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Realizing the Potential of the Los Angeles Electric Vehicle Market

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About the Study

The study sought to estimate the number of electric vehicles that would be purchased by City of Los Angeles residents over the next decade, and examine the effectiveness of policies to increase this number. The study was conducted using standard marketing analysis techniques to forecast new product adoption, including a conjoint survey and Bass diffusion model. The principal authors include a team of second year UCLA Anderson students, who completed the project with a Faculty advisor as part of their capstone requirement for the MBA program.

About the Authors

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For More Information

For more information on this study and the UCLA Luskin Center's Electric Vehicle research programs, contact Juan Matute at jmatute@ucla.edu or 310-267-5435.

Electronic copies

An electronic copy of the report is available at http://luskin.ucla.edu/ev

Cover photo

The front cover photo of the all-electric CODA sedan was provided by Los Angeles area-based CODA Automotive.

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1. Executive Summary

1.1 *Introduction*

The electric vehicle market is a rapidly increasing ecosystem, considered one of the fastest growing areas of green technology. Market research firms agree that the EV sector will gain market share from traditional and hybrid car sales in upcoming years. However, market share forecasts are scattered across a wide range, putting the share of EV sales between ~5% and ~50% by 2020.

The success of the EV market overall will depend on how well the market responds to incentives and whether it can overcome the barriers to adoption. The two main market enablers that will drive EV adoption are purchase subsidies and overwhelming consumer demand. The most significant barriers on the other hand are four-fold: (i) charging infrastructure (home and public), (ii) battery price and performance, (iii) range anxiety, and (iv) EV supply.

The Los Angeles market has several unique characteristics that will influence EV adoption. There are three key issues that differentiate Los Angeles' EV market: (i) high ratio of multifamily housing buildings and renters, (ii) high ratio of new and hybrid cars, and (iii) commuter market with high availability to multiple vehicles per household and limited public transit commuting. The Los Angeles market offers great potential, but public policy is essential to help consumers embrace EVs. Public policy can help reduce barriers and create an economic climate that encourages private investment and allows consumers to fully maximize the benefits of EV adoption.

1.2 *L.A. EV Market Forecast*

In order to assist the City of Los Angeles and the Department of Water and Power in its EV planning, a sales projection model was produced to predict the EV market share and adoption by zip code through the year 2020.

Key findings from the projection model include:

- **Electric vehicle sales** are projected to compose **9%** of total car sales in **2015** and **11.7%** in **2020**.
- Sixty-five percent of prospective early EV adopters are **multifamily residents and renters**, but these groups face major challenges in accessing home charging.
- **EV home charging** will be most concentrated in the west side, downtown, valley, and south bay regions, most of which show substantial multifamily residential populations.
- **EV charging will be concentrated in the daytime, mostly** in downtown and along the Wilshire corridor.

The projection model also tested three policy and incentive scenarios to assess the impact on EV sales:

- Incentives and policy options will have little effect until **supply constraints** on EV sales are removed, potentially several years in the future.

- **Increasing access to home charging** will have a substantial impact on EV sales if implemented before EV supply constraints are lifted.

1.3 *L.A. EV Market Survey Results & Analysis*

The L.A. EV market survey includes responses from 2,043 participants in the L.A. Metro Area. The 50-question survey was conducted via Internet to query people's general attitudes, preferences and behaviors that would influence their entrance into the EV market Based on the survey results; we segmented the population into three main categories: Early Adopters, Mid-Adopters, and Late Adopters. We further determined that Mid and Late Adopters had two sub-segments, which were distinguished along home ownership and income. This report analyzes the attitudes, behaviors, and preferences for each of the segments and identifies key barriers and obstacles for EV adoption in L.A.

Key findings from the survey include the following:

The City can help attract the majority EV with policies that lower Total Cost of Ownership (TCO) and raise the perception of how much value EVs offer.

- Measures to **help lower the upfront cost of EVs will make a significant impact in EV adoption, particularly among Mid-Adopters.** Respondents perceive large gaps between EV price and the value they offer. Over 80% of respondents said price is an important factor in the decision to purchase an EV and 71% believe that "EVs cost too much for what they offer."
- **Enacting and communicating a competitive and easy-to-understand electricity rate plan for EV recharging will also incentivize greater EV adoption, particularly amongst Mid-Adopters.** Over 70% of Mid-Adopters consider current gas prices to be an important factor when buying an EV compared to only 54% for Early Adopters. Likewise, 85% of Mid-Adopters care about battery recharge cost, compared to 66% of Early Adopters. An $83 monthly savings in fuel costs may be enough to convince 40% of the population to purchase (or at least consider) an EV.
- **Greater public awareness about EVs and EV incentives would help elevate the perceived value of EVs, particularly amongst Mid-Adopters.** Only 37% of respondents had at least some knowledge about EVs and only 29% were aware of available EV incentives. Lack of knowledge about EVs and EV incentives could deter many would-be adopters. For example, over 50% of Mid-Adopters cited lack of knowledge about the product as a reason for not liking EVs.

Increasing access to recharging opportunities beyond single-family home garages will be vital for all segments.

- **Without policies to facilitate access to at-home charging** for 61% of L.A.'s population that are renters or residents of multifamily buildings, **25% of respondents would be prevented from buying an EV due to perceived difficulties with EV charger installation.**
- Access to **public charging options outside the home or building garage** will be important for the 25% of survey respondents who park on the street.

- **For over 70% of L.A. drivers** who commute less than 30 miles per day (round-trip), **there are multiple charging schedules to fit their charging preferences.** Six to eight hours of Level II recharge every two to three days or three to four hours of Level II recharge every day would also be enough for most L.A. drivers. Alternatively, six to eight hours of Level I recharge every day would also suffice.

- **Early to Mid-Adopters are particularly interested in incentives that facilitate home charger installation.** Expedited permitting was important to 75% of Early to Mid- Adopters consider expedited permitting to be important and over 80% of Early to Mid-Adopters consider the $2,000 rebate for charger installation to be important.

- **Level I charging may be a realistic option to support and incentivize widespread adoption amongst non-single family homeowners and Mid to Late Adopters.** Seventy-three percent of commutes are below 30 miles (round-trip) and 76% of total driving is below 50 miles per day. At least 30% of Mid-Adopters show an interest in Level I charging (and another 30% of the population remain neutral who might be convinced to try Level I).

Actual driving patterns and range needs of L.A. residents make EVs highly suitable for the majority of day to day commutes and urban travel. Specifically, the City can undertake three initiatives to mitigate range anxiety amongst prospective EV drivers:

- **Shape the perceived need and desire to own a vehicle with extended range.** Seventy-three percent of commutes are below 30 miles (round-trip). Even accounting for additional and non-commute driving, 76% of total driving is below 50 miles per day. A 100 mile-range is enough for typical driving needs.

- **Positioning the EV as a second-plus vehicle in a family's suite of cars may help families with multiple car ownership consider an EV.** Almost 60% of respondents own two or more cars.

- **Car share could be an economical option to provide greater range flexibility for L.A. EV drivers, especially in low-income communities.** Almost 70% of respondents with household income less than $25,000 per year stated some level of interest in car share.

HOV lane access and monetary incentives, such as the $2,000 charger installation rebate and the federal and state tax credits will help attract Mid-Adopters and should be continued into the medium term. However, free parking will fail to significantly influence EV purchases.

- **HOV lane access for EVs will be an attractive incentive for Mid-Adopters.** Over 60% of Early to Mid-Adopters say that HOV lane access would be important.
- **Early to Mid-Adopters are receptive to monetary incentives that lower TCO, while incentives are not enough to sway Late Adopters.** Only 28% of Late-Adopters consider the $2,000 rebate for charger installation important when buying an EV, compared with the sample average of 73%.
- **Free parking may not prove to be a good incentive to attract incremental EV demand, as 59% of respondents state they never use street metered parking.**

1.4 *City Benchmarking*

Concurrent to understanding what EV adoption may look like for the city of Los Angeles, we researched other cities to understand the public policy options that Los Angeles could consider. This work stream is a largely qualitative examination of the incentives that other major cities around the world are enacting or seriously considering to increase EV adoption.

Emerging Themes

- **Many cities consider EVs as one of many components of a sustainable mobility strategy.** Public transit, bicycling, and walking are alternative modes of transportation to private vehicles, and many cities such as Portland and Seattle will not support EVs to the point where it incentivizes a resident to move from an alternative mode into an electric vehicle.
- U.S. cities are still in **early stages of implementation**; published strategies are not necessarily indicative of implementation status. Cities are polarized between not over-committing (largely due to an unsuccessful EV roll-out twenty years ago) and supporting mass adoption.
- The **speed at which residents can permit and install chargers varies** across cities. Many cities (Seattle, Houston) have developed online portals where permits are approved the same day. Other cities have targets of five to seven business days for approval. Portland has developed a process of conducting spot inspections (via Oregon's Minor Label program) where one of ten installations is inspected.
- The planning for **multifamily housing charging constraints** varies across cities. From our research, San Diego is the farthest along in this process, with charger company ECOtality and SDG&E serving as central points of contact for coordinating installation. Many cities face significant challenges in developing access to chargers for multifamily housing.
- Cities that are farther along in planning often have an enthusiastic private partner and **actively involved utilities.** SDG&E, PG&E, and Austin Energy have taken the initiative in getting heavily involved in planning for EV deployment.
- Cities are leveraging **car share programs** to promote EVs. Because of the public accessibility factor, car share programs are extremely popular with many cities. Some receive funding to assist with purchase of EV fleets and chargers (London, Chicago, Philadelphia), and others have partnerships where EV owners can charge their EV in ZipCar parking lots (Portland).
- **Direct Current (DC) fast charging** is a polarizing topic. Many are enthusiastic that fully charging a car in 20-30 minutes will satisfy customer needs and have plans to deploy infrastructure along freeways and high-traffic areas (Seattle, San Diego). Other cities believe that 20-30 minutes is unrealistic in satisfying customer demands for "fast" charging and are wary of investing in this technology (Austin).
- Currently there is **low consumer knowledge** and **little to no marketing.** Seattle's "Client Assistance Memos (CAMs)" are a unique feature that the city has undertaken in prior years to educate their public on various processes. SDG&E has posted high-level process flows on their website for EV buyers in search of installing a home charger.

1.5 *Recommendations*

Los Angeles is in a great position to become an EV city leader, with involvement of key stakeholders such as the Department of Water and Power. Federal and state subsidies for EV purchases and charging infrastructure will drive sales and EV demand will exceed supply for the next few years. In the study, we have explored EV policy options in cities worldwide, assessed consumer preferences, and projected EV supply and demand in the next ten years. Using this research, combined with an analysis of **applicability** and **feasibility** of implementation, we have developed the following policy recommendations for the City of Los Angeles.

Streamline permitting & installation process with an actively involved utility. Survey results indicate that expedited permitting is very important to Early and Mid-Adopters in Los Angeles. Permitting demands should be addressed within the same day. Los Angeles can look to Seattle and Houston for a model on turning around same-day requests. Charger installation is more difficult than permitting because more entities are involved, but exploring programs such as those in Portland, Austin, and San Diego may prove beneficial and relevant. Because Los Angeles owns the DWP, the city has additional policy and business opportunities to meet EV consumer demand than other cities.

Increase charging access in multifamily housing. Our market survey confirms that multifamily housing customers are a large part of the shapeable majority – namely, the Mid-Adopter market segment – and they could dramatically increase the adoption rate of EVs. The EV projection model currently has a significant demand constraint due to the lack of home charging availability for multifamily housing customers. By alleviating this constraint, the City could increase EV adoption to more than 13% of new car sales by 2020. The City should look toward San Diego and future UCLA Luskin Center projects to develop and implement charger access solutions for multifamily housing residents.

Increase consumer education and marketing. All customer segments revealed an overall lack of knowledge about electric vehicles and incentives, especially within the Mid-Adopters segment. Almost half of the respondents reported that this lack of knowledge is a barrier to purchasing an EV. Los Angeles should look to Seattle and San Diego as benchmark cities in effectively developing EV awareness.

2. Introduction

2.1 Market Forecasts

The electric vehicle ecosystem is rapidly increasing day by day. New start-ups are part of this vibrant market and established automakers are spending millions of dollars to develop electric models. Consumers are interested in electric vehicles, but have various concerns. According to Baum & Associates' U.S. Electric Forecast, the number of electric vehicle models is supposed to more than triple in the next five years. Their research shows that there will be 18 plug-in hybrid and 32 electric models by 2015, compared to three and 11 models in 2011, respectively [Baum & Associates, 2010]. According to McKinsey & Company's electric vehicle index, the United States is leading the EV market and is the only country with strong government support behind the initiative. In 2007, the United States dedicated $25 billion to advanced technology vehicles, including electric cars [Area Development Online, 201]. In 2009, President Obama announced his vision of having one million plug-in electric vehicles (PEVs) on American roads by 2015 [Bloomberg, 2009, City of New York, 2010; Green Car Congress, 2011]. He supported his idea with an additional $2.4 billion stimulus package for tax credits, infrastructure investments and other incentives to increase consumer demand for PEVs [Huffington Post, 2009; Guardian, 2009]. It is obvious that there is much movement in the EV market, though experts are still debating about its future and the rate of adoption by consumers. Table 1 summarizes the forecasts of selected companies.

A study released by JD Power and Associates in October 2010 estimates that 1.67 million hybrid electric vehicles (HEVs) and plug-in electric vehicles (PEVs) will be sold in the United States in 2020. This number accounts for approximately 10% of all light-duty vehicle sales. According to JD Power, battery electric vehicles (BEVs) will be less successful. According to their forecast, only 100,000 BEVs will be sold by 2020, which represents less than 1% of all vehicles sales. Their report cites BEV vehicle costs, battery technology and performance, and EV range as the primary barriers to adoptions [JD Power and Associates, 2010; The Heritage Foundation, 2011].

