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SECTOR IN-DEPTH
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Automotive Industry - Global

Automakers fully engaged on Battery Electric Vehicles, but the transition will pressure returns

» Automakers are fully engaged in the movement toward battery electric vehicles (BEVs) as part of their efforts to comply with emissions requirements. But the transition will pressure returns and is a credit negative for the sector because of the significant capital needed to support the initiatives, the low returns BEVs will generate through the early 2020s, and the hurdles to achieving broader consumer acceptance.

» BEVs are only one element of the electrification process. We expect that BEVs will represent approximately 7% to 8% of global new vehicle sales by the mid-2020s, rising to about 17% to 19% by the end of the decade. However, car companies will not rely solely on BEVs to meet emission requirements. They will rely on a range of alternative fuel technologies including BEVs, mild-hybrids, full hybrids, plug-in hybrids, and fuel cells.

» Electrification of vehicle portfolios will require considerable capital investment, but returns are lower than on internal combustion engines. Auto manufacturers are investing considerable capital in electrification. However, the returns on electrified vehicles become progressively lower than on internal combustion engines as technologies move to mild hybrids, full hybrids, plug-in hybrids, and finally fuel cells and BEVs. The shift to electrification will pressure returns that are already low. Moreover, the investments in electrification will occur at the same time the industry must invest in other rapidly-developing technologies — autonomous driving, connectivity, and ride sharing.

» The need to invest in multiple propulsion technologies increases the risks associated with electrification and heightens the need for strong balance sheets. There is considerable uncertainty around which electrification technologies will be most successful in balancing the need to: meet emission regulations; satisfy consumer preferences; and generate an acceptable return. Automakers often invest in multiple technologies simultaneously in order to preserve their operating and strategic flexibility within an evolving landscape. However, because major mid-course corrections may be needed as the environment continues to shift, maintaining a strong balance sheet and ample liquidity will be increasingly important.

» The auto industry has not been asleep on the move toward vehicle electrification. For the past decade designing vehicles to comply with increasingly demanding emission requirements has been a critical area of focus for the auto sector. Electrification technologies have been a key element of these strategies. The acceleration of electrification plans and the growing focus on BEVs is being driven by government policies, and by media and capital market attention garnered by Tesla Inc. (B2 stable).

BEVs to make up 7% to 8% of global automotive sales by mid-2020s, 17% to 19% by late 2020s

This Sector In-Depth analysis focuses primarily on the BEV element of the vehicle electrification process. BEVs are the most capital intensive and technologically complex element of this process; they receive the most attention from capital market participants and regulatory bodies; and investments in this area pose the greatest risk to the auto sector due to the uncertain path to profitability. We estimate that, in the US market today, manufacturers can lose from $7,000 to over $10,000 per unit on BEVs.

The key objective of this report is to provide our base-case forecasts for BEV penetration of the global automotive market. We expect BEVs will account for approximately 7% to 8% of global automotive shipments by the mid 2020s and that this penetration will rise to about 17% to 19% by the late 2020s.

The factors that will drive ultimate BEV penetration are highly fluid and evolving rapidly. Consequently, as factors driving BEV penetration become more clearly defined, we will update our BEV penetration forecasts. In addition, future analyses of automotive carbon transition risk will address a range of topics beyond the very targeted focus on BEV penetration rates.

Movement toward BEVs is credit negative for the sector

The movement toward BEVs is credit negative because:

» Carbon emission regulations in major markets are compelling auto makers to invest significant capital in vehicle electrification and the sale of BEVs.

» With its large number of competitors (as many as 10 in each major regional market), the auto industry generates some of the lowest profit margins, returns on assets, and returns on capital in the corporate sector. Returns are highest on internal combustion engines and become progressively lower on mild-hybrids, full hybrids, plug-in hybrids, fuel cells, and finally BEVs. BEVs for most mass/volume auto makers will likely remain unprofitable into the early 2020s.

» The pace at which BEVs will be broadly adopted by consumers is highly uncertain due to factors such as range limitation and battery charging times.

» The rate at which economic returns can be achieved on BEVs will depend on reductions in battery costs, technical improvements leading to longer driving ranges, and the time frame over which manufacturers can achieve adequate scale of production.

» There are multiple pathways to pursue electrification. BEVs are only one of these pathways, along with mild-hybrids, full hybrids, plug-in hybrids, and fuel cells.

The BEV investment burdens are magnified by carmakers also having to invest in three other emerging mobility trends – autonomous driving, connectivity, and ride sharing.

Strong balance sheets and healthy liquidity increasingly important with move toward electrification

Many auto manufacturers will invest in multiple technologies simultaneously to keep their options open as the evolving electrification landscape becomes more clear. Because of the fluid state of electrification and high likelihood companies will have to make midcourse corrections in their strategies, maintaining strong balance sheets and ample liquidity to support and absorb any such adjustments is critical. This level of financial flexibility goes beyond that which is necessary to contend with the sector's cyclicality.

