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September 01, 2020

How are EV/HEV trends paving the way for power electronics?


The global power electronics market is worth US$17.5 billion, and will experience a 4.3% Compound Annual Growth Rate (CAGR) from 2019-2025. According to the latest power electronics report published by Yole Développement (Yole), Status of the Power Electronics Industry, the power electronic market is poised to grow, with automotive applications as the strongest driver. Today, the automotive segment, especially EV/HEVs, drives both technological development and market demand. Indeed, huge investment has been announced by automotive OEMs into vehicle fleet electrification and an increasing number of electrified vehicles models are being released by the OEMs…

Yole, the market research & strategy consulting company, has investigated for a long while the power electronics world. With **the Power Electronics for Electric & Hybrid Electric Vehicles report** published this year, **Yole's Principal Analyst, Milan Rosina, PhD.** presents the technology evolution, the latest innovations and market trends.

The electric and hybrid electric vehicle (EV/HEV) market is growing rapidly and will reach more than 30 million new vehicles in 2025. EV/HEV represents a huge and sustainable market as EV/HEV deployment is driven by strong and sustainable drivers (FIG1). Amongst the most important d
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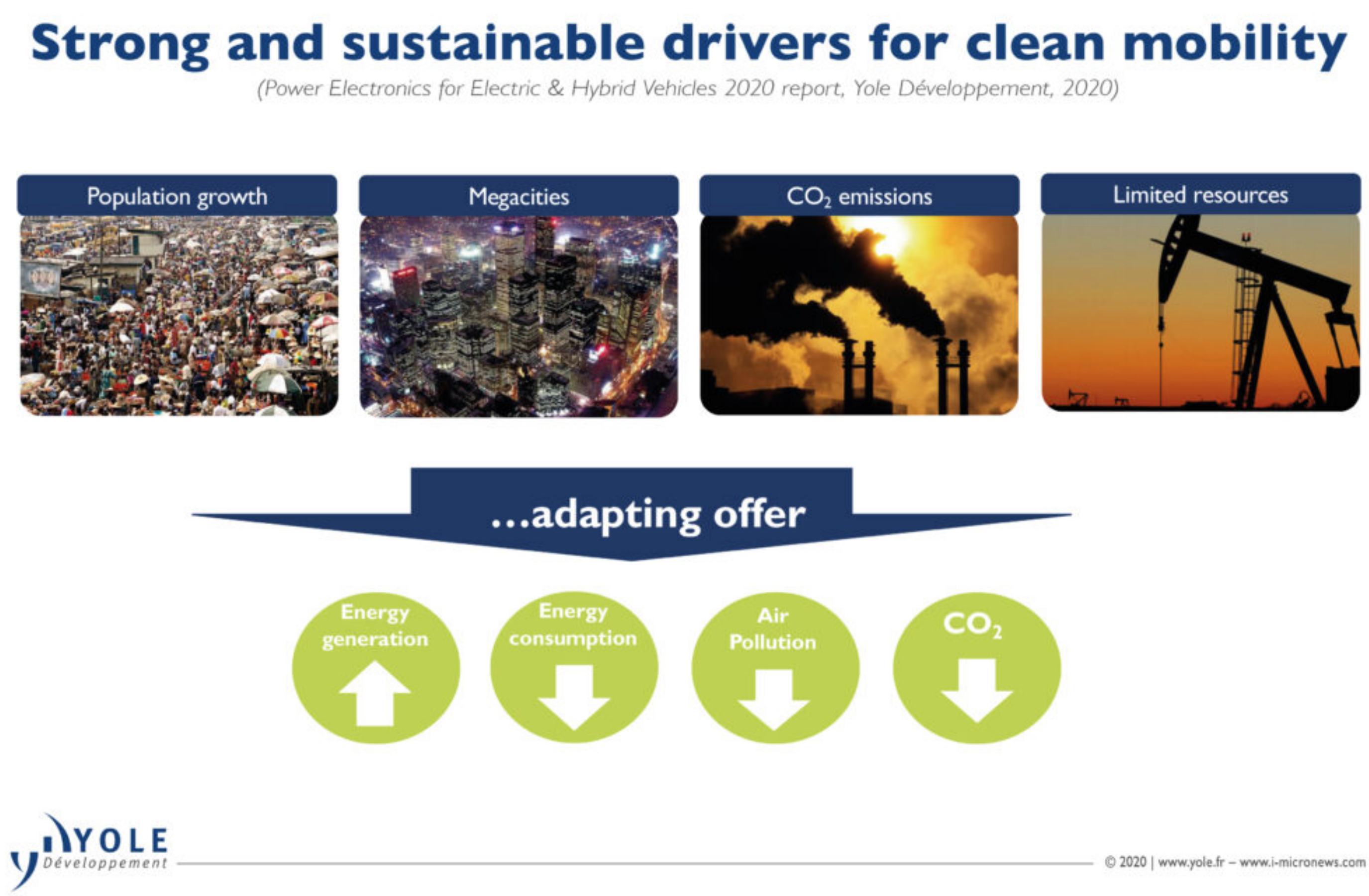

