Institut für Fahrzeugantriebe
& Automobiltechnik

Potential of CNG-Direct-Injection for Downsizing Engine Concepts

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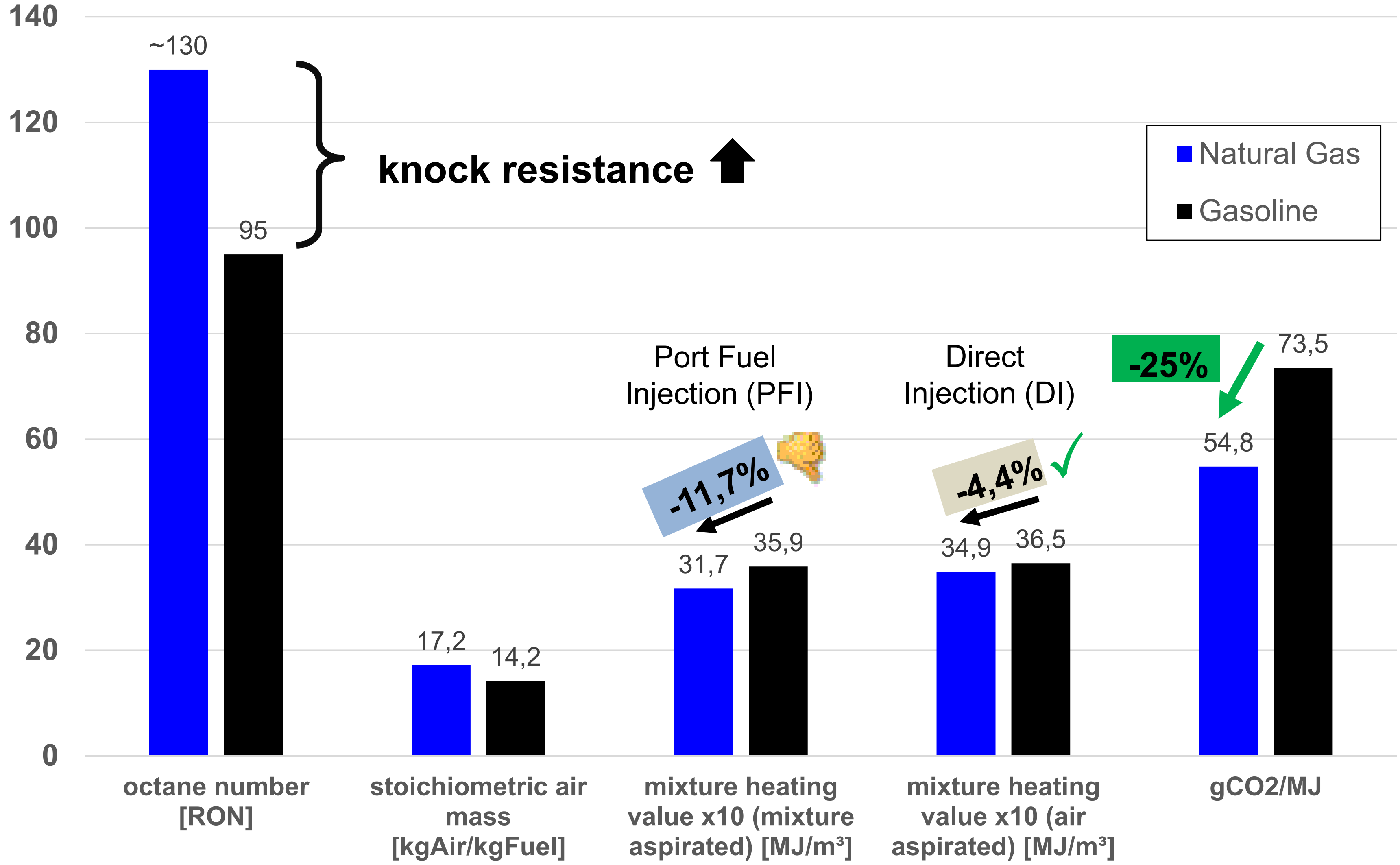
Motivation – Natural Gas Direct Injection

