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McKinsey Center for Future Mobility®

Making electric vehicles profitable

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Introduction

The future looks bright for electric-vehicle (EV) growth. Consumers are more willing than ever to consider buying EVs, and sales are rising fast. Most major markets have consistently registered 50 to 60 percent growth in recent years, albeit from small bases. More new models from a growing cadre of automotive OEMs make finding a suitable EV easier: in 2018 alone OEMs launched about 100 new models and sold two million units in total globally. Likewise, performance improvements continue with respect to range, performance, and reliability. Regulations in major car markets—namely China, the European Union, and the United States—compel OEMs to produce more EVs and encourage consumers to buy them.

However, there is a problem: today, most OEMs do not make a profit from the sale of EVs. In fact, these vehicles often cost $12,000 more to produce than comparable vehicles powered by internal-combustion engines (ICEs) in the small- to midsize-car segment and the small-utility-vehicle segment (Exhibit 1). What is more, carmakers often struggle to recoup those costs through pricing alone. The result: apart from a few premium models, OEMs stand to lose money on almost every EV sold, which is clearly unsustainable.

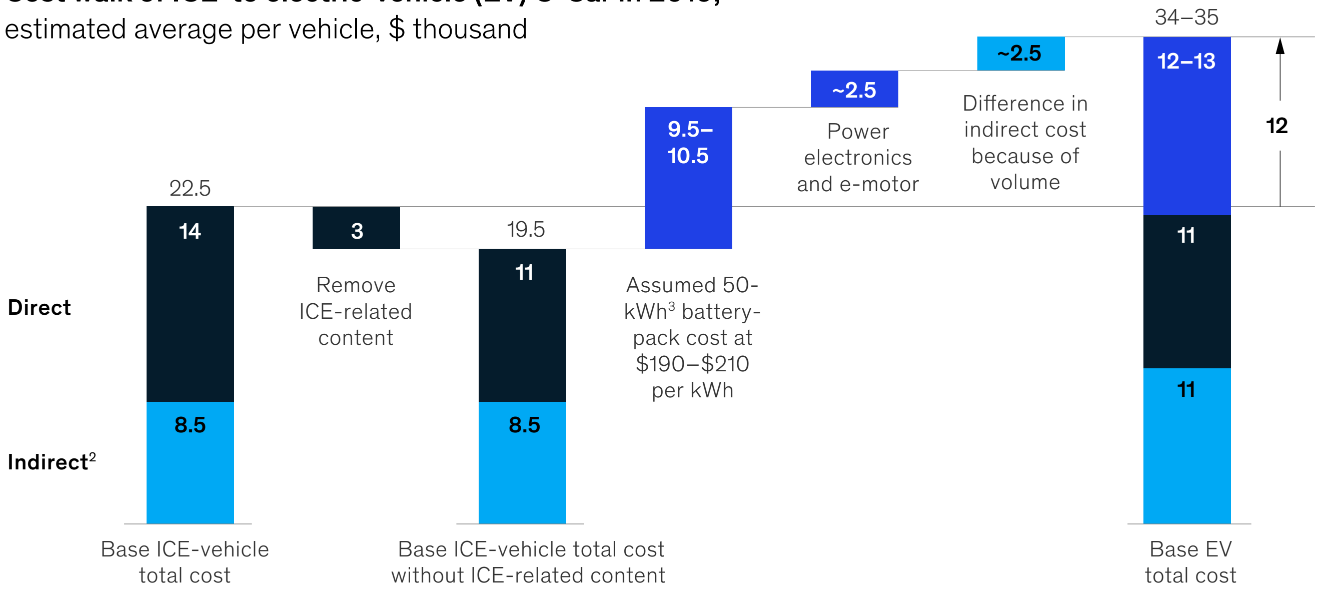
Many carmakers appear to be resigned to this fate, at least for now. Battery costs represent the largest single factor in this price differential. As industry battery prices decline, perhaps five to seven years from now, the economics of EVs should shift from red to green. Current thinking holds that the industry will continue to produce EVs—largely because it has little alternative in the face of stringent fuel-economy and emissions policies—and that the industry will, in the meantime, absorb the losses.

Our analyses show that better options exist, even today, to accelerate the industry toward profitability from both product and business-model perspectives. Some of these options include aggressively reducing cost through "decontenting," optimizing range for urban mobility, partnering with other automakers to reduce R&D and capital expenditures, targeting specific customer segments, and exploring battery leasing.

