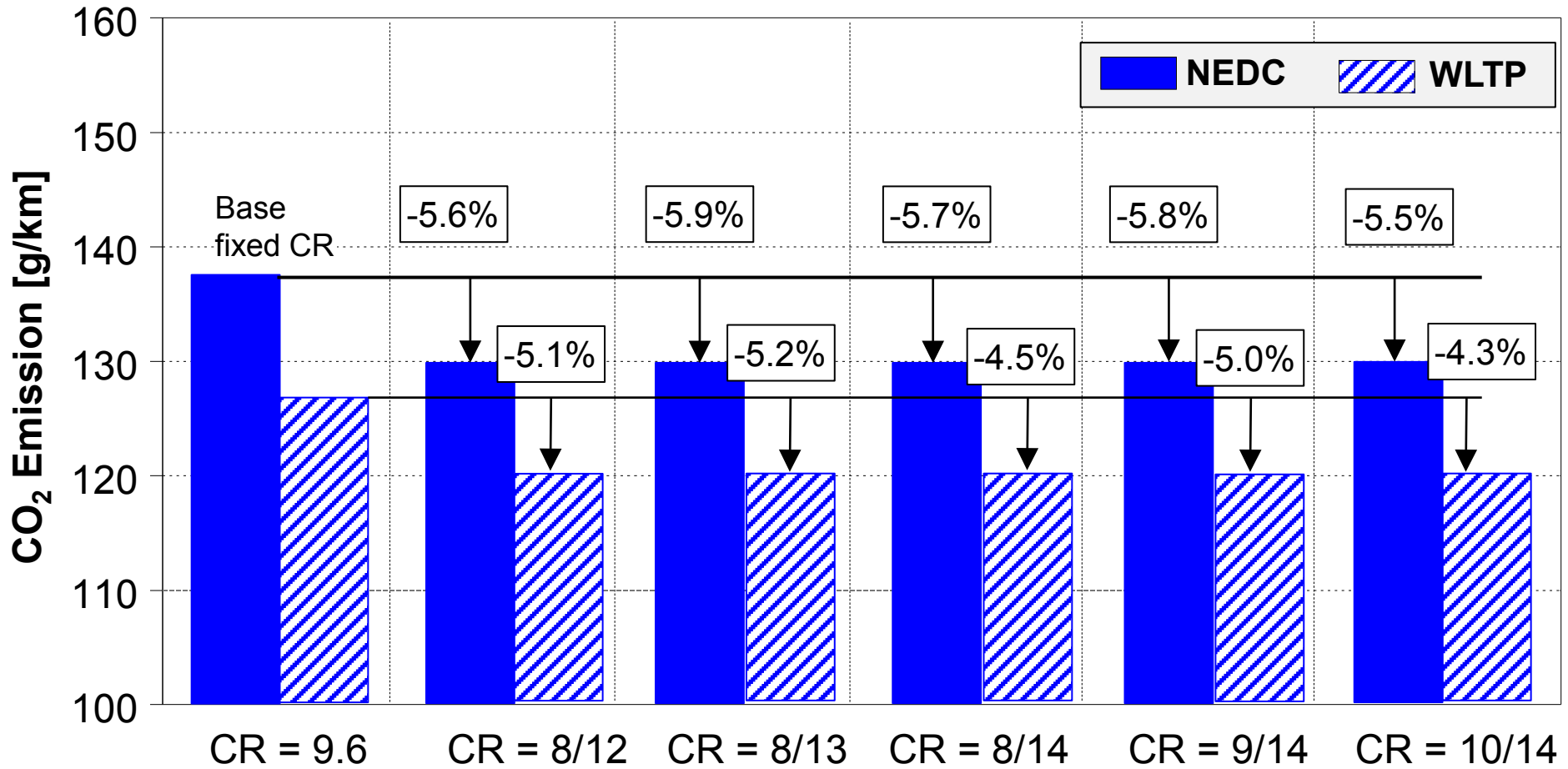


- Vehicle IWC 1372 kg
- 6-speed MT
- 2.0 L TC GDI, RON 95
- $P_{\max} = 180$  kW (const.)
- Base CR 9,6  
( $BMEP_{\max} = 22$  bar)
- $BMEP_{\max}$  (function of  $CR_{\text{low}}$ )