Fig. 1: Strong and sustainable drivers for clean mobility.

After a period "paving the way" dominated by a few EV/HEV players, we have entered a period of massive deployment of EV/HEVs by historical car makers. Customers have a growing choice amongst different vehicle suppliers, vehicle electrification types and vehicle models. Drivi
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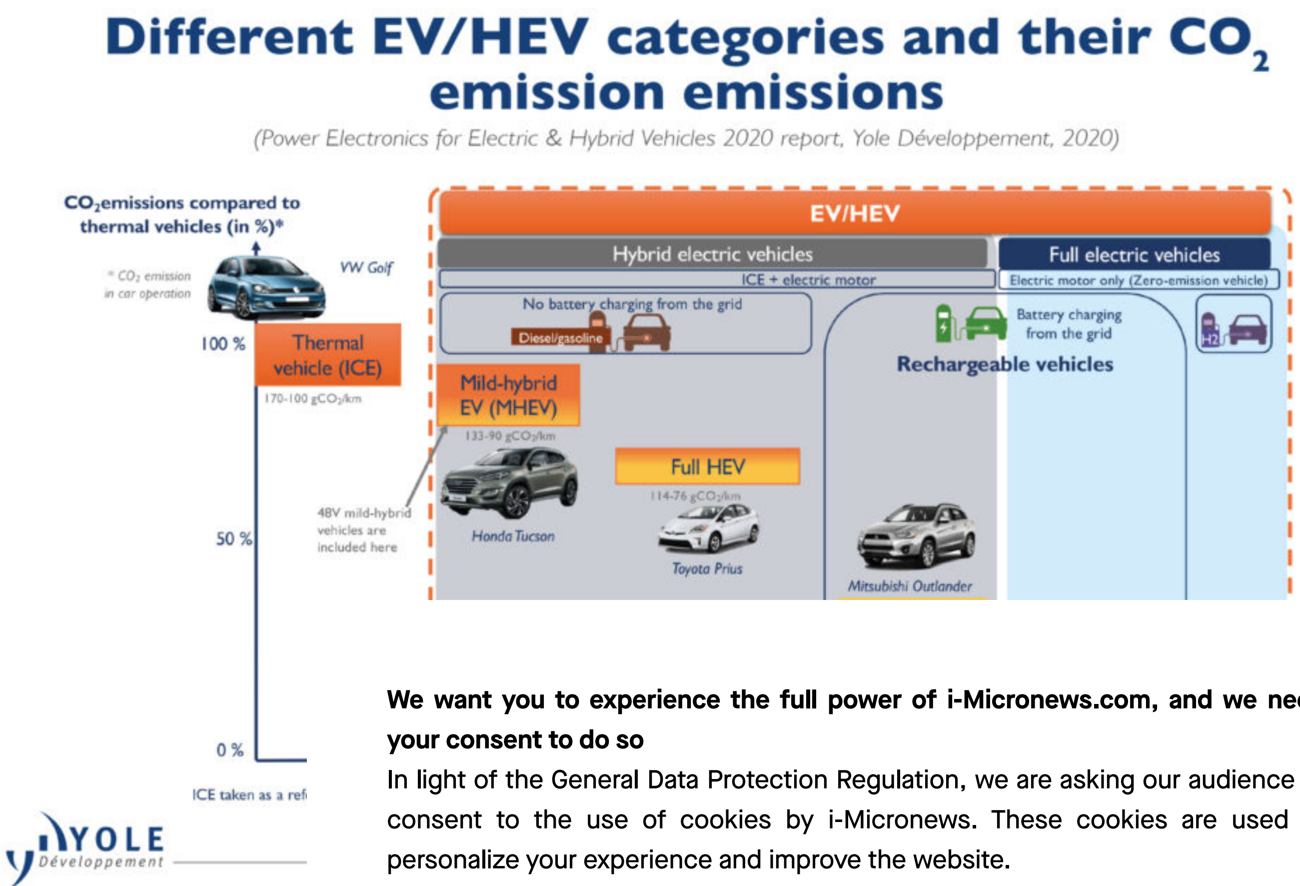
constraints. Traditional automotive OEMs are progressively adopting electrified vehicles at the risk of cannibalizing their ICE car sales. They have to bear the burden of existing ICE-related manufacturing facilities, employees, distribution and sales networks and have to build new know-how and capacity to manufacture electric vehicles. The whole automotive supply chain has to be rebuilt and this will take some time. A transition period exists where vehicles with different levels of electrification are offered to customers (Fig2). Hybrid electric vehicles offer various levels of CO_2 emission reductions compared to an ICE vehicle, from a few per cent for mild-hybrid electric vehicles (MHEV) up to about 50% for plug-in hybrid electric
vehicles (PHEVs).



