

# Hydrogen engine for commercial vehicles, a robust and sustainable technology option

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# H<sub>2</sub> Engine Technology

## Agenda

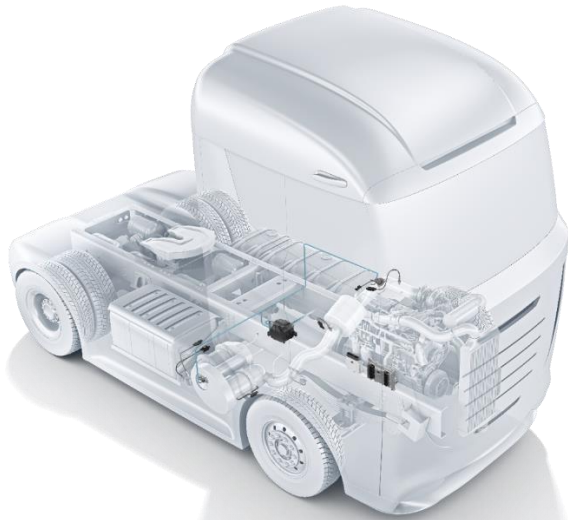
- 1 Motivation H<sub>2</sub>-Engine
- 2 H<sub>2</sub>-Engine Results
- 3 Overview of activities
- 4 Summary



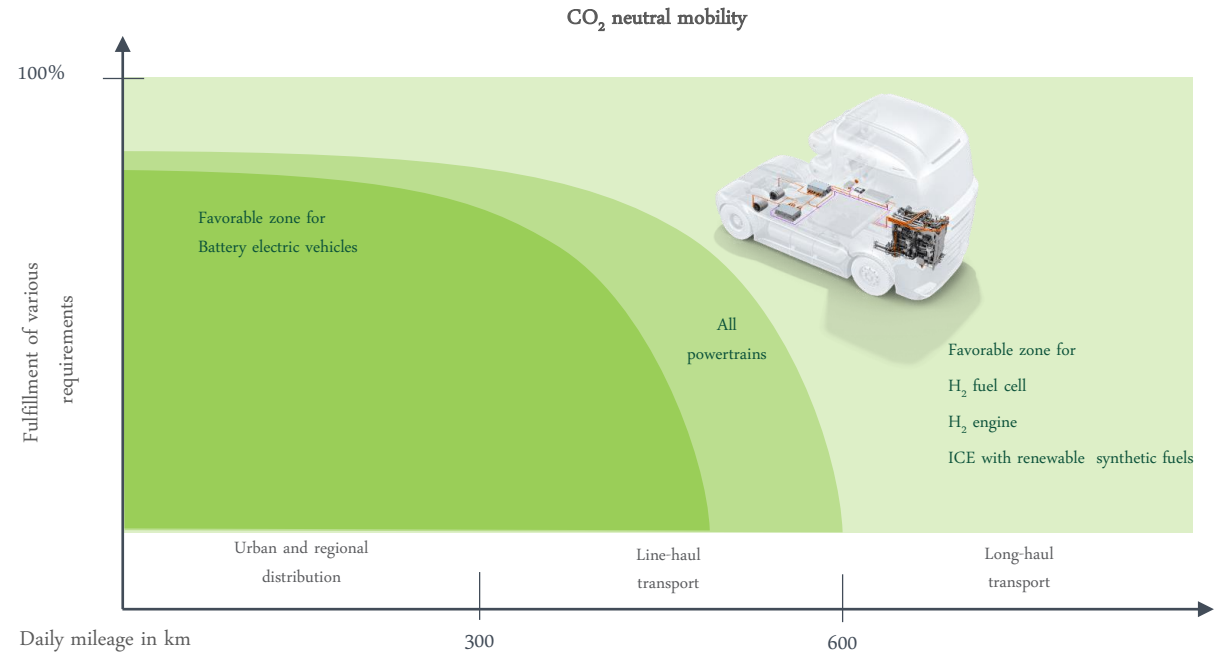
# H<sub>2</sub> Engine Technology

## Motivation: Paths towards CO<sub>2</sub>-neutral mobility

Today  
ICE as "all-rounder"



Example: Commercial Vehicles

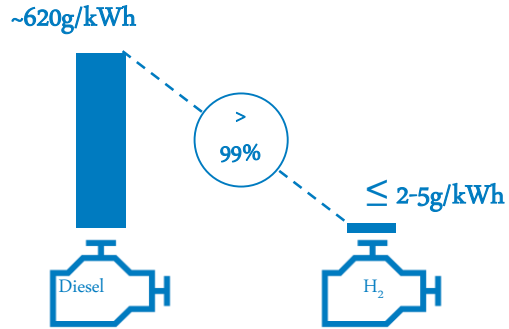


Commercial vehicle applications are highly heterogeneous (e.g. load, power, range, terrain, ....)

