

# H2 Powertrain Systems



Dr. Michael Kordon - AVL List GmbH – Techcenter Steyr



# Demands for different industries



**Pollutant free  
always and everywhere**

**Affordable**



**Minimize total costs of  
ownership**

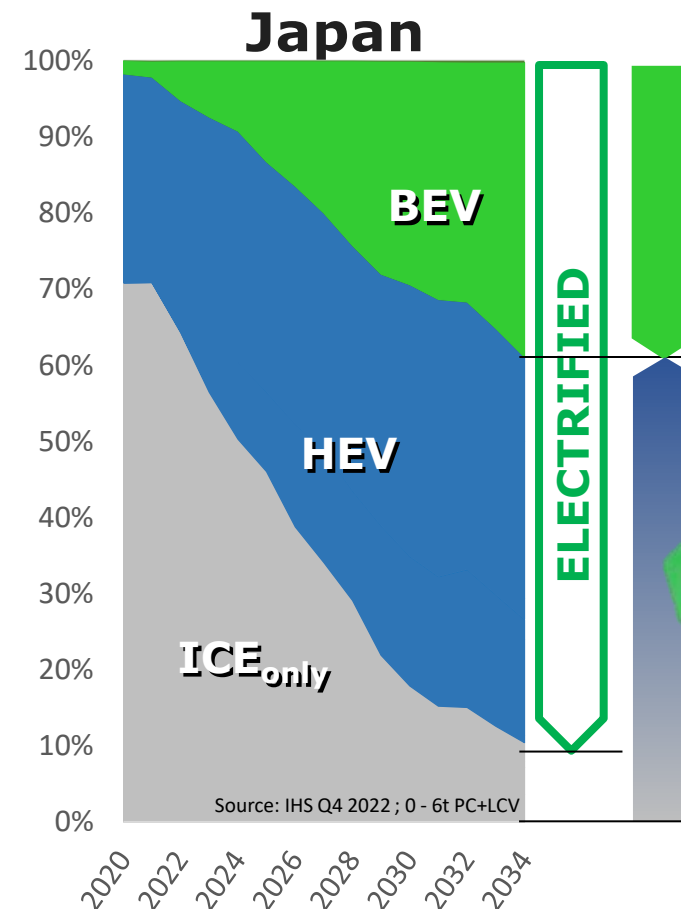
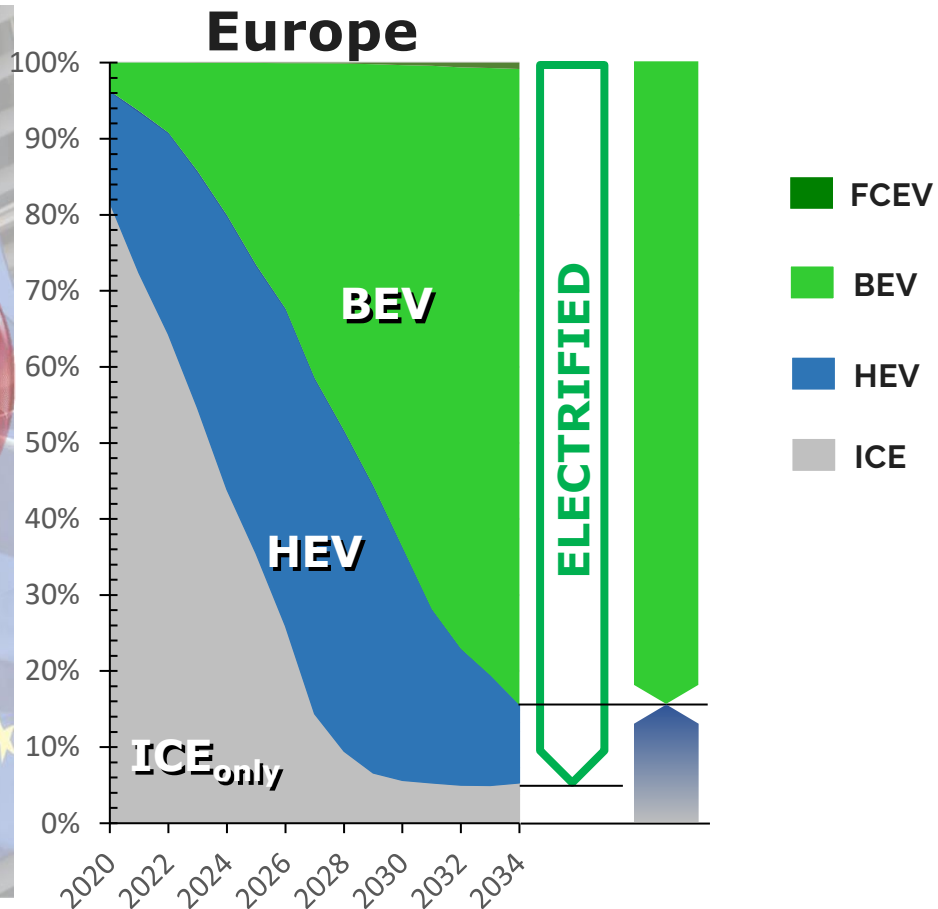
**Reliability**



