



FC4HD – Heavy-duty fuel cell road demonstrator

Fuel cell driven heavy duty vehicles

Challenges

- High Range – daily milage up to **800 km**
- High share of **highways**
- **High average speed** – Low inclinations
- Mostly point to point transport
- Almost **no stops** for loading/unloading
- Overnight in parking lots along the highway
- Legal breaks of **45min**



Fuel cell driven heavy duty vehicles

Challenge - Daily milage

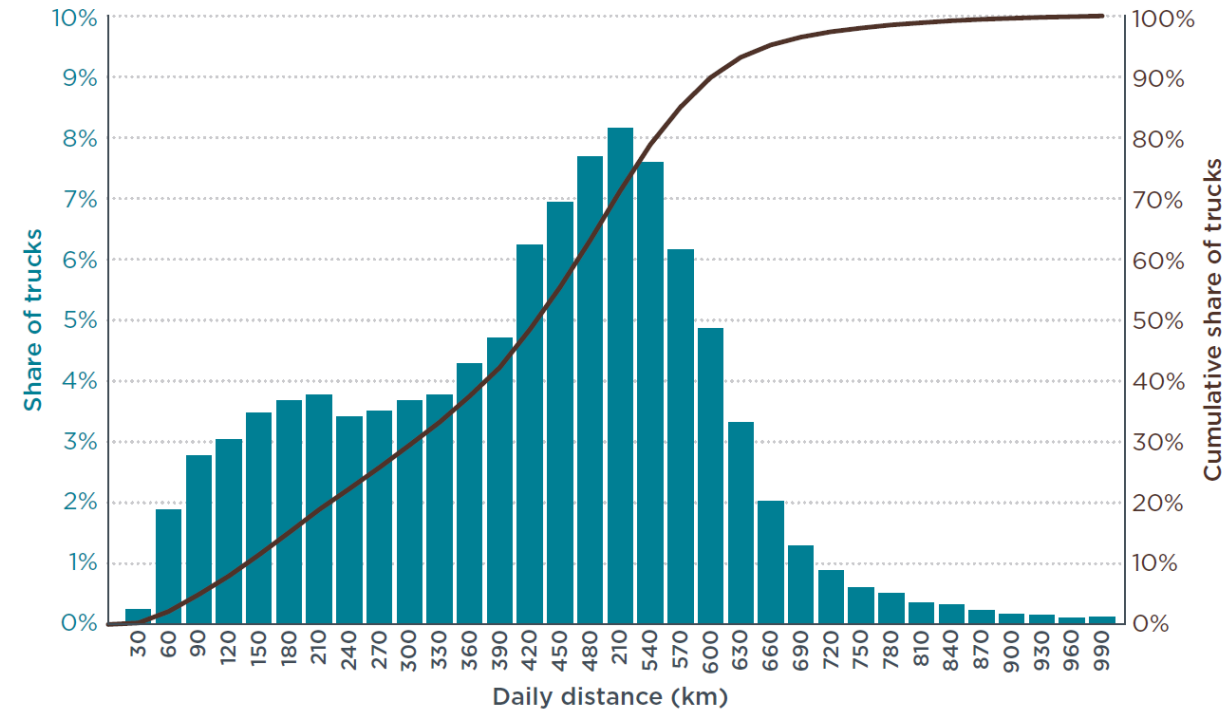


Customer expectation:

- milages **>1000 km**
- realistically only **640 -800 km**

Driver has to pause for 45min after 4,5h of driving.

- Enough energy **stored**
- **Refueling** has to fit



(Source: ICCT White Paper TCO-BET v4, November 2021)

Fuel cell driven heavy duty vehicles

Challenge - Truck Body



- Typical EU Long Haul Trucks (Class 5LH) have rather short wheelbases (**<4000 mm**) while having a sleeper cabin, increasing the length of the cabin.
- Building “**hydrogen towers**” behind the cabin with short wheelbases means **incompatibility** with certain trailers (16.5 m max length)
- **Increasing the wheelbase** also leads to problems with the allowed maximum length.
- **Changed heat rejection split** compared to ICE-based vehicles



AVL's Fuel Cell World Demonstrator Vehicles



Fuel Cell Demo Truck	Donor vehicle	KEYTECH4EV
DAF XF	Donor vehicle	VW Passat GTE
9800 kg	Vehicle curb weight	1746 kg
52 kWh	Battery size	9.9 kWh
~310 kW	Fuel cell system power	~55 kW
540 kW	e-drive power	100 kW
28.3 kg	Hydrogen tank capacity	3.8 kg
4	Number of tanks	3
approx. 13 min	Hydrogen refilling time	approx. 3 min
7.9 kg / 100 km	Hydrogen consumption	0.8 kg /100 km
>350 km	Driving range	>500 km



