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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

BRIEFING

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Supporting the electric vehicle market in U.S. cities

This briefing summarizes how state and local governments are supporting the development of local electric-vehicle markets in the 25 most-populous U.S. metropolitan areas.

INTRODUCTION

Over the next several decades, the global vehicle fleet will have to transition largely to zero-emission vehicles if global climate goals are to be met. For that to happen, a healthy electric vehicle market must take root and grow. Urban areas, with their concentrations of vehicle ownership, distinctive driving patterns, and particular transportation needs, are critical hubs for development of that market — especially now, while it remains in its nascent stage. Therefore, the public policies being developed and implemented in metropolitan areas right now are likely to be key influences on the vehicle market over the long term.

A recent ICCT report, *Assessment of leading electric vehicle promotion activities in United States cities*, surveys the policy landscape in 25 major U.S. cities to summarize and identify what strategies for supporting local electric vehicle markets are most effective (Lutsey et al, 2015). This briefing encapsulates that detailed report, and also provides an additional quantitative estimate of the effective cost of owning and operating battery electric vehicles in those 25 cities.

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BACKGROUND

The U.S. electric vehicle market grew from 97,000 new vehicles in 2013 to about 119,000 in 2014, an increase of about 23% (Hybridcars, 2015). Nearly every major auto manufacturer now offers at least one plug-in electric vehicle model, including fully electric battery electric vehicles (BEV) and plug-in hybrid electric vehicle (PHEV) models. Consumers in many major U.S. cities can choose from among 5 to 15 electric vehicle models. The Nissan Leaf leads the market, with sales over 30,000 units, or about one quarter of the plug-in electric vehicle market in 2014. Seven models (the Nissan Leaf, Chevrolet Volt, Tesla Model S, Toyota Prius Plug-in, Ford Fusion Energi, Ford C-Max Energi, and BMW i3) made up 88% of total U.S. electric vehicle sales in 2014 (Hybridcars, 2015).

Electric vehicle sales, however, are unevenly distributed, with several notable hot spots in the United States. Figure 1 illustrates how electric vehicle uptake varied across the 25 most populous U.S. metropolitan areas in 2014. The strongest markets, led by San Francisco, have nearly 3% shares for BEVs and for PHEVs. Atlanta's electric vehicle uptake is about 3% for BEVs but much less for PHEVs. Many cities are closer to the U.S. average electric vehicle uptake of 0.4% each for BEVs and PHEVs. Adding smaller cities to the sample confirms the pattern evident in the 25 largest urban areas, where the U.S. electric vehicle market has tended to concentrate in California, Georgia, Hawaii, Oregon, and Washington communities (Lutsey, 2015).

