

# Supercharging the Development of Electric Vehicles in China

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# Executive summary

China is entering a new phase of economic development, with a focus on achieving more sustainable growth. Faster adoption of electric vehicles (EVs)<sup>1</sup> is widely seen as an effective way to reduce China's growing dependence on imported oil, relieve pollution in congested urban areas, and help domestic OEMs and suppliers to gain a competitive edge over their stronger international rivals.

Yet, despite having invested more than RMB 37 billion in various forms of subsidies to OEMs, suppliers, consumers and researchers, China lags behind other leading markets in the development of its EV industry ecosystem. China has also missed its own targets for EV sales, infrastructure roll-out, and technology.

This paper looks at the current EV ecosystem in China, and highlights potential lessons that can be drawn from successful experience in other countries. It then seeks to frame a set of questions and options to inform discussions about the policy framework required to enable the development of electric vehicles in China. This paper does not make or imply recommendations for action by government or industry players.

What we have learned in analyzing public policies in China and other countries can be summarized as follows:

- Giving consumers greater choice in EVs, both imported and locally-produced battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), can stimulate EV demand and foster competition.
- Policy support to new, non-traditional entrants could bring stronger competition on the supply side and spur incumbents to faster action.
- While one-off financial incentives to encourage EV purchases are important to stimulate early demand, recurring financial incentives such as free or discounted parking and highway tolls, and non-financial benefits such as sharing of dedicated bus lanes and dedicated parking, to name only a few, are just as important.
- Government has an important role to play in working with the automotive and utility industries and other infrastructure providers to define a consistent set of national standards for EV charging and infrastructure development, and to provide additional policy support for developers, landlords, tenants and consumers to jointly push for the faster rollout of charging facilities.

These learnings raise some potential questions and choices on how China might most-effectively stimulate the development of electric vehicles:

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1 Electric vehicles throughout this article refers to Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs)

- Could there be a benefit from creating a national, harmonized list of EVs that qualify for subsidies? Including both imported and locally-produced BEVs and PHEVs on a nationally harmonized list could help to mitigate local protectionism;
- What is the most effective balance between traditional and non-traditional OEMs and suppliers? Introducing stronger competition to the EV supply side, for instance by issuing EV-only production licenses to non-traditional automotive OEMs and suppliers, can help stimulate innovation;
- What is the role for balancing financial and non-financial incentives to consumers to encourage EV purchase and make EV usage more convenient?
- How might the government collaborate with OEMs, suppliers and utility companies to develop a national standard for charging and communication protocols in order to avoid wasted and duplicate investments in non-compatible charging infrastructure and technologies?

Other choices, such as import duty exemptions or reductions for qualified EV products and the lifting of foreign ownership restrictions and JV requirements for EV production, could have a greater near-term impact on EV adoption and the development of the EV ecosystem. They would also send a clear signal of the government's determination to promote EV development in China. However, these measures would likely present challenges for local industry players.

Policy options such as restricting new vehicle registrations to EVs in heavily polluted and congested cities would likely have only a limited impact on reducing air pollution. Such options can also trigger unintended negative consequences for the automotive industry, such as the possibility of significant write-downs in the value of their R&D investments.

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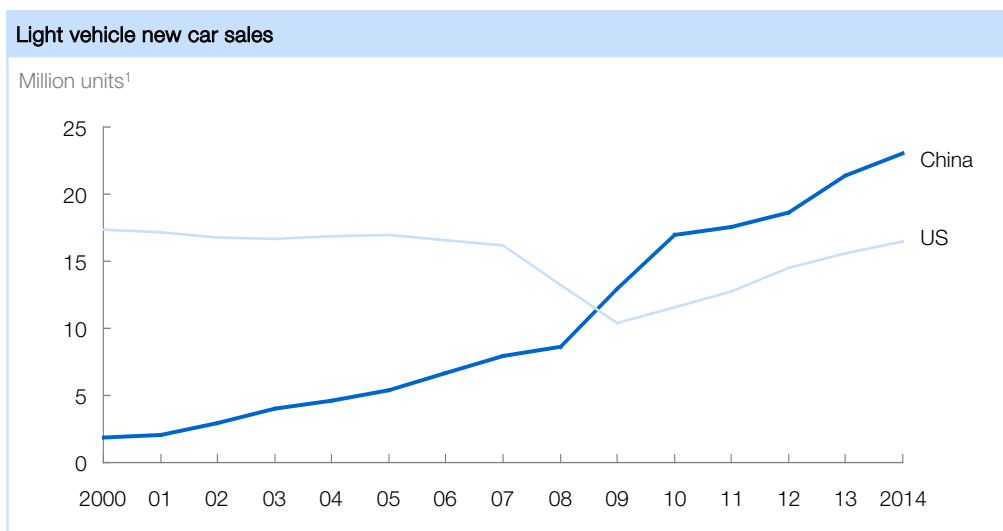
There are clear and significant benefits for China in developing EVs – for its environment, its local automotive industry, and its aspiring car buyers. We hope our perspectives will provide a fact base for constructive discussions among policy makers and industry players as they seek to position the EV industry on the right path going forward.

# Overview of China's electric vehicle development

In the past decade, China has not only become the world's second largest economy, it has also overtaken the United States as the world's largest automotive market (Exhibit 1).

## EXHIBIT 1

### China overtook the US as the world's largest automotive market in new car sales in 2009



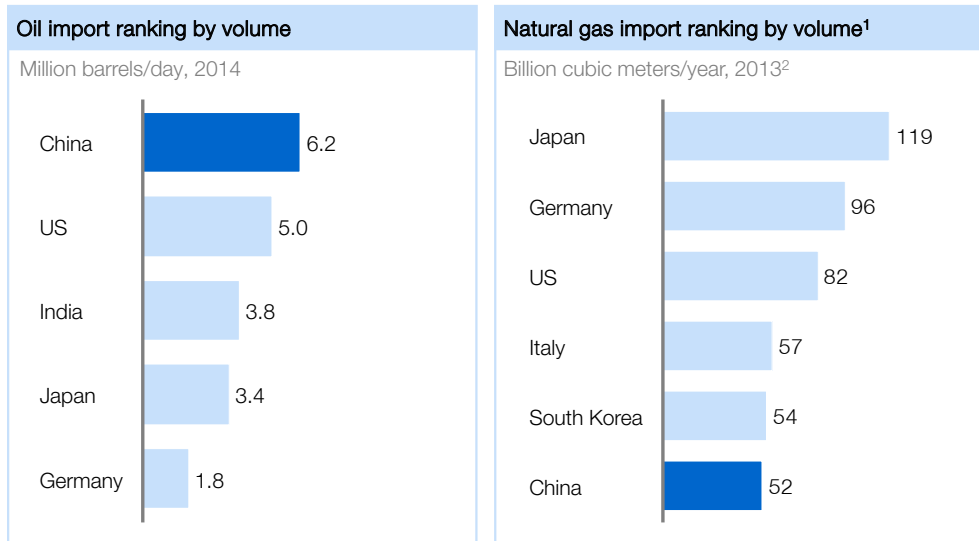
<sup>1</sup> All platforms and body sizes of passenger vehicles and light commercial vehicles  
SOURCE: IHS Automotive DRIVEN BY Polk

These achievements have come at a heavy price: today, it is difficult to visit any major Chinese city without encountering traffic congestion and poor air quality.

China has also become the world's largest importer of crude oil, the sixth largest importer of natural gas (Exhibit 2), and the world's biggest emitter of greenhouse gases (Exhibit 3). Despite the recent drop in global oil prices, triggered by increased unconventional extraction in the US, geopolitical tensions and regional conflicts in oil-producing countries such as Iraq, Libya and Yemen will likely continue to affect China's energy security in the years ahead.

