Trends in electric power train

1st Training in Bahia Blanca, ARG

12-14th of November 2018

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Which range does a car really need?

Is a range of less than 150 km a problem for you???

A real or a pseudo problem???

Is a range of 800 km really necessary???

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How much energy is in our fuels and batteries?

Comparison gasoline – Li-Ion battery?

Who knows the battery capacity of a TESLA S?

Who can answer this?

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Active Involvement: group activity

- We build groups of 2 to 4 people

- Group work (5-10min):
- Try to answer the raised questions about range and energy content of fuels!
- Write down your results!

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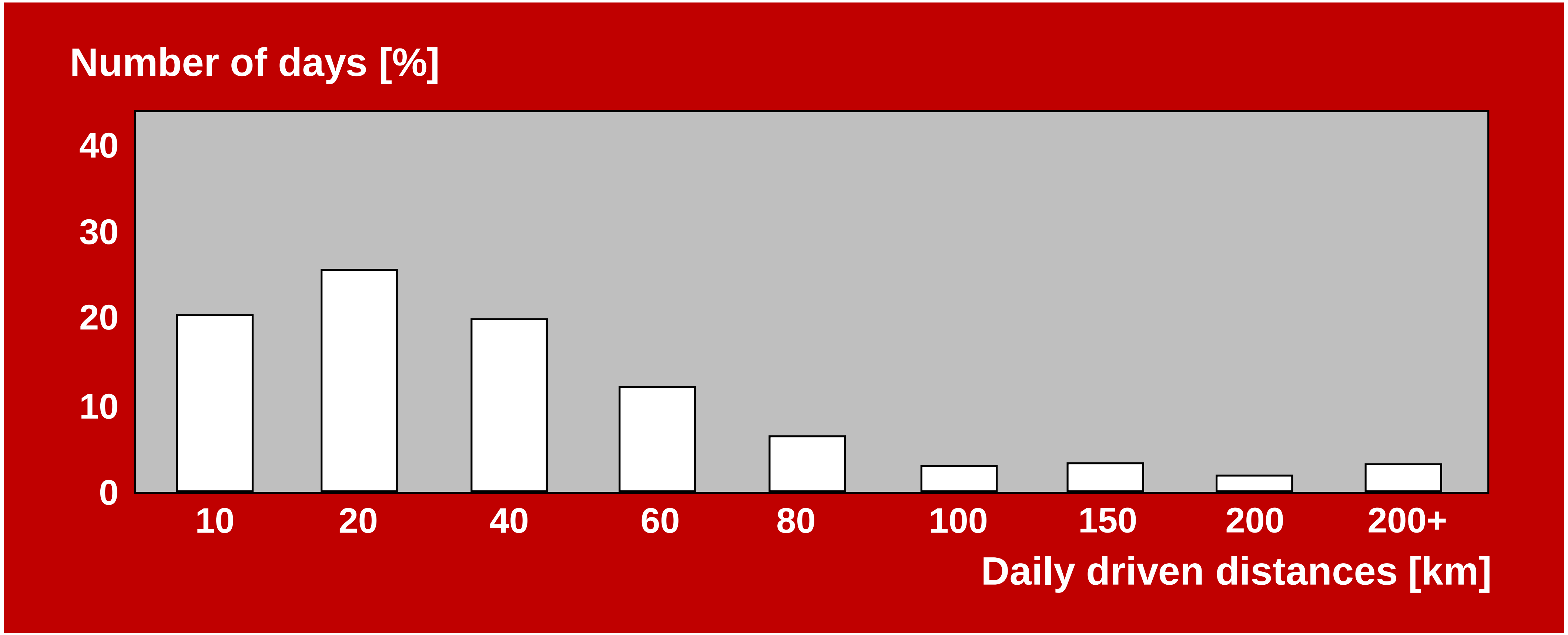
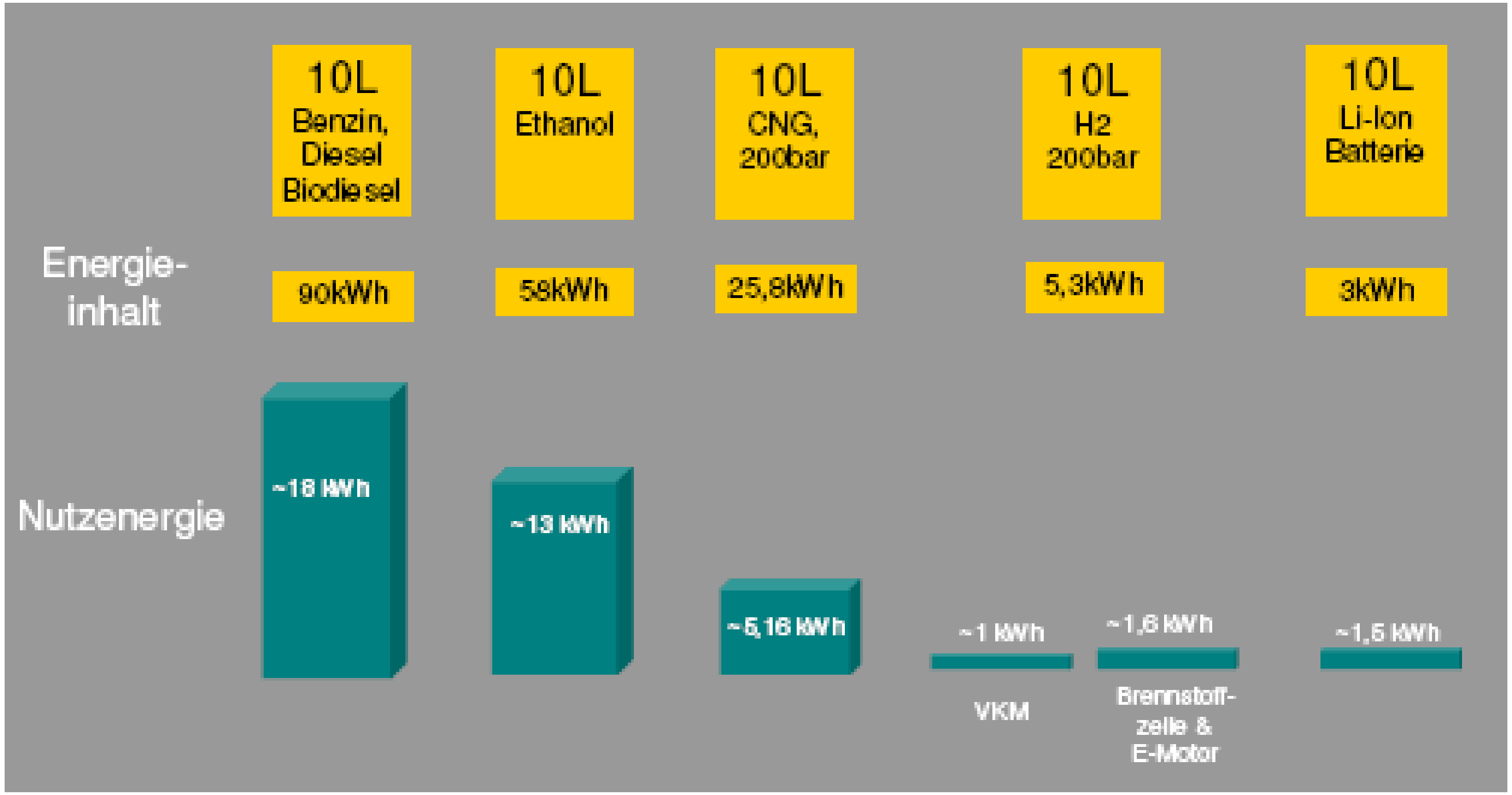
Range rquirements – European traffic analysis