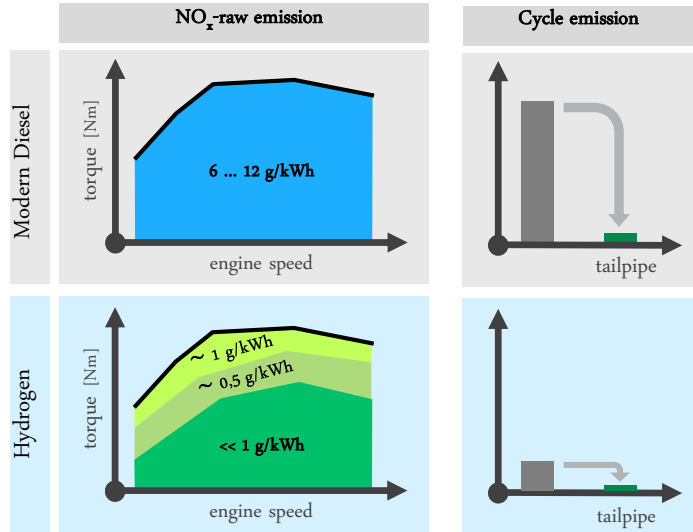
We need all technologies, to meet customer and societal needs of all applications

# H<sub>2</sub> Engine Technology

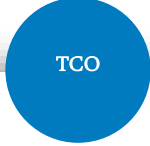
## Motivation: Arguments for the Hydrogen Engine powertrain!



- No CO<sub>2</sub> from combusting H<sub>2</sub>
- CO<sub>2</sub> due to a small amount of engine oil burning



- Clearly very low engine level emissions



### Technology evolution

From current engines

### Robustness

Like Diesel for different use cases

### Mainly steel and aluminum

Processing & Recycling known

### Engine Production & Assembly

Same as current engines

### Diagnostics and Service

Same as current engines

### Lower Upfront Cost

compared to other new powertrains --TCO

Technical and non-technical factors favor H<sub>2</sub>-Engine technology for CV segment

# H<sub>2</sub> Engine Technology

## Motivation: Arguments for the Hydrogen Engine powertrain!

PM/P  
N

HC

CO

### Particle Mass / Particle Number, Hydrocarbons, Carbon Monoxide

- Very low values due to C-free fuel
- Oxidation catalyst / particle filter
- For lifetime robustness mandatory EGT part

N<sub>2</sub>O

### N<sub>2</sub>O from Oxidation Catalyst

- Formation over lean DeNO<sub>x</sub> reaction due to HC emissions engine out
- Very low H<sub>x</sub>C<sub>y</sub> emissions (one/two digit ppm)
- Lean DeNO<sub>x</sub> is neglectable

### N<sub>2</sub>O from SCR Catalyst

- Formation depends on NO<sub>x</sub> engine out
- Significant decreased NO<sub>x</sub> engine out emissions

CH<sub>4</sub>

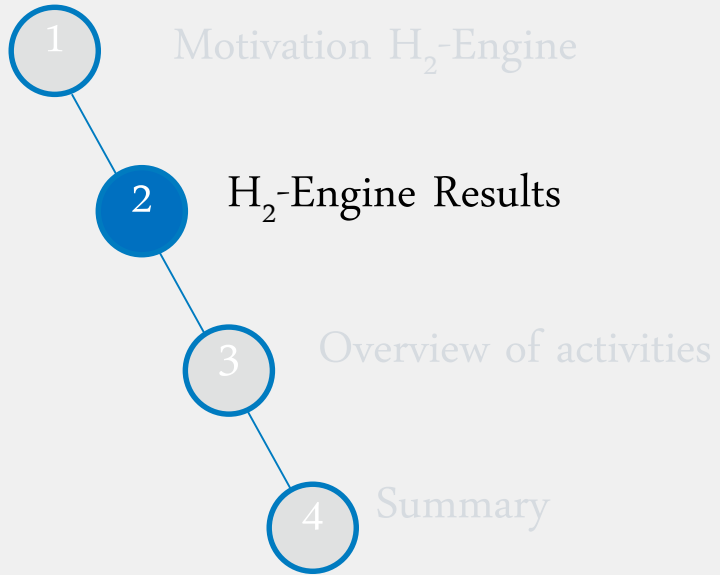
### CH<sub>4</sub> emissions / byproduct from EGT

- Very low total H<sub>x</sub>C<sub>y</sub> emissions (one/two digit ppm)
- no tendency to increased formation especially for CH<sub>4</sub> expected

Technical and non-technical factors favor H<sub>2</sub>-Engine technology for CV segment

