Towards ultra-efficiency and zero-emissions with methanol engines

SUMMETH Final Seminar
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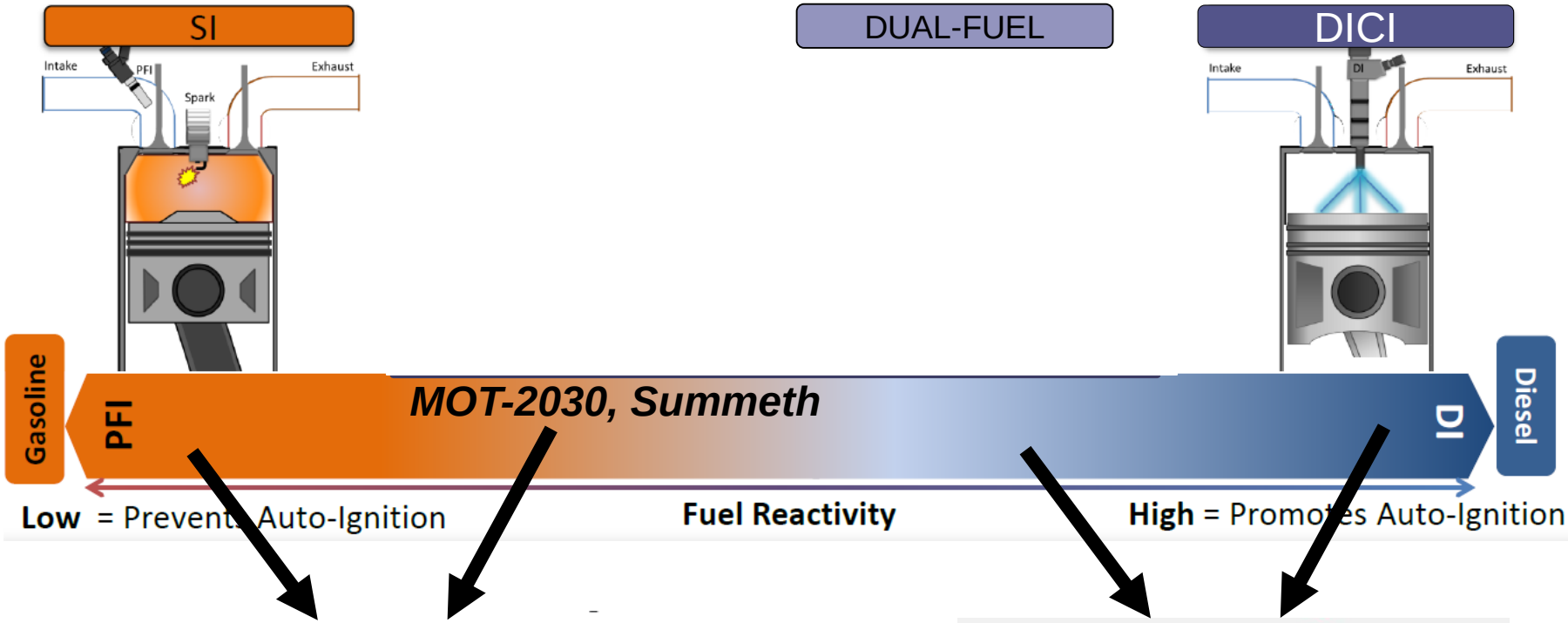
Taken for granted – but completely unnecessary crap!

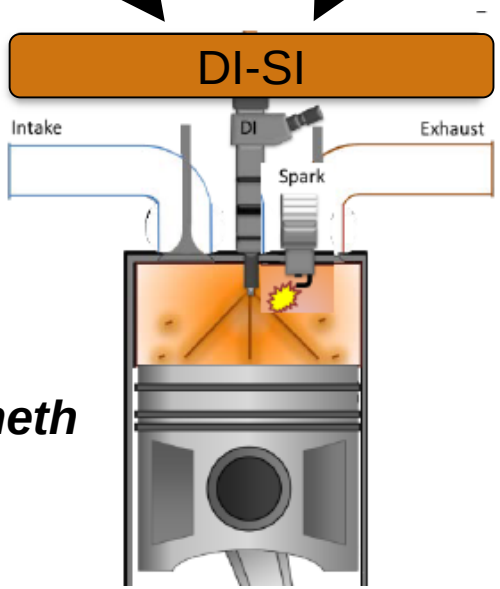
Methanol

- Can be produced at “low” cost from multitude of sources
- Compatible with gasoline, ethanol, butanol….
- Excellent GHG potential
- Toxic to humans and corrosive
- Reduced impact from spills (especially in water)

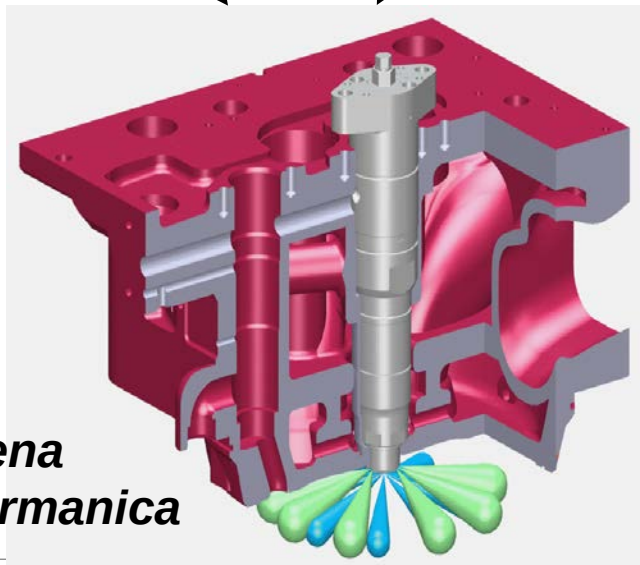
Green Pilot

ED95, MD95 (Summeth)

