Electrified Solutions for Efficient Transport in Truck & Bus

Waseda Symposium 2018

Lukas Walter

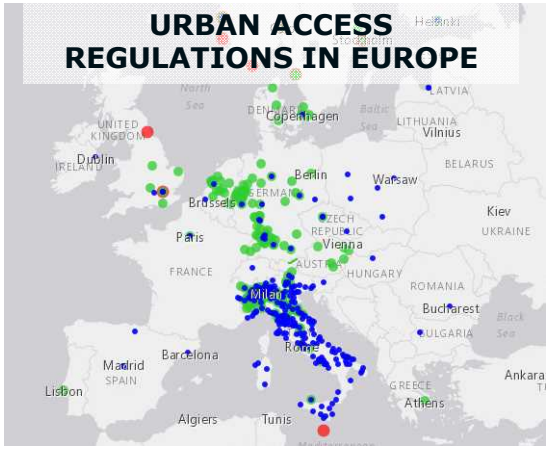
May 2018

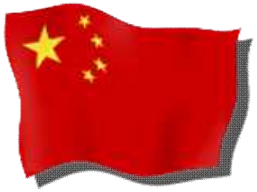
IS ELECTRIFICATION FOR TRUCK AND BUS GOING TO HAPPEN ?

IT IS ALREADY HAPPENING !

AND MUCH MORE TO COME …

Truck & Bus Electrification
Why?



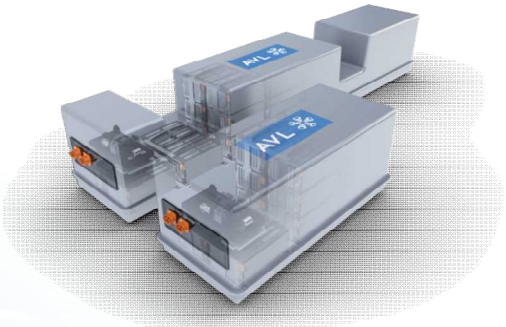


ZERO NOISE & ZERO EMISSION DRIVING IN CITY ZONES

Electrified trucks & busses
Chicken and Egg Problem

„Many products currently being hatched !“

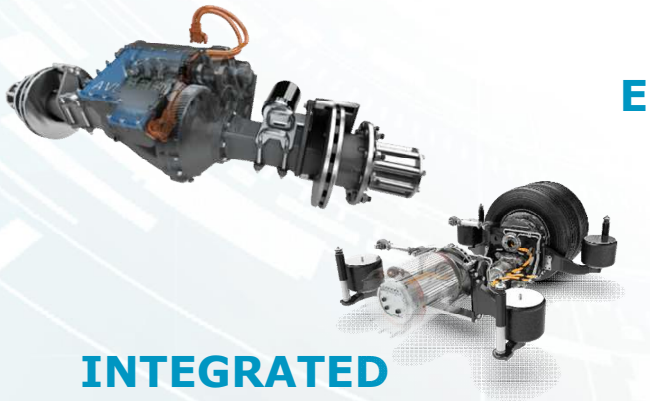
Major components for electrified trucks & busses