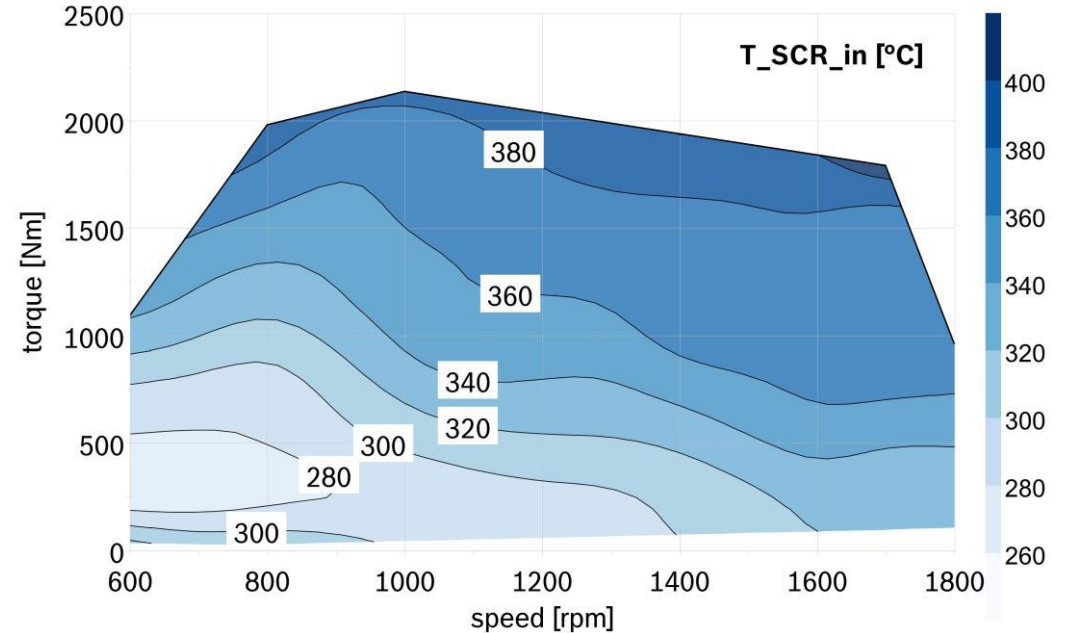
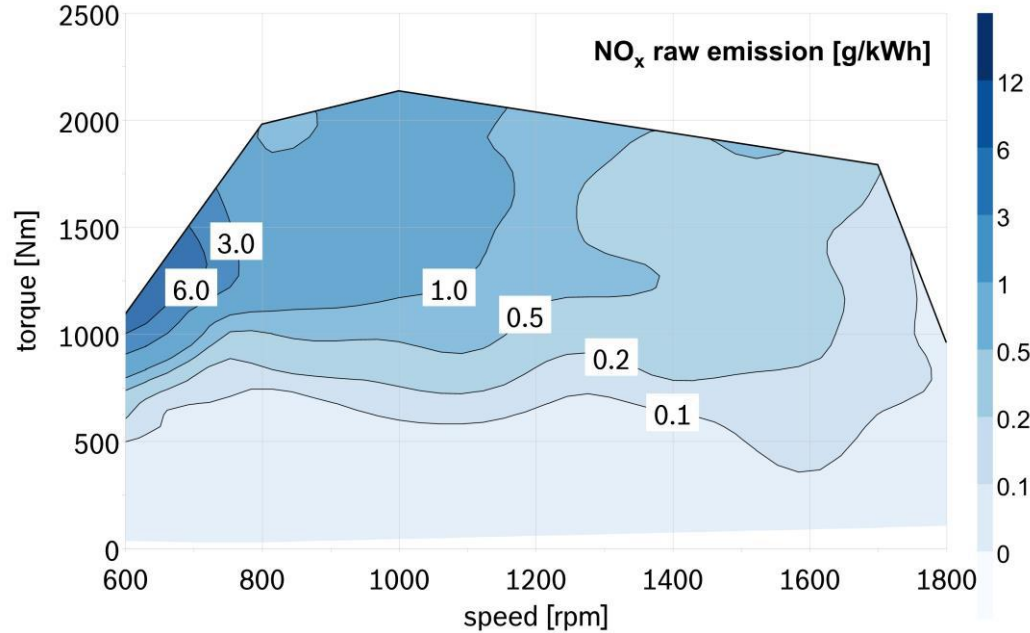
# H<sub>2</sub> Engine Technology

