

POWER ELECTRONICS FOR EV/HEV 2016: MARKET, INNOVATIONS AND TRENDS

Market & Technology report - March 2016

The power electronics market for EV/HEV will reach \$13B by 2021. Technology and business developments, as well as business opportunities, are expected in this growing industry.

KEY FEATURES OF THE REPORT

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- Analysis of electric and hybrid vehicle market development
- Market metrics and forecasts at vehicle level
- Geographical analysis, with particular focus on the Chinese market
- Market metrics and forecasts for power electronics (inverters, power modules, power devices)
- Technology analysis and trends for mechatronics
- Technology and trends for power packaging and power devices targeting automotive
- Business models and supply chain presentation and evolution

OBJECTIVES OF THE REPORT

The objectives of the report are to:

- Provide updated market metrics and forecasts for electrified vehicles
- Analyze the differences between geographical areas, as well as the incentives and deterrents for market growth
- Present the main technological trends and ongoing developments for power electronics that target automotive at each level (inverter, power module, power device)
- Provide updated market metrics and forecasts for power electronics (split by electrified vehicle type)
- Discuss battery evolution and its impact on power electronics
- Analyze business model evolution and supply-chain moves

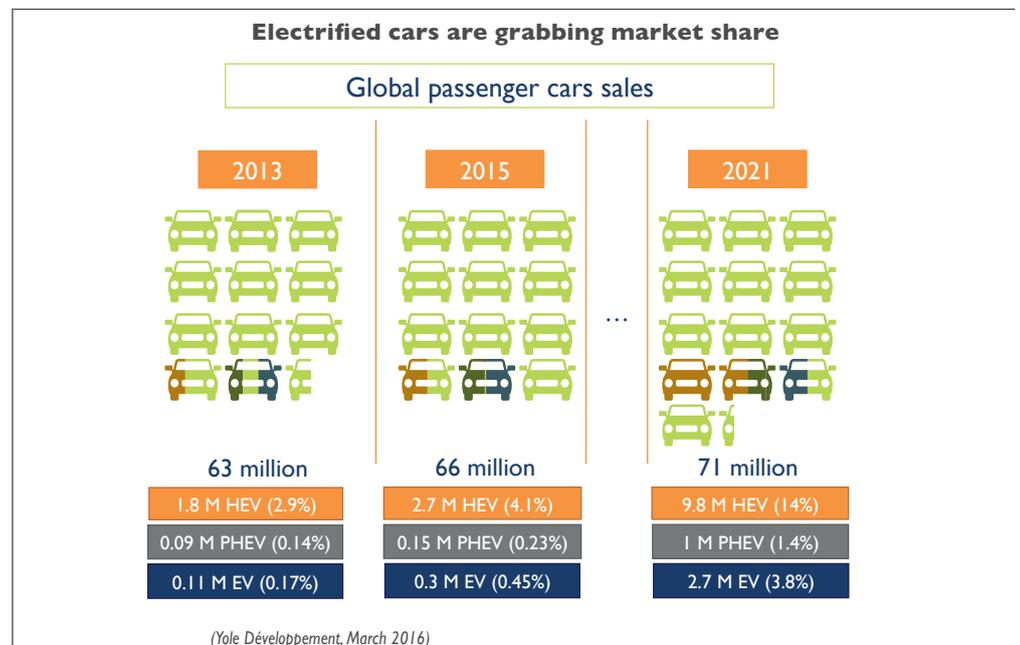
THE AUTOMOTIVE MARKET IS TURNING ELECTRIC

Sales of battery electric cars doubled between 2014 and 2015, an occurrence considered the first sign of the widespread acceptance of electrified cars. Pushed by aggressive targets in terms of CO₂ emissions, electrification is undoubtedly the “greenest” option for car makers, with “diesel-gate” strengthening this impression and improving the public’s opinion of electric cars. The offer for electric and hybrid cars is growing by leaps and bounds, with premium car makers like Aston Martin and Jaguar also involved, and established car makers like General Motors launching affordable electric vehicles with sufficient range to be competitive with gas-powered vehicles. Once seen as a fancy-yet-flawed technology, electric cars are now becoming attractive thanks to players like Tesla Motors and the financial benefits of owning an electric vehicle.

The development of a charging infrastructure and an increasing range have also helped boost the market.

Considering all of these advantages, along with the political push for the mass adoption of electric cars, the market could be even higher. However, in order for electrified cars to enjoy global appeal some obstacles still must be cleared, such as charging regulations and the high sticker price compared to ICE vehicles.