In the past, the EV/HI
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governmental CO_2 emission reduction targets, improvements of Li-ion batteries and their cost reduction as well as many other factors (Fig.3), the automotive industry is following a "stronger electrification" trend – an accelerated transition toward vehicles with longer electric mode driving range (mileage): PHEVs and BEVs. Indeed, PHEVs and full EVs offer the significant reduction of CO_2 emission so needed by car makers to reach CO_2 emission reduction targets.

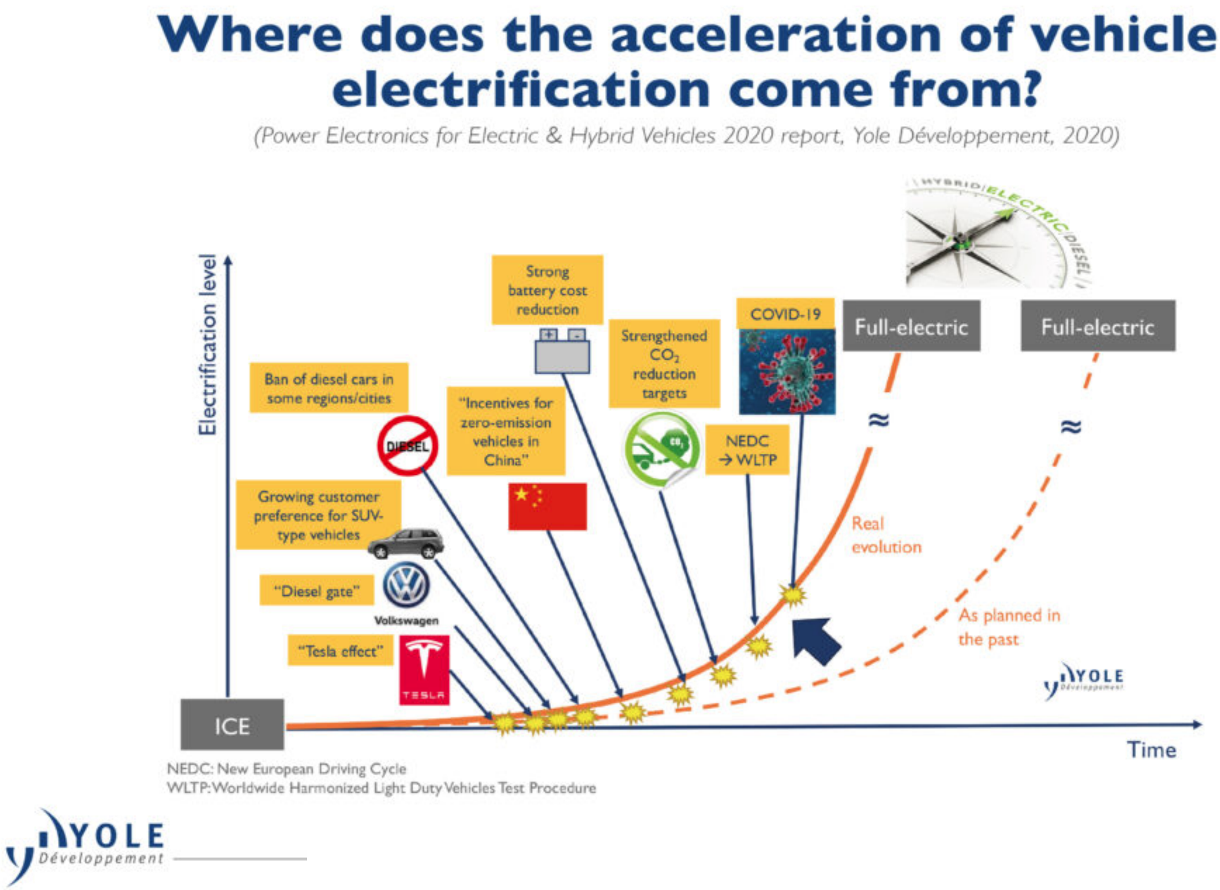

Fig: 3. The initial stra

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integrated in a vehicle, still represent a tiny part of the global EV/HEV market and will likely remain so. In the case of a fuel-cell electric vehicle, electricity is generated by a fuel cell stack using hydrogen. Several car makers, such as Toyota and Hyundai, are pushing fuel cell vehicles as a zero-emission transportation solution. Hydrogen, which is today produced mainly from fossil fuels, can be generated by electrolysis from renewable energy sources. The hydrogen approach for clean transportation has the advantage of fast car refueling (about 5 to 10 minutes), faster than the time to recharge a typical EV battery. But fuel-cell cars cannot be refueled at home and the overall energy efficiency is significantly lower compared to direct electricity use in the vehicle. The competition for fuel-cell vehicles with PHEV and BEV is tough. The high number of players involved in the development of battery and EV technology, resulting in rapidly improving battery and battery charging technologies together with decreasing battery costs play in favor of battery-powered passenger