China's Electric Vehicle Industry

China's electric vehicle policy has been ineffectual for the last four to five years. Now China is resetting its policy target. On the public welfare and environmental fronts, China plans to improve air quality and reduce greenhouse gas emissions. On the industrial front, it aims to go beyond gasoline and diesel vehicles and seek innovation in the automotive industry. This Cover Story looks closely into the ecosystem of China's electric vehicle industry and China's distribution policy.

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Tesla Readjusts its China Strategy, While Local Companies are Doing Well in China's Electric Vehicle Market

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The 20th session of the Conference of the Parties (COP20) took place in December 2014 in Lima, Peru. In the COP20, the world's two largest greenhouse gas emitters, China and the USA, which had been sitting on the fence, agreed to cut carbon emissions, and spurred a global response to climate change. Through the Intergovernmental Panel on Climate Change (IPCC), political leaders from around the world have reached a consensus that global temperatures must be prevented from increasing by two degrees Celsius compared to pre-industrialization levels, and put tremendous efforts into restricting vehicle exhaust—the main culprit of greenhouse gas (GHG) emissions.

Like internal combustion vehicles, the Nissan Leaf and the GM Chevrolet Volt sold more than 20,000 units every year, and the average price has fallen below USD 40,000, which is an affordable price for general car buyers.

In the United States, the Corporate Average Fuel Economy (CAFE) standard requires automakers' passenger vehicle fleets to double their fuel economy from 27.5 mpg in 2012 to 54.5 mpg by model year 2025. This year, Europe agreed to reduce average CO2 emissions for new car fleets from 130 g/km in 2015 to 95 g/km by 2020 and 75 g/km by 2025. Internal Combustion Engine Vehicles (ICEV) have significantly improved fuel economy, thanks to technological advances, such as eco-friendly diesel, turbochargers (turbine-driven forced induction devices that increase an engine's efficiency), dual-clutch transmissions (DCT, the combination of effective manual transmissions and convenient automatic transmissions), and Idle Stop and Go (ISG, technology that shuts off the engine while a car is idling). However, in order to meet emission targets set by each country, carmakers should increase the electrification of their new car lineups.

The global market for electric vehicles (EV), including hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV), battery electric vehicles (BEV), and fuel cell electric vehicles (FCEV), reached 2.22 million units in 2014. Global research firms IHS and B3 estimate that electric vehicles will represent 6.34 million units out of 100 million new car sales in 2020.

EV technology development accelerating

The electric vehicle market was received with pessimism at first. However, sales of Toyota's Prius Hybrid surpassed the 7 million unit mark, making Toyota the hybrid market leader. Hybrid technology has become ubiquitous with the emergence of latecomers. The BEV market had grown consistently, but began to take off following the launch of the Nissan Leaf and the GM Chevrolet Volt in 2010. Comparable to internal combustion engine vehicles, they have sold more than 20,000 units every year, and the average price has fallen below USD 40,000, which is an affordable price for general car buyers.

In April 2015, Beijing was hit by its worst yellow dust in 13 years.

European carmakers, which belatedly joined the race due to their advanced diesel technology, are also actively rolling out hybrid and luxury electric vehicles, intensifying market competition. In particular, the BMW i-Series has raised the bar for eco-friendly vehicles by transforming the whole manufacturing process to be eco-friendly, for example, applying electric vehicle-exclusive platforms and carbon fiber, and using wind-powered electricity during its manufacturing process. Tesla CEO Elon Musk, who is dubbed the real "Iron Man," has unveiled the Model S, a fully electric luxury sedan with a price tag of more than USD 100,000, securing his company a foothold in the market. Tesla went further by going open

