EV Powertrain Trends - Now and in the Future

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Yole Intelligence
Outline

• Overview of the complexity and design choices in EV powertrain
• How to satisfy electric vehicle user needs?
• Analysis of different approaches and their impact on power electronic components:
  – Battery vs SiC
  – 800V battery
  – Single motor vs dual motor approach
  – EV system integration
• Conclusion

The term “EV” means here a battery-powered full electric vehicle.
EV = a business opportunity to not miss

There is a strong business potential in electric vehicles, for automotive OEMs, Tier1s, component manufacturers and suppliers of various materials.

But how to take part of this rapidly growing business?

The term “EV” means here a battery-powered full electric vehicle.

<table>
<thead>
<tr>
<th>Year</th>
<th>MHEV</th>
<th>HEV</th>
<th>PHEV</th>
<th>BEV</th>
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<td>2030</td>
<td>50</td>
<td>100</td>
<td>55</td>
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Source: Yole Intelligence

EV:
- Rapidly growing and sustainable market
- High power per vehicle
- High count of power electronic components per vehicle
- Strong needs for innovations
How to choose the right EV design?

Any strategic decision concerning EV design and system/component choice is a very difficult task due to a very complex and rapidly changing environment.

- What is my starting point?
- How difficult to develop?
- Do I have right partners & suppliers?
- Time to develop?
- How to accelerate the development?
- Will end users buy my car? What is the car’s perceived value for them? What is the positioning of my competitors?
- Direct focus on full EV? Or disperse efforts by working on different electrification types?
- Where to put most effort & money?
- Any raw material issues?
- Rapidly changing and region-dependent subsidies and incentive mechanisms
- How big is the risk? Force innovation through quickly or move progressively?

MHEV  HEV  PHEV  BEV  FCEV

Li  Co  Nd  Ni
How to reach more EV customers?

However, today’s customers request a certain performance and comfort level.

Automotive OEMs need to increase the sales to get price advantage due to volume scaling and thus to increase the sales...

... and do not forget about the margins...
How to satisfy electric vehicle user needs?

High purchasing price is obviously one of them.
But three of the four main issues that dissuade customers from buying a full-electric vehicle are directly associated with electric vehicle charging:

**EV charging-related issues**

- **Range anxiety**: Can I drive far enough between recharges?
- **Charge anxiety**: Can I charge my car rapidly?
- **Waiting anxiety**: Can I rapidly access a charging point?

Higher car price compared to an ICE car

Why should I pay more for an electric car?

ICE    EV

$ $$$$
EV & EV charging

EV charging infrastructure deployment must go hand-in-hand with EV deployment.

One market drives each other
How to satisfy electric vehicle user needs?

Main focus

**EV charging-related issues**

- **Range anxiety**
  - Can I drive far enough between recharges?

- **Charge anxiety**
  - Can I charge my car rapidly?

- **Waiting anxiety**
  - Can I rapidly access a charging point?

**Higher car price compared to an ICE car**

- Why should I pay more for an electric car?

**ICE**  vs  **EV**

$ $ $ $  vs  $ $ $ $
Adding more energy is not a solution

In the last years, the average battery capacity per vehicle has been continuously increased. But a larger battery means:

- Higher vehicle price
- Higher weight
- Higher volume
- Poorer car driving behavior
- Higher energy consumption (kWh/100km) → negative impact on car driving range!
- Longer charging time → charge anxiety
- Higher dependence on raw materials
- Higher CO₂ emissions and global environmental impact

*Considering just adding battery cells, not using advanced cells with higher energy density*
It’s time to reduce the losses!

The reduction of losses from battery to wheels has many advantages:

- 🌟 Lower weight
- 🌟 Smaller volume
- 🌟 Greater car driving behavior
- 🌟 Shorter charging time (min/100 km)
- 🌟 Lower energy consumption (kWh/100km) → reduced environmental impact
- 🌟 Lower dependence on raw materials
Battery as a charging speed bottleneck

To do list:
- Enhance cell chemistry
- Enhance cell design and format
- Enhance BMS
- Enhance battery thermal management
- 400V batteries → 800V batteries
- High-power interconnections

Useable battery energy capacity and maximal DC charging power for various passenger vehicle models, as of Q4/2022.
Source: Yole Intelligence

400V → 800V
650V → 1.2 kV

Vehicles with fast charging capability, mainly represented by Tesla vehicles and vehicles based on 800V batteries
SiC - key technology for EVs

- Strong focus on SiC power module and SiC traction inverter development
- HUGE increase of SiC wafer and device manufacturing capacities
- Numerous partnerships between SiC wafer/device suppliers and automotive OEMs
- But
  - Cost SiC-MOSFET vs Si-IGBT
  - SiC die area vs manufacturing yield
  - What about GaN?
Limitations of a single motor approach

Torque – speed motor curve

Optimally one should use a given motor in torque/speed area with the highest efficiency.

But what to do when different torque speed values are needed?

Torque-speed curve and efficiency values for an EV electric motor (illustrative image and values only)
Advantages of a dual motor approach

Two (smaller) motors are easier to be integrated in the vehicle compared to one (big) motor and the weight of motors is more equally distributed across the vehicle.

In the case of two motors, each motor can be mainly used in the speed/torque range where its efficiency is maximal. Two motors will have different power/torque capability and may be based on different motor technologies.

Examples of technology flexibility choice when using 2 motors per vehicle

<table>
<thead>
<tr>
<th>M1</th>
<th>Motor technology</th>
<th>Motor power</th>
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<tbody>
<tr>
<td>Si-IGBT/SiC-MOSFET in traction inverter</td>
<td>Si-IGBT/SiC-MOSFET in traction inverter</td>
<td></td>
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</table>

Hyundai’s Genesis EV based on 800V E-GMP platform:
- 180kW rear axle motor
- Silicon-IGBT-based front inverter
- IGBT power module
- SiC-MOSFET-based inverter
- SiC power module

Image courtesy: Tesla

IS06.2: Milan ROSINA, Yole Intelligence
Integration choices in EVs

There are different options for integration. Trade-offs are needed including factors, such as compactness, performance, cost-saving, serviceability, supply chain management, flexibility, etc.
Consumer electronic players entering the EV business

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<tr>
<th>Mechanics/hardware/sales</th>
<th>Electronics/software/service</th>
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</table>

**Xiaomi aims to be an EV OEM**

2021/03, Xiaomi announced its Auto BU

‘Fight for Xiaomi Auto’ says the slogan

2021/03, Auto BU founded

Beijing plant, 300k capacity

1st BEV SOP

**Huawei chooses to be a supplier to multiple key systems, with close cooperation with selected OEMs.**

**Aito:** a new brand by Sokon and Huawei, with full solutions, plus Huawei dominates vehicle design and sales through Huawei stores.

**HI (Huawei Intelligent):** full ADAS solutions

**Conventional supplier:** hardware, such as LiDARs, AR-HUD, integrated e-axles, etc.
Conclusion

• EV is rapidly growing market and sustainable market.
• To sell more EV, their price has to be reduced.
• EV optimization has to be done with EV charging in mind.
• Many innovations and improvements on multiple vehicle systems are needed.
• Integration brings advantages in costs, volume, weight. It strengthens OEM’s position within the automotive supply chain.
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