

# HDGAS

11 April 2018 - Turin

## FINAL EVENT

Wednesday  
11 April 2018  
CNH Industrial Village  
Turin



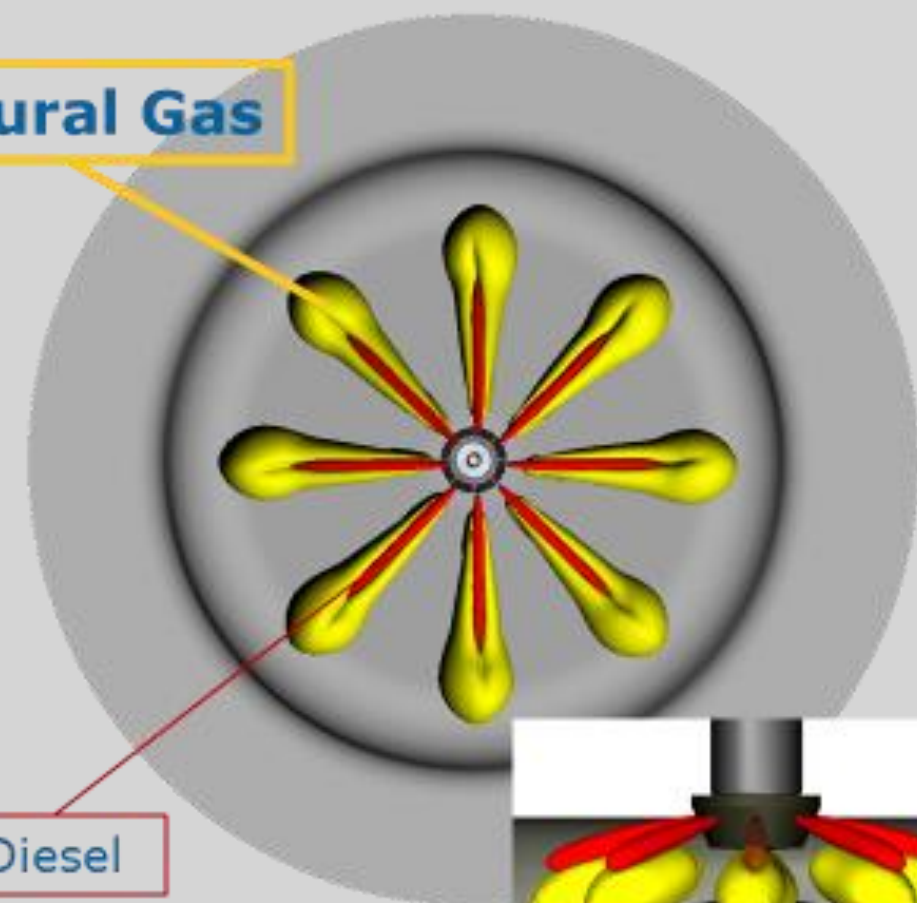


Anton **Arnberger**  
Technical Expert

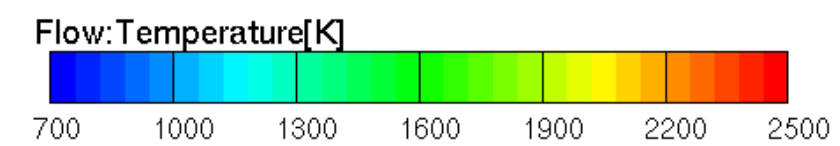
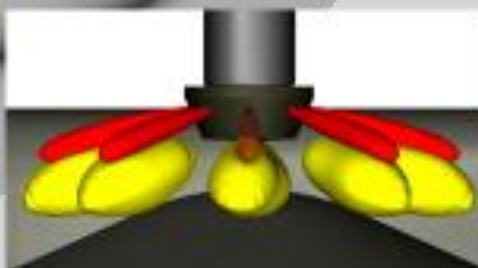
# HPGI principle

