How battery pack evolutions create opportunities for power electronics companies

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Yole Développement
• Yole Développement presentation
• Li-ion battery technologies, applications and market
• EV/HEV – How to differentiate?
• Supply chain reshaping and business opportunities
• Conclusion
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From Technologies to Market
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- Power Electronics
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- Solid-State Lighting & Display
- MEMS, Sensors & Actuators
- Imaging
- Photonics & Optoelectronics
There is a large variety of Li-ion technologies, products and applications.

<table>
<thead>
<tr>
<th>Li-ion chemistries</th>
<th>Cell sizes, shape and formats</th>
<th>Battery pack components</th>
<th>Battery pack design and size</th>
<th>Applications</th>
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</thead>
<tbody>
<tr>
<td>LCO</td>
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<td>NMC</td>
<td>NMC532 NMC622 NMC811</td>
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<td>LTO + Mixtures</td>
<td>Various anode materials, electrolytes, separators</td>
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Application focus of this presentation

- Plug-in HEV and BEV
- Electric buses and trucks
- Stationary battery energy storage
Fast growing market
EV will be the biggest segment

2017 – 2023 BATTERY PACK MARKET VALUE IN $M – SPLIT PER APPLICATION

Li-ion battery pack market value

Annual Li-ion battery pack market value, per application

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For more details see the Yole’s report: Li-Ion Battery Packs for Automotive and Stationary Storage Applications

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EV/HEV – How to differentiate?
HOW EV/HEV DRIVES TECHNOLOGY INNOVATIONS

EV/HEV = a unique combination of:

Strong need for innovation due to severely challenging requirements

Increasing battery size per vehicle / Increasing motor power

High manufacturing volumes (units) and growing demand and market value

EV/HEV needs drive innovations in power electronics, motors and battery packs.

Accelerated implementation of technology innovations
EV/HEV makers increasingly struggle to maintain their product differentiation.

ICE car engine: ~1,000 parts

EV/HEV engine: <100 parts

Simpler design, lower differentiating added value

Battery

Inverter / Converters / Chargers
WHERE ARE THE OPPORTUNITIES FOR POWER ELECTRONICS PLAYERS?

Battery pack components
- Cell
- BMS
- Thermal management
- Safety components
- Electrical interconnects
- Housing

Battery pack trends

Power electronic components can be found in battery pack or in inverters and other devices connected to the battery pack. The battery pack trends will impact both types of power components.

Battery applications
- DC/AC inverters
- DC/DC converters
- Battery chargers
- On-board chargers
OPPORTUNITIES FOR POWER ELECTRONIC PLAYERS

Adaptation of power electronic cooling solutions for battery packs

- Air-fan cooling
- Air-cooled chiller
- Air-cooled heat pipe
- Liquid-cooled chassis for electronics cooling for aerospace applications
  
  LYTRON

Cold plate
Pada

Adaptation needed
OPPORTUNITIES FOR POWER ELECTRONIC PLAYERS

Safety devices for battery packs

- Hybrid solutions
- DC rated
- 800V compatible
- Lightweight & compact solutions
- Vibration resistant
Power electronics, Concentrating Photovoltaics… → Battery

Suppliers of materials, processes and equipment developed for power electronics and other industries are looking for applications in growing Li-ion battery industry.

- Al wire bonding CPV
- Al wire bonding in Infineon power module
- Al wire for battery cells interconnections
- Ribbons in power electronics
- Ribbon bonds for battery cells interconnections

Images courtesy: System Plus Engineering, Hesse Mechatronics, Danfoss, Concentrix Solar
FOUR APPROACHES TO INCREASE CAR DRIVING RANGE

There are 4 main approaches to increase the driving range / reduce system costs.

The final choice of one or another approach depends on the company’s strategy and positioning, and type of vehicle.