Exhibit 1

There's a cost gap of about $12,000 between electric vehicles and internal-combustion-engine vehicles today

Cost walk of ICE[1] to electric-vehicle (EV) C-Car in 2019,
estimated average per vehicle, $ thousand



[1]Internal combustion engine.
[2]Includes average incentive cost of $2,000.
[3]Kilowatt-hour; includes battery-management system.
Source: Industry experts; UBS; McKinsey analysis

An industry in a jam

Understanding the challenges and opportunities for OEMs requires examination of the changing landscape of consumer attitudes, product availability, EV economics, and regulatory tailwinds.

Consumer preferences on electric vehicles

Consumers' EV preferences are shifting. The share of global consumers that would consider purchasing an EV is on the rise. In the United States, between 10 and 30 percent of consumers indicated their preference to consider an EV as their next purchase on national surveys.[1] In Europe, the reported share of consumers considering EV purchase was higher, at 40 to 60 percent,[2] and in China, it was over 70 percent, given the presence of strong government incentives to adopt these vehicles. [3] This trend is even more pronounced among customers younger than 50 years old living in urban areas. Sales in 2018 only provide a partial view, given that EVs accounted for less than 5 percent of sales in most markets. However, the pace of change tells a different story, with annual sales' growth rates now frequently in the range of 100 percent or more.

Product availability

On the supply side, this increasing demand will be met with a broader set of choices. Today, new EV models are launching at a rate of approximately

1 Russell Hensley, Patrick Hertzke, Stefan M. Knupfer, Nicolaas Kramer, Nicholas Laverty, and Patrick Schaufuss, "Electrifying insights: How automakers can drive electrified vehicle sales and profitability," January 2017, McKinsey.com; "AAA: 1-in-5 U.S. drivers want an electric vehicle," AAA NewsRoom, May 8, 2018, newsroom.aaa.com;"; Hoang Nguyen, "Middle of the road: An analysis of the automotive sector," YouGov, January 9, 2019, today.yougov.com.

2 Russell Hensley, Patrick Hertzke, Stefan M. Knupfer, Nicolaas Kramer, Nicholas Laverty, and Patrick Schaufuss, "Electrifying insights: How automakers can drive electrified vehicle sales and profitability," January 2017; "Electric Vehicles Survey results," Dalia Research, November 1, 2016, daliaresearch.com.

3 "Consumers in China increasingly enthusiastic about new-energy vehicles and eager for battery technology advancement, J.D. Power Survey finds," J.D. Power, February 26, 2018, jdpower.com; China Youth Daily, August 2018, cyol.net.

120 a year, providing significantly more options regarding vehicle segment, performance, feature set, and value. Compare this with the prior seven years, during which new plug-in-hybrid-EV (PHEV) and battery-EV (BEV) launches globally averaged about 20 per year, often with premium prices. Historically, domestic Chinese OEMs provided the widest selection of models, but by 2020, most global OEMs across China, Europe, and the United States will offer a broad range of vehicles and price points.

Electric-vehicle economics

Our survey from 2017 also revealed that an EV's purchase price and driving range are the biggest hurdles to wider consumer adoption—and both are linked inextricably to battery economics.[4] Today, a typical BEV in the United States, priced around $30,000, does not provide a reasonable payback period for many buyers, given the size and cost of a battery pack; to recoup the price premium for an EV versus an ICE vehicle through savings on fuel and maintenance, the payback period is five to six years for an average US buyer driving 13,000 miles a year. For high-mileage drivers exceeding 30,000 miles per year—such as full-time cab, Uber, and Lyft drivers—EVs are already "in the money" during a typical two- to three-year ownership or lease period. Looking ahead, each 20 to 25 percent improvement in battery cost reduces payback by one year, but OEMs will need to take other actions to accelerate profitability.

Regulatory tailwind

The role of the regulator in today's EV landscape cannot be overstated. Ever-tightening government emissions regulations act as direct stimuli for OEM EV investments, and current subsidies and tax exemptions help bridge gaps between OEM pricing and consumer willingness to pay. In China, for example, the 2018 regulatory-incentive system, including supply and demand incentives and restrictions, pushed global EV sales above one million units.[5] However, China is not the only major market increasing regulatory pressure. In December 2018, the European Union's 28 member states agreed to new carbon-dioxide regulations that would set a target of 37.5 percent reduction in car emissions by 2030 when compared with 2021. This was significantly more aggressive than the European Commission's original proposal of a 30 percent reduction.