Auto industry has not been asleep on carbon transition risk or electrification

One of the auto industry's major areas of focus for the past 10 years has been improving fuel economy and preparing to meet increasingly burdensome emission-reduction rules. The movement toward alternative fuel vehicles, including vehicle electrification

and BEVs, are an extension of this. We believe this focus, combined with the considerable capital being devoted to electrification, demonstrate the auto industry has not been asleep on this trend. The risks posed by electrification in general, and BEVs in particular, have not gone unrecognized by the industry. These risks have also been an important component of our assessment of the industry's credit profile.

The risks associated with emission-reduction regulations and the related challenges posed by the vehicle electrification were articulated in earlier research (see: *Automotive Sector Faces Rising Credit Risks from Carbon Transition*- September 2016; *Moody's Approach to Assessing the Credit Impacts of Environmental Risks* - November 2015; *Heat Map Shows Wide Variations in Credit Impact Across Sectors* - November 2015; and *Increasing Risks in Global Auto Sector* - November 2015).

Defining the categories of alternative fuel vehicles

There is considerable confusion around describing light-vehicle electrification, with a range of terms that are sometimes used interchangeably to define an "electric vehicle". In this analysis, Moody's uses the following definitions:

1) Battery Electric Vehicle: A battery electric vehicle (BEV) is all electric. Their large batteries represent the most significant part of the vehicles' cost. They require an extensive recharging network and can require charging times ranging from 20 minutes to more than 15 hours. Maximum driving range is about 300 miles. BEV penetration of global and regional automotive sales is our principal focus for this report.

2) Hybrids

- **Mild Hybrid Vehicle:** Mild hybrids use electric motors to assist internal combustion engines and allow the engine to shut off when the vehicle is at traffic lights or in stop-and-go traffic, improving fuel economy. Mild hybrid systems cannot power the vehicle using electricity alone. These vehicles generally cost less than full hybrids, but provide less substantial fuel-economy benefits.
- **Full Hybrid Vehicle:** Hybrids use an engine and an electric motor to power the vehicle. They have larger batteries and more powerful electric motors than mild hybrids, and can drive the vehicle solely on electric power for short distances at low speeds. These cost more than mild hybrids, but provide better fuel-economy benefits.
- **Plug-In Hybrid Vehicle:** Plug-in hybrids have rechargeable batteries, generally larger than those in hybrid electric vehicles, that can be recharged by plugging into a power source. This makes it possible to drive moderate distances using just electricity (this "all-electric range" is about 10 to 50-plus miles in current models.) During urban driving, most of a plug-in hybrid's power can come from stored electricity. The internal combustion engine powers the vehicle when the battery is mostly depleted, during rapid acceleration, or when intensive heating or cooling is required. Plug-in hybrids can provide CO_2 emission levels similar to that of BEVs, and are considered zero-emission vehicles under most regulatory frameworks.

3) Fuel Cell Electric Vehicle: Fuel cell electric vehicles are powered by hydrogen, and use a propulsion system similar to electric vehicles, where energy is stored as hydrogen converted to electricity. Unlike internal combustion engine vehicles, they produce no harmful tailpipe emissions — they only emit water vapor and warm air. Similar to BEVs, fuel cell vehicles require a large refueling infrastructure, but refueling can take less than 10 minutes and driving range is approximately 300 miles.

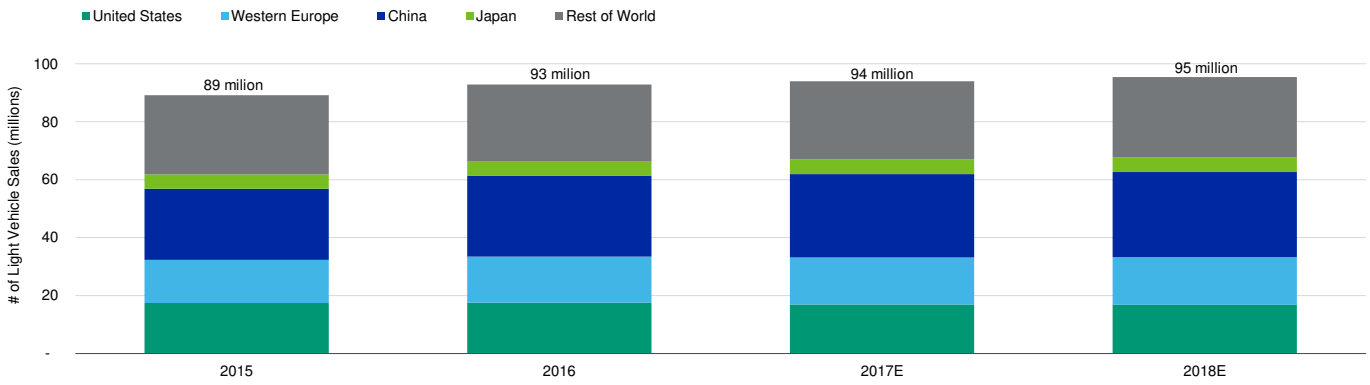
BEV will remain a small portion of global auto fleet

The global automotive industry is massive, both in terms of number of vehicles produced each year and total number of cars on the road worldwide. Over 90 million light vehicles are sold annually (see Exhibit 1) and by current estimates, there are approximately 1.2 billion total vehicles on the road worldwide. Comparatively, BEVs currently represent less than 1% of annual global sales and account for approximately 1.2 million[1], or 0.1%, of total vehicles on the road. We expect global penetration of BEVs as a percentage of annual sales to increase; however, significant penetration of BEVs in the global car stock is many years away, especially as the durability and average fleet age of existing vehicles continue to increase. We expect that BEV penetration of the global fleet on the road will approximate 2% by the mid 2020s and 5% by the late 2020s.