A September 2010 study by Pike Research estimates that 3.2 million PEVs and BEVs will be sold in the next five years worldwide, representing a compounded annual growth rate (CAGR) of 106% between 2011 and 2015. Out of the 3.2 million electric cars sold, approximately 840,000 will be sold in the United States, accounting for 26% of the global market. According to their research, there will be 200,000 plug-in hybrid electric cars (PHEVs) sold in the U.S. in 2015 [Pike Research, 2010]. In their March 2010 research, they also estimated that the United States will have more than 60,000 BEV sales in the same year [Detroit Chinese Business Association, 2010]. They claim that "PHEVs and BEVs will complement, rather than displace, the market for conventional hybrid electric vehicles, (...) Electric vehicles will follow the lead of hybrids" [Pike Research, 2010].

Deloitte Consulting's 2010 Electric Car Survey offers three scenarios with two forecast dates. According to their estimates, PHEV and BEV sales will be between 0.3 and 0.5% by 2015. Deloitte estimates it will jump between 1.9 and 5.6% by 2020 in the United States. These numbers translate to 45,000 to 75,000 electric vehicles sold by 2015 and 285,000 to 840,000 vehicles sold by 2020.

Their research shows that the electric vehicle awareness and interest will continue to grow. They suggest that awareness will increase to 75-93% from its 2010 level of 26%. Similarly, interest in electric vehicles will increase from 19% in 2010 to 28-55% by 2020. Deloitte Consulting predicts lower gains in getting electric vehicles into people's consideration set. They estimate a one to 31 percentage point uptick from the current 13%. It translates to a 14-44% consideration for the pool of people interested in EVs. Main barriers of adoption cited by the report are familiarity with EVs, brand considerations, charging concerns, infrastructure availability, range anxiety, and price and ownership costs [Deloitte Consulting, 2010].

According to the May 2009 McKinsey & Company's study called "Roads toward a low-carbon future: Reducing CO_2 emissions from passenger vehicles in the global road transportation system", the automotive sector has several options to counteract the EV market based on dominant technology(s). The worst case scenario for electric and hybrid vehicles is the "Optimized ICEs[1]" case, which assumes that car manufacturers are able to optimize the fuel efficiency of ICE vehicles. This would suppress the growth of hybrid and electric vehicles down to a combined market share of 1% both in 2020 and 2030. Hybrid vehicles would dominate the majority of that 1% market share. In the "Mixed technology" case, ICEs remain the lion share of the market but new technologies slowly gain market share. In this scenario, hybrids account for 10% and 23% of new vehicles sold in 2020 and 2030, respectively. Plug-in hybrids are estimated to have 5% market share in 2020 and 16% in 2030, and purely electric vehicles reach 1% by 2020 and triple it to 3% by 2030. It translates to worldwide sales of 3.75 million PHEVs and 0.75 million BEVs in 2020, and 14 million PHEVs and three million BEVs in 2030. The last scenario called "Hybrid-electric" is the most favorable for electric vehicles. In this case, electric vehicles and hybrids are estimated to have a combined market share of 25% in 2020 and 60% by 2030. Out of the 25% in 2020, hybrids have the most with 18%, followed by PHEVs (6%) and BEVs (2%). Both PHEVs' and BEVs' market share quadruples between 2020 and 2030, accounting for 24% and 8%, respectively. In this scenario, 4.5 million PHEVs and 1.5 million BEVs are sold in 2020, and 22 million PHEVs and 7 million BEVs in 2030 worldwide [McKinsey & Company, 2009].

Similarly to McKinsey & Company, The Boston Consulting Group (BCG) also provides several future scenarios for the EV market. Their first scenario called "Slowdown" envisions a world with low oil prices and minimal concerns about global warming. For this case, they estimate a 1% EV share of new car sales in North America by 2020. The other extreme scenario called "Acceleration" forecasts a world with $300/barrel oil prices and considerate amount of anxiety over climate issues. This case estimates a 10% market share of EVs in North America by 2020. BEVs and PHEVs both capture 5% market share under this scenario. BCG's middle case called "Steady pace" forecasts steadily increasing oil prices and increasing concerns around climate issues. In this scenario, BEVs are able to capture a market share of 2% and PHEVs are able to get 3% in the North American market by 2020 [BCG, 2009].

A study published by Bain & Company (Bain) in 2010 called "The e-mobility era: Winning the race for electric cars" analyzes the global demand for new electric cars in 2020. Bain's forecasts consider four key influences to the demand for alternative vehicles: oil prices, zero emission zone policies and regulations, climate change considerations and worldwide subsidies for the industry. They forecast

[1] ICE – Internal Combustion Engine vehicle; a conventional gasoline-powered vehicle with no electric drivetrain

that electric vehicles will represent between 7% and 50% of new car sales by 2020. In their "fundamental change" scenario, which includes $300/barrel oil prices combined with strict regulations and heavy investment into the EV market, they predict 20% BEV and 30% PHEV penetration of new car sales. On the other hand, they foresee a 2% market share of BEVs and 5% of PHEVs in the "little change" scenario. This case operates with the assumption that oil prices will stay below $100/barrel and no considerate subsidies are provided to boost the EV sector. Bain's medium scenario called "basic-scenario" estimates a 10% market share for BEVs and 15% for PHEVs. This case assumes $200/barrel oil prices in the medium term coupled with $10-30 billion subsidies to the EV sector worldwide [Bain & Company, 2010].

Table 1: Forecasts available for electric vehicles

Forecast	Geography	Forecast Year	Market share PHEV	Market share BEV	Market share Combined	Unit sales (million) PHEV	Unit sales (million) BEV	Unit sales (million) Combined
Pike Research	United States	2015				0.2	0.06	0.26
Deloitte Consulitng	United States	2015 2020			2015: 0.3-0.5% 2020: 1.9-5.3%			2015: 0.05-0.08 2020: 0.3-0.8
BCG	North America	2020	0-5%	0-5%	0-10%	0-1.35	0-1.35	2.7
JD Power and Associates	Worldwide and United States	2020		World: 1.8% US: <1%			World: 1.3 US: 0.1	
Bain & Company	Worldwide	2020	2-20%	5-30%	7-50%			
McKinsey & Company	Worldwide	2020 2030	2020: 0-6% 2030: 0-24%	2020: 0-2% 2030: 0-8%	2020: 0-8% 2030: 0-32%	2020: 0-4.5 2030: 0-22	2020: 0-1.5 2030: 0-7	2020: 0-6 2030: 0-29

2.2 Enablers and Barriers

2.2.1 Enablers

There are several enablers helping the electric vehicle industry become a significant force in the overall vehicle market. In our paper, we would like to outline two main enablers: stimulus money and consumer demand.

2.2.1.1 Stimulus Money

Over the last couple of years, the U.S. government has invested billions of dollars in supporting advanced technology vehicles. Boosting the EV market is a significant part of the Obama Administration's program to decrease the United States' dependence of foreign oil, fight climate change, increase the output of the American manufacturing industry and bring jobs to the country [MSNBC, 2010, Ernst & Young, 2010; City of New York, 2010].

According to a U.S. DOE report in July 2010, the U. S. Government invested $10 billion in advanced technology vehicles, with $5 billion assigned to the electric vehicle market. According to the study, "*these investments under the American Recovery and Reinvestment Act and DOE's Advanced Technology Vehicle Manufacturing (ATVM) Loan Program are supporting the development, manufacturing, and deployment of the batteries, components, vehicles, and chargers necessary to put millions of electric vehicles on America's roads*" [US DOE, 2010, p2]. Among the goals of the project are (i) establishing 30 battery and component manufacturing plants in the United States with enough capacity to support 500,000 electric vehicles annually, (ii) helping selected automakers (Fisker, Nissan and Tesla) to open electric vehicle manufacturing facilities in the country, (iii) investing in battery technology research to push down the cost of electric car batteries by 70% in the next five years, and (iv) adding 13,000 grid-connected vehicles and 20,000 charging spots by 2013 through several infrastructure pilot programs nationwide[US DOE, 2010].

Additionally, the commitment and support of the U.S. government for EVs provides confidence and interest for private and institutional investors to participate in the EV ecosystem. In the last year, several companies have raised money to extend their electric vehicle operations. Tesla raised more than $180 million in its initial public offering in July 2009. They have prominent stakeholders as Daimler AG or Toyota Motor Co. and Panasonic Co. [Wall Street Journal, 2010,]. In January 2011, CODA, a Santa Monica-based EV start-up, raised $76 million [Green Tech Media, 2011]. Finally, Fisker Automotive reached $1 billion of funding with a new $150 investment round in January 2011 [OC Register cars, 2011].

These investments – both public and private - clearly give momentum to the EV ecosystem and create significant incentives for a wide range of companies and institutions - auto industry players, green start-ups, universities, research centers, etc. - to enter the market and search for the holy grail.

2.2.1.2 Consumer Demand

According to a joint study by the City of New York and McKinsey & Company, 14-15% of New Yorkers purchasing a vehicle can be electric vehicle buyers by 2015. The study categorized 21% of city inhabitants as potential early adopters. Another 22% is estimated to be probable late adopters and another 19% is labeled as probable laggards [City of New York, 2010; Investopedia, 2011; McKinsey Quarterly, 2011].

Early adopter data shows strong demand for both BEVs and PHEVs. In early November 2010, Nissan confirmed that it reached 27,000 pre-orders worldwide for its all-electric Leaf [Nissan, 2011]. According to Chevrolet, Chevy Volt's official interest list has 50,000 names on it [Chevyvolt.org, 2011]. As a result of these strong interest numbers, car manufacturers are constantly updating their short-term production capacity forecasts. Last July, Chevrolet increased its 2012 Volt production capacity target from 30,000 to 45,000 cars [Huffington Post, 2010]. After several increases in their target, Chevrolet announced a 120,000 target capacity by 2012 [US DOE, 2011]. Nissan's goal is to produce 500,000 EVs by 2013 [New York Times, 2010a]. Nissan is currently committed to opening two plants (Smyrna, TN in 2012 and Sunderland, England in 2013) in addition to its Oppama, Japan facility. The three plants will have a combined capacity of 300,000 vehicles per year [Forbes, 2010].

Despite the overwhelming pre-launch demand for electric vehicles, there are several unanswered questions. One question is how the early EV experience will affect longer-term demand. In other words, will the automakers be able to provide an enjoyable experience to early EV buyers who then go out and spread the word? Auto makers seem cautious and are playing the vehicle deployment game strategically. For example, they are purposefully screening pre-registering customers to select the ones with home infrastructure installation and home charging (they favor single family homeowners vs. multifamily housing occupants) [Interviews with OEMs, EV Infrastructure Companies, Other Industry Stakeholders, 2010].

2.2.2 Barriers

Everybody agrees that the electric vehicle market has a long way to go. Every EV research study identifies several barriers to adoption that need to be mitigated in order for EVs to become mass market vehicles.

A research study released by Deloitte Consulting in 2010 identified six major barriers to adoption: (i) familiarity with EVs, (ii) brand, (iii) range anxiety, (iv) availability of home charging, (v) public infrastructure, and (vi) prices and cost of ownership [Deloitte, 2010].

The “Virginia Get Ready: Electric vehicles plan” study from October 2010 cited several barriers to EV adoption, six of them are related to the consumer side: (i) EV supply, (ii) home charging infrastructure, (iii) upfront costs and TCO, (iv) range, technology and servicing, and (v) limited understanding of EVs [Virginia Get Ready, 2010].

A 2010 study conducted by Harvard Kennedy School identified six main barriers to large scale adoption of EVs: (i) upfront costs of EVs, (ii) range anxiety, (iii) availability of charging infrastructure, (iv) technology uncertainty, (v) OEM[2] inertia and supply chain sunk costs, and (vi) lack of information [Philip & Wiederer, 2010].

For the purpose of our paper, we will analyze four broader areas of potential barriers to adoption: (i) infrastructure (home and public), (ii) battery price and performance, (iii) range anxiety, and (iv) EV supply.

2.2.2.1 Charging Infrastructure

One of the biggest barriers is the availability of places to charge electric vehicles [City of New York, 2010]. There are two types of infrastructure: home charging, installed in people’s home; public infrastructure, which occurs outside of the home. Currently, all major U.S. cities lack both home and public infrastructure to support EV use. EV industry experts expect that most charging will happen overnight in people’s homes [Philip & Wiederer, 2010]. The two main concerns with home charging are the availability of charging infrastructure for multifamily housing and the permitting and installation process for single family homes. Private industry players say local government and utility companies can facilitate EV adoption by simplifying the permitting and installation process. Local government can enable EV adoption through low permit fees, a simple installation process, charger rebates, tax credits, consumer programs and special rates [Interviews with OEMs, EV Infrastructure Companies, Other Industry Stakeholders, 2010; EPRI, 2010].

[2] Original equipment manufacturer

Local government also plays a role in increasing charging access for multifamily housing. Multifamily housing presents several obstacles to infrastructure installation. First, residents may not have garages or designated parking spaces. Charger installation is difficult for street parking and in older buildings. Upgrades may be required and EV owners may need to coordinate with the landlord or nearby property owners. Another issue is paying for the electricity used. Equipment needs to be installed and the property must verify that metering and billing are done properly, and that the EV spot is shared appropriately between all EV owners [Interviews with OEMs, EV Infrastructure Companies, Other Industry Stakeholders, 2010].

Estimates indicate that between 75-90% of charging will occur in the home, but the availability of public charging facilities will help ease range anxiety [Interviews with OEMs, EV Infrastructure Companies, Other Industry Stakeholders, 2010]. The installation of public infrastructure raises three questions: (i) who should pay for the infrastructure investment, (ii) where should public infrastructure be installed, and (iii) what kind of infrastructure should be installed.

Our research indicates that EV industry representatives believe infrastructure investment should come from the private sector rather than public. In this scenario, the public sector's role would be to create the appropriate environment through regulations, tax waivers, and clear standards [Interviews with OEMs, EV Infrastructure Companies, Other Industry Stakeholders, 2010].