**Ensure productivity**

**Harsh conditions**

# Why so different approaches ?



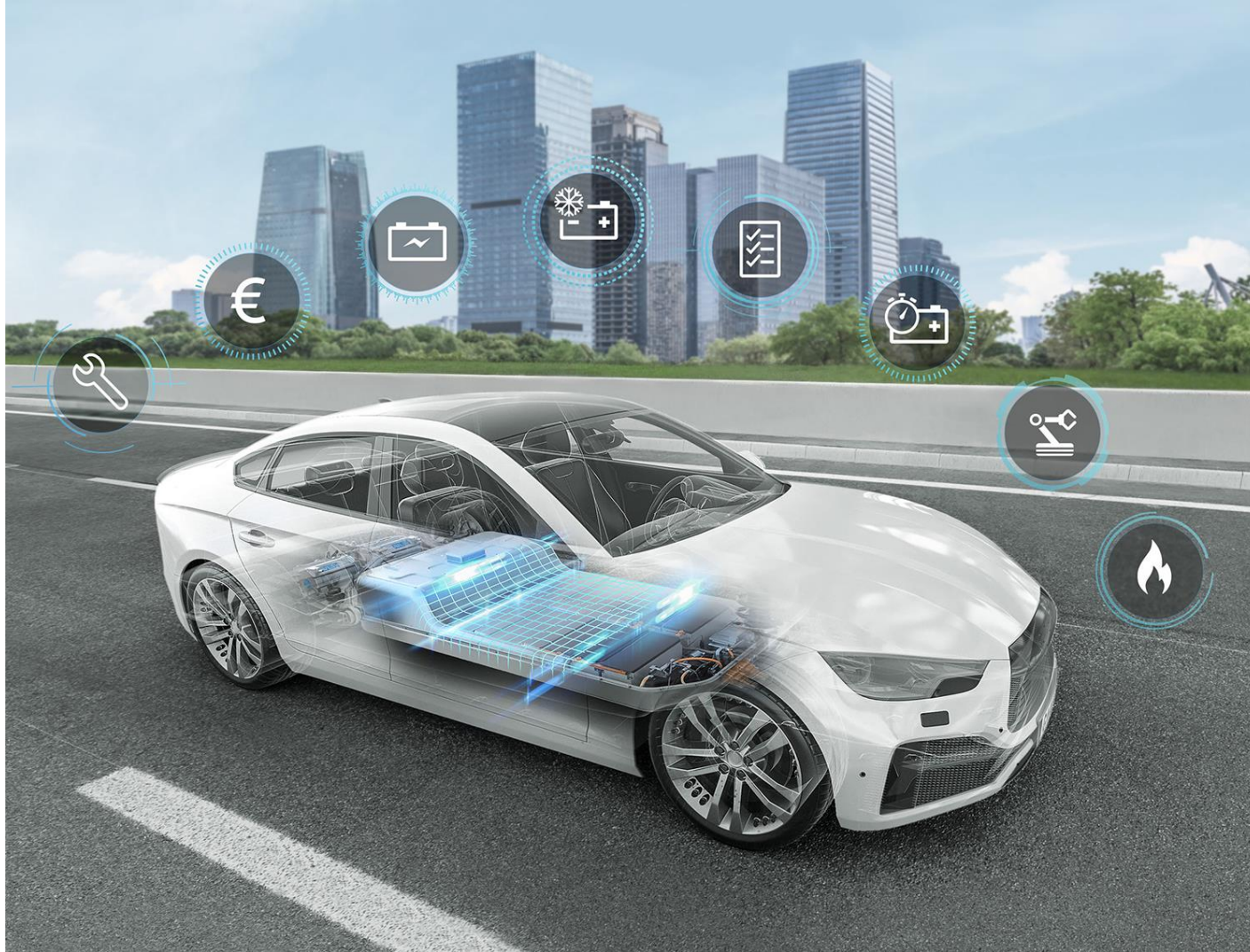
**CO<sub>2</sub> Legislation ("Tank to Wheel" or "Well to Wheel") is decisive**



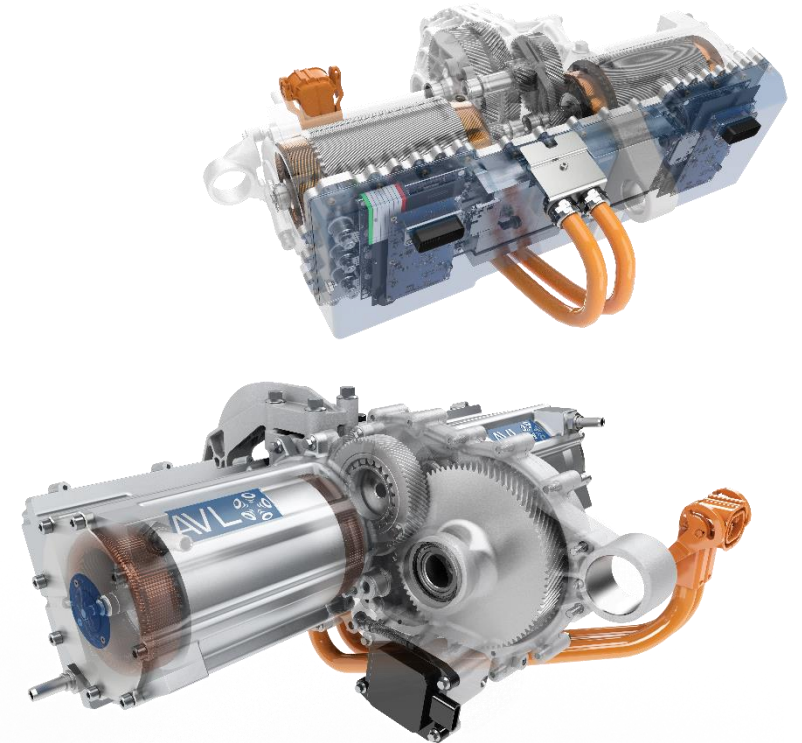




# New Energy Passenger Car Battery Electric – Mainstream in Europe



ELECTRIC DRIVE UNIT (EDU)





# Project Reference

## INEOS FCEV Grenadier Demo-Car



## INEOS debuts H2 fuel cell Grenadier at Goodwood

News | ⌚ 1 min read

A hydrogen powered version of INEOS's Grenadier 4x4 has made its debut at the Goodwood Festival of Speed, complete with a torque vectoring feature known as 'gecko capability'.



INEOS

Developed in partnership with Austrian engineering consultancy AVL, the Grenadier Demonstrator is based around BMW's newest hydrogen fuel cell and zero-emissions powertrain, claimed by INEOS to be the most powerful in the automotive sector.