Exhibit 1

Over 90 million light vehicles sold annually worldwide

Annual light vehicle sales globally



Note: China unit sales represent auto sales which includes both passenger vehicle and commercial vehicles.
Source: ACEA, CAAM, LMC, Moody's estimates

BEVs grow from less than 1% of annual global sales in 2017 to about 17% to 19% by late 2020s

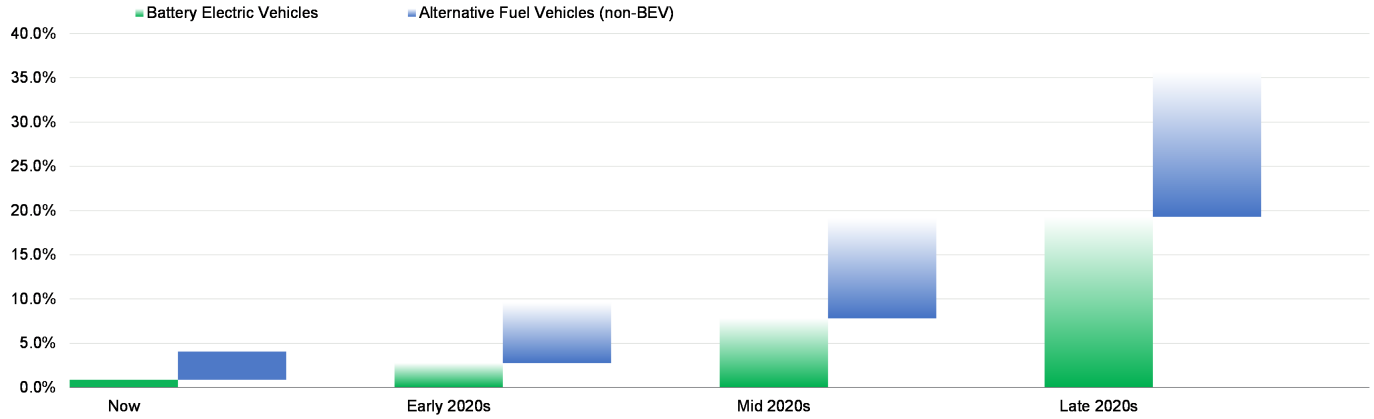
Our estimate of the portion of annual unit sales that will be generated from alternative fuel vehicles makes a distinction between BEVs and non-BEV alternative fuel vehicles, with non-BEVs including: mild hybrids, full hybrids, plug-in hybrids, and fuel cell vehicles. This view is based on rolling up the estimates of the penetration rates from each of the main geographic regions in the automotive sector, and weighting those estimates by the geographic distribution of sales in 2017.

BEVs will be about 7% to 8% of global auto sales by the mid 2020s. We estimate the penetration rate will then accelerate considerably, with BEVs reaching about 17% to 19% of annual sales by the end of the decade (see Exhibit 2), based on improved consumer acceptance as battery costs come down, driving range improves, and charging infrastructure expands.

Exhibit 2

BEVs remain a small percentage of total vehicle sales through the mid-2020s, accelerating thereafter

Global Penetration of Alternative Fuel Vehicle Sales– BEVs and non-BEV Alternative Fuel Vehicles



Source: Moody's Estimates based on regional estimates of penetration rates, weighted by the region's current relative contribution to total automotive sales

Key drivers of our global BEV forecasts

The size of the BEV market will evolve at a rapid pace and be driven primarily by:

» Existing government policies that promote the use of BEVs.

» Expectation that the cost of batteries will fall from the current level of about $200/kilowatt hour to under $100/kWh by the early 2020s.

» Base expectations that driving range on a single charge, currently approximately 300 miles, exceeds 350 miles by the early 2020s.

Regional estimates of BEVs and other alternative fuel vehicle sale

Key forecast factors that are unique to certain regions include:

» **United States:** The adoption of California Air Resource Board emission standards.

» **Europe:** The declining popularity of diesel engines and expanding plans to restrict the operation of internal combustion engines within certain cities.

» **China:** Ambitious government initiatives to promote BEV production by full-line manufacturers and by BEV-only manufacturers.

» **Japan:** High penetration of hybrids and support among Japanese manufacturers for fuel cell technology.

» **Rest of World:** Currently de minimis penetration by BEVs, due to financial limitations for building out charging infrastructure.

Major factors that would change our BEV forecasts

» Tesla being able to sell approximately 200,000 Model 3 vehicles during 2018.

» Acceleration of the pace at which battery cost declines and driving range increases.

» Significant additional capital investment devoted to BEVs in the form of vehicle manufacturing facilities, battery production capacity, or charging station infrastructure.

» Greater specificity from auto manufacturers with respect to unit sales expectations for BEVs.

» More restrictive emissions regulations such as the adoption of California Air Resources Board (CARB) standards by additional US states.

» A significant increase in gas prices.