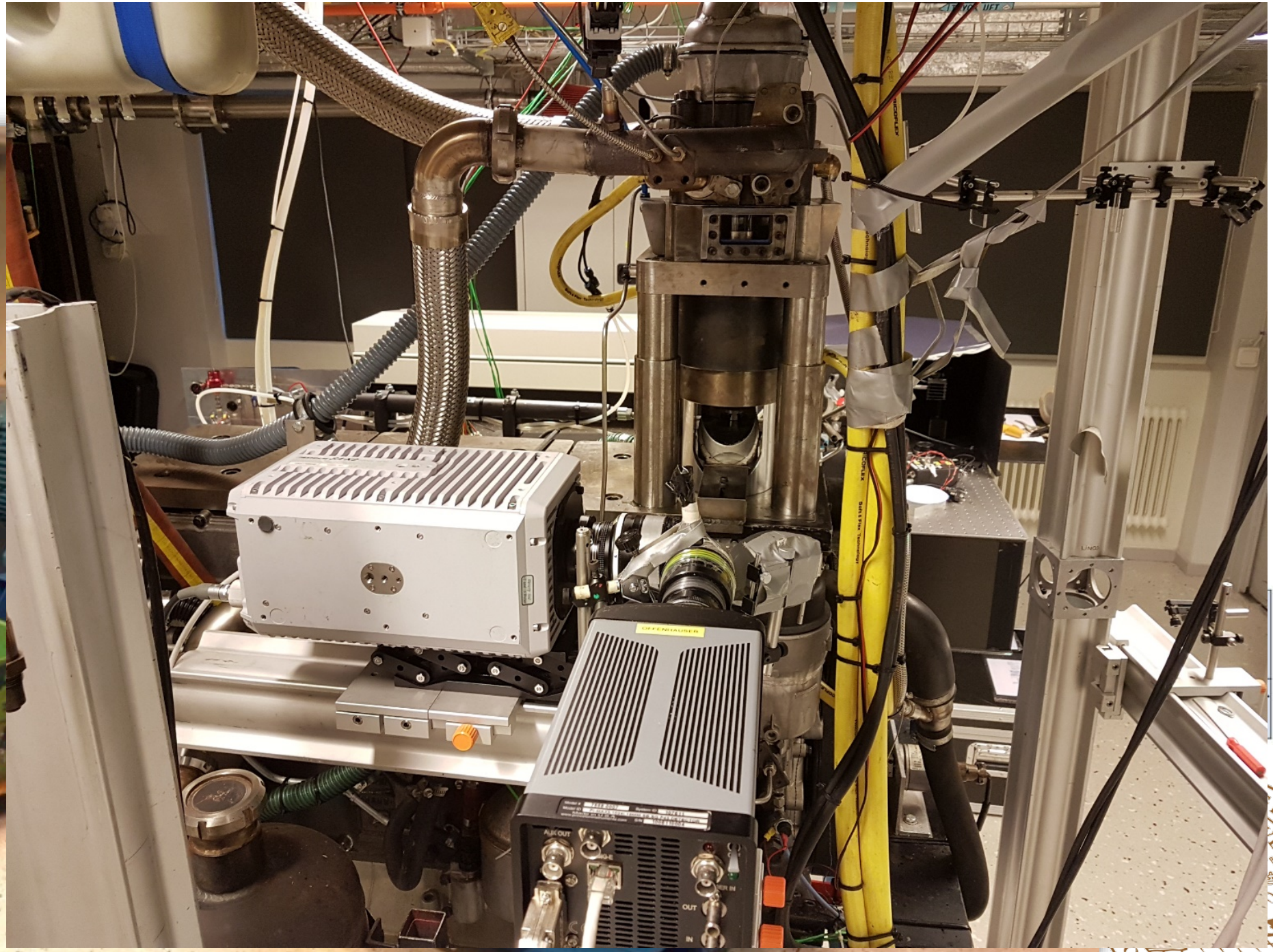




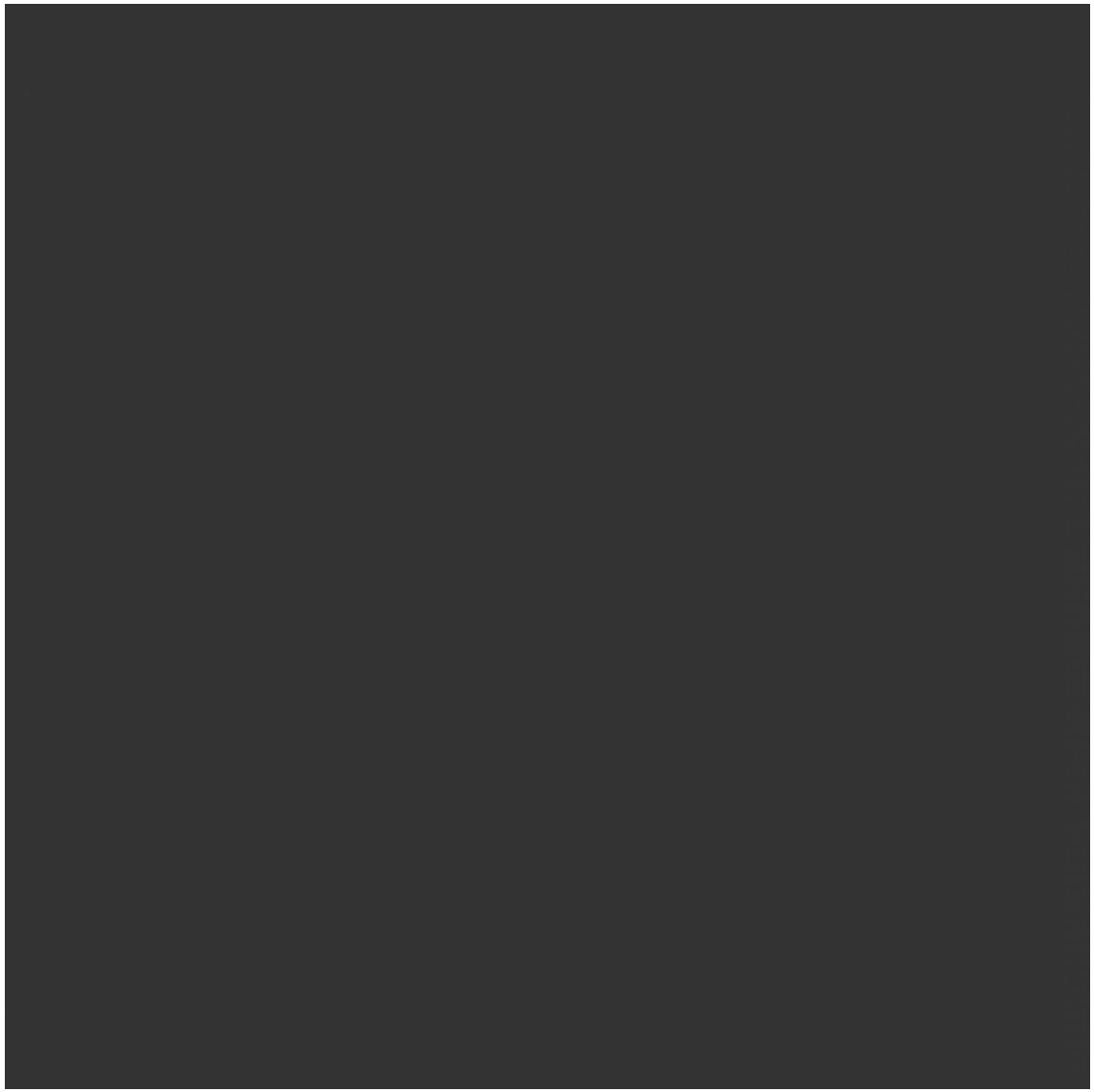
Summeth



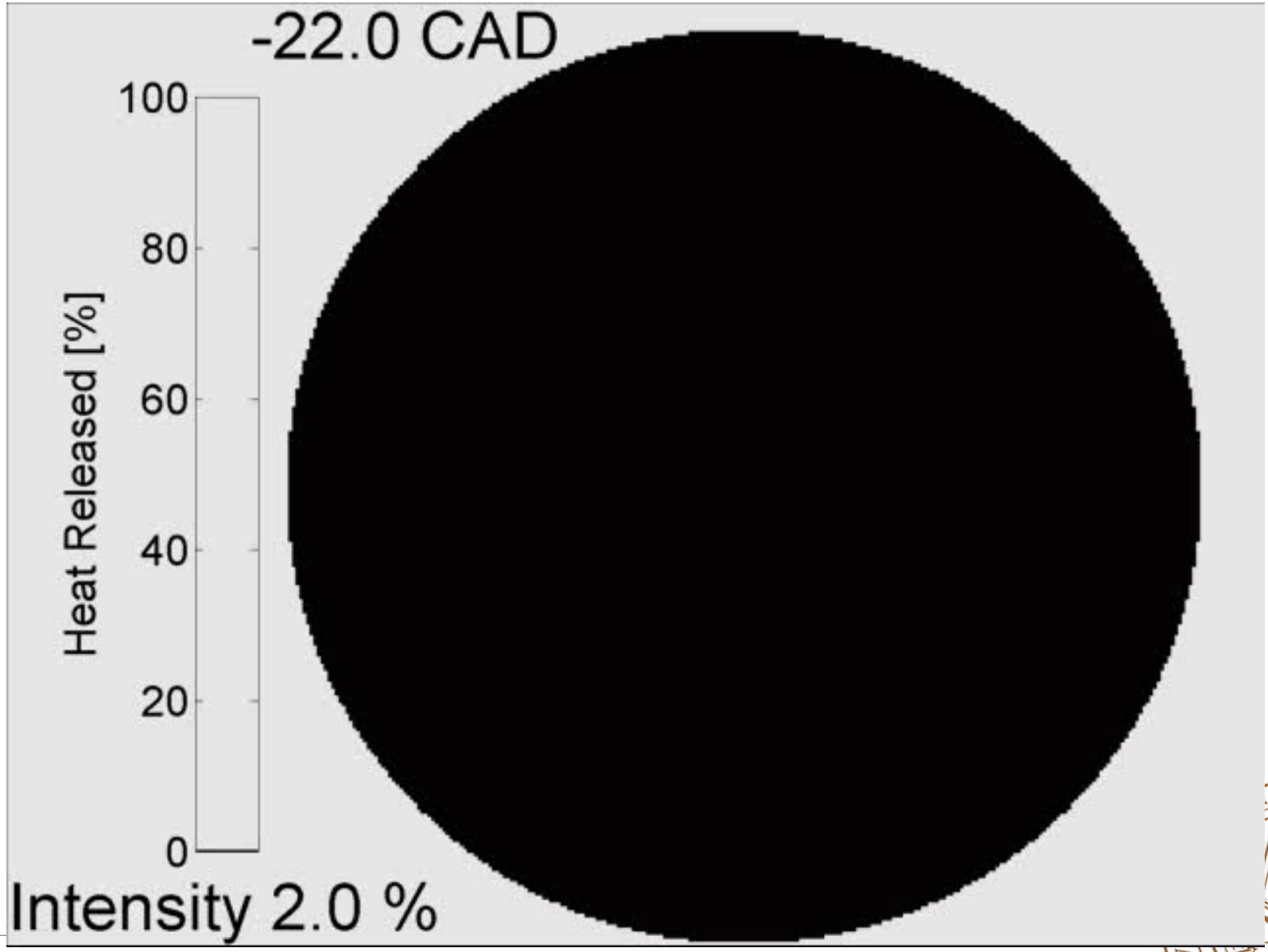
Stena Germanica


OFFENHAUSER
AUX OUT
OUT
IN

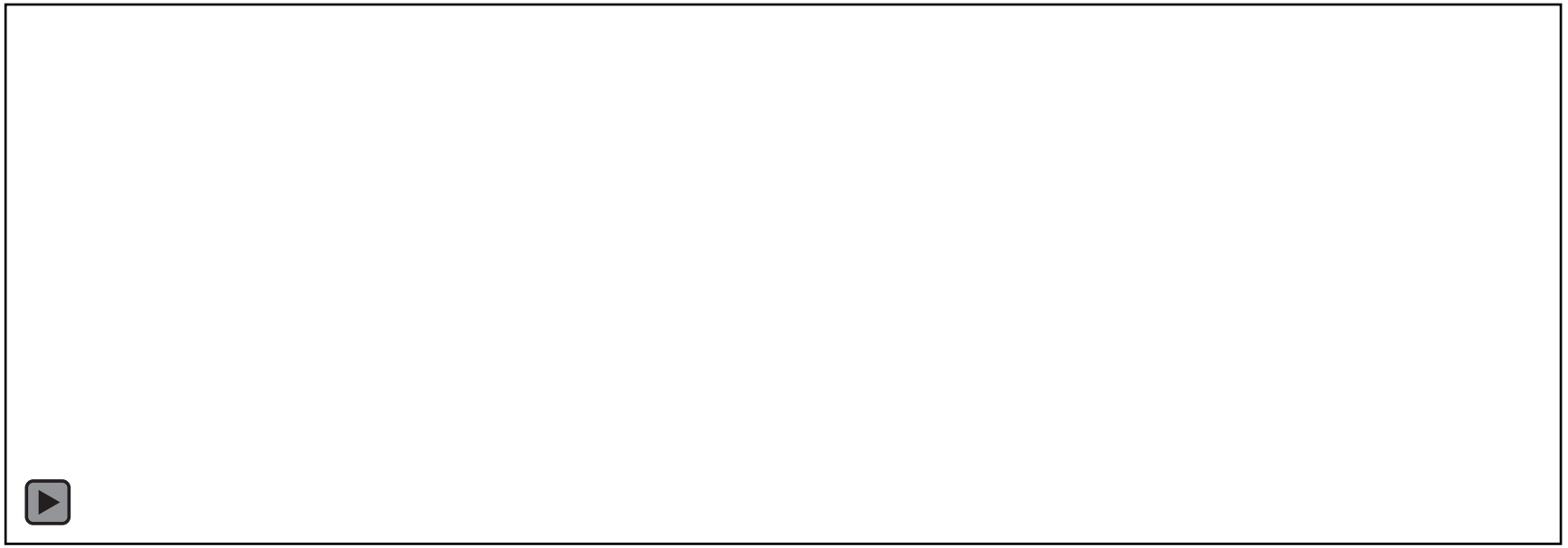
DI combustion – diffusion flame



SI combustion – flame propagation



Methanol PPC
Flat piston - triple injection case