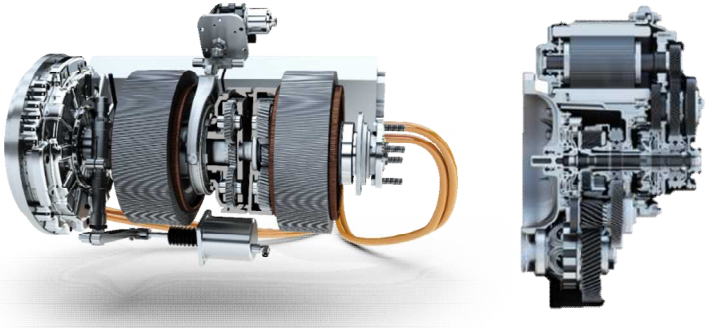
MODULAR BATTERY SYSTEMS

ADVANCED ENERGY MANAGEMENT

HIGH PERFORMANCE FUEL CELL SYSTEMS



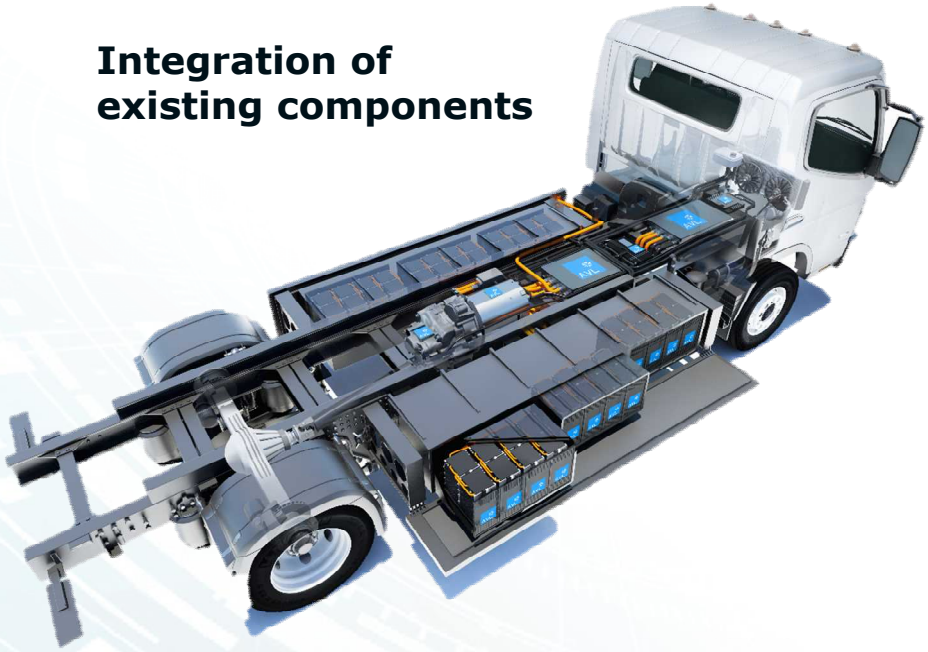
INTEGRATED ELECTRIC AXLES



DEDICATED HYBRID TRANSMISSIONS

Next generation electric trucks will consist of specific e-powertrains

Integration of existing components



CURRENT PRODUCTS

NEXT GENERATION

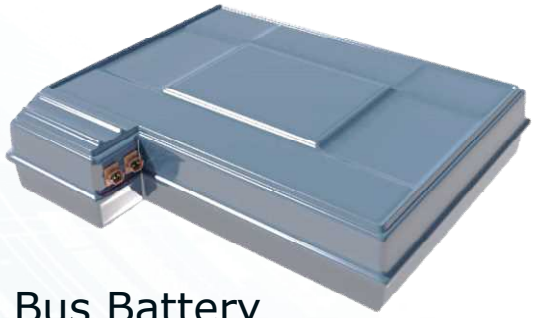
Specific component developments
(battery & e-axle)

DEVELOPMENT FOCUS:

- Performance increase
- Cost reduction
- Weight reduction

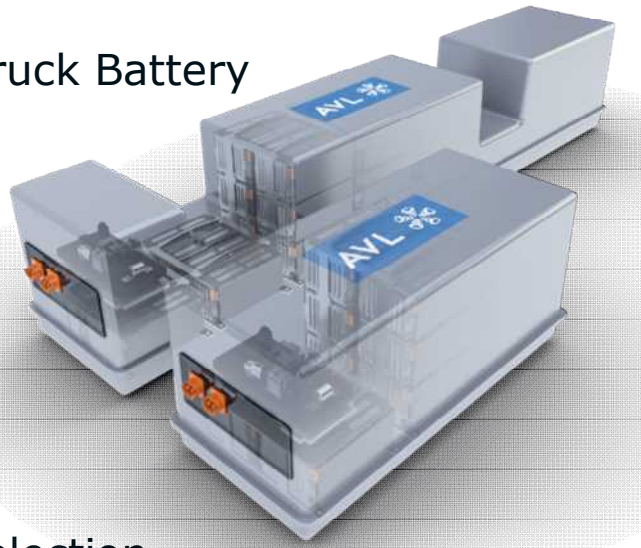
Modular battery design for truck & bus

Modular battery concept
applicable to different applications

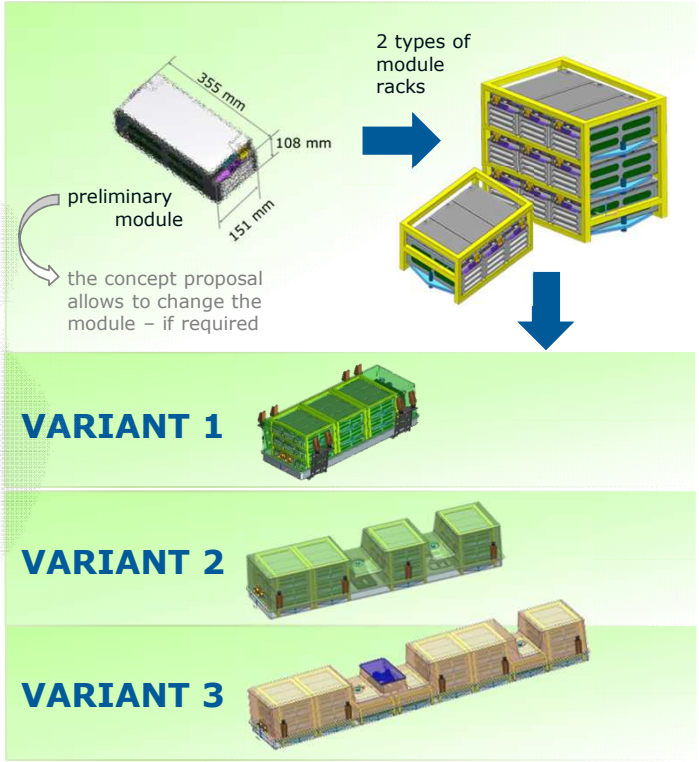


City Bus Battery

Truck Battery



- Integration of existing modules
- Flexibility in module / supplier selection
- Modularity in voltage level
- Modularity in energy content
- Advanced thermal concept
- Advanced sealing concept



