Powering the EV Revolution

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Editor-in-Chief of Power Electronics News, AspenCore

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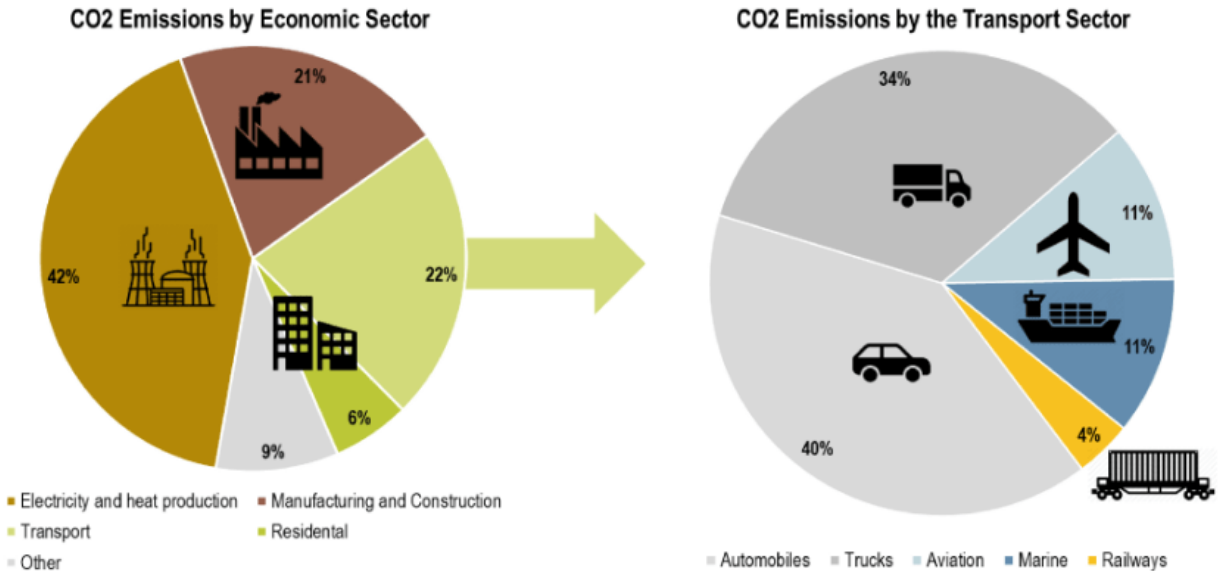
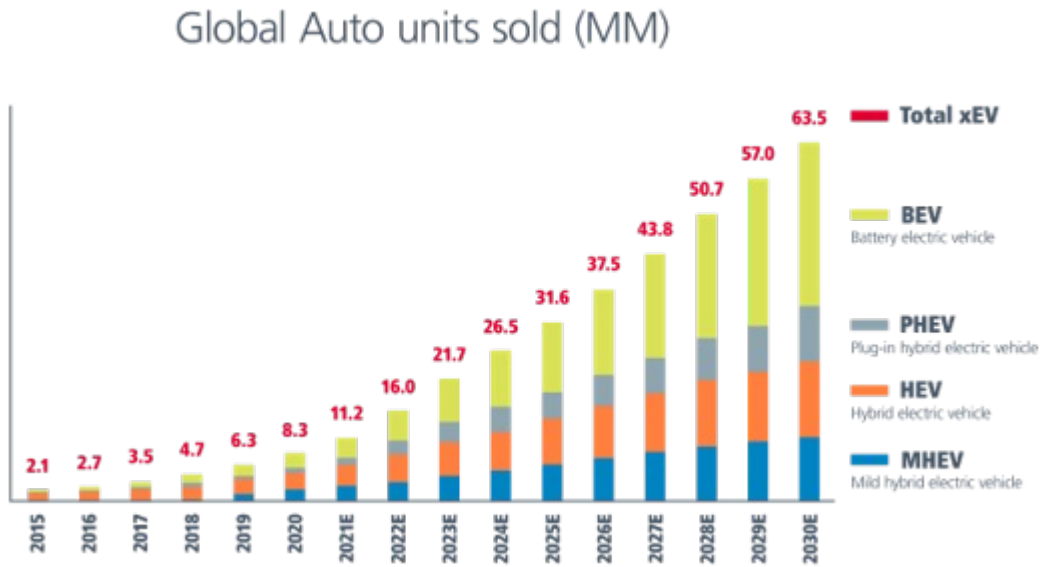
Energy Trends

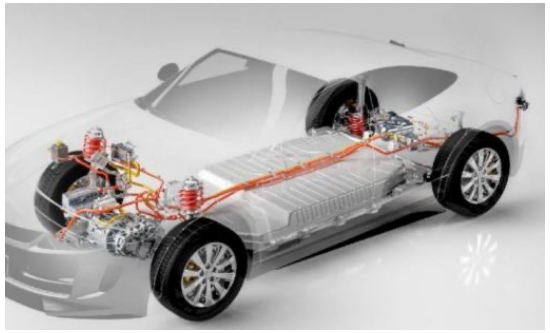


Source: International Energy Association



By 2030, battery electric vehicles (BEV) will account for 45% of all xEVs (Source: Credit Suisse estimates.)

To increase sustainability, electrification of mobility is inevitable in both, private and public transport segment.



Source: Texas Instruments

Key trends and issues for EVs development

Improving powertrain efficiency

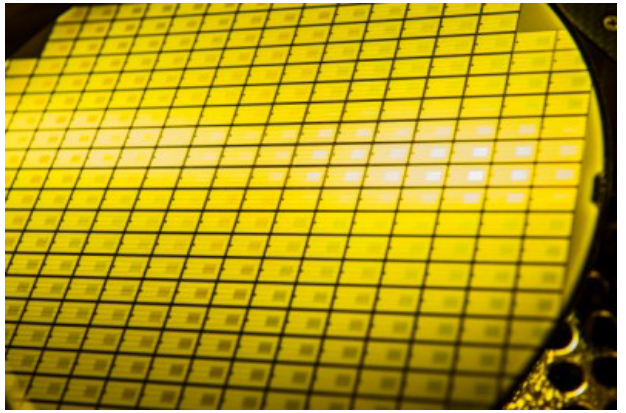
EV Infrastructure is improving

Regulations

Costs

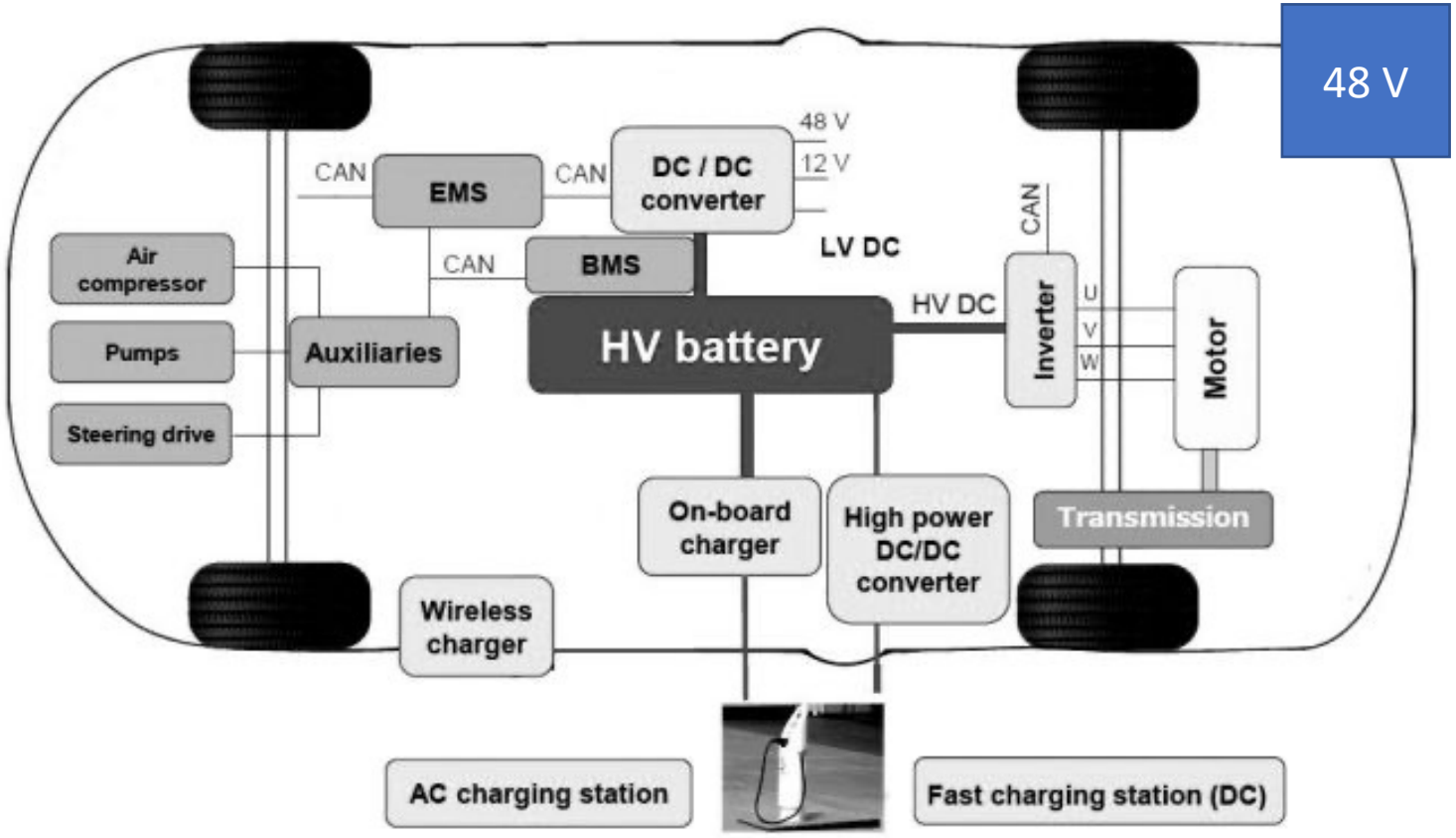
EV purchase price and driving range are the biggest hurdles to wider consumer adoption.