<https://auto.at/en/news/ineos-grenadier-fcev-gets-bmw-fuel-cells-earth-warping-torque-20230717.html>



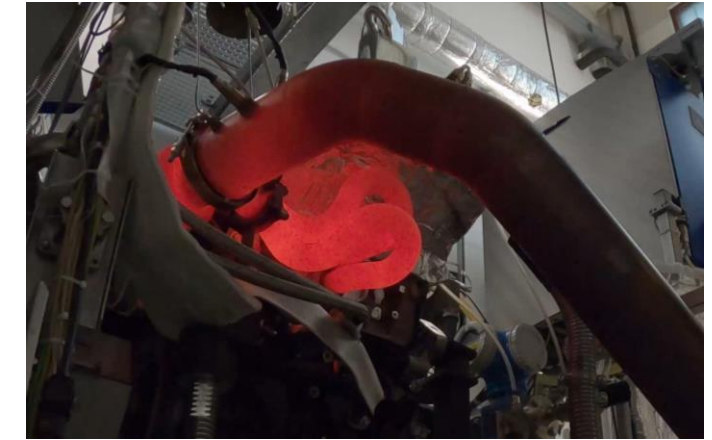
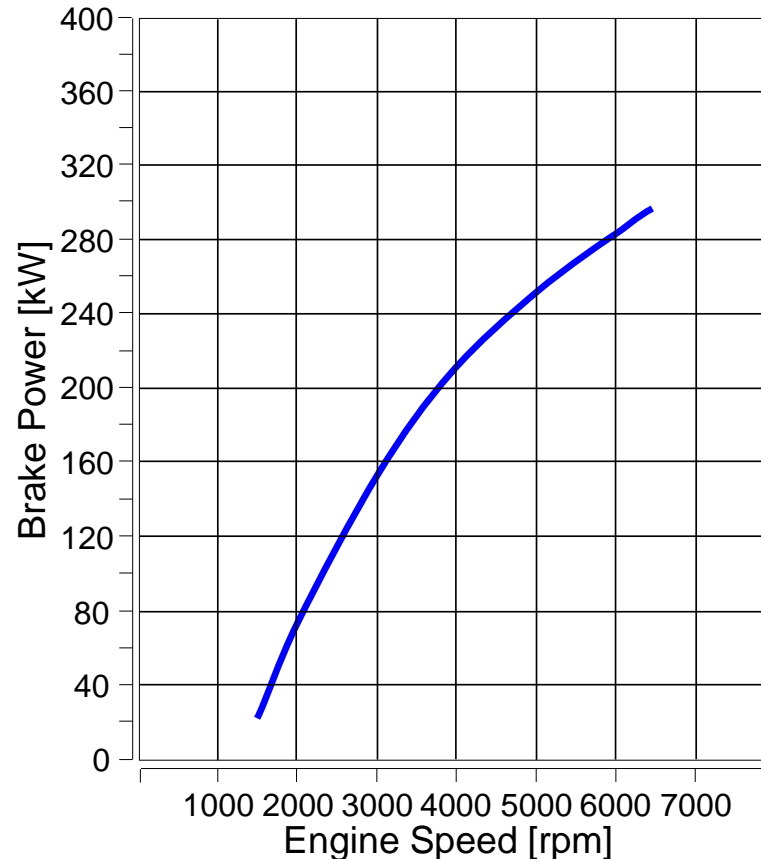
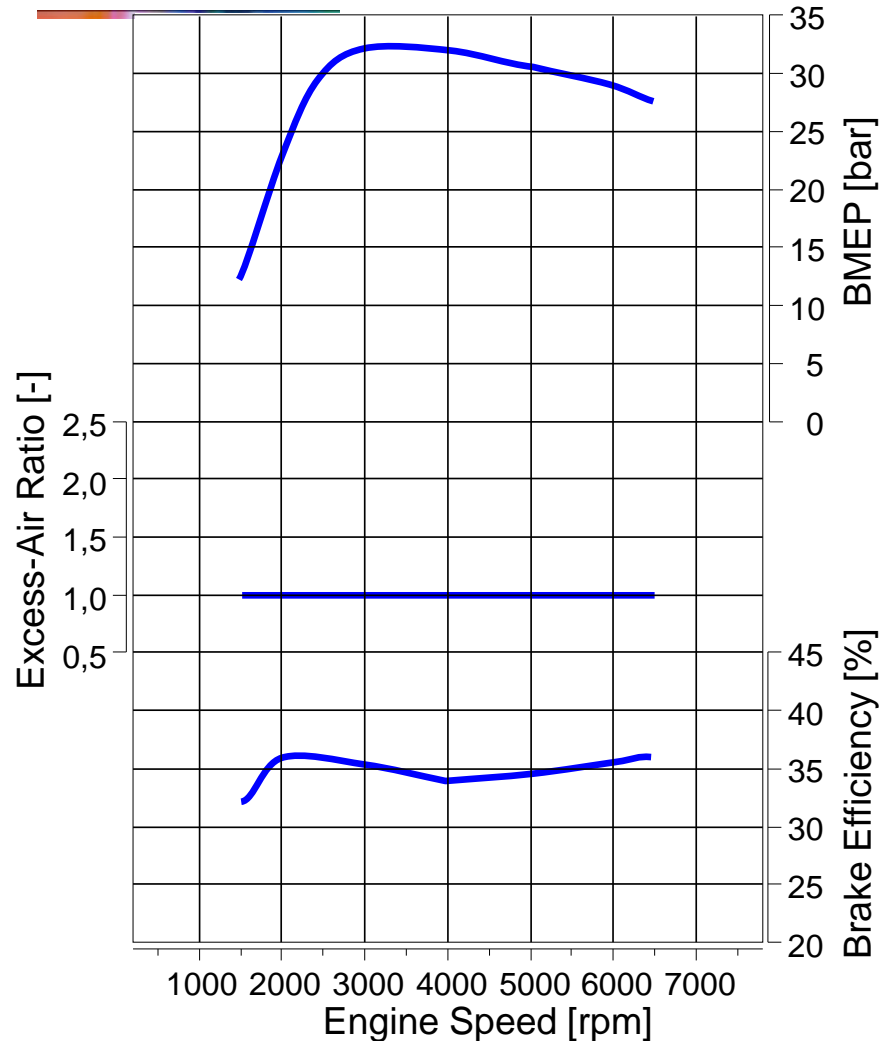
# AVL H2 Race Engine



- Baseline: 2l Gasoline TGDI
- Pentroof combustion chamber
- Side DI
- Tumble based combustion system
- Outwardly opening low / medium pressure DI injector
- Specific „cold“ hydrogen spark plug
- Specific ignition coils w/o residual charge
- Wastegate-TC, specific for hydrogen
- $\Lambda=1$  with water injection



# Highest Performance H<sub>2</sub> Engine – Full Load; Single Stage TC; Measurement



— H<sub>2</sub> – Lambda 1 + water inj.