electric vehicles. It is worth pointing out that FCEVs also have a high-voltage battery and several power electronic systems, including traction inverters, boost converters and DC-DC converters, which can be found in hybrid electric vehicles. FCEVs thus represent an opportunity for both hydrogen and fuel-cell stack suppliers as well as power electronic suppliers.

Let us analyze in more depth the environmental aspects of electric vehicles. Electric vehicles are considered as clean mobility. But are they so clean? Of course, in contrast to an internal combustion engine (ICE) vehicle, neither CO_2 nor NO_x emissions are generated by full electric vehicles or by PHEV driving in full e-mode. But electricity to charge

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and difficulties with the integration of renewable electricity sources with the grid. On the electricity consumption side, the charging of a huge number of PHEVs/BEVs at the same time would result in a strong and peaky demand on grid electricity, which might lead to grid instability and even grid failure. A smart integration of PHEV/BEV charging solutions with electricity generated from PV and wind is therefore needed. Where are the synergies to be found and what benefits would such integration bring?

PHEVs and BEVs contain batteries with relatively large capacity, about 9 to 15kWh and 25 to 100 kWh, respectively (Fig4). Therefore, a significant amount of electricity generated by a residential PV roof system could be stored in the EV battery. A large portion of PV generated electricity can therefore be consumed locally – either directly to supply power to house appliances or to charge the electric car, minimizing the issue with its integration into the grid.