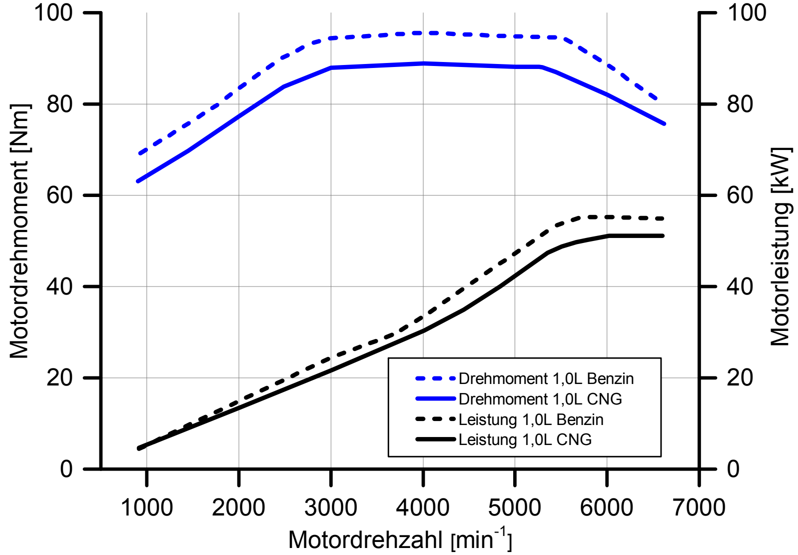


State of the Art – Natural Gas Engines

- □ Port Fuel Injection (PFI) – State of the Art
  - Displacement of air at WOT
  - Reduction of LowEnd Torque
  - Limited scavenging capabilities
  - Limited in catalyst heating strategies

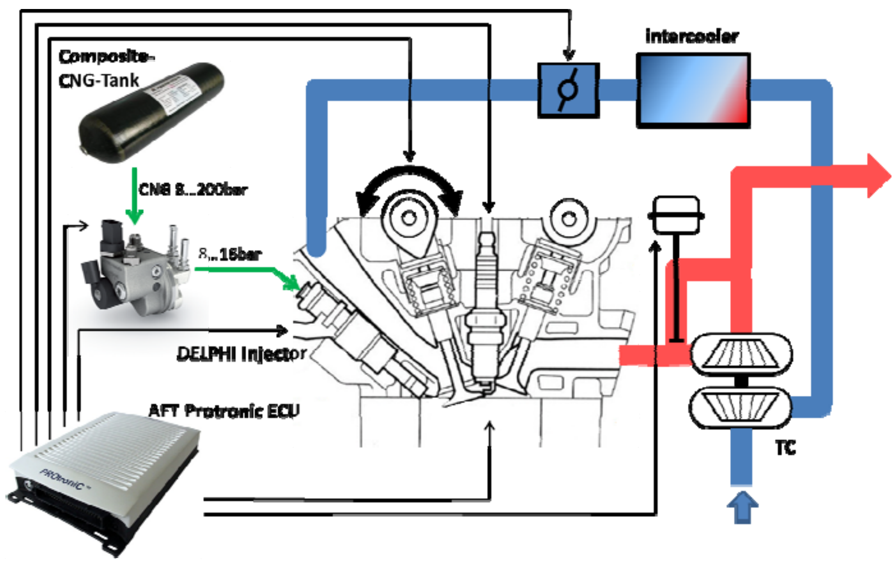
- ➢ New approach: CNG direct injection
  - No displacement of air at WOT
  - High scavenging capabilities
  - High LowEnd Torque
  - Postinjection for catalyst heating

