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Identifying the leading regional electric vehicle markets in the United States

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1. Introduction

Electric vehicle sales in the United States represented about 40% of global sales of electrics through 2015. These sales tend to be concentrated in several regions and in particular cities within those regions. Many state and city governments promote electric vehicles with consumer incentives and policy actions. Other groups—including utilities, automakers, nonprofit organizations, and businesses—also encourage electric vehicle purchases with actions such as deployment of charging infrastructure, outreach events, and informational campaigns. Patterns indicating what drives the market are emerging from all of these actions.

Previous studies have identified those markets with the most extensive policy actions, charging infrastructure, and other activities supporting the market for electric vehicles (e.g., see Searle et al., 2016; Lutsey et al., 2015, 2016; Jin et al., 2014). This study builds upon those works to analyze the leading markets for electric vehicles within major U.S. regions, including smaller and medium-sized urban areas. Such an analysis is an important step toward better understanding regional trends and identifying activities that are associated with higher electric vehicle uptake, including in smaller markets that have not yet been assessed.

This paper focuses on discerning which policy actions tend to define the regionally leading U.S. electric vehicle markets. The paper identifies the areas with the highest electric vehicle market shares and catalogues actions that support the uptake of electric vehicles. The assessment includes promotion actions by state policy (e.g., regulation, purchasing incentives), local policy (e.g., parking and lane access incentives, building codes), utility actions (e.g., charging infrastructure incentives, preferential charging rates), and public charging availability. In addition, electric model availability is analyzed as a key underlying factor in the development of electric vehicle markets. Finally, the assessment includes a discussion of the implications regarding best-practice policies that could be emulated in smaller and larger markets across the country.

2. Analysis

The focus of this analysis is metropolitan areas with the highest electric vehicle market share within each major region. The unit of analysis is the metropolitan statistical area, encompassing the larger areas where people typically reside, work, commute, and travel. Regions are defined as the Midwest, Mountain, Northeast, South, and West, based on the U.S. Census (2016). Within the West region, California is considered separately. The state's long-time focus on emissions regulations and electric vehicles makes it an outlier and benchmark for the rest of the country (see Searle et al., 2016). We identify the four leading metropolitan areas with the highest electric vehicle share in each region (five when there was an approximate tie). We include only areas with populations of more than 50,000, excluding a few smaller metropolitan areas that had generally fewer than 20 electric vehicle sales in 2015.

The analysis employs the same data sources and methods relating to electric vehicle purchases, charging infrastructure, model availability, and local promotion measures as in the authors' previous works (see Jin et al., 2014; Lutsey et

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al., 2015, 2016). The study quantifies how the leading areas in each region compare on these metrics. The following discussion highlights effective electric promotion programs in each region.

REGIONAL ELECTRIC VEHICLE SHARE LEADERS

Figure 1 shows the leading metropolitan areas by region for electric vehicle share in 2015. New electric vehicle registrations as a percentage of total new light-duty vehicle registrations are from IHS Automotive. The figure shows that electric vehicle market shares are generally higher in the West than elsewhere, although there are a number of isolated areas outside the West with relatively high uptake. Areas with the lightest color have less than 0.3% electric vehicle share of sales, whereas areas with the darkest color have from 6% to 10% uptake. The leading areas in terms of demand for electric autos in California range from 5% to 9%. Region-leading markets in the West and Mountain regions have rates as high as 3%, and leading cities in the Northeast, Midwest, and South have 0.6% to 2%. The national average sales rate was 0.7%.

The top four or five leaders in each region that are the primary focus of this study are labeled in the figure. Each of the labeled metropolitan areas are analyzed and discussed below. The metropolitan areas and their electric vehicle shares are listed in Table A1 of the Annex. Most of the cities have two to six times the electric vehicle uptake of their regional average.

PUBLIC CHARGING INFRASTRUCTURE

We assess charging infrastructure on a per capita basis. Public charger data are from the U.S. Department of Energy's Alternative Fuel Data Center (AFDC, 2016). We downloaded this data in January 2016 to reflect the number of charger outlets in 2015. The dataset provides the city, address, and number of outlets for each publicly available charging location. We analyze public Level 2 and direct current (DC) fast chargers per million population by area. DC fast charging allows a typical electric vehicle (e.g., Nissan Leaf) battery pack to be charged by 19 kWh or about 80% increase in its state of charge in approximately 30 minutes, whereas Level 2 would could take 3-4 hours for the same charge. Although most electric vehicle users

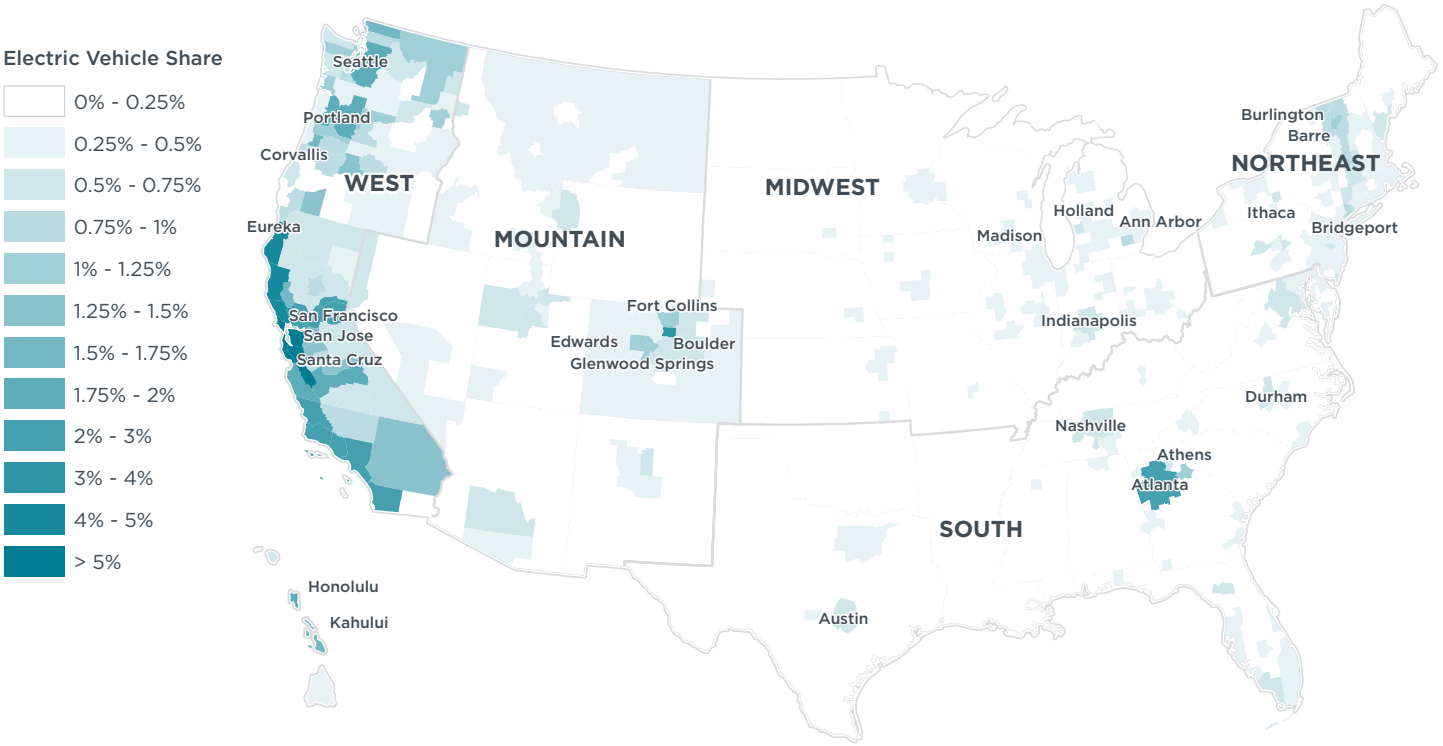

Figure 1. Electric vehicle share of new vehicle registrations in 2015, highlighting leading metropolitan areas in each region (new vehicle registration data from IHS Automotive)

rely primarily on home charging, followed by workplace and public charging (INL, 2015), this analysis focuses on public charging because of its potential for increasing visibility, viability, and confidence in expanded use of electric vehicles. Detailed data on workplace charging were not available across all the metropolitan areas, so its examination is limited.