## Agenda



# H<sub>2</sub> Engine Technology

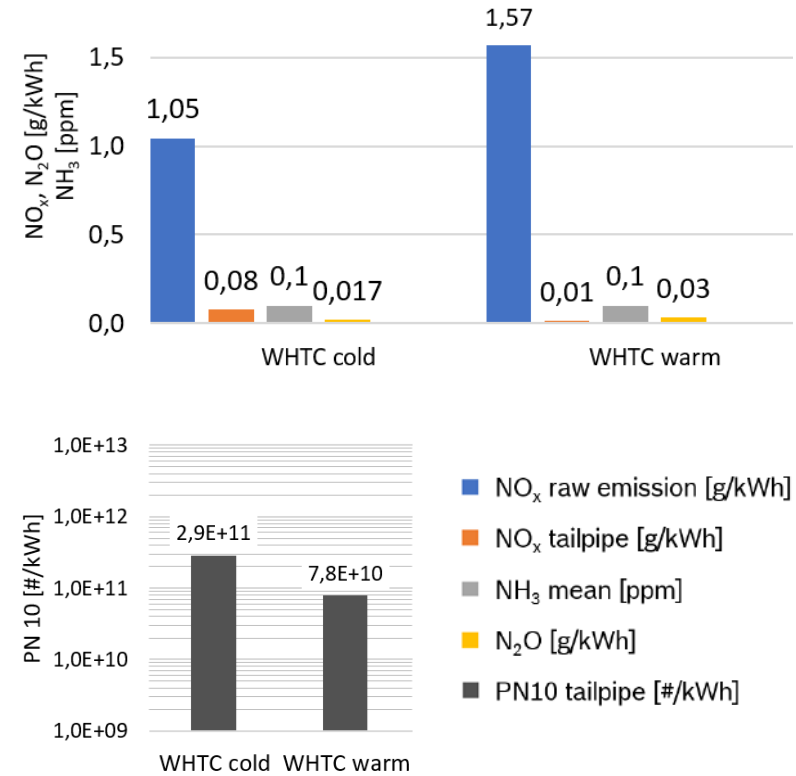
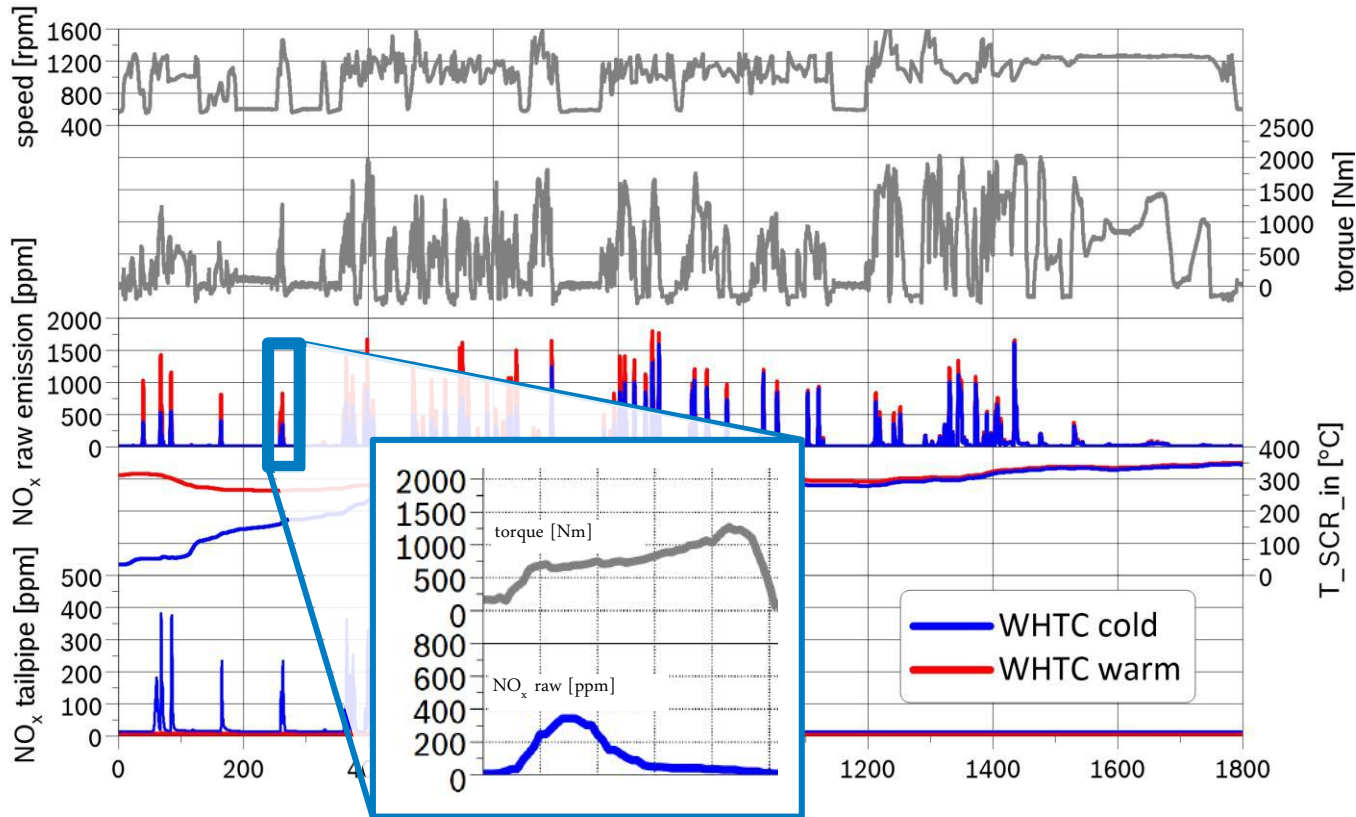
## Stationary results for PFI hydrogen engine