United States

Exhibit 3

BEV penetration in the US should get a boost from Tesla

Penetration of US Market: BEVs and Non-BEV Alternative Fuel Vehicles

	2017E	early 2020s	mid 2020s	late 2020s
Battery Electric Vehicles	0.6%	4% - 5%	7% - 8%	15% - 16%
Alternative Fuel Vehicles (non-BEV)	2.7%	6% - 8%	12% - 16%	20% - 25%
Total	**3.3%**	**10% - 13%**	**19% - 24%**	**35% - 41%**

Source: Moody's Estimates

The US is currently the world's second-largest market for BEVs, with about 100,000 units sold during 2017 — representing just 0.6% of this 17 million unit market.

The sale of BEVs in the US is highly unprofitable for most manufacturers due to high battery costs. However, we expect costs will improve steadily. The US Department of Energy estimates the cost of BEV batteries around $250 per kWh, but also anticipates that by 2022 prices will be about half that. Despite this, we still expect most BEVs sold in the US (other than those from Tesla) will be produced at sizable losses through 2020.

Regulation, mandated emissions limits, driving BEV production

As a result of the pressure that BEVs will place on margins and returns on investment, the major impetus for auto manufacturers to produce BEVs is to comply with emissions regulations. The most stringent regulatory regime in the US is that of California's Air Resource Board (CARB). The California regulations require that by 2025, 15% of each auto manufacturer's light vehicle sales in that state be zero-emission vehicles. Importantly, under the California regulations, zero emissions vehicles include full BEVs as well as plug-in hybrid electric vehicles. Plug-in hybrid emissions levels are not significantly greater than those of BEVs. The mix of BEV/plug-in hybrid sales in 2016 was approximately 55/45, with BEVs expected to gain only slightly more penetration this year.

California's zero emission vehicle mandates have effectively been adopted by 12 other states (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, Pennsylvania, Vermont, and Washington). Collectively we will refer to these states, and the others that will adopt the mandates, as the CARB-adopting states. Light vehicle purchases in these 13 states represented approximately 35% of total US sales during 2016.

BEV sales in the US increases to 7% to 8% of annual units sold by the middle of the next decade

With this CARB-based framework we estimate by the middle of the next decade, sales in the US of pure BEVs will be about 7% to 8% of the total, with Tesla expected to sell a significant portion of the units within the BEV category. This is a very significant increase, but BEVs will still be a modest portion of the overall car market and only a portion of the segment covering alternative fuel vehicles. We believe hybrids, broadly defined, will solidly outsell BEVs.

A base level of BEV sales in the mid-2020s is built by assuming that 35% of US industry unit sales are in CARB-adopting states, and that 15% of these sales must be zero-emission vehicles. We further assume the run-rate mix between BEVs and plug-in hybrids is 60/40. This would results in BEV sales of approximately 570,000 units per year by the mid 2020s – approximately 3.2% of the total market in order to comply with state mandates.

However, we expect that BEVs sold in the US by traditional auto manufacturers will exceed the base level that will be required by CARB-adopting state regulations for two reasons. First, regulatory regimes in China and Europe will require much more aggressive adoption of BEVs than in the US. Second, maintaining US BEV sales at levels that simply meet CARB-adopting state requirements would likely result in low unit volumes and consequently poor returns on investment. We anticipate that manufacturers will look to sell more BEVs than would be necessary to meet state requirements so that they can capitalize on the BEV investments made in other geographic regions, and in order to improve returns on US BEV operations. As a result, BEVs sold by traditional auto manufacturers will likely represent 4% to 5% of US retail sales by the mid 2020s, rather than the base level of approximately 3.2% that would be driven solely by CARB-based state regulations.

Build-up of Tesla portion

Tesla is acting as a disruptor in the industry. The key elements of Tesla's differentiating business model include:

» *Clean sheet approach*: Its vehicle design, engineering, and assembly processes have been formulated from a clean sheet of paper in order to produce BEVs in an efficient manner.

» *Luxury car price point*: A product lineup that will largely remain at the luxury, or near-luxury, retail price point.

» *Potential for BEV profits*: The company's high vehicle prices enable Tesla to produce BEVs profitably.

We expect Tesla will sell approximately 250,000 to 300,000 light vehicles in the US during 2018 (Model S, X, and 3). Our base assumption is that the company's long-term annual unit sales growth rate approximates 10% to 15% per year. These Tesla unit sales would be additive to those sold by traditional auto manufacturers, and would help lift total BEV penetration in the US to approximately 7% to 8% by the mid-2020s.

