VOLKSWAGEN

AKTIENGESELLSCHAFT

Challenge Electromobility

Barclays Future Powertrain Symposium

Dr. Tobias Lösche-ter Horst

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The brands - our Customers

Value creation in the automotive industry is undergoing change

Climate change
Downsizing
CO_2 emissions
Digitalization
Plug-In-hybrid
Urbanization
Hydrogen
Sustainability
Car sharing
E-mobility
Connected Car
Major cities
Battery technoloy
Lithium-ion
Peak Oil

Challenge no. 1: Reduction of CO_2 emissions

Europe

Regulation for fleet CO_2 emissions

2020
95 g CO_2/km

as of 2025
to be defined

China

Draft fleet fuel economy legislation (Phase IV)

2020
5 l/100 km

as of 2025
«5 l/100 km

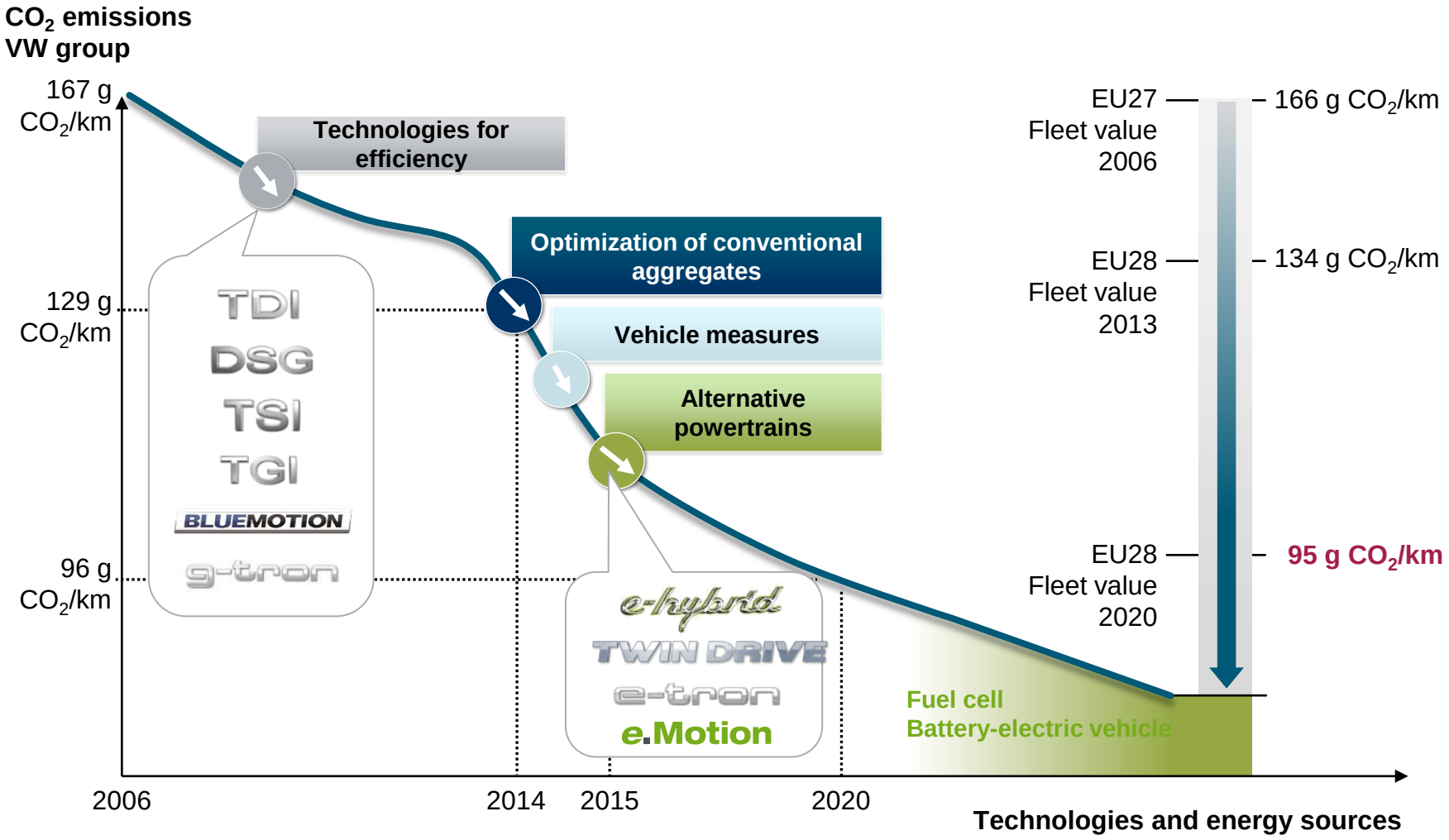
USA

Greenhouse Gas II

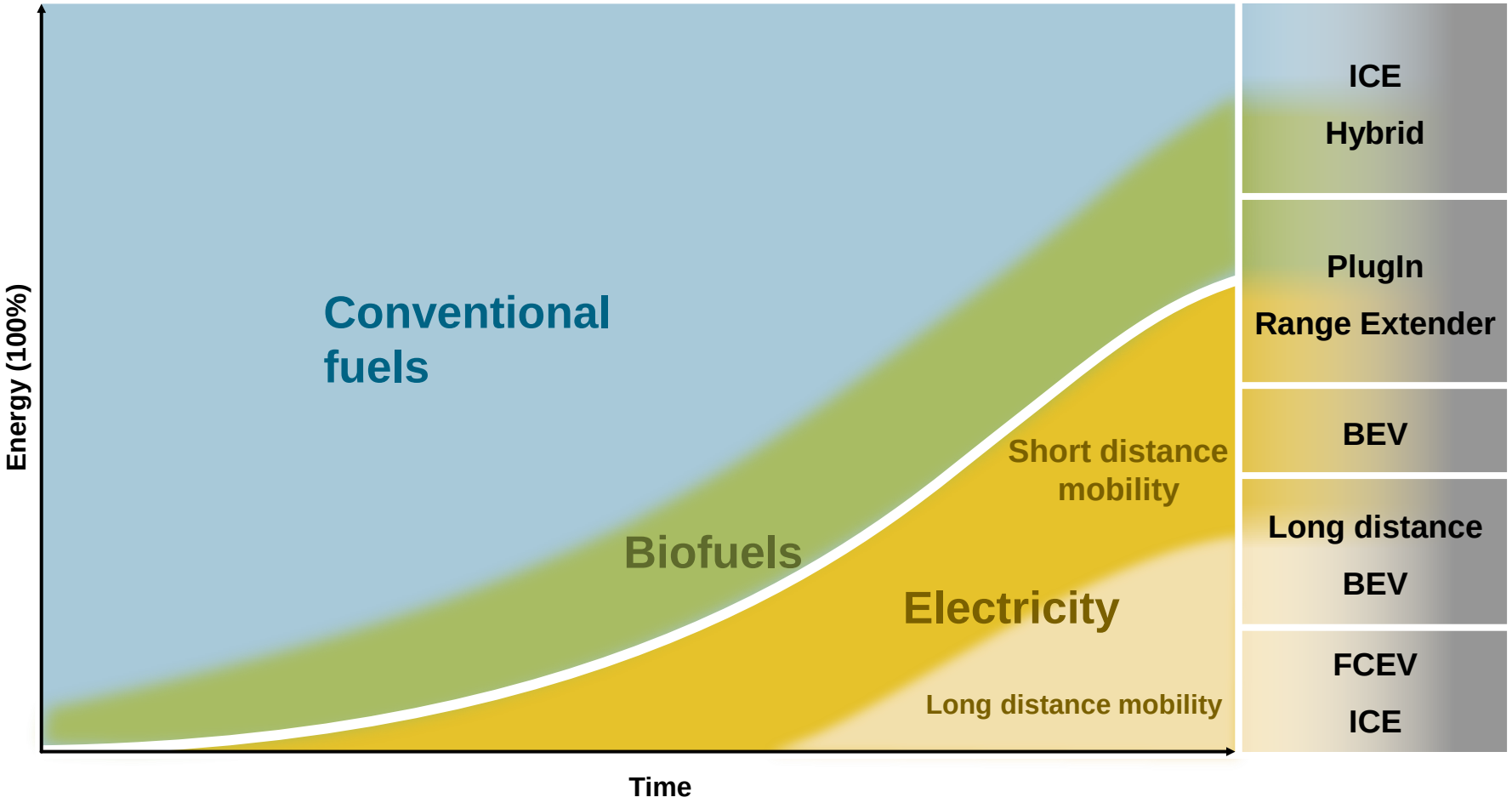
2020
125 g CO_2/km

2025
101 g CO_2/km

CO_2 trend in the Volkswagen Group



Possible Evolution of Sustainable Energy for the Automotive Sector



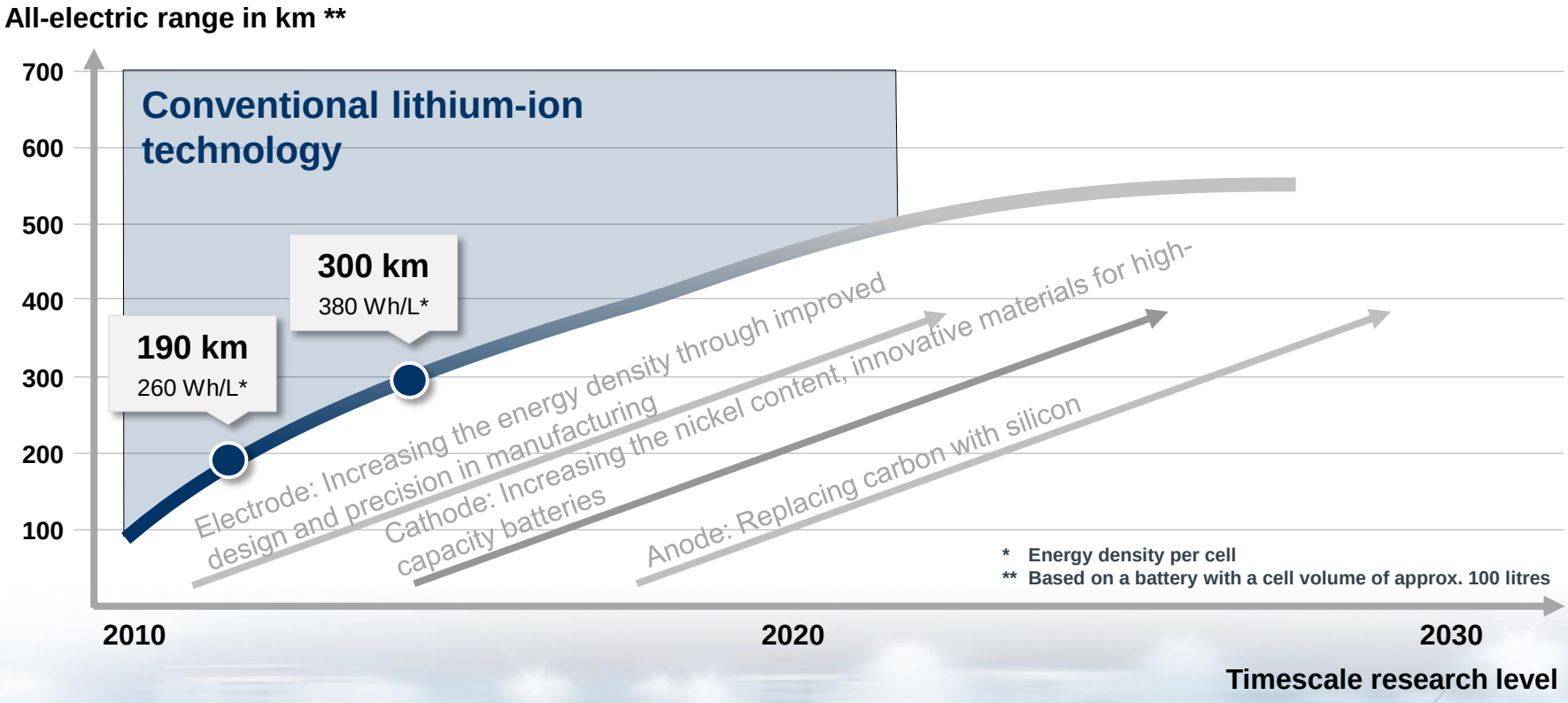
Mobility in Urban Areas

e-Golf

Technical Data

Maximum speed:	**140 km/h**
Electric motor:	85 kW
Torque:	270 Nm
Consumption, NEDC:	12.7 kWh/100 km
Electrical range (NEDC):	**190 km**
Energy content battery	24.2 kWh