Figure 2 summarizes the findings on public charging availability, showing only metropolitan areas with the highest electric vehicle share by region. Within each region, the metropolitan areas are listed in order of decreasing electric vehicle share. (e.g., Ann Arbor has the highest uptake among the areas in the Midwest.) As shown, the West and California had higher average charging availability than the other regions. The regional leaders tended– in 22 of 26 cases—to have greater public charging infrastructure than their regional average. In 13 of the 26 cases, the public charging infrastructure was more than double the national average. Those were Ann Arbor, Boulder, Edwards, Barre, Burlington, Austin, Seattle, Portland, Honolulu, Corvallis, Kahului, San Jose, and San Francisco. Three smaller areas, Barre, Burlington, and Kahului, stand out as having especially high availability of DC fast charging per capita.

ELECTRIC VEHICLE MODEL AVAILABILITY

Auto manufacturers make strategic decisions about where to deploy vehicles for sale and in what numbers. We analyzed data on which electric vehicle models were newly registered in each city as an indicator of model availability. For this study, which includes smaller metropolitan areas, we assess "models available" as all vehicles that were registered at least once in each marketing area in calendar year 2015. Although consumers could purchase and register vehicles outside their metropolitan area of residence, the total number of new electric models registered in each metropolitan area in 2015 is a reasonable measure of the relative availability of electric vehicles. In other analyses, we have applied a minimum vehicle criterion to exclude models that had very low new registrations, and such an approach works for larger markets (e.g., in Lutsey et al, 2016). Other methods, for example detailed counts of electric vehicles on dealership lots across cities throughout the year (e.g., see Reichmuth and Anair, 2016), would provide a more thorough analysis of the availability, deployment, and marketing efforts to make more vehicles available.

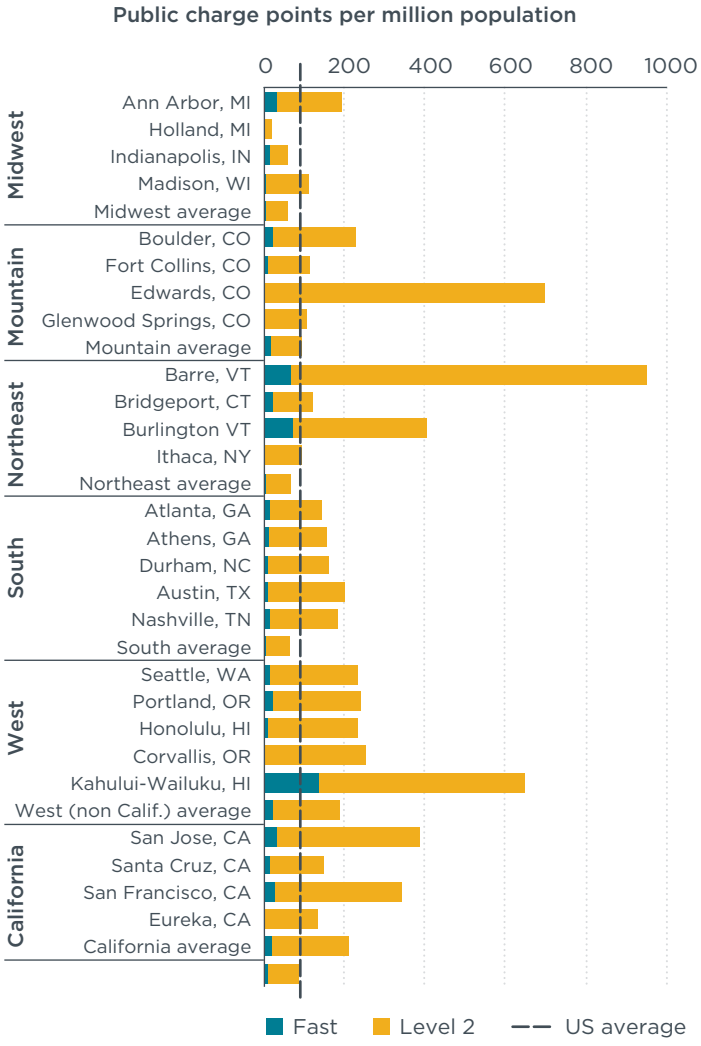

Figure 2. Public electric vehicle charge points per million population in metropolitan areas with regionally leading electric vehicle shares

Figure 3 summarizes the analysis of electric model availability, showing only metropolitan areas with the highest electric vehicle share in each region. The regional averages are based on all metropolitan areas in the region with populations above 50,000. The regional leaders tended to have greater model availability than their regional average. In 22 of 26 cases, regional leaders had more electric models available than their region's average. Typically, the areas with the highest electric auto shares either were large metropolitan areas (e.g., Atlanta, Seattle), or were near large metropolitan areas (e.g., Bridgeport, Connecticut, near New York City). The California markets generally had three times the number of electric vehicle models available than the national average.

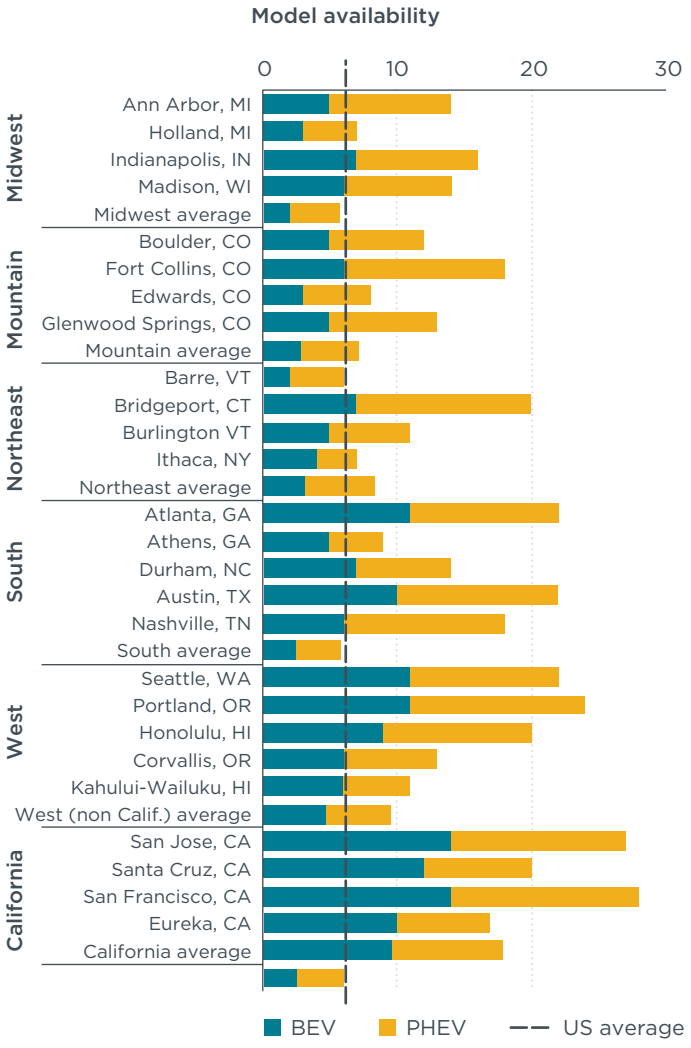

Figure 3. Electric vehicle model availability in metropolitan areas with regionally leading electric vehicle market shares

ELECTRIC VEHICLE PROMOTION ACTIONS

We assessed which electric vehicle promotion actions were in place among the regionally leading markets. The electric vehicle promotion actions that are assessed in this study include financial purchasing incentives, public charging infrastructure, state and local government policy, fleet programs, and additional promotion programs. We analyze the same 33 state, local, and utility actions here as in our most recent electric vehicle assessment of major metropolitan areas (see Lutsey et al, 2016). State and local information are publicly available, generally from government and utility websites as referenced below.