In a very large area of the map the nitrogen-oxide raw emissions are well below 1 g/kWh  
 Homogeneous SCR-temperature map with excellent SCR window ( $280^{\circ}\text{C} < T_{\text{SCR}} < 400^{\circ}\text{C}$ )

# H<sub>2</sub> Engine Technology

## WHTC results for PFI hydrogen engine

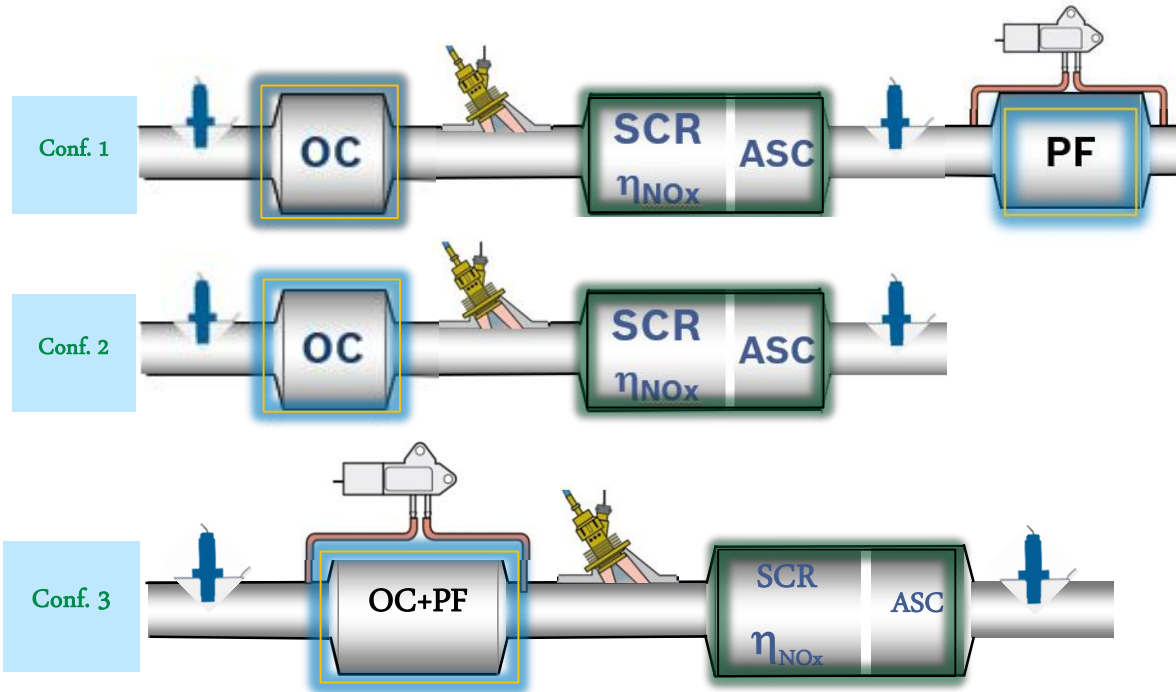


Very good emissions were achieved at WHTC with moderate application effort

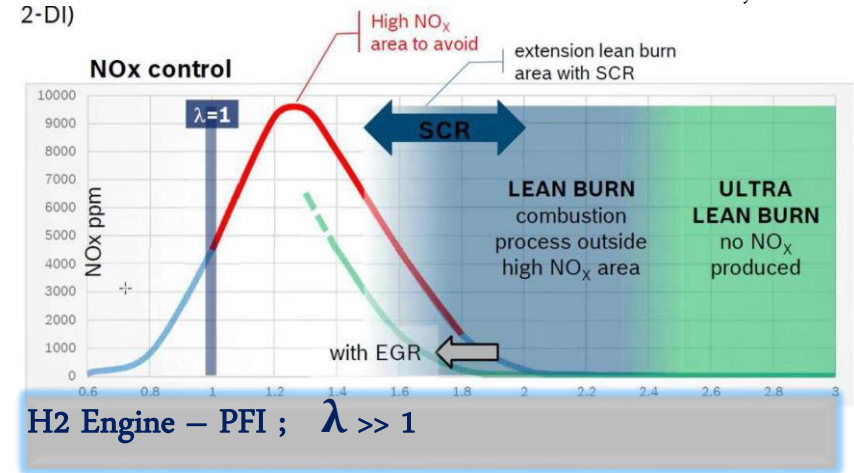


# H<sub>2</sub> Engine Technology

## EGT configurations - discussion



2-D1)



