

National Motorcycle Museum,
Solihull/UK, February 25th, 2026

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Senior Project Manager

Prepared for

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Future Propulsion Conference

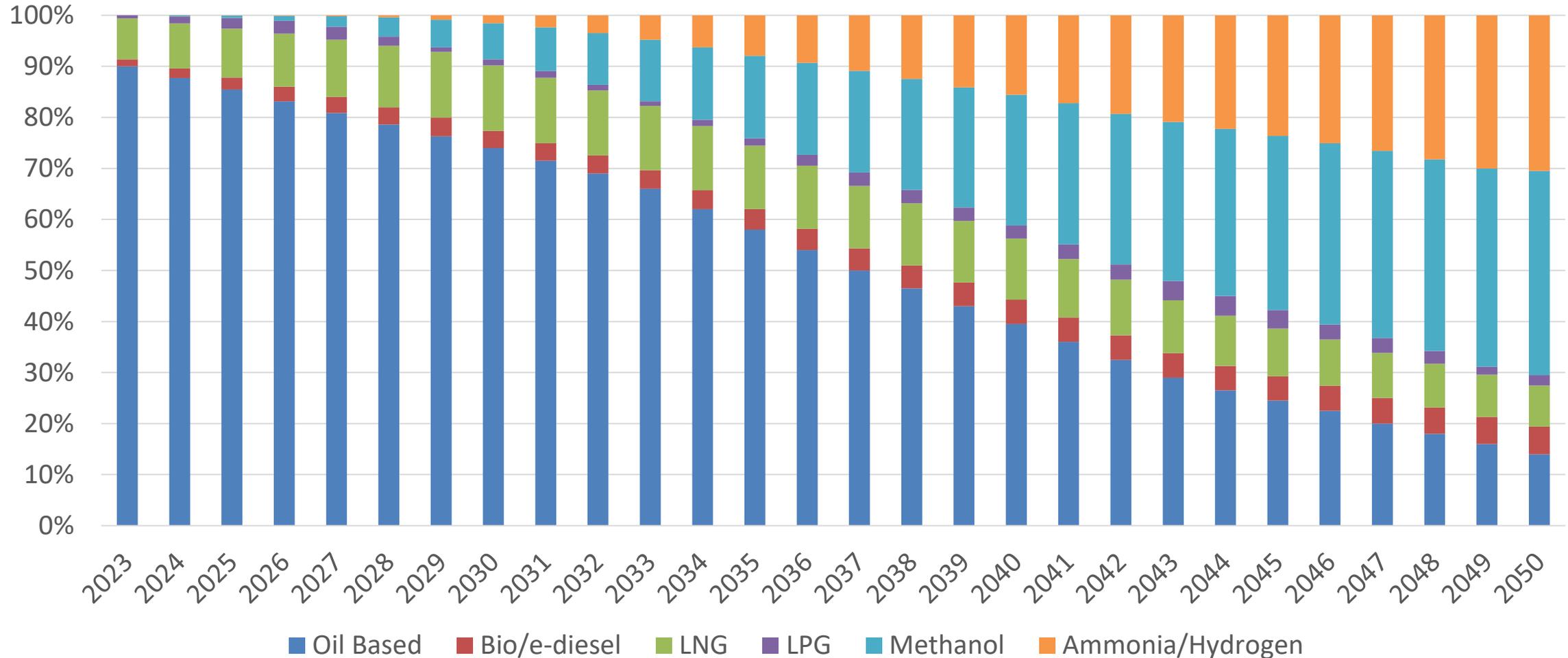
Optimized NH₃ Combustion System for Commercial Applications



Development towards sustainability drives the adoption of multiple renewable energy sources for marine transportation