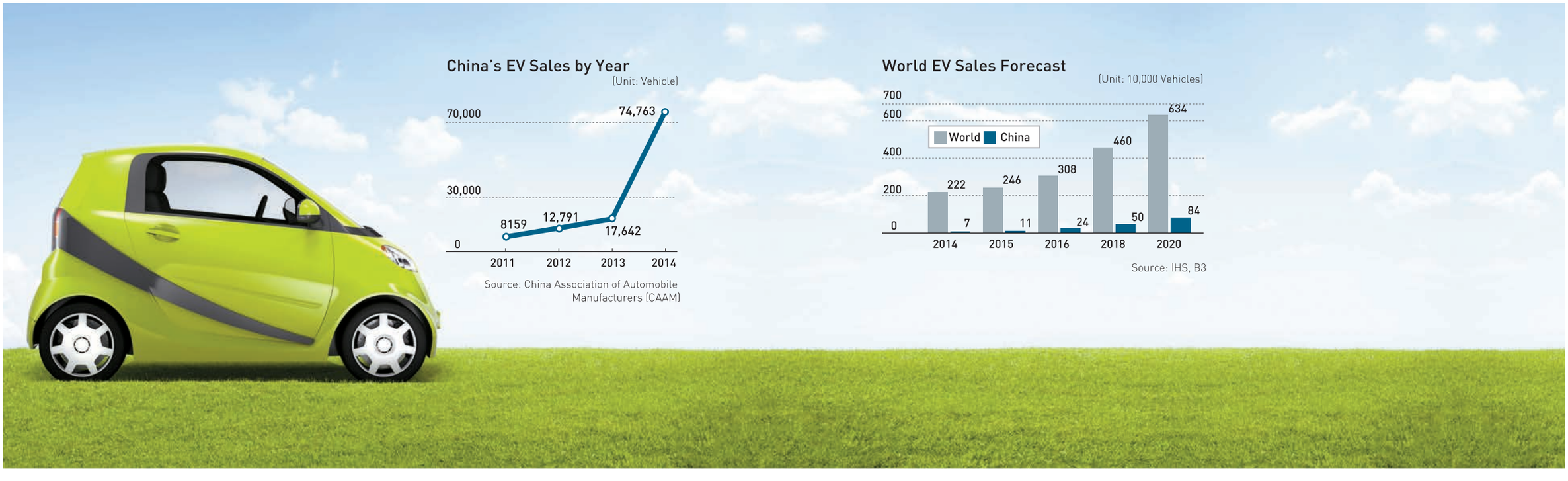
source, providing free Supercharger stations, and building the Gigafactory to sell around 350,000 units of EVs by 2020. The company is continuously shaking up the burgeoning EV market.

The electric vehicle market was not expected to blossom any time soon due to high battery pack costs, which account for almost half of EV costs. However, battery pack costs fell from USD 1,200/kWh (the kilowatt-hour, a unit of energy equivalent to one kilowatt of power expended for one hour) in 2010 to USD 500/kWh in 2014. The cost is expected to fall further, to about USD 200 within the next two to three years. According to the United States Advanced Battery Consortium (USABC), the EV battery cost target is USD 150/kWh for the economic feasibility and widespread acceptance of EVs.

South Korea's Samsung SDI, a leader in the global battery market, has built an EV battery plant for vehicles and energy storage systems (ESS) in Hefei, Anhui Province. LG Chem is planning to build a battery plant in China with the annual production capacity to supply batteries for more than 100,000 electric vehicles. Japan's Panasonic, in partnership with Tesla, has pledged to invest USD 5 billion in the Gigafactory, and will handle most of the battery packs for the 500,000 EVs produced annually in the factory. Some media sources predict that the cost of battery packs mass-produced in the Gigafactory will reach nearly USD 100/kWh, and the year 2020 will be the year that witnesses the popularization of electric vehicles.

With active government support, the Chinese EV market garners global attention

On April 16, 2015, Beijing was hit by its worst yellow dust in 13 years. Visibility declined to less than 500 meters, and the concentration of dangerous particulate matter rose to 1,000 micrograms per cubic meter at one point, 10 times higher than safe levels. China's yellow dust is mainly caused by economic growth, which entails urbanization, industrialization, and traffic density. The Chinese Ministry of Environmental Protection has announced that automobile exhaust is the major culprit of air pollution. Realizing the graveness of the situation, China has been taking various measures. An example is the introduction of electric vehicles. Before electric