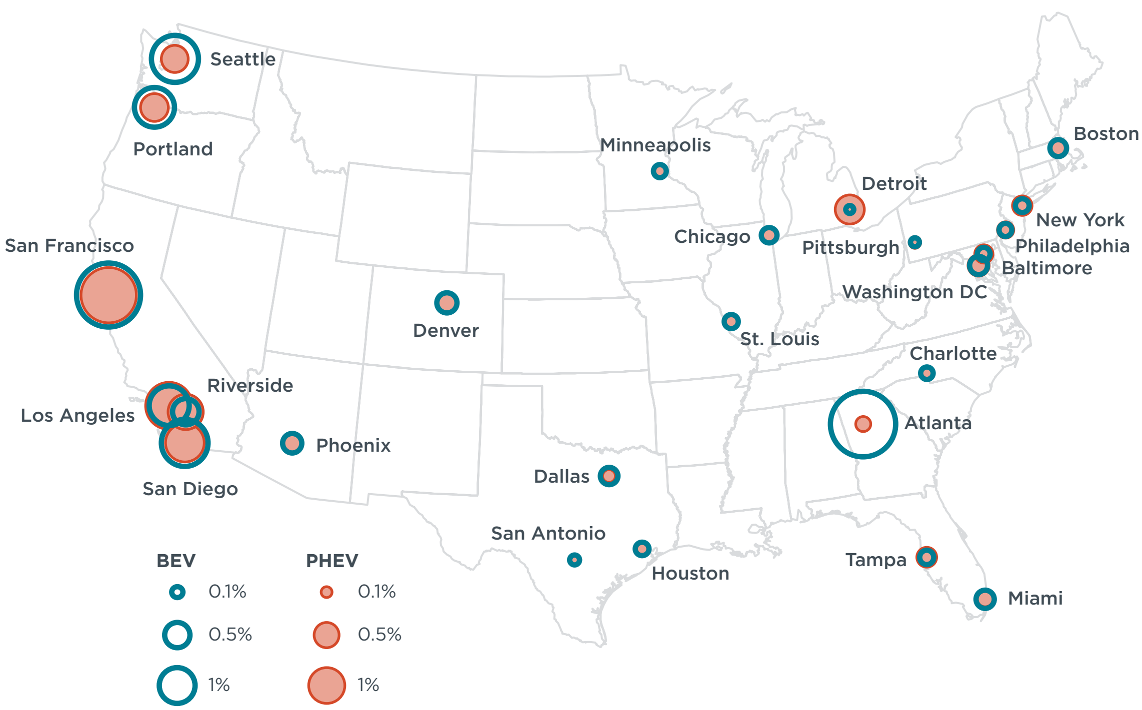

Figure 1. New 2014 plug-in hybrid and battery electric vehicle shares in 25 most populous U.S. cities. (Source: 2014 electric vehicle registration data provided by IHS Automotive.)

ELECTRIC VEHICLE BENEFITS

Electric vehicles have inherent fuel-saving benefits because they are substantially more efficient than comparable gasoline vehicles. Table 1 compares the Nissan Leaf, the most popular electric vehicle model in the U.S. (and the world), to its nearest equivalent non-electric model, the Sentra, as well as to the most popular hybrid, the Toyota Prius. As measured by fuel economy (gallon-of-gasoline equivalent) the Leaf is more than three times as energy efficient as the Sentra, and more than twice as efficient as the Prius, which is the most energy-efficient non-plug-in vehicle in the U.S. market.

Table 1. Specifications for 2015 battery electric, conventional, hybrid models

	Nissan Leaf	Nissan Sentra	Toyota Prius
Technology type	Electric	Gasoline	Gasoline (hybrid)
Manufacturer suggested retail price[a]	29,010	17,730	25,420
Vehicle footprint (ft^2)	44.7	44.4	44.2
Volume, cargo / interior (ft^3)	24 / 116	15 / 96	22 / 94
Power, engine / electric motor (hp)	NA / 107	130 / NA	98 / 60
Torque, engine / electric motor (ft-lb)	NA / 187	128 / NA	105 / 153
0-60 mph acceleration time (second)	6.6-7.4	9-9.3	9.7-10
Fuel economy (mpg)[b]	114	34	50
Range (mile)	84	449	595
Vehicle model sales in U.S. in 2014[c]	30,000	180,000	120,000

Sources: U.S. EPA, 2015; Toyota, 2015; Nissan, 2015a,b; AutoNews, 2015. AutoFiles.com, 2015

[a] Based on Nissan Leaf S; Nissan Sentra FE S; Toyota Prius Two versions of the models

[b] Adjusted label fuel economy, mile-per-gallon gasoline equivalent for electric vehicle based 33.7 kWh per gallon gasoline

[c] Include all nameplate sales, except Toyota Prius c, Prius v, Prius plug-in versions excluded

Electric vehicles' additional upfront costs compared to conventional vehicles can be substantially offset by their fuel-saving benefits. As Table 1 shows, the Nissan Leaf carries a cost premium of approximately $11,300 over a comparable Nissan Sentra and $3,600 over a Toyota Prius. The fuel costs for the Leaf, which the Environmental Protection Agency estimates consumes 0.30 kilowatt-hours (kWh) of electricity per mile, are 3 cents per mile (at $0.11 per kWh), compared to 10 cents per mile for the Sentra and 7 cents per mile for the Prius at the 2014 average gasoline price of $3.48 per gallon (US EIA, 2015). Across the 25 cities analyzed, this results in an average electric vehicle fuel savings of $3,000 compared to the most efficient hybrid Prius, and about $5,000 compared to a comparable non-hybrid (i.e., Sentra) over six years of ownership.

