BRIEFING

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Evaluating electric vehicle market growth across U.S. cities

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This briefing analyzes the development of the U.S. electric vehicle market in 2020 and the underlying state, city, and utility actions that were driving it.

INTRODUCTION

Despite the unprecedented global economic downturn caused by the COVID-19 pandemic, the global transition to electric vehicles maintained its momentum in 2020. About 3.1 million new plug-in electric vehicles were sold worldwide in 2020, representing about 4.2% of light-duty vehicle sales and an increase from 2.2 million in 2019.[1] While overall light-duty vehicle sales volumes were down across the industry, the growth of the electric vehicle market persisted and related automaker investments are accelerating.[2] With nearly 330,000 new sales in 2020, the United States is the third largest electric vehicle market, with about one quarter the sales of both China and Europe.

Figure 1 shows the annual electric vehicle sales in the United States from 2010 through 2020. The market has grown from a few thousand vehicles in 2010 to more than 315,000 vehicles sold annually from 2018 to 2020. In 2020, the electric share of new vehicle sales was approximately 2.4% in the United States, an increase from about 2% in 2019. The twelve companies highlighted in Figure 1 together accounted for 98% of the electric vehicles sold in the country. The Tesla Model 3 was the highest-selling model, with about 96,000 new sales in 2020, followed by the Tesla Model Y with 75,000 sales, and the Chevrolet Bolt with approximately 21,000 sales. Other high-selling electric models with between 10,000 and 20,000 sales in 2020 included the Tesla Model X, Toyota Prius Prime plug-in hybrid, and Tesla Model S. In 2020, battery-electric vehicles (BEV) made up 78% of sales, while plug-in hybrid electric vehicles (PHEV) represented 22%.

1 EV-Volumes (EV Data Center, 2020), http://www.ev-volumes.com/datacenter/.

2 Anh Bui, Peter Slowik, and Nic Lutsey, Powerplay: Evaluating the U.S position in the global electric vehicle transition, (ICCT: Washington, DC 2021), https://theicct.org/publications/us-position-global-ev-jun2021

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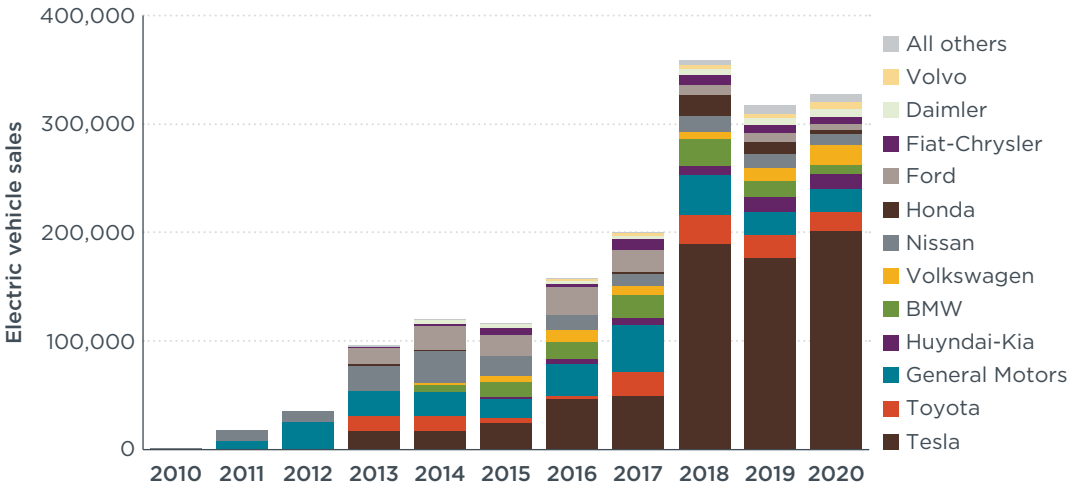

Figure 1. Automaker electric vehicle sales in the United States through 2020. Vehicle sales data are from EV-Volumes, 2021.

Electric vehicle model availability in the United States in 2020 was similar to 2019. The number of electric vehicle models with more than 1,000 sales increased from 29 in 2019 to 31 in 2020. In 2020, there were 59 models available, with at least one sale, and 12 models had more than 4,000 sales. Electric vehicle model availability in Europe and China, where incentives and regulations promoting electric vehicle sales are stronger, was about three to five times higher: Europe and China had 180 and 300 electric vehicle models with at least one sale, and 77 and 63 models that had more than 4,000 sales, respectively, in 2020.[3] The introduction of more electric models across more segments and in greater volumes is critical for electric vehicle market expansion. This is demonstrated by the 2020 introduction of the Tesla Model Y crossover sport utility vehicle, which immediately became the second-highest selling electric model. The more limited availability of other new 2020 PHEV model offerings such as the BMW X3 30e, Toyota RAV4, and Audi Q5 across the country resulted in sales of 2,500 to 4,000 in 2020.

Government policies are critical to reducing consumer barriers related to inadequate electric vehicle model availability, higher upfront costs, range and range anxiety, and lack of awareness and understanding. Despite the uncertainty posed by the Trump Administration's rollback of U.S. fuel economy standards and the lack of federal leadership on electric vehicles,[4] state and local stakeholders in the electrification transition increased their supporting activities. An increasing number of state and local authorities have announced their vision for all-electric mobility, adopted clean car and zero-emission vehicle regulations, and implemented stronger policies to increase infrastructure investment and electric vehicle market growth.

This briefing is an update of our annual U.S. electric vehicle market analysis of state, local, and utility company actions to promote electric vehicles. As done in our previous analyses, we assess relationships between electric vehicle uptake and various underlying factors including incentives, charging infrastructure, and regional policy

3 EV-Volumes (EV Data Center, 2020), http://www.ev-volumes.com/datacenter/.

4 Aaron Isenstadt and Nic Lutsey, Summary of the Trump Administration's fatally flawed U.S. light-duty vehicle efficiency standards, (ICCT: Washington, DC, 2020), https://theicct.org/publications/fatally-flawed-trump-NHTSA-analysis

actions.[5] The analysis is based on updated data to identify the latest market trends and best practice policy activities in 2020. The analytical focus is primarily on the 50 most populous U.S. metropolitan areas, which collectively accounted for about 55% of the nation's population and 77% of 2020 electric vehicle sales.[6]

INFRASTRUCTURE DEPLOYMENT, SUPPORTING POLICIES, AND ELECTRIC VEHICLE UPTAKE

This section summarizes key data on charging infrastructure deployment, electric vehicle policy support activities, and electric vehicle uptake. Policy data collected include 50 unique state, city, and utility actions that span across the 50 most populous metropolitan areas.

CHARGING INFRASTRUCTURE

Greater and more widespread electric vehicle adoption results in increased needs for charging infrastructure across various locations, including home, workplace, and public. Deploying infrastructure in line with electric vehicle growth is critical to ensure driver convenience and increase confidence and awareness among prospective drivers.

To assess the relative deployment of charging infrastructure across the major metropolitan areas, we evaluate the number of public and workplace chargers per million population, using data from PlugShare.[7] The unit of analysis is the number of chargers, as opposed to plugs, due to the increasing prevalence of dual-head chargers that typically do not allow for the charging of two vehicles simultaneously. The categorization of "public" and "workplace" charging is consistent with our previous analysis.[8] PlugShare is the most comprehensive data source available with detailed categorization of charging facilities by type and location. However, the data are based on voluntary user-update charger information, and there is evidence that the actual number of workplace and public chargers deployed are greater than what is reported here.[9] Previously, our infrastructure estimates were based on data from the U.S. Department of Energy Alternative Fuels Data Center (AFDC). Compared to AFDC, the PlugShare data include about 24% more public (including Level 2 and DC fast) chargers through 2020.

Figure 2 illustrates the number of public direct current (DC) fast, public Level 2, and workplace chargers per million population, based on PlugShare data in the 50 most populous metropolitan areas.[10] The areas are ordered from top to bottom based on the sum of public and workplace charging per capita. The 2020 U.S. average of 57 DC fast,

5 Most recently Anh Bui, Peter Slowik, and Nic Lutsey, Update on electric vehicle adoption across U.S. cities, (ICCT: Washington, DC, 2020), https://theicct.org/publications/ev-update-us-cities-aug2020

6 Population data is from U.S. Census Bureau, "Metropolitan and Micropolitan Statistical Area Population Totals: 2010-2020" (2021), https://www.census.gov/programs-surveys/popest/technical-documentation/research/evaluation-estimates/2020-evaluation-estimates/2010s-totals-metro-and-micro-statistical-areas.html

7 Charging data are from PlugShare (2021), https://www.PlugShare.com/.

8 Peter Slowik and Nic Lutsey, The continued transition to electric vehicles in U.S. cities, (ICCT: Washington, DC, 2018), https://theicct.org/publications/continued-EV-transition-us-cities-2018

9 Gordon Bauer, Chih-Wei Hsu, Michael Nicholas, and Nic Lutsey, Charging up America: Assessing the growing need for U.S. charging infrastructure through 2030, (ICCT: Washington DC, 2021), https://theicct.org/publications/charging-up-america-jul2021; Bingzheng Xu, Adam Davis, and Gil Tal, Estimating the Total Number of Workplace and Public EV chargers in California, (University of California Davis: Davis 2021), https://trid.trb.org/view/1759518

10 Population data is from U.S. Census Bureau, "Metropolitan and Micropolitan Statistical Area Population Totals: 2010 -2020" (2021).

248 public Level 2, and 82 workplace chargers per million population is shown near the middle. Overall U.S. public DC fast, Level 2, and workplace charging per capita in 2020 were up approximately 36%, 28%, and 19%, respectively, compared to 2019.