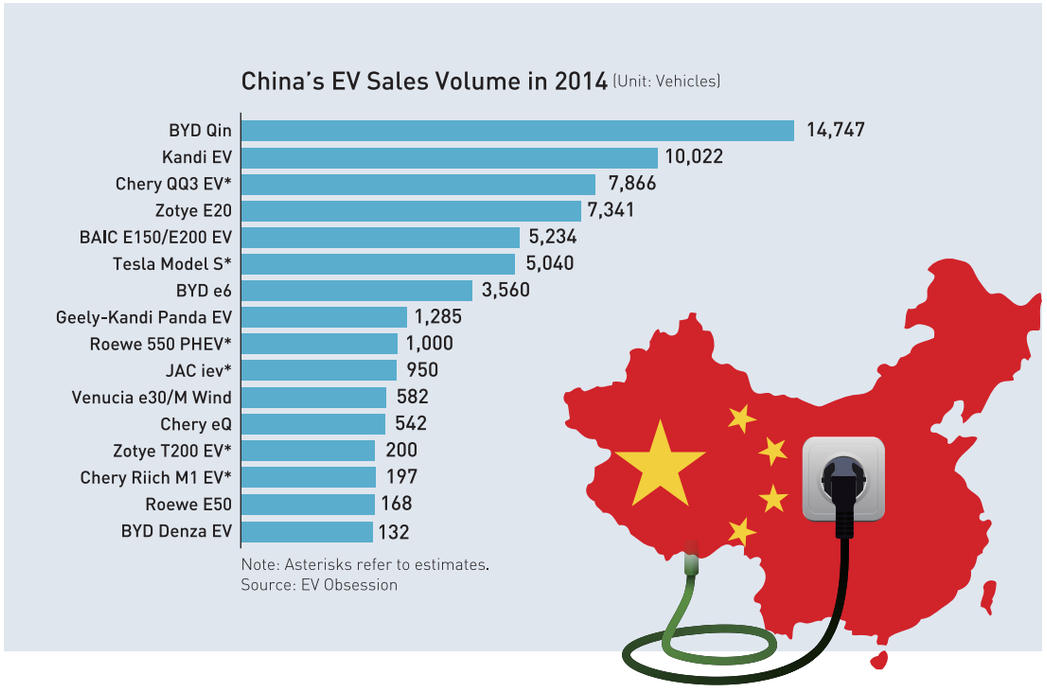


China's EV Sales by Year

Source: China Association of Automobile Manufacturers (CAAM)

World EV Sales Forecast

Source: IHS, B3



vehicle sales boomed, the entry barrier to the market was relatively low. China anticipated that its energy self-sufficiency would increase if it generated more of its electric energy from its rich coal resources.

According to the International Energy Agency (IEA), China had 83,000 electric cars (third most in the world), 36,500 e-buses, and 230 million e-bikes on the road in 2014. China's electric car sales totaled around 74,763 units that year. Although this represented only 3% of global electric car sales, it was a rise of 324% from 17,642 units in 2013, mainly thanks to the New Energy Vehicle (NEV) policy announced in July 2014. The Chinese government is sparing no effort to cut taxes and offer various support, with the aim of having 5 million EVs on the road by 2020.

China's electric car sales totaled around 74,763 units in 2014. This represented only 3% of global electric car sales, but was a rise of 324% from 17,642 units in 2013.

Anticipating that China would be the core of the global EV market, Tesla ambitiously entered China in 2014. That year, however, Tesla laid off about 180 of its 600 employees in China, including Tesla China President Veronica Wu. The company was hampered by insufficient Supercharger stations for China's massive land area, a staggering unit price of nearly USD 100,000, and months-long delivery times. In addition, Chinese consumers are different from American consumers, who are willing to accept any inconvenience due to a passion for eco-friendly luxury cars. In order to increase sales, Tesla had to amend its strategy in China to increase the number of Supercharger stations and cut delivery times.

By contrast, local Chinese automakers are doing fairly well. At the lead is BYD. With its all-electric vehicle line-up of E6 EV, Qin PHEV, and BUS K9 EV, the company sold more than 21,000 EVs in 2014, including hybrid cars. Another notable Chinese company is Kandi, which is causing a sensation in the low-speed and short-range EV market. Kandi's SD-5010 and 5011 models were chosen for Hangzhou City's short to long-term plan to provide 100,000 EVs to residents by 2018. With sales of 10,000 units last year, Kandi has closed on BYD and surprised the market.

The biggest reason for the success of Chinese carmakers is the government's active support: the Chinese government buys EVs directly for distribution and nurtures technology. EV sales in China are expected to rise by as many as 110,000 units by 2015 and 240,000 units by 2016.

The fragmented Chinese market means opportunity for Korea

As in other markets, China prefers to test technologies in the EV market through trial and error, rather than establishing safety standards and regulations, even though these technologies are not perfected. For this reason, Chinese automakers rapidly reorganize and adopt the products of small and medium-sized or foreign companies, and improve the functions of those products through many rounds of trial and error, instead of pursuing exclusive platforms and optimized parts.

The development of China's electric vehicle industry means opportunity for Korean companies, in particular EV battery companies. China generally prefers lithium iron phosphate (LEP) batteries, which are cheap because the raw materials are abundant, and which have a lower risk of ignition due to their thermal stability. Despite being cheap and safe, LEP batteries are limited in capacity due to low energy density. On the other hand, Korean battery companies excel at cathode batteries with higher energy density, such as nickel cobalt manganese (NCM) batteries, cathode batteries that improve upon the lithium cobalt oxide (LCO) type to increase safety, durability, and cost competitiveness. Lighter batteries with higher output improve the general functions of cars. For this reason, Korean companies are rushing to build production facilities in China and market their products. Shanghai Automotive Industry Co. (SAIC) is looking to cooperate with Korean companies to revamp existing models with improved electric motors and electric parts. Although China's EV market is still small, it will grow fast at an alarming speed, if it blossoms earlier than expected.