Table 1 summarizes our findings for the 26 regionally leading electric vehicle markets based on the 33 state, local, and utility electric vehicle promotion actions. Within each region, the metropolitan areas are listed in order of decreasing electric vehicle share. We find that many of these areas have more than 10 electric vehicle promotion actions in place. Four of the areas –including Portland, San Jose, San Francisco, and Santa Cruz—have 20 or more actions in place.

Perhaps among the more prominent policies supporting electric vehicle demand are state consumer financial incentives. These typically range from $1,000 to $3,000 per battery electric vehicle in most states, and they are typically about half as much for plug-in hybrid vehicles due to their lesser all-electric driving capability. The Colorado incentive of as much as $5,000 a vehicle is the highest. Related to the metropolitan areas in this study, there are substantial purchase incentives in California, Colorado, Connecticut, North Carolina, and Washington. The Georgia rebate was revoked in July 2015, and a Texas incentive was limited in its availability throughout the year, due to political and funding concerns related to the associated government expenditures to maintain the programs.

State regulatory programs also play key role directly, as well as in promoting further electric vehicle support actions. California and nine other states have adopted a Zero-Emission Vehicle (ZEV) regulatory program requiring an increasing percentage of new vehicles sales from now through 2025 to be electric-drive. Of the 26 metropolitan areas in this study, the four in California, four in the Northeast, and two in Oregon are in ZEV states. To foster technology development and help control associated costs, the ZEV regulation allows manufacturers to focus early electric vehicle deployment in California, delaying market introduction in the other

ZEV states. Beginning in model year 2018, manufacturers will be required to place increasing numbers of electric vehicles in the ZEV-adopting states outside of California.

Twelve of the 26 metropolitan areas have six or more city-level actions in place to promote electric vehicles. These are Ann Arbor, Indianapolis, Boulder, Fort Collins, Atlanta, Austin, Nashville, Seattle, Portland, San Jose, Santa Cruz, and San Francisco. Eleven of the metropolitan areas in this study have four or more major utility actions in place: Holland, Bridgeport, Atlanta, Athens, Austin, Honolulu, Kahului, San Jose, Santa Cruz, San Francisco, and Eureka. Examples of these local and utility actions are described below.

3. Discussion of regional results

This section provides further details on regions, including how each region compares with the U.S. average in electric vehicle uptake, public charging infrastructure, and model availability. As above, we include only metropolitan areas above 50,000 in population when computing regional averages. For model availability, we compare the number of electric models registered at least once in various regions against California to quantify the relative model availability. In addition, we discuss the leading metropolitan areas within each region in terms of electric vehicle share and highlight their key activities in encouraging sales of these autos.

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

		State action											Local action														Utility action							Total actions (out of 33)
	Metro area	State ZEV program	State ZEV Alliance participation	State low carbon fuel policy	State BEV purchase incentive	State PHEV purchase incentive	State fee reduction or testing exemption	State private charger incentive, support	State public charger promotion	State parking benefit	State fleet purchasing incentive	State manufacturing incentive	City electric vehicle strategy	Streamlined EVSE permitting process	EV-ready building code	City vehicle purchase incentive	City parking benefit	City private charger incentive, support	City carpool lane (HOV) access	City-owned EV chargers	US DOE EV Project key area	Workplace charging	City car sharing program link	City informational materials	City outreach events	City green fleet target	City electric vehicle fleet target	Utility charging pilot or other research	Utility public charging infrastructure	Utility time of use rates offered	Utility preferential EV rates	Utility private charger incentive, support	Utility info materials or outreach events	Utility cost comparison tool	
Midwest	Ann Arbor, MI						X						X				X			X		X		X	X	X				X	X		X		11
	Holland, MI						X													X										X	X		X	X	6
	Indianapolis, IN											X	X							X		X	X			X	X	X		X			X		10
	Madison, WI											X	X							X		X								X			X		6
Mountain	Boulder, CO				X	X		X	X		X							X		X		X	X	X	X	X							X		13
	Fort Collins, CO				X	X		X	X		X					X				X		X		X	X	X							X		12
	Edwards, CO				X	X		X	X		X																			X					6
	Glenwood Springs, CO				X	X		X	X		X									X					X								X		8
Northeast	Barre, VT	X	X									X								X										X			X		6
	Bridgeport, CT	X	X		X	X	X		X		X									X								X		X			X	X	12
	Burlington VT	X	X									X								X		X								X			X		7
	Ithaca, NY	X	X				X	X	X													X								X			X		8
South	Atlanta, GA								X			X	X	X					X		X	X		X	X	X		X		X		X	X	X	15
	Athens, GA				X	X			X			X								X		X	X					X		X		X	X	X	12
	Durham, NC						X		X		X	X	X							X		X		X		X		X					X	X	12
	Austin, TX						X						X				X			X		X			X	X	X			X	X	X	X		12
	Nashville, TN				X	X											X		X	X	X	X				X	X						X		10
West	Seattle, WA				X	X	X	X	X		X	X	X	X		X				X	X			X	X	X	X						X		17
	Portland, OR	X	X	X	/	/		X	X		X		X	X						X	X	X	X	X		X	X		X	X			X		20
	Honolulu, HI									X							X		X	X					X		X	X			X	X	10
	Corvallis, OR	X	X	X				X	X		X									X	X	X							X	X			X		12
	Kahului, HI									X										X				X	X			X		X			X	X	8
California	San Jose, CA	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	26
	Santa Cruz, CA	X	X	X	X	X		X	X		X	X	X							X		X		X	X	X		X	X	X	X		X	X	21
	San Francisco, CA	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	26
	Eureka, CA	X	X	X	X	X		X	X		X	X	X							X					X			X	X	X	X		X	X	18

"X" denotes electric deployment action in place in the metropolitan area in 2015; "/" is for incentives for smaller fraction residents in neighboring state
ZEV = Zero Emission Vehicle; BEV = Battery electric vehicle; PHEV = Plug-in hybrid electric vehicle; HOV = high-occupancy vehicle lane
EVSE = Electric vehicle service equipment

Figure 4 summarizes the regional differences in electric vehicle uptake and the leading metropolitan areas within each region. The figure documents the regional share of new vehicles that are electric (gray line, right axis). This shows how electric vehicle shares in 2015 were much higher in California and the non-California West than elsewhere. The figure also shows the metropolitan areas in each region that had the highest electric vehicle shares, as a percentage above the regional average. We identify the four leaders in each region (five when there was an approximate tie). A few metropolitan areas stand out as having substantially greater electric vehicle uptake compared with their region's average, including Boulder and Atlanta (more than 500% greater uptake) as well as Athens, San Jose, and Barre (more than 200% greater uptake).

Several of the leading areas highlighted in Figure 4 are large metropolitan areas. For example, San Jose, San Francisco, Seattle, Portland, Atlanta, Austin, and Indianapolis each tend to have more local electric vehicle promotion activity, greater model availability, more extensive public charging infrastructure, and higher electric vehicle uptake than their regional average. Other smaller metropolitan areas can also offer insights as to what factors are driving electric vehicle shares higher than elsewhere. These regional leaders tend to exhibit the same combination of conditions: incentives, higher model availability, high charging infrastructure, and a rich mix of local actions (e.g., Boulder, Athens, and Bridgeport). We provide greater details on the regional differences as well as exemplary electric vehicle promotion programs by the leading metropolitan areas in each region below.