## EXHIBIT 2

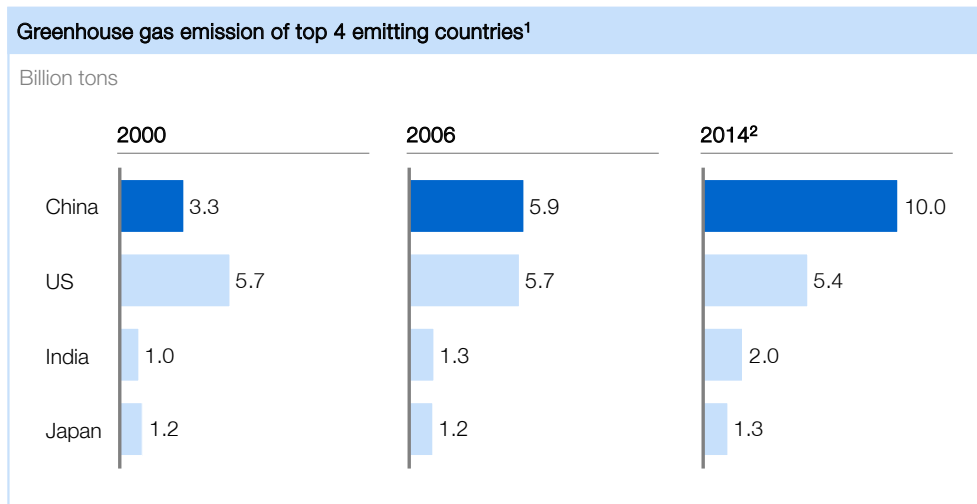
### China has become the world's biggest importer of oil and the 6th largest importer of natural gas



1 Includes both pipeline and LNG imports  
 2 2014 data will be released in June 2015 by BP statistical review  
 SOURCE: BP; IEA Monthly Oil Data Service; ITC Trade Map; EIA

## EXHIBIT 3

### China has been the world's biggest emitter of greenhouse gases since 2006



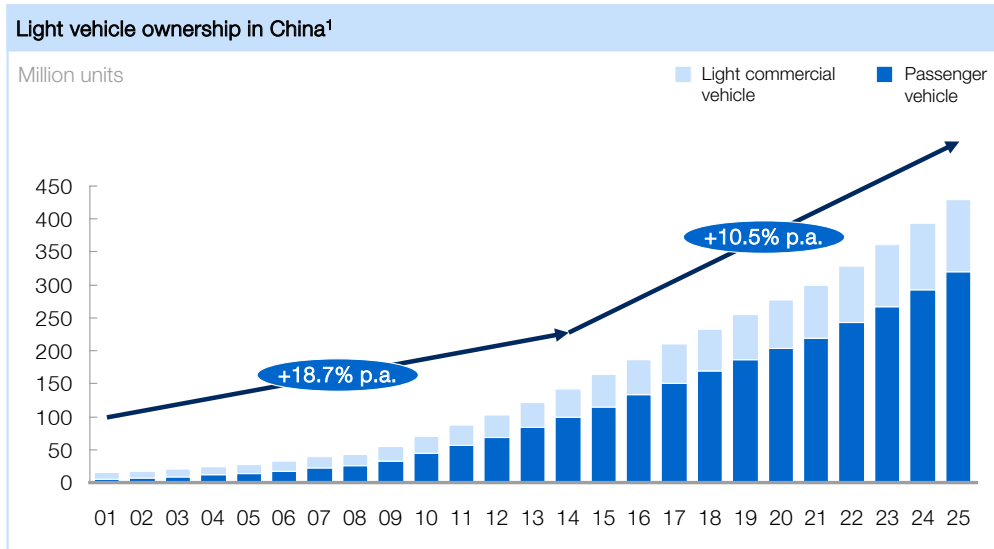
1 Based on 2014 ranking. Uses CO<sub>2</sub> ranking as proxy. CO<sub>2</sub> makes up the dominant share of greenhouse gas emissions by emission mass, with carbon monoxide being approximately one hundredth of CO<sub>2</sub> by total emission mass and nitrogen oxides being approximately one thousandth of CO<sub>2</sub>  
 2 Only 2013 data is available in the latest 2014 Edition IEA report. The 2014 data is reported by EIA for US and collected from press searches for China, India and Japan, which have been flat or decreased from 2013  
 SOURCE: IEA CO<sub>2</sub> Emissions from Fuel Combustion (2014 Edition); EIA; press search

Energy security and pollution challenges could worsen if action is not taken: by 2025, demand from China's automotive market (Exhibit 4) alone is expected to consume a quarter of the global crude oil supply (Exhibit 5), based on current production levels. EV adoption can help reduce China's dependence on imported oil.

A greater degree of vehicle electrification can help reduce urban pollution from car exhaust. However, given around 80 percent of China’s power is supplied from fossil fuels, the well-to-wheel reduction in CO<sub>2</sub> emissions of EV is only 29% less than that of ICE. EV adoption will therefore likely not have a significant impact on China’s overall greenhouse gas emissions (Exhibit 6).

EXHIBIT 4

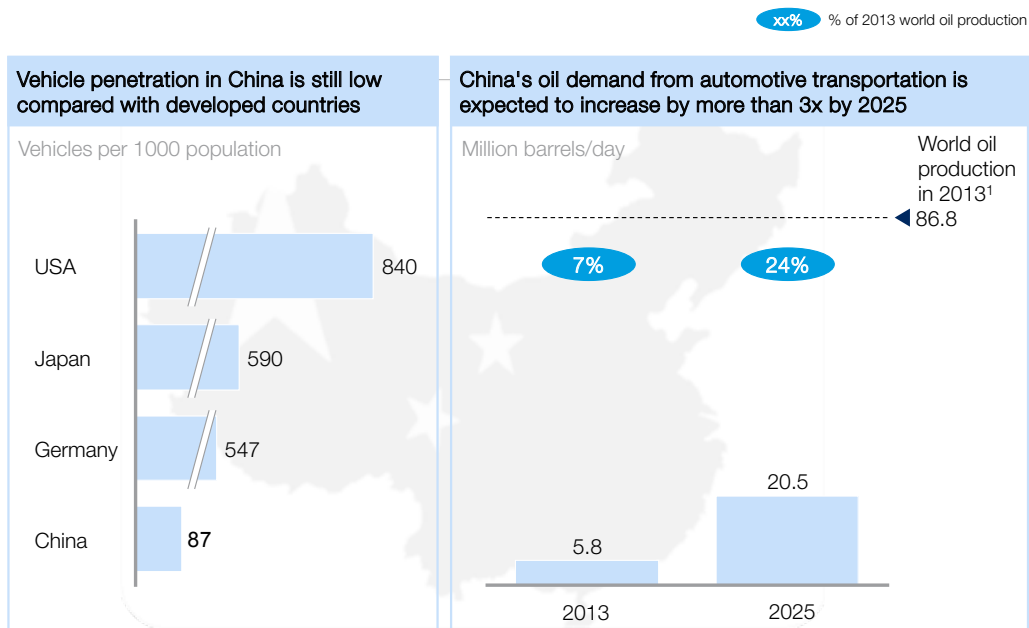
**China vehicle ownership is expected to reach a staggering 430 million units by 2025**



1 Pre-2022 data based on IHS Automotive DRIVEN BY Polk. Assumes the growth in light commercial and passenger vehicle segments continues at their respective 2016-2021 5-year CAGR till 2025  
 SOURCE: IHS Automotive DRIVEN BY Polk