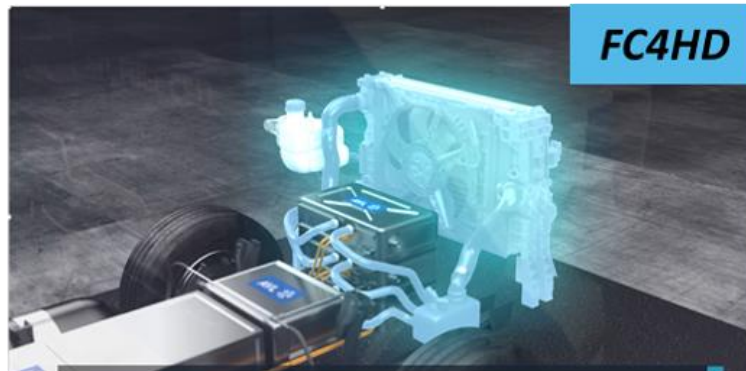
AVL develops and integrates Fuel Cell Powertrains from passenger vehicles up to various commercial applications

Fuel cell driven heavy duty vehicles

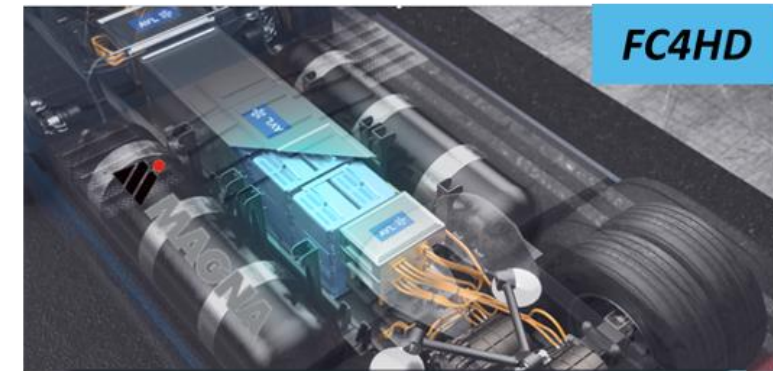
Solutions



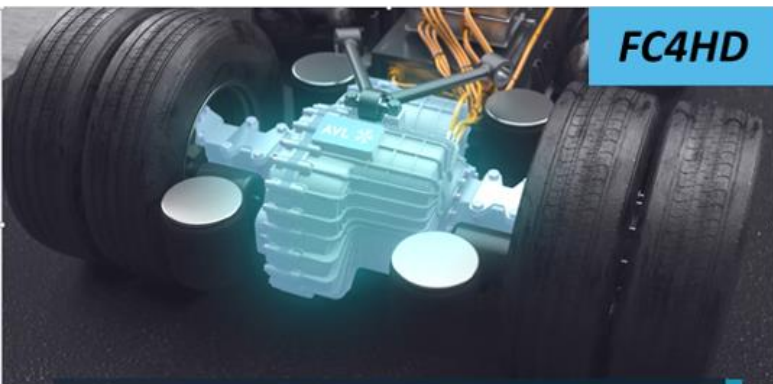
310kW Fuel Cell System



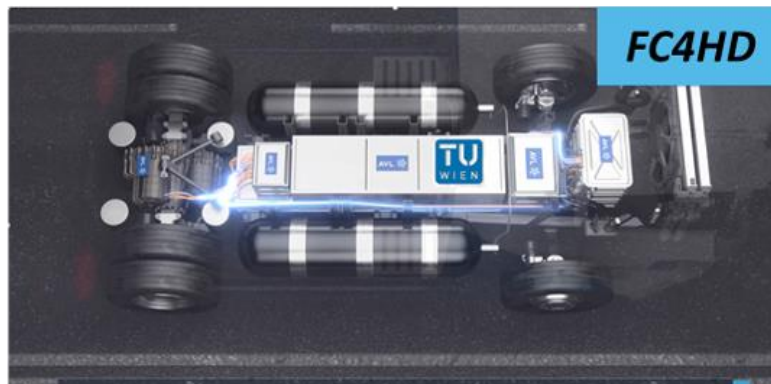
Advanced Vehicle Cooling



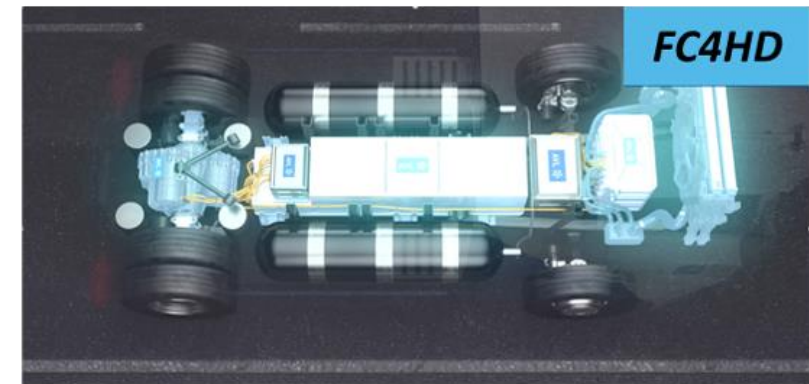
700bar H₂ Storage System