Auto ignition of spray plume and ignition propagation towards richer fuel zones with eventual diffusion controlled combustion

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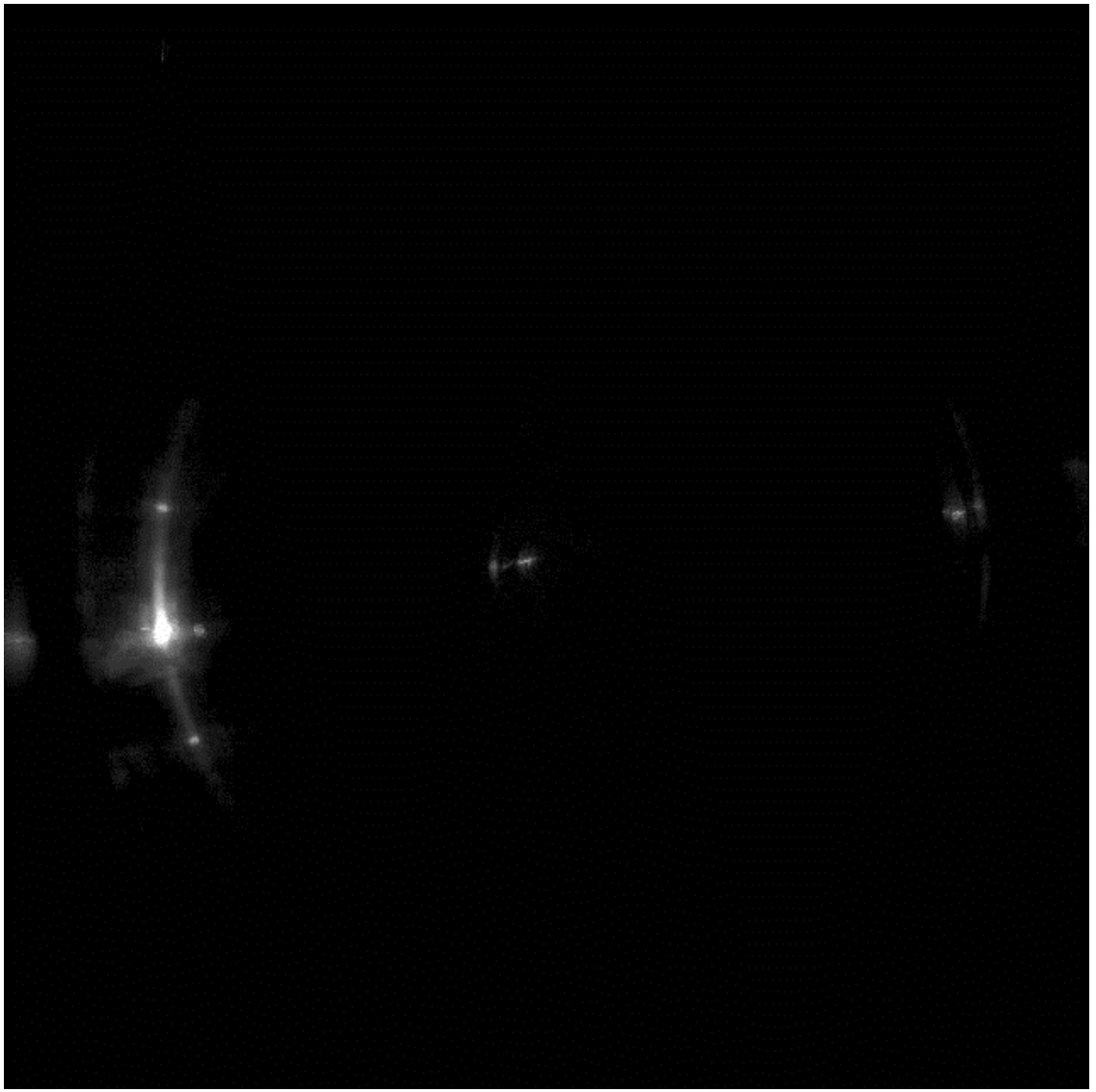
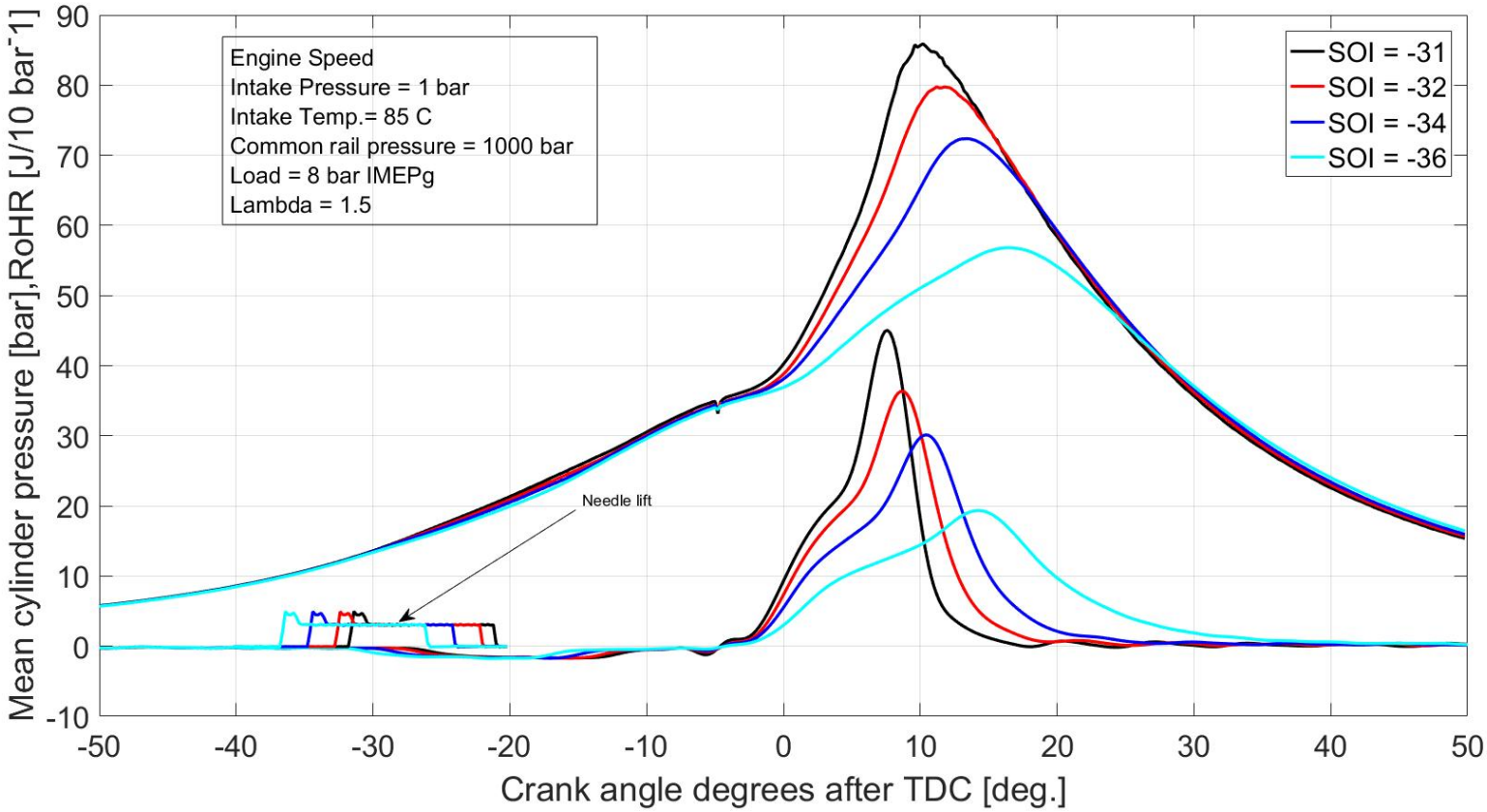
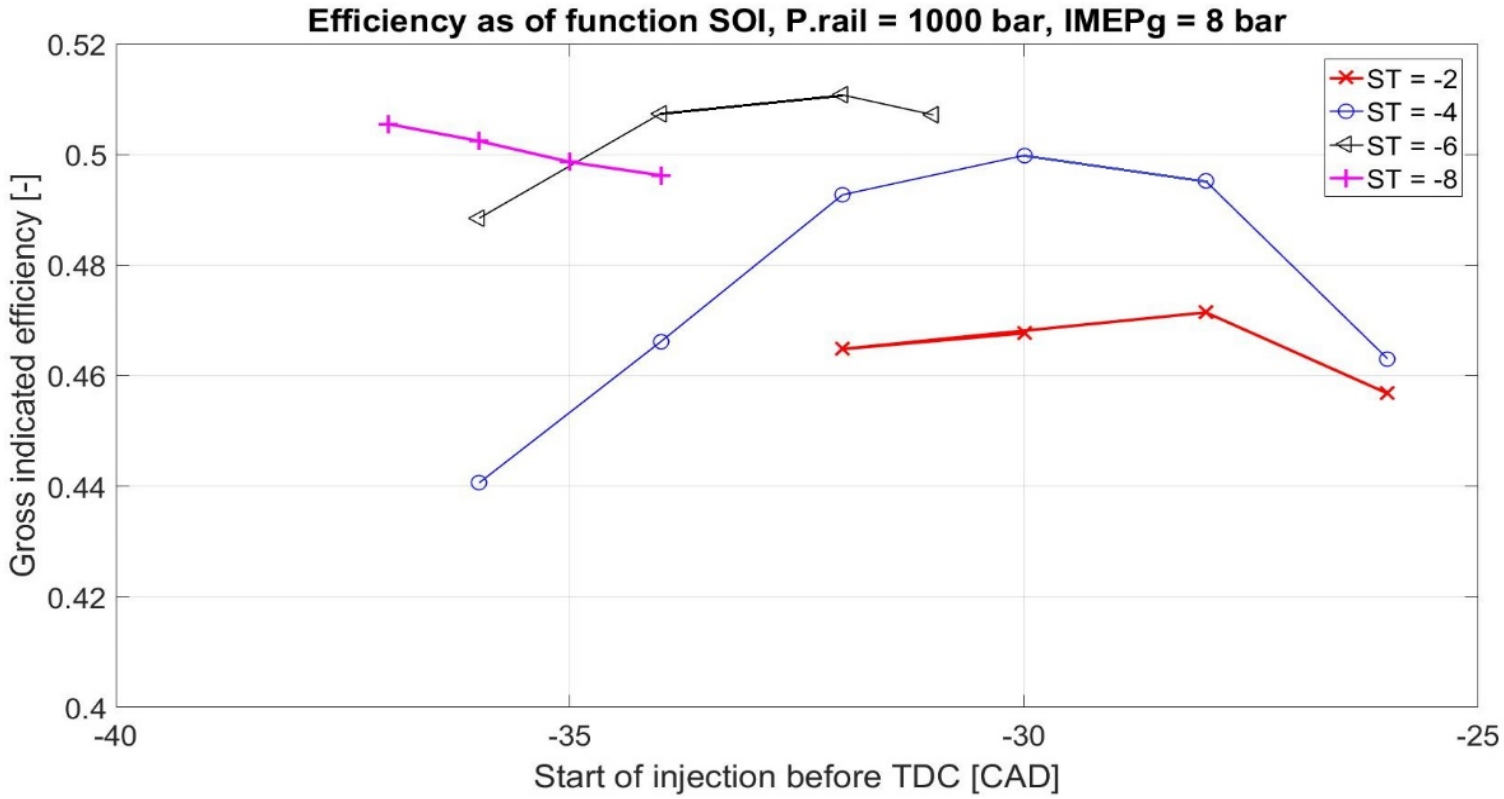
Combustion initiation…