Driving the Development of China's Electric Vehicles

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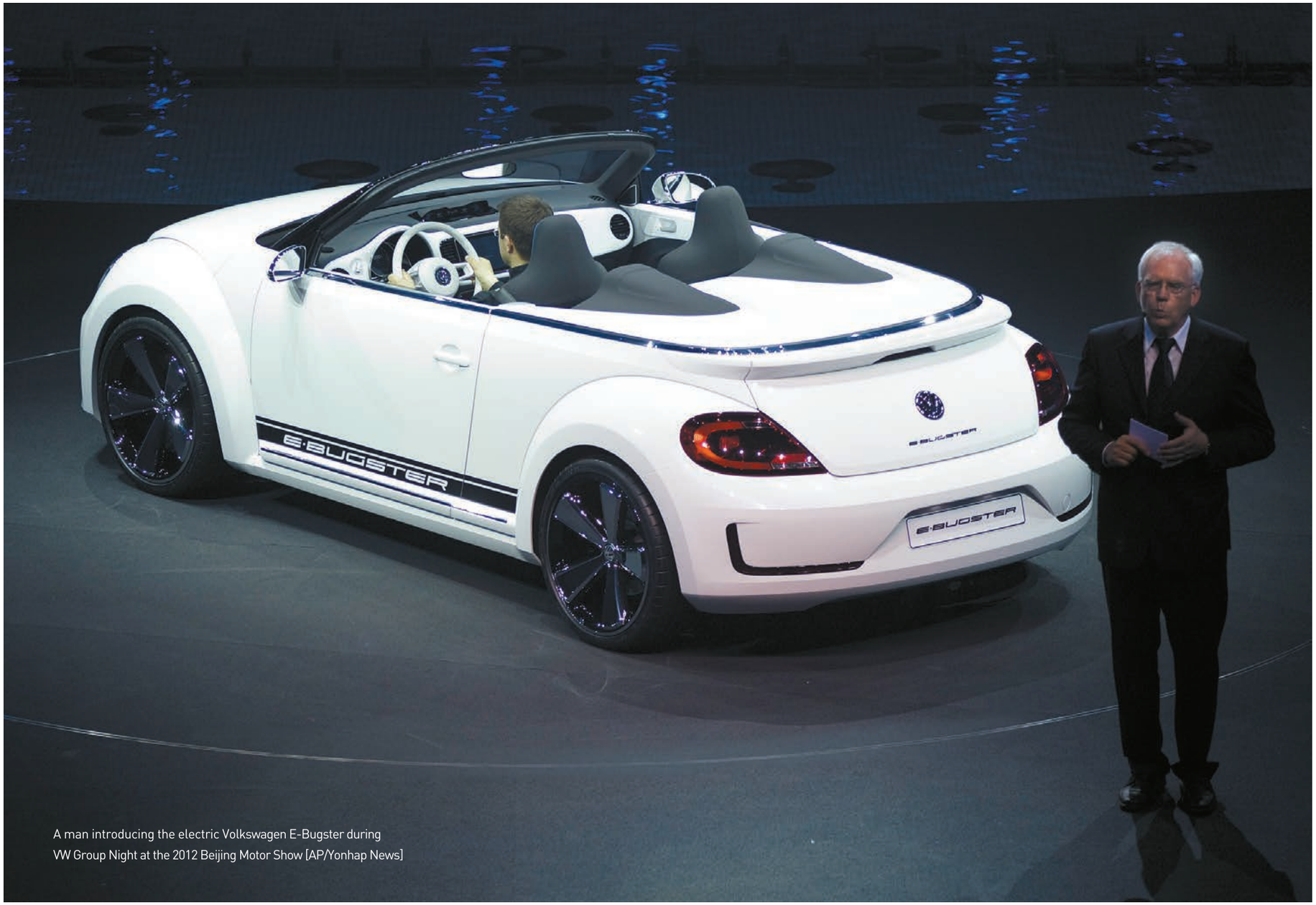


A man introducing the electric Volkswagen E-Bugster during VW Group Night at the 2012 Beijing Motor Show [AP/Yonhap News]

In October 2014, Yoon Sang-jik, Korean Minister of Trade, Industry & Energy, and Miao Wei, Chinese Minister of Industry and Information Technology, held the first ministerial talks in eight years. The agenda included discussions on automobiles, new materials, and energy. In the automotive industry, the two ministers agreed to join forces to develop electric vehicles and related standards, and nurture talent. It remains to be seen how much cooperation the two countries will be able to achieve in electric vehicles. What is clear is that both Korea and China consider EVs to be an important agenda item.

Ten Cities, One Thousand Cars (十城千輛) Program

Minister Miao Wei has spearheaded the promotion of EVs in China. Since graduating from the Department of the Internal Combustion Engine at Hefei University of Technology, he has worked for the automobile sector for more than 20 years, including for the China National Automotive Industry Corporation, the First Ministry of Machine-Building Industry under the State Council, and Dongfeng Automobile Corporation. When he was Deputy Secretary of Dongfeng Automobile Corporation, he transformed the almost bankrupt military truck maker into a profitable manufacturer of both trucks and passenger cars. In recognition of his achievements, he was nominated as a "Star of Asia" by *Businessweek*. Since he was appointed Vice Minister of Industry and Information Technology in 2008, Minister Wei has rolled out important policies on electric vehicles.