Power Semiconductors enable automakers to optimize performance, accelerate development and make EVs more affordable.



Source: STMicroelectronics

Powertrain



Source: Texas Instruments, https://www.powerelectronicsnews.com/benefits-of-sic-mosfet-in-powertrain-inverter-for-automotive-applications/

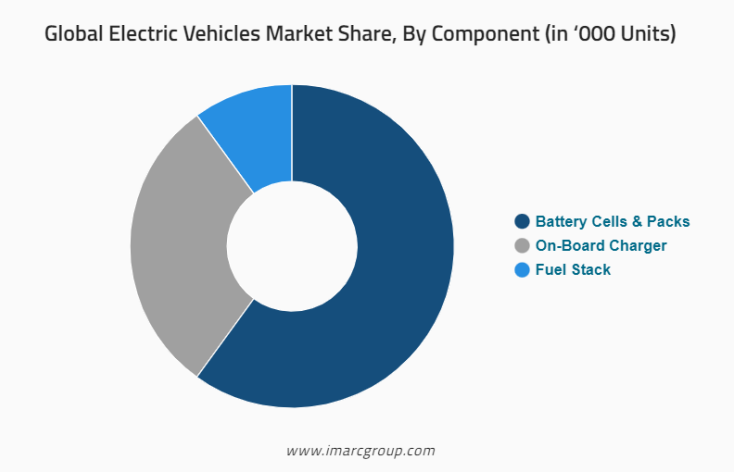
EVs have 90% fewer moving parts than an ICE (Internal Combustion Engine) car.

Electric Motor - Provides power to rotate the wheels.

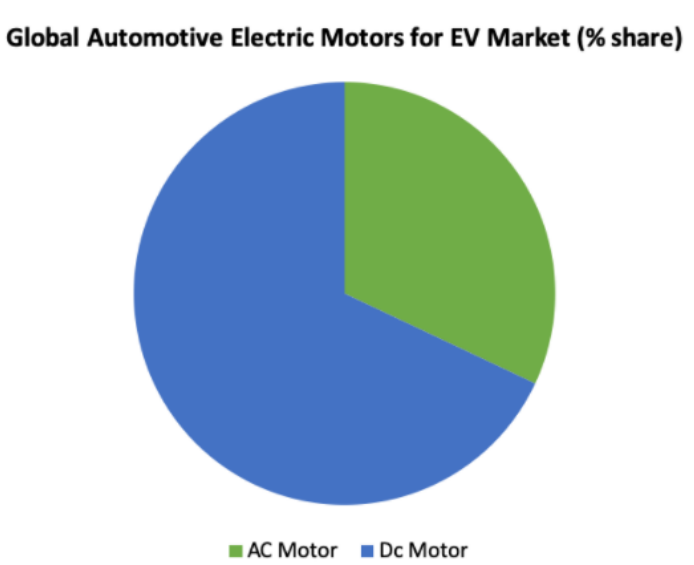
Inverter - Converts the electric current in the form of Direct Current (DC) into Alternating Current (AC)

Batteries - Store the electricity required to run an EV. The higher the kW of the battery, the higher the range.

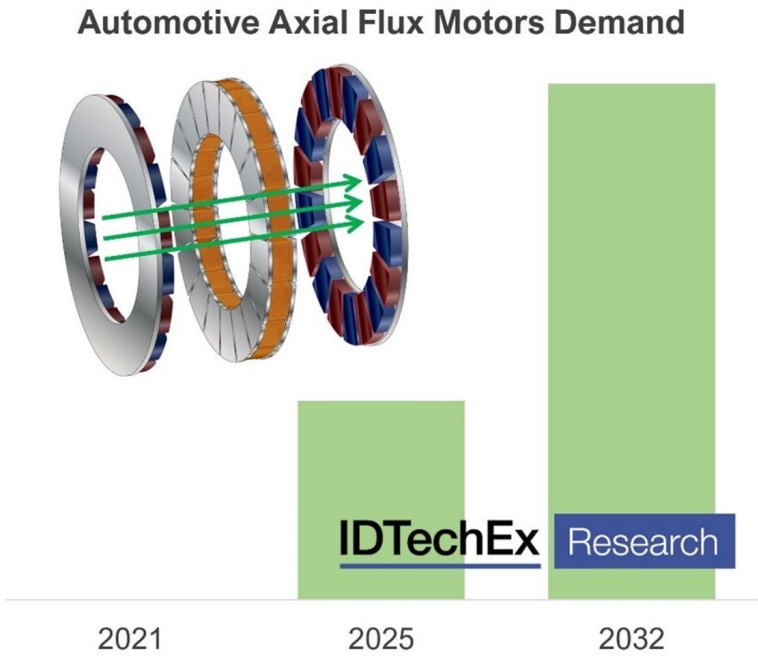
Charging - Plug into an outlet or EV charging point to charge your battery.

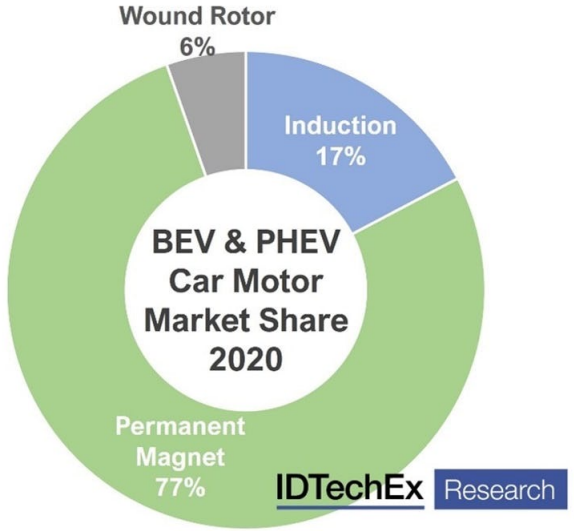


Electric Motor



**Source: DataM Intelligence Analysis



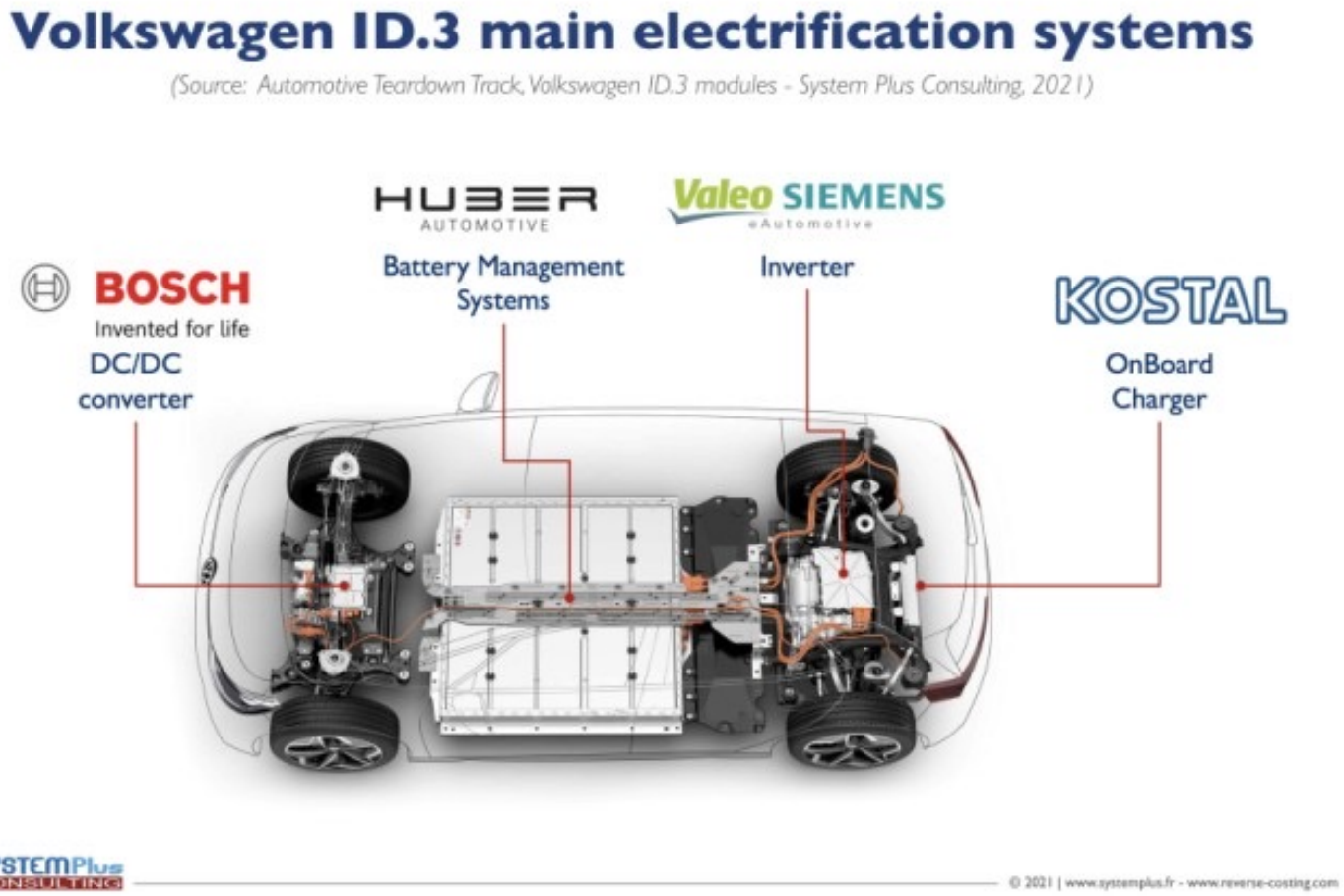


Electric motors truly are the driving force of electric vehicles (EVs). In addition to the batteries and power electronics, the electric motor is a critical component within the drivetrain.

