Technical Session -4 Fundamentals of EVs and Technology Development

EV technology development (Power electronics, Electric motors, Drivetrains & Batteries)

EV Technology: The Big Picture

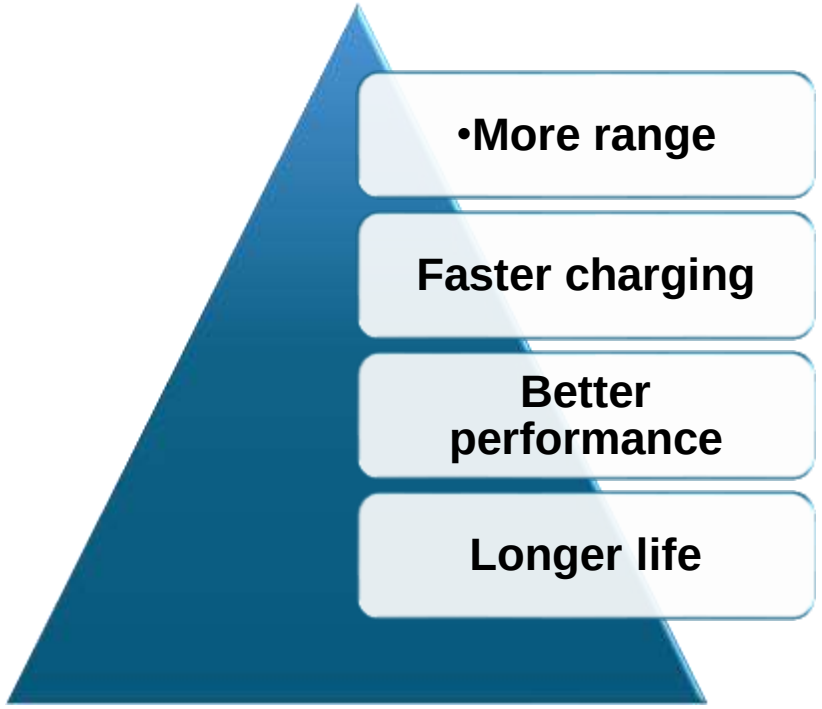
Battery
→ stores electrical energy

Power electronics
→ controls and converts electrical energy

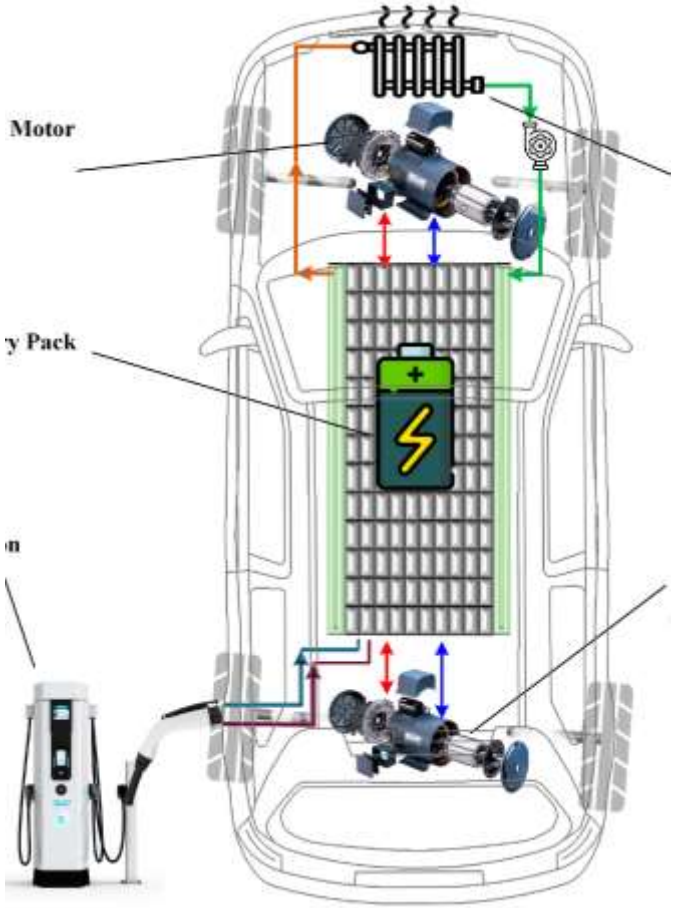
Electric motor
→ converts electrical energy into motion