MIDWEST

The Midwest includes 185 metropolitan areas in 12 states from Ohio in the East, to states as far west as North Dakota and Kansas. The Midwest's uptake of electric vehicles is 61% lower than the U.S. average. Our analysis shows that the underlying reasons are that the region has the lowest electric model availability and the lowest public charging infrastructure among the regions. Average Midwest model availability is 74% lower than the average for California. Public charging infrastructure per capita in the Midwest is 31% lower than the national average.

Ann Arbor, Michigan. Within the Midwest, Ann Arbor had the highest electric vehicle share—three times the Midwest average and 10% higher than the U.S. average. Ann Arbor

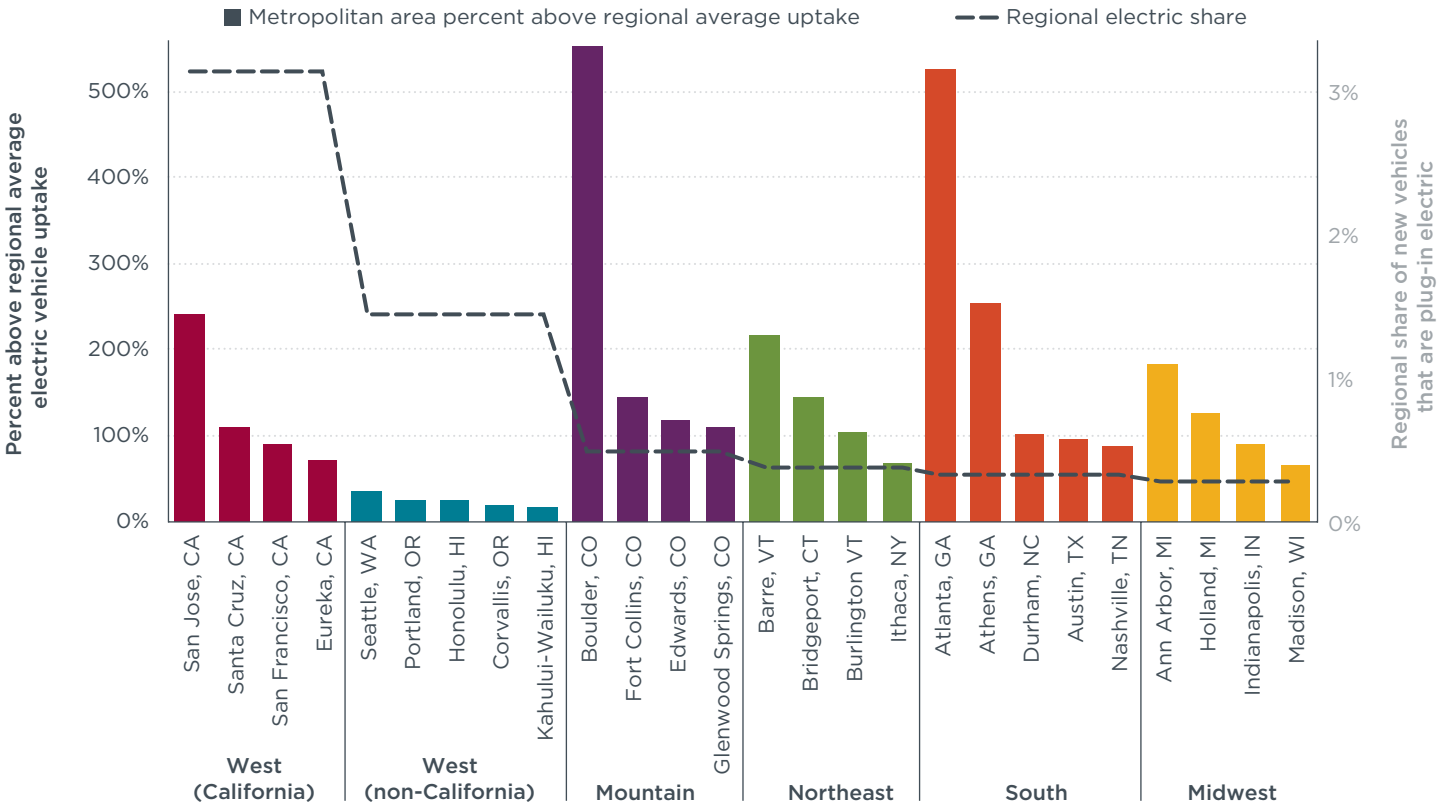

Figure 4. Regional electric vehicle share and regionally leading metropolitan areas

had three times the electric model availability of the Midwest average and many local promotion actions. The promotion actions include city charging and parking perks for electric vehicles, discounted utility charging rates, a city fleet green-car program, and a one-stop informational website for prospective electric auto consumers. Although the city is smaller, the area most likely benefits from greater electric model availability because it is close to the dealership-rich Detroit area. Its proximity to many of the auto industry's manufacturing, development, and research facilities also elevates awareness of the new technology and the models available. Sales potentially benefit from employee purchase discounts. The Drive Electric Ann Arbor Partnership helps coordinate the actions of local businesses, the Ann Arbor-based University of Michigan, the public utility DTE, and nonprofit organizations. The partnership also maintains a city webpage to support electric vehicles. As the seat of a major university, Ann Arbor shares characteristics with other leading areas for electric vehicles.

Holland, Michigan. The Holland area had the second highest electric vehicle share in the Midwest. Several lithium-ion battery supplier manufacturing units, including LG Chem, are in the Holland area. Three-quarters of Holland's new electric registrations in 2015 were Chevrolet and Ford plug-in hybrid electric vehicles. The market may benefit electric vehicles' expanding role in the local economy.

Indianapolis, Indiana. The Indianapolis area had three times the electric model availability and almost double the electric vehicle share of the Midwest average. The Indianapolis market also benefits from several local electric vehicle-related programs. The city has a goal to run its entire municipal fleet on alternative fuels by 2025. The Indianapolis utility provides consumer information and time-of-use rates for electric vehicles. The all-electric BlueIndy car-sharing program is ramping up toward 500 Bolloré Bluecar electric vehicles and 200 charge points, and its associated outreach and marketing help raise awareness.

Madison, Wisconsin. The Madison area had regionally high electric vehicle uptake despite an average charging infrastructure network and relatively few supportive actions by local government. The area's electric model availability was more than double the Midwest regional average (see Figure 3). Madison is the state capital and home to the state's largest university, perhaps suggesting greater awareness among policymakers and environmental nonprofits. The area also has city-owned electric vehicle chargers for public use as well as utility informational materials and time-of-use rates for charging.

MOUNTAIN

The Mountain region includes 71 metropolitan areas across the eight states that include some portion of the Rocky Mountains. The region has 30% lower electric vehicle uptake than the U.S. average. This may be because of relatively low electric model availability—68% lower on average than the metropolitan areas in California. The public charging infrastructure in the Mountain region is 12% higher than the national average.

The top metropolitan areas in the Mountain region by electric vehicle share are all in Colorado, which might be largely attributable to the state's consumer incentives of as much as $5,000 a car. Colorado also provides public charging and fleet purchasing support. The primary utility for these areas, Xcel Energy, provides informational materials and has several electric vehicle projects and partnerships (e.g., Refuel Colorado, Colorado Electric Vehicle Coalition). In addition, the multi-agency Charge Ahead Colorado program provides financial support for electric vehicles and charging equipment to fleets, governments, apartment complexes, nonprofits, and businesses.