Several pilot projects are testing different business models and location concepts to determine the optimal placement of public charging infrastructure. ECOtality's EV Project, funded by U.S. DOE grant money, is "the largest deployment of electric vehicles and charge infrastructure" [ECOtality, 2009]. Additionally, retailers (such as Whole Foods and Best Buy) and gas stations (BP and Arco) are installing charging stations to attract customers to their stores [Coulomb Technologies, 2010; CSNews, 2010; EPRI, 2010; USA Today, 2011].

There are also questions about the type of infrastructure that should be installed. Currently, three charging levels are available. Level I charging is 120V, which simply means plugging the car into a regular electrical outlet. Level 1 can charge a Nissan Leaf in about 22 hours. Level II charging is 240V, which requires upgrades and modifications. Level II charging can recharge a Nissan Leaf battery in about 8 hours. Level III (or DC Fast) charging is 480 V and charges a Nissan Leaf battery in about 25 minutes [Plug-in America, 2011]. Level II charging is considered to slow to meet consumer demand. However, Level III charging is expensive, requires extensive infrastructure upgrades, can negatively affect battery life and performance, and lacks U.S. standards set by the Society for Automotive Engineers (SAE) [Interviews with OEMs, EV Infrastructure Companies, Other Industry Stakeholders, 2010; Plug-in America, 2011; Plug-in Cars, 2011].

It is unclear how public infrastructure will support the EV market. However, public infrastructure is needed to ease range anxiety and to ensure that charging access is not a barrier for consumers [Philip & Wiederer, 2010].

2.2.2.2 *Battery Price and Performance*

Battery performance is one of the biggest concerns regarding electric vehicles. The main issues are (i) the costs of batteries, (ii) battery lifespan, and (iii) reliability and performance [Interviews with OEMs, EV Infrastructure Companies, Other Industry Stakeholders, 2010].

Battery cost is one the most cited concerns. The upfront costs associated with the battery were cited as a major adoption battery [BCG, 2009; Deloitte Consulting, 2010]. However, there is a lot of variance in the current cost estimates of lithium-ion battery packs. A 2010 BCG study states that lithium-ion battery packs cost between $1,000 and $1,200 per kWh in 2010 [BCG, 2010]. Other sources cite cost estimates in the range of $450-900 per kWh [Bloomberg, 2010; Green Tech Media, 2010]. Using these estimates, a Nissan Leaf 24 kWh battery pack would cost somewhere between $12,000-28,800. The Chevy Volt's 16 kWh pack would cost between $8,000-19,200. The costs released by electric car manufacturers are lower than these estimates. Nissan claims that its battery pack currently costs $375 per kWh, which means the total cost of Nissan's battery pack is $9,000 [Autoblog Green, 2010]. GM has been reluctant to release current battery pack costs for the Chevy Volt, but executives have hinted at costs of $600 per kWh, bringing the total cost just below $10,000 [Autoblog Green, 2010]. If these numbers are true, Nissan has already reached the U.S. DOE's 100-mile range target of costs below $16,000 by 2013 and BCG's 2020 battery pack estimate of $360-440 per kWh. GM has to work on catching up with Nissan's cost levels and the DOE's expected target of a $4,000 battery cost for a 40-mile range vehicle by 2015 [US DOE, 2010; BCG, 2010].

The lower-than-expected battery costs raise a question: why are today's EV models more expensive than their ICE counterparts? The Nissan Leaf has a sticker price of $32,780 and consumers receive a $7,500 federal tax rebate and state tax credits in some states [CNN, 2010]. A Chevrolet Volt costs more than $40,000, but has a $33,500 price after the $7,500 federal tax credit. Production scale may explain higher prices. Lower levels of production could make overall manufacturing costs higher than ICE cars despite the low battery costs. Another potential explanation is that car manufacturers are taking advantage of the tax incentives to sell at higher prices to early adopters.

The battery lifespan and reuse are also cited as concerns. Currently, major electric car manufacturers offer an eight-year or 100,000-mile warranty on EV batteries [Auto Week, 2010; Examiner, 2010; New York Times, 2010b]. However, the warranty doesn't mean that batteries are expected to have a 100% performance potential for eight years. For example, the Nissan Leaf is expected to have 20% capacity erosion by the fifth year [Interviews with OEMs, EV Infrastructure Companies, Other Industry Stakeholders, 2010]. Increasing the lifespan of EV batteries can significantly impact consumer adoption and the U.S. DOE has significantly invested in research to achieve a 14-year EV battery lifespan– similar to current ICE vehicles – by 2015 [US DOE, 2010].

Lastly, there are concerns about the reliability and performance of electric vehicles. Electric vehicles have a lower performance under extreme weather conditions (e.g., 28 miles for a Chevy Volt, 55 miles for a Nissan Leaf). Cold weather decreases performance by making the battery less efficient. Additionally, the heater drains battery power [BNET, 2011, The Washington Post, 2011]. Reportedly, the Mini E gets a range reduction of 30-35% in cold weather [New York Times, 2010c]. Nissan is estimated to have 35-40% range erosion in cold weather from its 100-mile advertised average [BNET, 2011].

Electric car manufacturers, particularly BEV makers, have been reluctant to deploy cars to potentially lucrative markets such as New York, Chicago or Toronto until more information is available about the EV's limits in colder climates. As a result, Nissan has chosen markets with more predictable weather conditions as beachhead markets. The first launch markets were in Hawaii, California, Arizona, Oregon, Washington, Tennessee and Texas [BNET, 2011; Nissan USA, 2011]. Chevy has had fewer problems with its PHEV and has been more adventurous in placing its products in markets with extreme weather conditions. They included New York as their primary markets along with California, Texas, and Washington, D.C. [San Francisco Business Times, 2010]. EVs have a long way to go in order to meet the needs of customers in colder climates in order to increase their market to its full potential.

2.2.2.3 EV Supply

There are questions about the ability of manufacturers to keep up with the demand in the early years of the electric vehicle boom. A recent study by the U.S. DOE estimates the supply of electric vehicles at 45,000 in 2011, with an eight-fold increase to 370,000 EVs by 2015. That represents a 69% compound annual growth rate over the next five years. BEVs will account for 64% of production in 2011, driven primarily by a ramp-up in production of the Nissan Leaf. The Nissan Leaf is estimated to provide 56% of the EVs supply between 2011 and 2015. The remaining 44% is forecasted to come from PHEV manufacturers. Table 2 contains the supply of EVs by car make between 2011 and 2015 [US DOE, 2011].

Table 2: Estimated US supply of electric vehicles, 2011-2015

Manufacturer	Model	Type	2011	2012	2013	2014	2015	Total
Chevy	Volt	PHEV	15,000	120,000	120,000	120,000	120,000	505,000
Fisker	Karma	PHEV	1,000	5,000	10,000	10,000	10,000	36,000
Fisker	Nina	PHEV		5,000	40,000	75,000	75,000	195,000
Ford	Focus	BEV		10,000	20,000	20,000	20,000	70,000
Ford	Transit Connect	BEV	400	800	1,000	1,000	1,000	4,200
Navistar	eStar	BEV	200	800	1,000	1,000	1,000	4,000
Nissan	Leaf	BEV	25,000	25,000	50,000	100,000	100,000	300,000
SEV	Newton	BEV	1,000	1,000	1,000	1,000	1,000	5,000
Tesla	Model S	BEV		5,000	10,000	20,000	20,000	55,000
Tesla	Roadster	BEV	1,000					1,000
Think	City	BEV	2,000	5,000	10,000	20,000	20,000	57,000
TOTAL			**45,600**	**177,600**	**263,000**	**368,000**	**368,000**	**1,232,200**
PHEV			16,400	125,800	131,000	131,000	131,000	545,200
BEV			29,200	51,800	132,000	237,000	237,000	687,000

Notes: Table excludes Chrysler, CODA, BYD, Honda, Mitsubishi, Hyundai, Toyota, Volkswagen and Volvo, all of whom announced supplying electric cars to the US market
Source: US DOE , 2011

Using Deloitte's forecast that there will be between 45,000 – 75,000 EV sales in 2015, supply figures indicate that there won't be problems in meeting demand. More aggressive estimates made by Pike Research estimate that 260,000 EVs will be sold in 2015, which is still below the forecasted supply. The complications arise in the demand and supply of different types of electric vehicles. Pike Research predicts there will be demand for 60,000 BEVs in 2015, compared to 200,000 PHEVs. The U.S. DOE forecasts a 2015 supply level of 237,000 BEVs, compared to 131,000 PHEVs. The forecasts indicate that the supply for BEVs will be four times larger than the demand, while PHEV supply will be short by 70,000 cars.

2.3 Los Angeles Market

According to McKinsey & Company's estimates, EV demand in New York will account for 16% of new car sales by 2015 [Investopedia, 2011]. It is very likely that the Los Angeles Metropolitan Area and the City of Los Angeles will have a higher than average demand for EVs, similar to New York. As a result, the benefits of EV adoption can be higher than in other areas (e.g. carbon emission reduction, noise from traffic). In order to unleash the full potential of EVs, policy makers at the City of Los Angeles need to proactively help the EV ecosystem gain market share. There are three unique characteristics that differentiate the Los Angeles EV market: (i) high ratio of multifamily housing and renters, (ii) high ratio of new and hybrid cars, and (iii) a commuter market with limited public transportation system [Interviews with OEMs, EV Infrastructure Companies, Other Industry Stakeholders, 2010].

Fifty-seven percent of the City's population lives in multifamily housing and 52% of city residents are renters. Both groups require special assistance in order to adopt EVs. As discussed earlier, aging electrical systems in older multifamily housing buildings make it difficult to install charging infrastructure. Additionally, the interests of multiple stakeholders (i.e. landlord, tenant, neighbors) need to be addressed. The Los Angeles car market is one of the biggest markets in the US. Over 40% of respondents in the region buy new cars rather than used cars, and 38% are willing to pay more than $26,000 for a new vehicle. Additionally, the Los Angeles accounts for almost 5% of new car sales in the U.S. hybrid market [Center for Automotive Research, 2011; R.L. Polk Data]. Between 2007 and 2009, more than 40,000 new hybrid vehicles were sold in the Los Angeles area. Research firms indicate Los Angeles will be one of the largest EV hubs in the country because of the similarities between the EV and hybrid vehicle market.

Los Angeles is a commuter market. According to Census figures, 78% of the city's population commutes by car. However, the average commute distance is low: more than 70% of people commute less than 15 miles to work. Drivers make frequent short-distance trips. The short trips, coupled with year-round mild climate, make Los Angeles an ideal market for electric vehicles.

In summary, the Los Angeles market seems to carry great potential for EVs. However, public policy is necessary to help mediate adoption barriers and to create an economic climate that enables investments by EV companies and assists consumers to benefit from EV adoption.

3. Market Forecast Model

3.1 Methodology

In order to provide the City of Los Angeles and the Los Angeles Department of Water and Power with realistic, evidence-based projections of electric vehicle sales and adoption rates through 2020, a robust quantitative adoption model was created as part of this study. The high-level methodology for the model is described in this section, while the detailed construction of the model and results are provided in Section 3.3 and data sources used are listed in Section 3.2.

3.1.1 Ratings-Based Conjoint for Car Valuation

As part of our survey, we asked a conjoint question. We presented each respondent with one profile containing descriptions of a gas compact vehicle, a hybrid gas-electric vehicle, a BEV, and a PHEV, and asked him or her to give a preference rating for each vehicle on a scale of 0 to 10. Each respondent received one randomly selected profile out of a total of 32.[3] In each profile, we varied the prices of BEVs and PHEVs, the availability of HOV lane access and free EV parking, the time and cost to install an EV charger or the availability of at-home charging, and the price of gas.[4]

3.1.2 Logit-Based Market Share Simulation

Starting with an individual's ratings for a group of products that compose a product category, there are three basic approaches to calculate probability of purchase for each product, and from that calculate sales market shares within the category. The three approaches are maximum utility, the Bradley-Terry-Luce (BTL) model, and the logit model. Green and Krieger (1988)[5] evaluate the three methods and their sensitivities to scale, whose conclusions are summarized here.

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[3] 16 profiles were designed for Single Family Home Owners (SFOs) and the other 16 were designed for Non-Single Family Home Owners (NSFOs). See Appendix: L.A. EV Market Survey Questions for profiles.

[4] See Appendix: L.A. EV Market Survey Questions. We also considered the possibility of conducting a rank/ratings or choice based conjoint analysis, but decided against in order to maximize questions on respondent attitudes, preferences, and behaviors and background information on EVs. Rank/ratings based or choice-based conjoint analyses may be worth considering for future surveys, as long as respondents are adequately knowledgeable about EVs and EV incentives. In addition, our forecast model was based on the premise that EVs would cannibalize hybrid gas-electric sales. Designers of future surveys might also consider testing for the possibility of clean vehicle category growth (following the introduction of EVs). Furthermore, future surveys might also benefit from testing for the cross-price elasticity between ICE, gas-electric hybrid, BEVs and PHEVs and offering a wider range of vehicles from which the respondents can choose.

[5] Green, Paul E. and Abba M. Krieger (1988), "Choice Rules and Sensitivity Analysis in Conjoint Simulators," *Journal of the Academy of Marketing Science*, 16 (Spring), 114-127.

The simplest choice model is maximum utility, which supposes that, among the relevant set of products, the individual will choose their highest rated choice. This method is simple to apply and has no sensitivity to scale or location, but it is quite unstable when products are rated similarly, such that a small change in rating can produce a very large change in outcome (if a product rating falls slightly below that of another product).