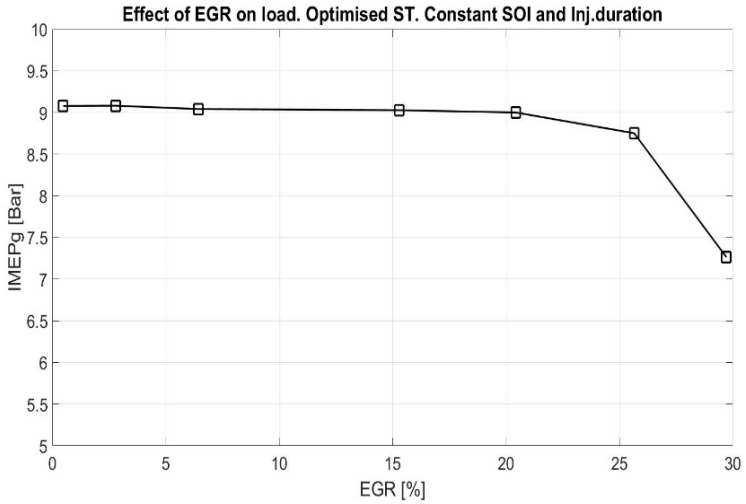
DI-SI resultat

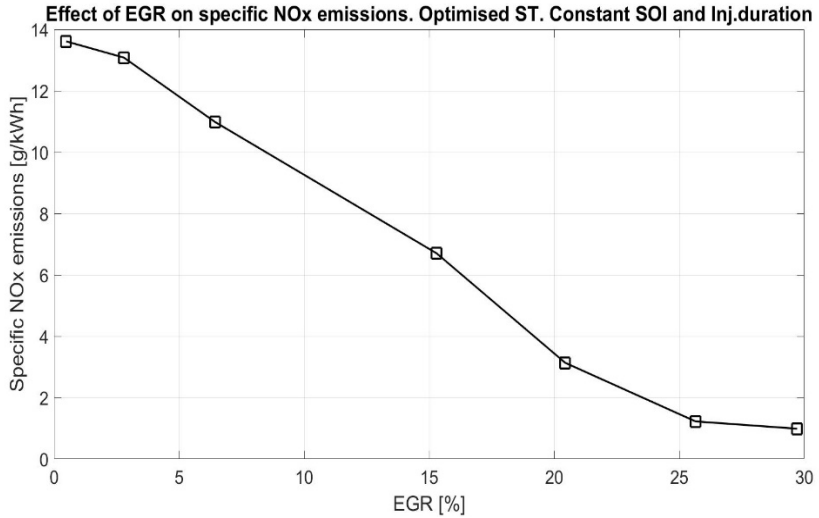


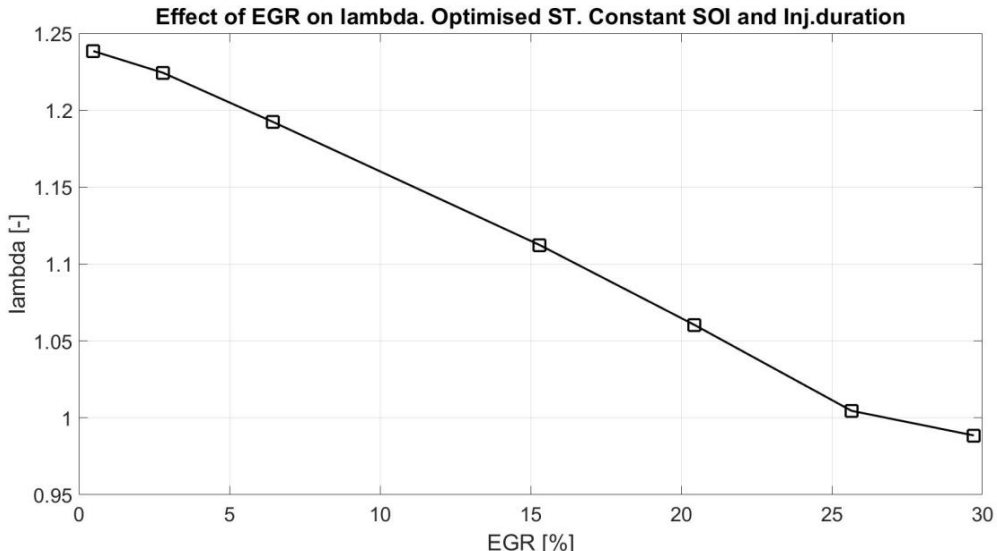
Stratified DI-SI show high efficiency and sensitivity



