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ASSESSMENT OF LEADING ELECTRIC VEHICLE PROMOTION ACTIVITIES IN UNITED STATES CITIES

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EXECUTIVE SUMMARY

Governments around the world are promoting electric vehicles to reduce oil consumption, climate-related emissions, and local air pollution. Efforts in the U.S. are especially diverse, with many state and local governments, civil society, and companies promoting awareness and sales of electric vehicles, as well as campaigning for policy, charging infrastructure, and financial support. Cities could represent an important focal point in the transition toward a robust electric vehicle market due to urban driving patterns and cities' concentration of vehicle ownership and charging networks. Although it is early in what is likely a decades-long transition toward an electric-drive vehicle fleet, the current diversity of electric-drive promotion actions provides a rich laboratory for what is working.

This original research analyzes the actions that are impacting electric vehicle deployment across major U.S. metropolitan areas. The 25 most-populous U.S. metropolitan areas analyzed in this paper represent more than 42% of the population, 46% of auto sales, 67% of new electric vehicle registrations, and 53% of the public electric vehicle charging infrastructure in the U.S. as of 2014. This research comprehensively catalogues the state, local, infrastructure, and utility actions that are spurring electric vehicle deployment and includes city-specific analysis of policy benefits to prospective electric vehicle consumers across the 25 urban areas. This analysis also seeks to discern the link between the promotion actions and the uptake of electric vehicles.

Figure ES-1 illustrates the share of new 2014 light-duty vehicles that are plug-in electric vehicles, across 25 major U.S. metropolitan areas. The figure compares the areas' new electric vehicle share (on the vertical axis) with the electric vehicle promotion activities (horizontal axis) and the public charger infrastructure (the size of the circles). The colors link cities that are in the same region of the country. The figure is based on the analysis of 30 state, city, and utility actions taken to promote electric vehicles and the per capita charging infrastructure in each area. As shown, there is great variation across the metropolitan areas, and San Francisco exhibits the most electric vehicle promotion actions and the highest share of new vehicles that are plug-in electric.

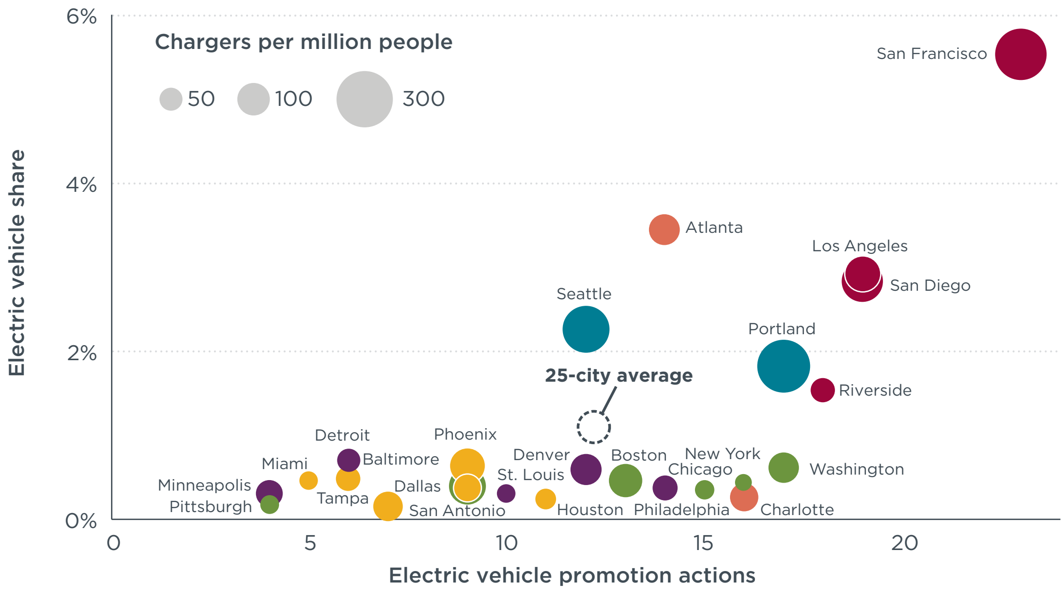

Figure ES-1. Electric vehicle promotion actions, charging infrastructure, and electric vehicle share of new vehicles in 2014 in the 25 most populous U.S. metropolitan areas (2014 electric vehicle registration data provided by IHS Automotive)

The research reveals several key findings that could be helpful in understanding electric vehicle policy actions and deployment patterns. Across these 25 cities, there was an average of a dozen electric vehicle promotion activities, and plug-in electric vehicles accounted for 1.1% of new automobiles in 2014, which is about 40% greater than the nationwide electric vehicle share. The seven cities with the highest electric vehicle share in 2014 — San Francisco, Atlanta, Los Angeles, San Diego, Seattle, Portland, and Riverside—had 2 to 7 times the average U.S. electric vehicle share. The top electric-vehicle adoption cities tended to have some combination of more electric vehicle promotion action, greater charging infrastructure per capita, greater consumer incentives, and greater model availability. Along with highlighting the leaders, this analysis also helps identify gaps in the promotion actions across various cities. For example, cities like New York have adopted many promotion actions and have high electric vehicle model availability, but have less charging infrastructure and state subsidies; on the other hand, cities like Denver have high incentives but low model availability. Many cities' electric vehicle markets appear to be held back by limited electric vehicle model availability.

Based on the findings, we draw the following four conclusions:

> ***Policy is driving accelerated electric vehicle deployment in several cities***. Among the seven leading electric vehicle-deployment cities, five are in states that have adopted California's Zero Emission Vehicle program, and six have attractive consumer incentives. Manufacturers are targeting these markets and making more electric vehicles more readily available, and electric vehicle sales are up as a result.

> ***Cities are leading on electric vehicles in diverse ways.*** Various cities across the U.S. are showing commitment and early success in developing the electric vehicle market. California cities' electric vehicle consumers are benefiting from state vehicle and fuel policy, long-term commitment to consumer incentives, and

implementation of city-level promotion actions, and their electric vehicle uptake is consistently higher than the U.S. average. Seattle has a mix of incentives, utility action, and charging infrastructure and has 3 times the U.S. average electric vehicle deployment. Atlanta's electric vehicle market has benefited from subsidies and carpool lane access; its battery electric vehicle sales were more than 8 times the U.S. average. Portland, with the most extensive electric charging network and extensive planning and outreach, is seeing 3 times the average U.S. battery electric vehicle sales, without subsidies.

Best practices for driving electric vehicles into the fleet are beginning to emerge. Consumer incentives, electric charging infrastructure, model availability, and city-level actions to promote awareness of electric vehicles are all positively linked with higher electric vehicle deployment. This analysis quantitatively supports the conventional wisdom of the "ecosystem approach," where many stakeholders — state and local, public and private — have key, high-impact roles in enabling the growth of the early electric vehicle market.

Cities are an important focal point for collaboration among governments, the auto industry, utilities, and advocacy. The 25 cities analyzed here represent about two-thirds of the U.S. electric vehicle market, and the leading cities have a lot of actors moving in the same direction. Continued and increased collaboration among local actors and state and federal agencies (for increased and prioritized public funding), non-profit groups (to leverage outreach and advocate for improved policy), utilities (to co-promote and incentivize electric vehicles), local businesses (to install workplace charging infrastructure), and automakers (to increase model availability and enhance marketing and outreach) could help align the various groups' efforts.

This assessment points toward many unanswered questions that warrant further investigation. Many cities in this report have been implementing substantial new policies, but without yet seeing electric vehicle deployment. Future sales data will reveal whether there are key missing policy ingredients, or whether what remains is a more widespread electric vehicle rollout by automakers. While some of the primary factors that are driving electric vehicle growth are becoming clearer, many are not. The roles of automaker marketing efforts, dealer actions, and utility action to promote electric vehicles seem clearly important and deserve greater study. Cases like Atlanta, where there has been success that is built almost exclusively upon one particular model (i.e., the Nissan Leaf), point to the need for further analysis of the underlying causes. Also, smaller and mid-sized cities that are outside this study's scope are innovating with electric-drive policies and have greater electric vehicle shares; these cities could be an important source of further lessons. Electric vehicle and battery technologies are improving rapidly, so increased range and cost reductions in next-generation electric vehicle models could be an important factor in future assessments. Furthermore, rigorous analysis of the relative value of home, workplace, and public charging could be especially important to steer public investments. Going forward, city-specific total cost of ownership analysis that sums up the above factors would be an important follow-on to this study.

This work has implications beyond providing a snapshot of the state of local U.S. electric vehicle deployment and policy. The U.S., the second-largest auto market and largest electric vehicle market in the world, is offering a rich laboratory for electric vehicle actions that could help in finding the complex recipe for launching the electric vehicle market. Likewise, cities around the world, especially in Europe, China, and Japan, are also innovating with, and learning from, new policies to promote electric vehicle uptake and use. Constant refinement on the precise mix of policy, improved technology, and consumer engagement will be needed to help chart out a sustainable path toward an electric-drive fleet.

I. INTRODUCTION

Governments around the world are implementing policies to promote electric vehicles to reduce oil consumption, climate-related emissions, and local air pollution, as well as stake an industrial leadership position in new advanced technology. Efforts in the U.S. are especially diverse, with many state and local governments, electric utilities, and automakers pushing to promote awareness and sales of advanced electric-drive vehicles, and the necessary regulatory, charging infrastructure, and financial support. Cities represent an important focal point in the transition toward an electric vehicle market due to urban driving patterns and cities' concentration of vehicle ownership and charging networks. It is early in what is likely to be a decades-long transition toward an electric-drive vehicle fleet, and questions abound as to whether best practices are beginning to emerge regarding electric-drive promotion actions.

The global electric vehicle market in 2015 is in a nascent stage, but is growing fast. Figure 1 summarizes electric vehicle sales by major automobile market through 2014 (Mock & Yang, 2014; EV Sales, 2015). The figure illustrates the global growth in annual electric vehicle sales to more than 100,000 in 2012, more than 200,000 in 2013, and more than 300,000 in 2014. Cumulatively this growth equates to more than 700,000 total global electric vehicle sales through the end of 2014. This growth is dominated by four main markets — China, Europe, Japan, and the U.S., with the U.S. automobile market accounting for 39% of global electric vehicle sales in 2014.

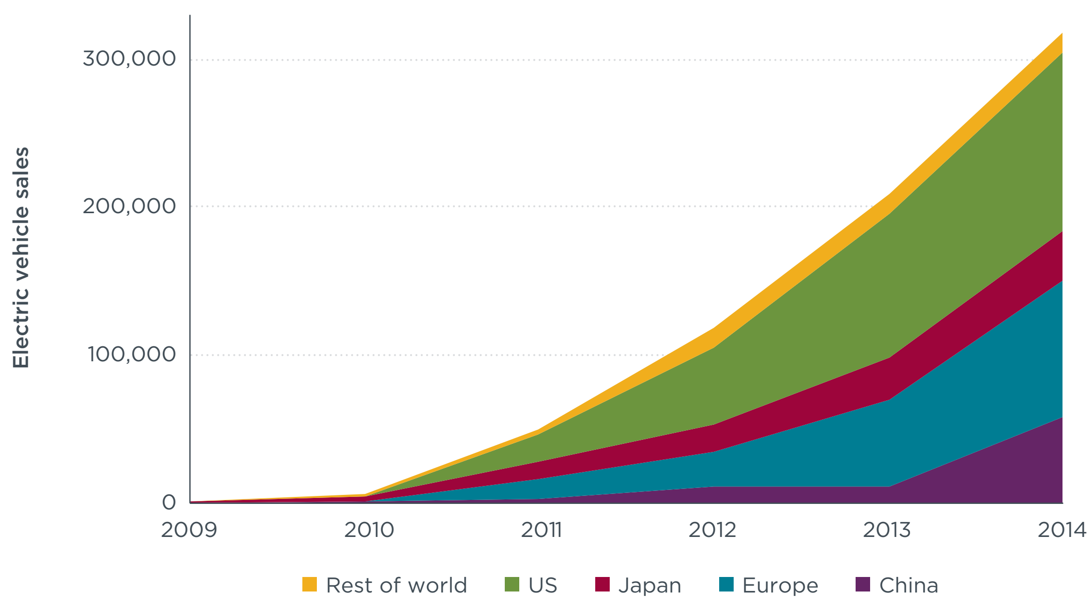

Figure 1. Annual global electric vehicle sales

With the continued introduction of new models, now by nearly every automaker, electric vehicle sales continue to increase (Argonne National Laboratory, 2014). Despite the growth in annual sales from hundreds in 2010 to more than 100,000 in 2014, the U.S. plug-in electric vehicle market remained less than 1% of new light-duty vehicle sales (Hybridcars, 2015). A number of leading regional and local markets have seen significantly higher electric vehicle sales uptake due to the use of state- and local-level electric vehicle incentives. In Europe, Norway and the Netherlands have demonstrated the impact of large subsidies and other policies to drive up electric vehicle share of passenger car sales to 5%-6% in 2013 (Mock & Yang, 2014), and up to 14% in Norway in 2014 (Yang & Tietge, 2015). Several U.S. states — California, Georgia, Hawaii, Oregon, and Washington — that have adopted increased fiscal and other measures to promote electric vehicles have, similarly, electric vehicle uptake of 2-4 times the national average (Jin et al., 2014).

A number of states continue to adopt new policies and convene stakeholder groups to prioritize and implement new electric vehicle promotion actions. California has taken a leadership role with its Zero Emission Vehicle (ZEV) program, which has specific requirements for the deployment of electric vehicles up to approximately 15%-20% of new light-duty vehicles sold by 2025 (CARB, 2011). Since the adoption of the major ZEV amendments in 2011, California has been implementing its ZEV Action Plan, which consists of a diverse set of policy, infrastructure, financing, and consumer actions. The California electric vehicle sales share was 2.5% in 2013 (Jin et al., 2014) and rose to 3.3% in 2014 (IHS Automotive), which is substantially higher than the projected ZEV requirements through 2016. Nine other states have also adopted the ZEV program (C2ES, 2014). In addition, eight of the 10 ZEV states have also adopted a ZEV Memorandum of Understanding and collaborated on a Multi-State ZEV Action Plan to prioritize and enact complementary actions to support electric vehicle deployment and use (NESCAUM, 2013, 2014). Much of the early electric vehicle deployment is concentrated in California (Lutsey, 2015).

A number of recent studies have reported on the types of key factors, barriers, and technology cost expectations that could be critical in driving a transition toward electric-drive (Greene et al., 2014a,b; NRC, 2013a, 2013b, 2015). Lower operating costs, especially in terms of electric vehicles' reduced fuel and maintenance costs, can reduce the total cost of owning and operating plug-in electric vehicles (Davis et al., 2013). The National Research Council found it would be difficult to offset electric vehicle price premiums by fuel savings alone, and that state and local electric vehicle purchasing rebates and access to carpool lanes, parking benefits, and reduced vehicle registration fees would be important to encourage electric vehicle ownership and use (NRC, 2013a). Collantes and Eggert (2014) indicate how various forms of financial incentives can contribute to making electric vehicles more attractive to consumers.

What mix of technical and cost improvements to electric vehicles, charging infrastructure deployment, and policy will bring electric-drive technology to the mass market is not yet clear. Jin et al. (2014) identified how many states are implementing various incentives, how these incentives are delivering consumer benefits, and how they are helping to spur electric vehicle sales in leading states. This work made a significant first step in quantifying the policies in place that are contributing to reducing the effective cost of ownership and operation of electric vehicles by from $2,000 to $5,000 per electric vehicle in several states. That state-level assessment concludes further investigation is warranted into how actions by city governments, utilities, and automakers at the local level influence vehicle sales.

Building on previous work, this assessment seeks to answer fundamental questions about what is driving the early electric vehicle market in major U.S. cities. It compiles and synthesizes data on policies, electric vehicle sales, electric vehicle charging infrastructure, and utility actions across the 25 most-populous U.S. metropolitan areas. These data are used to analyze which factors are improving the electric vehicle consumer proposition of owning and operating electric vehicles. Based on the new more detailed local data, the assessment develops a novel, more comprehensive framework for calculating the financial value of electric vehicle benefits from local policies. It also includes analysis of the impact of major electric vehicle promotion actions on electric vehicle sales and usage.

The next section discusses the background data and analytical approach of this report. Following that are reports on the analysis of state and local policies among the 25 metropolitan areas. The fourth section reports on the results of those policies, including the link between electric vehicle promotion actions and electric vehicle uptake.

II. APPROACH OVERVIEW

This section provides an overview of the analytical approach and discusses the data sources used in the assessment. The approach of this work entails research into the 2013-2014 actions in play across the 25 most populous U.S. cities to promote electric vehicles, electric vehicle sales, electric vehicle charging infrastructure, and the potential to increase the electric vehicle consumer proposition through 2020.

In essence, the study is designed to catalogue all actions that are affecting prospective electric vehicle consumers, in particular city-specific actions, and how such actions may be differentially impacting electric vehicle deployment across U.S. cities. The assessment involves the compilation and description of the electric vehicle promotion actions in each city, an estimation of the per-vehicle consumer benefit from existing policies in each city, and a statistical analysis of whether various electric vehicle support actions are linked to increased electric vehicle sales.

Table 1 summarizes the areas investigated within the study, and which actions were involved in the city-by-city cataloguing of action, the statistical analysis, and the per-vehicle consumer benefit analysis. Federal subsidies for electric vehicles and support for public charging infrastructure are incorporated across the cities. The study includes state-level actions such as vehicle purchasing incentives, carpool lane access, preferential parking access, vehicle registration fees, and fuel policy. The study captures city-specific actions that include analysis of the city-level incentives, charging network, utility actions, and model availability. Many of the electric vehicle promotion actions are quantified below (e.g., fiscal subsidies, charging stations per capita), whereas other actions are catalogued as qualitative (e.g., discrete yes/no for consumer awareness programs). As shown in the table and described below, a subset of the data was used in the statistical analysis to link actions to electric vehicle sales. A smaller subset of the actions was monetized to estimate the impact of existing policies on electric vehicle consumers across the 25 cities.