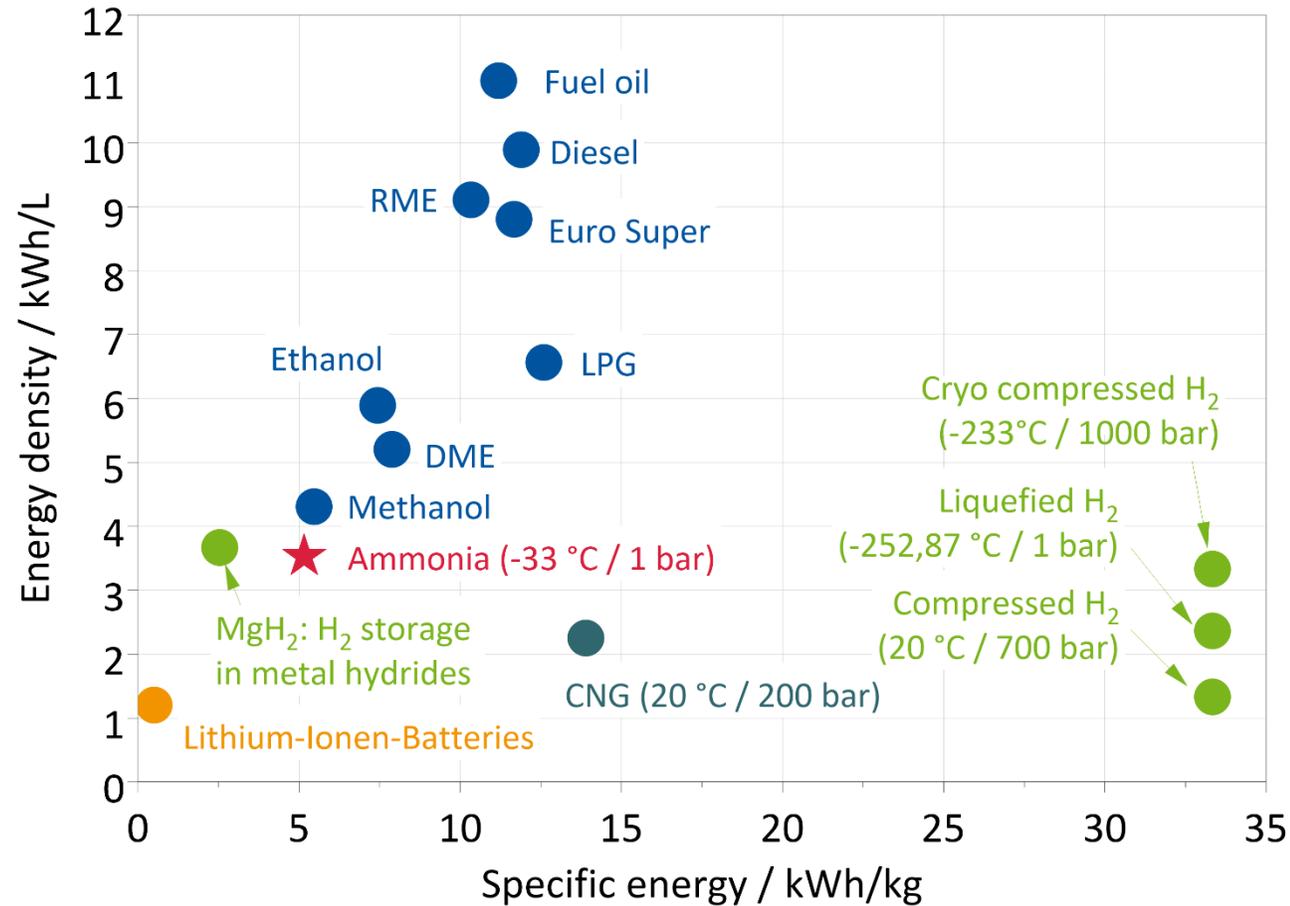


FINAL ENERGY CARRIER DEMAND

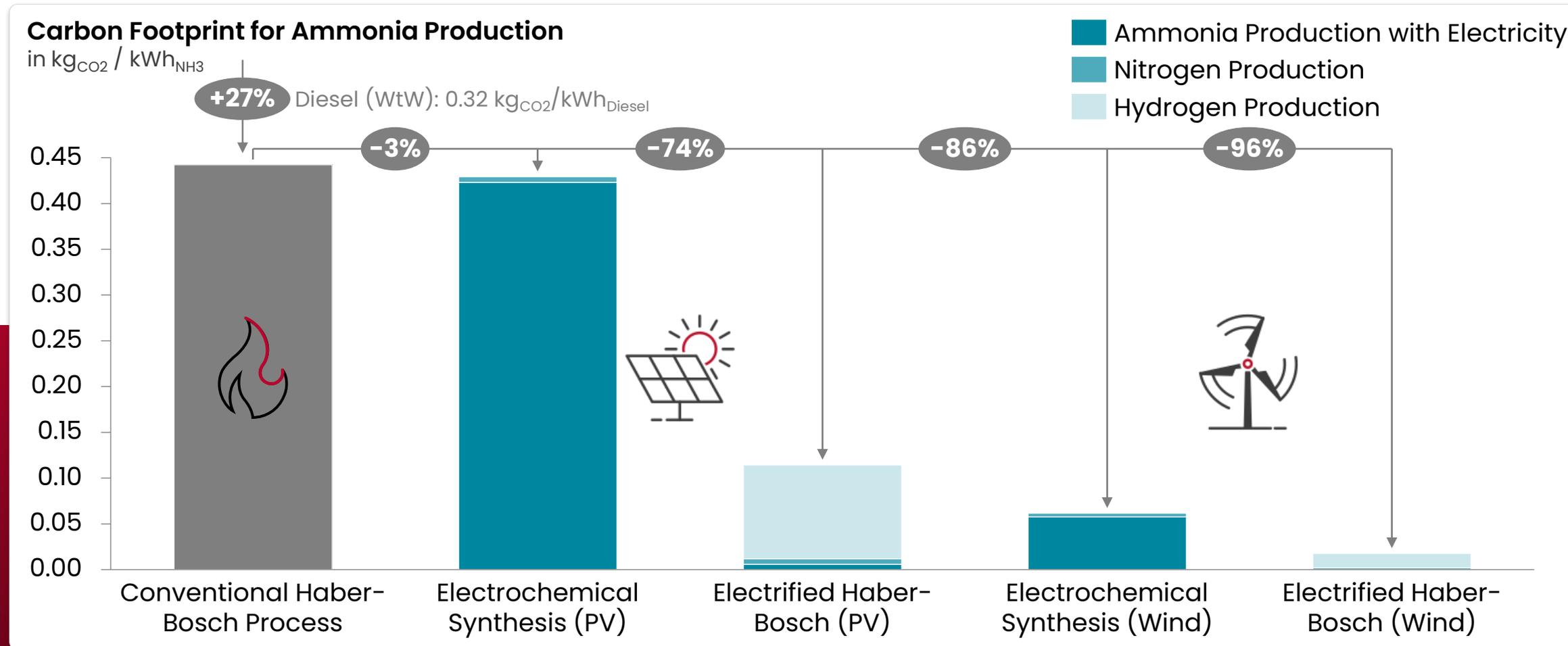


Source: "CARBON NEUTRAL FUEL PATHWAYS and TRANSFORMATIONAL TECHNOLOGIES", American Bureau of Shipping, 2024

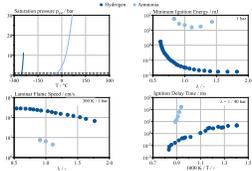
The volumetric energy density of ammonia is in a comparable level as Methanol, but fuel