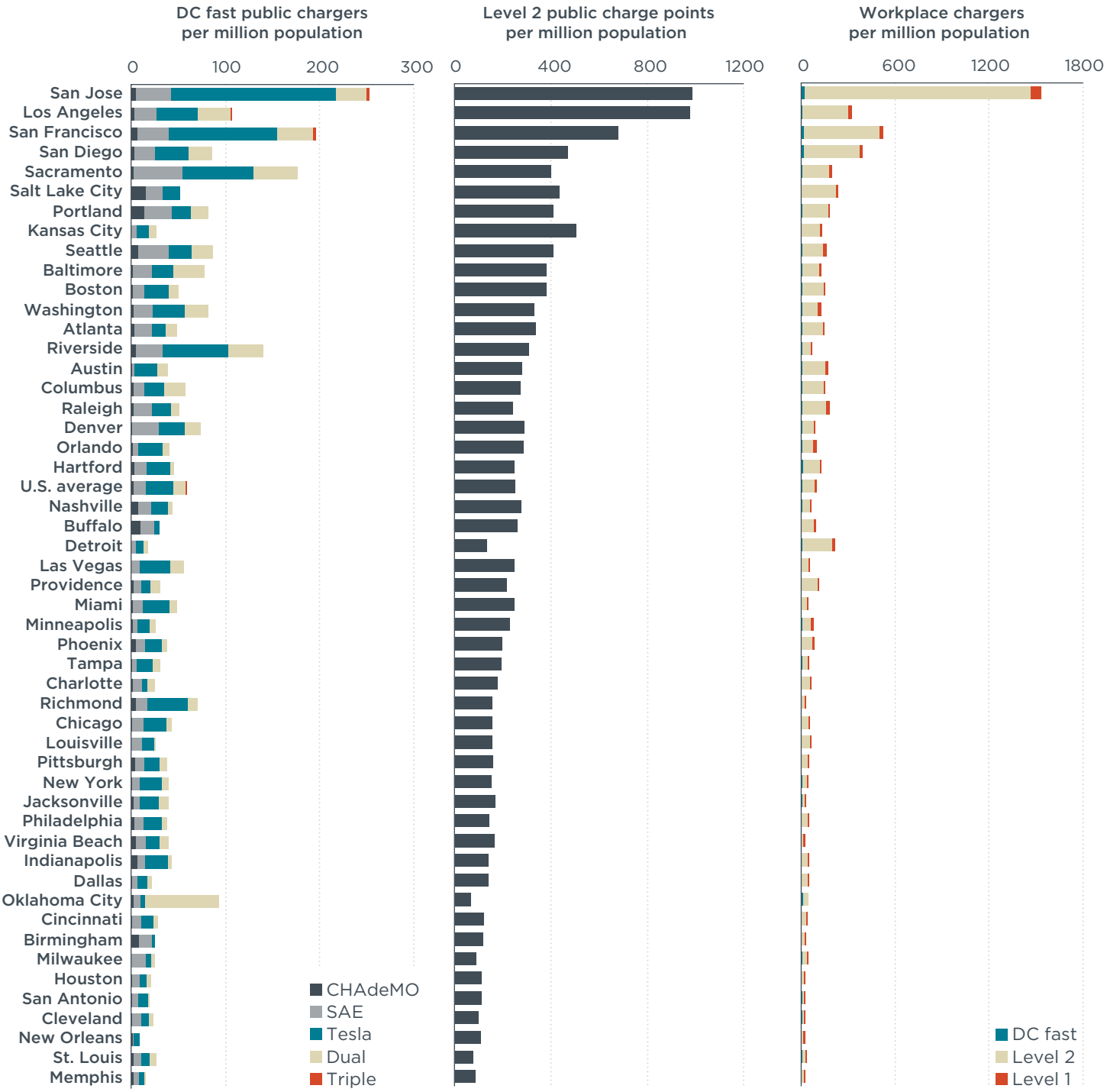

Figure 2. Public (DC fast and Level 2) and workplace chargers per million population in 2020 in the 50 most populous U.S. metropolitan areas. Data are from PlugShare.

Overall, public DC fast chargers made up about 16% of public chargers in the 50 metropolitan areas, while Level 2 chargers accounted for about 84%. San Jose, San

Francisco, Sacramento, Riverside, and Oklahoma City had the most DC fast chargers, with 93 to 253 DC fast chargers per million population. The public DC fast charging infrastructure deployment in these areas equates to about 1.6 to 4.5 times the U.S. average public Level 2 charging per capita. Areas with the most public Level 2 charging include San Jose, Los Angeles, San Francisco, San Diego, Salt Lake City, and Kansas City, with 400 to 985 chargers per million population. These areas had about 1.6 to 4 times the U.S. average public Level 2 charging per capita.

In terms of workplace charging, San Jose stands out with more than 1,500 chargers per million population. Other areas with relatively high workplace charging include Los Angeles, San Francisco, San Diego, Salt Lake City, and Detroit, with 210 to 520 chargers per million population. These levels of workplace charging per capita, excluding San Jose, are 2.5 to 6 times the U.S. average, and 1.5 times the average of the 50 metropolitan areas shown. Overall, about 91% of workplace chargers are Level 2, and the rest are a mix of DC fast and Level 1. The top five areas had about 11 times more total public and workplace chargers per capita than the bottom five areas.

The leftmost panel of Figure 2 shows the breakdown of public DC fast chargers, including CHAdeMO, SAE Combo, Tesla, dual, and triple. Dual-head DC fast chargers typically include one CHAdeMO connector and one SAE Combo connector, while triple-head DC fast chargers include one CHAdeMO, SAE Combo, and Tesla connector. Overall, across the 50 areas, about 46% of public DC fast chargers are Tesla connector, followed by SAE Combo at 25%, dual-head at 23%, CHAdeMO at 5.6%, and triple-head at approximately 0.2%.

Total public and workplace charging across the 50 metropolitan areas increased by about 30% from 2019 to 2020. This annual growth rate is approximately in line with the estimated charging needed by 2030.[11] Areas with the highest annual growth rates from 2019 to 2020 are Buffalo, Oklahoma City, Providence, and Los Angeles with growth rates of 45% to 90%. This momentum of growth in infrastructure deployment was accompanied by growth in approved utility infrastructure investments, with a three-fold increase in 2020 compared to 2019, which will ensure continued charging infrastructure deployment.[12] The relationship between electric vehicle uptake and public and workplace charging infrastructure is explored in sections below.

SUMMARY OF ELECTRIC VEHICLE SUPPORT ACTIVITIES

Table 1 summarizes the 50 unique electric vehicle policy activities that are tracked in this analysis, categorized by state, local, and utility actions, implemented in the 50 metropolitan areas. Only actions in place for more than half of calendar year 2020 are included. In addition to the 48 actions from the similar previous 2020 ICCT paper,[13] we include data on whether cities have conducted charging gap analysis and pledged to implement zero-emission areas in their jurisdictions.

11 Bauer, Hsu, Nicholas, and Lutsey, Charging up America: Assessing the growing need for U.S. charging infrastructure through 2030.