Energy storage comparison by volume



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Benefits of electric power trains

- Very high “battery-to-wheel” efficiency
- Zero local emissions
  - Important for big cities with massive air quality problems (Los Angeles, Shanghai and many more
- CO_2 neutral if energy is produced from wind, solar or hydro power
- New experience regarding driving behavior and performance
- High power at low speeds => no gear box necessary
- Still a relatively new technology
  - Great opportunity for future engineers

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Layouts of electric power trains

- Many different motor and battery locations possible
- More than one E-Motor can be used
  - No prop shafts needed for AWD
- New possibilities for vehicle dynamics control
  - Traction and stability control
  - AWD torque split
  - Torque vectoring
- Batteries can be difficult to package
  - For large batteries a floor-mounted concept can be used

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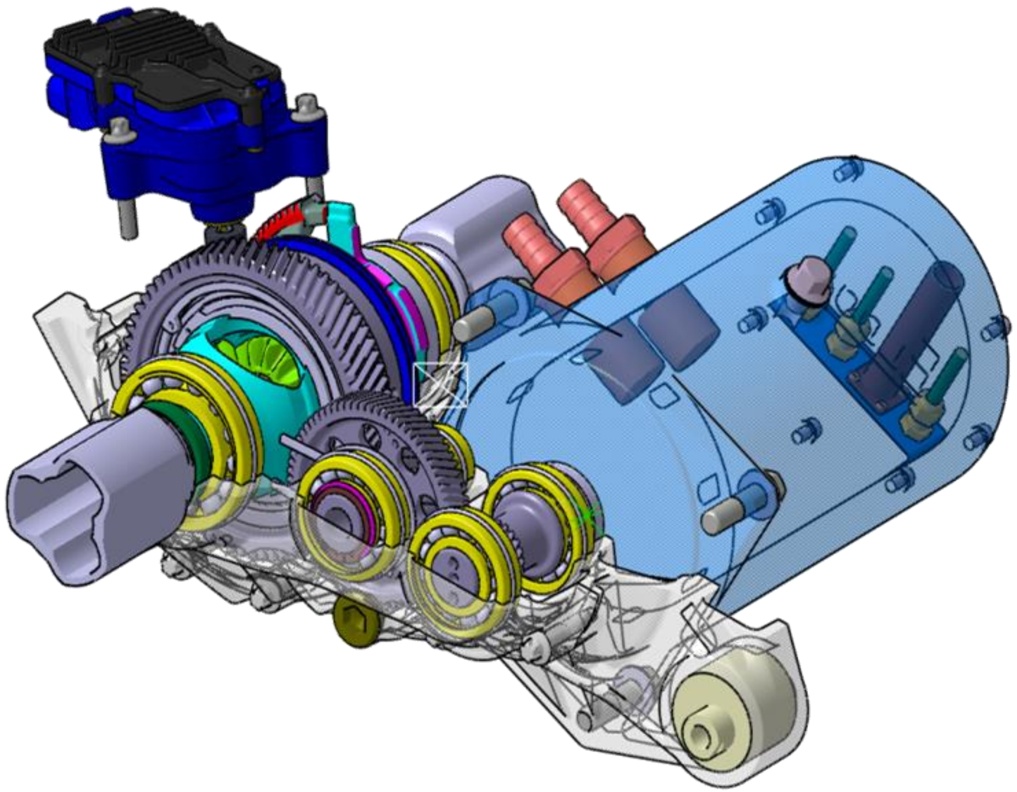
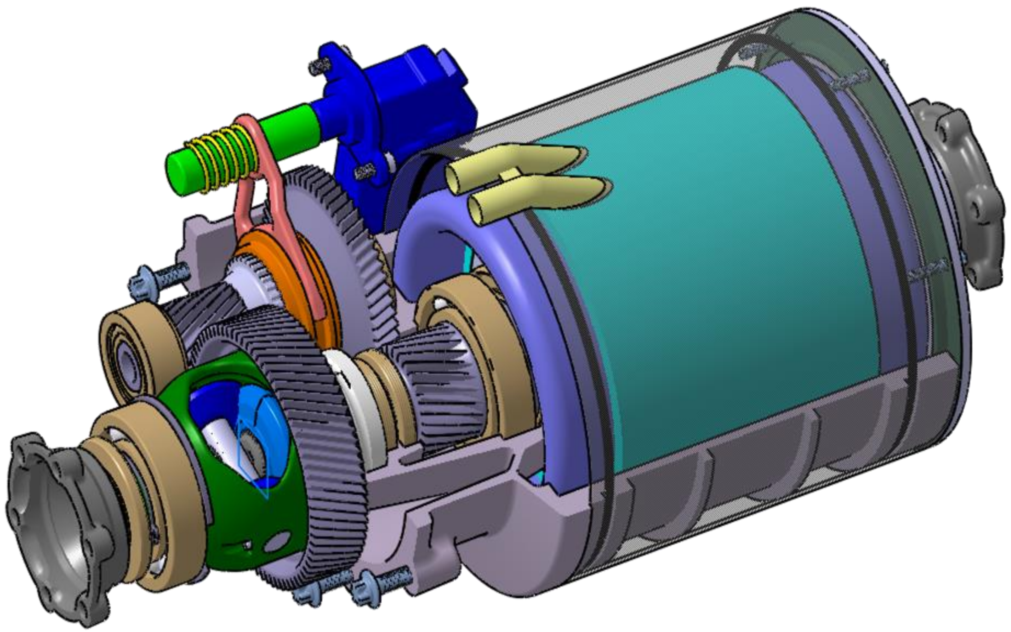
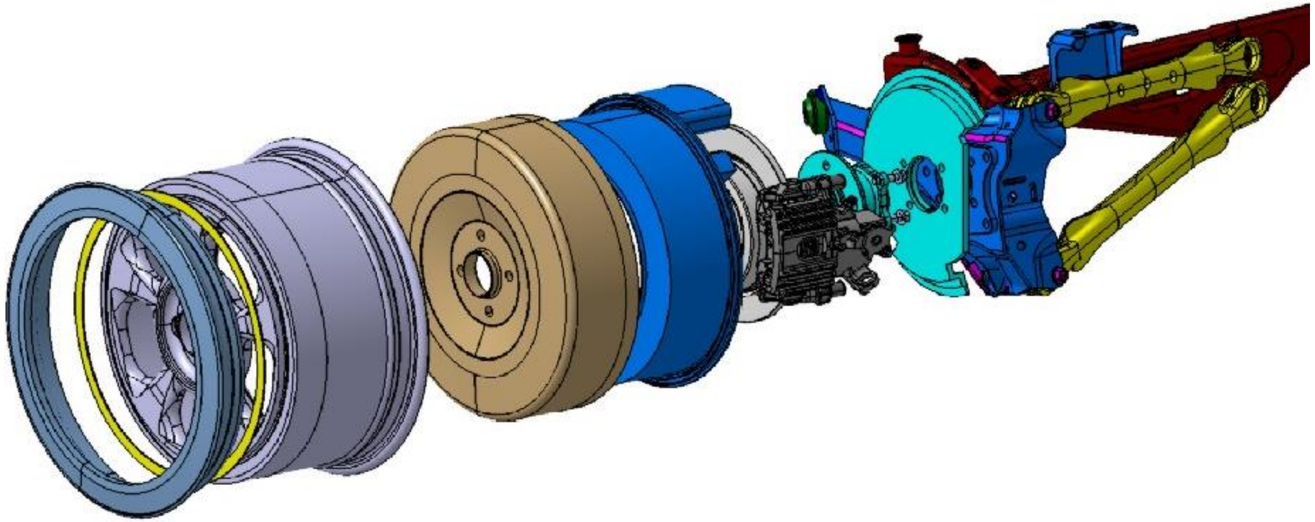
Layouts of electric power trains