Europe

Exhibit 4

Europe BEV penetration to reach about 25% by late 2020s

Penetration of Europe Market: BEVs and Non-BEV Alternative Fuel Vehicles

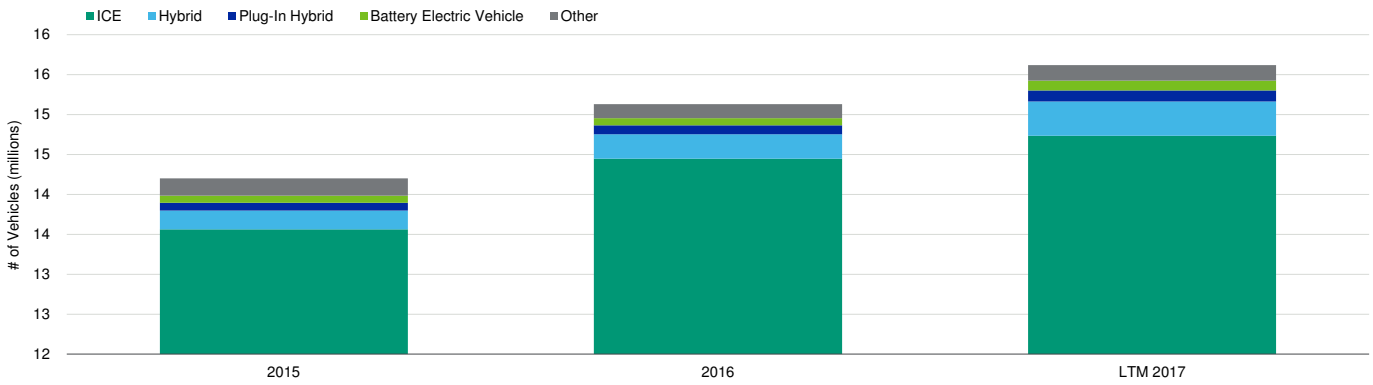
	2017E	early 2020s	mid 2020s	late 2020s
Battery Electric Vehicles	0.9%	2% - 3%	7% - 8%	25% - 30%
Alternative Fuel Vehicles (non-BEV)	2.0%	12% - 15%	23% - 27%	35% - 45%
Total	**2.9%**	**14% - 18%**	**30% - 35%**	**60% - 75%**

Source: Moody's Estimates

Exhibit 5

Alternative fuel vehicles represent a small proportion of total registrations in Europe

New car registrations in Western Europe by type of engine



Source: ACEA

During 2016, about 80,000 BEVs were sold in Europe, representing approximately 0.5% of the total European light vehicle market. European auto manufacturers face a significant challenge to meet the stringent CO_2 fleet emissions target level of 95g/km to be achieved by 2020/2021, particularly with the current shift away from diesel-powered vehicles towards gasoline-powered cars, as well as the consumers' preference for SUVs over sedans. Meeting those targets will only be possible by selling electrified vehicles such as mild-hybrids, full hybrids, and plug-in hybrids before a broader and more-efficient range of BEVs are introduced in 2020 and beyond.

The challenge especially for all premium manufacturers is to demonstrate technological capabilities and be among the leaders in alternative fuel vehicle technology. This will result in rising research and development costs and capital spending for most European OEMs. However, those rising costs are anticipated in our current ratings and captured in our upgrades for Bayerische Motoren Werke AG (A1 stable) and Daimler AG (A2 stable).

China

Exhibit 6

China estimated to have the highest BEV penetration among major auto markets

Penetration of China Market: BEVs and Non-BEV Alternative Fuel Vehicles

	2017	early 2020s	mid 2020s	late 2020s
Battery Electric Vehicles	2.3%	6% - 7%	16% - 17%	31% - 34%
Alternative Fuel Vehicles (non-BEV)	0.4%	1% - 3%	2% - 6%	2% - 7%
Total	**2.7%**	**7% - 10%**	**18% - 23%**	**33% - 41%**

Note: Non-BEV Alternative Fuel Vehicles (non-BEV) figures for China include PHEVs only
Source: CAAM, Moody's Estimates

China is the world's largest auto market, a market definition that includes both passenger vehicles and commercial vehicles, where unit sales reached 29 million in 2017. It is also the world's largest market for BEVs, with about 652,000 units sold last year, representing about 2.3% of total auto sales, according to the China Association of Automobile Manufacturers.

We expect that China will remain one of the largest markets for BEVs and that it will have one of the highest BEV penetration rates going forward. This will result primarily from aggressive government policies designed to: 1) promote the development and sale of new energy vehicles (including BEVs) by automakers; and 2) encourage new energy vehicle ownership by consumers. In addition, the low penetration rate of automobiles in China, combined with government support for the development and purchase of BEVs and other new energy vehicles, should help drive favorable economies of scale and lower costs of production for manufacturers.

By meeting regulatory targets under China's "passenger vehicle enterprise average fuel efficiency and new energy dual-point system regulation," automakers will avert regulatory expenses, an effective incentive to increase their production of fuel-efficient and new energy passenger vehicles including BEVs (under this regulation "new energy" passenger vehicles are defined as BEVs, plug-in hybrids, and fuel cell sedans, MPVs and SUVs). China's new energy vehicle sales will also be supported by the availability of low-priced new energy passenger vehicles that will lower the barriers to ownership. We believe these low-priced models will support the adoption of new energy vehicles, especially in less economically developed parts of China.

Supportive policies that encourage new energy vehicle ownership in China will also promote their adoption. In certain cities where vehicle ownership control is in place, ownership control on new energy vehicles has been eased through the designation of special new energy vehicle owernship ownership quotas. China also announced legislation to allow buyers, who are purchasing vehicles for personal use, to borrow up to 85% of the purchase price of new energy vehicles versus 80% for traditional fuel vehicles, to promote new energy vehicle purchases. We believe such policies will entice consumers to adopt new energy vehicles.