12 Atlas EV Hub (Electric utility filings, 2020), https://www.atlasevhub.com/materials/electric-utility-filings/

13 Bui, Slowik, and Lutsey, *Update on electric vehicle adoption across U.S. cities*

Table 1. Electric vehicle promotion actions across major U.S. metropolitan areas

Metropolitan area	State action																	Local action																											Utility action													Total actions (out of 50)
	State ZEV program	State International ZEV Alliance participation	State U.S. Climate Alliance participation	State low carbon fuel policy	State BEV purchase incentive	State PHEV purchase incentive	State increased incentive for low-income	State fee reduction or testing exemption	No state annual electric vehicle fee	State private charger incentive or support	State public charger promotion or support	State parking benefit	State fleet purchasing incentive	State manufacturing incentive	State allows direct sales to consumers	State ZEV funding from VW mitigation plan	State electric vehicle strategies	City quantitative electric vehicle goals	City electric vehicle strategies	City charging gap analysis	Streamlined EVSE permitting process	EV-ready building code	City EV purchase incentive	City parking benefit	City charger incentive or support	City toll reduction benefit	City carpool lane (HOV) access	City-owned EV chargers	City electric ride-hailing program or pilot	City electric carsharing program	City curbside, streetlight or right of way charging program	City informational materials	City outreach events	City outreach events with equity focus	City electric vehicle fleet or procurement target	City electric buses in public transportation	City green and healthy streets pledge	Utility electric vehicle strategies	Utility public charging infrastructure	Utility public charging infrastructure in low-income communities	Utility time of use rates offered	Utility preferential EV rates	Utility EV purchase incentive	Utility residential charger incentive or support	Utility increased charger incentive at multifamily properties	Utility commercial charger incentive or support	Utility EV info materials or outreach events	Utility EVSE info materials or support at multifamily properties	Utility cost comparison tool	Utility electric vehicle fleet	
Los Angeles	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x				x	x	x	x				x	x	x							x	x	x	x	x	x	x	x	x	x	x	44
Sacramento	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x		x			x	x	x													x	x	x	x	x	x	x	x	x	x	x	42
San Francisco	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x				x	x	x	x	x	x	x		x	x							x	x	x	x	x	x	x	x	x	x	x	42
San Jose	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x		x	x	x	x		x		x	x	x						x	x							x	x	x	x	x	x	x	x	x	x	x	39
San Diego	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x		x		x	x				x	x	x	x	x				x	x							x	x	x	x				x	x	x	x	36
Riverside	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x				x	x	x				x	x				x						x	x	x	x	x	x		x	x	x	x	x	x	x	34
Portland	x	x	x	x	x	x	x	x			x		x		x		x	x	x	x	x	x						x	x		x	x	x					x	x	x	x	x					x	x	x	x	33
Seattle	x	x	x		x	x				x	x		x	x	x		x	x	x	x	x	x						x	x		x	x	x	x	x	x			x	x								x	x	x	x	31
New York	x	x	x		x	x		x	x	x	x		x		x	x	x	x			x	x			x	x			x	x					x	x							x		x	x				x	x		x	29
Boston	x	x	x		x	x		x	x	x	x		x		x	x						x						x	x					x	x							x	x	x	x				x	x	x	x	27
Denver	x		x		x	x		x		x	x		x		x	x	x	x				x						x	x					x	x									x	x	x				x	x	x	x	26
Baltimore	x	x	x		x	x		x	x	x	x		x		x	x			x									x						x								x		x	x					x	x	x	x	24
Salt Lake City								x		x	x				x	x	x		x			x	x			x	x	x						x								x		x	x		x	x	x	x		x	x	24
Buffalo	x	x	x		x	x		x	x	x	x		x		x	x	x											x				x										x		x	x		x	x	x	x		x	x	23
Washington					x	x		x	x	x	x		x		x									x		x	x				x			x	x							x		x	x		x	x		x		x	x	22
Austin								x	x										x								x	x		x	x	x		x		x	x	x	x		x	x	x	x				x	x	x	x	20
Philadelphia			x		x	x	x		x	x	x		x		x		x										x				x			x	x										x			x	x	x	x	19
Pittsburgh			x		x	x	x		x	x	x		x		x		x										x					x		x											x			x	x	x	x	19
Phoenix								x	x	x	x	x			x											x	x						x											x	x	x	x				x	x	x	x	18
Atlanta								x						x	x				x		x	x					x	x				x			x										x			x				x	x	x	x	18
Minneapolis			x												x		x								x	x		x		x			x	x	x											x	x	x	x	x	x	x	x	18
Las Vegas			x					x	x		x				x	x	x											x					x											x			x	x			x	x	x	x	18
Providence	x	x	x					x	x	x	x				x	x	x														x	x		x	x																	x	x	x	18
Hartford	x	x	x		x	x		x	x	x			x	x			x											x				x																	x	x			x	17
Chicago			x					x			x		x		x						x	x					x				x			x	x																x	x	x	x	17
Charlotte			x					x			x				x		x		x		x					x	x				x			x																x		x	x	16
Raleigh			x					x			x				x		x		x		x		x			x	x				x																				x		x	x	16
Columbus															x		x	x	x		x			x			x			x	x	x		x				x	x											x	x	x	16
New Orleans					x	x			x	x	x										x						x			x				x																			x	x	x	15
Detroit			x								x			x	x																			x	x																			x	x	x	15
Richmond			x						x		x		x		x	x											x	x				x	x																							x	x	14
Miami									x						x	x				x			x				x					x		x																					x	x	13
Orlando									x						x	x				x							x					x		x	x																					x	x	13
Houston								x	x									x	x	x	x							x		x			x																							x	x	13
San Antonio									x														x					x			x	x	x		x																					x	x	11
Virginia Beach			x						x		x		x		x	x											x																													x	x	11
Indianapolis															x			x										x				x	x	x		x	x																					10
Louisville									x																							x	x	x	x		x																			x	x	10
Cincinnati															x				x				x				x					x	x		x																					x	x	10
Dallas								x	x																		x		x				x			x																			x		10
Oklahoma City										x	x		x			x																x																							x	x	9
Nashville															x		x						x				x					x	x																						x		9
Milwaukee			x					x																			x					x	x		x																					x		9
Tampa									x						x	x											x					x																							x	x	x	8
St. Louis															x																	x			x																					x	x	x	8
Memphis															x		x	x									x					x																							x		x	8
Jacksonville									x						x	x																																							x			7
Kansas City															x												x					x			x																					x			7
Birmingham																															x																							x			6
Cleveland								x							x																x																							x			6

Notes: "X" indicates that a given electric deployment action was in place in 2020. ZEV = zero emission vehicle; BEV = battery electric vehicle; PHEV = plug-in hybrid electric vehicle; VW = Volkswagen; HOV = high-occupancy vehicle; EVSE = electric vehicle service equipment

States, cities, and utilities continue to implement more electric vehicle promotion actions, although the relative number of actions varies greatly. As indicated in Table 1, six California cities had the most actions in place, with 34 to 44. Portland, Seattle, New York, Boston, Denver, Baltimore, Salt Lake City, and Buffalo had 23 to 33 actions. Among the major actions, at the end of 2019, Colorado became the eleventh U.S. state to adopt the Zero Emission Vehicle regulation, requiring increasing shares of electric vehicles in future years. Washington legislatively adopted the ZEV regulation in early 2020 and reinstated its electric vehicle sales tax exemption for used and new electric vehicles in late 2019.

Most metropolitan areas saw the adoption of several new policy actions in 2020. Seattle had the greatest annual increase in new actions, with five new state and local policy actions, including purchase incentives and a city charging gap analysis, from 2019 to 2020. Los Angeles, Richmond, and Washington, D.C. had two to three additional actions in place compared to 2019. Los Angeles offered increased utility incentives for charging at multifamily properties, Washington, D.C. provided utility incentives for residential and multifamily chargers and increased consumer awareness and education with online tools, and Richmond benefited from new charging and fleet actions at the state level in Virginia.

Cities are increasingly setting targets for electric vehicle adoption and planning accordingly with electric vehicle action plans. Recognizing that electric vehicles and charging infrastructure must grow in unison, seven cities had conducted a charging gap analyses in 2020, quantifying the number, type, and distribution of chargers needed, to guide infrastructure planning. Some cities are taking bolder steps to accelerate the shift to zero-emission mobility. Of the 50 areas, Austin, Los Angeles, and Seattle are signatories to C40's Fossil-Fuel-Free Streets Declaration, pledging to only procure zero-emission buses by 2025 and to ensure a major area of their cities are zero emission by 2030.[14]

Due to COVID-19 restrictions, many cities took innovative approaches to outreach with virtual events and conducted outreach with an equity focus. San Francisco provided informational sessions about electric vehicles both in English and Spanish. Seattle partnered with local community-based organizations to offer Spanish virtual events about benefits of electric vehicles and fair financing programs for buyers. Minneapolis conducted surveys in languages used by underserved communities and facilitated community engagement to understand, improve, and expand mobility options that the residents need.[15]

There were several additional policy developments that were adopted in late 2020. As they were not in place for more than half the year, such actions are not captured in Table 1. Boston released its electric vehicle roadmap in November 2020. Annual electric vehicle fees in California and Virginia went into effect in July and are not included. Baltimore, St. Louis, and Columbus introduced electric buses in late 2020,

14 "Fossil Fuel Free Streets Declaration", C40 Cities, accessed May 20th, 2021, https://www.c40.org/other/green-and-healthy-streets

15 "Taller de Incentivos Financieros Para Vehíchulos Eléctricos", SF Environment, accessed May 20th 2020, https://sfenvironment.org/event/taller-de-incentivos-financieros-para-vehiculos-electricos; "Cities turn to virtual electric vehicle education in 2020", Kelly Blynn, accessed May 20th 2020, https://www.nrdc.org/experts/kelly-blynn/cities-turn-virtual-electric-vehicle-education-2020; "Introducing the EV Spot Network", City of Saint Paul, accessed May 20th 2020, https://www.stpaul.gov/departments/public-works/transportation-and-transit/ev-spot-network

while Jacksonville, Orlando, and Tampa received state grants for electric buses procurement, demonstrating increasing momentum toward public buses electrification.

Several cities have adopted quantitative electric vehicle sales goals and strategies to identify near-term actions and plan for market growth. Table 2 shows eleven such areas. Denver, Los Angeles, and Sacramento aim for 15%, 25% and 35%, respectively, of all registered vehicles to be zero emission by 2025. In terms of electric vehicle sales share goals, Boston has a goal of 23% of new vehicle sales to be electric by 2025, New York City of 25% by 2025, Houston of 30% by 2030, and San Francisco of 50% by 2025 and 100% by 2030.

Table 2. Examples of city electric vehicle goals and strategies

City	Goal	Strategy	Strategy details
Boston	23% of new vehicle purchased are electric by 2025. Deploy 1,055 Level 2 and 320 DC fast chargers by 2025. 100% LDV municipal fleet electric by 2035	2020 zero-emission vehicle roadmap	Established 13 future actions to support widespread electrification and ensure affordable and convenient access to infrastructure.
Columbus	1.8% ownership by 2020. Deploy 900 public charging stations.	Publicly available ongoing and completed projects	Published playbooks identifying success and lessons learned from projects
Denver	15% of total registration by 2025, 30% by 2030, and 100% by 2050. 100% in city fleet by 2020	Opportunities for vehicle electrification in Denver Metro area and across Colorado	Discusses steps to address DC fast charging availability and multi-family housing charging access barriers
Houston	30% of new vehicle sales by 2030	Evolve Houston electric vehicle roadmap	Outlines awareness, affordability, and availability actions, with suggested key stakeholders
Los Angeles	25% of total registrations are ZEVs by 2025, 80% by 2035, and 100% by 2050. Deploy 10,000 public chargers by 2022; 28,000 chargers by 2028.	L.A.'s Green New Deal	Establishes targets with initiatives from 2021 to 2030
Memphis	5% of vehicle travel by 2025, 30% by 2035, and 50% by 2050	None identified	None identified
New York	20% of new registrations electric by 2025. Deploy 50 DC fast chargers citywide by 2020	$10 billion to install fast charging stations	None identified
Portland	Replace at least 10,000 vehicles. Double public Level 2 and DCFC. 30% in city fleet by 2020	2017 City of Portland electric vehicle strategy	Details 49 unique actions with lead bureaus
Sacramento	35% of total registrations are ZEVs by 2025	Electric vehicle strategy	Outlines 8 core performance targets with lead department and entities
San Francisco	50% of new registrations by 2025 and 100% by 2030	Proposed electric vehicle roadmap for San Francisco	Establishes 6 main strategies with lead and support authorities
Seattle	30% total registrations by 2030	Drive Clean Seattle Implementation Strategy	Coordinates 5 implementation actions with lead departments

Table 2 also lists several city electric vehicle strategy documents, which detail cities' goals and outline the actions needed to overcome barriers and accelerate market

growth.[16] One example is Boston's new zero-emission vehicle roadmap which outlines three main goals for transportation electrification: supporting widespread adoption of electromobility, ensuring equitable access to charging, and electrifying the municipal fleet. To meet these goals, Boston's roadmap identifies 13 main actions that target electric ride-hailing, carsharing, and micro-mobility programs, car dealership engagement, support for consumers' charging rights at rental properties, infrastructure deployment, and fleet procurement strategies.