In addition, electric vehicles offer the potential to save other significant costs and time. Maintenance costs for battery electric vehicles, with simpler powertrains and fewer moving parts, can be lower than for conventional gasoline-and-transmission vehicles. In addition, the use of regenerative braking on electric vehicles reduces brake system maintenance. Powertrain and driveline maintenance costs over ten years are estimated at $3,700 for a conventional vehicle, compared to $1,800 for a hybrid and $900 per electric vehicle (Davis et al, 2013). Typical conventional vehicle owners go to fueling stations as many as 50–60 times per year (US EPA and NHTSA, 2012). Since about three-quarters of electric vehicle charging occurs at home (INL, 2015), electric vehicle owners avoid most of those time-related costs as well.

But electric vehicles can have additional indirect costs. To speed up recharging time, most electric vehicle consumers purchase "Level 2" electric vehicle service equipment (EVSE) that typically costs $1,500 installed (Davis et al, 2013). The time savings gained by not having to stop to refuel can be partially offset if an electric vehicle must be charged away from the home or workplace.

The most significant indirect cost of electric vehicles for some consumers would be reduced range for shorter-range BEVs like the current Leaf. In the United States, the average new vehicle is driven approximately 13,000 miles per year over the first six years of ownership; for electric vehicles, that number is approximately 9,000 miles per year (US DOT, 2015; INL, 2014). These are averages, of course, and mask considerable variation across all vehicle owners. Yet these averages highlight how some electric vehicles are second or third vehicles in a household. In addition, appropriate comparable replacement vehicles might be rental car, or a vehicle from a car-sharing fleet (see Lin and Greene, 2011; Davis et al, 2013). These dynamics become less significant for longer-range BEVs and for areas with more extensive charging infrastructure (NRC, 2015).

ELECTRIC VEHICLE INCENTIVES

Purchase cost, even considering the substantial fuel savings in operation, is one of the most critical questions for plug-in electric vehicle technology. Most of the available BEV models offer an electric driving range of less than 100 miles and cost $5,000 to $15,000 more than their most comparable non-plug-in counterparts. Leading auto and battery supply companies have rapidly reduced the fundamental battery costs in recent years (Nykvist and Nilsson, 2015). Announcements of new electric vehicles with more range (up to 200 miles) at a lower price have greatly increased interest among consumers (e.g., see Lienert, 2015).

While electric vehicle sales volumes remain relatively low and costs relatively high, a number of government incentives are reducing the cost differential between electric and non-electric vehicles. These include fiscal incentives, such as exempting a vehicle purchase from sales taxes, or offering tax credits or rebates, which have generally been implemented at the state level. Exemptions from annual taxes and fees are also given in many regions. Various actions to promote deployment of charging infrastructure (e.g., tax incentives toward installation of charging equipment, public funding, utility support, workplace charging) are also being implemented. Many of the actions by governments aim to increase awareness, understanding, and confidence, while others directly and indirectly reduce the cost of purchasing or operating electric vehicles. This section summarizes the policies and their estimated consumer benefits. Benefits are estimated based on the discounted consumer benefit to the first owner of a battery electric vehicle over the average U.S. ownership period of six years (see Jin et al, 2014; Lutsey et al, 2015).

Subsidies. Tax credits, rebates, and exemptions from vehicle sales tax directly reduce the upfront electric vehicle cost. The most prominent electric vehicle incentive in the United States is the federal tax credit. The maximum federal credit of $7,500 per vehicle applies to battery electric vehicles and plug-in hybrids with at least 16 kWh of battery capacity (i.e., about 35 miles in electric range), and it offers a smaller credit for vehicles with lower battery capacity (IRS, 2015). Many states also have substantial consumer incentives. Colorado and, until recently, Georgia offered incentives of about $5,000 per battery electric vehicle (Georgia's expired in June 2015). Washington, California, and other states offer rebates, credits, and exemptions of up to $2,000–$2,500 per battery electric vehicle.