The BTL choice model corrects some these of issues by determining purchase probabilities for all products in the set based on the individual's ratings. For a product category composed of three products with assigned values V_1, V_2, and V_3, the probability of purchase P for the first product would be calculated as:

$$P_1 = \frac{V_1}{V_1 + V_2 + V_3}$$

While the BTL approach does not share the issues listed for the max utility approach, it does exhibit sensitivity to location, where arbitrarily increasing all of the values changes the calculated purchase probabilities.

Finally, the logit choice model follows a similar form to BTL, but raising the assigned product values to exponents:

$$P_1 = \frac{e^{V_1}}{e^{V_1} + e^{V_2} + e^{V_3}}$$

This method exhibits the attractive qualities of the BTL method, assigning similar purchase probabilities to closely rated products, but is not affected by location. Additionally, the exponential form enforces non-linear and increasing probability differences as values grow wider apart, which seems to be a reasonable effect. The logit model probabilities are, however, affected unrealistically by scaling each of the values by an arbitrary number, which ideally should not alter purchase probability.

However, the scaling effects of the logit choice model can be addressed by introducing a scaling factor for each value and performing an additional calibration step. The calibrated logit model then takes the form:

$$P_1 = \frac{e^{c*V_1}}{e^{c*V_1} + e^{c*V_2} + e^{c*V_3}}$$

The scaling factor *c* is then found as the value that maximizes the summation of the logarithm of the predicted purchase probability for the chosen (highest rated) product over all sampled survey respondents. This procedure effectively accounts for whichever scale (1 to 10, 1 to 100) happens to be presented to the survey respondents and removes the need for arbitrary rescaling.

The logit-based choice model is chosen for this study to convert the conjoint car valuations into purchase probabilities, and then to sales market shares. This is due to the benefits identified in the realistic behavior of the probability function, as well as the lack of significant issues or inappropriate assumptions.

3.1.3 Bass Diffusion Model for Projecting Hybrid Sales

The approach used in this study to explain and forecast hybrid car sales is based primarily on the classic new product diffusion model proposed by Bass in 1969[6]. The Bass diffusion model was applied originally to novel durable goods and sought to predict changing rates of adoption for the product category from introduction through eventual maximum penetration. Product categories studied in the original paper included black and white televisions, electric refrigerators, clothes dryers, and power lawnmowers.

The Bass diffusion model is based on the supposition that sales of a new product are based on two independent factors – an endogenous rate of sales based on the fundamental attributes of the product and the market, associated with the parameter *p*, denoted the coefficient of innovation; and a rate of sales related to level of adoption in the market, associated with the parameter *q*, denoted the coefficient of imitation. Including the size of the eventual market as the parameter *m*, new sales *S* in a given period *T* can then be estimated as a function of *p*, *q*, *m*, and the cumulative sales *Y* from previous periods:

$$S(T) = pm + (q - p) * Y(T) - \frac{q}{m} * Y^2(T)$$

In practice, the parameters *p*, *q*, and *m* can be estimated from time series sales data using a linear regression:

$$S_T = a + b * Y_{T-1} + c * Y_{T-1}^2 + \varepsilon$$

In this way, historic sales data for a product can be used to estimate the Bass model parameters, which can then be used to project sales levels going forward until the product reaches saturation.

In this study, the Bass diffusion approach is applied to project hybrid vehicle sales through 2020 based on historic sales data stretching from 2000 to 2009. This approach is chosen to project hybrid vehicle sales because, during the period in question, hybrid vehicles can be seen as a mostly novel durable product that could be expected to follow a similar adoption trend to those products considered by Bass. At the time of the study in Los Angeles, hybrid vehicle sales made up only a small percentage of all vehicle sales, but were growing at an increasing rate. The Bass model appears as an ideal approach since it accounts for both the non-linear sales growth rate in the near term, as well as predicts slowing sales to a maximum penetration level in the longer term. Both of these attributes are critical for the timeframe under study, and are not provided in a linear growth or constant growth rate model.

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[6] Bass, Frank M. (1969), "A New Product Growth Model for Consumer Durables," *Management Science*, 15, 215-227.

There are, however, some notable differences between this application and the assumptions in the classic Bass approach. First, the model is most appropriate when applied to a novel product group, whereas hybrid vehicles could be considered to be merely a new variant in the automobile category. While this is an important concern, the best test of applicability of the model could be considered to be its fit when applied to historic sales data. As shown in Section 3.3.2.1, the Bass regression model fits historic hybrid data in the City of Los Angeles well and, given the limitations of alternative approaches, it is concluded that the Bass diffusion model allows for the most reasonable projections.

Second, the Bass diffusion approach traditionally projects aggregate sales in the entire market, while for this study it is important to allow for sales projections at the level of individual zip codes. Specifically, sales in each zip code in each time period are estimated as a function of cumulative sales in that zip code in addition to demographic attributes of the zip code. In this way, it is possible to estimate different values for p, q, and m for each zip code. This can be considered somewhat of a divergence from the classic approach, so to address the applicability of modeling diffusion at the zip code level, several alternative models are fit in Section 3.3.2.3 to demonstrate that the results are in line with the more traditional approach. The two main alternatives are, first, a model aggregating sales for all of the City of Los Angeles, and second, models estimating sales at the zip code level as a function of sales in larger geographic areas (outside the zip code).

Lastly, while the classic Bass approach considers only purchases by new owners, and therefore not repurchases, in predicting sales through a longer period than the usable life of the product, it is necessary to make an assumption about the behavior of previous owners who may repurchase the product. For this study, it is assumed that previous owners have the same probability of purchase of a hybrid or electric vehicle as non-owners, so expired vehicles can simply be decremented from cumulative sales when they leave circulation. This assumption is considered to be conservative, since it is reasonable to assume that previous owners would be more likely to repurchase, given experience with the product type and the brand, but this effect is excluded from the model due to uncertainty in its estimation.

3.2 Data Sources

For the model, we used the following data sources:

- **Survey data (executed by Polimetrix / Yougov.com).** The survey gave us information on respondent demographics (age, race, income, and employment), home and car ownership, political affiliation, attitudes on the environment, technology, and EV incentives, and driving and parking patterns and preferences.
- **R.L. Polk hybrid registration.** We purchased hybrid registration data from R.L. Polk, a provider of automotive market research based in Southfield, MI. We obtained data for the 127 zip codes in the City of Los Angeles (per the L.A. City Department of Building and Safety) for the years 2000, 2001, 2002, 2004, 2006, and 2009.
- **Zip to zip trips.** We used data from the 2000 Census Transportation Planning Program (CTPP) survey, which lists zip to zip trip data for each of the 127 L.A. City zip codes of interest.
- **American Community Survey 2009.** For the most recent demographic and home ownership data for the City of Los Angeles, we used the 2009 American Community Survey from the U.S. Census.
- **Public Policy Institute of California (PPIC).** We used L.A. County political affiliation data from the Public Policy Institute of California (PPIC) Statewide Survey (March 2010).
- **Prop 23 voting results.** As a proxy for the "greenness" of each zip code, we downloaded Prop 23 voting results from the November 2010 Election.

3.3 Analysis

3.3.1 Determining EV Sales Market Share by Zip Code

The first major stage in projecting electric vehicle sales in Los Angeles requires predicting a sales market share for electric vehicles and traditional hybrid cars, together composing total 'green' car sales. In the first step, car valuation functions are estimated for LA residents based on the conjoint-styled question in the market survey. Car valuations are estimated as a function of the attributes of the car (price, HOV access, assumed gas prices) and the attributes of the survey respondent (income, environmentalism, single- or multi-family resident). Second, the attributes of the survey respondents are mapped onto representative demographic data for each LA zip code, and predicted valuations are calculated for representative zip code residents for hybrid and electric vehicles with baseline attributes. Finally, sales market shares are calculated for EVs and hybrid cars using a logit-based market simulation.

3.3.1.1 Survey Conjoint Regression for Car Valuation Function

As detailed in Section 3.1.1, survey respondents provide a 'value' between 1 and 10 for each of four car types, where the attributes of the battery electric vehicle (BEV) and plug-in hybrid electric vehicle (PHEV) are varied across respondents. A valuation function can then be estimated for each car type based on attributes of the respondent and attributes of the cars presented to the respondent:

$V_i = \alpha_i + \beta_{i1}*\text{income} + \beta_{i2}*\text{green} + \beta_{i3}*\text{car price} + \beta_{i4}*\text{HOV} + \beta_{i5}*\text{gas price} + \varepsilon$

Where, for i=1 to 4 corresponding to car types Gas, Hybrid, BEV, and PHEV respectively:

V_i = car valuation (1 to 10)
income = respondent's income from survey
green = from survey: 1 if respondent agrees that 'protecting the environment' is 'more' or 'equal' in importance to growing the economy, otherwise 0
car price = price of the car type ($) presented to the respondent (varies for BEV and PHEV)
HOV = If EV profiles presented include HOV lane access then 1, otherwise 0
gas price = price of gas presented to respondent in conjoint question ($2.50/gal or $5.00/gal)

Regression results are provided in Table 3 (note that separate regressions are run for single-family owners (SFO) and all others (NSFO)).

Table 3: Car Valuation Regression Results from Survey

Single-Family Homeowners:

	Hybrid			BEV			PHEV		
	Coefficient	t-stat		Coefficient	t-stat		Coefficient	t-stat	
Intercept	4.08	13.52	***	2.70	3.06	**	3.85	5.22	***
Car Price ($)				-1.98E-05	-0.71		-6.05E-05	-2.48	*
Gas Price ($)	0.125	1.83	.	0.155	1.27		0.335	3.60	***
Income ($)	8.88E-07	0.43		-7.52E-07	-0.37		1.04E-06	0.50	
Green (binary)	1.62	9.86	***	2.56	16.05	***	2.58	15.65	***
HOV (binary)				0.195	0.65				
	Adj. R^2 =	0.088		Adj. R^2 =	0.204		Adj. R^2 =	0.200	

Renters and Multi-Unit Residents:

	Hybrid			BEV			PHEV		
	Coefficient	t-stat		Coefficient	t-stat		Coefficient	t-stat	
Intercept	5.75	13.96	***	4.01	3.80	***	4.98	7.11	***
Car Price ($)				-1.07E-05	-0.31		-5.79E-05	-2.74	**
Gas Price ($)	-0.070	-0.88		0.022	0.25		0.226	2.14	*
Income ($)	7.49E-07	0.30		-3.67E-06	-1.43		-1.51E-06	-0.55	
Green (binary)	1.43	6.87	***	2.40	11.34	***	2.32	10.33	***
HOV (binary)				0.052	0.16		0.259	1.06	
	Adj. R^2 =	0.059		Adj. R^2 =	0.153		Adj. R^2 =	0.132	

Significance: 0 *** 0.001 ** 0.01 * 0.05 . 0.1

While the overall fit of the regression models is fairly low, as measured by adjusted R^2, the noted variables do generally appear to be significant in explaining how a respondent values the cars. It should be noted that a very good fit is quite unlikely, as there is substantial idiosyncratic variation in how each respondent addresses the survey question.

Several patterns appear from the survey regressions in Table 3. First, the fit is better for the EVs than for the hybrid car value, likely because price was varied for each of the EVs but not for the hybrid car. Second, the coefficients for car price and gas price are substantially higher for the PHEV than the BEV, which indicates much higher price sensitivity for the former vehicle. This matches the intuition that BEV support, due to the novelty of the car type, is related more to the attitudes of the customer than to the price, whereas the PHEV is treated more like a typical car, where price is one of the most important attributes. Third, along the same lines, although increasing gas prices show rising valuation for both types of EVs, the higher price sensitivity for PHEVs leads to a larger impact from rising gas prices, which could appear counter-intuitive since BEVs produce much higher gas savings. Lastly, multifamily housing residents and renters show substantially higher valuations for EVs. This is important because this group faces a large impediment to EV purchase based on availability of home charging installation (especially for those in older apartment building and those who park on the street at night).

Takeaway #1

PHEV demand is much more influenced by prices than BEV demand.

Takeaway #2

EV demand is higher for multifamily housing residents and renters, but these groups face major challenges for home charging.

3.3.1.2 Mapping Valuation Factors between Survey and Zip Code Data

In order to compare the car valuation functions derived from the survey results to information gathered about LA zip codes, equivalent factors must be drawn from the survey results and levels of similar data observed at each zip code. In order to apply the car valuation functions derived from analysis of the survey to LA zip codes in a representative way, equivalence must be drawn between reported attributes of survey respondents and levels of similar attributes observed in each zip code. Specifically, sensitivity to reported income in the survey can be applied directly to the listed household income levels from the American Community Survey for each LA zip code. To apply car value sensitivities to environmental concerns, the survey results on environmental issues will be compared to election results for Prop. 23 at the zip code level. In the survey, question 12 asked respondents whether protecting the environment was more or less important than promoting economic growth. Proposition 23 asked voters to make a similar assessment, with a 'yes' vote agreeing to suspend implementation of more stringent environmental protections until unemployment declines substantially[7]. Because there is not complete equivalence between the survey question and the wording of Proposition 23, a linear mapping is calculated by regressing, for each zip code, the percentage of 'no' votes on Prop 23 against the percentage of 'more or equal importance' responses when survey respondents are grouped by their home zip code. The results of

[7] California Proposition 23: "SUSPENDS IMPLEMENTATION OF AIR POLLUTION CONTROL LAW (AB 32) REQUIRING MAJOR SOURCES OF EMISSIONS TO REPORT AND REDUCE GREENHOUSE GAS EMISSIONS THAT CAUSE GLOBAL WARMING, UNTIL UNEMPLOYMENT DROPS TO 5.5 PERCENT OR LESS FOR FULL YEAR." For more information see the California Official Voter Information Guide: http://voterguide.sos.ca.gov/propositions/23/

the regression are provided in Table 4. Note that in the regression, the intercept is set to be 0, enforcing a strict linear mapping between the two measures.