EXHIBIT 5

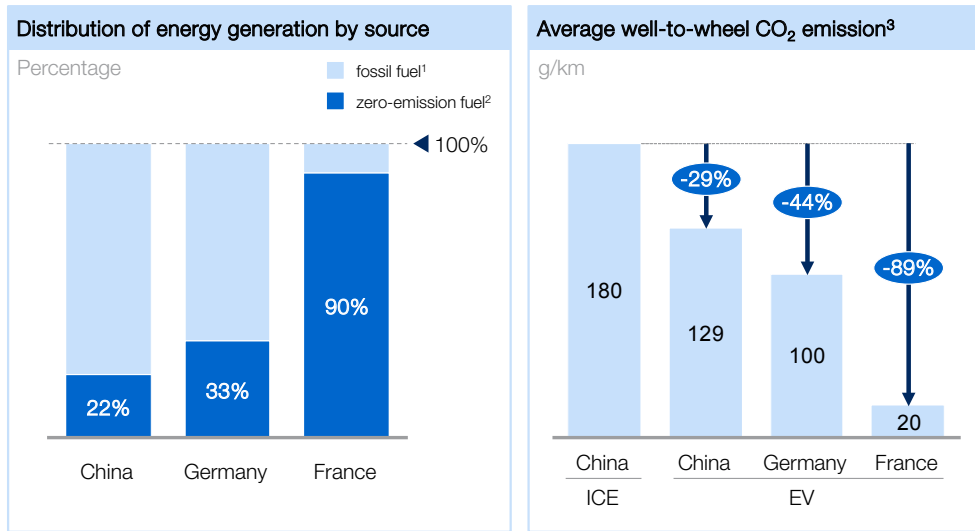
**China’s oil demand could reach a quarter of current world production by 2025**



1 The production level in 2025 will be different, but 2013 level is used to provide comparison due to limited ability to forecast 2025 output  
 SOURCE: Polk; EIA; Literature search; CAAM; World Bank; McKinsey analysis; IEA

EXHIBIT 6

**Impact on greenhouse gas emissions of EV adoption is likely to remain limited unless China shifts to cleaner power generation**

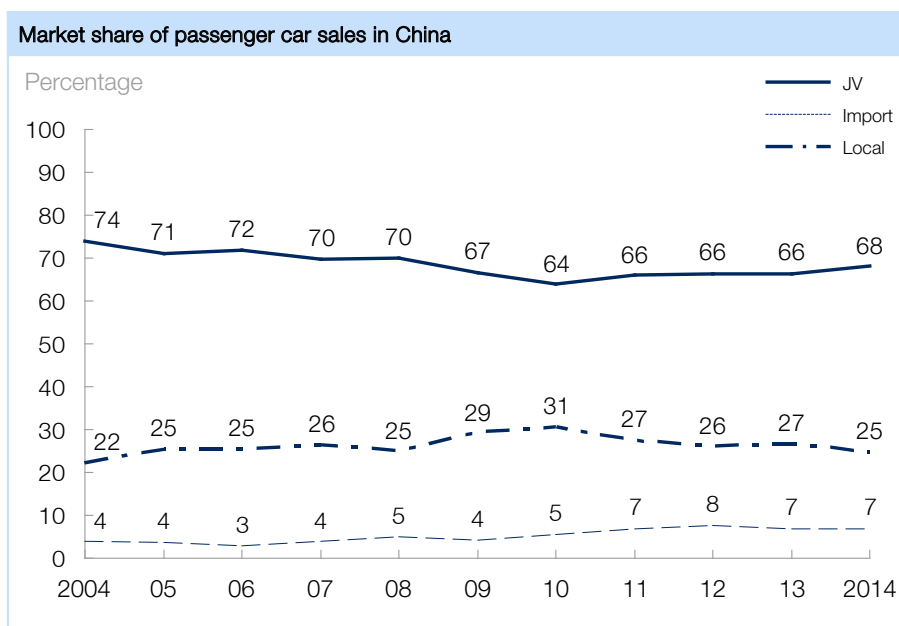


1 Depending on fossil fuel composition and efficiency of electricity generation, the upstream CO<sub>2</sub> emission may not be proportional to fossil fuel share, e.g., China has more coal-based generation (as opposed to gas-based) and sub-scale power plants than Germany  
 2 Includes renewables and nuclear  
 3 Of an average BEV in the market  
 SOURCE: McKinsey analysis

Additionally, the development of EV would give Chinese OEMs, who have long ceded market share to JV OEMs (Exhibit 7), a new opportunity to compete with their global peers.

EXHIBIT 7

**Chinese OEMs have ceded market share to JV OEMs**



SOURCE: IHS Automotive DRIVEN BY Polk







China has already invested over RMB 37 billion in government investment for EVs, including R&D grants for OEMs, suppliers and research institutions; charging infrastructure investments from SOEs; and purchase subsidies and tax breaks for consumers (Exhibit 8). Nevertheless, its global ranking in EV ecosystem development has fallen despite improvements in its overall score (Exhibit 9).

At the same time, China's EV technology development and vehicle sales have missed many of its initial targets (Exhibit 10). Even sales of Tesla in China slowed down after an initial wave of excitement, with 2014 registrations reaching only 44% of imported inventory, followed by the announcement of weak sales in China by the company's senior executives, and a reported 33% cut in its Chinese workforce<sup>2</sup>.

#### EXHIBIT 8

### China has spent over RMB 37 billion to build up the EV ecosystem

SELECTIVE MAJOR PROGRAMS

	Major areas of investment <sup>1</sup>	Investment amount RMB
	R&D <sup>2</sup>	8B
	Charging infrastructure <sup>3</sup>	11B
	Purchasing subsidy <sup>4</sup>	15B
	Tax reduction/ exemption <sup>5</sup>	3B

▪ Estimate does not include:

- Low-interest loans to OEMs and suppliers
- Direct subsidies, additional tax breaks and reduced rent to OEMs, suppliers and investors for factory and charging station construction outside the listed programs
- Long tail of small research grants that may have been awarded to universities by local authorities

<sup>1</sup> Only major areas of investment with publicly accessible information are included

<sup>2</sup> Includes 50M during 8th five-year (15M from SETC, 15M from SDPC, 20M from COSTIND), 50M during 9th five-year from National Major Technology Industrial Engineering Project, 890M during 10th five-year from MOST through Key Special Project of Electric Vehicles in the 863 program, 1.2B during 11th five-year from MOST through Energy-Saving and New-energy Vehicle Key Project in the 863 program, 2B during 12th five-year from MOST through Energy-Saving and New-energy Vehicle Key Project in the 863 program, and 4.2B during 12th five-year through New-energy Automotive Industry Technology Innovation Project, all of which are grants to a combined pool of research institutions, OEMs, and suppliers; other investment may include R&D through National Science Foundation, National Key Technology R&D Program, international cooperation

<sup>3</sup> Includes investment in charging stations and poles through State Grid and China Southern Grid; other government-led construction may exist

<sup>4</sup> Includes national purchasing subsidy of BEV and PHEV; subsidy provided by local government is excluded

<sup>5</sup> Includes 2B purchase tax, 0.6B consumption tax, and 0.04B vehicle and vessel tax; no other major tax benefits for EV exist

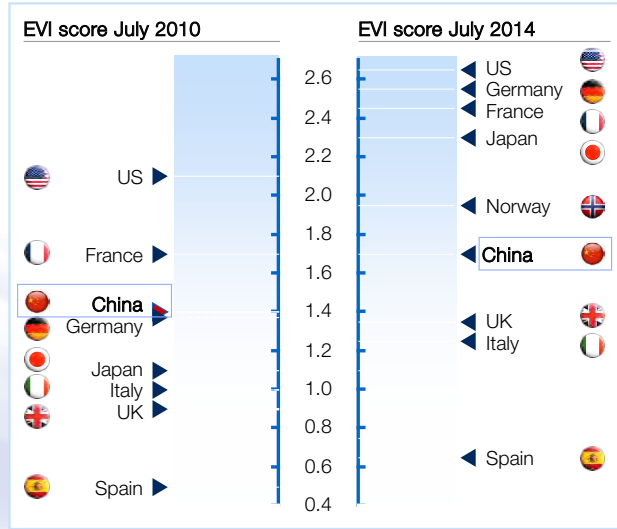
SOURCE: Press search; McKinsey analysis; government documents

