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BRIEFING

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Electric vehicle capitals of the world: What markets are leading the transition to electric?

This briefing identifies 20 cities with the highest electric vehicle uptake through 2016 and examines the associated local policies, incentives, and infrastructure that have helped spur electric vehicle sales growth.

INTRODUCTION

The electric vehicle market continues to expand, with more than two million electric vehicles sold worldwide by early 2017. Automakers continue to make commitments to shift their production to electric drive, and national governments have made ambitious plans to phase out internal combustion vehicles to meet their climate and air quality commitments. Electric vehicle sales are increasing across almost all markets, but are still disproportionately concentrated in a small number of major markets. In 2015, only 14 metropolitan areas accounted for almost a third of all electric vehicle sales.[1]

Cities and local governments around the world continue to develop clean vehicle policies to reduce greenhouse gases, improve air quality, and increase sustainability. Paris, London, Oslo, and Beijing, among others, have announced restrictions on the most polluting vehicles in order to improve air quality. Increasingly, cities are promoting electric vehicles specifically as a solution to environmental issues. Oslo,

1 Dale Hall, Marissa Moultak, and Nic Lutsey, Electric vehicle capitals of the world: Demonstrating the path to electric drive (ICCT: Washington DC, 2017). http://www.theicct.org/EV-capitals-of-the-world

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Los Angeles, Stockholm, Beijing, London, and the San Francisco Bay Area have announced their ambitions to become electric vehicle capitals or leaders. Some cities also have announced specific goals for electric vehicles, as shown in Table 1. In addition to the goals in the table, these and many other cities have goals to transition to electric municipal fleets, electric taxis, and electric buses.

Table 1. Electric vehicle goals announced by selected major cities

City	Target
Amsterdam	Zero-emissions transport within the city by 2025
London	70,000 ultra-low emission vehicles sold by 2020; 250,000 by 2025
Los Angeles	10% of vehicle stock electric by 2025; 25% electric by 2035
New York City	20% electric vehicle sales share by 2025
Oslo	Zero-emissions transport within the city by 2030
Shenzhen	120,000 new energy vehicles sold by 2020
Tianjin	30,000 new energy vehicles sold by 2020

In this briefing, we provide an update on the global electric vehicle capitals—that is, the cities leading the transition to electric drive with greater sales and sales shares than other markets. In determining which cities qualify as capitals, we consider those with the greatest cumulative number of electric vehicles on the road, indicating sustained success, and also emphasize greater recent uptake. Electric vehicle capitals highlighted in this briefing exceeded at least two of the following three conditions: 20,000 cumulative electric vehicle sales through 2016, 3,000 electric vehicle sales in 2016, and 5% electric share of new light-duty vehicles sales in 2016. Using these metrics, we identify 20 electric vehicle capitals: Beijing, Hangzhou, Qingdao, Shanghai, Shenzhen, Taiyuan, and Tianjin in China; Paris, France; Tokyo, Japan; Amsterdam, Rotterdam-The Hague, and Utrecht in the Netherlands; Oslo and Bergen in Norway; Stockholm, Sweden; Los Angeles, New York, San Francisco, and San Jose in the United States; and London, United Kingdom.

We assess electric vehicle sales in these markets through 2016, identify innovative electric vehicle support policies in these markets, and compare their charging infrastructure. In this analysis, electric vehicles include both battery electric vehicles and plug-in hybrid vehicles. We analyze markets at the metropolitan area level because of the regional nature of household travel patterns, to account for the effects of infrastructure and policy beyond the urban city center, and to allow more consistent comparisons across markets. Although the markets are named by the cities throughout, the data are all at the metropolitan area level. We also note that this briefing is focused on light-duty passenger vehicles. Some markets, especially in China, also have large numbers of electric buses and two- and three-wheelers.