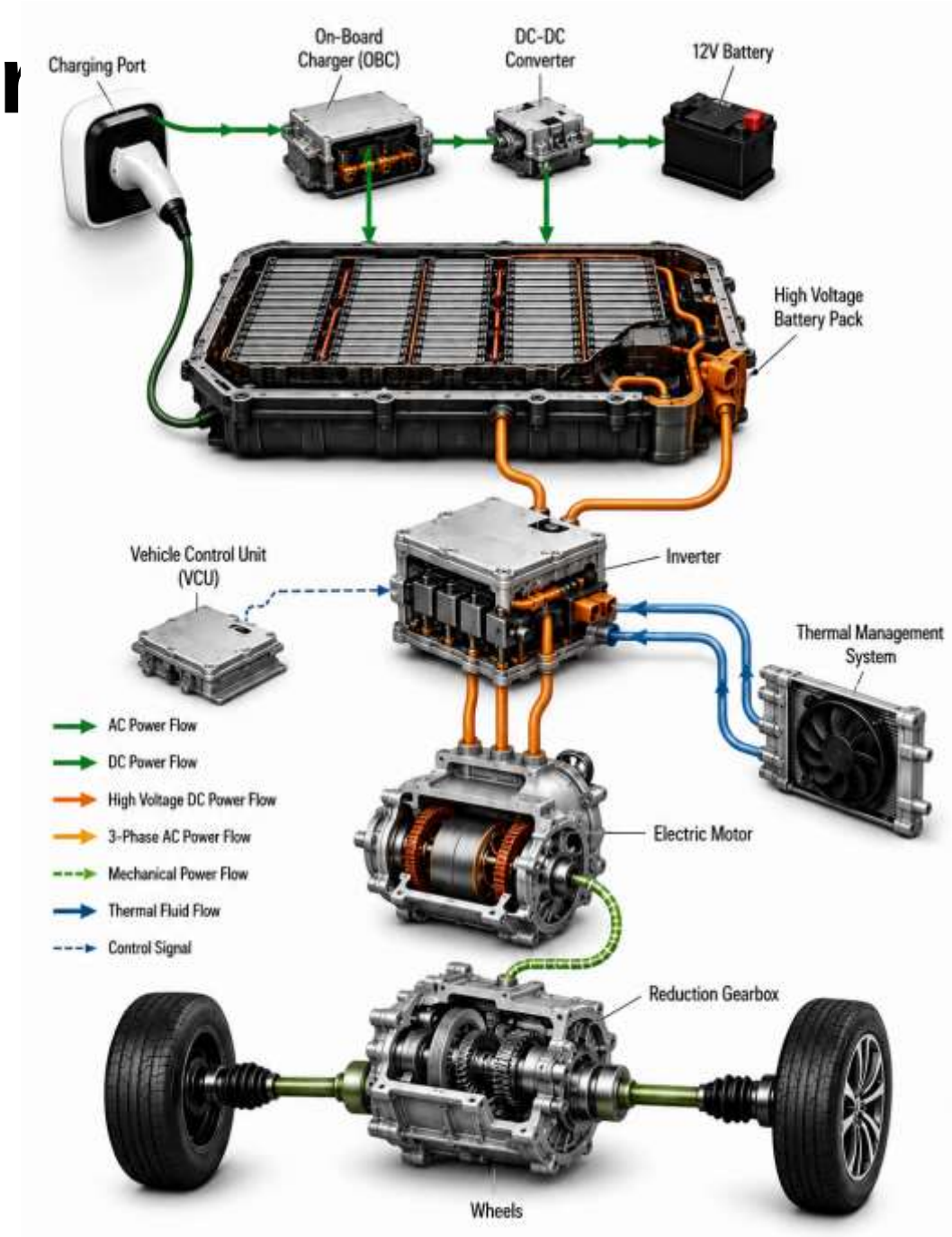
Drivetrain
→ transfers motor power to wheels