Carpool lane access. Access to high-occupancy vehicle (HOV) lanes for single-occupant electric vehicles can offer substantial time savings on major highways in congested cities. The incentive is greatest in cities such as Los Angeles, San Francisco, and Atlanta, where the estimated average time-saving benefits are over $1,000 per electric vehicle owner. HOV lane access also offers significant consumer benefits in Phoenix, Riverside, as well as Miami, San Diego, and Washington DC.

Public charger availability. Public charging infrastructure functionally increases electric vehicle range, boosts drivers' willingness to use the full vehicle charge, and raises public awareness. Portland, San Francisco, and Seattle have the most extensive public charging networks per capita among the 25 most-populous metropolitan areas. The potential consumer benefits of a more extensive public charging network derive from its ability to increase drivers' confidence to use more of the available battery charge and also to expand the functional electric vehicle range. Based on these benefits, the consumer benefit is the reduced use of a "replacement vehicle" to cover the same annual mileage of conventional vehicles. The most extensive public charging network, in Portland, is estimated to be worth about $2,000 per battery electric vehicle over a six-year vehicle ownership. Other infrastructure-leading cities, such as San Francisco and Seattle, confer about $1,000 per vehicle in equivalent value to BEV users.

Other policies. States and local governments offer a variety of other fiscal and non-fiscal incentives to promote electric vehicles. One such incentive is a tax benefit to help defray the cost of installing home-charging equipment in California, Maryland, New York, Pennsylvania, and elsewhere, which can be worth approximately $100–$300. Exemptions from annual registration fees and emissions testing requirements are in place in many areas and generally offer a benefit of about $100 to electric vehicle owners. On the other hand, some states charge electric vehicle owners an additional annual fee of $100–$500, meant to offset losses in gas tax revenues.

Figure 2 summarizes the battery electric vehicle consumer benefits from state and local incentives and charging infrastructure across the 25 most-populous U.S. metropolitan areas. The incentives shown are those applicable in late 2014. Also illustrated in the figure, based on data from IHS Automotive (2014), is the battery electric vehicle share. As shown, several of the states with the highest incentives also have relatively high battery electric vehicle shares. For example, San Francisco and Atlanta (and also Los Angeles, Portland, San Diego, and Seattle) offer relatively high incentives and have considerably higher electric vehicle uptake. The average battery electric vehicle sales share in the 25 metropolitan areas is 0.6%, and the U.S. average overall is 0.4%. San Francisco and Atlanta have over eight times the U.S. average battery electric share.