ELECTRIC VEHICLE SALES

Figure 1 shows estimated cumulative sales in the 20 electric vehicle capital cities, along with their 2016 share of passenger vehicles. Together, these 20 metropolitan areas account for 40% of the global electric vehicle stock and 43% of electric vehicle sales in 2016, but make up only 3% of the world's population and 8% of light-duty vehicle sales in 2016. Los Angeles leads the world with more than

100,000 cumulative electric vehicle sales, while Shanghai, Beijing, Oslo, and San Francisco each have more than 50,000 electric vehicle sales. The Norwegian cities of Bergen and Oslo had the highest electric vehicle sales shares in 2016 at 36% and 33% respectively, followed by Qingdao at 11% and San Jose at 10%. The 20 electric vehicle capitals are distributed across eight countries on three continents, indicating how electric vehicles are playing an important role in transportation decarbonization in diverse contexts.

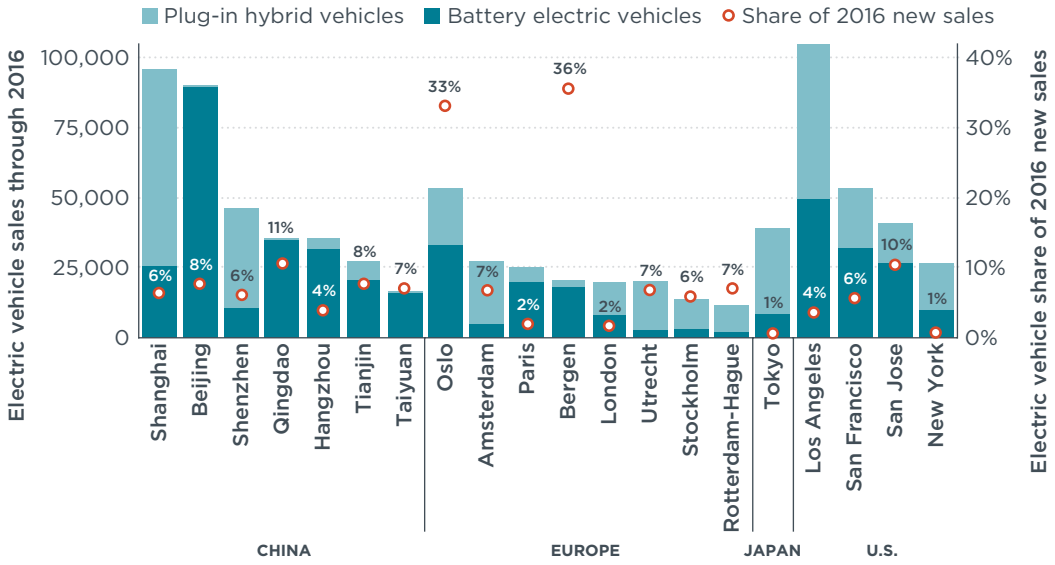

Figure 1. Cumulative electric vehicle sales and 2016 sales share in electric vehicle capital cities.

These cities differ in the makeup of their electric vehicle fleets. In Beijing, Qingdao, and Bergen, battery electric vehicles have made up the vast majority of sales, while in other cities, like Shanghai, Shenzhen, Stockholm, and markets in the Netherlands, plug-in hybrids have been much more popular. These differences, as well as differences in vehicle size, can be explained largely by incentive programs and model availability within different markets.

As previously discussed, almost all of these cities had higher electric vehicle sales shares than their national averages. This difference is most notable in San Jose and San Francisco (11 and 6 times the U.S. average, respectively) and Qingdao and Beijing (8 and 6 times the China national average, respectively). Oslo and Bergen had shares 15%–25% above Norway's 29% sales share, highest among countries. The Paris, London, and Amsterdam areas also were narrowly ahead of their respective national averages.

ACTIONS AND POLICIES

The 20 electric vehicle capitals have used a variety of innovative policies and actions at the local level to drive their respective electric vehicle markets. Before describing the local level policies, we emphasize that these markets all have major national-level policies to ensure that lower-emission and higher-efficiency vehicles continue to

enter the market.[2] Namely, China's fuel consumption standards and its New Energy Vehicle credit system strongly promote electric vehicles all across the country.[3] The European Union's carbon dioxide (CO_2) emission standards ensure advanced low-CO_2 technologies enter the fleet, and the Japan fuel economy standards have promoted vehicle efficiency at a comparable level. The California Zero Emission Vehicle requirements adopted by 10 states in the United States directly require increased deployment of electric-drive vehicles. As a result, each of these regions sees greater deployment of electric vehicles than elsewhere. The major local markets assessed below typically had 20–30 electric vehicle models available by the end of 2016, whereas consumers in most other markets have just a small number of electric models available.