Software & controls
→ coordinate the complete system



EV Technology Architectur



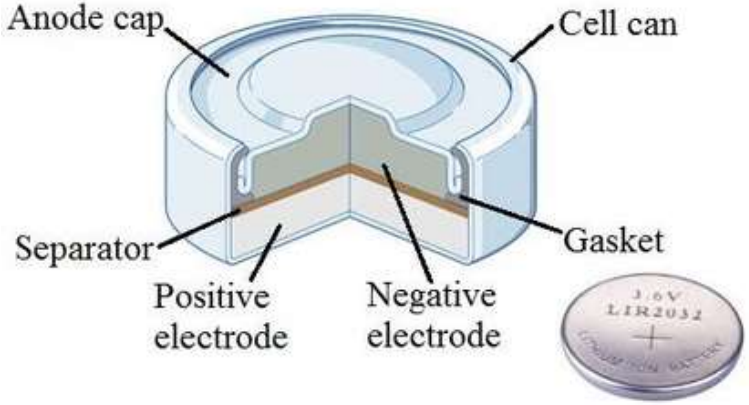


1. Battery

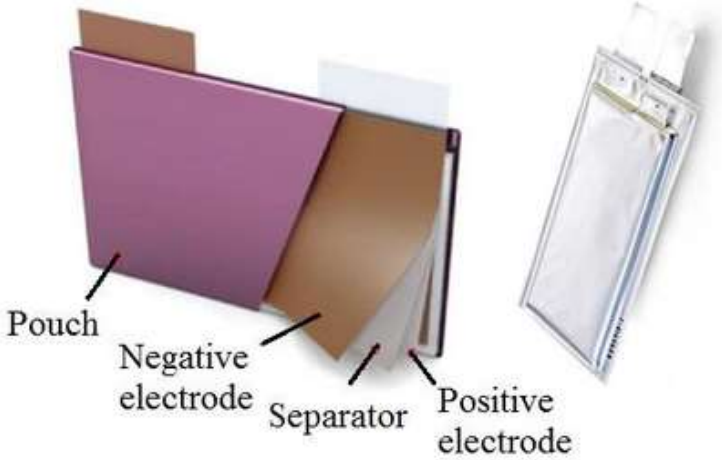
Cylindrical cell

Prismatic cell

Button cell



Pouch cell



Battery

LFP has changed the Global Battery Market

LFP advantages

- Lower material cost
- Good thermal stability
- Long cycle life
- Good fast-charging potential
-

However, NMC also emerged for applications where

- Higher energy density is required
- Lower weight weight is required,
- Suited for long-range/high-performance applications like sport cars, space program, military etc.

Why LFP Is Strategically Important ?

NMC supply chain
- Lithium
- ~~Nickel~~
- Manganese
- ~~Cobalt~~
- Graphite

LFP supply chain
- Lithium
- Iron
- Phosphate
- Graphite

LFP reduces exposure to
Nickel + cobalt
which are rare-earth metals

LFP cathode-material production remains almost entirely concentrated in China.