Boundary conditions:

- 4Cyl inline, 2L Miller engine
- CR 10.0:1
- Single stage TC
- H<sub>2</sub> direct injection
- Exhaust gas temperature limit 1000°C
- Lambda=1 plus PFI water injection

32 bar BMEP and 150kW/l can be achieved by Lambda=1 operation and water injection

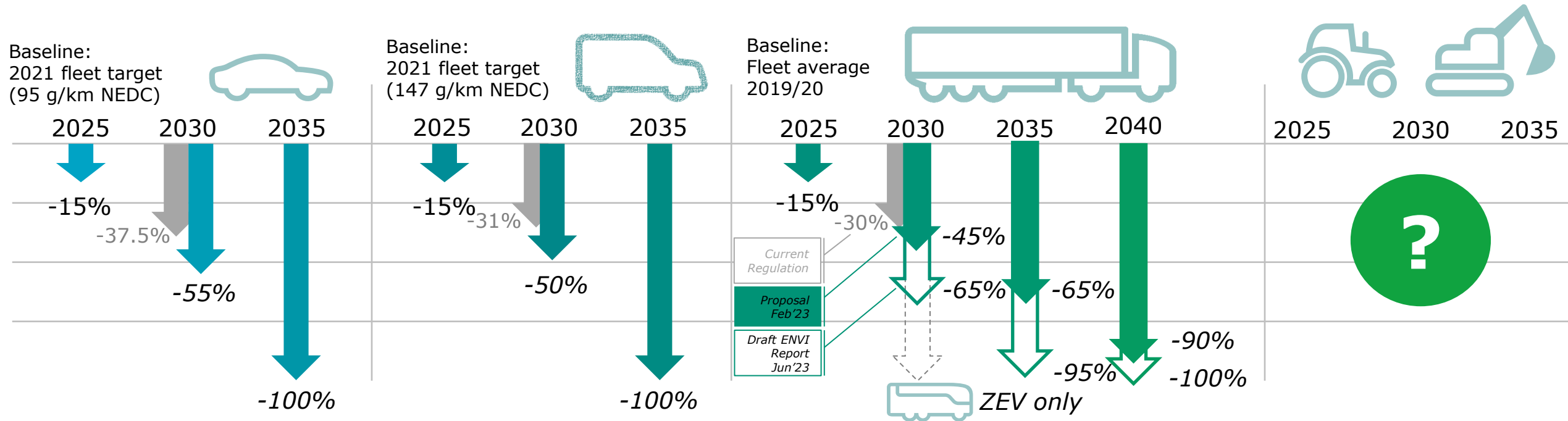






# Drivers for Hydrogen

## EU CO<sub>2</sub> Standards – Outlook across the Segments



Accepted ZEV<sub>CO2</sub>:  
BEV, FCEV  
*H<sub>2</sub>-ICE & ICE with E-Fuel*

Accepted ZEV<sub>CO2</sub>:  
BEV, FCEV, H<sub>2</sub>-ICE\*  
\*ZEV: max. 5 / 1 g/(t·km)

Potential ZEV<sub>CO2</sub>:  
BEV, FCEV, H<sub>2</sub>-ICE  
(E-Fuel, Alcohols)

Grey: targets in current regulation. ***Italics***: proposed.