Table 2 highlights several prominent actions and provides examples of their successful implementation. These actions include fleet programs, financial incentives, and nonfinancial benefits. In addition to the highlighted model city, we list other electric vehicle capitals implementing similar policies. This list, although not exhaustive, demonstrates that most capital cities have multiple supporting actions in place across several categories, including incentives, fleet actions, and programs to increase charging infrastructure availability. This aligns with the findings of research on cities in the United States, which indicates that a greater number of actions is correlated with higher electric vehicle uptake.[4,5]

These electric vehicle support actions each address specific needs and all play a role in building a complete market. Electrification of fleets represents a visible commitment at the local level, boosting initial sales while exposing more drivers to such vehicles. Education and outreach campaigns can increase awareness of electric vehicles and their benefits, especially among mainstream consumers and underserved communities. Nonfinancial incentives and driver perks make electric vehicles more attractive to potential buyers, supplementing financial purchase incentives.

2 "Global passenger vehicle standards," International Council on Clean Transportation, http://www.theicct.org/info-tools/global-passenger-vehicle-standards

3 See Hongyang Cui and Hui He, Proposed temporary management regulation for corporate average fuel consumption and new-energy vehicle credits for new passenger cars in China (ICCT: Washington DC, 2017). http://www.theicct.org/proposed-temp-mgmt-regulation-CAFC-and-NEV-credits-china

4 Peter Slowik and Nic Lutsey, Expanding the electric vehicle market in U.S. cities (ICCT: Washington DC, 2017). http://theicct.org/leading-us-city-electric-vehicle-2017

5 Yan Zhou, Danilo Santini, Kelly Vazquez, and Marcy Rood, "Contributing factors in plug-in electric vehicle adoption in the United States: A metro/county level Investigation" (Transportation Research Board, 2017). https://trid.trb.org/view.aspx?id=1439160

Table 2. Innovative electric vehicle support actions and example cities

Policy or program	Model city	Details	Other cities with action
City fleet goal	Los Angeles	Half of city fleet electric as of 2017	Oslo, Amsterdam, San Jose, New York, San Diego, Shenzhen, Tianjin
Taxi electrification	Beijing	Replacing all 69,000 city taxis with electric vehicles through government subsidies	Taiyuan, London, Amsterdam, Hangzhou, Tianjin, Shenzhen, Qingdao
Electric car sharing program	Paris	Autolib' program contains 4,000 cars and 6,000 charge points	Shanghai, Los Angeles, Amsterdam, London, Hangzhou, Beijing, Shenzhen, Tianjin, Qingdao, Taiyuan
Public bus electrification	Shenzhen	All buses zero-emission by October 2017	Los Angeles, London, Shanghai, Beijing, Tianjin, Hangzhou, Qingdao, Taiyuan
Free public charging	Oslo	Free charging with renewable energy at all Level 2 charge points	Stockholm, Bergen
EV-friendly building and parking codes	London	1 in 5 new parking spaces must have an EV charge point	San Francisco, Los Angeles, New York, Shenzhen, Hangzhou, Beijing, Shanghai, Qingdao
Special road or lane access	San Francisco	Electric vehicles may use carpool lanes and pay reduced bridge tolls	Los Angeles, San Jose, Oslo, Shenzhen, Bergen, San Diego, Beijing, Shanghai, Tianjin, Hangzhou, Taiyuan
Vehicle registration benefits	Shanghai	Electric vehicles bypass expensive license plate auction system	Beijing, Shenzhen, Tianjin, Hangzhou
Parking benefits	Amsterdam	Electric vehicles obtain free public parking spots and priority for permits	Shanghai, Utrecht, Oslo, San Jose, Shenzhen, Taiyuan
Local purchase incentives	Qingdao	Local subsidies of $5,000-$9,000 per electric vehicle	Beijing, Shanghai, The Hague, Hangzhou, Tianjin, Shenzhen, Taiyuan

These policies are carefully tailored to fit local contexts. For example, the rugged geography of Norway increases the value of exempting electric vehicles from tunnel and ferry tolls (a policy that has since been scaled back due to the volume of electric cars on the roads). Major cities in China, suffering from heavy congestion and pollution, have implemented strict vehicle registration quotas; exempting electric vehicles from this quota makes them very attractive to residents. Additionally, some of these cities in China allow electric cars to drive even on days when internal combustion engine vehicles are banned to reduce pollution. The congestion in major cities in California makes access to high-occupancy vehicle lanes on freeways a valuable perk. In Amsterdam, electric vehicle drivers have priority for parking permits, while the waiting list for other vehicles can last years.