Japan

Exhibit 7

Penetration of non-BEV alternative fuel vehicles remains high in Japan

Penetration of Japan Market: BEVs and Non-BEV Alternative Fuel Vehicles

	2017E	early 2020s	mid 2020s	late 2020s
Battery Electric Vehicles	0.3%	0% - 1%	3% - 4%	10% - 11%
Alternative Fuel Vehicles (non-BEV)	28.7%	30% - 35%	36% - 40%	45% - 50%
Total	**29%**	**30% - 36%**	**39% - 44%**	**55% - 61%**

Source: Moody's estimates

Japan is the third largest country by unit sales after China and the US, and the fourth largest regional market, including Europe. In 2016, total unit sales in Japan was about 5 million of which about 0.3% (14 thousand[2]) was BEVs and about 27% (1.35 million[3]) was alternative fuel vehicles (i.e. hybrids and plug-in hybrids). Our estimate of the proportion of hybrid cars and BEVs is based on the 2030 objectives set by the Japanese Ministry of Economy, Trade and Industry,[4] published in March 2016. The ministry aims to increase the proportion of BEVs and plug-in hybrid vehicles to 20%-30% of domestic new car sales in 2030, along with 30%-40% for hybrid vehicles and up to 3% for fuel cell electric vehicles. Measured by total number of vehicles on the road, the ministry wants BEVs and plug-in hybrids to account for about 16% by 2030. These objectives are used to help calculate Japan's Nationally Determined Contribution to the Paris Agreement, which we adopt as our base case scenario, as described in a report we published in June 2016.[5]

Based on these objectives, we estimate that by 2030 nearly half of total domestic unit sales will be hybrid cars including plug-in hybrids — including "light motor vehicles" and regular and small commercial vehicles, in addition to passenger cars.

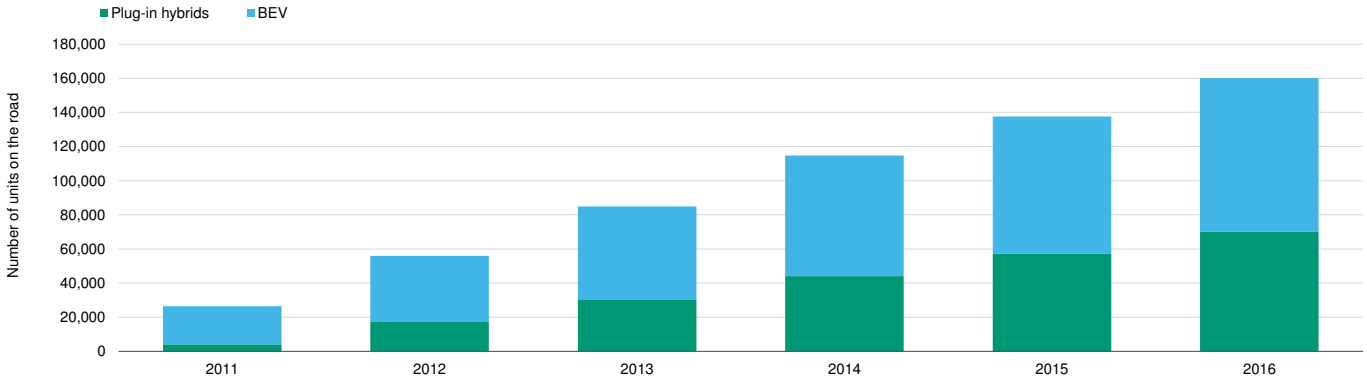
Currently, hybrid cars account for a large proportion of total unit sales in Japan relative to the other key global markets, due to the early introduction of Toyota Motor Co.'s *Prius* in 1997, as well as Honda Motor Co. Ltd.'s *Insight* in the late 1990s, and the track record of such vehicles in the country since. In 2017, we expect hybrid vehicles (including plug-in hybrids) will account for about 29% of total unit sales, which is already significantly higher than 4.6% in the US.

For 2017, we expect the proportion of both plug-in hybrids and BEVs to remain small at around 0.3% of total unit sales each. Thus far, plug-in hybrids have been growing at a higher pace than BEVs (Exhibit 8), but to achieve the above objectives, we assume BEVs will grow at a similar pace to plug-in hybrids during the 2020s.

Exhibit 8

Plug-in hybrids are increasing faster than BEVs in Japan

Registered units of BEVs and plug-in hybrids on Japan's roads



Source: Next Generation Vehicle Promotion Center in Japan

Both Toyota and Honda have been focusing on fuel cell electric technology for long-distance driving, but began devoting more resources to the BEV sector in recognition of increasingly important role the product will play in global markets. We expect the growth rate of mild and full hybrids will decline as the companies increase their focus on plug-in hybrids and BEVs. Nevertheless, hybrids and plug-in hybrids will still account for a significant proportion of total unit sales in 2030.

Japan's goal in 2030 requires high growth in plug-in hybrids and BEVs during the 2020s, but take-up of BEVs could be restrained by financial constraints at automakers. Plug-in hybrids and BEVs require new components and larger battery capacities that will increase automakers' cost base. Given already thin margins across the global auto sector, automakers may not be able to accommodate further margin pressure originating from the required take-up of zero or low-emission vehicles.