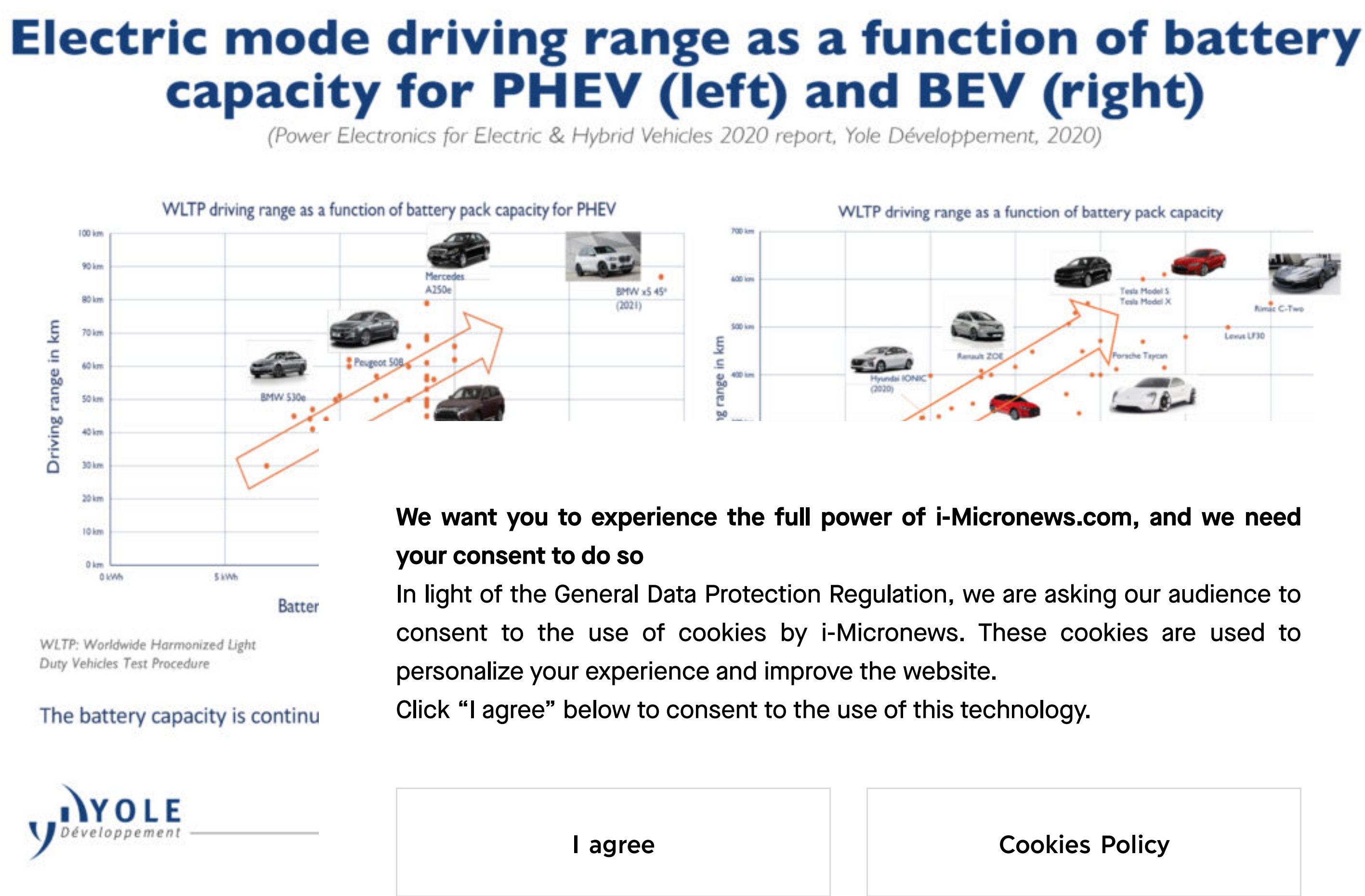

Fig. 4: Electric mo

BEV (right). The battery capacity is continuously increasing, thus achieving longer driving range, as indicated by the arrows.

In the case of bi-directional EV/PHEV charging solution, energy from the car battery can be used in the house (Vehicle-to-Home or V2G). In the case of a vehicle fleet, the electricity from numerous batteries can be supplied to the grid (Vehicle-to-Grid or V2G), providing grid services such as energy arbitrage, frequency regulation, voltage support, reserve capacity and transmission & distribution deferral.