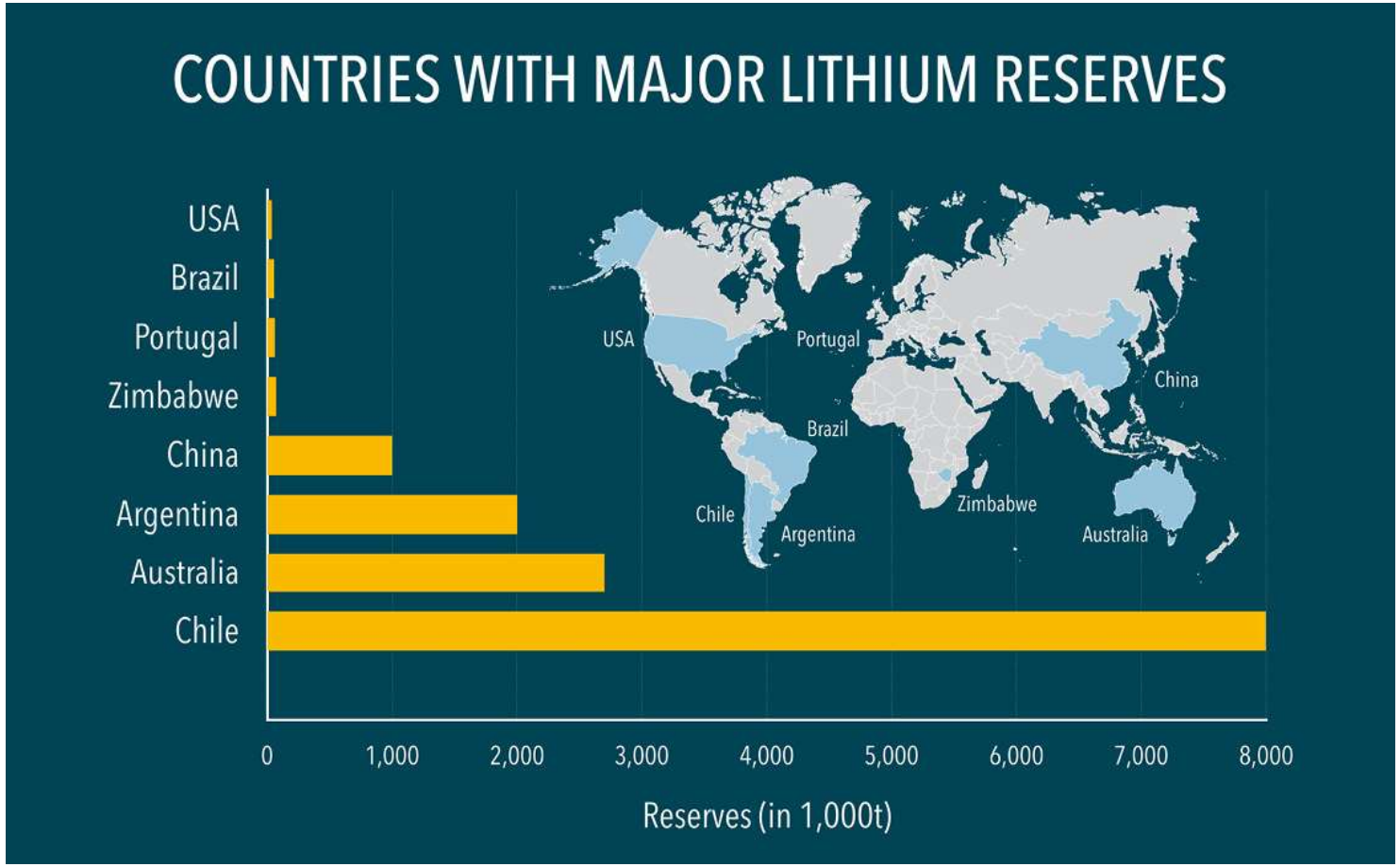
Energy and Propulsion (Cont'd) Battery

CRITICAL MINERALS - An EV Battery Is Also a Mineral Supply Chain

Share of total mineral demand going to batteries

- Lithium — ~85%
- Cobalt — ~70%
- Nickel — >10%

Lithium is now strongly battery-driven commodities; nickel is increasingly influenced by batteries but remains important across other industrial applications.



Energy and Propulsion (Contd.)