**DIESEL LIKE  
COMBUSTION  
PROCESS**

Natural Gas



Diesel



**VOLVO**



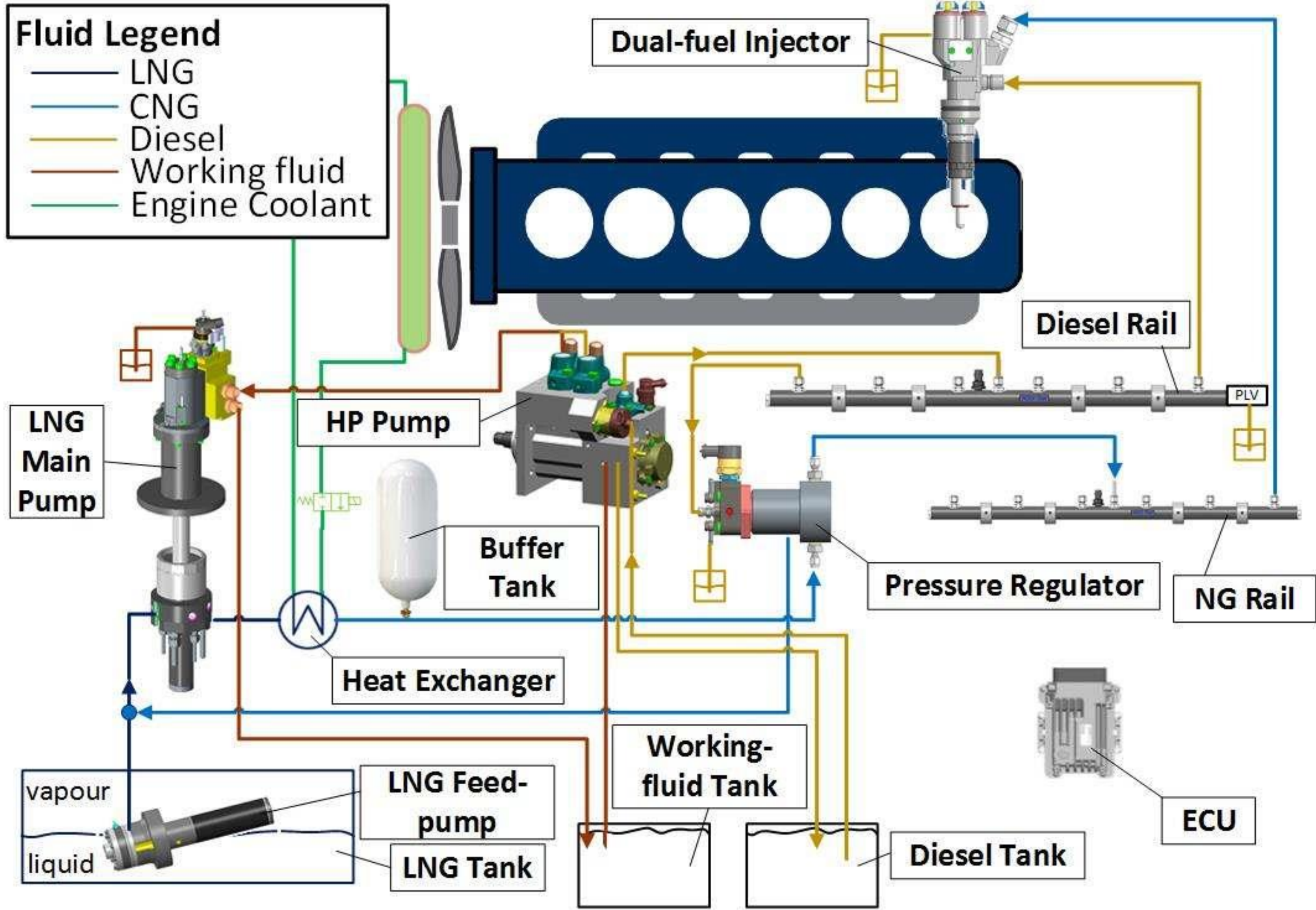
**BOSCH**

Invented for life