Lithium-ion battery: Roadmap for high-energy batteries

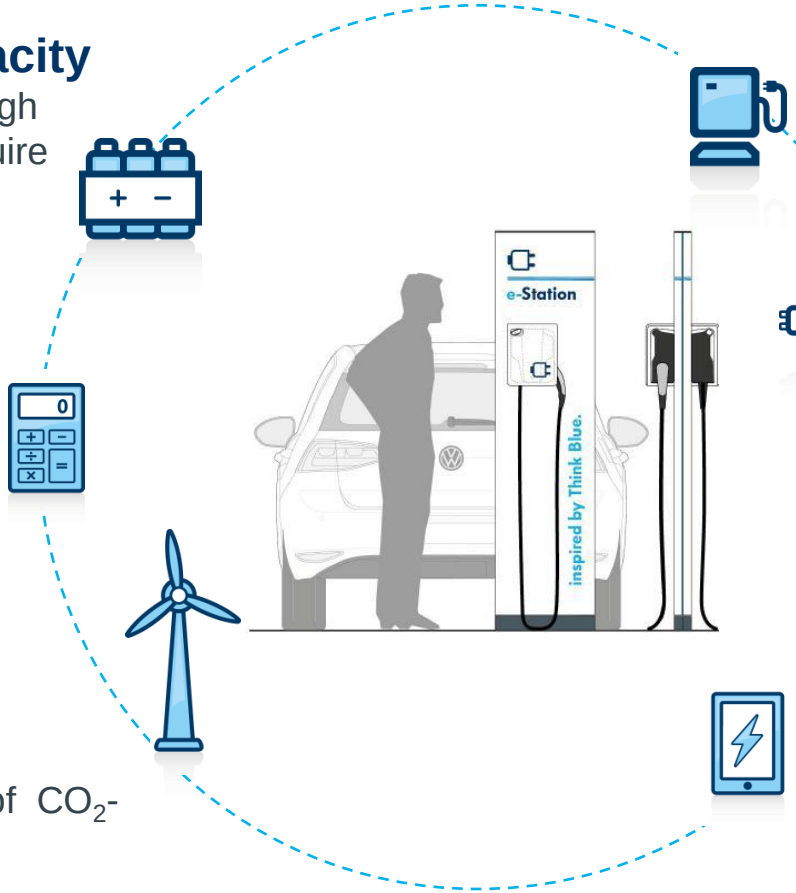


Challenges of Charging

Charging capacity
HV-batteries with high energy content require higher charging capacities.

Operation
Economic efficiency of operation of charging stations

Regenerative energy
Further expansion of CO_2-neutral mobility



Charging infrastructure
Extensive provision of charging stations

Charging interface
Worldwide standardization of the charging plug

Charging comfort
Automatic charging via induction

Access charging station
Standardized authentication and billing

Long-Range Mobility

CO_2 measures – research activities

Engine efficiency measures

- Extreme pressure injection
- Combined motor charging
- Variable valve train
- Variable compression
- Cylinder deactivation
- Downspeeding
- Reducing friction
- Alternative materials
- Optimized lightweight construction
- Coating