examples of motor & gear box concepts

Layouts of electric power trains



Wheel hub motor concepts

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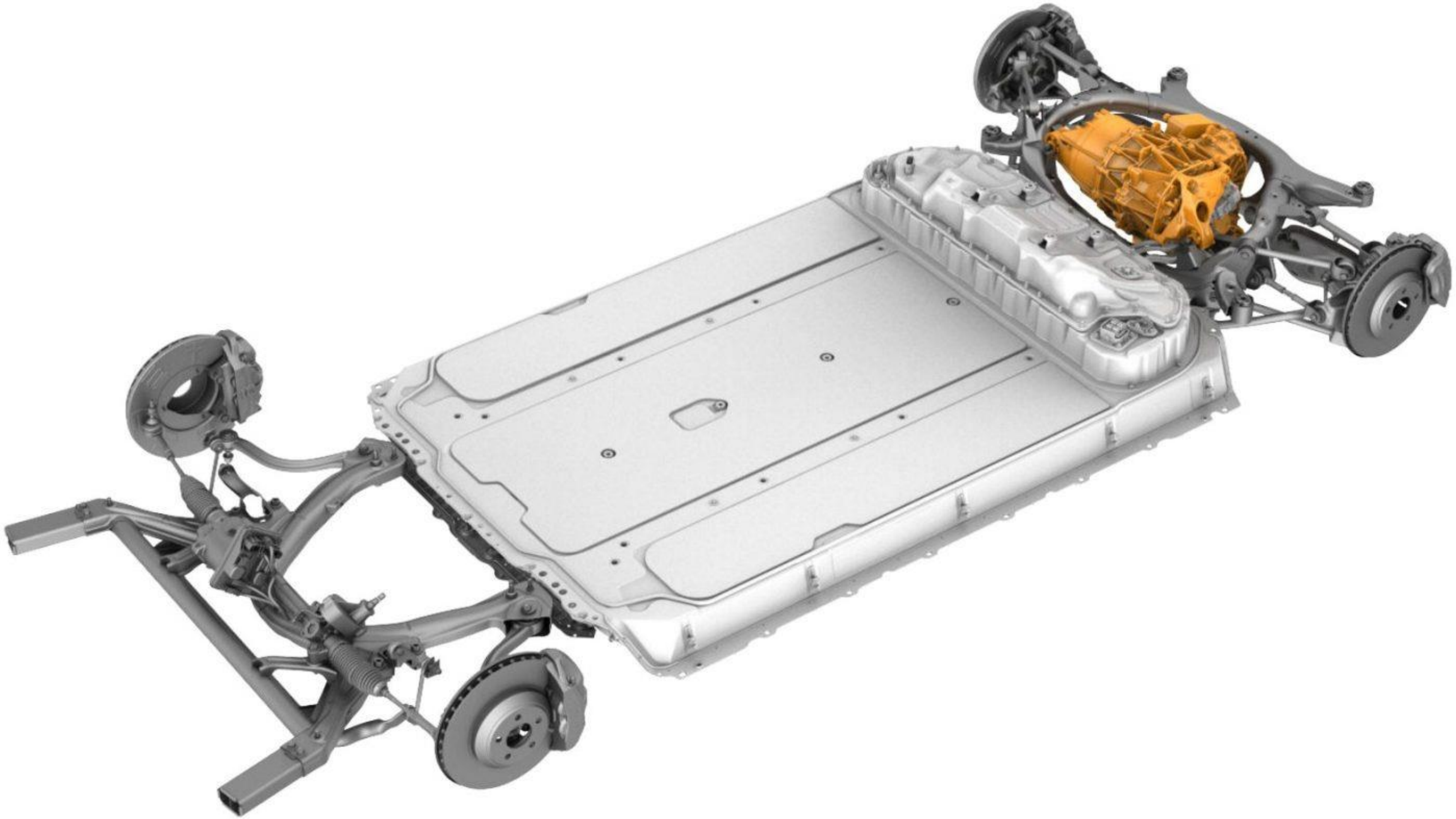
Layouts of electric power trains



