Towards sustainable mobility – Why hydrogen is the most promising option

ALF
Alternative Fahrzeugantriebe

Prof. Dr.-Ing.
Thomas von Unwerth

Department
Advanced Powertrains

CHEMNITZ UNIVERSITY OF TECHNOLOGY

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Impacts of conventional mobility

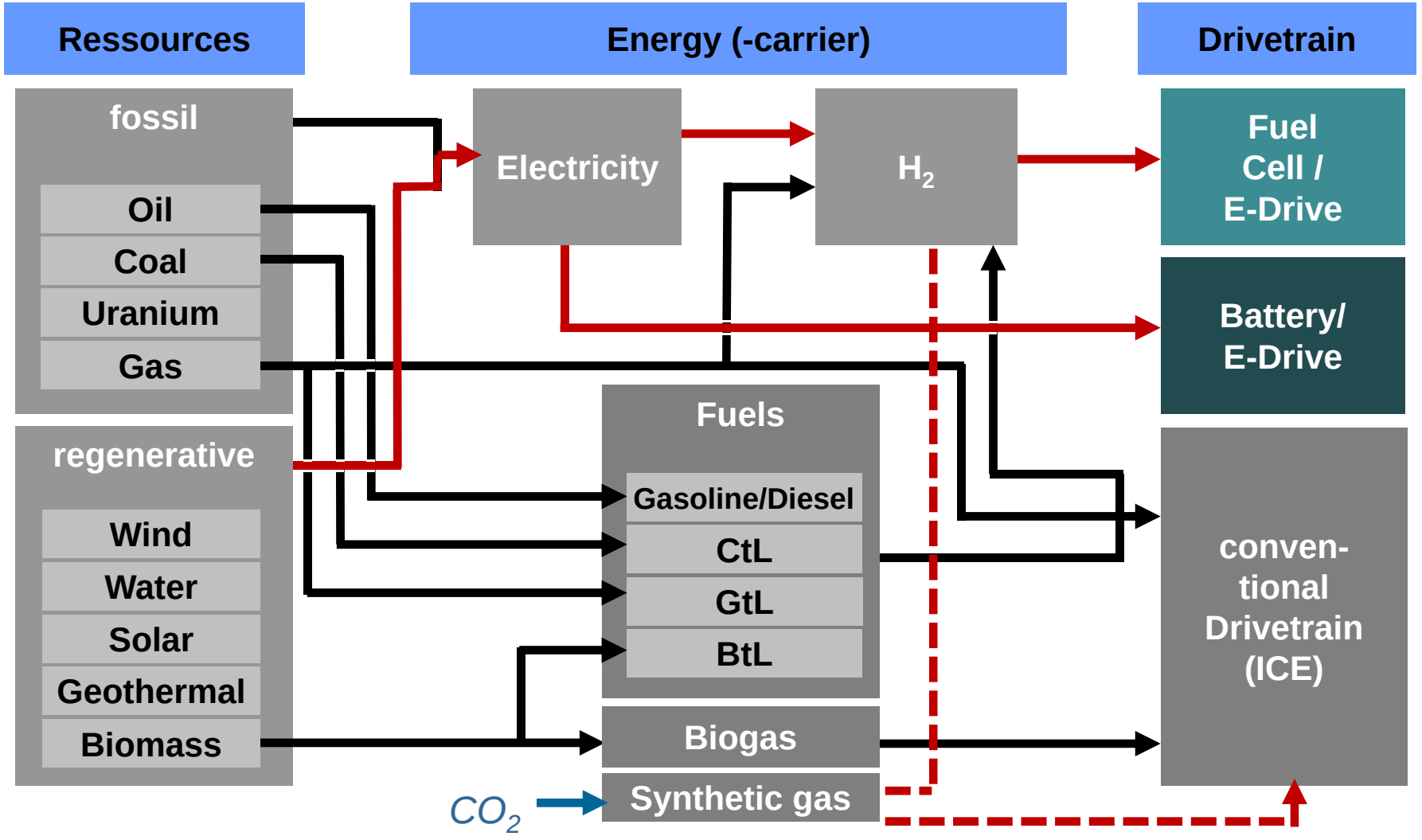
Global earth warming

Energy shortage

⇒ CO_2-Reduction

⇒ Energy safety

Replacement options for the transport sector



Driver for Electrification

Society:

- increasing awareness of ecologic/economic issues
- climatic changes
- lobbyists

Legislation:

- emissions / fuel consumption
- incentives / tax benefits
- driving bans / city-charges
- ZEV-Legislation

Advanced drivetrains / Electrification

Energy sector:

- Fuel availability and local dependencies
- shortage of ressources
- decreasing oil production

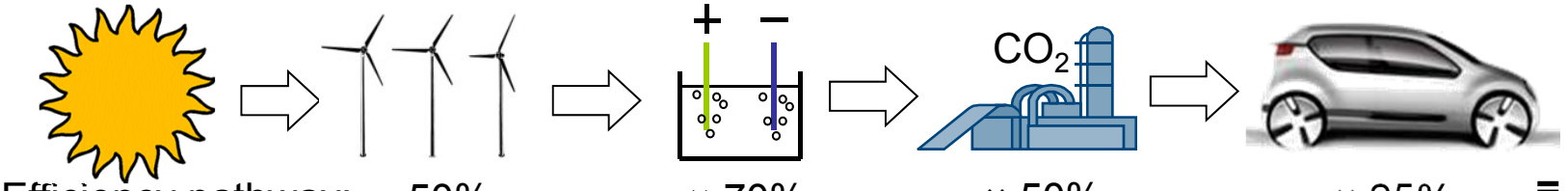
Competition:

- increased activities
- more launches of series vehicles
- market positioning

Efficiency chains compared

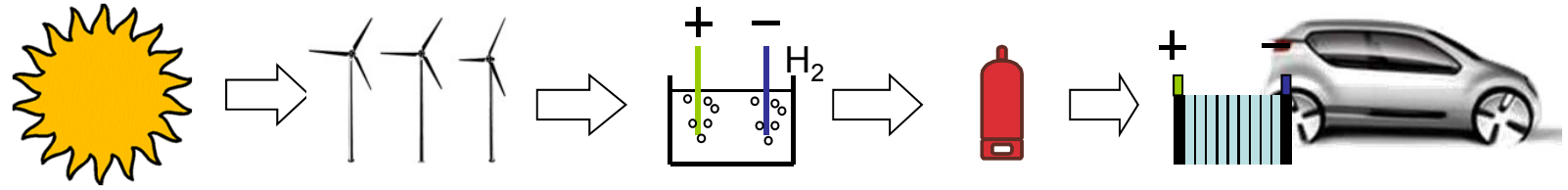
Efficiency pathways

Wind power – Hydrogen – Methane – Gas vehicle



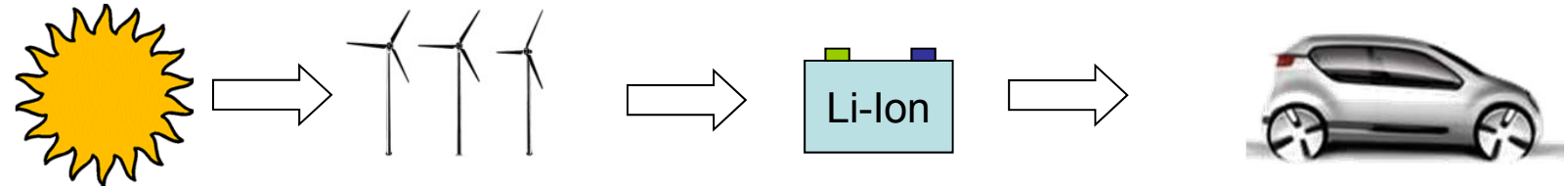
Efficiency pathway: 50% × 70% × 50% × 25% **= 4,4%**