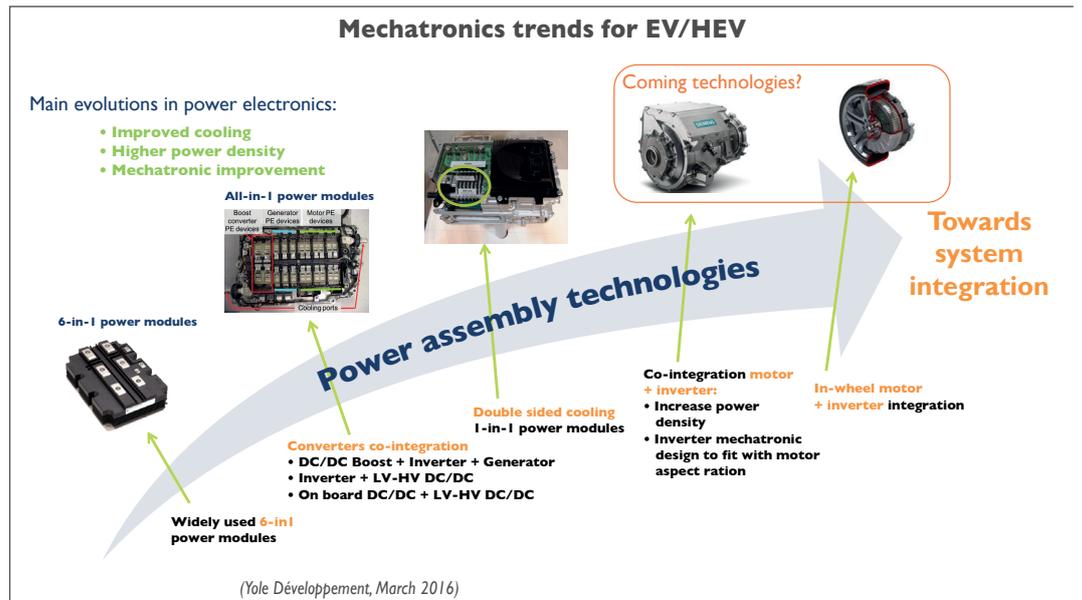
In this report, you will find a detailed analysis of electrification’s pros and cons, as well as updated market metrics and forecasts for electric cars (by electrification type) and associated power electronics (inverter, power module, and power device). Market insights are also provided for the batteries used in electrified vehicles.



POWER ELECTRONICS: TECHNOLOGICAL INNOVATIONS AND BREAKTHROUGHS WILL BE DRIVEN BY AUTOMOTIVE EVOLUTION

EV/HEV represented 30% of the overall power module market in 2015. By 2021, we expect this share to reach almost 50%, meaning a \$2.3B market and 13M cars. Power electronics’ technical evolution is thus following automotive requirements.

Increasing the power density is one main challenge still to be conquered: volume constraints are formidable inside a car, and power is already high. Innovations are needed at all levels of power electronics (inverter, power module, and power device), and also on the battery side.



Enhancing energy density to achieve higher autonomy ranges, while at the same time decreasing the battery pack price, is mandatory to generalize the use of electric cars.

At inverter level, the general trend is to increase integration. Each electrification type demands a specific solution. In the case of mild hybrid vehicles, where volume is very limited and power is relatively low, more and more cars are equipped with a smart motor (inverter + motor) solution. For full hybrid and plug-in hybrid vehicles, other solutions are employed, such as a “centralized power electronics box”. For battery electric vehicles, many different integrated solutions are being developed (in-wheel drive for instance). This report provides presentation and analysis of different technological solutions per electrification type.

At power module level, thermal management and reliability are the two main characteristics for