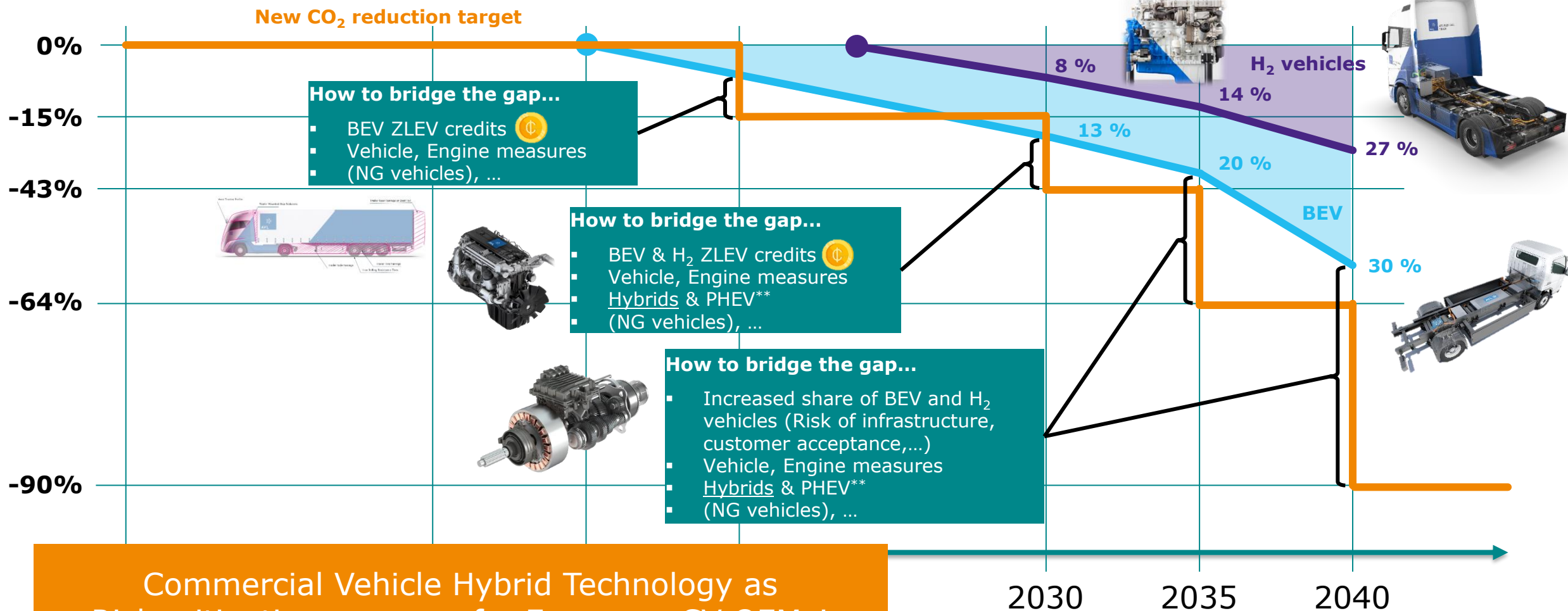


# Management Meeting YuChai | AVL, 20.10.2023

## EU forcing additional Hybrid-Technology for HD Trucks?



EU ZLEV-Impact scenario\* TL\_Low



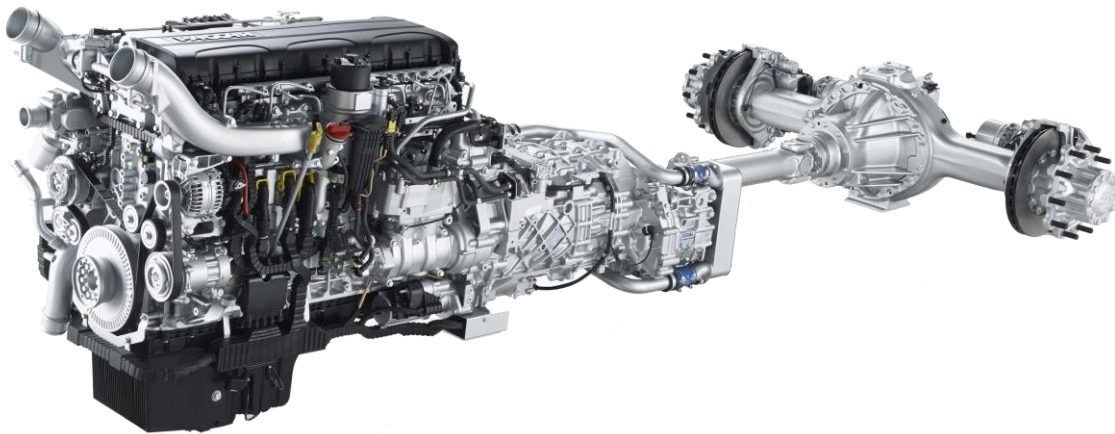
\* Commission staff working document (2023) 89 final: Impact scenario

