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Electrifying insights: How automakers can drive electrified vehicle sales and profitability

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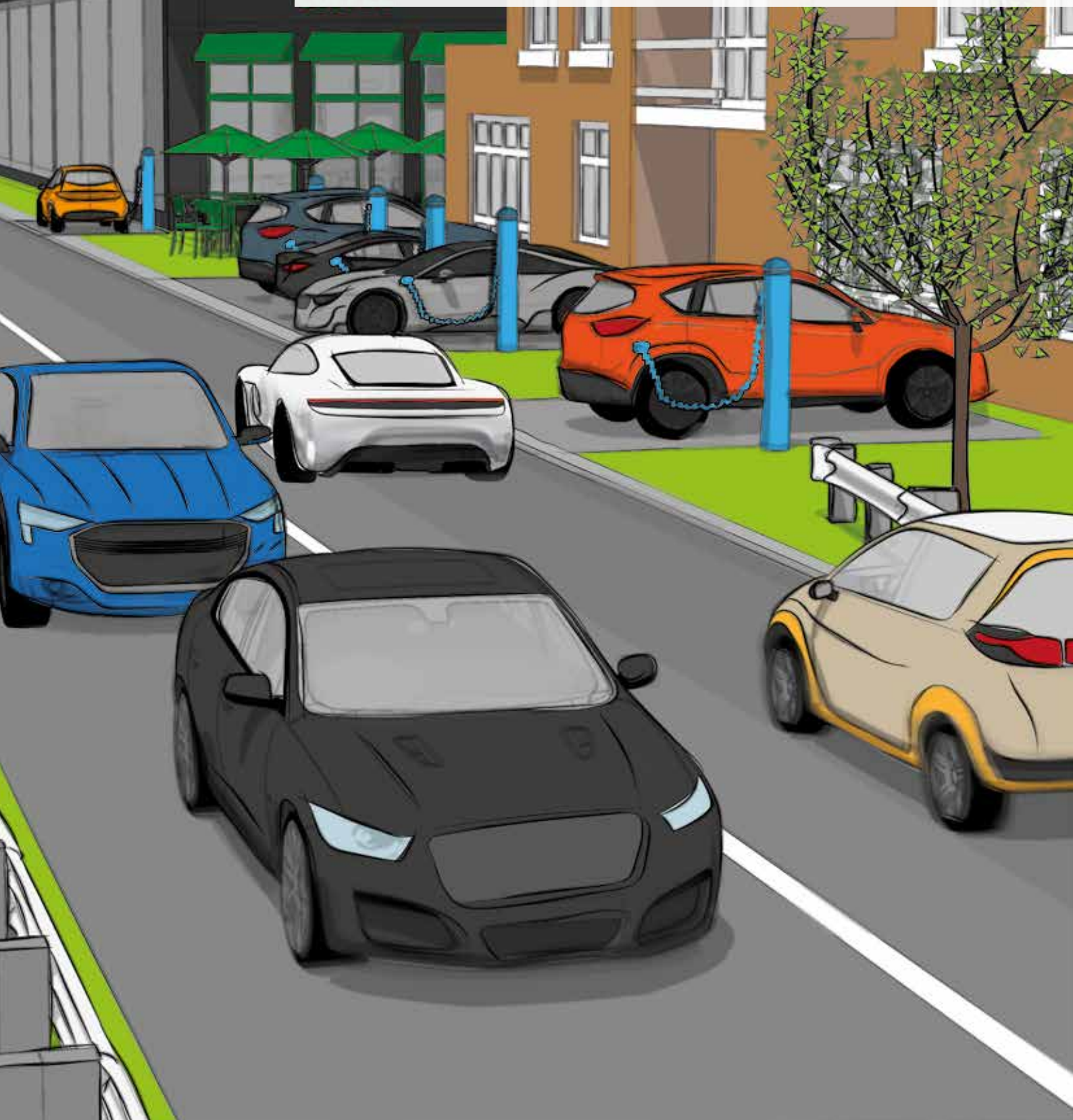

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Introduction and key messages

Auto shows are premiere events for presenting new electrified vehicle (EV) models and e-mobility strategies.[1] Yet at recent salons, the limelight returned to SUVs, pickups, and crossovers powered by combustion engines. Besides enjoying red-hot sales right now, these models with conventional powertrains are generally much more profitable, relegating many EV models to the shadows.

The muted reception for EVs reflects the industry's tempered excitement about the short-term economic potential for electrification. Automakers know that the need for electrification strategies will grow, given that global sales of battery electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs) have grown quickly from ~6,000 units in 2010 to more than 400,000 units through the first three quarters of 2016.[2] They also view e-mobility as essential to achieving compliance with emission and fuel economy targets and mandates. At the same time, it is clear that internal combustion engines (ICE) will remain a critical part of most automakers' powertrain strategies.

As a result, automakers face a difficult challenge: They must strike the right balance between selling enough EVs to comply with tightening regulatory fleet emissions and fuel economy targets, while also preventing the incremental cost of adding battery packs from cannibalizing corporate profits. At the same time, automakers cannot afford to lose focus on ICE models, which are often more profitable.

Against this backdrop, this report provides fresh insight from the latest McKinsey research (Text box 1) into three pressing questions for the auto industry at large:

- What is driving current e-mobility momentum, and how will this develop?
- What are the critical considerations for automakers as they create e-mobility strategies?
- How can automakers set up e-readiness strategies that also avoid profitability shocks?

Text box 1: McKinsey's e-mobility research

- **Preferences:** Conducted a global survey of EV consumer preferences – an online survey of ~3,500 consumers in the US, Germany, and Norway, plus another survey of ~3,500 consumers in China[3]
- **Segments:** Used statistical approaches (factor analysis, Ward's method, k-means clustering) to model a data-driven composition of current and future EV consumer segments based on attitudes, demographics, and EV feature preferences
- **Perceptions:** Uncovered consumer perceptions along the buying process, from initial consideration to purchase, by comparing potential EV buyers to actual EV owners

1 In this report "EV" refers to battery electric vehicles and plug-in hybrid vehicles

2 IHS Automotive

3 If regions are not referenced for a specific insight in this report, it is because survey results were very similar across regions

Electrifying insights – key messages

I. Consumer demand is starting to shift in favor of electrified vehicles and has strong disruption potential

- Around half of consumers in the US and Germany say they comprehend how electrified vehicles and related technology work versus almost 100% of consumers for ICE vehicles
- Between almost 30 and 45% of vehicle buyers in the US and Germany respectively consider an EV purchase today
- Less than 5% of potential buyers ultimately purchase an EV over an ICE model (~4% in the US, ~3% in Germany, and ~22% in Norway – due in part to government subsidies)

II. Automakers will need greater agility to address challenges that hinder EV profitability

- Consumers are excited about EVs today, but concerned about driving range; high costs for battery packs make the cost of offering ICE-equivalent range prohibitive
- Automakers may be capital constrained as they simultaneously invest across multiple mobility megatrends (autonomy, connectivity, electrification, and shared mobility)
- Cracking the code for EV profitability will be critical for automakers as they roll out broader e-mobility strategies and new EV models to meet emission and fuel economy targets as well as consumer needs for range, convenience, and affordability

III. Automakers can "electrify" their customer base – more profitably – by offering more tailored EVs and deploying new business models

