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China's Automotive
Opportunity
*Leading the Transition
To New Energy Vehicles*



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EXECUTIVE SUMMARY

Since the introduction of the automobile in the late 1800's, the internal combustion engine (ICE) has emerged as the dominant vehicle propulsion technology. However, at the end of the 19th century, it was the electric vehicle (EV¹) that actually outsold all other types of cars. In fact, the EV was introduced several decades earlier than ICE-powered cars. However, ICE eventually surpassed the EV due to its virtues of speed, power and range.

Since the 1970s, there has been a growing awareness of the lack of sustainability of petroleum-based consumption. Rising concerns over the impact of carbon emissions on the environment have increased the pressure on finding alternative energy technologies that can eventually replace the ICE. Recent technological advances are bringing new energy vehicles back into the spotlight. We believe a new era of alternative energy technology will emerge in the 21st century automotive industry, and this represents a key opportunity for China and its domestic car companies to assume a leading role in this transition.

Global daily oil consumption is still increasing steadily. According to a BP report, it is estimated that global daily oil consumption will reach 93 million barrels by 2020. In 2007, over half (57%) of global daily

oil consumption was contributed to transportation. Statistics of IEA show that transportation will account for more than 62% of global oil consumption by 2020, while emerging markets, such as China, are the major forces driving the increase in global oil consumption. The Energy Economics and Strategy Research Center of China's National Development and Reform Commission (NDRC) estimates that oil demand will be nearly 560-600 million tons in China by 2020.

Continuous global warming results in increasingly worsened living environment. According to scientists, global average temperatures will increase between 1.4 and 5.8 degrees Celsius by 2100. Rising temperature is likely to cause catastrophic results, such as rising sea levels due to melting polar ice caps (18-59 centimeters in 2100), and more

HUGE MARKET POTENTIAL FOR NEW ENERGY VEHICLES (NEV²) IN CHINA

frequent natural disasters (i.e. floods, droughts). Global warming is mainly caused by the world wide increase in CO₂ emissions, which is more significant in developing countries. China is one of the biggest emitters of CO₂. According to EIA, China's CO₂ emissions per capita is increasing full speed and will catch up to 1/3 of the US's in 2030.

Cost is still the major barrier in EV.

As the power source of EV, battery technology has been a major barrier for the development of EV. However, recent progress has pushed the technology to the minimum threshold of consumer acceptance. In addition, the energy density of electric battery has been continuously increasing and is approaching the minimal threshold for market acceptance.

China is the world's largest auto market and will keep a rapid growth rate over a quite long period of time. As the balance of global economic power has been shifting eastward to places like India and particularly China, the attention of most of the automotive industry development has in recent years been concentrated on the Asia-Pacific region where China is expected to capture over a half of the growth in the next ten years. China's automotive market has doubled its size since 2003 – with annual sales soaring from 4.56 million to 9.67 million in 2008. During this period of time, the market share of passenger vehicles (excluding buses, trucks and other commercial vehicles) has increased from 50% to 60%.

To address the economic crisis, the Chinese government launched a series of stimulus initiatives in an effort to achieve a targeted GDP growth of 8%. These initiatives have

had a remarkable impact on the automotive market in the first half of 2009. A large proportion of Chinese auto consumers are composed of first-time buyers who have actively leveraged preferential policies on their purchases in the form of tax incentives. For the overall calendar year of 2009, China's market grew beyond 13 million units against 10.4 million in the US.

China's automotive industry will continue to experience strong growth over the foreseeable future. Global Insight has forecast that over the next ten years China will account for more than half of the growth of the Asia Pacific region with annualized growth of 6% through 2018. It is also noteworthy that while China is experiencing the growth of the auto market, environmental pollution has mounted and a decrease in home-exploited crude oil has been observed. As China's auto market continues to grow, pollution significantly increases

while China's self-sufficiency rate of crude oil continues to decrease.

As the leading automotive market, China has the opportunity to drive the standards and architecture for the global auto industry and has a clear and compelling need to reinvent the propulsion technology of the automobile.