Example of Tesla Model 3 power train & battery layout

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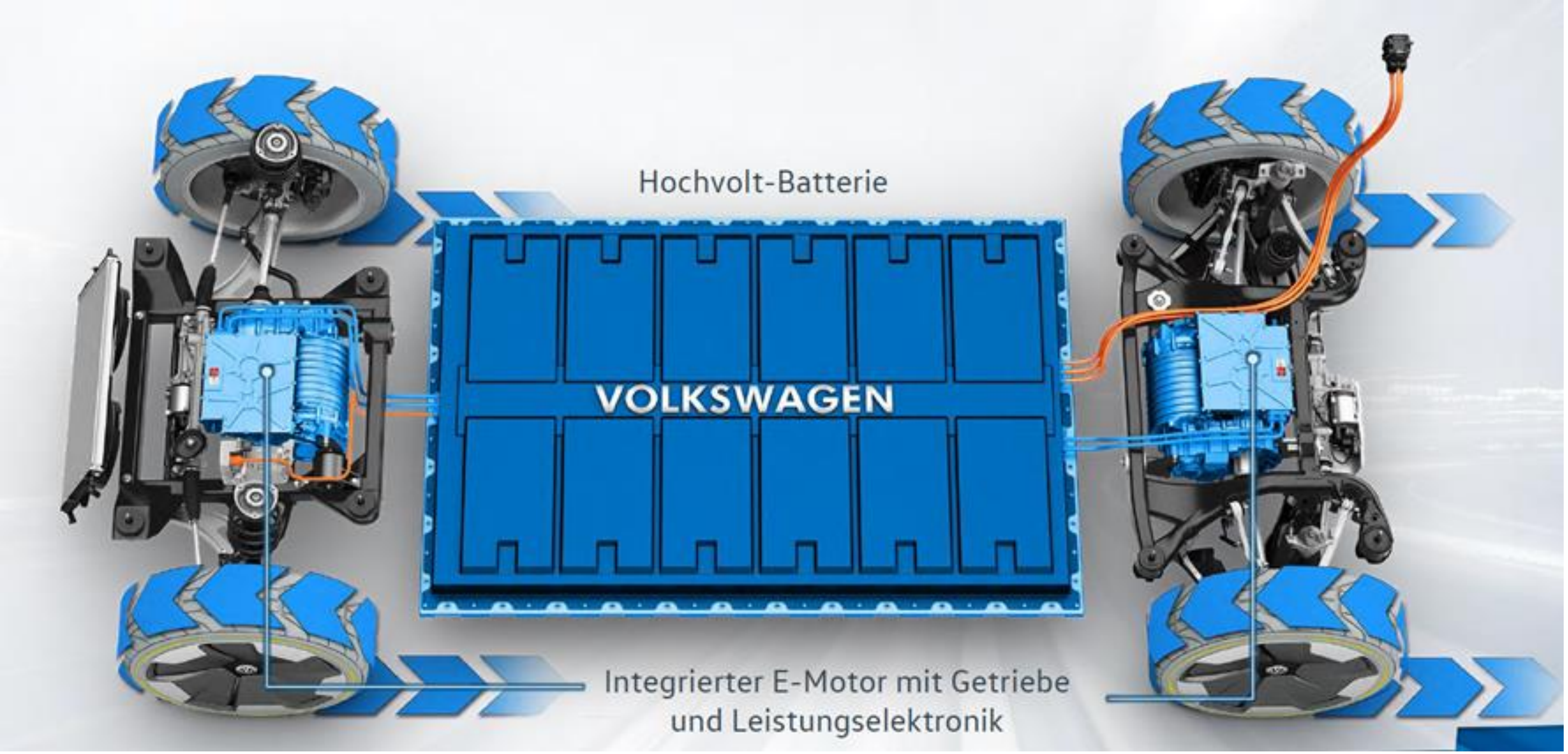
Layouts of electric power trains



Example of VW concept power train & battery layout

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Requirements on e-motors and inverters

- Motors and inverters are being integrated into one unit
  - Less space, less weight
- Motor development goes in two directions:
  - Low speed direct drive motors => no gearbox necessary => great efficiency
  - High speed motors => high power density => low weight
- Motor research focusing on:
  - Materials for windings and magnets
  - Cooling and transmission technology
- Inverter research targets:
  - Advanced semi-conductors (GaN, SiC) for faster switching => NVH, efficiency
  - Torque control strategy

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Requirements on e-motors and inverters

Achievement of all operating points in the torque/speed map with the boundary condition of the max./min. battery voltage respectively current:

- **high efficiency**
- **low weight***
- **small size***
- **maintenance free / low wear**
- **small NVH**
- **high isolation class**
- **EMC compliance, correct design**
- **high robustness, reliability, long life-time**
- **high quality of control**
- **low costs**

* The task is to find the smallest and lightest motor with sufficient thermal inertia (short term overload capability) which fulfills the power requirements in all operating conditions!