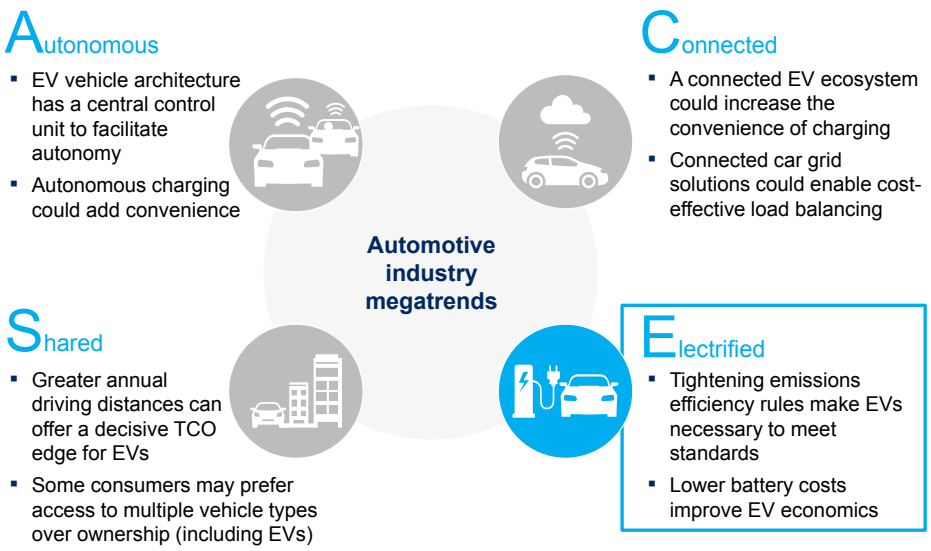
- Near term, there are sizeable underserved segments of consumers who want basic e-mobility solutions with lower range requirements
- Longer term, EV buyers will also look for more driving range, increased driving utility, and a broader set of capabilities and features
- Automakers can address a broader range of EV segments by deploying new business models (e.g., car sharing and fleet operator) that take advantage of favorable EV economics

I. Consumer demand is starting to shift in favor of electrified vehicles and has strong disruption potential

To understand why e-mobility has the strong potential to be disruptive, we need to initially consider it in the context of other megatrends shaping the auto industry (Exhibit 1). The expansion of four mobility megatrends – autonomous, connected, electrified, and shared ("ACES") – will have game-changing effects on the automotive market. The ACES trends are likely to drive more change over the next decade than has occurred over the last 50 years. In the long term, these megatrends will likely be self-reinforcing.

Exhibit 1 Automotive industry megatrends are self-reinforcing and will likely accelerate the transition to e-mobility in the long term

Examples of potential EV reinforcement points from other automotive megatrends



SOURCE: McKinsey Sustainable Mobility Initiative

In addition, of these four megatrends, "electrified" – e-mobility – has significant potential to disrupt the market in the short term, due to four powerful forces that are at work today:

1. Consumer demand shifting in favor of e-mobility
2. Faster-than-anticipated improvements in key technologies
3. Increased urbanization across the globe, creating more pull for green mobility solutions
4. Accelerating regulatory forces at national, regional, and city levels.

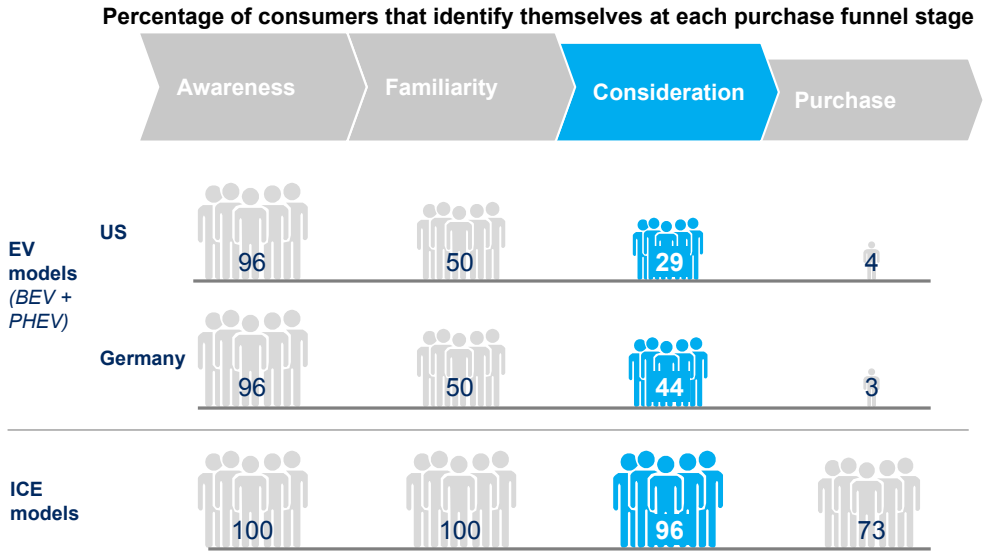
1. Consumer demand shifting in favor of e-mobility

EV sales have grown at a rapid pace over the past five years, with a recent surge in Europe and China. We expect this shift to EVs to continue to gain momentum.

The latest McKinsey consumer research on vehicle electrification indicates that today a large share of prospective new vehicle buyers in the US and Germany consider purchasing an EV model (for BEV and PHEV – 29% in the US, 44% in Germany) (Exhibit 2). For BEVs alone, the share of considering consumers stands at ~20% in the US and ~30% in Germany. These shares of "consideration" indicate substantial latent demand for EVs. Since ~50% of all consumers today are not yet familiar with EVs and related technology, an automaker could relatively quickly increase the number of potential buyers by running a focused marketing/ consumer education campaign.

Exhibit 2 Between almost 30 and 45% of vehicle buyers in the US and Germany respectively consider an EV purchase today

Percentage of responses, US and Germany, 2016

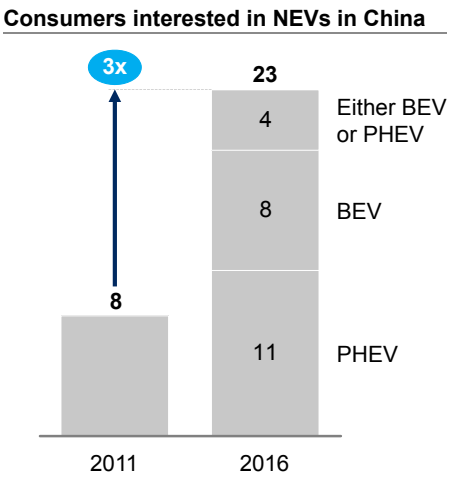


SOURCE: McKinsey Sustainable Mobility Initiative – 2016 Electrified Vehicle Consumer Surveys

Similarly, McKinsey's survey of Chinese consumers shows that interest in "new energy vehicles" or NEVs (covering both BEVs and PHEVs) has tripled over the last five years (Exhibit 3). This sharp increase is due in part to significant government support for NEVs, which includes substantial investments in an improved EV-charging infrastructure, increased purchase subsidies, tax exemptions, and fewer restrictions for EVs regarding license plate access and restricted driving days in Tier-1 cities.

Exhibit 3 Consumer interest in China for NEVs (new energy vehicles), including BEVs and PHEVs, has tripled over the last five years

Percentage of responses, China



SOURCE: McKinsey Sustainable Mobility Initiative – 2016 Electrified Vehicle Consumer Surveys

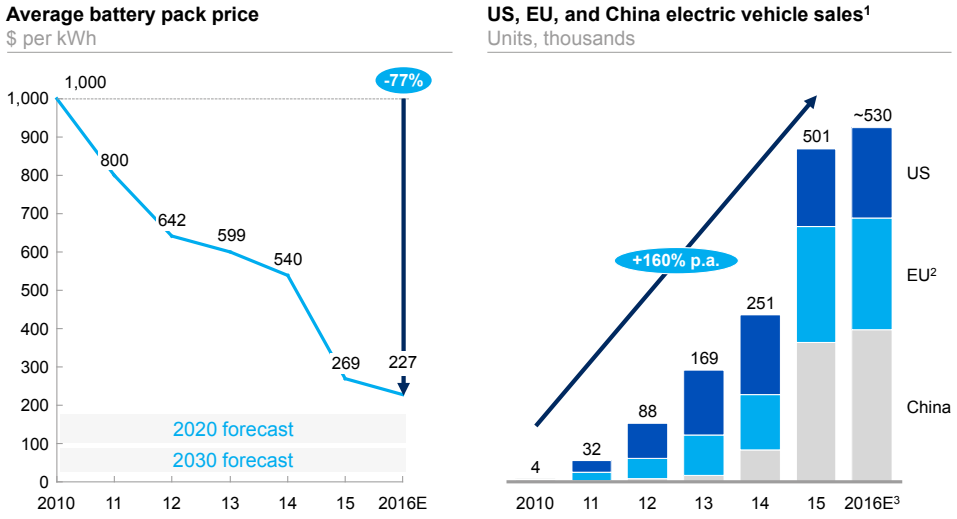
Moreover, consumer excitement about upcoming EV models reflects positive near-term growth potential. As an example, between the start of pre-ordering on March 31, 2016, and year-end, consumers globally placed more than 380,000 orders for the upcoming Tesla Model 3 – the largest number of pre-orders for any car in history.