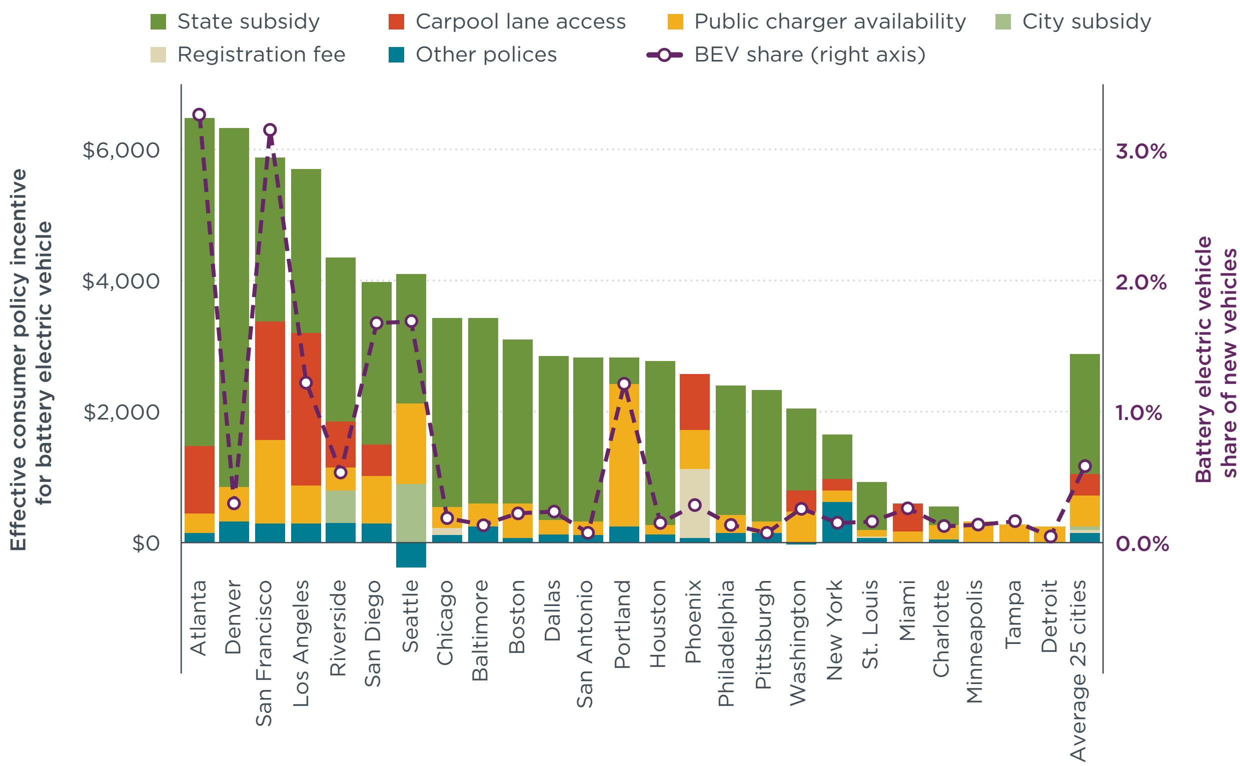

Figure 2. Battery electric vehicle consumer benefits and new vehicle share for 25 most populous U.S. metropolitan areas. (2014 electric vehicle registration data provided by IHS Automotive.)

Education and awareness. States, localities, workplaces, and public utilities are also taking actions to raise awareness and educate the public about electric vehicles' fuel-saving benefits. Examples include consumer information about available vehicle models, cost calculators, policy support for charging infrastructure, and fleet purchasing guidelines that support electric vehicle purchases. As our recent work highlights, U.S. cities vary dramatically in the number and type of electric vehicle promotion actions they have in place. The six leading cities have 17–23 of thirty known and demonstrated electric vehicle promotion actions, whereas six other cities have seven or fewer in play. All of these actions help to address the general lack of information about what plug-in electrics are, their fuel-saving benefits, and the availability of incentives (NRC, 2015; Krause et al, 2013; Krupa et al, 2013).

ELECTRIC VEHICLE COST OF OPERATION

This section quantifies how electric vehicle incentives impact the effective cost of ownership of a typical battery electric vehicle versus its non-electric counterpart. Like the energy-efficiency comparison using Table 1, this analysis compares a battery electric Nissan Leaf to the hybrid Toyota Prius and a conventional Nissan Sentra across the 25 U.S. cities. As analyzed here, the total cost of operation includes the vehicle purchase, gasoline (or electricity) consumption, maintenance cost, and the policy incentives discussed above. The evaluation is based on an average six-year vehicle ownership and annual costs in future years are included at a 5% discount rate.

Fuel prices are from U.S. EIA (2015) and annual vehicle ownership costs are based on AAA (2015). Policy incentives are from the policy analysis (Lutsey et al, 2015).

Figure 3 summarizes, for the example city of San Francisco, the total costs of owning and operating a typical battery electric vehicle. The figure includes the impact of existing policy incentives and compares the battery electric vehicle operation cost to comparable conventional and hybrid vehicles. In the San Francisco example, the total six-year cost of operating an electric vehicle would be about $48,000, compared to about $36,000 to $40,000 for the reference vehicles. The electric vehicle costs include electricity, home charging equipment, maintenance, insurance, financing, and tax. This also includes the replacement cost of utilizing another vehicle for longer trips. Federal, state, and local incentives, including support for public charging infrastructure, reduce the total cost to approximately $35,000. That is, in San Francisco the existing policy support reduces the average cost per mile to operate electric vehicles by about a third, from 72 cents per mile to 52 cents per mile. The battery electric vehicle, as shown, has a 4% lower cost per mile than the conventional gasoline 34-mpg car, and 11% lower cost per mile than the 50-mpg hybrid when factoring in consumer incentives available in San Francisco.