Modular Battery Concept for Trucks

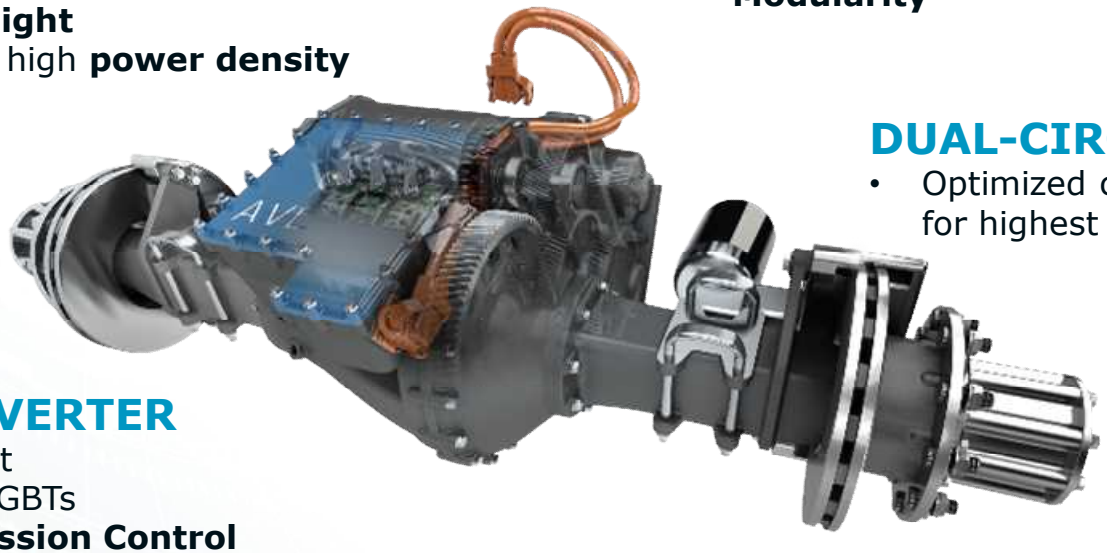
Electric axle for MD & HD trucks

HIGH PERFORMANCE E-MOTOR

- PSM technology for high **efficiency**
- High rotation speed (16.000 rpm) for low **cost** and **weight**
- Direct oil cooling for high **power density**

2-SPEED REDUCTION TRANSMISSION

- Highest **efficiency**
- **Modularity**



DUAL-CIRCUIT COOLING SYSTEM

- Optimized component temperatures for highest **performance and durability**

INTEGRATED INVERTER

- **800V** for low current
- Cheap and reliable IGBTs
- Integrated **Transmission Control**
- Good **EMC** behavior