Boulder, Colorado. Within the Mountain region, Boulder had the highest electric vehicle share, with more than 3% of new 2015 vehicles being plug-in electric. The city has informational web materials and has hosted electric vehicle outreach events such as ride-and-drives. In addition, Boulder probably benefits from being near the larger metropolitan area of Denver, helping to give consumers access to about double the electric model availability of the Mountain average. One action that stands out has been a highly visible dealer campaign by Nissan of Boulder as part of the Solar Benefits Colorado program. The program offered company group-buy discounts of more than $8,000 for the purchase or lease of a Nissan Leaf, an all-electric car whose list price starts at around $30,000 (see Smith, 2015 and City of Denver, 2015). Boulder Nissan has played an active role in electric vehicle education and outreach; the new 2016 EV benefits program is displayed on the dealership website landing page (Boulder Nissan, 2016).

Fort Collins, Colorado. The Fort Collins area had more than twice the electric vehicle share and more than three times the electric model availability of the Mountain region average. We identified 13 electric vehicle promotion actions, including many at the city and state levels. Along with Boulder with the University of Colorado, Fort Collins is home to Colorado State University, a large academic research institution, and the city is a major technology center. In terms of outreach, the Drive Electric Northern Colorado Initiative involves a public-private partnership and strong community participation to promote

and support electric vehicle ownership. The Fort Collins area also had a negotiated discount price for Nissan Leaf group purchases that offered a $9,000 discount in addition to state and federal incentives.

Edwards, Colorado. The Edwards area had more than double the electric vehicle share of the Mountain region average in 2015. The Edwards area has an especially extensive charging infrastructure, about seven times the region average. Local policy support actions and model availability are not high for the region. More than half of Edwards' electric vehicle registrations were the Tesla Model S, which costs $66,000 and higher, making it plausible that many of these are for second homes in the many nearby resort towns.

Glenwood Springs, Colorado. The Glenwood Springs area had more than double the electric vehicle share and model availability of the regional average. The area has eight state and local support policies. The local university presence may be a factor in spurring electric vehicle demand. For example, efforts by both the city and nearby Colorado Mountain College Glenwood Springs have resulted in public electric vehicle charging infrastructure that offers free charging to students, employees, and the general public. In late 2014, Glenwood Springs was a key location for electric vehicle charging during the EV Rally of the Rockies. The outreach event increased local prospective consumer understanding and familiarity with the technology.

NORTHEAST

The Northeast region includes 90 metropolitan areas in the nine Mid-Atlantic and New England states. The region had an electric vehicle share that was about half the national average and charging availability that was 21% lower than average. Metropolitan areas across the Northeast typically have many of the electric vehicle incentives and promotion activities in place. However, model availability has been limited to an average that was 59% below that of California.

Each of the leading Northeast areas are in states that have adopted the ZEV regulation, indicating electric vehicle market shares are expected to increase in the next couple years. All of these metropolitan areas have public charging stations for electric vehicles. Generally, the applicable utility company websites contain information on electric vehicles, community outreach activities, and time-of-use rate options for customers. Three of the areas are somewhat smaller than many of the other region-leading areas in this report, including two cities that are partially known as university towns.

Barre, Vermont. The Barre area's 1.2% electric vehicle share was three times the Northeast average and about 70% higher than the national average. The area had the most charging infrastructure of any in this study with more than nine times the Level 2 and 14 times the DC fast charging per capita of the region's average (See Figure 2). This area also had lower model availability and fewer local actions than other Northeast leaders. Ford plug-in hybrid electric vehicle sales made up two-thirds of the electric market, so strong Ford dealer engagement is suspected. Relatedly, Vermont had an innovative 2014 program that included financial incentives to consumers as well as 11 participating dealers for electric vehicle purchases or leases.

Bridgeport, Connecticut. The Bridgeport area had more than double the electric vehicle uptake, 80% higher charging availability, and 170% more model availability than the Northeast average. The area's high electric model availability most likely benefits from its proximity to New York City. Bridgeport had 12 electric vehicle promotion activities, with many at the state and utility level.

Burlington, Vermont. The Burlington area had twice the electric vehicle uptake, six times the charging infrastructure, and 50% greater electric model availability compared to the Northeast average. The municipally owned utility Burlington Electric has supported electric vehicles by deploying charging infrastructure and providing information related to location, type, and availability. The University of Vermont in Burlington may have played a role in spurring electric vehicle uptake; the university continues to support electric vehicles through its recent partnership with Burlington Electric.

Ithaca, New York. Compared with the Northeast average, Ithaca had 68% higher electric vehicle uptake and 42% higher electric charging availability, but low rankings of local electric vehicle policy and model availability. Ithaca is a smaller city with a large university presence, Cornell University, suggesting that perhaps the progressive character of the university community might be a factor.

SOUTH

The South region includes 275 metropolitan areas in 17 states from Texas to Delaware. The region's electric vehicle consumption was 53% below the national average. Two potential reasons are that the region had low availability of electric models and public charging infrastructure. Average model availability in metropolitan areas of the South was about 72% lower than in the leading areas of California. Public charging infrastructure was 25% lower than the U.S. average.

The leading South region areas each offer a combination of charging infrastructure, model availability, and local and state incentives that encourage electric vehicle use more than the rest of the region. These include several major high-tech growth areas as well as several with a major university.

Atlanta, Georgia. The Atlanta area's electric vehicle sales share of more than 2% exceeded the regional average by six-fold and was triple the U.S. average. The Atlanta electric market benefited from Georgia's state consumer incentive of $5,000 per car. However, the legislature revoked the incentive in July 2015, related to questions about the increasing government expenditures, and replaced it with disincentives in the form of additional specific fees for electric vehicles. The Nissan Leaf accounted for more than three-quarters of Atlanta's electric vehicle sales, suggesting that manufacturer and dealership efforts were major contributors. Access for single-occupant electric vehicles to high-occupancy vehicle (HOV) lanes provided a strong nonfinancial incentive in 2015. Georgia Power offered a $250 rebate program for the purchase and installation of each new residential electric vehicle charger.

Athens, Georgia. The Athens area had more than three times the electric vehicle uptake of the regional average. The area's market dynamics were the same as Atlanta's as the state reversed its incentive program at mid-year. Athens had more than twice the charging infrastructure as the regional average and 80% higher model availability. As in Atlanta, about three-quarters of electric vehicle sales were Nissan Leafs. However, Athens, a much smaller city than Atlanta, is largely a university town centered on the University of Georgia, and it does not have HOV lanes. Athens has an electric car-sharing service called JuiceCar.

Durham, North Carolina. The Durham area had more than double the electric vehicle uptake, charging infrastructure, and model availability compared with South region averages. The city and county of Durham have created information web materials to increase electric vehicle awareness and understanding. The city has also begun to integrate electric vehicles into its municipal fleet. The utility has a fleet electric-vehicle program and is engaged in electric vehicle research.

Austin, Texas. The Austin area had about double the electric vehicle uptake, three times the charging infrastructure, and four times the model availability of regional averages. Austin also has a Climate Protection Plan to make the entire city fleet carbon-neutral by 2020. Austin Energy offers support of as much as 50%, or as much as $1,500, for the purchase and installation of Level 2 home charging units. The utility also offers a low fixed rate for charging at home as well as access to public charging stations though the Plug-In Everywhere network as part of its EV360 program. The city and the utility have promoted electric vehicles and educated consumers on their benefits through the Plug-In Partners campaign.

Nashville, Tennessee. The Nashville area had about double the electric vehicle uptake, three times the charging infrastructure, and three times the model availability compared with regional averages. Nashville electric auto users benefit from access to about 60 miles of HOV lanes, a state purchasing rebate, and green parking permits. Nashville's municipal fleet has begun to incorporate electric vehicles. Two-thirds of the area's electric vehicle sales were Nissan Leafs, which the company builds at its assembly plant in nearby Smyrna, Tennessee. The Leaf's dominance of the local market suggests that the factory and local Nissan promotions resulted in greater consumer awareness.