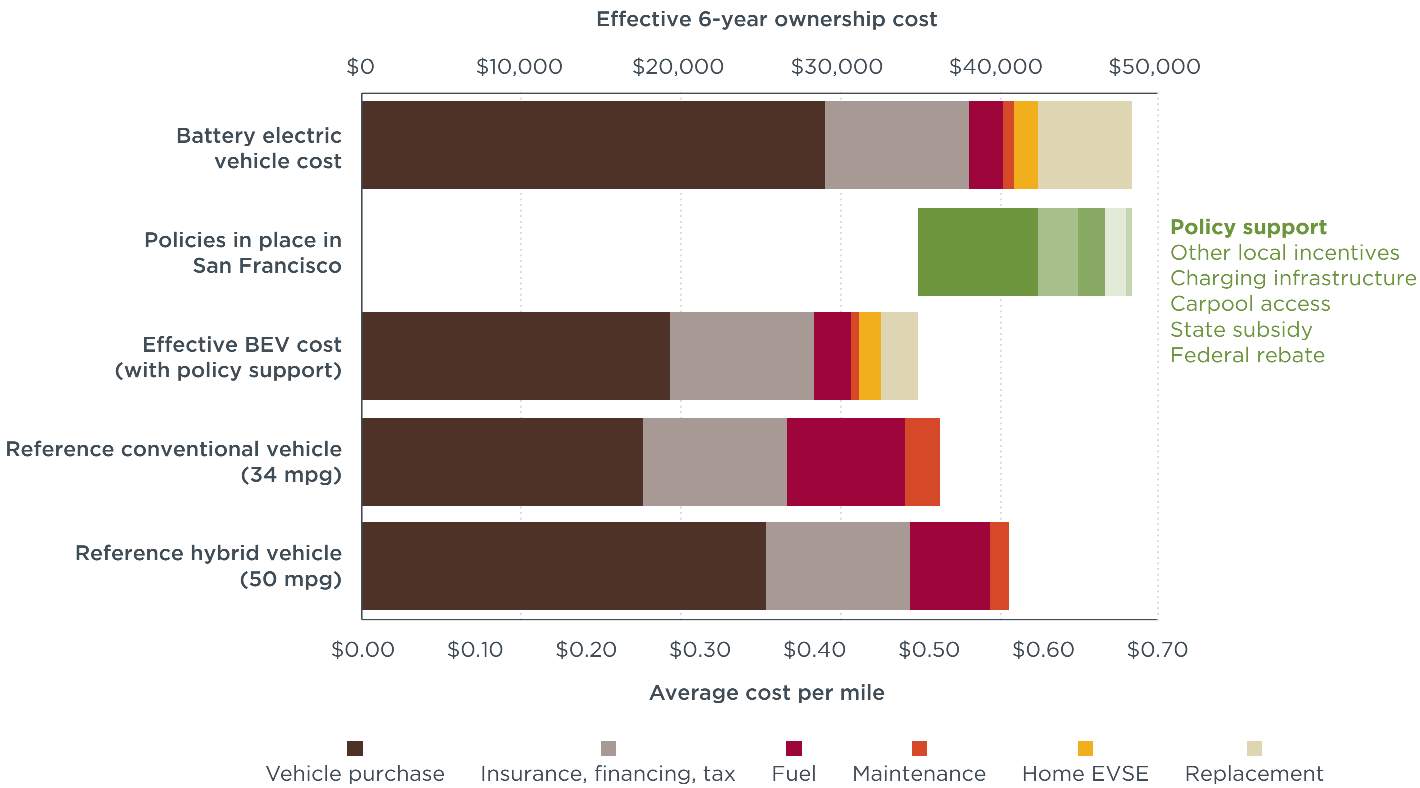

Figure 3. Cost of ownership for battery electric vehicle with policy support, compared to conventional and hybrid vehicles, in San Francisco area.