The PHEV/BEV battery capacity (9 to 100 kWh) is much larger than the capacity of a typical battery used in residential energy storage systems (1 – to 5 kWh) and is continuously increasing. So, under certain conditions, the PHEV/BEV battery can substitute the need for an additional stationary battery storage system, such as a system used during electricity grid failure or at remote sites without access to the grid.

The synergies between BEV/PHEV charging solutions and renewable energy generation motivate power electric players to develop combined solutions, such as bidirectional EV chargers or PV inverters with energy storage or EV charging options. On a larger scale, the synergies can be used in solutions such as microgrids, smart charging and solar charging stations. The power electronic solutions initially developed for EV/HEV can be adapted for other markets, such as charging infrastructure.

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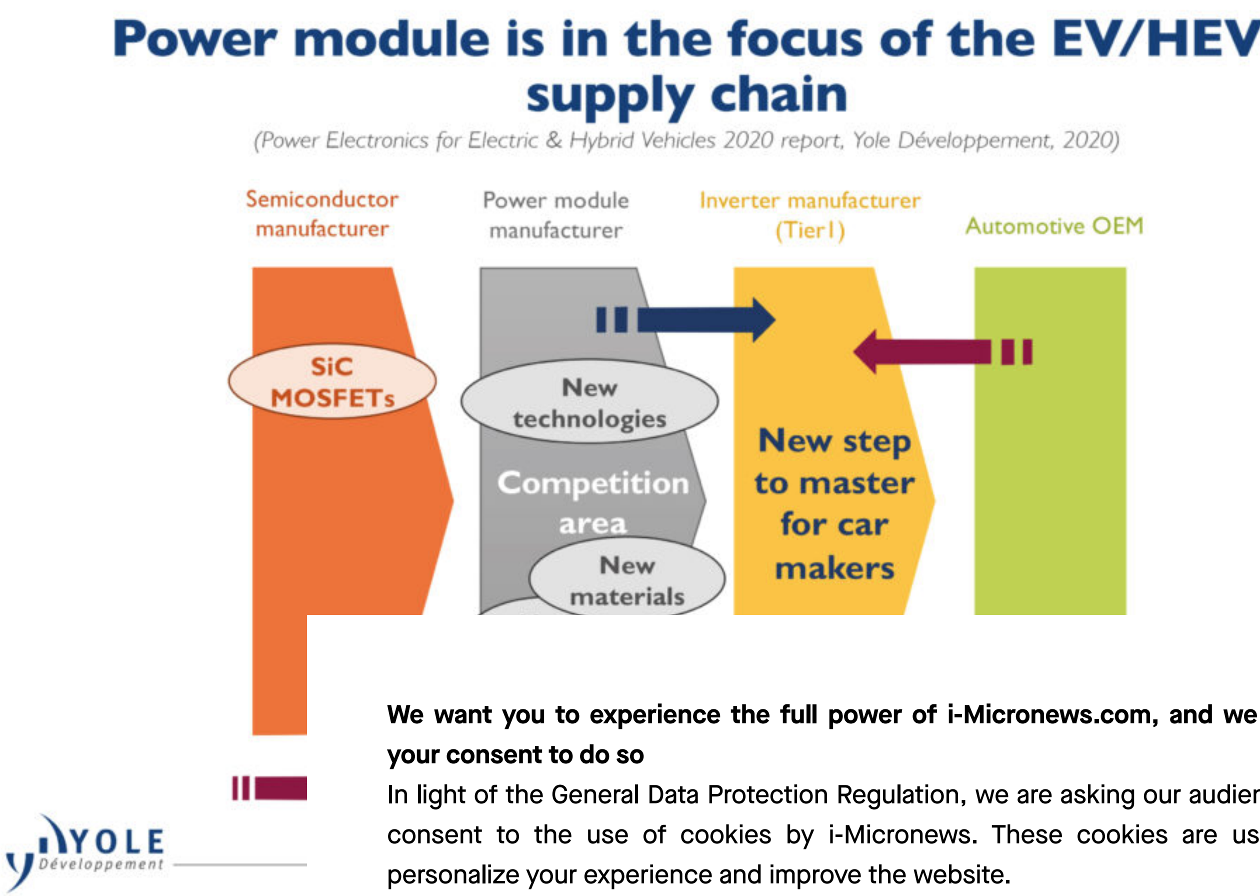
traction inverters, on-board chargers, and DC-DC converters, EV/HEV is driving innovations in power electronics. Due to their severe space constraints, power density requirements and strong need for reliability, EV/HEVs require extensive innovation especially in the design of power modules for traction inverters, which is the main power market segment for EV/HEV.