In 2009, China outstripped the USA and Japan to become the world's largest automobile market, with both sales and production topping 18 million units. This marked the time for China to seek qualitative growth. China focused on the fact that there was no leading global company in the EV market. During this time, Dongfeng, together with the Chinese Ministry of Science and Technology, launched the Ten Cities, One Thousand Cars (十城千輛) program with a view to guiding the automobile industry. As a primer policy to jumpstart the use of electric vehicles, the program selected 10 pilot cities to provide 1,000 EVs each year for the three years from 2010 to 2012. Miao emphasized the importance of independent and creative EV technologies when he visited an automaker in Shenzhen to award a subsidy for electric vehicles. Furthermore, EV subsidies have been expanded from public purchases to private purchases in six cities, including Beijing, Shanghai, and Shenzhen.

Since Miao Wei became the Minister of Industry and Information Technology in 2010, he has led the launch of the Energy Saving and New-Energy Vehicle Industry Development Plan (2012-2020) and set a target to increase accumulated sales of EVs to 5 million units by 2020. This was a very ambitious plan, considering that targets of advanced countries ranged from around 1 to 2 million units.

However, the Ten Cities, One Thousand Cars program has failed to meet this target. As China's mid-to-long-term target seems unattainable, some people say that the country's EV policy has generally failed. Except for official vehicles, and public transportation such as buses and taxis, no significant achievement has been made for many reasons, including a lack of charging infrastructure, regional incompatibility, short driving range because of limited battery capacity, and insufficient response to consumer needs. In 2014, China's sales of new energy cars reached 74,000, including 45,000 EVs. Sales rose four times from 17,000 units in 2013, but still fell short of the 2015 target of 500,000 units. Even though China is undoubtedly the world's largest automobile market, new energy cars account for only 0.3% of total automobile sales in China, far lower than the 1.4% of the USA.

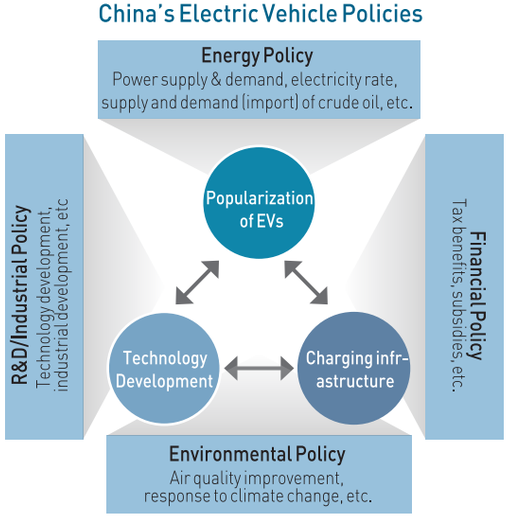
Despite this underwhelming result, the Chinese government is determined to popularize EVs through multi-faceted measures. In July 2014, the Chinese government announced a series of action plans for the Energy Saving and New-Energy Vehi-

EV Target by Country

Country	Target	Major Program
Korea	200,000 EVs by 2020	The Plans for Promoting Electric Vehicles (2014)
China	500,000 EVs by 2015 5 million EVs by 2020	Energy Saving and Energy Automobile Industry Planning (2012~2020)
USA	1 million EVs by 2015	EV Everywhere Grand Challenge Blueprint (2012)
UK	1.7 million EVs by 2020	Committee on Climate Change (2010)
Germany	1 million EVs by 2020	National Development Plan for Electric Mobility (2009)
France	2 million EVs by 2020	-
Norway	50,000 EVs by 2020	-
Japan	50% of sales by 2020	Next-Generation Vehicle Strategy 2010

Note: EVs include all-electric vehicles, plug-in hybrid electric vehicles (PHEV), fuel cell electric vehicles (FCEV), and hybrid electric vehicles (HEV)
Source: Committee on Green Growth

China has invested USD 3.7 billion in R&D of EVs, becoming the world's second largest investor after the USA, followed by France, the United Kingdom, Germany, and Japan.



cle Industry Development Plan, such as tax cuts for new energy car purchases, government and public institution purchases of new energy cars, and guidelines and advice to accelerate the distribution and use of new energy vehicles. Hybrid cars, which are classified as a different type of energy-saving vehicle, were subject to lower subsidies, but these subsidies have recently increased.

Despite active government support, substandard technologies and infrastructure

As early as 1991, China began conducting research and development on EVs at a national level. The development of EVs was incorporated into the Key Special Project of Electric Vehicles under the 8th Five-Year Plan. China was about seven years ahead of Korea, which began R&D in 1998 as part of the national G7 and next generation vehicle development projects. Since then, China has continued development of EV technology: EVs were added into the National Key Science and Technology Industrialization Projects in 2001, while the Key Science and Technology Project of Energy Saving & New Energy Vehicle was approved in 2006. As a result, 595 EVs developed in China went into pilot operation during the 2008 Beijing Olympic Games. In 2012, the State Council identified EVs as one of seven strategic new industries, and the Ministry of Science and Technology has reiterated the importance of technological innovation through the 12th Five-Year Special Plan for the Development of Electric Vehicle Technology. By 2015, China had invested USD 3.7 billion in EV R&D, becoming the world's second largest investor after the USA (USD 24.4 billion), followed by France, the United Kingdom, Germany, and Japan.