Naturally, cities benefit from, and are constrained by, policy at the regional and national level. This is especially the case for financial incentives and tax benefits, which frequently are determined by national governments, but are influential in driving electric vehicle sales within cities. The value of financial incentives for electric vehicles in each

capital city is shown in Figure 2.[6] Although most incentives are implemented at the national level, there are some exceptions. For example, cities in China may supplement national incentives for new energy vehicles, some Japanese cities or prefectures have implemented valuable tax exemptions, and The Hague in the Netherlands has added a rebate for battery electric vehicles to the national government's incentives. Other local governments, including Paris, Los Angeles, Taiyuan, and some prefectures in Japan, have made additional benefits available for those who trade in an old or polluting vehicle; such incentives are not included in the figure below.

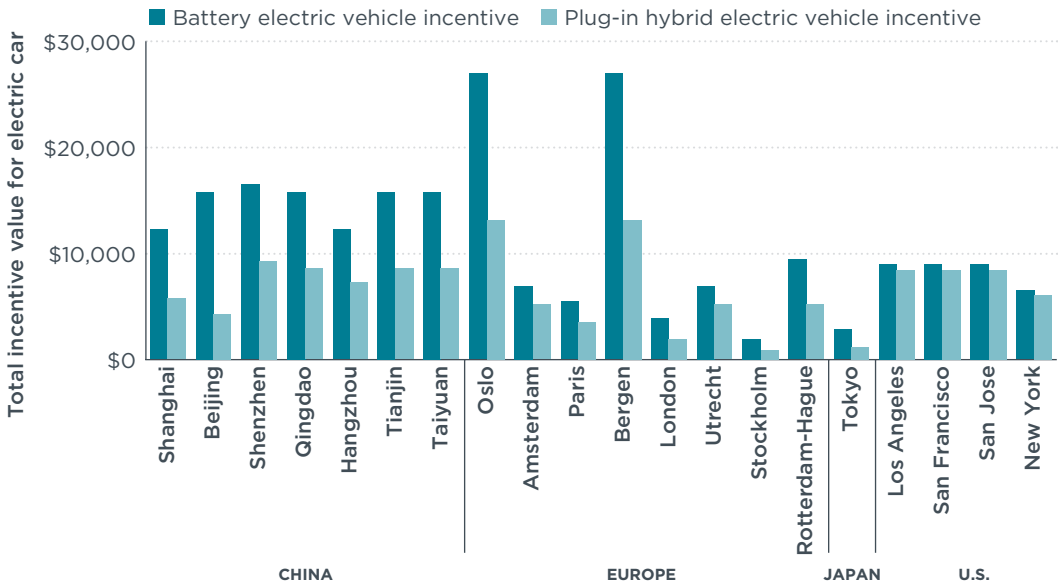

Figure 2. Incentive value for battery electric and plug-in hybrid vehicles in electric vehicle capital cities. All values are in 2016 U.S. dollars, based on representative models for a given market.

CHARGING INFRASTRUCTURE

Electric vehicle charging infrastructure is a key enabler and driver of the electric vehicle market, and public charging especially has been linked to electric vehicle uptake in major markets.[7]

Figure 3 illustrates the amount of public charging infrastructure in electric vehicle capitals in absolute numbers and in per-capita and per-electric vehicle terms. We note that some of the charging points in cities in China, especially the direct current (DC) fast charge points, may be available only to electric buses and not to private electric cars. As shown in the figure, electric vehicle capitals vary widely in concentration and type of charging infrastructure. The need for public charging varies based on housing type, private charging availability, and travel patterns. However, public charging also increases driver range confidence and broader awareness of electric vehicles, creating positive feedback between charging infrastructure and electric vehicle uptake.