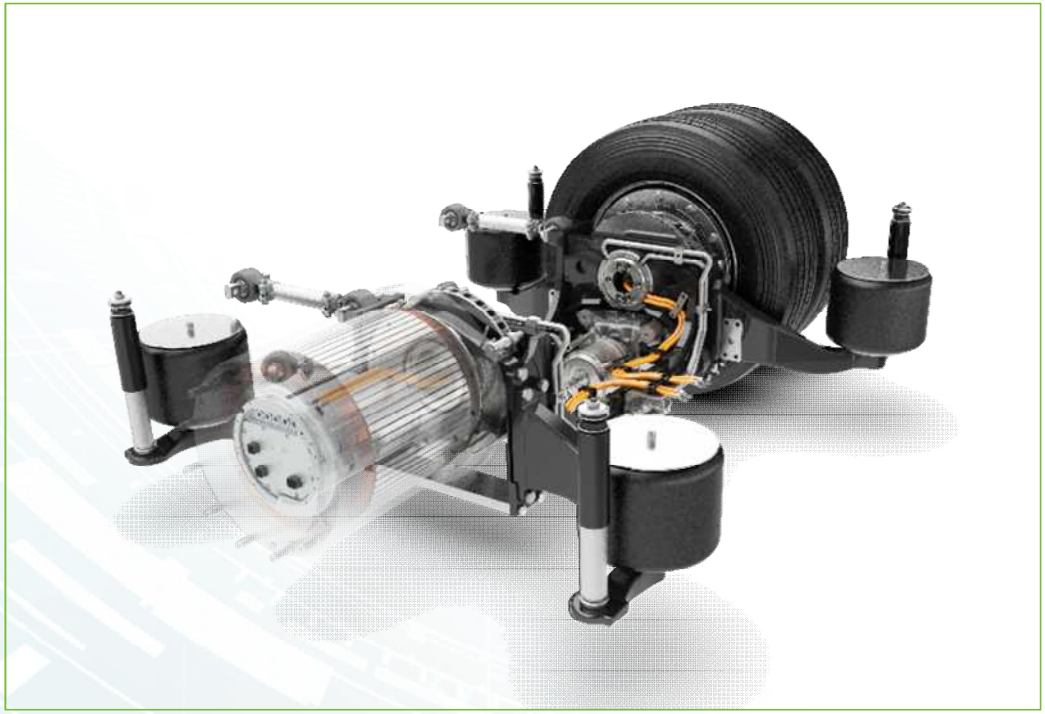
MINIMIZED VEHICLE INTERFACES

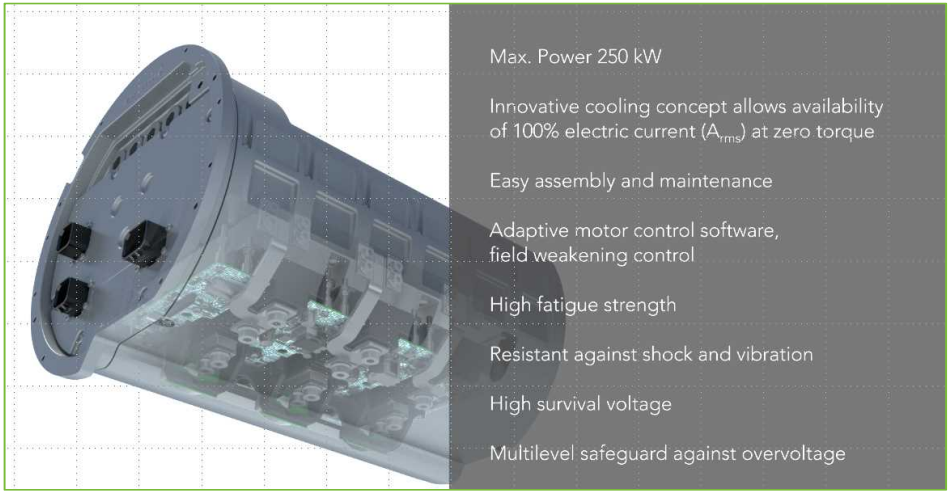
- Standard vehicle interfaces
- Lowest number of vehicle interfaces (highest **robustness**)
- **Pre-assembly** & EOL testing possible

Electric axle for City Bus Example

ZIEHL-ABEGG

AVL

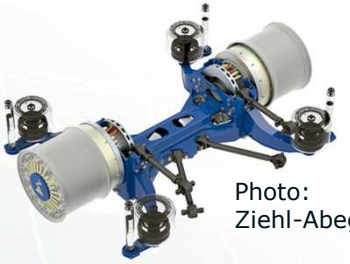




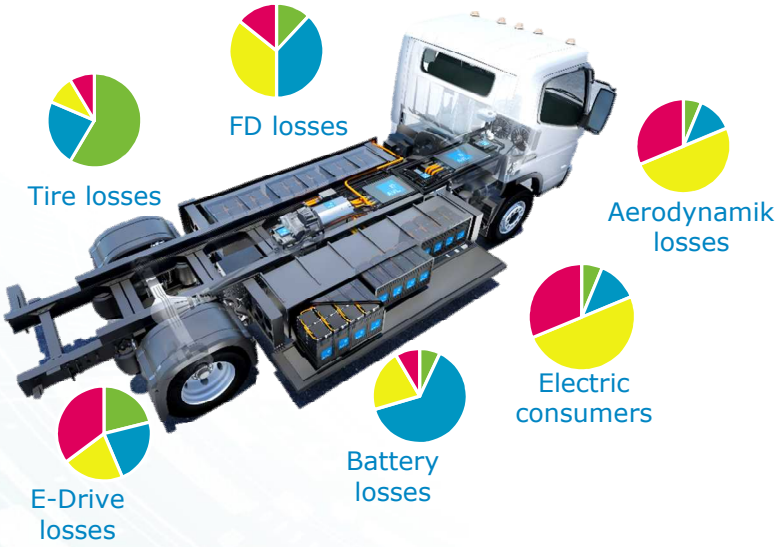
Publication of e-axle with AVL
Vienna Engine Symposium
April 2018

- **Wheel-hub direct-drive (w/o transmission)**
- **250 KW**
- **9.000 Nm on each wheel**
- **AVL fully-integrated power electronics**
- **SOP: mid 2018**

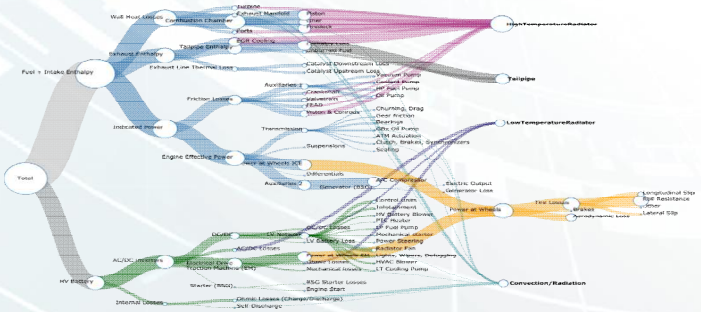
E-Drive Technologies
High degrees of modularity possible

	Application	Powertrain
LCV	Truck 4x2 5,5 ton 	Integrated E-Axle 
	Bus 6 m 	
HD / MD	Truck 4x2 7,5 -18 ton 	Center drive 
	Truck 6x2 -26 ton 	
	City bus 6-12 m 	Wheel selective drive  Photo: Ziehl-Abegg
	City bus - 18 m 	