4 Russell Hensley, Patrick Hertzke, Stefan M. Knupfer, Nicolaas Kramer, Nicholas Laverty, and Patrick Schaufuss, "Electrifying insights: How automakers can drive electrified vehicle sales and profitability," January 2017, McKinsey.com.
5 Total EV sales in China from January to November 2018 was approximately 730,000.

Accelerating toward profitability

At the beginning of this article, we highlighted the fact that today's EVs are costlier to produce, and consumers have a rather limited willingness to pay a premium for EVs. The combination of these two factors leads to lower profitability of today's EVs versus today's ICE vehicles.

However, based on our analyses, it is possible to use today's technology to design a profitable EV—one that would be cost-competitive with ICE vehicles by the early to mid-2020s. In our study, we analyze the example of a small- to midsize EV that is today approximately $12,000 more costly, and therefore less profitable, than a similar ICE vehicle. The challenge: find cost and revenue levers to narrow the gap.

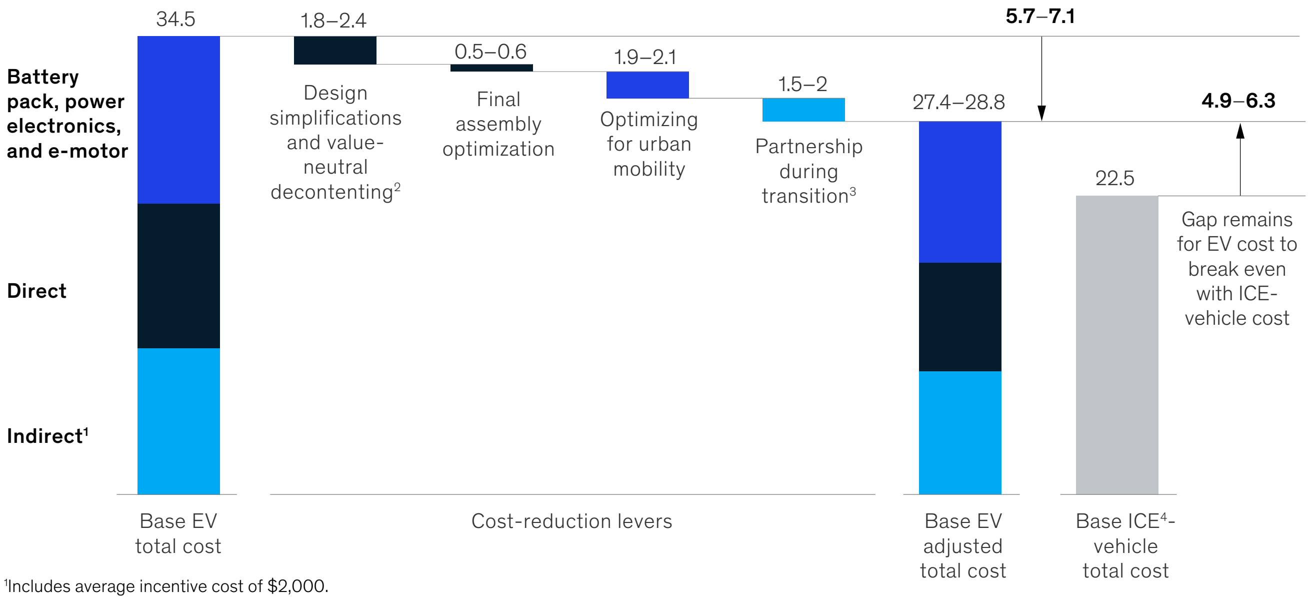
Optimize electric-vehicle designs for the market

We believe OEMs can reduce their EV costs by $5,700 to $7,100 by pursuing strategic decontenting paired with a dedicated EV platform (Exhibit 2). This could be accomplished leveraging new freedom in design unlocked by using electric rather than ICE subsystems and applying leading strategies in low-cost ICE design and from cutting-edge EV-focused OEMs.

Exhibit 2

Cost-reduction levers could bring down electric-vehicle costs considerably

Base electric-vehicle (EV) total cost, with cost-reduction levers in 2019,
estimated average per vehicle, $ thousand



[1]Includes average incentive cost of $2,000.
[2]Reduction in non–internal-combustion-engine (ICE) content that does not affect safety.
[3]Assumes combined average annual production of ~150,000 units.
[4]Internal combustion engine.
Source: Industry experts; McKinsey analysis

