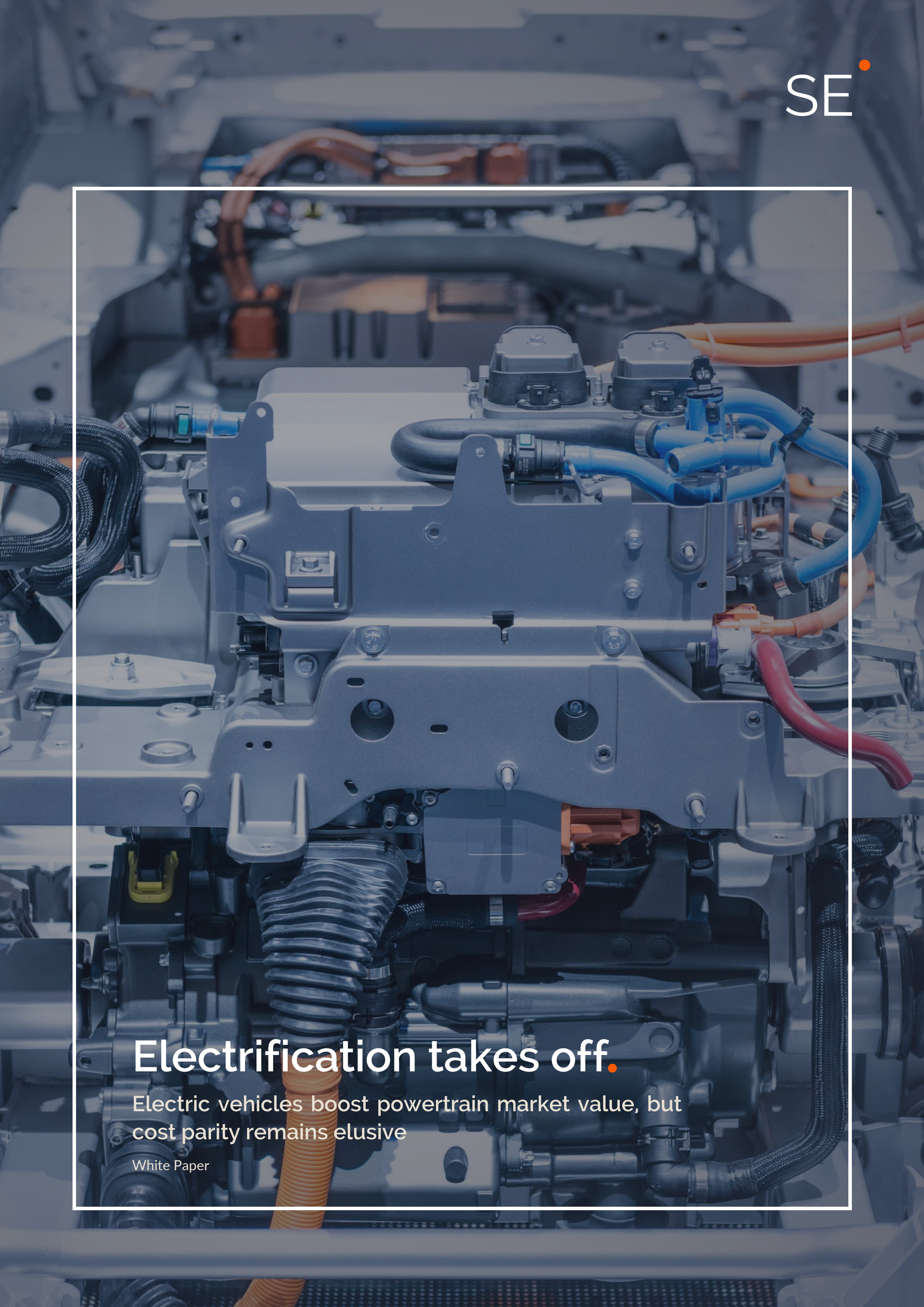

Electrification takes off.

Electric vehicles boost powertrain market value, but cost parity remains elusive

White Paper

Giving substance to a new reality.

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Management Summary

Recent shifts in the automotive powertrain market are just a token for what is to come: Electrified and fully electric powertrains will increase their market share dramatically within this decade. This will hugely change the component market: The findings of our research suggest that the powertrain component market is expected to grow by 300 billion Euro until 2030 reaching 656 billion Euro. This growth is mainly driven by xEV components, which are expected to increase their market share from 1/6 of the total powertrain market to almost half.