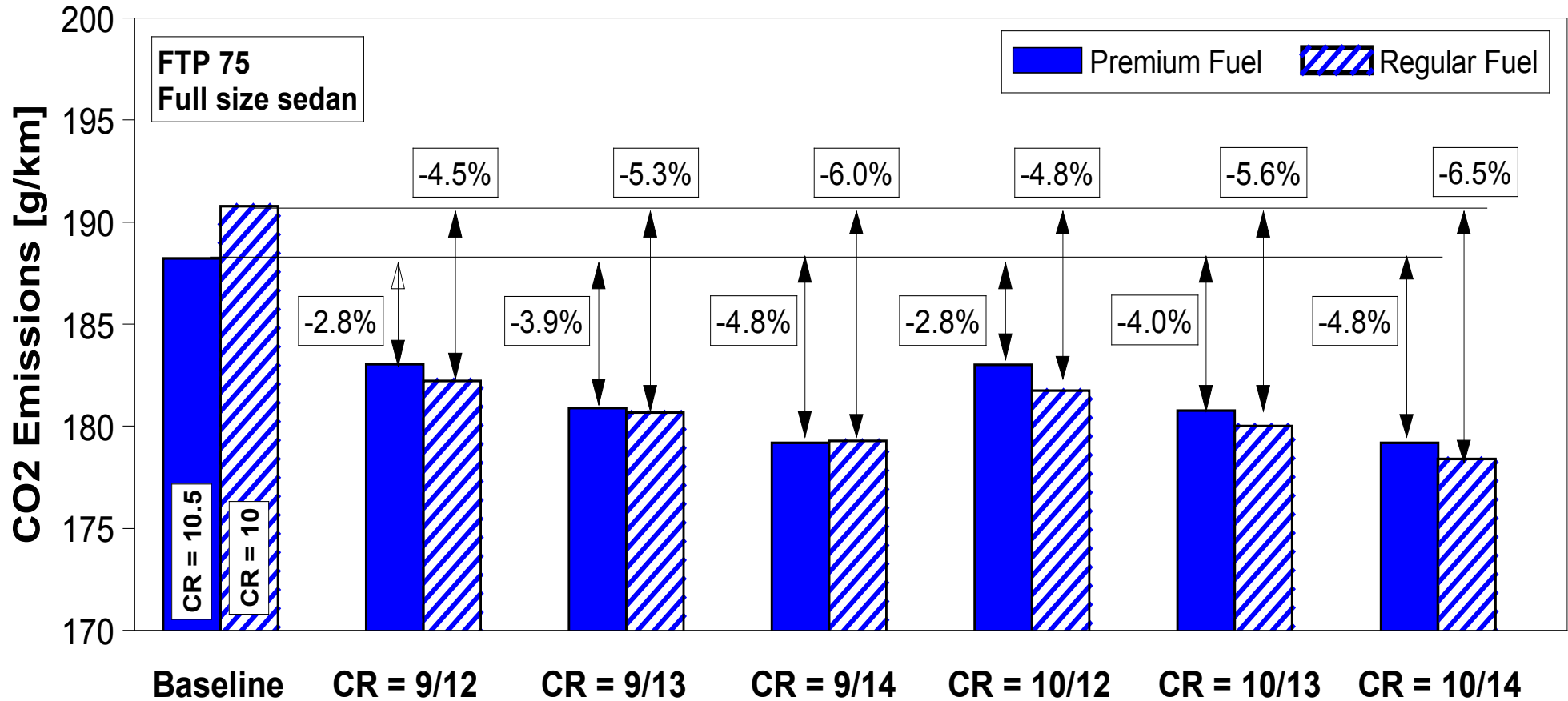
### Layouts of CR stages

8/12      8/13      8/14      9/14      10/14

# CO<sub>2</sub> Reduction Potential Simulation Results - Europe



# CO<sub>2</sub> Reduction