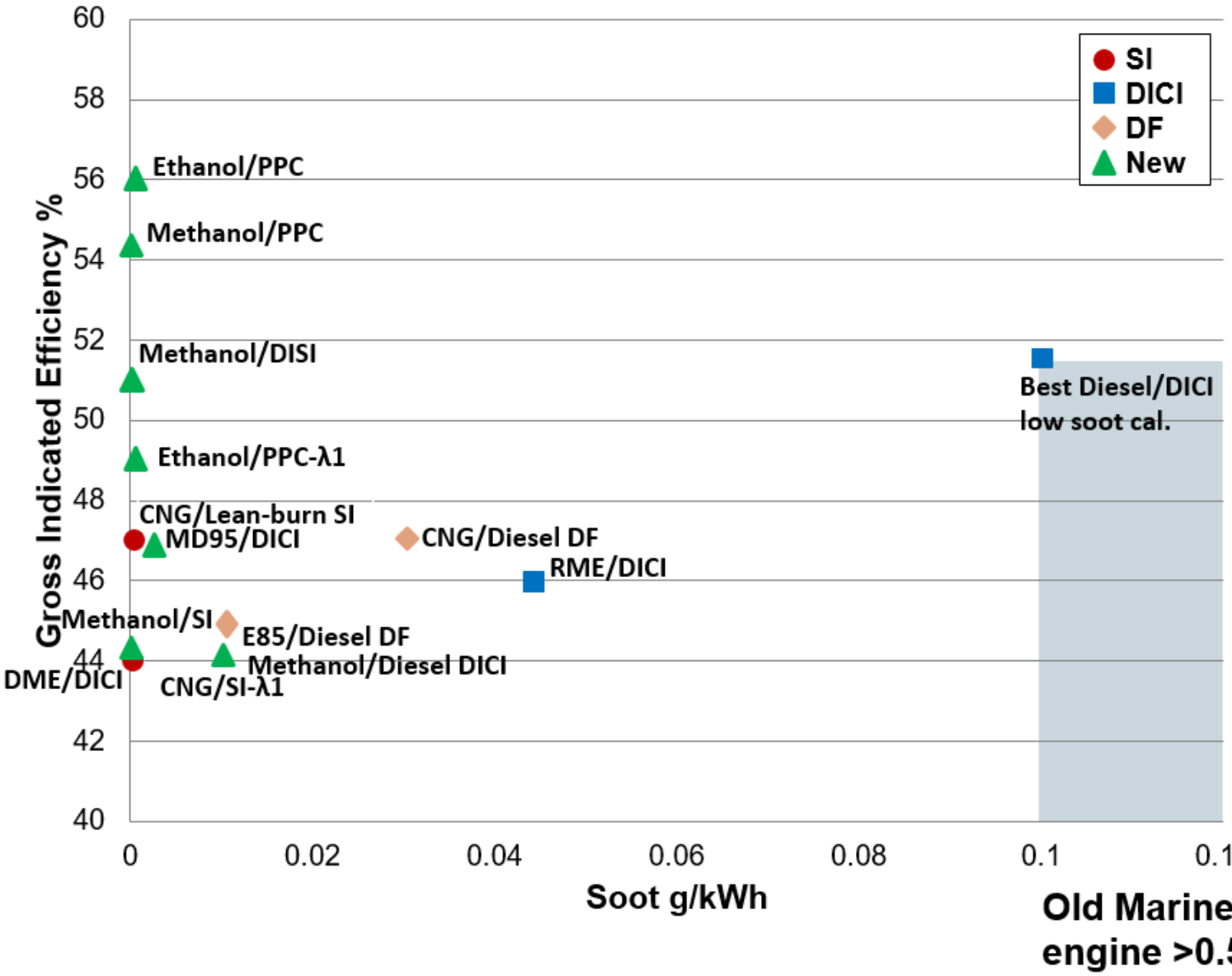
>46% GIE possible with lambda 1.0 (and thus TWC)



