



CNG-Diesel Powertrain – a concept to improve the profitability of Diesel engines in commercial vehicles

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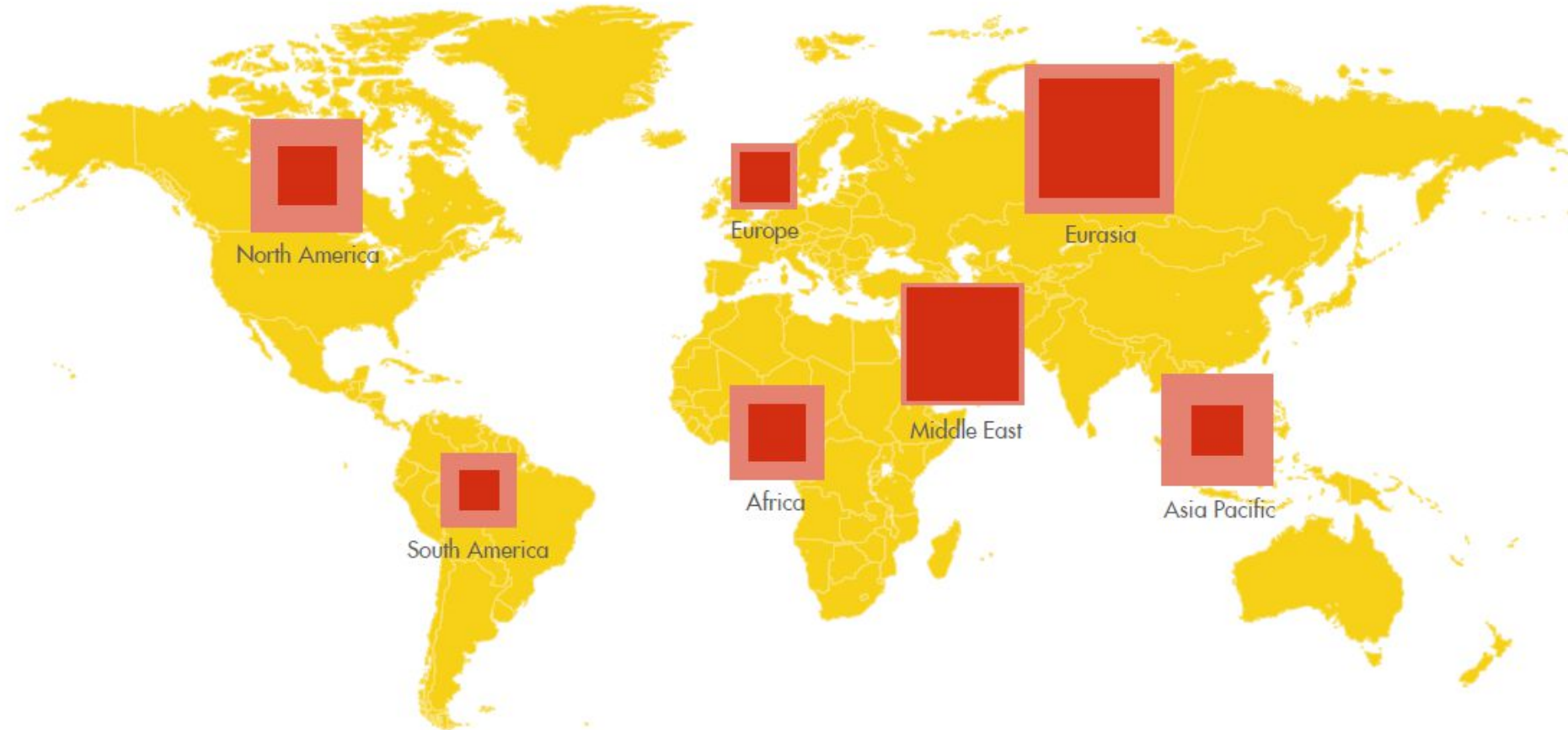
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Agenda