Potential Simulation Results - USA

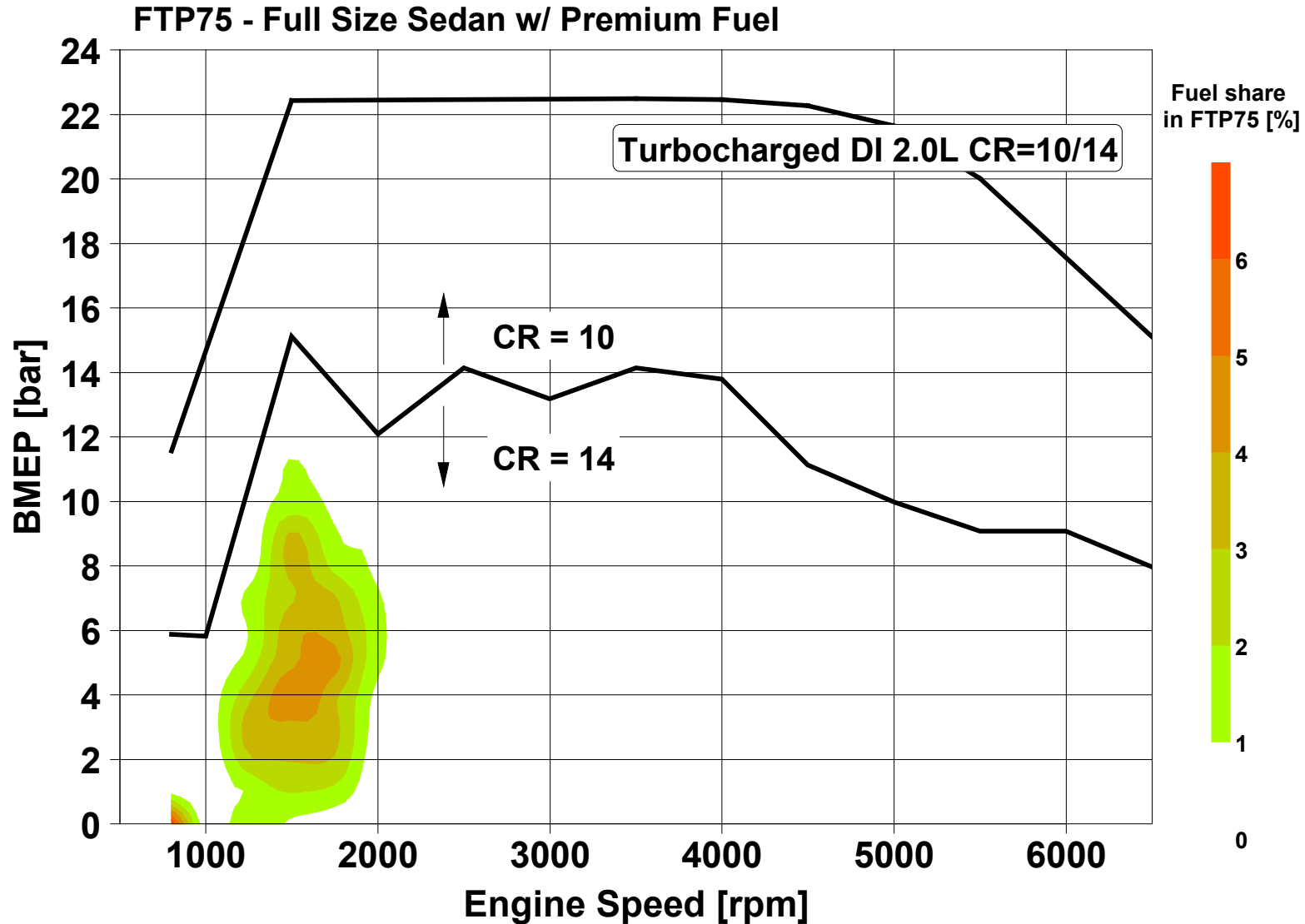


**Vehicle: 1670 kg (3682 lbs)**

**Engine: 2.0L GTDI w/ P = 180 kW; RON 95**

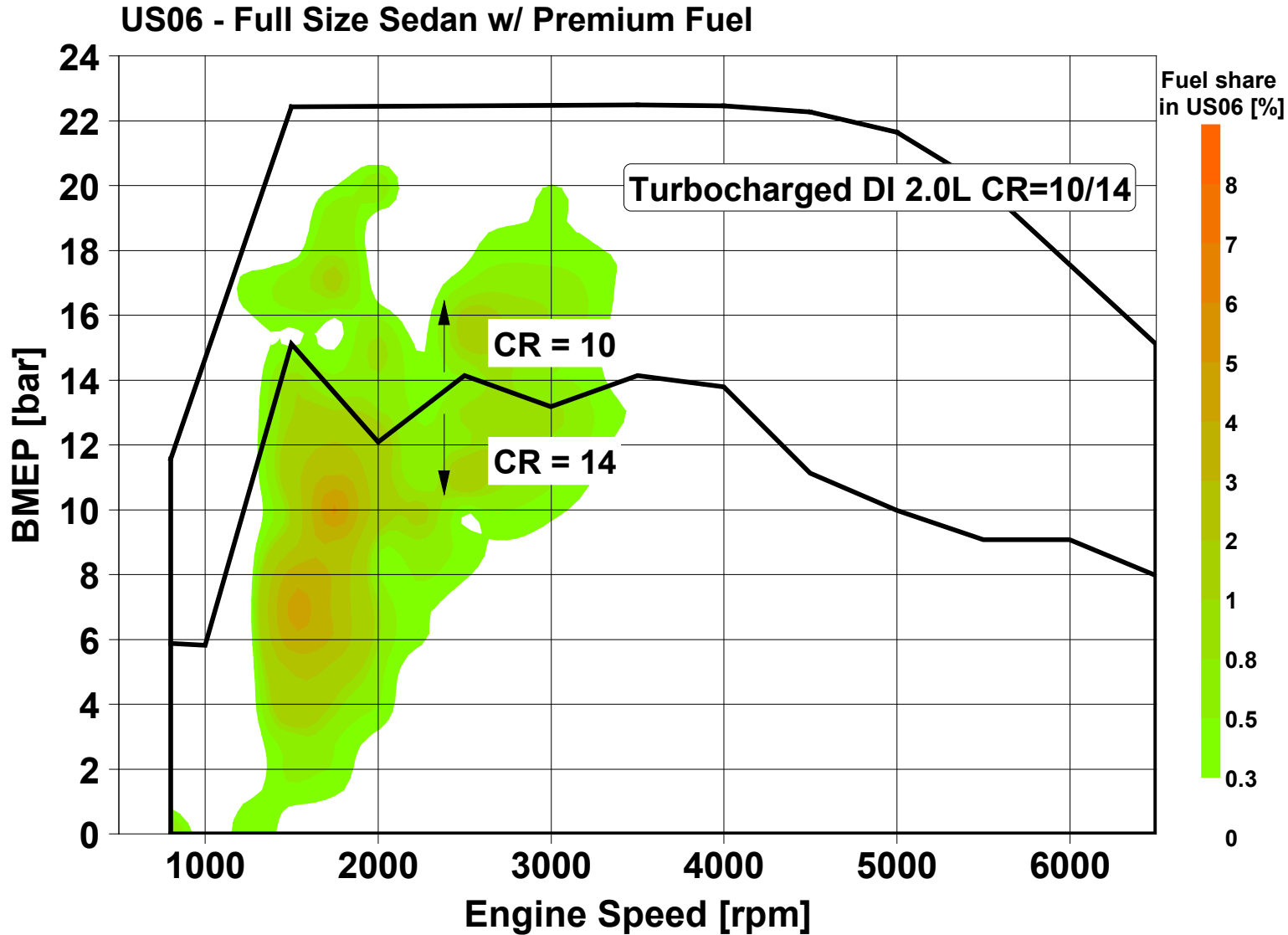