6 Details on methodology given in Zifei Yang, Peter Slowik, Nic Lutsey, and Stephanie Searle, Principles for effective electric vehicle incentive design (ICCT: Washington DC, 2016). http://www.theicct.org/principles-for-effective-EV-incentive-design

7 Dale Hall and Nic Lutsey, "Emerging best practices for electric vehicle charging infrastructure" (ICCT: Washington DC, 2017). http://www.theicct.org/emerging-electric-charging-practices

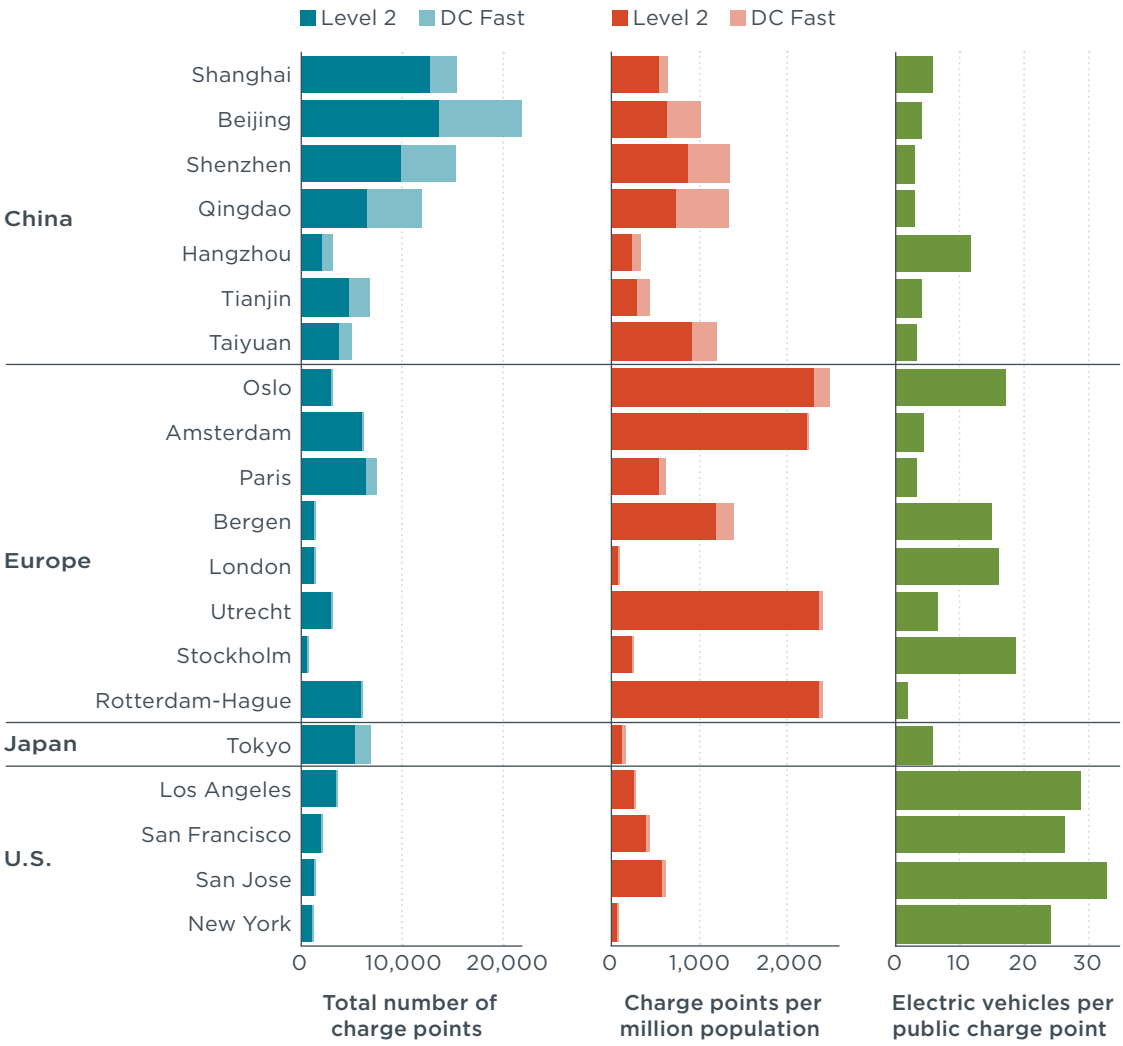

Figure 3. Public electric vehicle charging infrastructure (left), public charge points per million population (center), and ratio of electric vehicles per public charge point (right) in electric vehicle capital cities.