Wind power – Hydrogen – Fuel Cell – Electric vehicle



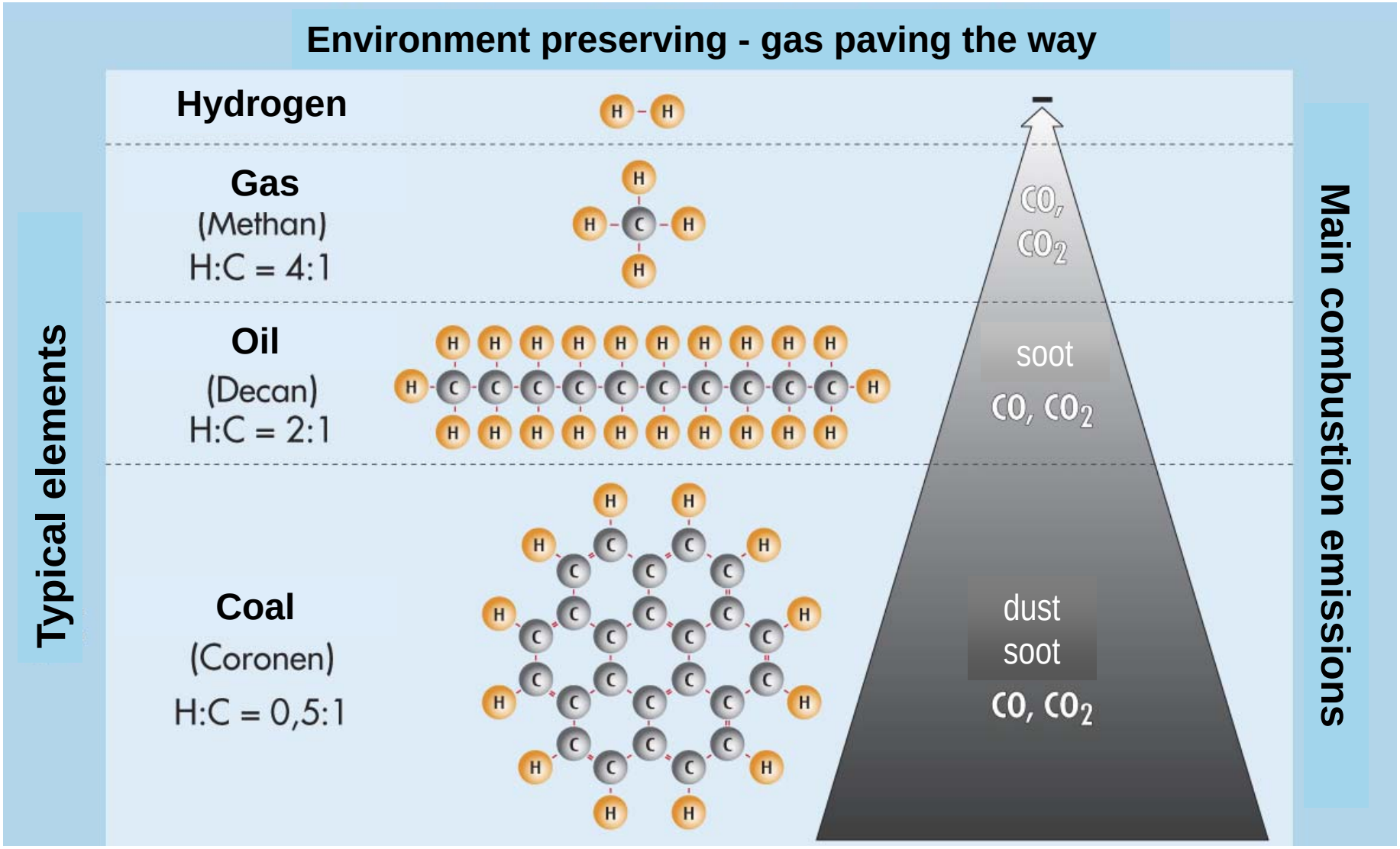
Efficiency pathway: 50% × 70% × 90% × 50% × 80% **= 12.6%**

Wind power – Battery – Electric vehicle

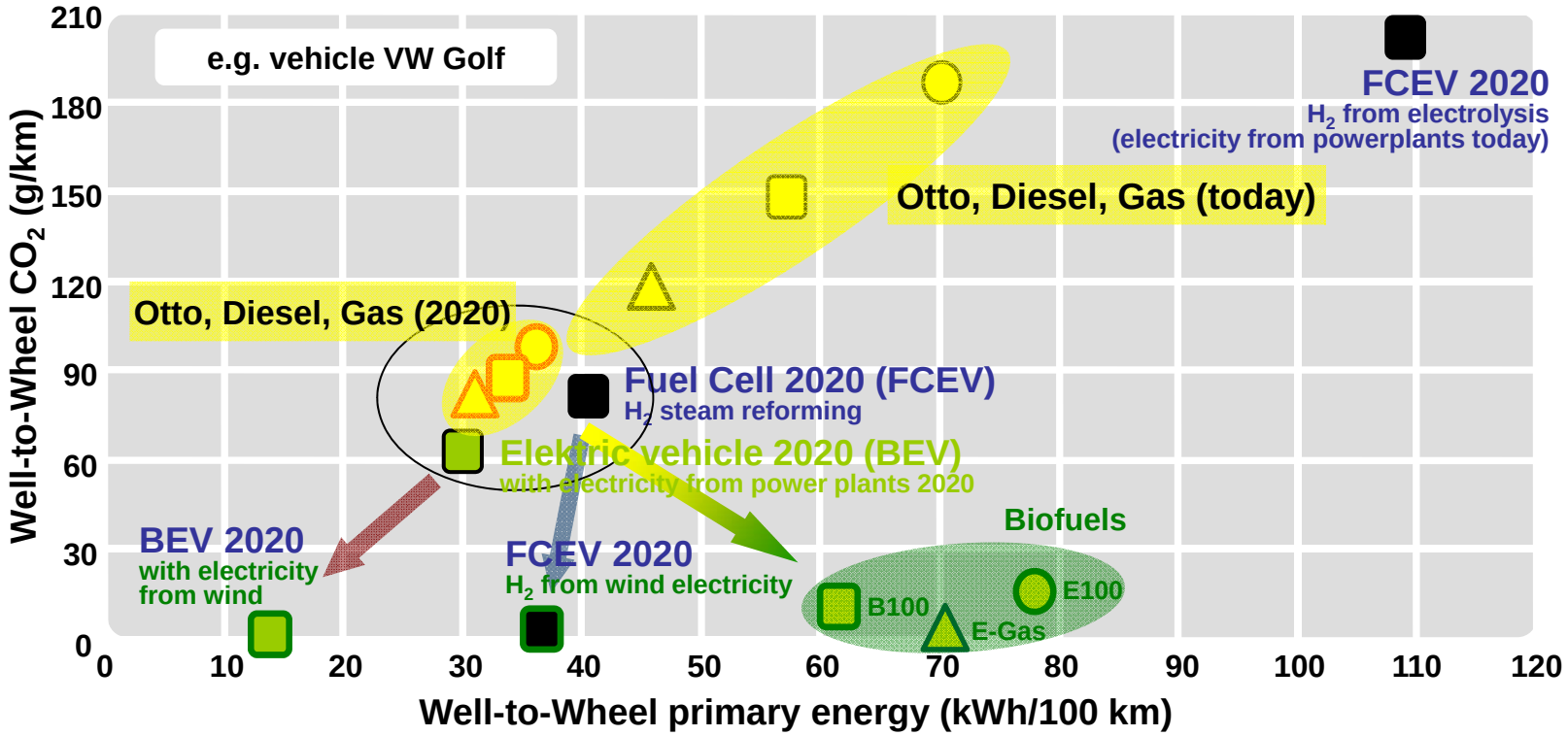


Efficiency pathway: 50% × 95% × 90% × 80% **= 34.2%**

Natural gas as a bridge to hydrogen



Potential of CO2- and energy efficiency drivetrains (till 2020 incl. vehicle measures)