Unfortunately, China falls behind advanced countries in key EV technologies, such as batteries, power management, and control systems. Except for BYD, most Chinese EV makers import batteries from Japan and Korea. Despite high dependence on government subsidies, they tend to develop EVs in partnership with global automakers instead of developing their own technologies.

There are stumbling blocks for the charging infrastructure project, one of the key pillars of popularizing EVs. The biggest problem of all is the high cost burden on China Southern Power Grid Company and State Grid Corporation of China (SGGC), which are responsible for charging infrastructure in Southern and Northern China. SGGC plans to build 10,000 charging stations by 2020 by actively seeking private investment.

China's EVs at a crossroads

The remarks of Wang Binggang (王秉剛), chief consultant to the State 863 Energy Saving and New Energy Vehicle Project, deserve keen attention. In March 2015, he said that subsidies for EVs have been earmarked until 2020, but will possibly be withdrawn thereafter. So far, direct subsidies have been a major pillar of popularizing EVs. In the future, support will be focused on improving consumer convenience in driving, parking, and charging. The competitiveness of EVs will depend on how much EV makers can reduce production costs.

With report cards for only two or three years, it is unfair to judge China's EV policies, which are integrated with measures in various sectors, such as finance, science and technology, industry, energy, environment, and transportation. Even though actual results have fallen short of the ambitious target, it is premature to evaluate the Chinese government's policies on EV technology development and popularization. Although popularization of EVs has been delayed, it is worthy of attention that many Chinese government departments are putting energy into EVs that will replace internal combustion engine vehicles.

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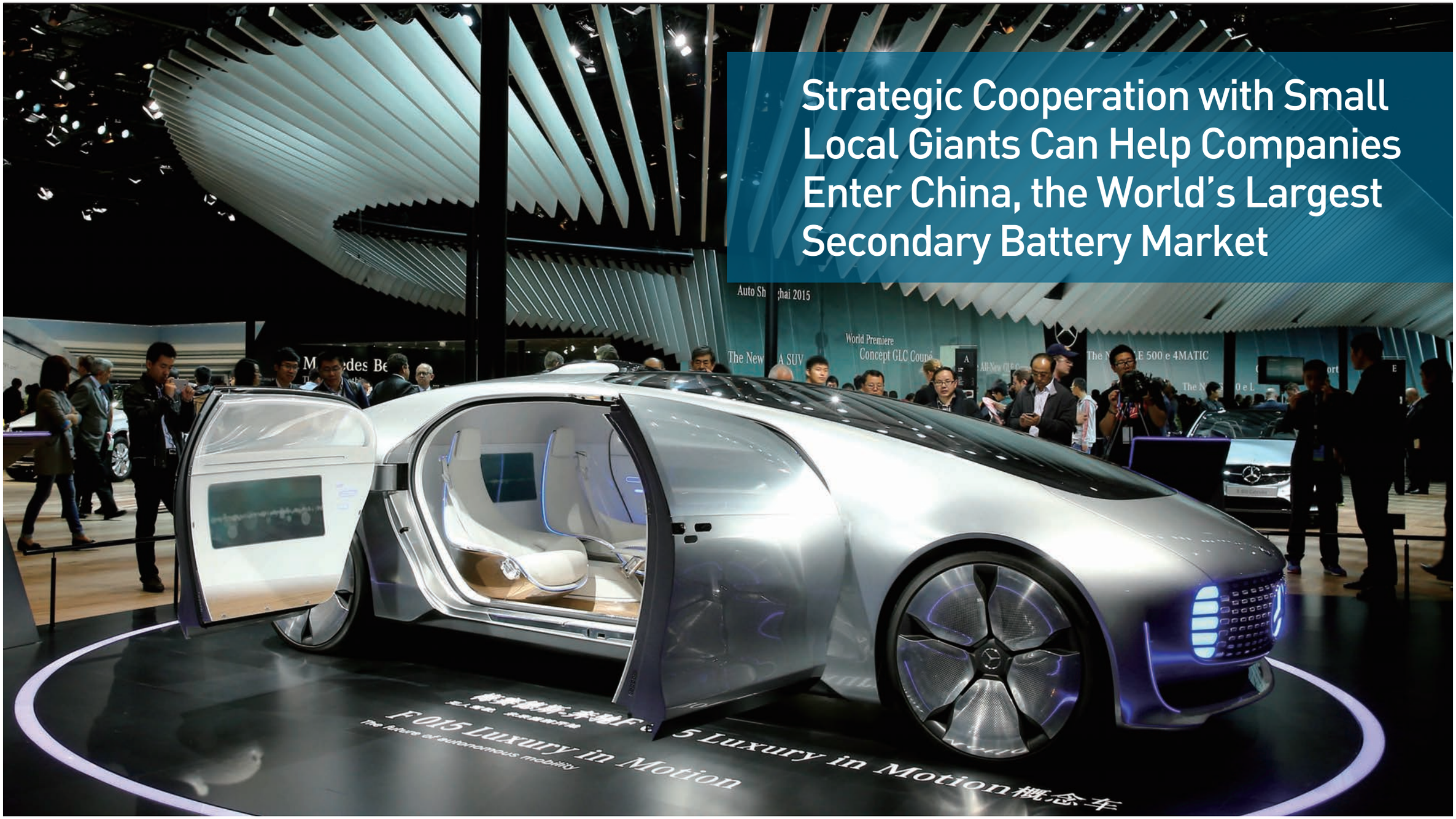
Strategic Cooperation with Small Local Giants Can Help Companies Enter China, the World's Largest Secondary Battery Market