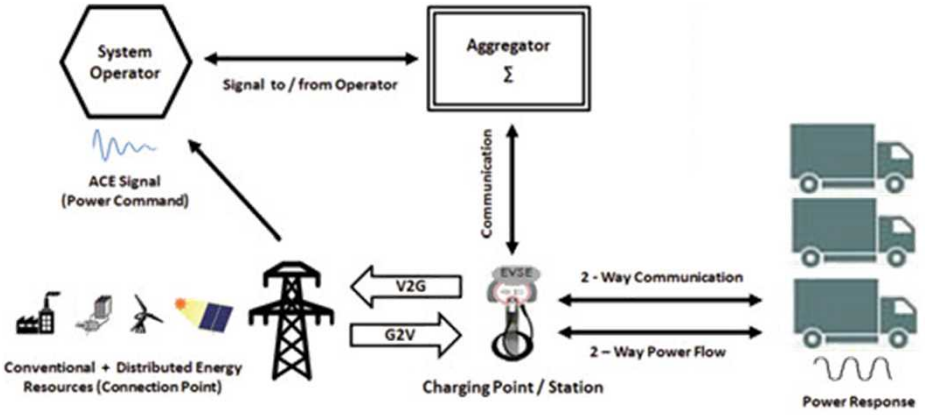
Vehicle energy management
From Grid to Wheel



Vehicle Energy Transfer and Losses



- Energy consumption reduction and increased vehicle reliability by advanced analyses and controls
- Improved vehicle productivity
- Optimization of charging and power grid requirements by connected vehicle technologies



Vehicle integration into the grid

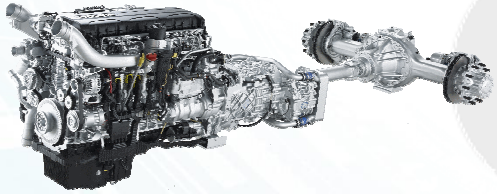
Basic Charging Concepts

Charging Concept	Infrastructure Costs	Vehicle Costs	Charging Performance
OVERNIGHT CHARGING - in the depot 	**Low** Chargers only in the depot	**High** Large battery capacity	30 – 150 kW 50 – 800 V DC
OPPORTUNITY CHARGING - at the station 	**High** expensive charging systems in stations	**M** sm expens depend	

AVL Electric Bus – City of Regensburg
30% Reduction of Battery Size

Degrees of Electrification

Fuel-Cell Electric



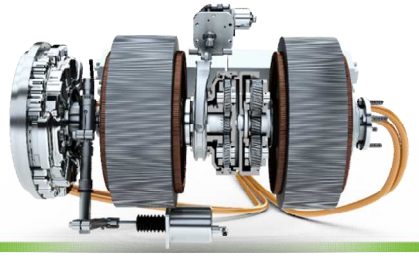
ICE traditional

Battery Electric

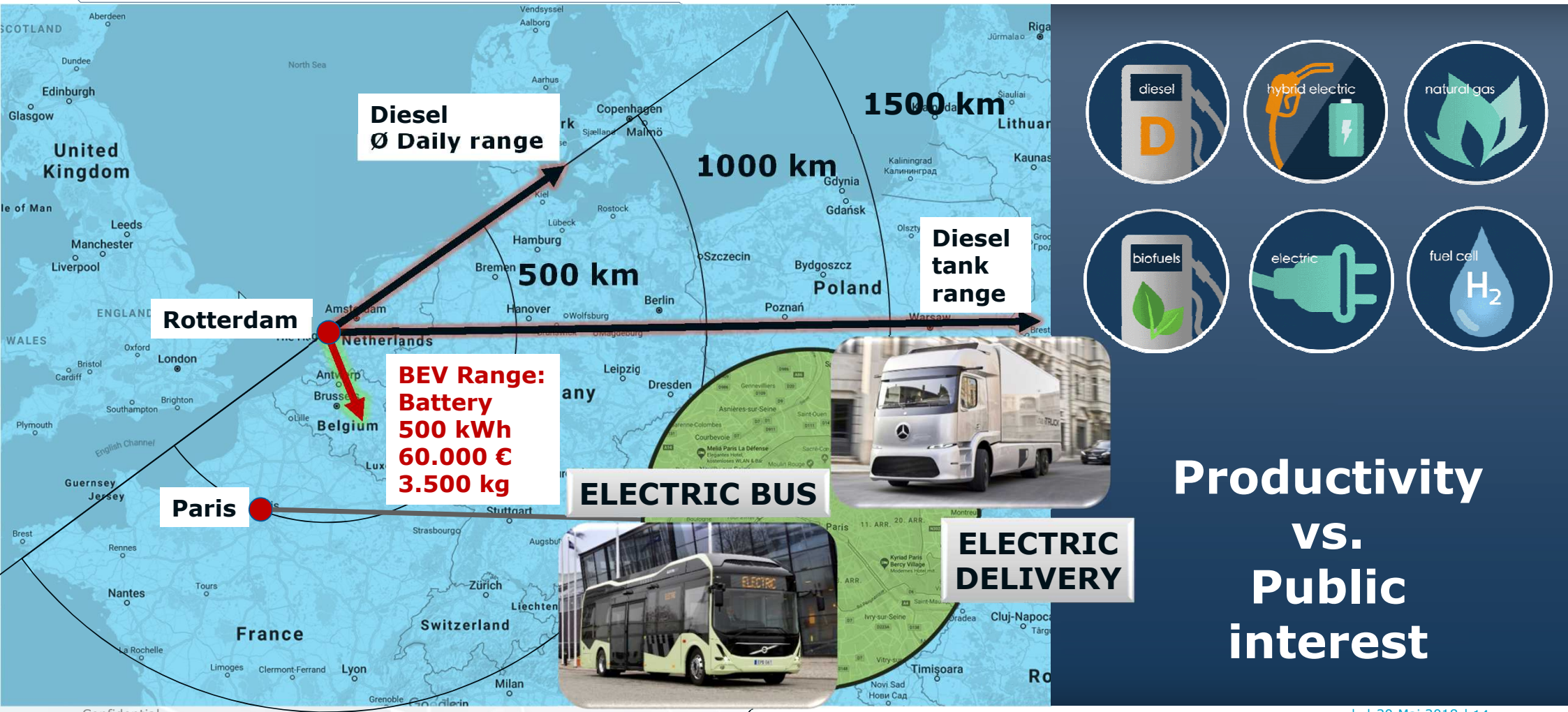
Mild-hybrid

Full-hybrid

Dedicated-hybrid



What is the challenge ?