ELECTRIC VEHICLE UPTAKE

In 2020, electric vehicle uptake across the United States was approximately 2.4%, an increase from 2% in 2019.[17] The 50 most populous metropolitan areas accounted for about 77% of new 2020 electric vehicle registrations, approximately 61% of the total light-duty vehicle market, and 55% of the U.S. population. These 50 areas together had electric vehicle uptake of roughly 3.2%, more than five times the 0.6% uptake in the rest of the country. Estimates of new 2020 electric vehicle sales at the metropolitan area level are based on a variety of sources. Estimated metropolitan area-level electric vehicle data are approximated from 2020 state-level new vehicle registration data from the Alliance for Automotive Innovation and 2019 electric vehicle uptake data at the metropolitan area level,[18] with corroboration from other available data sources.[19]

Figure 3 shows the 2020 estimated electric vehicle share of new vehicle sales across the more than 900 metropolitan statistical areas. The 50 most-populous areas are labeled. At the metropolitan level, areas on the West Coast tend to have the highest uptake, with additional hotspots in Colorado, Utah, Hawaii, and the Northeast. San Jose had the highest share at about 21%, followed by the other California areas San Francisco, San Diego, Los Angeles, and Sacramento, as well as Seattle and Portland, with uptake ranging from about 4.8% to about 12%. Other areas with above national average uptake include Denver, Boston, Washington, D.C., Boston, Austin, Las Vegas, Phoenix, Salt Lake City, Raleigh, and New York City. In terms of new sales in 2020, the

16 City of Boston, "Zero-emission vehicle roadmap" (2020), https://www.boston.gov/sites/default/files/file/2020/12/Boston%20ZEV%20Roadmap_1.pdf; "Electric vehicle charging infrastructure", City of Columbus, accessed May 26, 2020, https://smart.columbus.gov/projects/electric-vehicle-charging-infrastructure; City and County of Denver Department of Environmental Health & Southwest Energy Efficiency Project, "Opportunities for vehicle electrification in the Denver Metro area and across Colorado" (2017), https://www.denvergov.org/content/dam/denvergov/Portals/771/documents/EQ/EV/EVFinalReport.pdf; Evolve Houston, "Electric vehicle roadmap" (2019), https://www.evolvehouston.org/; Los Angeles Mayor's Office of Sustainability, "L.A.'s Green New Deal" (2019), https://plan.lamayor.org/sites/default/files/pLAn_2019_final.pdf; "Climate Action Plan", City of Memphis, accessed May 26, 2020, https://memphistn.gov/news/what_s_new/climate_action_plan; "Electric vehicle charging hubs", New York City Mayor's Office of Sustainability, accessed May 20th 2020, https://www1.nyc.gov/site/sustainability/our-programs/ev-charging.page; Portland Bureau of Planning and Sustainability, "2017 City of Portland electric vehicle strategy" (2016), https://beta.portland.gov/sites/default/files/2019-07/final_electric-vehicle_report2016_web.pdf; City of Sacramento, "Electric vehicle strategy" (2017), https://www.cityofsacramento.org/-/media/Corporate/Files/Public-Works/Electric-Vehicles/EVStrategy_171206_FINAL_DRAFT_CityOfSacramento.pdf; San Francisco Mayor's electric vehicle working group, "Proposed electric vehicle roadmap for San Francisco" (2019), https://sfenvironment.org/sites/default/files/fliers/files/sfe_tr_ev-roadmap.pdf; Seattle Office of Sustainability & Environment, "2017 Drive Clean Seattle Implementation Strategy" (2017), https://www.seattle.gov/Documents/Departments/Environment/ClimateChange/Drive_Clean_Seattle_2017_Report.pdf

17 Measured as the percentage of new light-duty vehicle registrations that are plug-in electric, including BEVs and PHEVs. 2020 registration data are derived from Alliance for Automotive Innovation's Electric vehicle sales dashboard, https://www.autosinnovate.org/resources/electric-vehicle-sales-dashboard, and 2019 metro and state electric vehicle sales from Bui, Slowik and Lutsey, Update on electric vehicle adoption across U.S. cities.

18 U.S. Light-Duty Advanced Technology Vehicle (ATV) Sales (2011-2020) Dashboard (Alliance for Automotive Innovation, 2020), https://www.autosinnovate.org/resources/electric-vehicle-sales-dashboard and Anh Bui, Peter Slowik, and Nic Lutsey, *Update on electric vehicle adoption across U.S. cities*

19 Atlas EV Hub (Automakers Dashboard, 2020), https://www.atlasevhub.com/materials/automakers-dashboard/; California New Car Dealers Association, (California Auto Outlook, 2020), https://www.cncda.org/wp-content/uploads/Cal-Covering-4Q-20.pdf

Los Angeles area was the largest with about 46,000 electric vehicles, followed by San Francisco with about 24,000, New York with about 23,000, San Jose with about 16,500, and Washington, D.C. with about 11,000.

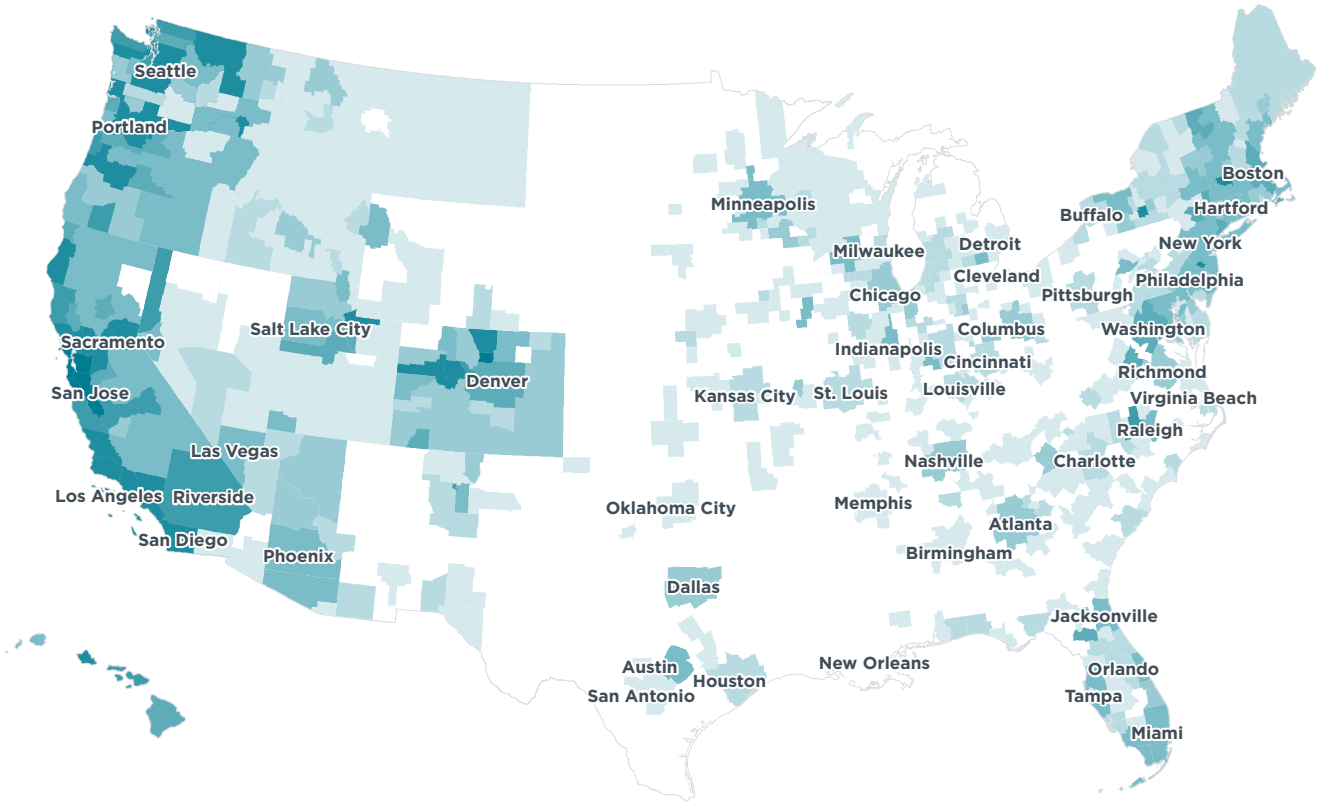

Figure 3. Electric vehicle shares of new 2020 vehicle registrations by metropolitan area.

Compared to 2019, many states observed growth in sale shares in 2020. New York, Florida, Pennsylvania, and Rhode Island had growth from 25% to 32%, reflecting increased sale shares in many of the metropolitan areas. States with 15% to 24% annual growth include Illinois, Kentucky, Nevada, and Utah, as well as the District of Columbia. California alone accounted for about 40% of electric vehicle sales in the country, and electric vehicles accounted for more than 8% of new 2020 vehicles in the state. The District of Columbia, Hawaii, Oregon, and Washington each had more than 5% electric vehicle sale shares, followed by Massachusetts, Nevada, and Vermont at approximately 3%.