Integrated e-Axle



Predictive Energy Management



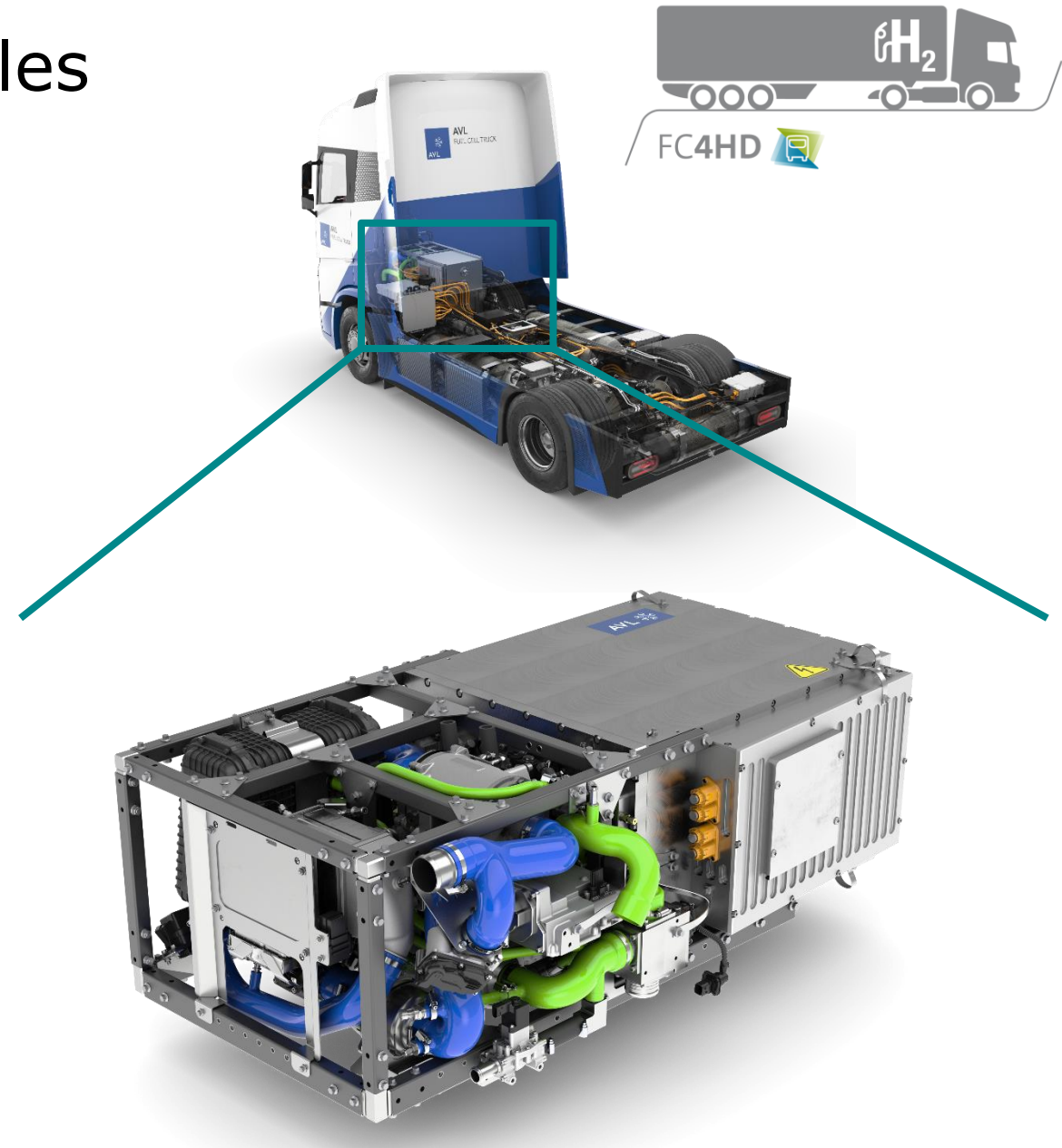
Smart System Integration

Fuel cell driven heavy duty vehicles

Solutions – Fuel Cell system

AVL Fuel Cell System

- FCS net rated power (BOL/EOL)
2 x 154 kW / 136 kW
- Max. FCS **efficiency** (BOL): **~55 %**
- **Stack** development by AVL
- Fuel cell **system integration** by AVL
- **Highest** fuel cell **power density**



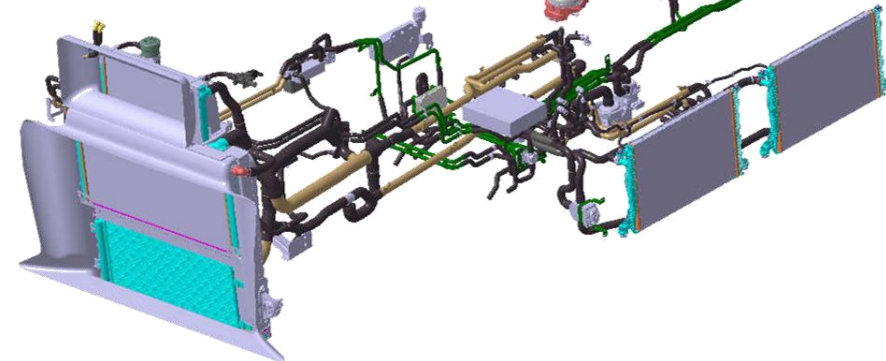
