TMFB

Alternative Kraftstoffe aus Fischer-Tropsch-Synthese in Kombination mit Hydroformylierung für verbrauchs- und emissionsarme Verbrennungsmotoren von heute und morgen

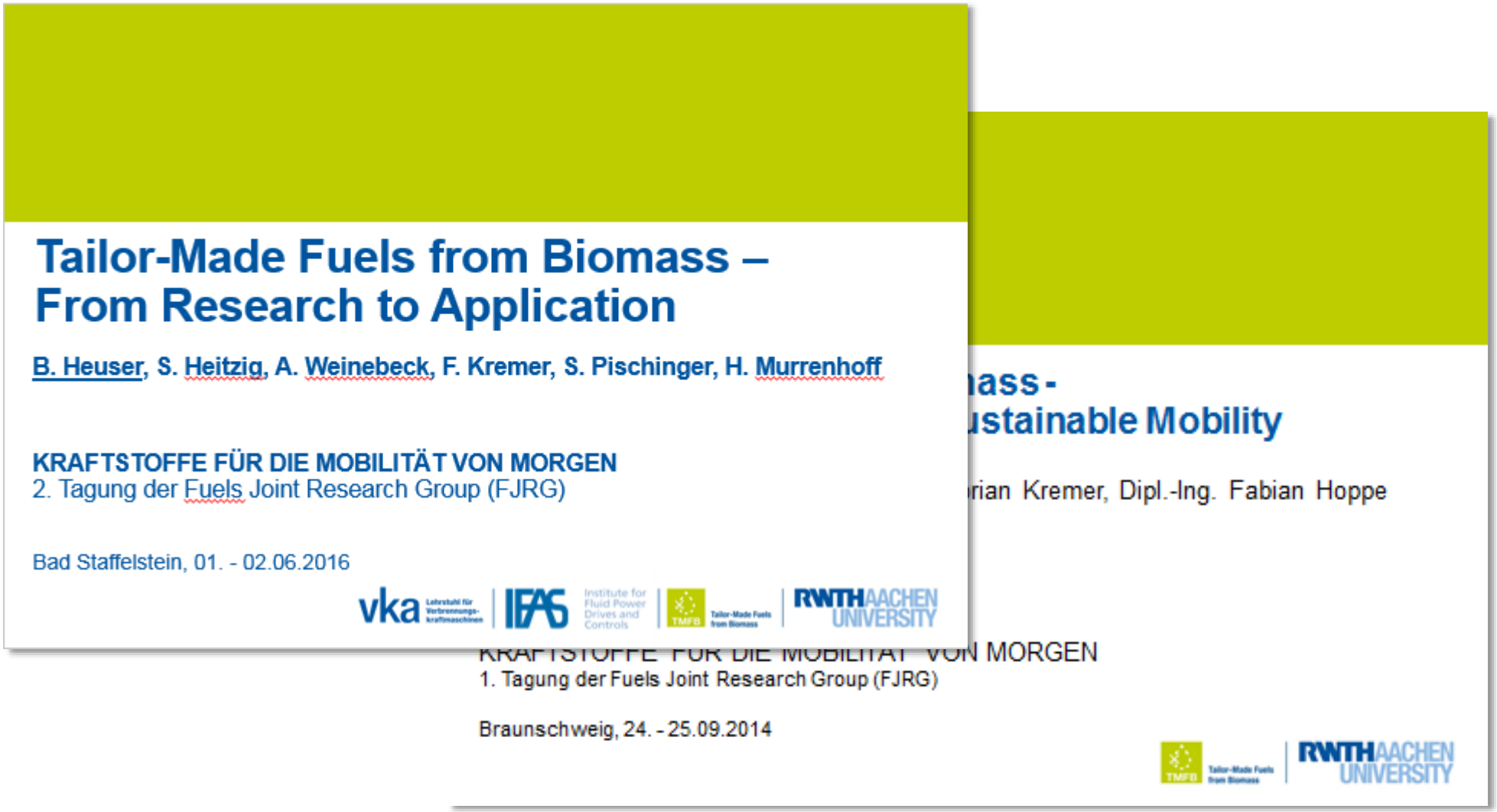
Bastian Lehrheuer, M. Zubel, D. Neumann, B. Heuser, K. Thenert, W. Leitner, S. Pischinger

KRAFTSTOFFE FÜR DIE MOBILITÄT VON MORGEN
3. Tagung der Fuels Joint Research Group (FJRG)

Braunschweig, 20. - 21.09.2018

vka Lehrstuhl für Verbrennungskraftmaschinen | ITMC | TMFB Tailor-Made Fuels from Biomass | RWTH AACHEN UNIVERSITY

Tailor-Made Fuels from Biomass @ FJRG Conference



The “Fuel Design Process” as an Integrated Approach between Propulsion and Production Technology

Propulsion

Combustion and emissions
- Mixture formation
- Ignition behavior
- Emission formation
- Lubrication
- …

Thermo-physical properties
- Density
- Viscosity
- Surface tension
- Vapor pressure
- ...

The Fuel Design Process

Production

Molecular structures
- Combustion mechanism
- C/H/O content
- Functional groups
- Detailed connectivity
- …

Synthetic processes Pathway design
- (Bio-)catalysis
- Reaction engineering
- Systems process engineering
- ...

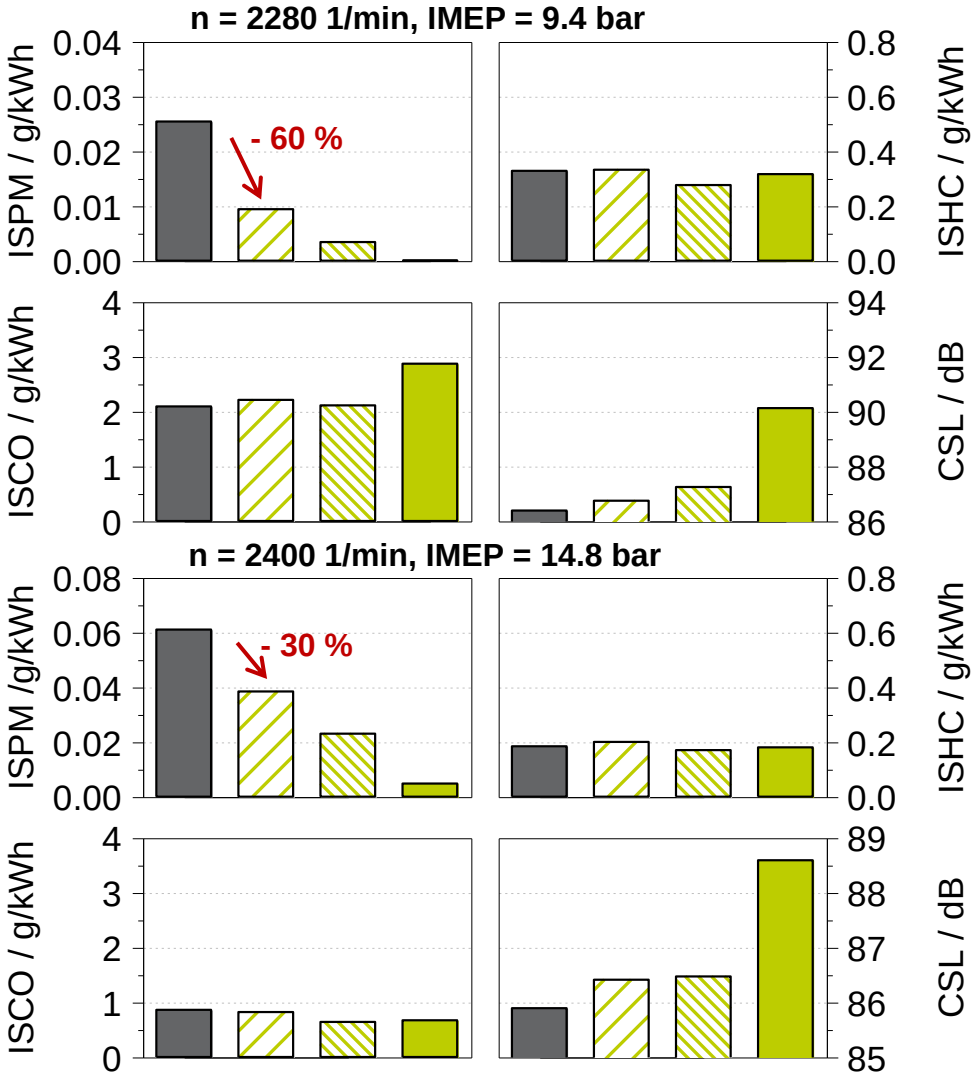
W. Leitner, J. Klankermayer, S. Pischinger, H. Pitsch,
K. Kohse-Höinghaus, Angew. Chem. Int. Ed. 56 (2017) 5412–5452.

