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China's Risky Drive into New-Energy Vehicles

AUTHOR
Scott Kennedy

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China Innovation
Policy Series

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Center for Strategic & International Studies
1616 Rhode Island Avenue, NW
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202-887-0200 | www.csis.org

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The China Innovation Policy Series

In 2016, CSIS launched the China Innovation Policy Series (CIPS). The purpose of this initiative is to better understand both Chinese innovation policy and the actual performance record of Chinese efforts at high-technology innovation, and on that basis, assess the implications for industry, China's trading partners, and the global economy.

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CIPS is managed by the Freeman Chair in China Studies in cooperation with the Technology Policy Program at CSIS. The report authors are: Scott Kennedy, deputy director of CSIS's Freeman Chair in China Studies and director of the Project on Chinese Business and Political Economy; James A. Lewis, senior vice president at CSIS; Samm Sacks, senior fellow in the Technology Policy Program; and Will Carter, deputy director and fellow in the Technology Policy Program. Research support is headed by Qiu Mingda of the Freeman Chair in China Studies.

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Previous Reports

Scott Kennedy, *The Fat Tech Dragon: Benchmarking China's Innovation Drive* (August 2017)

Samm Sacks, *Disruptors, Innovators, and Thieves: Assessing Innovation in China's Digital Economy* (January 2018)

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This report is based both on documentary evidence, which is cited in the footnotes, and over 50 interviews with industry experts and government officials, which are not. Interviews were carried out in China, the United States, and Japan between August 2017 and July 2018. I am grateful to everyone who shared their time and insights with me. To protect their identity, I have only referred to them in general terms within the report text. I also appreciate the participants of several events—including those held at the Council on Foreign Relations, Harvard University, University of North Dakota, University of Oklahoma, the University of Ottawa, Zhejiang University, the American Chamber of Commerce in China, and CSIS—for their feedback on the findings and suggestions for additional research.

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Executive Summary

China has made developing new-energy vehicles (NEV) a top priority. The hope is that NEVs will help the country go from a technological follower to a leader in the automobile sector, reduce the country's dependence on imported oil, and improve air quality.

To achieve these goals, China has employed an intensive, government-led effort to generate supply of NEVs, batteries, and other key components and also promote consumer demand. By our estimate, the Chinese government has spent over RMB 390 billion (\$58.8 billion), equivalent to over 42 percent of the sector's entire commercial activity. Key government policies include: R&D funding, emissions guidelines, requirements that a minimum proportion of one's fleet are NEVs (the dual-credit system), mandates for Chinese-foreign joint ventures and technology transfer, buyer subsidies, tax exemptions, license plate restrictions, government procurement, and mandates and funding to support the construction of a comprehensive charging infrastructure.

The results of these efforts are mixed. China has by far the world's largest NEV market, with over 600,000 passenger vehicles sold in 2017 and likely over 1 million total NEVs in 2018, of which 75 percent will be battery-powered electric vehicles and the rest plug-in hybrids. China now boasts an eclectic mix of NEV makers, including older state-owned stalwarts, well-developed independent producers, and a slate of new entrants. Moreover, China's battery makers have improved the quality of their batteries; they currently have almost all of domestic demand and are poised to expand exports.

At the same time, the sector faces some immense challenges. Policies to support supply are likely to be more successful than those encouraging demand. The chances for profitability in the near-to-medium term are low and the chances for overcapacity are high. The quality of China's NEVs is still not equivalent to that of traditional cars. Given the continued dependence on fossil fuels as an energy source, NEV adoption may only be shifting the location of air pollution, not reducing it. And China's effort is generating diplomatic tensions because of discrimination against foreign automakers and battery producers and could worsen should Chinese NEV makers export their vehicles at cut-rate prices.

The future of China's NEV sector will depend on how several wild cards play out: the extent to which government policy will shift in a more market-oriented direction; whether quality and performance of China's NEVs will advance; whether commercially viable alternatives to lithium-ion batteries (such as hydrogen fuel cells) emerge; and

whether the mobility revolution, built around ridesharing and autonomous vehicles, takes hold in China and elsewhere.

Given these developments, it would be a mistake to assume that just because China has a larger NEV sector, it is somehow leading a “race” that the United States must join in order to catch up or win. Unless the relative benefits of one kind of energy creation and storage technology become overwhelming, the United States should promote technology diversity and competition amongst the various options. In addition, promoting technology development will not result in technology deployment on a wide scale without additional incentives to generate both sustained supply and demand. Finally, given the size and significance of the Chinese market, the United States must hold China accountable to its existing commitments and promote greater commercial opportunities for U.S. companies in their market. The health of the global auto industry is too important to allow it to be threatened by China’s own potential market distortions.

1 | Introduction: A Roadmap

When I first arrived in China in the 1980s, the roads were dominated by buses, trucks, and agricultural vehicles, all belching out toxic exhaust. Of course, they competed for space with streams of bicycles. There were virtually no private cars, taxis had to be ordered in advance by phone, and gas stations were as, the Chinese like to say, rare as “phoenix feathers and unicorn horns.” What a difference three decades make. As Chinese grew wealthier, they parked their bicycles in exchange for cars. In the late 1990s, urbanites started driving more regularly, using the official vehicles from their offices for their personal needs, renting cars for jaunts during the weekends, and occasionally bringing home their own car.¹ Since then the passenger auto market in China has exploded, with the People’s Republic of China (PRC) becoming by far the largest car market in the world. The 25 million in passenger car sales in China in 2017 (not to mention the 4 million in commercial vehicles sold) accounted for fully 35 percent of the global market, compared to just 8.6 percent for the United States (see Figure 1-1).

The amazing story of growing demand has not been matched by as positive a story on the supply side. There are several highly successful homegrown automakers whose production quality has improved immensely over the past decade, and the vast majority of cars driven in China are produced domestically. At the same time, the top-selling brands still hail from elsewhere—from Japan, South Korea, Europe, and the United States. And despite higher emissions standards, automobiles are still major contributors to China’s highly visible air pollution and its world-record carbon emissions.

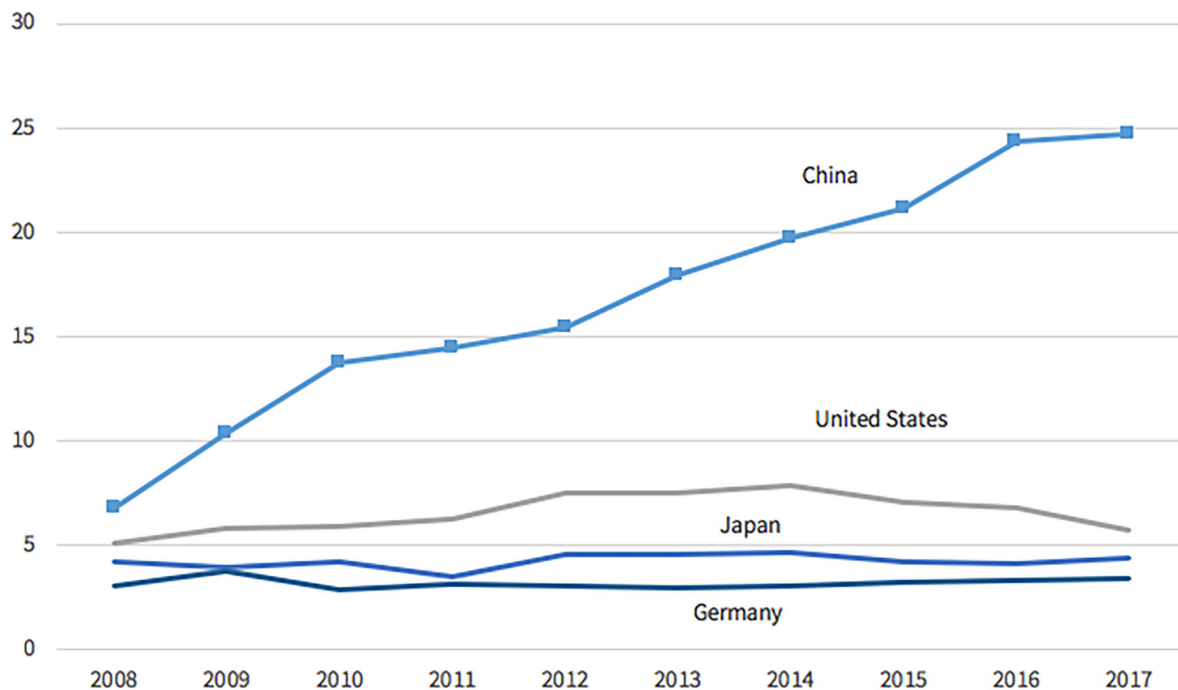
China’s solution to these challenges is the new-energy vehicle (NEV). Over the last decade Beijing has massively increased its support for producers and provided huge incentives to make NEVs more affordable for consumers. Early results were not promising; in 2011, Shanghai had no more than 500 NEVs on its streets, and their typical range on a full charge was under 100 kilometers (62 miles).²

But a few short years later, there is now a substantial domestic NEV industry, and as with passenger cars more generally, China is by far the world’s largest NEV market. By 2020, China aims to have annual sales of 2 million NEVs, which would be 20 times the figure for the United States.

1. Peter Hessler, *Country Driving: A Chinese Road Trip* (Harper Perennial, 2011).

2. Andrew Browne, “China’s World: Why the Electric-Car Market is Low Wattage,” *Wall Street Journal*, November 27, 2013, <https://www.wsj.com/articles/china8217s-world-why-the-electriccar-market-is-low-wattage-1385473836>.

Figure 1-1: Passenger Vehicle Sales, 2008-2017 (Millions)



Sources: China Association of Automobile Manufacturers, U.S. Department of Commerce Bureau of Economic Analysis, Japan Automobile Manufacturers Association, German Association of the Automotive Industry.

Moreover, China has also seen an explosion in ridesharing, and intensive efforts are being put toward autonomous vehicles and other forms of intelligent operations and networked services. Given that car ownership in China is still far lower than in United States—106 cars per 1,000 people compared to 800 per 1,000 people—China could potentially lead a global transformation of the auto sector toward a mobility model in which cars are transformed from personal possessions into ubiquitous service tools.³ The auto industry was central to industrialization and the transformation of the global economy in the twentieth century. If the mobility model is realized in practice, the industry is poised once again to play a key role in revolutionizing lives and economies in the twenty-first century.

Given what is at stake, China's headlong sprint toward electric cars raises questions about the more passive approach taken by the United States, where some states have pressed ahead but where federal government policy and industry strategy still center around internal-combustion engine vehicles (ICV). In the United States, only 0.2 percent of cars on the road today are NEVs.⁴ Tesla is widely respected and growing rapidly, but it still operates in a distinctly niche market. Other major U.S. manufacturers have started to demonstrate greater interest in NEVs, but it is still unclear how fast they will move forward. European and Asian countries have also jumped on the NEV bandwagon with ambitious goals and supporting policies. The question is whether Washington should

3. Shasha Chen and Beibei Nie, "New Cars in a New Economy," *CKGSB Knowledge* 27 (Fall 2017): p. 21-24, <http://english.ckgsb.edu.cn/wp-content/uploads/2018/04/CKGSB201709-150dpi-Unprotected.pdf>.

4. Jess Shankleman, "Electric Car Sales Are Surging, IEA Reports," *Bloomberg*, June 7, 2017, <https://www.bloomberg.com/news/articles/2017-06-07/electric-car-market-goes-zero-to-2-million-in-five-years>.

see itself as in a race with China and others to provide leadership in new-generation transportation, and if so, what policies should it adopt to boost its own industry's chances of success or to foster greater international cooperation.

The purpose of this report is to present a balanced assessment of the current state and future trajectory of China's NEV sector and the implications for the United States and the entire industry. There is a great deal of hyperbolic extremism on both sides, with some offering breathless praise for China's apparently far-sighted leadership and others declaring its efforts as bound to fail abysmally.⁵ The reality is far more mixed; China's industry has made tremendous progress and could help drive a broader shift toward NEVs far beyond China. Yet there are substantial challenges, as profitability for the sector has yet to arrive and is far from assured, a product of likely overcapacity, mixed quality of domestically produced NEVs and batteries, and insufficient charging infrastructure. It is also not clear that the transition toward NEVs will reduce overall pollution levels. China's NEV push has already generated diplomatic tensions, and if China ends up exporting NEVs at cut-rate prices, those tensions will be sure to rise.

Chapter 2 explains the evolution of Chinese policy for the auto sector and NEVs over the past quarter century. Here we find signs of surprising continuity that should raise significant concerns about government interventionism and discriminatory treatment of foreign producers; yet there also appear to be some more novel steps akin to efforts in Europe and California being taken to promote the sector. But government policy is only the start of the story, not the end, a foundational principle for this entire series examining China's high-tech drive. Chapter 3 outlines the rapid development of industry, including overall production, the rise of several kinds of NEV original equipment manufacturers (OEM), and the development of the domestic supply chain, most notably several battery makers. Chapter 4 presents the other side of the story, with an examination of worrying dangers that could overwhelm this recent progress. These include a clear imbalance between supply and demand, a growing strain on resources and little evidence that adoption of NEVs has reduced air pollution, and greater commercial tensions with foreign OEMs, battery makers, and governments. Chapter 5 then looks ahead at several "wild cards" that could determine the NEV sector's future, including potential developments in Chinese policies, how the lurking danger of overcapacity is handled, whether technology and overall vehicle quality continues to improve, whether alternatives to lithium-ion batteries (such as hydrogen fuel cells) become more cost effective, and whether the mobility model, involving both ridesharing and autonomous vehicles, comes to dominate the transportation sector.

The final chapter concludes with a discussion of the implications for U.S. policy. By some measures, China may be winning the NEV race, but the United States should not mimic Chinese industrial policy. Instead, it should promote technological diversity as well as use a variety of market incentives to promote greater consumer demand. At the same time, the United States and others may also need to protect themselves should China's

5. Representative of this perspective is the consistently optimistic blog series, "The Chinese Are Coming," by ZoZo Go, <https://www.zozogo.com/blog/>. Also see Zongyuan (Zoe) Liu, "China's Plan to Dominate the Global Electric Vehicle Supply Chain," Center for Advanced China Research, September 26, 2018, <https://www.ccpwatch.org/single-post/2018/09/26/Chinas-Plan-to-Dominate-the-Electric-Vehicle-Supply-Chain>.

industry suffer from overcapacity and export NEVs at unfairly low prices. The health of the global auto industry is too important to allow it to be threatened by China's own potential market distortions.

2 | China's Turbocharged NEV Policy

The core puzzle China has struggled with in developing its auto industry, and many industries for that matter, is how to most effectively cooperate and compete with the global industry leaders. Would China advance more by developing its own purely independent domestic firms that try to catch up on their own, or should China seek partnerships with the world's best so they could be nurtured gradually in all facets of the sector and eventually emerge as equals? In the auto sector, perhaps because of a lack of self-confidence, Chinese industrial policy has emphasized the latter approach. Joint ventures for traditional ICVs have yielded decidedly mixed benefits for China's domestic producers, yet this approach has been extended into NEVs, although with a few twists meant to accelerate domestic learning, technological independence, and commercial success. At the same time, additional policy measures have been enacted to incentivize production and demand for NEVs in a way that has never been needed for ICVs.

The Auto Sector's Ambiguous Embrace of the Joint Venture Model

When the Reform era began, China's legacy auto industry was built almost exclusively out of direct support from the Soviet Union. Chinese cars were largely carbon copies of original Soviet designs, save for very modest tweaks. And the sector was tiny; in 1985, China produced a total of 5,200 passenger cars.⁶ Given that poor record, China determined that the only way it could successfully develop its own sector would not be to go fully independent, but to switch horses and collaborate with Western automakers. One of the first efforts was Beijing Jeep, a joint venture established in 1984 with American Motors Corporation (AMC). In what would be a common theme repeated elsewhere, the company struggled mightily between the competing goals of the two parties, with the Chinese wanting to acquire technology as cheaply as possible and the foreign side wanting to limit technology transfer while maximizing sales and income.⁷

A policy favoring partnerships was solidified in 1994 when China issued its first comprehensive industrial policy guidelines for the auto sector, which in fact was China's first contemporary industrial policy for any sector. The goal was to support a few large-

6. G. E. Anderson, *Designated Drivers: How China Plans to Dominate the Global Auto Industry* (John Wiley & Sons, 2012), p. 51-58; and Eric Harwit, *China's Automobile Industry: Policies, Problems, and Prospects* (M.E. Sharpe, 1995).

7. Jim Mann, *Beijing Jeep: A Case Study of Western Business in China* (Westview Press, 1997); John F. Burns, "A.M.C.'s Troubles in China," *New York Times*, April 11, 1986, <https://www.nytimes.com/1986/04/11/business/amc-s-troubles-in-china.html>.

scale producers, but also set performance criteria for continued support. Central to the plan was the encouragement of joint ventures to promote technology learning and eventual independence. Foreign ownership was capped at 50 percent to ensure the domestic party did not lose control of any decisions and operations, and foreign producers could at most have two partnerships in China. The Chinese side primarily provided land, workers, and some capital, while the foreign parties contributed the fundamental technology and car designs, detailed knowledge about manufacturing and marketing, and links to the global supply chain. At the same time, tariffs on imported cars were kept quite high while tariffs on parts were somewhat lower, limiting imports and facilitating connecting China to global supply chains while it developed a local parts sector as well. By the year 2000, there were 15 joint ventures between the world's leading producers from Asia, the United States, and Europe on the foreign side and large state-owned enterprises (SOE) on the Chinese side. The most prominent domestic partners were located in Shanghai (Shanghai Automotive Industry Corporation), Changchun (First Auto Works), Beijing (Beijing Automotive Industry Corporation), Wuhan (Dongfeng Motor Corporation), and Guangzhou (Guangzhou Automobile Group). Another dozen were established over the next decade.⁸ In addition, hundreds of joint ventures in auto parts were also established, with foreign companies such as Bosch, Siemens, Continental, Densel, and Delphi.