Even though all the xEV powertrain components in scope are increasing by three-figure percentages, high voltage batteries remain the most important system. Batteries are not only driving the market growth but remain, due to their high per-vehicle price, also the main obstacle in reaching cost parity between ICE-based and BEV-powertrains.

Legal and statutory requirements will make internal combustion powertrains more expensive, but cost parity between ICEs and BEVs will be elusive before 2030 according to our findings. In 2025 for example, a C-Segment BEV powertrain with a 60kWh battery is expected to still be 45% more expensive than a gasoline P2 MHEV. This gap is smaller for larger and more premium vehicles which is one of the key reasons for today's portfolio shifts which OEMs are making.

Our research suggests that OEM profitability within this decade will suffer because of increasing electrification unless cars are sold at a price premium, OEMs strategically move to larger cars, other vehicle parts become significantly cheaper or a breakthrough in battery price (and technology) is achieved. All these levers need to be pursued to defend vehicle margins. If not, increasing BEV powertrain costs will lead to drastically decreasing automotive profits in this decade.

Electrification takes off

After decades of dominance of internal combustion engine (ICE)-based powertrains that only left consumers the choice of fuel type, the range of powertrain types in the market has become a lot broader. Vehicles like Mitsubishi i-MiEV, Nissan Leaf or BMW i3 were introduced to the global market as battery-electric alternative to the fuel-burning incumbents while Toyota Mirai or Hyundai ix35 FCEV even gave an early outlook on a potential future powered by hydrogen. While all these vehicles – especially the fuel cell powered ones - only have been sold or leased in small numbers, they were at the beginning of a market shift, that is now picking up speed. Increased environmental awareness and supporting legislation aiming at reducing CO_2-emissions of the mobility sector are forcing OEMs to increase efficiency and electrify conventional combustion powertrains across segments by adding mild hybrids (MHEVs), full hybrids (FHEVs) or plug-in hybrid vehicles (PHEVs) in between their pure combustion based and battery electric vehicle line-up.

For this research, we are aiming at quantifying the effect of this shift on the powertrain market. We decomposed powertrains of ICE vehicles, electrified vehicles and battery electric vehicles (BEV) as well as fuel cell electric vehicles (FCEV) into 21 clusters that were then attributed either to ICE power trains, only to electrified powertrains (xEV) or into components that are in use in both of the two groups – figure 1 provides an overview on the clusters in scope of this white paper.

300 bn€

Expected global market growth for the powertrain components in scope of this study – about 250 bn€ are due to electrified power trains

Our results suggest strong growth in the global powertrain market from 356 bn € to 656 bn € in 2030, translating to 7% annually and even 13% CAGR for the years between 2021 and 2025 followed by a significant deceleration to 3% CAGR until 2030.

While the overall “pie” is getting bigger, there are some shifts within the size of the pieces expected. China will grow by four percentage points to 35% of the global market, mostly at the cost of the rest of the world, while Europe and NAFTA remain rather constant at around 20%.

However, we discovered significant shifts between the clusters. While ICE components make up three quarters of the total market in 2021, this share is reduced to 59% until 2025. At the end of the study period in 2030, xEV components will already have surpassed ICE-components by 6 percentage points and add up 48% of the total market. Nominally, ICE components still grow by 12 bn € within the 9-year focus period, but their peak will be reached in 2025 and from this year on, overall market growth will be solely driven by xEV-components.

This movement is visible in all the regions in scope, but the pace of this shift is different. In Europe, the xEV component market will surpass the ICE components in 2026 due to strong xEV growth of 21% CAGR and a decline of -6% CAGR of ICE components at the same time, while in China ICE component CAGR is 1%. There, xEV components will overtake their conventional counterparts one year later while in NAFTA this will take until 2029. The peak of ICE component volumes will be reached in Europe in 2023, 2 years earlier than in China and NAFTA. By far the biggest single cluster will be high-voltage batteries which will increase by 162 bn € and amount to 196 bn € in 2030 - a quarter of the total powertrain component market.

These developments are driven on the one hand by legislation such as impending ICE-bans all over the world and xEV subsidies, but also by BEV product improvements in terms of range, charging speeds and shrinking cost – and thus price – difference between conventional vehicles that will be addressed in the following chapter.