A key emerging motor technology is that of axial flux. The magnetic flux is parallel to the axis of rotation in an axial flux motor (compared to perpendicular in radial flux machines).

A key consideration for the EV motor market is that of magnetic materials.

Powertrain: Volkswagen (VW) ID.3



Three battery sizes are available:

- 45 kWh (with a range up to 330 km),
- 58 kWh (with a range up to 420 km), and the largest,
- 77 kWh with a 550-km range.

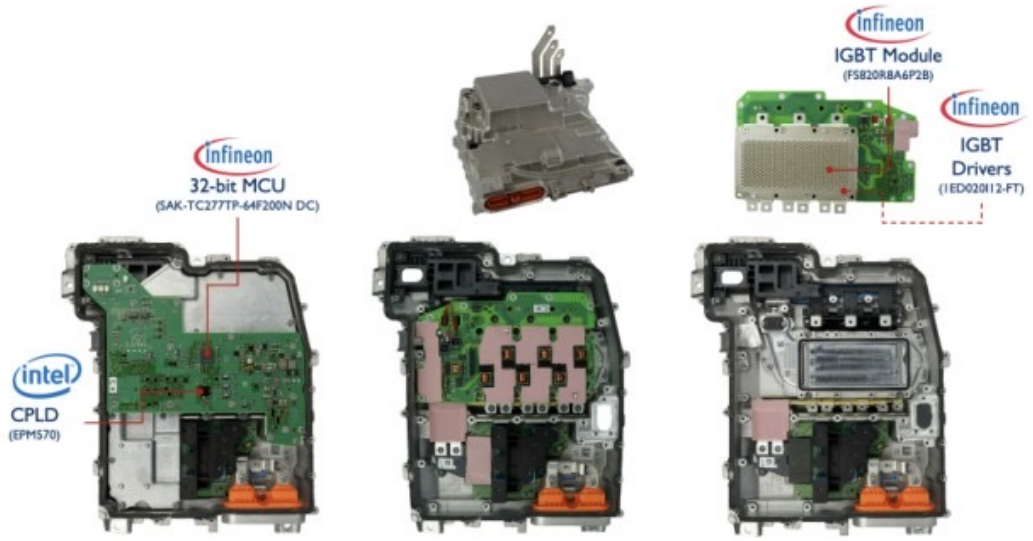
The latter has 12 modules, each of which consists of 24 lithium-ion cells. It operates at 408 V and can also be recharged with direct current, up to 125 kW.

For More Information: https://www.electronicproducts.com/under-the-hood-vws-id-3-electric-vehicle/

Powertrain: Volkswagen (VW) ID.3

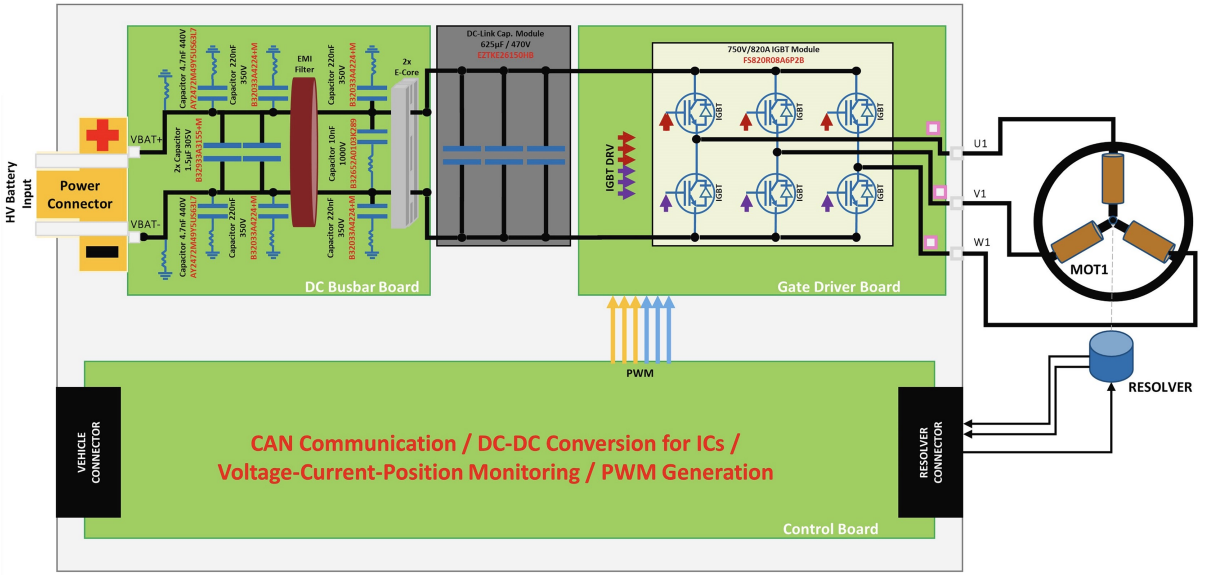
Volkswagen ID.3 inverter disassembly

(Source: Automotive Teardown Track, Volkswagen ID.3 modules - System Plus Consulting, 2021)



Volkswagen ID.3 inverter block diagram

(Source: Automotive Teardown Track, Volkswagen ID.3 modules - System Plus Consulting, 2021)