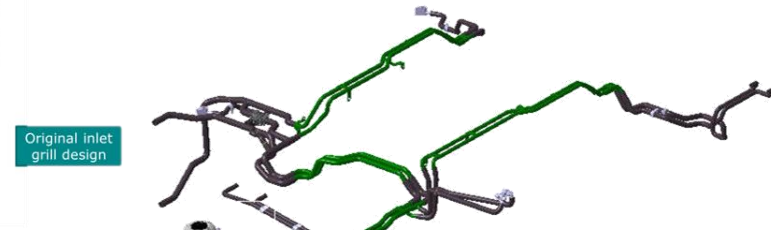
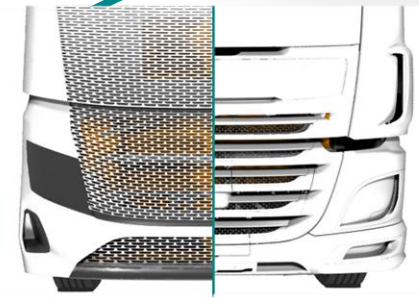
Fuel cell driven heavy duty vehicles

Solutions – Thermal system



AVL Thermal System

- **All thermal circuits** are interconnected via valves or heat exchangers
- **Load split between circuits** depending on boundary conditions
- **Airflow management** around and over cabin to improve airflow to radiators on vehicle side
- **High performance HV-fan** for FCS cooling