Intensified stress from traditional energy supply and environmental protection. As the size of the auto market inexorably expands, China will play an increasingly significant role in the development of new automotive technologies. China's emergence as the leading automotive market in terms of sales has several implications. While most attention has been paid to relative sales performance of the foreign and domestic companies, what is arguably of more long-term significance is the impact of China's market expansion on energy consumption and

environment. Ten years ago, Beijing, Xi'an, Shenyang, Shanghai and Guangzhou were already listed among the Top Ten cities with the worst air pollution. The massive growth of the automotive market only adds to the problem. Additionally, China imports two-thirds of its oil, and its ever-increasing thirst has had a dramatic impact on global energy prices. Based on the current growth trend, China will possess 1.5 billion vehicles and consume 2.5 billion tons of oil by the year 2020. No doubt, China has a clear and compelling need to reinvent the propulsion technology of the automobile.

“To start from scratch” and lead the transition to new energy technology. China may lag over a decade behind the leaders in the development of advanced automotive industry. However, given its advantages on costs and markets, China has developed the potential to take the lead in the development of new

China's automotive industry will continue to experience strong growth over the foreseeable future.

energy vehicles market where each player is essentially starting from scratch (see Exhibit 1).

Regarding the technologies on lead-acid batteries, NiMH batteries and lithium ion batteries, a large number of players have developed their core technologies and product portfolios. For example, China has abundant resources and technologies for lithium ion battery production and has stepped into the rapid growth stage since 2001, facilitated by the quick emergence of large enterprises specializing in lithium ion battery production, e.g. BYD, B&K and others. In the last few years, Chinese enterprises have achieved

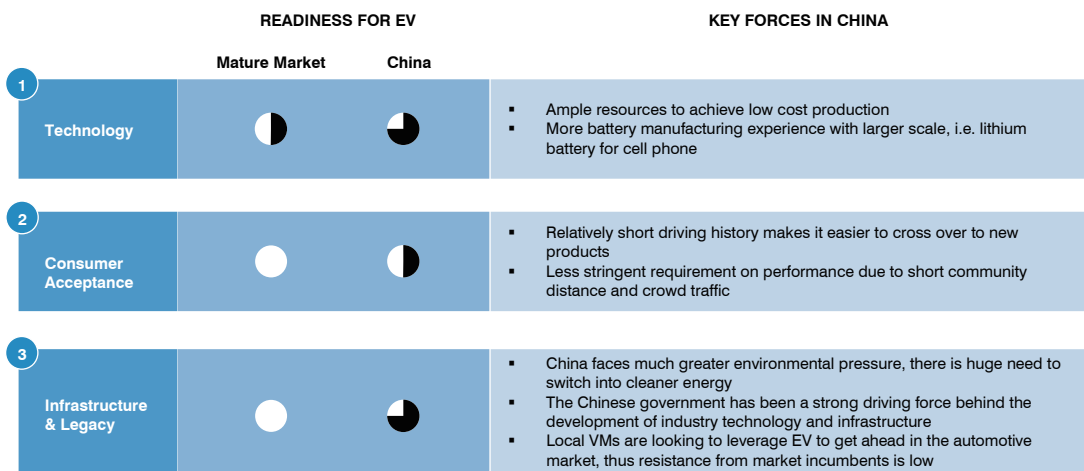
a solid market share of 34% in the global lithium ion battery market, of which BYD has rocketed into the top five largest manufacturers. At present, China has evolved into one of the largest global lithium ion battery manufacturing bases, one that accounts for 17% of the global output in 2008.

On the issue of consumer acceptance, consumer habit in China is still in the forming process due to a relatively short driving history. China has very low car ownership penetration compared with developed countries. As a result, the realistic and potential cost of switching from a traditional vehicle to NEV is lower and less

adjustment is needed in consumer driving habits. Moreover, Chinese citizens rely much more on public transportation. Public transportation companies will be more willing to switch to new energy vehicles even if private consumers are reluctant to buy EVs.