Table 1. Electric vehicle promotion actions researched in this study

Area	Action	Catalogued city-by-city in this report	Included in statistical analysis	Quantified in city-specific consumer benefit analysis
Federal	Vehicle efficiency standards			
	Vehicle purchase subsidy			
	Vehicle charging infrastructure	X	X	X
State	Zero Emission Vehicle program	X	X	
	Vehicle purchase subsidy	X	X	X
	Fee reduction or testing exemption	X	X	X
	Home charger incentive, support	X	X	X
	Public charging	X	X	X
	Parking benefit	X	X	X
	Fleet purchasing incentive	X	X	
	Manufacturing incentive	X	X	
	Low carbon fuel policy	X	X	
City	Vehicle purchase subsidy	X	X	X
	Parking incentive	X	X	
	City fleet purchasing	X	X	
	Carpool lane access *	X	X	X
	Car sharing program link	X	X	
	Local electric vehicle strategy	X	X	
	Website, informational materials	X	X	
	Outreach, education events	X	X	
Infrastructure	Public Electric Vehicle Service Equipment (EVSE) incentives	X	X	
	City-owned public chargers	X	X	X
	U.S. Department of Energy EV Project key area	X	X	
	Streamlined EVSE permitting process	X	X	
	EV-ready building code	X	X	
	Workplace charging	X	X	
Utility	Preferential rates for charging	X	X	
	Home charger support	X	X	
	Cost comparison tool	X	X	
	Website, informational materials	X	X	
	Other outreach activities	X	X	

** While carpool lane access is determined at the state level, the value of the benefits is determined at the city level.*

The scope of the work covers the 25 most populous U.S. cities. Figure 2 illustrates the locations of the analyzed cities. To inclusively incorporate the broader city population, geographic area, travel patterns, and driving network, the unit of analysis for this city-based study is the metropolitan statistical area (MSA). Generally this means that each of the major metropolitan areas includes at least one major urban center and several counties that surround it. The MSA is defined based on designations laid out by the U.S. Office of Management and Budget (OMB, 2013), reflecting broader social and economic interactions, commuting patterns, and weekend activities. Throughout the report we use the terms "metropolitan area" and "city" synonymously.

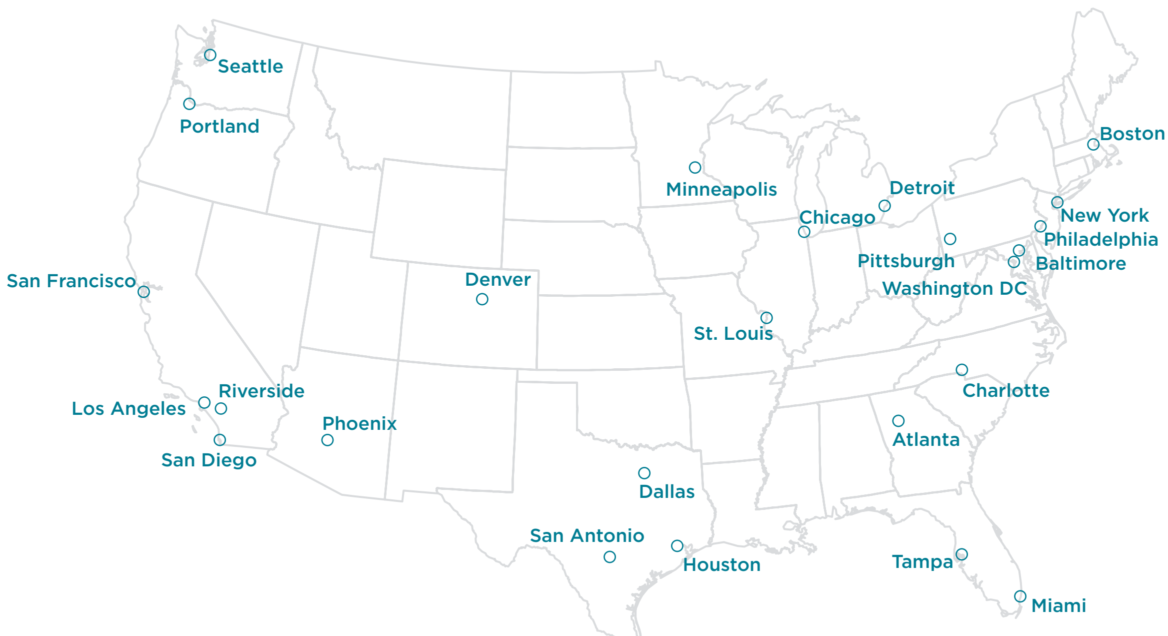

Figure 2. Location of the U.S. metropolitan areas that are the focus of this report

The data analysis uses the latest and most comprehensive information available, including 2014 data on vehicles, charging infrastructure, and electric vehicle promotion actions. The new electric vehicle share data is based on the latest available full year of vehicle registration data at the time of the analysis for calendar year 2014. The electric vehicle charging infrastructure data is from 2014. Public charging station data are analyzed, and some additional data on workplace charging are also compiled and discussed, but residential charging equipment is not analyzed. The electric vehicle promotion actions used in the statistical analysis and summarized in the current state of city-specific electric vehicle activity, the "City electric vehicle profiles," are based on 2014 data and information.

Table 2 summarizes the key data and sources that are referenced in this study in order to analyze the various factors related to electric vehicle deployment. The electric vehicle registrations and overall light-duty vehicle registrations over the year 2014 are from IHS Automotive (2015), and are viewed as synonymous with vehicle sales. Data from the U.S. Department of Energy (U.S. DOE) are used to assess the availability of public charging infrastructure.

Table 2. Data sources in this assessment of electric vehicle-related actions

Data	Sources	Notes
Vehicle sales data	IHS Automotive, 2014	• BEV, PHEV, and overall light-duty vehicle sales of 25 metropolitan areas by metropolitan statistical area
Population	U.S. Census, 2014a	• 2013 population of 25 metropolitan areas, based on metropolitan statistical area
State policy benefits to consumers	Jin et al., 2014 U.S. DOE, 2014a	• Vehicle purchase subsidy • Registration and licensing fee • Emissions testing exemption • Parking benefit • Carpool lane access
City/local policy	U.S. DOE 2014b Jin et al., 2014 Local electric vehicle readiness plans*	• Vehicle purchase subsidy • Parking incentive • Fleet purchasing incentive • Value of carpool lane access • EVSE incentives • Car sharing program link • City electric vehicle strategy • Website, informational materials • Outreach, education events
Charging equipment availability	U.S. DOE, 2014c	• Charging infrastructure availability by type (DC fast, Level 2) and location per metropolitan area
Gasoline station availability	U.S. Census, 2014b	• Number of gasoline stations per metropolitan area
Value of charging infrastructure	Lin and Greene, 2011 Davis et al., 2013 Auto Rental, 2014	• Based on value of replacement vehicle, charging equipment availability, gasoline station availability
Utility rates and activity	Many utility-specific websites*; Anair & Mahmassani, 2012	• Time-of-use $/kWh rates • Home charger support • Website, cost-comparison, informational materials, and other outreach

Notes: DC = direct current; kWh=kilowatt-hour; kW=kilowatt; EV=electric vehicle; BEV=battery electric vehicle; PHEV=plug-in hybrid electric vehicle; HOV=high-occupancy vehicle; * See Appendix for local policy and utility information sources

Several major policy actions that are promoting the early electric vehicle market are not included in this analysis. Also omitted, although they could be important factors, are federal and industry research and development efforts to spur technology breakthroughs, as well as public-private partnerships to coordinate research and infrastructure efforts. Because these factors are relatively unlikely to have any differential impact across U.S. cities and their precise impact on consumers is unclear, these types of national policies were deemed less important to characterize in this analysis.

Although there could be significant differences in consumers' knowledge about vehicle technology, awareness and understanding of existing policy incentives, demographics, and attitudes across the urban areas (e.g., see Krause et al., 2013; Kurani & Tal, 2014), such factors are not examined in this study. More specifically, it includes no analysis of the extent to which automaker-specific and dealer-specific actions (e.g., marketing, dealer incentives) are impacting electric vehicle deployment. In addition, although model availability is analyzed here, more specific analysis of actual electric vehicle supply and electric vehicle inventories in 2014 are not assessed.

III. ANALYSIS OF ELECTRIC VEHICLE ACTIONS IN MAJOR U.S. CITIES

This section consists of four parts: (a) the description and cataloging of actions being undertaken to promote electric vehicles; (b) an evaluation of the benefit that electric vehicle consumers accrue from the various electric vehicle promotion actions; (c) an assessment of electric vehicle shares; and (d) a statistical analysis of the extent to which diverse actions are supporting electric vehicle sales across the 25 cities under consideration.

CATALOGUING ACTIONS TO PROMOTE ELECTRIC VEHICLES

Many actions to promote electric vehicles are planned and implemented at the state level, whereas other actions are city-specific, driven by governments and utilities. Although there is clearly overlap in the support, engagement, and funding of actions, the electric vehicle support actions are discussed separately for the federal, state, and local levels. When there are applicable differences in how the electric vehicle promotion actions impact battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), such differences are noted.

Federal actions

Although there are many federal actions to promote the development and deployment of electric vehicles, we note three of the most relevant for this study: regulatory requirements, federal subsidies for electric vehicles, and funding for charging infrastructure.

Regulatory incentives in vehicle efficiency standards. Federal and California greenhouse gas emission and efficiency standards that get progressively more stringent are perhaps among the most important general drivers for electric vehicles over the long term. As the standards progressively lower carbon dioxide (CO_2) emissions, by approximately 4% per year, new vehicles are pushed toward greater efficiency and eventually — from 2020 and beyond — toward advanced technologies, and potentially electric-drive. By model year 2025, new light-duty vehicles will be required to meet fleet-wide CO_2 standards that are approximately equivalent to 54.5 miles per gallon fuel economy. The motivation for automakers to deploy electric vehicles is due to these vehicle technologies' very low carbon emissions, as well as additional regulatory incentives like zero gram-per-mile CO_2 accounting and "multiplier" credits that count each of these vehicles as more than one vehicle (see U.S. EPA and NHTSA, 2010, 2012; CARB, 2011; Lutsey & Sperling, 2010). The adopted regulations are projected to require that electric vehicles make up about 2% of new 2025 sales for fleet-wide compliance (U.S. EPA, 2012). These electric vehicle inducements are uniformly applicable across all U.S. cities and are not analyzed further in this study.

Electric vehicle subsidies. In the federal U.S. program, plug-in electric vehicles with a minimum of 5 kilowatt-hour (kWh) battery capacity are eligible for $2,500 per vehicle, scaling up at $417 per kWh to a maximum of $7,500 per vehicle of 16 kWh or greater. Generally this means that plug-in hybrid electric vehicle models with all-electric ranges from 11 to 25 miles (18 to 40 km) receive approximately $2,500 to $4,000; this includes popular Toyota, Ford, and Honda plug-in hybrid models. Based on battery capacity requirements, essentially all BEV models and some PHEV models with relatively high all-electric range (e.g., Chevrolet Volt) receive the maximum $7,500 credit. These tax credits are applicable for 200,000 total BEV and PHEV vehicles per manufacturer, and the incentives are phased out for the year following manufacturers' 200,000th BEV/PHEV sold (see IRS, 2014). These electric vehicle incentives apply uniformly across all the cities in this study; as a result, these are not included in the city-specific analysis below.

Funding for electric vehicle charging infrastructure. A substantial fraction of the funding support for the deployment of electric charging infrastructure has come from the U.S. DOE, as part of the 2009 American Recovery and Reinvestment Act. The Act provided $400 million for the transportation electrification project. The U.S. DOE-administered grants, as well as similar state grants, generally include cost sharing with electricity charging partners (e.g., ECOtality, ChargePoint) and partnering with cities to ensure an aligned, planned, and efficient rollout of charging equipment. At present there are more than 8,000 electric charging stations and at least 21,000 charge outlets across the U.S. (U.S. DOE, 2014c). The electric vehicle charging infrastructure of the various charge types, as deployed at the local level, is discussed further and analyzed below.

State-level actions

Many states offer some form of direct and indirect incentives, as well as other regulatory, infrastructure, and utility policy actions to promote electric vehicles in the cities investigated in this study. This section briefly describes the various state actions covered in this study, largely drawn from Jin et al. (2014). In cases where a metropolitan area significantly overlaps multiple state jurisdictions, the policies in place in all relevant states are counted. Also, we note that there is some overlap between state-level activities presented here and the activities discussed in the subsequent city-level section.

Zero Emission Vehicle Program (direct electric vehicle deployment requirements). Adoption of the California ZEV program is the most direct policy change any state can take to ensure increased electric vehicle deployment. California now requires that electric vehicles constitute approximately 15% of new automobile sales in the state in 2025. The ZEV program is designed to be flexible in allowing various forms of electric-drive vehicle technologies, including BEVs, PHEVs, and hydrogen fuel cell electric vehicles (FCEVs). Expected compliance includes sales shares of approximately 9% PHEV, 4% BEV, and 2% FCEV in 2025, including associated cumulative sales of approximately 1.6 million BEVs, PHEVs, and FCEVs in California through 2025 (CARB, 2011).

ZEV program compliance could occur with greater or lesser shares of the three main technologies; for example, if there were no FCEVs, the PHEV and BEV shares would be significantly higher. The ZEV provisions grant credits to vehicles according to their estimated electric driving range on prescribed testing cycles. For example, a 50-mile (80-km) PHEV gets 1.0 credit, a 100-mile (161-km) BEV gets 1.5 credits, and a 300-mile (483-km) FCEV gets 4.0 credits. PHEVs with electric vehicle ranges from 10 to 40 miles (16-64 km) can accrue 0.4 to 0.9 ZEV credits.

The electric range is generally based on the Urban Dynamometer Driving Schedule, or "city," test cycle, but other conditions affect the precise crediting. The program allows credit trading between companies, and noncompliance is subject to a $5,000 fine per vehicle. Nine other states (Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont) have adopted ZEV programs (C2ES, 2014). Eight of these states support ZEV implementation with a formal Action Plan (NESCAUM, 2014). Based on total vehicle sales across those states, the ZEV sales in non-California states would almost double the total impact of the ZEV program. Eleven of the cities considered in this study are in states that have adopted the ZEV program.

Vehicle purchase subsidies. Purchase subsidies usually are offered in the form of tax credits and rebates for electric vehicles. Some states offer the same subsidies to all types of electric vehicles, some provide a different amount to PHEVs and BEVs (sometimes based on battery capacity), and others offer the benefit only to BEVs. Examples are California's Clean Vehicle Rebate Project, which offered $2,500 for BEV and $1,500 for PHEV purchases in 2013; Colorado's motor vehicle credit that offers up to $6,000 based on battery capacity and purchase year; Massachusetts' MOR-EV rebates of up to $2,500 for plug-in vehicle purchases; and Georgia's income tax credit for ZEV purchases and leases of 20% of the vehicle cost, up to $5,000. Georgia's program is set to expire in mid-2015.

In addition to income tax credits, purchase subsidies include state sales tax exemptions for electric vehicle purchases and related services. Examples include Washington's retail sales tax exemption for alternative fuel vehicles; Maryland's excise tax credit of up to $3,000 based on battery capacity for purchase or lease of a plug-in vehicle; and the District of Columbia's excise tax exemption for high fuel economy vehicles (Jin et al., 2014). Based on our research, 14 of the cities have some form of vehicle purchasing incentive for BEVs and 12 for PHEVs; these numbers include three metropolitan areas that span two or more states.

Fee reduction or testing exemption. This category includes license tax reductions and registration fee reductions applicable to electric vehicles. Arizona, the District of Columbia, and Illinois offer this type of incentive. Arizona's fee exemption is the largest, providing a benefit equivalent to $1,000 over the lifetime of an electric vehicle (Jin et al., 2014). These state incentives apply to four of the 25 cities in this study.

In addition, at least 20 states require annual or biennial emissions inspections and exempt electric vehicles. Thus electric vehicle owners avoid paying the inspection fees required of other vehicle owners. For example, Connecticut exempts electric vehicles from a required biennial emissions inspection, which typically costs $20. We take estimates from Jin et al. (2014) to include the modest time saving benefits from this exemption, as relevant for the 14 applicable cities.

On the other hand, several states have additional annual fees for electric vehicles that are meant to approximately cover the forgone highway taxes that would otherwise be paid as a per-gallon fuel tax. For example, Nebraska ($75 per vehicle), Virginia ($64), Washington ($100 for BEVs, but none for PHEVs), Colorado ($50), and North Carolina ($100) have such fees (Jin et al., 2014). These state fees add to the cost of BEVs in five of the 25 cities, and the cost of PHEVs in three of the cities.

Home and public charger incentives and support. Many states offer subsidies for home chargers and public chargers in the form of tax credits, rebates, and grants. Generally, a state covers a percentage of the cost, capped at a certain amount. Some states subsidize both hardware and installation cost, while some subsidize only hardware or only installation cost. For home chargers, Maryland offers a rebate equal to 50% of the cost of qualified electric vehicle service equipment (EVSE) up to $900 for individuals, $5,000 for businesses, and $7,500 for retail service stations. Georgia offers a subsidy for business enterprises that install public chargers, worth 10% of the cost of the charger and its installation up to $2,500. The EV Infrastructure Rebate Program in Illinois covers 50% of the cost of equipment and installation with a cap based on the type of station; more than $350,000 was awarded in 2013, funding a total of 130 stations in that program (Jin et al., 2014). Homeowners and businesses in 12 of the 25 cities of this study benefit from state EVSE programs.

Parking benefit. Two U.S. states provide free parking for electric vehicles. In Hawaii, electric vehicle drivers can park at meters free of charge (except under specific circumstances). Nevada requires all local authorities with public metered parking areas to establish a program for alternative fuel vehicles to park in these areas without paying a fee. In Jin et al. (2014), the Hawaii and Nevada free parking benefits were estimated to be worth approximately $1,000 and $600 per vehicle, respectively, over the electric vehicle lifetime. Although these state parking benefits can be significant in some regions, they do not apply to any of the cities in this study.

Carpool lane access. Ten states offer unrestricted access to high-occupancy vehicle (HOV) or carpool lanes for electric vehicle drivers. California and Florida also exempt electric vehicles from toll charges on high occupancy toll (HOT) lanes, sometimes called "express lanes" but essentially HOV lanes that single occupancy vehicle drivers can access by paying a toll. Access to HOV and HOT lanes reduces the time that electric vehicle drivers spend on the road during peak traffic hours. Some states require a separate sticker, decal, or license plate to use HOV lanes, which usually costs a small amount of money. HOV access stickers can be limited in numbers and command a substantial effective vehicle price increase among used vehicles with a valid sticker (Blanco, 2009). These state incentives were estimated to offer consumer benefits of hundreds of dollars in some states (e.g., Georgia, Tennessee) to more than $1,000 in others (e.g., California, Hawaii) over the lifetime of an electric vehicle (Jin et al., 2014). Carpool lane benefits are applicable for eight of the 25 cities of this study.