\*\*PHEV definition still under discussion

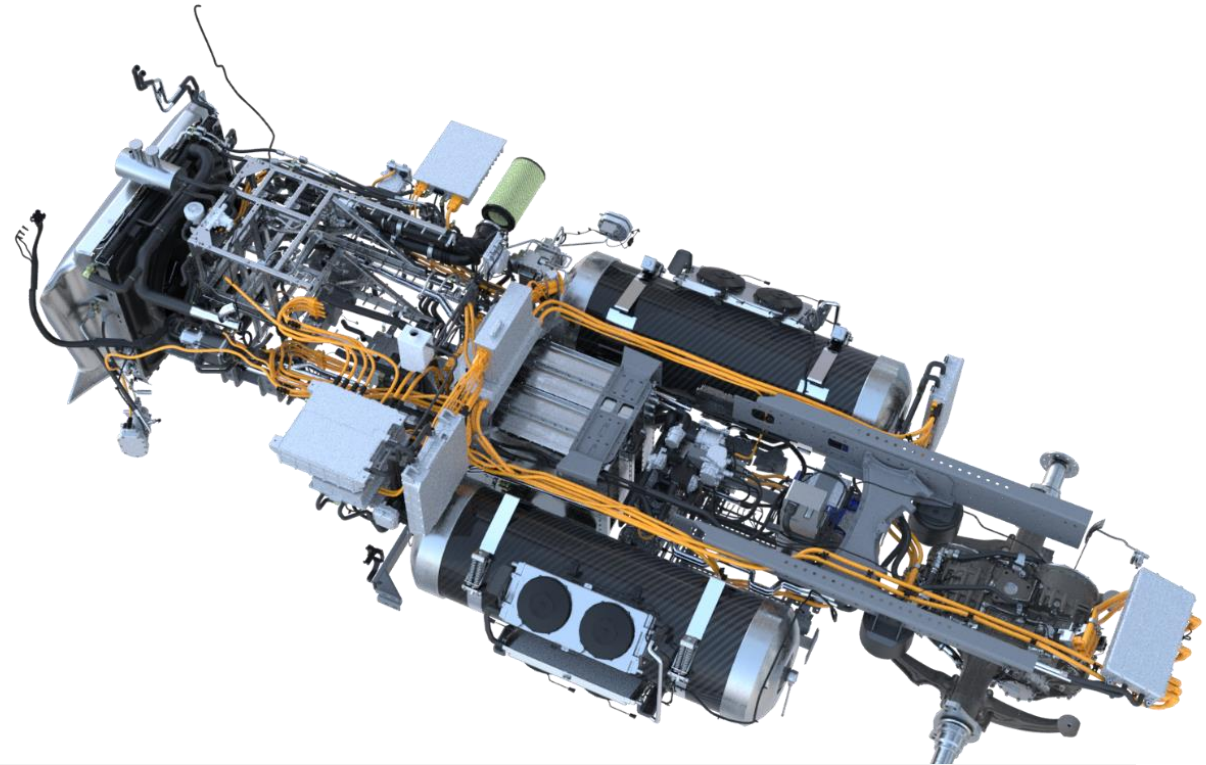


# Comparison FC vs. ICE based Truck

ICE based Powertrain



FC Powertrain w/o Fuel Cell



Complete different transfer of energy from storage to wheel

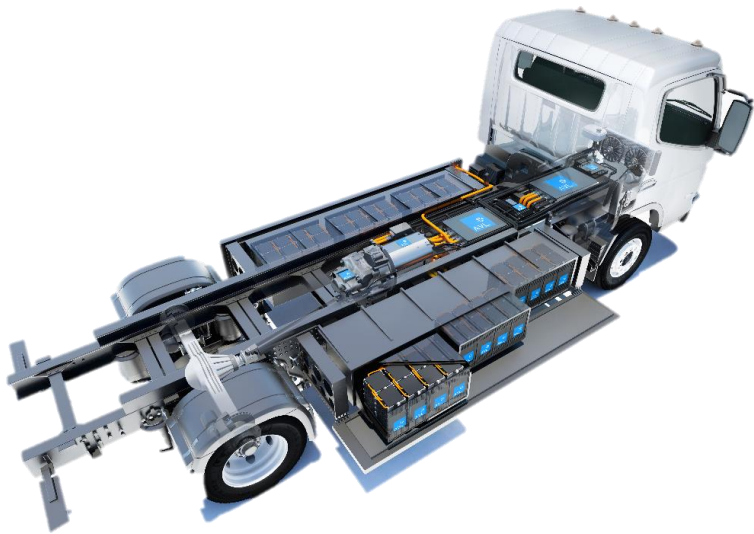


# New Energy On-Road Trucks

## Battery Electric / Fuel Cell Electric



Generation 1 – LD/MD BEV



Maximum re-use of existing components

Off-the shelf solutions

Generation 2 - LD/MD BEV



Optimized Range

Dedicated component developments  
e.g. Battery & e-Axle

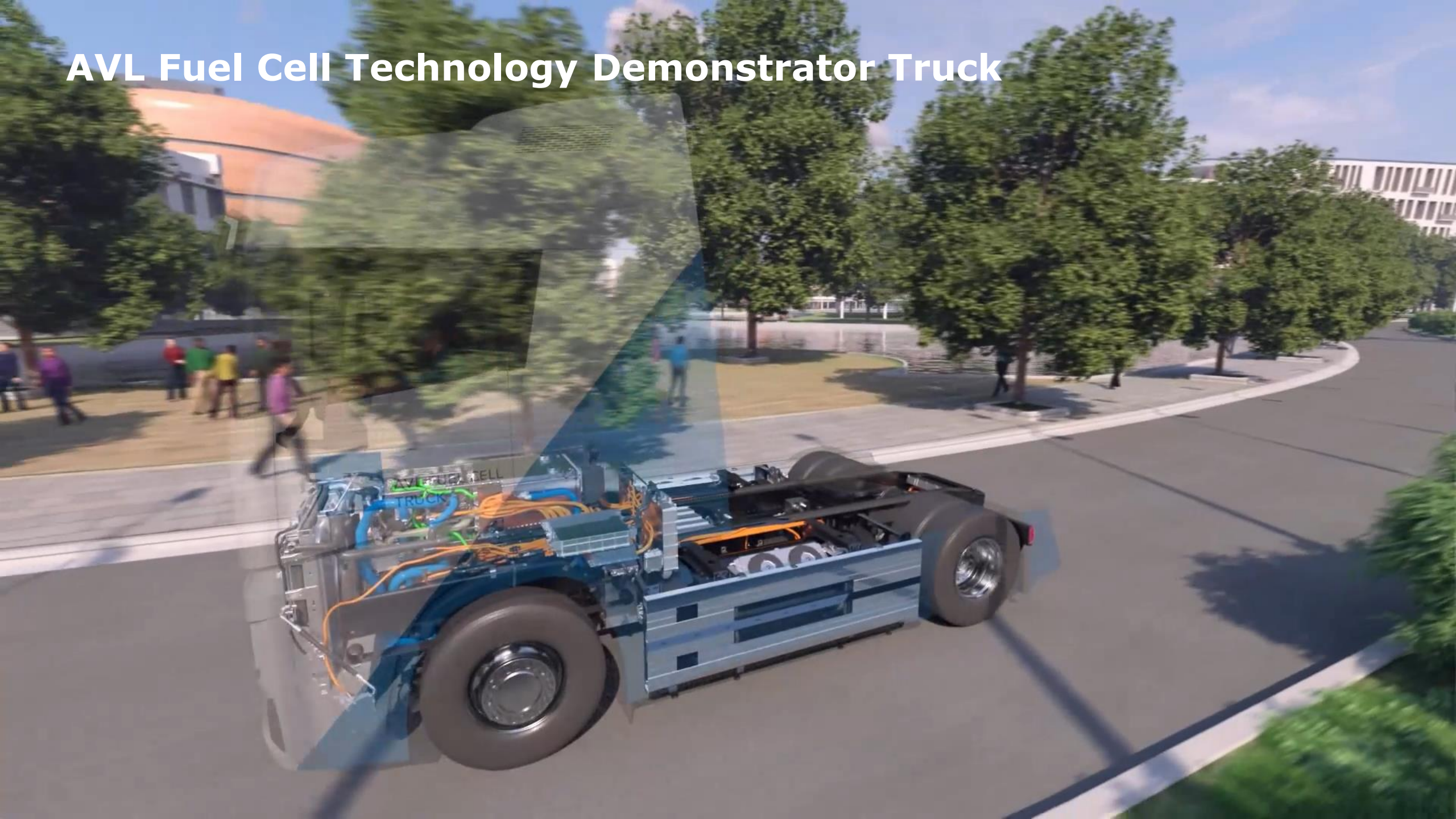
Generation 2 – HD Fuel Cell



Long Range

Maximum flexibility using  
existing trailers

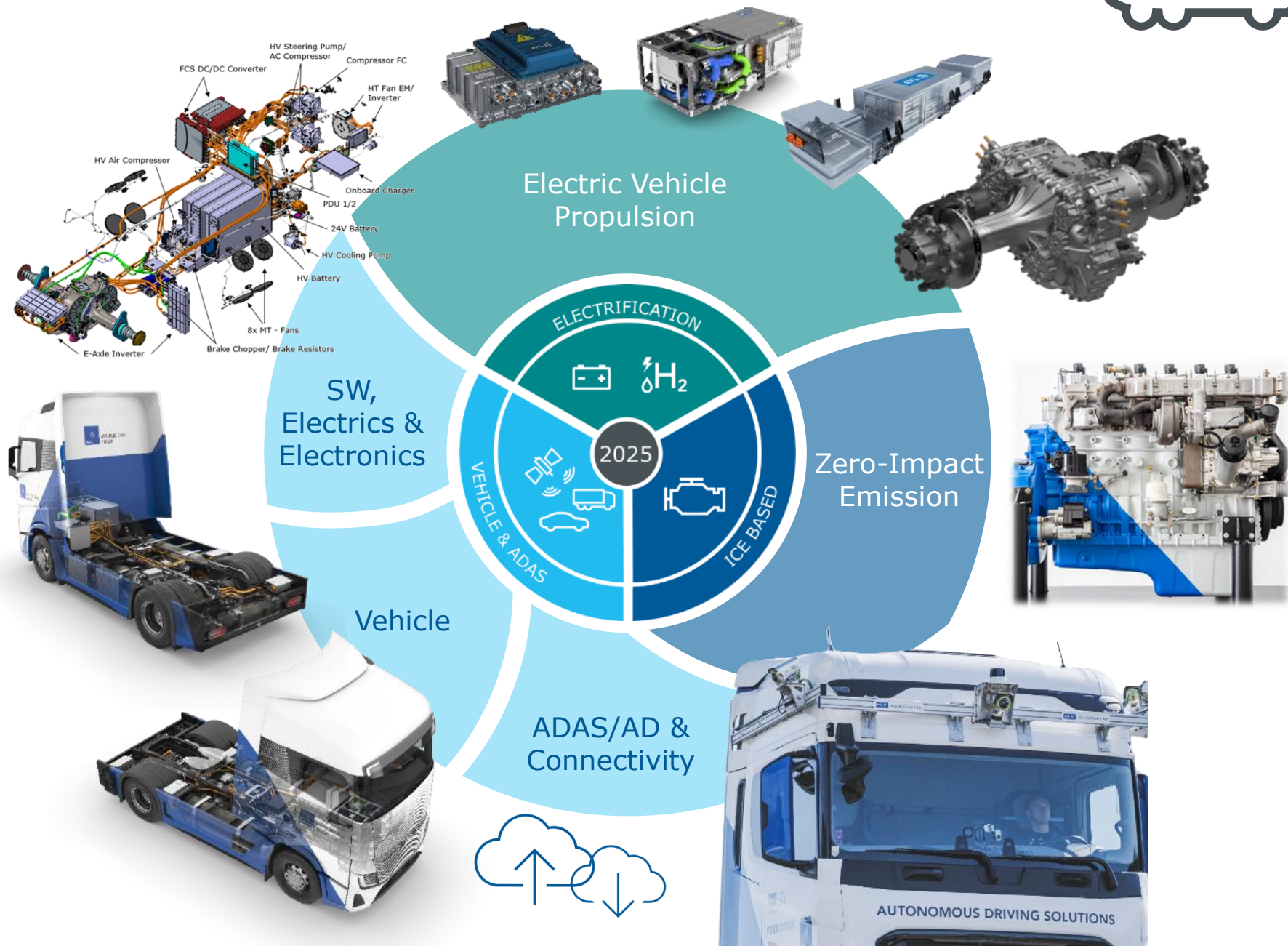
# AVL Fuel Cell Technology Demonstrator Truck





# Commercial Vehicle Focus Areas

AVL









# Commercial Driveline & Vehicle Technology

## Tractor & mobile working machines



### Battery Electric (<150HP)

- 100% coverage of daily work from complete fleet w/o charging not possible
- High potential for battery electric tractor up to 150 HP
- Electric multispeed axle/transaxle
- Cell to module battery pack

### Wider application of battery electric tractors enabled by

- **Autonomous tractors with additional storage for energy**
- **Adopted agricultural processes**

### Fuel Cell

#### Challenge:

- Packaging of H<sub>2</sub>
- Cooling System

### ICE Hybrid (>130HP)

- Power split high voltage hybrid systems
- Best overall rating under consideration of different criteria
- Electrical energy for implements
- Fuel consumption reduction >5% compared to conv. CVT Tractor

- **CO<sub>2</sub> neutral liquid energy carriers required**
- **Multi Fuel Engine**

