The battery electric vehicle: Why mass adoption is inevitable, yet elusive

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When will battery electric vehicles (BEVs) reach the tipping point and overtake the internal combustion engine (ICE) as the power source of choice? This question is already agreed by most industry observers one that defines the modern automotive era.

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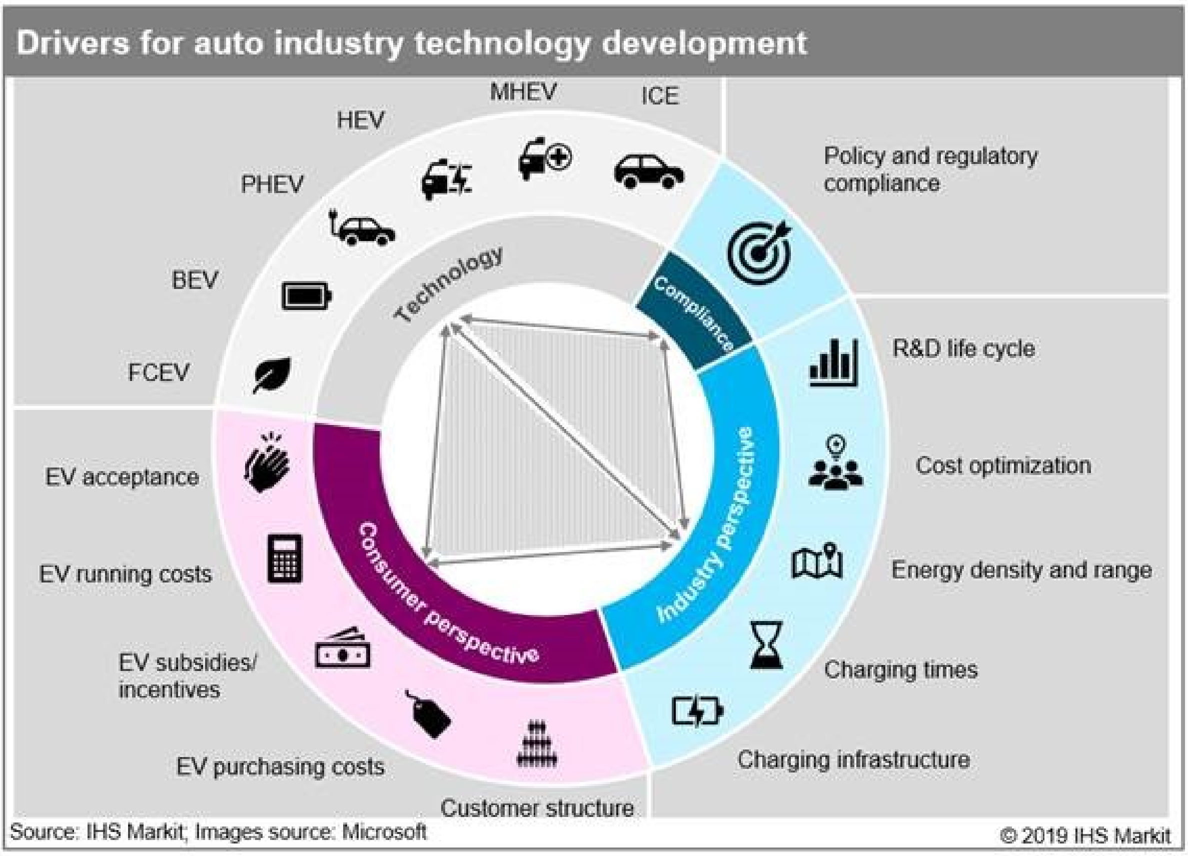
Perhaps the question we should be asking is: “When will the four key elements that make up the entire market framework achieve parity, driving consumers to choose BEVs over ICE?”

Each of the four key driving forces is affected by a number of variables, all are often highly regionalized, and they form a complex matrix in which vehicle price is only one part of the equation. Charging infrastructure and regulatory frameworks must align. Whole-of-life costs, reliability, and convenience models must improve, and regulation and legislation must enact changes before any tipping point occurs.



Consumer perspective

The cost of the battery in a BEV currently represents a significant proportion of the overall vehicle cost. We will select the Nissan Leaf in the UK as an example. The base-trim 40-kilowatt-hour (kWh) 2019 model has a manufacturer suggested retail price (MSRP) of GBP31,500 (USD40,000), prior to subsidies. It is impossible to know precisely how much Nissan pays for the landed cost of the 40-kWh pack, but our 2019 industry average estimate would be in the range of USD250/kWh, which allocates USD10,000 of the overall vehicle cost for the battery pack. That is 25% of the MSRP attributable to the pack. According to IHS Markit powertrain experts, if the entire cost of the powertrain is factored in, including motors, power electronics, and software, then around 35% of the total MSRP of the UK specification Leaf is attributable to the "powertrain."

This cost puts BEVs at considerably higher prices than traditional ICEs, despite the relative simplicity of the battery/motor powertrain in comparison to a modern ICE. However, this scenario is fluid and changing as battery technology evolves and the capacity to produce increases. The cost per kWh is reducing steadily and the point at which a BEV hits pricing parity with ICE technology is approaching quickly.