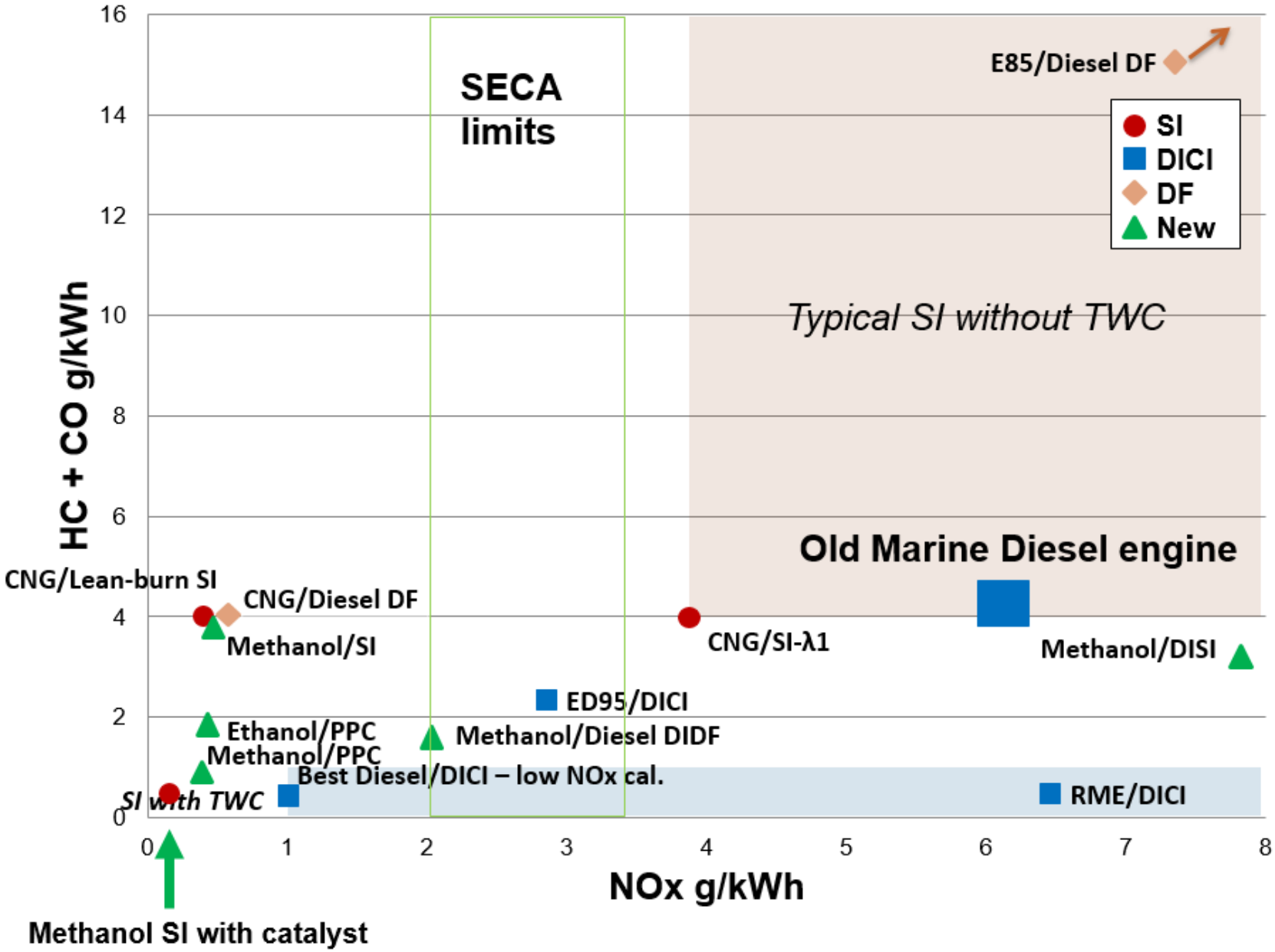




GIE and engine-out soot - HD engines

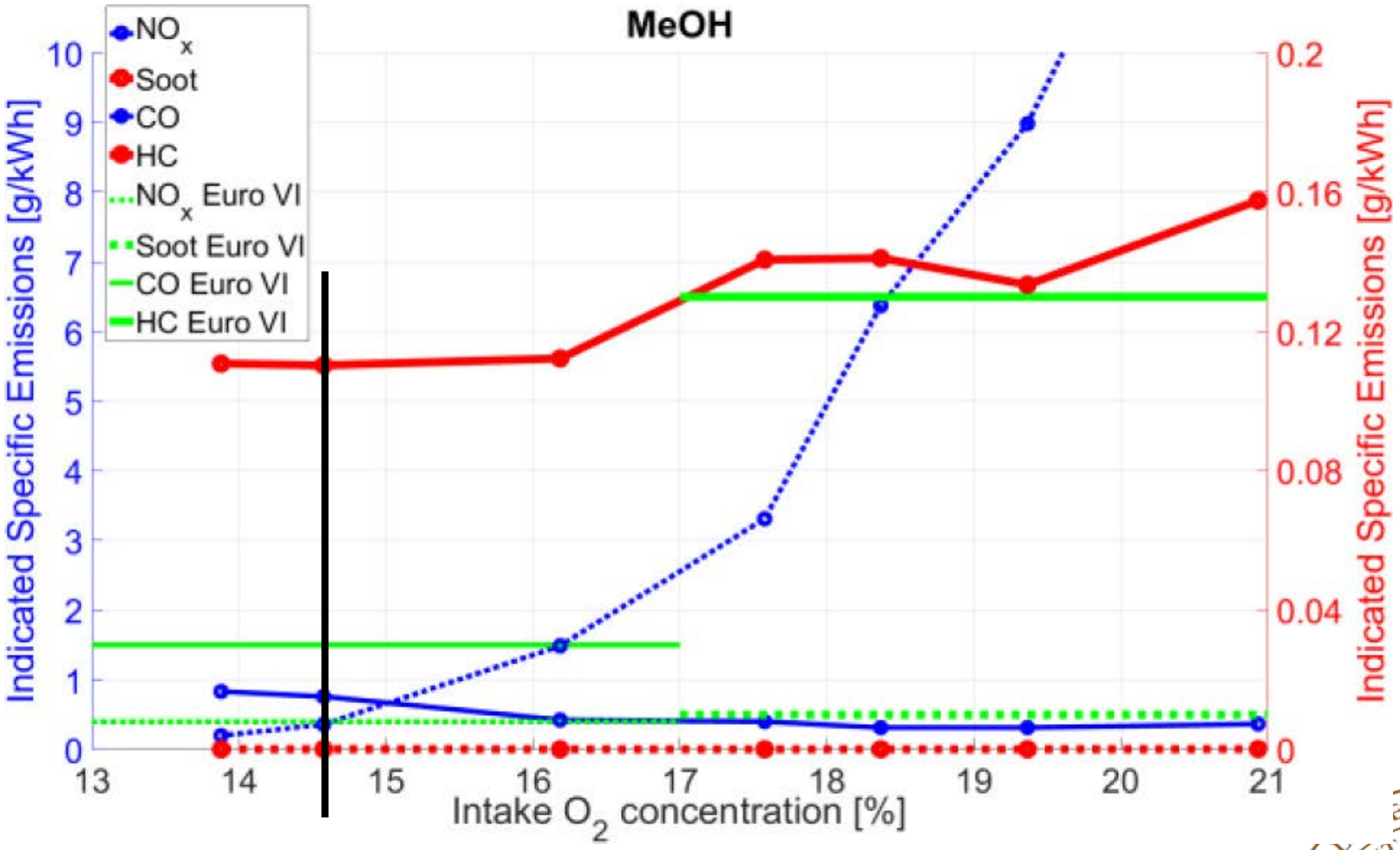


Engine-out emissions - HD engines



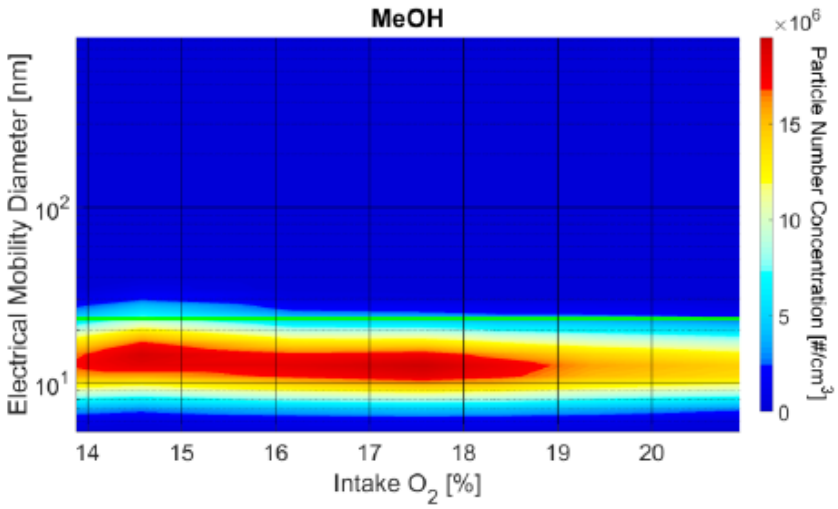
Towards “zero” emissions

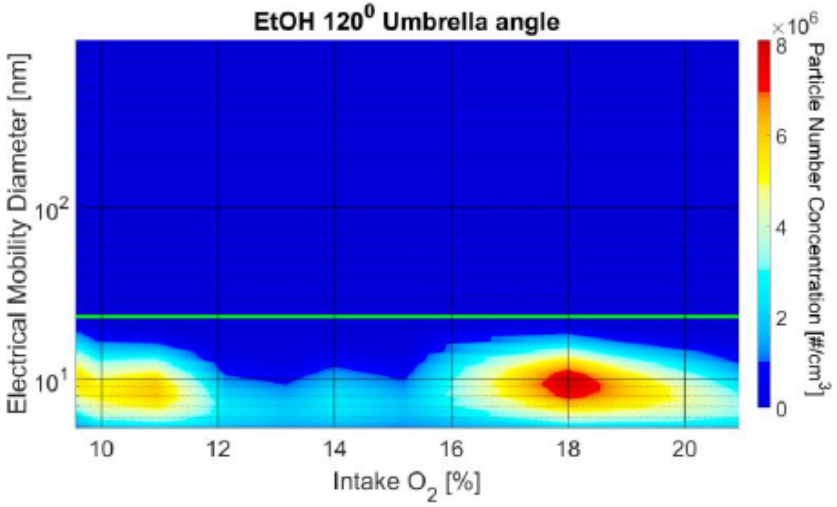
PPC meet EURO VI w/o EATS (steady state)

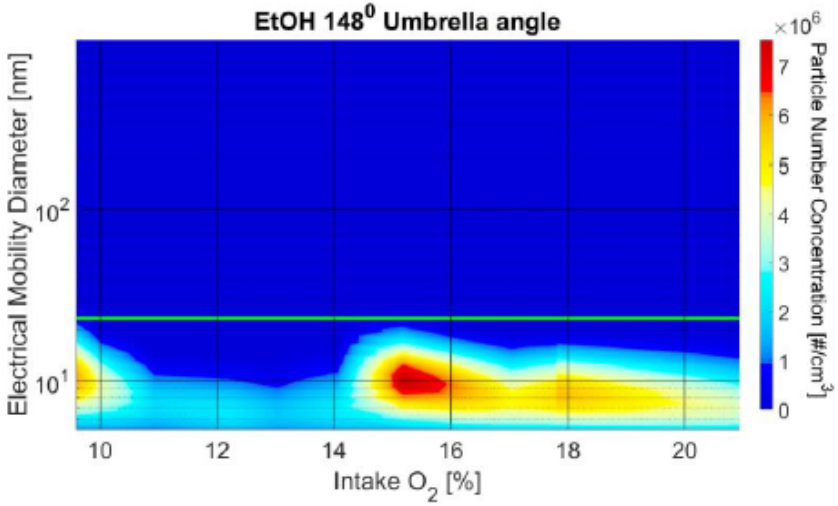


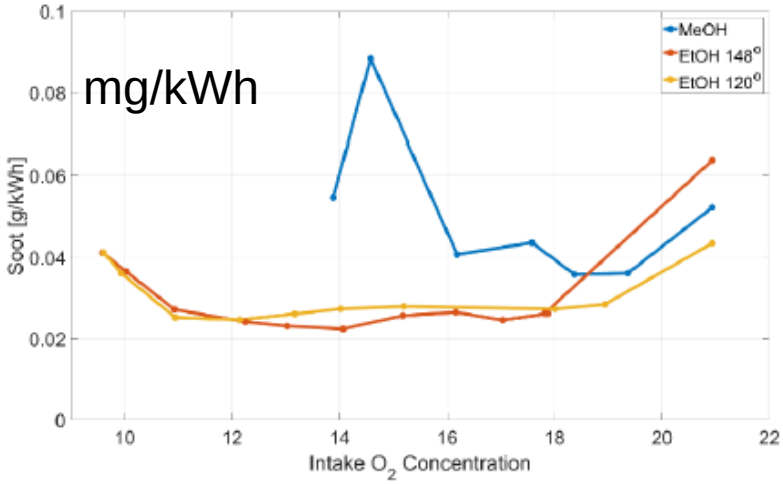
Shamun et al.