1. Motivation for combined CNG diesel combustion
2. Integration of the CNG System in diesel Sprinter
3. Status quo of the project challenges
4. Fuel saves and emissions
5. Conclusion

Natural Gas in place worldwide



Potential for more than 230 Years

■ Conventional Gas Resources
■ Unconventional Gas Resources

Source: IEA World Energy Outlook, WoodMackenzie, Shell Interpretation

Fuel prices in Germany

- CNG prices very stable compared to diesel prices
- project started beginning of 2014 → price differences more attractive than actual prices
- energy based comparison CNG still cheaper

Comparison fuel prices diesel vs. CNG 2008 - 2016



Source: www.gibgas.de
www.adac.de

The Sprinter: due to BlueEfficiency features best TCO in market



Project-Target:

additional CNG system to improve TCO with minimal impact on basic powertrain

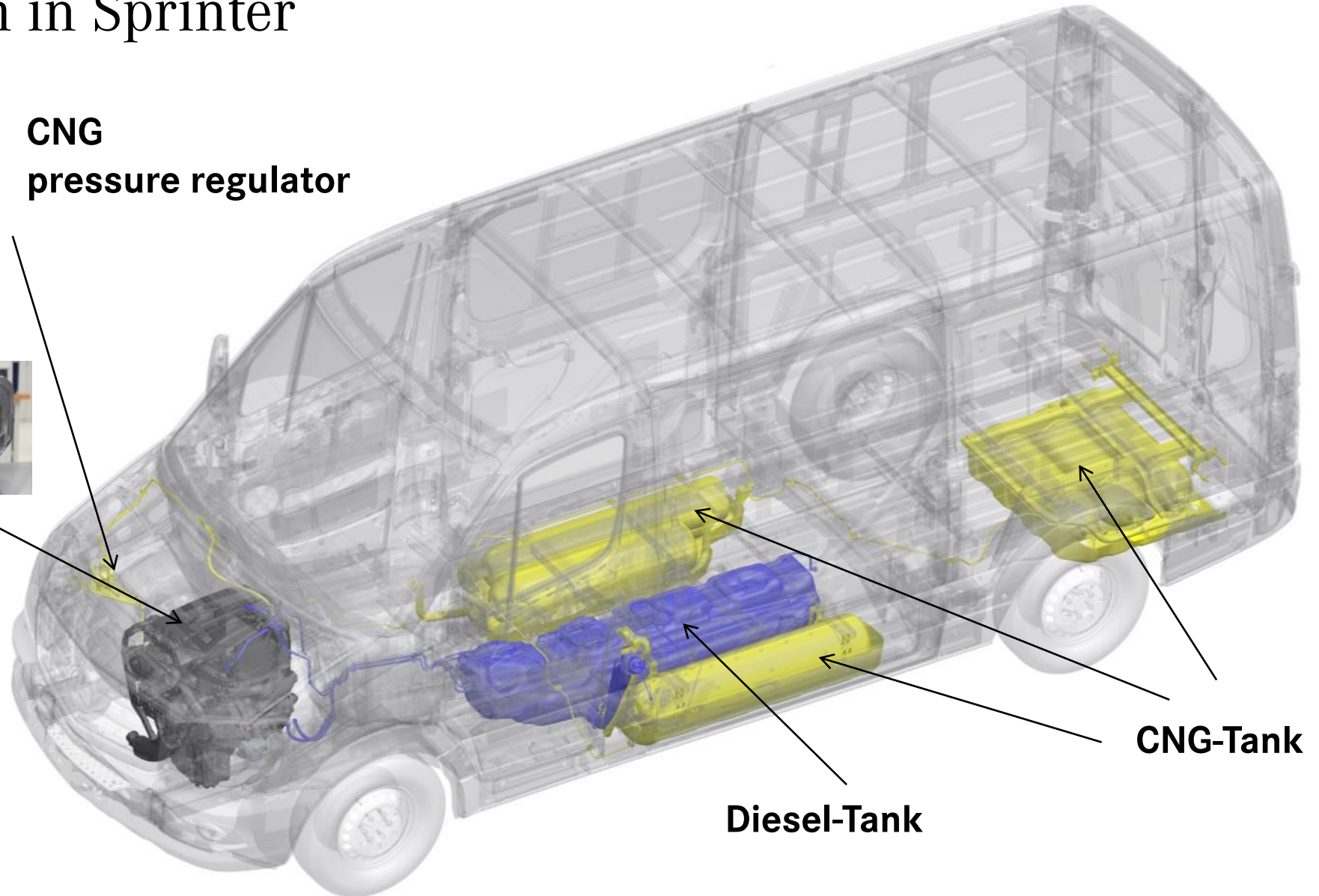
Dual Fuel System in Sprinter



**CNG
pressure regulator**



**CNG - Injector
in manifold**



CNG-Tank

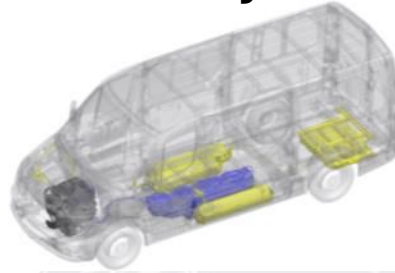
Diesel-Tank

Status quo of the challenges to fulfill the project targets

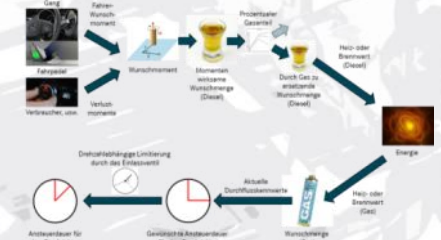
Switching diesel to CNG diesel combined combustion

— goal
— status quo
0: poor - 5: excellent

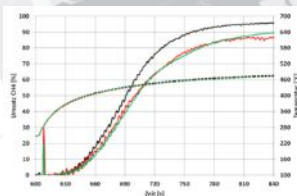
costs and packaging of CNG System



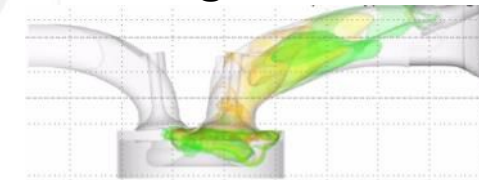
Airpath model and torque model for combined CNG/diesel combustion