JoongAng Photo

In August 2014, Samsung SDI had a groundbreaking ceremony for a BEV plant in China. [JoongAng Photo]

The 16th Shanghai International Automobile Industry Exhibition (Auto Shanghai 2015), was held with great success in April. Targeting the Chinese market, some 2,000 automakers and parts companies from around twenty countries participated in the largest motor show in the world. In 2009, China trumped the USA to become the world's largest auto market. In 2013, over 20 million vehicles were sold in China, setting a record for a single country. Sales climbed another 6.8% in 2014, totaling 23.5 million vehicles. China's car market is fifteen times larger than South Korea's domestic market, where 1.5 million vehicles were sold last year.

With a growing domestic auto market, mounting trouble for the Chinese government

With the growing auto market, trouble is mounting for the Chinese government. The share of homegrown brands in the domestic market dropped markedly, from 46% in 2010 to 38% in 2014. Hardest hit was the share of Chinese sedans, which fell from 31% to 22%. General assessment points to the failure of local manufacturers to catch up with the technology and brand power of global corporations as Chinese consumers rise in income level and gain appreciation.

Another trouble is worsening environmental pollution. The Financial Times reported that in order to combat environmental pollution in China, annual investment of RMB 2 trillion is necessary over the next five years, but the related budget represented merely 15% of that amount. China's air pollution stems partly from a sudden increase in air contaminant emissions as the Chinese shift from bicycles to automobiles. Thus the Chinese government is taking immense interest in introducing electric vehicles (EVs). The Chi-

At a conference, Stella Li, Senior Vice President of BYD Company Ltd., applauds the news of a US factory opening. [AP/Yonhap News Agency]

nese government is focusing on nurturing the market for electric vehicles and other environmentally friendly vehicles to chase two hares at once: resolving air pollution issues and increasing the share of local brands in the domestic auto market.

Regretfully, proliferation of electric vehicles is being delayed. A number of issues are at work, including high EV prices, low gas prices, doubts about the safety of EVs, and inadequate charging infrastructure. But most of all, the secondary battery, a core component of EVs, is not yet competitive enough in price and performance. The battery pack of a plug-in hybrid vehicle (PHEV) accounts for a quarter of the car's value, and weighs over 100 kg, keeping consumers at bay. Stability under collision, high temperature, and extreme cold is an important quality for automotive batteries, but given the current technology, earning consumer trust looks likely to take some time.

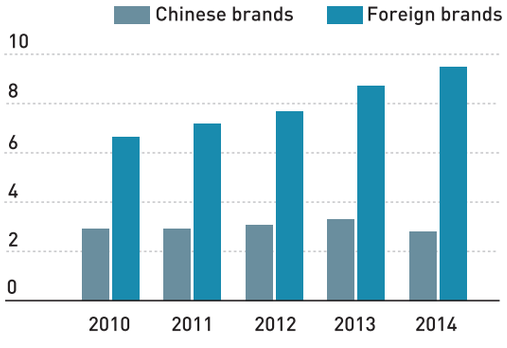
The four key components of a secondary battery are positive materials, negative materials, separators, and electrolytes. Worldwide, Chinese companies make up six of the top ten producers of positive materials, six of the top ten producers of negative materials, two of the top ten producers of separators, and five of the top ten producers of electrolytes.

Low price and advanced technology of secondary batteries are key to EV proliferation

In August of last year, Samsung SDI held a groundbreaking ceremony for an EV battery (secondary battery) plant in Xian, China, where the company plans to invest USD 600 million. LG Chem, SK Innovation, and other Korean secondary battery makers are competing to enter the Chinese market with large investments.