Fleet purchasing incentive. Several states have policies and guidelines to support fleets in leading the shift toward purchasing and using electric vehicles. As part of the Pacific Coast Climate (PCC) initiative, California, Oregon, and Washington are pushing to expand the use of ZEVs in fleets, with the goal that 10% of new vehicle purchases for public and private fleets will be electric vehicles by 2016 (PCC, 2014). These efforts include guidance and support for public and private fleet managers to shift their procurement investments. Many other states included in this study also have guidelines to introduce more alternative fuel vehicles, and especially electric vehicles, into their fleets, though typically without specific deployment targets like the three PCC states. There are 10 states with fleet purchasing guidelines of some kind, and these state programs are applicable to seven of the 25 cities in this study.

Manufacturing incentive. Several states offer incentives for the development and manufacturing of electric vehicles and their components. Applicable to the cities within this study, California, Georgia, Illinois, South Carolina, and Virginia have offered such incentives. California has invested $48 million, along with additional matching non-state funding, in in-state manufacturing projects on electric vehicle projects and has also allocated $38 million for medium- and heavy-duty electric vehicle demonstrations (Smith & McKinney 2013). Other examples include Illinois' Industry Development Grants, Georgia's Advanced Vehicle Job Creation Tax Credits, South Carolina's Battery Manufacturing Tax Incentives, and Virginia's Clean Energy Manufacturing Grants and Clean Transportation Technology Investment Funding (U.S. DOE, 2015h; Illinois, 2015). Often these policies are tied to explicit requirements for minimum amounts of new job creation and associated private investments in new manufacturing facilities. These programs are applicable for nine of the 25 cities in this study.

Low carbon fuel policy. A number of fuel-side regulatory approaches also provide an incentive for energy providers and consumers for electric vehicle deployment and use. Three states — California, Oregon, and Washington — could have significant low carbon fuel regulatory policies in place through 2020 and beyond (CARB, 2015a; ODEQ, 2015; WSDE, 2014). These policies will increasingly help motivate obligated fuel providers, electric utilities, and third-party electric charging station operators to track, report, and increasingly charge electric vehicles (Malins et al., 2015). A recent study indicates the value of such low carbon fuel policies could amount to $200 to $500 per vehicle per year of BEV use (Yang, 2013). California and Oregon have adopted these policies, but Washington has not. These policies are therefore considered here in the cataloguing of electric vehicle promotion activities for the four California cities and Portland.

In addition, direct economy-wide carbon policies that include transportation fuels are under consideration. For example, California has adopted a carbon cap-and-trade framework that is expected to include transportation fuels within its economy-wide carbon emission cap in 2015 (CARB, 2015b). Although such low carbon fuel and cap-and-trade policies could accrue benefits for prospective electric vehicle users in the future, the consumer benefits of these policies are not quantified in this 2013-2014 assessment.

City-level actions

In addition to the state-level electric vehicle promotion activity outlined above, many additional actions are coordinated, adopted, and implemented at the local level. These actions, although generally less quantifiable as consumer benefits, include incentives to promote private fleet purchasing, local parking benefits, city fleet purchasing, and outreach actions to support general electric vehicle awareness. This section briefly describes these actions and summarizes the applicability for the 25 cities in this study.

Vehicle purchase subsidy. In addition to federal and state vehicle purchasing support, several cities offer additional financial support to promote electric vehicle purchases. Particular to this study, Riverside and San Francisco have offered such incentives. In 2013, Riverside offered a $2,500 incentive for vehicle purchases or leases, and San Francisco offered $400 to $700 for purchases of PHEVs and BEVs, respectively, for individuals and businesses. The Riverside incentive was reduced to $500 per vehicle for 2014. In addition, Chicago offered heavy-duty electric vehicle conversion and purchasing vouchers in 2014. For this study, only Riverside and San Francisco's incentives are included in the quantification of city purchasing incentives.

Parking benefits. In addition to previously mentioned state-level incentives related to parking, several local authorities are helping to provide additional, designated parking for electric vehicles. For example, several mid-sized cities like San Jose, Sacramento, Santa Monica and Hermosa Beach in California, and New Haven, Connecticut, offer such benefits.

Of the cities in this study, three were identified as having substantial local parking policies that would increase designated parking for electric vehicle users. Boston has a program to make off-street parking available for electric vehicles. Denver requires that new lots with at least 100 spaces have at least one designated for electric vehicles. Based on a 2007 policy, Philadelphia requires reserved electric vehicle spaces when there are plug-in resources nearby. New York City's new 2014 policy requires that 25% of new parking be electric vehicle ready, with an expectation of at least 5,000 new such spots over the next seven years. These policies generally are linked to guidelines for charging stations or electric vehicle ready wiring in the parking facilities.

City fleet purchasing. Among the 25 cities considered here, 15 have some form of purchasing grants or incentives supporting increased electric vehicle deployment in city fleets. Most of the programs include the purchase of between five and 50 electric vehicles in 2013-2014. They also can take advantage of various fleet practices such as group procurement and ownership of on-site charging infrastructure and relatively routine vehicle usage patterns. Beyond simply incrementally increasing electric vehicle sales and displacing less efficient vehicles, these programs also are meant to more generally increase the exposure and awareness of electric vehicles. In addition, they can be part of overall goals to install charging infrastructure by making city fleet charging infrastructure available to the city fleet and the public. For example, Charlotte received a grant from the U.S. DOE to support the purchase of 11 electric vehicles and 29 charging stations that would also be available to the public. In other examples, Dallas purchased eight electric vehicles in 2013, and Seattle replaced 43 conventional vehicles with BEVs from 2011-2013.

Carpool lane access. As outlined above, carpool lane access for single-occupant electric vehicles is allowed in 10 states and thus is applicable for eight of the 25 cities in this study. Local and regional transportation planning agencies plan for and manage the road network, including the use of the carpool lanes, although authority to adopt this policy is held by state governments. The eight applicable metropolitan areas are Atlanta, Los Angeles, New York, Phoenix, Riverside, San Diego, San Francisco, and Washington. Based on the Jin et al. (2014) analysis, the carpool lane benefits are re-evaluated on a city level in this study for these eight cities that allow carpool lane access to electric vehicle users.

Car-sharing program links. Embracing shifts in new car ownership patterns, several cities are seeing electric vehicle deployment in their emerging car-sharing networks. Some car-sharing programs are bringing electric vehicles into their urban vehicle fleets. This practice increases electric vehicle sales and also gives an opportunity to incrementally increase the awareness, exposure, and level of comfort of electric vehicle use among prospective consumers. Within this study, seven cities have some such car-sharing electric vehicle link. Zipcar in Chicago — working with the city of Chicago and the Clean Cities Coalition — has been using electric vehicles in its fleet since 2012. Philadelphia and Portland also are working with Zipcar on their programs. Other examples include Houston's Fleet Share, San Diego's SmartCitySD with Car2go, and BMW's program in San Francisco.

Local electric vehicle strategy. Many cities have established written strategic plans to document, align, and plan the various interrelated actions described here. These can serve as important documents for stakeholders to work on together to learn and coordinate actions of city officials, diverse city groups, county officials, state officials, automakers, and electricity provider representatives. The U.S. DOE has funded and collaborated on many of these projects with the Clean Cities Community Readiness Plans (U.S. DOE, 2014d). Based on our research, community, city, and regional electric vehicle readiness plans have been developed for 16 of the 25 cities in this study.

Website and other informational materials. Many cities include informational, educational, and outreach activities among their actions to promote electric vehicles, as increasing the availability of information is critical while the electric vehicle market is still in its early stages. Less than half of U.S. consumers are at least somewhat familiar with the top electric vehicle models (Vyas & Hurst, 2013) and less than 35% of California households are aware of incentives offered for electric vehicles (Kurani & Tal, 2014). General information about electric vehicles, links to external sources, and information about charging infrastructure are quite common in the web-based resources that cities are hosting. Most cities in this study (i.e., 20 of the 25) make some such informational materials available.

Outreach and education events. There are many community-organized events to help promote greater understanding of electric vehicles and the particular models available. Through a review of city electric vehicle planning and discussion with city officials, we found that at least eight of the 25 cities have organized or hosted such events. There are also many automaker-specific outreach events, which include events accompanying the auto shows in Detroit, Los Angeles, New York, and Washington, DC.

Electric charging infrastructure

This section summarizes local actions that are taking place to ensure an adequate electric charging infrastructure to support the increasing shift toward an electric vehicle fleet. Many of these actions are interrelated with what has been discussed above. For example, the infrastructure funding comes from federal, state and local government sources, and much of the planning for the infrastructure is done by and with local planning officials and local equipment providers.

City-owned public chargers. Along with helping to administer and direct state, federal, and private investments for charging infrastructure, many cities are directly installing charging equipment. Many of the projects are partially funded by federal or state funding, and many of the charging stations are made free for public use. Within this study, 18 of the 25 cities have installed charging equipment. Many have installed less than 10 stations. Others, like Houston, Los Angeles, and San Francisco, have installed more than 50 stations.

Public EVSE incentives. In addition to directly creating charge points, cities may offer to partially finance the construction of privately-owned public charging stations to accelerate the deployment of charging equipment. In San Francisco, the Bay Area Air Quality Management District (BAAQMD) allocated $1 million in 2013 to help expand the Bay Area network of publicly available DC quick chargers, with funding available to property owners or tenants for up to $20,000 per DC quick charger. In 2014, the BAAQMD offered funding for EVSE along regional transportation corridors in the region through the Electric Vehicle Infrastructure Project. Similarly, Chicago's Drive Clean Station Rebate Program offers incentives for DC quick charge stations from a combination of local funds and federal grants. Only these two cities among the 25 in this study offer local funds to support private construction of electric vehicle charging stations.

U.S. DOE EV Project key area. The nationwide "EV Project" sponsored by the U.S. DOE was launched in 2009 to study electric vehicle driving and charging activity and support the deployment of home and public chargers. Since its start, the U.S. DOE and cost-share partners have provided approximately $230 million to support project activities. The partnership among U.S. DOE, General Motors, Nissan, Ecotality, Idaho National

Laboratory, and city partners includes extensive data collection, analysis, and learning from emerging best practices of electric vehicle charging patterns across the U.S. cities (U.S. DOE, 2014g). Although this is a federal program, it is categorized as a city-level action for those cities engaged in the program. In total 12 of the 25 cities in this study are part of the EV Project.

Streamlined EVSE permitting process. Several cities have identified and made efforts to minimize the issues related to the permitting of electric vehicle charging equipment. We identified actions in four of the 25 cities in this study (i.e., Atlanta, Charlotte, Portland, Seattle) that are intended to streamline the permitting process for residential and commercial charging infrastructure. As one example, Charlotte has an online permitting service that gives contractors the ability to obtain an EVSE permit in about 20 minutes (CCG, 2013). Portland has streamlined its processes to be able to permit charging stations in less than 48 hours (City of Portland, 2010).

Electric vehicle-ready building code. Another fundamental policy to support charging infrastructure in the long term is ensuring that residential and commercial buildings are "electric vehicle-ready." Two cities in this study have included provisions in city building codes to ensure that new buildings include or are prepared for EVSE installation. Los Angeles requires that newly constructed buildings provide the necessary hardware for plug-in electric vehicle charging. One- and two-family dwellings and townhouses must be equipped with at least one PEV charging outlet, which is a 208/240 volt, 40 ampere, grounded alternating current outlet, or panel capacity and conduit for such outlet installation. Other residential buildings that have a common parking area must be equipped with charging outlets in at least 5% of the total parking spaces or offer panel capacity and conduit for these upgrades in the future. The parking area of new high-rise residential and nonresidential buildings must include PEV charging outlets in at least 5% of the total parking spaces. San Francisco's building code similarly includes a provision that requires new structures to be wired for car charging stations.

Workplace charging. A number of workplaces are installing electric charging stations as an amenity for employees and to generally enable greater electric vehicle use. The U.S. DOE's "Workplace Charging Challenge" is a national program in support of its EV Everywhere Grand Challenge that encourages and provides support to employers that provide charging to their employees. A summary of the partners that have workplace charging is shown in Table 12 in the appendix.

Twenty-two of the 25 cities in this study have at least one Workplace Charging Challenge partner that has installed workplace electric vehicle charging. Six of the cities have at least five partnering organizations with workplace charging. Los Angeles leads with 10 partners, followed by Detroit and New York with eight partners each. Overall, as outlined in the 2014 update report (U.S. DOE, 2014f), the Workplace Charging Challenge program through 2014 included more than 250 workplaces, with total installed and planned charging stations almost doubling nationwide from 2,000 units in June 2013 to about 3,900 in May 2014. Most of the chargers are 240 volt alternating current (240V AC), and 35 are direct current (DC) fast charging. Approximately 80% of the stations offer electricity free to employees; 1 in 67 employees drive electric vehicles to work when electricity is free versus 1 in 97 when the employee pays a fee for the electricity. It is noted that there are many other employers that are not in the DOE workplace charging program. A reliable estimation of the total number of workplace charge points across the cities of this study is not available.

Utility-specific actions

Many utilites are playing active roles in collecting information, engaging with policymakers and automakers, and promoting electric vehicle deployment. We investigated and categorized a number of actions being undertaken by major utilities in the cities within this study's scope. Although multiple utilities may serve different counties within a metropolitan statistical area, this study focuses on the primary utility providing electricity to the residents of the metropolitan area.

Utility charging pilot or other research. To prepare for a growing portion of customers that use electric vehicles, a number of utilities have engaged in pilot programs that offer free residential charging station installation in exchange for the utility's right to collect data on charging usage. Utilities in six cities have created such pilot programs: Georgia Power (Atlanta), Duke Energy (Charlotte), Con Edison (New York), APS (Phoenix), San Diego Gas and Electric, and Pepco (Washington). In addition to pilot studies, utilities may also sponsor or participate in EV research, including papers or data gathering projects. Utilities in six cities have engaged in additional research, including Duke Energy (Charlotte and Florida), Con Edison (New York), PECO Energy Company (Philadelphia), APS (Phoenix), and San Diego Gas and Electric. In all, eight of the 25 cities have participated in research supporting better charging service for electric vehicles.

Preferential rates for charging. Utilities may offer a multitude of incentive programs for customers who own electric vehicles. Some utilities offer discounted rates for electric vehicle charging, and many offer time-of-use (TOU) rates, which allow charging at much lower cost during off-peak hours. Standard residential rates and time-of-use rates are taken from the 2012 Union of Concerned Scientists report by Anair and Mahmassani (2012) as well as from examining website rate information from the primary utility in each area. Utilities in 18 of the 25 cities offer time-of-use rates.

One critical component of realizing these potential cost savings is the addition of a separate meter. An alternative approach is switching to a residential TOU plan. That can save money on charging an EV, but those savings can be eroded by normal household energy use during peak hours. The Dallas utility TXU Energy, for instance, offers free nights and weekends, but the peak rate can cost over 16 cents per kilowatt-hour, meaning that consuming any household energy during peak hours would reduce the savings gained by charging an EV during free off-peak hours. In their report, Anair and Mahmassani find that in nearly half the cities they examined, switching to a TOU rate could provide annual savings of at least $100 for electric vehicle owners. Separate EV meters can help realize the savings of charging an EV away from peak hours while still allowing households to maintain a standard residential plan. EV owners in six of the 25 cities have the option to install separate EV meters that use TOU plans, which would allow them to keep their household on standard residential plans. These include the Pacific Gas and Electric "EV-B" rate plan in San Francisco; the San Diego Gas and Electric "EV Time-of-Use" rate; the DTE Energy "PEV Rate" in Detroit; the separate EV metering option from the Los Angeles Department of Water and Power; and the electric vehicle rate offered by Con Edison for New York City. For the purposes of this study, utilities are given credit for preferential electric vehicle rates only if separate metering is offered.

The price difference between TOU base rates and TOU off-peak rates tend to cluster in geographic regions: Several utilities along the mid-Atlantic coast offer the smallest price difference between plans, while utilities in California offer the largest rate differences. For example, Washington, Charlotte, and Baltimore all tended to have average rate differences that amount to several cents per kilowatt-hour, whereas California cities offer an effective reduction of around ten cents per kilowatt-hour or more for off-peak vehicle charging. Based on the complexities of approximating the precise charging times within the utility rate structures, including multiple utilities in each city, and consumer behavior, we do not quantify the monetary benefit per electric vehicle user from the various utility actions. However, it is acknowledged that these rate differences, and utility-provided information to promote them, could be quite significant

Home charger support. Some utilities also offer rebates for home and commercial charging stations. Utilities in four of the 25 cities offer some level of cost-sharing for charger installation, three for residential chargers, one for commercial, and one for both. Among the largest such incentives is what DTE Energy provided for Detroit residents: the utility contributed up to $2,500 to purchase and install a charging station and a separately-metered circuit.

The “Charge Up L.A.!” program run by the Los Angeles Department of Water and Power (LADWP) offers rebates for both residential and commercial customers: the department offers $750 for a residential EV charger with an additional $250 if it is installed on a dedicated meter, and commercial customers are eligible for a $1,000 rebate for installing a Level 2 charger, or $15,000 for a DC Fast Charger. In Philadelphia, PECO offers $1,000 toward the cost of installing up to two Level 2 public chargers for government, institutional and non-profit customers, and will pay local counties up to $3,000 to install a Level 2 public charging station.

Duke Energy in Charlotte has offered incentives to a limited number of customers as part of a pilot program measuring and analyzing customer charging behavior. Duke Energy’s pilot “Plug In Electric Vehicle Charging Station Program” began in 2011, was designed to run for a minimum of two years and was open to 150 residential customers. In return for allowing Duke Energy to collect charging data, the utility offered to contribute up to $1,000 for a charging station, but requires that the customer pay $250 to keep the equipment once the pilot has ended. In addition, some utilities provide additional support in charger installation (e.g., panel relocation and upgrading, including adding higher-power lines).

Utility information and cost comparison tools. As a complement to city outreach campaigns, utility companies play a role in providing educational materials about electric vehicle charging to their customers. All utility companies reviewed made some information about EV charging available on their websites, and 22 provided in-depth information, including basic information about EVs, the steps a prospective EV owner should take to install a home charger, the rates available, and any applicable incentive programs. Six of these utilities provided a customized cost comparison tool that would show the cost of operating an EV compared to a traditional internal combustion vehicle.

Other utility outreach activities. In addition to providing information on their websites, many utilities engage in additional outreach activities that may include purchasing electric vehicles for the utility fleet, installing public chargers, and participation in conferences or stakeholder groups that promote electric vehicles. Utilities in 24 of the 25 cities participate in at least one of these activities. Eighteen of the utilities include electric vehicles among their fleet. Eight of the utilities have installed public charging locations within their service areas, including Georgia Power (Atlanta), TXU Energy (Dallas), Entergy Texas (Houston), Los Angeles Department of Water and Power, CPS

Energy (San Antonio), San Diego Gas and Electric, Seattle City Light, and Duke Energy Florida (Tampa). Seven utilities in eight cities have participated in collaborations with stakeholder groups, listed in Table 3.