Direct shift gearbox

- Ratio
- Efficiency
- Starting performance
- Low rotational speed concepts

Drivetrain

- Thermal management
- Use of exhaust gas heat
- Micro Hybridization





Highly electrified solutions for individual mobility

Passat Variant GTE

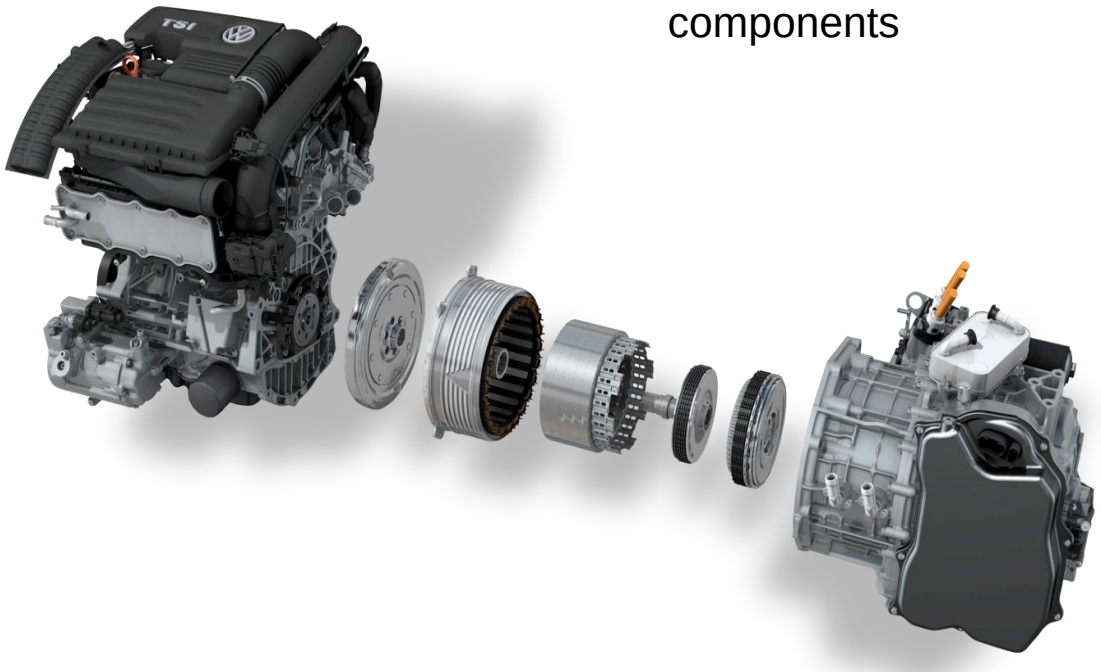
Technical Data

Maximum speed:	225 km/h
Fuel consumption, combined:	**1.6 l/100 km**
CO_2 emissions, combined:	**37 g/km**
Electrical range (NEDC):	50 km
Range in total (NEDC):	**1,091 km**
Unloaded weight:	1,660 kg

Advantages of the parallel hybrid concept

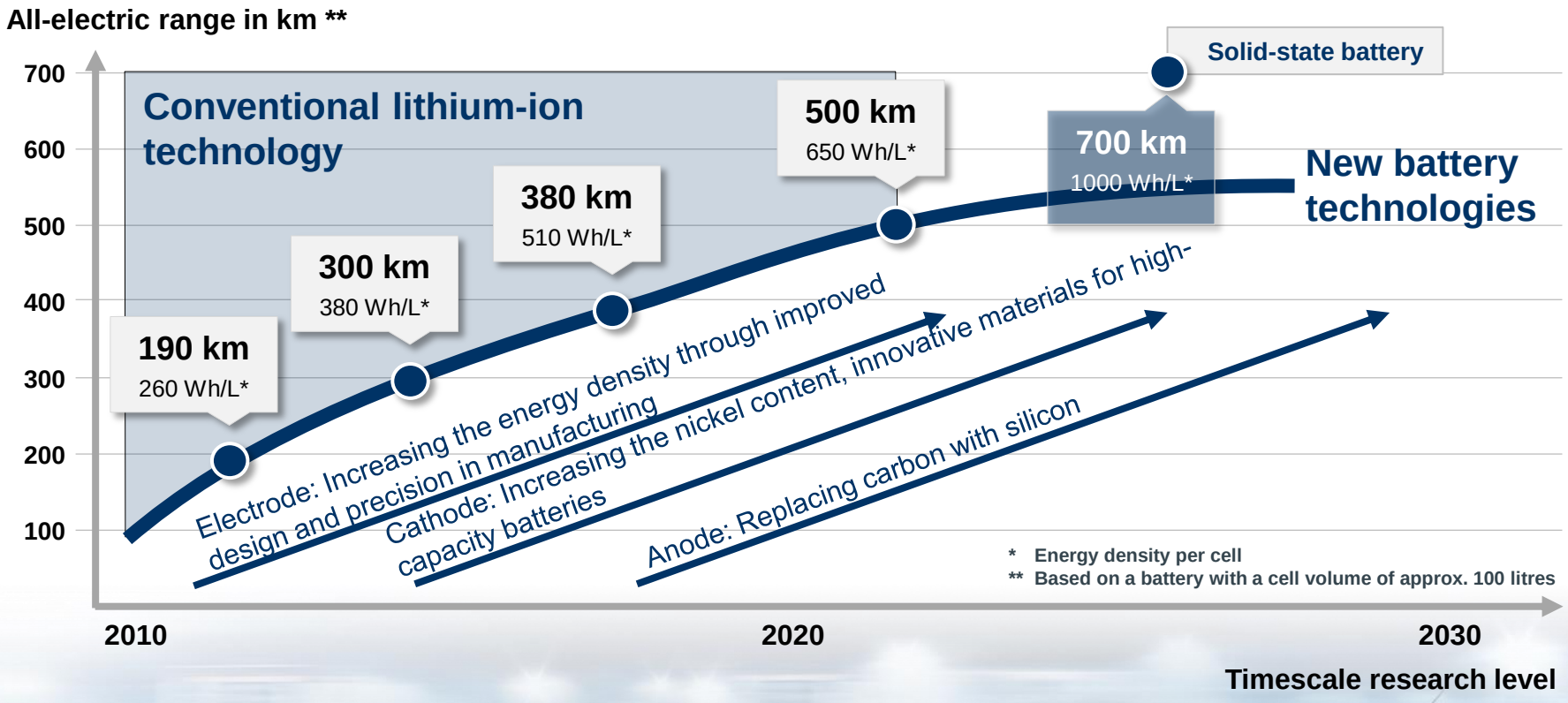
- High fuel-saving potential
- Sporty driving performance
- Repeatable driving properties
- Module capability
- E-traction module

- Scalability
- Degree of electrification
- Mild- / Full- / Plug-In Hybrid
- TDI®, TSI®, DSG®
- Modularity of powertrain components