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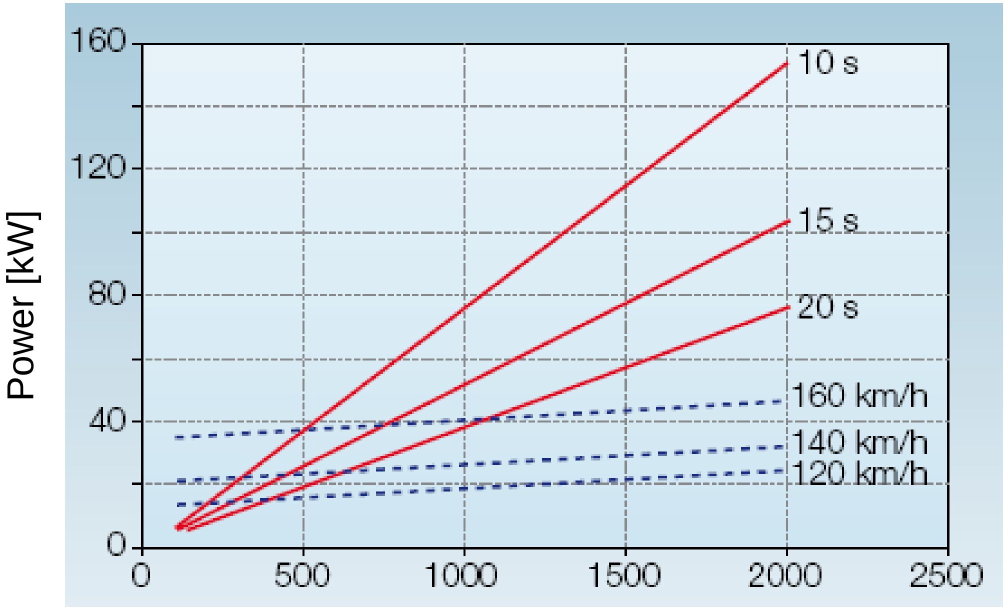
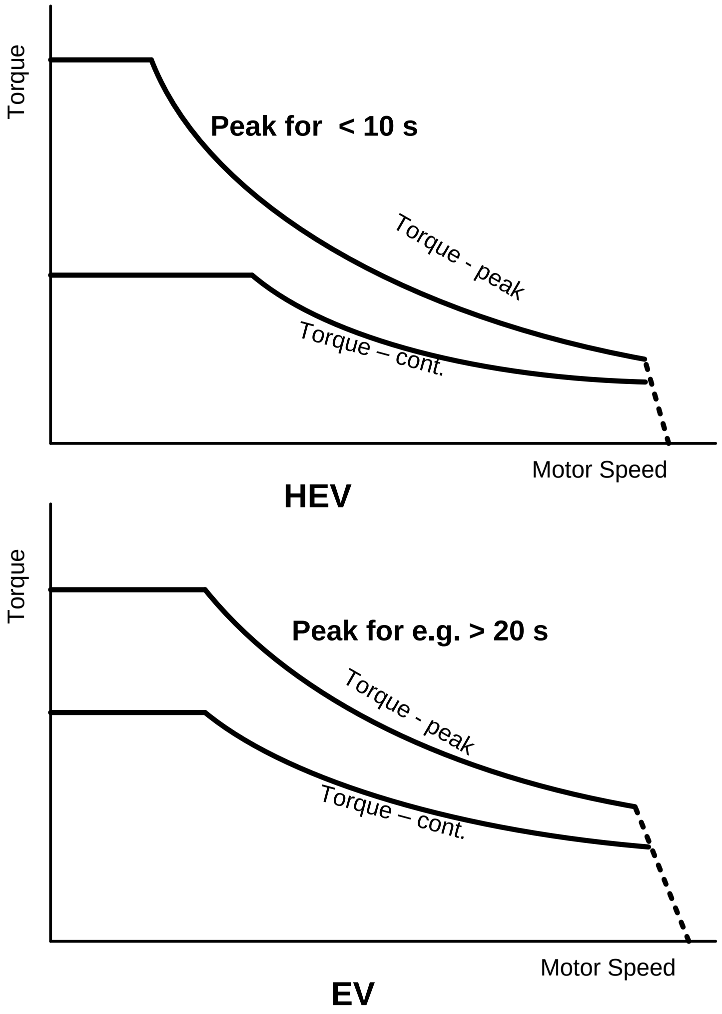
E-motor - short term overload capability



Dietrich P.: Hybridantriebe – der erste Schritt zum Elektroauto? Eine Übersicht über die verschiedenen Hybridkonzepte. Bulletin SEV/AES 1/2008