WEST

The West region includes the five states that touch the Pacific Ocean. Within this region we separated California from the remaining four states' 42 metropolitan areas to better highlight key differences. In 2015, the non-California West region had double the electric vehicle uptake of the U.S. average—with a 1.4% market share versus 0.7%. Two reasons are the region's higher availability of electric models and public charging infrastructure. Average electric model availability was greater than the national average and the average for the four other regions. Compared with California however, the four other states in the region had about half the model availability. Public charging infrastructure in the region was more than twice as high as the national average.

Each of the leading metropolitan areas in the non-California West had some sort of consumer incentive in place (e.g., purchase incentive, private charging infrastructure incentive, free parking). In addition, all of these areas have extensive public charging availability for electric vehicles. Two of the leading areas in this region are in states that have adopted the ZEV regulation, indicating their electric sales shares are expected to increase in the next couple years.

Seattle, Washington. The Seattle area, with a 2% electric vehicle share, topped uptake in other metropolitan areas of Washington, Oregon, Hawaii, and Alaska. This was partly because model availability more than doubled the regional average, and charging availability was higher. The area has implemented many local and state government actions, including exemption from state, country, and city purchase taxes that can amount to over $2,500 per electric vehicle.

Portland, Oregon. The Portland area almost matched Seattle's 2% electric vehicle share. Underlying factors include having more than twice the model availability and about 25% more charging availability than the regional average. The area has 18 state, city, and utility electric vehicle promotion actions in place. The electric vehicle market is assisted by the ZEV regulation, which supports electric vehicle deployment, and the Clean Fuel Standard, which ensures that charging providers are incentivized.

Honolulu, Hawaii. The urban Honolulu area electric vehicle market accounted for almost 2% of vehicle sales. The market benefits from model availability that is more than twice the regional average and a charging infrastructure network that is above average. The shorter travel distances in Honolulu might also encourage auto buyers to choose electrics. Hawaii offers innovative parking policies for electric vehicles, including free parking and the requirement that at least one parking space be designated for electric vehicles in facilities with parking for at least 100 vehicles. Drivers in electric vehicles have access to HOV lanes. The car rental company Enterprise offers the option to rent electric vehicles and use charging stations, increasing consumer awareness and familiarity with the technology.

Corvallis, Oregon. The Corvallis area had the fourth highest electric vehicle share in the non-California West, with above-average charging infrastructure and model availability for the region. Compared with U.S. averages, Corvallis had about triple the charging infrastructure and about double the model availability. The area benefits from many state electric vehicle promotion policies, including the ZEV regulation and Clean Fuel Standard. Like many cities on this list, Corvallis is home to a major research university, Oregon State University.

Kahului-Wailuku, Hawaii. The Kahului area has a high electric vehicle share, partially because of the same state electric vehicle promotions that Honolulu has. The area also has one of the most extensive charging infrastructure networks of any of those in this study. The utility Maui Electric provides a cost-comparison tool online, time-of-use rate option for customers, and informational material on installation of electric charging equipment. As in Honolulu, the state's parking policies for electric vehicles offer a significant incentive to consumers.

CALIFORNIA

Because California represents about half the U.S. electric vehicle market, its metropolitan areas are considered separately from the rest of the West region. In 2015, California metropolitan areas on average had more than twice the charging infrastructure availability, more than three times the electric model availability, and more than four times the electric vehicle market share as national averages. The states ZEV regulation benefited all of the leading California electric vehicle markets. The market share leaders are primarily served by the utility Pacific Gas & Electric, which offers a wide array of consumer outreach, customer information on cost and fuel savings, preferential rates for electric vehicle charging, and public charging infrastructure support.

San Jose, California. The San Jose area had the highest electric vehicle share of any metropolitan area in the United States with 9.4% of new vehicles being plug-in vehicles. There are eight cities in the San Jose area that recorded 10% to 18% electric vehicle market shares. The smaller cities tend to have additional local electric vehicle promotion actions (Searle et al, 2016). The San Jose area is tied for the most local, state, and utility electric vehicle promotion actions (26); has the greatest workplace charging per capita; and has the largest public charging infrastructure network of any metropolitan areas nationally (Lutsey et al, 2016). The San Jose area has more than 1,400 workplace charge points at more than 20 workplaces (US DOE, 2015; Olexsak, 2016). An example of a workplace supporting electric vehicles is Google, whose offices have hundreds of charge points and aim to designate 5% of parking spots for electric vehicles. Other local measures include streamlined residential permitting for home charging installation and free metered parking for electric vehicles that are registered in San Jose or purchased from licensed dealership in San Jose. San Jose has started to incorporate electric vehicles in its municipal fleets and has set a goal of 100% alternative fuel vehicles by 2020.

Santa Cruz, California. The Santa Cruz area's 6% electric vehicle market share nearly doubled the California average and was eight times the U.S. average. Santa Cruz's GreenFocus program promotes electric vehicles more widely and reduces city fleet vehicle emissions by incorporating electric vehicles. Santa Cruz provides free charging and free or preferred parking for electric vehicle owners. The city engages with the Monterey Bay Electric Vehicle Alliance, a regional planning group, to promote adoption of plug-in electrics. The area's public charging infrastructure was 70% higher than the national average but slightly below the California average.

San Francisco, California. In the San Francisco area, 5% of new vehicle registrations were for plug-in electric vehicles. The San Francisco area's electric vehicle share, electric model availability, and public charging infrastructure were each 50%-75% greater than the California average. The area is tied for the most city, state, and utility electric vehicle promotion actions in place (26), after San Jose. Within the area, 12 cities including Oakland and Berkeley had 6%-14% electric vehicle shares and tended to adopt additional local actions (Searle et al, 2016). The utility Pacific Gas & Electric has approximately 1,200 electric vehicles in its own fleet, helping to increase familiarity with and general awareness of the new technology. Many metropolitan area and county governments are engaged in the Electric Vehicle Fleet National Demonstration Project, a coalition to purchase 90 government fleet electric vehicles and accompanying charging stations.

Eureka, California. The Eureka area, with a 5% electric vehicle market share, had about 50% greater uptake than the California average—more than 6 times greater than the national average. The area had about 60% more public charging infrastructure than the U.S. average but fell below the California average. Eureka is engaged in a multi-phase plan to roll out public charging stations.

4. Conclusions

This study analyzes the electric vehicle promotion activities that coincide with the leading electric vehicle markets across the United States. We identify the leading areas in each region in terms of the share of new vehicles that are plug-in electrics. Differing from previous work focusing on the largest cities, the assessment includes smaller and mid-sized metropolitan areas with high electric vehicle uptake. We find that generally the areas across the United States that have the highest electric vehicle uptake also have much greater model availability, more extensive public charging networks, and more state and local policy actions to support the market.

Figure 5 summarizes the electric vehicle promotion actions, model availability, and electric vehicle shares of the 26 metropolitan areas from this analysis. Electric vehicle promotion actions on the vertical axis represent city, state, and utility policies that spur electric vehicle sales. The horizontal axis is the total number of electric vehicle models available. The size of the circle representing each metropolitan area is proportional to the electric vehicle share (ranging from 0.5% to 9.4%). Colors indicate the region of the metropolitan areas, including the four or five areas in each region that had the highest electric vehicle uptake.