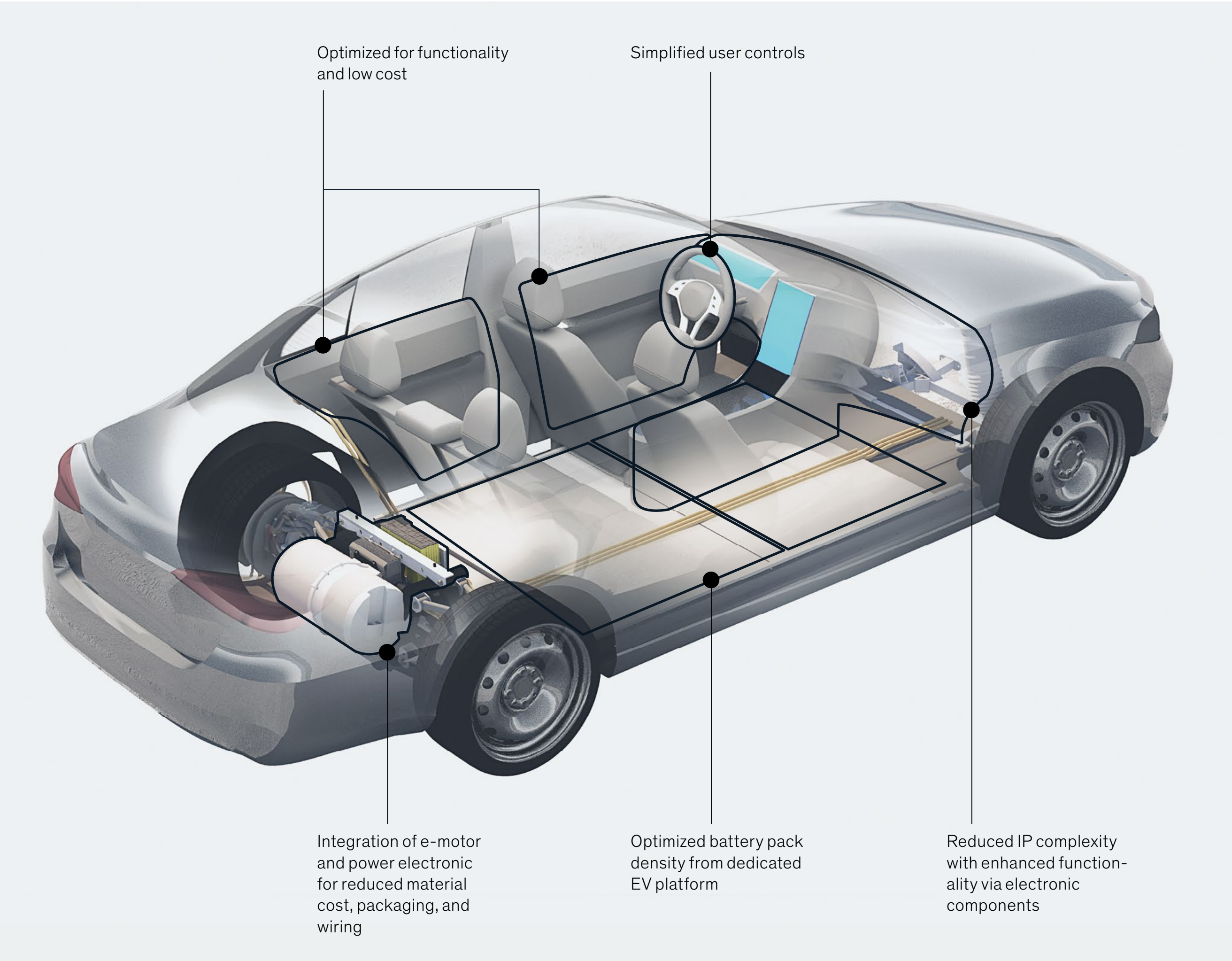
Design simplifications and value-neutral decontenting

OEMs can take lessons from leading e-vehicle concepts, for which our proprietary teardown study revealed that cockpit, electronics, and body simplifications netted up to $600 in reduced costs, without removing core feature content tied to value generation for the OEM.[1] Eliminating extra displays, buttons, switches, wiring, modules, and additional structural components, as well as reducing the overall design complexity, drove major savings. Our experts also noted that OEMs can only capture all of these material cost savings when using a dedicated EV platform that enables better packaging of interior cabin space, power electronics, motors, and battery packs. However, we also gain insights by benchmarking low-cost designs from the non-EV world. Our analysis shows that OEMs can apply these learnings and create fun-to-drive and simple vehicles costing $1,300 to $1,800 less through smart feature choices, design-specification adjustments, and manufacturing improvements—all without compromising safety. Some of these content choices include using more basic vehicle electronics with fewer powered options, straightforward body styling and lighting, uncomplicated seat designs, and simplified interior trim (Exhibit 3). Our work suggests that companies can extract component savings of 20 to 30 percent with these design approaches, including by adjusting material specifications and negotiating with suppliers with the shared objective of EV profitability.