Many conditions must be improved for EV proliferation and popularization, but most crucially, EV secondary battery (lithium-ion battery) technology must improve, and battery prices must drop. Attaining economies of scale to reduce production costs is the motive behind secondary battery manufacturers making immense capital investments despite the risks in the EV market, which has yet to mature. The majority of market research institutions and battery producers project

Chinese Companies Losing Their Grip on the Domestic Market (Unit: 1 million vehicles)



Source: WSJ, Center for Asian American Media (CAAM)

that EV battery prices will have dropped by more than half by 2020. In other words, advanced batteries will provide more than double the mileage for the cost, which will be a decisive factor in popularizing EVs.

Secondary batteries are considered to be one of the three major electronic components of the 21st Century, the others being semiconductors and displays. In the initial phase of development, Japanese companies, including Panasonic and Sony, dominated the market. Samsung and LG entered the market in the 1990s and continuously made heavy investments, making South Korea the market leader by 2010. Fueled by end-market growth, Chinese companies, such as ATL, Lishen, and BYD, are gaining fast on Korean and Japanese companies. The growth trend of end-market products, such as electric vehicles, smart phones, and smart watches, is expected to drive the secondary battery market, which has a projected annual growth rate of over 30%. Since China emerged as the world's largest smart phone market in 2011, local smart phone makers, most notably Xiaomi and Huawei, have demonstrated explosive growth.

Market research firm IHS estimates that last year, a total of 2.25 million electric vehicles were sold globally, including 400,000 PHEVs and battery electric vehicles (BEV). In China alone, 70,000 PHEVs and BEVs were sold, accounting for nearly 18% of global sales. The Chinese government has set a goal of reaching accumulated sales of 5 million EVs by 2020, and implemented various supportive measures, entailing subsidies and infrastructure expansion. Behind the Chinese government's concern for EV proliferation is its intention to lead the global market by involving local companies from the beginning of the EV industry value chain and nurturing them.

The parts and materials sectors, particularly the EV batteries and battery materials sectors are of special note. The growth trend of Chinese companies is noteworthy, though they have not yet made great advances in the large secondary battery packs used in electric vehicles, with the exception of BYD, which took 5th place in global shipments in 2014. The same year, five Chinese companies—ATL, Lishen, BYD, Coslight, and BAK—were among the top ten companies in global shipments of the small secondary batteries used in IT devices, such as smart phones and tablets (SNE Research). These five companies combined have a modest global market share of 20%, but the figure is growing steadily.

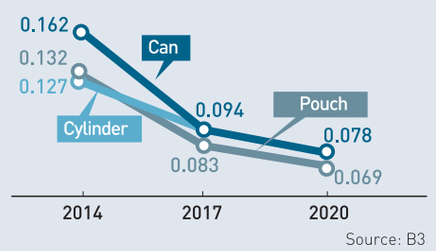
Chinese producers of parts and materials for secondary batteries

The reign of the three kingdoms of Korea, China, and Japan in the secondary battery market extends to the battery materials market. Here, too, Chinese companies are making marked leaps. The cost structure of secondary batteries is heavily concentrated on materials. Materials account for around 60% of the cost of lithium-ion batteries, which shows how large the battery materials market is.

The four key components of a secondary battery are positive materials, negative materials, separators, and electrolytes. Worldwide, Chinese companies made up six of the top ten producers of positive materials, six of the top ten producers of negative materials, two of the top ten producers of separators, and five of the top ten producers of electrolytes in 2014 (SNE Research). In the past, Chinese products were preferred for low-cost general purpose batteries, and Korean and Japanese products were preferred for high-functioning batteries. With the enhancement of Chinese technology, however, the market share of Chinese companies is growing in high-functioning batteries.

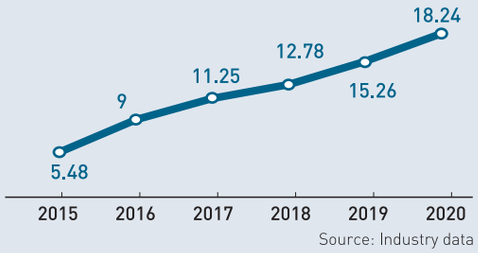
As global battery manufacturers flood into China, cooperative relations with Chinese materials companies are expected to flourish, especially considering the keen interest of the Chinese government in promoting Chinese-made parts and materials to nurture domestic companies. Companies along the EV industry value chain are entering China from around the world, and the rivalry between local and foreign companies is becoming fierce. Therefore, investment must follow careful risk analysis. If large-scale green field investment seems too heavy a burden, it is worth considering the strategic option of discovering and expanding cooperation with small local giants in various sectors, for example, to supply parts and materials or secure sales networks, thereby gaining leverage in entering the Chinese market.

Projection for Lithium-ion Battery Prices (Unit: USD/Wh)



Source: B3

EV Battery Market Size (Unit: USD 1 billion, projected)



Source: Industry data