CH₄-conversion on oxidation catalyst

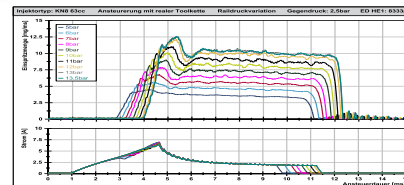


Position of CNG Injector for best mixing behaviour



combustion behaviour for low CNG emissions engine out

Selection of CNG System to fulfill demands on full and part load

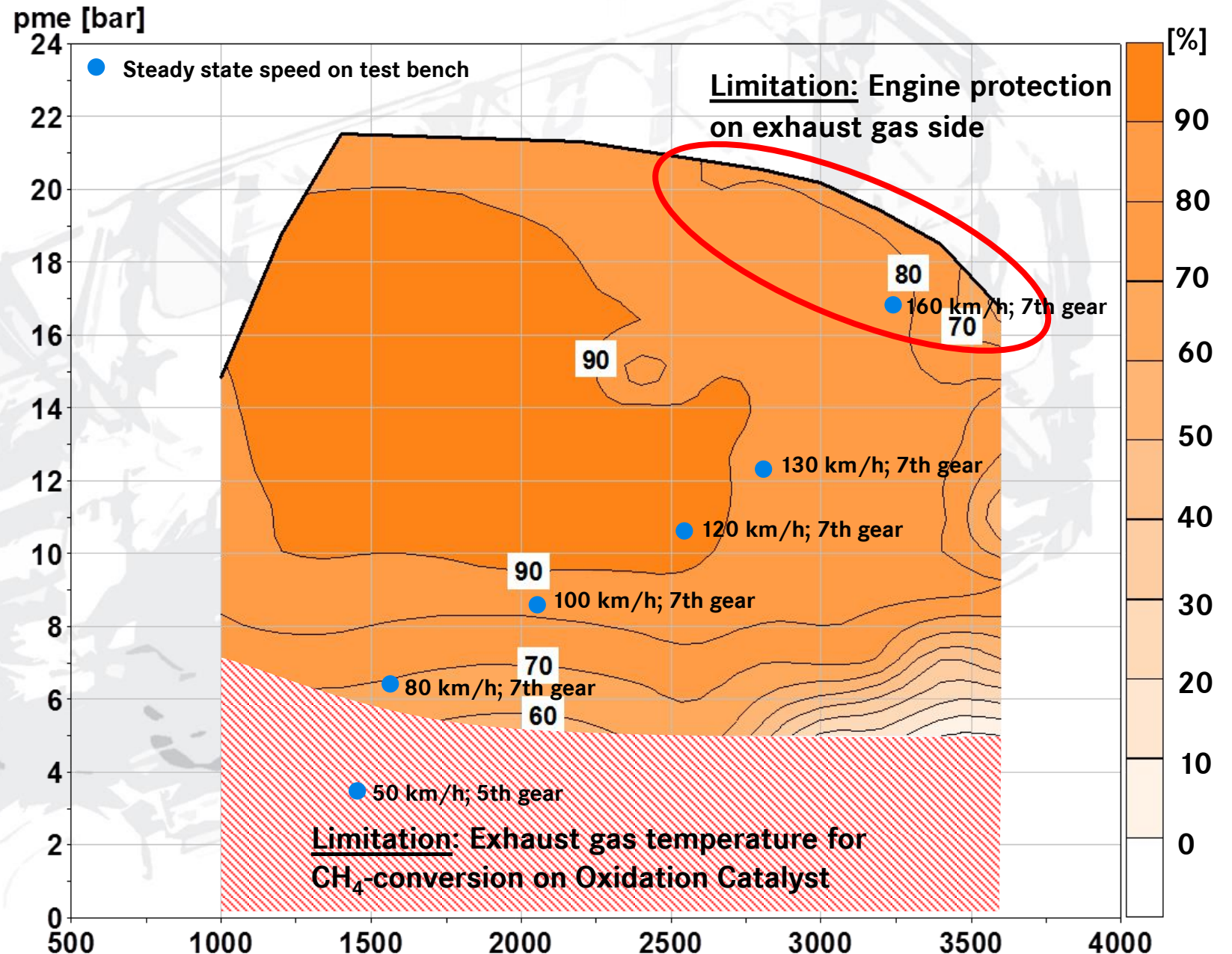


Combustion System



CNG to Diesel Ratio

- up to 90% CNG mass ratio in the engine map
- no CNG in lower load due to low temperature at the exhaust gas system
- Same engine out power between diesel only and CNG/diesel combined combustion