- on basis of today's energy sources all drivetrain concepts can achieve a similar level
- highest potential for CO_2- & energy efficiency show electric vehicles depending on energy sources

First electric vehicle by Porsche
14. April 1900 world exhibition - Paris

2 wheel hub motors

P_{max} = 2 x 7 PS

P_{rated} = 2 x 2,5 PS (at 120 rpm)

44 cells 300 Ah Accu at 80 V

V_{max} = 50 km/h

Range 50 km

Anti-rollback locking ratchets

Electric front brakes,
mechanical rear band brakes

Total weight 980 Kg

Battery weight 410 Kg

1 front wheel 115 Kg

Ca. 300 cars sold

First Fuel Cell-electric van by GM 1967

Alcaline fuel cell

P_{FC} = 5 kW

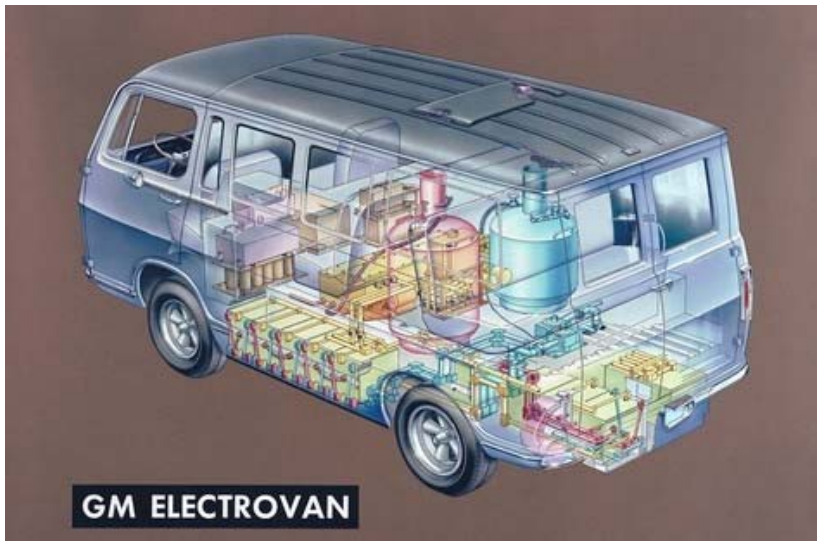
P_{Motor} = 32 kW

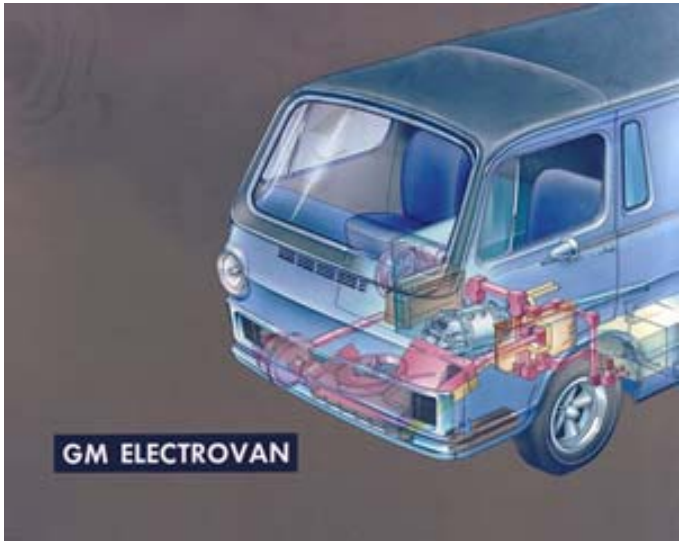
Total weight 3500 kg

V_{max} = 105 km/h

Range 200 km

Liquid Hydrogen (LH2)