EXHIBIT 9

### China has fallen in its global ranking of EV ecosystem development

**McKinsey Electric Vehicle Index (EVI)<sup>1,2</sup>**

5= most developed, 0 = least developed



**Explanation**

- Supply**
  - Production outlook:** Forecast of EV's share in vehicle production stays low while Germany, France, UK increased dramatically
  - EV model outlook:** share of EV prototypes in all models of local OEMs stays high like Germany, Japan, and US
  - Government support on EV development:** R&D support from government stays low like other countries, except US
- Demand**
  - EV penetration:** Increased, while other countries increased to higher share
  - Model variety:** Increased, but Germany, Italy and France increased much more
  - Cost savings:** Travel cost savings stays the highest due to low electricity prices, with other countries stable
  - Government subsidies:** remains good, but France, UK, and US increased
  - Non-financial benefits:** improved, but not as fast as Italy

1 EVI is a McKinsey proprietary tool  
 2 Includes PHEV, BEV, but not conventional HEV  
 SOURCE: McKinsey analysis

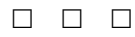
EXHIBIT 10

### China's EV sales, charging infrastructure, and technology development are also falling short of China's initial targets

■ Current situation  
 ■ Target

Areas	2015 target vs current situation	2020 target	Additional insights
<b>Sales<sup>1</sup></b> In thous. units	<p>134 (27%)</p>	5000	<ul style="list-style-type: none"> <li>70% of accumulated total was sold in 2014</li> </ul>
<b>Charging stations<sup>2</sup></b> In units	<p>636 (32%)</p>	10000 (State Grid target announced)	<ul style="list-style-type: none"> <li>41% of all installations were made in 2014</li> </ul>
<b>Charging poles<sup>2</sup></b> In thous. units	<p>27 (7%)</p>	N/A	<ul style="list-style-type: none"> <li>35% of all installations were made in 2012, followed by a drop-off</li> </ul>
<b>Patents<sup>3</sup></b> In units	<p>4,926 (164%)</p>	N/A	<ul style="list-style-type: none"> <li>Patents for core EV technology is the only area that exceeds target</li> </ul>
<b>Battery energy density<sup>4</sup></b> In Wh/kg	<p>90 (60%)</p>	300	<ul style="list-style-type: none"> <li>Likely reach 150 Wh/kg by 2015/16<sup>5</sup></li> </ul>

1 Includes both passenger vehicles and commercial vehicles; target extracted from Energy-saving and New-energy Automotive Industry Development Plan (2012-2020)  
 2 The charging station and poles data are reported by State Grid and China Southern Grid, which covers the majority of public EV infrastructure; target extracted from The 12th Five-Year Special Plan for the Development of Electric Vehicle Technology  
 3 Excludes patents from foreign applicants; target extracted from The 12th Five-Year Special Plan for the Development of Electric Vehicle Technology; while government target does not specify the type of patent in this target, it is important to note that China's patents include utility and design patents on top of invention patents, which tends to inflate the patent number size; Chinese patents are also registered overseas through the Patent Cooperation Treaty  
 4 Target extracted from Energy-saving and New-energy Automotive Industry Development Plan (2012-2020)  
 5 BYD announced in late 2014 that its LFP batteries technology will reach 150Wh/kg in 2015, but no production realized yet  
 SOURCE: Energy-saving and New-energy Automotive Industry Development Plan (2012-2020); The 12th Five-Year Special Plan for the Development of Electric Vehicle Technology; Press search; McKinsey analysis



Given the strong interest from both the public and private sectors in the development of EV as part of the government's drive toward sustainable economic development, the following chapters outline first the government's role in shaping the EV market, looking at the current situation in China and potential learnings from other countries, then set out potential options for stimulating EV development in China, drawing on that experience.

# Review of the government's role in shaping the EV market development in China and in other countries

To date, the Chinese government has invested over RMB 37 billion to accelerate the development of China's EV ecosystem. Investments have included R&D grants for research institutions, OEMs and suppliers; charging infrastructure investments by State Grid and China Southern Grid; and EV purchase subsidies and tax incentives for consumers. The government has also formed local consortia with OEMs, suppliers and infrastructure players, and issued regulatory standards on fuel efficiency and emissions, among other actions. Despite these measures, the development of China's EV industry has fallen short of China's own targets.

We compared China's case with other countries and conducted a series of expert interviews in order to inform discussions about EV development, amongst government and industry participants. The following is a summary of our findings regarding the current situation in China with potential learnings from other markets, covering three aspects of the ecosystem (Exhibit 11).

## EXHIBIT 11

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### Key aspects of EV development

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1



**Providing attractive supply** as alternatives for ICE

2



**Stimulating demand** through consistent/recurring incentives

3



**Unlocking development trends** by addressing key enablers

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## Providing attractive supply as alternatives for ICE

### The current situation in China

To stimulate local demand and foster healthy competition, there are four areas which can be helpful to consider: 1) the purchase subsidization catalog, 2) import tariffs, 3) the subsidization of both BEV and PHEV, instead of one versus the other, and 4) involvement of non-traditional players to stimulate innovation.

**Purchase subsidization catalog.** China awards EV purchase subsidies only to locally-produced models in order to build national champions in EV. China's national MIIT catalog of qualifying EVs includes about 150 models, and this national catalog is complemented by additional subsidy-matching at the local level in many provinces and cities, whose catalogs show varying levels of consistency with the national catalog (Exhibit 12).

EXHIBIT 12

### EV subsidies are inconsistent across cities in China

City	Adopt national MIIT catalog for local subsidy qualification?	Local subsidy matches national NEV subsidy 1:1?	Local subsidy difference from national standard
Beijing <sup>1</sup>	✗	✓	<ul style="list-style-type: none"> <li>PHEV exclusive</li> <li>Total subsidy less than 60% of the retail price</li> </ul>
Shanghai <sup>2</sup>	✗	✗	<ul style="list-style-type: none"> <li>40/30 thsd. RMB for BEV/PHEV</li> </ul>
Shenzhen	✓	✓	<ul style="list-style-type: none"> <li>N/A</li> </ul>
Chongqing	✓	✗	<ul style="list-style-type: none"> <li>Total subsidy less than 60% of the retail price</li> </ul>
Guangzhou	✓	✗	<ul style="list-style-type: none"> <li>Total subsidy less than 60% of the retail price</li> </ul>
Hangzhou	✓	✗	<ul style="list-style-type: none"> <li>30/20 thsd. RMB for BEV/PHEV</li> </ul>
Hefei	✓	✗	<ul style="list-style-type: none"> <li>BEV with range&gt;150km: match national subsidy 1:1</li> <li>Other NEV: 20% of national subsidy</li> </ul>
Nanjing	✓	✗	<ul style="list-style-type: none"> <li>35/20 thsd. RMB for BEV/PHEV</li> </ul>
Tianjin	✓	✓	<ul style="list-style-type: none"> <li>N/A</li> </ul>
Wuhan	✓	✗	<ul style="list-style-type: none"> <li>Total subsidy less than 60% of the retail price</li> </ul>

<sup>1</sup> Beijing uses a local shortlist including 8 domestic models from BAIC (Beijing), Brilliance BMW (Shenyang), BYD (Shenzhen), Chang'an (Chongqing), JAC (Anhui), SAIC (Shanghai), which are the only qualified models to receive subsidy from Beijing government; Beijing shortlist is in talks for removal

<sup>2</sup> Shanghai uses a local shortlist including 10 domestic models from BAIC (Beijing), BYD (Shenzhen), Chery (Anhui), JAC (Anhui), Lifan (Chongqing), SAIC (Shanghai), SGM (Shanghai), which are the only qualified models to receive subsidy from Shanghai government

SOURCE: Press search; government announcements; McKinsey analysis

The current subsidization scheme faces three major issues:

First, the exclusion of imported EVs from national and local catalogs provides an advantage to locally-produced models, and thus has not been conducive to allowing global competition to stimulate market demand and innovation.