2. Faster-than-anticipated improvements in key technologies

Also helping to set the stage for greater EV growth are advances in battery efficiency translating into lower cost and higher range, and an accelerating rollout of wide-scale charging infrastructure in the US, Europe, and China.

Decreasing battery prices. From 2010 to 2016, battery pack prices fell roughly 80% from ~$1,000/kWh to ~$227/kWh (Exhibit 4).[4] Despite that drop, battery costs continue to make EVs more costly than comparable ICE-powered variants. Current projections put EV battery pack prices below $190/kWh by the end of the decade, and suggest the potential for pack prices to fall below $100/kWh by 2030.[5] Lower costs for battery packs could potentially bring base versions of the Chevy Bolt below $30,000, and base versions of the Tesla Model 3 below $40,000 after the $7,500 federal tax subsidy is applied. However, the unsubsidized price of these EVs is still above the average price of around $35,000 for a new vehicle purchase in the US (~$29,500 in Europe, ~$24,000 in China).[6,7,8] Yet if battery costs continue to trend downwards, a clear path exists towards EV and ICE model price parity in selected segments in the next decade.

Exhibit 4 Rapid decreases in battery prices have helped accelerate EV sales, especially in Europe and China



1 Plug-in hybrid electric vehicles and battery electric vehicles; excludes low-speed vehicles and hybrid electric vehicles without a plug
2 Includes Denmark, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, and the UK
3 Extrapolated based on Q1-Q3 2016 IHS data and assuming continued growth in all three markets in Q4
SOURCE: IHS, Bloomberg, New Energy Finance

4 All $ figures in this report are based on 2016 US $
5 Bloomberg New Energy Finance
6 Kelley Blue Book, December 2016
7 JATO, September 2016
8 National Development and Reform Commission of China

Increased vehicle range. Since 2013, the estimated range for many EVs has increased significantly. For example, base models of the Nissan Leaf and Tesla Model S grew from 75 and 208 miles per charge in 2013 to about 107 and up to 249 miles in 2017, respectively.[9] That range increase of approximately 20-40% is primarily due to larger battery packs – the Nissan Leaf base battery pack grew from 24 kWh to 30 kWh and the Tesla Model S base battery pack capacity grew from 60 kWh to 75 kWh (Tesla customers are given a software upgrade option to use the full 75 kWh of available capacity in the base model). The additional mileage helped offset some of the range concerns that consumers cite as a major deterrent to EV purchases.

Accelerating scale of charging infrastructure. Recent projections for global charging station deployments estimate that public and private installations could grow from around 2 million in 2016 to over 12 million in 2020.[10] Analysis of public charging infrastructure as part of McKinsey's Electric Vehicle Index (EVI) shows that markets like the US and Germany have seen the ratio of EVs versus public charging stations worsen slightly (e.g., the US went from 12.4 EVs per charging station in 2015 to 13.2 in 2016). However, many new investments have been announced and should improve these ratios soon. In the US, automakers will invest billions of dollars in new charging infrastructure over the next ten years. In Europe, a group of premium and mass-market automakers will work together to install numerous fast-charge points. In China, national government investments increased the total number of charging poles to ~110,000 in 2015 (50% are public), up from only ~8,000 poles in 2011.

3. Increased urbanization across the globe, creating more pull for green mobility solutions

Global populations will continue to shift toward cities with >1.1 billion new urban residents by 2030. This growth will increase the need for new mobility solutions that meet high standards for air quality in cities. It also suggests that a larger share of people may drive shorter distances on average per trip, requiring less range. McKinsey's recent study Future of Mobility highlighted three distinct mobility scenarios for big cities ("progressive urban mobility," "private autonomy," and "clean and shared"). All three scenarios demand more sustainable mobility solutions, including significantly higher electrification of the fleet.

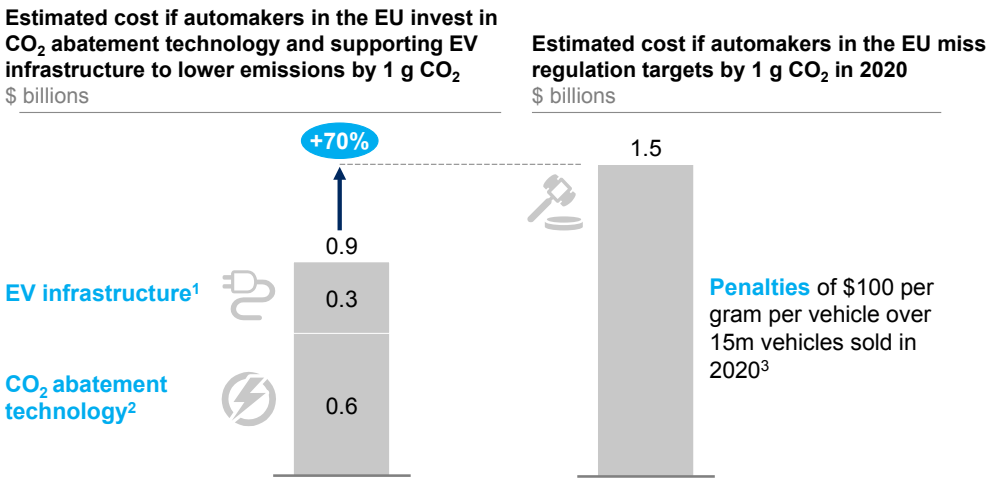
4. Accelerating regulatory forces at national, regional, and city levels

When automakers fall short of regulatory targets (e.g., due to higher-than-anticipated sales of SUVs), they have to make a trade-off decision: accept a penalty or absorb the cost of lowering their fleet emission level. For the federal fleet targets proposed for 2020 in the US, the EU, and China, our calculation shows that automakers are likely to be better placed if they take an approach to "comply" with mandated levels and so avoid penalty payments. In practical terms, this would likely translate into investing in carbon dioxide abatement technologies (e.g., ICE efficiency improvement technology, hybridization, and electrification) and EV-supporting infrastructure (Exhibit 5).

9 Department of Energy (www.FuelEconomy.gov), EPA

10 IHS Automotive

Exhibit 5 Given that CO_2 penalties could be ~70% more expensive for OEMs relative to investing in carbon abatement technologies and EV infrastructure, they are likely to pursue regulatory compliance



1 To reduce emissions by 1 g CO_2, 100k more EV sales in the EU are necessary in 2020/2021; translates into an additional car parc of 300k units (assuming smooth ramp-up), which requires 12k additional charging stations (9k slow and 3k fast-charging stations) and assumes a cost of ~$11k per slow-charging station and ~$70k per fast-charging station)
2 Assumed average abatement cost of $42/g CO_2/km for 15m vehicles in 2020 – linear regression analysis of abatement technologies (e.g., electrification, lightweighting)
3 Assumes a penalty of ~$100 per g CO_2/km and 15m new vehicles sold in the EU in 2020

SOURCE: McKinsey Sustainable Mobility Initiative, European Commission

Besides the national regulatory targets for emissions and fuel economy, automakers can expect strict emission and fuel economy regulations worldwide to continue at state/province and city levels, where some of the most dynamic regulatory changes are occurring.

Some federal governments are promoting disruptive regulatory regimes. For example, Norway is considering policies to more aggressively reduce ICE model sales and strive for 100% EV sales by 2025. Governments have also added monetary incentives for EV buyers (e.g., the EUR 4,000 subsidy in Germany) and tax credits (e.g., exemption from motor vehicle taxes for ten years in Germany).