From 2nd FJRG Conference: Blend of 80% v/v Diesel and 20% v/v 1-Octanol Very Close to EN590 Limits!

	Unit	EN590 Diesel	80% Diesel 20% 1-Octanol	50% Diesel 50% 1-Octanol*	1-Octanol	EN590 Limits
Boiling Range	°C	180-350	180-350	180-350	195	
Amount Evaporated 250°C	% v/v	**19.1**	**39.9** ✓	**60.1** ✓	**~100** ⚡	**< 65**
Amount Evaporated 350°C	% v/v	**94.7**	**95.8** ✓	**97.35** ✓	**~100**	**> 85**
Calorific Value	MJ/kg	42.9	41.8	40.5	38.2	
Density (15°C)	kg/m³	**834**	**835** ✓	**836** ✓	**837**	**820 - 845**
CN / DCN*	-	**52.3**	**49.1** ✓	**42.6** ⚡	**33.8** ⚡	**> 51**
Oxygen Content	% m/m	0.14	2.9	6.22	12.3	
Vapor Pressure	mbar	<1	<1	<1		
Kinematic Viscosity	mm²/s	**3**	**3.6** ✓	**4.5** ✓	**5.7** ⚡	**2 – 4.5**
Enthalpy of Vaporization	kJ/kg	358	412	460	562	
Flame Point	°C	**78**	**79** ✓	**80** ✓	**81**	**> 55**

* interpolated (mass/volume or molar quantities)

From 2nd FJRG Conference: Blend of 80% v/v Diesel and 20% v/v 1-Octanol Shows up to 60% Soot Reduction



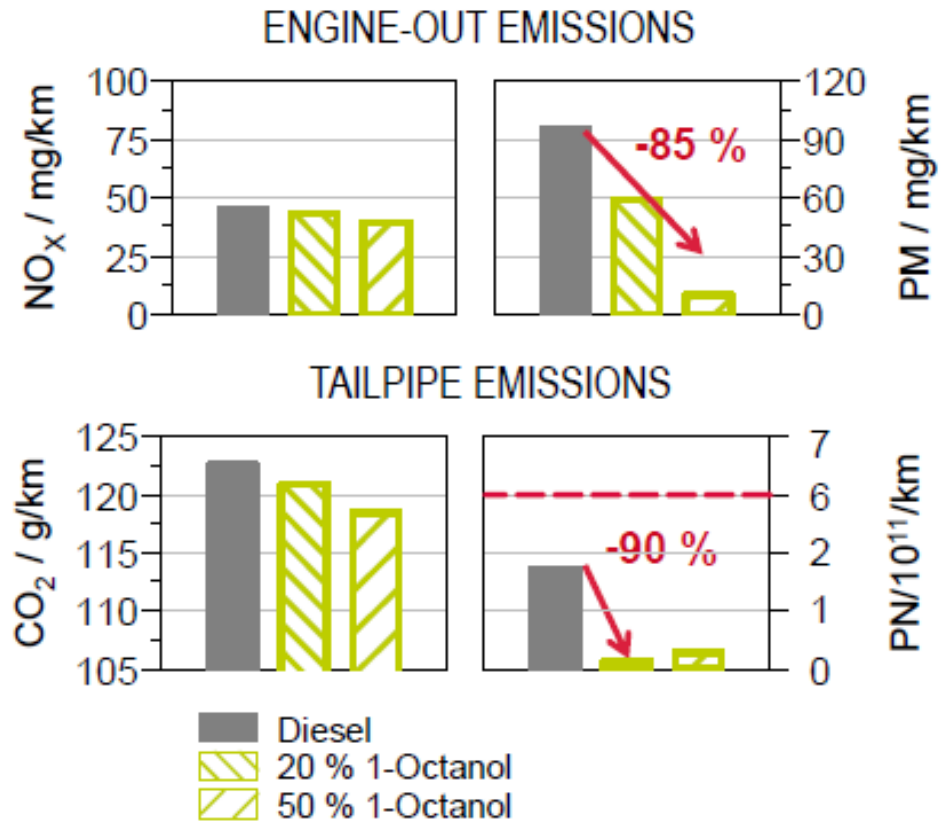
Diesel
80% Diesel / 20% Octanol
50% Diesel / 50% Octanol
Octanol

- By blending 20% of 1-octanol into EN590 Diesel fuel, soot reductions in the range of 30 – 60% can be achieved
- At the same time no increase in HC, CO nor combustion noise
- **A blend of 80% EN590 Diesel with 20% 1-octanol seems to be suited for usage in Diesel engines**

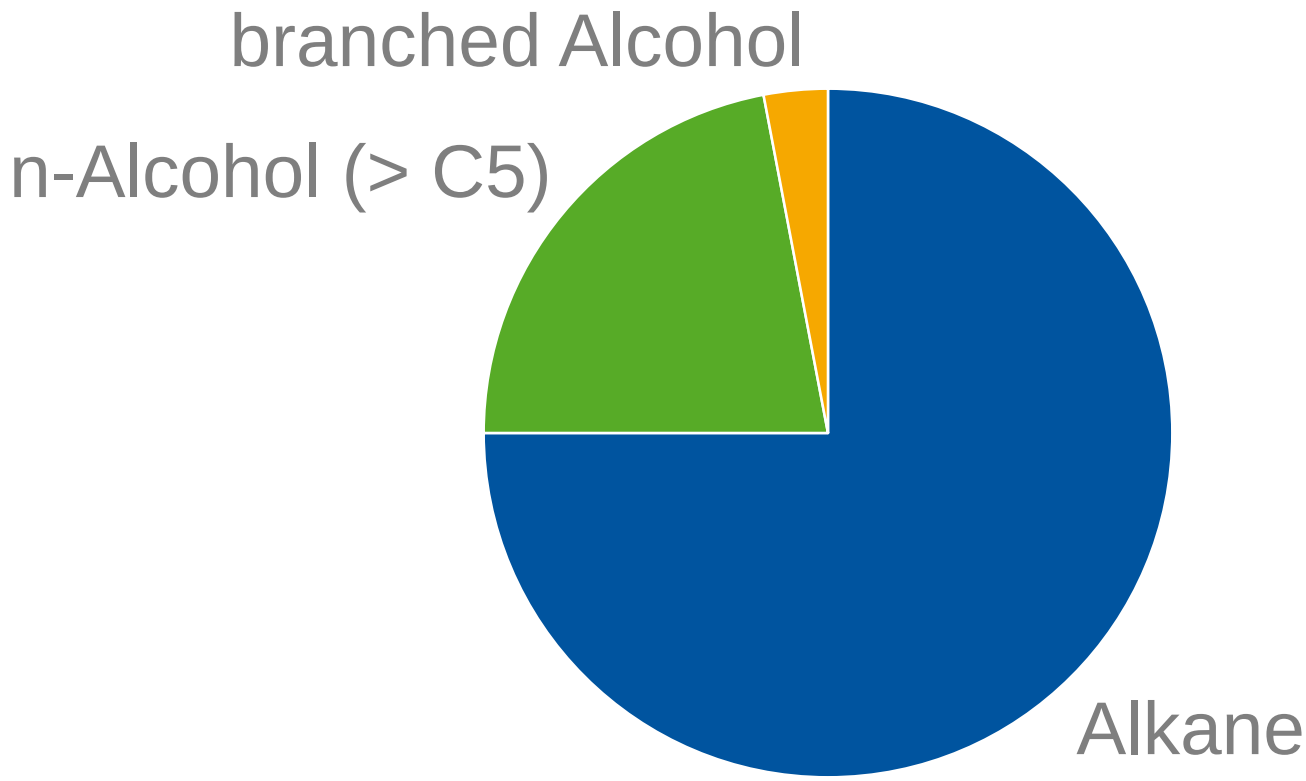
IS**: Indicated specific…
CSL: Combustion sound level