Long-Range Electromobility

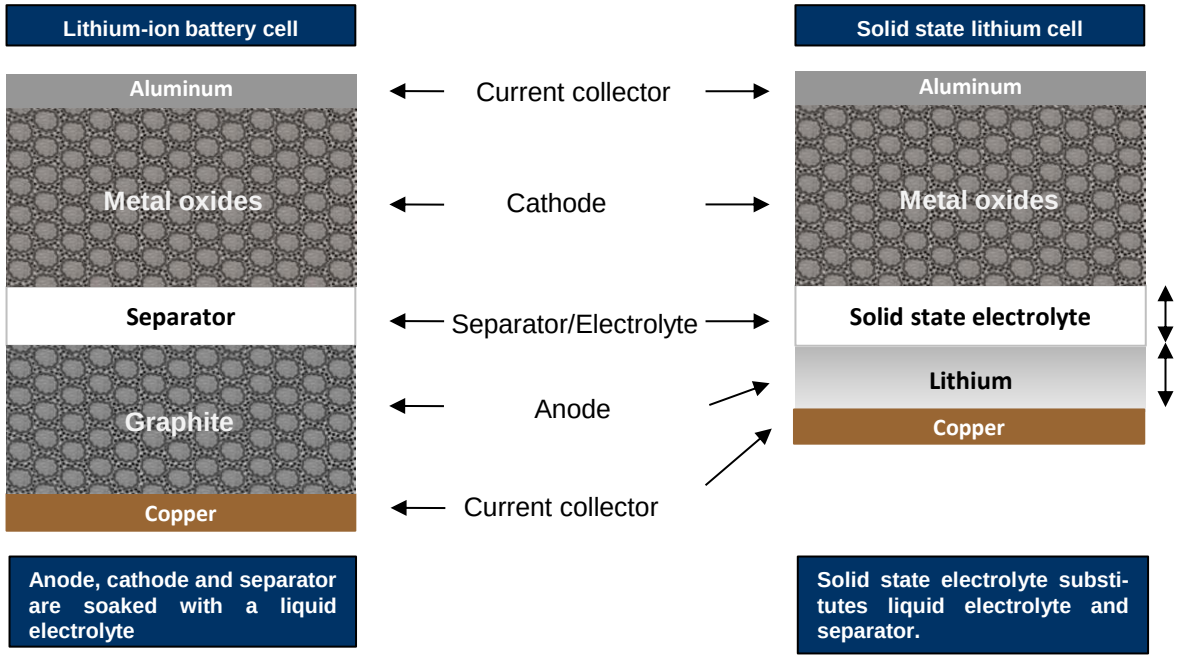
Beyond lithium-ion battery: Solid state battery



Battery with solid-state electrolyte

Technological leap:

- Higher energy densities compared to lithium-ion-technolgy
- Better safety
- Compact design



Challenges:

Materials:

- Bad ionic conductivity in the solid-state electrolyte
- High volume change between charged and discharged cell
- Lower efficiency

Processes:

- Complicated processing of the layers
- Ensuring the atomic scale of the interphase morphology
- High costs

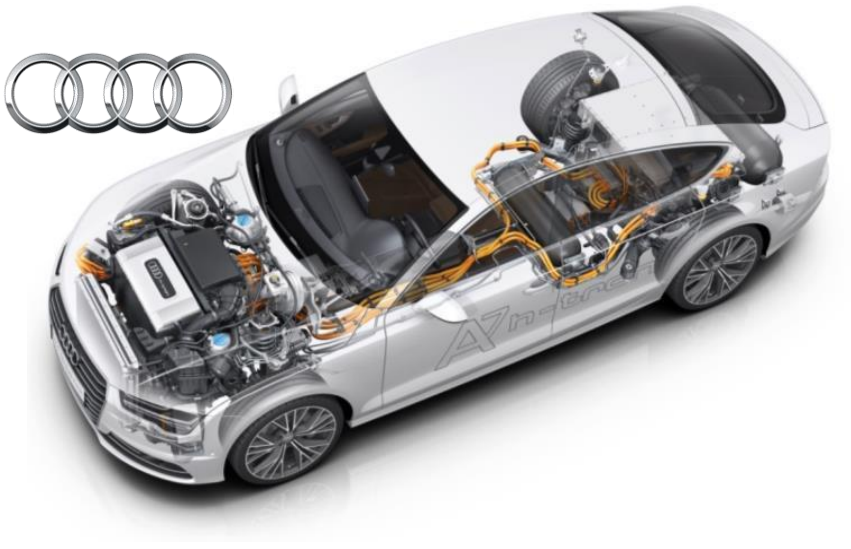
Fuel cell

Audi A7 Sportback h-tron quattro

Volkswagen NMS HyMotion

HyMotion4 – two vehicle concpets with one fuel-cell system

Fourth generation of fuel cell vehicles in Volkswagen Group research



Volkswagen NMS HyMotion	
E-machine:	100 kW
v_{max}:	160 km/h
0-100 km/h:	12 sec
Range:	420 km
Battery:	1.1 kWh

HyMotion 4

Performance: 80 kW

Audi A7 Sportback h-tron quattro	
E-machine:	2 x 85 kW
v_{max} :	180 km/h
0-100 km/h:	8 sec
Range:	> 500 km
Battery:	9.5 kWh

Challenges of fuel-cell technology

- Simplification of system complexity
- Ensuring life-time requirement
- Reduction of costs
- Development of a supplier landscape
- Regeneratively produced hydrogen
- Extensive provision of filling station infrastructure

Electric vehicles – challenge filling time

Petrol

Pump:

27,000 kW

(approx. 50 dm³/min)

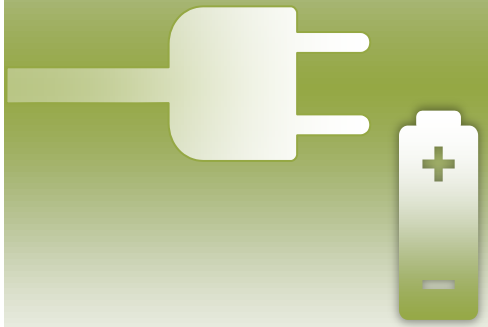
1,000 km/min

Electricity

3 x 230V:

10 kW

(three-phase current)