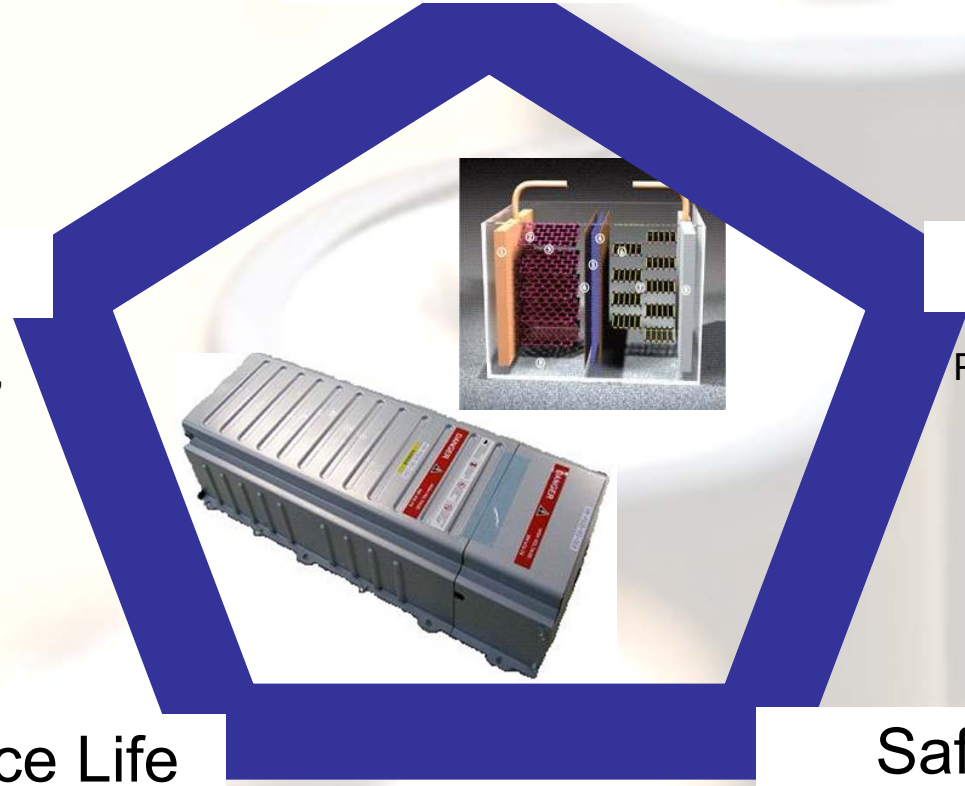




Challenges for electric storage/conversion technology

Cruising range, availability of
power-consuming comfort devices

Energy



Costs

Economic efficiency,
market acceptance,
recycling

Power

Performance, dynamics

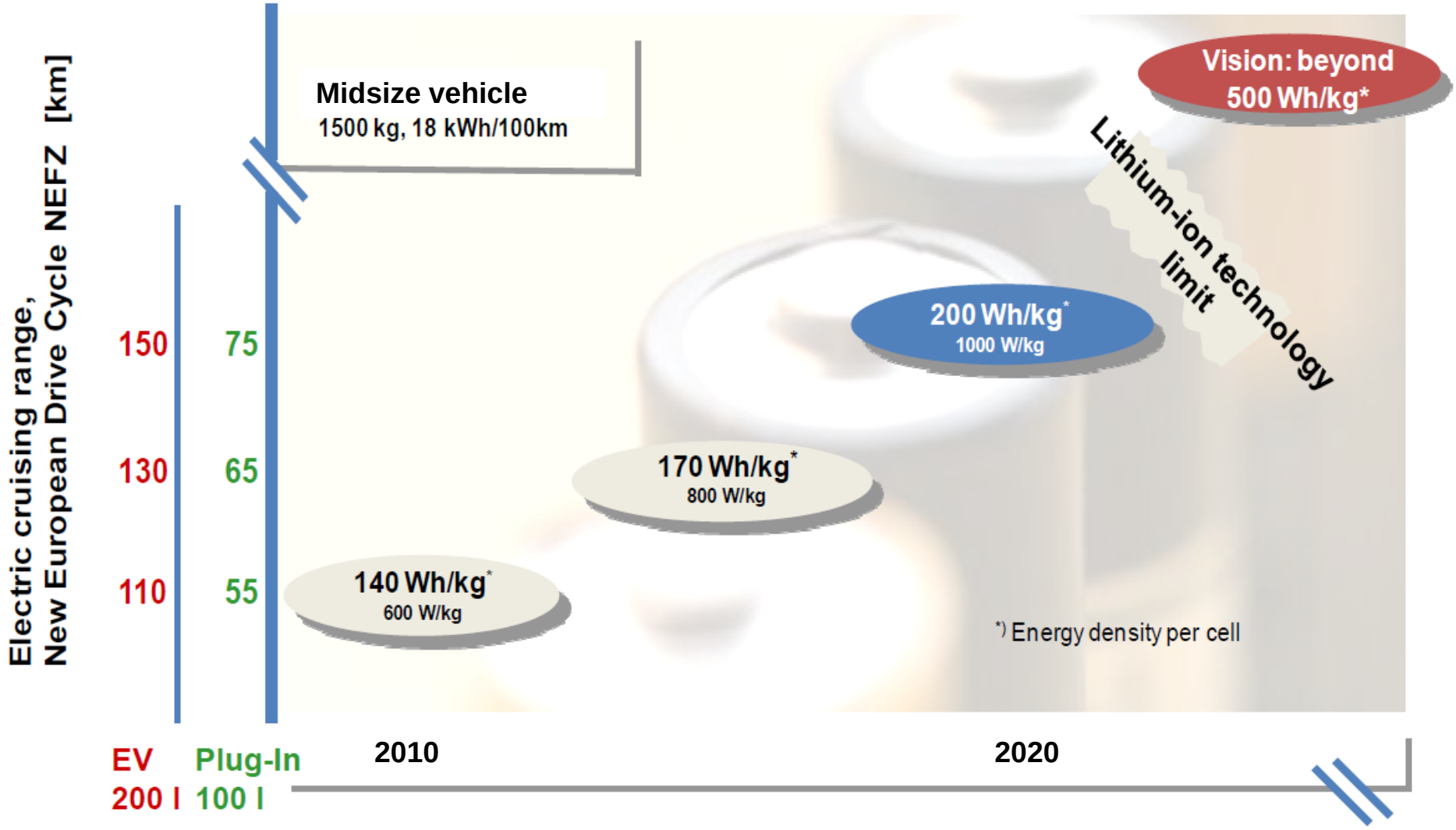
Service Life

Cycles, life span

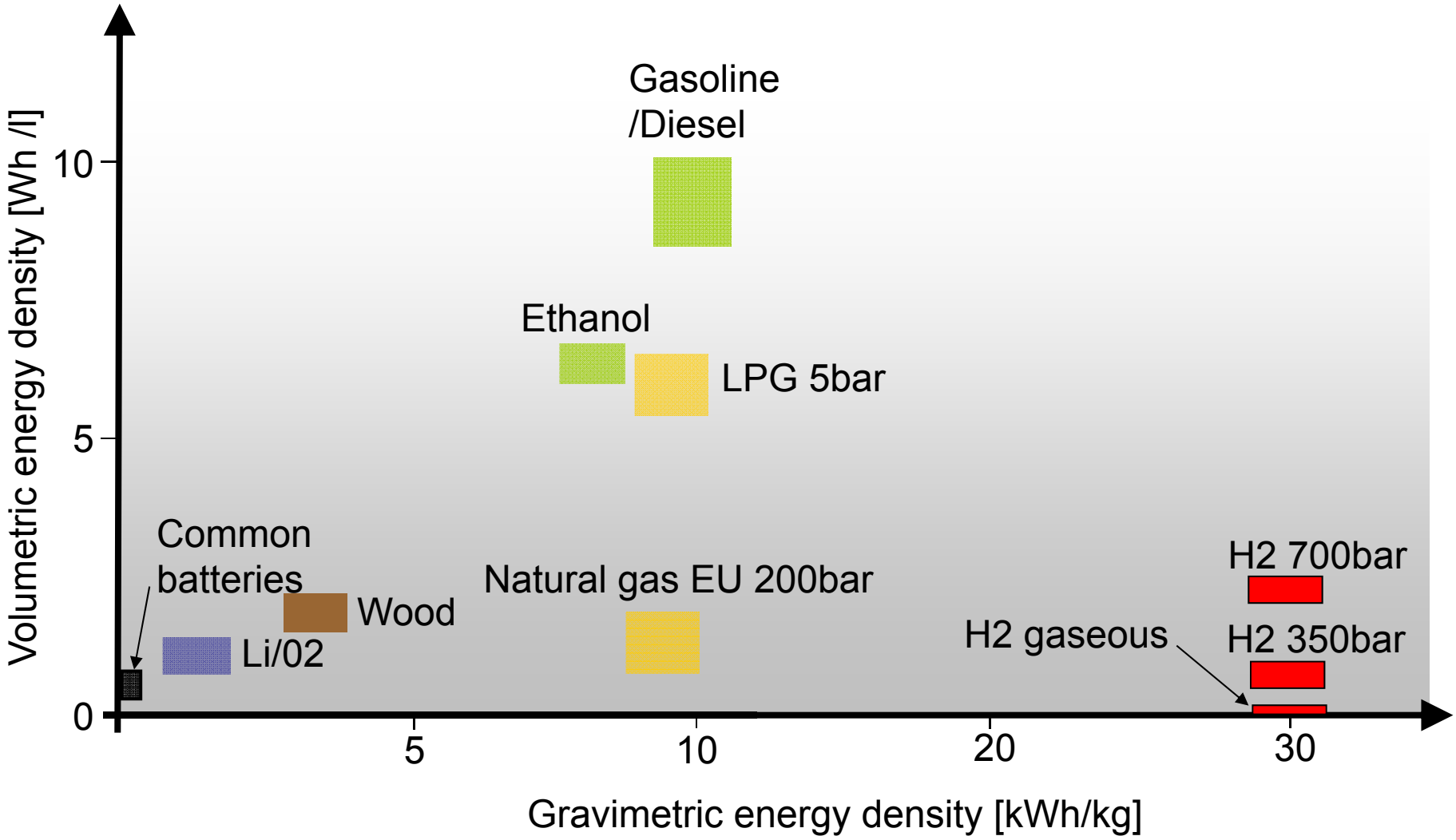
Safety

Defects, accidents, misuse,
maintenance

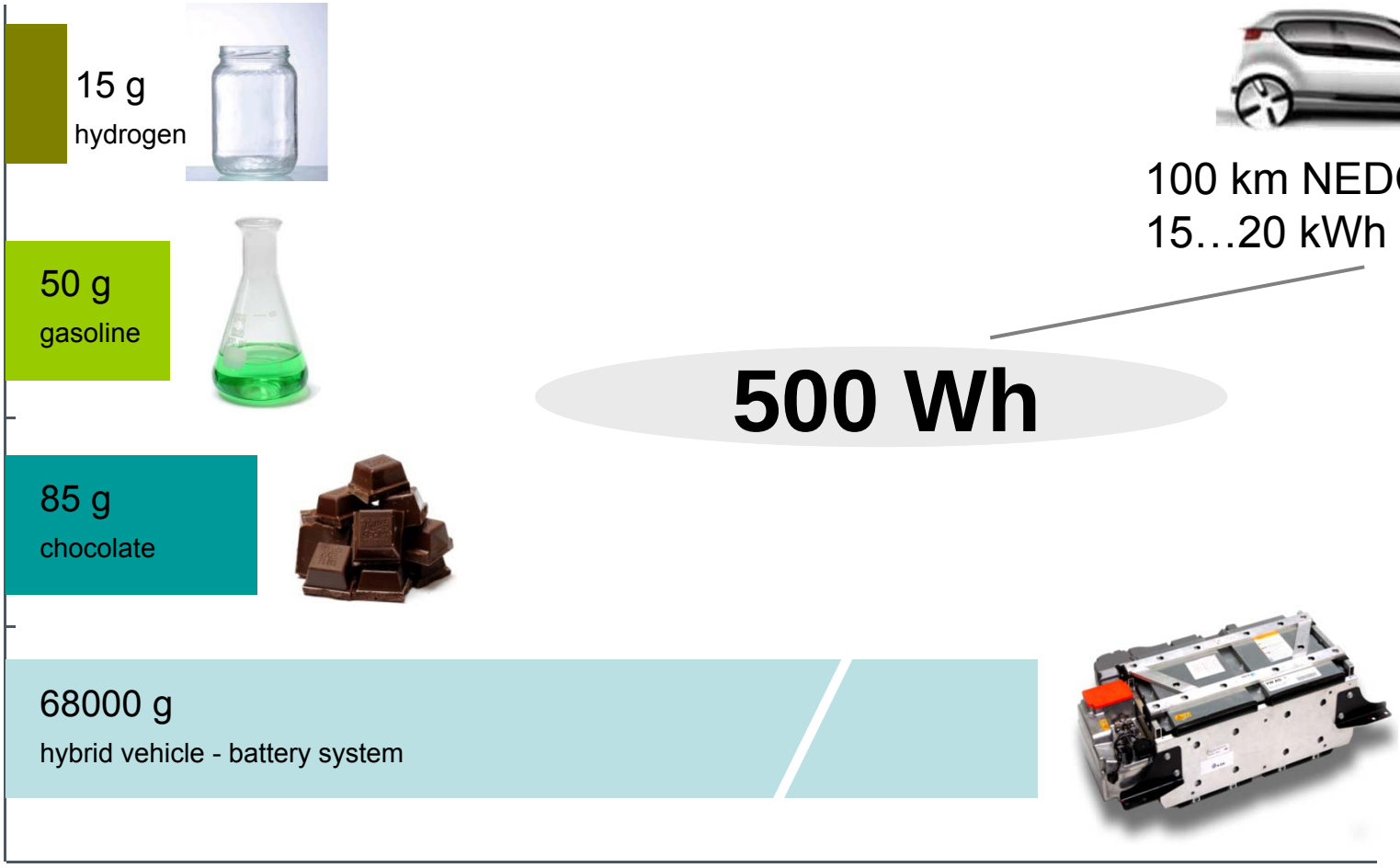
Development of high-energy storage technology



Comparison of energy densities



Capacities of energy storages



Volume and weight for 500 km range

	Diesel	*Compressed Hydrogen*	*Li-Ion battery*
	400 kWh chemical energy	***6 kg H2 @700 bar = 200 kWh chemical energy***	***100 kWh electrical energy***