**Transmission: 7 Speed wet DCT**

# CO<sub>2</sub> Reduction Potential Simulation Results - USA





# CO<sub>2</sub> Reduction Potential Simulation Results - USA





# Content

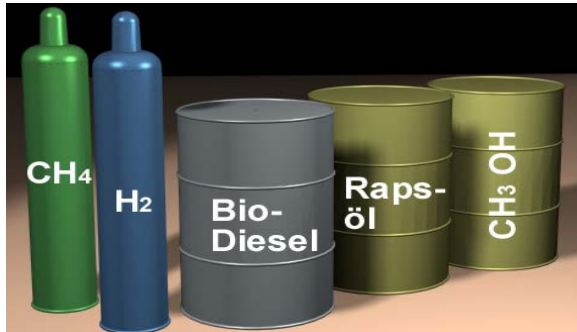
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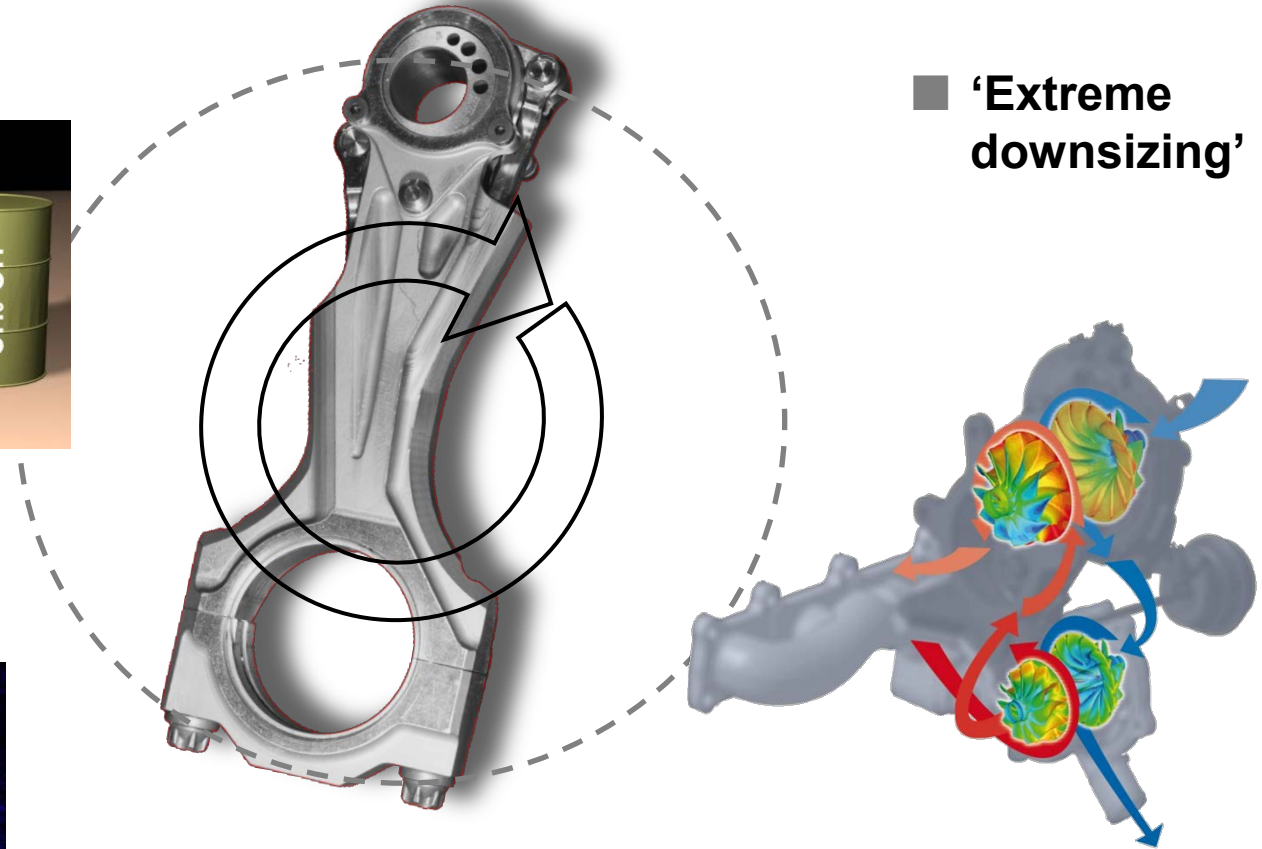
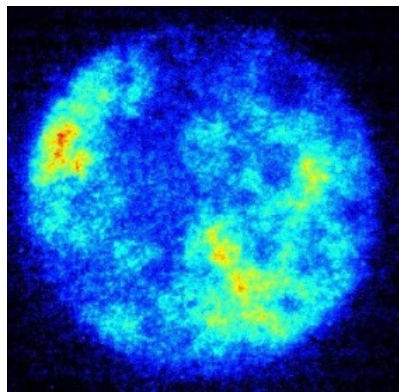
# Combination with Future Technologies