Further, infrastructure could present a bottleneck in terms of expanding plug-in hybrids and BEV sales in Japan. In 2015, the average distance between charging stations fell to around 30 kilometers in Japan, a reasonable distance for BEVs to travel considering battery capacity today. However, density varies depending on the region and additional infrastructure is required. Currently, such initiatives are led by Nippon Charge Service – a joint venture of Japanese automakers, electric companies, and the Development Bank of Japan Inc. (A1 stable). The large initial investment and the time required to get returns will prevent other companies from entering this infrastructure business.

Rest of World (ROW)

Exhibit 9

BEV penetration will remain low in ROW

Penetration of ROW Market: BEVs and Non-BEV Alternative Fuel Vehicles

	2017E	early 2020s	mid 2020s	late 2020s
Battery Electric Vehicles	0%	0.2% - 0.5%	0.5% - 1%	1% - 2 %
Alternative Fuel Vehicles (non-BEV)	2%	2% - 3%	3% - 4%	5% - 6%
Total	**2%**	**2.2% - 3.5%**	**3.5% - 5%**	**6% - 8%**

Source: Moody's Estimates

Automotive markets outside of the US, Europe, China, and Japan account for approximately 29% (over 25 million units) of total global light vehicle shipments. However, these markets currently account for a negligible amount of BEV sales. We do not expect BEVs to gain significant penetration in the ROW through 2030, due to the capital requirements associated with installing the necessary charging infrastructure and the high price of BEVs relative to average transaction prices in most of the ROW markets.

There are certain ROW markets in which BEVs may gain notable penetration over the long term. These include India, Korea, and Canada. Current BEV penetration in these markets is very small, with India the lowest. Nevertheless, the small size of these markets relative to the US, Europe, China, and Japan will limit their impact on the trajectory of global BEV demand and on the credit impact that BEVs have on automakers' credit ratings.

Major auto companies' announced electrification plans and implementation timing

Major auto companies have announced significant elements of their vehicle electrification initiatives. In many cases these strategies embrace a range of electrification options (mild-hybrids, full hybrids, plug-in hybrids, fuel cells and BEVs). Moreover, these announcements often contain little specificity concerning company expectations for unit sales, portfolio mix, or the amount of capital to be devoted to any one vehicle electrification option. This lack of specificity reflects the uncertainty faced by manufacturers concerning factors such as consumer preference for various electrification options, the returns that can be generated, and the best combination of technologies to meet mandated emission levels.

We would view these strategies favorably, to the extent that a company demonstrates progress in introducing an electrification technology into its portfolio and establishing market acceptance. We also recognize that, due in part to the efficiency of the global

supplier network, the auto industry has a history of rapidly making technologies available to many companies when those technologies are efficient and in demand. Consequently, a first-mover advantage in incorporating a technology may not be sustainable over the long term, and relative advantage positions will likely shift over time. We also view strategies favorably if they are supported by strong balance sheets and liquidity positions. As companies need to shift focus from one technology to another in response to market and regulatory constraints, having the capital necessary to fund such course corrections will be critical.

This listing of select automotive manufacturers is by rating level for now, as there is considerable uncertainty and lack of specificity at this point to develop a list of manufacturers' relative positioning for pursuing an electrification strategy. Nonetheless, this will shift as plans become more transparent and companies get closer to meeting the milestones they established.

» **Toyota (Aa3 stable)** has expanded its focus on electrification and launched an in-house venture to develop electrified vehicles in December 2016. Toyota had been skeptical of the long-term viability of BEVs due to their range and charging limitation, but it has recently begun to devote more resources to the BEV sector. It will aim to have annual global unit sales of over 5.5 million for electrified vehicles (i.e. BEVs, hybrids, plug-in hybrids, and fuel cell vehicles) by around 2030, including over 1 million of BEVs and fuel cell vehicles. Toyota said (in December 2017) it will begin a feasibility study with Panasonic Corporation (A3 stable) on prismatic batteries (an alternative to cylindrical cells in lithion ion technology in which the cells are flat, so space efficient).

» **BMW (A1 stable)** maintains a flexible strategy to offer all powertrain options across various platforms. The company expects to have an electrified option for all models by 2020, and 25 models (12 BEV and 13 hybrids) by 2025. Within the next couple of years, BMW will launch full-electric versions of certain models, including the *MINI* and *X3*.

» **Daimler (A2 stable)** expects 15% - 25% of all production to be electric by the mid-2020s. Through its Mercedes-Benz brand, the company plans to offer electrified model in every passenger car model series by 2022, in total more than 50 electrified variants. Daimler plans to invest at least $10 billion toward its electrification strategy and will invest $1 billion in the US to produce all-electric Mercedes SUVs and build a new battery plant.

» **Nissan (A2 stable)/Renault (Baa3 stable)** have focused on electric vehicles since introduction of the Nissan *LEAF* in December 2010 and Renault *Zoe* in March 2013. By June 2017, the alliance (including Mitsubishi Motors) sold over 480,000 electric vehicles. Nissan acquired a 34% stake in Mitsubishi Motors Corp. in October 2016. By 2022, the three-way alliance aims to build an electric vehicles with over 600 km[6] range, reduce battery cost by 30% from 2016, launch 12 new zero-emission electric vehicles, and introduce new common electric vehicle platforms.