The results of the joint-venture approach in ICVs have been decidedly mixed. Imports have dropped from 90 percent to 10 percent of the passenger car market, but the dominant models in most segments have been foreign brands. And no Chinese automaker has been able to compete successfully in the luxury market. Most importantly, although the domestic partners certainly gained invaluable knowledge and experience through the joint ventures, they largely remained dependent on their foreign partners to achieve technological sophistication and consistent quality and reliability. Their ability to independently innovate and create attractive models valued by consumers is quite circumscribed.⁹

Ironically, the most dynamic segment of the domestic industry has been independent producers who have emerged in spite of industrial policy guidelines. The first was Zhejiang-based Geely, which jumped into the industry in 1999 with an aggressive lobbying effort to acquire a manufacturing license. It has been followed by many others, including BYD, Great Wall, and Chery. Some, such as Geely, are private firms; others, such as Chery, are owned by local governments.¹⁰ Each has been able to lure away talent from the larger joint ventures, but rather than work closely with global manufacturers, they instead have benefited from collaborating with automobile technical design firms from Europe, including Pininfarina (Italy) and AVL (Austria). This has allowed them to make incremental improvements in all facets of their cars, including to the engine, interior, and the body.¹¹ Industry observers interviewed for this report believe Geely has progressed the furthest with localization, but the independents as a class have generally proven nimbler and more

8. Anderson, *Designated Drivers*, p. 64-67, 267-269.

9. Ibid.; and Eric Thun, *Changing Lanes in China: Foreign Direct Investment, Local Government, and Auto Sector Development* (Cambridge University Press, 2006).

10. Chery is owned by the municipal government of Wuhu in Anhui province. BJEV is a subsidiary of Beijing-based BAIC.

11. Kaidong Feng, "Chinese Indigenous Innovation in the Car Sector," in Yu Zhou, William Lazonick, and Yifei Sun, eds., *China as an Innovation Nation* (Oxford: Oxford University Press, 2016), p. 133-164.

adaptable than their traditional SOE cousins. This contrast is directly relevant for Chinese efforts in electric cars.

Toward NEVs: Policy Goals and Key Players

China was certainly far from the first country to show substantial interest in electric vehicles. The core technology was first developed and deployed elsewhere in Asia, North America, and Europe. But in the last decade, Chinese national policy has whole-heartedly embraced NEVs and has made them a much higher priority than has the U.S. government.

China has focused on NEVs for three reasons. First, Chinese producers have never been able to fully replicate the world's best internal combustion engines, a challenge that still befuddles the Chinese whether the engines are in cars, ships, or aircraft. An electric motor has far fewer moving parts and is easier to master. Second, a move toward electric would reduce their dependence on imported oil. In 2013, China became the world's largest net importer and imported 8.4 million barrels per day in 2017.¹² And third, a shift toward electric would reduce car emissions, an important contributor to China's infamous air pollution problem.

Although there has been broad consensus on addressing these goals, there has been disagreement about which kind of technology to focus on. The National Development and Reform Commission (NDRC), China's super-ministry in charge of industrial policy, has advocated that attention be placed heavily on hybrid vehicles (that combine an internal combustion engine, battery, and electric motor, with the latter often being charged by an internal generator), in part because doing so would require little additional charging infrastructure and be easier for China to transition toward. By contrast, the Ministry of Science and Technology (MOST) has been a consistent advocate for pure battery-electric vehicles powered entirely by rechargeable lithium-ion batteries. In their view, hybrid technology is dominated by Japanese makers (Toyota in particular) and is likely more of a transitional technology than pure electric-battery cars. The latter also achieves a theoretical higher miles-per-gallon equivalent than hybrids, resulting in potentially greater overall energy savings. Although hydrogen fuel cells are theoretically even more economical and cleaner, fuel cells are more technologically complicated and still more expensive than lithium-ion batteries.

Initial policy was relatively equally balanced. In 2010, China identified "new-energy vehicles" as one of seven broad categories of "strategic emerging industries" that would receive major government support. And within this category it listed both hybrids and pure-electric cars.¹³ But over time, pure-electric cars have increasingly received more support. There is good logic to such a choice, but it also reflects the unexpected level of policy influence of the former Minister of Science and Technology, Wan Gang. Although the only cabinet minister who was not a member of the Communist Party, his long experience working at Audi and in the auto sector has given him an outsized voice in shaping policy. Hybrids and other forms of non-fossil fuel energy sources receive some government support, but the growing push in the direction of pure-electrics is unmistakable.

12. "China Surpasses U.S. as Largest Crude Oil Importer," The Maritime Executive, February 3, 2018, <https://www.maritime-executive.com/article/china-surpasses-u-s-as-largest-crude-oil-importer>.

13. Scott Kennedy, "Indigenous Innovation: Techno-nationalist Retreat?" GaveKal Dragonomics, March 2, 2012.

Although the contest between MOST and the NDRC over which kind of technology to emphasize has been central to the evolution of policy, the NEV sector is shaped by a much larger set of policy tools and actors. MOST has long provided subsidies for R&D for batteries and other NEV-related technologies. The NDRC awards the right to manufacture NEVs for companies, including for Chinese-foreign joint ventures. The Ministry of Industry and Information Technology (MIIT) approves company plans for power trains, determines which car batteries are eligible to receive subsidies in connection with car sales, and sets product requirements for vehicle safety. The Ministry of Environmental Protection (MEP) sets China's rules for fuel economy standards. The Ministry of Transportation (MOT) sets out broad policies for the transportation routes on land, rail, and water, including road safety and the application of smart technologies (for example, used in autonomous driving systems). The Ministry of Public Security (MPS) also plays a role in road safety, including related to accidents and criminal activity. There are reports that MOST may soon be shuttered, and if so, that will likely leave MIIT and NDRC as more powerful but still contending with other regulators.

In addition to government agencies, there are three organizations that play a significant and institutionalized role in setting and implementing NEV policies. The China EV100 is a group of national experts from government, industry, and academia who provide thought leadership on the sector and all the relevant policy issues shaping it, from alternative kinds of battery technology to consumer demand and market access. The China Automotive Technology and Research Center, Co., Ltd. (CATARC), provides policy advice, sets NEV standards, and tests and certifies NEV components.¹⁴ The China Association of Automobile Manufacturers (CAAM), an industry group closely tied to the government, also suggests industrial guidance to manufacturers and coordinates standard-setting and self-regulatory efforts among manufacturers. Beyond these groups are the auto companies themselves, which because of their technical knowledge, commercial experience, and connections amongst each other and with officials, also have a say in how policy is conceived and implemented.

The result of having so many participants is a great deal of activity that on the surface suggests a proactive, unified, and well-coordinated plan, but which in actuality also reflects a variety of competing agendas that are not always working in concert with one another. Hence, actual NEV policy fits the historic pattern of being the product of compromises amongst various participants.¹⁵

NEV Policy: Big Goals and a Comprehensive Set of Tools

China's initial efforts at NEVs actually started not with cars but with buses, as Beijing municipal authorities and a local university provided 50 electric buses for use during the 2008 Beijing Olympics.¹⁶ But the real beginning of the NEV push came in 2010, when, as noted above, NEVs were identified as one of seven "Strategic Emerging Industries" (SEI).

14. Both are technically independent, but they are in practice closely aligned with MIIT. For more about both organizations, their websites, respectively, are: <http://www.chinaev100.org>, and http://www.catarc.ac.cn/ac_en.

15. Andrew Mertha, "Fragmented Authoritarianism 2.0: Political Pluralization in the Chinese Policy Process," *China Quarterly* 200 (December 2009): 995-1012, <https://www.cambridge.org/core/journals/china-quarterly/article/fragmented-authoritarianism-20-political-pluralization-in-the-chinese-policy-process/EA5E4FE9316DA47EB-53C777C879DCA29>.

16. "Beijing Will Put Into Service 50 Electric Buses During Olympics," *Car Weekly* (Qiche zhoubao), August 3, 2007, <http://auto.sohu.com/20070803/n251398507.shtml>.

As an SEI, a whole range of support for the industry was unleashed. But the biggest great leap on NEV policy occurred in 2015, with the release of the *Made in China 2025* plan, which cemented electric vehicles as a key target of the Xi Jinping administration. The plan set the goal of having domestic producers increase their market share in NEVs to 70 percent by 2020 and 80 percent by 2025, and to 80 percent of electric car batteries and engines by 2020.¹⁷ A series of policy steps soon followed, and they were crystallized in a comprehensive “Medium- and Long-Term Development Plan for the Automotive Industry” issued in April 2017.¹⁸ A central goal of this plan is for total NEV production to reach 2 million vehicles by 2020 and account for 20 percent of all auto sales by 2025.¹⁹

China’s NEV policy is comprehensive in scope and addresses three broad needs: 1) creating a supply of increasingly higher-quality cars and parts, particularly by domestic producers; 2) generating sustained demand from individual consumers and corporate and government organizations; and 3) developing a ubiquitous charging infrastructure needed to power cars and reassure both producers and consumers.

CREATING SUPPLY

There have been a range of policies meant to develop the underlying NEV technology and vehicles. The first has been extensive funding for research and development of the whole range of technologies associated with electric vehicles, particularly for their batteries, engines, and the chassis. This funding primarily has come from MOST, but other central and local government agencies and research foundations have also provided support over the years.²⁰ Government support in the early years was directed toward foundational technologies, but over time has shifted toward more advanced materials, capabilities, and processes.

Not surprisingly, a central area of focus has been the battery, which can account for 50 percent of a car’s production cost. China has spared no effort to foster this industry across the entire supply chain, including raw materials, components, battery design, manufacturing, and recycling. The government has gradually raised requirements for the energy density of batteries, which is central to extending the range of NEVs.²¹

While supporting the growth of a domestic battery sector, the government has gradually raised obstacles to foreign battery producers’ market access. Starting in 2015, the Ministry of Industry and Information Technology (MIIT) began issuing a “white list” of batteries approved to be included in NEVs that would be eligible to receive subsidies. The creation

17. “*Made in China 2025*” Roadmap for Key Area Technologies, State Manufacturing Power Construction Strategy Advisory Group, October 2015, pp. 92-116.

18. “Notice on Printing and Adopting the ‘Medium and Long-Term Development Plan for Automobiles’,” Ministry of Industry and Information Technology, National Development and Reform Commission & Ministry of Science and Technology (“三部委关于印发《汽车产业中长期发展规划》的通知”, 工业和信息化部, 国家发展改革委, 科技部), April 25, 2017, <http://miit.gov.cn/n1146295/n1146562/n1146650/c5600446/content.html>.

19. Li Fusheng, “China takes road to global auto power,” *China Daily*, April 26, 2017, http://www.chinadaily.com.cn/business/motoring/2017-04/26/content_29086394.htm.

20. Yang Shiming, “MOST’s NEV Research Projects May Bring the Rain of ‘Red Packet’: Eight Hotspots,” D1EV, (杨世明, “科技部新能源汽车研发专项或带来红包雨 八大抢点,” 第一电动网), February 27, 2015, <https://www.d1ev.com/kol/37587>.

21. “Notice on Printing and Adopting the ‘Plan for Promoting Automobile Power Battery Industry Development’,” Ministry of Industry and Information Technology, National Development and Reform Commission, Ministry of Science and Technology, & Ministry of Finance (“四部委关于印发《促进汽车动力电池产业发展行动方案》的通知”, 工业和信息化部, 发展和改革委员会, 科学技术部, 财政部), March 1, 2017, <http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757018/c5505456/content.html>.

of the list was a way to promote domestic battery makers. Despite having production in China, LG Chem and Samsung SDI were not included in the list between 2015 and 2017.²² And the world's other prominent producer, Panasonic, was not eligible since it does not manufacture batteries in China. In 2018, official responsibility for the white list reportedly shifted to a domestic auto association (CAAM), and LG Chem and Samsung SDI were added to the list, but it is still unclear whether cars that carry their batteries will be eligible for the subsidies.²³ As a sign of possible thawing, LG Chem broke ground on a second plant in China in October 2018 and said a portion of the production would be sold in China.²⁴

Vehicle technology and production has been even more heavily shaped by the approach to foreign manufacturers. As with traditional internal combustion cars, China continued the joint venture model into NEVs but with some added expectations. To encourage foreign producers to operate in China in the first place, China set car tariffs at 25 percent. As with IC cars, it required foreign producers to be in joint ventures with Chinese manufacturers and capped foreign ownership at 50 percent. Moreover, to promote technology transfer, starting in 2009 China required that the joint venture lead to new mastery of at least one of three core technologies for NEVs: the battery, the electric motor, or the inverter. In early 2017, China required that joint ventures master all three of these elements.²⁵ On top of these requirements, starting in 2017 the NDRC appears to have mandated that newly created joint ventures would need to produce new brands that are not associated solely with the foreign partner.²⁶ So not only has technology transfer been a regulatory mandate, but so has diminishing the presence of non-Chinese brands. In early 2018, China announced that it would eliminate the joint venture requirement at the end of 2018, but as to be discussed later in the report, this change may be more superficial than at first meets the eye.

As important as the joint venture requirement has been, perhaps the most enduring way China has promoted the NEV sector is through policies that ban highly polluting vehicles and incentivize the production by domestic and foreign producers alike of greener cars. The first way this has been done is through traditional emissions and fuel-economy standards. China's first comprehensive emissions standards were issued in 2000. China is currently implementing its fifth version (known as Stage V) for "light duty" vehicles

22. "Company List of 'Standard Conditions for the Automobile Power Battery Industry' (Batch 1)," Ministry of Industry and Information Technology ("《汽车动力蓄电池行业规范条件》企业目录(第一批)," 工业和信息化部), November 11, 2015, <http://www.miit.gov.cn/n1146285/n1146352/n3054355/n3057585/n3057590/c4418252/content.html>.

23. The South Korean companies appear to have been targeted not only for industrial policy reasons but as part of China's retaliation against South Korea for its cooperation with the United States in the deployment of the THAAD missile defense system. As a sign of thawing, in October 2018 LG Chem announced it would open a second battery plant in China. Michael Herh, "Will China Lift Sanctions against Korean Battery Firms?" *BusinessKorea*, May 24, 2018, <http://www.businesskorea.co.kr/news/articleView.html?idxno=22504>; Daishi Chiba, "Panasonic braces for all-out war with Chinese rivals," *Nikkei Asian Review*, May 8, 2018, <https://asia.nikkei.com/Spotlight/Electric-cars-in-China/Panasonic-braces-for-all-out-battery-war-with-Chinese-rivals>.

24. "LG Chem Breaks Ground on 2nd EV Battery Plant in China," *Nikkei Asian Review*, October 23, 2018, <https://asia.nikkei.com/Business/Companies/LG-Chem-breaks-ground-on-2nd-EV-battery-plant-in-China>.

25. Marika Heller, "Chinese Government Support for New Energy Vehicles as a Trade Battleground," National Bureau of Asian Research, September 27, 2017, <https://www.nbr.org/publication/chinese-government-support-for-new-energy-vehicles-as-a-trade-battleground/>.

26. Charles Clover and Sherry Fei Ju, "Chinese State Agency Puts Brake on Seat Electric Car," *Financial Times*, August 20, 2017, <https://www.ft.com/content/a3c6a0c0-83ef-11e7-a4ce-15b2513cb3ff>.

(passenger cars), but in late 2016 the Ministry of Environmental Protection issued a 6A version that will take effect in Beijing and Shanghai in 2019 and nationally in 2020. The Stage 6B standard for “heavy-duty” vehicles (buses and trucks) will come into force in 2022, which is even stricter than the comparable Euro 6 standard.²⁷ Since the early 2000s, China also has issued increasingly stringent fuel-economy standards as well, again adopting a system parallel to the European Union, all in the hope of reducing pollution and improving engine technology and performance.²⁸

But the most consequential and novel policy for driving NEV production going forward is the new system raising incentives for all auto manufacturers to make NEVs an increasing minimum proportion of their overall fleets. In 2017, China adopted a “dual-credit system” modeled on California’s “zero emission vehicle” program, which was first adopted in 2012.²⁹ As with carbon and other pollution markets, car companies receive credits for producing NEVs, more for pure-electric than hybrids. The government then sets a minimum proportion of credits for automakers to reach; those that produce above the credit threshold can sell their credits, while those who do not meet them are required to buy credits. In China, the Ministry of Industry and Information Technology originally mandated automakers’ overall fleets hit an 8 percent target by the end of 2018, but after extensive lobbying, most notably from the German government, China delayed initial implementation by one year and delayed mandatory compliance to 2020. However, it set the initial 2019 rate at 10 percent.