The popularization of NEV and EV largely relies on the relevant services, infrastructure and facilities, such as repair and maintenance, construction of infrastructure (i.e. Recharging Station) and new specific services (i.e. insurance for NEV), which are still at a preliminary stage.

Exhibit 1
Comparing to mature markets, China appears ready to address the challenges in introducing electric vehicles



Source: Booz & Company analysis

EVOLUTION OF NEV IN CHINA

In recent years, the Chinese government has accelerated the pace of energy structure adjustment, given the ever-increasing oil price and environmental pressure resulting from industrialization. In fact, over a decade ago, the Chinese government became the driving force in the development of NEV with a stronger focus. There are three phases in the development.

Phase 1: Clean Auto Action (1999-2002) with an investment of 100 million RMB

In 1999, Beijing, Xi'an, Shenyang, Shanghai and Guangzhou were listed in the World Top Ten Cities with the worst air pollution. To mitigate air pollution, big cities implemented a set of initiatives, such as improvement of the emission of fossil fuel vehicles to meet Euro II Standard, CNG and LPG vehicles' R&D and demonstration, as well as other CAFV³'s R&D. A total of 13 ministries, including the Ministry of Science and Technology,

initiated the "Air Purification Program: Clean Auto Action" to promote clean energy vehicles in 19 cities, which were either most polluted or had resource advantages. In this phase, the government did not put forward specialized requirements for NEV; and NEV did not serve a national strategy.

Phase 2: Electric Vehicle Key Project (2002-2006) with an investment of 880 million RMB

From the perspective of development strategy of the national automobile industry, the Tenth Five Year Plan introduced the goal to commercialize and industrialize EVs. The National 863 Program set the Electric Vehicle Project and identified the FCV, EV and HEV as the priorities for the development of HEV. The Government cooperated with businesses, academics and research institutions, to conduct R&D jointly.

A “3X3” R&D mechanism (3 Horizontal Plans: FCEV⁴, HEV⁵ and EV; 3 Vertical Plans: force assembly, driving electric motor and dynamic battery) was initiated in the project (see Exhibit 2). It focused on the establishment of a rigorous process that is in alignment with whole

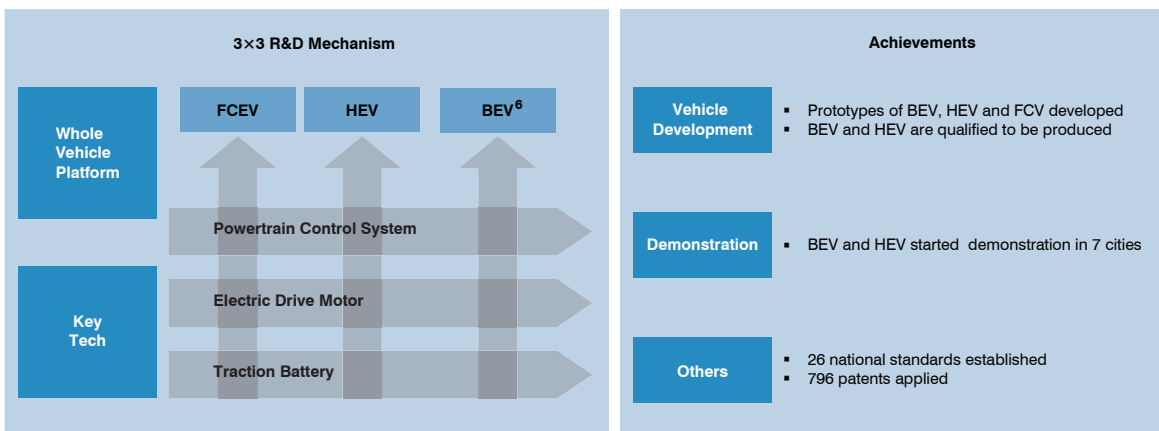
vehicle R&D discipline, and proposed a basic principle of development oriented, key component and related materials linked, infrastructure development aligned, and policies, technical standards and assessment techniques simultaneously developed.