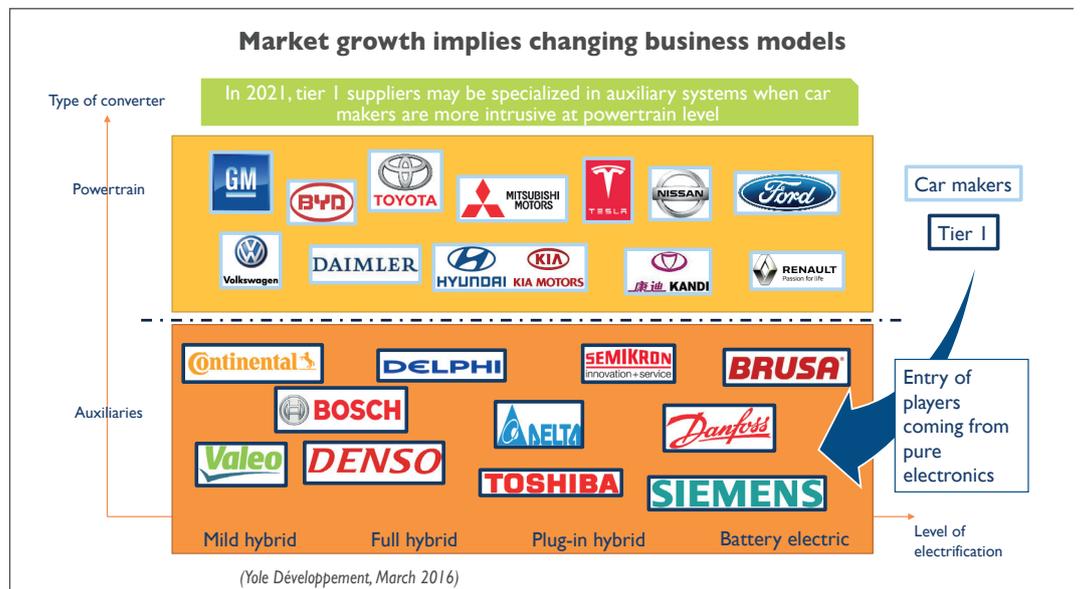
improvement. Progress has been made both on module design and on materials used (silver sintering, double-side cooling, over-molded modules, etc.). Among the different module shapes offered i.e. 6-in-1, 2-in-1, Yole Développement (Yole) is analyzing the different solutions chosen by car makers for their cars, as well as general trends for the future.

Big opportunities are ongoing at the power device level thanks to the growth of wide band-gap materials like gallium nitride and silicon carbide. Toyota’s announcement that silicon carbide (SiC) will be implemented en masse in their cars by 2020 confirms that SiC for automotive is a reality. Nevertheless, Si IGBTs still have advantages (i.e. maturity, cost, multi-sourcing) and room for improvement. EV/HEV represented 23% of the IGBT market in 2015, and Yole expects this share to grow to 39% by 2021 for a \$2B market.

MARKET GROWTH CAN RESHAPE THE ENTIRE VALUE CHAIN

The electrified vehicles market is expected to quadruple from 2015 – 2021, and the associated power electronics market at inverter level will reach

\$13B by 2021 too. This huge added value is attracting many players, in particular at power module level, where companies from the inverter side are getting



involved and hoping to gain market share (for instance Continental, which is integrating its own power module into its solution). Meanwhile, players from the pure power electronics field like Semikron and Siemens are also entering the automotive market via the powertrain (power module or inverter).

Today, inverters are mainly provided to car manufacturers by tier I suppliers with off-the-shelf products. This solution is employed by car makers that still lack the know-how to make their

own power electronics system. The drawback of this approach is that car makers aren't able to differentiate from their competitors and risk losing their identity, which once came from the thermal engine. This is the main reason why car makers are becoming increasingly intrusive at inverter level. In the future, we expect car makers to secure their own powertrain and leave auxiliary converters to suppliers. In this new EV/HEV report, Yole analyzes the business models and supply chain evolution, including newcomers and the positioning evolution.

ELECTRIC AND AUTONOMOUS VEHICLES: A COMMON FUTURE?

During the last few months, several projects combining autonomous and electric vehicles have been widely discussed in the press: Apple, Google, Tesla Motors, and Faraday Future have all been

named as leaders in this field. An overview of the potential synergies and differences between autonomous and electric vehicles is provided in this report.

COMPANIES CITED IN THE REPORT (non exhaustive list)

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WHAT'S NEW

- Updated market estimates and forecasts for power electronics in electrified vehicles
- Comparison with former EV/HEV market estimates and forecasts
- In-depth analysis of technical solutions at inverter level, with a focus on mechatronics
- Analysis and trends for power integration and packaging for automotive
- Ranking of power electronics suppliers for EV/HEV
- Updated supply chain for vehicles currently on the market
- Analysis of battery evolution and fuel-cell technology potential
- Introduction to synergies between electrified and autonomous vehicles



AUTHOR

Coralie Le Bret has been an analyst in power electronics and compound semiconductor technologies since 2014, at Yole Développement, the "More than Moore" market research and strategy consulting company. She graduated from INSA Lyon with an engineering degree in material sciences, specializing in semiconductors and microelectronics. At Yole Développement she is in charge of electro-mobility, and she uses her expertise on materials and semiconductors to follow power devices and power packaging evolution.



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CONTACTS

- For more information about :
- Consulting Services: Jean-Christophe Eloy (eloy@yole.fr)
 - Financial Services: Jean-Christophe Eloy (eloy@yole.fr)
 - Report Business: Fayçal Khamassi (khamassi@yole.fr)
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