This does not mean in practice that a fleet must be 10 percent NEVs. Although the details of the policy are quite complicated, a central feature is that car companies will receive four credits for producing pure-electric vehicles with a range above 250 kilometers (155 miles), two credits for hybrids, and zero for traditional IC cars. Assuming an automaker produces 1 million vehicles in 2019, it would need to produce 25,000 pure-electric vehicles to reach the 10 percent threshold ($25,000 \times 4 = 100,000$). With total production of all passenger cars in 2019 expected to reach 35 million, the baseline output for NEVs, if all pure-electric and with a range over 250 km (155 miles), would be 875,000. Given the actual mix of vehicle types and ranges, full compliance likely translates into a total NEV market in 2019 of 1.3 million vehicles.³⁰

If implementation follows the original plan, the minimum dual-credit requirements will gradually rise annually, about two percentage points per year, requiring NEV production to grow rapidly over the next decade and accounting for an ever-increasing proportion

27. “China’s Stage 6 Emission Standard for New Light-Duty Vehicles (Final Rule),” Policy Update, International Council on Clean Transportation, March 2017, https://www.theicct.org/sites/default/files/publications/China-LDV-Stage-6_Policy-Update_ICCT_20032017_vF_corrected.pdf. For a historical summary of national and regional standards, see “Overview,” TransportPolicy.net, <https://www.transportpolicy.net/standard/china-light-duty-emissions/>.

28. Hongyan H. Oliver et al., “China’s Fuel Economy Standards for Passenger Vehicles: Rationale, Policy Process, and Impacts,” *Energy Policy* 37, no. 11 (November 2009): p. 4720-4729.

29. For California’s formal plan, see “2016 ZEV Action Plan,” Governor’s Interagency Working Group on Zero-Emissions Vehicles, October 2016, https://www.gov.ca.gov/wp-content/uploads/2017/09/2016_ZEV_Action_Plan.pdf. For a hypothetical example describing compliance, see Paul Weissler, “California ZEV Law Gets Simpler, More Challenging,” SAE International, December 7, 2017, <https://www.sae.org/news/2017/11/california-zev-law-gets-simpler-more-challenging>.

30. Yue Wang et al., “Analysis of Typical Automakers’ Strategies for Meeting the Dual-Credit Regulations Regarding CAFC and NEVs,” *Automotive Innovation* 1 (2018): p. 15-23; and Charles Clover, “China’s electric car push set to trigger ‘war of attrition,’” *Financial Times*, November 16, 2017, <https://www.ft.com/content/110144ac-c846-11e7-ab18-7a9fb7d6163e>.

of new vehicles on the road. The standards will be easiest to meet for companies already focused on NEVs and hardest for those who produce large fleets of entirely ICVs.

GENERATING DEMAND

Policies meant to expand demand have focused on making NEVs affordable and easier to acquire relative to ICVs.

The most important way by far to expand demands has been subsidies. The listed price of NEVs globally has been much higher than similarly sized ICVs due to the high cost of the batteries. Subsidies in one form or another have been used everywhere to make NEVs more affordable and attractive due to consumer concerns about car quality and fears of being stranded with an empty battery. In China the Ministry of Finance began offering subsidies in 2010. As Figure 2-1 shows, they were based on the car's battery power until 2013 but have since been set according to a car's total range and other performance criteria.³¹ In 2018, the minimum range of NEVs receiving subsidies was raised 50 percent, to 150 kilometers (93 miles) on a full charge, while NEVs with a range of 300 kilometers (186 miles) and over would receive a higher subsidy. Provincial governments also have been authorized to offer subsidies for NEVs provided they met minimum range requirements. Provinces originally could offer a subsidy as high as those awarded by the central government, but starting in 2017, provincial government support has been capped at 50 percent of the central level.³² Subsidies originally were awarded directly to consumers, but since 2013 have gone to car manufacturers, who in turn pass along the savings to consumers.³³ To avoid local protectionism, the central government has mandated that provincial subsidies should not be limited only to cars manufactured in their jurisdiction.³⁴ Consistent with the broader policy, subsidies for battery electric

31. "Notice on Commencing the Trials for Subsidizing Private Purchase of New Energy Vehicles," Ministry of Finance, Ministry of Science and Technology, Ministry of Industry and Information Technology, and the National Development and Reform Commission ("关于开展私人购买新能源汽车补贴试点的通知," 财政部、科技部、工业和信息化部、国家发展改革委), June 4, 2010, <http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757018/c3757144/content.html>; "Notice on Adjusting the Fiscal Subsidy Policy on the Promotion and Application of New Energy Vehicles," Ministry of Finance, Ministry of Science and Technology, Ministry of Industry and Information Technology, and National Development and Reform Commission ("关于调整新能源汽车推广应用财政补贴政策的通知," 财政部、科技部、工业和信息化部、国家发展改革委), December 29, 2016, <http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757018/c5449722/content.html>; "Notice on Adjusting and Improving the Fiscal Subsidy Policy on the Promotion and Application of New Energy Vehicles," Ministry of Finance, Ministry of Science and Technology, Ministry of Industry and Information Technology, and National Development and Reform Commission ("关于调整完善新能源汽车推广应用财政补贴政策的通知," 财政部、科技部、工业和信息化部、国家发展改革委), February 15, 2018, http://jjs.mof.gov.cn/zhengwuxinxi/zhengcefagui/201802/t20180213_2815574.html.

32. Each province's rules are distinctive and have been issued at different times. For Beijing, a provincial-level municipality, see "Notice on Issuing the 'Revised Regulations on Managing Fiscal Subsidy for the Demonstration and Application of New Energy Vehicles in Beijing,'" Beijing Bureau of Finance, Beijing Science and Technology Commission, and Beijing Economics and Information Commission ("关于印发<北京市示范应用新能源小客车财政补助资金管理细则>(修订)的通知," 北京市财政局, 北京市科学技术委员会, 北京市经济和信息化委员会), April 6, 2016, http://www.bjcz.gov.cn/zwxx/tztg/t20160414_602511.htm; and "Notice on Adjusting the Relevant Policies on the Demonstration and Application of New Energy Vehicles in Beijing," Beijing Science and Technology Commission, Beijing Development and Reform Commission, Beijing Economics and Information Commission, Beijing Bureau of Finance, and Beijing Bureau of Transport ("关于调整北京市示范应用新能源小客车相关政策的的通知," 北京市科学技术委员会, 北京市发展和改革委员会, 北京市经济和信息化委员会, 北京市财政局, 北京市交通委员会), February 16, 2017, http://kw.beijing.gov.cn/art/2017/2/17/art_19_38242.html.

33. "Notice on Continuing the Promotion and Application of New Energy Vehicles," Ministry of Finance, Ministry of Science and Technology, Ministry of Industry and Information Technology, and National Development and Reform Commission ("关于继续开展新能源汽车推广应用工作的通知," 财政部、科技部、工业和信息化部、发展改革委), September 17, 2013, http://www.gov.cn/zwgk/2013-09/17/content_2490108.htm.

34. Jiang Xueqing, "New-energy vehicles 'turning the corner'," *China Daily*, January 11, 2014, <http://usa.chinadaily->

vehicles (BEV) have been higher than for plug-in hybrids (PHEV). Overall subsidies as a percentage of the total listed price have been quite high, but they have started to fall over the last year.

Figure 2-1: Chinese Subsidy Rates for NEV Passenger Cars

		2010		2017		2018	
		BEV	PHEV	BEV	PHEV	BEV	PHEV
Central Government							
Eligibility Requirements	Battery Power	15 kwh	10 kwh	-	-	-	-
	Range	-	-	100 km	50 km	150 km	50 km
	Lowest Speed Over 30 Minutes	-	-	100 km/h	-	100 km/h	-
	Energy Intensity	-	-	90 wh/kg	-	105 wh/kg	-
Amount (RMB, thousands)		Up to 60	Up to 50	20-44	20-25	15-50	22
Provincial Governments							
From 2017, 50% of central gov't		-	-	10-22	10-12.5	7.5-25	11
Total Subsidy (RMB, thousands)		60 max	50 max	30-66	30-37.5	22.5-75	33

In addition to outright subsidies, the government has provided tax incentives for NEVs. The most important is a waiver of the sales tax for NEVs.³⁵ Passenger cars (those with engines of 1.6 liters or less) originally incurred a tax of 10 percent, but to promote the auto sector sales taxes were cut in half in late 2015 to 5 percent. They have since been re-raised, to 7.5 percent in 2017 and back to the original 10 percent in 2018.³⁶ The National People's Congress (NPC) issued the initial law exempting NEVs from sales taxes in 2011. Actual implementation began in 2014, with regulations issued jointly by the Ministry of Finance, the State Administration of Taxation, and MIIT. They renewed the waiver at the end of 2017 for another three-year period, and hence, it will not expire until at least the end of 2020.³⁷

The third way demand has been created has been to restrict the issuance of license plates for ICVs and make them more easily available for NEVs. The initiative began on an

ly.com.cn/2014-01/11/content_17230599.htm.

35. The government also waives an annual vehicle usage tax for NEVs, which ranges from RMB 300 to RMB 600 per vehicle.

36. "China's Auto Sales Drop Due to Decreased Demand, Tax Hike," *China Daily*, May 12, 2017, http://www.chinadaily.com.cn/business/motoring/2017-05/12/content_29318251.htm; Brenda Goh, "Tax Cut Rollback to Sap China Sales Growth for Automakers in 2018," Reuters, January 9, 2018, <https://uk.reuters.com/article/uk-china-autos-toyota/tax-cut-rollback-to-sap-china-sales-growth-for-automakers-in-2018-idUKKBN1EY10I>.

37. "China to Maintain NEV Purchase Tax Exemption for Another 3 Years," Reuters, December 27, 2017, <https://www.reuters.com/article/china-autos-tax/china-to-maintain-nev-purchase-tax-exemption-for-another-3-years-idUSB9N10J00C>. For the original regulations, see "Notice on Exempting Vehicle Sales Tax for New Energy Vehicle Purchases," Ministry of Finance, State Administration of Taxation, and Ministry of Industry and Information Technology ("关于免征新能源汽车车辆购置税的公告," 财政部, 国家税务总局, 工业和信息化部), August 1, 2014, <http://www.chinatax.gov.cn/n810341/n810755/c1150779/content.html>; and "Notice on Exempting Vehicle Sales Tax for New Energy Vehicle Purchases," Ministry of Finance, State Administration of Taxation, Ministry of Industry and Information Technology, and Ministry of Science and Technology ("关于免征新能源汽车车辆购置税的公告," 财政部, 国家税务总局, 工业和信息化部, 科技部), December 26, 2017, <http://www.chinatax.gov.cn/n810341/n810755/c2985330/content.html>.

experimental basis in 2011, then expanded following State Council regulations in 2015. It has since grown to at least 19 cities, which account for over 95 percent of all NEVs sold in the country. In Beijing, where the city has tried to cap the overall level of cars on the road, the chances of winning the lottery for a license plate for an ICV is 0.2 percent, not much better than a regular lottery ticket. NEV buyers face far fewer restrictions in receiving a license plate for their new cars.³⁸

Finally, China has gone to its ace in the hole, government procurement. NEVs were originally placed on procurement lists in 2011 as just a standard purchase item. In 2014, the central government mandated that at least 30 percent of new vehicles purchased by central ministries and local government agencies in demonstration cities be NEVs. The required proportion has risen over time and spread to more cities. In 2015, the Ministry of Transportation, Ministry of Finance, and MIIT issued a joint regulation mandating that provinces annually increase the proportion of NEV buses in their fleets. At the same time, the relevant central and local government agencies have been sure to set aside enough budget funds to cover these expenditures.³⁹

BUILDING CHARGING INFRASTRUCTURE

The Achilles heel for the NEV sector globally has been insufficient charging infrastructure. Without ubiquitous charging that is reliable and inexpensive, it is difficult to have manufacturers commit to produce NEVs at massive scale or persuade consumers to buy NEVs to replace their ICVs. China's situation is made more complex by the fact that most people live in apartment buildings with insufficient public parking to accommodate every residence's vehicle, let alone NEVs.

Chinese authorities appear to have taken these lessons to heart and have been attempting to address this challenge on multiple fronts. The Ministry of Science and Technology, MIIT, and others have supported extensive R&D efforts into technologies for charging, transmission, and large-scale storage; developed a unified standard for charging devices; and mandated that charging facilities are built in new residential communities, on highways, and in cities. The State Grid, Southern Grid, and their subsidiaries have gotten the lion's share of business, but domestic private enterprises (such as Tgood, Star Charge, and Titan Energy) and foreign companies (such as ABB and Delta) are also involved in the market. By the end of July 2018, there were 275,000 charging poles installed in public locations, up 52 percent from a year earlier. So far, public charging facilities are not evenly distributed, with 58 percent concentrated in just five locales—Beijing, Shanghai, Guangdong, Jiangsu, and Shandong—but China plans to have 4.5 million poles and 12,000 charging stations up and running by 2020.⁴⁰ If properly distributed and functioning, this would be sufficient to meet the expected demand.

38. Shasha Chen, "New Cars in a New Economy," *CKGSB Knowledge* 27 (Fall 2017): p. 21-24; "China Issues 150,000 Plates for New Energy Vehicles," *China Daily*, December 26, 2017, <http://www.chinadaily.com.cn/a/201712/26/WS5a420ce9a31008cf16da38ef.html>; and Jack Perkowski, "What China's Shifting Subsidies Could Mean For Its Electric Vehicle Industry," *Forbes*, July 13, 2018, <https://www.forbes.com/sites/jackperkows-ki/2018/07/13/china-shifts-subsidies-for-electric-vehicles/>.

39. Teddy Ng, "Green-Energy Cars Land on State Wish List," *South China Morning Post*, November 26, 2011.

40. Zheng Xin, "Charged Up at Pole Position," *China Daily*, September 10, 2018, http://www.chinadaily.com.cn/cndy/2018-09/10/content_36882172.htm. For more details, see *China Charging Infrastructure Development Annual Report 2017-2018* (China Electric Vehicle Charging Infrastructure Promotion Alliance, July 2018), p. 14-15.

Adding Up Chinese Policies

China's efforts to develop supply, generate demand, and build out infrastructure is as comprehensive as that of any country in the world. As Figure 2-2 shows, China is doing far more than the United States across all areas, and the U.S. policy effort is centered in a single state, California. China's strategy is more akin to that of several European countries, such as the United Kingdom and the Netherlands.

Figure 2-2: Comparison of NEV Policies in Major Markets

Policy Areas		China	United States	United Kingdom	Japan
Goals	Sales	2 million annual sales by 2020; 20% of annual sales by 2025	Greenhouse gas emission target in California	100% zero-emission vehicle sales by 2040	1 million by 2020; 50%-70% of annual sales by 2030
	Technology Priority	Battery electric vehicles (BEV)	-	-	Hybrid, BEV, fuel cells
	Conventional Engine Phase-Out	-	-	by 2050	-
Supply	Battery Sector Support	y	y	-	y
	Emissions Standards	y	y*	y	y
	Fleet Production Requirements	y	-	y	-
	Producer Subsidies	-	-	-	-
	R&D Subsidies	y	y	y	-
	Technology Transfer Mandates	y**	-	-	-
Demand	Buyer Subsidies & Rebates	y	y*	y	y
	Government Procurement	y	-	-	y
	License Plate Limits	y	-	-	-
	Traffic Restrictions	y	y	y	y
	Vehicle Tax Exemptions	y	y	y	y
Charging	Charging Infrastructure	y	y	y	y

Notes: * The policy is mandated by some state governments. ** The policy was officially eliminated on July 28, 2018.

But as is often the case, China sets itself apart in the scale of its government funding. The Chinese authorities have never issued a comprehensive summary of its spending on the NEV sector, but we estimate that the Chinese central and local governments have directly spent over RMB 320 billion (\$48.3 billion) between 2009 and 2017 in supporting the

industry's development. Although most of the funds have gone toward subsidies for NEV sales, likely to the tune of RMB 245 billion (\$36.6 billion), there have been substantial outlays for government procurement, R&D, and infrastructure subsidies. These figures do not include the value of the sales tax exemption, which we calculate to be around RMB 70 billion (\$10.4 billion). These figures are not only large in absolute terms, they cumulatively are equivalent to 42.4 percent of total sales of all NEV vehicles over this period. That is an amazingly high ratio of government funding for any kind of commercial activity, in China or anywhere else in the world.⁴¹

Figure 2-3: Chinese Government Spending, 2009-2017

Type	Amount (RMB, billions)
Sales Subsidies	245.0
Infrastructure Subsidies	15.0
Research & Development	12.9
Government Procurement	50.3
Sales Tax Exemption	70.0
Total	393.7
<i>Total Vehicle Sales</i>	929.1
Government Spending as Percentage of Total Sales	42.4%

Source: Author's estimates. See Appendix for details.

Despite the massive amount of spending and breadth of policies, there is one way in which China has not gone as far as some; China has yet to firmly set a goal of going all-NEV and eliminating internal combustion engine vehicles. In 2017, France, Germany, India, the Netherlands, Norway, the United Kingdom, and 10 U.S. states said their goal was to eventually phase out conventional cars. Following that wave of announcements, MIIT Vice Minister Xin Guobin in September 2017 hinted that China was considering the same move. Some in the Chinese and foreign media concluded that this goal had been firmly announced. China did not immediately refute the reports because it had the benefit of driving investment in the sector, but in January 2018 senior Chinese officials put the matter to rest by clearly stating that it was too early to set such a goal and that ICVs would have a long future in China.⁴² Other industry analysts have suggested that even those countries that have been more explicit may never be able to fulfill those pledges.