**AVL**



# HPGI system architecture



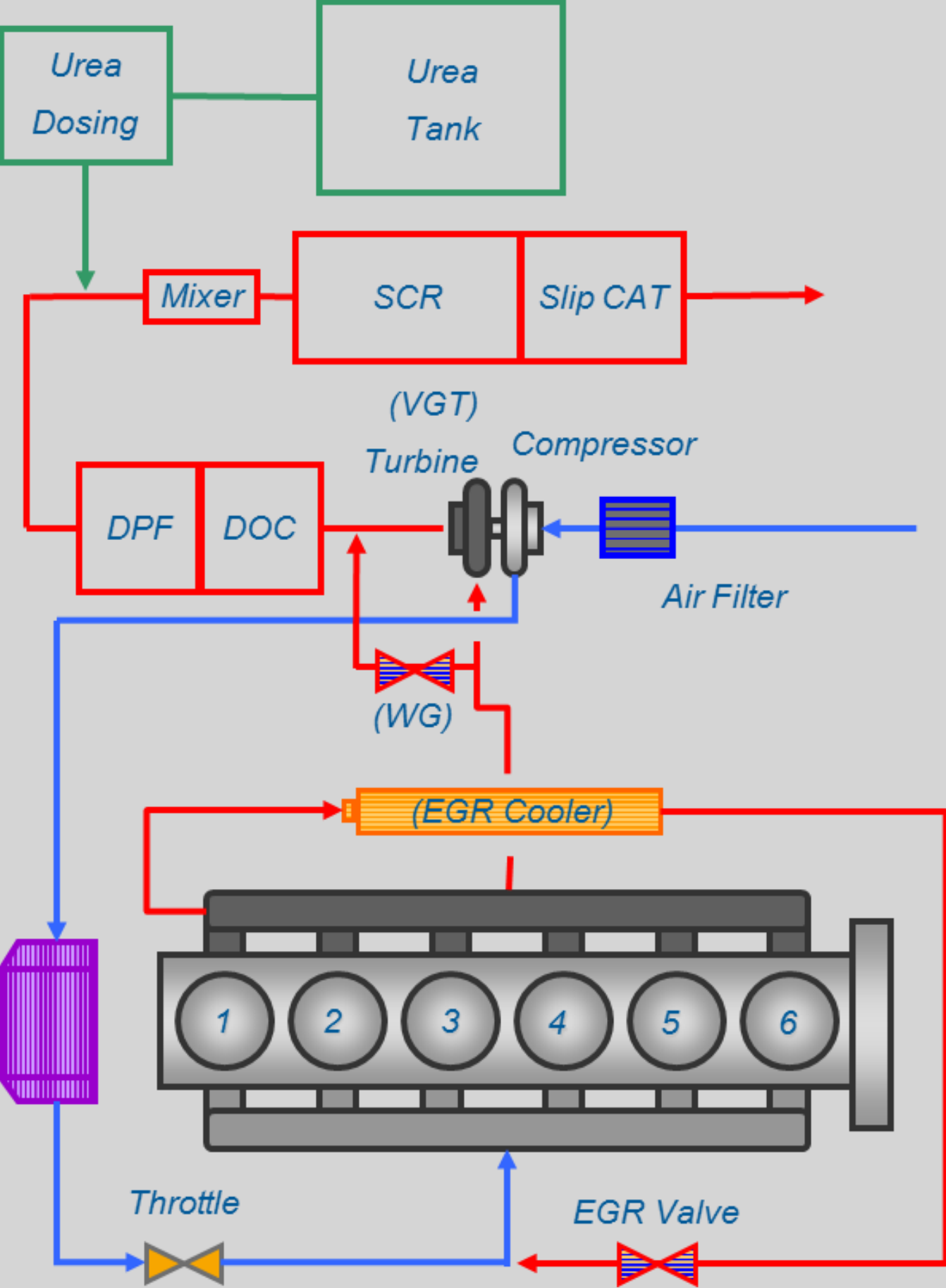
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# HPGI system architecture