Figure 4 summarizes the total cost of ownership for battery electric vehicles across the 25 U.S. metropolitan areas. The total includes vehicle purchase cost, electricity and fueling cost, other annual costs, and policy incentives as described above. Cities are sorted from left to right, lowest electric vehicle ownership costs to highest. The two right-most bars in the chart show total cost of ownership for the average hybrid and conventional gasoline vehicle models, for purposes of comparison. The "cost parity range" for the average ownership cost of the hybrid and conventional gasoline vehicles is shown as a gray band across the data; this specifically highlights the cities where battery electric vehicle costs can be lower than costs for their non-plug-in counterparts. As the figure shows, San Francisco, Atlanta, Denver, and Los Angeles have effective ownership costs below the conventional gasoline vehicle after average policy benefits are included. The other 21 cities have total six-year ownership costs that are higher than the comparable 34-mpg car — but lower than that of the 50-mpg hybrid. On average, battery electric vehicles' ownership cost (56 cents per mile) is higher than the comparable gasoline vehicle (53 cents per mile) and less than the 50-mpg hybrid (60 cents per mile).

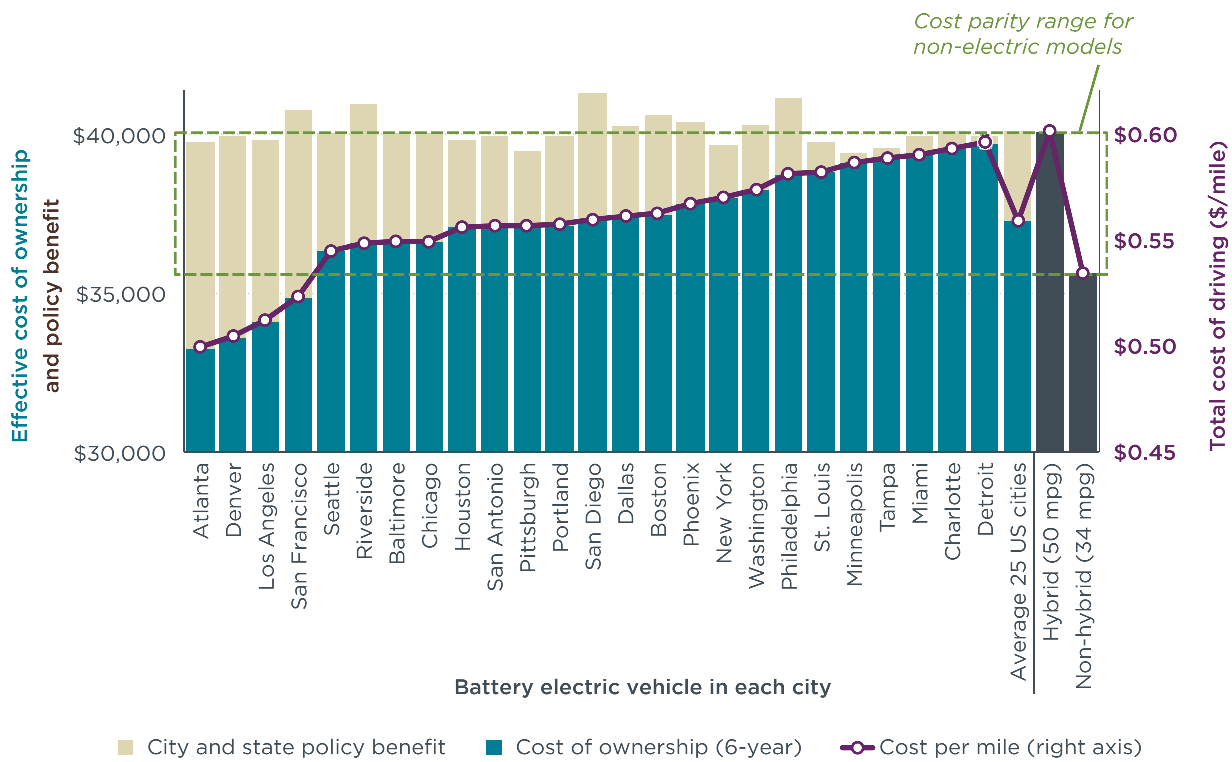

Figure 4. Policy benefit and total cost of ownership for battery electric vehicles in 25 U.S. metropolitan areas, compared to hybrid and non-hybrid gasoline vehicles.