Phase 3: Energy Saving and New Energy Vehicle Key Project (since 2006) with an investment of 1.1 billion RMB

The Energy Saving and New Energy Vehicle Key Project was initiated in the 863 Program in the Eleventh Five Year Plan (see Exhibit 3), which

Exhibit 2
3x3 R&D mechanism and achievements

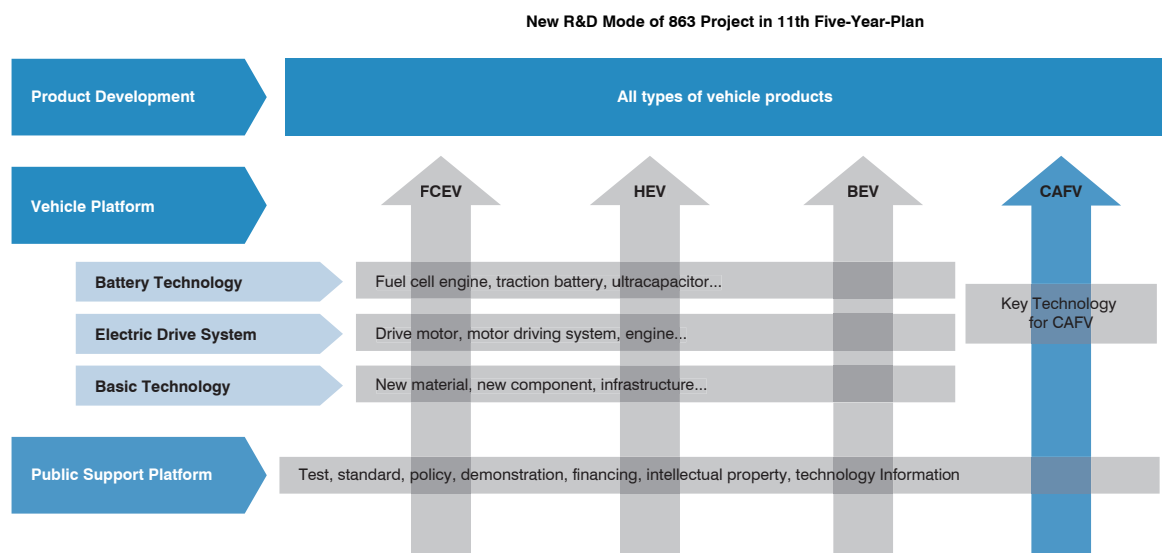
- Milestone in phase 2: Electric Vehicle Key Project in 863 Program during 10th five-year Plan (2002-2006)
- Government Investment: 880 Million RMB



Source: MOST; Booz & Company analysis

Exhibit 3
Energy saving and new energy vehicle key project

- Milestone in phase 3: Energy Saving and New Energy Vehicle Key Project in 863 Program during 11th five-year Plan (2006-2010)
- Government Investment: 1.1 Billion RMB (for 2006-2008)