Diesel like combustion

Efficiency and power density similar to Diesel

NOx and PM emissions significantly lower than Diesel

Highest potential to reduce CO<sub>2</sub> Long haul truck application

**Cold LNG recommended**

Carry over of diesel engine air path and after treatment

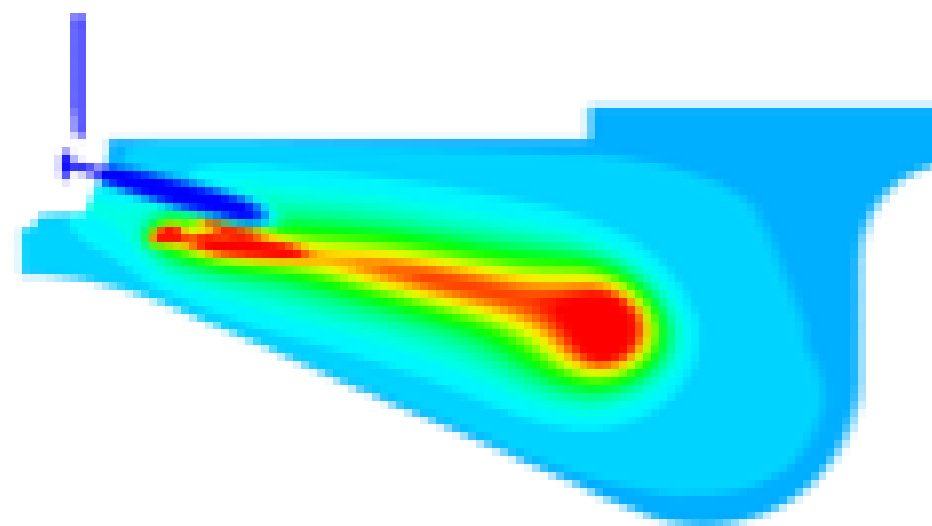
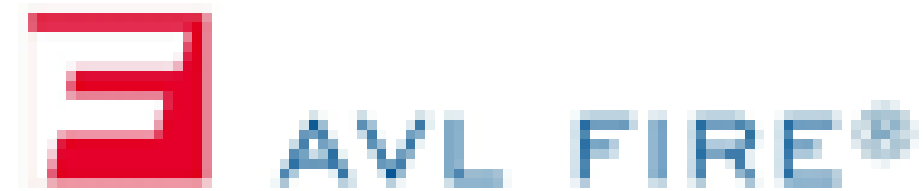
**2 Fuels + DEF**