» **Honda (A2 stable)** has said it intends to have electric vehicles (i.e. hybrid, plug-in hybrids vehicles, fuel cell vehicles and BEVs) account for two-thirds of its global sales by 2030. Like Toyota, Honda was a early adopter of hybrid technology and has a competitive position in this sector. The company is shifting its traditionally independent stance on R&D and set up a joint venture in July 2017 with Hitachi Automotive Systems, Ltd., a subsidiary of Hitachi, Ltd., (A3 stable) to develop motors for electric vehicles.

» **Volkswagen (A3 negative**) has set goals to produce 2-3 million all-electric vehicles by the mid-2020s and to electrify all of the company's models by 2030. Over the next decade, the company plans to invest up to €70 billion, including €20 billion to electrify across all brands and €50 billion for the purchase and development of batteries. In addition, VW plans to invest €10 billion for electromobility in China in an effort to sell at least 1.5 million electric vehicle there by 2025.

» **Hyundai (Baa1 stable)/Kia (Baa1 stable)** will continue to roll out electric vehicles in key markets including Korea, US, Europe and China in 2018. Over the longer term, Hyundai and Kia together aim to create a full line-up of eco-friendly vehicles, consisting of 31 models (10 hybrid, 11 plug-in hybrid, 8 BEV and 2 fuel cell) by 2020. The companies together aim to become the second largest manufacturer in the alternative fuel vehicles market by 2020.

» **Ford (Baa2 stable)** has announced that it plans to invest more than $11 billion in electrification over the period from 2015 to 2022 to expand it electrified vehicle lineup to include 40 vehicles globally, including 16 BEVs. Important elements of its electrification plan include a Chinese partnership that will support the electrification of 70% its vehicle sales in that market by 2025. We expect that Ford's electrification plans will focus heavily on hybrids.

» **General Motors (Baa2 stable)** is very aggressively pursuing a BEV electrification strategy, as evidenced by the launch of the all-electric *Bolt*. Importantly, the company states that it is developing an all-electric vehicle platform that will support production of BEVs across a range of vehicles and expects to achieve BEV profitability by the early 2020s. GM also maintains that its near-term capital expenditure program will not be materially increased by these plans.

» **Tesla (B2 stable)** produces only BEVs (Models S, X and 3). The company is in the process of launching the high-volume Model 3 with expectations that production will approximate 150,000 to 200,000 units during 2018.

Exhibit 10

Announced plans by auto manufacturers have a range of electrification options, with few specific

Rated OEMs, listed by rating category, with BEV plans and expected implementation

OEM	Current Key BEV Models	Early 2020s	Mid 2020s	Late 2020s
TOYOTA		2020: Roll out electric vehicle in China	By 2025: Electrified option for all models	By 2030: Over 5.5 million annual sales of electrified vehicles, incl. over 1 million BEV and fuel cells
BMW	BMW i3	2019: Mini BEV 2020: X3 BEV 2021: iNEXT BEV	By 2025: 12 BEV models	
Mercedes	Mercedes B-Class	2020: Generation EQ line BEVs	By 2022: 10 BEV models By 2025: 15%to 20% of total sales electric vehicles	
HONDA	Clarity EV	2019: BEV model in Europe		By 2030: Electric vehicles to be 2/3rd of total sales
RENAULT NISSAN MITSUBISHI	Nissan Leaf Renault ZOE		By 2022: 12 BEV models	
VW	VW e-Golf	2018: Audi E-Tron Quattro 2019: Mission E 2019: VW I.D.	By 2025: 3 million BEV sales	By 2030: Electrify all 300 models (incl. hybrids)
HYUNDAI KIA MOTORS	Hyundai Ioniq EV Hyundai Yuedong EV Kia Soul EV & Ray EV	By 2020: 8 BEV models	By 2025: 14 BEV models	
Ford	Focus Electric	By 2020: 13 BEV & hybrid models	By 2022: 16 BEV models By 2025: 15 electrified Ford & Lincoln models in China	
GM	Chevy Bolt	2 new BEV crossovers By 2020: At least 10 NEVs in China	By 2023: 20 BEV models By 2025: All brands in China electricfied	By 2026: 1 million electrified vehicles globally
TESLA	Model S Model X Model 3	By 2020: Model Y & New Roadster		

Source: Company reports

Moody's Related Research

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Endnotes

1 International Energy Agency: Global EV Outlook 2017

2 Next Generation Vehicle Promotion Center in Japan: **http://www.cev-pc.or.jp/tokei/hanbai3.html** (in Japanese)

3 Same as above

4 "Compilation of the Road Map for EVs and PHVs toward the Dissemination of Electric Vehicles and Plug-in Hybrid Vehicles", Ministry of Economy, Trade and Industry in Japan, March 2016

5 Environmental Risks: Moody's to Analyse Carbon Transition Risk Based on Emissions Reduction Scenario Consistent with Paris Agreement, June 2016

6 Based on the New European Driving Cycle (NEDC) methodology.

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