Source: MOST; Booz & Company analysis

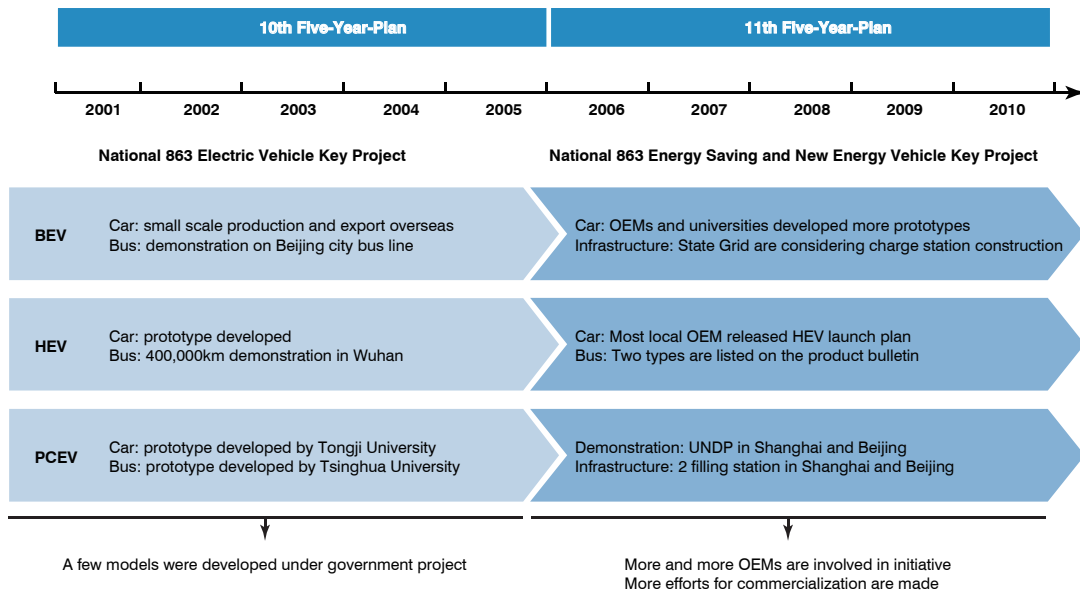
included the R&D for all types of vehicle products and identified the new R&D model. The project covered the R&D of energy saving and new energy technologies, research of key components such as traction battery,

motor and fuel cell engine, as well as the application of technical standards and tests.

With this structure, China has made significant progress in the

development of key technologies, but more effort is needed on the OEM⁷ side (see Exhibit 4).

Exhibit 4
Progress in development of key technologies



Source: MOST; Booz & Company analysis

LONG ROAD AHEAD FOR NEV DEVELOPMENT IN CHINA

The global economic crisis is a triggering event that freezes debate on whether change is needed and creates opportunities for collaboration between government and industry. Such collaboration is essential for the successful transition from the conventional ICE to NEV technology. To impel the energy saving and industrialization of NEV, the Ministry of Science and Technology, working with the Ministry of Finance and the National Development and Reform Commission, is sponsoring an ambitious plan to promote the use of NEVs, initially targeting 13 pilot cities, which includes Beijing, Shanghai, Chongqing, Changchun, Dalian, Hangzhou, Jinan, Wuhan, Shenzhen, Hefei, Changsha, Kunming, and Nanchang. The plan includes support for the development of energy-saving technology for use in government fleets, including buses, postal, and sanitation vehicles. The plan targets the deployment of 60,000 energy saving vehicles in China by 2012.

National governments and global OEMs also took notice of China's commitment to fund the development of its NEV infrastructure. About 45% of China's \$588 billion USD stimulus plan is to be invested in projects related to developing China's infrastructure, which includes support for a variety of clean car technologies. As a result, local governments support the development of energy-saving

technology for use in government fleets, including buses, postal and sanitation vehicles; give priority to the EV and promote collaboration with businesses to develop infrastructure to support NEV.

For example:

- Beijing: purchased 800 hybrid buses from Beijing Foton
- Shanghai: hydrogen fuel cell car project was initiated by Shanghai Major Project Promotion Office as a 2008 Olympics project
- Jinan: promotes NEVs and plans to use HEV buses to replace some of the old bus system to meet the requirement of National Sports Meeting
- Shenzhen: is going to establish a charging station in the downtown area for NEVs; and the F3DM dual mode EV was first launched in Shenzhen which is the first mass produced dual mode EV in the world
- Wuhan: becomes new energy resource experimental unit for Nissan, and Nissan will contribute 300 hybrid buses to the city
- Chongqing: purchased hybrid buses from Chang'an Group
- Changchun & Dalian: partnered with FAW

Meanwhile, local vehicle manufacturers (VM⁸) in China are viewing NEV as an opportunity to catch up with foreign counterparts, thus are actively engaging. Local OEMs fall far behind foreign counterparts in the conventional automotive market: the domestic top two VMs are merely 12% of the size of Toyota in sales; and most advanced ICE technologies are controlled by global players. Therefore, NEV might give local VMs a chance to catch up because there is no large gap in relevant technology, while local VMs enjoy some natural resource and development cost advantages.