# HPGI development in HDGAS

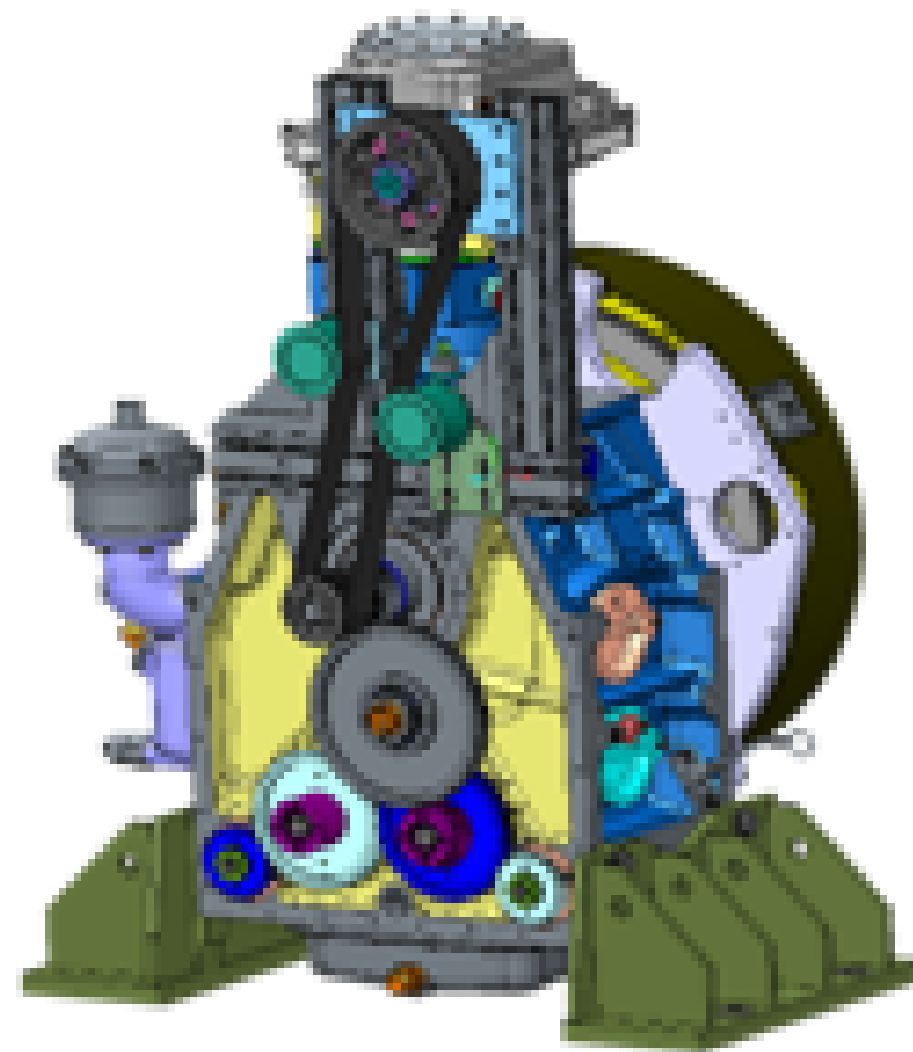
## CFD combustion analysis

Layout - Nozzles



## SCE research

500bar  
Nozzle Variations  
P&E investigations



## MCE calibration

300bar  
fixed Hardware  
Calibration for c/h WHTC



**VOLVO**



**BOSCH**

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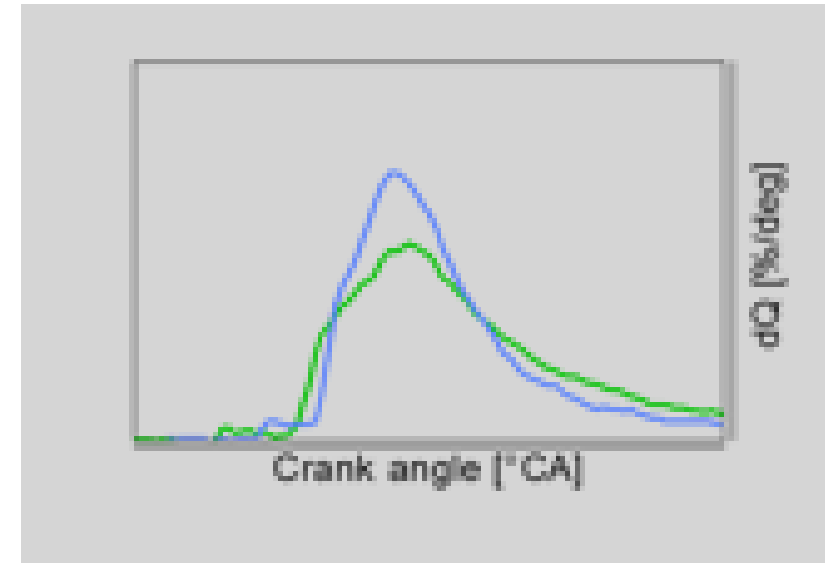
**AVL** 