Nonetheless, whether parity is the factor preventing the wholesale shift to BEVs is questionable even today and remains highly dependent on regional market factors. After considering the many different government subsidies, parity can have a significant impact when coupled with additional government investments in support of the consumer perspective, such as in the Norwegian market. Here, subsidy commitments have been strong enough to result in pricing parity and have taken price off the table during consumer decision making. Yet it is unlikely that this action alone would have triggered the BEV success being witnessed in the Norway. For example, in the UK, where

Renault markets a B-segment Clio and Zoe at close to parity (after a GBP5,000 government subsidy) the Clio still far outsells the Zoe BEV by 10 to 1 (the Clio's 20,000 units versus the Zoe's 2,000 units sold in calendar year 2018), which shows that with the current technology paradigm and infrastructure provision, the longstanding objections of range anxiety, and ease of charging, remain significant obstacles in consumers' minds.

Equally important to outright costs is the "convenience factor" and ease of use. Changing consumer behavior by requiring an apparent step back in convenience requires a psychological shift. We feel this shift is more profound than overcoming the pricing hurdle. So, even if total cost of ownership (TCO) and range objections can be fully countered, asking the vehicle end-users to alter their behavior to accommodate a full range recharge time of more than 10 minutes, means there is still work to do. In a global 2019 consumer survey across eight major countries, the IHS Markit supply chain and technology team identified that three of the top four reasons for not purchasing a BEV is related to charging and/or range-related factors.

Industry perspective

Regardless of the issue of parity, several significant hurdles remain to the wholesale adoption of BEVs, of which infrastructure provision remains the biggest. The rise in urban living challenges BEV use in the high-density areas of the city. Personal ownership of vehicles in city centers is traditionally low, and living in an apartment and owning a BEV in the city makes ownership challenging at best and simply not feasible at worst. Car-sharing schemes utilizing BEVs still require dedicated charging points and space for them. Electric taxis and ride-hailing services present greater feasibility, but both businesses focus in detail on cost per kilometer, vehicle longevity/reliability, and time in service to remain competitive. Therefore, a pure BEV might still struggle to make a convincing argument.

Charging infrastructure provision alone, however, does not convey the complex nature of consumer needs when transitioning to fully electrified motoring. While public charging infrastructure clearly needs to be abundant, available, and reliable to quash the fears of skeptical consumers, it also needs to provide sufficiently rapid power delivery to provide a seamless experience not unlike that of gasoline refueling. This need must be met while continuing to keep pace with not only electric vehicle (EV) rollout but vehicle-side power management technology evolution. AC charging performance will improve with the mass advent of higher-power onboard chargers, while DC fast-charging capability is improving, albeit restrained by battery acceptance rates relating to thermal management and, consequently, durability. The evolution of battery technologies should facilitate significant improvements here.

The fossil-fuel distribution model, where suppliers ensure you have ample access to the product, is not being matched in terms of BEV charging infrastructure. We are witnessing even in relatively BEV-friendly markets such as the UK, a combination of ad-hoc government infrastructure coupled with manufacturer and power supply company initiatives that is slowly creating a network that remains patchy. Despite a significant rollout in such markets (more than 10,000 public charging locations exist in the UK with more than 30,000 charging connectors), user experiences vary greatly, and the business model for EV charge point operators (CPOs) remains extremely challenging. This difficulty is due to not only EV sales remaining low, but also the capability of the technology. In the US for example, higher peak-power levels (in kW) during charging introduce higher one-time monthly payments from utilities, which CPOs must recoup with a greater quantity of charging events throughout the month, while also paying for quantity of power drawn (in kWh) as well as rent on premises. CPOs have begun to turn a profit on individual DC fast-charging locations where throughput exceeds 100 vehicles per day and predominantly vehicles supporting DC fast charging are visiting. However, this confluence remains rare. Conversely, the 2019 Thanksgiving holiday saw long lines at Tesla Supercharger locations on popular routes such as Interstate 5, as peak demand exceeded supply and the recent uptake of the popular Model 3 put strain on charging provision.

The lack of universal EV charging networks is perhaps one of the biggest practical hurdles in the terms of the “tipping point.” The average consumer is not particularly interested in working out and planning which charging network they will and won’t be able to use when they finally make that EV purchase, each and every time they make a long-distance trip that cannot be covered by domestic charging and a full battery. For many fleet or company-car drivers, BEV adoption remains impractical.

Once pricing parity is achieved, there is a growing belief that the cost of BEVs will continue to fall, or that carmakers will continue to lower MSRPs of BEVs based on the cost of the power source. This expectation does not bear much relation to the actual practice of manufacturers over time and ignores the need to build margin into the price of BEVs, partly to recoup sunk costs in the technology, and because shareholder behavior is not geared to support an acceleration of BEV parc at the expense of profitability. Indeed, there is a strong likelihood that BEVs could represent a larger profit opportunity than ICE based on the simplicity of the components, and so the pricing floor seems destined to be relatively high.