## ■ Alternative fuels



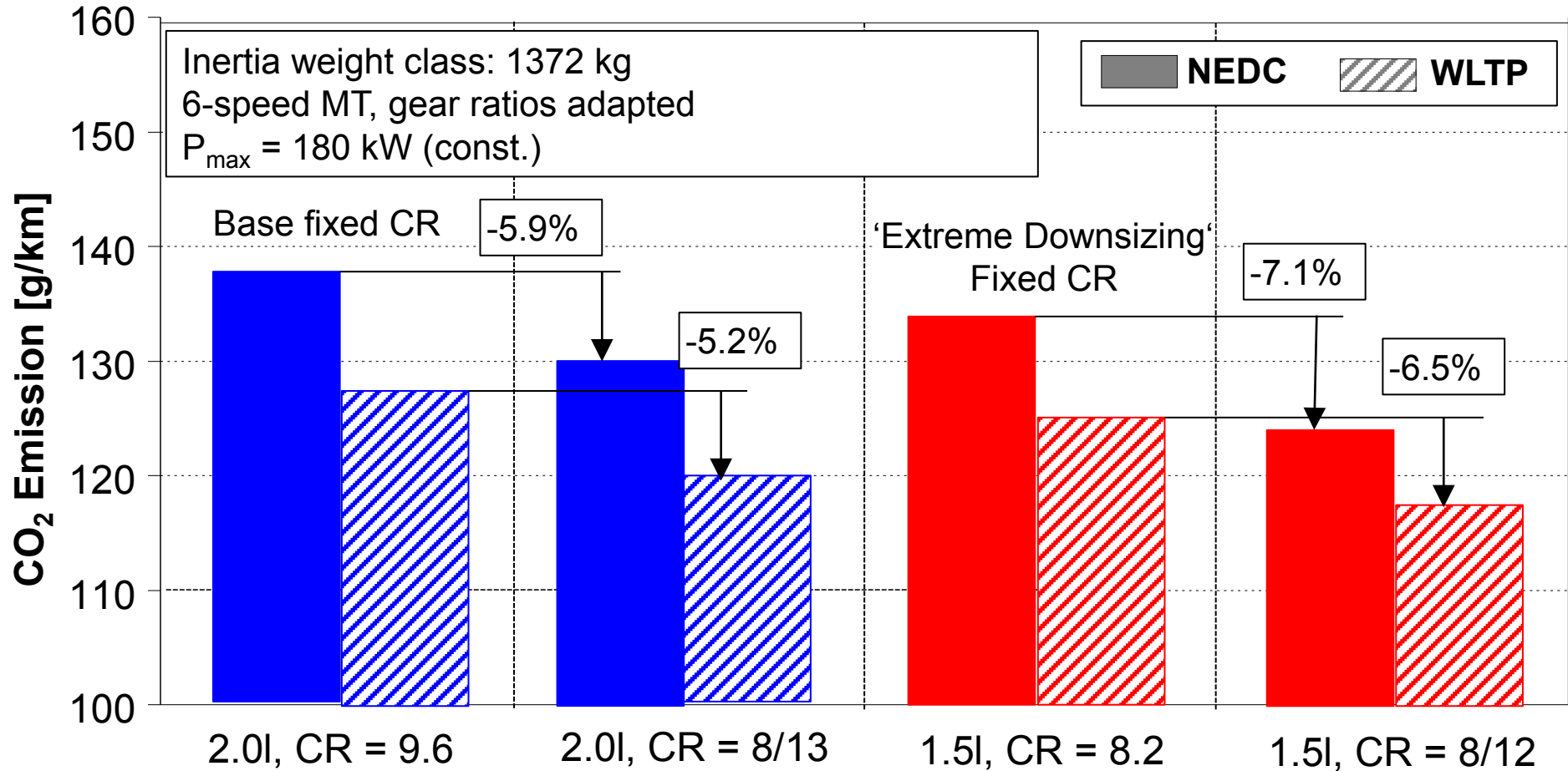
## ■ Gasoline controlled auto ignition (GCAI)