1 km/min

Hydrogen

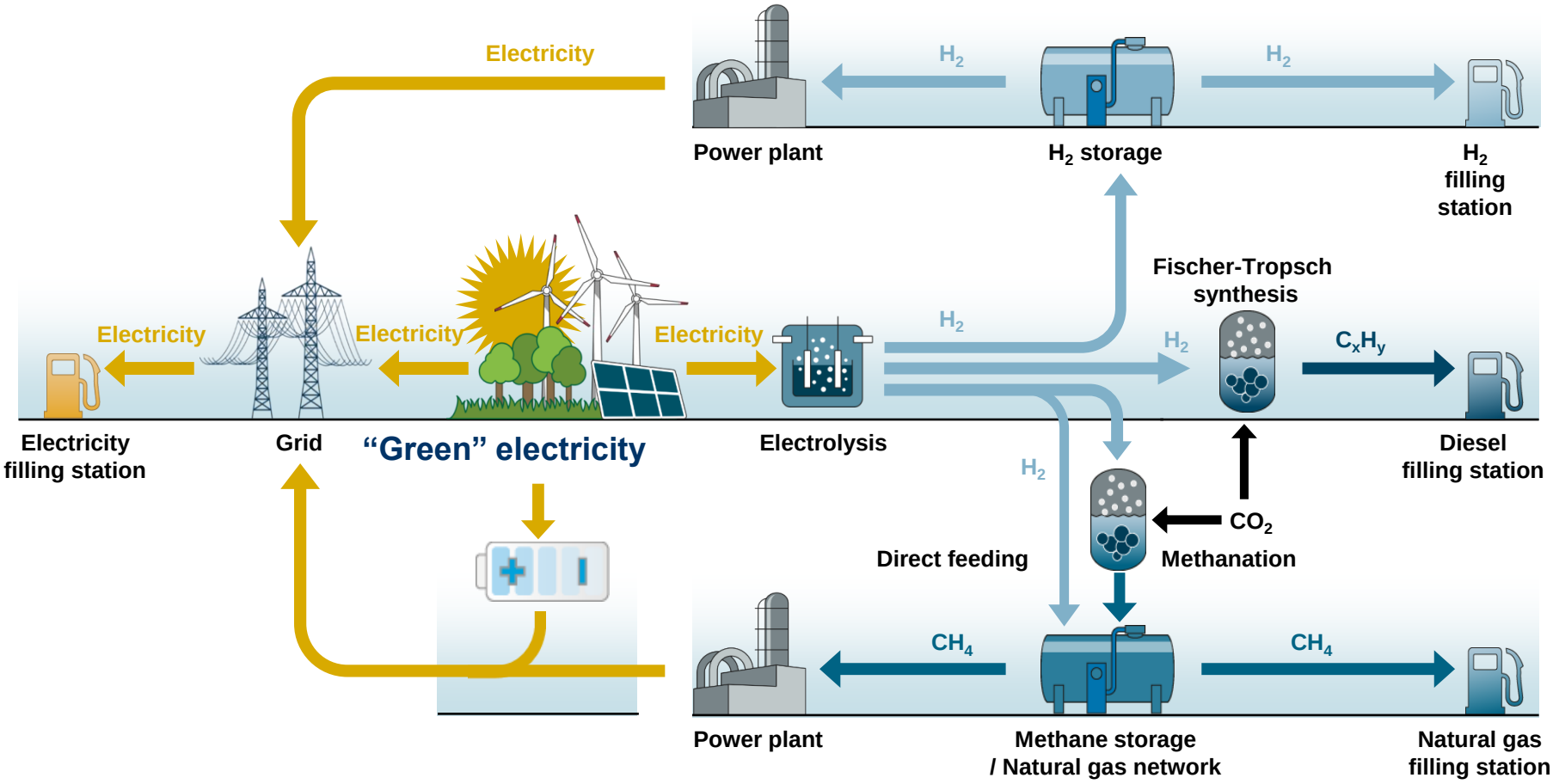
Filling station

2,000 kW

(approx. 1 kg/min)