Second, the national list qualifies most locally-produced EVs by using easy-to-meet minimum criteria in performance and length of battery guarantee, while using only the driving range to determine the subsidization amount. This broad inclusion risks spreading the subsidy too thin, may forego opportunities to double bet on emerging winners and to incentivize constant improvement, and opens up the subsidy to potential gaming by OEMs (for instance, by manufacturers offering EVs with only minor modifications to their internal combustion engine (ICE) offerings). In a recently revised draft of the qualification requirements, China is beginning to consider filtering the qualified models further with

R&D capabilities, production scale and safety, among others, though criteria have not yet been provided.

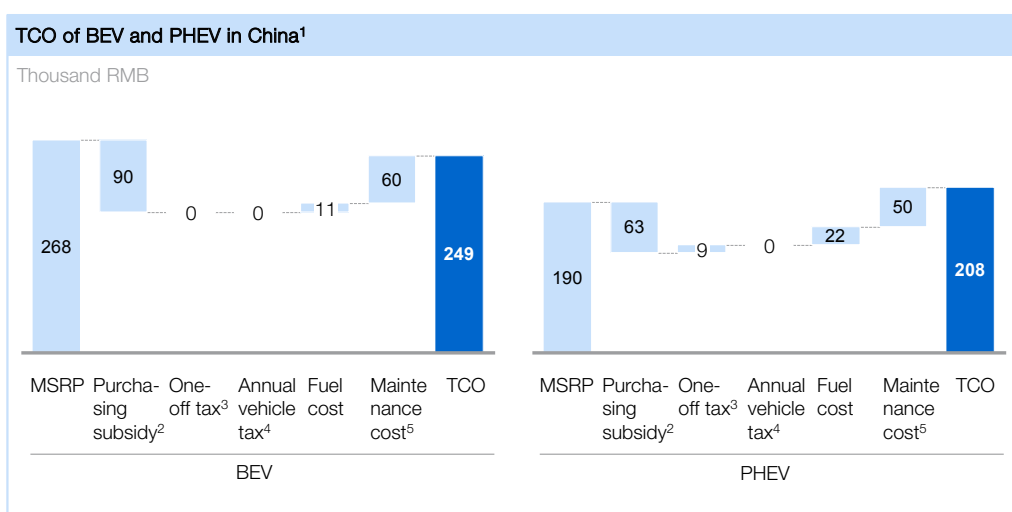
Third, the inconsistency in qualified EVs in some cities, such as Beijing and Shanghai, creates ambiguity among consumers about which models are included. Beijing and Shanghai currently match national subsidies only for models on their own shortlists – 8 for Beijing and 10 for Shanghai – creating an advantage for local models over both foreign and other domestic vehicles. Recently, Beijing has announced that it will begin to move away from its local short-list and follow the national MIIT catalog. Shanghai has yet to follow suit.

**Import tariffs.** While tariffs on imported cars may encourage foreign OEMs to produce locally, the application of tariffs on imported EVs can limit their demand, and thereby limit the chance that foreign models might otherwise have to stimulate market development and demand through additional competitive offerings. Given the relatively nascent stage of EVs in China, accelerating consumer adoption and encouraging industry innovation may need to take priority over the location of production.

**Subsidization of BEV vs. PHEV.** There is some discussion in the industry on whether China should continue to subsidize both BEVs and PHEVs, or focus subsidies only on BEVs. Given the state of infrastructure development, the driving behavior of Chinese drivers and the cost of batteries, PHEVs will likely offer a total cost of ownership (TCO) advantage to consumers for the foreseeable future, and continue to co-exist with BEV technology (Exhibit 13). Despite lower purchase subsidies, the TCO of PHEV over a 10-year lifetime is lower than that of BEV, primarily due to lower price and expected maintenance cost, driven primarily by the smaller battery in PHEVs. Going forward, it is likely that both BEV and PHEV-based EVs will continue to provide competitive offerings, and both will merit continued inclusion in the subsidization catalog.

#### EXHIBIT 13

### PHEV has a lower TCO than BEV despite lower subsidy



<sup>1</sup> Based on Venucia E30 for BEV and Qin for PHEV, assuming annual driving distance of 15k km for 10 years

<sup>2</sup> Assuming local subsidy matches national subsidy 1:1 as in Beijing, Tianjin, and Shenzhen

<sup>3</sup> BEV is exempt from one-time vehicle purchase tax and consumption tax paid by ICE, while PHEV is exempt from vehicle purchase tax only; vehicle purchase tax is 10% of MSRP and consumption tax is 1%-40% of MSRP for ICE depending on displacement

<sup>4</sup> BEV and PHEV are exempt from annual vehicle and vessel tax paid by ICE, which is 60-5400 RMB/year depending on displacement

<sup>5</sup> Based on BYD estimation of maintenance cost for BEV and expert estimated adjustment for PHEV

SOURCE: McKinsey analysis; government documents; OEM websites

**Involvement of non-traditional players:** The emergence of new technologies such as autonomous driving and telematics is attracting non-traditional players into the automotive industry. In March, China’s Alibaba and SAIC Motor announced the establishment of a RMB 1 billion fund to jointly develop an internet-connected car, joining the likes of Google, Apple and Tesla in providing technology-driven stimulus to the automotive industry.

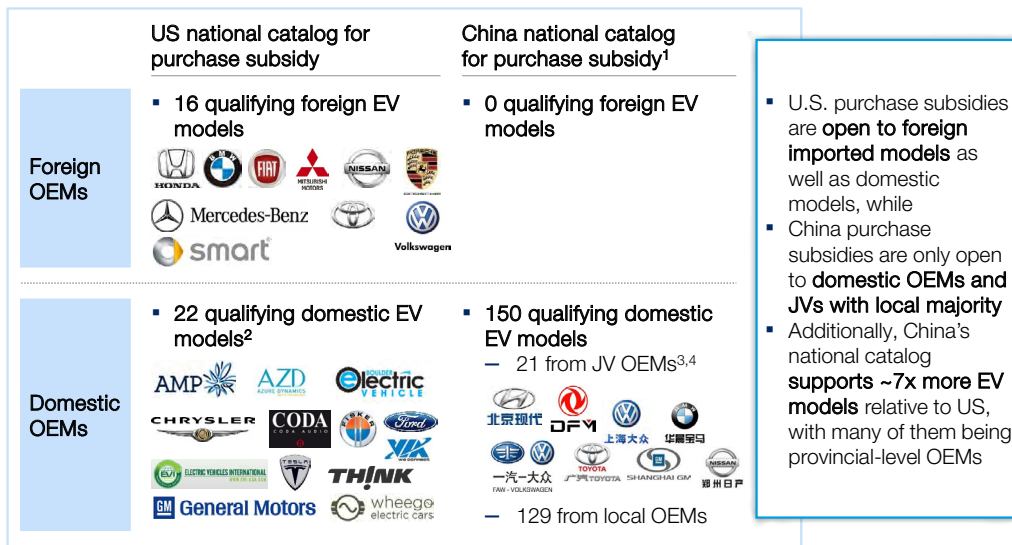
While examples remain limited in China, the increased involvement of non-traditional players in the automotive industry can accelerate the technological development of the industry and spur incumbents to faster action. In China, technology companies are currently limited to partnerships with manufacturers and suppliers. Additional policy support, for instance by issuing licenses for non-technology players to mass produce innovative vehicles, could enable non-traditional players to shake up the Chinese automotive industry.