In line with government mandate, many local brands, some with support of foreign partners, participate in NEV development and integrate the corresponding plan into their long-term strategy. For example:

- SAIC: invested RMB 2 billion for NEV development
- Chang'an: established NEV JV and plans first hybrid car for 2009
- FAW/DFM: have hybrid buses in pilot operation
- Chery: introduced plans for the hybrid car A5 and electric car S18
- BYD: introduced plans for the F3DM dual-mode electric car

According to the China Association of Automobile Manufacturers, the top ten local VMs in terms of sales, including SAIC, FAW, DFM, Chang'an, GAIG, BAIC, Brilliance, Chery, CNHTC and JAC, will seek opportunities to collaborate in NEV development. They will not only cooperate to develop key powertrain and component, but also jointly set the standards for EV and components. Initially required by government, now developing NEV is gradually integrated into the long-term strategy of many Chinese VMs.

Moreover, universities also respond proactively to the government's initiatives. For example, Tsinghua University established a laboratory for alternative power system development.

In view of the large market potential in China, foreign OEMs are prioritizing NEV development in China. For example, Toyota supports the HEV R&D work of CATARC while GM established two NEV R&D centers in China and cooperates with SGM and PATAC to develop new HEV.

China's push for electric cars was clearly on display at the Shanghai Motor Show in April 2009, as alternative propulsion technologies became the hottest exhibition themes. Local manufacturers, such as BYD, Geely, Great Wall, Brilliance and Chery, introduced many EVs and other energy-saving vehicles.

At present, energy consumption of Chinese consumers is lower than that of their peers in developed markets, and the Chinese government could, through proper guidance, encourage them to pay more attention to energy efficiency. But how could policymakers promote energy-saving vehicles in the domestic market? The existing promotion of NEVs in 13 pilot cities is a good beginning to lead and influence the individual car buyers. Chinese policymakers may also consider promulgating additional financial and policy incentives: stronger credit and fund support for manufacturers to develop NEVs and batteries, more subsidy for individual NEV buyers and more developed infrastructure such as charging stations.

However, environmentally friendly vehicles must offer tangible customer benefits or they will ultimately fail. Forcing revolutionary technology into the market can be counterproductive

- and GM's EV1 program provides us with a good example. Launched in December 1996, EV1 was a pilot small electric car with a total production volume of 1,000. The fiberglass made vehicle (600 kg) was equipped with 32 lead acid batteries (400 kg) as main power source. The 102 KW motor provided a range from 40 miles (in Northeast states in the winter) to 90 miles (in California). GM had invested \$350 million on development. In spite of the costly efforts of GM to develop and promote the car, the high cost of ownership of the EV1 ultimately limited its market acceptance. Ultimately, GM withdrew the EV1 from the market.

BYD has recently introduced the first mass produced plug-in EV that uses a home outlet, yet market acceptance remains challenging. On December 15, 2008, BYD launched F3DM, a dual-mode EV, in Shenzhen and accepted fleet orders from China Construction Bank and the Shenzhen Municipal Government. Retail sales began in September 2009 with a MSRP of RMB 149,800. As an EV with a 125 KW power output, nine seconds for 0-100km/h acceleration, a seven hours charging time with a normal household power outlet, and 100 km of maximum distance for one charge; F3DM is available in 14 1st-tier and 2nd-tier cities in China.

After over a decade of development, the NEV industry in China has made some breakthroughs in terms of technology and infrastructure. Though consumer environmental consciousness is apparent, economic considerations still remain the key decision criteria. In fact, Chinese consumers make their buying decisions with a focus on the price to performance ratio and overall cost of ownership. On these measures, VMs must continue to pursue both further breakthroughs in order to gain marketplace acceptance of NEV technology.