Increasing technology portfolio for OEMs

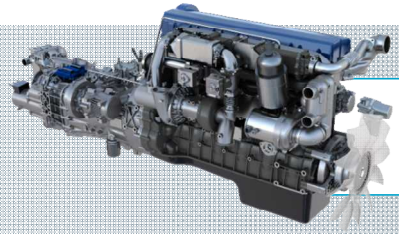
PAST

TODAY

- Low CO_2 Truck
- Alternative Fuel
- Electrified Road
- Hybrid – Last Mile
- Electric
- Fuel Cell

AVL Technology Highlights

- Low CO_2 Truck
- Alternative Fuel
- Electrified Road
- Hybrid – Last Mile
- Electric
- Fuel Cell



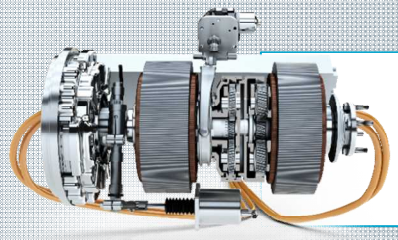
Low CO2 Powertrain

Supertruck II

-25% CO_2

BioDiesel **-100% CO_2**

HDGAS



Hybrid Powertrain

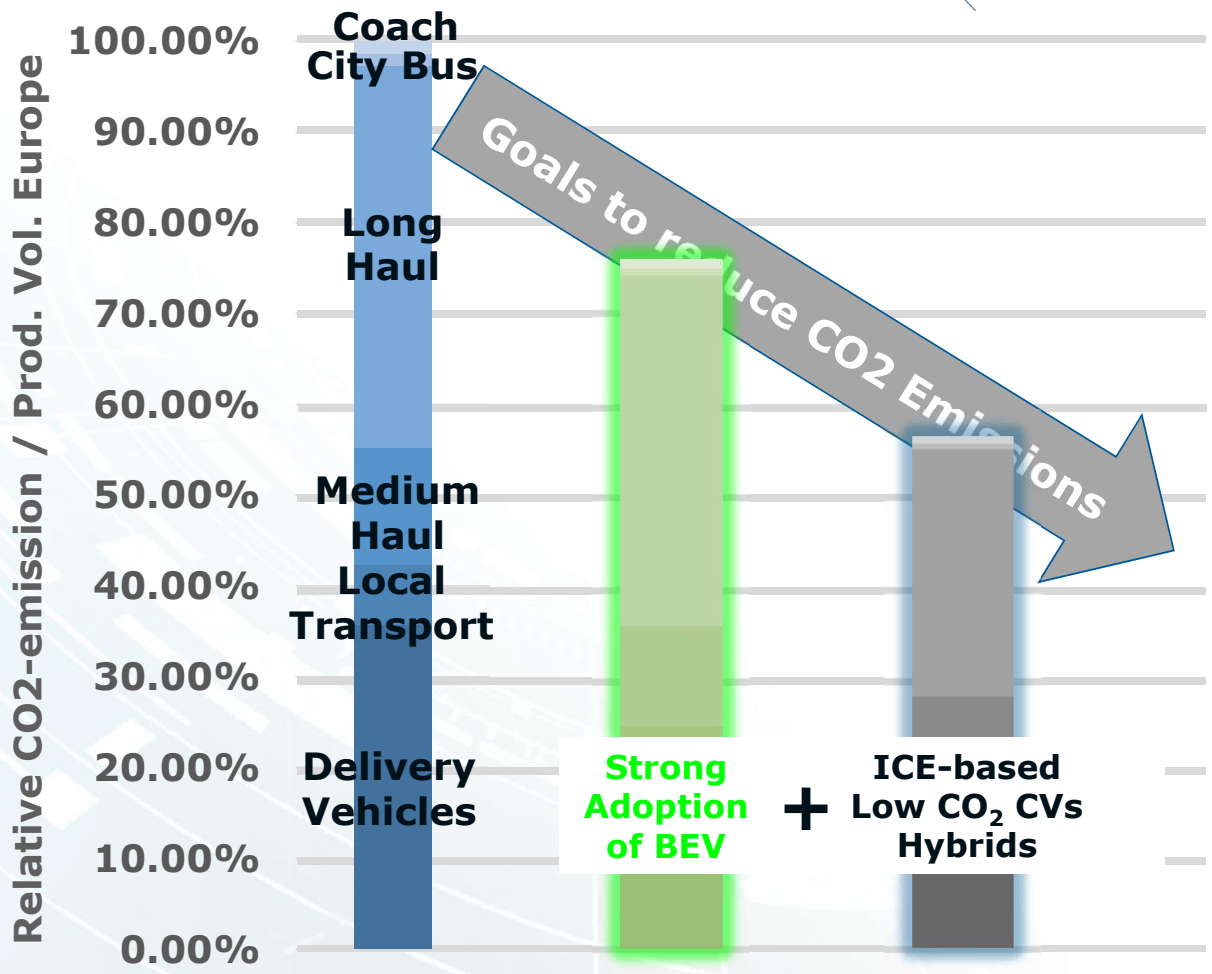