Table 3. Utility partnerships and stakeholder groups

Cities	Utilities	Partnership
Charlotte	Duke Energy	North Carolina Plug-in Electric Vehicle Taskforce
Denver	Xcel Energy	Project FEVER (Fostering Electric Vehicle Expansion in the Rockies)
Detroit	DTE Energy	Center for Automotive Research
Miami	Florida Power and Light	Electric Vehicles Stakeholder Summit
Los Angeles **Riverside** **San Diego** **San Francisco**	Los Angeles Department of Water and Power Southern California Edison San Diego Gas and Electric Pacific Gas and Electric	Plug-in Electric Vehicle Collaborative (PEVC)

Summary of actions

Table 4 catalogues the actions described above that are designed to promote electric vehicles across the 25 urban areas considered in this study, ordered according to cities with the most-to-least total electric vehicle promotion actions in place. As shown, implementation of the 30 actions in the state, city, infrastructure, and utility areas across the cities varies greatly. Seven cities have seven or fewer of the activities, 11 cities have between nine and 15 activities, and seven cities have more than 15 of the activities supporting electric vehicles.

Of the actions listed, the average number per city is 12. Of note, the four California cities are the leading electric vehicle actors, showing comprehensive use of regulatory, state, city, infrastructure, and utility actions. In addition, Atlanta, Charlotte, Portland, Seattle, and Washington all exhibit high numbers of electric vehicle support actions. On average, California cities have adopted 20 actions, cities in non-California ZEV program states have adopted 12 actions, and cities that are not in ZEV states have adopted 9 actions.

Table 4. Summary of electric vehicle promotion actions across major U.S. cities

Metropolitan area	State action										City-level action														Utility action						Total actions (30 possible)
	State ZEV program	State BEV purchase subsidy	State PHEV purchase subsidy	State fee reduction or testing exemption	State home charger incentive, support	State public charging	State parking benefit	State fleet purchasing incentive	State manufacturing incentive	State low carbon fuel policy	City vehicle purchase subsidy	City parking benefit	City fleet purchasing	City carpool lane (HOV) access	City car sharing program link	City electric vehicle strategy	City website or informational materials	City outreach or education events	City EV supply equipment financing	City-owned EV chargers	U.S. DOE EV Project key area	Streamlined EVSE permitting process	EV-ready building code	Workplace charging	Utility charging pilot or other research	Utility preferential rates EV charging	Utility home charger support	Utility website, informational materials	Utility cost comparison tool	Other utility outreach activity	
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	**23**
Los Angeles	X	X	X		X	X		X	X	X			X	X			X			X	X		X	X		X	X	X		X	**19**
San Diego	X	X	X		X	X		X	X	X			X	X	X	X	X				X			X	X	X		X		X	**19**
Riverside	X	X	X		X	X		X	X	X	X		X	X		X	X			X						X		X	X	X	**18**
Washington	X	X	X	X	X			X	X				X	X	X		X				X			X	X			X	X	X	**17**
Portland	X	X	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	X		X	**16**
Philadelphia	X	X	X		X							X			X	X	X	X		X	X			X	X		X	X		X	**16**
New York	X	X			X							X	X	X		X	X	X		X				X	X	X		X		X	**15**
Atlanta		X				X			X					X		X	X	X			X	X		X	X			X	X	X	**14**
Chicago		X	X	X		X		X	X				X		X				X		X			X				X	X	X	**14**
Boston	X	X	X			X		X				X	X				X	X		X				X				X		X	**13**
Denver		X	X			X		X				X	X				X	X		X				X				X		X	**12**
Seattle		X	X		X	X		X					X			X	X			X	X	X								X	**12**
Houston		X	X										X		X	X	X			X	X			X				X		X	**11**
St. Louis		X	X	X		X		X	X											X				X				X		X	**10**
Baltimore	X	X	X		X			X												X				X				X		X	**9**
Dallas		X	X										X			X	X	X		X				X						X	**9**
Phoenix				X	X									X						X	X			X	X			X		X	**9**
San Antonio		X	X										X				X			X								X		X	**7**
Detroit																		X						X		X	X	X		X	**6**
Tampa																		X		X				X	X			X		X	**6**
Miami														X										X				X	X	X	**5**
Minneapolis																				X				X				X		X	**4**
Pittsburgh		X	X		X																			X							**4**

"X" denotes given electric deployment action is in place in the metropolitan area in 2014
ZEV = Zero Emission Vehicle; BEV = Battery electric vehicle; PHEV = Plug-in hybrid electric vehicle; HOV = high-occupancy vehicle lane

Public charger availability

Public charger availability across the U.S. is based on many actions at various government levels and by a number of major industry electricity providers. A primary factor in the expansion of the U.S. EVSE network has been the availability of American Recovery and Reinvestment Act funding distributed through the U.S. DOE. In addition, this research identified that at least seven states (California, Colorado, Georgia, Illinois, Oklahoma, Pennsylvania, and Washington) have provided direct funding or other financial incentives for the installation of publicly available chargers. A number of cities are also active in helping plan, incentivize, and support the increase in electric charging infrastructure. State and city action is complemented by several active industry providers, including ChargePoint and AeroVironment.

Figure 3 illustrates the locations of all the public electric vehicle charging stations across the U.S., based on the Alternative Fuel Data Center database (U.S. DOE, 2014c). As shown, much of the charging station network is located near major cities, and the majority of the charging network—about 53% of the approximately 24,000 public chargers—is located within the 25 urban areas considered in this analysis. These metropolitan areas include 40% of the DC fast chargers and 55% of the public Level 2 chargers in the country. Also shown in the figure are the boundaries of the 25 metropolitan statistical areas, revealing how some of them (e.g., Riverside) represent much larger land areas than others, which is important in analyzing the data on charger availability.

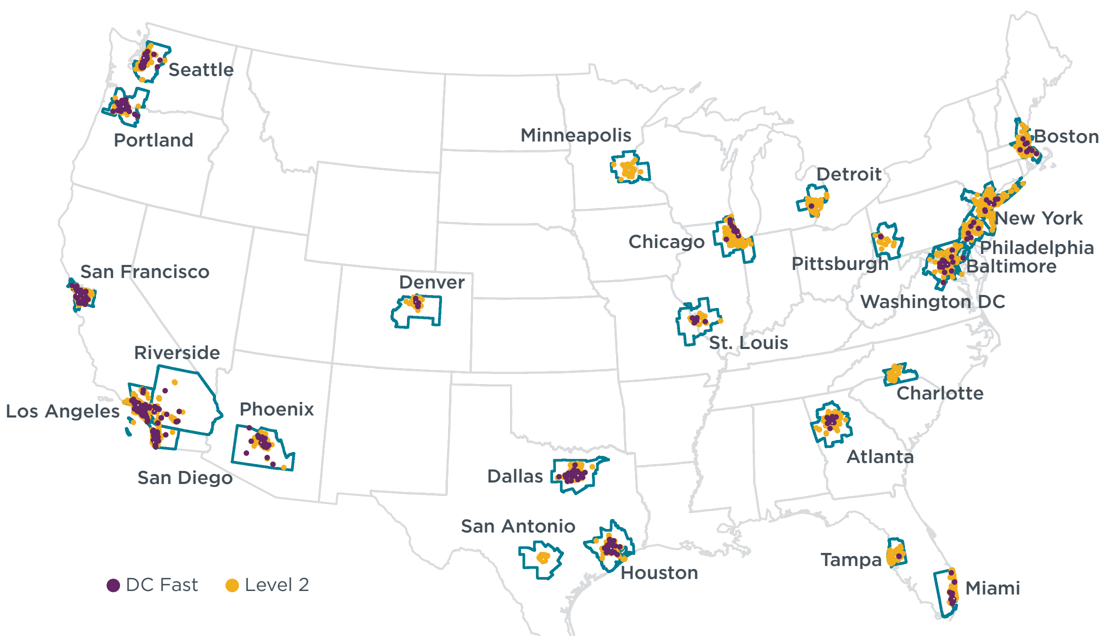

Figure 3. Illustration of public electric charge points, in 25 most populous U.S. cities

Analysis of the public electric chargers across the 25 cities reveals differing levels of charger infrastructure deployment. Figure 4 summarizes the number of public electric chargers per capita, per new registered vehicles, and per land area. This figure approximately quantifies the charger availability and relative coverage of electric vehicle users' major area of travel. Within the Figure 4 data are a number of key differences among the cities. There are 5.7 public DC fast chargers and 88 public Level 2 chargers per million people on average across the 25 cities. The left pane shows Phoenix, Portland, San Francisco, San Diego, and Seattle offer more than twice the average number of DC fast or Level 2 chargers per capita. Portland especially stands out in its per capita charger availability, with nearly 5.8 times the number of DC fast chargers and 2.5 times the number of Level 2 chargers than the 25-city average.

The chargers per new registered vehicle data show a similar result, but when looking at public charger density, Los Angeles stands out. This MSA has more than four times the average charger availability per unit land area. These data also are used in assessing the relative value of the charging infrastructure in these MSAs.

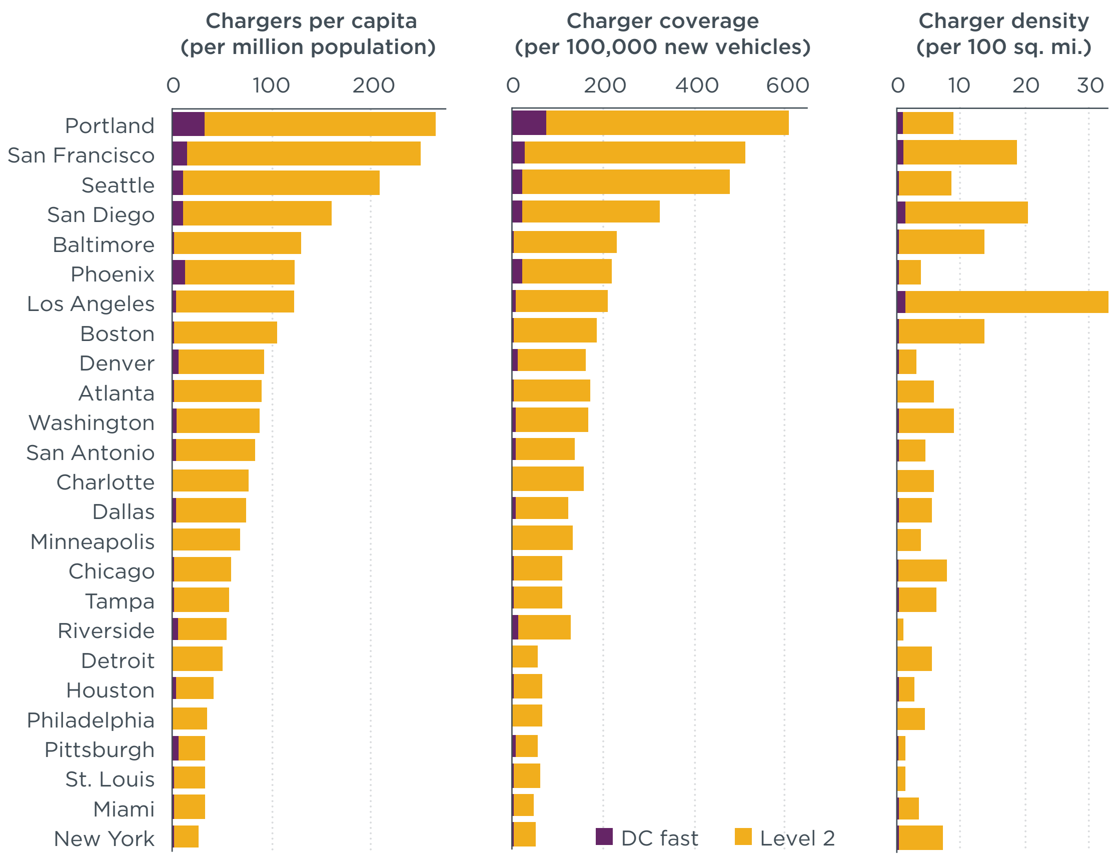

Figure 4. Electric chargers per capita, per new registered vehicles, and per land area across the 25 most populous U.S. cities

EVALUATION OF ELECTRIC VEHICLE PROMOTION ACTIONS

For metropolitan areas that significantly spanned multiple states, the state incentives were weighted according to the approximate population. This was relevant for Charlotte (North Carolina, South Carolina), New York (New Jersey, New York), Portland (Oregon, Washington), St. Louis (Missouri, Illinois), and Washington (District of Columbia, Maryland, Virginia). Weightings of metropolitan areas in states that represented less than 10% of the city population (e.g., New York City's connection to Connecticut) were not included.

Valuation of public charger availability

Because battery-powered electric vehicles typically have a driving range less than that of conventional gasoline- or diesel-powered vehicles, many consumers may not feel comfortable driving long distances without recharge capability. The availability of charging stations can provide consumers greater range as well as increased range confidence and preclude the need to use other vehicles (e.g., within household or rental) for longer trips.

To acknowledge the drawback that a limited vehicle range might present for electric vehicle drivers, we develop an evaluation framework that is similar in effect and based upon the rationale applied elsewhere in the literature. In essence, the extent to which a typical electric vehicle user is losing range or functionality, they have the ability to use other cars within their household or a rental car. Davis et al. (2013) estimate the average lifetime replacement cost to make up for the forgone travel from limited electric range to be approximately $3,800 per BEV. Based on Lin and Greene (2011) a 50th-percentile driver of a 100-mile BEV over 10 years would be able to rent a vehicle replacement to cover longer range trips for approximately $2,600, based on an approximate $15 per day car rental. We start from the Lin and Greene method and update for consistent assumptions for this study to approximate the replacement cost for BEV owners' use of another (i.e., non-BEV) vehicle. In addition, this estimation method is used to quantify the approximate value of BEV use of a public electric charging infrastructure that reduces the need for such replacement vehicles.

Several assumptions were used in estimating city-specific value of charger availability. We surveyed rental car rates across the 25 cities at RentalCars.com in April 2015 for the lowest price, including taxes and fees, for a one-day compact size car, defined as Nissan Versa, Ford Focus, or similar. Outlier rates were checked for additional dates and websites to ensure the prices here are representative. The average of the three least expensive rates was applied for each city to calculate the average "replacement vehicle" cost for prospective battery electric vehicle users. The average rental rate was $38 per day, and nearly all cities' rates were between $32 and $50 per day. For consistency, this analysis applies a discount rate of 5% for future cost and benefits. A vehicle ownership of six years is assumed, based on the average length of ownership of a new car (PR Newswire, 2012). As a result, we estimate the potential replacement vehicle cost to range from $3,000 to $6,000 across the 25 cities, with an average of $4,300, over the six-year first-owner vehicle lifetime.

The value of the charger network is indexed to the potential maximum cost of the replacement car value. In quantifying the charger network value, the replacement car cost is assumed to be equal to the full potential benefit for the optimal, ideal fast-charger availability of a hypothetical charger network that was everywhere that a given electric vehicle user wanted them over the six-year ownership timeframe. As a proxy to estimate the relative scale of the charging infrastructure availability, the network of gasoline stations in each city is assumed to be the ideal level of availability, based on the network's growth over decades of response to vehicle users' demand. From this maximum network coverage, the value of the existing charger network was scaled according to the relative charger availability. DC fast charge points are evaluated as being equivalent to the value of each gasoline station, and each Level 2 charging station is estimated as being half as valuable, due to the additional time inconvenience. The total number of public electric vehicle chargers is compared to the number of gasoline stations in each metropolitan area, based on 2014 U.S. Census data.

Figure 5 summarizes the estimated value, by city, of the charging network for an electric vehicle owner. The figure, based on the assumptions outlined above, indicates how various cities are at different stages in building out their electric vehicle charging network. Several metropolitan areas, especially Portland, San Francisco, and Seattle, have built out charging networks that are beginning to match the coverage of the area's fueling station coverage. These three cities are evaluated here as potentially offering about $1,000 to $2,000 per electric vehicle in increased vehicle utility over the assumed six-year vehicle ownership period. Other leading cities with significant electric vehicle charging networks include San Diego, Phoenix, and Los Angeles. The rest appear to be at earlier stages with electric vehicle charging networks that provide comparatively less value to current and prospective electric vehicle consumers.

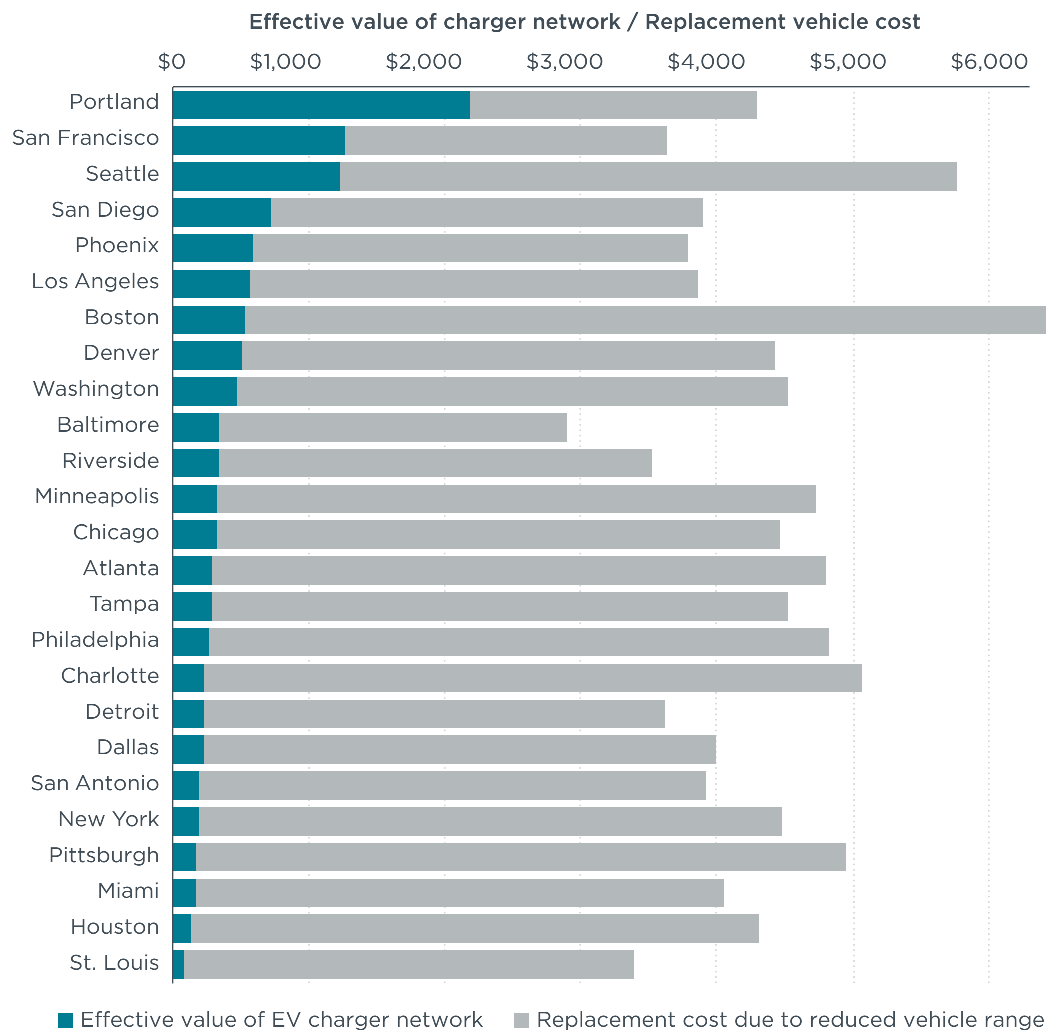

Figure 5. Summary of 2014 estimated effective value of charger network and remaining replacement vehicle cost for electric vehicles

Valuation of carpool lane access

The value of carpool, or high-occupancy vehicle, lane access across the cities in this study is evaluated based on an approximation of potential time savings. Carpool lanes generally offer time savings because they are typically less congested than non-HOV lanes on similar routes. The value of the effective benefit of access to the carpool lane for a single-occupancy electric vehicle user varies greatly by city, route, time of day, and season.