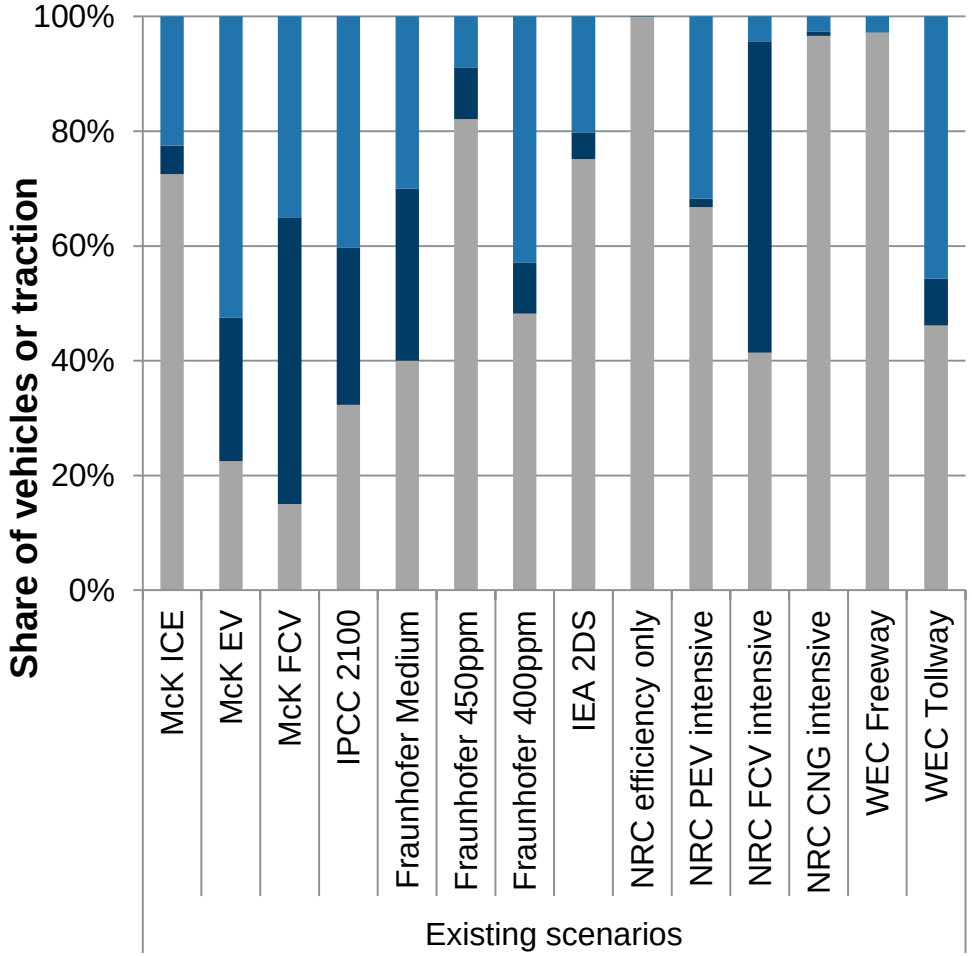
100 km/min

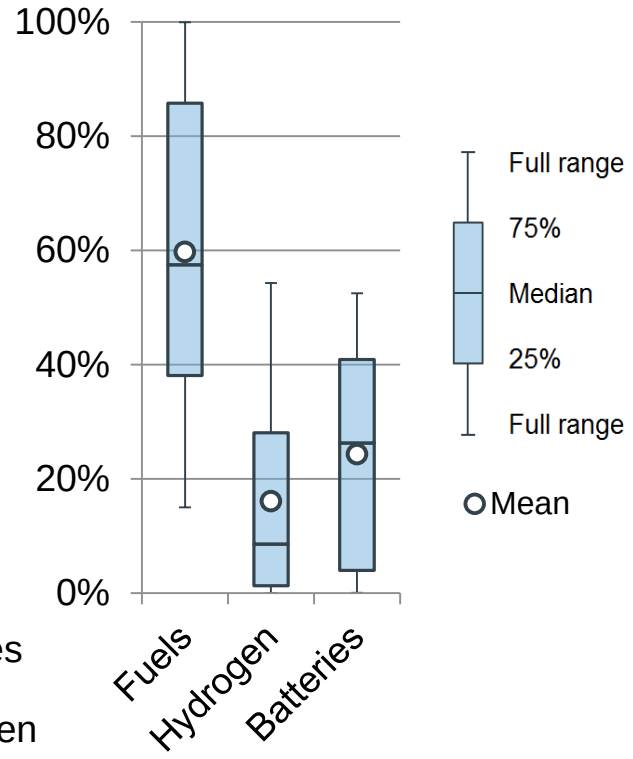
Options for storing and using „green“ electricity



The question after future vehicle concepts can only be answered in context with future energy solutions of the energy sector.