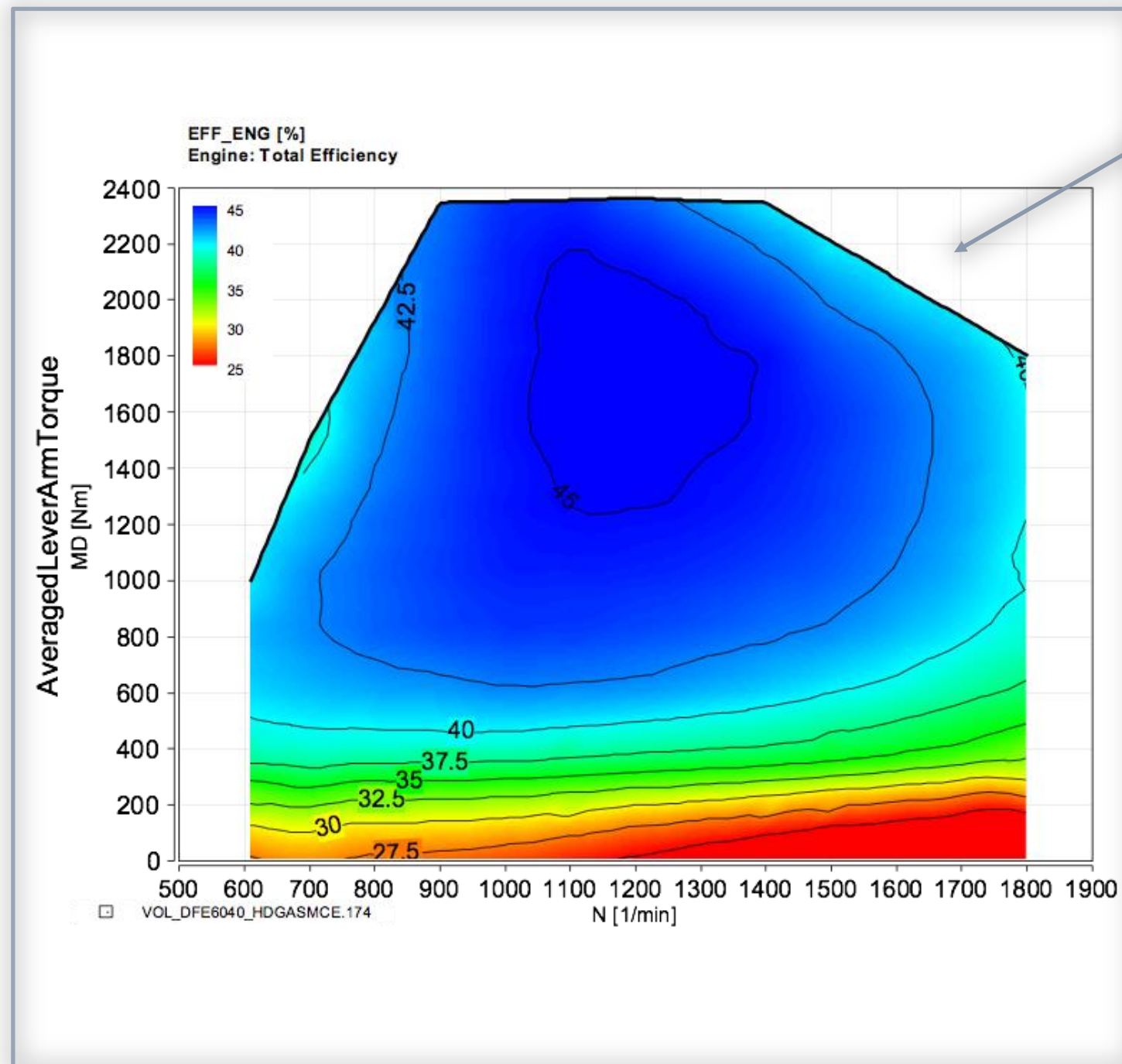
# HPGI Results

## Efficiency

- Map 300bar System



Increased injection pressure can improve full load efficiency and is an enabler for higher PCP