After 2nd FJRG Conference: The 1-Octanol Blends Have Been Proofed in Vehicle Tests as Well

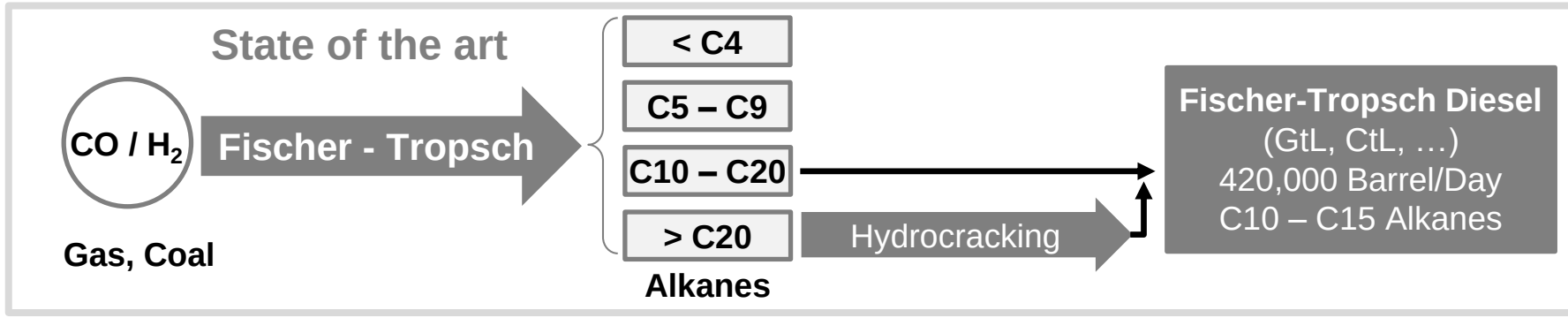
- 4-cylinder Diesel engine (OM651)
- 2143 cm³ displacement
- EURO VI legislation
- DOC and DPF Exhaust after treatment
- High- and low pressure EGR
- NEDC driving cycle



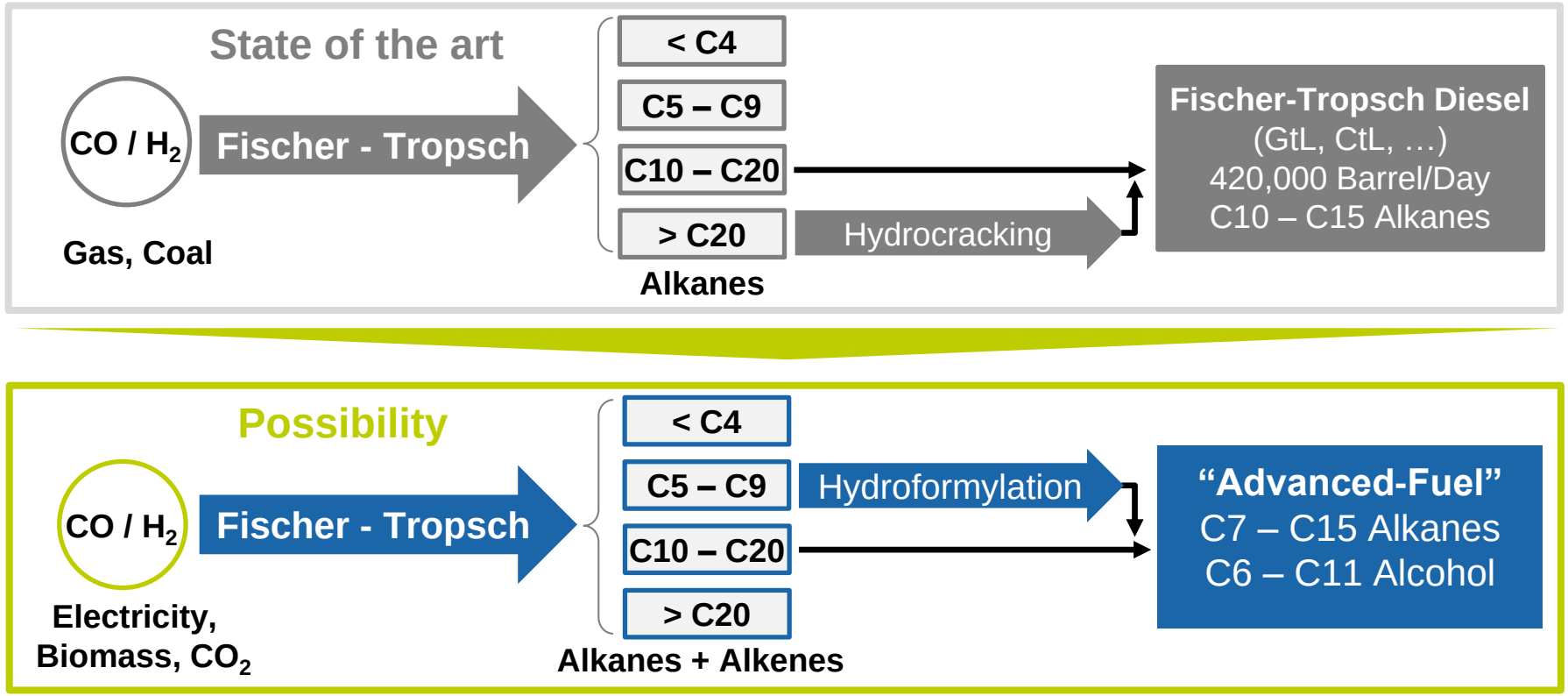
Conclusion from This Results: Alkane-Alcohol Blends Show High Emission Reduction Potential with Very Good Drop-In Capability