system	*43 kg*	*125 kg*	*830 kg*
fuel	*33 kg*	*6 kg*	*540 kg*
system	*46 L*	*260 L*	*670 L*
fuel	*37 L*	*170 L*	*360 L*

(Ref.: CEP)

Electric vehicles – filling duration

electricity

high power plug
10 kW

→ 1 min „filling “
= 1 km driving

hydrogen

filling station
2.000 kW (ca. 1 kg/min)

→ 1 min filling
= 100 km driving

gasoline

filling station
27.000 kW (ca. 50 l/min)

→ 1 min filling
= 1.000 km driving

Electric vehicles – Infrastructure

Charging and fueling

Charging stations at Lisboa
(source: zeitonline.de)

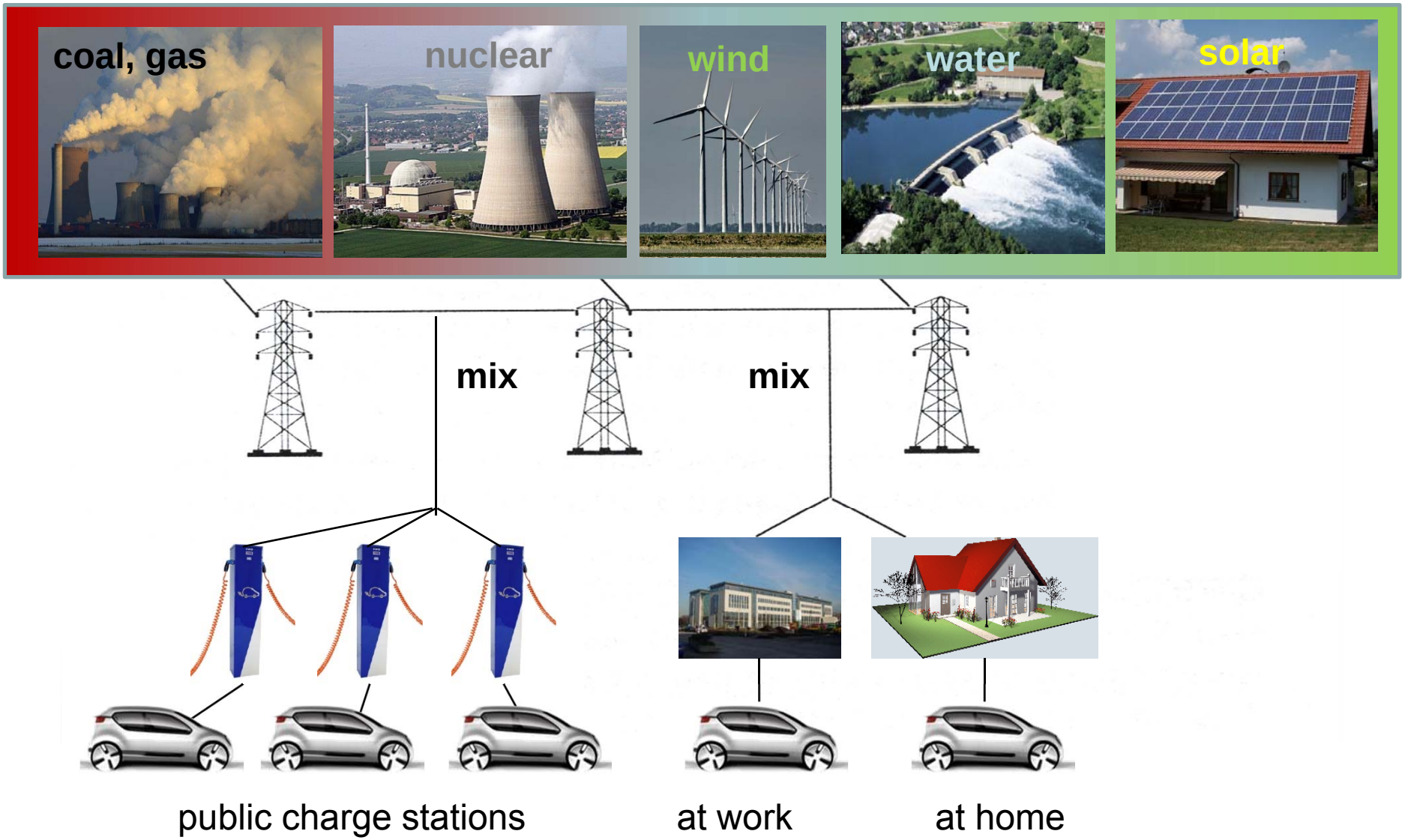
Hydrogen fueling station at Berlin
(source: cleanenergypartnership.de)

Charging station at Berlin
(source: berlin.de)