ANALYSIS OF ELECTRIC VEHICLE MARKET DEVELOPMENT AND UNDERLYING FACTORS

This section evaluates in more depth the underlying factors that are supporting electric vehicle market growth. It evaluates charging infrastructure deployment, electric vehicle model availability, incentives, and promotion actions and their relationship with electric vehicle uptake.

CHARGING INFRASTRUCTURE AND ELECTRIC VEHICLE UPTAKE

Using data from PlugShare, we analyze the public and workplace charging deployment through 2020 for the 200 most populous metropolitan areas.[20] Figure 4 plots the public Level 2 and DC fast charging infrastructure against electric vehicle share with the bubble size proportional to the 2020 new electric vehicle sales. Selected markets with high uptake or high infrastructure counts are labeled. The U.S. average of 305 chargers per million population and electric vehicle uptake of about 2.4% is shown in black in the lower left. Based on the PlugShare data, the overall 2020 U.S. public charging availability increased by approximately 30% from 2019.

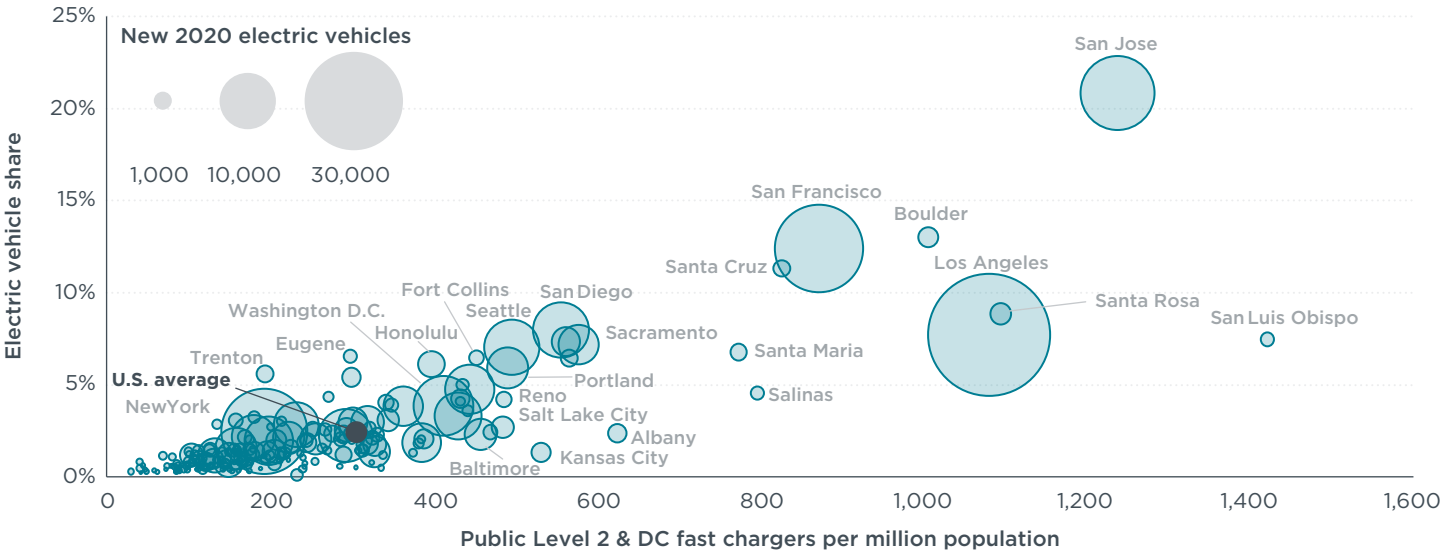

Figure 4. Electric vehicle share of new vehicles and public chargers per million population for the 200 most populous U.S metropolitan areas. Charging infrastructure data are from PlugShare.

As shown, areas with higher electric vehicle uptake generally have more public chargers deployed. The five areas with the highest uptake had from 2.7 to 4 times more public chargers than the U.S. average. Of the 200 most populous metropolitan areas, the top-10 electric share markets collectively averaged about 10% electric share and 935 public chargers per million population. Regional leaders with relatively high electric vehicle uptake such as Austin, Denver, Boston, Portland, Seattle, and Washington, DC had above average infrastructure deployment with approximately 320 to 500 public chargers per million population. Several less-populated areas stand out with high electric vehicle market shares and above average public charging, such as Boulder, Fort Collins, Honolulu, Reno, and several California cities. Half of the U.S. population lives in an area with fewer than 200 chargers per million population, which is about 20% of the public charging availability in the top-10 electric vehicle markets.

Figure 5 illustrates the relationship between workplace charging infrastructure per capita and electric vehicle share in 200 most populous metropolitan areas.[21] As above, the estimated new 2020 electric vehicle sales are represented by the bubble sizes. The U.S. average of 2.4% electric vehicle uptake and approximately 82 workplace chargers per million population is shown by the black data point.

20 Charging data are from PlugShare (2021), https://www.PlugShare.com/.

21 Charging data are from PlugShare (2021), https://www.PlugShare.com/.

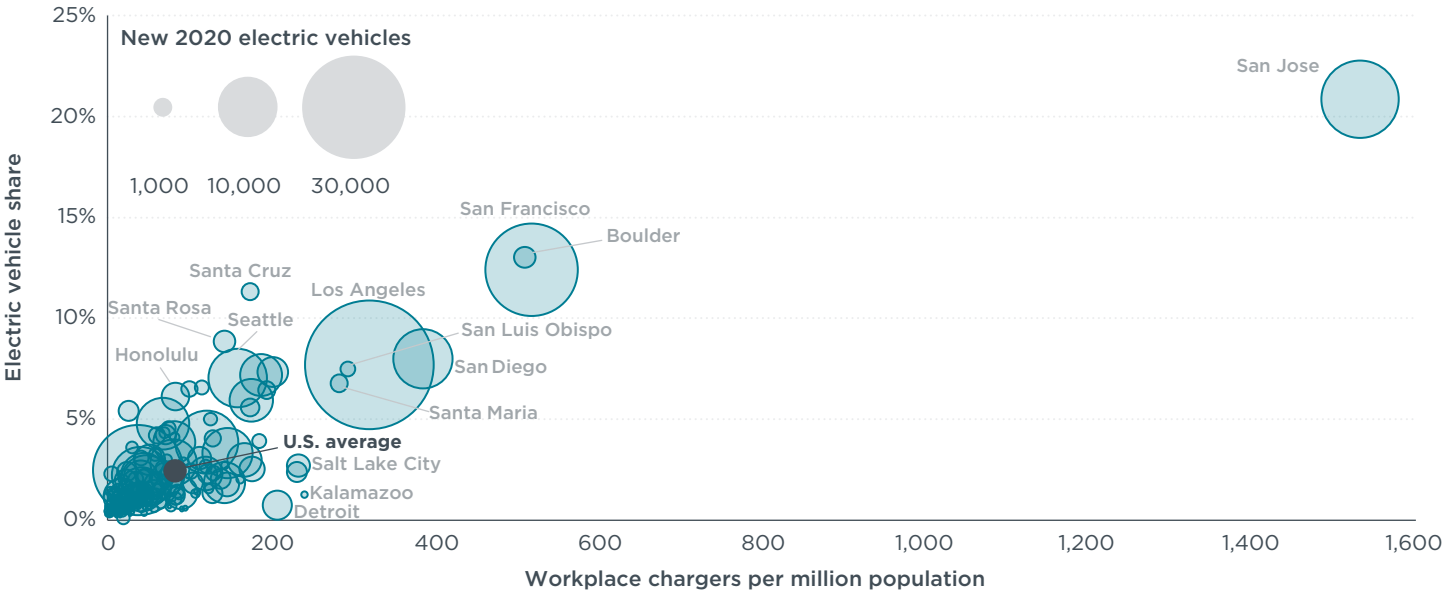

Figure 5. Electric vehicle share of new vehicles and workplace chargers per million population for the 200 most populous U.S metropolitan areas. Charging infrastructure data are from PlugShare.

Similar to public charging infrastructure distribution, the figure shows an approximate trend where areas with the most workplace charging typically have higher electric vehicle shares. San Jose stands out with the most public charging and electric vehicle uptake. Other areas that have 300 or more workplace chargers per million population and high uptake include several cities in California and Boulder. Of the 200 most populous metropolitan areas, the 10 markets with the highest uptake collectively averaged 430 workplace chargers per million population. Of the 10 areas with the highest workplace charging, eight had above average uptake. Approximately half of the U.S. population lives in an area with fewer than 42 workplace chargers per million population, which is less than 10% of the workplace charging availability in the top-10 electric vehicle markets.

Showing the relationship of cumulative electric vehicles and charging infrastructure further shows the emerging trends. Figure 6 plots the relationship between public chargers and cumulative electric vehicles from 2011 through 2020 in eight major metropolitan areas with greater than 3% uptake in 2020.[22] These eight areas together account for about 17,000 public chargers, or 17% of total public chargers in the United States through 2020, and about 26% of cumulative U.S. electric vehicle sales through 2020. Each of the areas shown have more than 20,000 cumulative electric vehicle sales, and the number of public chargers deployed ranges from about 1,100 (Denver) to 4,100 (San Francisco). Overall, the figure shows a clear trend where electric sales and public charging infrastructure grow in unison, but with somewhat different ratios by market. While not shown, the largest market of Los Angeles follows a similar trend; it has the most public chargers (about 14,000, or 14% of U.S. charging) and cumulative electric vehicle sales (about 290,000, about 17% of U.S. electric vehicles).