Table 4: Regression Results Mapping Environmental Attitude onto Prop 23 Voting

	No on 23 %		
	Coefficient	t-stat	
Green (%)	0.786	38.92	***
	Adj. R^2 =	0.852	

Because the regression coefficient is highly significant and the fit is good (85.2% R^2), the results support the validity of the mapping approach. In the model, therefore, the listed regression coefficient is applied to the Prop 23 'no' vote percentage to convert it the percentage that would be expected to answer the similar survey question as 'more' or 'equal' importance.

3.3.1.3 Logit-Based Green Car Market Share Calculation

Having established that the relevant customer attributes in determining valuations for the various green car types are income, environmental attitude, and single-/multifamily housing residence, the population of each zip code is then divided into groups representing each permutation of these attributes. Using 14 income brackets and binary parameters for environmental attitude ('no' on Prop 23) and multifamily housing residence, this produces 56 combinations that vary in representation between zip codes but collectively encompass the entire population. These combinations of attributes are treated as representative homogeneous consumer groups, and all are listed in Table 5.

Table 5: Consumer Segment Attributes and Predicted Green Car Sales Market Share

Customer Group	Single-Family Owner	Proposition 23 Vote	Income	Car Value (1-10) Hybrid	Car Value (1-10) BEV	Car Value (1-10) PHEV	Green Car Market Share Hybrid	Green Car Market Share BEV	Green Car Market Share PHEV
1	Yes	Yes	Less than $10,000	6.10	5.05	4.88	52.8%	25.1%	22.1%
2	Yes	Yes	$10,000 to $14,999	6.10	5.05	4.88	52.9%	24.9%	22.2%
3	Yes	Yes	$15,000 to $19,999	6.11	5.04	4.89	53.0%	24.8%	22.2%
4	Yes	Yes	$20,000 to $24,999	6.11	5.04	4.89	53.1%	24.7%	22.2%
5	Yes	Yes	$25,000 to $29,999	6.12	5.04	4.90	53.2%	24.6%	22.3%
6	Yes	Yes	$30,000 to $39,999	6.12	5.03	4.91	53.3%	24.4%	22.3%
7	Yes	Yes	$40,000 to $49,999	6.13	5.02	4.92	53.4%	24.2%	22.4%
8	Yes	Yes	$50,000 to $59,999	6.14	5.02	4.93	53.5%	24.0%	22.5%
9	Yes	Yes	$60,000 to $69,999	6.15	5.01	4.94	53.7%	23.7%	22.6%
10	Yes	Yes	$70,000 to $79,999	6.16	5.00	4.95	53.8%	23.5%	22.7%
11	Yes	Yes	$80,000 to $99,999	6.17	4.99	4.96	54.0%	23.2%	22.8%
12	Yes	Yes	$100,000 to $119,999	6.19	4.97	4.98	54.3%	22.8%	23.0%
13	Yes	Yes	$120,000 to $149,999	6.21	4.96	5.01	54.6%	22.2%	23.2%
14	Yes	Yes	$150,000 or more	6.22	4.94	5.03	54.8%	21.9%	23.3%
15	Yes	No	Less than $10,000	4.48	2.49	2.30	68.8%	16.7%	14.5%
16	Yes	No	$10,000 to $14,999	4.48	2.49	2.31	68.9%	16.5%	14.6%
17	Yes	No	$15,000 to $19,999	4.49	2.48	2.31	69.0%	16.4%	14.6%
18	Yes	No	$20,000 to $24,999	4.49	2.48	2.32	69.0%	16.4%	14.6%
19	Yes	No	$25,000 to $29,999	4.50	2.47	2.32	69.1%	16.3%	14.6%
20	Yes	No	$30,000 to $39,999	4.50	2.47	2.33	69.2%	16.2%	14.6%
21	Yes	No	$40,000 to $49,999	4.51	2.46	2.34	69.3%	16.0%	14.7%
22	Yes	No	$50,000 to $59,999	4.52	2.45	2.35	69.4%	15.8%	14.7%
23	Yes	No	$60,000 to $69,999	4.53	2.45	2.36	69.5%	15.7%	14.8%
24	Yes	No	$70,000 to $79,999	4.54	2.44	2.37	69.7%	15.5%	14.8%
25	Yes	No	$80,000 to $99,999	4.55	2.43	2.39	69.8%	15.3%	14.9%
26	Yes	No	$100,000 to $119,999	4.57	2.41	2.41	70.1%	15.0%	14.9%
27	Yes	No	$120,000 to $149,999	4.59	2.39	2.43	70.3%	14.6%	15.0%
28	Yes	No	$150,000 or more	4.60	2.38	2.45	70.5%	14.4%	15.1%
29	No	Yes	Less than $10,000	6.96	6.09	5.51	53.0%	28.3%	18.7%
30	No	Yes	$10,000 to $14,999	6.97	6.06	5.49	53.5%	27.9%	18.6%
31	No	Yes	$15,000 to $19,999	6.97	6.04	5.49	53.8%	27.6%	18.6%
32	No	Yes	$20,000 to $24,999	6.98	6.02	5.48	54.1%	27.4%	18.5%
33	No	Yes	$25,000 to $29,999	6.98	6.01	5.47	54.4%	27.1%	18.5%
34	No	Yes	$30,000 to $39,999	6.99	5.98	5.46	54.9%	26.7%	18.4%
35	No	Yes	$40,000 to $49,999	6.99	5.94	5.45	55.5%	26.2%	18.4%
36	No	Yes	$50,000 to $59,999	7.00	5.90	5.43	56.1%	25.6%	18.3%
37	No	Yes	$60,000 to $69,999	7.01	5.87	5.42	56.7%	25.1%	18.2%
38	No	Yes	$70,000 to $79,999	7.02	5.83	5.40	57.4%	24.6%	18.1%
39	No	Yes	$80,000 to $99,999	7.03	5.78	5.38	58.3%	23.8%	17.9%
40	No	Yes	$100,000 to $119,999	7.04	5.70	5.35	59.5%	22.8%	17.7%
41	No	Yes	$120,000 to $149,999	7.06	5.61	5.31	61.0%	21.6%	17.4%
42	No	Yes	$150,000 or more	7.07	5.56	5.29	61.8%	20.9%	17.3%
43	No	No	Less than $10,000	5.53	3.68	3.19	68.8%	18.3%	12.9%
44	No	No	$10,000 to $14,999	5.54	3.66	3.18	69.2%	18.0%	12.8%
45	No	No	$15,000 to $19,999	5.54	3.64	3.17	69.5%	17.8%	12.7%
46	No	No	$20,000 to $24,999	5.55	3.62	3.16	69.7%	17.6%	12.7%
47	No	No	$25,000 to $29,999	5.55	3.60	3.16	70.0%	17.4%	12.6%
48	No	No	$30,000 to $39,999	5.56	3.57	3.14	70.4%	17.1%	12.6%
49	No	No	$40,000 to $49,999	5.56	3.54	3.13	70.9%	16.7%	12.4%
50	No	No	$50,000 to $59,999	5.57	3.50	3.11	71.4%	16.3%	12.3%
51	No	No	$60,000 to $69,999	5.58	3.46	3.10	71.9%	15.9%	12.2%
52	No	No	$70,000 to $79,999	5.59	3.43	3.08	72.4%	15.5%	12.1%
53	No	No	$80,000 to $99,999	5.60	3.37	3.06	73.2%	14.9%	11.9%
54	No	No	$100,000 to $119,999	5.61	3.30	3.03	74.1%	14.2%	11.7%
55	No	No	$120,000 to $149,999	5.63	3.21	2.99	75.3%	13.3%	11.4%
56	No	No	$150,000 or more	5.64	3.15	2.97	75.9%	12.8%	11.2%

In addition to demographics and behavior, car preference is influenced by the attributes of the car types studied. The survey-derived car valuation functions in Section 3.3.1.1 include sensitivity to car price, HOV lane access, and prevailing gas prices. Baseline car attributes are chosen to represent conditions without government incentives, and are listed in Table 6.

Table 6: Baseline Green Car Attributes for Sales Projections

Car Parameter	Base Case	Notes
Hybrid Price	$24,000	*Toyota Prius MSRP*
BEV Price	$35,000	*Nissan Leaf MSRP plus $2000 charger installation*
PHEV Price	$43,000	*Chevrolet Volt MSRP plus $2000 charger installatioı*
Gas Price	$3.14	*US Average for 2010*
EV HOV Access	No	

Applying the car valuation functions derived in Section 3.3.1.1 to each of the consumer groups, including the mapping adjustment from Section 3.3.1.2, and applying the baseline vehicle profiles in Table 6, values between 1 and 10 are calculated for each car type (hybrid, BEV, and PHEV).

Sales market share within the 'green car' segment for each consumer group are then determined based on the logit market simulation approach detailed in Section 3.1.2:

$$Hybrid\ Sales\ Share\ S_1 = \frac{e^{c*V_1}}{e^{c*V_1} + e^{c*V_2} + e^{c*V_3}}$$

Where:

S_1 = sales market share for traditional hybrid vehicle within 'green car' segment (hybrid, BEV, and PHEV)
V_1 = predicted car valuation (1 to 10) for traditional hybrid vehicle
V_2 = predicted car valuation (1 to 10) for BEV
V_3 = predicted car valuation (1 to 10) for PHEV
c = scale coefficient

Market share for each green type is determined by replacing the car value in the numerator with each predicted car value. The scale coefficient c is used to account for the arbitrary range used in valuation in the survey (1 to 10). Determination of the scale coefficient is described in Section 3.1.2.

Finally, predicted sales market shares at the zip code level are composed by averaging the sales share for each consumer group, weighted by representation in the zip code. Predicted market shares for each zip code are listed in Appendix 7.6.

3.3.2 Projecting Green Car Sales with Bass Diffusion

As a precursor to projecting EV sales, total sales in the "green car" segment (hybrid, BEV, and PHEV) are projected at a zip code level through 2020. Until 2011, hybrid cars were the only vehicle in the "green car" segment. After the introduction of EVs to the market that year, it is assumed that hybrid, BEV, and PHEV cars will split the total green car sales projected in each zip code based on the breakdown from Section 3.3.1.3. To project green car sales, a zip code-level Bass penetration model approach is used, as described in Section 3.1.3, based on the historic hybrid registration data from 2000 to 2009 obtained from R.L. Polk.

3.3.2.1 Bass Regression Results

The core application of the Bass penetration model uses a linear regression to estimate sales in one period as a function of cumulative sales in previous periods and the square of cumulative sales. In order to predict sales for LA zip codes individually, some modifications are made to the approach. First, the data points in the regression are taken as sales in individual zip codes rather than a single sales figure for the city each year. Second, attributes of the zip code, such as income level and average commute distance, are included as variables in the sales regression, both as stand-alone factors as well as interacted with cumulative sales. Third, rather than using raw registration figures, hybrid sales are normalized to the number of households in the zip code to better account for the substantial variation in zip code size. Lastly, a dummy variable is included for registrations in 2009 to account for the financial crisis and subsequent recession, since car sales declined substantially during this period. Results of the best fit regression are listed in Table 7.

Table 7: Best-Fit Hybrid Sales Regression Results

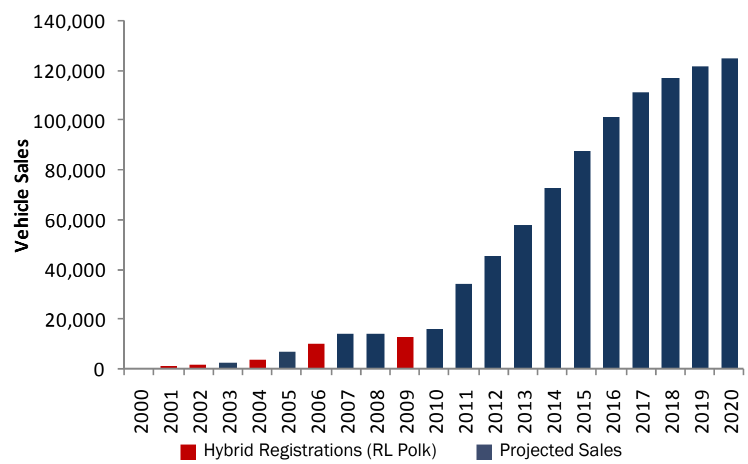
	Green Car Sales per HH		
	Coefficient	t-stat	
Intercept	-0.0061	-3.33	***
Cumulative Sales	1.353	14.47	***
(Cumulative Sales)^2	-0.659	-10.78	***
Income $100k+ (%)	0.0050	4.57	***
No on Prop 23 (%)	0.0087	3.24	**
Recession (binary)	-0.014	-1.68	.
SFO (%)			
Commute Distance (mi)			
Cumulative Sales:SFO	0.233	6.88	***
Cumulative Sales:No on Prop 23	-1.278	-10.71	***
Cumulative Sales:Commute Distance	-0.010	-1.71	.
Recession:Income $100k+	-0.050	-14.29	***
Recession:Commute Distance	0.00077	2.05	*
Recession:No on Prop 23	0.017	1.76	.
	Adj. R^2 =	0.858	

Significance: 0 *** 0.001 ** 0.01 * 0.05 . 0.1

3.3.2.2 Green Car Sales Projection to 2020

The hybrid sales model from Section 3.3.2.1 can then be used to extrapolate green car sales between 2010 and 2020 by, each year, incrementing cumulative sales and then calculating new sales in each zip code. Two modifications are made to this base approach. First, to account for the finite life of hybrid cars and EVs, it is assumed that these cars leave circulation after 8 years, reducing cumulative sales in each period by the exact amount of sales in the previous eight years. This approach results in sales eventually reaching a stable level rather than, as in the strict application of the Bass model, dropping to zero. Second, because the US recession began in 2008 and its effects on car sales lasted into 2010, the recession dummy variable is applied partially to these two years, effectively reducing predicted sales below typical (non-recession) levels. Predicted green car sales are shown in Figure 1.