We estimate the average value of carpool lane access for the eight cities that provide this particular electric vehicle incentive and for which there is significant highway mileage with applicable carpool lanes. The eight cities are Atlanta, Los Angeles, New York City, Phoenix, Riverside, San Diego, San Francisco, and Washington. Some cities have one relevant highway (e.g., I-10 in Phoenix), whereas Atlanta and the California cities have three or more relevant highways with carpool lanes.

This benefit is approximated here for each city with carpool lane access incentives based on factors including metropolitan areas' overall congestion, availability of carpool lanes, and the relative relief offered for use of the lanes. The approach here is identical to that of the Jin et al. (2014) state analysis, but in this case the HOV value is accounted for separately using the particular data for each metropolitan area. The benefit per consumer of HOV access in each metropolitan area is calculated based on the equation:

$$V_{HOV} = P_t \times C_c \times P_r$$

Where:

V_{HOV} = value of HOV lane access for electric vehicles

P_t = percentage of traffic alleviated by HOV access

C_c = congestion cost

P_r = percent HOV relief

Each of the variables is evaluated as follows. Percentage of traffic alleviated by HOV access is estimated as the percentage of congested highways in a metropolitan area that have HOV lanes, based on examination of Google map images. This is roughly calculated as the number of roads with HOV lanes that had significant traffic during the weekday morning rush hour divided by the total number of state and interstate highways with significant traffic in the metropolitan region. Congestion cost is taken from the Texas A&M Transportation Institute (TTI) Urban Mobility Report (Schrank et al., 2012), which is based on time spent in traffic in each city and other factors. Percent HOV relief is a rough approximation factor that is included to account for the fact that only some fraction of congestion during an average commute occurs on highways and may thus be relieved by HOV lane access. We apply a 50% HOV relief factor in this analysis. See Jin et al. (2014) for further details.

We note several additional caveats. For California, extremely short HOV lanes (i.e., those less than 5 miles) are excluded. Toll discounts of 10% during off-peak hours on the New Jersey Turnpike and New York State Thruway also were excluded because these discounts are small and variable, depending on travel length, and these routes appear to have low travel volume compared to most HOV lanes analyzed here. Plate and sticker fees to achieve HOV access are subtracted from the final benefit of HOV lane access and discounted if they are annual fees. The future annual benefits, consistent with assumptions elsewhere in this report, are discounted with a 5% discount rate and summed over six years of ownership.

We compare the benefit calculated with this approach to results with other estimates of the value of HOV access in California. In California, a hybrid vehicle with an HOV sticker was worth about $1,200 more than one without a sticker in 2009 (Blanco, 2009), which is equivalent to about $1,300 in 2013 dollars according to the US Bureau of Labor Statistics CPI inflation calculator. In our analysis, we calculate the average HOV lane access benefit to be approximately $500 (San Diego), $700 (Riverside), $1,804 (San Francisco), and $2,300 (Los Angeles) for electric vehicles over a six-year period. Atlanta and Phoenix were found to offer $1,000 and $800 in carpool lane access benefits per vehicle. Of the eight applicable cities, New York City and Washington's carpool lane values were the smallest at approximately $200-$300, due in part to the relatively limited share of the highway network that has HOV lanes.

Summary of electric vehicle consumer benefits

Many electric vehicle promotion activities offer effective monetary benefits to electric vehicle consumers, whereas others have benefits that are not as easily evaluated in monetary terms. Of the 30 electric vehicle promotion actions summarized in Table 4, 11 actions are evaluated in this study's analysis of the effective benefits for electric vehicle consumers. The actions quantified for consumer benefits include state and city subsidies, financial support for home chargers, registration fee exemptions, carpool lane access, and availability of public charging. Although many actions were catalogued, no attempt is made here to quantify the benefits to electric vehicle consumers due to the actions like the ZEV program, state outreach activities, and many of the city actions (e.g., fleet purchasing, regional electric vehicle strategy, car-sharing program links). Many of the state actions were previously analyzed in Jin et al. (2014), and the value of the charger availability and carpool lane access benefits are re-examined above. The benefits are estimated separately for BEVs and PHEVs, as the policies impact each somewhat differently.

Figure 6 summarizes the benefits for BEV consumers from the various electric vehicle support actions analyzed in this study. The total amount of monetary support to BEV consumers varies substantially across the 25 major metropolitan areas considered. Cities with the greatest BEV support are San Francisco, Atlanta, Denver, Los Angeles, Riverside, and San Diego. Each of these cities has an electric vehicle benefit package of infrastructure and policy incentives worth $4,000 to $6,000 per BEV over the assumed six-year ownership of the electric vehicle.

After these leading cities, 12 others offered incentives worth between $2,000 and $3,500 in benefit per BEV. BEV owners in the remaining seven cities experience less than $2,000 in BEV benefits. The simple average of the 25 cities' total benefit package is approximately $2,800 per BEV. The three most substantial benefits offered are vehicle purchasing subsidies, public electric charging availability, and carpool lane access. It is noted that these reflect incentives in place in late 2014; Chicago and Atlanta are losing their state subsidies in 2015, and some incentives were newly adopted in 2014.

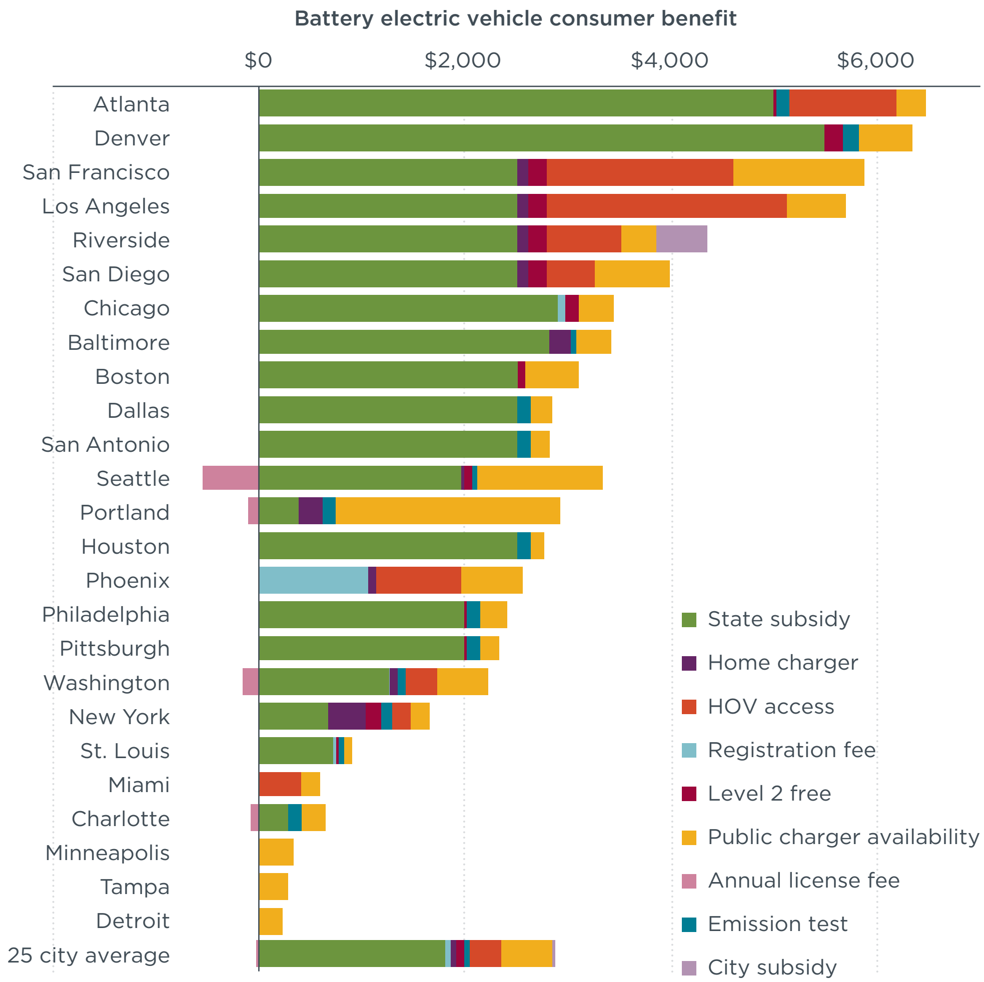

Figure 6. Summary of battery electric vehicle consumer benefits from electric vehicle policy actions across 25 most populous U.S. cities in 2014

Figure 7 summarizes the benefits for PHEV consumers from the various electric vehicle support actions analyzed in this study. The total amount of monetary support to PHEV consumers varies substantially across the 25 major metropolitan areas. Cities with the greatest PHEV support are San Francisco, Los Angeles, Chicago, Denver, and Riverside. Each of these cities has an electric vehicle benefit package of infrastructure and policy incentives that is worth $3,000 to $4,000 per PHEV over the assumed six-year ownership of the electric vehicle. After these five leading cities, Dallas, Houston, San Antonio, and San Diego offer $2,200 to $2,600 per PHEV. PHEV owners in the remaining 16 cities experience less than $2,000 in PHEV policy benefits. The simple average of the 25 cities' total benefit package is approximately $1,600 per PHEV. The two most substantial PHEV benefits offered are vehicle purchasing subsidies and carpool lane access. Because the consumer value of public electric vehicle charger availability is based on the cost of reduced range from BEVs, it is not included for PHEVs.

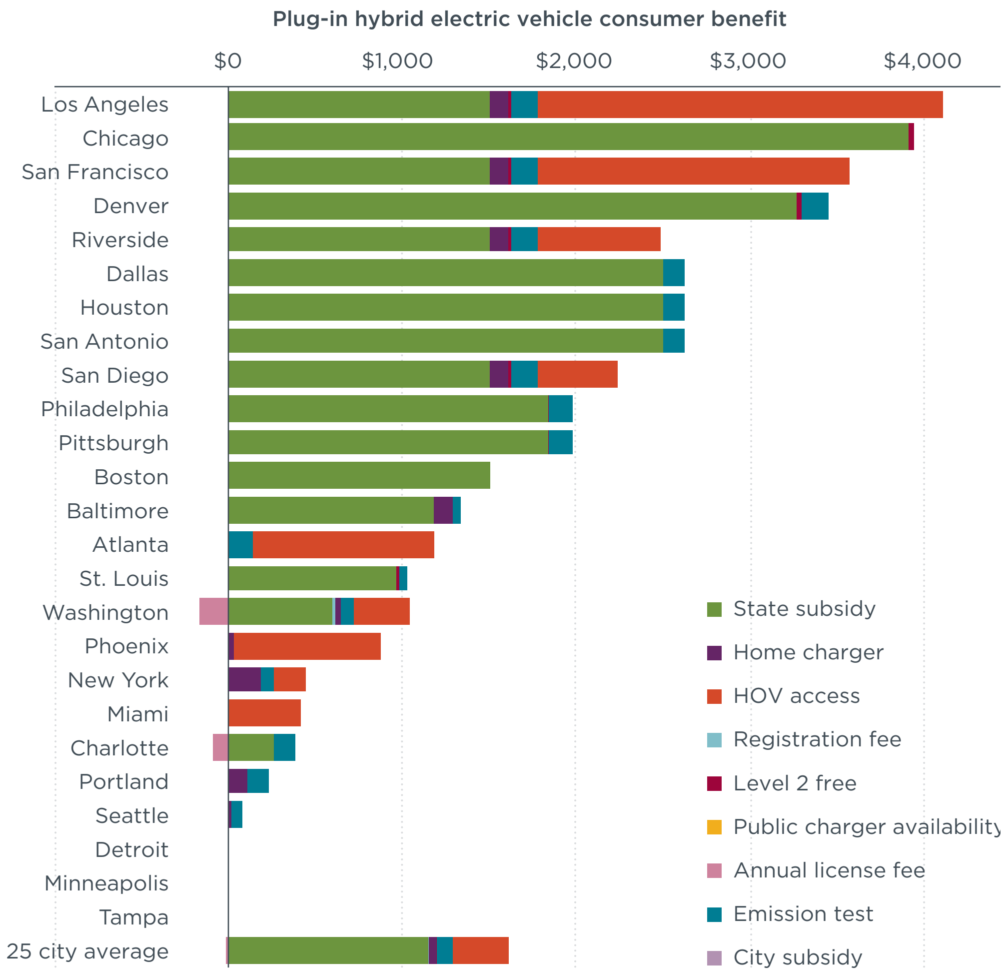

Figure 7. Summary of plug-in hybrid electric vehicle consumer benefits from electric vehicle policy actions across 25 most populous U.S. cities in 2014

ELECTRIC VEHICLE SHARES AND PATTERNS ACROSS CITIES

The information outlined above provides a number of clear indications about the effectiveness of electric vehicle promotion activities that are underway across the U.S. in 25 major metropolitan areas. A key indicator of the impact these actions are having is the extent to which new electric vehicle sales have picked up in these cities. In this section we analyze new electric vehicle patterns across the cities — including new electric vehicle market share, new electric vehicles per population, geographic patterns with electric vehicles, how urban electric vehicle shares compare with the surrounding areas, and differences in electric vehicle model availability.

New electric vehicle shares. Based on data from IHS Automotive on new PHEV, BEV, and overall light-duty vehicle registrations, we analyze the deployment of electric vehicles in the 25 metropolitan areas. Figure 8 summarizes the share of new vehicles that are electric vehicles, as well as the electric vehicle sales per capita in 2014 of both PHEV and BEV types. On both a per-capita and sales share basis, four of the eight leading cities are in California (San Francisco, Los Angeles, San Diego, and Riverside); the others are Atlanta, Portland, Seattle, and Detroit.

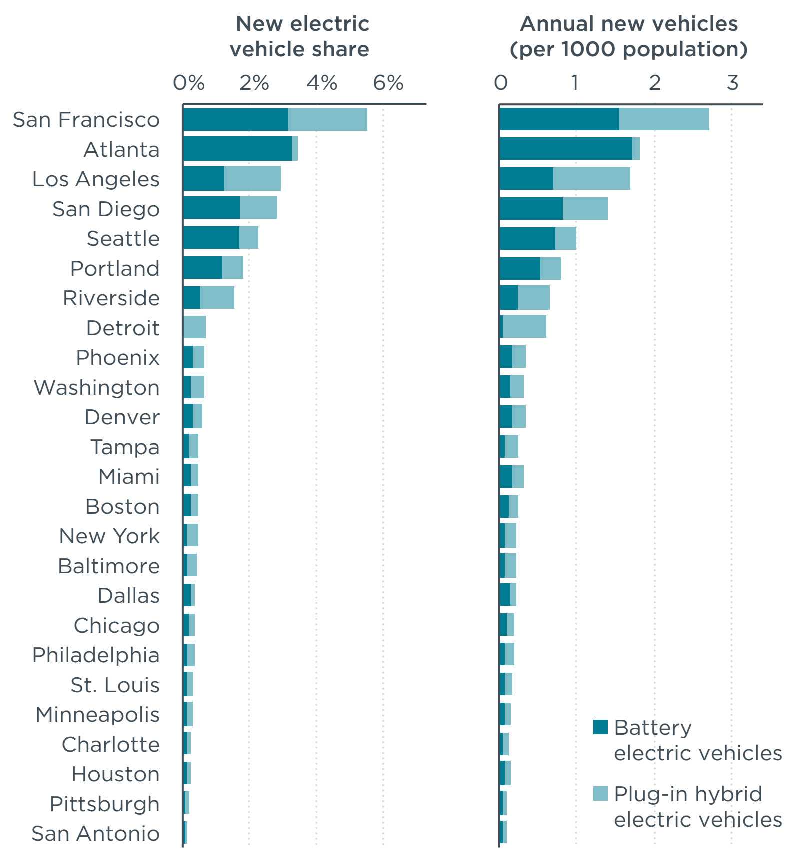

Figure 8. Electric vehicle shares and new registrations per capita across 25 most populous US cities in 2014 (2014 electric vehicle registration data provided by IHS Automotive)

Figure 9 illustrates how the PHEV and BEV shares compare geographically, and several trends are readily apparent. First, the five west coast cities of Seattle, Portland, San Francisco, Los Angeles, and San Diego stand out as having high PHEV and BEV shares. Many cities show a clear pattern where BEV and PHEV shares are very roughly the same size. However, Atlanta shows a much higher BEV share than PHEV; conversely, Detroit shows a substantially higher PHEV share. Midwestern and Northeast cities have generally higher PHEV shares than BEVs, but elsewhere BEV shares typically are greater then PHEVs.