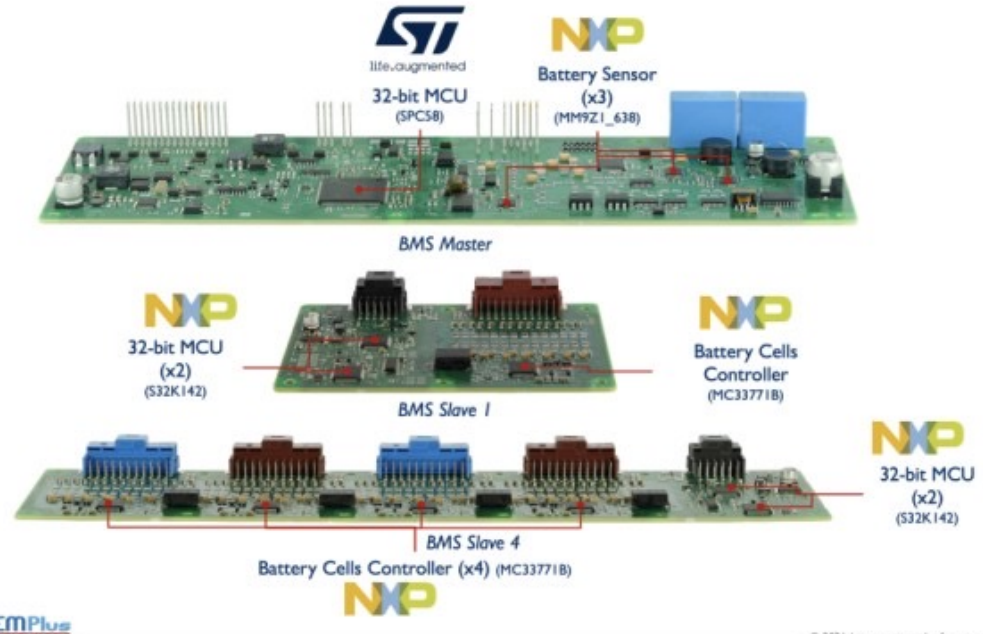
Powertrain: Volkswagen (VW) ID.3

Volkswagen ID.3 On-Board charger disassembly

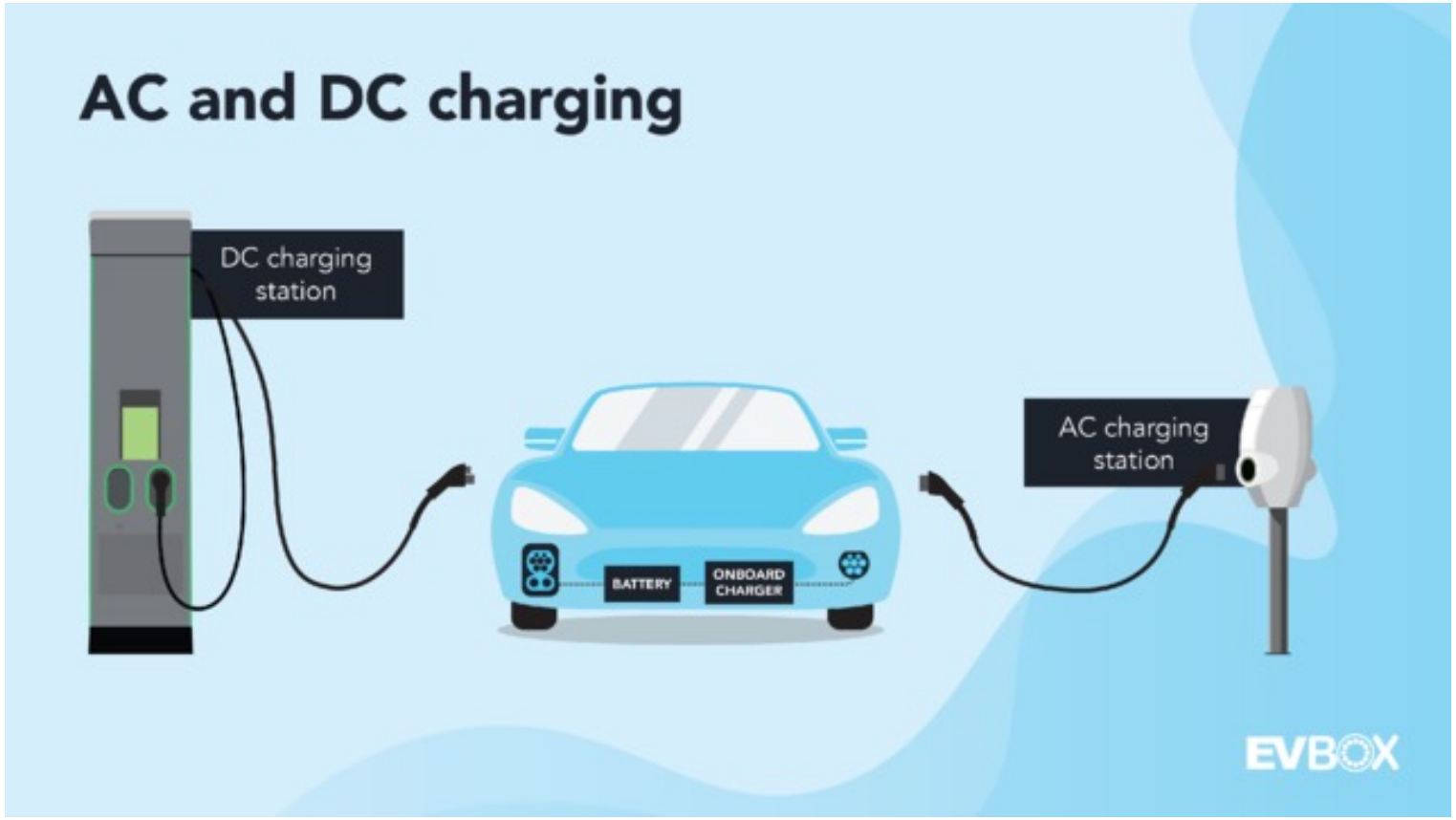
(Source: Automotive Teardown Track, Volkswagen ID.3 modules - System Plus Consulting, 2021)

Volkswagen ID.3 battery management system (BMS)

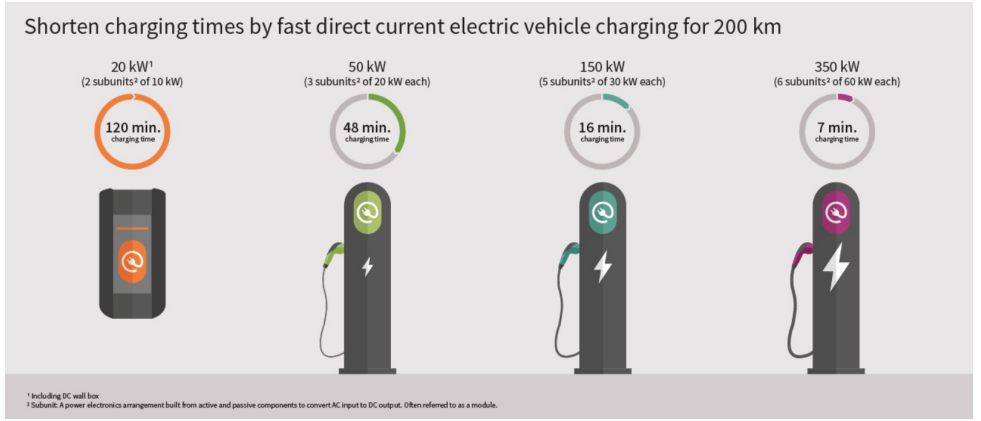
(Source: Automotive Teardown Track, Volkswagen ID.3 modules - System Plus Consulting, 2021)



Charging Stations



Source: https://blog.evbox.com/



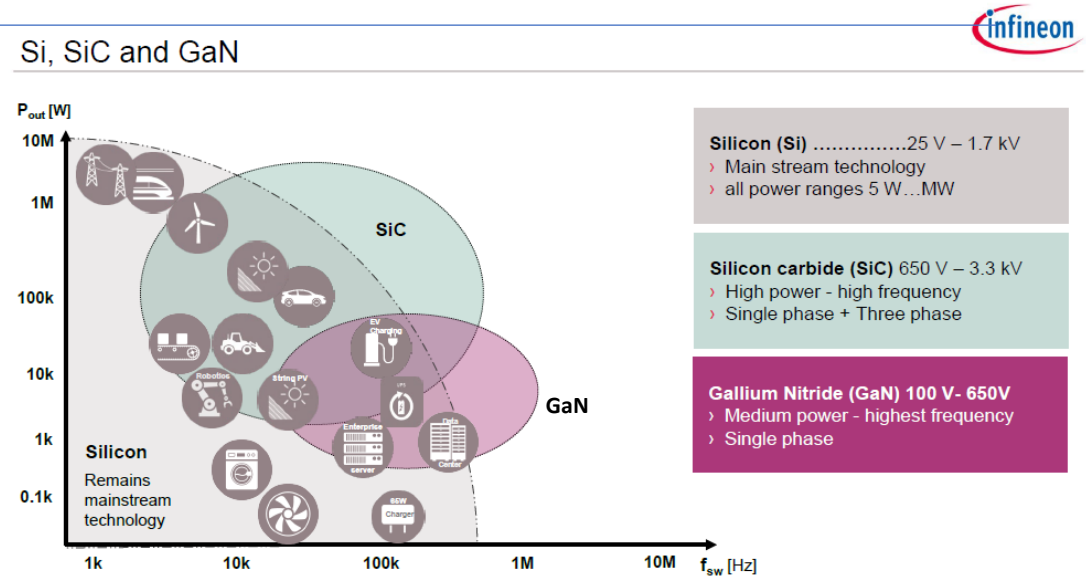
Source: https://www.infineon.com/cms/en/applications/industrial/fast-ev-charging/

A high-power DC charger converts an incoming three-phase AC power into the DC voltage required by the vehicle's battery

Wide bandgap Semiconductors

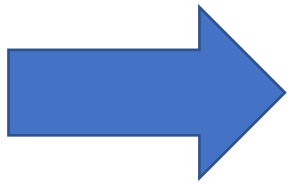
	Si	SiC-4H	GaN
Bandgap	1.1 eV	3.25 eV	3.4 eV
Electron mobility μ_n (cm^2/V s)	1,450	950	1,200
Breakdown Electric Field E_{br} (MV/cm)	0.3	3	3.3
Saturation electron drift velocity v_s (10^7 cm/sec)	1	2	2.2
Thermal Conductivity Θ (W/cm K)	1.5	4.9	2.3
Maximal Operation Temperature (°C)	125	500	650

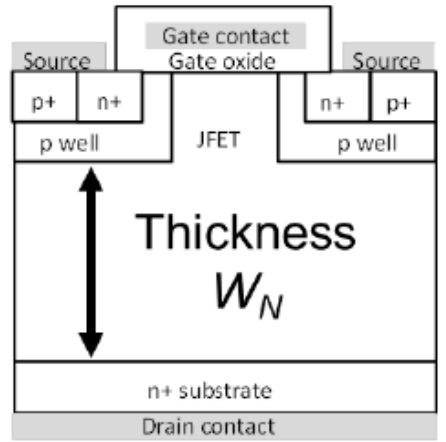
Source: STMicroelectronics



WBG semiconductors such as GaN and SiC offer significant performance improvements and allow operating with efficiency and reliability even in the most severe conditions.