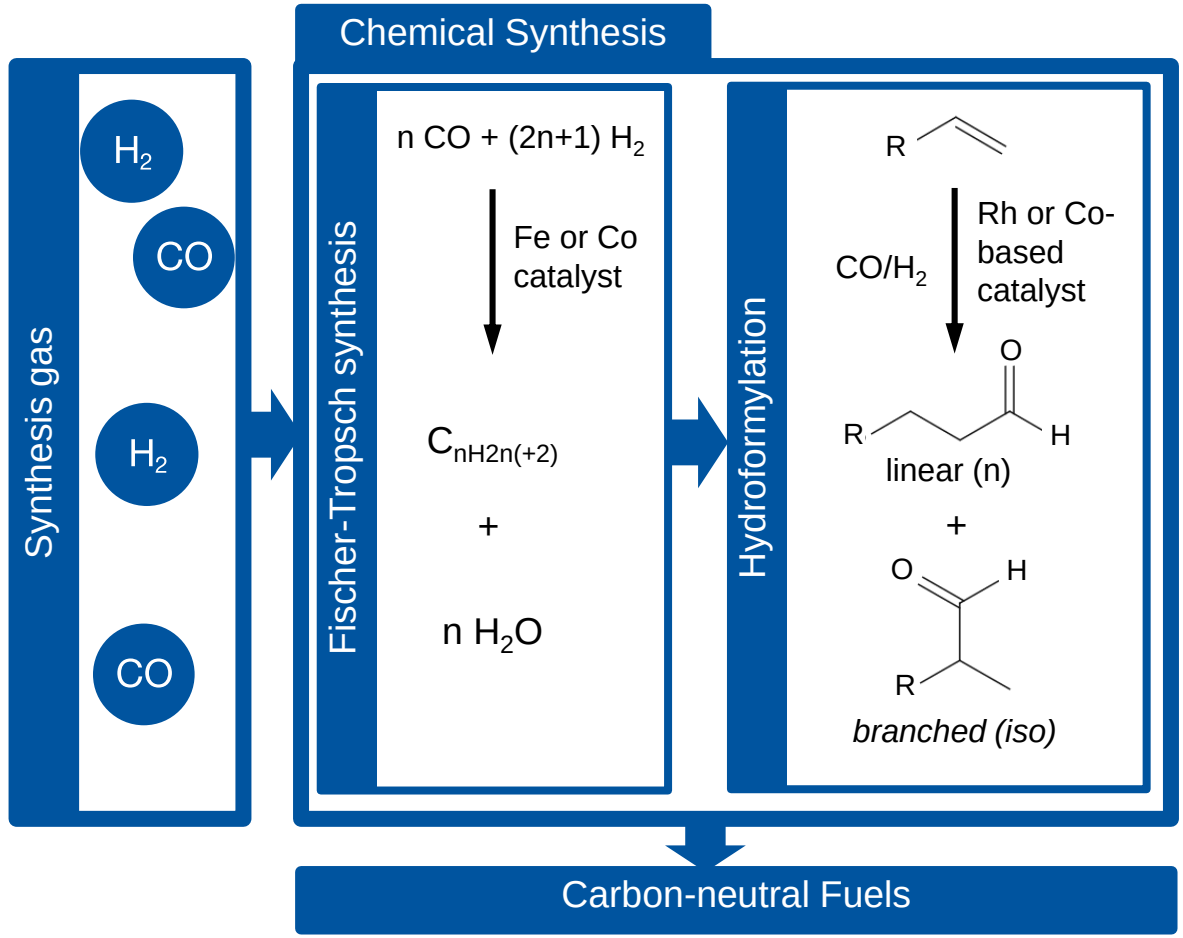
Fischer Tropsch Synthesis: a Well Known Process Since Decades



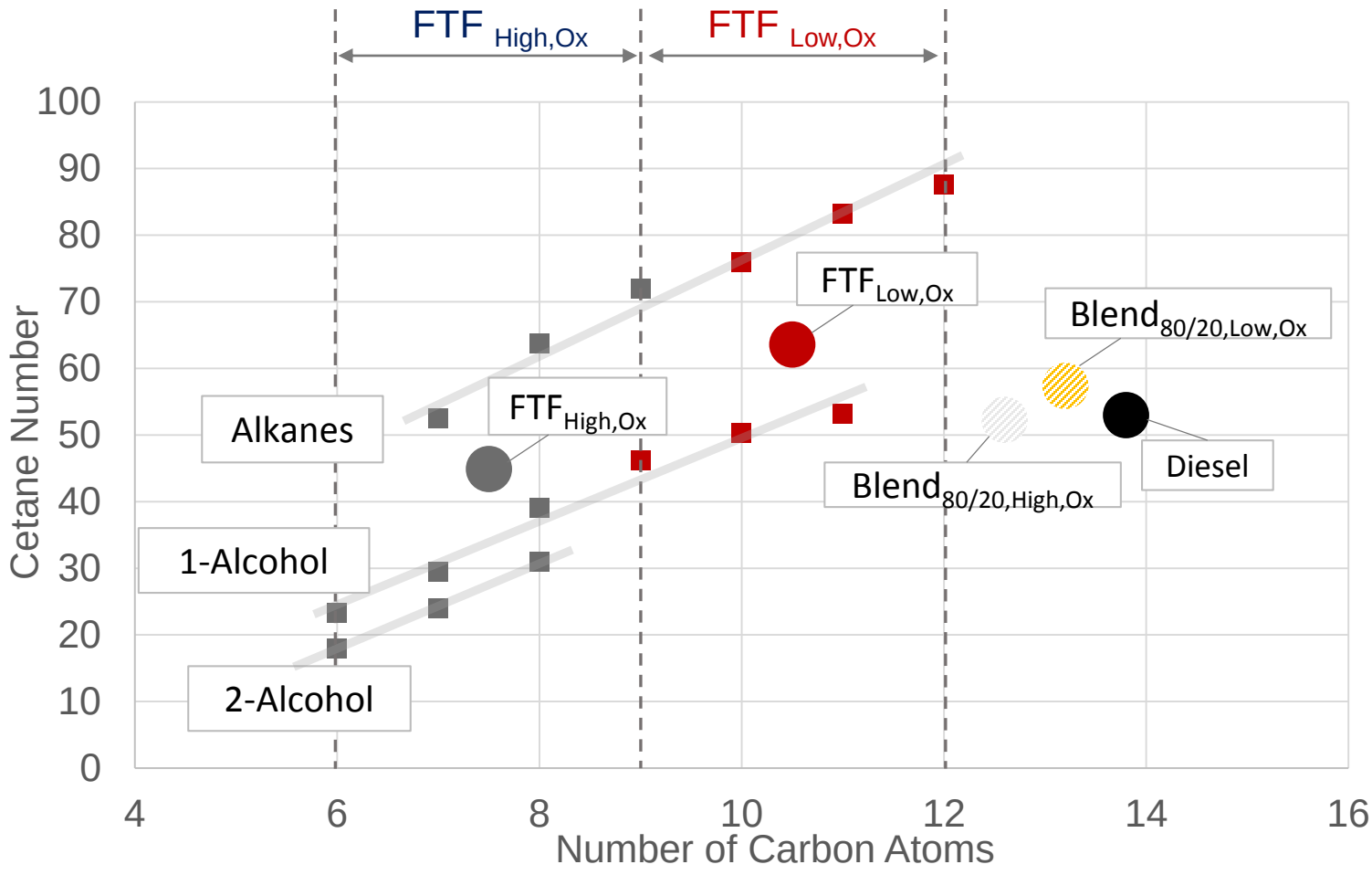
Fischer Tropsch Synthesis Coupled with Hydroformylation is a Technically Controllable and Scalable Process



Power-to-Liquid Based on Fischer Tropsch Synthesis is a Promising Path Towards Sustainable Synthetic Fuels