**DNO<sub>x</sub> System** : Considered to be carryover from BSVI Stage 2



Supply Module 2.2



DCU – VD1CC001

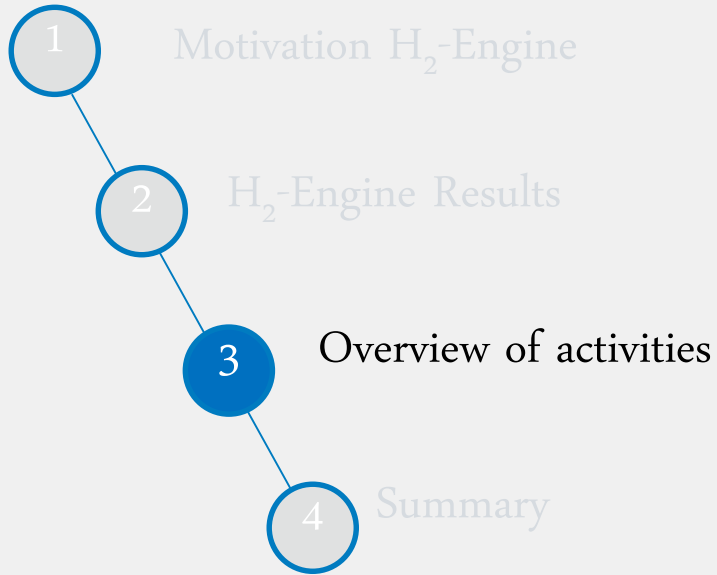


Dosing Module 2.2

Various EGT Configurations are in discussion ; Finalization based on engine results and use cases

# H<sub>2</sub> Engine Technology

## Agenda



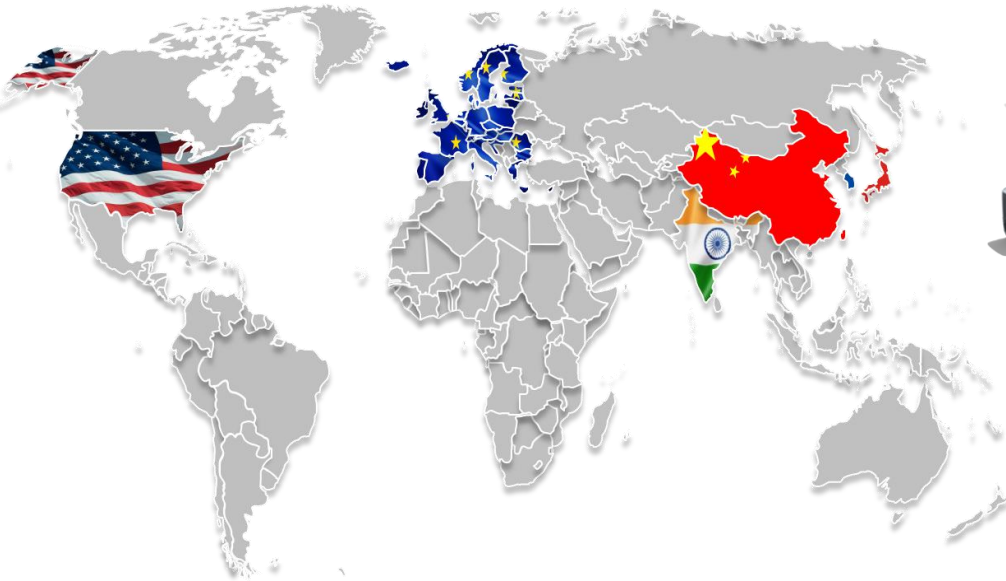
# H<sub>2</sub> Engine Technology

## Worldwide Activities and RB Portfolio

### Worldwide Activities

### Segments

### Regional Drivers (extraction)



	<ul style="list-style-type: none"> <li>Shape H<sub>2</sub> eco system proactively</li> <li>India pledges to reduce emission intensity by at least <b>45%</b> by 2030.</li> <li>Become self-sustainable regarding energy imports</li> </ul>
	<ul style="list-style-type: none"> <li>EU Green Deal – GHG emission reduction</li> <li>CO<sub>2</sub> legislation (HDV)</li> <li>Shareholder sustainability pressure (OHW)</li> </ul>
	<ul style="list-style-type: none"> <li>Ministry of Industry and Information Technology encourage the development of H<sub>2</sub>-Engines</li> </ul>
	<ul style="list-style-type: none"> <li>Shareholder sustainability pressure</li> </ul>
	<ul style="list-style-type: none"> <li>CO<sub>2</sub> neutrality</li> </ul>
	<ul style="list-style-type: none"> <li>H<sub>2</sub> for securing energy supply</li> </ul>

Well established co-operations with OEMs over all segments. High number of R&D activities worldwide.