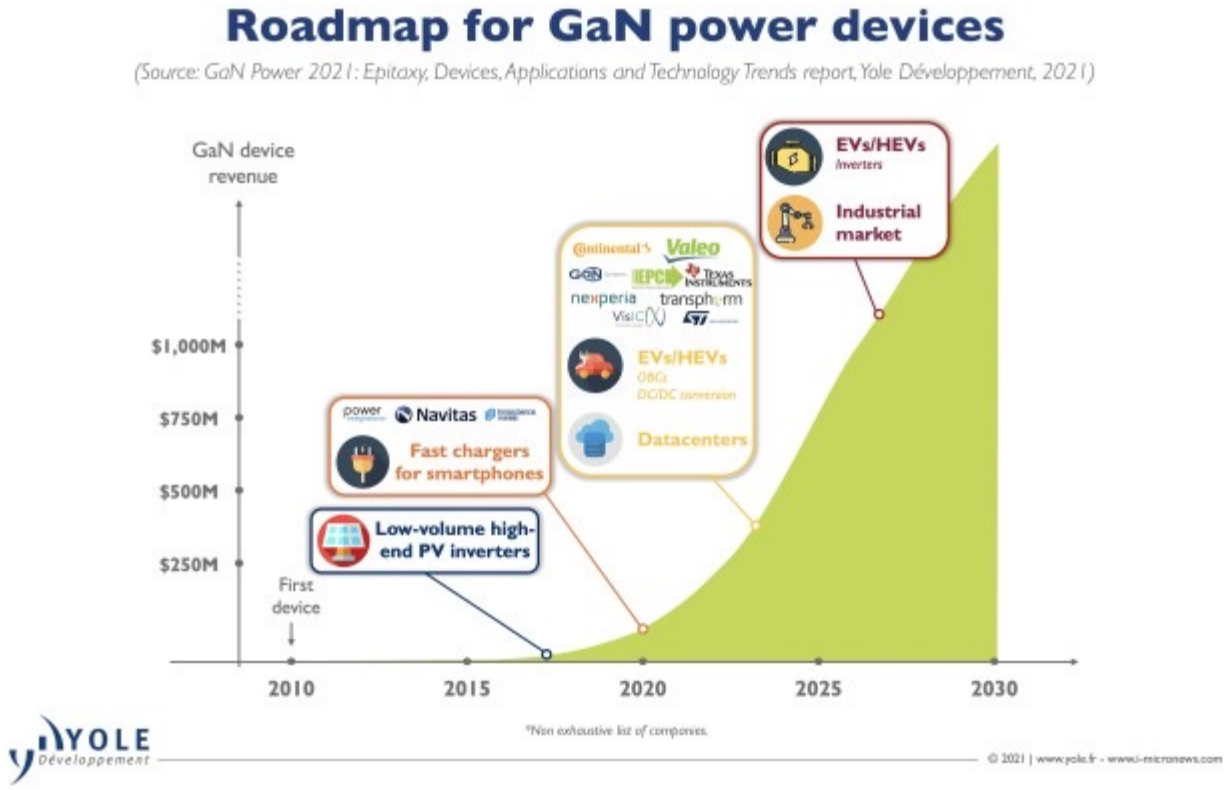
- lower on-resistance
- higher breakdown voltage
- higher thermal conductivity
- operation at higher temperatures
- greater reliability
- near-zero reverse-recovery time
- excellent high-frequency performance





Source: Victor Veliadis, PowerUP 2021

Wide bandgap Semiconductor: GaN



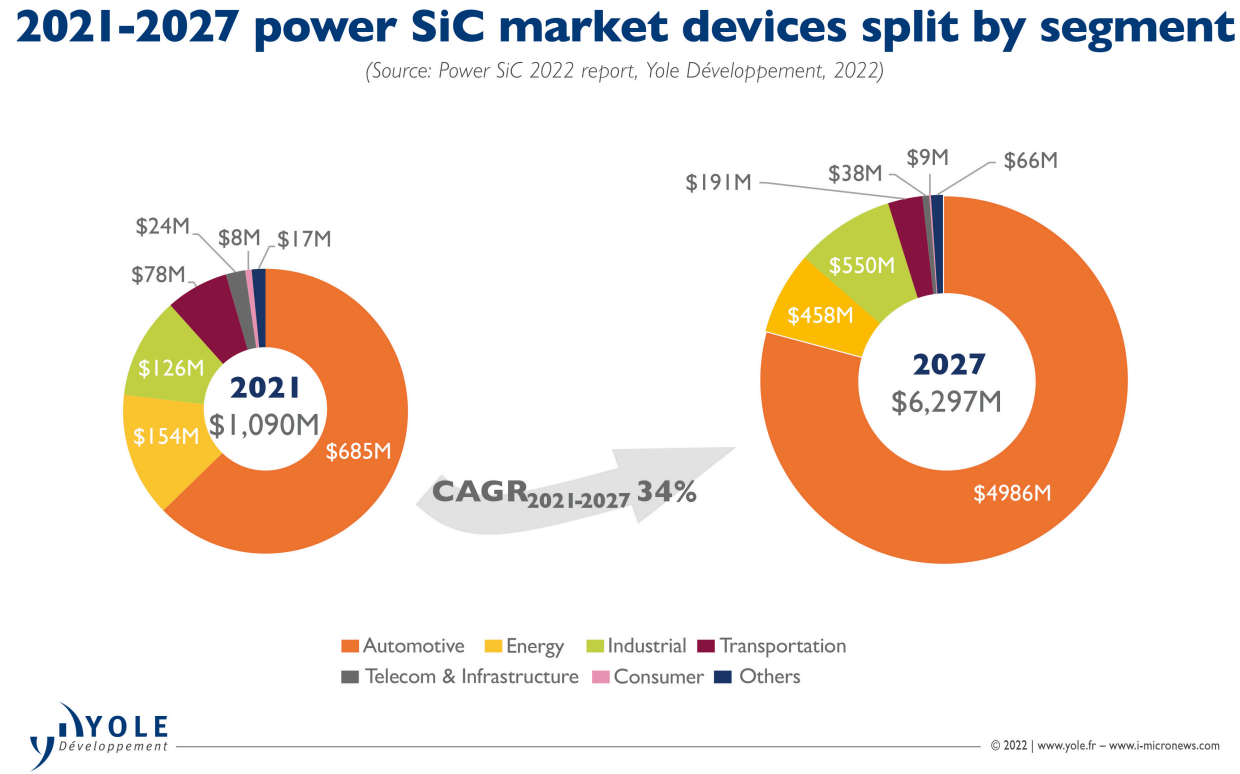
Source: https://www.powerelectronicsnews.com/gan-for-electric-vehicles/

OEMs are demanding these powertrain systems to deliver more and more power to reduce EV charging times but without an increase in their size, as the passenger space in the car cannot be compromised.

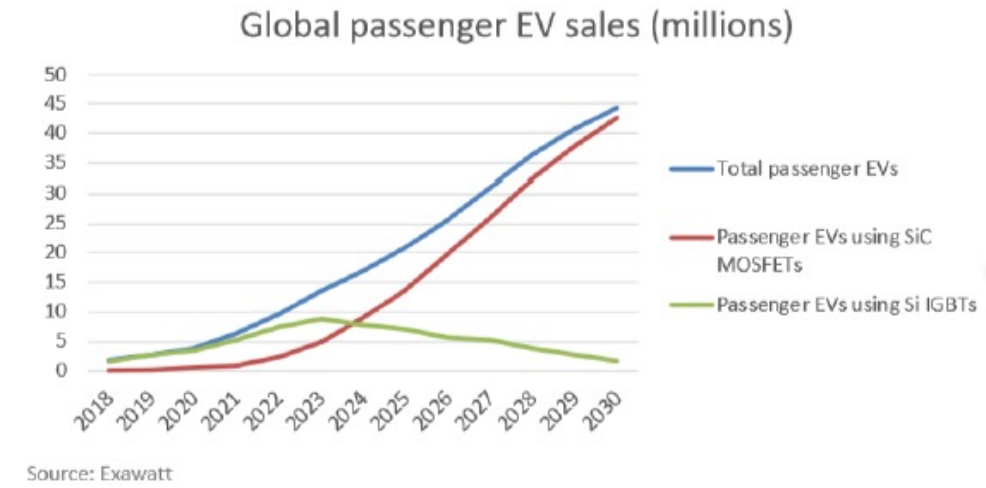
The key to achieving high power density is to maintain efficient operation at high switching frequencies.