system complexity is lower compared to H₂ storage



The carbon footprint of ammonia can be greatly reduced by utilizing renewable electricity sources during the production process.



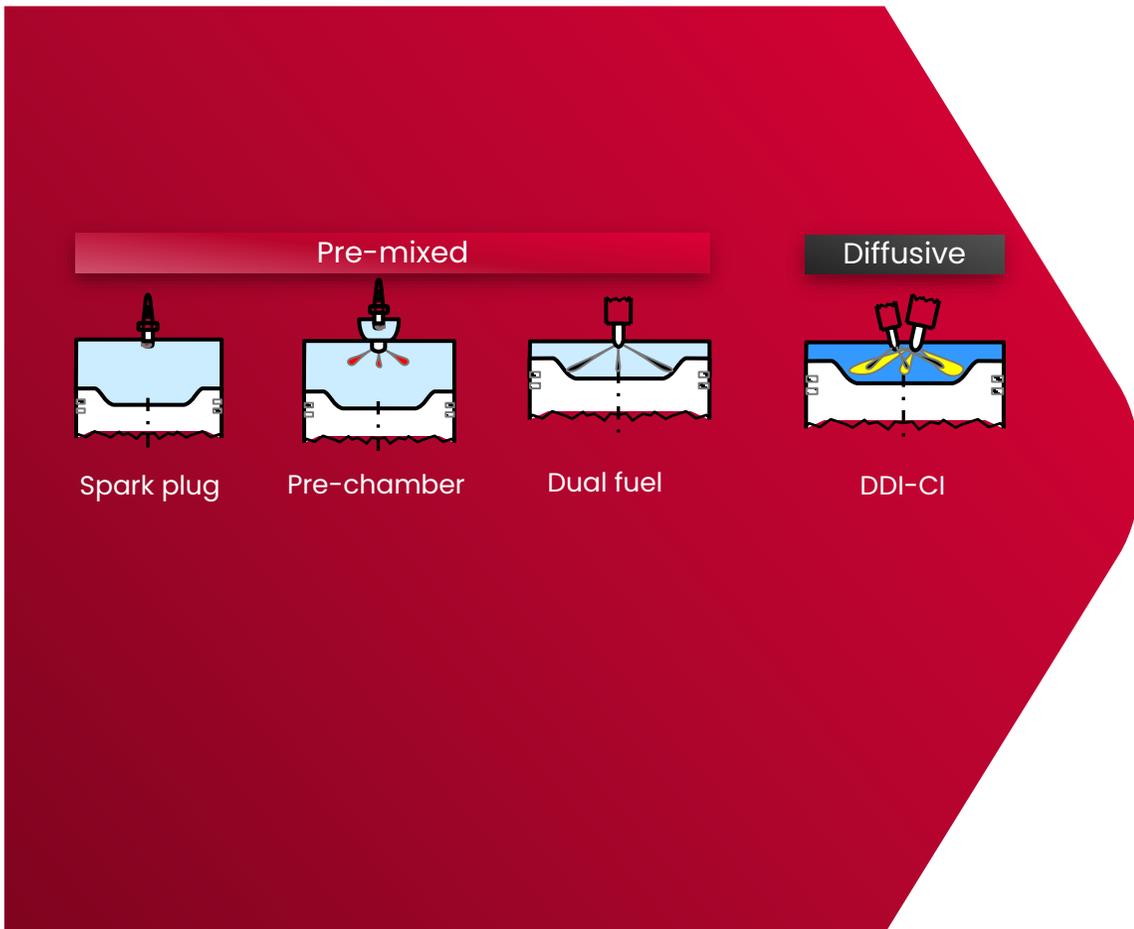
The fuel properties of ammonia differ significantly from Hydrogen and have a major impact on the combustion system layout