Electric City-Bus PT in Operation

Battery SOP Programs

AVL Integrated Electric Truck

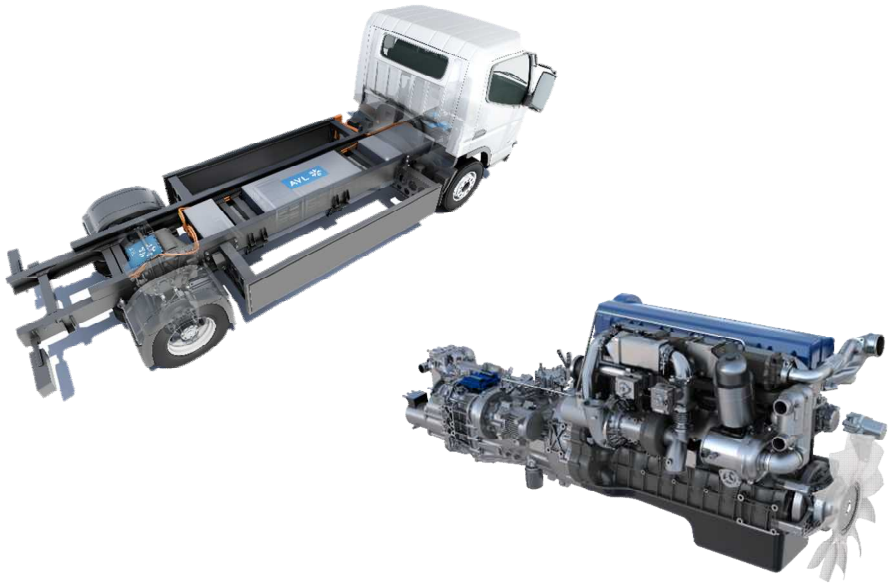
Fuel Cell Powertrain Layouts

Low CO2 Transportation Commercial Vehicles



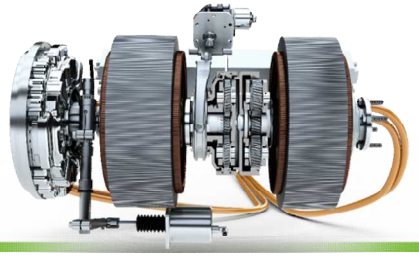
Achievement of CO2 goals for Commercial Vehicles requires:

Electrification + High Efficiency ICEs



Degrees of Electrification

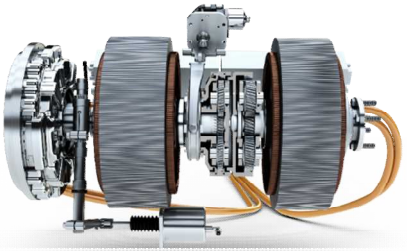
Dedicated-hybrid



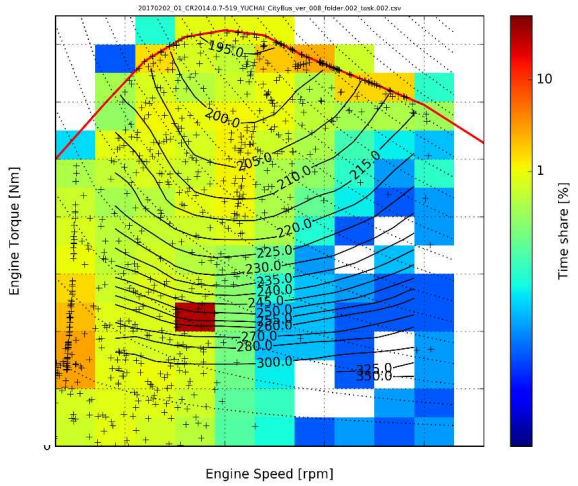
Combining the best of all powertrain technologies