Source: GaN Systems, https://www.powerelectronicsnews.com/electric-vehicle-inverters-get-gans-efficient-cost-effective-values/

Wide bandgap Semiconductor: SiC



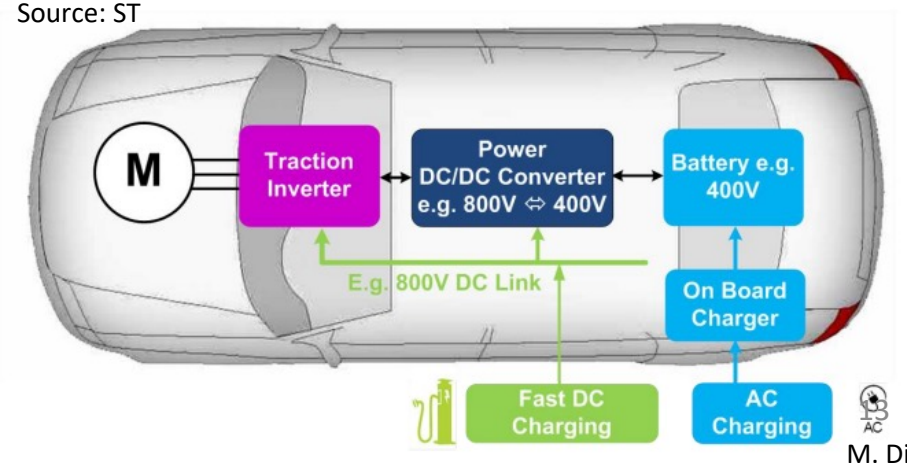
Thanks to Yole – For More Info: https://www.eetimes.com/sic-and-gan-a-tale-of-two-semiconductors/



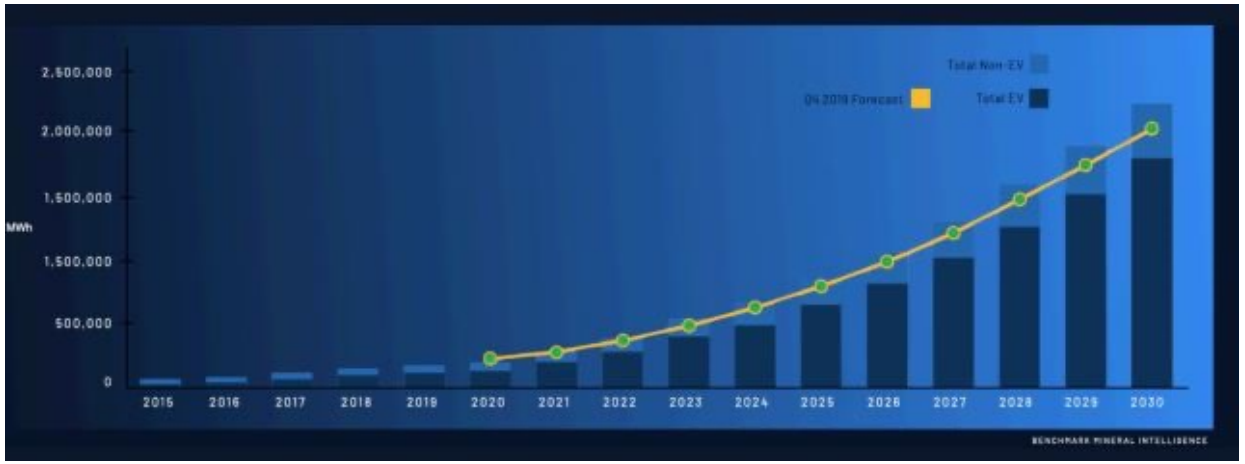
Presented by S. Lambert, Automotive EE Times Conference

- Traction Inverter
- HV DC-DC Converter
- On-Board Charger

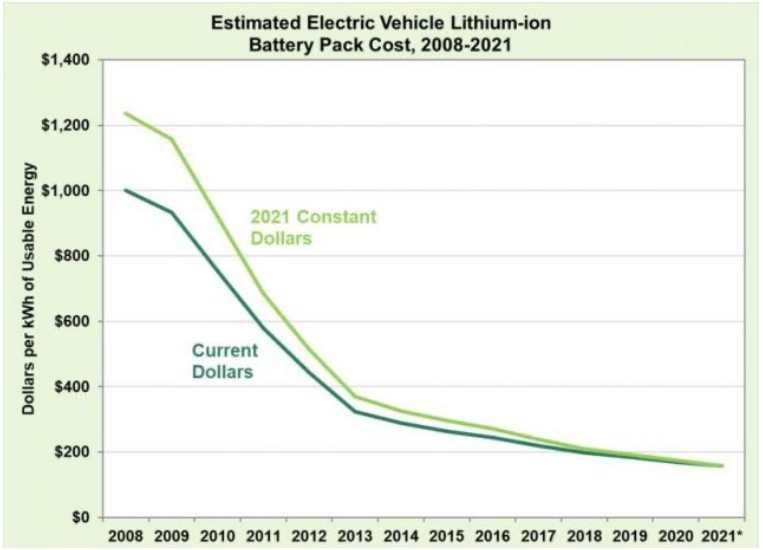
Source: ST



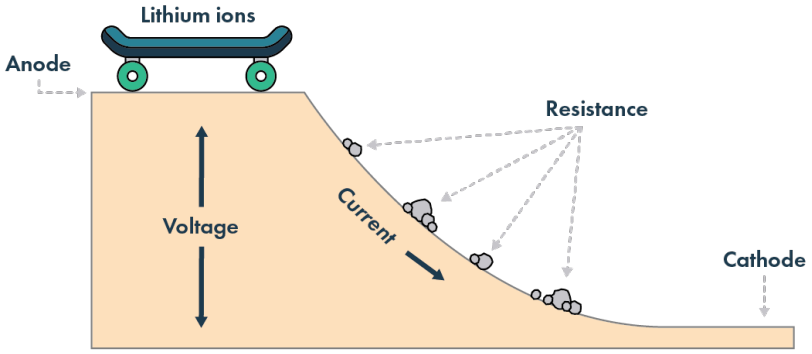
Battery



Battery demand growth (Source: OneD Battery Science)



Sources: 2018–2021 – U.S. DOE, Vehicle Technologies Office, using Argonne National Laboratory's BatPaC: Battery Manufacturing Cost Estimation Tool.



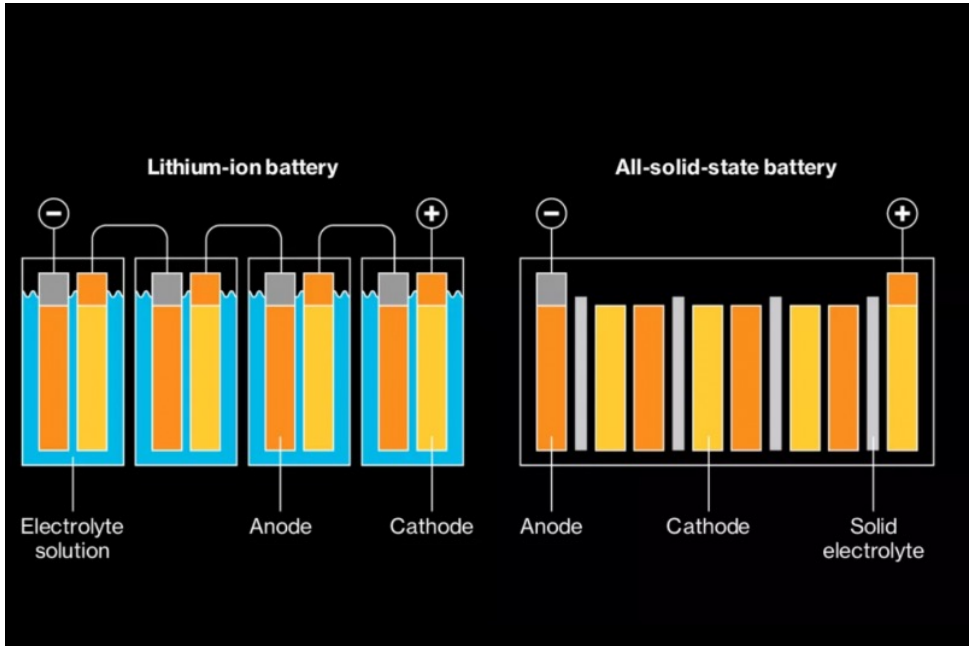
Source: www.quantumscape.com/

Some firms are pioneering novel materials for component cooling and battery chemistry, with the goal of achieving the best efficiency at the lowest working temperatures.

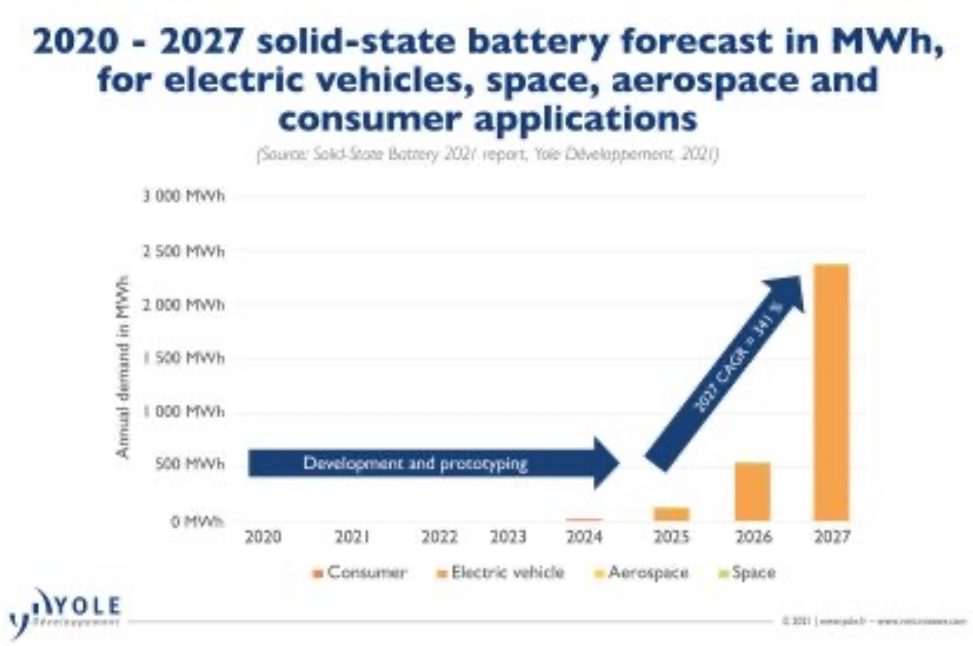
Most plug-in hybrids and all-electric vehicles use lithium-ion batteries like these.