Natural Aspirated Engine



H.J. Neußer: Der neue Erdgasmotor von Volkswagen, MTZ 04/2013

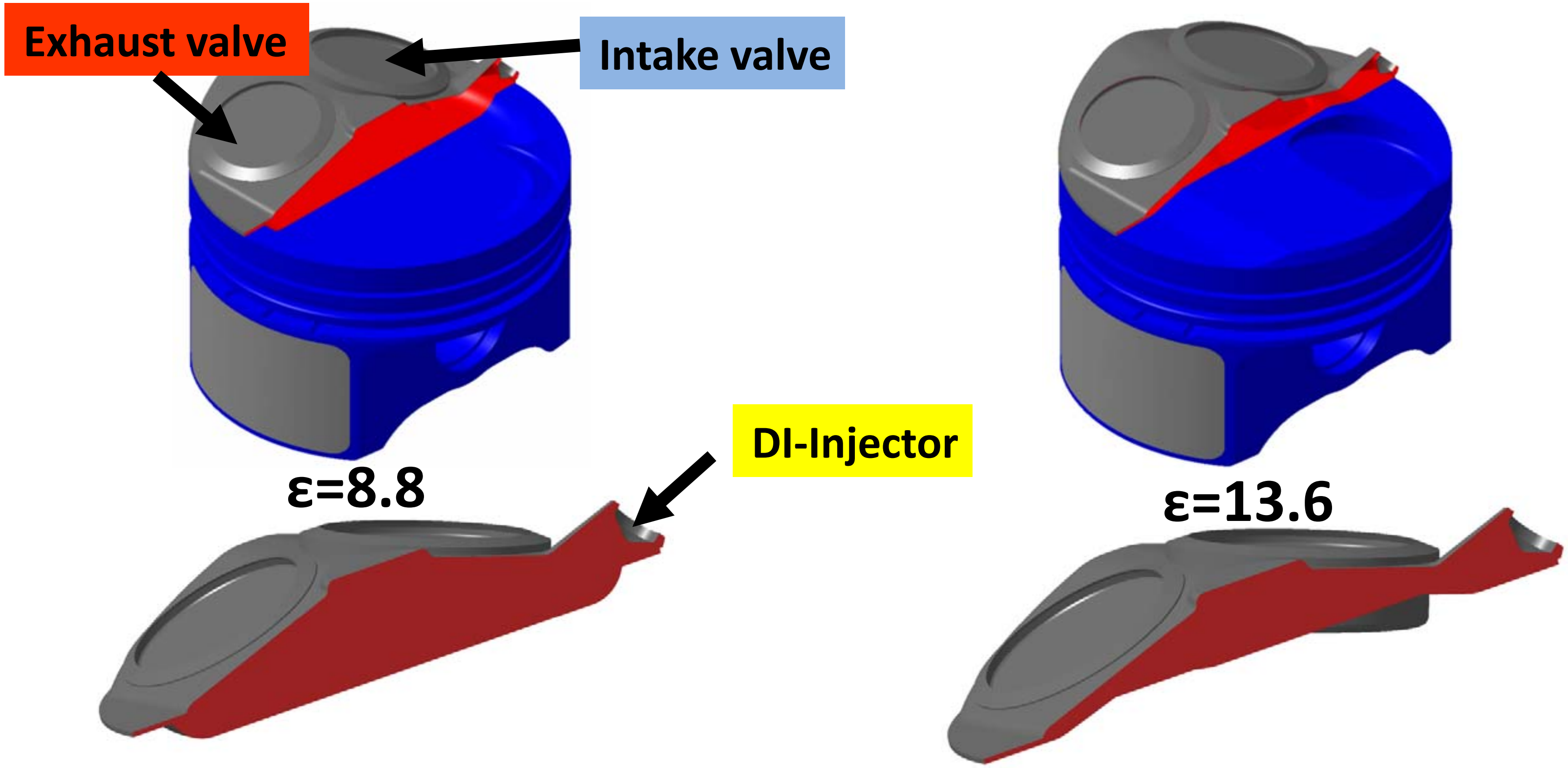
Engine Modifications



	Base Engine	Act. Engine
No. of cylinders	3	
Valves per cylinder	4	
Valve train	DOHC	**I-VCP**
Displacement	658 cm³	
Compression ratio	8,8	**13,6** **12,0**
Fuel	RON 95	**CNG**
Mixture formation	Gasoline DI	**CNG-DI**
Charging	Turbo	