Intake O_2 concentration sweep





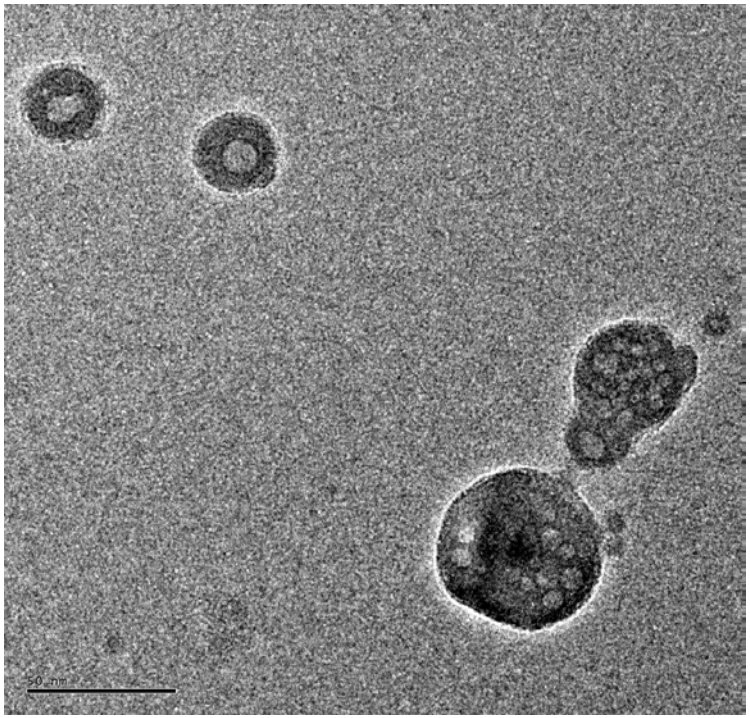


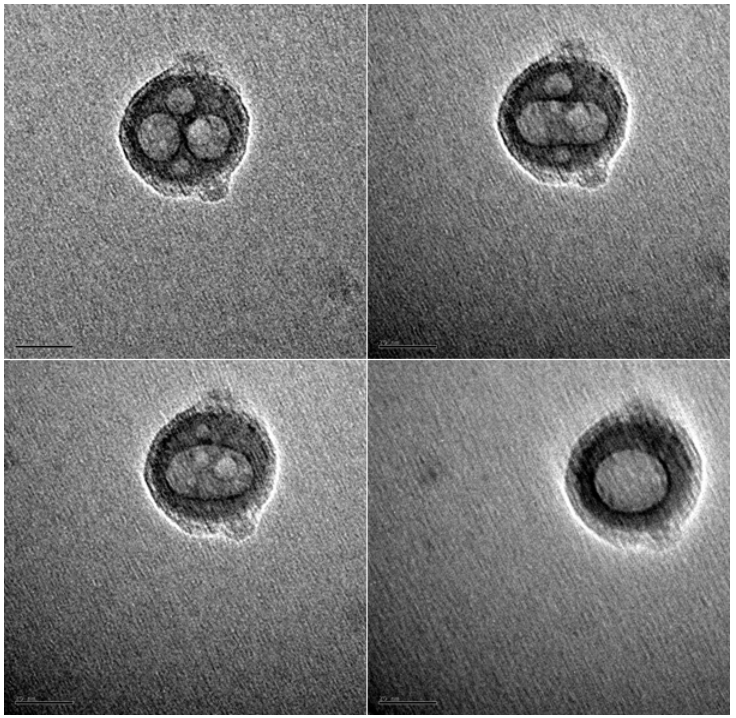


Shamun et al.

Detailed PM characterization

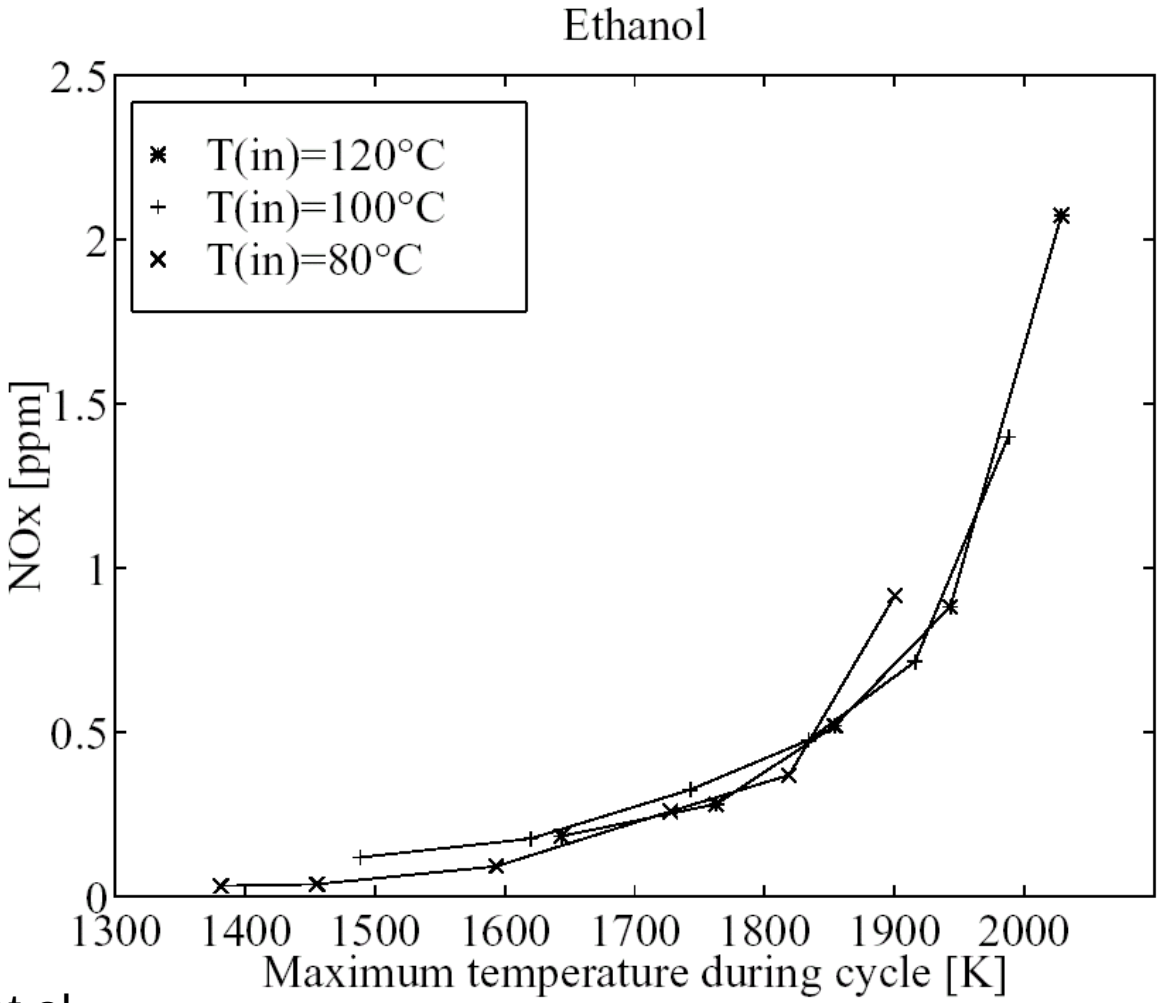
Liquid core particles





PM from methanol combustion originates from the lubricant (oxides of Zn, Ca, P, S). There is no black carbon.