[1] Antoine Chatelain, Mauro Erriquez, Pierre-Yves Moulière, and Philip Schäfer, “What a teardown of the latest electric vehicles reveals about the future of mass-market EVs,” March 2018, McKinsey.com.

Exhibit 3

Decontenting or design revision may be an opportunity for electric vehicles



Source: McKinsey

Optimizing for urban mobility

For many customer segments, today's EVs offer either too little driving range, such as smaller EVs with ranges of fewer than 100 miles, or too much, such as luxury EVs with ranges of approximately 300 miles, when compared to actual driving patterns. The average vehicle-miles traveled (VMT) for an urban population is around 20 miles per day in the United States, and it increases to around 30 miles per day when accounting for demographic groups that drive more.[2] Assuming today's battery efficiency in kilowatt-hours (kWh) per mile, a potential sweet spot for urban customers is approximately 25 kWh of energy. However, if we account for consumer preference to use the same vehicle for suburban and occasional rural travel, the optimal battery capacity increases to approximately 40 kWh, equating to~250 kilometers, or about 160 miles, based on average VMT in rural areas. A reduction in battery capacity to 40 kWh, from 50 kWh, would save $1,900 to $2,100 today, while the range would still enable most consumers, especially those in urban environments, to complete trips without any sacrifice to their daily routines.

Final assembly optimization

Our recent study of EV design also suggests that a purpose-built EV platform is simpler to assemble and could deliver up to $600 in savings per vehicle in lower fixed-cost allocation. [3] That savings come from having fewer components to assemble in an optimized EV platform and requiring less capital in EV-only plants versus complex plants that combine ICE-vehicle and EV lines.

Partnership during the transition

During the next five to seven years, as the industry transitions toward electrification but struggles with profitability, automakers should more strongly consider partnering and collaborating with competitors. At a time when OEMs face the possibility of retooling numerous models and platforms for electrification, collaborating with other OEMs can reduce the fixed-cost burden of R&D, tooling, and plants. Benefits will be especially high if OEMs can share EV platforms and plants, which can still enable multiple model variants. These alliances will also be most beneficial when they enable higher-volume procurement of the same battery cells and power electronics to take advantage of scale that is otherwise elusive when going it alone. In fact, some automakers have already announced a range of different global partnerships focused on reducing the cost of designing and producing EVs.[4] In our analysis, we examined the impact of two OEMs codeveloping a dedicated EV platform, which could lead to two to three times the volume spread across a similar fixed-cost base—reducing costs by $1,500 to $2,000 per vehicle.

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2 Summary of travel trends: 2017 National Household Travel Survey, US Department of Transportation, July 2018, nhts.ornl.gov.

3 Antoine Chatelain, Mauro Erriquez, Pierre-Yves Moulière, and Philip Schäfer, "What a teardown of the latest electric vehicles reveals about the future of mass-market EVs," March 2018, McKinsey.com.

4 In August 2017, Mazda Toyota announced a joint-venture plant in the United States at the cost of $1.6 billion, where the two companies will work together on EVs, in-car electronics, and advanced safety, with projected annual production capacity of 300,000. In January 2019, Ford and VW announced a memorandum of understanding to explore partnership options for EV development.

Boosting margins beyond cost cutting

OEMs could explore several other efforts to improve margins.

Communicating electric-vehicle economics to customers

Per insights from EV-consumer surveys, some consumer subsegments may present the opportunity to boost take rates and pricing.[1] This analysis suggests that more than 40 percent of EV shoppers may be willing to pay a small premium, but history shows that convincing even the most enthusiastic customers to pay a more significant premium is difficult.

We see more opportunities in a targeted "value-selling" approach, in which OEMs find ways to explain better the full economic benefits of an EV. For example, a consumer paying 10 percent more for an EV than for an ICE vehicle will achieve breakeven with a comparable ICE vehicle in close to one year if he or she also includes fueling and maintenance costs in the calculation. However, our dealer surveys show that this approach is rarely used. OEMs must do a better job in informing all stakeholders in the sales channel to educate buyers regarding the benefits of EV ownership. For instance, spending an extra $20 per month in financing or lease payments juxtaposed with saving about $60 per month in fuel and maintenance costs should be a great deal for most consumers. This assumes annual mileage of roughly 14,000 miles, with consumers who drive more experiencing even larger paybacks.[2]

The economics for EV owners will also be better in cities like London, where EV drivers do not pay the congestion charge of £24 per day in 2019.