In the US, ten states have adopted the ZEV (zero emission vehicles) standard issued by CARB (California Air Resources Board). This mandate stipulates that for “any automaker with annual sales greater than 60,000 vehicles, at least 14% of the vehicles they produce and deliver for sale in California must meet ZEV requirements.” CARB is also taking a leading role in setting stringent fuel economy standards, independent of the federal-level requirements issued by the Environmental Protection Agency (EPA).

In Europe, cities like Berlin have created “green zones,” where drivers of higher-emission vehicles are forced to pay steep fines if they enter these zones. When temporary driving restrictions occur in cities like Beijing to combat air pollution, BEV drivers are exempt and can drive freely, generating more interest in EVs.

II. Automakers will need greater agility to address challenges that hinder EV profitability

While e-mobility is likely to be highly disruptive, significant uncertainty exists about the timing of EV adoption and how quickly, or not, that will ramp up. Regardless of which EV forecasts automakers believe and plan for, they will need to be more creative and agile in order to surmount four major challenges that hinder EV profitability today.

1. The battery barrier: Unfavorable battery economics will remain a profitability barrier for the next two to three product cycles. Although battery prices have declined by ~80% since 2010, the 2016 estimated pack cost of ~$227/kWh means that a 60 kWh battery becomes a $13,600 component of the car. This does not include additional systems such as e-motors, high voltage wiring, on-board chargers, and inverters. Given current system costs and pricing ability within certain segments, companies that offer EVs face the near-term prospect of losing money with each sale. Under a range of scenarios for future battery cost reductions, cars in the C/D segment in the US might not reach true price parity with ICE vehicles (without incentives) until between 2025 and 2030, when battery pack costs fall below $100/kWh, creating financial headwinds for automakers for the next two to three product cycles.

2. The trade-off trap: Relying only on ICE optimization as an alternative to EV investment delivers diminishing returns and will be insufficient. Automakers continue to invest in combustion technologies to squeeze incremental efficiency. ICE vehicle efficiency can be enhanced through a broad application of engine improvements (e.g., downsizing, turbocharging), mild hybridization (e.g., start-stop, 48V), transmission improvement (CVT, dual clutch), lightweighting, and aerodynamics, albeit at a cost. These innovations will help, but deliver diminishing returns. From a baseline of 130 g CO_2/km in Europe today, we believe incremental abatement potential of ICE powertrain vehicles (including mild hybridization) could be around 25%. To reach these levels, automakers would need to pursue more aggressive engine downsizing, incorporate greater lightweight construction, rollout mild hybrid systems across the fleet, and enhance aerodynamics. Even with such additions, a sizeable gap to future regulatory targets likely exists, with each level of efficiency improvement more costly than the last.

3. Capital crunch: Making investments in ICE vehicle platforms and autonomous/connected technology puts automakers into a capital crunch, even before EV investments. Ongoing investments for ICE platform improvements and simultaneous investment in the other mobility megatrends (autonomy, connectivity, and shared mobility) will only raise competition for the capital funding required for EVs. This will further squeeze or delay investments required for new plants, tooling, R&D, and go-to-market strategies. The higher short-term ROI from ICE vehicles makes investing in EVs a difficult, but necessary proposition. Given the increasing demand for innovation on multiple fronts, automakers will need to thoroughly analyze how to make the most of limited human and capital resources – i.e., the how, where, and when to divest assets.

4. Supply/demand mismatch: The lack of investment in EV platforms across a range of vehicle models is perpetuating a supply versus demand mismatch – a difficult cycle to break. Today, a lack of EV models tailored to serve a fast-growing, but nascent set of EV buyers is problematic. Current high-selling EV models have focused on the less price-sensitive premium consumer market; however, few EV alternatives exist today for consumers most interested in small-car-based SUVs and crossovers. At the same time these segments have witnessed double-digit growth globally, with five-year growth levels of 12%, 15%, and 63% in the US, Europe, and China respectively.[11]

11 IHS automotive

III. Automakers can "electrify" their customer base – more profitably – by offering more tailored EVs and deploying new business models

For many in the industry, the transition from ICE to electrified powertrains is the signature challenge of their professional careers. In addition to the profound shift in the technology paradigm, the challenge is even more daunting given the market forces and resource constraints described in the previous chapter. They potentially recalibrate industry profitability, leaving many players with limited room to maneuver at a time when exploration and "trial-and-error" are essential.

In this situation, in addition to pursuing cost excellence along the value chain, automakers should strengthen their "e-readiness" – the combination of internal and external capabilities required to win in an electrified future. They can start by pulling three fundamental levers: 1) better understand how diverse preferences of emerging EV consumer segments fit into e-mobility strategies; 2) develop vehicles that match the nascent demand for e-mobility from emerging EV consumer segments; and 3) deploy additional new business models that take advantage of EV economics for consumers and automakers.

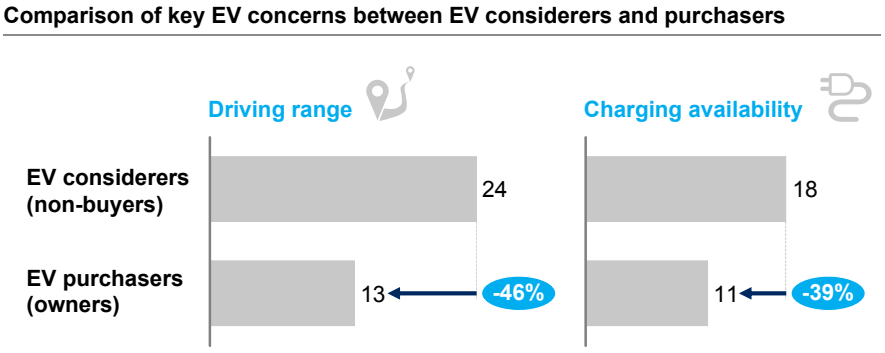
1. Better understand how diverse preferences of emerging EV consumer segments fit into e-mobility strategies

Deeper knowledge of customer concerns, motivations, and willingness to pay can help automakers strengthen their e-readiness. McKinsey's consumer research from the US, Germany, Norway, and China reveals a number of insights that automakers can apply as they work to develop segment-specific e-mobility strategies that can scale.

A large gap exists between perceived and real-world "range anxiety" and charging. Today's EV owners in the US and Germany are much more satisfied with EV driving range and charging infrastructure than potential buyers (Exhibit 6). Despite a natural positive bias from EV owners, this data suggests that a gap exists – and can be overcome – between perceived charging/range anxiety and true driving experience.

Exhibit 6 A large gap exists between perceived and real-world range anxiety and charging availability in the US and Germany

Percentage of responses, US and Germany

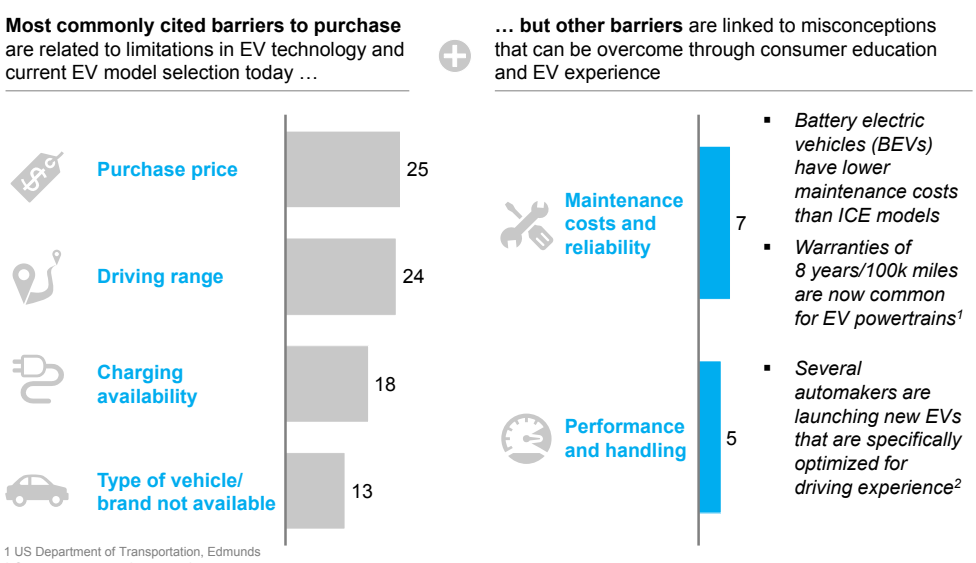


SOURCE: McKinsey Sustainable Mobility Initiative – 2016 Electrified Vehicle Consumer Surveys