Vehicle Mass [kg]

Typical for peak and cont. operation



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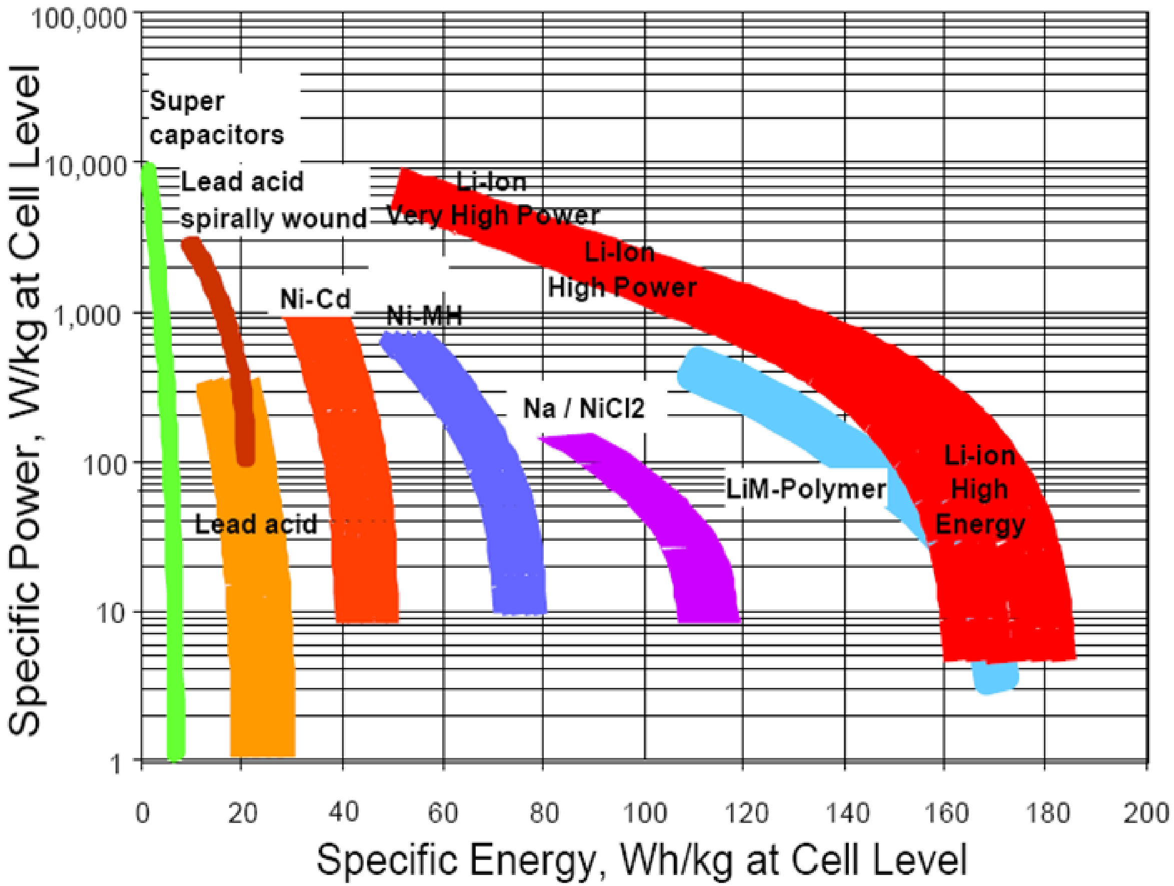
Battery technology – comparison of cell types



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Battery technology/developments

From the before mentioned cell types the focus lies on:

- Li-Ion battery
  - Versatile chemistry => high energy or high power cells possible
  - For passenger cars high energy density is most important => range
- Super capacitors
  - Highest power density
  - Suitable for high power demand applications
  - Limited capacity => no use in passenger cars because of low range
  - When combined with fast charge infrastructure, super caps can be an option for short distance transportation => logistics or inner city public transport