22 Charging data are from PlugShare (2021), https://www.PlugShare.com/.

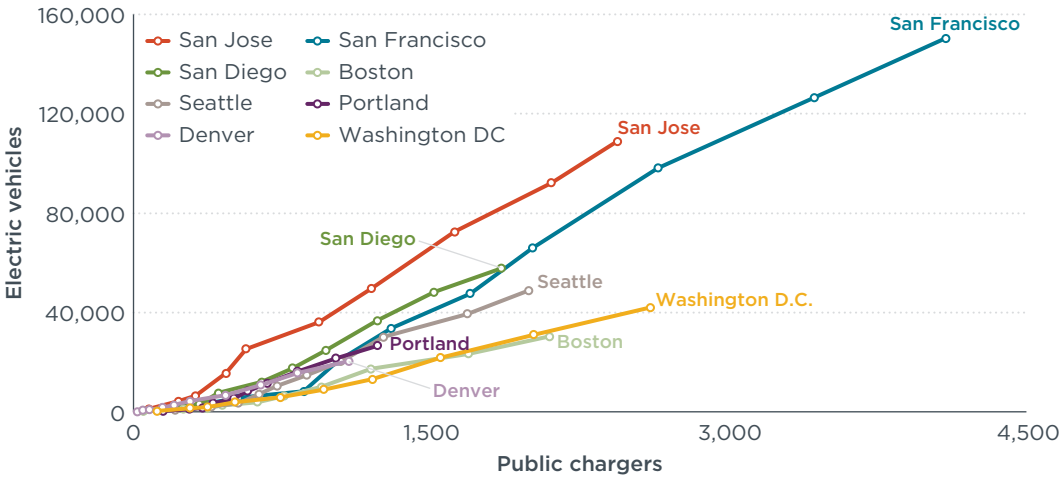

Figure 6. Number of public chargers and cumulative electric vehicle sales from 2011 through 2020 in eight major metropolitan areas. Public charging infrastructure data are from PlugShare.

Figure 6 also shows that electric vehicle-to-public charger ratios tend to increase with electric vehicle uptake. The ratio of electric vehicles to public chargers in the top 10 uptake areas in 2020 ranges from 14:1 in Boston to 44:1 in San Jose. The electric vehicle-to-public charger ratios in the areas with the lowest 2020 uptake typically ranged from 7:1 to 9:1. To provide context to these electric vehicles to public charging ratios, the average ratio of electric vehicles to public chargers in the 50 most-populous metropolitan areas was 21:1 in 2020, which is up from about 19:1 in 2017. These ratios reinforce previous findings whereby the more developed markets trend toward higher electric vehicle-per-charger ratios due to market maturity and the evolution from basic geographic infrastructure coverage to higher utilization.[23]

MODEL AVAILABILITY AND ELECTRIC VEHICLE UPTAKE

Greater availability of models in more vehicle segments and in higher volumes that meet consumers' wide range of needs and preferences is critical to market growth. Across the United States in 2020, there were 59 electric vehicle models with at least one sale and 31 of which with more than 1,000 annual sales. This is a substantial increase from just 5 electric vehicle models being sold in 2011.

Figure 7 illustrates the relationship between state-level model availability and electric vehicle uptake for the 50 U.S. states plus the District of Columbia.[24] Model availability data at the metropolitan-area level are not available, but for large metropolitan areas the models available is expected to closely match the state-level numbers shown. The bubble size is proportional to the new 2020 electric vehicle sales in each state, and the bubble color indicates whether states had adopted the ZEV regulation (blue) or not (yellow). More detailed data on the number of state electric vehicle sales for each model are not available, so model availability is defined as models with at least one new sale in 2020. Thus, some of the electric vehicle models counted in the figure may not be available with large inventory or beyond a few selected showrooms.

23 Michael Nicholas, Dale Hall, and Nic Lutsey, Quantifying the electric vehicle charging infrastructure gap across U.S. market, (ICCT: Washington, DC, 2019), https://theicct.org/publications/charging-gap-US

24 Model available in each state is from Atlas Hub's Automakers Dashboard, (Atlas Hub, 2020), https://www.atlasevhub.com/materials/automakers-dashboard/

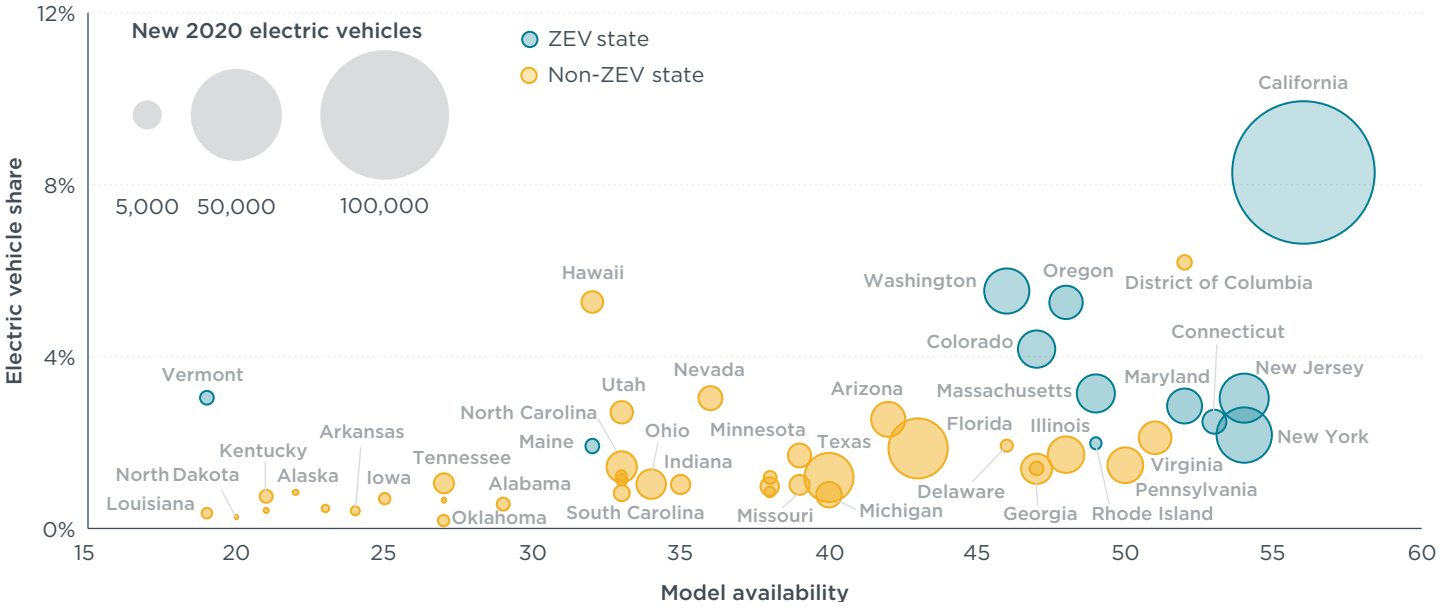

Figure 7. Electric vehicle shares of new vehicles and model availability in the 50 states and District of Columbia.

Figure 7 illustrates a general trend where states with greater model availability tend to have higher electric vehicle uptake. The figure shows the largest bubbles are clustered on the right side of the figure, indicating that states with more models available tend to have greater new electric vehicle sales volumes. Four of the five states (California, Florida, New York, New Jersey) with the most 2020 electric vehicle sales, representing over 57% of U.S. sales, had 40 or more models available. Four of the five areas with the highest electric sales share (California, District of Columbia, Washington, and Oregon) had uptake above 5% and more than 45 models. The bottom five states in new 2020 electric sales shares (Oklahoma, North Dakota, Mississippi, Louisiana, and Arkansas) had less than a 0.4% electric share and less than 28 models. Half the U.S. population lives in a state that has 43 or fewer models, while Californians have access to 56 models.

Figure 7 also shows how states with ZEV regulations tend to have higher model availability than those without. These states also tend to have the highest 2020 electric vehicle uptake. Of the ten states with the highest model availability, seven have enacted ZEV regulations. Overall, states with such regulations represented 32% of the U.S. population and 31% of U.S. vehicle sales, and accounted for 63% of U.S. electric vehicle sales. States with ZEV regulations had a combined new electric vehicle share of 5% and an average of 47 models available, compared to those without such regulations having a combined 1.3% electric share and an average of 34 models available. There are also some counterexamples of states with ZEV regulations with low model availability and states without ZEV regulations with high model availability. Vermont and Maine have enacted ZEV regulations but have below average model availability, perhaps a result of their smaller populations. Washington, DC, Virginia, and Pennsylvania do not have ZEV regulations but have high model availability, perhaps due to their large populations and bordering states with such regulations.

POLICY INCENTIVES AND ELECTRIC VEHICLE UPTAKE

Financial and non-financial incentives support electric vehicle market growth by reducing costs and providing additional convenience. Alternately, policy actions such

as fees specific to electric vehicles act as disincentives. Figure 8 shows the estimated value of consumer incentives and the estimated electric vehicle share of new vehicle sales in 2020 across the 50 metropolitan areas. The areas are ordered from left to right based on highest uptake. Quantification of incentives includes estimates of state, city, and utility purchase incentives; HOV lane access; toll reductions; "other" incentives such as free parking or reduced state fees or emissions inspections; and electric vehicle-specific fees. Overall, the figure shows how most high-uptake areas have substantial incentives, and low-uptake areas tend to impose fees and have few incentives.