CONCLUSIONS

Technology developments and policy support continue to reduce the total cost of owning and operating a battery electric vehicle, to the point where in some areas of the United States it is now less than that of comparable non-plug-in electric vehicles. This briefing assesses the consumer proposition for battery electric vehicles across 25 metropolitan areas in 2014, using data on fuel costs, electricity prices, and state and local policies. As the companion analysis (Lutsey et al, 2015) and this follow-on briefing show, the consumer proposition for battery electric vehicles is especially improving in cities with proactive electric vehicle support policies. Based on the above findings, four main conclusions can be drawn.

Battery electric vehicles are increasingly becoming competitive for average vehicle consumers. All-electric vehicles offer average fuel savings of $3,000 when compared to the most efficient hybrids, and about $5,000 relative to a comparable non-hybrid over six years of ownership. These fuel savings, along with policy support, are reducing the total cost of owning and operating a battery electric vehicle below that of the leading hybrid in all 25 cities analyzed, and below the cost for a comparable conventional vehicle in four of the 25 cities.

Policies that reduce effective electric vehicle ownership costs are priming the early market. The leading metropolitan electric vehicle markets tend to have consumer subsidies, public charging infrastructure, and other incentives that make electric vehicles more attractive to prospective buyers. In addition to the dramatic fuel-saving benefits, policy support is helping to defray the upfront cost differential for the new advanced technology as well as alleviate consumer information and convenience issues. Two cities with the best array of consumer policy benefits for prospective battery electric vehicle buyers in 2014, San Francisco and Atlanta, saw an uptake by consumers in 2014 over eight times the national average (i.e., over 3% versus 0.38% nationally). In these two leading cities, the cost of owning and operating a battery electric vehicles in 2014 was about 5% lower than operating a comparable conventional vehicle and 15% lower than a comparable hybrid. Georgia's electric vehicle incentive expired in June 2015, and in 2016 and beyond this will challenge the electric vehicle market that has been developing in Atlanta.

Gaps in awareness, education, information, and model availability are inhibiting growth in the electric vehicle market. Although policies to reduce operating costs of electric vehicles matter, they only partly explain trends in the early market. There are several cities—especially Denver—with substantial policy incentives but without the proportionate vehicle sales, indicating that widely recognized barriers are preventing greater uptake. Limited availability of electric vehicle models and lack of awareness of the models that are available, their fuel-saving benefits, and consumer incentives remain fundamental barriers in many areas (See, e.g., NRC, 2015; Krause et al, 2013; Krupa et al, 2013).

Extending electric vehicle policy incentives through 2020 is likely to be critical to sustaining market growth. Technology developments and emerging policy actions could further improve the value proposition for prospective battery electric vehicle buyers. Based on battery innovation and manufacturing cost reductions of about 6% per year, battery electric vehicles could see costs reduced by about $9,000–$11,000 over the 2010–2025 time period (NRC, 2013). Recent research by Nykvist and Nilsson (2015) shows that leading battery and auto manufacturing companies are even outpacing this trend. Many next-generation electric vehicle announcements from automakers promise greater range and lower vehicle costs in the 2015–2020 time frame. Extension of federal, state, local, and public utility electric vehicle promotion policies through the next-generation of plug-in electric vehicle launches in 2016–2020 is likely to be critical. Innovative fuel policies, actions by utilities, and more widespread workplace charging could also multiply consumer benefits in an expanding electric vehicle market (See, e.g., Yang, 2013; Ryan and Lavin, 2015; U.S. DOE, 2014).

When mainstream consumers will be able to make the case to buy a battery electric vehicle on basic household economics grounds is a key question for the success of this still-maturing technology. As this analysis shows, that time is already here in some places where pioneering electric vehicle policies are in place.

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