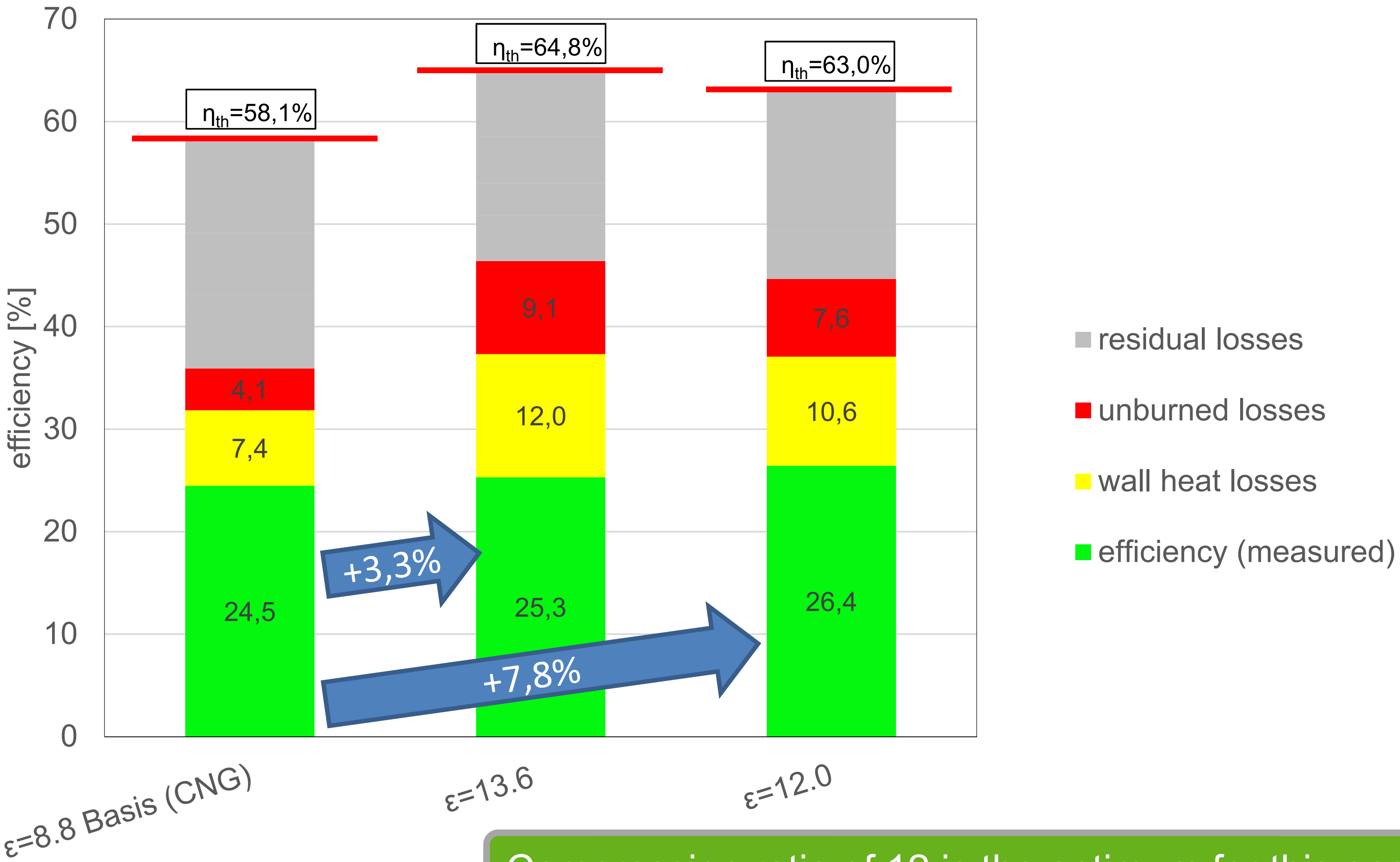
P., Hofmann et al: Der CULT Antrieb: Hocheffizienter CNG Motor mit Direkteinblasung, Wiener Motorensymposium 2013