Fischer Tropsch Synthesis Allows a High Variability in Fuel Compositions



FTF $_{High,Ox}$

- Alcohol share = **40% m/m**
- Alkane share = **60% m/m**

→ max. alcohol share

- Oxygen share = **6% m/m**

Blend $_{High,Ox}$

- Oxygen share = **1.3% m/m**

FTF $_{Low,Ox}$

- Alkane share = **90% m/m**

→ max. alkane share

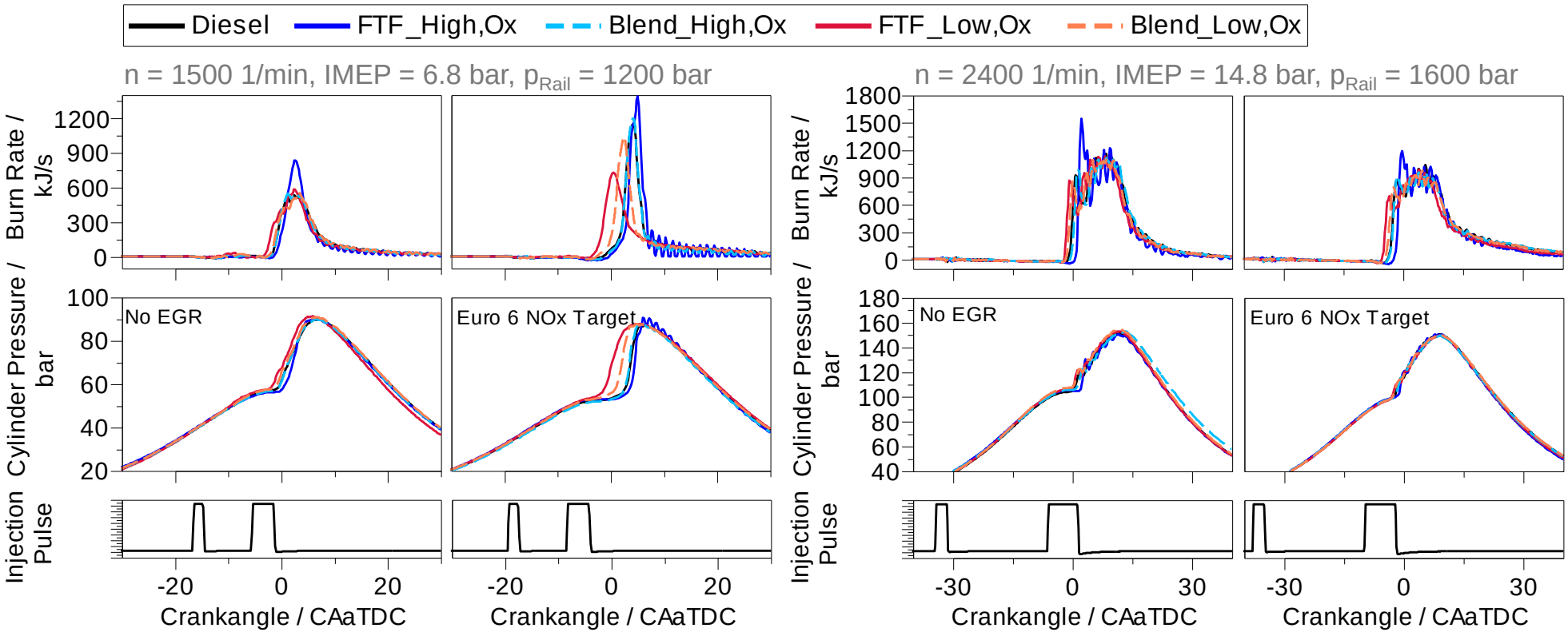
- Oxygen share = **1.1% m/m**

Blend $_{Low,Ox}$

- Oxygen share = **0.7% m/m**

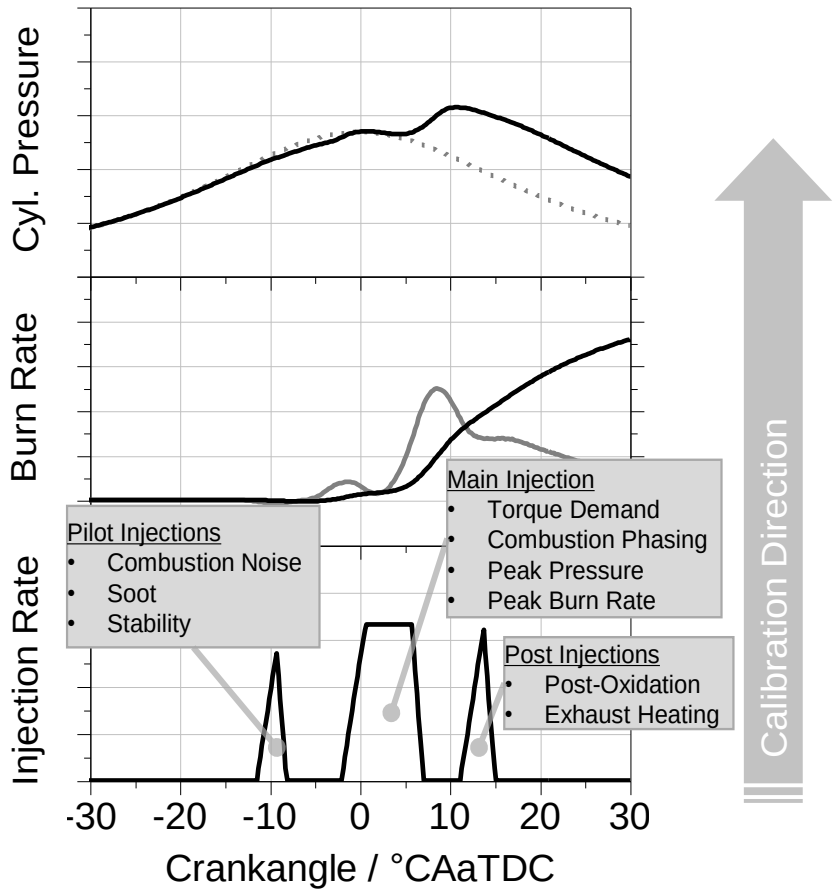
Due to Variable Fuel Compositions, the Combustion Behavior Can Change Significantly – a Challenge for the Engine Control System