**Potential learnings from overseas**

If we compare the Chinese and US national catalogs of subsidy-qualifying EVs (Exhibit 14), two interesting contrasts become apparent. First, the US catalog of qualifying EVs is open to models that are produced overseas. Second, the number of qualifying domestically produced models in China is roughly seven times that in the US, providing a stark illustration of how thin the Chinese subsidy is being spread across China’s many OEMs.

EXHIBIT 14

**In contrast to the US, China only offers subsidies for domestic models**



<sup>1</sup> Beijing and Shanghai provide local subsidy based on their own catalogs, in addition to national subsidy based on national catalog

<sup>2</sup> Logos not exhaustive

<sup>3</sup> Beijing is in transition to a cancellation of the catalog, which would acknowledge more EV models in future

<sup>4</sup> China holds majority in any auto JV in China by law

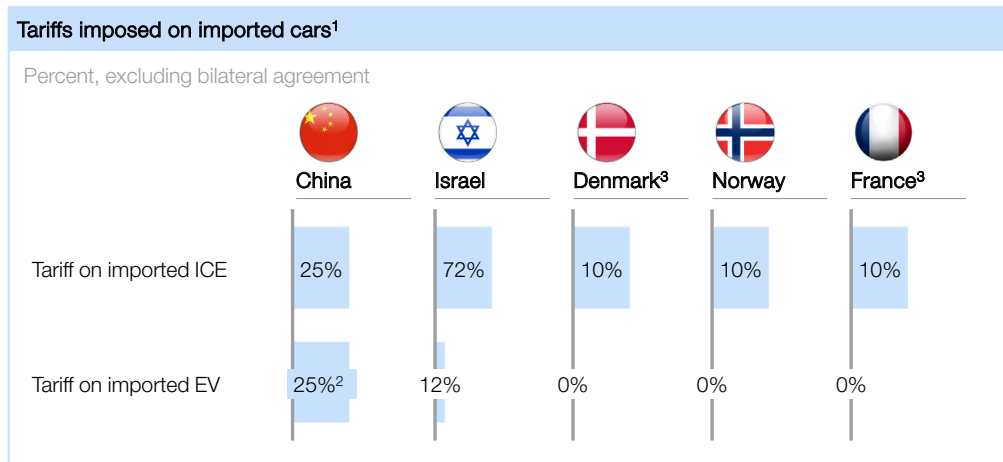
SOURCE: US IRS; government document; McKinsey analysis

While many countries, like China, impose high tariffs on imported cars, many have exempted EVs from tariffs to ensure the availability of attractive EV products at locally competitive prices (Exhibit 15). Countries like Israel impose tariffs as high as 72% for ICEs, but reduce them to as low as 12% for EVs. Other countries waive it completely, such as Norway, whose EV market share is currently the world’s highest in both BEV and PHEV. The reduction or elimination of import tariffs on EVs in China might represent an opportunity to further accelerate EV adoption.

## EXHIBIT 15

## Unlike some other markets, China does not offer lower import tariffs on EVs

ILLUSTRATIVE



<sup>1</sup> Tariffs differ based on trade partner agreement and vehicle parameters, so deviation should be anticipated, e.g., EU imposes 0%-10% tariff on EV with majority being 0%; The figures are mainly from external reports, for illustrative purposes only

<sup>2</sup> China's State Administration of Taxation is considering a policy offering import tax discount for EV, with the details under discussion

<sup>3</sup> Denmark and France follow the EU tariff standard

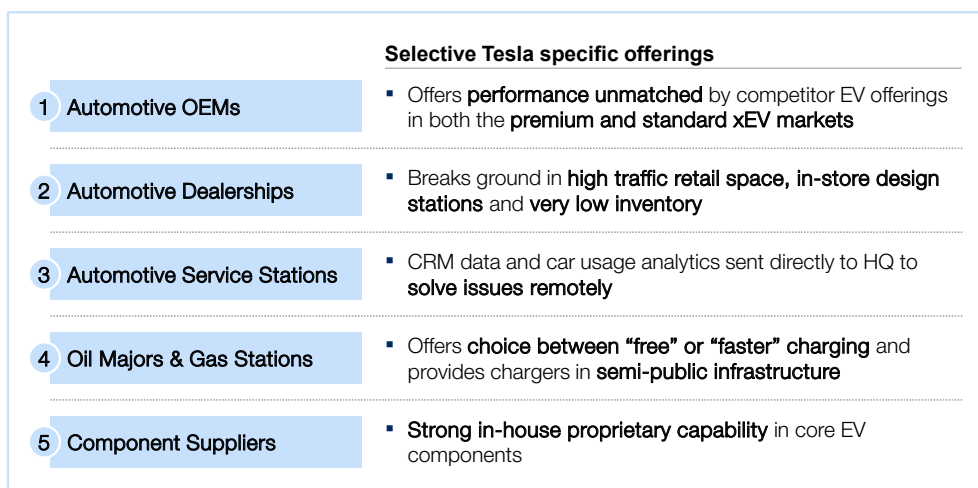
SOURCE: Rainchst Auto; European Commission Taxation and Customs Union TARIC; Press search

The US's open door policy that allows non-traditional OEMs like Tesla to compete in the traditional automotive market could be an interesting example to consider. While Tesla has yet to become profitable, it has demonstrated to traditional OEMs the existence of market demand for EVs, and has spurred other OEMs to invest in their own EV programs. Its innovation in battery technology, sales channels, maintenance programs, charging stations and OEM partnerships has stimulated greater competition in the EV ecosystem (Exhibit 16). These innovations would not have been possible had the US not allowed non-traditional OEMs to produce vehicles, providing an opportunity for them to experiment and compete with more established, traditional OEMs.

## EXHIBIT 16

## The launch of Tesla spurred innovation across the US automotive value chain

ILLUSTRATIVE



SOURCE: McKinsey analysis; press search



## Stimulating demand through recurring incentives

### Current situation in China

China offers an attractive one-time financial incentive to encourage consumers to purchase EVs. Combined, national and local purchase subsidies are worth up to USD 17,000, with additional savings available from a sales tax exemption.

However, China provides less attractive recurring financial incentives for consumers such as free or reduced parking fees and highway tolls, utility rebates, or free charging at certain locations. China also currently offers only a small exemption on its annual vehicle tax.

China has created a number of innovative non-financial incentives to encourage EV ownership, such as granting license plates without a lottery process, and lifting the usual driving restrictions by plate number in highly congested cities. However, it has yet to roll out other incentives at scale, such as dedicated toll booths, sharing of dedicated bus and carpool lanes, access to low-emission zones, dedicated parking in public and semi-public parking lots, and exemptions from waiting lists for parking permits.

### Potential learnings from overseas

While the one-time financial incentive is an important factor to drive EV adoption, experience in Norway, the US, UK and Germany have demonstrated that recurring financial and non-financial incentives are also important (Exhibit 17). For instance, 59% of EV owners in the US said having carpool lane access was extremely or very important in their decision to purchase an EV.






For recurring financial incentives, Norway, for example, offers free or reduced parking, free tolls nationwide, and free EV charging at its 3,000 charging points, on top of its one-time purchase subsidy.

For non-financial incentives, certain states in the US allow EVs to use carpool lanes, which are typically available only to vehicles with two or more passengers during peak commute times. This allows consumers to bypass traffic jams and acts as a powerful incentive, particularly to the well-off commuter. Germany, for example, set several low emission zones to provide EVs with preferential access. This range of options offered in other countries could be tested in China and rolled out broadly if successful.