This analysis demonstrates and provides examples of the building blocks that are helping to develop electric vehicle markets across the United States. This study reinforces findings elsewhere, whereby a comprehensive set of state, local, charging infrastructure, utility, and automaker actions

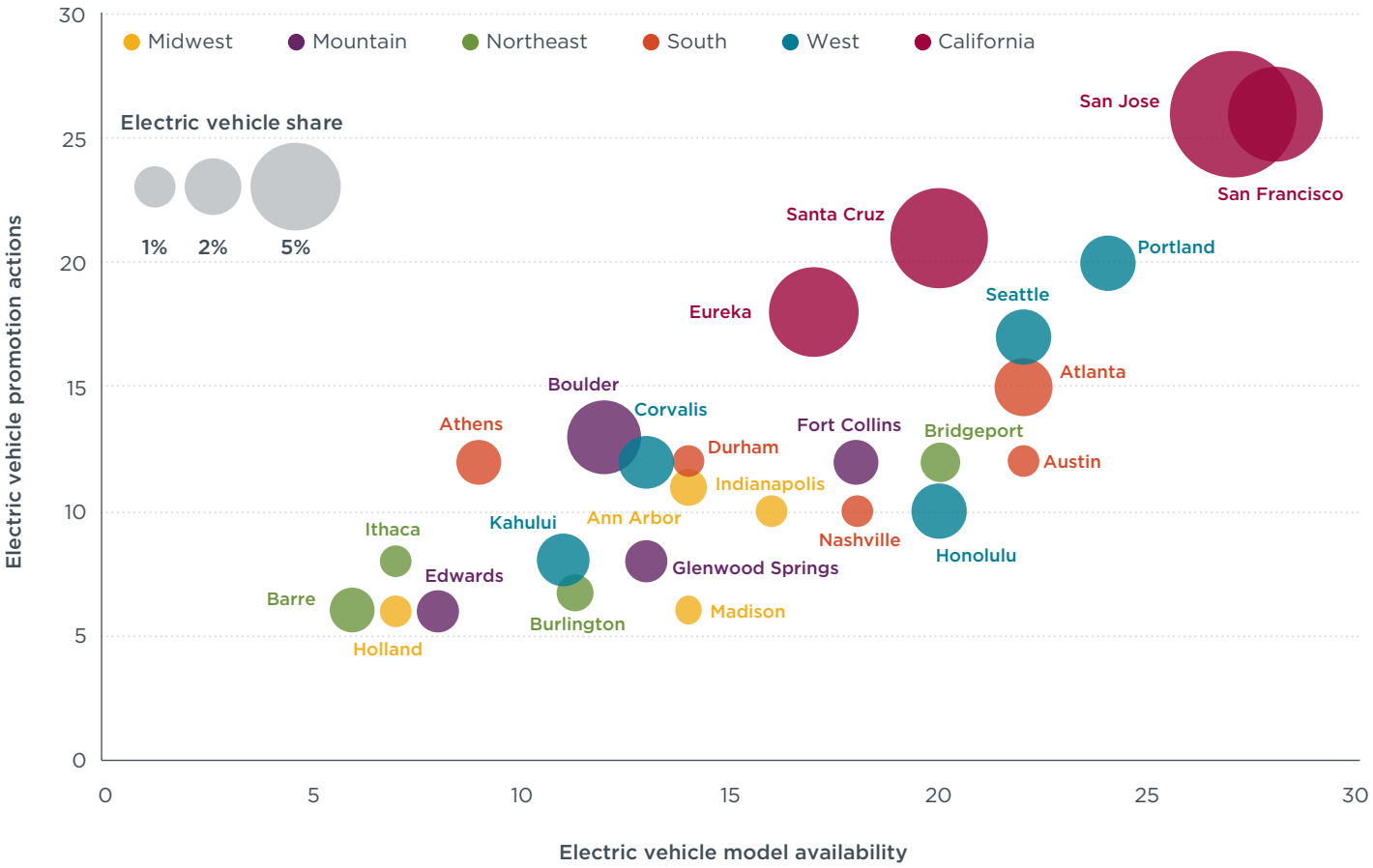

Figure 5. Electric vehicle promotion actions, model availability, and shares on the regionally leading metropolitan areas in electric vehicle uptake in the United States

are key to expanding the electric vehicle market. We make the following conclusions based on the findings.

- ***State policy.*** Regulatory policy, in particular the Zero-Emission Vehicle program, is a key driver for the early market. Many of the leading electric vehicle markets in this study are in ZEV states (e.g., California, Connecticut, New York, Oregon, and Vermont). The program could be especially important in the years ahead, as it drives increased model availability, which is found to be a limiting factor for the electric vehicle market.
- ***State incentives***. Most of the region-leading electric vehicle markets benefited from state-level financial incentives. Notable examples are those in Colorado, Georgia, California, Washington, Connecticut, and Tennessee. The two Georgia areas are especially illustrative, as the reversal of the electric vehicle incentive in mid-2015 essentially halted the market there. State non-financial incentives are also important. The region-leading markets of Atlanta, Honolulu, Nashville, San Jose, and San Francisco offered carpool lane access to electric vehicles.
- ***Local electric vehicle support***. Offering local parking perks for electric vehicles, progressively integrating electric vehicles into municipal fleets, and implementing electric-vehicle-ready building codes are increasingly common among the leading metropolitan areas for electric vehicle penetration. Many of the leading areas for electric vehicle uptake around the country also implemented electric vehicle readiness plans and multi-stakeholder groups (e.g., city governments, regional governments, local businesses, utilities, nonprofits) that were working together on outreach, coordination on charging infrastructure, and other local measures.
- ***Charging infrastructure.*** The regional electric vehicle share leaders tended to have greater public charging infrastructure than their regional average. These cities had a combination of government and workplace charging infrastructure support that is expanding home, public, and workplace charging options. In 14 of the 26 cases (Ann Arbor, Austin, Barre, Boulder, Burlington, Corvallis, Honolulu, Edwards, Kahului, Nashville, Seattle, Portland, San Jose, San Francisco) the public charging infrastructure was more than double the U.S. average. The San Jose area had exceptional workplace charging with more than 20 companies providing more than 1,400 charge points at work places.
- ***Utility promotion actions.*** Many regional electric vehicle share leaders had proactive electric power utilities supporting electric vehicles with outreach activities, preferential charging rates, and deployment of public charging infrastructure. Examples are Atlanta, Austin, and Honolulu. Electric power utilities have opportunities to become even more engaged, with public utility commissions in California and Oregon moving toward utility financing of charging infrastructure (e.g., see Edison International, 2016; SDGE, 2016).

These growing electric vehicle markets across the United States might signal an increased awareness in these communities regarding the emerging electric vehicle technology. Further support for the new market will require continued re-examination as electric vehicle adoption expands from early adopters to fast-following consumers, especially with the coming next generation of electric vehicles. The leading electric vehicle markets identified here are a collection of larger high-technology cities, as well as smaller university towns. The exact underlying characteristics of these types of communities, whether they have more proactive governments, more nonprofit activities, more progressive dealer actions, or other demographic characteristics, warrant further investigation. From this analysis it seems clear that the electric vehicle market is emerging, albeit concentrated within pockets. Widespread adoption of actions like those in place in the leading electric vehicle markets will continue to encourage broader expansion of the market.