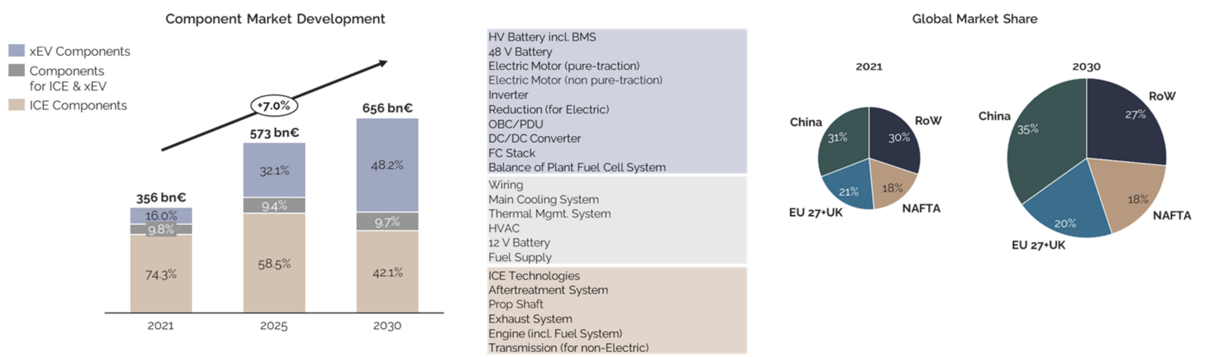

Figure 1: Global market for powertrain components is growing strong with an expected volume of 656 billion Euro in 2030, 300 billion Euro more than 2021 – the market shares of the regions remain mostly constant with China slightly at the expense of RoW

Cost Parity remains elusive – for now

The less complicated but more expensive powertrain is the key reason for higher BEV prices. Since high voltage batteries as energy source for the electric powertrain are the most expensive part of a BEV, reducing battery cost will be crucial to reaching cost parity between internal combustion vehicle powertrains and battery electric vehicles. Optimizations on other parts outside the powertrain will be able contribute a part as well and reaching cost parity is also being made easier by tougher emission limits for ICE-vehicles which we expect to require some form of electrification that will be driving the combustion powertrain price up. Reflecting this development, from 2025 this study compares BEVs to P2 MHEVs that for are for example equipped with a 48V battery and have a non-traction electric motor.

When reading other publications on battery price developments, a frequently cited number to reach cost parity is a battery price of 100 US$/kWh (e.g. BloombergNEF, 2020), which in February 2022 corresponds to around 90 €/kWh. Based on our calculations, we cannot confirm that cost parity can be achieved at this price level. Most publications that cite the 100 US$/kWh-target moreover do not specify for which segment, which battery size are used and what powertrain it is compared to.

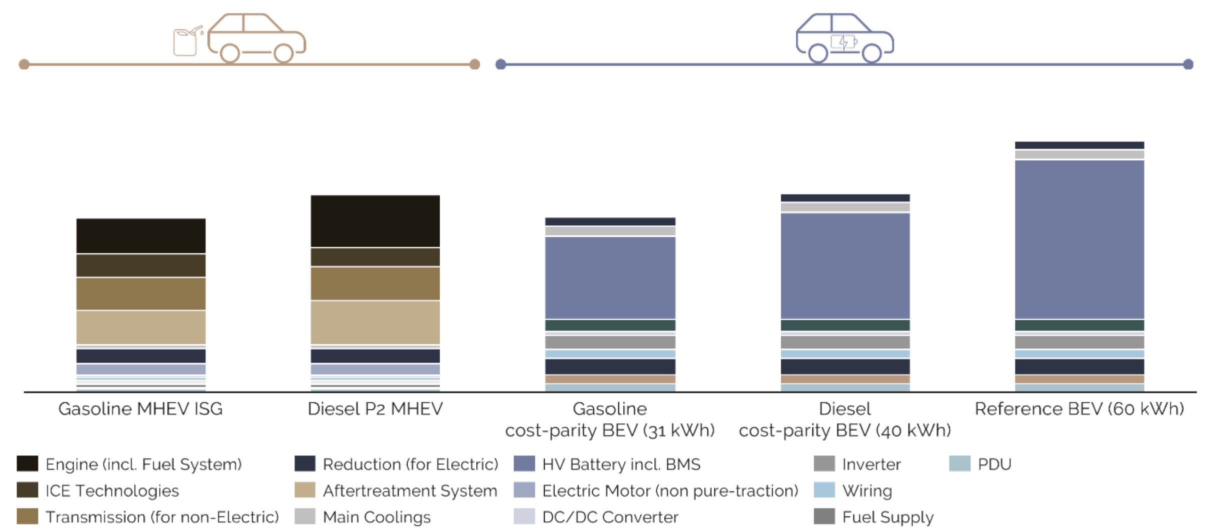

Figure 2: Exemplary powertrain breakdowns for C-segment vehicles in 2025 – due to emission requirements, ICEs must be at least MHEVs but the gap to a reference BEV with a usable battery size is still significant