Mobility scenarios for 2050

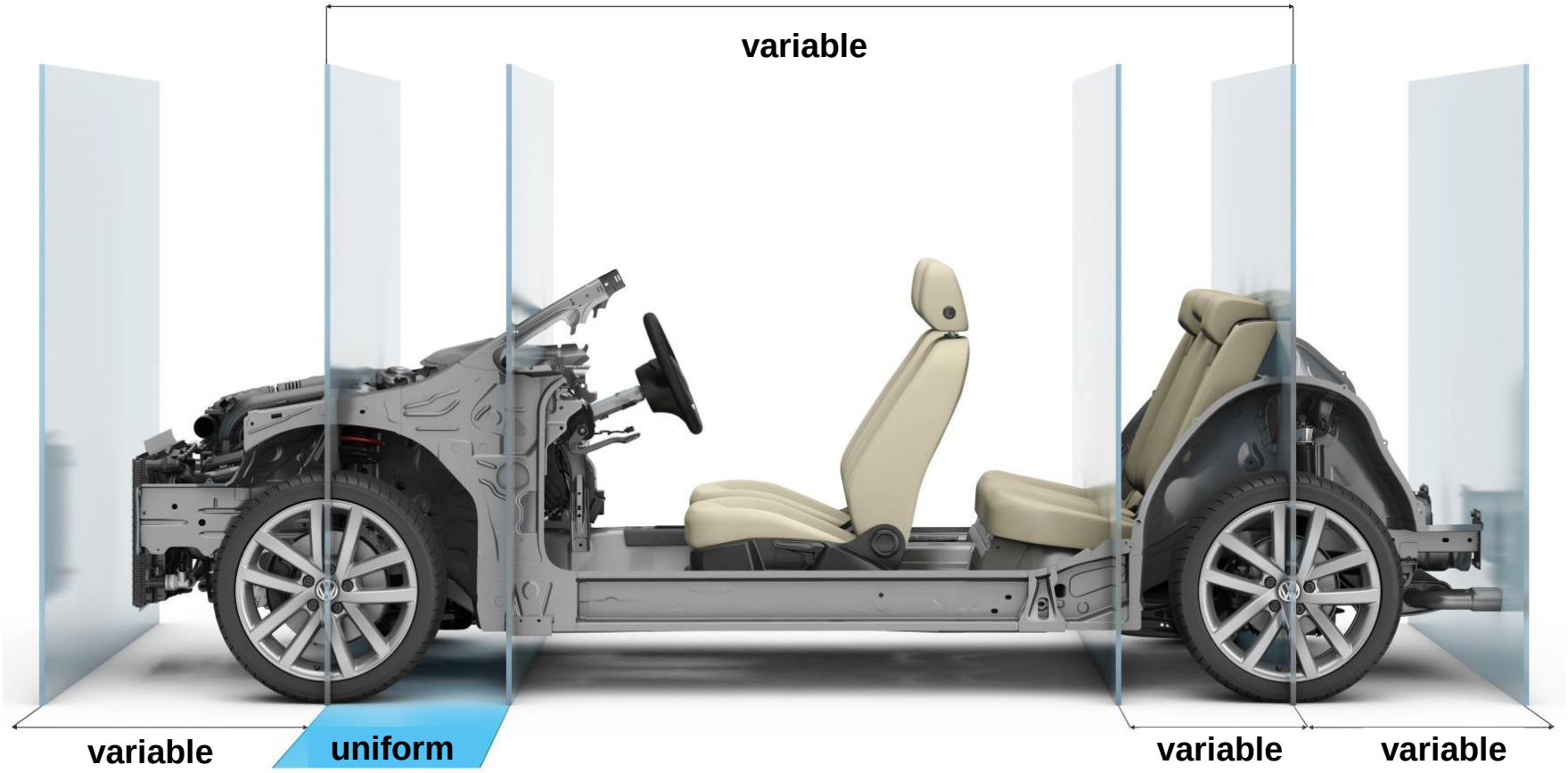




Fuels (hybridization incl.)
PHEV: 50 % Battery, 50 % Fuels

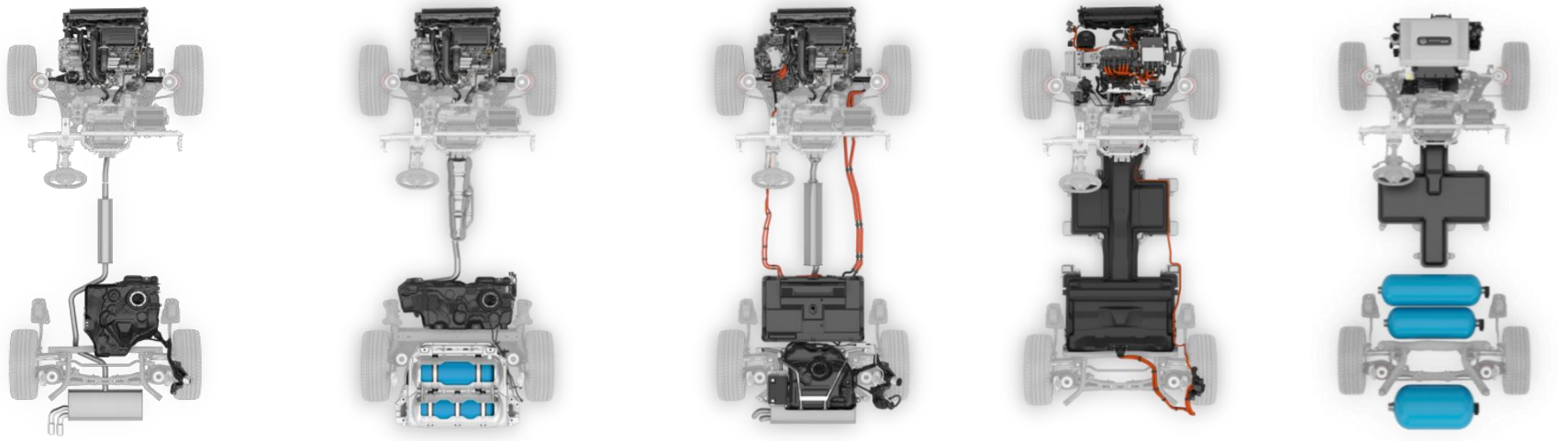
Quelle: McKinsey & Company (2010), Palzer & Henning (2014), IPCC (2014), Schade et. Al. (2010), IEA (2012), NRC (2013), WEC (2011)

Basic architecture of MQB



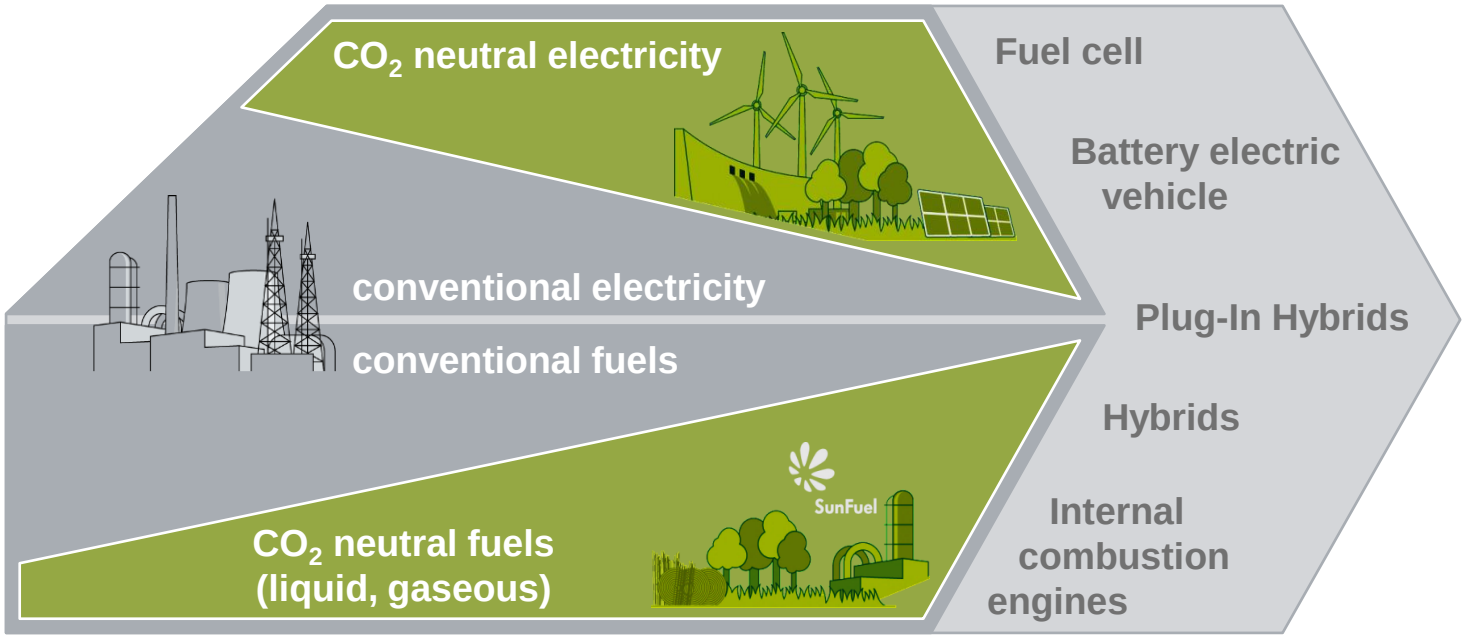
Powertrains of MQB

Conventional		Alternative/Regenerative		Electric		Fuel Cell
Diesel	Gasoline	Ethanol	CNG	Plug-In Hybrid	Electric powertrain	Hydrogen



Use of diferent powertrains in different segments and brands possible

Coexistence of propulsion systems



Thank you!