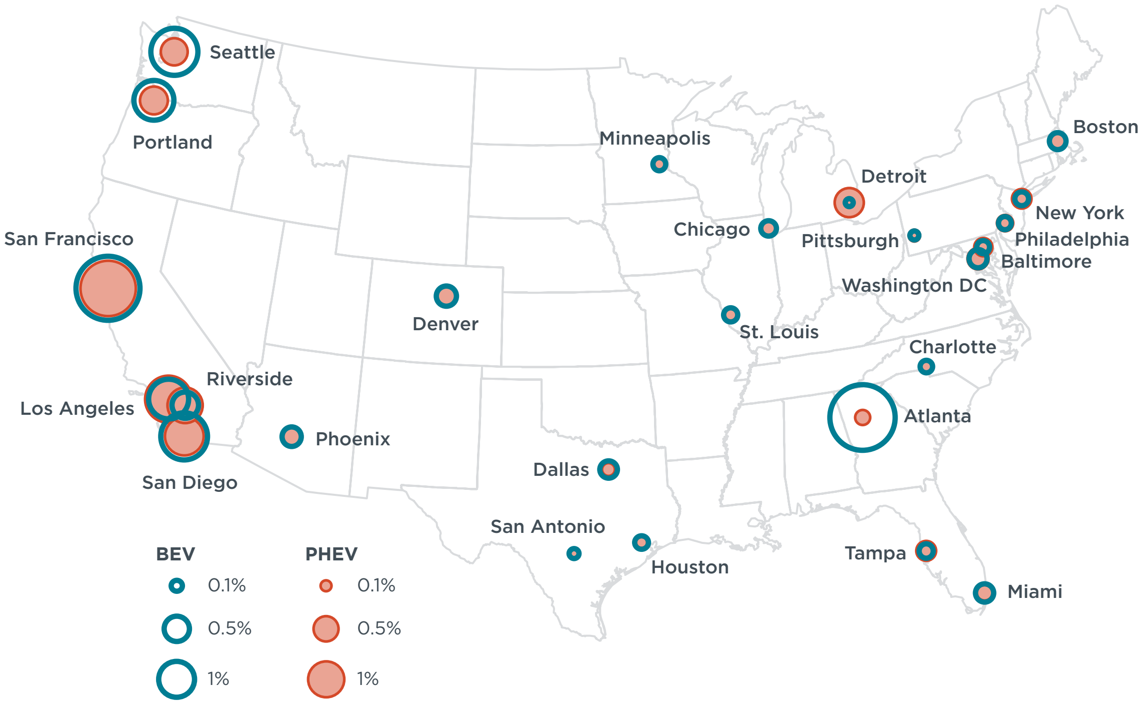

Figure 9. Illustration of new 2014 plug-in hybrid and battery electric vehicle shares in 25 most populous US cities (2014 electric vehicle registration data provided by IHS Automotive)

Electric vehicle model availability. We expected that electric vehicles sales would be greater in areas where a larger number of models were being promoted and readily available. Exact data on electric vehicle supply to the various markets or the electric vehicle inventories throughout 2014 were now available, so the actual vehicle availability data could not be determined directly. To estimate model availability in each city, we looked at the number of vehicle models that had at least one new vehicle registration in 2014. Based on that information, every city had between 14 and 26 models of plug-in electric vehicles available for sale. That is shown in the right column of Figure 10. To determine where greater vehicle availability made a difference, we filtered the data to only include models that were sold in significant numbers, using a cutoff of 20 new registrations per city in 2014. This reveals much greater variation across the cities. The left column of Figure 10 shows eight cities had six or fewer new electric vehicle models with at least 20 registrations. On the other hand, just six cities had more than 14 models available with at least 20 new registrations. This offers an approximate and indirect measure of the level of automaker actions in the various urban areas, possibly reflecting manufacturers' strategic rollout approach, manufacturer and dealer electric vehicle incentives, and dealer efforts across the major cities. This metric — models with at least 20 new annual registrations — is used below as an index for *relative model availability* across the cities.

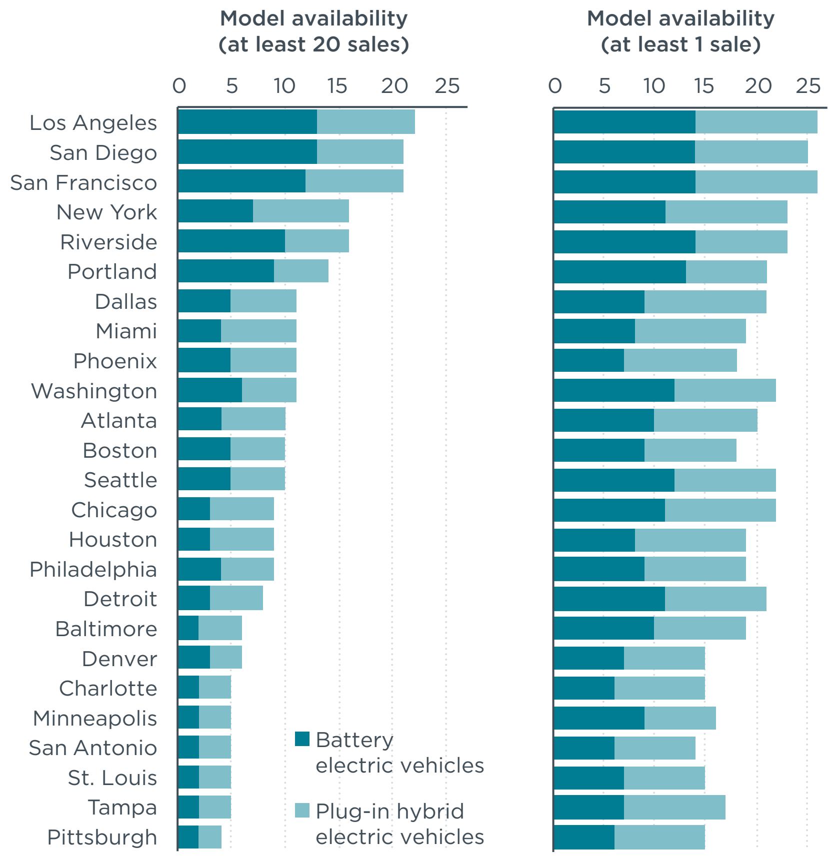

Figure 10. Number of electric vehicle with at least 1, and at least 20, new registrations in US cities in 2014 (2014 electric vehicle registration data provided by IHS Automotive, 2014)

City EV shares versus their surrounding states' EV shares. Figure 11 shows how the share of electric vehicles in each metropolitan area compares with the comparable share within the same state(s), but outside the metropolitan area. Eighteen of the 25 metropolitan areas have greater electric vehicle shares than their surrounding states. Based on a simple average across the 25 study cities in the figure, the metropolitan area electric vehicle shares are approximately the same as their surrounding areas.

We conducted a statistical analysis (paired, one-sided t-test) to evaluate whether a difference emerges when comparing individual cities to the surrounding state(s). The test resulted in a p-value of 0.15, indicating there is not a statistically significant difference between electric vehicle sales rates in the 25 study cities and the surrounding areas. Nonetheless, several cities had substantially higher electric vehicle shares than their surrounding areas. Atlanta, Philadelphia, Washington, and Minneapolis had electric vehicle shares that are at 2.6 to 8.2 times greater than their surrounding states. Several other cities, including Riverside, Baltimore, and San Antonio, have electric vehicle shares that are 30%-60% lower than their respective surrounding states.

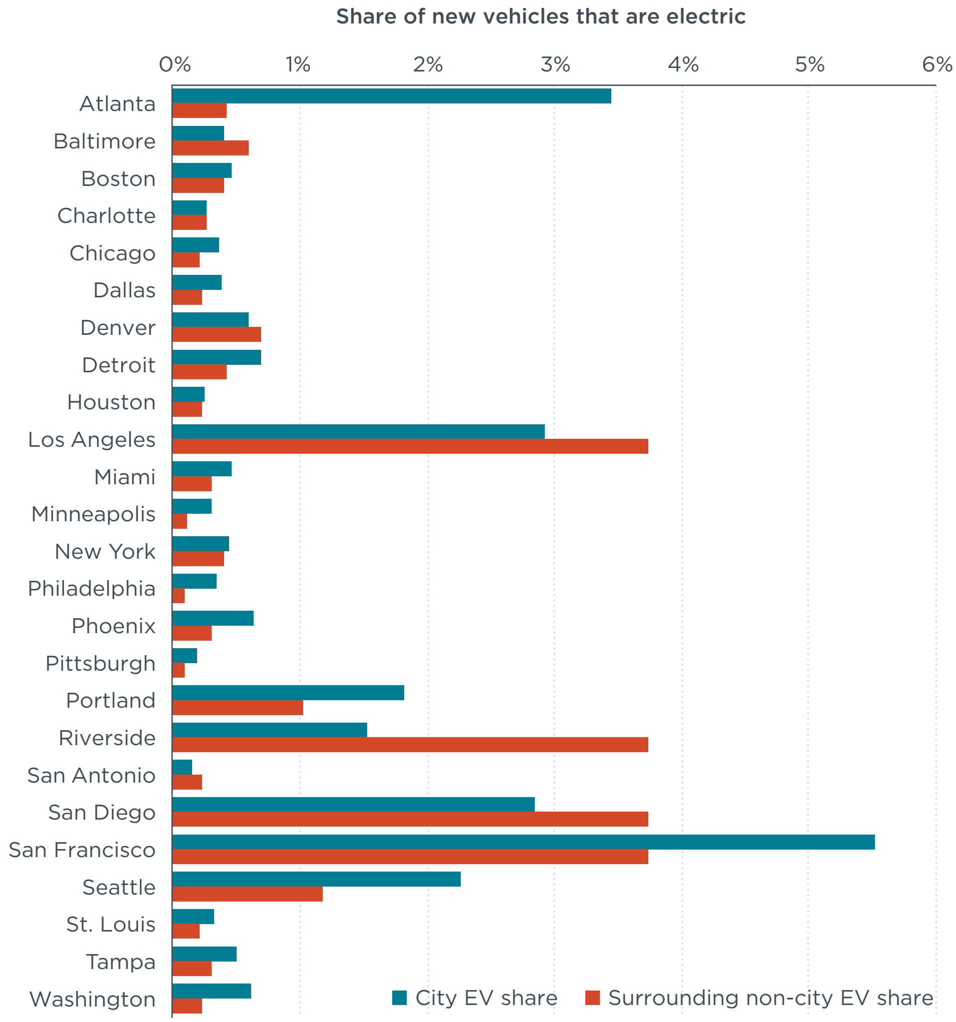

Figure 11. Share of new vehicles that are electric vehicles, in U.S. metropolitan areas versus their surrounding states (2014 electric vehicle registration data provided by IHS Automotive)

STATISTICAL ANALYSIS OF ELECTRIC VEHICLE PROMOTION ACTION AND DEPLOYMENT

To help understand the relative importance of EVSE infrastructure and various state, city, and utility actions to promote electric vehicle sales, we analyze the statistical relationship between these factors and the share of electric vehicles among all new car sales within a city. Because of the limited sample size (i.e., 25 cities) and the large number of factors catalogued (30 actions, plus the value of consumer benefits and EVSE density), factors were grouped into broad categories. In this analysis we include subsidies, public charger availability, total electric vehicle promotion actions, and model availability as independent variables to potentially discern their relationship with electric vehicle sales across the 25 cities.

Stepwise linear regressions are used here to test the relationship between several metrics of electric vehicle market share and the various electric vehicle promotion actions. Table 5 summarizes the initial 11 variables considered in this analysis. As shown, numerous forms of the data are investigated, including combined and separate variables for BEV and PHEV, as well as non-monetized and monetized electric vehicle actions. To produce standardized coefficients, the set of values for each variable was scaled to a mean of 0 and a variance of 1. Our determination of the final statistical models is based on an iterative, bidirectional process of eliminating variables that provide the least explanatory power, re-adding previously dropped variables and comparing the overall model fit, as measured by the adjusted R-squared value at each stage. In addition, the selection of independent variables avoided overlapping factors. For example, the use of a variable for monetized policy benefit (e.g., state subsidy) was never included at the same time as another variable for total promotion actions that included the same variable.

The variables in the table are shown for completeness; however, we note that a number of the variables are not used in the final best-fit statistical regressions presented below, as their omission improved the statistical fits. For example, a number of variations on the income variable were explored, but they did not lead to improved statistical relationships.

Table 5. Summary of variables investigated for new electric vehicle share correlation

Factor	Description (and range)	Electric vehicle	Plug-in electric vehicle (PHEV)	Battery electric vehicle (BEV)
State monetized actions	The number of state actions with direct monetary value to EV consumers (6 possible)[1]	X	X	X
State non-monetized actions	The number of state actions not assigned a monetary value (4 possible)[2]	X	X	X
City monetized actions	The number of city and utility actions with direct monetary value to EV consumers (6 possible)[3]	X	X	X
City non-monetized actions	The number of city and utility actions not assigned a monetary value (14 possible)[4]	X	X	X
Action diversity	The number of action categories filled by state, city, and utilities[5] (8 categories)	X	X	X
Monetized BEV benefits	The monetary value of benefits offered for BEVs[6] (range from $0 to $6,188)	X		X
Monetized PHEV benefits	The monetary value of benefits offered for PHEVs[6] (range from $0 to $4,102)	X	X	
BEV models available	The number of BEV models with at least 20 sales in the metropolitan statistical area (range from 2-136)			X
PHEV models available	The number of PHEV models with at least 20 sales in the metropolitan statistical area (range from 2-9)		X	
All EV models available	The number of EV models with at least 20 sales in the metropolitan statistical area (range from 4-22)	X		
Chargers per capita	The number of public chargers, both DC fast and level 2 (range from 27 to 264)	X	X	X
Percent income >$100,000	Percentage of households with a combined income of over $100,000 in 2013 (latest year available), from U.S. Census (range from 3.7% to 14.3%)	X	X	X

[1] BEV subsidy, PHEV subsidy, registration exemption, charging equipment support, public charging support, parking benefit or incentive, and carpool lane (HOV) access.
[2] State ZEV program, fleet purchasing incentive, manufacturing incentive, and low-carbon fuel policy
[3] Vehicle purchasing incentive, parking benefit, EV supply equipment financing, utility home charger incentive, and utility preferential charging rate.
[4] City fleet purchasing, car sharing program link, city electric vehicle strategy, website or info materials, outreach or education events, city-owned electric chargers, EV project key area, streamlined EVSE permit process, workplace charging partners, in-depth utility website, utility rates comparison information, utility outreach
[5] Categories considered: outreach & education, subsidy/rebate, residential charging support, public chargers, parking benefit, public fleet purchasing, public-private partnerships, and integrating EVs into long-term planning
[6] Include state subsidy, registration fee, annual license fee (cost), value of home charger, free level 2 charging, emission test exemption savings (cost of test and time savings), carpool lane access, city subsidy, and range home. The benefit of public charger availability is excluded, as it coincides with chargers per capita.

IV. RESULTS

This section reports on the findings from the analysis, pointing out several high-level findings related to patterns and notable examples among the cities. Throughout the analysis, a number of basic findings emerged that help clarify the importance of this city-focused approach to the study of electric vehicles. In terms of basic statistics, the 25 most populous U.S. metropolitan areas in this study represent –

- 42% of the 2013 U.S. population
- 46% of the 2014 U.S. light-duty vehicle sales
- 67% of the 2014 U.S. electric vehicle sales
- 53% of the 2014 U.S. public electric chargers

In addition to these general statistics, we also note several average statistics that pertain to the 25 major metropolitan areas of this study. The major cities have, on average, adopted 12 of the 30 electric vehicle promotion activities catalogued in this study for 2014. In terms of relative electric vehicle shares, these cities have, on average, 1.1% new electric vehicle share (compared to 0.8% for the U.S. as a whole) in 2014. Averaging across the 25 cities, battery electric vehicle consumers in the major cities are receiving about $2,800 in monetized benefit through state, city, and infrastructure benefits, compared to about $1,600 in monetized benefit for plug-in hybrid electric vehicles.

In the following sections, we summarize several findings about the links between the electric vehicle promotion actions, incentives, charging infrastructure, and model availability and electric vehicle shares, as well as compare the 25 cities on these dimensions and identify which cities are leading in each of the particular areas.

STATISTICAL LINK BETWEEN ELECTRIC VEHICLE PROMOTION ACTIONS AND UPTAKE

As described above, separate statistical models are developed for the overall electric vehicle, BEV, and PHEV shares, based on the electric vehicle factors catalogued in this analysis. Table 6, 7 and 8 present the standardized coefficients and p-values for the best-fit model for overall new electric vehicle share, BEV share, and PHEV share, respectively. In interpreting the results, we consider a p-value < 0.05 to indicate a significant statistical relationship between a parameter and the relevant vehicle sales share. The table captions also give the R^2 value of the best-fit model, indicating how well the regression model predicts the real data points. R^2 values range from 0 to 1, with 1 indicating a perfect fit and lower values indicating that there is variation in the data that is not captured by the model parameters.

Table 6. Best-fit statistical regression for electric vehicle share as function of charging infrastructure, monetized benefits, and model availability; R^2 value: 0.74

	Standardized Coefficient	P-value
Intercept	0.000	1
Chargers per capita	0.444	0.002
Monetized BEV benefits	0.283	0.029
EV models available	0.393	0.008

Table 6 summarizes the best-fit model for electric vehicle share across the 25 metropolitan areas, showing a statistically significant relationship with chargers per capita, monetized BEV benefits, and the total number of EV models available. The best-fit model for BEV share, shown in Table 7, similarly includes chargers per capita and monetized BEV benefits as statistically significant predictors of BEV share. In addition, city non-monetized actions improved the BEV best-fit model, although it was not a statistically significant factor. The best-fit model for PHEV share, shown in Table 8, includes as a significant predictor the total number of actions taken by the city and local utility provider that have a monetary value, along with the number of chargers per capita. The total value of the benefits offered for PHEVs was not a statistically significant factor, but it did improve the overall model fit.

Table 7. Best-fit statistical regression for BEV share as function of charging infrastructure, monetized benefits, and non-monetized actions; R^2 value: 0.65

	Standardized Coefficient	P-value
Intercept	0.000	1
Chargers per capita	0.481	0.004
Monetized BEV benefits	0.375	0.015
City non-monetized actions	0.210	0.18

Table 8. Best-fit statistical regression for PHEV share as function of charging infrastructure, city monetized benefits; R^2 value: 0.82

	Standardized Coefficient	P-value
Intercept	0.000	1
Chargers per capita	0.589	0.000
City monetized actions	0.562	0.000
Monetized PHEV benefits	0.175	0.104

In all three stepwise regressions, a significant amount of variation remains among the sales shares that is not explained by the variables provided. This analysis shows a strong relationship between the electric vehicle share in a city and the available charging infrastructure, incentives and city-level actions, but there remain factors that also strongly influence electric vehicle share that are not captured here. Although we find the regressions informative in showing the strength of association between certain factors, their predictive power is limited for several reasons. First, the set of 25 cities provides a limited sample size. Second, many of the incentive programs have very recently come into place and did not apply to sales throughout 2014. In particular, the tax rebate in Texas and the tax credit in Maryland were only available starting in spring and summer of 2014, respectively. The effects of these rebates and other efforts to support electric vehicle infrastructure might be seen more clearly over the next few years as consumer awareness increases.