## EXHIBIT 17

## One-off financial incentives are comparable to other countries but fewer non-financial and recurring-financial incentives

✓ Available and substantial in scale    ✓ Available but limited in scale    ✗ Not available

	Financial					Non-financial				
	Purchasing subsidy	Sales and use tax reduction	Congestion tax reduction	Toll reduction	Utility subsidization	Lane share <sup>1</sup>	Low emission zone	Parking privilege	Driving restriction by plate <sup>1,2</sup>	License priority <sup>2</sup>
 Norway	✓	✓	✗	✓	✓	✓	✓	✓	✗	✗
 Germany	✗	✓	✗	✗	✓	✓	✓	✓	✗	✗
 US	✓	✓	✗	✓	✓	✓	✗	✓	✗	✗
 UK	✓	✓	✓	✗	✗	✗	✓	✓	✗	✗
 China	✓	✓	✗	✓	✗	✓	✗	✓	✓	✓

<sup>1</sup> These benefits are being introduced starting late 2014 in selective pilot cities, which currently have limited scale

<sup>2</sup> Driving restriction by plate number and license limit only exist in China, thus cannot be adopted as non-financial benefits in other countries

SOURCE: Industry expert interview; McKinsey expert interview; press search

## Unlocking development trends by addressing key enablers













### Current situation in China

The government plays a critical role in setting technological standards for charging. Such coordination is needed to ensure that the nationwide charging infrastructure can support the EVs on the road regardless of model.

The charging infrastructure in China is far from standardized, but two high-level emerging trends can be observed. First, the charging station has emerged as the preferred way to repower electric vehicles. The battery-swapping concept pioneered by Tesla remains a continuing experiment, though on a limited scale, and one which may likely be best suited for vehicle fleets. Second, medium to slow charging at home and in public parking lots will likely fulfill most charging needs. Rapid charging will likely serve as a complement to medium and slow charging, positioned at gas stations and rest stops along highways (Exhibit 18).

EXHIBIT 18

The medium-to-slow home and workplace charging will likely fulfill most of the battery charging needs of EV owners

Targeted usage	Charging technology	% of total charging demand	Desired locations
 <p>Regular charging</p>	Slow or medium charging	~80%	 Home parking  Workplace parking  Public parking lots  Hotel/Motel parking
 <p>Rapid charging</p>	Rapid charging	~15%	 Inside regular gas stations  Off major-expressways, intersections  City center parking
 <p>Range extension</p>	Rapid charging	~5%	 Off major-highways ~70km from city center  Conveniently located at rest stops

SOURCE: Expert interview; press research; McKinsey analysis

The government can also influence standards in four other charging-related areas where standardization is currently lacking. Installations from OEMs and different local authorities are often incompatible, making cross-province travel difficult and exacerbating the problem of the scarcity of charging stations.

The first, and most commonly mentioned, is the physical charging socket format used at gas stations and on the EV itself. The second is the communication protocol between the charger and the battery management system of the car, including monitoring systems to ensure safe charging and to indicate the battery’s power level. The third is the payment and membership network system for charging, which will become increasingly important in China as more private-sector investors enter the charging station installations business (to ensure maximum utilization, the membership ID system and payment system will need to be compatible across all charging station offerings). The fourth is interconnectivity and standardization of battery sizes to reduce logistical difficulties in maintenance, repair, replacement and even battery swapping, should it become a niche alternative.

Currently, physical socket compatibility and software interconnectivity are the two most pressing issues. The ongoing revision of the national EV charging standards is seen as a step in the right direction, but it will be important to ensure this revision does not stop short at socket types and communication protocol, but looks ahead to include the other two key areas.

The Sino-German Electric Vehicle Charging Project, announced in July 2014<sup>3</sup>, is another standardization initiative currently underway. In this project, China and Germany will jointly

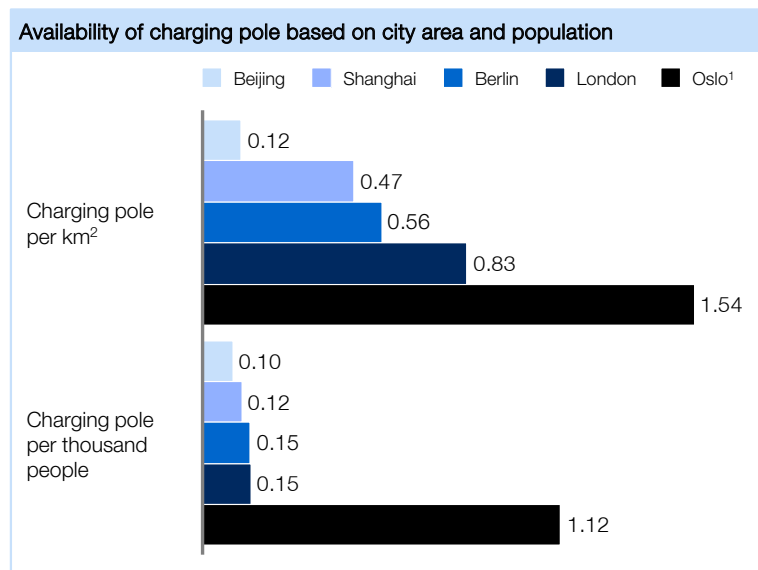
3 The Sino-German Electric Vehicle Charging Project, Ministry of Industry and Information Technology of the People’s Republic of China, July 2014

develop the technical solutions, installation procedures, and viable business models for charging infrastructure in both private and public areas. An important element of this project is the two nations' commitment to unify their EV charging standards, so that imported EVs from either country will be able to use the charging infrastructure in the other. Such cross-national standardization will become increasingly important to encouraging investment in charging infrastructure, as the world continues to consolidate into fewer standards.

In addition to standardization challenges, China also faces supply shortages and location mismatches for its charging stations. China's megacities lag behind those in other countries in the number of charging poles per unit area (Exhibit 19), and insufficient investment in charging poles has constrained EV demand growth. In addition, many of the existing charging facilities are located in areas of government control or where land is relatively cheap (e.g., in the suburbs or underground), not where charging demand is high. Government can however mobilize the private sector to fill the supply gap and private sector involvement could lead to more favorable charging locations, based on market dynamics.

EXHIBIT 19

### Charging infrastructure supply in China's megacities lags that of leading EV countries



<sup>1</sup> Oslo may be considered as an outlier in the benchmark as its area and population is comparatively smaller than the other cities under consideration, while Norway has an exceptional record in EV infrastructure supply overall

SOURCE: McKinsey analysis; press search

Finally, consumers in China's megacities face difficulties installing the faster wall-box chargers, and instead must often resort to using the slower home wall sockets, which take 12-15 hours to charge for a typical BEV. Many people in Chinese megacities live in dense apartment building complexes. While some residents in urban high-density apartment complexes have purchased dedicated parking, many resort to roadside parking on a first-come, first-served basis. A home-based EV charging pole requires a dedicated parking space, a significant expense for the average car buyer. In addition to the cost of installing the wall-box, car owners must go through a lengthy approval process with the utility company as well as the property management committee that oversees their apartment complex. Additional government support will likely be needed to help consumers tackle these inconveniences.