Policy and regulatory compliance

The most powerful instrument that can be wielded in terms of accelerating BEV availability is the regulatory framework. Many Western European governments such as France and the UK are already articulating the prohibition of using an ICE vehicle from 2040.

However, any administration that bans ICE cars and forces consumers towards BEVs without significant subsidy or proper infrastructure is likely to face a considerable challenge. The impact of the regulatory environment obviously differs from region to region and is a significant driving force in this equation.

To illustrate this point, IHS Markit data forecasts light vehicle market share for plug-in electric vehicles (PEVs) in Europe (a combination of plug-in hybrid—PHEV—and BEV) at 9.3% by 2021, rising four-fold to 40.0% by 2031. Whereas in the US, we forecast PEVs to take 5.2% in 2021, again rising four-fold, but only capturing 20.0% of the light-duty market by 2031. Furthermore, in the EU28 countries with increasingly stringent CO2 regulatory frameworks, and in China, where its New Energy Vehicle (NEV) policy compels operating OEMs to EV manufacturers in the country, the regulatory pressure is hugely influential and will have a marked effect on reaching any tipping point regarding BEV take-up. However, the US is currently the obvious exception (here, by “US”, we mean outside California and those US states adopting its stricter emission standards—“section 177” states). Fuel economy regulations are not conducive to encouraging BEV demand, fuel remains cheap by international standards, and associated political will remains largely absent.

Technology

Finally, it also is not a “binary” situation where it is merely traditional ICE technology versus BEV with regard to the current technology paradigm. OEMs have more tools at their disposal in terms of meeting the more stringent emissions environment that will evolve in Europe, in particular, during the next decade. ICE-based solutions, such as petrol/electric hybrids in the many various forms, provide much of the gains without the drawbacks of BEVs. If pricing parity were the only consideration, then BEVs may well become the powertrain source of choice, but factor in any or all of the above and the argument becomes nuanced and less clear.

Technology is critical to the above market framework and, almost without question, the battery is a key parameter. Indeed, many of the “industry perspective” factors in the framework could be overcome with improvements relating to battery technology and the associated supply chain. For example, batteries with higher energy density, or more pertinently, specific energy (energy per unit mass) would mitigate the need for such extensive fast-charging infrastructure rollout. Similarly, reductions in the costs of raw materials, manufacturing, and research and development (R&D) associated with batteries would help achieve cost parity (or indeed a cost advantage) for BEVs.

Progress toward superior battery technology appears set to continue in the coming decade or so, as a result of the combined efforts of academia, the R&D community, and automotive industry participants. Developments in the underlying chemistry are focused on achieving an energy density of 500 watt-hours per kilogram and costs below USD100/kWh, with acceptable levels of stability, cyclability, and safety. The use of a solid or solid-polymer electrolyte within the battery cell that is lithium metal based, rather than a liquid medium of lithium-ion constituents, is undoubtedly key to facilitating it. Technologies already exist to achieve the technical parameters mentioned, with low-volume solid-state battery cells already in production since 2018. However, meeting all the above, while enabling mass-market automotive scale manufacturing volumes and achieving robustness to meet automotive durability needs, remains a key obstacle. Handling a solid-state electrolyte in processed form is challenging owing to its highly flexible, unstable, and inherently slippery form. Low-temperature performance of solid-state cells also remains a critical unknown, with industry participants intimating that this might require solutions focused at the battery module- or pack-level to be overcome.

Summary

The point at which a battery can match ICE for cost parity is forecast to be in the range of USD80–100 per kWh. This, based on the rough expectation that for a cost of USD8,000–10,000, an OEM will be in a position to install a 100-kWh battery pack into a vehicle, provides total system power of between 250 and 300 brake horsepower in a powertrain that would offer about 500 miles of range (this equation in itself is hugely dependent on the rate of energy density improvement, which in turn opens up wider segment applications and is also dependent on test cycle and vehicle mass). This combination of cost, range, and performance will certainly be at parity to an equivalent diesel while also moving considerably closer to the cost of an equivalent gasoline option. IHS Markit holds the view, as indicated in the above forecast, that it may take until 2030 for this example to apply to all passenger car segments, with larger vehicles (less dependent on energy density advancements due to having more room) likely to reach this point earlier. In the interim period, PEV market share is forecast to make up more than a third of all new vehicles sold in Europe, but only a fifth in the US. Significant? Yes, but there is no imminent wholesale shift, or "tipping point" anticipated in the next decade. Rather, a gradual adoption will occur as the other key elements align to make PEVs a realistic and preferential choice for the consumer.

From a supply chain perspective, the financial reality of profitability remains a concern in the medium-to-long term for battery cell producers. While, in principle, battery cell production would seem to be the most in demand and, therefore, lucrative constituent of the electric vehicle, cost targets and profitability at the OEM level remain hugely challenging to achieve. OEMs are naturally exerting huge pressure on raw material providers and supply chain tiers to drive down costs as they look to lock in financially viable supply with those capable of providing the required scale. If this business doesn't deliver the required margins, raw material providers might consider delaying bringing capacity onstream, and tier-1 suppliers might not commit to significant capital investment in new manufacturing capacity, which could hugely impact market growth.

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