A HEALTHY WIN-WIN INDUSTRY ECOSYSTEM IS KEY TO SUCCESS

Innovations in both technology and business models will be needed to succeed in the EV industry.

Consumers' greatest concerns about EV over ICE are cost, performance and infrastructure. To win over consumers, simultaneous technological and business model innovations are needed. Technology innovation could provide a solution that balances performance (power, range, etc) and cost. Business model innovation could meet the needs of consumers while benefiting all stakeholders in the industry value chain (*see Exhibit 5, page 12*). From the EV manufacturers' viewpoint, they must start by setting up appropriate technology and business innovation models and work backwards to win over consumers.

BYD's technological innovation has brought a huge cost advantage while improving performance. In addition, BYD also innovates its business model. By integrating battery and EV R&D, while other OEMs do it separately, it integrates battery manufacturing with the role of a traditional VM to capitalize on the current battery and auto manufacturing resources and facilities. Moreover, BYD also prioritizes the role that local government (or utility) plays by approaching local government as the first customer base to create the market and working closely with these partners to develop the market

in order to increase production size and drive down cost.

Using a "Cooperation model". In order for the technological innovation to achieve performance and cost balance, the cooperation model is a sound approach. Potential shortfalls in going alone may include compatibility issues resulting in great compromises on vehicle performance, and negative impact on achieving critical mass due to lack of standardization, thus making it difficult to drive down costs. However, joint R&D opportunities could leverage the "Know-How" of each party to improve vehicle performance, reach critical mass and drive down cost. In May 2009, Volkswagen signed an understanding memorandum with BYD to seek the possibility of joint development in the fields such as Li-ion battery for hybrid electric and full electric vehicles. Such cooperation can allow the partners to bring their complementary resources to bear and to address the requirements of capital, technology and market, while reducing the costs and risks to realize the mass-production of EVs.

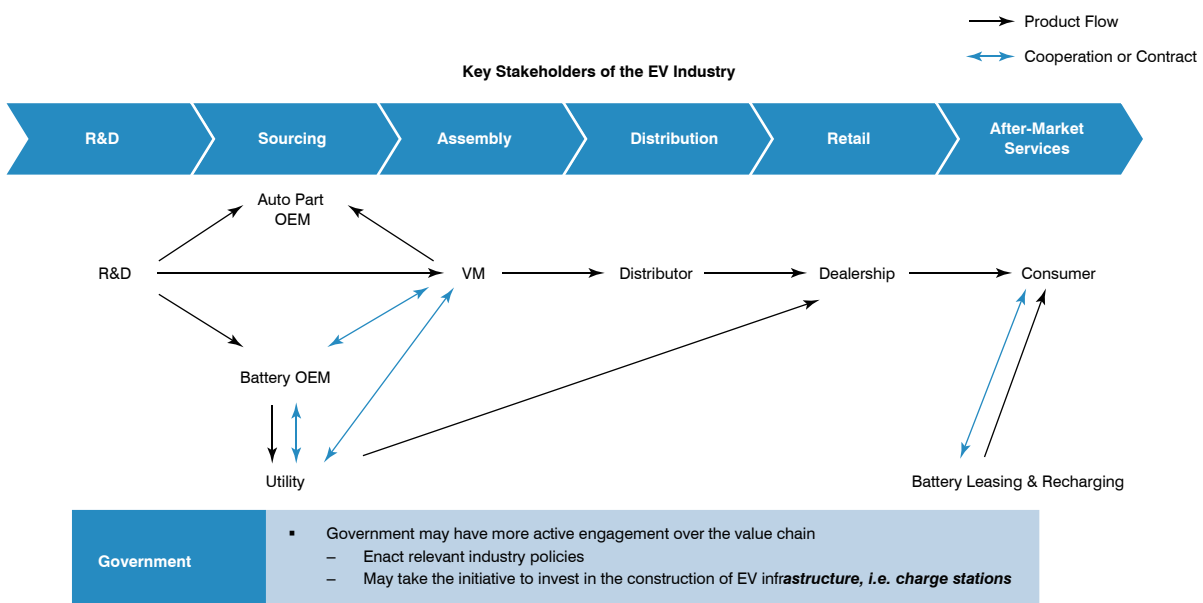
Build up sufficient infrastructure. Replacing traditional ICE with other technologies—such as hybrid electric, full electric, hydrogen powered vehicles or clean diesel - requires collaboration between businesses and the government to develop the