Notwithstanding these limitations, several basic findings emerge from the three best-fit statistical regressions for electric vehicles, BEVs, and PHEVs. A common thread in all three statistical models is that the number of public chargers per capita is a significant factor in city electric vehicle share. Public charging infrastructure can ease range anxiety, extend the functional range of BEVs, offer a financial incentive when the electricity is provided for free, and serve as a visible sign of local government and business support for EVs. As Jin et al. (2014) note in their analysis of state-level vehicle incentives, charger availability is an especially cost-effective incentive for BEV owners. Similar per capita measures of workplace charger availability were not publically available and, as a result, were not considered in the analysis. The number of per capita chargers may function both as a direct factor driving EV sales and an indicator of a number of other electric vehicle conditions (stakeholder collaboration, awareness efforts, businesses responding to customer interest) that affect electric vehicle awareness and attractiveness in metropolitan areas.

Monetary incentives and actions with a monetary value to electric vehicle owners are found to be linked with a greater sales share across both categories of electric vehicles. The total monetary value of BEV incentives (e.g., most prominently state fiscal incentives and carpool lane access) are found to be significant and strong drivers for increased BEV shares across the metropolitan areas (see Figure 6). In addition, local monetized actions, such as parking benefits, EVSE charging equipment subsidies, and preferential rates for home charging, are found to be significant in increasing PHEV shares. In the case of PHEVs, the model shows a stronger statistical relationship between the number of monetized actions than the total value of those actions. A possible interpretation of this finding is that individual consumers may place a higher value on different incentives, so a range of different incentives will attract more interest in electric vehicles than maximizing the incentive in a single category.

The availability of electric vehicle models is also a significant factor in predicting overall electric vehicle shares across the metropolitan areas. As with charger availability, this factor may function both as a direct influence on electric vehicle purchases and an indicator of other conditions. The greater model availability, of up to 15-22 electric vehicle models in the leading cities, represents a broader range of sizes, styles, prices, and manufacturing companies from which a customer might choose. In addition, the number of available models marks the automakers' relative investment in attempting to deliver, provide dealer incentives and training, and marketing to increase electric vehicle sales in each area. Automobile manufacturer and dealer interest in selling electric vehicles within a given metropolitan area also reflects the automaker's early strategic rollout decision. Such factors are largely outside of state or local control, but city governments and utilities may form partnerships with manufacturers and dealers to encourage sales in their area.

ELECTRIC VEHICLE SHARES COMPARED WITH PROMOTION ACTIONS

Figure 12 summarizes the data above on new electric vehicle shares in 2014, charging infrastructure and electric vehicle promotion activities across major U.S. metropolitan areas. The electric vehicle activities researched in this study include state vehicle and fuel regulations, city incentives and outreach programs, infrastructure support, and utility actions. As shown, the 25 metropolitan areas show substantial variation in electric vehicle shares, the level of public electric vehicle charging infrastructure, and electric vehicle promotion actions. As shown in Figure 13, Atlanta, the California cities (San Francisco, Los Angeles, San Diego, Riverside), Portland, and Seattle have the greatest new electric vehicle share and have among the most electric vehicle promotion actions. All the other cities are below the 25-city average of 1.1% electric vehicle share. The median electric vehicle share for the 25 cities is 0.5%, compared to the national U.S.

average of 0.8%. Several leading cities — Portland, San Francisco, and Seattle — have charging infrastructure that is more than double the average charging network-per-capita of the 25 cities and is among the top six in electric vehicle share.

Figure 13 also shows that different areas are seeing great variation in state-, city-, infrastructure-, and utility-based electric vehicle promotion actions. The four California cities have the most overall electric vehicle promotion actions in place and are each among the top seven cities for electric vehicle share. Many of the cities that have the lowest electric vehicle share also have relatively less well-developed electric charging infrastructure and fewer electric vehicle support actions in place.

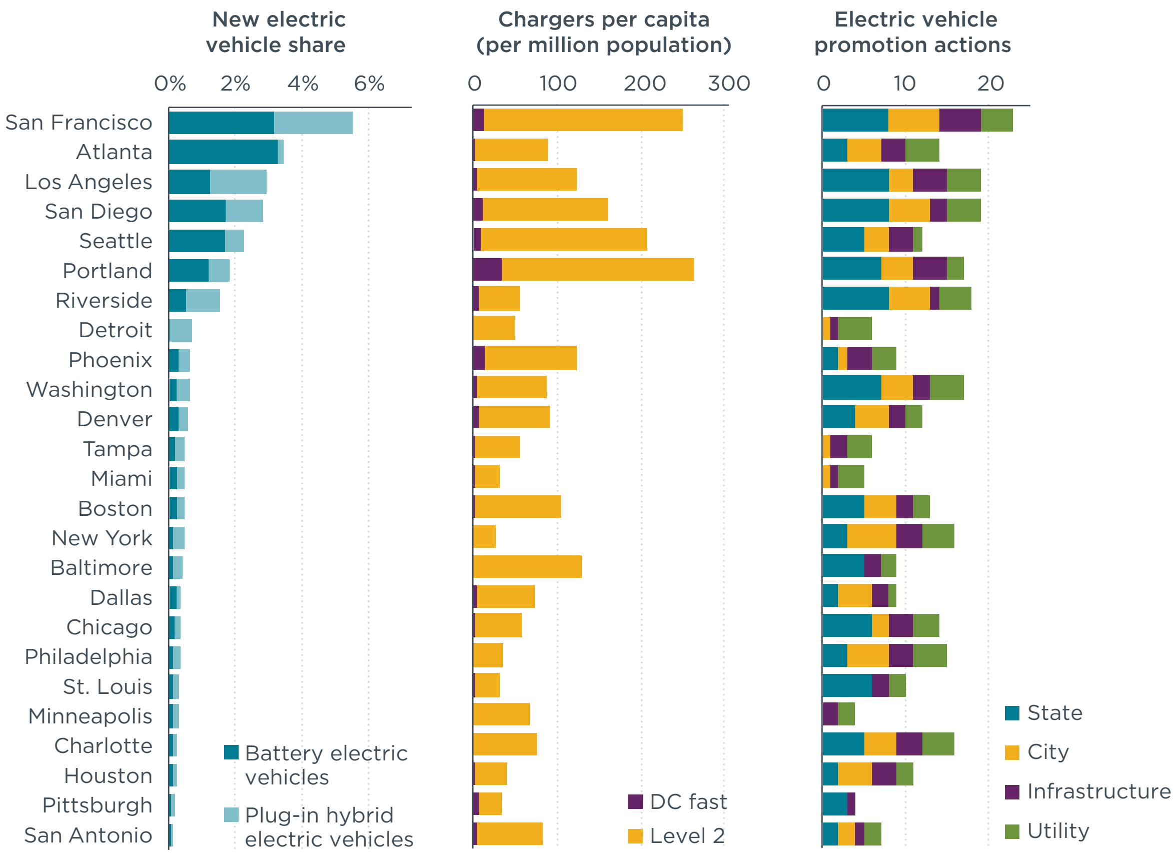

Figure 12. New electric vehicle share, chargers per capita, and electric vehicle promotion actions in the 25 most populous U.S. metropolitan areas in 2014

Noting that the above data and statistical analysis found connections between charging infrastructure, monetized electric vehicle support for consumers, model availability, and electric vehicle support policies and the electric vehicle shares, these variables are highlighted here. Due to the numerous variables, and the complexity of the relationships, the following two figures depict three variables at once as "bubble charts." The charts are normalized to the average of the 25 cities in the assessment, to help show each city's relative strengths and deficiencies. In addition, the colors of the data provide a basic regional connection between the 25 metropolitan area data points — California is red, the Northwest blue, the Northeast and Mid-Atlantic green, the Southeast orange, the South yellow, and the Midwest and Rockies purple.

Figure 13 presents the findings above on new electric vehicle shares in 2014, electric vehicle promotion activities, and charging infrastructure across major U.S. metropolitan areas. It shows electric vehicle promotion action on the vertical axis and charging infrastructure on the horizontal axis. The data points' bubble sizes reflect the electric vehicle share of new vehicles. The figure normalizes the variables from above, such that the 25-city average defines the origin, a -1 represents zero, and a +1 represents double the 25-city average. As shown in the upper-right quadrant, five cities have more electric vehicle promotion actions and greater charging infrastructure per capita than the average. The upper-right cities (i.e., Los Angeles, Portland, San Diego, San Francisco) represent four of the six highest electric vehicle shares. Cities in the upper-left quadrant have relatively low charging infrastructure. Cities in the lower-right quadrant, Baltimore and Phoenix, have relatively few electric vehicle promotion actions in place. The cities in the lower-left quadrant have few electric vehicle promotion actions, relatively sparse charging infrastructure, and generally have low electric vehicle sales.

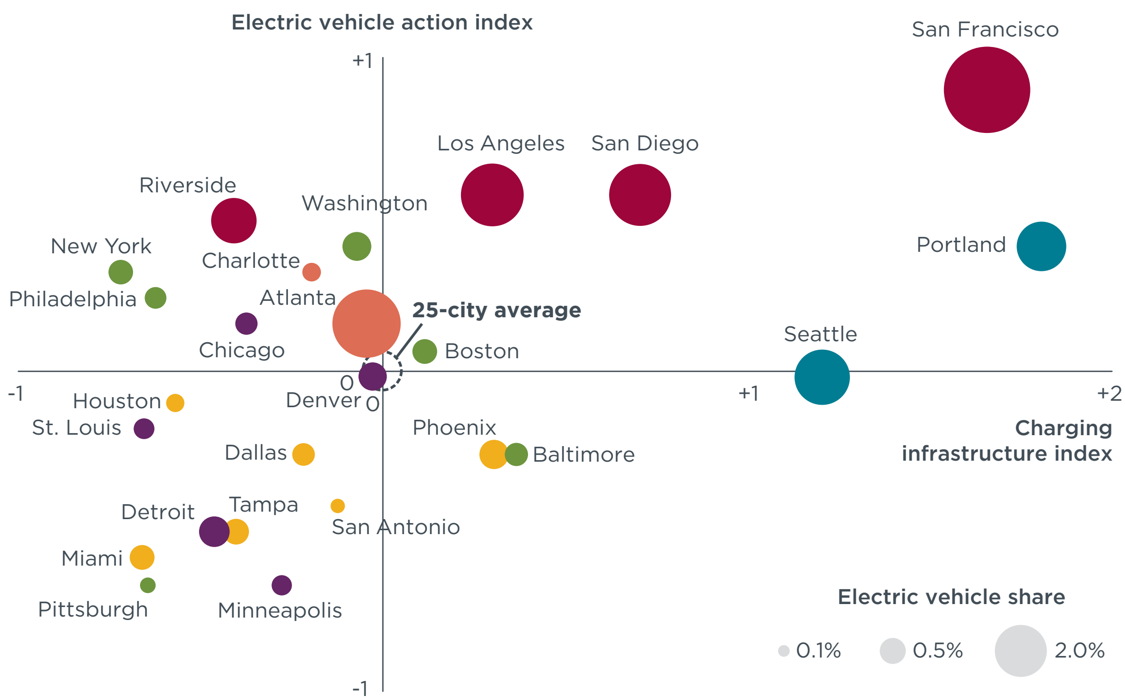

Figure 13. Electric vehicle promotion actions, charging infrastructure, and new electric vehicle shares in 2014 in the 25 most populous U.S. metropolitan areas

Figure 14 presents the findings above on new electric vehicle shares in 2014, model availability, and average monetized consumer benefit across the major U.S. metropolitan areas. Here the area's electric vehicle model availability is shown on the vertical axis, its monetized consumer benefit on the horizontal axis, and the size of the data point bubble reflects the electric vehicle share of new vehicles. The average monetized benefit is the simple average of the BEV and PHEV per-vehicle benefit (from Figure 6 and Figure 7). As in Figure 14, this figure normalizes the variables such that the 25-city average defines the origin, a -1 represents zero, and a +1 represents double the 25-city average. As shown in the upper-right quadrant, the four California cities have substantially greater electric vehicle model availability and greater consumer policy benefits than the average. Cities in the upper-left quadrant have high model availability but offer relatively few consumer policy incentives. Cities in the lower-right quadrant, including Atlanta, Chicago, and Denver, experienced relatively low model availability. The cities in the lower-left quadrant have low model availability and low consumer policy incentives.

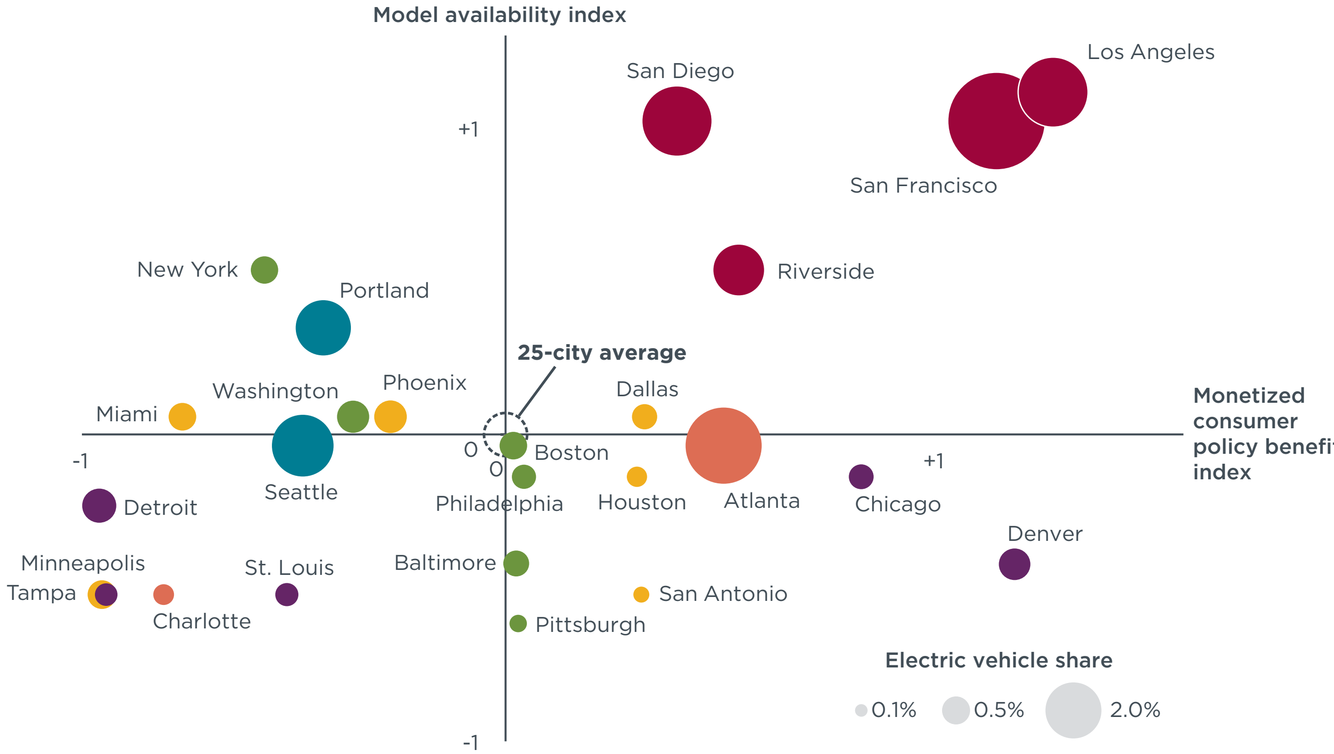

Figure 14. Electric vehicle model availability, monetized policy benefit, and new electric vehicle shares in the 25 most populous U.S. metropolitan areas

Looking more closley at the underlying data on new vehicle uptake by model, in most cases the electric vehicles sales were spread widely among the various available models. There were several cases, though, where the new electric vehicle registrations in 2014 were dominated by individual vehicle models: Atlanta (88% of all new electric vehicles were Nissan Leafs), Seattle (55% Nissan Leaf), Tampa (46% Chevrolet Volt), Detroit (42% Chevrolet Volt), and Miami (41% Tesla Model S). Such cases indicate that dealer and auto manufacturer rollout decisions, which were not analyzed here, are likely to be important underlying factors.

Figure 15 illustrates the share of new vehicles that are plug-in electric (vertical axis), the number of electric vehicle promotion actions (horizontal axis), and charging infrastructure per million people (bubble size) in the 25 most populous U.S. metropolitan areas. Atlanta, Portland, Seattle, and the four California cities each have above-average adoption of electric vehicle promotion actions and also have average electric vehicle shares that are well above average. Most of these leading cities also have above-average charging infrastructure availability. However, six cities (Boston, Charlotte, Chicago, New York, Philadelphia, and Washington) have a number of electric vehicle promotion actions that is above average, but still have a less-than-average electric vehicle share. The remaining 12 cities all have below-average electric vehicle promotion actions and electric vehicle shares.

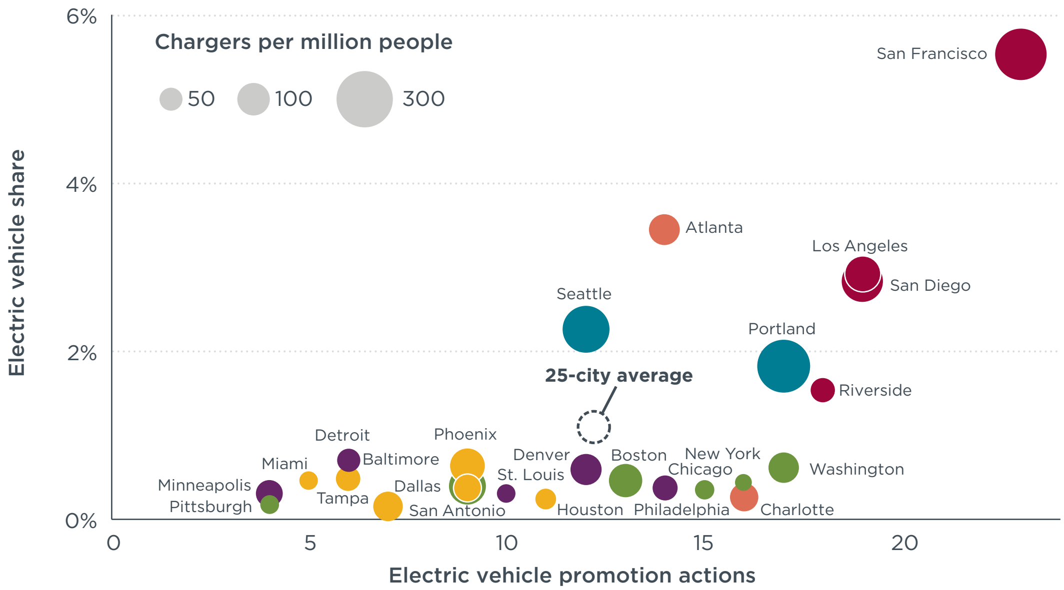

Figure 15. Electric vehicle share, electric vehicle promotion actions, and charging infrastructure per million people in the 25 most populous U.S. metropolitan areas (2014 electric vehicle registration data provided by IHS Automotive)

IDENTIFYING LEADING CITIES BY VARIOUS METRICS

Summing up the basic statistics from above, Table 9 identifies the top five cities across many of the major electric vehicle variables that are analyzed in this assessment. It shows there are many diverse cities that are leading in electric vehicle shares, electric charging availability, electric vehicle promotion activities, electric vehicle model availability, and other variables. The table also shows there is no single obvious metric that alone indicates the leading electric vehicle cities, as each city has its own relative strengths and deficiencies.