Exploring new business models

Automakers that take a bolder approach to closing the profitability gap can also experiment with a range of new business models for niche segments. Example ideas include targeted direct sales to fleets and battery leasing (Exhibit 4).

Economically, it makes sense to target fleet customers with EV models, given that these fleets typically fall into a high-mileage category in which the total cost of ownership (TCO) of EVs is beneficial—and they prioritize TCO higher than other buying factors. Direct selling to these customers can reduce selling costs by about $1,000 per vehicle by circumventing showroom costs. Given the positive business case for fleet customers and their more predictable and simple charging logistics, these customer segments are early use cases for high EV take rates.

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1 Russell Hensley, Patrick Hertzke, Stefan M. Knupfer, Nicolaas Kramer, Nicholas Laverty, and Patrick Schaufuss, "Electrifying insights: How automakers can drive electrified vehicle sales and profitability," January 2017, McKinsey.com.

2 According to ADAC, EVs are already reaching TCO parity at different segments in Germany (for example, smart EQ fortwo coupe versus smart fortwo 0.9 turbo and Tesla Model X 100D versus Audi SQ7 TDI), considering operating and maintenance costs, energy cost, and depreciation with an assumed holding period of five years with 15,000-kilometer annual mileage.

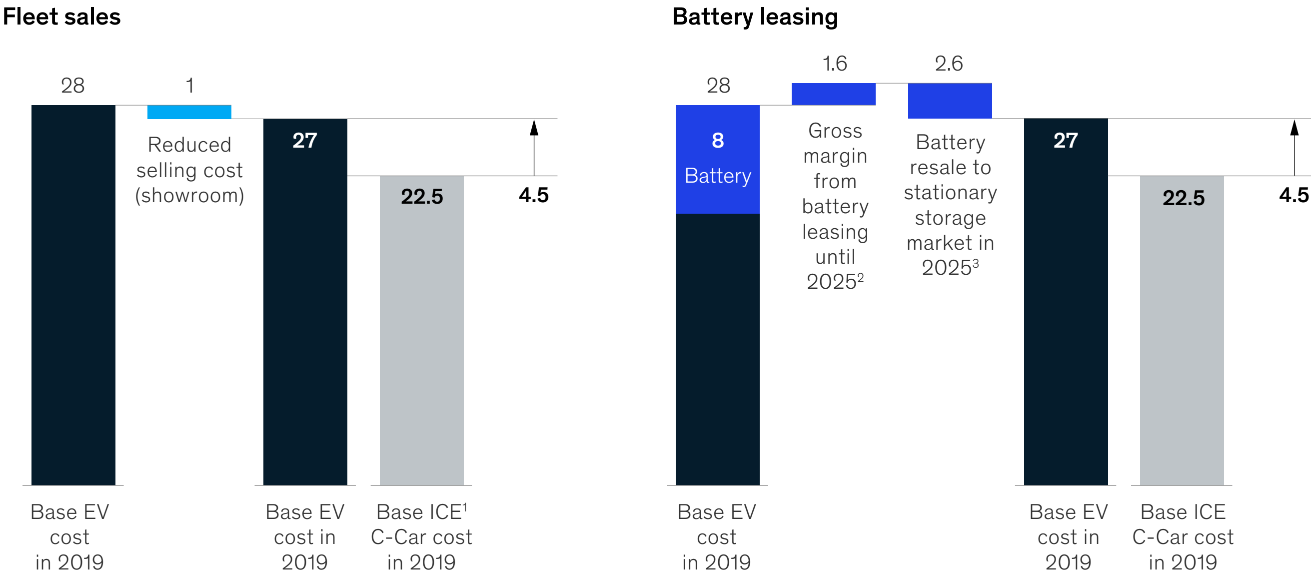
OEMs could offer to lease batteries separately from the vehicle and resell older batteries to the stationary storage market for secondary use. Battery leasing has a potential to attract consumers who shy away from purchasing an EV due to uncertainty in performance and degrading capacity of batteries today. OEMs operating a successful battery-leasing program could add more than $1,000 in revenue per vehicle during the assumed lease term of five years. A customer would be paying a monthly fee to lease the battery, with an assumption of added margin on the depreciated value of the battery pack.[3] This could be an increasingly viable profit-generating idea, but we still assume that this will only appeal to a minority of customers today.