Engine Modifications
Increasing the compression ratio – Combustion chamber shape



Compression ratio ε [-]	Surface / Volume ratio [cm^{-1}]	Δ
8,8	3,32	↓ +64%
13,6	5,43	

Increasing compression ratio – Effects



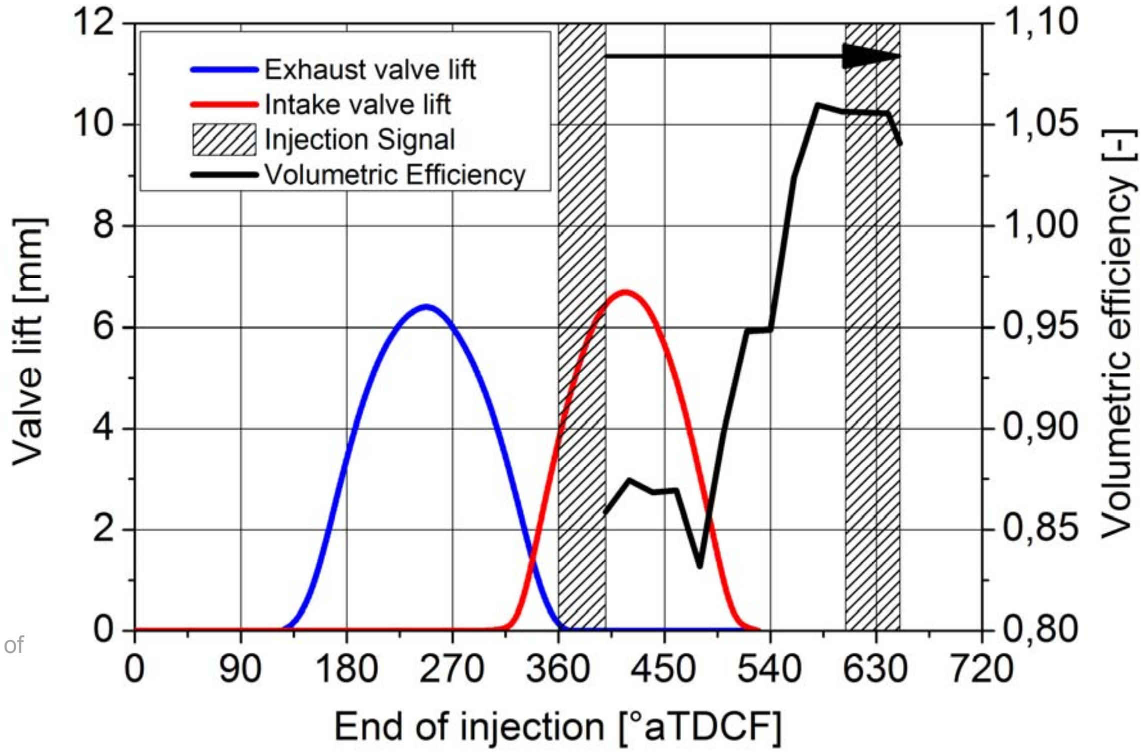
Compression ratio of 12 is the optimum for this engine

Operating point: n = 2000 min^{-1} BMEP= 4 bar

Operating Strategies for Direct Injection – WOT

Injection Timing

- In PFI engines A/F mixture is aspirated and air is displaced partially by fuel
- Direct injection engines aspirate pure air, fuel is injected after IVC