COMBUSTION ANALYSIS OF DIFFERENT FUELS AT CONSTANT INJECTION RATE

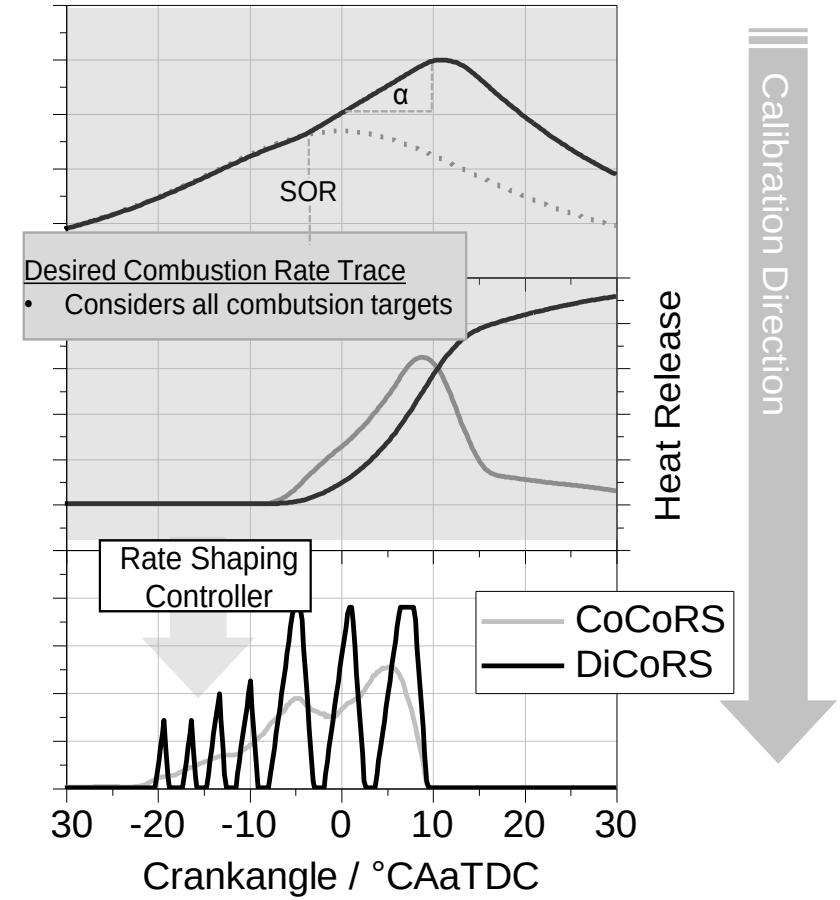


Digital Combustion Rate Shaping (DiCoRS): Control Approach to Compensate for Varying Fuel Properties

Conventional Approach



DiCoRS

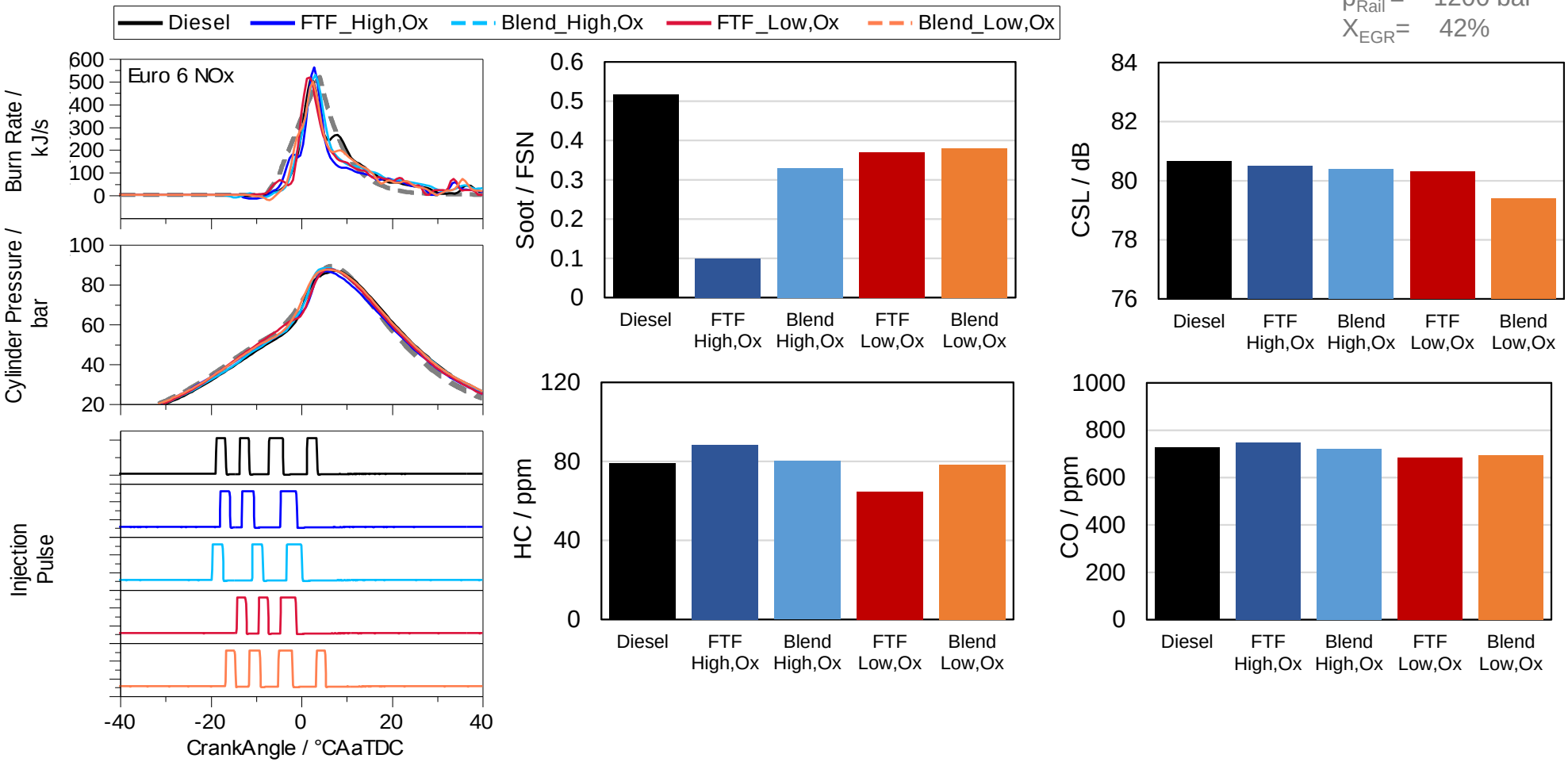


Source: NEUMANN, Daniel et al.;: Power-to-Liquids – Kompensation variierender E-Fuel Zusammensetzungen mittels Digital Rate Shaping. In: 39. Internationales Wiener. Düsseldorf : VDI-Verlag, 2018, S. 230–258

DiCoRS Compensates Successfully the Varying Combustion Properties of All E-Fuels – Benefit in Soot Emissions with Oxygenates