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Annex: Additional data sources

Table A1. Metropolitan areas with highest electric vehicle shares in each region

Region	Metropolitan area	Population	Electric vehicle share	Electric vehicle share compared to regional average
Midwest	Ann Arbor, MI	354,240	0.8%	2.8
	Holland, MI	112,531	0.6%	2.2
	Indianapolis, IN	1,953,961	0.5%	1.9
	Madison, WI	627,431	0.5%	1.6
Mountain	Boulder, CO	310,048	3.2%	6.5
	Fort Collins, CO	315,988	1.2%	2.5
	Edwards, CO	52,460	1.1%	2.2
	Glenwood Springs, CO	74,681	1.0%	2.1
Northeast	Barre, VT	354,240	2.1%	6.3
	Bridgeport, CT	112,531	1.2%	3.6
	Burlington VT	1,953,961	0.7%	2.0
	Ithaca, NY	627,431	0.6%	2.0
South	Atlanta, GA	5,522,942	2.1%	6.3
	Athens, GA	197,905	1.2%	3.6
	Durham, NC	534,578	0.7%	2.0
	Austin, TX	1,883,051	0.6%	2.0
	Nashville, TN	1,757,912	0.6%	1.9
West*	Seattle, WA	3,610,105	2.0%	1.4
	Portland, OR	2,314,554	1.8%	1.3
	Honolulu, HI	983,429	1.8%	1.3
	Corvallis, OR	86,591	1.7%	1.2
	Kahului, HI	160,292	1.7%	1.2
California	San Jose, CA	3,610,105	9.4%	3.4
	Santa Cruz, CA	2,314,554	5.8%	2.1
	San Francisco, CA	983,429	5.3%	1.9
	Eureka, CA	86,591	4.8%	1.7

*See Figure 1 for regional boundaries; * "West" excludes California*

Table A2. Data sources for electric vehicle promotion actions in each of the cities assessed in this study

City	State	Local	Utilities	OUTREACH, OTHER
Ann Arbor	Michigan Legislature (2015)	Government Fleet (2013a); Spalding (2013); Ann Arbor DDA (2016); City of Ann Arbor (2016a,b)	DTE Energy (2016)	National Drive Electric Week (2015); USDOE (2016)
Holland	Michigan Legislature (2015)	Holland Board of Public Works (2016); Smith (2011)	Consumers Energy (2016)	
Indianapolis	Indiana Code (2016)	Vision Fleet (2015); Government Fleet (2013b); City of Indianapolis (2012)	Duke Energy (2016)	National Drive Electric Week (2015); BlueIndy (2016); USDOE (2016)
Madison	State of Wisconsin (2013)	City of Madison (2016)	We Energies (2016)	National Drive Electric Week (2015); USDOE (2016)
Boulder	Colorado Department of Revenue (2014); State of Colorado Energy Office (2014)	City of Boulder (2016)	Xcel Energy (2016)	National Drive Electric Week (2015); eGo CarShare (2016); USDOE (2016)
Fort Collins	Colorado Department of Revenue (2014); State of Colorado Energy Office (2014)	City of Fort Collins (2016); Drive Electric Northern Colorado (2016a)	Xcel Energy (2016)	Drive Electric Northern Colorado (2016b); USDOE (2016)
Edwards	Colorado Department of Revenue (2014); State of Colorado Energy Office (2014)		Holy Cross Energy (2015)	
Glenwood Springs	Colorado Department of Revenue (2014); State of Colorado Energy Office (2014)	Colorado Mountain College (2014a, 2016)	Xcel Energy (2016)	Colorado Mountain College (2014b)
Barre	State of Vermont (2016); Department of Motor Vehicles (2016a)	VTDigger (2014)	Green Mountain Power (2016)	
Bridgeport	State of Connecticut (2016)	BGreen Bridgeport (2013)	Eversource (2016a,b)	
Burlington	State of Vermont (2016); Department of Motor Vehicles (2016a)	VTDigger (2014)	Burlington Electric (2016)	USDOE (2016)
Ithaca	ZEV Task Force (2016); State of New York (2016a,b); NYSERDA (2013)	State of New York (2016c)	New York State Electric & Gas (2016)	USDOE (2016)
Atlanta	State of Georgia (2016); Georgia Code (2016)	State Road & Tollway Authority (2016)	Georgia Power (2016)	National Drive Electric Week (2015); USDOE (2016)
Athens	State of Georgia (2016); Georgia Code (2016)	Georgia Environmental Finance Authority (2014)	Georgia Power (2016)	Perry (2013); USDOE (2016)
Key West	The Florida Sentate (2012); Department of Motor Vehicles (2016b); The Florida Legislature (2015)			
Durham	N.C. Clean Energy Technology Center (2016); North Carolina General Assembly (2016)	City of Durham (2011); City of Durham (2016)	Duke Energy (2016)	USDOE (2016)
Austin	AFDC (2016); Department of Motor Vehicles (2016c)	Austin Energy (2016a); Yeomans (2014); Austin Area Electric Vehicle Association (2016)	Austin Energy (2016b)	National Drive Electric Week (2015); USDOE (2016)

City	State	Local	Utilities	OUTREACH, OTHER
Nashville	State of Tennessee (2016a)	Metropolitan Government of Nashville (2016); State of Tennessee (2016b); Regional Electric Vehicle Initiative (2016); Gonzalez (2015)	Nashville Electric Service (2016)	USDOE (2016)
San Jose	Brown (2013); California Air Resources Board (2016a,c); Center for Sustainable Energy (2016); State of California (2016a,b); California Environmental Protection Agency (2015); Charge Across Town (2016); City of San Jose (2016); Newsom (2011)	City of San Jose (2016a,b); San Jose Downtown Association (2016); California Air Resources Board (2016b); Government Fleet (2013c); Bay Area Climate Collaborative (2015)	Pacific Gas and Electric Company (2016); California Plug-In Electric Vehicle Collaborative (2016)	Bay Area Climate Collaborative (2015); USDOE (2016); Center for Sustainable Energy (2016); USDOE (2016); Wrightspeed Powertrains (2016)
Santa Cruz	California Air Resources Board (2016a,c); Center for Sustainable Energy (2016); State of California (2016a,b); California Environmental Protection Agency (2015)	California Air Resources Board (2016b); City of Santa Cruz (2013, 2016a, b); MB-PEVCC (2013)	Pacific Gas and Electric Company (2016); California Plug-In Electric Vehicle Collaborative (2016)	Monterey Bay Electric Vehicle Alliance (2016); USDOE (2016); National Drive Electric Week (2016); Santa Cruz Chamber of Commerce (2014)
San Francisco	California Air Resources Board (2016a,c); Center for Sustainable Energy (2016); State of California (2016a,b); California Environmental Protection Agency (2015)	California Air Resources Board (2016b); Bay Area Air Quality Management District (2016a); Bay Area Air Quality Management District (2016b)	Pacific Gas and Electric Company (2016); California Plug-In Electric Vehicle Collaborative (2016)	Bay Area Air Quality Management District (2016a); Bay Area Air Quality Management District (2016b); USDOE (2016)
Eureka	California Air Resources Board (2016a,c); Center for Sustainable Energy (2016); State of California (2016a,b); California Environmental Protection Agency (2015)	The Eureka Energy Committee (2010); Redwood Coast Energy Authority (2014)	Pacific Gas and Electric Company (2016); California Plug-In Electric Vehicle Collaborative (2016)	Redwood Coast Energy Authority (2016)
Seattle	State of Washington (2015)	City of Seattle (2016a)	Seattle City Light (2016)	National Drive Electric Week (2016)
Portland	State of Oregon (2016a); State of Oregon (2016b); State of Oregon (2016c)	City of Portland (2016a); City of Portland (2016b)	Portland General Electric (2016a,b)	USDOE (2016)
Honolulu	State of Hawaii (2016)	State of Hawaii (2012); Honolulu Star Advertiser (2012); Honolulu Clean Cities (2016)	Hawaiian Electric (2016)	Honolulu Clean Cities (2016)
Corvallis	Oregon Department of Environmental Quality (2016a,b); State of Oregon (2016a,b); Oregon Laws (2016); California Environmental Protection Agency (2015)	City of Corvallis (2010); Regional Electric Vehicle Initiative (2016);	Pacific Power (2016)	USDOE (2016)
Kahului-Wailuku	State of Hawaii (2016)	State of Hawaii (2012); Guzman (2015); University of Hawaii Maui College (2016)	Maui Electric (2016)	University of Hawaii Maui College (2016)
Bellingham	Washington State Department of Revenue (2016); Washington State Legislature (2016a,b); California Environmental Protection Agency (2015)	Relyea (2014)	Puget Sound Energy (2016)	National Drive Electric Week (2015)

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