Some consumers have misconceptions about EV maintenance costs, reliability, and driving performance. Our research suggests that a subset of potential buyers in the US and Germany are also concerned that EV maintenance costs will be higher despite fewer moving parts and that EVs are slower/less fun to drive than ICE models (Exhibit 7). These views and other misconceptions on range and charging need to be proactively addressed, in part through an "education" campaign. Multiple analyses show that EV maintenance and operating costs are lower, high-mileage warranties on hybrid systems and EV batteries are now the industry standard, and several premium brands are designing EVs to enhance both efficiency and driving performance.[12,13] Based on a comparison of five EVs across five automakers and their comparable size ICE counterparts from the same brands, EVs typically had 20-40% lower five-year maintenance costs.[14]

Exhibit 7 Misconceptions about EV maintenance costs, reliability, and driving performance can be overcome to help improve purchase conversion

Percentage of responses, US and Germany



1 US Department of Transportation, Edmunds
2 Statements to press by automakers

SOURCE: McKinsey Sustainable Mobility Initiative – 2016 Electrified Vehicle Consumer Surveys

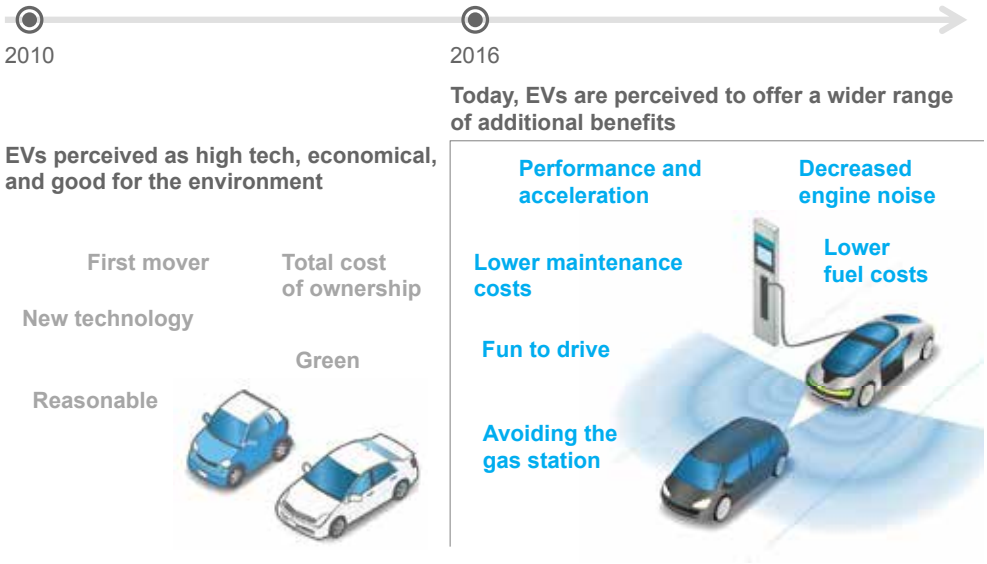
On the other hand, there is a growing portion of potential EV buyers that are well educated about EV benefits. While early adopters of EVs were focused on high-tech features and sustainability, McKinsey's research shows that many potential buyers now cite a wider set of perceived benefits (Exhibit 8). Exemplifying this shift, acceleration and driving performance are now among the top benefits that many potential buyers now cite when considering EVs. The benefit of instant torque from e-motors was not a part of the consumer conversation for early EV models.

12 Multiple sources, including US Department of Transportation, Idaho National Laboratory, Wired, Insideevs.com

13 US Department of Transportation, Edmunds, public statements by automakers

14 Edmunds

Exhibit 8 EV owners in the US and Germany currently value a wider range of benefits than earlier buyers, who focused on economic and environmental benefits



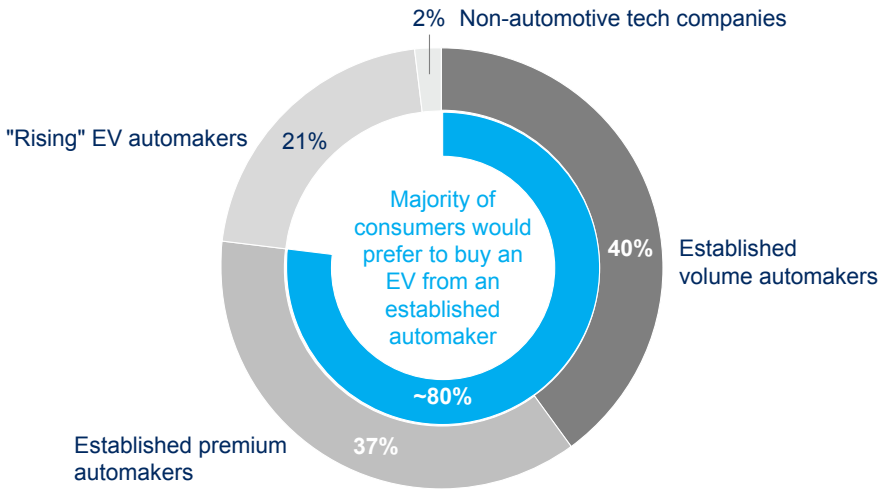
SOURCE: McKinsey Sustainable Mobility Initiative – 2016 Electrified Vehicle Consumer Surveys

EV-specific brands are exciting consumers – but potential EV buyers still place greater trust in traditional automakers. Having built strong brands, EV-focused automakers like Tesla continue to generate buzz from the automotive press and consumers. As part of our consumer survey, we ran an experiment where non-branded EVs were shown to respondents next to a brand logo in random combinations. The result: consumers' likelihood to purchase an EV increased 20 to 40% when they were able to choose an EV model with a Tesla badge over other premium or volume car brands.

What was surprising, however, is that, in terms of "trust," traditional brands are still compelling. Consumers indicate the highest levels of trust in EV models from established automakers whose portfolios consist of mainly ICE models (Exhibit 9). This indicates that established automakers can improve their chances of growing EV sales by developing EV-specific brands or sub-brands. Naturally, success also depends on the quality and diversity of EV models launched with the right mix of compelling designs and driving experience. Automakers that choose to focus e-mobility efforts on pure "compliance cars" for markets like California, may find a market among consumers looking for basic EVs, but also need to anticipate and plan for consumers' rising "table stakes" expectations.