The Swedish Energy Agency gives Stena Recycling SEK 70.7 million in support for the investment in a new battery recycling plant in Halmstad.

Solid State Battery



Source: www.carexpert.com.au



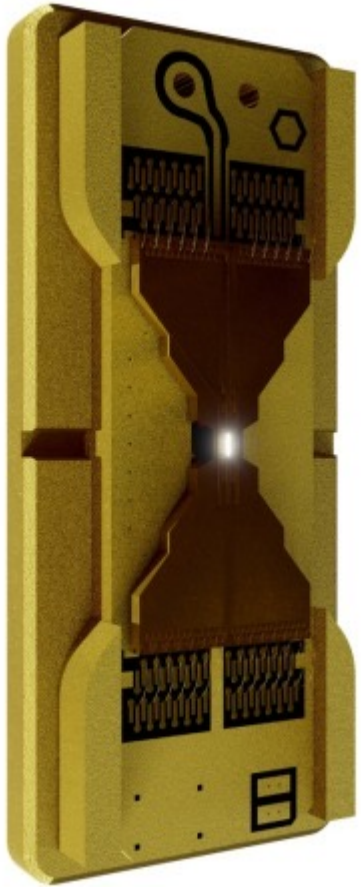
What are the advantages of solid state batteries ?

How are they different from lithium-ion batteries ?

Why is difficult to mass produce solid state batteries?

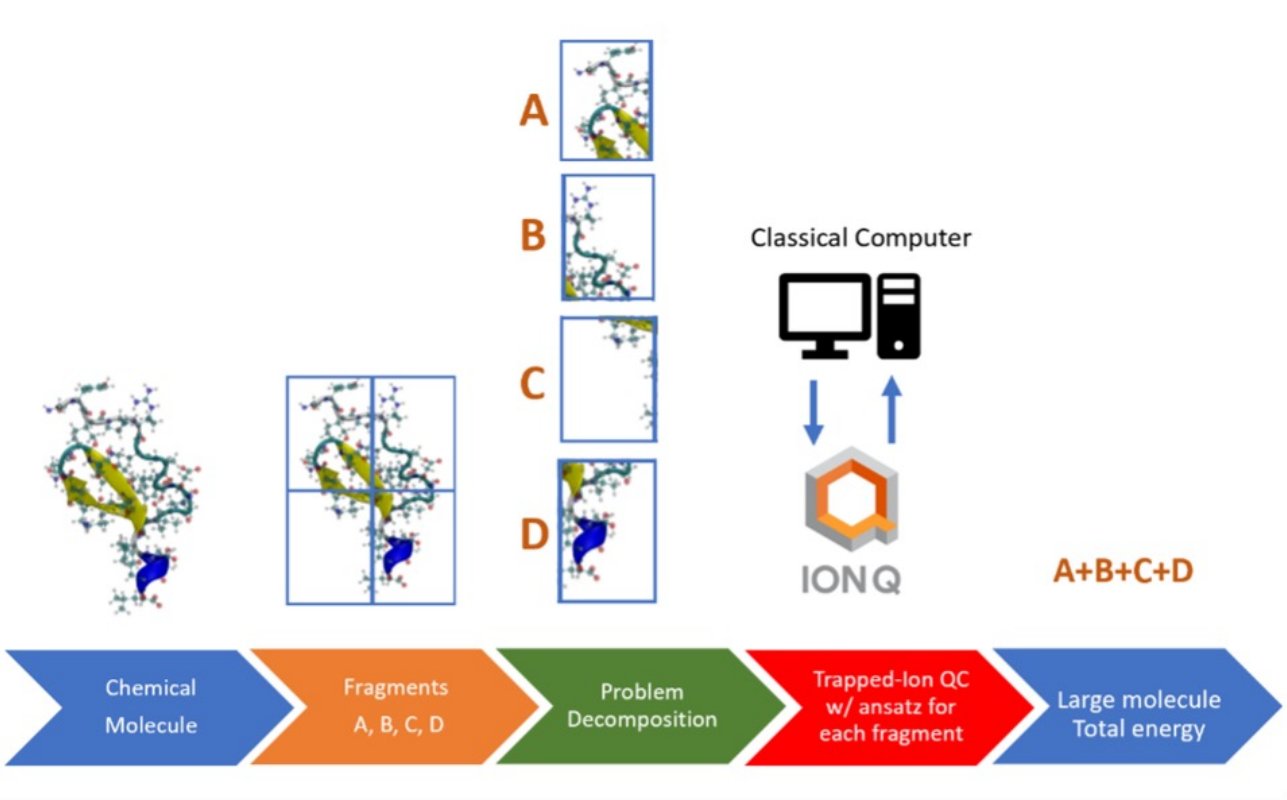
Who's trying to make them ?

Battery: Quantum Computer



IonQ ion trap device. (Source: IonQ)

Lithium-ion cells that power most EVs are based on raw materials, the mining of which can have serious environmental impact



For More Info: https://arxiv.org/abs/1902.10171 - Ground-state energy estimation of the water molecule on a trapped ion quantum computer

Battery: Lego Swapping

Battery Swapping Station (Source: Ample)

The lithium batteries in electric cars still take a certain amount of time to recharge, depending on the capacity of the battery or the charging infrastructure available, whether we charge in AC or DC.

For quicker recharging, there is the possibility of replacing the battery on the fly, an operation that takes much less time, but to perform this “Battery Swapping” operation, the battery housing on the car must be designed in a special way.

Battery Module (Source: Ample)

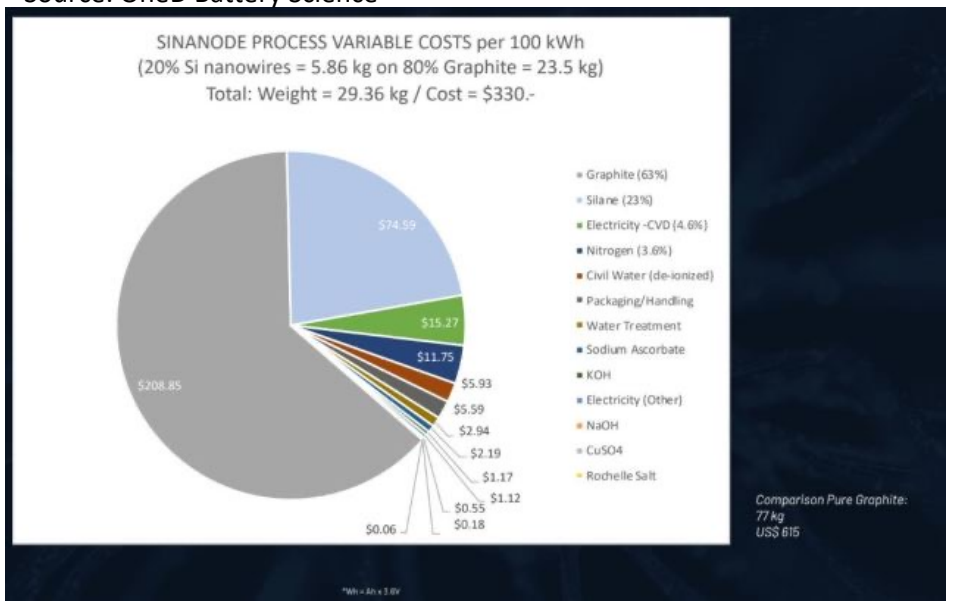
Battery: Material

Source: Addionics

By moving to 3D electrode designs, batteries can achieve three key performance improvements: increased energy density, lower internal resistance, and safer and longer-lasting performance due to better heat dissipation and higher mechanical stability.

For More Info: https://www.powerelectronicsnews.com/a-novel-physical-design-enables-next-generation-batteries

Source: OneD Battery Science

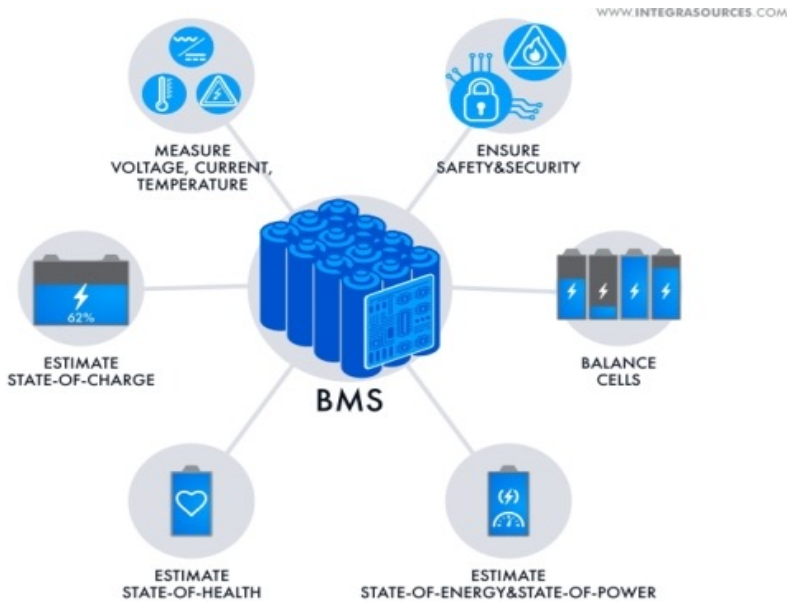


SINANODE, a step in the battery manufacturing process that fuses silicon nanowires onto commercial graphite powders used in the anodes, increases energy density and lifetime while reducing costs of EV batteries.