infrastructure in tandem with the development of the technology. The economics of the product itself and ultimate market acceptance is very much dependent on the availability of the infrastructure to recharge or replenish the fuel. It is not realistic to expect a company to reinvent the technological underpinnings of the automobile, unless there is a concurrent development and investment in the infrastructure to support that new technology vehicle.

As the largest automotive market, and because the China government has the capacity and willingness to invest in the infrastructure for the new energy technology, we have every reason to believe that China's NEV market will reach significant scale. When it does, the Chinese car companies will begin to close the gap relative to the industry leaders. What makes the development of alternative propulsion technology particularly challenging is not simply

the vehicle itself—but the need for invention of the infrastructure for delivering renewable sources of electricity and installation of battery charging/replacement stations. As the largest car market, and the place with the largest need for alternative energy solutions, we can expect to see China place a heavy emphasis on development of the EV infrastructure. The country that leads the development of this infrastructure will undoubtedly lead in attracting

Exhibit 5
The value chain of the EV industry – a new ecosystem



Source: Booz & Company analysis

Endnotes

- 1 EV = Electric Vehicle
- 2 NEV = New Energy Vehicle
- 3 CAFV = Combustion Alternative Fuel Vehicle
- 4 FCEV = Fuel Cell Electric Vehicle
- 5 HEV = Hybrid Electric Vehicle
- 6 BEV = Battery Electric Vehicle
- 7 OEM = Original Equipment Manufacturer
- 8 VM = Vehicle Manufacturer

the investment in development of the technologies that plug in to that infrastructure.

Business model innovation should address the interests of different stakeholders, thus a transition from “paying for hardware” to “paying for mileage” would be practical. Utility companies, such as State Grid, are well-positioned to act as a battery leasing and charging vendors: another revenue generation source as a battery owner, large existing customer base, mature infrastructure and networks in place to serve potential EV clients, amendment to the revenue fluctuation from current product portfolio. On the other hand, consumers are unwilling to own battery as it takes up a huge part of the entire vehicle budget, its life cycle tends to be short and value depreciation is severe and individual battery product may have compatibility issues with recharging station networks.

In summary, consumer acceptance of new energy vehicles is a major challenge. While the infrastructure investments already described will help tip the scales in favor of new energy vehicles, consumers must also be convinced that the price and performance of the new energy vehicle can in fact meet their expectations. As a national priority, we can expect the Chinese government to help by offering incentives for the retail consumer

to purchase NEV. As 85% of Chinese consumers are first time car buyers, with less experience with gasoline-powered cars, and are already accustomed to short distance, low-speed commuting conditions, these factors are very favorable for the acceptance of the less-performed electric cars. The Chinese government’s willingness to invest in the infrastructure to support alternative propulsion technology will ultimately help drive demand side market acceptance. This is where China has the opportunity to take the lead, and that will drive supply side investment in new technology. For the development of NEVs, the infrastructure must come first—and this will drive supply-side innovation. It takes a combination of business and government working together to make such a transformational change possible—and nowhere in the world is there a closer link between business and government than in China.

Energy saving, carbon reduction and pollution abatement are not only development trends around the world, but priorities for the Chinese government. Without awareness of these, Chinese vehicle manufacturers will be left behind or even defeated, by their global rivals. China should leverage the existing advantages to success in a new battlefield—the EV market.

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Booz & Company’s senior partner and chairman for Greater China, specializing in definition and implementation of business strategies, organizational effectiveness, and corporate transformation. He has assisted several hundred companies—headquartered both within and outside China—on all aspects of business related to China and its integration with the rest of the world.

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