SUMMARY

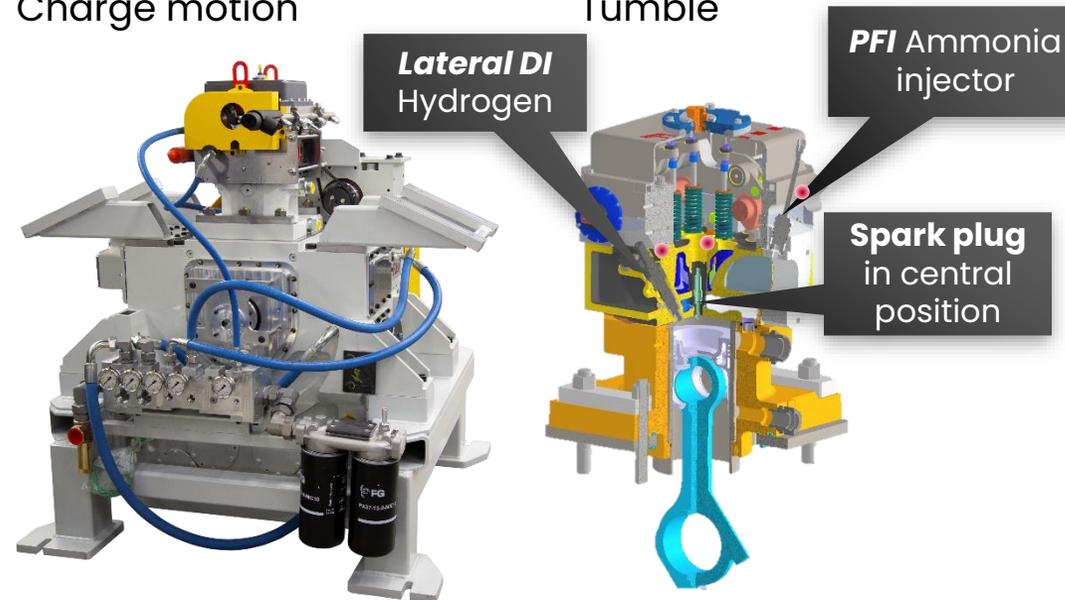
- Significantly higher ignition energy for ammonia
- Significantly lower laminar flame speed for ammonia
- Significantly longer ignition delay for ammonia
- Lower adiabatic flame temperature with ammonia

Ammonia combustion concepts and FEV-HD single cylinder research engine setup



Technical Data:

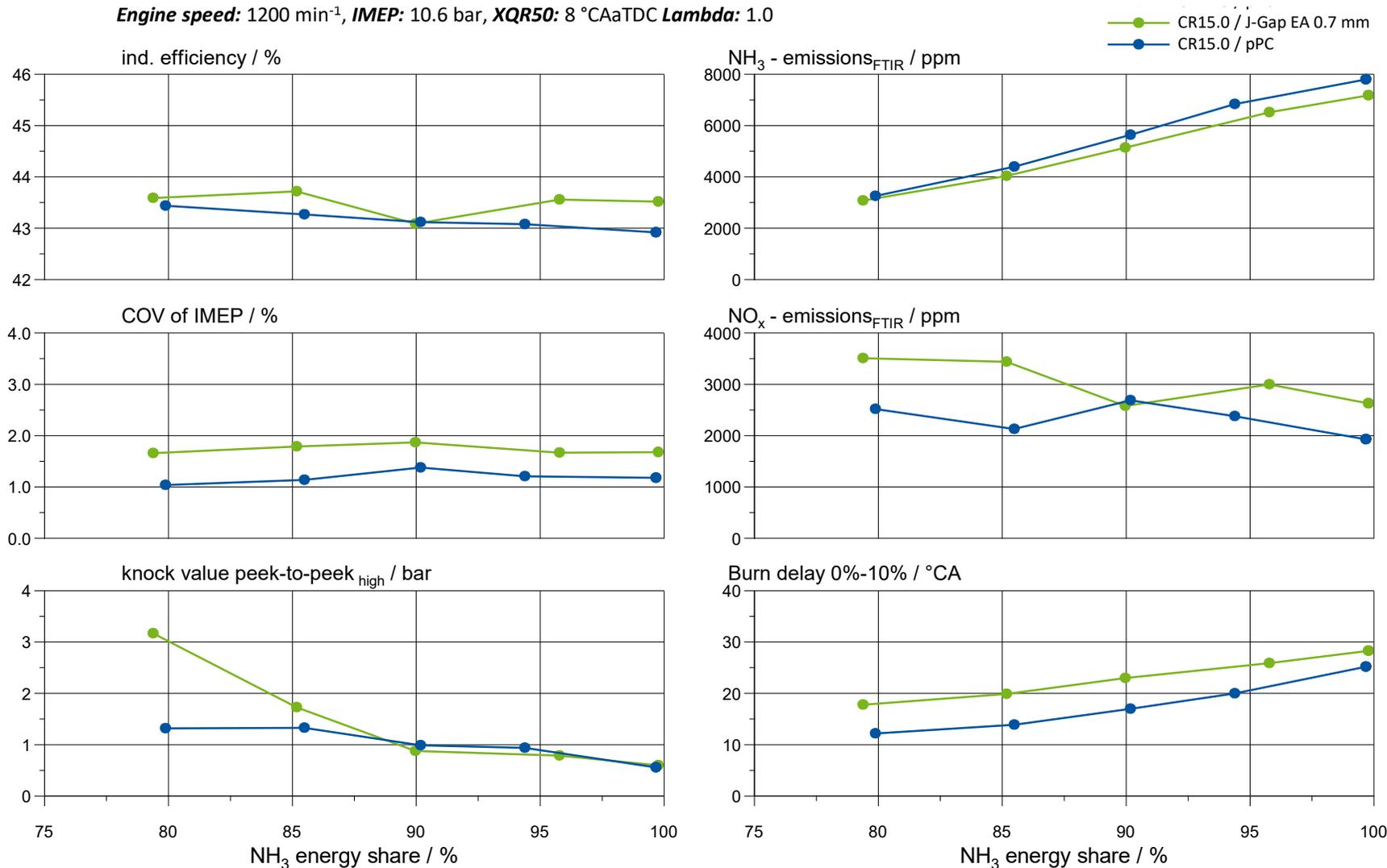
Bore / Stroke	132 / 156 mm
Swept volume	2.13 dm ³
Compression ratio	15
Peak firing pressure (max.)	up to 300 bar
Charge motion	Tumble