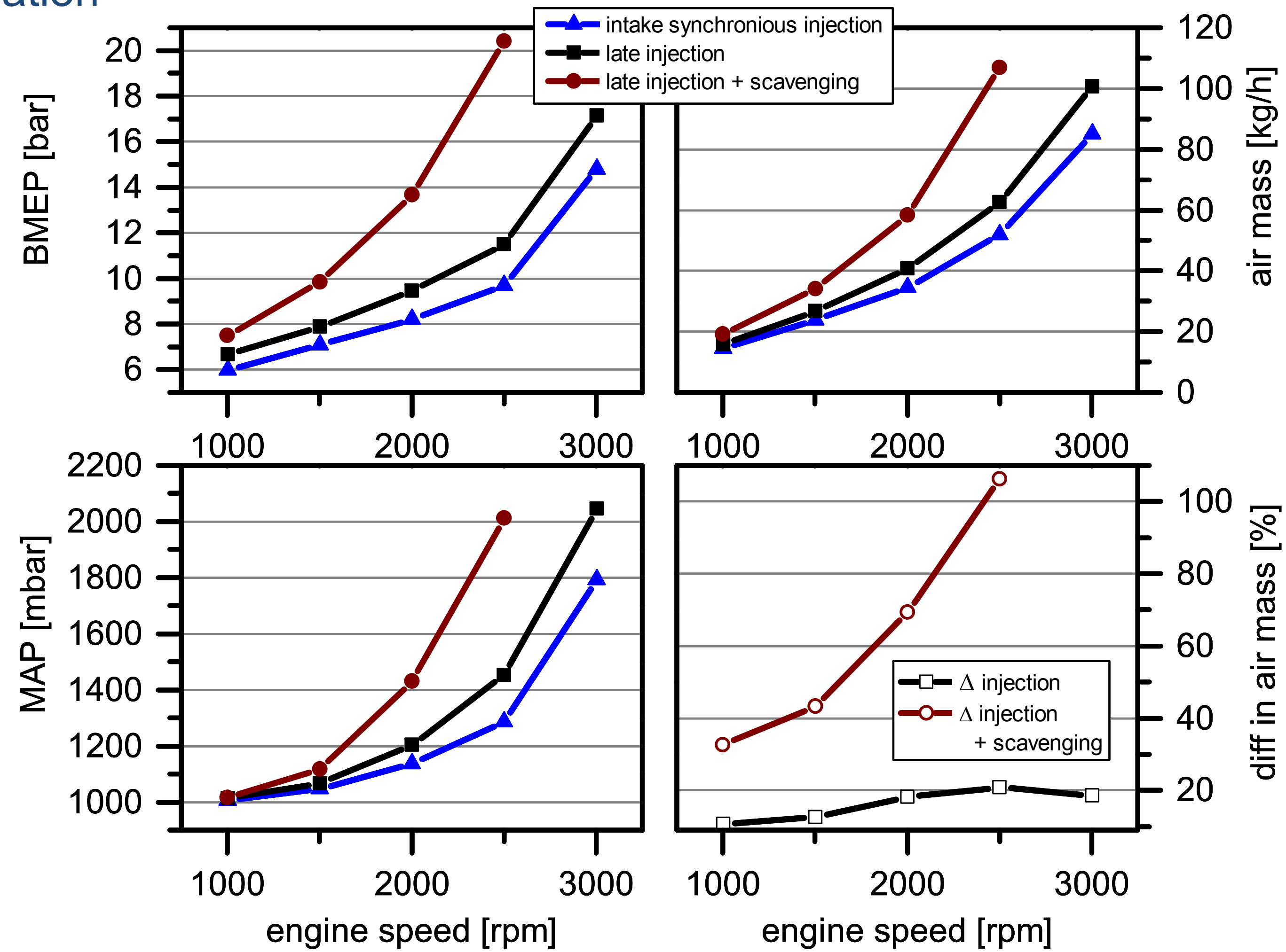


T. Hofherr, F. Forsthuber: Potential of direct Injection for Increasing the LowEnd Torque of Boosted CNG Engings, 8. Konferenz Gasfahrzeuge, Stuttgart 2013

Injection after IVC gains 20% volumetric efficiency compared to intake-synchronous injection