## ■ 'Extreme downsizing'

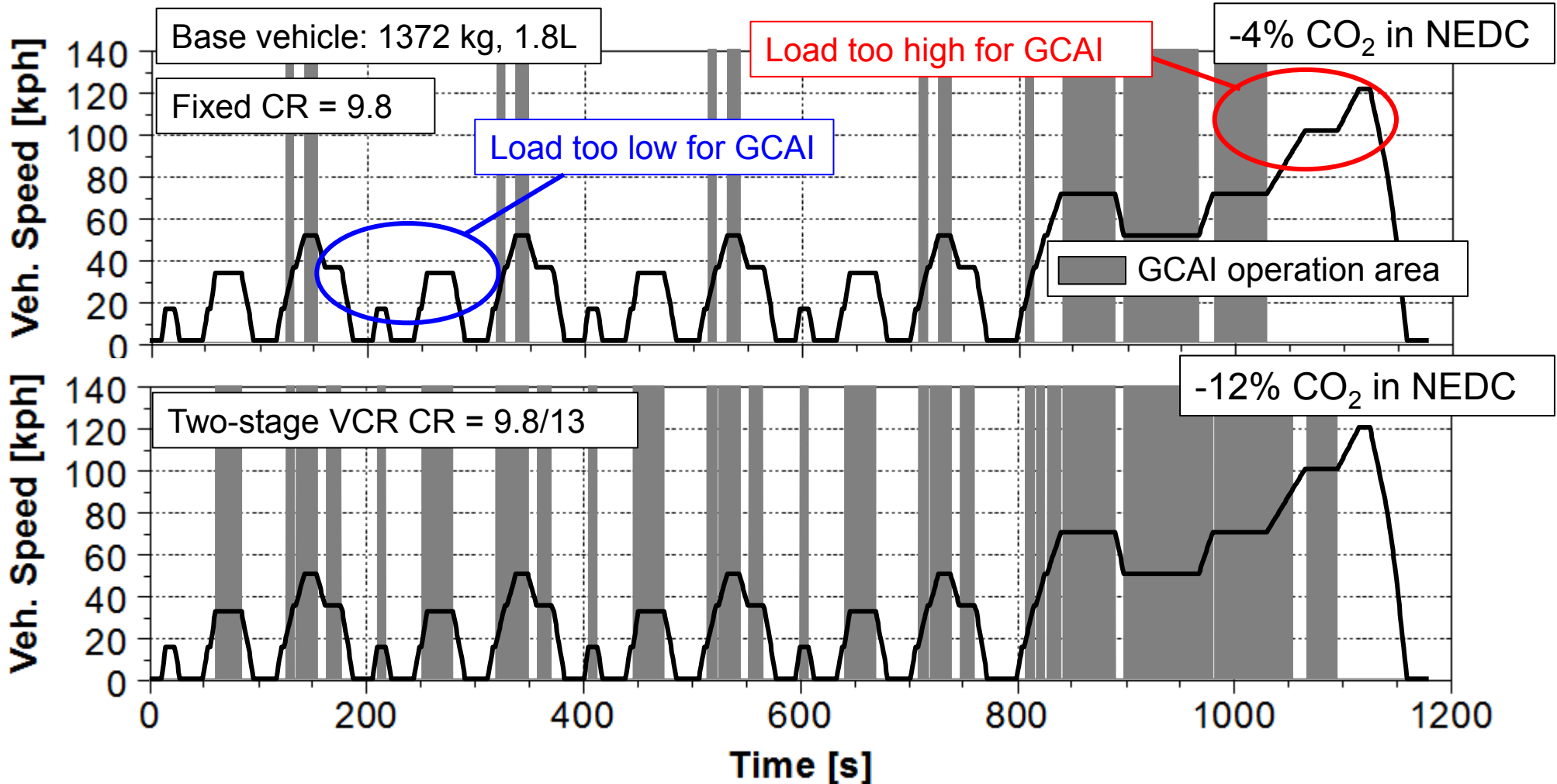
# Combination with Future Technologies

## Two-stage VCR Combined with 'Extreme' Downsizing



# Combination with Future Technologies

## Two-stage VCR Combined with GCAI - Gasoline Controlled Auto Ignition

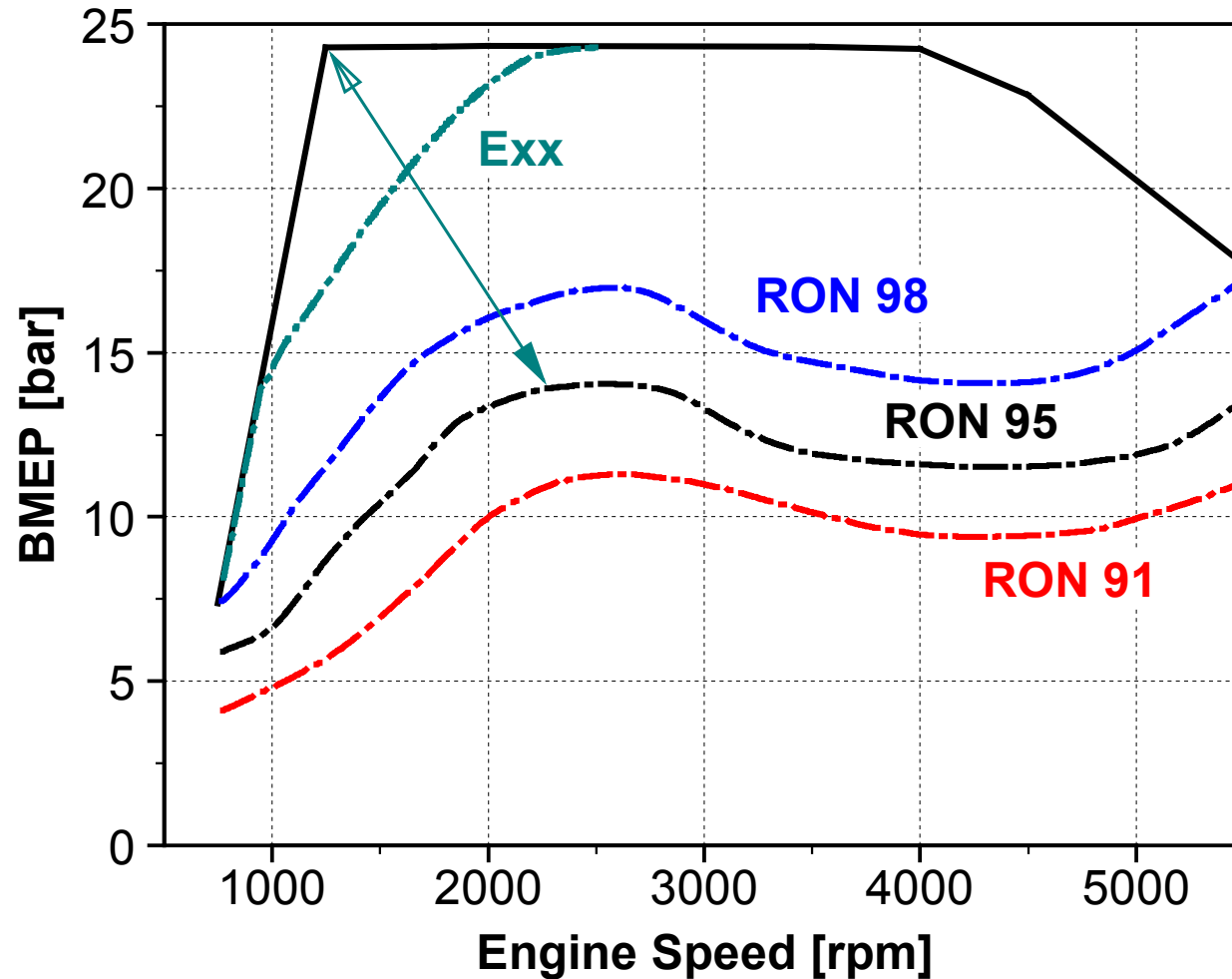


# Combination with Future Technologies

## Two-stage VCR Combined with Alternative Fuels



2.0l, TC, Two-Stage VCR 8/12 (optimized for RON 95)



# Two-stage VCR System

## Summary and Conclusions

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- VCR can help to resolve the conflict between part load and full load CR layout especially for boosted downsized gasoline engines
- The presented two-stage VCR system is based on a variable length conrod with eccentric piston pin suspension and can be adapted to existing engines with moderate effort
- The transition time can be adjusted according to the thermodynamic requirements
- CO<sub>2</sub> reduction potential for moderate downsized GDI engines 5 – 6%
- Increased benefit for extreme downsized GDI engines of up to 7% in NEDC
- Operating area of GCAI technology can be significantly enlarged resulting in up to 12% CO<sub>2</sub> reduction in combination with two-stage VCR in NEDC
- The higher knock resistance of alternative (flex) fuels can be used via adaptation of the VCR shift line in the map

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## Two-stage VCR system

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**Thank you for your kind attention!**