The addition of hydrogen to ammonia combustion has only a moderate impact on the combustion characteristics

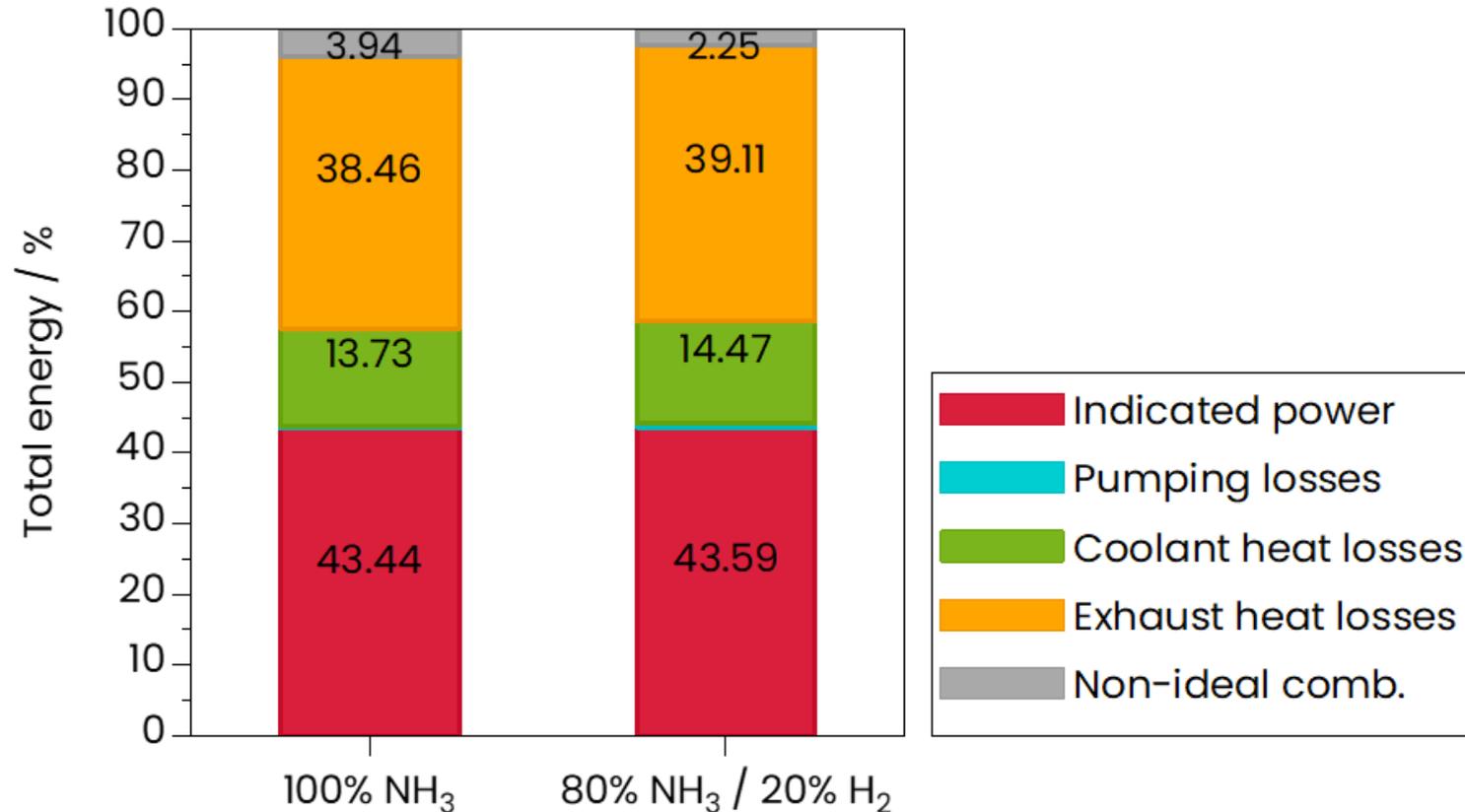
Engine speed: 1200 min⁻¹, IMEP: 10.6 bar, XQR50: 8 °CAaTDC Lambda: 1.0