While OEMs and research institutes suggest a battery price decline to 58€/kWh in 2030, our battery price forecast reflects recent developments in the raw material prices for batteries such as cobalt, nickel and lithium and the resulting insecurity regarding battery pack price developments from now until 2030. This leads to our assumption, that a battery pack for C-segment vehicles can be produced for 70€/kWh in 2030. For large E-segment battery packs, this amount is expected to be closer to 60€/kWh due to cost-digression of non-cell parts of the battery pack.

46 €/kWh

Is the battery price that would lead to cost parity with a 2030 C-segment gasoline MHEV

Based on this battery price forecast, our research results suggest that to be able to equip a C-segment vehicle with a decent size battery of 60 kWh in 2030 at the same price as the comparable P2 MHEV, the battery pack would need to be manufactured for 46 €/kWh, for a D-segment vehicle and a practice-oriented 90 kWh battery pack, the target price needs to be 34€/kWh.

Taking a more detailed look at the powertrain cost distribution, the main components of an ICE powertrain in our research are:

- Engine
- ICE technology like valve lift systems or turbochargers
- Exhaust gas aftertreatment
- Transmission
- Fuel system
- Exhaust system

For a C-segment gasoline car in 2025 these clusters will add up to 4.200 €, which is still 800 € less than the cost of the 60 kWh BEV high voltage battery alone that we define as a practical C-segment reference vehicle. In total, the gasoline MHEV powertrain consisting of all component clusters for this study is expected to cost 5.500 € while the reference BEV powertrain will be much more expensive. For Diesel, we expect the cost of the main ICE components mentioned above to add up to 5.000 € alone, but since Diesel vehicles are mostly a European phenomenon, further comparisons will be based on gasoline vehicles.

In our model, to reach cost parity in a C-segment vehicle, the only usable variable to reach cost parity is reducing battery capacity since all other powertrain components will still be required in the same way to make the vehicle move and fulfill the requirements of the segment. The BEV battery capacity that matches the powertrain cost of a gasoline MHEV with integrated starter generator would have a capacity of 31kWh. This translates into a range of about 200 km - a vehicle like that will hardly be successful in the market or even make customers trade their ICE vehicles for a BEV. Repeating the cost-parity calculation for 2030, the total price gap to the reference BEV can be reduced to 1.400 € and the cost parity battery-capacity grows to 40 kWh, which will still be a tough to sell for most customers.

Moving up into the D-segment, higher requirements regarding engine power and resulting powertrain enhancements raise the cost of the conventional powertrain components, leading to a cost-parity battery size of 35 kWh in 2025 and 43 kWh in 2030 which is even further from the average customer demand for D-segment battery capacity, which we expect at 94 kWh in 2030.

Walking along the C-segment value curve in year 2025 in figure 3 illustrates which components will be removed or altered when switching from a P2 MHEV to a 60kWh BEV. Power electronics for example are already part of an MHEV. On-board charger (OBC), an electric traction motor and the HV-battery will be added for the BEV only. Our analyses underlines that with realistic battery capacities required to address customer range anxieties, cost parity will not be achieved by a wide margin, e.g. 45% in our C-segment example.