## Emissions - c/h WHTC

	Weighted result	DF	Result x DF	Limit value
CO <sub>2</sub>	503,24 g/kWh	-	- g/kWh	- g/kWh
CO	106,66 mg/kWh	1,30	138,66 mg/kWh	4000 mg/kWh
NMHC	11,51 mg/kWh	1,40	16,12 mg/kWh	160 mg/kWh
NO <sub>x</sub>	151,36 mg/kWh	1,15	174,06 mg/kWh	460 mg/kWh
CH <sub>4</sub>	301,35 mg/kWh	1,40	421,88 mg/kWh	500 mg/kWh
PM	1,321 mg/kWh	1,05	1,39 mg/kWh	10 mg/kWh
PM <sub>number</sub>	4,071E+10 N/kWh	-	-	6,0 *10 <sup>11</sup> N/kWh
FC	191,22 g/kWh	-	-	- g/kWh
NH <sub>3</sub>	0,63 ppm	-	-	10 ppm

Remarks  
Dual-fuel project: status report (non type approval)  
"Heavy-Duty Dual-Fuel (HDDF) Type 1A engine"



# HPGI Results

## • Objectives

- Emission compliance Euro VI
- -20% GHG
- 800km range
- >90% substitution rate (GER)



## • Additional Development Goals

- Efficiency comparable to state of the art diesel
- Negligible EO soot emissions
- CH<sub>4</sub> < Euro VI without Methane-after treatment
- Carry over of Euro VI aftertreatment system & diesel heat up strategies



**VOLVO**



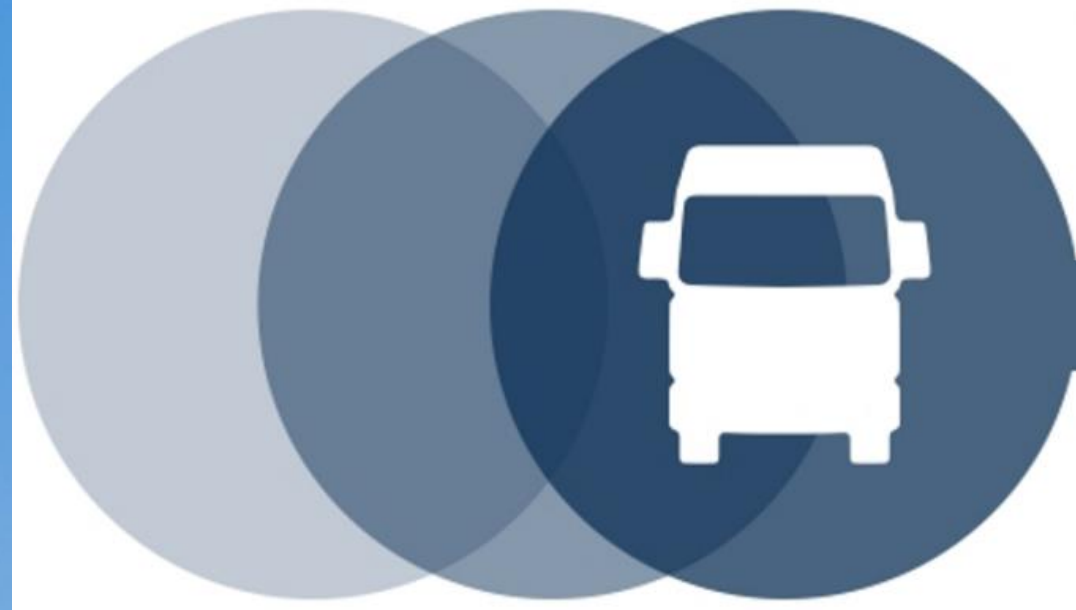
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