Electric vehicle markets in Norway and the Netherlands have the highest concentration of public charge points, but universal charging benchmarks that span all these global markets are not yet evident. Cities in China have a much higher share of DC fast charge points, at 16%–45% of all public charge points, while only 1%–2% of charge points in cities in the Netherlands are DC fast chargers. Furthermore, the ratio of electric vehicles per charge point (right panel) also varies widely. This ratio is lowest in Utrecht, Rotterdam-The Hague, Amsterdam, and Paris, where many of the charge points are used for overnight street parking, while the ratio is highest in cities in the United States, where private home charging and workplace charging are more common.

As with electric vehicle sales, these cities generally have more extensive charging infrastructure on a per capita basis than other markets. For example, while Tianjin is roughly in line with the average for the rest of China, the other six China capitals have 4–10 times greater charging density. Although the selected markets in California have less charging per capita than other electric vehicle capitals in Europe or China, they have 2–4 times the average for the United States outside of these cities. Additionally,

the California cities rate highly in terms of workplace charging infrastructure. San Jose and San Francisco especially have far greater numbers of workplace charging stations, driven largely by deployment from tech firms there.

REFLECTIONS

Based on this synthesis of electric vehicle uptake data and the underlying support policies in place, we draw five summary reflections:

Just 20 cities account for about 40% of the world's electric vehicles. These cities are each in their own way helping to overcome electric vehicle barriers, propelling the market forward, and leading by example. As shown in Figure 4, these 20 electric vehicle capitals are responsible for 40% of global electric vehicle stock of about 2 million cumulative global passenger electric vehicles in 2016. These diverse cities, representing eight countries across Asia, Europe, and North America, accounted for 43% of electric vehicle sales in 2016.

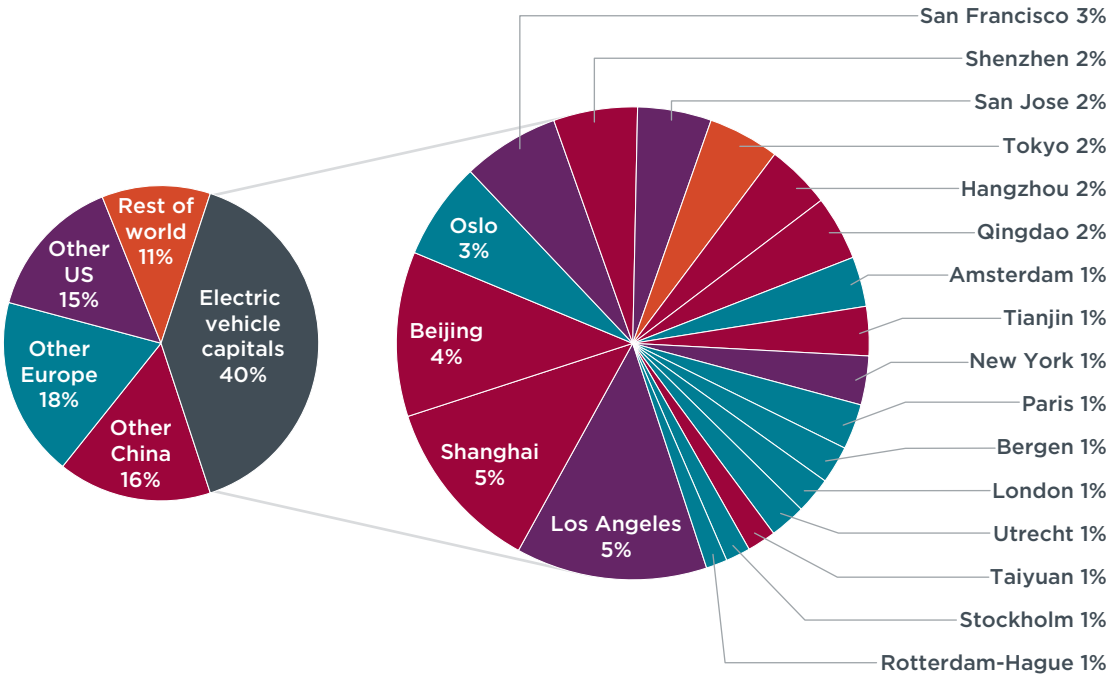

Figure 4. Estimated cumulative electric vehicle sales in electric vehicle capitals, expressed as percentages of the global electric vehicle stock through 2016.