From Policy to Performance

Although China has not made such a pledge, it is clear that it is taking almost every step possible to promote the industry. But what matters, of course, is to what extent ambition matches reality. Hence, a critical task of this report is to construct a balance sheet of the

41. For a detailed explanation of this report's calculations and relevant sources, see the Appendix of this report.

42. Nathan Bomey, "A Jolt for Electric Cars," *USA Today*, September 13, 2017; Nic Lutsey, "The transition to electric cars: How can policy pave the way?" International Centre for Trade and Sustainable Development, October 19, 2017, <https://www.ictsd.org/opinion/the-transition-to-electric-cars-how-can-policy-pave-the-way>; Li Xiyin, "MOST Minister: Optimistic Attitude Re NEV Sales Reach 1M Units This Year," *The Paper* ("科技部部长:对今年新能源车销量达到100万辆持乐观态度"《澎湃新闻》), January 20, 2018, https://www.thepaper.cn/newsDetail_forward_1959414.

industry's actual commercial performance. In the next section, we document the stunning and impressive growth of China's NEV sector. We then turn to examining the industry's substantial challenges.

3 | The Market Zooms Ahead

Chinese officials have set lofty goals for the rapid advancement of the NEV sector. Although there are some real problems that are the product of this rushed effort, which will be discussed in the next chapter, planners have a right to crow as a result of some eye-popping statistics. The sector is large and growing quickly; there is a growing number of dynamic companies, technology is improving, and the domestic supply chain is growing.

A Large and Quickly Expanding Market

China has long been the world's largest passenger car market, surpassing the United States over a decade ago. That lead has continued to grow since, with China selling almost 25 million passenger vehicles in 2017. Sales have stalled in 2018 because of the restoration of a higher sales tax (10 percent), but NEV purchases have continued to expand quickly. Chinese bought 600,000 passenger NEVs in 2017 and are on pace to buy 800,000 in 2018. If you include buses and other kinds of non-passenger vehicles, total sales in 2017 reached 794,000, including 666,000 pure-electric vehicles and 128,000 plug-in hybrids.⁴³ NEVs were already 2.4 percent of total passenger sales in 2017. If current trends continue, NEVs could potentially reach the government's goal of being 20 percent of all auto sales by 2025. In addition to passenger cars, China has by far the largest electric bus market, with 200,000 on the road by the end of 2017.⁴⁴

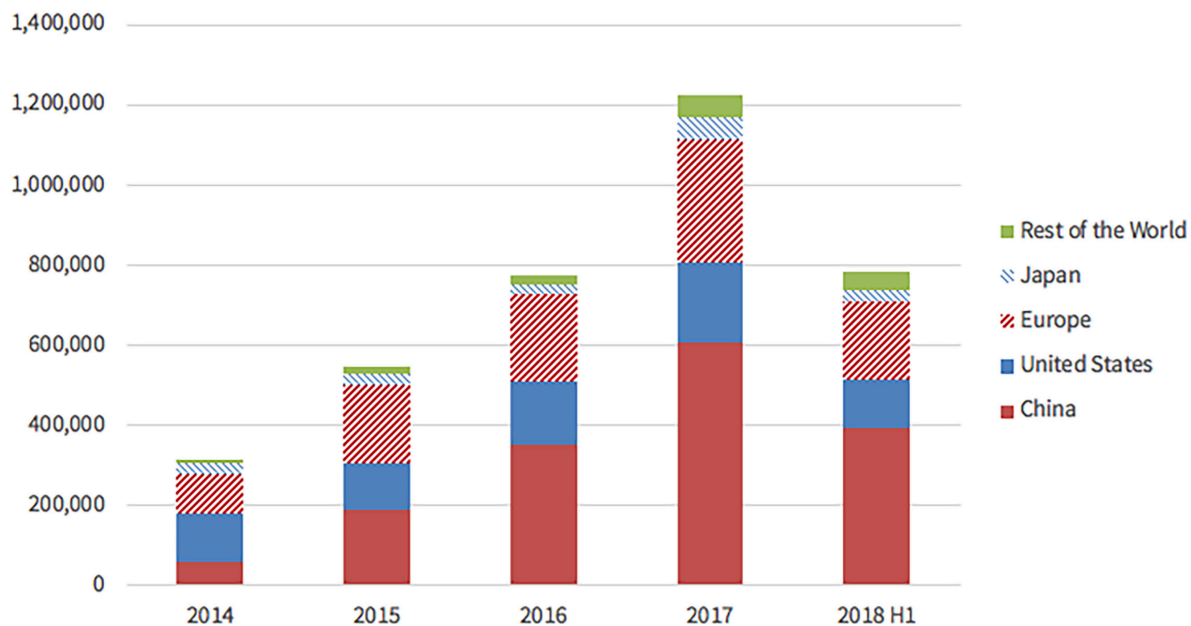
China alone already accounts for the lion's share of the global market. Even though sales elsewhere are expected to pick up in the coming years, by one estimate China should still account for 39 percent of the global market in 2030.⁴⁵ Simply by dint of size, China is moving into position to potentially decisively shape the decisions of vehicle companies around the globe, the rest of the supply chain, and other kinds of market innovations, including autonomous vehicles.

43. "Automotive Statistics," China Association of Automobile Manufacturers, <http://www.caam.org.cn/english/newslist/a101-1.html>.

44. Mo Yelin, "China to Have 200,000 Electric Buses by End 2017," Caixin, December 1, 2017, <https://www.caixinglobal.com/2017-12-01/china-to-have-200000-electric-buses-by-end-2017-101179158.html>.

45. "Electric Vehicle Outlook 2018," Bloomberg New Energy Finance, June 2018, <https://about.bnef.com/electric-vehicle-outlook/>.

Figure 3-1: Global NEV Sales, 2014-2018 H1



Source: EVvolumes.com

A Diverse Group of Manufacturers

A small number of car companies, mainly domestic independents, jumped into the NEV market in the 2000s, but since then the number of producers has exploded. There are almost 500 electric-vehicle makers, of which approximately 100 make electric cars.⁴⁶ NEV producers can be divided into three groups: domestic independents, joint ventures, and new NEV entrants.

Best known among the independents is Shenzhen-based BYD, which was founded in 1995 as a battery company and started trying to develop NEVs in 2003. BYD, which stands for “build your dreams,” launched its first NEV, the hybrid F3DM, in late 2008.⁴⁷ It has since developed a large fleet of pure-electric and hybrid passenger cars and buses and has expanded into monorails. That said, BYD still produces a large number of traditional cars. By 2017, BYD had over 220,000 employees, of whom 20,000 were involved in one way or another in R&D. Its products are made in 33 factories around the world.⁴⁸

46. Trefor Moss, “China Has 487 Electric-Car Makers, and Local Governments Are Clamoring for More,” *Wall Street Journal*, July 19, 2018; *China Industry Statistical Yearbook 2017* (National Bureau of Statistics, 2018), p. 62. For a database listing the top 90 car manufacturers, their car models, and sales figures, see the China page on “Carsalesbase,” <http://carsalesbase.com/china-car-sales-data/>.

47. BYD first developed a pure-electric version, the F3e, in 2006, but due to a lack of charging facilities in Shenzhen, it was kept off the market. Wang Chenyuan, “BYD Abandons the Pure Electric Model F3E,” *The Economic Observer* (“比亚迪放弃纯电动车型F3E,” 经济观察网), December 7, 2010, http://www.eeo.com.cn/industry/real_estate/2010/12/07/188276.shtml.

48. Liang Dongmei et al., “Probing for Secrets Behind BYD’s Mystique,” *Caijing*, February 9, 2010; Chai Hua, “BYD to Increase Market Presence of SkyRail,” *China Daily*, May 26-27, 2018, <http://usa.chinadaily.com.cn/a/201805/26/WS5b08dce6a31001b82571c729.html>; and from the company’s website, “About BYD,” <http://www.byd.com/en/CompanyIntro.html>.

Figure 3-2: NEV Joint Ventures in China

Year Established	Chinese Partner	Foreign Partner	NEV Models in China	NEV Plans*
1985	SAIC	Volkswagen	e-Golf	
1991	FAW	Volkswagen	Audi e-Tron	
1992	Dongfeng	PSA Peugeot Citroen		By 2018
1993	Dongfeng	Nissan		Planned
1995	Changan, Jiangling	Ford	Energi	
1995	Fujian Motor Industry Group	China Motor Corp, Mitsubishi		Planned
1997	SAIC	General Motors	Buick, Chevy, Cadillac	
1998	GAC	Honda		By 2018
2001	Changan	Ford	Mondeo PHEV	
2002	SAIC, Wuling	General Motors		Planned
2002	BAIC	Hyundai		By 2018
2002	Dongfeng, Yueda	Kia	Huaqi E300, K5	
2003	Dongfeng	Nissan	Venucia Chenfeng	
2003	FAW	Toyota		By 2018
2003	Dongfeng	Honda	Spirior	
2003	Brilliance	BMW	BMW, Zinord	
2004	GAC	Toyota	Lerhero, Camry	
2005	BAIC	Daimler		New JV
2005	Changan	Mazda		By 2019
2007	Fujian Motor Industry Group, BAIC	Daimler		Planned
2010	Dongfeng	Yulong	Yulu EV2	
2010	BYD	Daimler	Denza	
2011	Changan	PSA Peugeot Citroen		By 2019
2012	GAC	Mitsubishi	Qizhi PHEV	
2012	Chery	Jaguar Land Rover		By 2018
2014	Dongfeng	Renault		By 2022
2014	Dongfeng	Nissan	Sylphy, Leaf	
2015	BAIC	Borgward	BXi7	
2017	Geely	Volvo		New NEV JV
2017	JAC	Wolkswagen		New NEV JV
2017	Zotye	Ford		New NEV JV
2017	Dongfeng	Renault, Nissan		New NEV JV
2018	Great Wall	BMW	Mini	
2018	Geely	Proton		New JV

Note: Listed dates refer to time when existing joint venture will begin NEV sales. “Planned” means NEV sales in existing joint venture have been announced but without a specific timeline. “New JV” or “New NEV JV” means the partners are forming a new company that will produce NEVs.

Beyond BYD, a handful of other independents that originally started in ICVs have expanded into NEVs. Among them are Geely, Great Wall, Jianghuai Corp (JAC), Chery, and BJEV. Hangzhou-based Geely may be best known for acquiring Volvo in 2010, but it has invested in four separate NEV ventures, two with domestic companies (Kandi and Emerald Automotive) and two with foreign partners (Volvo and Detroit Electric).⁴⁹ BJEV, a subsidiary of Beijing-based BAIC, issued its first NEV in 2009 and now annually produces a diverse fleet of over 100,000 NEVs.⁵⁰

The second group of producers are the Chinese-foreign joint ventures. Dominant in traditional ICVs, most have not made a large volume of NEVs yet; but as of mid-2018, sixteen had begun manufacturing and another eighteen were planning to build and sell models in the near future. As seen in Figure 3-2, one segment are older joint ventures that have added NEVs to their portfolio. But since 2014, at least nine new joint ventures have been established, and several of these are with smaller, private Chinese companies with limited experience. The best example is Ford's joint venture with the modestly sized Zhejiang-based producer, Zotye.

Another change from the past is that whereas MNCs had seen China as a follower market, it appears many now are modifying their global strategies based on signals from China. The country's large market and the dual-credit system may explain why several companies, including General Motors, Ford, Volvo, and Daimler, have pledged to dramatically expand in the coming years the number of NEV models they produce, not just for China, but for other countries as well.⁵¹ The lure of China may be leading the entire industry to no longer view NEVs as a niche market.

The last group is composed of newly created companies focused entirely on NEVs who draw their funding and employees from diverse sources in and outside of China. As with the earlier era of independents, most are led by a charismatic founder, but only some of them have previous experience in the auto sector, with several emerging out of China's internet firms and other start-ups. These companies have been mocked by analysts as "PPT manufacturers" (PPT制造商), as able to make fantastic presentations in front of funders but unable to actually build quality cars. Perhaps the most infamous is Faraday Future, founded by LeEco CEO Jia Yueting. Registered in the United States with plans to manufacture high-performance NEVs that would challenge Tesla, LeEco and Faraday Future ran into major financial difficulties, facing mountains of debt and dim prospects.⁵²

49. Edward Tse, *China's Disruptors: How Alibaba, Xiaomi, Tencent, and Other Companies are Changing the Rules of Business* (New York: Penguin, 2015), p. 133-134.

50. BAIC is one of the early SOEs and is in joint ventures with Hyundai and Daimler, but BJEV is included among the "independents" because it operates with no foreign partner.

51. Keith Bradsher, "China Hastens A Global Move to Electric Cars," *New York Times*, October 10, 2017, <https://www.nytimes.com/2017/10/09/business/china-hastens-the-world-toward-an-electric-car-future.html>; Akihide Anzai, "Volvo wants half of sales from electrics in 2025," *Nikkei Asian Review*, April 25, 2018, <https://asia.nikkei.com/Business/Companies/Volvo-wants-half-of-sales-from-electrics-in-2025>; "Mercedes-Benz Year of Innovation Setting the Pace for Future Growth," *China Daily*, November 21, 2016, http://www.chinadaily.com.cn/cndy/2016-11/21/content_27436078.htm.

52. Zen Soo and He Huifeng, "LeEco raises US\$1b to put electric cars on the road," *South China Morning Post*, September 21, 2016, <https://www.scmp.com/business/article/2020951/leeco-raises-108b-funding-electric-car-hoping-compete-tesla>; Xie Yu, "LeEco Founder Jia Yueting Receives Financial Lifeline from Mystery Hong Kong Investor," *South China Morning Post*, April 19, 2018, <https://www.scmp.com/business/companies/article/2142483/leeco-founder-jia-yueting-receives-financial-lifeline-mystery>; and Mo Yelin and Zheng Lichun, "Cash-Strapped Electric Car Firm Gets Into Spat With Real Estate Giant," *Caixin*, October 8, 2018, <https://www.caixinglobal.com>.

But there are a few others that are more promising and still worth following. Among them is Guangzhou-based Xpeng Motors, which is jointly funded by Alibaba, Foxconn, and Xiaomi founder Lei Jun. Its 1,800 employees designed their first car, but they have contracted production to the Haima Automobile Group, located in Zhengzhou, Henan. Similar to a software firm's Beta test, they produced 400 cars and gave them away so they could collect feedback from drivers.⁵³ Another ambitious start-up is Nanjing-based Byton. Heavily staffed with former executives from BMW as well as from Apple and Google, Byton recently began promotion for its first model, a pricey SUV that uses facial recognition to unlock the doors, is installed with Amazon's Alexa and has a 49-inch wide screen on the dashboard.⁵⁴

Perhaps the most intriguing of this category of companies is NIO. Founded in 2014 by serial entrepreneur William Li in Shanghai, the company was able to attract initial funding from a who's who list of Chinese and global investors, including Tencent, CITIC Capital, Sequoia, TPG, Temasek, and Warbug Pincus.⁵⁵ NIO promotes itself as a global start-up with employees from over 80 countries with an approach very different from traditional producers. To build buzz and develop its initial expertise, NIO designed a concept sports car (the EP9), which in 2016 set the record as the world's fastest electric car.⁵⁶ Its aim is to build new-generation cars that are electric, autonomous, and fully connected to the internet. Hence, 60 percent of its 1,800 employees have a background in information technology and only 40 percent in autos. And rather than only produce a car and then hand consumers over to dealers, NIO's business model is based on maintaining a relationship with owners through the life of the car to provide a range of services, from battery charging to insurance to internet-based services. And like Xpeng (and as with many ICT companies), it is outsourcing manufacturing, in its case to Jianghuai Corp (JAC), a state-owned producer based in Anhui province that makes a range of vehicles but is best known for its trucks. In early 2018, NIO launched its first model, an SUV (the ES8), in Shanghai and Shenzhen. The most distinctive element of the car is the battery. Rather than having owners self-charge, at home or in public stations, NIO is providing both a battery swapping service and a mobile charging service.⁵⁷ This is a risky strategy, given the high capital costs for the charging infrastructure, but it could potentially open a new stream of revenue in a sector where profits have been few and far between. It was on this basis that NIO went forward with its initial public offering (IPO) on the New York Stock Exchange in September 2018.

Two-plus decades after China launched its initial industrial policy for the auto sector, domestic independents have expanded their sales considerably, particularly for certain

com/2018-10-08/cash-strapped-electric-car-firm-gets-into-spat-with-real-estate-giant-101332725.html.

53. Shelly Banjo, Yan Zhang, and Dana Hull, "Tesla Is Getting a China Factory. This \$4 Billion Startup Will Be Waiting," *Bloomberg*, July 16, 2018, <https://www.bloomberg.com/news/features/2018-07-16/tesla-rival-hits-4-billion-valuation-before-selling-any-cars>.

54. Chang Jun and Zhou Pan, "Byton EV startup chose China for its base," *China Daily*, January 9, 2018, <http://usa.chinadaily.com.cn/a/201801/09/WS5a546192a31008cf16da6026.html>.