1. Larger battery size (kWh) & new battery technologies
2. Higher Voltage → 800 V battery
3. High-efficiency DC/AC and DC/DC conversion
4. High-efficiency and lightweight AC motor

Source: Yole Développement
Driving range (NEDC) as a function of battery energy capacity

- Driving range (mileage) increases as battery size grows and efficiency improves.
- There is a clear trend towards larger battery energy capacity, driven by decreasing battery price and increasing customer demands for longer driving range.

source: Yole Développement
Today, most EV/HEV car batteries are based on a voltage level of 200 - 400V.

The battery voltage increase will also impact power electronics components and motor which have to be rated at higher voltage.

EV/HEV electric engine power as a function of battery voltage.

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What are the approaches chosen by different players?

Three main approaches exist today. SiC technology can be an ultimate goal for all three of them.

- **Tesla Model 3 inverter**: Battery voltage: 400V → 800V
- **Porsche Taycan**: Battery voltage boost converter
- **Toyota Prius**: Present → Future

**SiC**

Traction inverter: Silicon → SiC
Supply chain reshaping and business opportunities
EV/HEV PLAYERS’ OPPORTUNITIES IN BATTERIES

• Amongst other power electronic companies, EV/HEV players are strongly looking for the differentiation

• Battery makes differentiation

→ Developing and manufacturing new battery cells in-house?...

  • Chemistry know-how

  • Complex multicomponent materials and interface phenomena in battery cells

  • Large manufacturing capacity required with related know-how about the process control

• …battery manufacturing is not car maker business (some exceptions exist)

What about:

• Partnerships?

• Investment into battery companies?
The annual demand for battery packs will reach 6.3 MUnits by 2023. The demand in units is important for evaluation of market potential for power electronic components.

For more details see the Yole’s report: Li-Ion Battery Packs for Automotive and Stationary Storage Applications.
The lack of semiconductor devices for battery inverters, converters and chargers can be the future bottleneck for EV/HEVs.
WHAT WILL BE THE IMPACT OF GROWING EV/HEV FLEET?

- Growing EV/HEV fleet
- Fast charging
- Smart charging
- Growing battery production

V2G, V2H, V2X... Smart charging

- Irregular peaky loads
- EV/HEV demand
- With battery energy storage

EV/HEV charging and fast charging → Need for grid with high demand / response flexibility

2nd battery life (in stationary energy systems)

Lower cost

Accelerated deployment of other battery applications → stationary battery energy storage

PHEV & BEV

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400 km / 100 kWh = 1kWh for 4 km drive

Daily drive: 60 km → 15 kWh

~15 kWh / day

Every % of charging losses will further increase the energy demand

(Clean) Electricity sources to be added!

Electricity supply, smart charging and charging efficiency are crucial!
SEE BEYOND ELECTRIC CAR…

Power devices?

Electricity supply?

Recycling?

Raw material?
Car makers
SUPPLY CHAIN RESHAPING
Non-exhaustive overview of the players involved
CONCLUSION

• Strong and growing demand for Li-ion battery packs, driven mainly by EV/HEV market.
• The technology evolution in battery has impact requirements on power electronic components.
• Differentiating added value needed.
• The early identification of key technology trends in battery packs and battery applications will give a competitive advantage for power electronics players.
• Be aware of power device bottleneck!
• EV/HEV is a hurricane moving and reshaping the whole power electronics and battery supply chains
• Huge opportunities for power electronics players:
  • Battery pack components
  • Devices linked to batteries (inverters, chargers…)
  • Charging solutions and charging infrastructure
Dr. Milan Rosina is a Principal Analyst for Energy Conversion & Emerging Materials at Yole Développement. Before joining Yole, he worked as a Research Scientist and a Project Manager in the fields of photovoltaics, microelectronics, and LED. Dr. Rosina has more than 15 years of scientific and industrial experience with prominent research institutions, an equipment maker, and a utility company. His expertise includes new equipment and process development, due diligence, technology, and market surveys in the fields of renewable energies, energy storage, batteries, power electronics, thermal management, and innovative materials and devices.

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