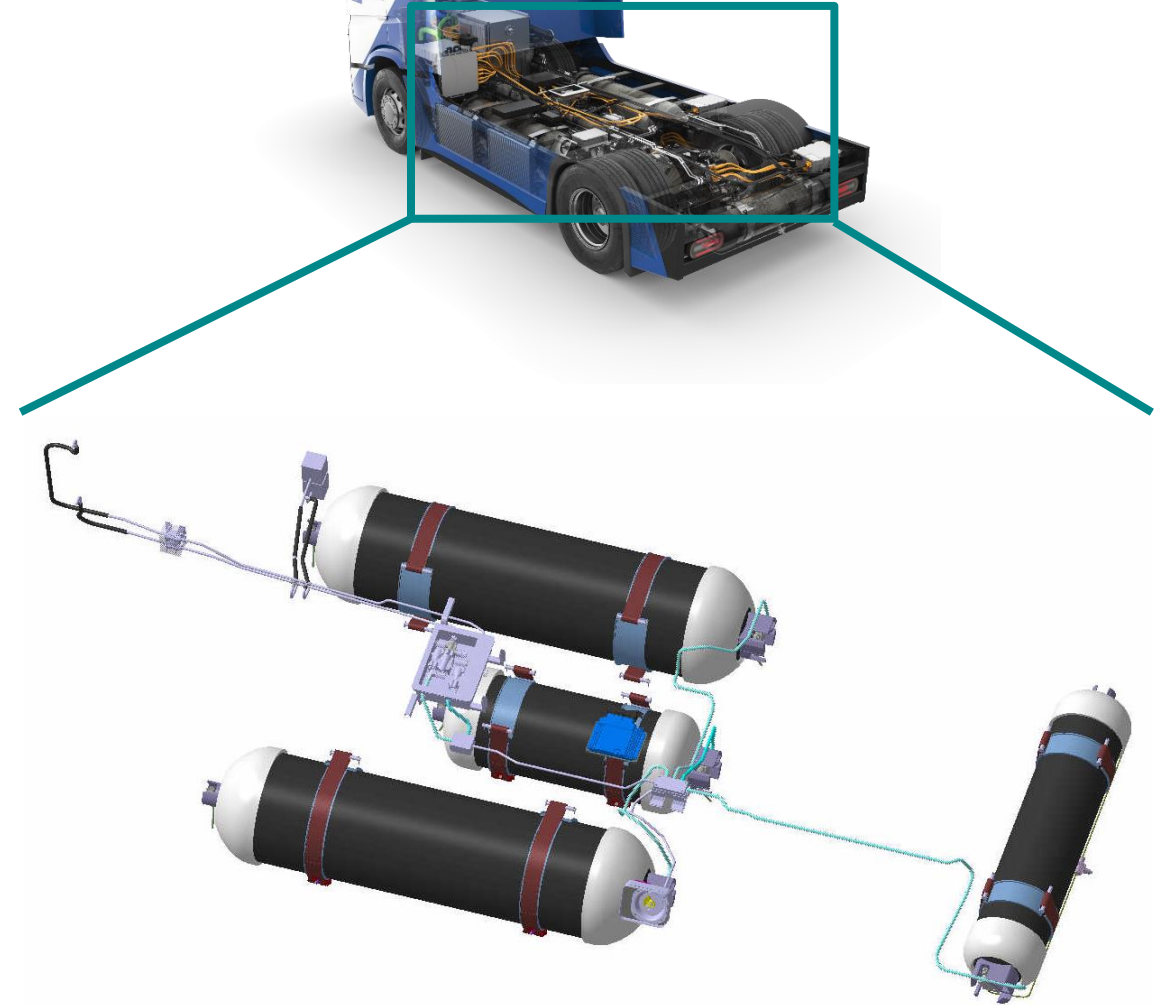
Fuel cell driven heavy duty vehicles

Solutions – Tank system



Tank System

- **ECE R134** sets minimum distances from possible crash impact zones to the tank, limiting the possible tank diameter
- By designing high strength “crash worthy” tanks, the tank diameter can be increased
- Project Partner MAGNA **provided the tanks incl. initial certification**
 - Most efficient usage of space within wheelbase
 - Variable lengths possible, adapting the tanks to different wheelbases