Worldwide drive towards CO<sub>2</sub> neutrality and H<sub>2</sub> as strategic fuel

# H<sub>2</sub> Engine Technology

## Bosch India Engagement

### OEM engagement



- Proof of Concept
- Series Development

Bosch has acquired series projects



- Proof of Concept discussions

Focused efforts and investments  
H<sub>2</sub> Engine & Test Infrastructure

### BOSCH INDIA EFFORTS



- Fully functioning H<sub>2</sub> Engine Test facility
- Customer & Internal Platform Programs



- Bosch Technology Demonstrator Vehicle



- Partnership in H<sub>2</sub> Engine technology Dev.
- Powertrain sub systems

We are among the first few facilities established in India for H<sub>2</sub> Engine



End-End System level support with comprehensive product portfolio & Services in H<sub>2</sub>E domain

Bosch India is leading in developing H<sub>2</sub> Engine Technology  
Collaborating with IN-OEMs, Industry bodies for successful technology shaping

# H<sub>2</sub> Engine Technology

## Bosch India Engagement

Phase I



H<sub>2</sub> storage yard

H2ICE



FCPM



Upcoming

Phase II



- Compressor
- dispensing

Phase III



- Electrolyzer
- Captive usage

# H<sub>2</sub> Engine Technology

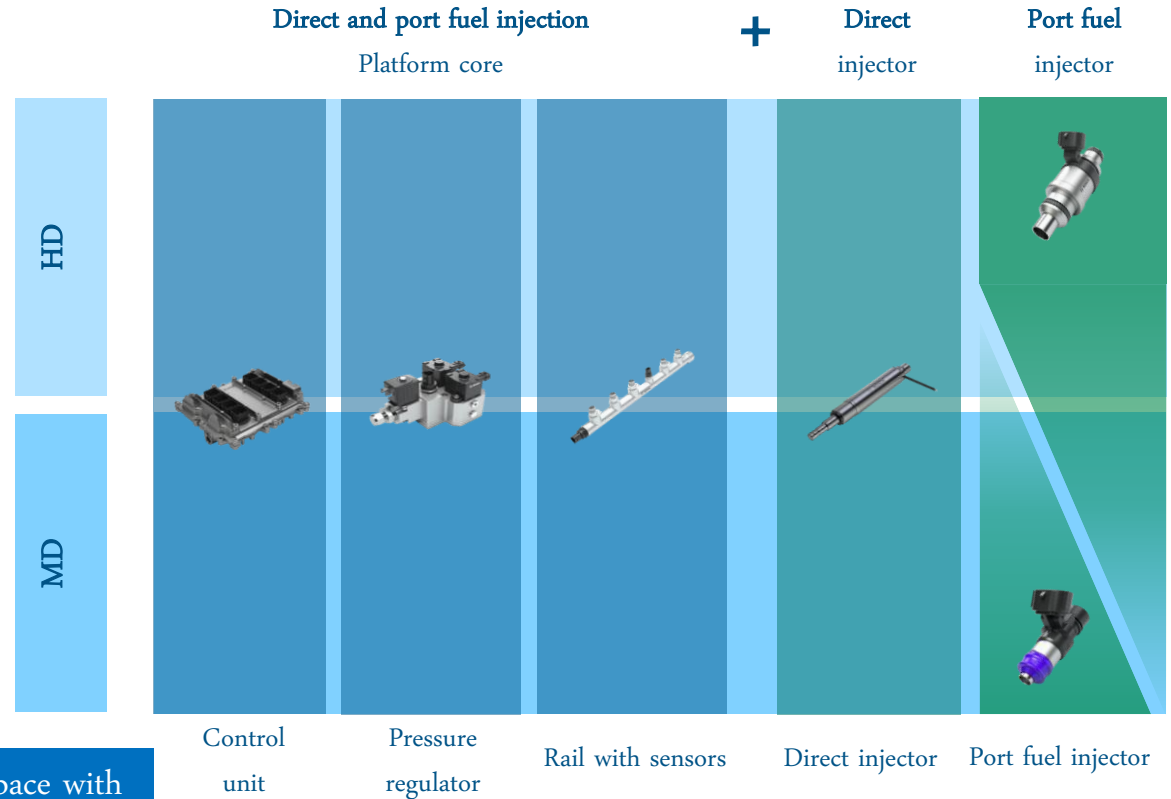
## H<sub>2</sub> Injection System MD/HD

### Bosch supports port fuel and direct injection

Smart platform variant frame to support customer strategy

- First introduction with port fuel system for medium duty
- Port fuel system for heavy duty production ready end of 2024
- Direct injection system production ready end of 2025