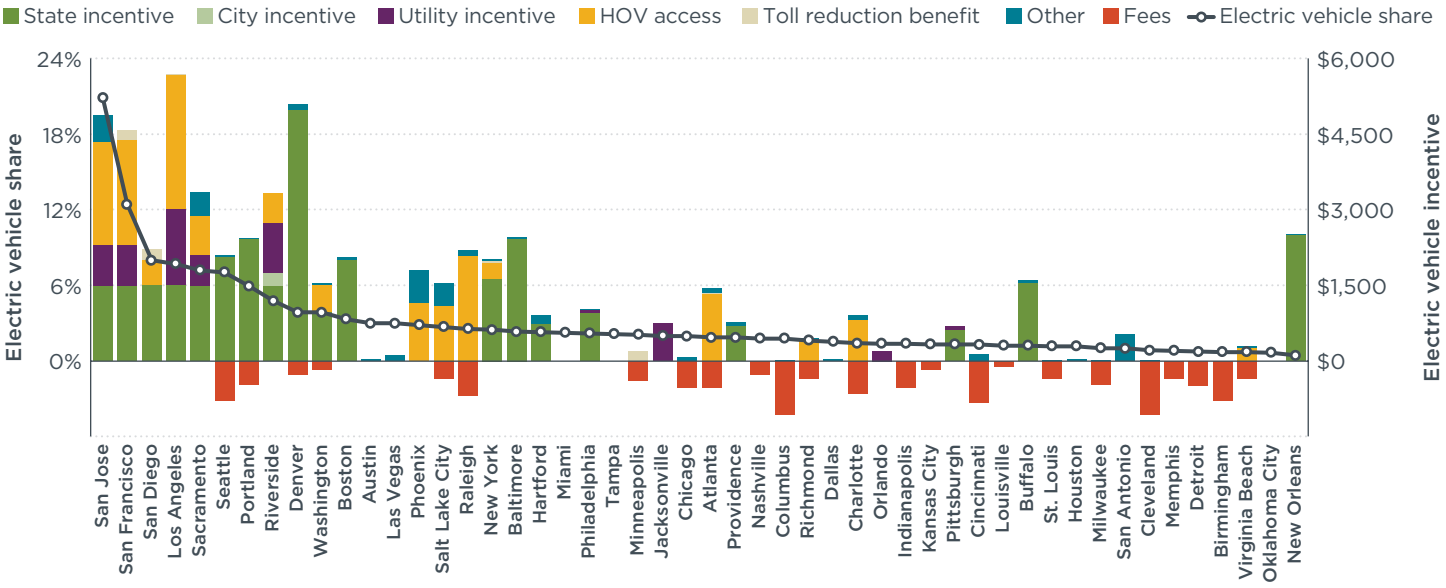

Figure 8. Electric vehicle shares of new vehicles and available consumer incentives in the 50 most populous U.S metropolitan areas.

As shown on the left of Figure 8, California drivers benefit from a state rebate, utility incentives, and HOV access. Colorado offers the most substantial purchase incentive with its $5,000 electric vehicle tax credit. Washington reinstated its sales tax exemption for electric vehicles which typically provides an exemption of about $2,000, and Massachusetts increased its rebate from $1,500 for BEVs and $0 for PHEVs to $2,500 for BEVs, and $1,500 for PHEVs. Drivers in Maryland, New York, and Oregon also receive from approximately $1,500 to $3,000 state purchase incentives. Rebate values decreased in California, Pennsylvania, and Connecticut. Although not shown in the figure, states including California, Oregon, and Pennsylvania offered increased rebate values for low- and moderate-income consumers to expand electric vehicle access. The electric utility serving Jacksonville is the only utility outside of California that offers a substantial purchase incentive.

More states impose electric vehicle-specific taxes or fees in 2020, increasing to 16 from 12 states in 2019. New states with such fees in 2020 included Alabama, Illinois, Ohio, and Oregon. These taxes and fees are shown as disincentives with red bars in Figure 8, and are present in 21 of the 50 most-populous U.S. metropolitan areas, up from 15 areas in 2019. California's electric vehicle fee began in late 2020 and thus is excluded here. Overall, most of the areas that are in states with annual electric vehicle fees are shown on the right of Figure 8 and had below average uptake. Of the 26 electric vehicle markets with below 2% uptake, 17 were in a state with some sort of annual fee.

There are also some counterexamples of areas with low incentives and relatively high uptake, and these areas tend to have several other supporting policy measures. In Austin and Las Vegas, although there are no electric vehicle purchase incentives, there are numerous infrastructure support programs, such as incentives for residential, commercial, and fast charging infrastructure from utilities. Especially in Austin, city- and utility-level activities are relatively abundant to help overcome awareness and convenience barriers.

PROMOTION ACTIONS AND ELECTRIC VEHICLE UPTAKE

A comprehensive package of state, city, and utility promotion actions is key to overcoming electric vehicle barriers and continued market growth. Figure 9 displays how electric vehicle sales share relates to state, city, and utility promotion actions in 2020 across the 50 areas. The metropolitan areas are ordered from left to right based on highest to lowest market share. The figure shows a visual trend where areas with the most actions tend to have higher uptake. The five areas with the highest shares were in California and had 36 to 44 actions. These areas tended to have a strong mix of state, city, and utility actions. Other areas with more than 3% uptake, including Seattle, Portland, Riverside, Denver, Washington, DC, and Boston, had 22 to 34 actions in place. The bottom ten areas of uptake tended to have fewer than 16 actions, which is less than half of the number of actions in high-uptake areas.

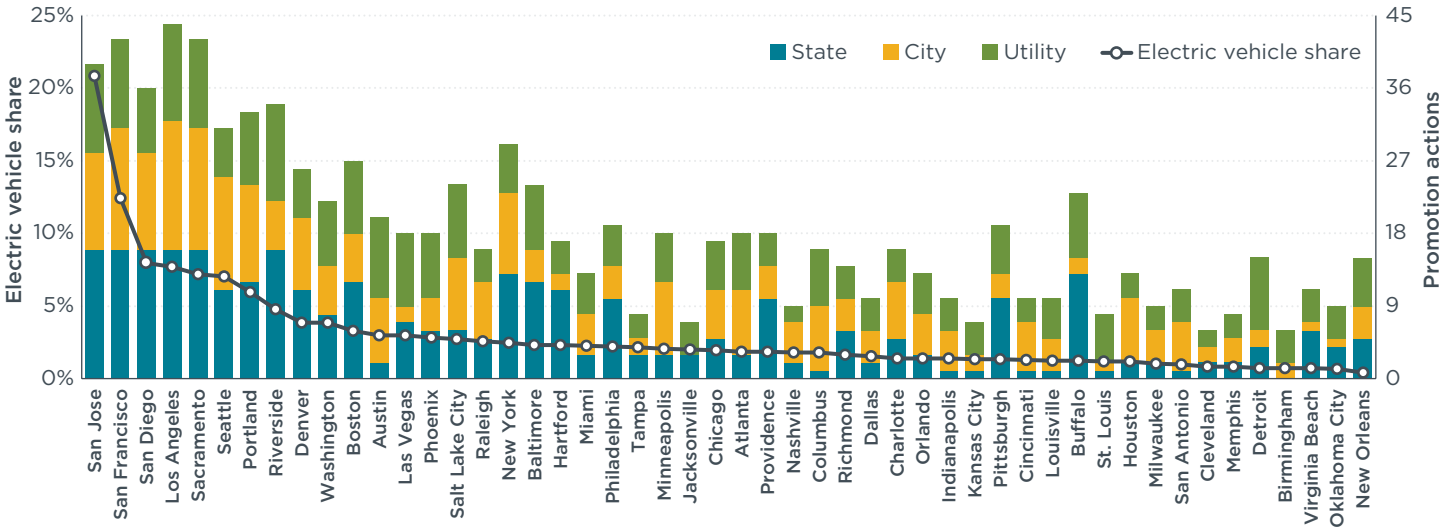

Figure 9. Electric vehicle shares of new vehicles and promotion actions in the 50 most populous U.S metropolitan areas.

The figure also reveals relative gaps in policy actions. Austin had many city and utility actions and above average electric vehicle uptake, yet state-level actions were lacking. Las Vegas had many utility and some state-level actions, yet city actions appeared limited. Columbus had several city and utility actions in place, but state-level actions were limited. Pittsburgh and Buffalo had strong state-level support and several utility actions, but local actions were limited, and these areas had below-average uptake. Other areas that could benefit from greater city-level actions include Jacksonville, St. Louis, and Oklahoma City. Areas that could especially benefit from greater utility-level actions include Tampa, Nashville, Cincinnati, Houston, Milwaukee, Cleveland, and Memphis.

COMPARISON OF 50 MAJOR METROPOLITAN AREAS

The relationship between electric vehicle uptake and the underlying factors outlined above is further analyzed across major metropolitan areas. Figure 11 summarizes electric vehicle uptake, public and workplace chargers per capita, consumer incentives, and promotion actions across 50 metropolitan areas, ordered from top to bottom based on estimated 2020 electric vehicle sale shares.[25] The figure shows a trend where areas with the highest shares tended to have a high number of public chargers, strong consumer incentives, and many promotion actions. The top ten areas in terms of electric vehicle shares largely overlap with the top 10 areas for public and workplace charging infrastructure (seven of the top ten), incentives (eight of the top ten), and promotion actions (eight of the top ten).