Figure 1: Predicted Green Car Sales in LA - 2000 to 2020



3.3.2.3 Agreement with Alternative Bass Approaches

Because this adoption model operates on sales at the zip code level rather than aggregated over the entire market, this section provides a comparison between this approach and two alternative Bass-style regressions based on different geography.

First, the projections from the zip code-level model are compared against projections made using a more traditional Bass approach, aggregating sales and cumulative sales across all zip codes into one data point for each year, and running a regression, as described in Section 3.1.3, in the form:

$$S_T = a + b * Y_{T-1} + c * Y_{T-1}^2 + \varepsilon$$

Again, a recession dummy variable is included for sales in 2009. The results of the regression are listed in Table 8.

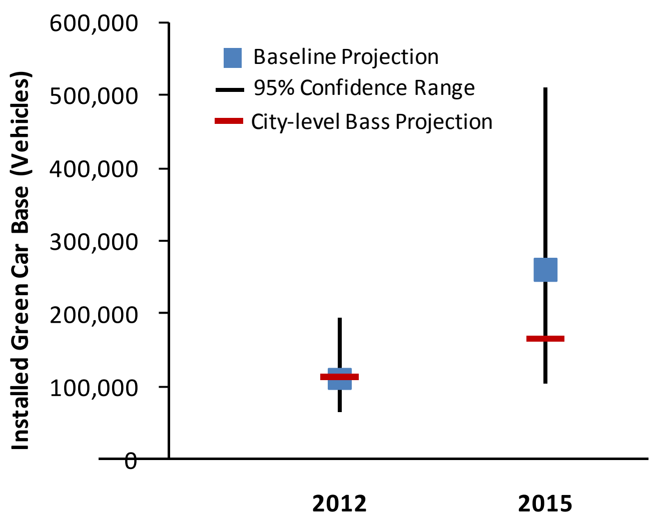
Table 8: Regression Results for City-Level Adoption Model

	City-Level Green Car Sales		
	Coefficient	t-stat	
Intercept	500.6	2.85	
Cumulative Sales	0.681	6.98	*
(Cumulative Sales)^2	-3.46E-06	-0.58	
Recession (binary)	-14190	-1.19	
	Adj. R^2 =	0.997	

Significance: 0 *** 0.001 ** 0.01 * 0.05 . 0.1

By projecting green car adoption using this regression model, the results can be compared against the projections from the zip code-level model. Figure 2 plots cumulative sales projections for both models, along with the 95% confidence interval for green car sales at the zip code level (described in Section 3.3.3.3).

Figure 2: Comparison of Zip Code and City Level Bass Adoption Models



The projections from the city-level adoption model appear generally lower than those from the zip code model, but are within the 95% range of estimates. When assessing which is the more accurate prediction, it should be noted that while the city-level regression shows a very good fit to the data, the sample size is quite small (based on six years of data), while the zip code level regression is based on a much larger data set (720 degrees of freedom) and is also a good fit (85.8% adjusted R^2). Still, the lower projection from the city-level model could be taken as evidence that adoption toward the lower end of the model range could be more likely than the higher end.

As a second check on the zip code level modeling approach, the regression results in Section 3.3.2.1, where sales in a specific zip code depend on cumulative sales *within the zip code in question*, are compared against regressions which estimate sales with a specific zip code depending on cumulative sales in a larger geographic area (specifically within 1, 3, 5, 10, and 20 miles of the zip code in question). This test addresses the supposition that the network effects driving sales are most related to the level of adoption in the immediate vicinity of the consumer and not based on adoption in a larger area. Table 9 lists the results of the regressions.

Table 9: Comparison of Regional Network Effects on Zip Code Sales

	Adj. R^2	t-stat	
		Cum. Sales	$(\text{Cum. Sales})^2$
Within Zip Code	0.858	14.5 ***	-10.8 ***
Within 1 mile	0.797	9.90 ***	-14.4 ***
Within 3 miles	0.238	2.37 *	-2.62 **
Within 5 miles	0.264	-0.52	-2.25 *
Within 10 miles	0.266	-1.01	-1.98 *
Within 20 miles	0.246	0.41	-3.37 ***

Based on the fit of the regression models, these results appear to indicate that network effects are best using adoption within the zip code rather than a larger area, as this provides the best fit to the sales data. The fit appears to fall off quite fast when moving beyond a three mile radius, indicating small sales regions.

Considering the results of these two comparisons, the zip code-level sales model approach appears to be reasonable to use for the purposes of projecting green car sales in Los Angeles.

3.3.3 Results of EV Sales Projection Model

The final EV sales projection model, presented in this section, combines the predicted EV sales market shares from Section 3.3.1.3 with the green car sales projections from Section 0. Both sets of estimates are at the zip code level, so EV sales can be projected by zip code as well. This section provides the baseline results of the projection model, as well as underlying assumptions and model sensitivity, while Section 3.3.3.3 examines the predicted effects of alternate policy scenarios.

3.3.3.1 Baseline Projection Results

For 2011 through 2020 the EV sales projection model operates by applying the projected sales breakdown for every individual zip code (from Section 3.3.1.3) to the predicted green car sales in that zip code each year (from Section 0). Two adjustments are made to this approach: near-term supply constraints and multifamily housing charging access, which are detailed in Section 3.3.3.2. Electric vehicle sales projections and EV installed base for the City of Los Angeles are shown in Figure 3 and Figure 4, respectively.

Figure 3: Projected Hybrid and Electric Vehicle Sales in Los Angeles - 2000 to 2020

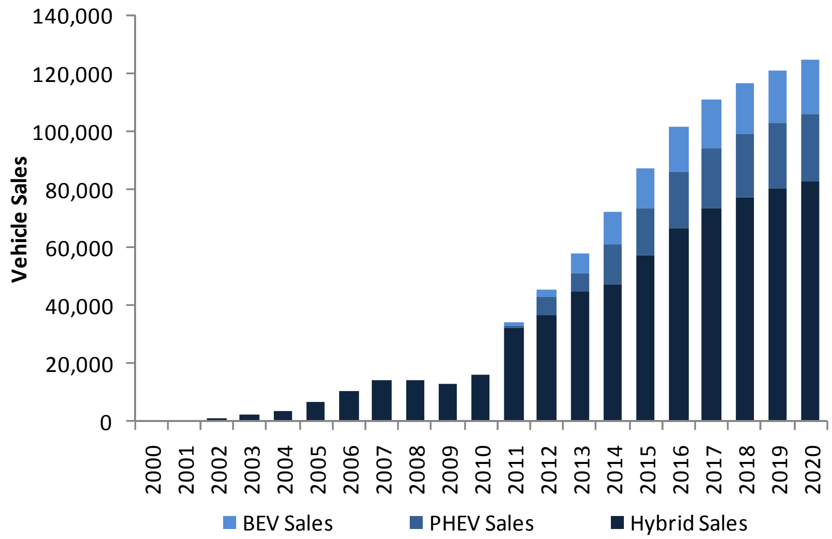
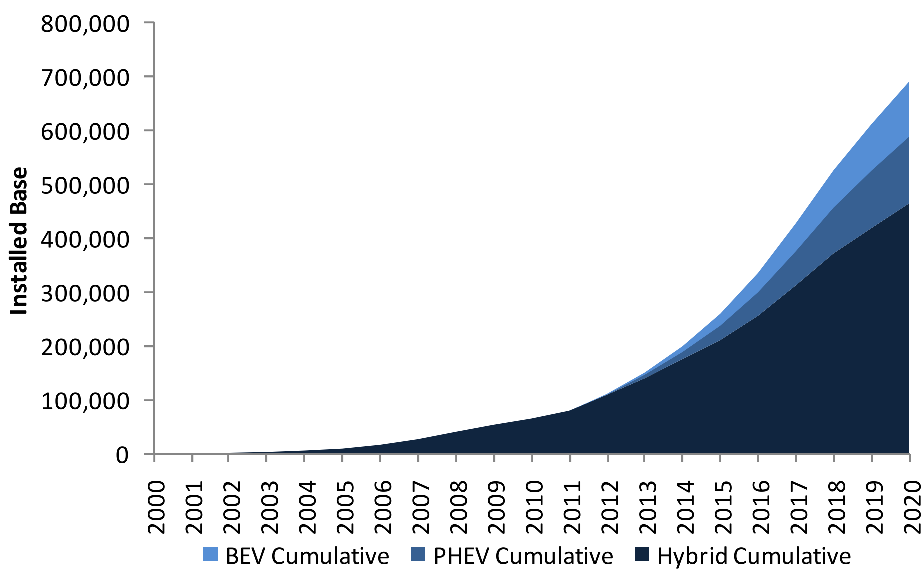


Figure 4: Projected Hybrid and Electric Vehicle Installed Base in Los Angeles - 2000 to 2020



Combining BEV and PHEV into a single EV category, installed EV base (based on cumulative EV sales) is plotted by zip code in Figure 5 and

Figure 6 for 2015 and 2020 respectively.

Figure 5: Total EV Installed Base (Vehicles) by Zip Code – 2015

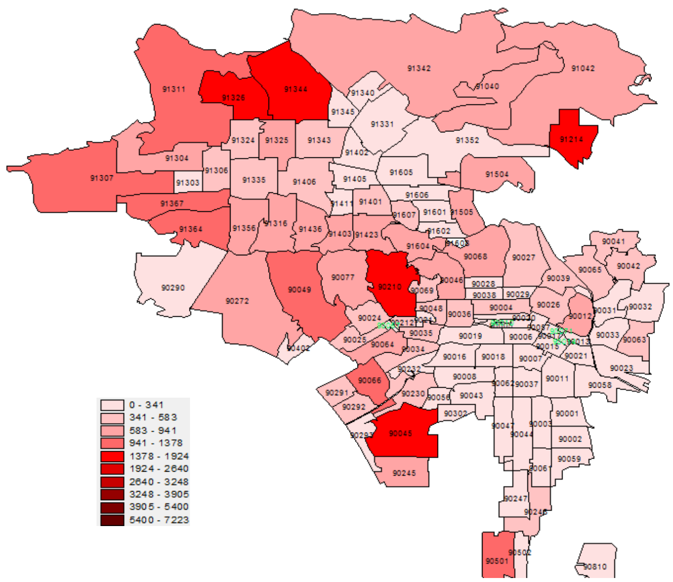
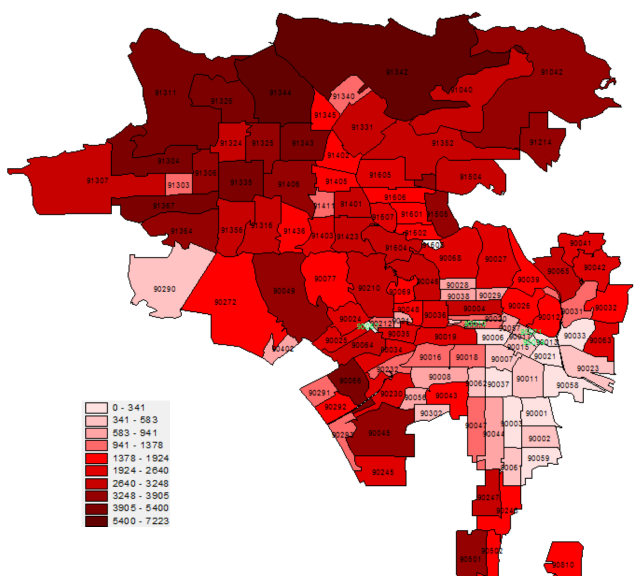


Figure 6: Total EV Installed Base (Vehicles) by Zip Code – 2020



3.3.3.2 Additional Model Constraints: Vehicle Supply and Home Charging Access

Two major constraints are applied to the EV sales projection model to adjust sales with variables other than predicted demand. First, based on the results of the survey discussed in Section 4.2.3, 56% of LA residents claim that they would not buy an electric vehicle if they didn't have access to charging where they park at night. Based on discussions with public and private EV stakeholders, it is currently very unlikely that renters and multifamily housing residents would have charging infrastructure available to them or be able to have it installed without major difficulty. In the projection model this small proportion is taken to be 5%, so that predicted demand for BEVs among renters and multifamily housing residents is reduced by 56% of the remaining 95%, or 53% overall. It is assumed that PHEV demand would not be reduced in the same way, due to the ability to operate on gasoline.

Second, it is widely accepted that sales of electric vehicles will be severely limited for several years due to limited supply available for purchase. This is due to the relatively low manufacturing targets for announced EV models, as well as the small number of models currently in production. As more car manufacturers announce EV offerings, and as current manufacturers increase production to match growing demand, lack of supply will be less of an impediment. The U.S. Department of Energy provides nationwide EV supply projections for currently announced models several years into the future, as described in Section 2.2.2.3. These nationwide numbers are adjusted to project supply for the City of Los Angeles based on the proportion of hybrid vehicles in Los Angeles compared to the country. Applying these supply estimates for the first three years of EV sales, 2011 through 2013, produces the sales constraints in Table 10.

Table 10: EV Supply Constraints in City of LA, 2011 to 2013 (Cars)

	BEV	PHEV	Total EV
2011	1422	799	2221
2012	2523	6127	8650
2013	6429	6381	12,810
2014	Unlimited	Unlimited	Unlimited

3.3.3.3 Sensitivity of Projection to Estimates and Assumptions

The projection model has three sources of uncertainty. The first is the accuracy and precision of the survey results. The baseline EV and policy assumptions used to estimate market share in Section 3.3.1.3 and Bass regression results in Section 3.3.2.1 used to project green car sales are also uncertain.

To address the first issue, accuracy and limitations of the survey results are described in Section 4.1. For the second issue, sensitivities to the baseline car parameters and other underlying assumptions are explored in Section 3.3.5 in investigating possible policy and incentive scenarios.

To address the third source of uncertainty, the results of the Bass regression that is used to project green car sales and serves as the backbone of the EV adoption model, Figure 7 and Figure 8 show the baseline sales and installed vehicle base, respectively, along with 'high' and 'low' projection cases tracing the 95% confidence range for the green car sales projection[8].