Battery

Emerging Battery Technologies

Sodium-ion

Advantages:

- Abundant raw material
- Reduced lithium dependence
- Potentially lower cost
- Good low-temperature performance

Limitation:

Lower energy density than leading lithium-ion cells

Solid-state

Advantages:

- Higher energy density
- Potential safety benefits
- New cell designs

Limitations:

- Manufacturing complexity
- Cost
- Scale-up

Power Electronics & Controls

Key components

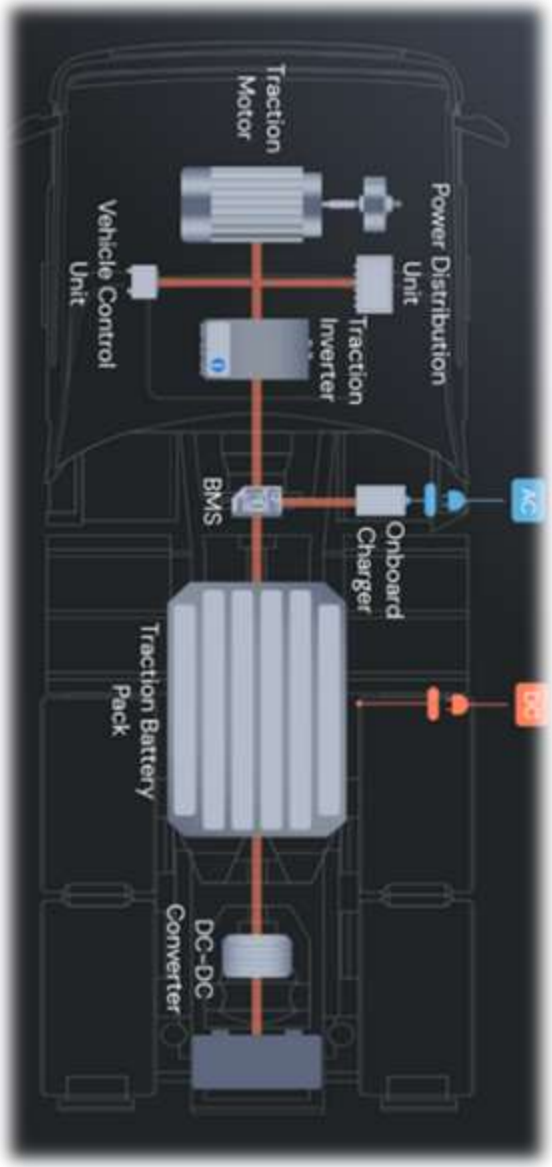
Inverter
It is used to controls motor power.