55. Hao Yan, "Investments help internet startup Nio kick off mass production," *China Daily*, November 13, 2017, http://www.chinadaily.com.cn/business/motoring/2017-11/13/content_34469044.htm; Trefor Moss, "The Fast and the Financed: China's Well-Funded Auto Startups Race to Overtake Tesla," *Wall Street Journal*, December 17, 2017, <https://www.wsj.com/articles/the-fast-and-the-financed-chinas-well-funded-auto-startups-race-to-overtake-tesla-1513498338>.

56. "NIO EP9 - World's Fastest Electric Car sets Nurburgring Record," <https://www.youtube.com/watch?v=NRT-loURydAo>.

57. Shirley, "First NIO battery swapping station prepares for service in Shenzhen," *China Automotive News*, May 22, 2018, http://autonews.gasgoo.com/new_energy/70014660.html.

Figure 3-3: Top Selling Passenger Car Manufacturers in China, 2017

Producer	Brand	Sales	Market Share (%)
SAIC-VW	Skoda, VW	2,063,100	8.3
SAIC-GM	Cadillac, Buick, Chevy	1,998,700	8.1
FAW-VW	Audi, VW	1,957,200	7.9
SAIC-GM-Wuling	Baojun, Wuling	1,894,800	7.7
Dongfeng-Nissan	Nissan	1,251,000	5.1
Geely	Geely	1,248,000	5.1
Changan Auto	Changan	1,128,300	4.6
Great Wall Motors	Great Wall	950,000	3.8
Changan-Ford	Ford	828,000	3.4
Beijing Hyundai	Hyundai	755,000	3.1

Source: China Association of Automobile Manufacturers

segments, such as SUVs and smaller sedans. That said, according to the China Association of Automobile Manufacturers (CAAM), as Figure 3-3 shows, the leading manufacturers are still the older joint ventures that depend primarily on the technology and brand recognition of their foreign partners. According to the CAAM, Chinese brands had only 38.2 percent of the passenger car market in August 2018.⁵⁸ As Figure 3-4 shows, six of the top ten passenger cars are foreign brands, and of the Chinese brands, only the Haval H6 and the Boyue are produced by Chinese independents (Great Wall and Geely, respectively). If the focus is narrowed to only sedans, foreign models still hold nine of the top ten spots, with Geely's Emgrand ranked just sixth.⁵⁹ Six of the top ten are Volkswagen models.

Figure 3-4: Top Selling Passenger Cars in China, Jan-Aug 2018

Brand and Model	Sales
Volkswagen Lavida	320,100
Nissan Sylphy	283,600
Wuling Hongguang	282,400
Haval H6	271,400
Toyota Corolla	258,100
Baojun 510	250,500
Volkswagen Sagitar	208,600
Volkswagen Jetta	200,300
Volkswagen Tiguan	195,800
Boyue	177,500

Source: China Association of Automobile Manufacturers

Note: Chinese producers are in RED

58. "Brief Analysis of Passenger Car Sales by Country, August 2018," <http://www.caam.org.cn/zhengche/20180911/1605219056.html>.

59. All data comes from the China Association of Automobile Manufacturers, which issues sales data monthly:

Figure 3-5: Top Selling NEV Models in China, 2017

Producer	Model	2017 Sales (units)	Market Share (%)
BAIC BJEV	EC180/200	78,079	12.9
Zhi Dou	D1/D2	42,342	7.0
BYD	Song	30,920	5.1
Chery	eQ	27,444	4.5
JAC	iEV6S	25,741	4.3
BYD	e5	23,601	3.9
Geely	Emgrand EV & PHEV	23,324	3.9
BYD	Qin	20,738	3.4
SAIC	Roewe eRX5	19,510	3.2
Zotye	E200	16,751	2.8
JMC	E100	15,491	2.6
BYD	Tang	14,592	2.4
Changan	Benni	14,549	2.4
BAIC BJEV	EU-Series	13,158	2.2
JMC	E200	12,347	2.0

Source: EVvolume.com

The picture changes dramatically when one looks at NEVs (see Figure 3-5). Here, every one of the leading selling models are Chinese brands. The top two sellers, from BAIC and Zhi Dou, are both micro cars, but a wide assortment of mid-sized sedans, MPVs, and SUVs are also strong sellers. Chinese are even more dominant in electric buses. BYD and Henan-based Yutong are the leading producers. Total sales in China were only 89,500 in 2017, down from 116,000 in 2016, as a result of declining subsidies, but this still leaves China far and away the world's largest market for electric buses. Not surprisingly, 99 percent of the world's 385,000 electric buses in operation are in China.⁶⁰

Chinese NEV producers have started to export as well. In 2017, China exported over 956,000 vehicles, of which 106,000 were NEVs. The vast majority were pure-electric, with only 2,000 being hybrids. The great majority went to a single country, Bangladesh (78,500), followed by India (13,600) and South Korea (4,200). Although China has exported barely any passenger NEVs to the United States (just 214 in 2017), Chinese electric bus makers have had more success. BYD and Yutong have started to fill relatively sizable orders for city bus fleets in the European Union and the United States.⁶¹

<http://www.caam.org.cn/newslist/a34-1.html>. Another helpful source for recent data is Focus2move. See "Best Selling Car Models in China. The Top 100 of the 2018," September 27, 2018, <https://focus2move.com/best-selling-cars-models-in-china/>.

60. Linda Poon, "How China Took Charge of the Electric Bus Revolution," CityLab, May 8, 2018, <https://www.citylab.com/transportation/2018/05/how-china-charged-into-the-electric-bus-revolution/559571/>; "Total Number of Electric Buses Sales in China for 2017," Clean Technica, February 4, 2018, <https://cleantechnica.com/2018/02/04/china-100-electric-bus-sales-just-89546-2017/>.

61. Cui Dongshu, "2017 China NEV Export Analysis: Passenger Car Performance Good," D1EV, February 22, 2018, <https://www.d1ev.com/kol/62881>; Christian Shepherd, "China Busmaker Yutong in Overseas Drive," *Financial Times*, April 15, 2016, <https://www.ft.com/content/3642622a-fafa-11e5-8f41-df5bda8beb40>.

Developing the Supply Chain and Technology

The rapid growth in NEV manufacturing and sales is not only due to government mandates but also the product of progress with the development of a full supply chain and the underlying technologies for automobiles and batteries.

In addition to the several hundred auto manufacturers, China boasts almost 13,400 companies that produce auto components and car bodies, which collectively employ over 3.3 million workers.⁶² They are capable of providing all of the components that go into passenger vehicles. According to official statistics, Chinese auto companies reportedly invest about 2 percent of their sales revenue in R&D.⁶³ One industry veteran estimates that Chinese original equipment manufacturers (OEMs) invest 75 percent of the R&D budget toward NEVs, a figure comparable with levels by automakers in other countries. There is no figure separately reported for OEMs that only make NEVs, but one would expect their attention to R&D to be substantially higher.

The results of these efforts in terms of new technology is mixed. On the one hand, Chinese companies are filing an ever increasing number of patents. In 2015, the most recent year for which we have data, Chinese authorities granted over 84,000 patents. Most were utility model patents, another 30 percent were for design, and almost 20 percent were invention patents. The patents cover every part of the car: the body (22,608), the chassis (24,126), electronics (22,244), and the engine (10,227). 84 percent of patent awardees were Chinese residents, and only 16 percent were non-Chinese. Among invention patents, 43 percent were Chinese residents and 57 percent were from outside China. Within the NEV sub-sector, almost 3,000 invention patents were granted in 2015, most of which applied to the battery (998), followed by power management (331) and the electric engine (164).⁶⁴ On the other hand, it does not appear these patents reflect any kind of major innovations but rather minor differences to technologies that exist elsewhere or are in fact the locally registered patents of items first invented or developed elsewhere.

Although Chinese have not made substantial innovations in auto technology, there are some notable areas of progress over earlier Chinese performance. In the mid-1990s, when China stepped up its effort to develop a car industry, there were only a small number of suppliers, and none could provide components for the world's leading brands. Today, China has over 13,000 auto suppliers who serve the world's leading car manufacturers, both through the joint ventures and via exports to their factories beyond China, including Ford, GM, Tesla, Daimler, VW, and many others. According to industry experts, Zhejiang province's Ningbo is one of the key centers for auto suppliers. The Minth Group has 600 R&D staff and exports 70 percent of its production, while Ningbo Xuesheng Auto Technology has become a leading aluminum processor that supplies Tesla and others.

Chinese companies have started to invest resources in improving the quality and reducing the weight of the car chassis, a critical way to extend the range of NEVs. Although the

62. China reports that there are 1.3 million employees in final car manufacturers, just over 25 percent of the sector's total workforce. *China Industry Statistical Yearbook 2017*, p. 62.

63. *China Automotive Industry Yearbook* (China Automotive Industry Yearbook House, various years).

64. *China Automotive Technology Development Report 2016* (Beijing Institute of Technology Press, 2016), p. 153-169.

leaders in this area are in Germany and Japan, Chinese companies are carrying out R&D independently and with British firms on a variety of composite materials and carbon fiber. Guangzhou-based In Far is considered one of the country's leaders, while Beijing Automotive has an R&D center in Tokyo focused on composites and carbon fiber. The expense for new materials to replace stainless steel and aluminum is still high, but China offers an opportunity to reduce costs through expanded scale.

The technology where China has made the most progress is in car batteries. In this regard, China has been trying to catch up with a sector that itself has been undergoing immense changes in the last three decades. Japanese industry was the first to find a realistic alternative to lead-acid batteries, developing the first lithium-ion batteries in the 1980s. But not all lithium-ion batteries are alike, as the composition of chemicals and design affects their energy density, safety, and reliability. The world's leading producers, which now include Panasonic, Samsung SDI, and LG Chem, have moved away from the traditional lithium iron phosphate (LFP) toward batteries composed mainly of nickel manganese and cobalt (NMC). They are even adjusting the ratio of these materials and doing R&D on entirely other kinds of chemistries, so-called "flow" batteries that utilize zinc. At the same time, they have been developing new kinds of individual "cells," which make up the larger battery "packs" that sit under NEVs, to achieve better all-around performance.⁶⁵

Chinese makers have gradually moved up the learning curve in the industry, adjusting the chemistry and structure of their batteries to be more aligned with those of the leading producers. In so doing, they have used the benefit of limiting market access to the world's leading producers to their advantage. There are now dozens of Chinese electric car battery makers, but two stand out. The first, unsurprisingly, is BYD, the first major entrant to the field. Until recently, BYD used the more traditional chemistry for their batteries, and hence, had lower energy intensity. In addition, their batteries were made exclusively for their own NEVs. But in the past two years, BYD's batteries have shifted in the direction of industry leaders, and they recently started to produce batteries for other auto companies.⁶⁶

The other battery producer that is even more successful is Contemporary Amperex Technology Limited (CATL, 宁德时代). Located in Ningde, Fujian, CATL began in 2011 as a joint venture with TDK of Japan. Best known for its tape cassettes, TDK contributed some of the original battery technology but then was bought out by CATL a few years later. Although one might emphasize their potential political connections that could result from Xi Jinping having served as the party secretary of Ningde in the late 1980s, industry analysts consistently praise CATL's technology and commercial performance. Boasting 100 scientists with doctorates, the company invests extensively in R&D, and it has inked supply contracts with BMW, VW, and Daimler. In 2016, CATL already had capacity of 7.6 gigawatt hours (GWh) of batteries per year and plans to raise its production to 50 GWh by 2020, making it substantially larger than Panasonic/Tesla's gigafactory in Nevada.⁶⁷ It was

65. Gianfranco Pistoia and Boryann Liaw, eds., *Behavior of Lithium-Ion Batteries in Electric Vehicles: Performance, Safety, and Cost* (Springer, 2018); Lauren Goode Gear, "Batteries Still Suck, But Researchers Are Still Working On It," *Wired*, May 22, 2018, <https://www.wired.com/story/building-a-better-battery/>.

66. Zheng Lichun and Mo Yelin, "BYD Powers Up Battery Output with Changan Automobile Tie-Up," *Caixin*, July 6, 2018, <https://www.caixinglobal.com/2018-07-06/byd-powers-up-battery-output-with-changan-automobile-tie-up-101295403.html>. According to BYD staff, the company has applied for 18,000 patents and been awarded 15,000.

67. Henry Sanderson, Tom Hancock, and Leo Lewis, "Electric Cars: China's Battle for the Battery Market," *Finan-*

on this basis that CATL listed in mid-2018 on the Shenzhen stock exchange's "ChiNext Board," which is devoted to promoting high-tech innovators.⁶⁸

Chinese companies have also invested in all of a battery's components and ingredients, including lithium and cobalt. China has invested extensively in cobalt, lithium, and nickel mines abroad, and it has encouraged the development of domestic processors and refiners.⁶⁹

The result of all of these efforts is that even though China does not have the world's most innovative battery makers, their technology is not far behind the world's leaders, they have developed the entire supply chain, and they are aggressively scaling up their production capacity. By one estimate, total capacity in China will rise from 135 GWh in 2018 to 405 GWh by 2023 and over 630 GWh in a decade.⁷⁰ The result of these efforts is that the cost of batteries, and with them full cars, is falling, while driving range and other signs of quality are rising.

Charged Up

China's NEV market may be the envy of the world. It is built on the foundations of a clearly articulated vision, extensive funding, and a whole range of additional policy tools to promote NEV producers and suppliers, individual and institutional consumers, and the underlying infrastructure. The number and quality of domestic NEV makers have risen quickly. Most of the world's major automakers have promised to expand the proportion of NEVs in their fleets available in China and have committed to develop electric versions of many of their models for the United States, Europe, and other markets. And China's battery makers are in the midst of catching up with their counterparts in Japan and South Korea and could become dominant international suppliers. In short, China's NEV market looks not only viable, but potentially pathbreaking, and not just for China, but should vehicle electrification spread across every continent, for the global auto sector as well.

But before we get ahead of ourselves, the sector's rapid growth is just one side of the story. There is another side that must be considered. The market dynamics of the sector, questions of technology sophistication and product quality, the extent to which it helps address pollution concerns, and the effect on foreign producers and the global market are all substantial problems that could challenge the long-term viability of China's approach. These issues are the topic of the next chapter.

cial Times, March 2017, <https://www.ft.com/content/8c94a2f6-fdcd-11e6-8d8e-a5e3738f9ae4>.

68. "Daimler to buy electric car battery cells from China's CATL," Reuters, May 2, 2018; Mo Yelin, "World's Biggest Electric-Car Battery Firm Stays Juiced," Caixin, June 12, 2018, <https://www.caixinglobal.com/2018-06-12/worlds-biggest-electric-car-battery-firm-stays-juiced-101269458.html>.

69. Scott Patterson and Russell Gold, "There's a Global Race to Control Batteries—and China Is Winning," *Wall Street Journal*, February 11, 2018, <https://www.wsj.com/articles/theres-a-global-race-to-control-batteriesand-china-is-winning-1518374815>; Ke Dawei, "Shares in Lithium Producer Sink 29% in Lackluster Debut," Caixin, October 12, 2018, <https://www.caixinglobal.com/2018-10-12/shares-in-lithium-producer-sink-29-in-lackluster-debut-101334395.html>.

70. Jeff Desjardins, "Battery Megafactory Forecast: 400% Increase in Capacity to 1 TWh by 2028," Visual Capitalist, October 19, 2018, <http://www.visualcapitalist.com/battery-megafactory-forecast-1-twh-capacity-2028/>.

4 | Problematic Turns

Introduction

Although China's NEV sector has grown by leaps and bounds and could potentially lead the world away from the internal combustion engine, the industry is also facing substantial difficulties that should temper the current wave of enthusiasm. This chapter explores four big challenges: the sector's troubling market dynamics, the sector's level of technological development and product quality, its effect on resources and pollution, and the tensions created with international suppliers and other governments.

A Shaky Market

China's NEV sector is huge and there is a great deal of commercial activity, but it is far from a well-developed and smoothly functioning market. As detailed in Chapter 3, government spending is equivalent to over 40 percent of total NEV sales, meaning the industry would not exist without such extensive state intervention. One could use an "infant industry" argument to justify this funding, but it is far from guaranteed that the NEV sector will graduate from such support and operate over an extended period following market principles.