[3] Renault ZOE offers battery-leasing options to customers on its 41-kilowatt-hour battery-pack model, starting at £59 per month for 4,500 annual mileage up to £110 per month for unlimited mileage.

Exhibit 4

New business models, such as fleet sales and battery leasing, could improve profitability

Base electric-vehicle (EV) total cost with new business models for improved profitability, price per vehicle, $ thousand



[1]Internal combustion engine.
[2]Assumes 5-year leasing period; assumes 30% gross margin on depreciated value of battery pack.
[3]Assumes 70% original capacity; assumes resale to remanufacturer at ~$65 per kilowatt-hour in 2025 (assume no margin by OEM on resale of battery pack; remanufacture could potentially derive margin from repurposing battery pack).
Source: Industry experts; McKinsey analysis

Operating in an increasingly complex environment

Beyond cost and regulatory pressures, OEMs must also contend with an increasing complex set of choices in product design, capital allocation, and changing mobility dynamics in cities.

Product design

OEMs have reached a crossroads on vehicle-platform design, with a number starting to invest in "native," or purpose-built, EV platforms, while others primarily produce EVs based on modified ICE-vehicle platforms. Purpose-built EV platforms are lower in material cost and allow better performance in range, acceleration, and interior space. They do, however, come with additional investments in new, stand-alone platforms, leading to higher fixed-cost allocation, especially when initially produced in lower volumes.

Each automaker would need to save more than $4,000 per vehicle in direct materials cost to recoup the estimated $1 billion in incremental fixed costs for a dedicated platform if selling about 50,000 units per year over five years. Today's mass-market EVs typically sell at volumes between about 30,000 and 80,000 vehicles globally.[1] Significant debate, especially for passenger-car segments, resides around the choice of a pure EV platform versus a versatile platform that can house both EV and ICE power trains.

[1] 2018 Nissan Leaf sales are approximately 80,000 per year; Chevy Bolt sales are approximately 30,000 per year.

OEMs that choose to make a BEV or PHEV from a modified ICE platform to limit capital investment will often have to sacrifice higher material costs driven by the "overdesigned" platform and face challenges in battery packaging, not only in the same capacity (sacrificing range), but also in a less cost-efficient manner, potentially making them less exciting to consumers.

Capital allocation

In addition, we have witnessed bolder actions by cities to address air-quality challenges, and pressure will increase as demographic shifts favor migration of more people to urban areas. Cities are counting on EVs to be part of the solution, and, in many cases, individual-city emission regulations will be stricter and will require higher EV adoption than will national regulations. (See sidebar, "Changing mobility dynamics in cities: Micromobility's role," for a view on another part of the solution.) For example, in Beijing, license-plate restrictions continue to shift consumer demand to EVs, and taxi fleets are also going electric, with 70,000 EV taxis now on the streets. In Europe, London is expanding ultra-low-emission zones with daily fees and pushing to add charging stations at one out of every five parking spots. In the United States, cities such as San Jose offer consumer-purchase incentives of $2,500 on top of federal incentives to improve consumer economics, and California emission regulations are more stringent than regulations on the US federal level.

Changing mobility dynamics in cities: Micromobility's role

Microvehicle segments offer possible solutions but are not sufficient.

In parts of Asia, especially China and Southeast Asia, two-wheel and three-wheel e-scooters and e-rickshaws are playing an increasing role in electrifying transport. One example of a microvehicle is a low-speed electric vehicle (LSEV): these three- or four-wheel vehicles outsell mainstream EVs two to one, with approximately two million in sales per year in China.

However, consumers unfamiliar with two-wheel driving are not likely to switch, and LSEVs are limited to very low driving speeds and would not pass Western crash tests. The Chinese government is also debating more restrictions for LSEVs, as these vehicles are clogging roadways, require no licenses, and are threatening traditional EV growth.