Exhibit 9 Nearly 80% of consumers in the US and Germany are more likely to "trust" new electrified vehicle models from established auto brands

Share of consumers indicating trust in EVs from each type of automaker, US and Germany



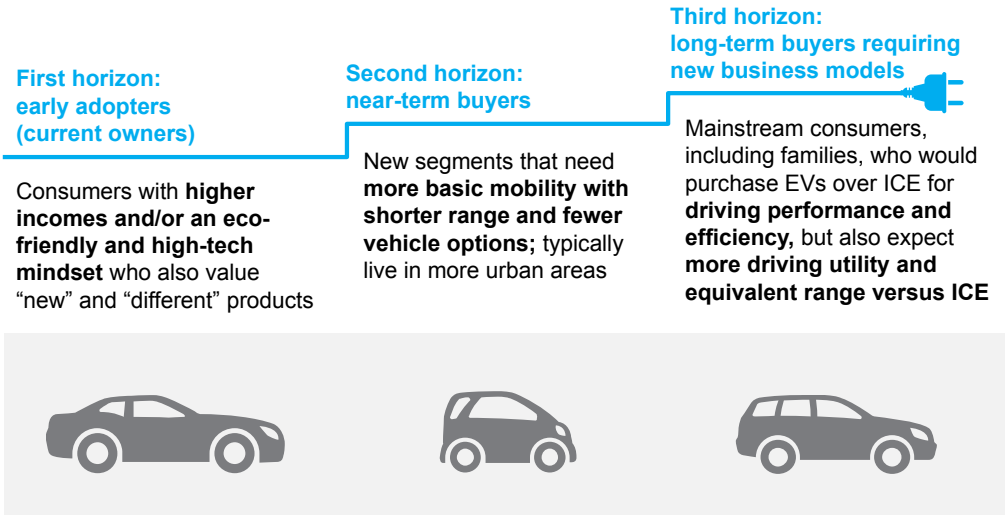
SOURCE: McKinsey Sustainable Mobility Initiative – 2016 Electrified Vehicle Consumer Surveys

2. Develop vehicles that match the nascent demand for e-mobility from emerging EV consumer segments

Our research and analysis suggest that EV adoption is likely to occur over three horizons (Exhibit 10). It also confirmed that near-term buyers want more basic e-mobility solutions without the range and utility required by more demanding future buyers. Such "basic EVs" are still rare and offer a development opportunity for automakers to expand their EV model portfolio.

Exhibit 10 Following early adopters, EV consumers in the second horizon need more basic and affordable mobility; longer-term buyers do not want to compromise on utility or range

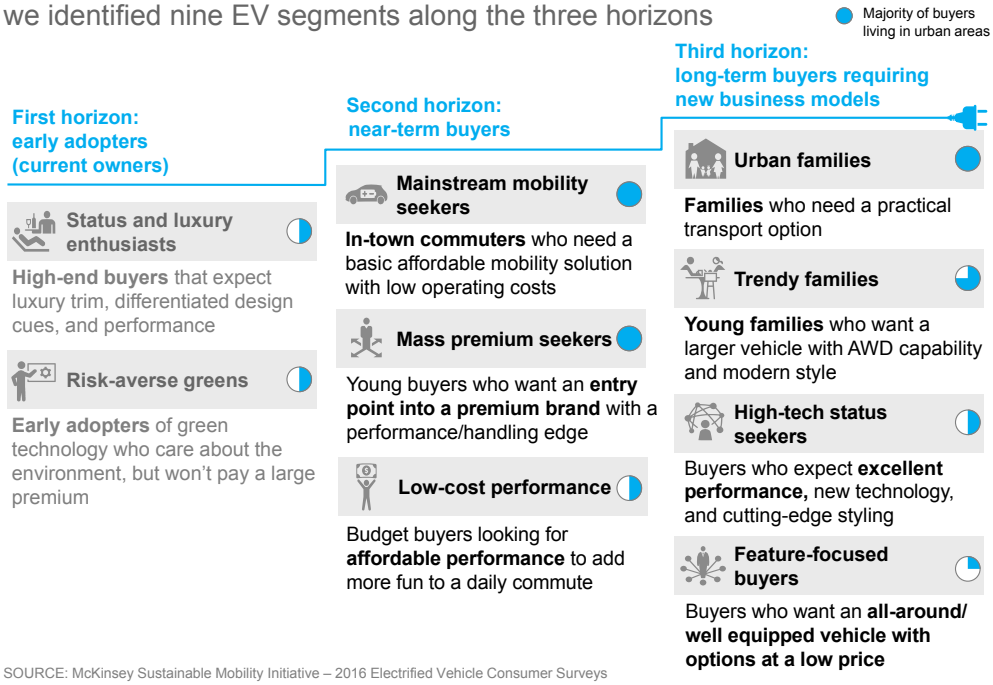
Three horizons of EV adopters



SOURCE: McKinsey Sustainable Mobility Initiative – 2016 Electrified Vehicle Consumer Surveys

McKinsey's in-depth statistical analysis of survey respondents in the US, Germany, and Norway identified nine EV consumer segments (Exhibit 11). Two segments – "status and luxury enthusiasts" and "risk-averse greens" – demand the type of high-end performance (e.g., Tesla Model S) and/or purpose-built sustainability (e.g., Nissan Leaf, Chevy Volt) associated with the most successful EV models today.

Exhibit 11 Based on analysis of common demographics and preferences, we identified nine EV segments along the three horizons

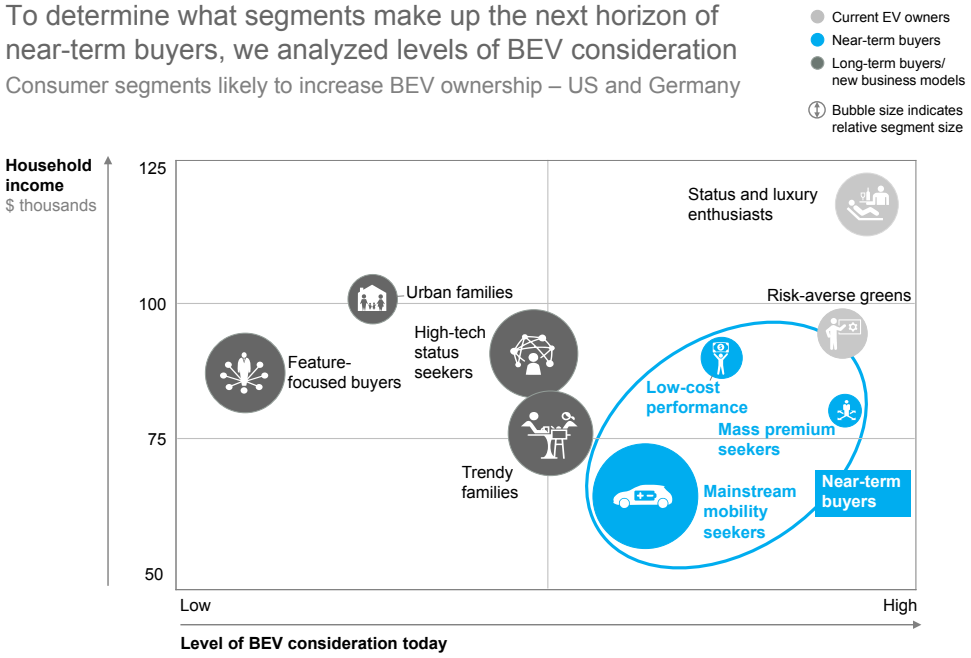


SOURCE: McKinsey Sustainable Mobility Initiative – 2016 Electrified Vehicle Consumer Surveys

Findings for the other seven consumer segments indicate near-term unmet demand for more basic mobility solutions (e.g., lower-range, smaller vehicles, less driving utility). Our research suggests that the potential next-mover EV adopters could be the three consumer segments "mainstream mobility seekers," "mass premium seekers," and "low-cost performance," driven by the highest rates of consideration for EVs today (Exhibit 12).

Exhibit 12 To determine what segments make up the next horizon of near-term buyers, we analyzed levels of BEV consideration

Consumer segments likely to increase BEV ownership – US and Germany



SOURCE: McKinsey Sustainable Mobility Initiative – 2016 Electrified Vehicle Consumer Surveys

These near-term EV buyers may be satisfied with less costly, purpose-built EVs with smaller battery packs and shorter ranges. They live predominantly in urban settings and travel 25 to 35 miles on average per day, which is well within the range of current EV models and 20 to 30% less than consumers in our survey who live in the suburbs (Exhibit 13).