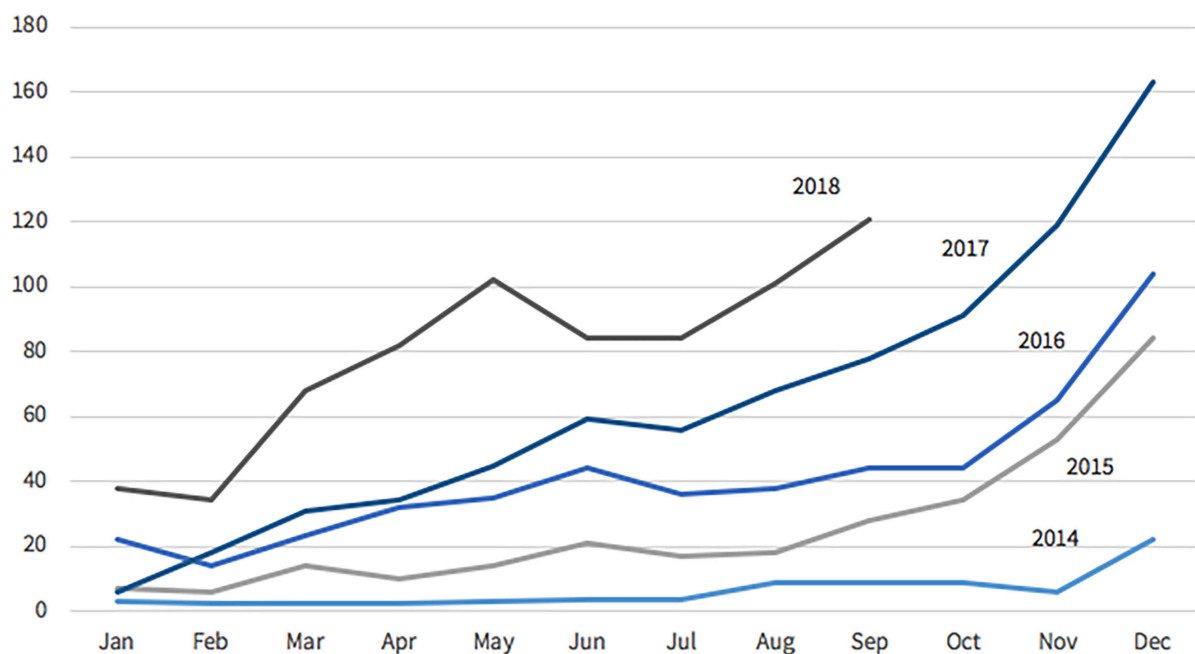
A core issue seems to be that policies meant to promote supply appear to be more effective than those designed to generate demand.

This is first visible in the size of the industry. Chinese officials can take pride in attracting lots of private and foreign investment, but the number of car makers is also a negative, as it clearly reflects an investment bubble. There are well over 100 domestic manufacturers and almost three dozen joint ventures with production under way or plans to start production very soon. Car companies may be drawn by the government funding, the new requirement to diversify one's auto fleet with an increasing proportion of NEVs (the dual-credit system), and self-confidence in their own products and hopes that they can outlast the competition. Regardless of their motivation, each week sees the emergence of new companies and new models. China's NEV sector is in what one analyst calls, "the Warring States Period," a reference to the era before China was unified and was beset by battles amongst smaller kingdoms. No matter how large the Chinese market grows, it is inconceivable that most of these companies could survive very long if market demand was the main determining factor of their fates.

At the same time, demand for NEVs is unlikely to keep pace. Sales growth has been strong, but that appears to be largely the result of subsidies for electric cars and restraints on allowing new license plates for traditional ICVs. Most sales of NEVs are still to government agencies and other public bodies, not individual consumers.

A clear sign that demand is abnormal is to recognize the very odd annual pattern of sales. As Figure 4-1 details, NEV sales spike at the end of every year. This is not because buyers are treating themselves to a holiday gift, but because government agencies do not set their vehicle procurement targets until late in the year. In addition, because subsidy rates typically change at the beginning of each year, December is the last month when buyers can obtain the higher rate.

Figure 4-1: The Annual Late-Year Bounce in NEV Sales (thousands)



Source: China Association of Automobile Manufacturers

In fact, several scandals involving subsidy fraud were reported in the media in 2015 and 2016. The cases triggered a Ministry of Finance investigation in which authorities found that some government agencies and state-owned enterprises used state funds to purchase NEVs to satisfy procurement requirements but did not actually put the cars on the road due to lack of interest. Hence, the government has issued a regulation stating that NEVs purchased by the government must be driven a minimum distance of 30,000 kilometers (18,641 miles) in order for the subsidy to be granted.⁷¹

71. "Notice on Adjusting the Fiscal Subsidy Policy on the Promotion and Application of New Energy Vehicles," Ministry of Finance, Ministry of Science and Technology, Ministry of Industry and Information Technology, and National Development and Reform Commission ("关于调整新能源汽车推广应用财政补贴政策的通知", 财政部、科技部、工业和信息化部、国家发展改革委), December 29, 2016, <http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757018/c5449722/content.html>.

It is far from clear that there is genuinely deep consumer demand for NEVs. A national survey of Chinese consumers by J.D. Power showed a strong general interest in NEVs, but a large percentage of those open to buying NEVs based their choice on subsidies and easier availability of license plates for NEVs. They also expressed concerns about the declining charging range, charging time, battery life, breakdowns, and difficulties with recycling. Hence, one J.D. Power executive interpreted the results rather starkly: “There is still a gap between such fervor and real demand, however. When governmental incentives gradually fade away, auto manufacturers need to be cautious and get prepared for the potential decrease of demand for NEVs.”⁷² No NEV in China ranks highly among consumers.⁷³

Interviews with Chinese in different parts of the country and abroad reinforce this impression. Chinese consumers still see buying NEVs as a distinctive ethical act in which they make some compromises in quality to their typical consumption behavior. They still view NEVs as of lower quality than traditional ICVs yet as more expensive, and they highlight concerns about charging as a reason to avoid NEVs. Taxi drivers told me that original driving ranges on their cars went down substantially over time as their batteries degrade, a problem that is magnified in colder climates.

The consequences for an imbalance in supply and demand are clear. Even if production costs continue to fall, if there is insufficient demand at high enough prices, the sector overall will not be profitable. And it would be hard to imagine any individual firm being able to be profitable in such an environment. Of course, this would not be a radical change from the NEV sector’s history, since the record is clear: No NEV maker has ever been profitable, not in China or anywhere else. Hence, the prospects for profitability in the short- to medium-term are not very high.

A related potential result of this forthcoming disjuncture in supply and demand is a repeat of what has been witnessed in other sectors driven by government support—overcapacity. This story has been replayed before numerous times—in solar, steel, aluminum, glass, and cement—and the dynamics in NEVs seem eerily similar. Even domestic Chinese voices typically supportive of government intervention have raised this concern, suggesting that caps on production may be needed.⁷⁴ But all that does is temporarily limit supply without addressing the fundamental incentives motivating producers and keeps the better companies from being able to achieve economies of scale. In order to outlive their competitors, companies will be driven, first, to seek more government funding, and second, to cut their prices. Such a price war in an overcrowded market could lead to a huge drop in income and induce a wave of rescues by local governments and other investors to avoid failures.

Who in China is best positioned to survive a price war and pressures for consolidation? Companies that have garnered industry respect, such as Geely and BJEV, may prosper long term, but it is difficult to say because so much depends on an unpredictable mix of

72. “Consumers in China Increasingly Enthusiastic about New-Energy Vehicles and Eager for Battery Technology Advancement, J.D. Power Survey Finds,” February 26, 2018, http://mexico.jdpower.com/sites/default/files/2018048_china_nev_survey_.pdf.

73. “Despite Booming Sales, SUVs Are Losing Appeal in China, J.D. Power Finds,” J.D. Power, November 1, 2017, https://www.jdpower.com/sites/default/files/china_appeal_2017196_v2.pdf.

74. Zhang Hongpei, “Chinese developers rush into rising NEV sector, but risk overcapacity and lack of talent,” *Global Times*, August 20, 2018, <http://www.globaltimes.cn/content/1116226.shtml>.

trends in supply and demand and the ability of individual companies to execute their manufacturing plans and business models. Among the newest generation of NEV makers that hail from the internet sector, many point to NIO as the most likely to endure. It is on track in 2018 to produce 10,000 vehicles through its partnership with JAC. Yet analyst reviews are mixed.⁷⁵ Interview sources raised questions about the quality of the cars and the battery replacement model, which requires NIO to spend a great deal on battery stock, charging equipment, and services. Emblematic of these challenges is the recent comical case in which in order for a NIO SUV owner to drive outside Shanghai during the Mid-Autumn Festival holiday, NIO sent along three gas-powered charging trucks with four employees to accompany the NEV on its journey.⁷⁶ It's conceivable NIO will benefit from high-density ownership in big cities and turn this into a major profit source, but this model has never been successfully applied elsewhere.

Quality and Infrastructure: Still a Ways to Travel

Although there has been substantial improvement in the quality of NEV models and the infrastructure has grown, challenges persist. The mixed impressions of consumers may be based partly on outdated information, but there is some truth to their concerns. Despite filing thousands of patents, Chinese NEV makers do not have a lot to show for these efforts in the way of genuine innovations. Independent analysts reported to me that NEV car quality is still generally below that of ICVs, including the exterior modeling, interior design, and performance. There has been an upgrade in the chemistry of car batteries, but they are still in general heavier than those of the world's leading producers, and some have raised questions about consistency of performance and their degradation rate. Claims of ranges of 400-500 kilometers (250-310 miles) are not typically reflected in practice.

The charging infrastructure is growing but is still limited and regionally unbalanced. Even with substantial and sustained investment, it will take a long time to expand charging in residences, public spaces, and roadways. In addition, it still takes much longer to charge an NEV than it does to fill up with a tank of gas, not just in China but everywhere. Rapid-charging infrastructure is still a small proportion of what is being installed. The longer there is insufficient charging, the more difficult it will be to change perceptions amongst potential consumers.

Resources and Pollution

One of the most important selling points of the NEV sector is its promise to improve the environment and reduce pollution in comparison to ICVs. There is certainly this potential, but it is not guaranteed because an NEV over the course of its life does draw on substantial resources from nature and requires a great deal of energy. China's NEVs are far from carbon-neutral and affect the environment and climate in China and elsewhere.

75. Yang Ge, "China's Tesla Rival Steps on Accelerator," Caixin, October 16, 2018, <https://www.caixinglobal.com/2018-10-16/chinas-tesla-rival-steps-on-accelerator-101335574.html>; Catherine Larkin, "China's Tesla Wannabe NIO Gets Mixed Early Reviews From Analysts," Bloomberg, October 8, 2018, <https://www.bloomberg.com/news/articles/2018-10-08/china-s-tesla-wannabe-nio-gets-mixed-early-reviews-from-analysts>.

76. Liangziwei, "Modern Version of Horse Drawing Trains! NIO Deployed Gasoline Trucks to Deliver Charging Vehicles," (量子位, "现代版马拉火车!蔚来出动燃油板车运送充电车服务,"), September 29, 2018, https://mp.weixin.qq.com/s/W7QblCyN_yDPdDJjaUPqpQ.

In production, the biggest environmental downside of electric vehicles are the materials that make up the battery, including lithium, nickel, manganese, and cobalt. Demand for lithium has skyrocketed and shows no sign of abating, which explains growing Chinese investment in mines around the world.⁷⁷ The most problematic of the materials from a resource depletion and environmental perspective is cobalt. Over 60 percent of the world's raw cobalt ore comes from a single country, the Democratic Republic of Congo (DRC). Not surprisingly, dozens of Chinese companies have invested in DRC mines. One such firm, China Molybdenum Co., Ltd., controls 12 percent of the world's cobalt supply. Chinese investors have faced accusations of using child labor and engaging in corruption.⁷⁸ And because of growing Chinese demand, the price of cobalt quadrupled in two years, from just over \$10 per pound in May 2016 to almost \$43 per pound in July 2018, before settling to \$26 per pound in October 2018.⁷⁹ There is a significant chance that the situation with cobalt could repeat the story with rare earth metals, which are mined almost entirely in China.⁸⁰ To address the concerns in the cobalt supply chain, the Chinese have set up an industry body, the "Responsible Cobalt Initiative," but these challenges are far from solved.⁸¹ These issues will only become more acute if estimates of a tenfold increase in battery production levels over the next decade are realized.

The next big environmental challenge for NEVs relates to the energy that powers them. Although NEVs do not have gas tanks, the batteries must be charged using electricity, and in China the great majority of electricity comes from thermal power plants that run on coal and other fossil fuels. The proportion of electricity coming from coal alone has dropped somewhat, from 76.8 percent in 2010 to 64.5 percent in 2017, but 71.7 percent of electricity still comes from fossil fuels.⁸² One interview source estimated that coal would need to fall below the 50 percent threshold for NEVs to reduce overall pollution emissions. On top of this, if China moves toward high-speed charging for NEVs, that will put greater demands on the electricity grid. This is why some analysts refer to NEVs not as electric cars but as "coal cars."⁸³ If the original energy source of NEVs does not change, then NEVs

77. Henry Sanderson, "China's largest lithium producer set for HK IPO to fund SQM purchase," *Financial Times*, August 20, 2018, <https://www.ft.com/content/82f1e200-a483-11e8-926a-7342fe5e173f>.

78. Luo Guoing, Li Liuxi, and Mo Yelin, "Electric-Vehicle Craze Drives Rush for Congo Cobalt," *Caixin*, August 6, 2018, <https://www.caixinglobal.com/2018-08-06/electric-vehicle-craze-drives-rush-for-congo-cobalt-101312238.html>.

79. Data from "Infomine," <http://www.infomine.com/investment/metal-prices/cobalt/5-year/>.

80. Rare earth mining has resulted in substantial environmental degradation in parts of China, and the world is heavily dependent on China for these materials, which go into a wide variety of commercial and military technologies. Scott Kennedy, "Rare Earths: Rocky Road for China Inc(herent)," *GaveKal Dragonomics*, January 12, 2012; and "The Californian Rare Earths Mine Caught Between Trump and China," *Bloomberg*, September 26, 2018, <https://www.bloomberg.com/news/articles/2018-09-27/the-californian-rare-earths-mine-caught-between-trump-and-china>.

81. "Daimler to buy electric car battery cells from China's CATL," *Reuters*, May 2, 2018, <https://af.reuters.com/article/africaTech/idAFL8N1S959Q>.

82. "National Electrical Industry Statistical Bulletin 2010," China Electricity Council ("全国电力工业统计快报, 中国电力企业联合会."), February 23, 2011, <http://www.cec.org.cn/nengyuanyudianlitongji/hangyetongji/dianlingyeshuju/2011-02-23/44236.html>; "Generation of Electricity Increases Steadily, Structural Adjustment of Sources Improves," National Bureau of Statistics ("电力生产稳步增长, 电源结构调整优化," 国家统计局.), March 19, 2018, http://www.stats.gov.cn/tjsj/zxfb/201803/t20180319_1588744.html; "CEC Releases 'Yearly Analysis and Forecast of National Supply and Demand of Electricity 2017-2018,'" China Electricity Council ("中电联发布<2017-2018年度全国电力供需形势分析预测报告," 中国电力企业联合会), February 1, 2018, <http://www.cec.org.cn/guihuayutongji/gongzuodongtai/2018-02-01/177584.html>; and "Generation of Electricity Increases Steadily, Structural Adjustment of Sources Improves," National Bureau of Statistics ("电力生产稳步增长, 电源结构调整优化," 国家统计局.), March 19, 2018, http://www.stats.gov.cn/tjsj/zxfb/201803/t20180319_1588744.html.

83. One industry analyst prior to becoming an MIIT official questioned the ability of NEVs to reduce pollution.

may not reduce air pollution but simply shift it from coastal China to the interior where coal is burned.

A final unaddressed problem from NEVs is battery recycling. Batteries degrade and provide a shorter range over time, raising the likelihood that batteries will not have the same lifespan as the rest of the car. Millions of NEVs are being accompanied by an even larger number of batteries that contain toxic materials. China has started a pilot recycling plan in several cities, but it will require massive expansion and innovation to reduce the potential negative externalities that could emerge from used batteries.⁸⁴

Multinationals, Market Access, and the Global Market

The final problem for the sector is how Chinese industrial policy discriminates against foreign producers of NEVs and other elements of the supply chain. This results in reduced market access, lower quality of technology and products on the market, and possibly strains on the global market. Together they portend greater diplomatic tensions between China and others.

China's auto sector has long had substantial barriers, with high tariffs and the joint venture requirement for manufacturers. This framework continued into the NEV era but has been modified.⁸⁵ Most important has been the dual-credit system, which encourages producers to have a certain proportion of their fleets be NEVs. Many foreign makers have started to produce NEVs in existing joint ventures or created new companies with local partners to do so. These regulations are quite constraining, and some MNCs would prefer to take a more gradual approach to NEVs than the Chinese government is requiring because they are not as certain about future demand. They also are highly concerned about requirements to share technology and build potential future competitors. That said, there is also some bewilderment about continuing this policy approach given that the joint venture approach primarily resulted in greater dependency by domestic producers on their foreign partners, not independent innovation.

Moreover, there is still a significant amount of policy ambiguity looking forward. First is the dual-credit system. Producers are not certain that the specific targets set for 2019 and 2020 will remain in place or be changed depending on actual circumstances. Moreover, it is even more unclear if the process will operate as a true credit market, where firms with an abundance of NEVs can sell credits to those facing a shortage, and if so, how the price of credits will be set. One can imagine a situation in which there is massive overcapacity created by a rush into NEVs; in such a situation, if the credit system operated like a true market, those who avoided following the pack should be able to acquire credits at minimal cost. But it is possible Chinese authorities could be using the system as more of a mandate and treat the credit process more like a regulatory penalty than a market exchange.

He said that they were more polluting than traditional cars because the underlying energy came from coal. Neil Gough, "Mainland Green Car Scheme Still on Track Despite Talk of Infighting," *South China Morning Post*, September 9, 2011.

84. Jason Tan, "Pilot Plan to Charge Up Electric Battery Recycling," *Caixin*, July 26, 2018, <https://www.caixinglobal.com/2018-07-26/pilot-plan-to-charge-up-electric-vehicle-battery-recycling-101308861.html>.