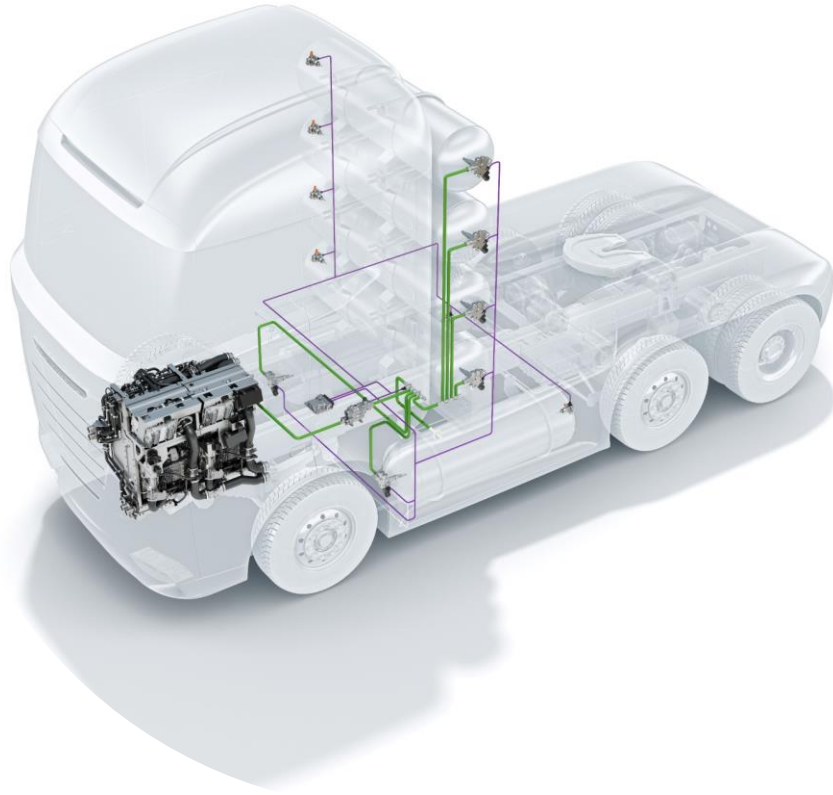
### Product portfolio



With existing know-how and infrastructure, we can ramp up and keep pace with the growing needs.

# H<sub>2</sub> Engine Technology

## Bosch a Competent Partner



**Complete H<sub>2</sub>-Engine System, Fuel Cell Electric System (Fuel System, Tank system, After treatment, Sensors & Actuators)**

**End-to-End Engineering Services**

**Series Applications and Demonstrations**

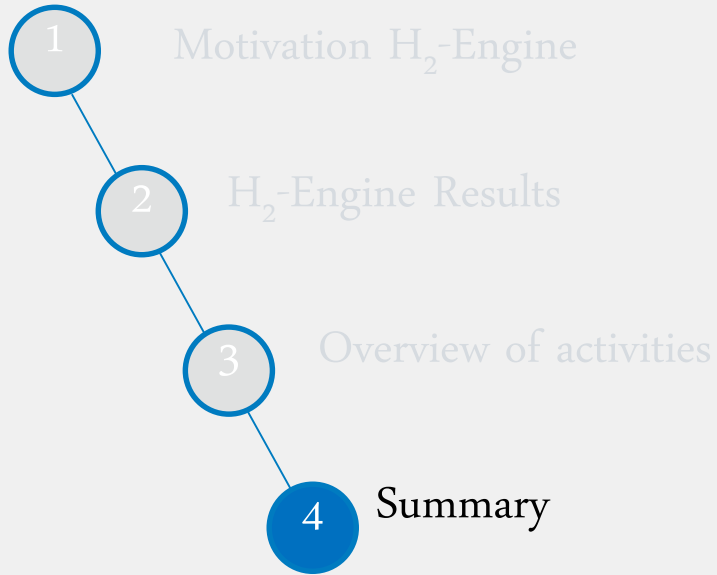


**Robust Control Systems and Software**

**State-of-the art H<sub>2</sub>-E and FCEV Testing Infrastructure**

# H<sub>2</sub> Engine Technology

## Agenda





# H<sub>2</sub> Engine Technology

## Summary

- India market will require diversified solutions viz Diesel, CNG, Hydrogen, Electric,..
- Hydrogen as next suitable alternate fuel after Diesel for long-haul trucks subjected TCO/ H2 Infra.
- H2 Engine allows ease of adaptation in short and medium term implementation
- Competency: System integration, standardization, efficiency & cost innovation
- To our Customers : Bosch with mature technology, dedicated engineering support, global presence...