Exhibit 13 Three consumer segments – near-term buyers – look for affordable electrified mobility solutions and have lower range expectations

Overview of near-term EV buyers

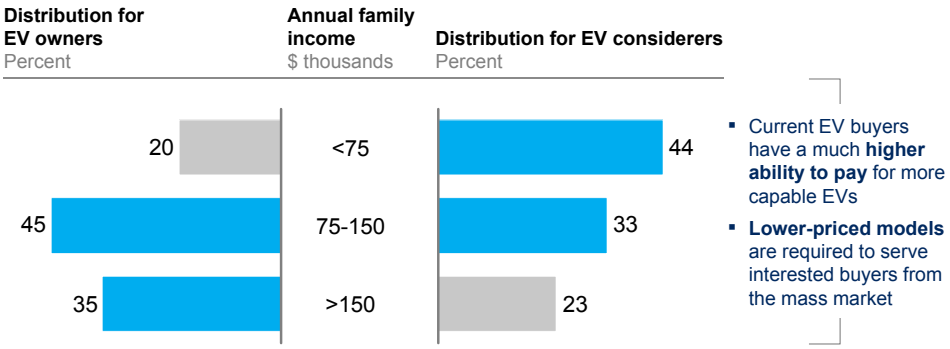
			Importance of …				
Segment	**Living area(s)**	**Average daily commute**	**Range**	**Tech-nology**	**Branding/ design**	**Perfor-mance**	**Potential EV offering**
Mainstream mobility seekers	Urban areas	25 miles	Medium	Medium	Low	Medium	Low-cost small EV with reduced battery size, lower performance, and fewer advanced tech-nology features as standard
Mass premium seekers	Urban areas	30 miles	Low	High	High	High	An entry-level EV model from a premium brand with good performance and style, used primarily for short commutes
Low-cost performance	Suburban/urban	35 miles	Medium	Medium	Low	High	"No frills" mass-market brand EV with good driving performance at an affordable price

SOURCE: McKinsey Sustainable Mobility Initiative – 2016 Electrified Vehicle Consumer Surveys

These three segments have lower household incomes than early adopter segments (Exhibit 14). On the one hand, any automaker designing vehicles must then be judicious about keeping cost/price to a minimum. On the other hand, large cities in the US, Europe, and China offer significant sales and scale potential, as they are becoming the most progressive environments for sustainable transport solutions (in terms of restrictions for ICE models and incentives for EV buyers). Indeed, buyers may be willing to pay a small price premium for an EV model if in return they get a perceived benefit of added "performance" and de facto greater mobility access within cities.

Exhibit 14 The next horizon of electric vehicle buyers may have lower average household incomes than current buyers

Income of current and future EV owners, US example

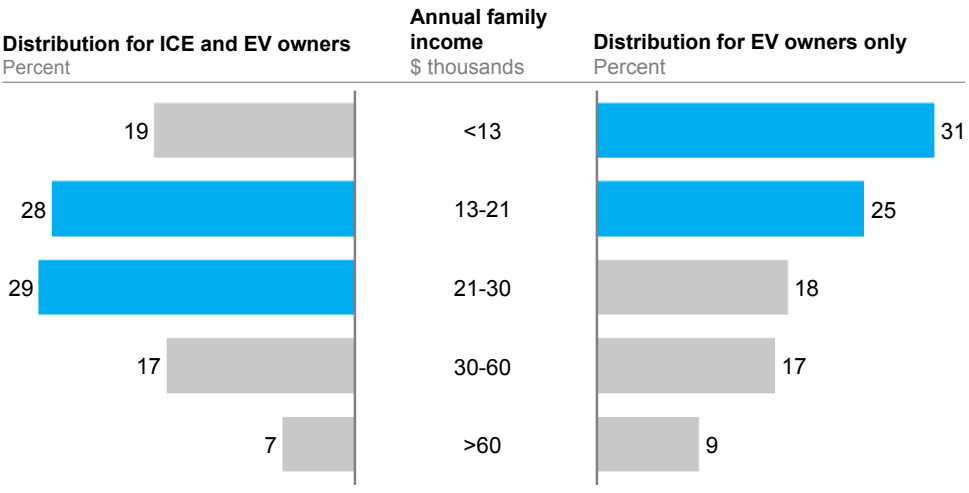


SOURCE: McKinsey Sustainable Mobility Initiative – 2016 Electrified Vehicle Consumer Surveys

Notably, current EV owners in China are already budget-focused, matching the profiles of the next-mover EV consumer segments in the US and Europe (Exhibit 15). This suggests that the mass-market potential for more basic EVs could be a global trend and offer broader opportunities to invest in new global EV platforms.

Exhibit 15 Unlike in the US and the EU, the income of current EV owners in China is already lower than that of other vehicle buyers

Income distribution of survey respondents in China, 2016



SOURCE: McKinsey Sustainable Mobility Initiative – 2016 Electrified Vehicle Consumer Surveys

3. Longer-term, deploy additional new business models that take advantage of EV economics for consumers and automakers

Our research and analysis identified four additional large consumer segments, "urban families," "trendy families," "high-tech status seekers," and "feature-focused buyers," that could be convinced to buy EVs in the longer term. However, these segments have high expectations for driving utility and are less willing to sacrifice driving range (Exhibit 16). Household incomes for these potential EV consumers are typically lower ($50,000 to $150,000) than for early adopters, and they are unlikely to pay a premium for an EV versus a comparable ICE vehicle.

Exhibit 16 Four consumer segments – long-term buyers – have higher expectations for EV range, performance, and features, but will not pay a significant premium

Overview of long-term EV buyers

Segment	Living area(s)	Household income $ thousands	Average daily commute	Importance of … Range	Technology	Branding/ design	Performance	Potential EV offering
Urban families	Urban areas	50-125	35 miles	Medium	Medium	Medium	Medium	Larger low-cost EV with more cabin space, longer range, and some advanced technology features
Trendy families	Urban areas	50-150	35 miles	High	High	High	Medium	Stylish electrified utility with a longer range; a family vehicle from a premium brand
High-tech status seekers	Suburban areas	50-250	40 miles	High	High	High	High	A high-tech performance EV with longer range, but priced lower than models today
Feature-focused buyers	Suburban areas	50-125	40 miles	High	Medium	Medium	High	Loaded all-around EV offered at a reasonable price with a longer range

SOURCE: McKinsey Sustainable Mobility Initiative – 2016 Electrified Vehicle Consumer Surveys

In order to serve this larger set of potential EV buyers while maintaining profitability, automakers will need to experiment with and deploy new business models. The first step, a common denominator of these new business models, is to center the economics of EV ownership on total cost of ownership (TCO) and not on purchase price or traditional lease rates. In turn, this implies that automakers can shift their go-to-market models to selling e-mobility as a package or service as opposed to a product. This shift could help automakers increase sales of more capable EVs at higher price points without sacrificing profitability.

Of the different business model alternatives to traditional vehicle ownership, automakers can better leverage the unique characteristics of EV economics when compared to ICE-powered vehicles (Exhibit 17). To illustrate the options open to automakers, we describe three such business model alternatives – e-hailing, car sharing, and peer-to-peer car rental.

Exhibit 17 Automakers can sell EVs in a range of alternative mobility models to improve economics

Emerging mobility models that can improve EV economics

	Mobility model	Description of model	Typical trip duration
Traditional alternatives to vehicle ownership	Traditional rental cars	Renting cars to individual drivers for a predetermined number of days	Days
	Taxis	Hired to transport passengers point-to-point; based on distance and time traveled	Minutes
	Carpooling	Traditional method of aggregating carpools by driver and riders; based upon a fixed departure schedule	Minutes/hours
Emerging vehicle ownership alternatives	E-hailing	On-demand hiring of a private car using a virtual app or electronic device; one group of riders matches with one driver	Minutes
	Shared e-hailing	On-demand hiring of a shared-occupancy car using a virtual app or electronic device; multiple riders can match with one driver	Minutes
	Car sharing – fleet operator	On-demand short-term car rentals with the vehicle owned and managed by a fleet operator	Hours
	P2P car rental	Consumers go onto platform and share individual vehicles. A peer-to-peer way to rent vehicles per hour or per day	Hours or days
	Carpooling v2.0	Technology and app-enabled carpooling between a non-professional driver and riders to share empty seats; multiple riders can match with one driver	Minutes/hours

SOURCE: McKinsey Sustainable Mobility Initiative

E-hailing and shared e-hailing. Given the lower TCO for EVs, fleet managers that operate e-hailing programs may prefer EV models over ICE models. Automakers could increase fleet EV volumes by offering fleet operators more competitive sales/leasing options that detail the lower operating costs as compared to ICE variants. The feasibility of this model depends on the availability of rapid-charging infrastructure and active support for the expansion of rapid-charging stations. A promising sign for this business model is that consumers today are excited about EV models for e-hailing. In our research, more than 30% of consumers said they preferred an EV model over an ICE model when using e-hailing services. In addition, our research indicates that around 35% of those consumers said they would pay a premium for a ride in an EV.