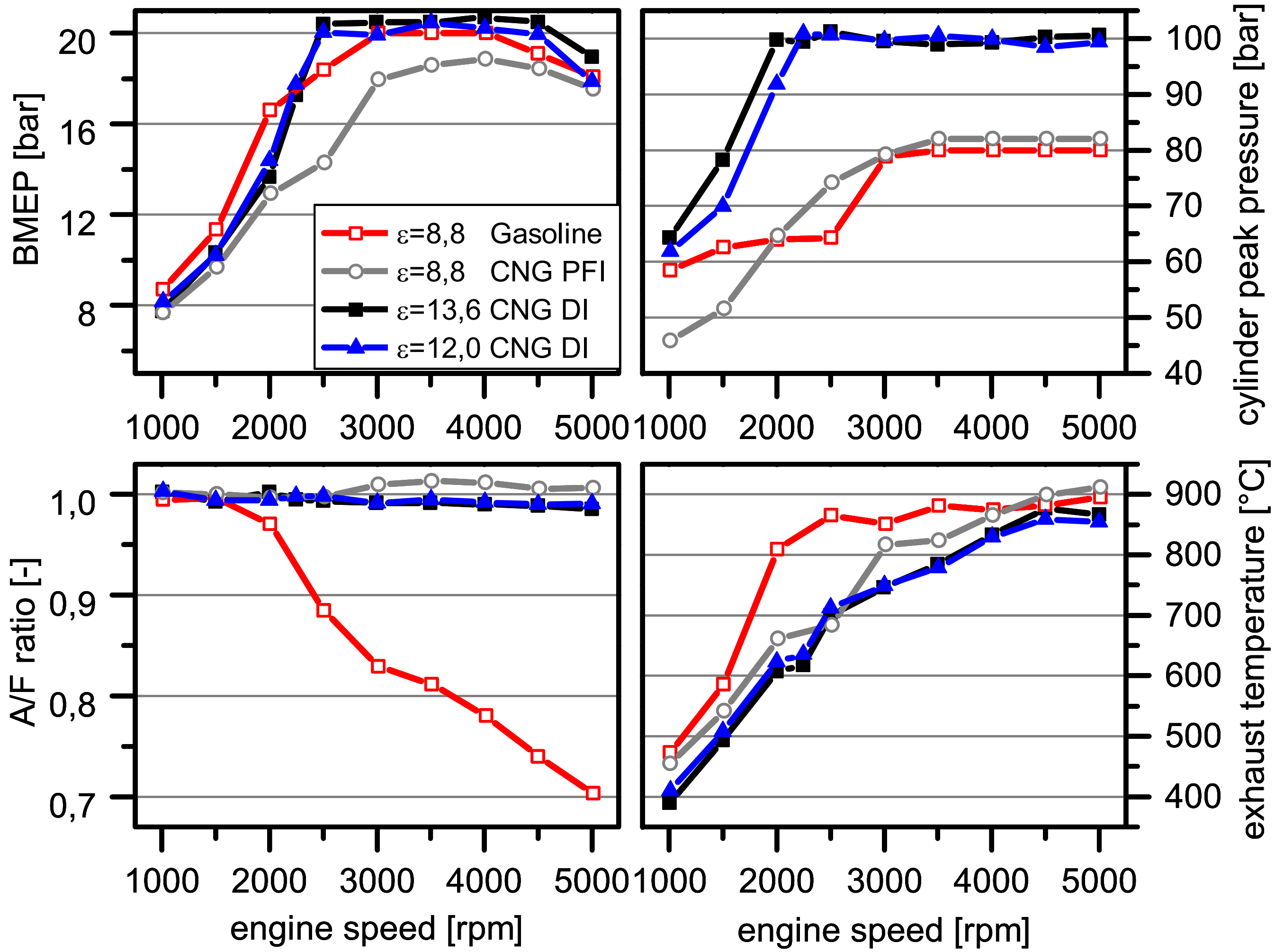
Operating Strategies for Direct Injection – WOT