The addition of hydrogen to ammonia combustion does not lead to a major improvement of efficiency. Faster heat release is compensated by higher heat loss



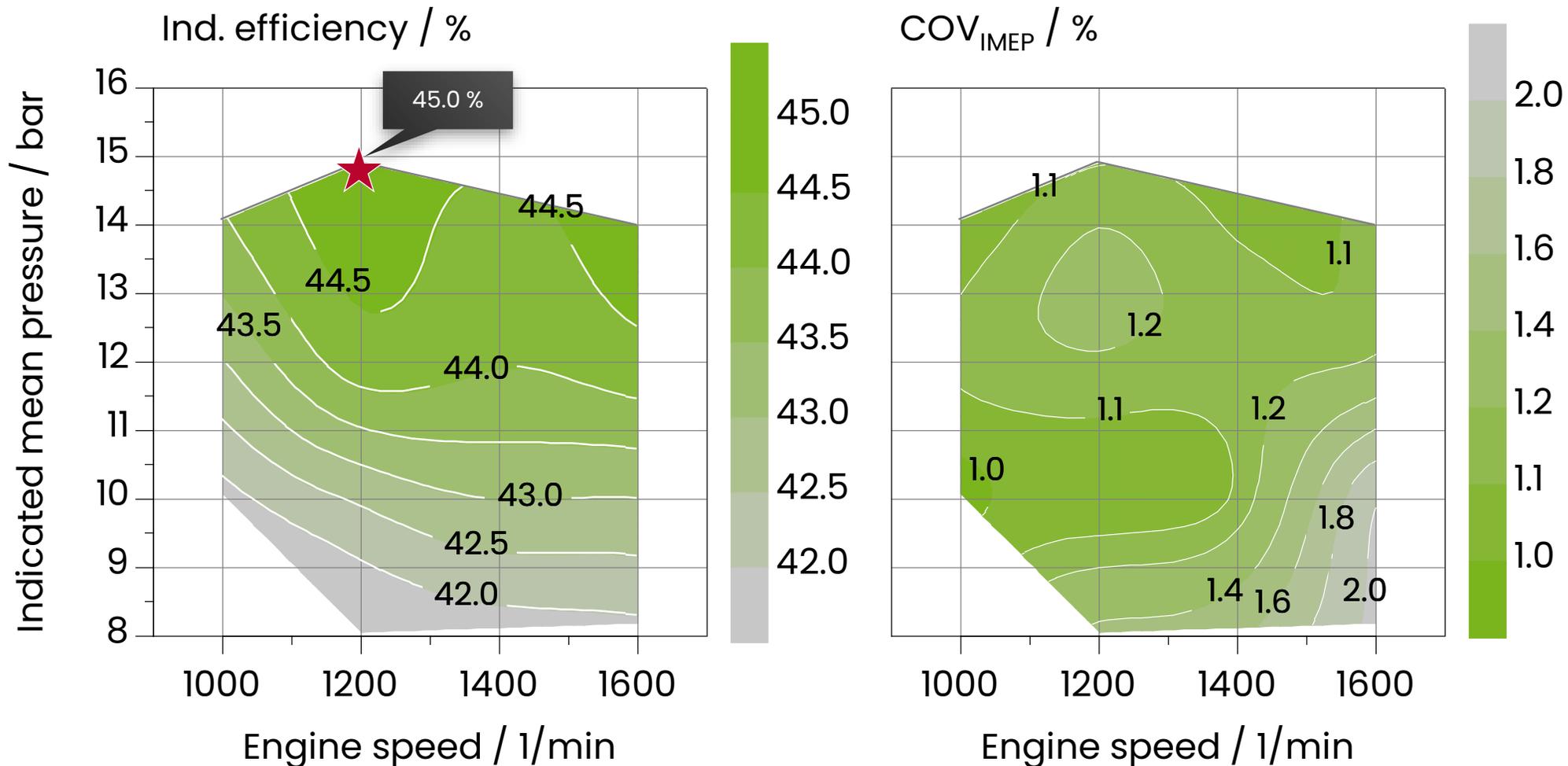
n = 1200 1/min; IMEP = 10.6 bar
 MFB50 = 8° CA aTDCF; rel. AFR =1.0