Figure 7: EV Sales Projection Sensitivity to Bass Regression Results (95% Confidence Range)

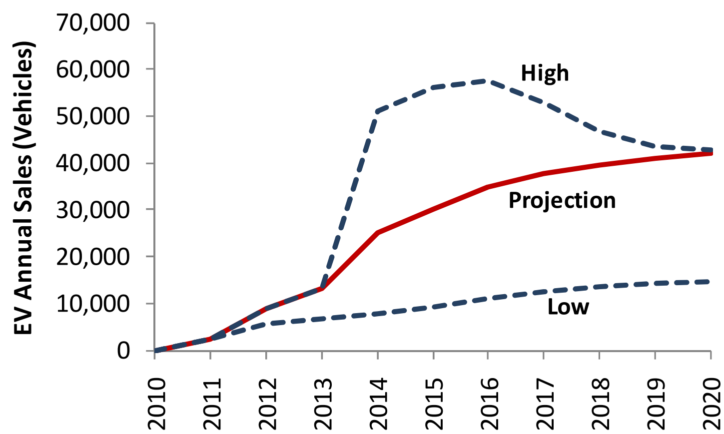
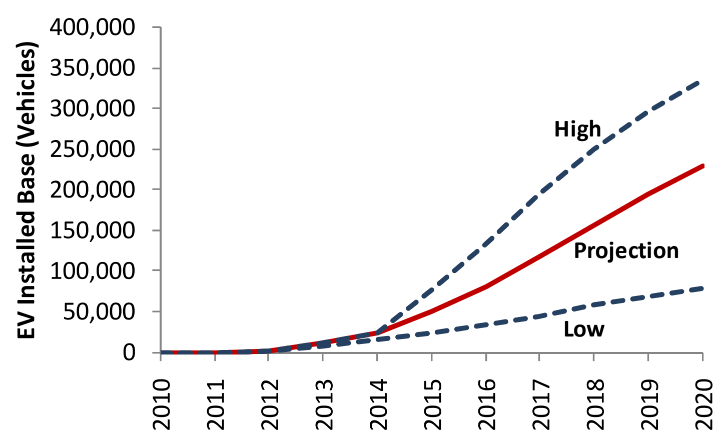


Figure 8: EV Installed Vehicle Base Projection Sensitivity to Bass Regression Results (95% Confidence Range)

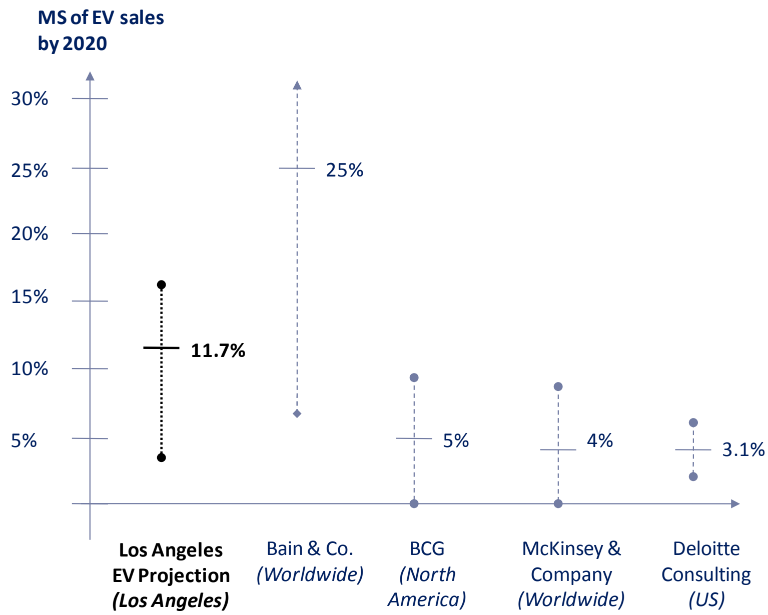


[8] Prediction interval for EV sales is calculated using the same projection model, including all noted assumptions and adjustments, except that the sales number for each zip code, for each year, is incremented or decremented by the regression standard error of the forecast multiplied by 2.2, the t-value necessary to bound 95% of the distribution. Note that due to the non-linear nature of the Bass sales projection with respect to time, this bounding approach will not affect the predicted long-run sales rate, which leads to 'high' case sales approaching the baseline by 2020.

3.3.3.4 Comparison of LA Projection to Earlier Studies

In order to assess whether the listed projections of electric vehicle sales are within a reasonable range, the results from this model are compared with EV sales projections made by earlier publicly available consulting studies. Figure 9 plots projected EV sales in 2020 as a percentage of total car sales, along with the confidence interval for each study (for the confidence interval for this study, see Section 3.3.3.3).

Figure 9: Comparison of EV Sales Projection for Los Angeles to Earlier Studies



The predicted EV market share in this study is higher than several of the other consulting studies, although it should be noted that the listed studies predict market shares for all of the US, North America, and worldwide as indicated. Based on LA's experience as a leader in hybrid vehicle sales, it is not unreasonable to believe that electric vehicles will have stronger sales in Los Angeles than in the country as a whole. In fact, the listed McKinsey study projects electric vehicles to compose 15% of new vehicle sales in New York City by 2015, which is substantially higher than the 9% projected by this study for Los Angeles in 2015[9]. Considering the differences in projection geography and the overall uncertainty of the estimates, there is no real indication that the results of this projection model are out of line with other studies.

3.3.4 Projection of Geographic EV Charging Requirements

One of the concerns for Los Angeles public officials, especially for the Department of Water and Power, is where electric vehicles will be concentrated geographically while charging. Identifying

[9] McKinsey Quarterly, 2011; http://sites.som.yale.edu/energy/2011/02/07/mckinsey-quarterly-analysis-of-demand-for-electric-vehicles/ (retrieved, 02-14-2011)

potential areas of high electric vehicle concentration helps to indicate where residential electric grid improvements may be necessary, as well as where the highest impact may be for public charging infrastructure. To address this concern, predicted geographic electric vehicle concentration is mapped by zip code (vehicles per square mile) for both daytime and nighttime charging, based on the results of the baseline EV projection model.

3.3.4.1 Projection Results: Nighttime Charging Density

Since the baseline EV projection model predicts installed EV base by zip code, nighttime EV concentration can be determined simply as the installed EV base normalized by the area of the zip code (square miles). The model associates EVs with the zip code in which they are registered, so it is assumed that overnight charging will occur in the zip code where the EV is registered. Geographic nighttime EV concentration is plotted by zip code for 2015 and 2020 in Figure 10 and Figure 11 respectively.

Figure 10: Geographic Concentration of Nighttime EV Charging in 2015 (vehicles per square mile)

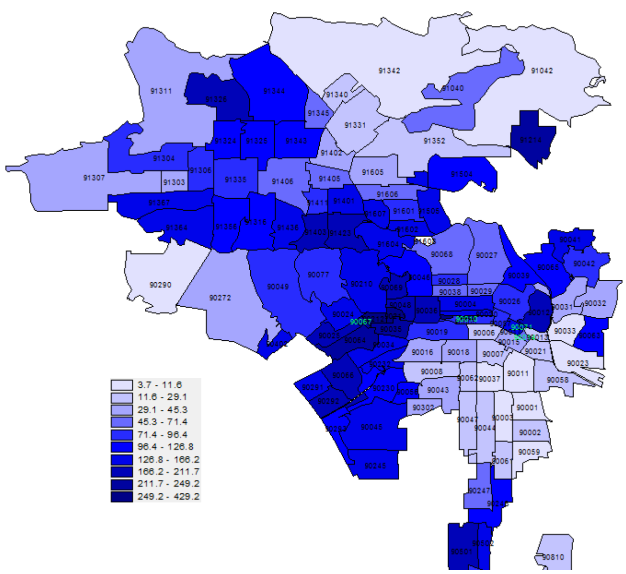


Figure 11: Geographic Concentration of Nighttime EV Charging in 2020 (vehicles per square mile)

Takeaway #3
EV home charging will be most concentrated in the west side, downtown, valley, and south bay regions, most of which show substantial multifamily housing populations.

3.3.4.2 Projection Results: Daytime Charging Density

To estimate daytime charging needs geographically, the EV registration numbers from the projection model are used in conjunction with the zip-to-zip driving patterns described in Section 3.2. Specifically, the predicted EVs registered in each zip code (from the model) are distributed into 'destination' zip codes based on the percentage of trips from the home zip code to the destination, out of all trips from that zip code. This effectively distributes the EVs in LA under the assumption that owners of EVs follow the same driving patterns as non-owners. Finally, since EV numbers are calculated only for LA city zip codes, but commuters enter LA from a much wider array of origins, daytime EV numbers are adjusted upward based on the percentage of trips to the destination zip code which come from the 127 LA city zip codes (i.e. if only half of the trips to a certain zip code originate in the 127 zip code region, the calculated number of daytime EVs is doubled to account for EVs that originate outside the studied region). Geographic daytime EV concentration is plotted by zip code for 2015 and 2020 in Figure 12 and Figure 13 respectively.

Figure 12: Geographic Concentration of Daytime EV Charging in 2015 (vehicles per square mile)

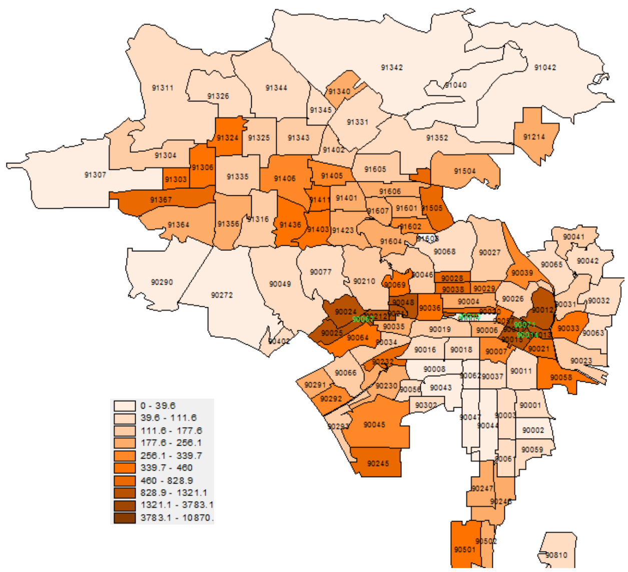
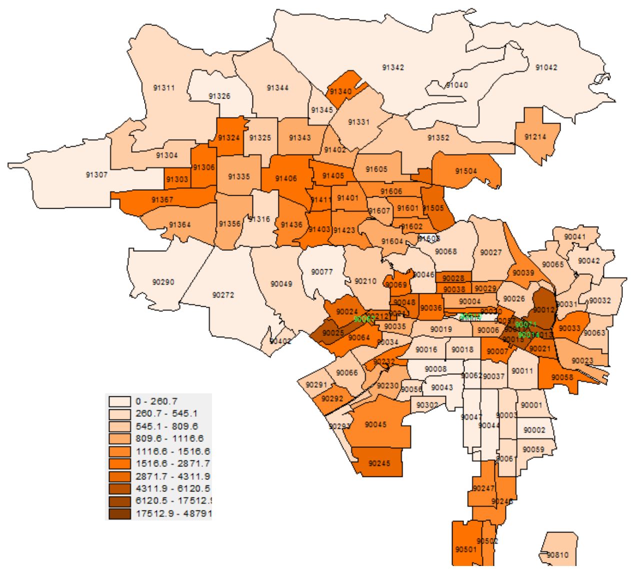


Figure 13: Geographic Concentration of Daytime EV Charging in 2020 (vehicles per square mile)



Takeaway #4

Daytime charging needs will be much more concentrated than in the nighttime, with the greatest concentration downtown and along the Wilshire corridor.

3.3.5 EV Adoption Impact from Potential Policy and Incentive Options

The city is also interested in assessing the impact to EV adoption of various policy initiatives, to determine the best course of action that will make Los Angeles a leader in the electric vehicle market. The EV projection model can test the impact of several possible incentive and policy scenarios. Scenario 1 examines the impact of the current $12,500 available in federal and California tax rebates on EV sales. Scenario 2 addresses the impact of increasing access to home charging for multifamily housing residents and renters. Scenario 3 shows the impact of including HOV access stickers as an incentive for EV purchasers.

The projection model indicates that, while rebates show the largest absolute increase in EV sales, increasing access to home charging for multifamily housing residents and renters shows a substantial impact as well. HOV lane access is less important. While no assessment is made here of cost-effectiveness, it is likely that rebates would appear less attractive due to the impact of low marginal sales from high overall spending on the program. As noted earlier, the predicted high demand and the expected constraints on supply in the next few years means that policy incentives can’t help increase the number of EV sales until more EV vehicles are available In this case, rebates would effectively be wasted over the next 2-3 years, possibly exhausting funding before any real sales impact could be generated. However, incentives may affect the breakdown of EV sales among distinct groups (e.g. single family homeowners versus multifamily residents).

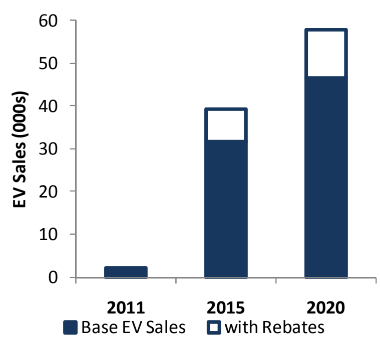
Takeaway #5

Incentives and policy options will have little effect on the total number of EVs sold until global supply constraints on EV sales are removed, potentially several years in the future. Incentives and policy options may be successful if targeted at certain consumer groups who face challenges to adopting EVs.