85. For a summary of U.S. government concerns, see: United States Trade Representative, *2017 Report to Congress On China's WTO Compliance* (Washington, DC: January 2018), p. 88-90.

There is also insufficient clarity about the joint venture mandate. In late 2017, China began to publicly issue musings about ending the joint venture requirement, clearly with an eye toward attracting Tesla to build domestic production.⁸⁶ And in the Spring 2018, the Chinese government announced that it would phase out the joint venture requirement over four years, beginning with first allowing independent foreign NEV makers by the end of 2018.⁸⁷ This change, though, may only be relevant for producers who have yet to establish local partnerships, because even if joint ventures are not officially required, it is not easy to escape from an existing one. In addition, there is still a gap between being allowed to register a company and being approved to manufacture specific models or build domestic distribution and service networks.

All of this ambiguity is making it more difficult for foreign automakers to make plans, not just for China, but for their global operations. But foreign industry puts up with these challenges because of how big China is. As one industry insider told me, “To stay in the market, you have to join in the game even though you know the game isn’t fair.”

Although foreign automakers have to maneuver a challenging environment, the obstacles for foreign battery makers have been even higher, as China has essentially banned foreign producers from being able to sell in China. The key tools were the original white list of approved makers and then the informal ban on South Korean producers as punishment for South Korea’s cooperation with the United States on missile defense. Nissan’s AESC had their batteries make it on to the white list in June 2017, but in August 2018, AESC announced it was being acquired by a Chinese investment firm, GSR Capital.⁸⁸ LG Chem found a modest way around the blockade by licensing its technologies to Geely, who then produces the batteries for its own NEVs.⁸⁹ One may expect that the door to foreign producers will gradually open, but only as CATL, BYD, and other domestic producers gain greater competitiveness at home and abroad.

Perhaps the biggest challenges as a result of China’s strategy will not occur in China but in other markets. If supply outpaces demand, as we expect, domestic producers will be left with substantial inventories. The natural solution would be to ramp up exports, most likely at cut-rate prices, perhaps first among China’s neighbors and to developing countries, but perhaps eventually to advanced industrialized economies. Although the world’s auto market does not have the exact dynamics of commodities such as steel and solar panels, a rush of Chinese exports could create challenges not only for individual competitors abroad but also put pressure on the entire auto industries of other countries and the global supply chain. Hence, worries about market access in China would be dwarfed by diplomatic discord over the auto industry’s future.

86. “China Will Consider Resumption of New Electric Car Permits,” Bloomberg News, November 14, 2017, <https://www.bloomberg.com/news/articles/2017-11-14/china-is-said-to-consider-resumption-of-new-electric-car-permits-j9z5kq65>.

87. Trefor Moss and Mike Colias, “China to Ease Rules on Foreign Auto Makers,” *Wall Street Journal*, April 17, 2018, <https://www.wsj.com/articles/china-to-ease-rules-on-foreign-auto-makers-1523963345>.

88. Technically speaking, the foreign battery makers have only been indirectly targeted. The rules have stated that NEVs with unapproved batteries have not been eligible for subsidies. Zhi Dongxi, “A ‘Three-Power Fight’ in Car Batteries, Who Expelled the Koreans?” Sina.com, (“汽车动力电池‘三国杀’，是谁赶走了韩国人？” 智东西), November 16, 2017, <http://tech.sina.com.cn/cs/2017-11-16/doc-ifynwnty3356260.shtml>.

89. Trefor Moss, “Power Play: How China-Owned Volvo Avoids Beijing’s Battery Rules,” *Wall Street Journal*, May 17, 2018, <https://www.wsj.com/articles/power-play-how-china-owned-volvo-avoids-beijings-battery-rules-1526551937>.

5 | Wild Cards Down the Road

Introduction

This drive across China's electric car landscape reveals a complex picture. China has the world's largest and fastest growing NEV industry, but rapid expansion should not necessarily be applauded. The industry also faces a range of substantial technical, commercial, and diplomatic challenges. The industry's future trajectory will turn heavily on how several factors play out in the coming years, both in China and elsewhere. This chapter focuses on the four most important "wild cards" that could make or break China's NEV sector.

China's NEV Policies

The most obvious variable that could affect the direction of the industry is government policy. Several stand out as particularly crucial.

Subsidies. Official policy is to cut subsidies that incentivize buyers by 20 percent in 2018 and fully phase them out by 2020.⁹⁰ And, in fact, subsidies have started to level off while sales have continued to grow.⁹¹ But there are no guarantees that sales will continue to expand. Instead, NEVs could soon suffer the same fate of the broader auto industry, where overall sales are down substantially. Even if the sticker price of NEVs is able to be reduced because of declining battery costs, if sales falter at all, the government will be forced to reconsider re-raising subsidies.

Tariffs. China announced in mid-2018 that it would reduce auto tariffs from 25 percent to 15 percent. The new level is still a significant barrier to imports, and one can expect foreign governments to push China to reduce these tariffs even further.⁹²

Joint Ventures. In addition to lowering tariffs, China has also announced that the joint venture requirement for autos will be lifted gradually, first with NEVs by the end of

90. Xiao Ying and Liu Xiao, "China to Intensify Clawback of Electric Vehicle Incentives," Caixin, January 19, 2018, <https://www.caixinglobal.com/2018-01-19/china-to-intensify-clawback-of-electric-vehicle-incentives-101200245.html>.

91. Mo Yelin, "New-Energy Car Sales Double Despite Subsidy Slowdown," Caixin, July 12, 2018, <https://www.caixinglobal.com/2018-07-12/new-energy-car-sales-double-despite-subsidy-slowdown-101301217.html>.

92. Robert Ferris, "China Lowering Auto Tariffs Is No 'Breakthrough' in Tense Trade Talks with US," CNBC, May 22, 2018, <https://www.cnbc.com/2018/05/22/china-lowering-auto-tariffs-is-no-breakthrough-in-trade-talks.html>.

2018, for commercial vehicles in 2019, and for the entire sector by the end of 2022.⁹³ But eliminating the regulatory requirement will not necessarily translate into commercial practice. Not surprisingly, the first company to take advantage of this change, Tesla, does not yet have a factory or joint venture in China.⁹⁴ On the one hand, dissolving a joint venture or changing its terms could be quite expensive for the foreign partners, and that price may be too high for them to pay. It is still illegal for the foreign party in an existing joint venture to split and create a new company that produces traditional-engine cars, lowering the commercial benefits of a split. On the other hand, should MNCs part company from their local partners, the Chinese partners would stand to lose both the cachet of the foreign brand and the learning opportunities that come from the technological and market sophistication of their MNC partners. While Chinese companies would be forced to up their game, the Chinese government could come forth with a range of alternative protectionist measures related to emissions, safety inspections, distribution, and competition policy aimed at responding to the new competitive environment. This would provide some protection in the short term but would also exacerbate diplomatic tensions with the United States, Japan, South Korea, and the European Union.

The Dual-Credit System. As noted in Chapter 4, ambiguity over the dual-credit system is making it difficult for foreign companies to plan their investments. The same is true for domestic firms as well. A mandate that one must meet would be far different than being permitted to buy credits from those who over-produced. This begs the question of how quickly China wants to transition toward NEVs and whether it is willing to use market incentives to shape manufacturer behavior as opposed to government fiat.

An All-NEV Commitment? In September 2017, Chinese officials said they were investigating the possibility of setting an all-NEV goal as some countries in Europe have done. More senior officials walked back those ideas in January 2018, saying that ICVs would have a long future in China. But should Chinese NEV and battery makers continue to make progress with their technology and market share, one could see Chinese policy pivot in a more committed direction. If so, this would increase the pressure on all producers, domestic and foreign, to transition their broader fleets toward an electrified future.

Overcapacity and Consolidation. NEVs have yet to be proven profitable anywhere. It is conceivable things could change in China given the size of the market. But with so many NEV manufacturers, even if China reaches its stated goal of having 2 million NEVs sold in 2020, with further increases afterward, there most likely will not be enough sales to go around. It is almost guaranteed that a large swath of current producers will not be able to make ends meet. The initial question is how the Chinese government will manage the short-term challenge of overcapacity. The NDRC has drafted plans for capping production

93. Until 2022, MNCs will only be able to buy out the partners from their existing joint ventures and will not be able to create new factories that produce ICVs. Norihiko Shirouzu and Adam Jourdan, "China to Open Auto Market as Trade Tensions Simmer," Reuters, April 17, 2019, <https://www.reuters.com/article/us-china-autos-regulation/china-to-open-auto-market-as-trade-tensions-simmer-idUSKBN1H00YA>; Zheng Lichun et al., "Chinese Automakers Drive Into New Landscape," Caixin, June 10, 2018, <https://www.caixinglobal.com/2018-06-11/chinese-automakers-drive-into-new-landscape-101274199.html>.

94. In 2017, Tesla exported 17,000 cars to China. Daniel Ren, "Tesla Sets Up 100m Yuan R&D Subsidiary in Shanghai," *South China Morning Post*, May 15, 2018; Zheng Lichun and Mo Yelin, "Update: Tesla Gets Green Light for Shanghai Factory," Caixin, May 25, 2018, <https://www.caixinglobal.com/2018-05-25/quick-take-tesla-wins-approval-for-shanghai-factory-101256480.html>.

of both traditional cars and NEVs, but that is a very blunt and indiscriminate instrument that could hamper all producers.⁹⁵

The larger, long-term issue is how the Chinese government will address the industry's structure. Will the Chinese government allow local governments and other investors to prop up struggling producers, as it did in the solar industry, permitting overcapacity to grow unchecked, or will it force carmakers to face a different choice: go under or be absorbed by a more successful producer? And if Beijing pursues consolidation, will it allow this process to unfold organically or itself play matchmaker? Authorities have driven mergers and corporate restructuring in sectors dominated by SOEs, such as in telecom, rail, and energy.⁹⁶ Despite the broader auto sector and NEVs in particular being populated by a higher proportion of private companies, observers should not assume the state will take a wait-and-see approach.

Quality, Performance, and Cost

Even if policy is arranged to support the healthy development of NEVs, whether the industry successfully develops will be determined primarily by whether automakers can make higher-quality cars that consumers want and can afford. To date, NEVs are a niche product, even in China, and much has to change for them to become attractive to a mass market.

The design elements of NEVs are certainly improving, and there is no reason why their exterior, interior, entertainment systems, handling, and safety shouldn't continue to improve in the coming years. The big question concerns their energy source—the batteries and charging infrastructure. Trying to extend the range for batteries is akin to trying to fit more transistors on microchips, and just as Moore's Law has begun to show its fallibility, improvements with lithium-ion batteries have their limitations. They are becoming cheaper to produce at scale; in less than a decade NEVs may be cost-competitive with traditional cars even without subsidies.⁹⁷ But it is an open question to what extent their range, reliability, and safety can be further improved.

And should the scientific breakthroughs with batteries continue, success or failure for individual companies will come down to execution ability. Given the large number of players, picking winners and losers may depend less on technological sophistication than on management skills, manufacturing quality, commercial strategy, and post-sales service. And every NEV player in China will depend on the emergence of a ubiquitous charging infrastructure that erases all doubts about possibly being stranded or having to pause a trip for an extended period while charging up. Should those concerns about quality and infrastructure be addressed, NEVs may cease to be a novelty purchase and become more mainstream.

95. "China Aims to Slam Breaks on Car Capacity," *Global Times*, September 13, 2018, <http://www.globaltimes.cn/content/1119491.shtml>.

96. Norihiko Shirouzu and Yilei Sun, "Automakers Fret as China Clamps Down on Capacity, Seeks Consolidation," *Reuters*, September 4, 2018, <https://www.reuters.com/article/us-china-autos-investment-analysis/automakers-fret-as-china-clamps-down-on-capacity-seeks-consolidation-idUSKCN1LK0GZ>.

97. "Electric Vehicle Outlook 2018," *Bloomberg New Energy Finance*, June 2018, <https://about.bnef.com/electric-vehicle-outlook/>.

Alternatives to Lithium

China may improve its battery technology and charging infrastructure and find a way to manage the supply chain and recycling, but there is a broader question mark about trends in energy creation and storage technology. Lithium-ion batteries create less pollution than internal combustion engines, but they clearly have some downsides. There are other technologies that may be as good or even better for energy creation and storage, including flow batteries, liquid metal batteries, biofuels, and hydrogen fuel cells. Japanese, South Korean, and German automakers are taking a highly eclectic approach toward new-generation autos, investing heavily in many technologies, including hybrids, batteries, and fuel cells, the last of which promises ranges of 700-1,000 kilometers (435-620 miles).⁹⁸ And some are still expending substantial resources on making the internal combustion engine more fuel efficient.

Although there are some Chinese universities and research organizations doing R&D on hydrogen fuel cells, in part funded by the central government, fuel cells have received nowhere near the support lithium-ion batteries have. China is in essence pinning all of its hopes on one technology. Should other approaches end up being substantially superior in quality and cost, it is possible that China will be locked into an inferior pathway.⁹⁹ Such an outcome would make today's forward-looking approach look obsolete within a decade or two.

The Mobility Model

China's interest in promoting NEVs has been driven by a desire to reduce air pollution and dependence on imported oil but also by a desire to overcome the dependence on foreign companies who dominate the technology surrounding the internal combustion engine. Moving to NEVs portends a future where China could leapfrog its competitors into an era of greater independence and dominance. Whereas alternative energy storage technologies could imperil China's drive into battery-powered electric vehicles, there are other disruptive technologies and business models that could substantially strengthen its prospects. In particular, the development and adoption of autonomously-driven vehicles managed by ridesharing organizations would create the greatest opportunity for NEVs to expand quickly. In such a situation, cars would mainly be owned and managed as large fleets, and many would follow pre-assigned routine driving routes. Charging could be managed at a fleet-wide level and spread out across the day to stabilize demand from the electric grid.

The world and China are certainly taking significant strides in this direction, with rideshare expanding quickly everywhere and extensive efforts being made on autonomy. But it is still not clear whether the current personal ownership model dominant across the world will be replaced by a full-scale mobility model in the coming years, and if so, when these changes would occur in China.

98. Naomi Tajitsu and Maki Shiraki, "Toyota plans to expand production, shrink cost of hydrogen fuel cell vehicles," Reuters, July 26, 2018, <https://uk.reuters.com/article/us-toyota-hydrogen/toyota-plans-to-expand-production-shrink-cost-of-hydrogen-fuel-cell-vehicles-idUKKBN1KG0Y0>.

99. Varun Sivaram, *Taming the Sun: Innovations to Harness Solar Energy and Power the Planet* (Cambridge, MA: MIT Press, 2018), p. 221-239.

Beyond the Middle Kingdom, ridesharing firms such as Uber, Lyft, Grab, and Ola have grown by leaps and bounds, expanding ridership at geometric rates. At the same time, a whole phalanx of companies and organizations from many sectors have invested individually and in coalitions to develop autonomous driving technologies. Although there are five levels of autonomy, the critical distinction is between driver-assisted autonomy (levels 1 & 2) and driver-replacement (levels 3, 4, and 5).¹⁰⁰ There is already substantial deployment of vehicles with driver-assistance technologies and extensive road testing of more advanced autonomy systems. Alphabet's Waymo, which was launched in 2009, has logged more miles than anyone else, and its technology is likely to be central in any rollout in the United States.

That said, even as technological barriers are being overcome, a ridesharing, autonomous-car future in the West is far from guaranteed. Ridesharing has mainly taken away business from taxi and car rental companies, but sales of privately owned cars continue to grow in many markets, perhaps because of the unique benefits one receives from a private car as opposed to a shared one.¹⁰¹ Moreover, growth in rideshare has fallen as price discounts and other benefits have been withdrawn, which raises doubts about whether rideshare firms can move toward sustained profitability over the long term. Autonomous driving technology has progressed substantially, but it's still not clear when driver-replacement technology will be ready for widespread deployment. On top of that, there will need to be substantial regulatory changes at the national and local level and changes in the insurance industry. My expectation is that in the United States and other advanced industrialized economies, ridesharing will likely continue to supplement private car ownership and that advanced autonomous driving systems are still at least 5-10 years away from widespread commercial deployment.

In China, there are huge incentives pushing toward a full-scale mobility model that integrates ridesharing with electric autonomous-driving vehicles. China is likely to be an earlier implementer of 5th-generation (5G) telecommunications technologies, and autonomous driving may be one of the best applications to benefit from having the much greater bandwidth for rapid machine-to-machine communications that 5G facilitates. Rollout of the technology would spur massive investment that could benefit a long list of companies across the supply chain and around the country. Moreover, autonomous driving could help reduce the high number of traffic-related deaths, injuries, and property damage that beset China's roads.¹⁰² To this end, Baidu has followed in Waymo's footsteps

100. Isabel Harner, "The 5 Autonomous Driving Levels Explained," IoT For All, November 6, 2017, <https://medium.com/iotforall/the-5-autonomous-driving-levels-explained-b92a5e834928>.

101. Wolf Richter, "Uber and Lyft Are Gaining Even More Market Share Over Taxis and Rentals," Business Insider, July 30, 2018, <https://www.businessinsider.com/uber-lyft-are-gaining-even-more-market-share-over-taxis-and-rentals-2018-7>. Such benefits include indefinite storage of one's possessions, travel without strangers or knowledge by outsiders, easier change of destination while in transit without permission or notification of others, and sentimental attachment.