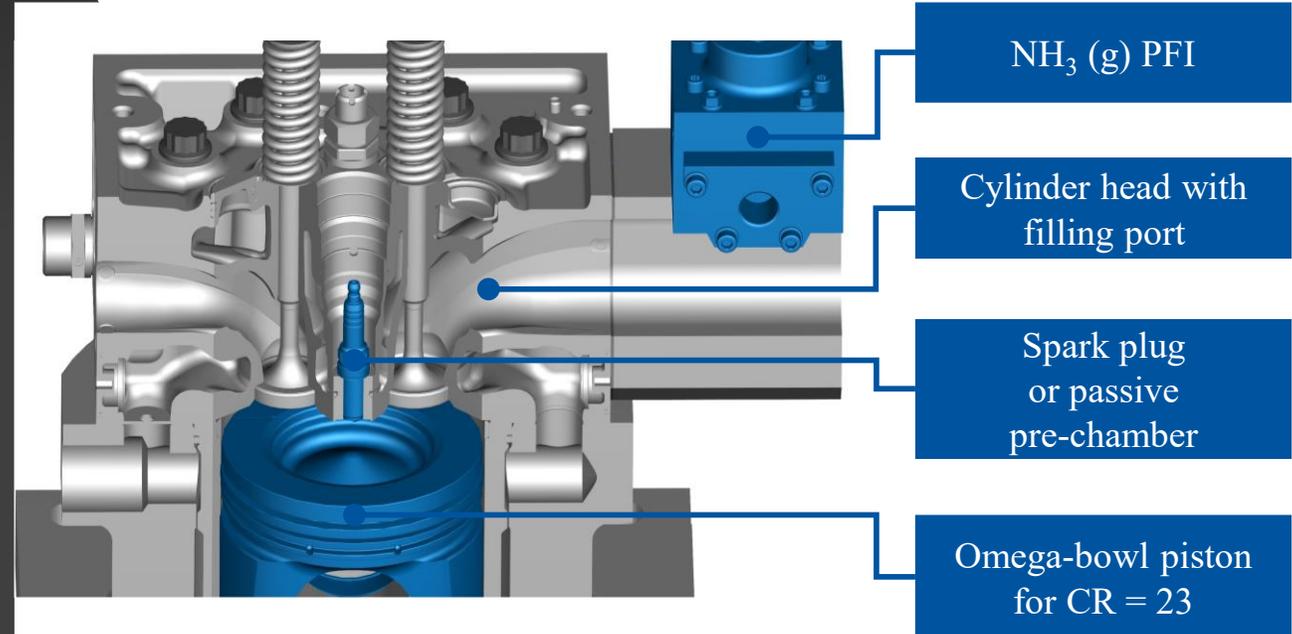
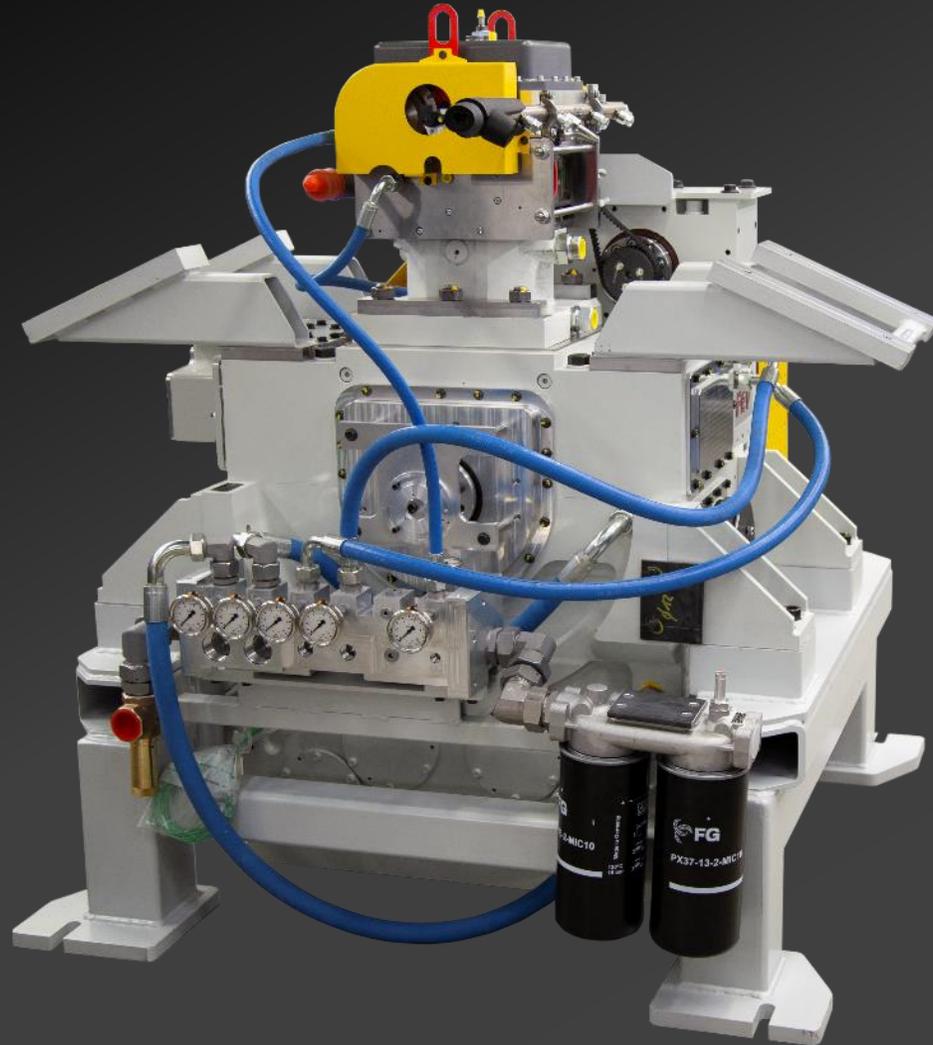
A good combustion characteristics can be demonstrated across a wide engine operation area with 100% ammonia and stoichiometric AFR.