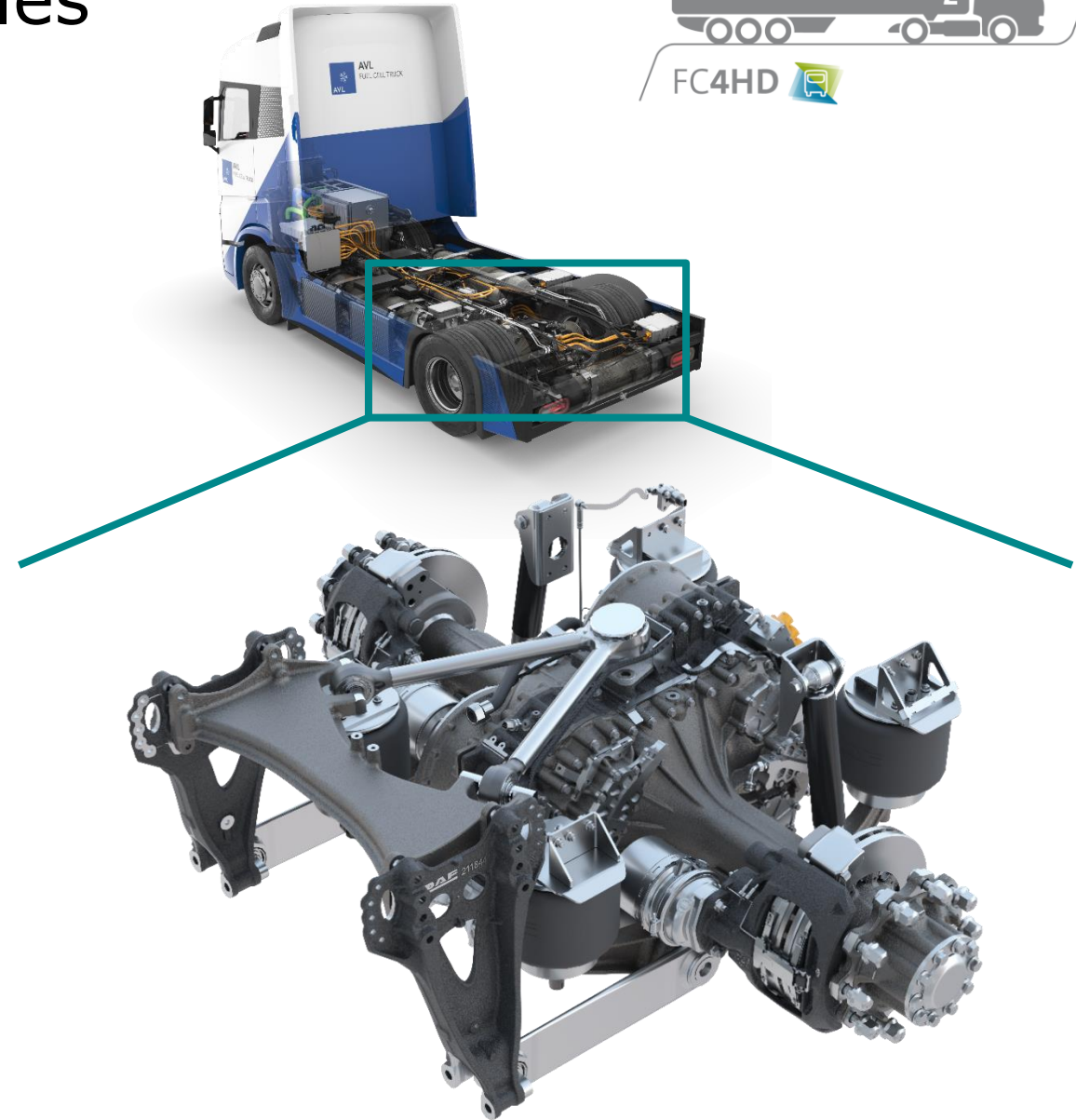
Fuel cell driven heavy duty vehicles

Solutions – e-drive



AVL HD e-Axle

- **Integration of e-motors** into drive axle increases packaging space within ladder frame
- **Free space** in ladder frame can be used for
 - Fuel Cells (In Engine space)
 - Batteries (In Transmission space)
 - Auxiliary integration (Space usually consumed by prop shaft)
- **400 kW continuous** power
- **540 kW peak** power



Fuel cell driven heavy duty vehicles

Solutions – Predictive Controls



AVL Predictive control solution

High system complexity requires

- Holistic development approach using **Model-based-development** (AVL Digital Twin)
- **Predictive Energy Management** to achieve **highest H2 efficiency** and performance
- Predictive **Lifetime Management** to optimize TCO
- Consideration of **all relevant sub-systems** is **key to optimize** the overall energy management

Predictive energy management

Targets of energy management

- Max. Vehicle performance
- Optimize H2 efficiency / Range
- Optimize Component aging

Fuel cell characteristics

- System efficiency
 - Component limits
- Influenced by aging over lifetime



Predictive ENERGY MANAGEMENT

Power split between

- Fuel cell system(s)
- Battery system

Predictive LIFETIME MANAGEMENT

- Optimization and balancing of component lifetime
- Ensure high H2 efficiency and vehicle performance
- Optimization of TCO for customer

Integration of Predictive Lifetime Management

- Integration in energy management
- Optimize component lifetime
- Keep high H2 efficiency and vehicle performance

→ Reduce TCO for customer

Battery characteristics

- System efficiency
- Battery capacity
- Component limits

→ Influenced by aging over lifetime



Vehicle Integration of a Fuel Cell Powertrain for 4x2 Heavy Duty Truck

Q&A

Contact



LOCATION

AVL Commercial
Driveline and Vehicle
Schönauer Straße 5
4400 Steyr
Austria



PHONE

T: +43 316 787 5950
M: +43 664 88606079



EMAIL

wolfgang.gruber@avl.com



WEBSITE

www.avl.com



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AVL 

www.avl.com