Car sharing – fleet operator. Automakers or other companies can maintain a fleet of EVs to provide consumers with access to mobility for a monthly- or mileage-based subscription fee. Consumers who subscribe to a car-sharing program could be incentivized to choose EVs (e.g., offering free charging with the service). This business model offers consumers a flexible choice of vehicles based on need and does not require consumers to pay a high upfront price for an EV. For instance, as a daily commuter, a consumer could pick up a fully electric model during the week, but then trade it in for a larger SUV for a weekend road trip. By not requiring consumers to purchase EVs outright, automakers can still ensure EV volumes are transacted (and included in ZEV mandates and fleet-wide emissions targets).

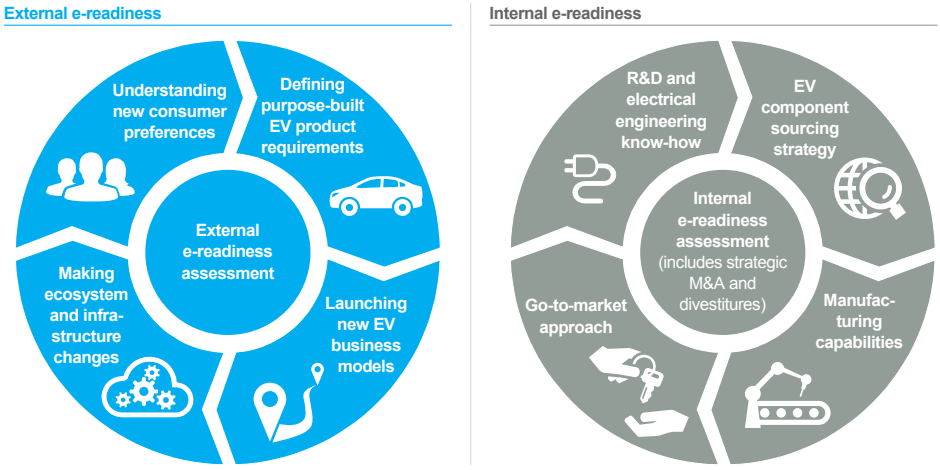
P2P (peer-to-peer) car rental. Providing a way for EV owners to share the vehicle they own with other consumers can offset the higher upfront cost of a more capability-rich EV with larger batteries. The P2P model ensures a (monthly) income for EV owners and improves the utilization of their cars (typically vehicles remain unused more than 96% of the time). Vehicles with higher utilization have a much lower TCO due to lower maintenance, energy, and driver costs. Automakers that provide, or partner with, a platform for EV owners to share an EV after purchase could remove the cost barrier for buyers who cannot justify higher monthly payments without the additional P2P sharing income. Some Tesla owners already use this model today, renting out their Model S on P2P sharing apps for one week per month.

Adapting e-mobility strategies – some points to consider

At the brink of EV disruption and in the face of significant market uncertainty, it is important for automakers to develop a clear vision for their e-mobility strategies through an assessment of their e-readiness. The following key questions provide a starting point for automakers to not only reflect on their external e-readiness (Exhibit 18), but also to prepare internally, e.g., building electrification engineering capabilities, creating capital transition plans from ICE to EV, investing in dealer education, and considering divesting legacy technology infrastructure.

Exhibit 18 To be prepared for the acceleration of electrification, automakers need a clear understanding of both the internal and external dimensions of e-readiness

Dimensions of automaker e-readiness



SOURCE: McKinsey Sustainable Mobility Initiative

- **Consumer e-readiness:** *How can we refine and strengthen our efforts to educate drivers about the benefits of EVs?*

  Effective communication/marketing to address consumer concerns and the true benefits of EVs (e.g., reliability, charging convenience, performance) is critical to drive higher e-mobility adoption.

- **Product e-readiness:** *Is our product portfolio aligned with the preferences and requirements of emerging EV consumers in different segments?*

  A large share of EV products today meet only the needs of niche consumer segments and miss the true opportunity to serve consumers who want more basic mobility solutions.

- **Business model e-readiness:** *Are we exploring new business models with more attractive economics for future EV consumers and are we engaging partners to help?*

  Creative approaches to shift EV economics from purchase price to TCO can help overcome cost barriers for consumers and improve automaker profitability.

- **Ecosystem e-readiness:** *Are we ensuring that infrastructure rollout is not a bottleneck but instead provides a stepping stone for new EV growth?*

  The industry and individual automakers need to support efforts to facilitate the effective and efficient rollout of more charging infrastructure and ecosystem with common standards and an attractive ROI for multiple stakeholders.

□ □ □

It will remain vital that industry players design e-mobility strategies that fit the unique context of their market, brand, and consumer profile. While there is certainly no standard playbook that explores the questions of where, how, and when to compete, this document can serve as a launching pad to help automakers refine their e-mobility strategies and to potentially secure profitability in an increasingly electrified vehicle world.

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Recent McKinsey publications on the automotive industry

This report was powered by the McKinsey Automotive and Innovation Center (MAIC). Further information on disruptive automotive trends can be found in other recent McKinsey publications:

An integrated perspective on the future of mobility
Mobility is something we take for granted in today's world. Our desire for mobility has its own constraints, however, as we cannot escape the resulting air and sound pollution, and in most urban cities car drivers already spend too much time sitting in traffic. The Future of Mobility white paper, jointly developed by McKinsey and Bloomberg New Energy Finance, seeks to answer the eminent question of how the various trends in electric/autonomous vehicles, shared mobility, sustainable energy storage, etc. can be expected to impact the future of mobility systems.

Automotive revolution – perspective towards 2030
The automotive industry will change dramatically over the next years. Four concurring trends – autonomous driving, connectivity, electrification, and shared mobility – will create opportunities for traditional automakers and new players alike. Our report provides scenarios depicting what kind of changes are coming and how they will affect the industry.

Monetizing car data
As privately owned vehicles use sensors to become increasingly connected to each other and to external infrastructure, a massive amount of data is being generated. Yet, while gathering such data is now routine, actually identifying insights that can be monetized is still in its nascent stages. Our new report, "Monetizing car data: New service business opportunities to create new customer benefits," analyzes consumer perspectives on the prospect of accessing car-generated data, and identifies and assesses the value and requirements of possible car-data-enabled use cases. We find that the global revenue pool from car data monetization could be as high as $750 billion by 2030 – and our report sheds light on how industry players can quickly build and test car-data-driven products and services and develop new business models.

Finding the fast lane: Emerging trends in China's auto market
After years of double-digit growth, China's auto market is slowing down. A cooling economy is one of the primary factors in the deceleration of what remains the world's largest market for automobiles. But other factors, such as changing consumer behavior and attitudes towards cars, are also at play. To better understand what China's auto buyers think and how they behave when making one of the biggest purchases of their lives, McKinsey conducted an extensive survey of over 3,500 consumers in March 2016.

Urban mobility at a tipping point
As more of the world's cities become congested and polluted, new business models and technologies are emerging to solve the mobility challenge. In this report, we lay out a framework that describes a system-level approach to considering the evolution of urban mobility. We also highlight a set of urban archetypes, defined by population density and the maturity of public transit; the mobility system of each archetype can be expected to evolve along a different path. Our analysis suggests that a mobility revolution is on the way for much of the world and we anticipate big improvements in the quality of life for city residents.

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