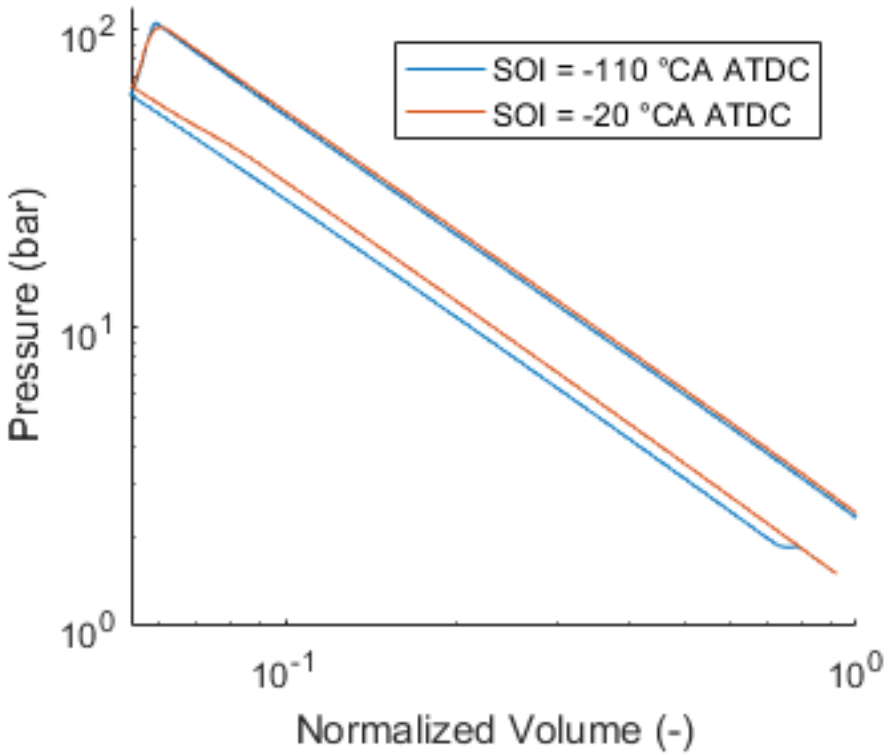
NOx emissions

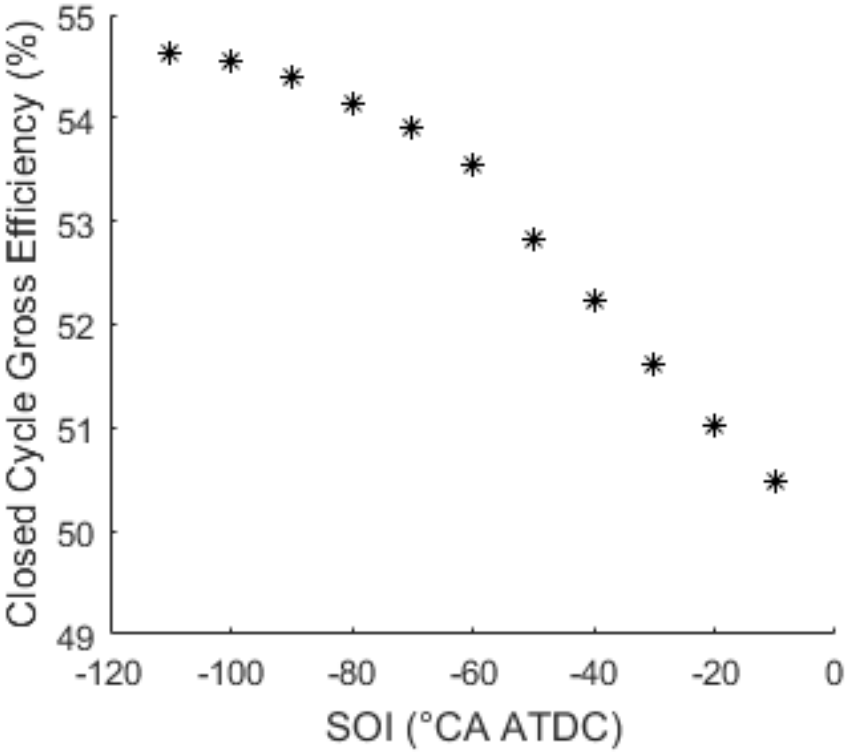


Christensen et al.

Towards ultra-efficiency

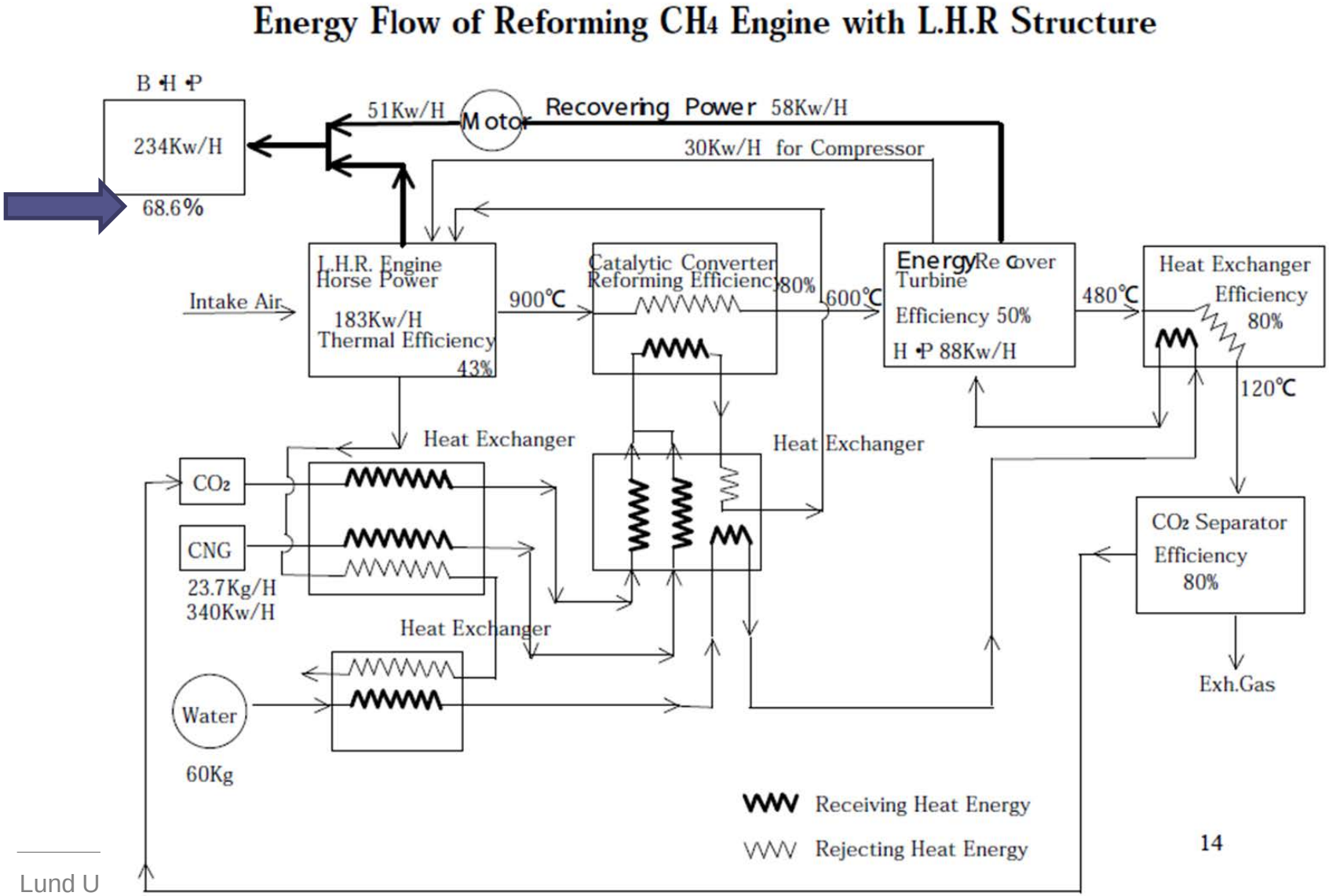
Exploiting the high heat of vaporization of methanol for reduced compression work





System simulations performed by Erik Svensson, Lund University

Methanol excellent candidate for reforming (Chemical turbo)



Preliminary estimated “general” strength and weakness of various methanol engine concepts

Engine type	Robustness	Retrofitting	Efficiency	Operation cost	Power	Noice	HC	CO	NOx	soot
DICI Diesel	0	0	0	NA	0	0	0	0	0	0
DICI Diesel with particulate filter / SCR	0	(-)	-	NA	0	0	0	0	++	++
MD95	-	-	0	-	-	0	0	0	0	+
MD95 with particulate filter / SCR	-	--	-	-	-	0	0	0	++	++
PFI-SI Lean burn	-	-	0	-	-	++	-	-	++	++
PFI-SI TWC	-	-	-	-	0	++	++	++	++	++
DI-SI Lean burn	-	-	+	+	-	+	-	-	+	++
DI-SI TWC	-	-	0	0	0	+	++	++	++	++
Dual-Fuel	(-)	--	--	-	-	+	--	--	0	+
DI-Dual-Fuel	0	-	0	+	0	0	-	-	+	+
PPC	--	-	++	++	0	-	0	0	++	++

The factors above are sensitive to several engine operating parameters and should be analyzed carefully in detail before implementation

Summary

250-1200 kW Methanol engine concepts:

Suitable for short term implementation

- PFI-SI with Three-Way Catalyst
  - Excellent emissions performance
  - Simple and relatively mature
- MD95 with particulate filter or SCR
  - Similar concept ED95 already in production

Suitable for mid term implementation

- DI-SI with Three-Way Catalyst
  - High efficiency and excellent emissions performance
- DI-Dual Fuel with particulate filter or SCR
  - Dependable
  - Efficient and clean

With potential for future applications

- PPC combined with DI-SI with oxidizing catalyst
  - Potentially very high efficiency and low emissions

OEM development needed!

Summary

Methanol:

- Can be used in a number of engine concepts
- No soot (oxygen content)
- Small particulates from oil are present
- Can reduce NOx (high heat of vaporization => reduced temperature)
- Provides in general high efficiency (can be better than diesel engines)
- DI concepts reduce CO and HC (for instance formaldehyde) and risk for in-cylinder corrosion
- Simple exhaust aftertreatment probably enough

- Potential for further improvements
  - Still little methanol engine research and OEM development
  - Improved in-cylinder temperature control for near zero emissions
  - Exploiting the high heat of vaporization for reduced compression work
  - Methanol great for fuel reforming: Is >60% efficiency within reach?

Thank you!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