# Commercial Engines: Fuels and its Properties

## Future Fuels for Mobile Applications On- and Off-Road



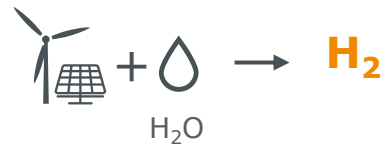
### Carbon-free Fuels

#### Hydrogen $H_2$



#### Electrolysis

Electricity



### Carbon-based (neutral) Fuels

#### Methane $CH_4$



#### RNG: Methanation



#### BNG: Bio-Fuel Production



#### Alcohols $CH_3-(CH_2)-OH$



#### Bio Alcohol / Synthesis



**Methanol:** Gasification of Biomaterial + Synthesis or Methanol synthesis

**Ethanol:** Sugar Fermentation

#### Paraffins $C_nH_{2n+2}$



#### E-Fuel (e.g. Fischer Tropsch)



#### HVO: Isomerization





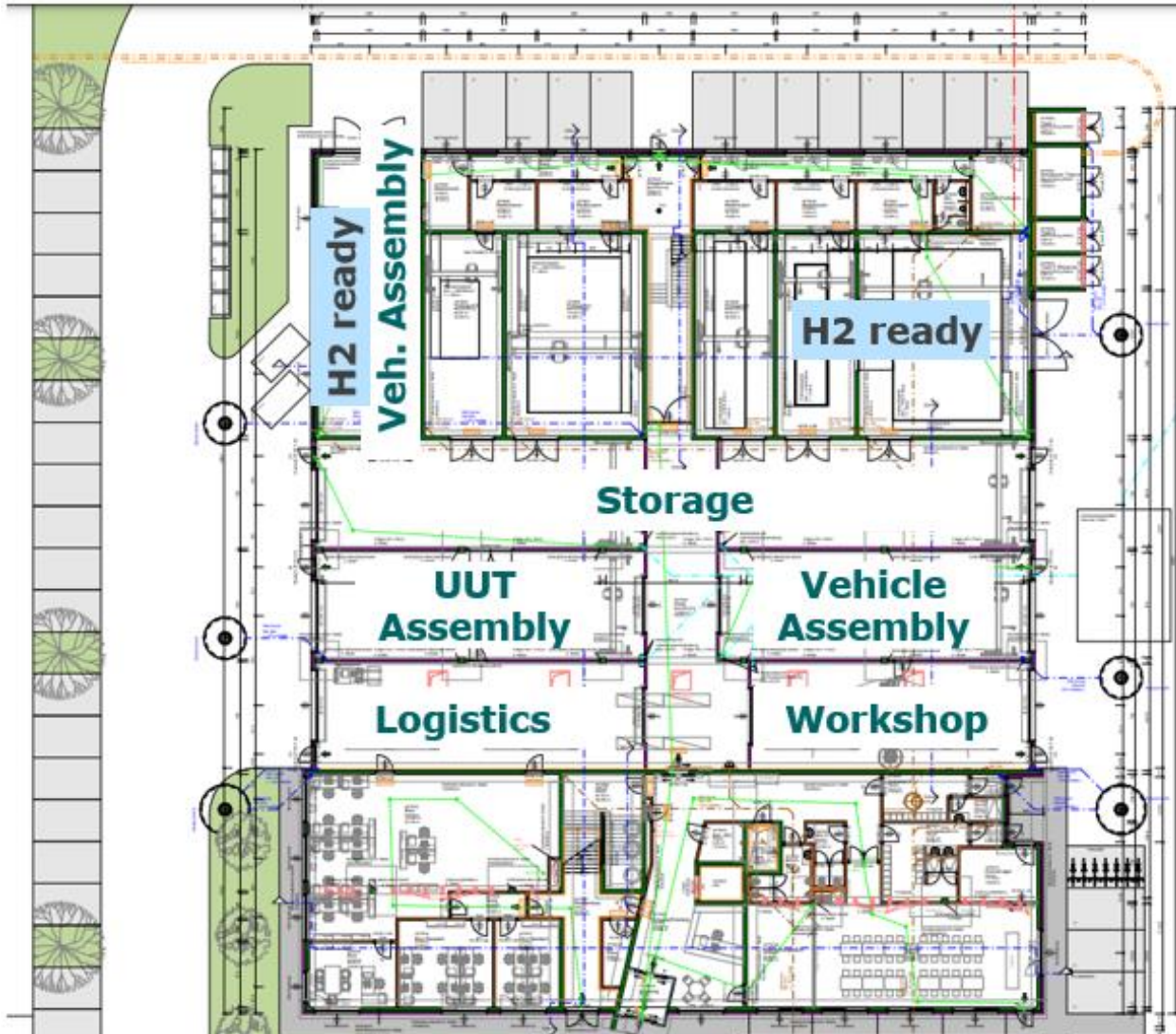
AVL Commercial Driveline and Vehicle

# AVL Techcenter Steyr

AVL



# TECH CENTER @ STEYR



- Workshops for Truck, Bus & Tractor
- H<sub>2</sub> ready assembly and test
- Test beds for
  - Vehicle
  - Powertrain
  - E-Axles



# News from Steyr

## 2023 New HD Tech Center



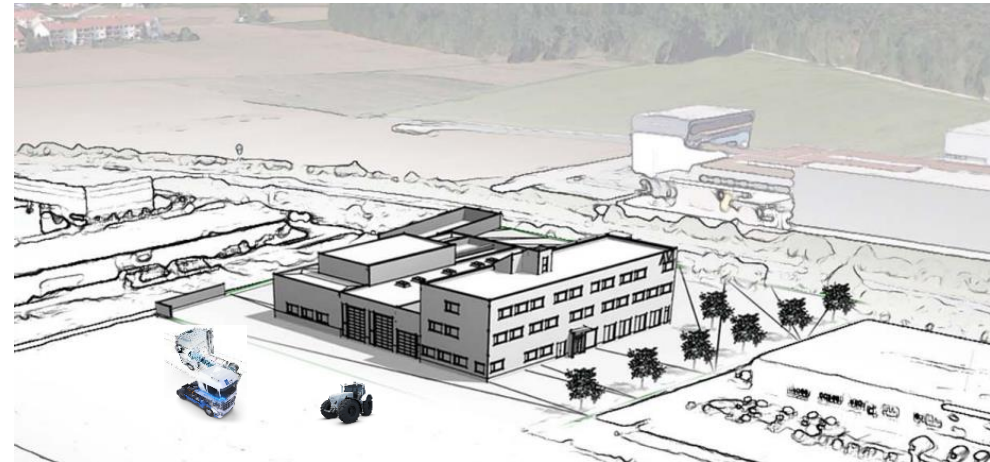
March 2023



September 2023

### AVL Steyr Commercial Vehicle Competence Center

- Office building for **>150 employees**
- Test facility with **6 high-performance testbeds** (up to 125.000 Nm wheel-torque)
- Testbeds and workshop are prepared **for electrification and hydrogen** (incl. supply)
- 5 **battery simulators** with total output of **1,7MW**
- Opening planned for spring 2024



Outlook: April 2024



We are your reliable partner for  
any investment project,  
from the early planning stages  
all the way to production and beyond.

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