Strong regulatory and fiscal policy has driven the early electric vehicle market. The markets with the highest electric vehicle uptake—in China, Europe, Japan, and the United States—are in regions with a combination of vehicle CO_2 or efficiency regulations, strong consumer incentives, and direct electric vehicle requirements. The U.S. markets especially are supported by the California Zero Emission Vehicle regulation. China has consistently applied strong fiscal incentives and has now adopted its New Energy Vehicle quota scheme that is similar to California's ZEV regulation. Many nations across Europe have spurred the market with some of the most generous incentives. The European Union has had some of the more stringent CO_2 standards and is now considering direct electric vehicle requirements to complement the standards. These regions have each had sustained electric vehicle consumer incentives, typically valued at

$5,000 to $10,000 per vehicle. With the combination of regulatory and fiscal measures, the major local markets typically had at least 17 electric vehicle models available to prospective consumers across several vehicle classes, while the highest-uptake markets in California, China, and Norway had around 30 models available.

Cities are developing innovative ways to support the electric vehicle market. Cities complement the national, provincial, and state actions with policies to fit the local conditions. Cities are electrifying municipal fleets, buses, car-sharing programs, and taxis. Top electric vehicle markets and associated local utilities are deploying public charging infrastructure, as well as indirectly promoting infrastructure by requiring that buildings and parking facilities be wired to support electric vehicles. Cities are providing preferential access for electric vehicles to parking, bus lanes, carpool lanes, and toll roads to steer the vehicle fleet toward electric. Some cities with the most pervasive air quality problems are beginning to authoritatively exercise their control over access to the city. By exempting electric vehicles from strict registration lotteries or auctions, as in Shanghai and Shenzhen, cities shift the market and send a strong signal that electric vehicles are the future. Cities like Paris and London have even indicated their intention to restrict high-polluting combustion vehicles and preferentially admit electric vehicles.

Accelerating the transition to electric requires a comprehensive suite of actions. Greater electric vehicle adoption faces barriers of model availability, cost, convenience, and consumer understanding. A portfolio of actions, offered by multiple players, is in place in all the leading markets. National policies spur electric vehicle investment, deployment, and availability. Consumer incentives ensure that electric vehicles are affordable in the near term, as their costs continue to drop. Governments and utilities are helping to build out the necessary charging infrastructure to ensure the convenience of electric vehicles is fully realized. Local policies especially are increasing awareness that electric vehicles are here today and offer substantial benefits to consumers. The California cities exemplify the broad approach across state and local agencies, electric power utilities, private companies, and nonprofit organizations.

***Electric vehicle adoption and benefits have not yet reached most emerging markets*.** Although the transition to electric drive is taking hold in new markets, this market development is greatly disproportionate: The 20 leading markets with more than 40% of all electric vehicles account for just 3% of the global population and 8% of 2016 passenger vehicle sales. The cities are predominantly in China, Europe, Japan, and the United States, countries with a strong desire to develop the electric vehicle market for environmental and industrial policy reasons and the ability to provide incentives. As electric vehicles become more affordable, emerging markets beyond China will need to adopt innovative policies that are tailored to their local conditions to see similar growth and benefits.

Cities as diverse as Amsterdam, London, Los Angeles, New York City, Oslo, and Shenzhen have set ambitious goals for electric vehicle uptake and are backing up these goals with action. The path ahead toward full electrification will surely require sustained efforts with policy, much greater electric vehicle infrastructure build-out, and broader awareness as lower-cost and longer-range electric vehicles enter the fleet. Beyond persistence in these actions, integrating electric drive with autonomous and shared mobility presents still greater opportunities and challenges. While the transition to electric is still in its early phases, early market successes point to a future with many more electric cars as the technology advances and supporting policies become more widespread.