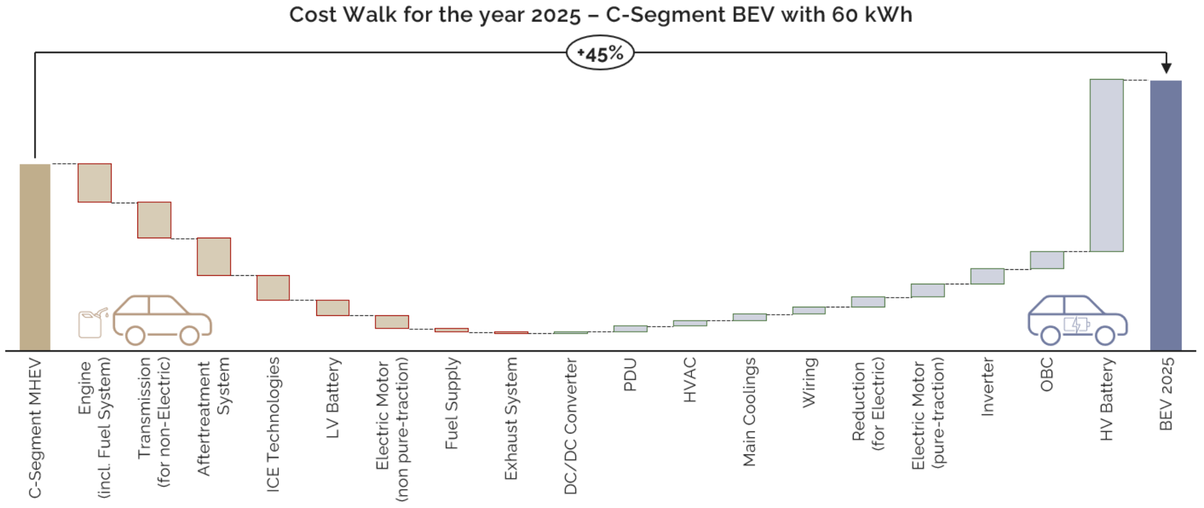

Figure 3: C-segment value walk from P2 MHEV to 60kWh BEV in 2025 – BEV is estimated to be 45% more expensive than ICE-based MHEV

With the battery accounting for 61% to 65% of total electric powertrain cost in 2025, depending on vehicle segment, it is key to cost parity and its price will play a deciding role in the pace of acceptance and the market success of battery electric vehicles and automotive OEMs.

Implications & Outlook

The Financial Times cited Daimler CEO Ola Källenius in February of 2021 that “Mercedes-Benz will earn as much from electric cars as its luxury combustion engine models by the end of this decade”. While the powertrain costs of ICEs and BEVs are converging with premium segments, which benefits luxury car makers such as Mercedes Benz, our research doesn’t suggest that the same convergence will happen to volume segments any time soon. In order for OEMs to keep their profit margins, BEVs will need to be sold at a price premium, other vehicle parts next to the powertrain need to be made significantly cheaper to compensate the higher cost or a breakthrough in battery price (and technology) needs to be achieved. If neither of these solutions can be realized, the increased BEV powertrain costs will lead to drastically decreasing automotive OEM-profits in this decade while demand for BEVs grows due to customer demand and/ or statutory requirements.

Many possible solutions are currently under development to reduce the battery pack cost, from new ways of integrating the battery into the vehicle, switches in cell chemistry to reduce cost and dependency on rare materials that we are discussing in our white paper “Running out of metals” to a technology leap to e.g. solid state batteries that might be just around the corner.

Until then, OEMs will need to apply different cost reduction methods to secure profits and hope for government subsidy programs to be continued, since they are helping to reduce the BEV (and PHEV) vehicle sales price to a competitive level compared to ICE-based vehicles. While European OEMs are launching larger, premium priced BEVs to defend margins, Asian OEMs start to demonstrate that cost reductions seem possible and that BEVs can be made and sold at price levels comparable to conventionally powered vehicles. US and European OEMs soon might find themselves in a situation where they are caught between governments forcing them to sell zero-emission vehicles and customers that might not be willing or able to pay the price premium for electric vehicles. Recent announcements by GM and Honda to produce millions of “affordable” BEVs from 2027 indicate that OEMs are taking on the fight.

Research Approach:
For our research, we broke down automotive powertrains into 21 main component clusters as depicted in Figure 1. Nine of those are pure xEV clusters, meaning those are only built into electric and electrified vehicles, six of them are only required in ICE-based cars. The remaining six are required by both vehicle types but in different forms – like a wiring harness, which is required for electric and combustion vehicles but is way more complex and thus costly for an electric vehicle.
Based on our project experience and additional input from AVL’s cost engineering team, we determined an EU- and China-based price baseline and learning rate for each sales segment of passenger cars and light commercial vehicles (up to 3.5 tons) and every cluster – reflecting the additional complexity per powertrain type as described above. The result of these calculations are component prices per cluster for each year from 2021 to 2030. Combining these with production volumes from IHS markit database from Q4/2021, we generated insights on component market volumes and values for the regions in scope: China, Europe consisting of the EU27 plus UK, NAFTA and the rest of the world (RoW).

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