Fast-forward to 2025: Electric-vehicle cost parity

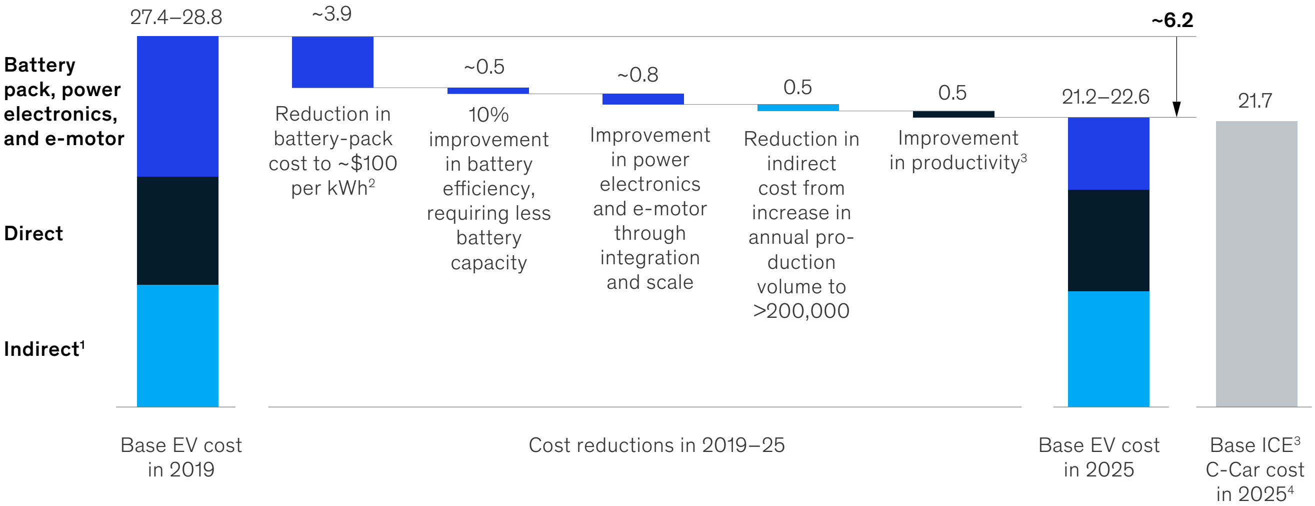
While not as profitable as ICE vehicles today, our analysis shows that EVs have the potential to reach cost parity with and become equally—or even more—profitable as ICE vehicles by around 2025 (Exhibit 5). McKinsey and other industry experts have conducted detailed studies on the potential cost trajectory for EVs, including battery-cost and efficiency improvements, power-electronics scale economies, and indirect cost reduction based on increased volume production. We believe these can unlock $5,100 to $5,700 in cost reductions per vehicle. We assume battery-cost and related price declines will continue, driven by chemistry and scale improvements, although it is fair to assume that we may witness short-term upward price movement in markets with constrained supply. Alternatively, we may see even faster price declines if competitive intensity rises among battery makers seeking volume.

Based on our analyses, an OEM could expect to break even in cost with EVs compared to ICE vehicles, and thus even achieve a profit margin of 2 to 3 percent per vehicle, in 2025. This scenario holds true in the absence of any premiums in pricing paid by consumers or any subsidies provided by governments. Application of the newer business models described above are also excluded here.

Exhibit 5

By 2025, cost reductions could greatly improve electric-vehicle profitability

Base electric-vehicle (EV) total estimated cost per vehicle in 2025 under the aggressive scenario, $ thousand



[1]Includes average incentive cost of $2,000.
[2]Kilowatt-hour; includes battery-management system.
[3]Internal combustion engine.
[4]Assumes 1% annual productivity improvement—reduced from historical value of 2–3% because of OEM investments in emerging technologies (eg, autonomous vehicle, electric power train, connectivity, shared mobility).
Source: Industry experts; McKinsey analysis

Conclusion

While it is true that the majority of EVs are not generating profits today, our analysis shows that OEMs should not be fatalistic about their plight, nor can they afford to wait for reductions in battery costs to change this dynamic. We believe there are multiple levers that automakers can pull, even today, to help accelerate their path toward mass-market EV profitability. Taken together, we believe that OEMs can reach a break-even cost basis for mass-market EVs compared to ICE vehicles in the next few years—and for some targeted customer segments, even achieve earlier and higher profitability with EVs.

Based on our analyses, accelerating EV profitability will, however, require some bold steps, including the following:

— making tough choices around EV-platform design, including balancing lower material cost with higher capital allocation and maximizing volume where possible

— applying more ambitious cost-reduction approaches to EVs, including design simplification, value-neutral decontenting, and aggressive purchasing strategies

— evaluating new potential partnerships with competitors to share R&D, tooling, and production costs for new EV platforms

— considering more creative use of alternative EV-specific business models that can boost margins

There is no debating that the next five years will be a challenging transition period for automakers and suppliers alike. Consumers, city dynamics, regulators, and competitors will increase pressure on most OEMs to switch more quickly from ICE vehicles to EVs, often with little consideration of EV economics.

The key debates are thus: Which automakers will crack the code of EV profitability first, what bold actions and visions will they pursue, and, as a result, how will the global automotive industry be permanently reshaped?

Authors

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