Fuel Saves

Distance from Stuttgart to Leipzig: 470 km

Fuel-cost diesel only: 82,63 €

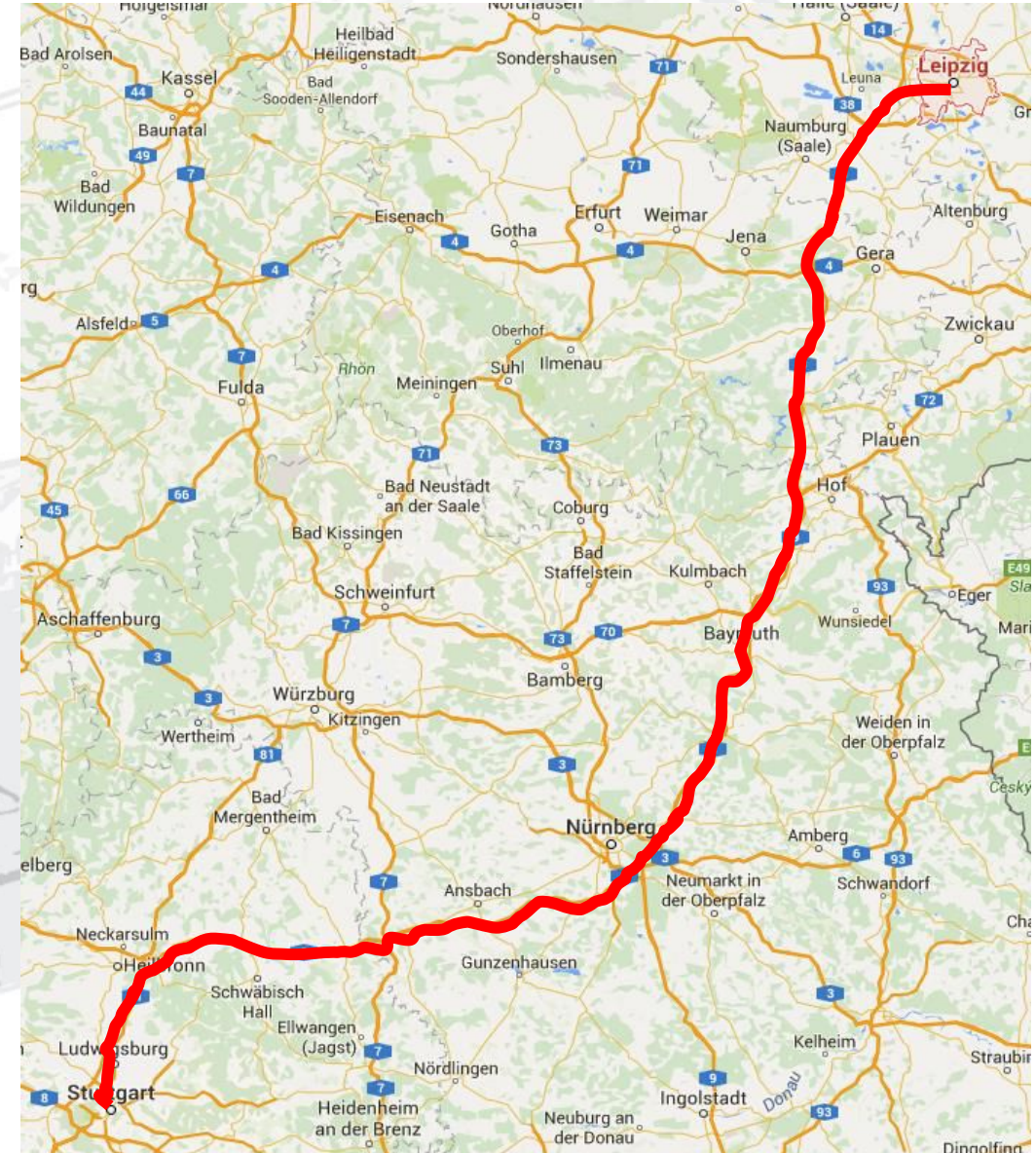
Fuel-cost CNG-diesel combined: 57,67 €

Savings: 24,96 €

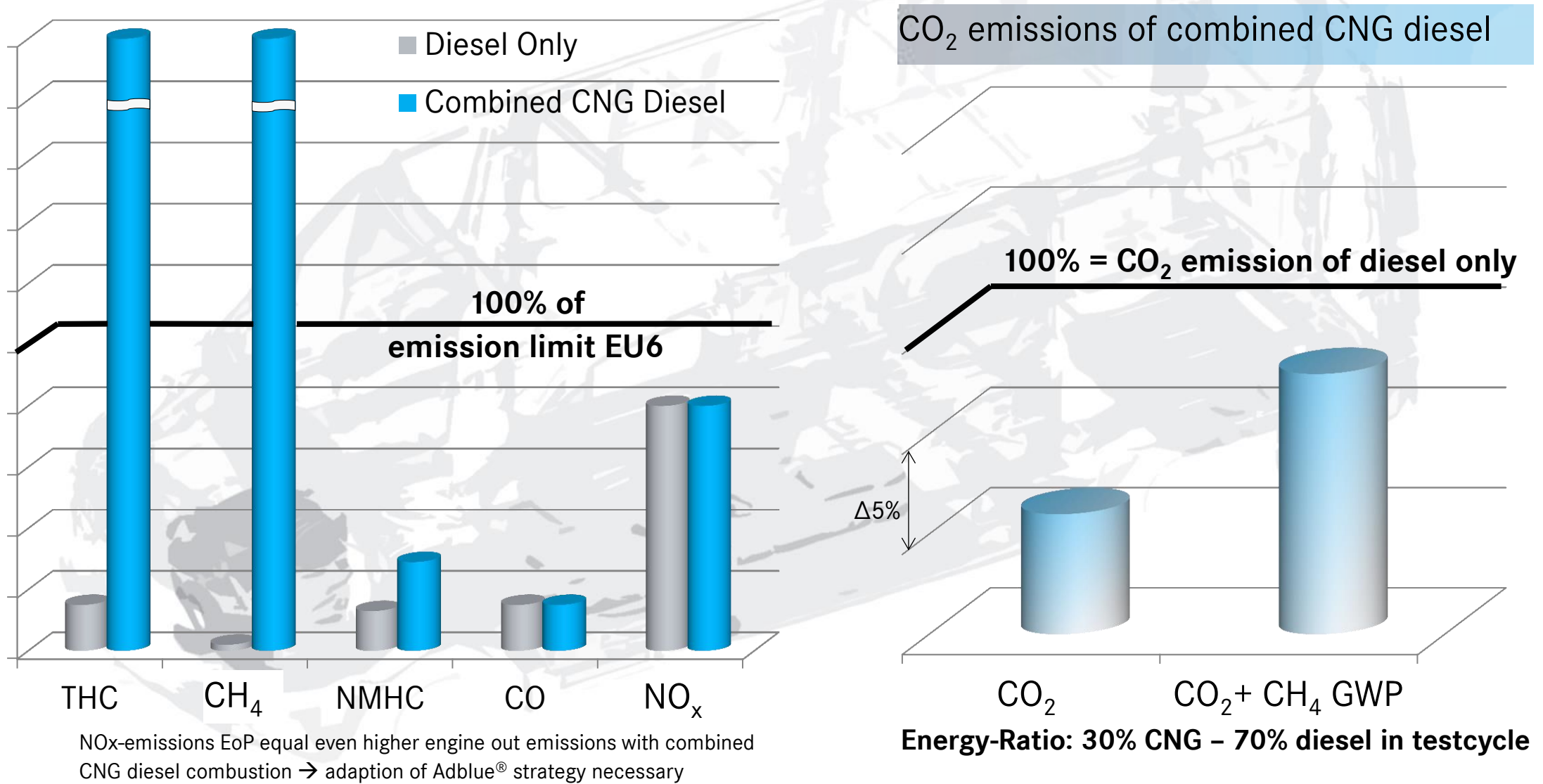
Remarks:

consumption based on BAB130

Fuel-cost: 1,35€ Diesel, 1,10€ CNG (prices at the beginning of the project)



Emissions



Conclusion

- The combination of diesel and CNG is an attractive way for reducing TCO and CO₂ emissions for commercial vehicles
- To bring these benefits to market, a change in the legislation is required
- The drivability of the system as shown is nearly full filled in all boundary conditions (high, cold, sea-level, ...) and switching between diesel only and combined CNG diesel is unsuspecting
- Modern passenger car diesel engine shows many features, which help to perform the combination of CNG and diesel combustion
- A further development on the CH₄ conversion on the oxidation catalyst has to be done to get the best performance of the powertrain in combination with low emissions



Thank you for your attention!

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