102. The World Health Organization estimates 260,000 deaths in road accidents each year in China. This is far higher than the Ministry of Public Security's reported figure of just over 60,000 in 2016. The ministry only reports fatalities that occur within seven days of an accident, whereas the WHO data is based on reports from Chinese health authorities. Choi Chi-yuk, "Traffic's Toll: Road Accidents Kill 700 People a Day in China," *South China Morning Post*, May 24, 2016, <https://www.scmp.com/news/china/society/article/1952218/traffic-toll-road-accidents-kill-700-people-day-china>; *China Statistical Yearbook 2017* (Beijing: China Statistics Press), p. 777; and Cheyuzhe, "In 2017, How Many People Died in Road Traffic Accidents in China?" (车语者, "2017年, 中国道路交通事故死亡人数到底是多少?"), February 25, 2018, <https://xw.qq.com/cmsid/20180225A08U0H00>.

by organizing the Apollo project to develop an integrated solution for the different layers of the system: the vehicles themselves, the system hardware (such as LiDAR and RADAR), a virtual driving system, and the cloud-based network to store and move data. A wide range of other high-tech companies are involved in the effort, and testing is underway in different parts of China and abroad. It is for these reasons that one seasoned observer told me, “China is driving an automobility revolution.”

Despite China’s efforts and such optimism, there still appears to be a long distance between the ambition and the autonomous future some envision for China. Waymo had a huge head start over Baidu, and that gap has grown. Waymo has logged over 5 million miles on public roads. China only legalized open road testing in December 2017, pushing Chinese to test in the United States. But between August 2016 and November 2017, Waymo vehicles logged over 350,000 miles in California, while those from Baidu traveled only 1,900 miles. During that time, Baidu vehicles were 145 times more likely to require manual intervention by the driver to avoid collisions.¹⁰³ Even if China makes progress on the core technology, adapting the technology to real-world conditions on China’s congested and chaotic roads, where the movements of drivers and pedestrians are hard to predict, presents a monumental challenge. China has also said it will develop domestically created standards and use its own BeiDou GNSS system instead of the global leader GPS. In addition, foreign vendors will face limited opportunities in many parts of the supply chain for both industrial policy and national security reasons, which will not only raise commercial tensions but also slow down China’s ability to rollout an effective system that consumers and authorities all trust. Finally, the regulatory hurdles are equally daunting because of the competing agendas of so many national and local bureaucracies, among them those championing the auto sector, information and communications technologies, cybersecurity, and public safety. There may be no greater political challenge in China than coordinating amongst this thicket of actors and interests.

An Uncertain Future

In sum, a range of futures is imaginable. At one end, it is possible that there will be some sort of industry consolidation that will eliminate less competitive producers, that NEVs will continue to improve in quality and become less expensive, that lithium-ion batteries will dominate the energy storage sector for the foreseeable future, and that the mobility model will come to China sooner rather than later. The result would be unbridled success for the NEV sector up and down the supply chain. At the other end, it is possible consolidation will be less than sweeping, that car quality and price will continue to lag, that lithium-ion batteries will be overtaken sooner than expected by alternative energy sources, and that autonomous driving will arrive later in China than elsewhere because of technological and political reasons. Although there are good rationales for either the most optimistic or most pessimistic scenario, the actual outcome is likely to be somewhere in the messy middle.

103. Frank Hersey, “Baidu’s Autonomous Cars Have to Be Taken Over by Humans Every 41 Miles,” Technode, May 2, 2018, <https://technode.com/2018/05/02/baidus-autonomous-cars-disengage/>.

6 | Flashing Lights: Implications for the United States

Introduction

By any measure China is winning the race to develop its NEV sector. China has more NEV makers and electric cars and buses on the road than anyone else in the world. Its leading battery makers not only dominate at home but are poised to expand exports dramatically. The mobility revolution built on electrically-powered, autonomously-driven ridesharing fleets may provide another new turbo boost to propel the industry to new heights. But such a future is far from guaranteed. As this report details, China's NEV industry faces a variety of substantial challenges—among them likely overcapacity, uneven quality, and insufficient charging infrastructure—that portend low prospects for profitability in the near-to-medium term. Moreover, the gains achieved so far have rested heavily on massive government spending, equivalent to over 40 percent of the sector's commercial activity. And policies for fleet requirements, joint ventures, and batteries have created substantial diplomatic tensions.

It is worth asking whether the gains to date and the future prospects are worth all of these costs. In a decade observers may look back and credit China's automakers, battery producers, investment community, and industry regulators as visionaries. But a decade hence, should demand for pure-electric NEVs stall, everyone in China will share in the blame for putting all of their eggs in this one basket.

Given this context, observers who are envious of China's approach should withhold their applause for the moment. The United States federal and state governments as well as industry stakeholders should heed both the positive lessons and negative warnings that the Chinese experience provides. In addition, because of China's size, the United States is directly affected by the PRC's strategy and must respond on behalf of its industry and consumers.

Policy Recommendations

Most importantly, it would be a mistake to assume that just because China has a larger NEV sector, it is somehow leading a "race" that the United States must join in order to catch up or win. But whether the United States moves squarely toward pure-electric NEVs or in some other direction should only be marginally affected by China's choices.

Second, it still makes little sense to mandate a single technology that may not attract sufficient demand or be made obsolete by other technologies in the near future. Unless the relative benefits of one kind of energy creation and storage technology become overwhelming, the United States should promote technology diversity and competition amongst the various options, from lithium-ion to fuel cells to biofuels.

Third, promoting technology development will not result in technology deployment on a wide scale without additional incentives to generate both sustained supply and demand.¹⁰⁴ The United States should continue to examine the effectiveness of policies adopted in China, Europe, and Japan, including higher fuel-economy and emissions standards, rationing license plates for ICVs, and expanded tax incentives for NEV purchases. In addition, should rechargeable battery technology be determined as the best way to proceed, steps need to be taken to make charging more widely accessible and faster. Several states have already experimented with some of these policies, but there could be a larger role for the federal government, not just as a regulator but as a coordinator of strategies involving auto companies, info tech and telecom firms, battery makers, public utilities, the investment community, and consumer groups.

The same kind of flexible support should also be available for autonomous vehicles, a technology in which the United States is clearly a pathbreaker. As it matures in a safe direction, the United States can consider more fully how to combine the potential benefits of new energy, ridesharing (particularly in urban areas), and autonomous driving. But just as with the energy component, the federal government needs to take care not to overly intervene in the market and mandate autonomous driving if a societal consensus has yet to emerge.

Finally, although the U.S. focus should first and foremost be on its transportation sector, this study has implications for American China policy. Given the size and significance of the Chinese market, the United States must hold China accountable to its existing commitments and promote greater commercial opportunities for U.S. companies in their market. Ideally, China should be persuaded to take a more market-friendly approach toward the sector.¹⁰⁵ Key steps in this direction would include implementing its pledge to allow wholly-foreign owned enterprises to manufacture cars in China, further lowering its tariffs for imported cars, and opening its battery market to foreign producers regardless of whether they have invested in China. If China goes forward with its dual-credit system to promote production of more NEVs, it is imperative that the system operate as a true credit market in which those who choose to produce fewer NEVs can purchase credits at a market-based rate and not be unduly penalized for treating the system as a market, not a mandate. Finally, should overcapacity emerge and China begin to export its NEVs in substantial numbers at unfairly low prices, the United States and China's other trading partners should utilize their respective fair-trade rules to file antidumping or countervailing duty cases at the national level or lodge a case with the WTO. The health of the global auto industry is too important to allow it to be threatened by China's own potential market distortions.

104. Carol D. Leonnig and Joe Stephens, "For Obama's Green-Car Revolution, Fits and Starts," *Washington Post*, December 7, 2011.

105. For a detailed list of suggestions from the American business community, see *AmCham China White Paper: 2018 American Business in China* (Beijing: American Chamber of Commerce in China, 2018), pp. 162-170.

These policy guidelines do not guarantee that the United States will win in a race to develop the next generation of automobiles, but they reduce the likelihood of costly policy mistakes in the United States and increase the chances that China's drive into new-energy vehicles will be somewhat less risky and instead follow a more market-oriented direction that benefits industry and consumers, within China and beyond.

Appendix

This appendix aims to explain how we calculated our estimates for various components of government spending and total value of China's NEV market.

The Chinese government has never provided a reliable comprehensive summary of its financing for the industry, but it has offered a variety of data on the various elements of support that can be used to construct reasonably reliable estimates.

The Ministry of Finance and MIIT have reported data on central government subsidies for buyers; those can be used as a baseline to calculate local government subsidies, which until 2016 could equal the central government spending and since 2017 could be only half as much.¹⁰⁶ Using these data yields a total of RMB 155.7 billion between 2009 and 2017.

Figure A-1: NEV Subsidy Estimate Based on Official Reports (RMB, billions)

	Central Gov't	Local Gov't	Total
2009-2015	33.4	33.4	66.8
2016	37.6	37.6	75.2
2017	9.1	4.6	13.7
Total	80.1	75.6	155.7

106. "Bulletin regarding the Special Inspection on the Public Access of Local Budgets and Financial Accounts, and Subsidy for the Promotion and Application of NEVs," Ministry of Finance News Office ("关于地方预决算公开和新能源汽车推广应用补助资金专项检查的通报," 财政部新闻办公室), September 8, 2016, http://www.mof.gov.cn/zhengwuxinxi/bulinggonggao/tongzhitonggao/201609/t20160908_2413434.htm; "Public Disclosure on the Primary Checking of the Subsidy for the Promotion and Application of NEVs in 2016," Ministry of Industry and Information Technology ("关于2016年度新能源汽车推广应用补助资金初步审核情况的公示," 工业和信息化部), May 17, 2017, <http://www.miit.gov.cn/n1146295/n1652858/n1653100/n3767755/c5647658/content.html>; "Public Disclosure on the Primary Checking of the Subsidy for the Promotion and Application of NEVs in 2016 (Batch 2)," Ministry of Industry and Information Technology, November 28, 2017 ("关于2016年度新能源汽车推广应用补助资金(第二批)初步审核情况的公示," 工业和信息化部), <http://www.miit.gov.cn/n1146285/n1146352/n3054355/n3057585/n3057592/c5931108/content.html>; "Public Disclosure on the Primary Checking of the Subsidy for the Promotion and Application of NEVs in 2017 and the Previous Year," Ministry of Industry and Information Technology ("关于2017年及以前年度新能源汽车推广应用补助资金(第二批)初步审核情况的公示," 工业和信息化部), May 25, 2018, <http://www.miit.gov.cn/n1146295/n1652858/n1653100/n3767755/c6191983/content.html>; and "Public Disclosure on the Primary Checking of the Subsidy for the Promotion and Application of NEVs in 2017 and the Previous Year (Additional)," Ministry of Industry and Information Technology ("关于2017年及以前年度新能源汽车推广应用补助资金初步审核(补充)情况的公示," 工业和信息化部), May 25, 2018, <http://www.miit.gov.cn/n1278117/n1648113/c6396715/content.html>.

This figure seems low when compared against the actual number of NEVs sold during this period that should have been able to benefit from subsidies. A respected Beijing-based consulting firm estimates that the total government expenditure on NEV subsidies between 2009 and 2017 was close to RMB 200 billion. Other experts have reported that NEV subsidies were RMB 59 billion in 2015 and at least RMB 83 billion in 2016.¹⁰⁷ Their methodology applied to the entire period would yield a sum higher than our estimate. Our buyer subsidy calculation is based on annual sales and the reported subsidy rates for NEV passenger cars and buses for each year.

Our other estimates are more in line with official reporting. The infrastructure subsidies estimate is based on the likely funding that MIIT has provided cities for their efforts to promote NEV sales, but it does not include other kinds of potential government spending on infrastructure.¹⁰⁸ The figure for R&D in the sector as a whole assumes 70 percent of R&D for the entire auto sector over this period went to NEV technology.¹⁰⁹ And the government subsidy figure assumes that 40 percent of government procurement of autos went toward NEVs.¹¹⁰

In each instance, we attempted to be conservative in our calculations. Our estimate does not include standard kinds of implicit subsidies that many companies in high-priority sectors in China receive, such as low-cost or free land and low-cost bank loans. As a result, actual Chinese government support for the sector and individual companies may be substantially higher than what we report.

The total value of the NEV market begins with the total number of NEVs sold between 2009 and 2017, which is reported to be 1,738,7000 vehicles.¹¹¹ We estimate that commercial vehicles (primarily buses) accounted for 30 percent of sales and passenger vehicles 70 percent. With no reliable data on vehicle pricing, we estimate the average price

107. On subsidies to promote NEV sales, see “Expended Over 400 Billion in 11 Years: Leaving Subsidies Will Be Moment of Ultimate Battle Between Chinese and Foreign NEV Makers” (“11年耗资4千多亿, 补贴退出将是中外车企新能源决战之时”), D1EV, January 11, 2018, <https://www.d1ev.com/kol/60938>; “Local NEV Subsidies May Be Eliminated, Experts Call The Weakening of Subsidies the Counterattack Day for Foreign Invested Firms” (“新能源汽车地方补贴或取消, 专家称补贴淡出时是外资反攻日”), *Securities Daily*, December 20, 2017, <http://www.ccstock.cn/auto/qichedongtai/2017-12-20/A1513701536454.html>.

108. “Notice on Rewarding the Construction of NEV Charging Facilities,” Ministry of Finance, Ministry of Science and Technology, Ministry of Industry and Information Technology, and National Reform and Development Commission (“关于新能源汽车充电设施建设奖励的通知,” 财政部、科技部、工业和信息化部、发展和改革委员会), November 18, 2014, http://www.mof.gov.cn/gp/xxgkml/jjjss/201411/t20141125_2512126.html; “Notice on Rewarding the Installation of NEV Charging Infrastructure and Strengthening the Promotion and Application of NEV during the 13th Five-Year-Plan Period,” Ministry of Finance, Ministry of Science and Technology, Ministry of Industry and Information Technology, National Development and Reform Commission, and National Energy Commission (“关于‘十三五’新能源汽车充电基础设施奖励政策及加强新能源汽车推广应用的通知,” 财政部、科技部、工业和信息化部、发展和改革委员会、国家能源局), January 11, 2016, http://www.most.gov.cn/tztg/201601/t20160120_123772.htm.

109. *China Statistical Yearbook of Science and Technology* (National Bureau of Statistics & Ministry of Science and Technology, various years).

110. On government procurement: “Notice on Printing and Adopting the Implementation Plan on Procurement of NEV by Government and Public Sector,” National Government Offices Administration, Ministry of Finance, Ministry of Science and Technology, Ministry of Industry and Information Technology, and National Development and Reform Commission (“关于印发政府机关及公共机构购买新能源汽车实施方案的通知,” 国管局、财政部、科技部、工业和信息化部、发展改革委), July 14, 2014, <http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757018/c3763293/content.html>; “Implementation Opinions on the Promotion and Application of NEV in the Transport Industry,” Ministry of Transportation (“关于加快推进新能源汽车在交通运输行业推广应用的实施意见,” 交通运输部), March 13, 2015, http://www.gov.cn/gongbao/content/2015/content_2883248.htm.

111. “Automotive Statistics,” China Association of Automobile Manufacturers, <http://www.caam.org.cn/english/newslist/a101-1.html>.

of commercial vehicles to be RMB 1.2 million and passenger cars RMB 250,000. It is quite possible both are an overestimate. Our total market value estimate does not include the wholesale market for parts and components or the used-car market.

About the Author

Scott Kennedy is deputy director of the Freeman Chair in China Studies and director of the Project on Chinese Business and Political Economy at the Center for Strategic and International Studies (CSIS). A leading authority on Chinese economic policy, specific areas of focus include industrial policy, technology innovation, business lobbying, U.S.-China commercial relations, and global governance. Kennedy has been traveling to China for over 30 years and has interviewed thousands of officials, business executives, lawyers, non-profit organizations, and scholars. He is the author of *The Fat Tech Dragon: Benchmarking China's Innovation Drive* (CSIS, August 2017), and *The Business of Lobbying in China* (Harvard University Press, 2005). He has edited three books, including *Global Governance and China: The Dragon's Learning Curve* (Routledge, 2018), and *Beyond the Middle Kingdom: Comparative Perspectives on China's Capitalist Transformation* (Stanford University Press, 2011). His articles have appeared in a wide array of policy, popular, and academic venues, including the *New York Times*, *Wall Street Journal*, *Bloomberg Brief*, *Foreign Affairs*, *Foreign Policy*, *China Quarterly*, *China Journal*, and the *Journal of Contemporary China*. He is currently writing a book, tentatively titled, *The Power of Innovation: The Strategic Importance of China's High-Tech Drive*.

Prior to joining CSIS, Kennedy was a professor at Indiana University (IU) for over 14 years. From 2007 to 2014, he directed the Research Center for Chinese Politics & Business, and in 2014 became the founding academic director of IU's China Office. From 1993 to 1997, he worked at the Brookings Institution. Kennedy received his Ph.D. in political science from George Washington University, his M.A. in China studies from Johns Hopkins School of Advanced International Studies, and his B.A. in foreign affairs from the University of Virginia.

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1616 Rhode Island Avenue NW
Washington, DC 20036
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