The rapidly growing power electronic device market attracts interest of different players in the EV/HEV supply chain. With a strong focus on power modules, changes in business models and a re-shaping of the supply chain are expected (Fig6).



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change of voltage ranking of components used: from components rated at 650 – 750V, one moves to 1,200V rated components. Integrated solutions, such as electric axle where motor, gear and traction inverter are integrated in one compact system, require enhanced cooling solutions and optimized electrical interconnections.

The introduction of SiC technology is pushing the development of new power device packaging solutions, since SiC devices can work at higher junction temperatures and higher switching frequencies with smaller die sizes. Power module packaging solutions are moving toward high-performance materials and a reduction in the number of layers, size, and interfaces, while conserving electrical, thermal, and mechanical characteristics.

Three main trends are observed in power module technology development and optimization: power module design, materials, and processes used. Indeed, while the choice of power module material and its design are primordial for device performance, the "design for manufacturing" is crucial to reduce the costs. The choice of different technology approaches is often interlinked.

In terms of substrate, the most common choice for power module packaging is Al_2O_3 DBC (direct-bonded copper). The industry is moving toward materials offering better mechanical stability and higher thermal conductivity (e.g. Si_3N_4, AMB). In order to make the power module package more stable thermally, and to take advantage of SiC's properties, reliable and robust die attach is required. Therefore, the use of silver sintering is increasing, both in

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Electric vehicles have become an inevitable part of sustainable energy transition toward clean energy sources. But there is still a lot of work to do to fully benefit from all synergies and to improve the EV/HEV environmental impact by offering highly efficient and optimally matched power electronic solutions.

This article has been written in German for Automobil Elektronik – 2020 (Publisher: Huthig).

About the authors

Milan Rosina, PhD, is Principal Analyst, Power Electronics and Batteries, at Yole Développement (Yole), within the Power & Wireless division. He is engaged in the development of the market, technology and strategic analyses dedicated to innovative materials, devices and systems. His main areas of interest are EV/HEV, renewable energy, power electronic packaging and batteries.

Milan has 20 years of scientific, industrial and managerial experience involving equipment and process development, due diligence, technology, and market surveys in the fields of renewable energies, EV/HEV, energy storage, batteries, power electronics, thermal management, and innovative materials and devices.

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company ENGIE in Fr

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(Yole). She is involved

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reliability analysis (MOSFET, IGBT, HEMT, etc). In addition, Ana is leading the quarterly power management market updates released in 2017.
Previously Ana was involved in a high-added value collaboration related to SJ Power MOSFETs, within the CNM research center for the leading power electronic company ON Semiconductor. During this partnership and after two years as Silicon Development Engineer, she acquired a relevant technical expertise and a deep knowledge of the power electronic industry.
Ana is author and co-author of several papers as well as a patent. She holds an Electronics Engineering degree completed by a Master and PhD. in micro and nano electronics from Universitat Autonoma de Barcelona (SP).

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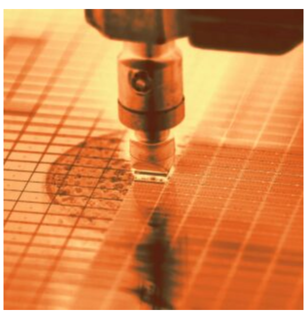

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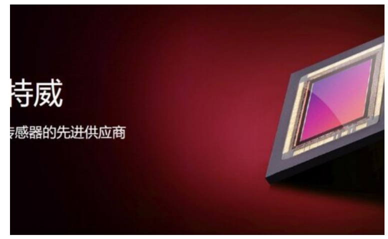

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