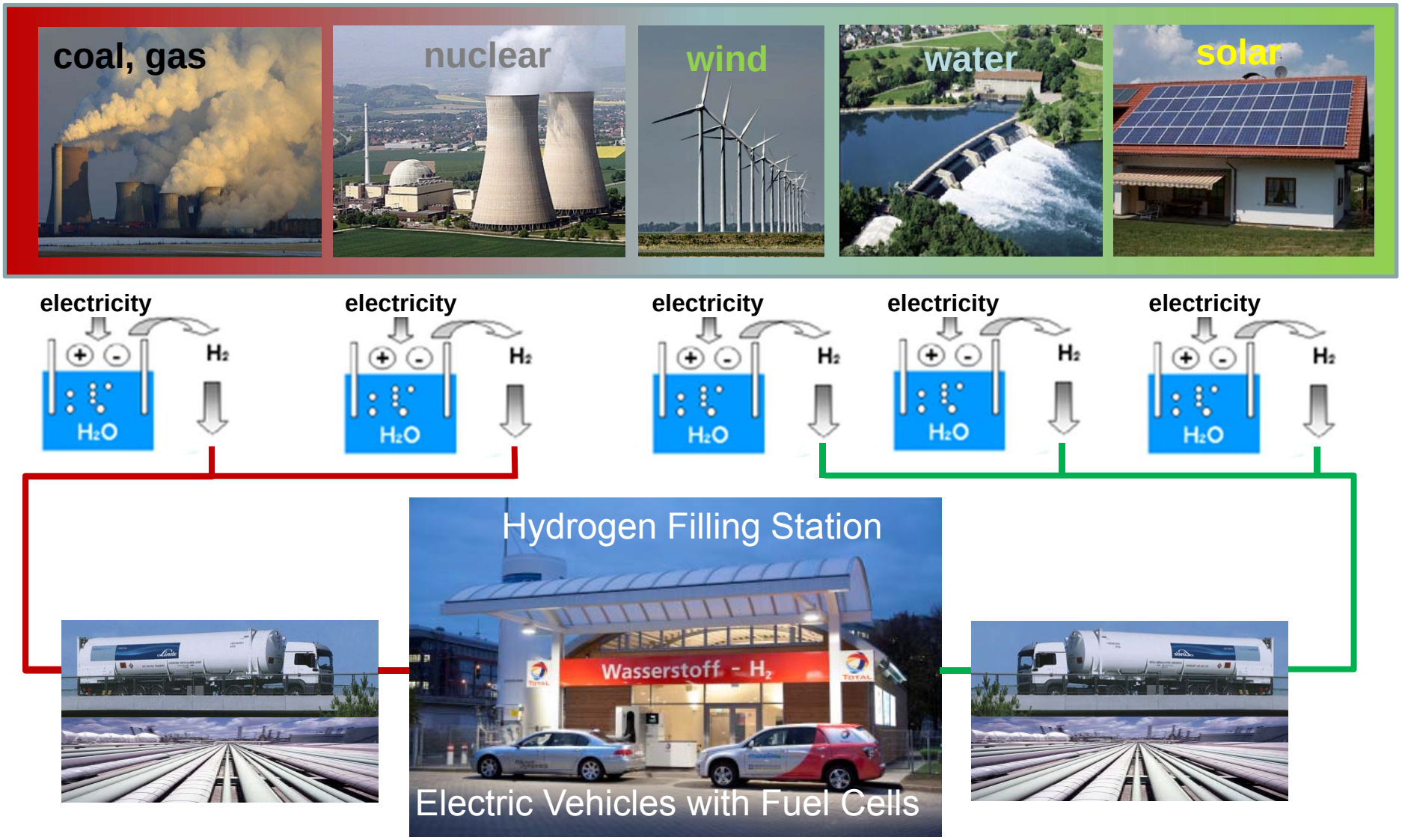
HFS at NYC
(source: dailytech)

Honda solar H2-station LA
(source: Honda)