The four California cities (i.e., San Francisco, Los Angeles, San Diego, and Riverside) are represented numerous times in the summary table for their electric vehicle sales, sales shares, charger availability, promotion actions, and model availability. Seattle, Portland, and Atlanta are also identified as leaders in many of the categories, spanning vehicle shares, electric vehicle consumer policy benefits, and electric vehicle promotion actions. New York and Detroit are called out multiple times for their electric vehicle sales. Washington is shown as a leader in its promotion actions and its higher-than-surrounding area electric vehicle share. Denver is a leader in its consumer benefits in both vehicle categories. In addition, Baltimore, Chicago, Miami, Minneapolis, Philadelphia, Pittsburgh, and Phoenix are listed once each for various categories.

Table 9. Leading cities among the 25 most populous U.S. cities in various electric vehicle-related statistics

Statistic	1st	2nd	3rd	4th	5th
Sales: Battery electric vehicle	Atlanta	Los Angeles	San Francisco	San Diego	Seattle
Sales: Plug-in hybrid electric vehicle	Los Angeles	San Francisco	New York	Detroit	Riverside
Sales share: Battery electric vehicle	Atlanta	San Francisco	Seattle	San Diego	Los Angeles
Sales share: Plug-in hybrid electric vehicle	San Francisco	Los Angeles	San Diego	Riverside	Detroit
Sales per capita: Battery electric vehicle	Atlanta	San Francisco	San Diego	Seattle	Los Angeles
Sales per capita: Plug-in hybrid electric vehicle	San Francisco	Los Angeles	San Diego	Detroit	Riverside
City-to-surrounding-non-city sales ratio: Electric vehicles	Atlanta	Philadelphia	Washington	Minneapolis	Pittsburgh
Electric chargers per capita (DC fast)	Portland	San Francisco	Phoenix	San Diego	Seattle
Electric charger per capita (Level 2)	San Francisco	Portland	Seattle	San Diego	Baltimore
Most total electric vehicle promotion actions	San Francisco	Los Angeles, San Diego	—	Washington, Riverside	—
Most monetized policy benefits: Battery electric vehicle	Atlanta	Denver	San Francisco	Los Angeles	Riverside
Most monetized policy benefits: Plug-in hybrid electric vehicle	Los Angeles	Chicago	San Francisco	Denver	Riverside
Model availability: Battery electric vehicle	Los Angeles, San Diego	—	San Francisco	Riverside	Portland
Model availability: Plug-in hybrid electric vehicle	Los Angeles, San Francisco, New York	—	—	San Diego	Miami

*Colors of city names based regions: California is **red**, Northwest **blue**, Northeast and Mid-Atlantic **green**, Southeast **orange**, South **yellow**, Midwest and Rockies **purple**.*

V. CONCLUSIONS

This original research has sought to analyze the actions that are impacting electric vehicle deployment across major U.S. cities. Based on this analysis of 25 major U.S. metropolitan areas, several basic statistics underscore the importance of a city-based approach to better understanding electric vehicle patterns. The cities in this study represent more than 42% of the U.S. population, 46% of U.S. auto sales, 67% of new electric vehicle registrations, and 53% of the overall U.S. public electric vehicle charging infrastructure. These cities on average saw a new electric vehicle share of 1.1% in 2014. Compared to a nationwide average electric vehicle share of 0.8%, the 25 cities in this study had an average electric vehicle deployment that was 40% greater, and many individual cities had deployment that was much greater than that. Based on these basic snapshots of 2014, electric vehicles are being deployed disproportionately in major cities, so it is an important moment to serve these cities with an up-to-date understanding of electric vehicle and charging infrastructure trends and best practices that are emerging.

This research comprehensively catalogues the actions that are spurring electric vehicle deployment in major U.S. urban areas. In addition, the analysis goes beyond the basic data to discern links between the deployment of electric vehicles and the prevailing electric vehicle promotion activities, charging infrastructure, vehicle model availability, and incentives. The research reveals several key findings that could be helpful in understanding electric vehicle deployment patterns. The electric vehicle activities researched in this study include state vehicle and fuel regulations, city incentives and outreach programs, infrastructure support, and utility actions. Cities are seeing great variation in electric vehicle promotion actions and uptake. Several of the cities with the most active electric vehicle promotion activity are experiencing greater electric vehicle uptake.

Based on the findings, we draw the following four conclusions.

Policy is driving accelerated electric vehicle deployment in several cities. Among the seven leading electric vehicle-deployment cities, five are in states that have adopted California's ZEV program, and six have attractive consumer incentives. Manufacturers are targeting these markets and making more electric vehicles more readily available, and electric vehicles sales are up as a result.

Cities are leading on electric vehicles in diverse ways. Various cities across the U.S. are showing commitment and early success in developing the electric vehicle market. In California cities, electric vehicle consumers are benefiting from state vehicle and fuel policy, long-term commitment to consumer incentives, and implementation of city-level promotion actions, and California's electric vehicle uptake is consistently higher than the U.S. average. Seattle has a mix of incentives, utility action, and charging infrastructure and has 3 times the U.S. average electric vehicle deployment. Atlanta's electric vehicle market has benefited from subsidies and carpool lane access; its battery electric vehicle sales were more than 8 times the U.S. average. Portland, with the most extensive electric charging network and extensive planning and outreach, is seeing 3 times the average U.S. battery electric vehicle sales, without subsidies.

Best practices for driving electric vehicles into the fleet are beginning to emerge. Consumer incentives, electric charging infrastructure, model availability, and city-level actions to promote awareness of electric vehicles are all positively linked with higher electric vehicle deployment. This analysis quantitatively supports the conventional wisdom of the "ecosystem approach," where many stakeholders — state, local, public and private — have key, high-impact roles in enabling the growth of the early electric vehicle market.

Cities are an important focal point for collaboration among governments, the auto industry, utilities, and advocacy. The 25 cities analyzed here represent about two-thirds of the U.S. electric vehicle market, and the leading cities have a lot of actors moving in the same direction. Continued and increased collaboration among local actors and state and federal agencies (for increased and prioritized public funding), non-profit groups (to leverage outreach and advocate for improved policy), utilities (to co-promote and incentivize electric vehicles), local businesses (to install workplace charging infrastructure), and automakers (to increase model availability and enhance marketing and outreach) could help align the various groups' efforts.

This assessment points toward many unanswered questions that warrant further investigation. Many cities in this report have been implementing substantial new policies, but without yet seeing increases in electric vehicle deployment. Future sales data will reveal whether more time is needed for these actions to get traction, whether there are key missing policy ingredients, or whether what remains is a more widespread electric vehicle rollout by automakers. A more rigorous time-series analysis of electric vehicle sales, changing incentives, and relative model availability over the 2013-2015 timeframe could, for example, be especially valuable.

While some of the primary factors driving electric vehicle growth are becoming clearer, many are not. The roles of automaker marketing efforts, dealer actions, and utility action to promote electric vehicles seem clearly important and deserve greater study. Cases like Atlanta, where there has been success that is built almost exclusively upon one particular model (i.e., the Nissan Leaf), point to the need for further analysis of the underlying causes. Electric vehicle and battery technologies are improving rapidly, so increased range and cost reductions in next-generation electric vehicle models could be an important factor in future assessments. Furthermore, rigorous analysis of the relative value of home, workplace, and public charging could be especially important to steer public investments. Going forward, city-specific total cost of ownership analysis that sums up the above factors would be an important follow-on to this study.

Also, small and mid-sized cities that are innovating with electric-drive policies and have greater electric vehicle shares were outside this study's scope. In presenting this assessment of 25 major metropolitan areas and their electric vehicle-related characteristics, we emphasize that there could be many other leading cities and other leading actions to spur electric vehicle deployment. A number of localities that are seeing the largest shares of electric vehicle sales in the U.S. are not top-25 U.S. cities by population and were therefore outside the analysis scope. Based on 2014 new vehicle data, the cities of San Jose, Santa Cruz, Eureka, and Truckee (California); The Dalles, Corvallis, and Hood River (Oregon); Kahului and Honolulu (Hawaii); Boulder (Colorado); and Bremerton and Olympia (Washington) also were among the highest electric vehicle sales share cities (Lutsey, 2015). Further study to glean additional lessons from these cities is warranted.

This work has implications beyond providing a snapshot of the state of local U.S. electric vehicle deployment and policy. The U.S., the second-largest auto market and largest electric vehicle market in the world, is offering a rich laboratory for electric vehicle actions that could help in finding the complex recipe for launching the electric vehicle market. Likewise, cities around the world, especially in Europe, China, and Japan, are also innovating with, and learning from, new policies to promote electric vehicle uptake and use. Constant refinement on the precise mix of policy, improved technology, and consumer engagement will be needed to help chart a sustainable path toward an electric-drive fleet.

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APPENDIX

These additional resources and links were used in the research on electric vehicle promotion actions across some of the metropolitan areas in this study.

Table 10. Summary of regional and city electric vehicle strategy, or readiness, plans

Metro area	Link to study
Atlanta	http://www.plugingeorgia.com/index.php/about-plug-in-georgia http://www.atlantaga.gov/index.aspx?page=18
Charlotte	http://www.advancedenergy.org/portal/ncpev/docs/GreaterCharlottePEVReadinessPlan-Version1.1-February 2013.pdf
Dallas	http://www.electrictechnologycenter.com/pdf/Volume 2 CCET - Texas Triangle Plan Oct 2012.pdf
Denver	http://denvercleancities.org/Colorado PEV Readiness Plan.pdf
Detroit	http://cec-mi.org/wp-content/uploads/2011/11/Plug-In-Ready-Michigan.pdf
Houston	http://www.greenhoustontx.gov/ev/houstondriveselectric.html
New York	http://www1.eere.energy.gov/cleancities/pdfs/nyc_readiness_plan.pdf
Philadelphia	http://www1.eere.energy.gov/cleancities/pdfs/delaware_valley_readiness_plan.pdf , http://www1.eere.energy.gov/cleancities/pdfs/delaware_valley_readiness_plan_ii.pdf
Portland	https://www.portlandoregon.gov/shared/cfm/image.cfm?id=309915
Riverside	http://innovation.luskin.ucla.edu/content/western-riverside-plug-electric-vehicle-deployment-plan
San Diego	http://energycenter.org/sites/default/files/docs/nav/programs/pev-planning/san-diego/San_Diego_PEV_Readiness_Planning_Guide-2013_low-resolution.pdf
San Francisco	http://www.bayareapevready.org/assets/Bay-Area-PEV-Readiness-Plan-Summary-2013-web.pdf, http://www.pevcollaborative.org/sites/all/themes/pev/files/docs/ba_pev_plan.pdf
Seattle	http://www.seattle.gov/environment/transportation-and-land-use/electric-vehicles

Source: U.S. DOE, 2014d

Table 11. Summary of resources used to understand local power utility electric vehicle promotion activities

Metro area	Utility(ies)	Sources
Atlanta	**Georgia Power**	http://www.georgiapower.com/environment/electric-vehicles/learning-options.cshtml http://m.bizjournals.com/atlanta/blog/atlantech/2014/10/georgia-power-to-invest-12m-in-driving-electric.html?r=full
Baltimore	**Baltimore Gas and Electric Company**	http://www.bge.com/smartenergy/pluginelectricvehicles/CommonQuestions/Pages/How-much-does-it-cost-to-recharge-the-plug-in-electric-vehicle.aspx https://www.bge.com/myaccount/billsrates/ratestariffs/electricservice/Pages/Electric-Services-Rates-and-Tariffs.aspx
Boston	**NSTAR**	http://www.nstar.com/ss3/residential/rates_tariffs/rates/rates.asp http://nstar.plugmyride.org/
Charlotte	**Duke Energy**	http://www.duke-energy.com/plugin/pev-choosing-right-pev.asp http://www.duke-energy.com/pdfs/NCPEV.pdf
Chicago	**ComEd**	https://www.comed.com/technology/electric-vehicles/Pages/cost-calculator.aspx https://www.comed.com/technology/electric-vehicles/Pages/rate-options.aspx
Dallas	**TXU Energy**	http://www.txu.com/en/about/press-releases/2011/20111117-txu-energy-offers-deep-nighttime-discounts.aspx http://www.txu.com/en/about/press-releases/2011/20111208-txu-energy-dont-be-fooled-by-the-weather.aspx
Denver	**Xcel Energy**	http://www.xcelenergy.com/Environment/Doing_Your_Part/Repower_Your_Driving/Ready_For_You_To_Plug_In http://www.electricridecolorado.com/
Detroit	**DTE Energy Company**	http://bit.ly/1Asosud https://www2.dteenergy.com/wps/wcm/connect/e71c5dc4-2c71-47fb-8b5c-f19840502943/D1.9+PEV+Rate.pdf?MOD=AJPERES
Houston	**Entergy Texas, TXU energy**	http://www.entergy.com/our_community/environment/ev.aspx http://www.entergy-texas.com/your_home/tariffs.aspx
Los Angeles	**Los Angeles Department of Water and Power**	http://bit.ly/1IVx16X (http://www.ladwp.com) http://bit.ly/1AffwIW (http://www.ladwp.com)
Miami	**Florida Power and Light Company**	http://www.fpl.com/environment/electricvehicles/electricvehicles.shtml http://www.fpl.com/rates/pdf/Residential.pdf
Minneapolis	**Xcel Energy**	http://www.xcelenergy.com/Environment/Doing_Your_Part/Repower_Your_Driving# http://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory PDFs/rates/MN/Me_Section_5.pdf
New York	**Con Edison**	http://www.coned.com/electricvehicles/
Philadelphia	**PECO Energy Company**	https://www.peco.com/Environment/GreenVehicles/EletricVehicles/Pages/FAQs.aspx https://www.peco.com/Savings/ProgramsandRebates/Documents/EV Tear Off Pad v08 Terms Only.pdf
Phoenix	**APS**	https://www.aps.com/en/communityandenvironment/environment/electricalvehicles/Pages/home.aspx https://www.aps.com/library/rates/ET-SP.pdf
Pittsburgh	**West Penn Power Company**	https://www.firstenergycorp.com/content/customer/help/saving_energy/electric-vehicles.html
Portland	**Portland General Electric, Pacific Power**	https://www.portlandgeneral.com/community_environment/initiatives/electric_vehicles/default.aspx https://www.portlandgeneral.com/residential/your_account/billing_payment/time_of_use/pricing.aspx

Metro area	Utility(ies)	Sources
Riverside	**Southern California Edison**	https://www.sce.com/wps/portal/home/residential/electric-cars/!ut/p/b1/pVPJbsIwE...
San Antonio	**San Antonio Public Service (CPS Energy)**	http://www.cpsenergy.com/About_CPS_Energy/Who_We_Are/Research_and_Technology/Plug_In_Vehicles/PlugIn_recharging_cost.asp https://secure.cpsenergy.com/ElecVehicle/subscription.jsp
San Diego	**San Diego Gas and Electric**	http://www.sdge.com/electric-vehicles http://www.sdge.com/clean-energy/ev-rates
San Francisco	**Pacific Gas and Electric Company**	http://www.pge.com/en/myhome/saveenergymoney/pev/index.page http://www.pge.com/cgi-bin/pevcalculator/PEV http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_EV.pdf
Seattle	**Seattle City Light**	http://www.seattle.gov/light/electricvehicles/ http://www.seattle.gov/light/rates/ratesdatabase.asp
St. Louis	**Ameren Corporation**	https://www.ameren.com/environment/electric-vehicles/charging-times-estimated-cost https://www.ameren.com/missouri/rates/electric-full-service-bundle
Tampa	**Duke Energy Florida, Inc.**	http://www.duke-energy.com/plugin/pev-choosing-right-pev.asp http://www.duke-energy.com/rates/progress-energy-florida.asp
Washington	**Pepco**	http://potomacelectricpowerco.org/energy/blueprint/pluginveh/EnergyCalculator/ http://www.pepco.com/education-and-safety/rates-101/

Table 12. Summary of Workplace Charging Challenge partners in 25 metro areas

Metro area	Number of partners	List of partners
Atlanta	5	Cisco Systems; City of Atlanta; Coca-Cola; Georgia Institute of Technology; Siemens
Baltimore	2	General Motors; University of Maryland Baltimore Medical Center
Boston	5	Cisco Systems; National Grid (2); Osram Sylvania; Raytheon (2); Schneider Electric (2)
Charlotte	1	Duke Energy
Chicago	3	MetLife; Prairie State College; Schneider Electric (2)
Dallas	5	Capital One; General Motors; Raytheon; Schneider Electric; Verizon
Denver	1	Raytheon
Detroit	8	AVL Engineering; Chrysler Group; DTE Energy (7); FEV North America; Ford Motor Company; General Motors (7); Nissan North America; Schneider Electric
Houston	2	ABB; NRG Energy
Los Angeles	10	AVL Powertrain Engineering; General Motors (3); Nissan North America; NRG Energy; Raytheon; Samsung Electronics; San Diego Gas & Electric; Schneider Electric; Southern California Edison
Miami	1	Broward County
Minneapolis	1	3M
New York	8	Bloomberg LP; General Motors; Hertz (2); MetLife; New York Power Authority; NRG Energy; Siemens; Verizon
Philadelphia	1	Bentley Systems
Phoenix	2	NRG Energy; Wesco International
Pittsburgh	1	Wesco International
Portland	3	City of Beaverton; JLA Public Involvement; Portland General Electric (7)
Riverside	0	
San Antonio	0	
San Diego	2	Nissan North America; San Diego Gas & Electric
San Francisco	4	Alameda County; Hertz; Lawrence Berkeley National Laboratory; NRG Energy
Seattle	0	
St. Louis	3	Lewis and Clark Community College (2); MetLife; Schneider Electric
Tampa	2	MetLife; TECO Energy (7)
Washington	3	Capital One; Raytheon; SemaConnect

Based on U.S. DOE, 2014e,f
Where partners have multiple charging station locations, the number is shown in parentheses.