combination



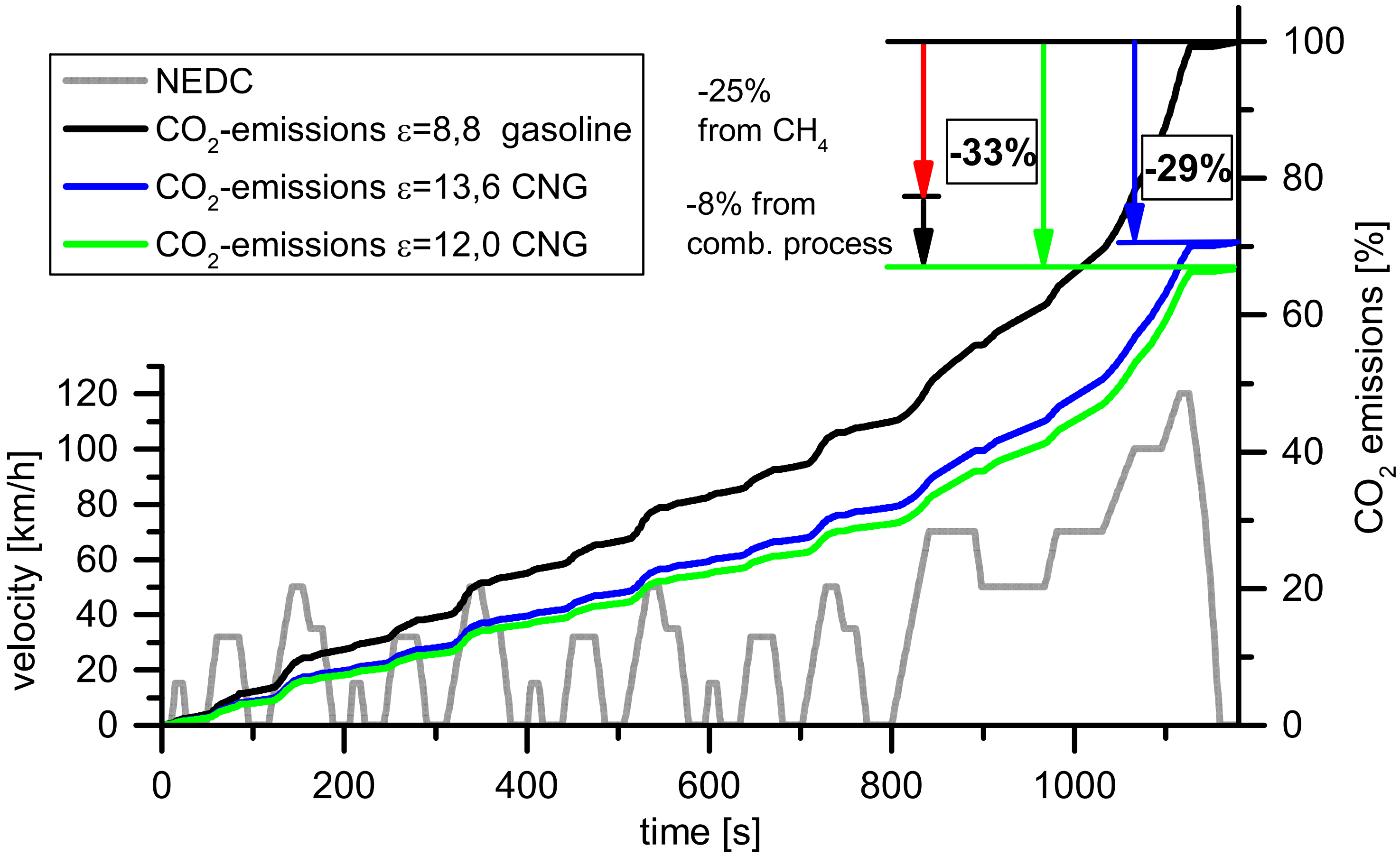
Late injection + scavenging double achievable torque

WOT – comparison different systems



Low End Torque of Gasoline can almost be achieved with CNG-DI @ high efficiency

Optimization – Results during the NEDC



Good compromize between high compression ratio and combustion chamber shape has to be found

Conclusion

- Development of an combustion process for CNG DI
- CNG allows significant raise in compression ratio
- Combustion chamber shape / wall heat losses / unburned losses limit the maximum compression ratio
- With CNG-DI the LowEnd Torque of gasoline is almost achievable
- Natural gas and optimized combustion process reach a reduction of CO_2 emissions of 33%

Thank you for your attention!

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