COMPARISON OF FUELS WITH COMPARABLE BURN RATE

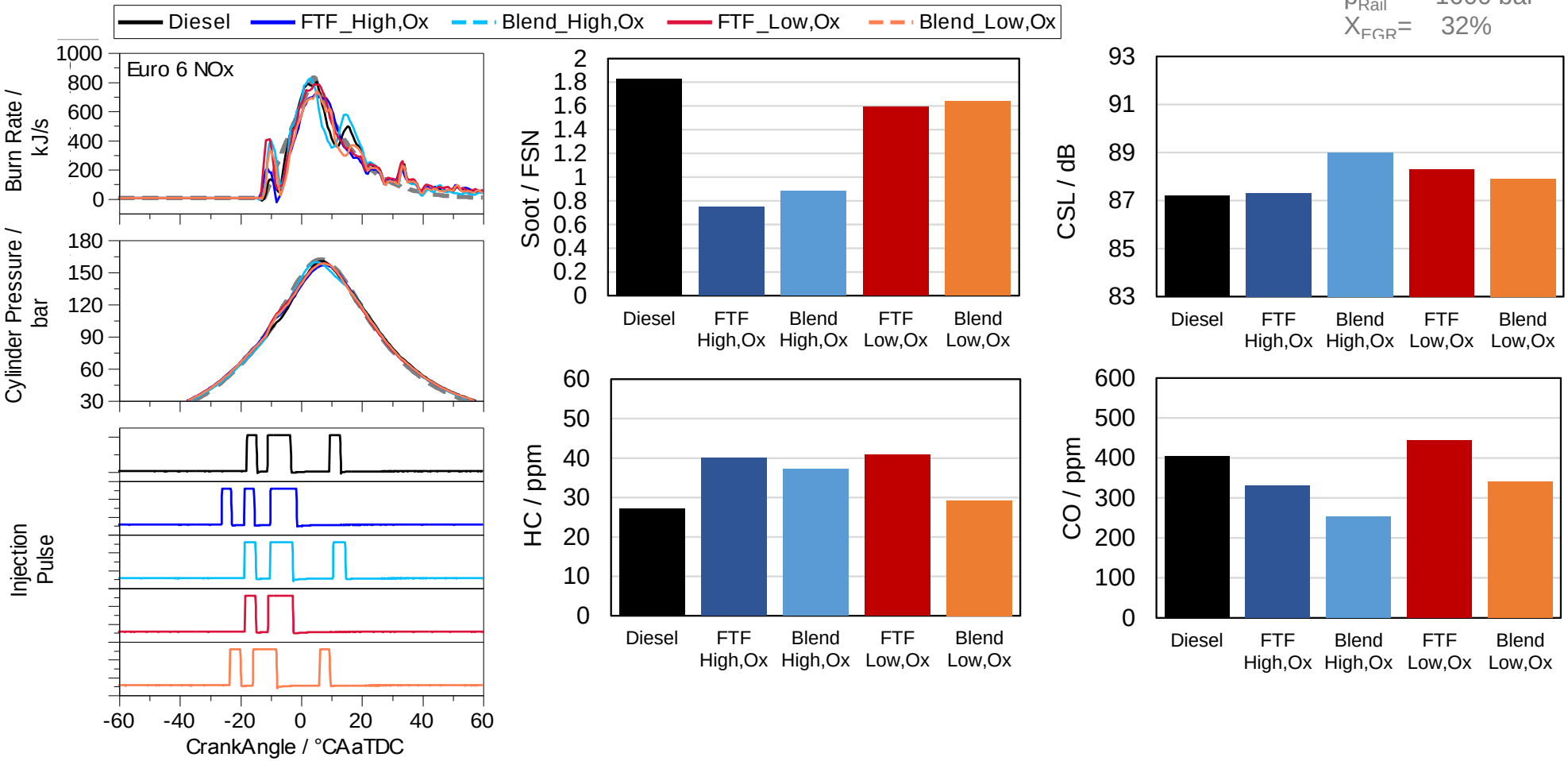
n = 1500 1/min
IMEP = 6.8 bar
p_{Rail} = 1200 bar
X_{EGR} = 42%



DiCoRS Compensates Successfully the Varying Combustion Properties of All E-Fuels – Benefit in Soot Emissions with Oxygenates

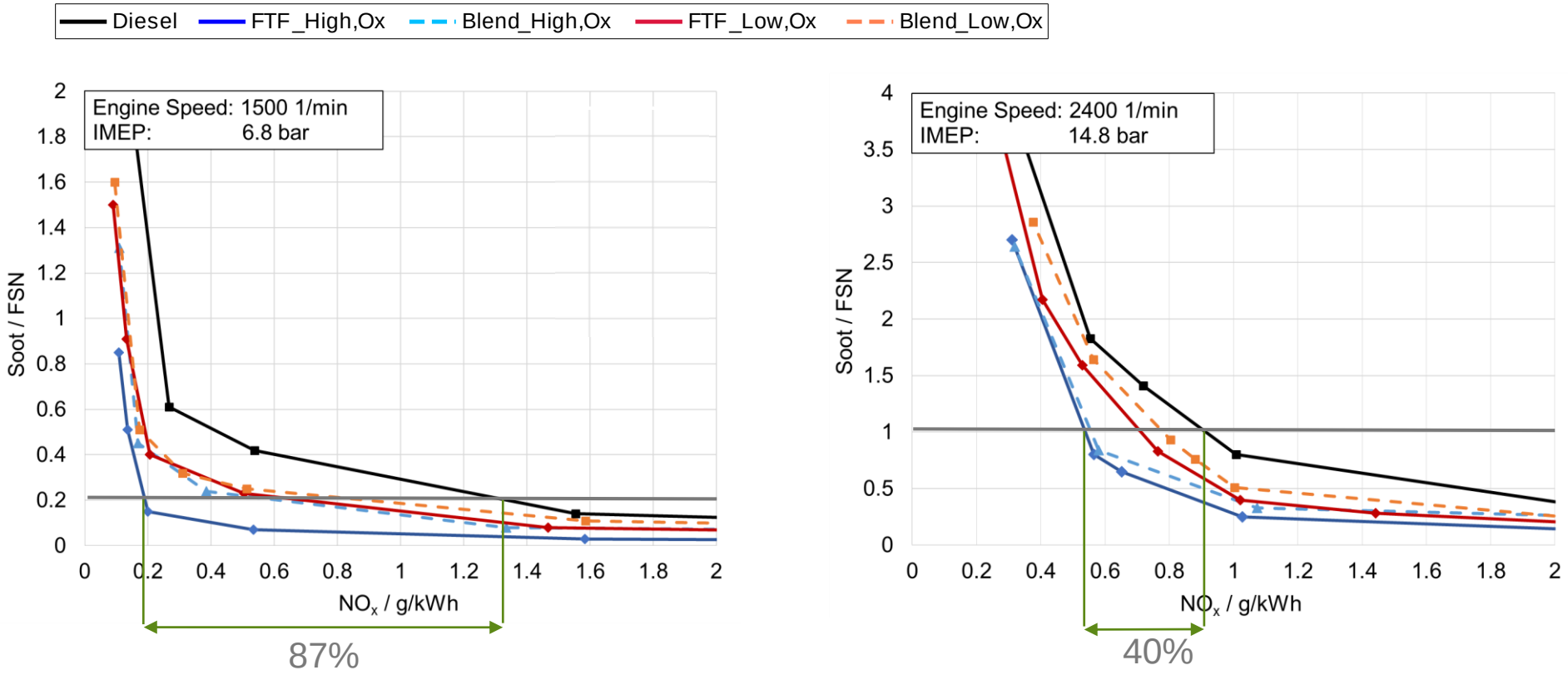
COMPARISON OF FUELS WITH COMPARABLE BURN RATE