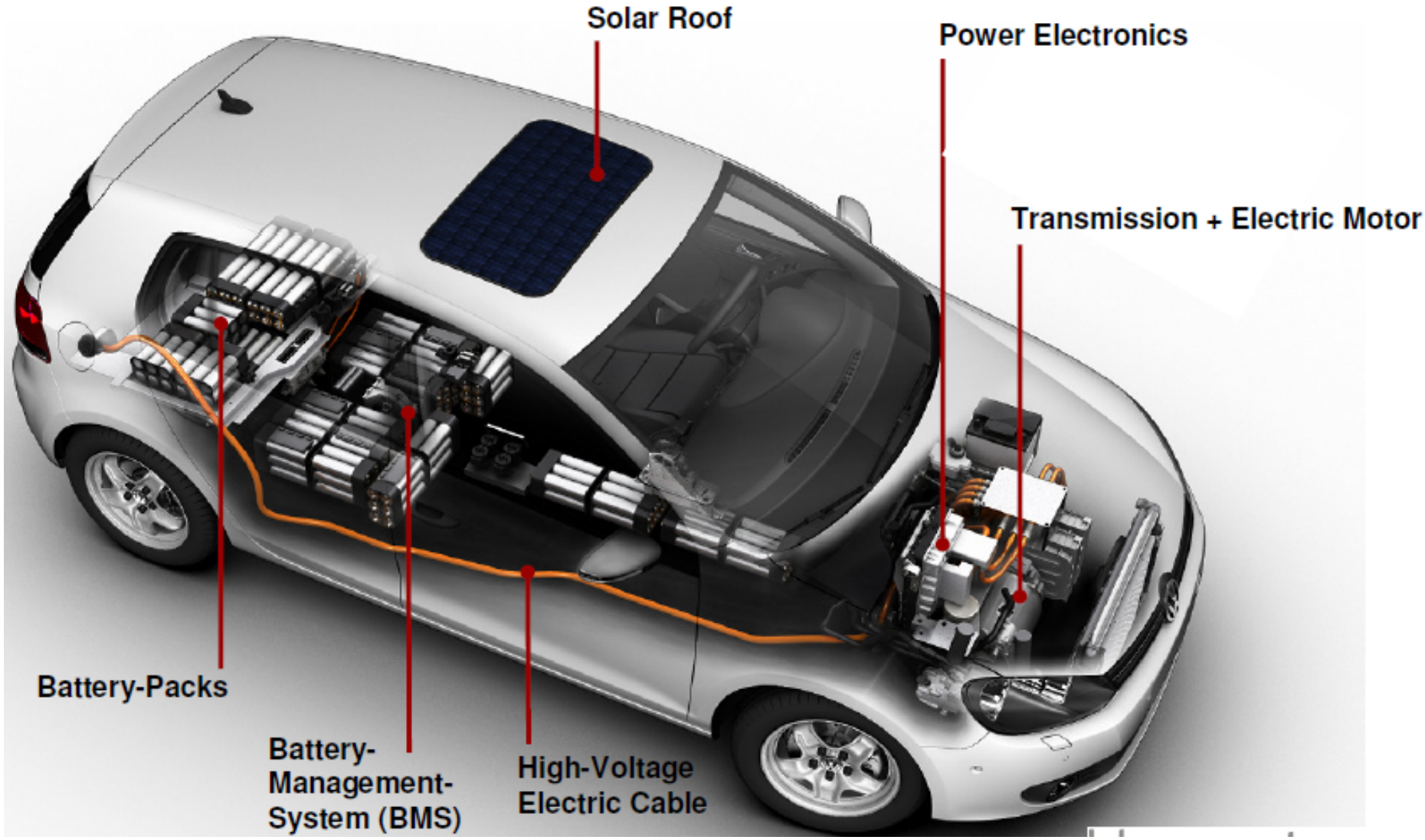
Energy path with electricity



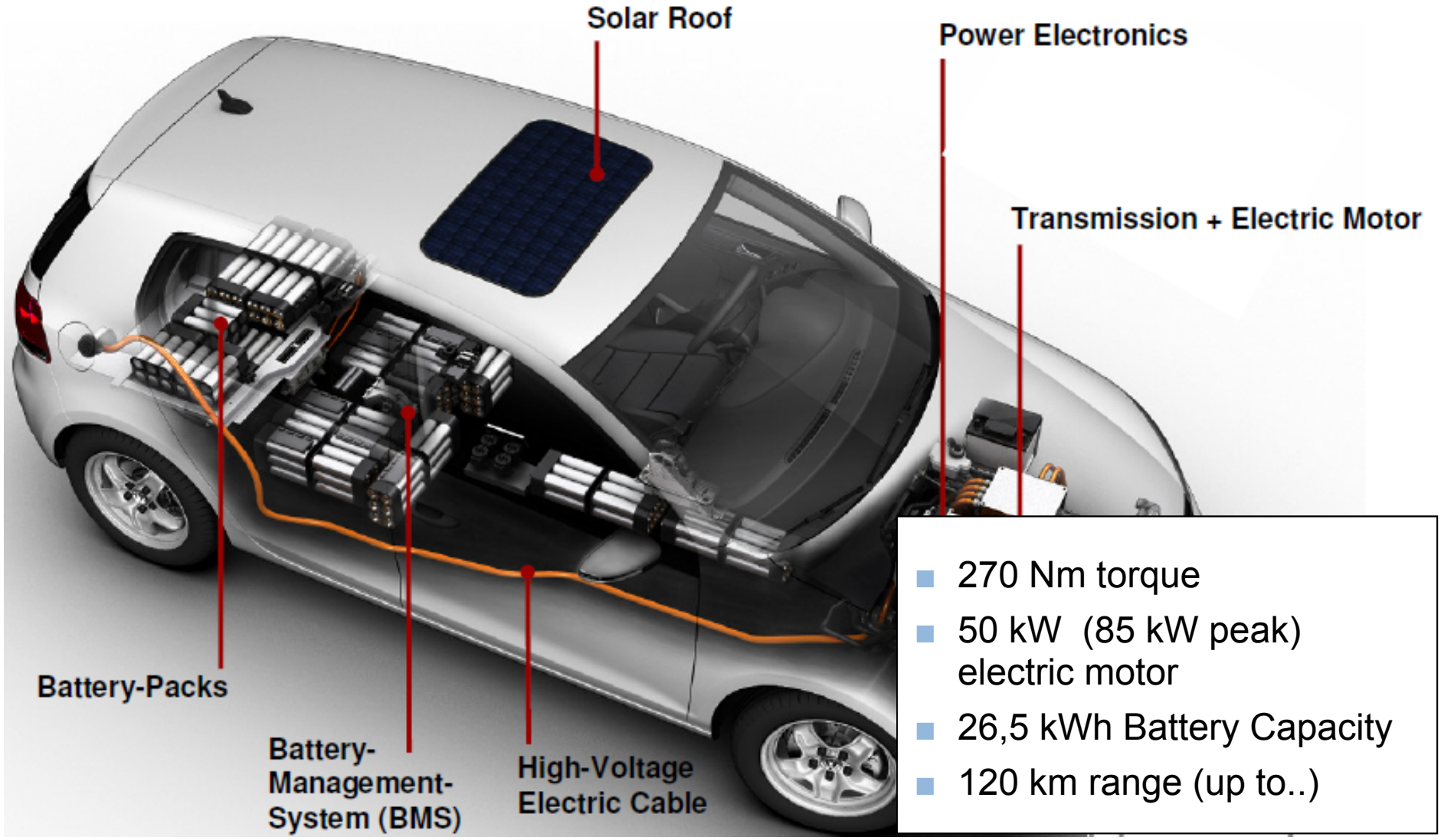
Energy path with hydrogen



Concept E-Golf



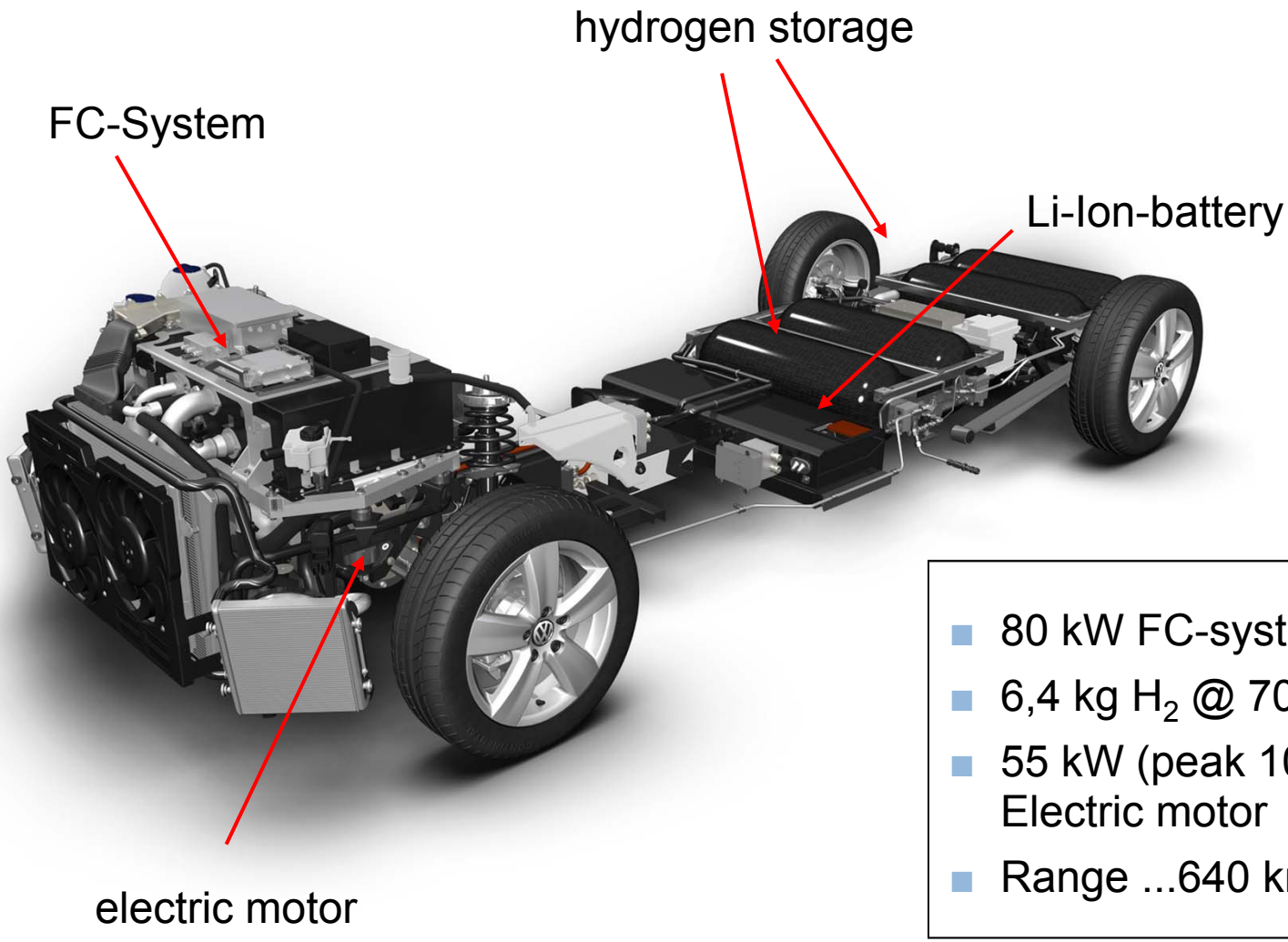
Concept E-Golf



- 270 Nm torque
- 50 kW (85 kW peak) electric motor
- 26,5 kWh Battery Capacity
- 120 km range (up to..)