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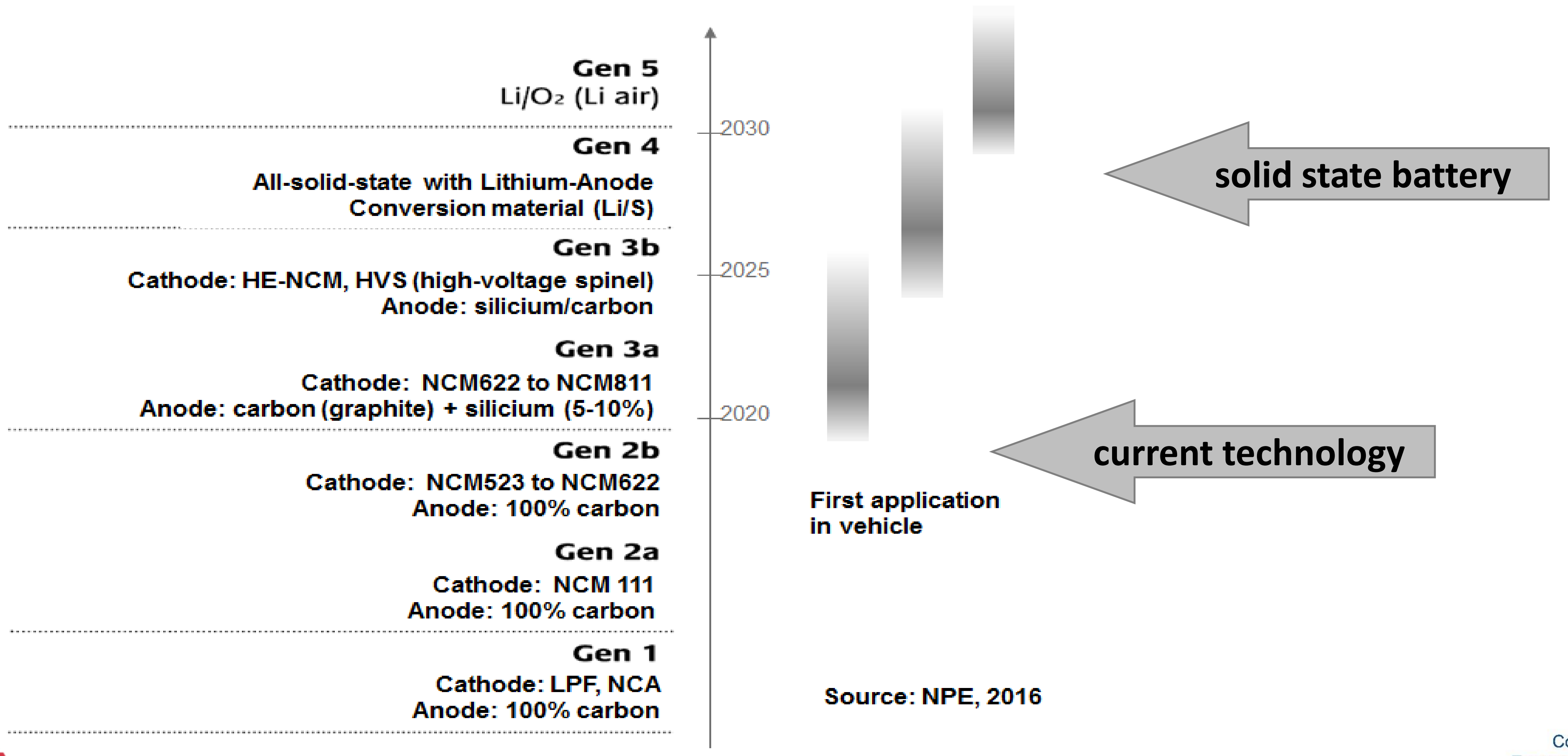
Battery technology – Li-Ion cell generation



Source: NPE, 2016

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Charging technologies – conductive charging (plug-in)

- Systems are already available
- Best efficiency of all charging systems
- Charging infrastructure is growing and growing
  - Still not enough if everybody would drive electric
- Different types of plugs are available => no world wide standard
  - In europe the IEC 62196 Type 2 connector is used mostly
  - In the USA the Type 1 and Combo 1 connectors are used mostly
  - Chinese OEMs prefer the GB/T standard
  - In Japan the CHAdeMO connector is used mostly

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Charging technologies – conductive charging (plug-in)

CHAdeMO (IEC 62196 type 4, DC), IEC 62196 combo2 (DC only), and IEC 62196 type 2 (AC)

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Charging technologies – inductive charging

- Same principle as wireless charging of smart phones
- Via coils and high frequency, the energy is sent from the charging unit into the floor of the vehicles
- No plugs and cables needed
- So far not suitable for the high power demands of charging big batteries
- influence of high frequency electro-magnetic fields on animals and humans need to be investigated further, to avoid any negative results

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Charging technologies – fast charging

- technology to shorten the charging time
- fast charging requires sophisticated thermal management
  - to prevent a reduction of the battery's durability and lifetime
  - to prevent a loss of efficiency of the charging process itself
- presents major challenges to the power grid (power demand & stability)
- Stress on the grid can be reduced with buffering batteries in the charging stations
- first solutions are already available on the market
  - helps to meet users' range anxiety
  - field tests show that users barely rely on fast charging
  - because they tend to charge their vehicles at home or work.

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Battery swapping systems

- require a high level of standardization
  - effects OEMs in their freedom of design
- Battery cannot be used as a stressed member of the chassis
  - increasing weight and complexity
- Requires constant availability of charged batteries
  - This is a financial and logistical challenge
- Currently not an option for passenger cars
- Could be a good option for fleet operation
  - e.g. for logistics applications or public transport

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Trends in electric power train

Questions??

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