n = 2400 1/min
IMEP = 14.8 bar
p_{Rail} = 1600 bar
X_{EGR} = 32%



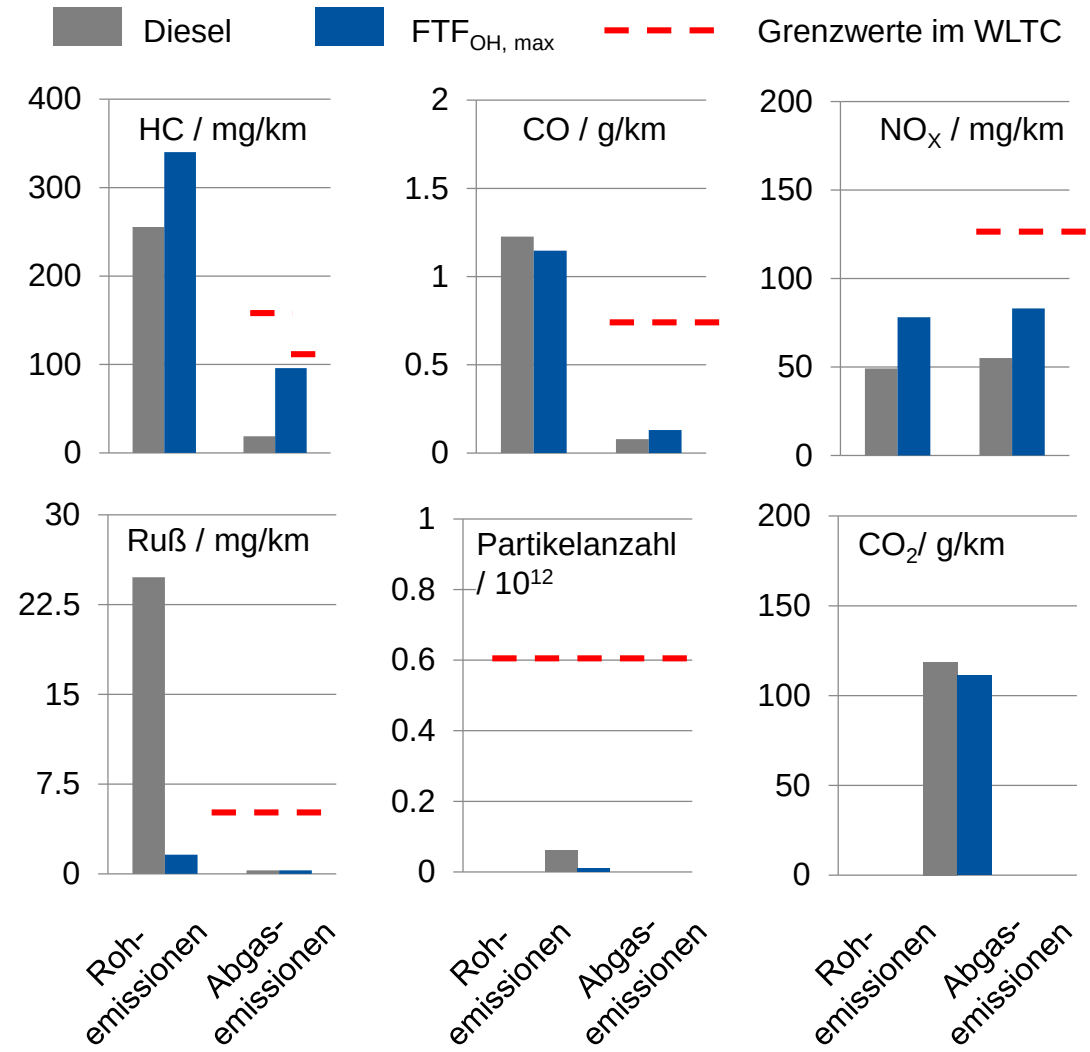
Fischer Tropsch fuels allow a simultaneous reduction of soot and NO_x emissions, a coordinator can be used to identify the optimum

IMPROVEMENT OF THE SOOT/NO_X TRADE-OFF

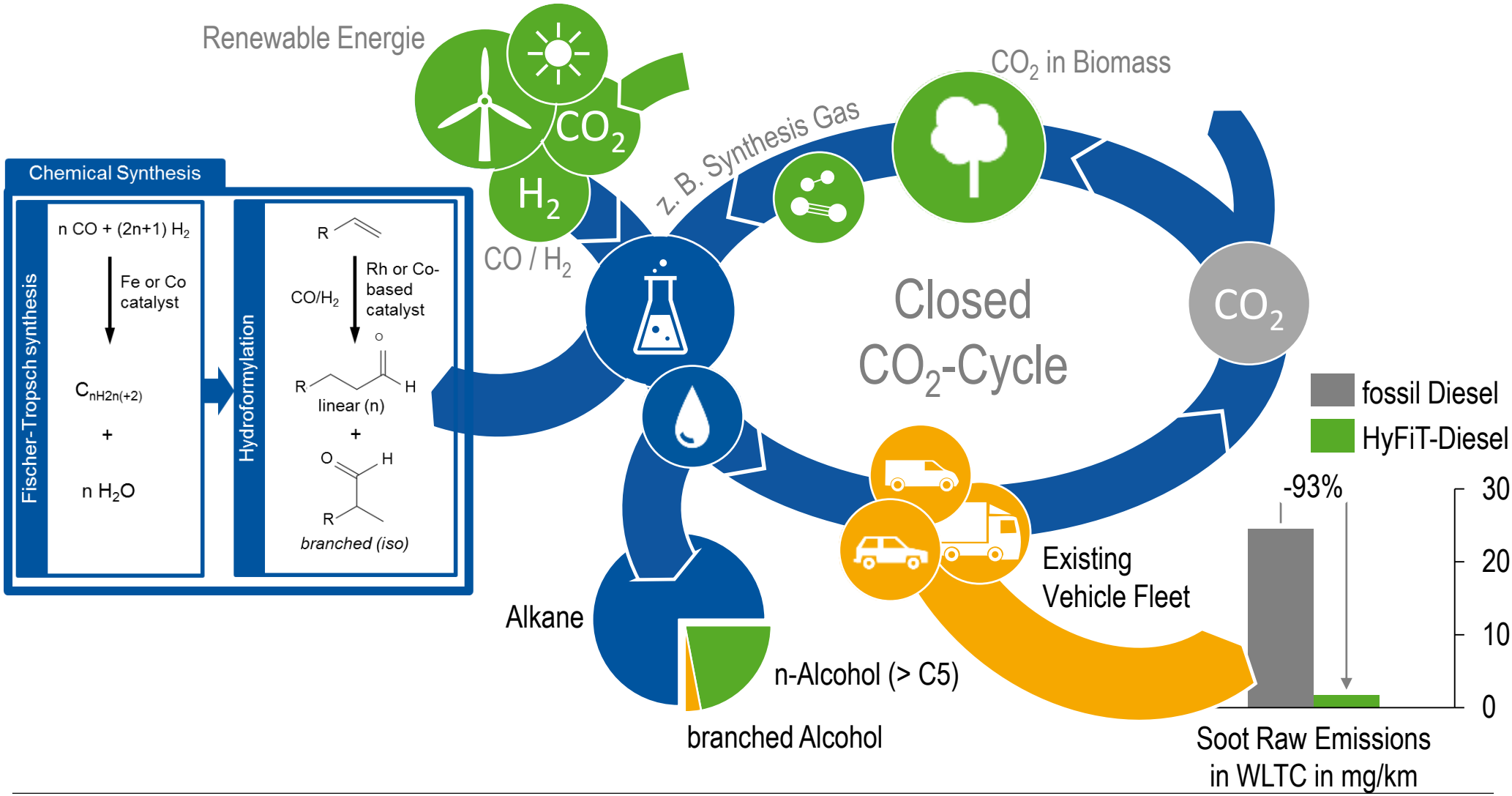


After 2nd FJRG Conference: The 1-Octanol Blends Have Been Proofed in Vehicle Tests as Well

- 4-cylinder Diesel engine (OM651)
- 2143 cm³ displacement
- EURO VI legislation (NEDC calibration)
- DOC and DPF Exhaust after treatment
- High- and low pressure EGR
- **WLTC** driving cycle



Conclusion from This Results:
Alcane/Alcohole Blends Show High Emission Reduction Potential



TMFB

Bastian Lehrheuer, M. Zubel, D. Neumann, B. Heuser, K. Thenert, W. Leitner, S. Pischinger

Thank you for your attention!

Contact: **Bastian Lehrheuer**
COO Cluster of Excellence
„Tailor-Made Fuels from Biomass“

RWTH Aachen University
Fuel Design Center
Schinkelstraße 8, 52062 Aachen
Tel.: +49 241 80 95352
Mobile: +49 151 56643608

E-Mail: Lehrheuer@vka.rwth-aachen.de
Internet: www.vka.rwth-aachen.de / ww.fuelcenter.rwth-aachen.de
Follow us on Facebook: www.facebook.com/tailormadefuelsfrombiomass

vka Lehrstuhl für Verbrennungskraftmaschinen | ITMC | TMFB Tailor-Made Fuels from Biomass | RWTH AACHEN UNIVERSITY