ENGINE MAPPING WITH PASSIVE PRE-CHAMBER

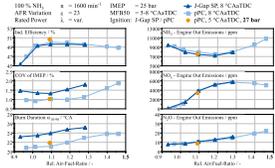


FEV's Fuel Flexible HD SCE was used in the SI NH₃ configuration



	Unit	Value
Bore x Stroke	mm	132 x 156
Displacement	dm ³	2.13
Compression Ratio	-	23 : 1
Intake Ports	-	Filling port

Ammonia combustion is compatible with very high compression ratio's benefitting engine efficiency.



SUMMARY

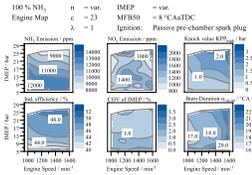
- High peak efficiencies of up to 50.8% indicated efficiency can be realized.
- Passive pre-chamber with improved lean-burn capability and minor efficiency benefits.
- Relative air fuel ratio of 1.3 ideal for exhaust aftertreatment (NO_x/NH₃ ratio ~ 1)

Engine operation with pure ammonia is possible across a wide engine speed and load range, but low load operation can be challenging



SUMMARY

- Peak indicated efficiency reached is 49.3%
- No knocking observed in investigated map area
- Short burn duration and good combustion stability



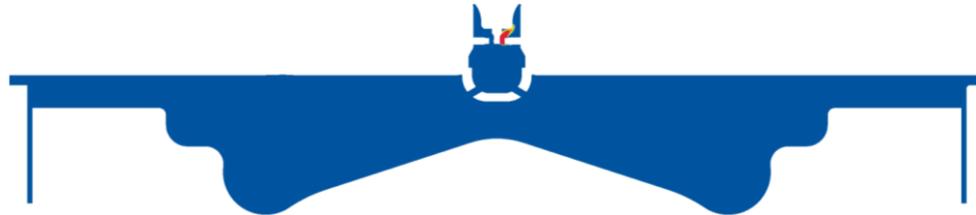
CFD simulation of the combustion process shows an asymmetric flame propagation. Combustion chamber geometry optimization and ignition system optimization are key for further improvements.



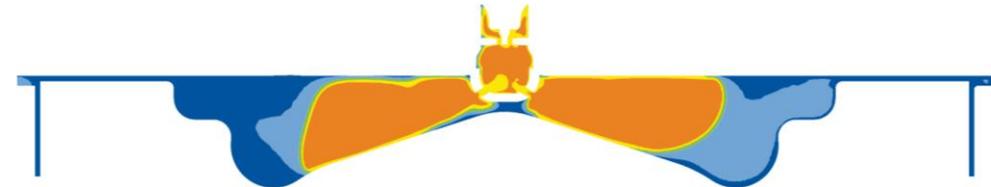
100 % NH₃ n = 1600 min⁻¹ IMEP = 27 bar
 Simulation ε = 23
 λ = 1.1 MFB50 = 5 °CAaTDC
 Ignition: Passive pre-chamber

Temperature / K		1750
2750		1500
2500		1250
2250		1000
2000		750

- 16 °CAaTDC - Ignition



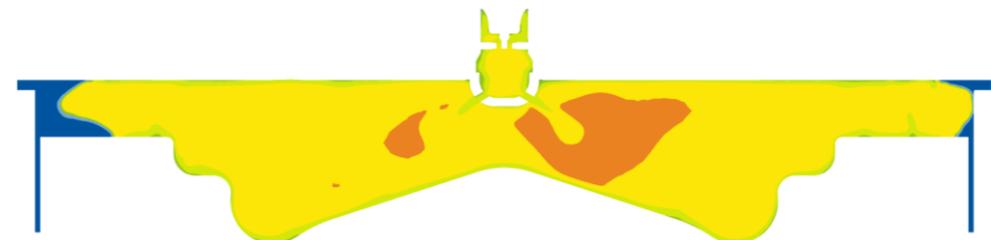
-1 °CAaTDC - MFB10



5 °CAaTDC - MFB50



20 °CAaTDC - MFB90



SUMMARY AND OUTLOOK

NH₃ as energy source enables highest efficiency through knock free combustion even at highest compression ratios.

- Experimental investigations of ammonia combustion on a HD-SCE show promising results regarding engine efficiency and width of engine operating area.
- The unique properties of ammonia enable knock-free operation even at high engine loads and high compression ratios
- Combustion stabilization by addition of hydrogen is not mandatory
- CFD simulation indicates further optimization potential through optimization of combustion chamber geometry and ignition system layout
- Future investigations are planned with Diesel pilot injection.

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