Benefit of a dedicated hybrid powertrain

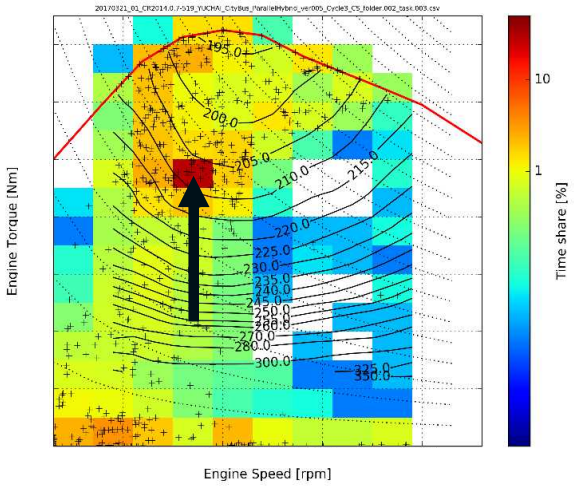
Results for same application and cycle



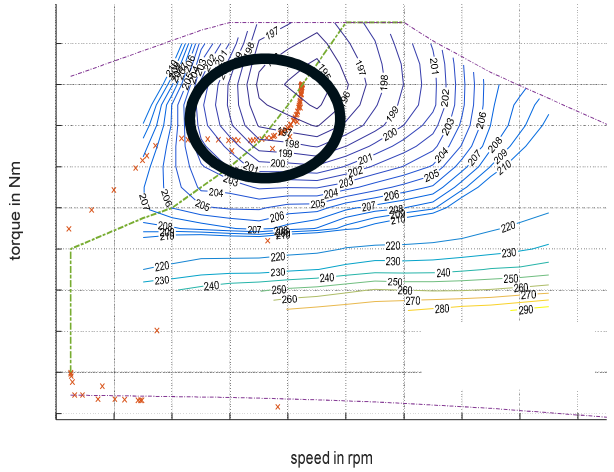
Conventional Advanced AMT



P2-Hybrid



Dedicated Hybrid-PT



Baseline

Shifted main operating point

Operation in best point

AVL Leading Technology
Dedicated Hybrid for Commercial Vehicles

800V

165 kW (continuous)

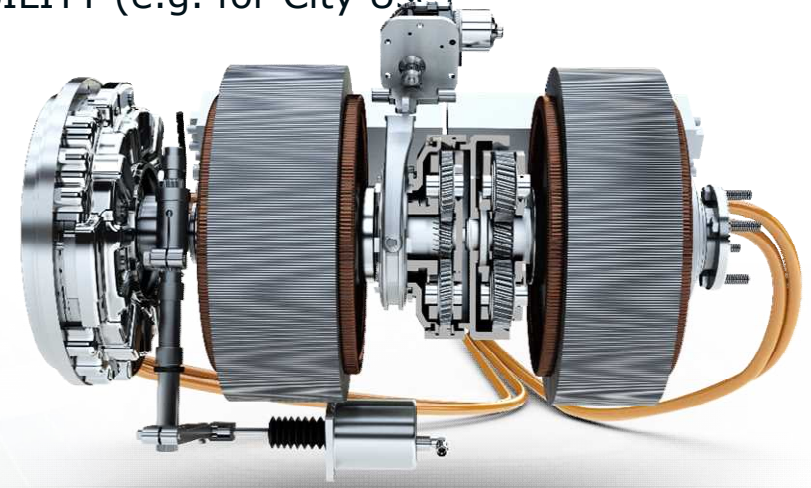
10-15.000 rpm (e-motors)

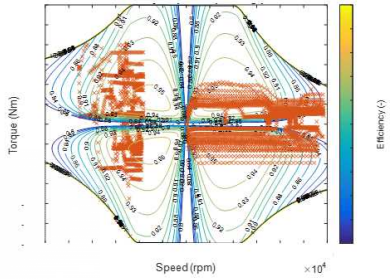
~300 kg (w/o oil)

18t GVW (Bus or Truck)

AVL Dedicated Hybrid Powertrain for Truck&Bus:

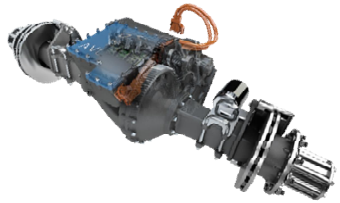
- EASY INSTALLATION → FITS IN STANDARD PACKAGE
- HIGH EFFICIENCY OF DRIVETRAIN
  - RUN ICE IN BEST POINT → NARROW ENGINE OPERATION
  - PURE E-DRIVE MODE, LAST MILE CAPABILITY (e.g. for City Use)
- HIGH PERFORMANCE
- LOW WEIGHT
- MODULARITY & SCALABILITY (MD & HD)

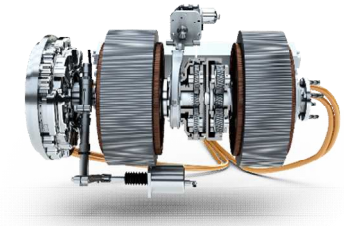




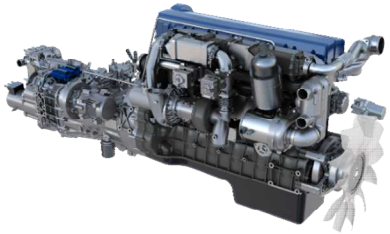
Cost of Complexity of Product Portfolio

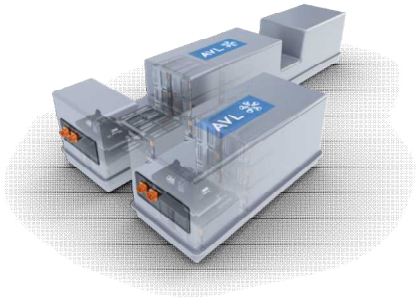
- Low CO_2 Truck
- Alternative Fuel
- Electrified Road
- Hybrid – Last Mile
- Electric
- Fuel Cell





Product Portfolio Optimization using Component Modularity





THANK YOU VERY MUCH
FOR YOUR ATTENTION !