Fuel cell drivetrain
VW Caddy HyMotion3

Fuel cell drivetrain
VW Caddy HyMotion3

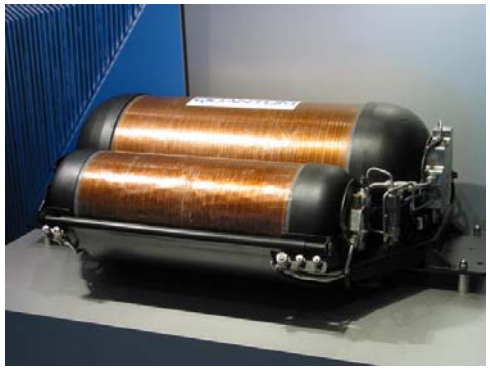


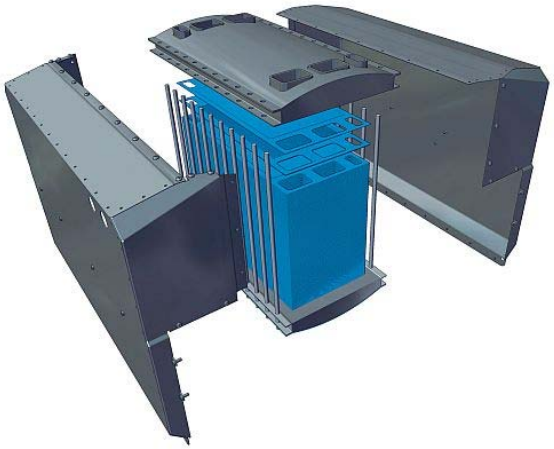
- 80 kW FC-system
- 6,4 kg H_2 @ 700 bar
- 55 kW (peak 100 kW) Electric motor
- Range ...640 km

New value chain – new components

New functions
New technologies

New processes
New players

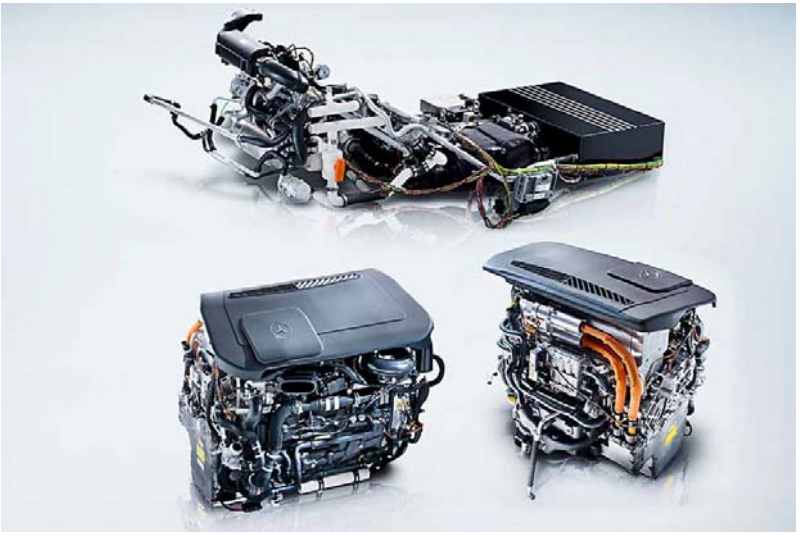




Fuel Cell Powertrains – Current development

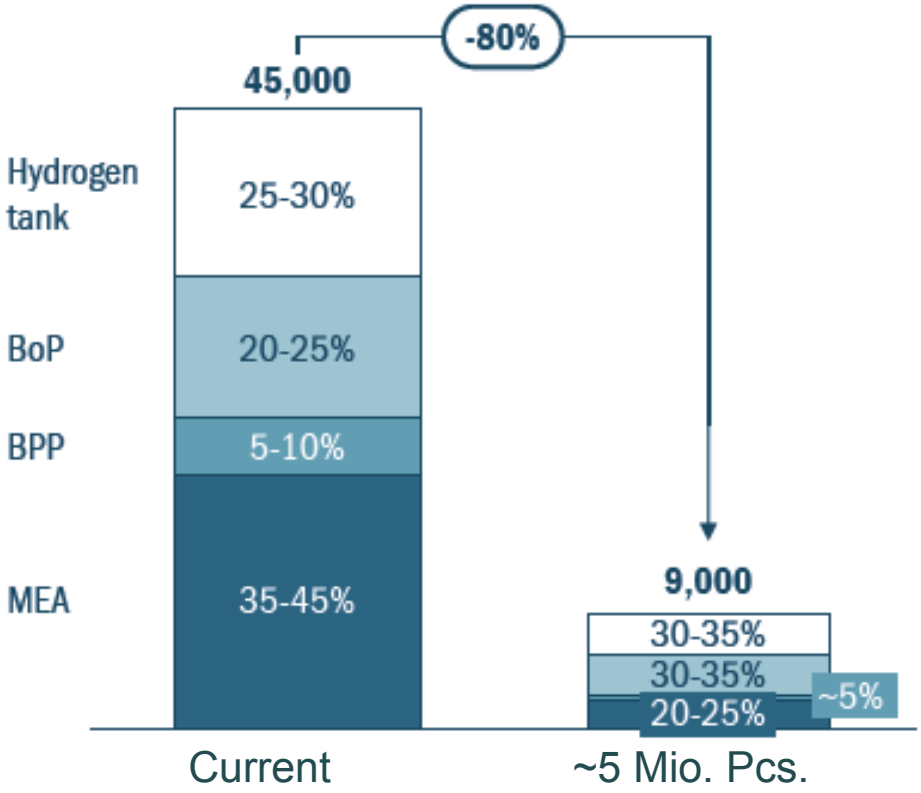
Main focus

- Decrease of system complexity
- Use of series components from ICE
- Integration, standadization
- Use of less precious metals (Pt catalyst, Au coated BIP)



(Source: adacemobiltiy.wordpress.com)

Estimated FC System cost [EUR/vehicle]



- Reduced Pt to < 10g per vehicle
- Simplified BOP
- Improved production technologies
- Mass production, Economies of scale

(Source: Roland Berger Consult)

Chances and challenges of hydrogen mobility

Chances

Society
- *Ressource independency*
- *Climate protection, emissions reduction*
- *Energy safety*
- *No lack of comfort for mobility*

Economy
- *Technology advantages*
- *Mobile storage of energy*
- *New jobs*
- *New business segments*
- *New provider for energy in the automotive sector*

Challenges

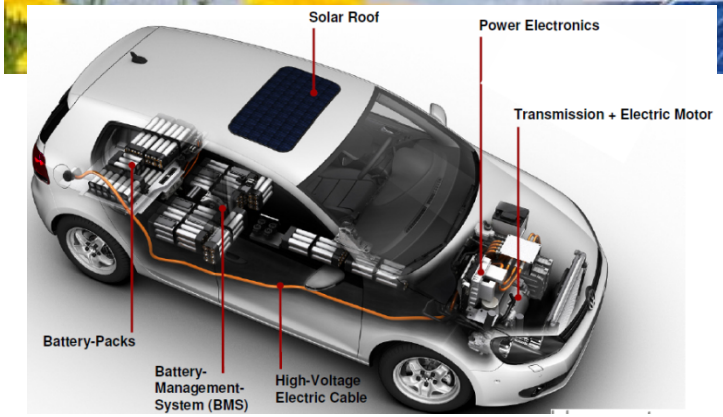
Society
- *Dependency from new raw materials*
- *Missing infrastructure*

Economy
- *Investments*
- *Cost targets for series production*
- *Time to market*
- *Decreasing sales of conventional powertrain components*
- *New competitions for market shares*

Even better mobility option than hydrogen?

Thank you for your attention

Hydrogen and fuel cells – The future in e-mobility



Short term – short range mobility

Long term – long range mobility

(Sources: Volkswagen AG)