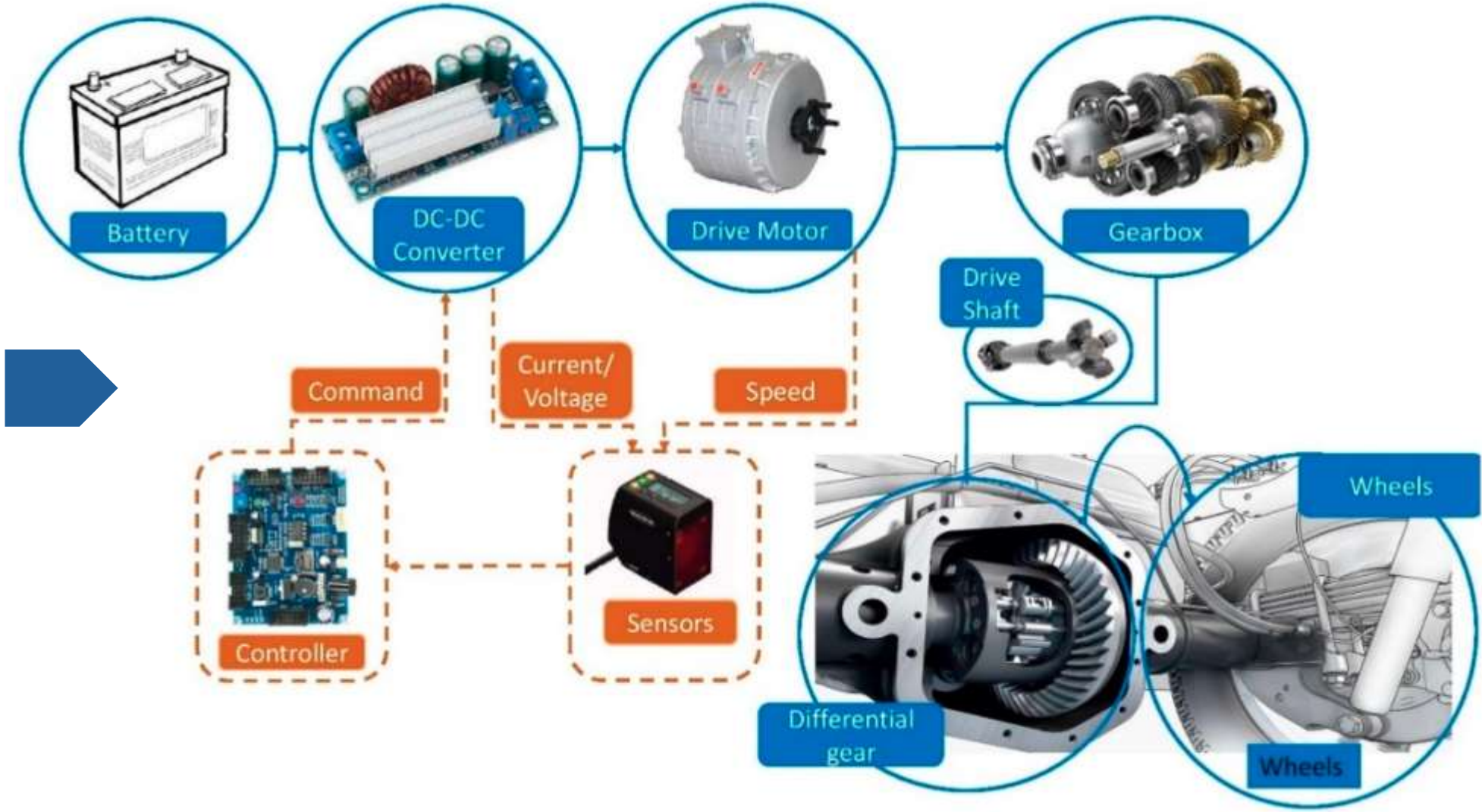
DC/DC converter
They are used to supplies lower-voltage systems. Since different components operates at different voltages.

On-board charger
It manages AC charging into the battery. However for DC fast chargers, it bypass that on-board chargers and charge the battery.

Motor Control Unit (MCU)
it motor operation by coordinating the inverter and motor according to driver demand and vehicle conditions.
It receive information like motor speed, acceleration padel position, temperature etc.

Power Electronics & Controls (Cont'd)





EV Motors

ELECTRIC PROPULSION TECHNOLOGY

Electric Motors: The Other Half of the EV Powertrain

Motor Families

- **Permanent Magnet Synchronous Motor**
  - high efficiency / power density
- **Induction Motor**
  - no permanent magnets
- **Switched Reluctance**
  - no permanent magnets / different control approach

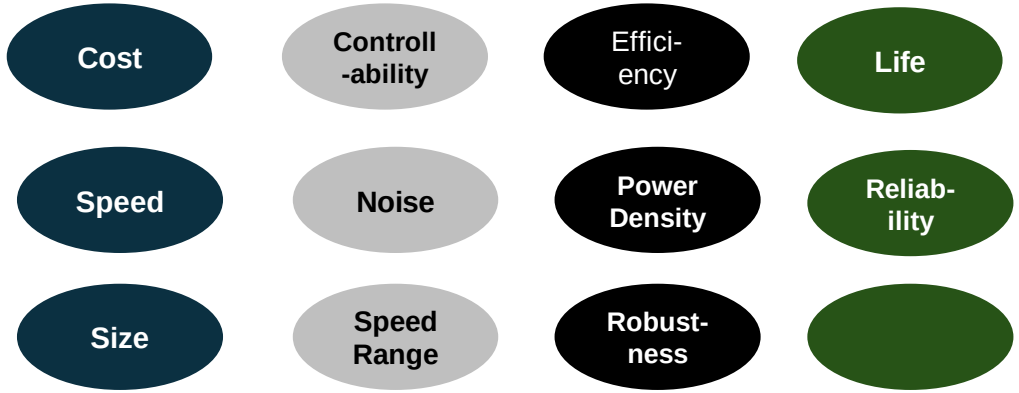
The industry is trying to simultaneously achieve:

- Higher efficiency
- Higher power density
- Lower cost
- Higher speed
- Less rare-earth dependence

Permanent Magnet types

Magnet free types

Common performance criteria



EV Motors (Cont’d)

High-Efficiency Propulsion

- Electric motors can achieve very high efficiency, often exceeding 90% over substantial portions of their operating range.
- Much less energy is lost as heat compared with an ICE powertrain.
- Higher motor efficiency directly contributes to lower energy consumption and greater driving range.

High & Instant Torque

- Electric motors can deliver high torque from very low/near-zero speed.
- Provides rapid vehicle response and strong initial acceleration.
- No need to wait for combustion-engine RPM to build up.

High Power Density & Compact Packaging

- High power output from relatively compact machines.
- Enables flexible vehicle packaging and more cabin/vehicle space.
- Continuous improvement focuses on power density, efficiency, cooling and weight reduction.

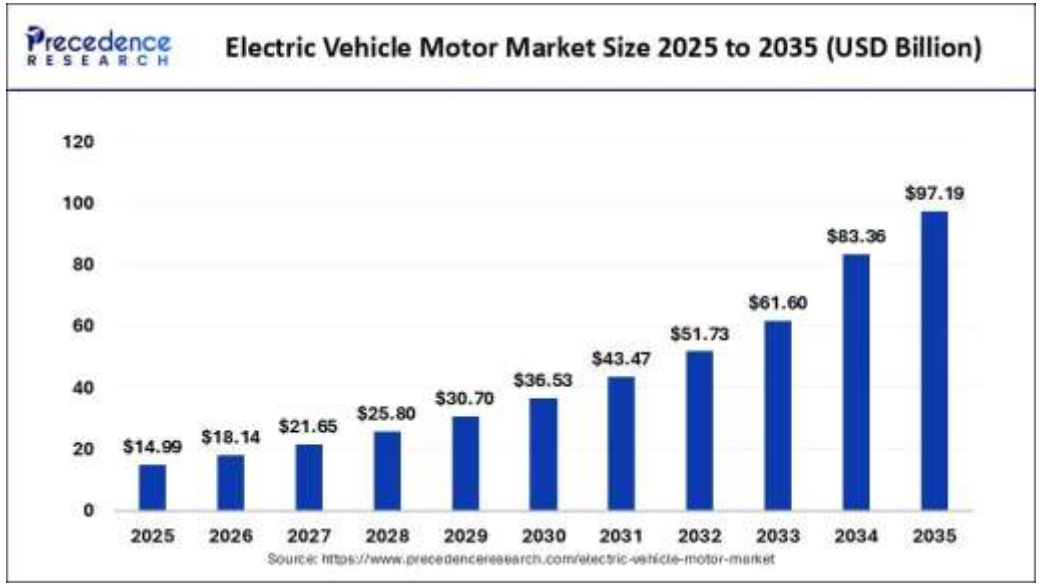
Regenerative Braking

During deceleration:

Wheels → Motor → Generator → Power Electronics → Battery

- Motor operates as a generator and part of the vehicle's kinetic energy is recovered in battery

EV Motors (Cont'd) – Market



Landscape:

Moderately consolidated due to many regional/international players. Mergers, acquisitions, JVs, expansion into new markets are common.

- *Dec 22, India's Shriram Pistons announced acquiring majority stake in Singapore's EMF Innovations (designer, manufacturer of EV motors)*
- *Oct 22, Bosch announced to invest USD 260 million to expand the production of EV motors for the Rivian R1T pickup truck at its Charleston plant in South Carolina, US.*

Major Players

1. Bosch Mobility Solutions
2. ABB Co. Ltd.
3. Nidec Corporation
4. Brose Fahrzeugteile SE & Co. KG
5. Johnson Electric Group

Market Concentration

Q&A