- Low surface area
- Electrically connected
- No inactive materials

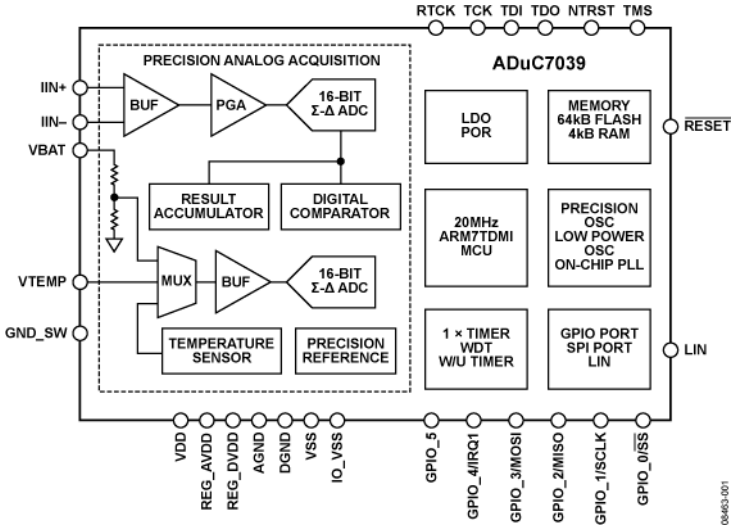
For More Info: https://www.powerelectronicsnews.com/nanosilicon-graphite-anodes-increase-efficiency-of-next-gen-ev-batteries/

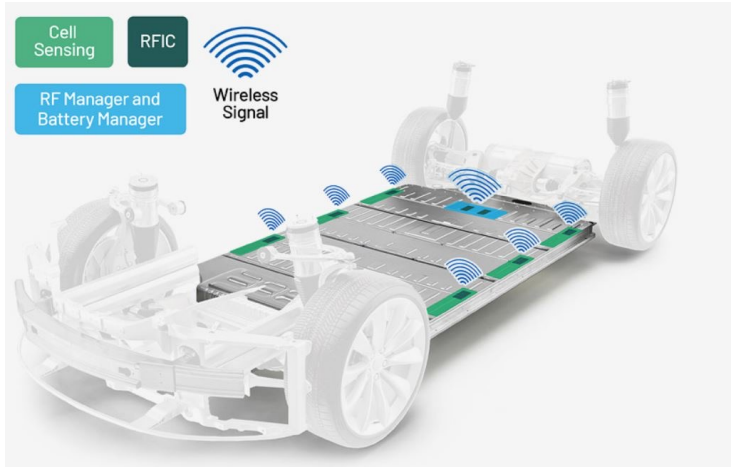
Battery Management Systems



(Source: Integra Sources)

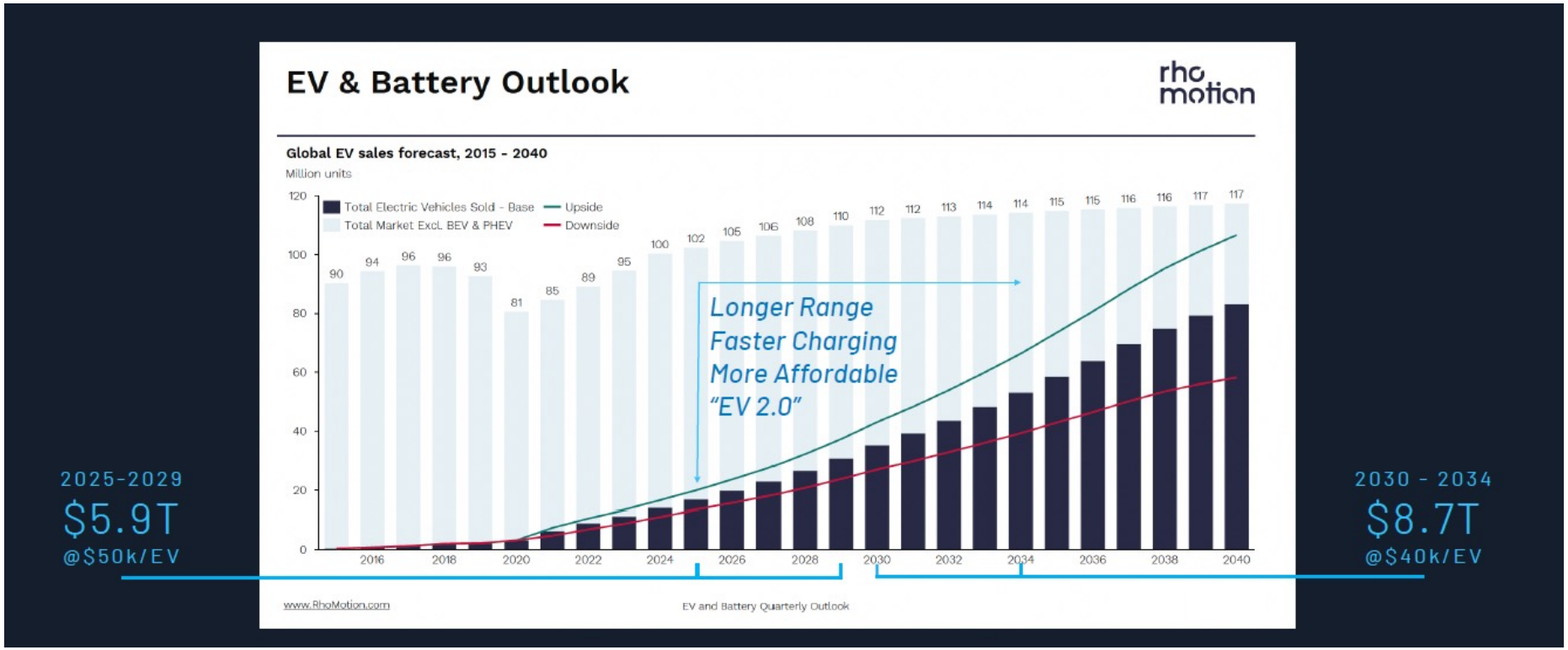
A battery management system (BMS) focuses on a battery. BMS tasks include voltage and current control, thermal management solutions, fire protection, and cybersecurity.





Wireless Battery Management System in EV (Source: ADI)

Challenges and Conclusions



- Long Range: Efficiency and Battery
- Cost
- Smart Grid
- Fast Charging

Thanks to Vincent Pluvinange, CEO at OneD Battery https://onedsinanode.com

How Can EVs Become Greener?

Reference: links

Power Electronics News www.powerelectronicsnews.com

EEWeb – www.eeweb.com

EE Times – www.eetimes.com

EE Times Europe – www.eetimes.eu

Newsletters: Power Electronics News (blog and LinkedIn), my profile on LinkedIn.

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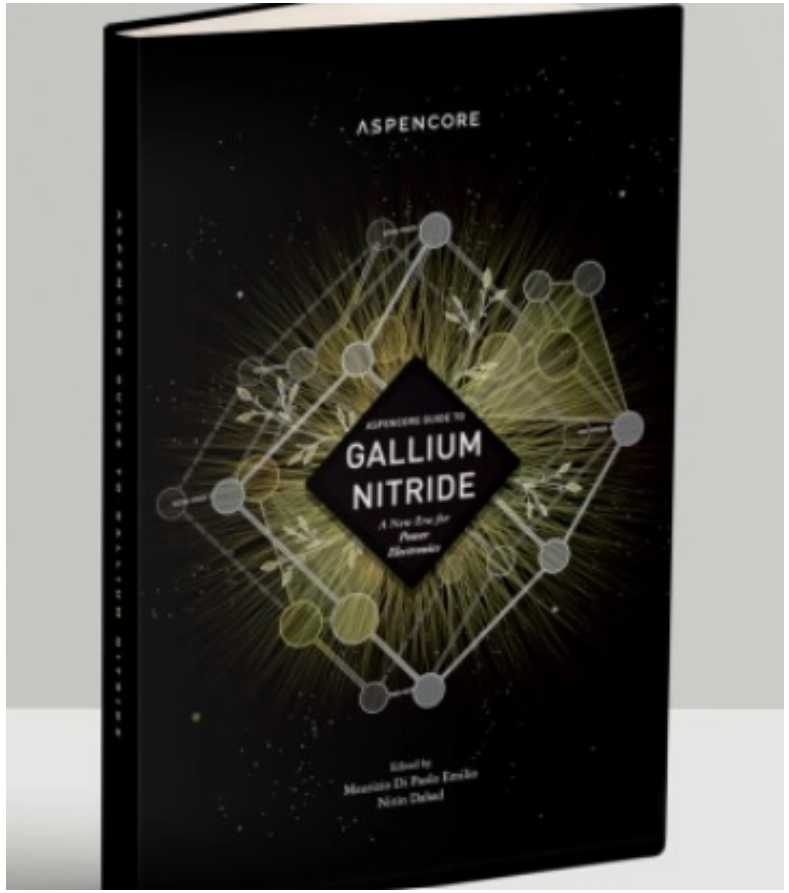

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