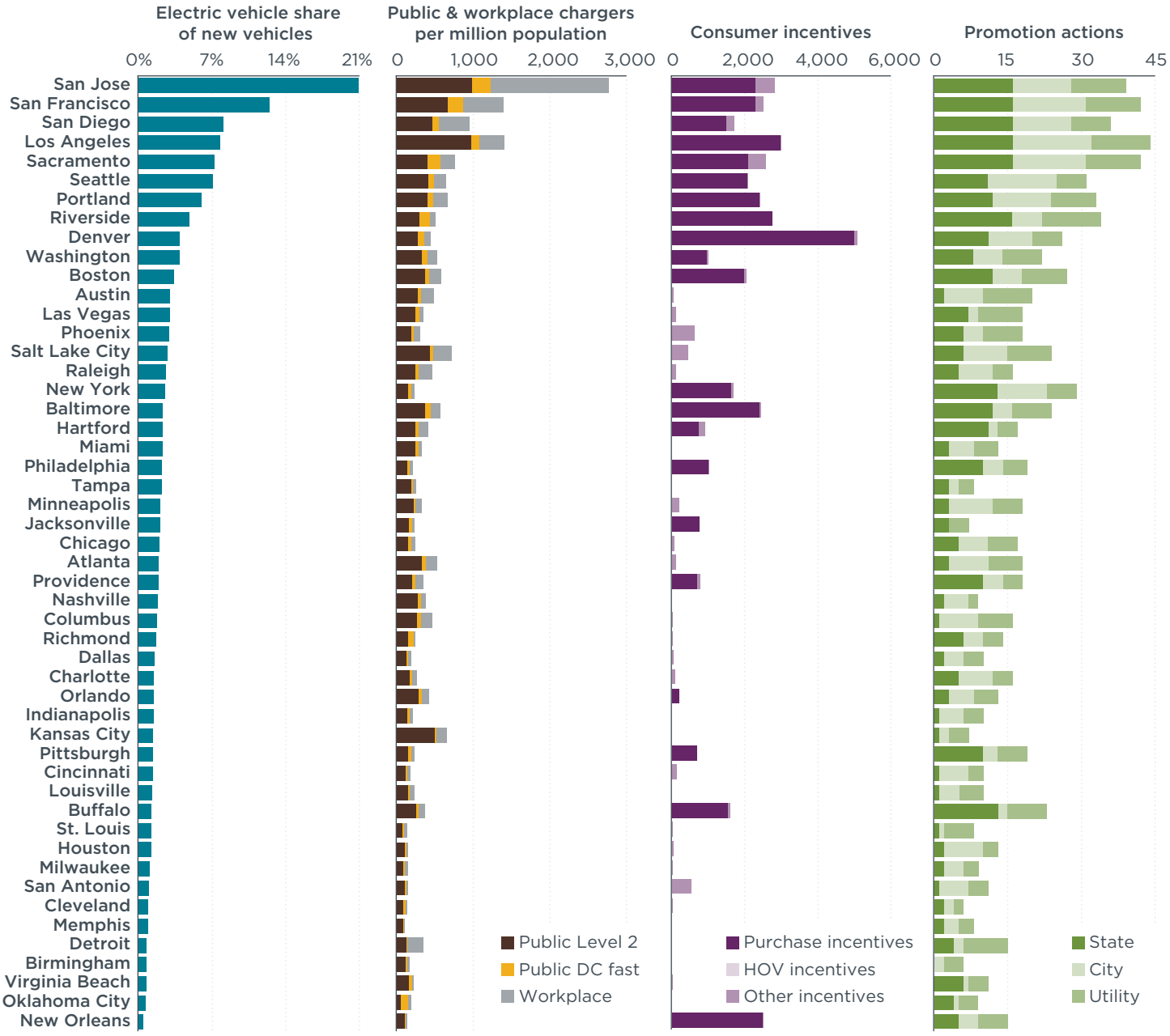

Figure 10. 2020 electric vehicle uptake, charging infrastructure incentives, and promotion actions in the 50 most populous U.S. metropolitan areas. Public and workplace charging infrastructure data are from PlugShare.

25 Public and workplace charging infrastructure data are from PlugShare (2021), https://www.PlugShare.com/.

There are also some metropolitan areas where the various charging, incentive, and policy action variables do not follow the general trend with electric vehicle uptake. As mentioned earlier, Austin and Las Vegas had almost no incentives but benefited from promotion actions and charger availability. Although local-level electric model data are not available for 2020, previous analyses found electric vehicle model availability to be very limited in these areas. Kansas City is shown with strong public charging, yet promotion actions and consumer incentives are generally lacking. Pittsburgh and Buffalo have incentives and promotion actions, but relatively low market uptake and could benefit from greater infrastructure deployment. Previous analysis found electric vehicle model availability in these areas to be limited.

CONCLUSIONS

Despite the economic downturn caused by the global COVID-19 pandemic and the Trump administration's vehicle efficiency regulation rollback, electric vehicle sales and sales shares in the United States remained steady in 2020. This research indicates that, to some extent, states and cities have picked up the slack with continuing support for electric vehicles. The new Biden administration's rejoining of the Paris Agreement and its goals of decarbonizing the economy by 2050 and for half of new vehicle sales to be electric by 2030 demonstrate renewed federal leadership. But, related to electric vehicles, uncertainties remain with regard to strengthened federal and state regulations, expanded financial incentives, infrastructure investments, and how industry will step up to the challenge of transitioning to electric vehicles. The activities identified in this briefing will remain important to overcoming electric vehicle barriers and market growth. The states and cities with the greatest electric vehicle market success continue to have the strongest and most comprehensive policy supports. Our analysis leads us to the following four conclusions:

Regulations that require greater electric vehicle model availability are essential to market growth. Access to electric vehicle models is limited across the country. Europe and China each had stronger regulations, three to five times more electric models available, and four times the annual 2020 electric vehicle sales of the U.S. market.[26] States with ZEV regulations had a combined new electric vehicle share of 5% and typically at least 13 more electric models available than non-ZEV regulation states, which had a 1.3% average electric vehicle share. States with ZEV regulations were responsible for about two-thirds of 2020 U.S. electric vehicle sales and less than one-third of overall light-duty vehicle sales. These developments underscore how critical it is for the federal greenhouse gas emission and fuel economy regulations, and especially the state ZEV regulations, to drive electric vehicle models into the market and at greater volumes.

State, city, and utility support packages are continuously being developed to accelerate the electric vehicle market. Various states, cities, and utilities are actively reducing consumer barriers through comprehensive policy packages of vehicle regulations, incentives, infrastructure deployment, and creative education campaigns, with growing focus on expanding access more broadly. More states are moving toward adopting the powerful ZEV regulation to require increasing shares of electric vehicles, most recently Colorado and Washington, and other states are now making similar moves. Metropolitan areas with the greatest electric vehicle uptake in 2020 had a

26 Anh Bui, Peter Slowik, and Nic Lutsey, Power play: Evaluating the U.S position in the global electric vehicle transition, (ICCT: Washington, DC 2021), https://theicct.org/publications/us-position-global-ev-jun2021

strong mix of state, city, and utility promotion actions. Eight of the 10 highest electric-uptake areas had the most such actions, with 31 to 44 actions. In contrast, the areas with the lowest uptake tended to have less than half this amount.

Consumer incentives remain important for market development. Incentives help to reduce electric vehicles' upfront cost while technology costs continue to decline. The top 11 metropolitan areas with the highest uptake had substantial consumer incentives ranging from $1,500 to more than $5,500. These incentives are offered in various forms, including state, cities, and utility purchase incentives, HOV access, toll reduction, free parking, and other forms of fee reduction. Of the ten areas with the highest uptake, eight had the most substantial incentives, worth $2,200 to $5,700. In contrast, eight of the ten areas with the lowest uptake offered less than $600 in consumer incentives. Of the 26 large markets with below 2% uptake, 17 were in states with electric vehicle fees in place, disincentivizing electric vehicle market growth.

Electric vehicle uptake grows with charging infrastructure growth. Even though most charging is done at home, electric vehicle growth is linked to greater availability of public and workplace charging. Infrastructure deployment is on pace to meet the expected public charging needs through 2025 based on the 30% annual growth rate in public charging from 2019 to 2020.[27] Of the 200 most populous metropolitan areas, the ten with the highest uptake averaged a 10% electric share and 935 public chargers per million population. In contrast, half of the U.S. population lives in an area with just 20% of the public charging availability in those top-ten markets. For workplace charging, the ten areas with the highest uptake averaged 430 workplace chargers per million population, while half of the U.S. population lives in an area with less than 10% of this leading benchmark.

The briefing demonstrates state and local authorities' key role in overcoming electric vehicle adoption barriers. Such actions sustained U.S. electric vehicle uptake, but the uptake has been uneven given the lack of federal leadership over the 2017–2020 time frame. As a result, the U.S. market substantially lags behind Europe and China, and there is risk that many areas of the United States will be left behind. Early Biden administration signals indicate renewed federal action on electric vehicles, with perhaps strengthened regulations, expanded financial incentives, and new infrastructure investments on the way. Even with renewed federal action, cities and states remain critical to develop innovative policies to meet their stronger emission-reduction goals.[28]

27 Gordon Bauer, Chih-Wei Hsu, Mike Nicholas, and Nic Lutsey, Charging up America: Assessing the growing need for U.S. charging infrastructure through 2030.

28 For examples, see Hongyang Cui, Pramoda Gode, and Sandra Wappelhorst, *A Global overview of Zero Emission Zone (ZEZ) progress,* (ICCT: Washington, DC, 2021), https://theicct.org/publications/global-cities-zez-dev-EN-aug21; Dale Hall, Hongyang Cui, Marie Rajon Bernard, Shuyang Li, and Nic Lutsey, *Electric vehicle capitals: Cities aim for all-electric mobility,* (ICCT: Washington, DC, 2020), https://theicct.org/publications/electric-vehicle-capitals-update-sept2020; Marie Rajon Bernard, and Dale Hall, *Efficient planning and implementation of public chargers: Lessons learned from European cities*, (ICCT: Washington, DC, 2020), https://theicct.org/publications/European-cities-charging-infra-feb2021; Lingzhi Jin, Hui He, Hongyang Cui, Nic Lutsey, Chuqi Wu, Yidan Chu, Jin Zhu, Ying Xiong, and Xi Liu, *Driving a green future: A retrospective review of China electric vehicle development outlook for the future*, (ICCT: Washington, DC, 2021), https://theicct.org/publications/china-green-future-ev-jan2021.