## Potential learnings from overseas

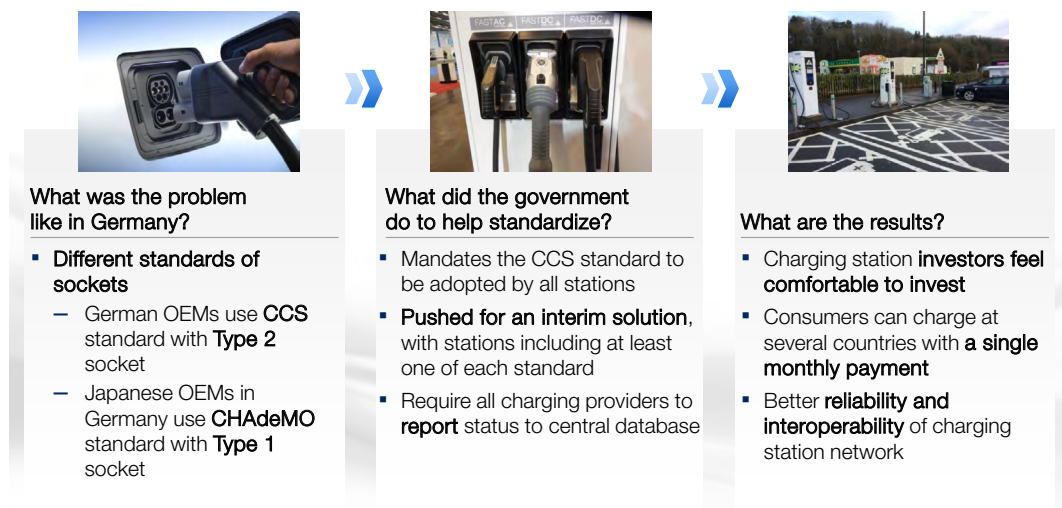
Experience in Germany might provide some useful learnings for China as it seeks to address challenges in standardization and migration to a single standard.

Like China, Germany faced an array of different standards of sockets adopted by different OEMs for their charging stations. German OEMs use a standard known as CCS with Type 2 socket, while Japanese OEMs use an incompatible standard, the CHAdeMO with Type 1 socket.

Germany mandated the CCS standard to be adopted by all charging stations, and required all charging stations to report their charging station's status to a central government database within a specified timeframe. The German government also pushed for an interim solution, with stations including at least one charger for each standard (CHAdeMO, CCS, and AC fast-charging) so that different standards could be accommodated before a full migration (Exhibit 20).

### EXHIBIT 20

#### Germany offered an interim solution to ensure compatibility during standards migration



SOURCE: Expert interview; press search

International examples offer interesting models for public-private cooperation. In Norway, the government facilitated the building of non-public charging stations through the Climate and Environment Fund, which was established with multiple contributors and is run as a standalone fund. Mandatory contributions into this fund by ecosystem stakeholders allowed it to put together a longer term plan, ensuring openness to all key stakeholders and helping with the standardization of charging stations. The U.K.'s "Plugged-in-Places" program makes available £30 million to be shared among cities, encouraging local government and business to participate and bid for funds. The bidding process introduces a free-market mechanism into the distribution of public funds, which helps ensure the money is spent more effectively with locations that match market demand for charging stations.

Tesla's auto-routing software, which helps drivers plan routes that factor in the availability of charging stations, is another example worth examining more closely. By helping car owners more efficiently utilize the few charging stations available, they allow drivers to feel more confident that they'll have enough spots where they can recharge their vehicles, thus removing one of the most significant barriers to purchase.

# Potential initiatives to stimulate EV development in China

Analysis suggests there are a number of initiatives China might consider to stimulate the development of electric vehicles. We discuss below options that could be considered in the near-term, as well as additional options that contain more uncertainty, and which would require further investigation and discussions with industry stakeholders.

## Providing attractive supply as alternatives for ICE

### Give consumers greater choice of locally-produced and imported models to stimulate EV demand and foster healthy industry competition

#### Potential near-term options:

**China might consider opening the national list of qualifying EVs to imported models to stimulate market innovation and demand.** While adoption is nascent and volumes are low, accelerating consumer adoption and encouraging innovation may be more important than the location of production. To mitigate risks to domestic incumbents, China could consider a phased approach, awarding lower subsidies for imported EVs in the beginning to provide time for domestic players to respond.

**The national list and any local variations could be harmonized to further avoid biases toward particular domestic models.** The harmonized list would need to continue to support both BEVs and PHEVs, as both technologies are expected to remain competitive in the foreseeable future.

**China might also consider gradually shortening the national subsidization catalog over time based on increasingly stricter criteria in the areas of performance, safety, and scale, among others.** Similar to the direction proposed by the latest revised draft of the subsidization criteria, this would allow China to focus its subsidies on emerging winners, naturally select out laggards, and incentivize borderline players to become more competitive. A potential risk of this action is the possible reduction of uncompetitive players from the market, leading to the loss of jobs. This option is also more likely to invite protests from less competitive domestic players, who have invested in modifying their ICE offerings to qualify for the EV subsidies.

#### Additional options:

**China might consider exempting imported EVs from tax tariffs to stimulate competition and spur the development of the EV industry.** Similar to the rationale for including imported cars in the national subsidy, such an action would level the playing field and offer the best EV offerings from around the world to Chinese consumers to stimulate adoption. A potential downside to this measure would be the likely reduced willingness of foreign EV players to relocate production to China, which could mean foregone employment and

investment. This could also trigger attempts by imported brands to lobby for the reduction of the ICE tariff, or offer small modifications to their ICE offerings in order to qualify as EV.

**China could use EVs as a test case and open it to 100% foreign ownership, thereby eliminating the need for foreign-local joint ventures.** However, this would likely reduce the government's ability to exercise direct influence over foreign EV players, and could invite objections from existing JVs.

### Consider enabling non-traditional automotive players to compete in order to spur incumbents into taking faster action

Potential near-term options:

**China might consider issuing EV-only production licenses to qualified investors to give non-traditional automotive OEMs and suppliers the opportunity to compete on a level playing field with traditional OEMs.** China's technology companies are currently limited to forming partnerships with manufacturers and suppliers, and are unable to shake up the automotive industry through the design and assembly of innovative vehicles.

## Stimulating demand through recurring incentives

### Consider rolling out a wider range of recurring financial and non-financial incentives to encourage consumer adoption of EVs

Potential near-term options:

**China might consider complementing attractive one-time consumer financial incentives with other recurring consumer financial incentives and non-financial incentives.** Recurring financial incentives might include free or reduced parking fees and highway tolls, utility rebates, and free charging at certain locations. Non-financial incentives may include dedicated traffic lanes and toll booths during certain hours, access to low-emission zones, dedicated parking in public and semi-public parking lots, and the elimination of waiting lists for parking permits.

Industry experts interviewed consider such incentives to be effective in complementing financial incentives as a means to stimulate consumer demand. They suggest **non-financial incentives that address congestion, such as preferential road access and dedicated parking in city centers, are most likely to stimulate demand, followed by recurring financial incentives.** While some cities in China are exploring non-financial incentives on a small scale, China might consider selectively rolling them out to other cities.

## Unlocking development trends by addressing key enablers

Work with stakeholders across the EV ecosystem to define a consistent set of national standards for EV charging and jointly push for faster rollout

### Potential near-term options:

China could ensure the revision of the national EV charging standard covers standardization of payment and membership systems, battery formats, as well as the most frequently cited socket types and communication protocols.

### Additional options:

China could consider mandating all standards to be available at each charging station as an interim solution, as Germany did prior to the complete migration to a unified charging standard. While helpful as an interim solution, this could lead to waste, as duplicate chargers will need to be offered to ensure compatibility prior to the complete migration to a unified standard. Relying on an interim solution such as this might also lengthen the amount of time needed for the migration.

Additionally, to support home charging installations, **China could consider making it mandatory for future apartment complex developers to have major charging-specific power lines pre-wired to the parking lot** to simplify the approval and installation process for EV car buyers. It might also consider subsidizing home charging pole installation for EV car buyers through utility rebates, while enforcing policies to **make it mandatory for existing apartment complexes to approve wire routing of charging stations deemed safe by utilities.**

Finally, **China could also consider mandating – or otherwise facilitating – the collection and sharing of information on charging station locations among OEMs and EV associations.** This, coupled with routing software that can plan routes along the available charging locations, would reduce the number of charging stations needed, increase the utilization of each, and alleviate consumer concerns. However, this measure may entail challenges in coordination and accountability among the various stakeholders.



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