3.3.5.1 Scenario 1: Federal and State Purchase Rebates

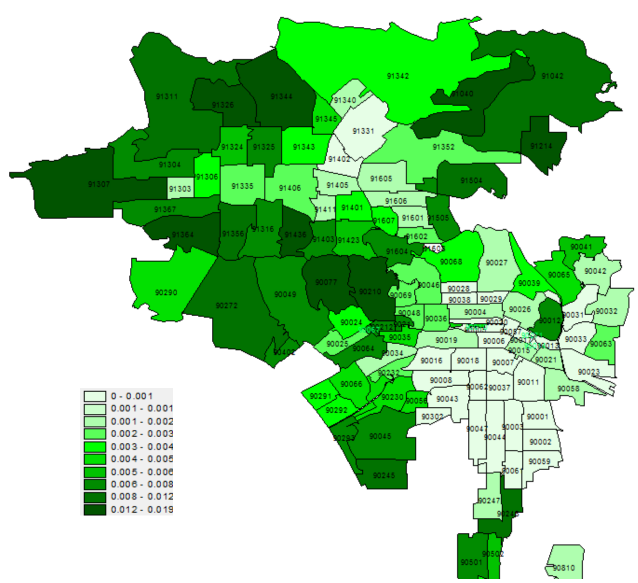
To assess the long-term adoption impact of EV rebates, totaling \$12,500, the model is adjusted to decrease the effective price of a BEV from \$35,000 to \$22,500 and that of a PHEV from \$43,000 to \$30,500. The resulting predicted increase in EV sales over the baseline is shown in Figure 14.

Figure 14: Projected Increase in EV Sales from \$12,500 in Purchase Rebates



When considering the impact of an incentive program, it is important to take into account not only the magnitude of sales increase, but also whom it most benefits. To address this concern, the increase in EV sales is plotted *per household* in Figure 15 for each LA zip code.

Figure 15: Increase in EV Sales per Household in 2015 from Purchase Rebates

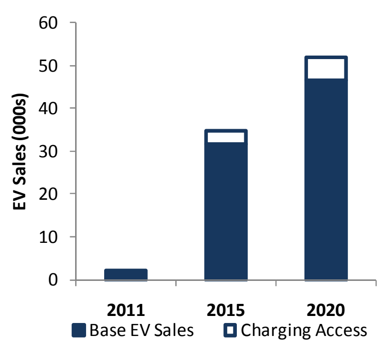


Takeaway #6
Rebates show the highest absolute impact on sales, but the generated marginal sales likely do not justify the potential cost of the program.

3.3.5.2 Scenario 2: Strong Focus on Multifamily housing Charging Access

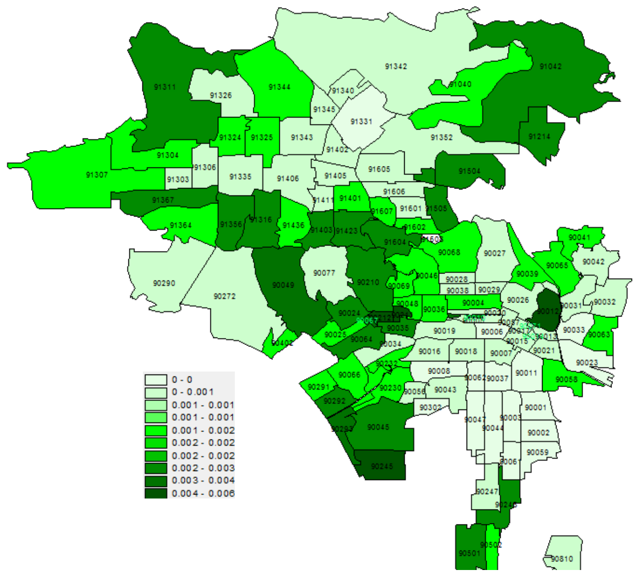
This section explores the impacts of increased home charging access for multifamily housing residents and renter. As noted in Section 3.3.3.2, the baseline projection model assumes that, without additional emphasis from the City, only 5% of multi-unit residents and renters will have access to charging where they park at night. Based on the results of the survey, as noted in Section 4.4.3, 56% of LA residents claim that they would not purchase an EV if they did not have access to charging at home. The City therefore has a substantial opportunity to increase EV sales through initiatives that facilitate charger installation in multifamily housing, such as streamlined permitting, incentives for landlords, partnerships with charging companies, and building regulation. Figure 16 shows the impact on EV sales of a theoretical increase in charging access to 50% of residents in 2015 and 2020.

Figure 16: Projected Increase in EV Sales from 50% Access to Residential Charging



To demonstrate where this impact is most pronounced, the increase in EV sales is plotted *per household* in Figure 17 for each LA zip code.

Figure 17: Increase in EV Sales per Household in 2015 from 50% Access to Residential Charging



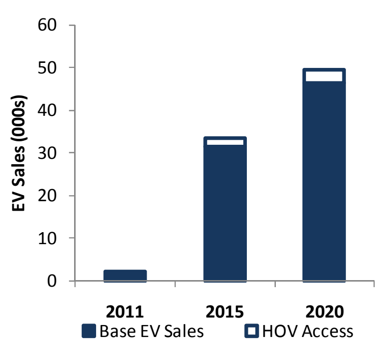
Takeaway #7

Increasing access to home charging will have a substantial impact on BEV sales if implemented before EV supply constraints are lifted.

3.3.5.3 Scenario 3: HOV Access for Electric Vehicles

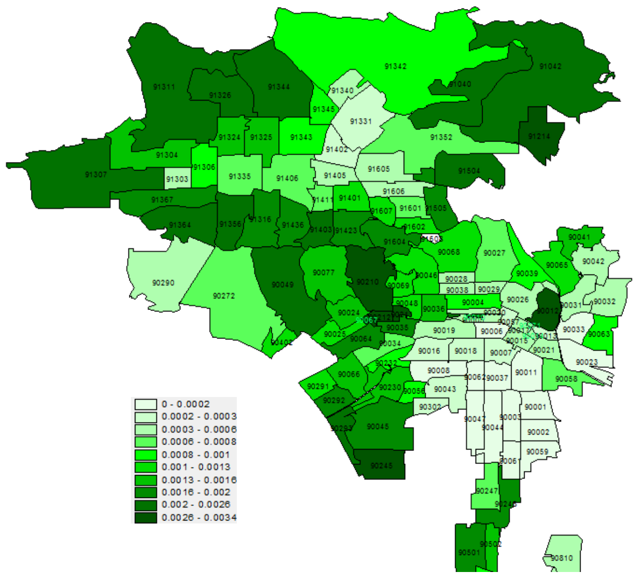
The final incentive scenario considered is providing EV purchases with HOV lane access stickers, similar to those initially provided to hybrid vehicle purchasers. Figure 18 shows the impact on EV sales of providing HOV access to EV purchasers in 2015 and 2020.

Figure 18: Projected Increase in EV Sales from HOV Access



To demonstrate where this impact is most pronounced, the increase in EV sales is plotted *per household* in Figure 19 for each LA zip code.

Figure 19: Increase in EV Sales per Household in 2015 from HOV Access



Takeaway #8

The benefits of allowing HOV lane access to EVs appear minimal.

4. Survey Results & Analysis

4.1 Survey Methodology

The L.A. EV market survey was designed to identify the key drivers and barriers to EV adoption in L.A. The survey asked 2,043 respondents from the L.A. Metro Area over 50 questions about their attitudes, behaviors, and preferences that would influence them to purchase an EV.[10] We asked respondents about their attitudes on the environment and new technology; driving and parking behavior; home and car ownership; sensitivity to vehicle purchase price and maintenance / fueling costs; and relevant demographic data.[11]

Our questions were based on several hypotheses about the EV market based on our preliminary research. First, we hypothesized that Early to Mid-Adopters would be more politically liberal, care more about the environment, and be more receptive to new technology than Late Adopters, who might place a greater emphasis on price and value, design, or luxury and comfort. Second, potential savings in fuel and maintenance costs of EVs would attract Early to Mid-Adopters, while higher upfront purchase costs might deter some Mid to Late Adopters. Finally, respondents who drive fewer than 50 to 100 miles per day and have the flexibility to install EV charging equipment at home would be more likely to purchase an EV.

In order to ensure that respondents' ratings and opinions about EVs were reliable and well-informed, we also provided detailed explanations about BEV and PHEV technology, EV charging options, and government purchase incentives.[12] Significant education was necessary as only 30% of survey respondents had any knowledge about EVs or EV incentives. We also primed respondents with additional context and factors for consideration, prior to asking about their attitudes concerning

[10] The L.A. Metro Area includes the City of Los Angeles and parts of L.A. County. Of the 2,043 survey respondents, 506 were from the City of Los Angeles. Due to differences in demographic factors (i.e. education, household income, and political affiliation), as well as single family home ownership, we applied trimmed weights to the survey sample to match the City of Los Angeles as closely as possible without sacrificing statistical robustness. For a comparison of the weighted vs. non-weighted survey population, see Appendix: Survey Sample and Weighting.

[11] Demographic data included age, race, gender, education, political affiliation, household income, marital status, and employment. See Appendix: L.A. EV Market Survey Questions.

[12] See Appendix: L.A. EV Market Survey Questions. In order to provide respondents with adequate EV knowledge while minimizing the effects of survey fatigue, we maximized the use of graphical explanations of EV technology and charging, EV costs and incentives, and environmental impact. Designers of future surveys might also consider incorporating the following tools: (1) A video to provide explanation of EVs and EV technology (see Southern California Edison (SCE)'s EV Video Channel at http://www.sce.com/PowerandEnvironment/PEV/ videochannel/default.htm); (2) an online tool to calculate EV total cost of ownership based on one's current driving needs and electricity rates (see SCE's Plug-In Car Rate Assistant on http://www.sce.com/PowerandEnvironment/ PEV/rate-charging-options.htm and the Rocky Mountain Institute Project Get Ready's TCO Calculator at http://projectgetready.com/js/tco.html); and (3) an online tool to calculate the environmental impact of adopting EV (see Project Get Ready's TCO Calculator).

EVs.[13] We concluded the survey by presenting each respondent with the conjoint question discussed in the market forecast section of this paper.

The internet survey was fielded for two weeks starting on January 3, 2011 by Polimetrix / Yougov.com, a public policy research and polling services firm based in Palo Alto, CA. The survey had a response rate of 43.4% and a non-completion rate of 9%. Survey respondents were rewarded with Polimetrix points redeemable for cash and other prizes.[14]

4.2 Market Segmentation

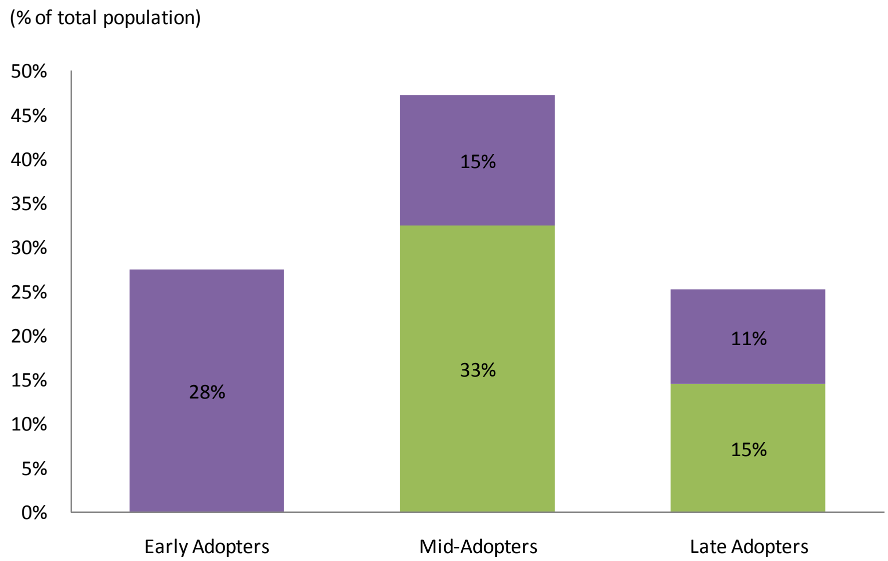
Based on respondents' vehicle preferences, demographic characteristics, and attitudes on EVs and EV incentives, we identified three primary market segments which we labeled as Early, Mid, and Late Adopters. In addition, Mid-Adopters and Late-Adopters each broke down into 2 sub-segments, primarily along economic and home ownership lines. These sub-segments were labeled as Mid Single Family Owned (Mid-SFO), Mid Non-Single Family Owned (Mid-NSFO), Late Single Family Owned (Late-SFO), and Late Non-Single Family Owned (Mid-NSFO).[15]

[13] For example, before asking about how much of a problem the 100 mile range of a BEV would be, we asked respondents how many miles they drove per day on average, how many times they drove more than 100 miles in one day and how many cars they own in their household, with a reminder that they can use an ICE vehicle for longer trips. When reminded to consider their true range needs and the possibility of using an EV for short local commutes and relying on a second household vehicle with extended range for longer trips, a surprising 60% of respondents replied that the 100 mile range of a BEV would not be a problem at all or a minor problem only. In future EV surveys, researchers should consider testing the effect of priming on the respondent by asking questions on range anxiety prior to and after any context is provided to the respondent.

[14] For more on the composition, recruitment, and weighting of the survey sample, see Appendix: Survey Sample and Weighting.

[15] We used k-means clustering analysis to segment the population based on respondents' preference ratings of vehicle types (on a scale of 0 to 10) and what they considered to be important when making the decision to purchase an EV (on a scale of 1 to 5). These factors included EV price, range, environmental impact, the current cost of gasoline, the cost to recharge an EV battery, and wider availability of EV models. We also segmented the population based on respondent importance ratings for EV incentives, such as the $2,000 incentive for charger installation, expedited permitting for EV charger installation, HOV lane access, and free street parking.

Figure 20 Distribution of Market Segments



Our segmentation was consistent with our market hypotheses. The Early Adopter segment preferred clean-tech vehicles (including all EVs and gas-electric hybrids) over traditional gas compact vehicles, cared a lot about the environment and new technology, and were generally interested in EV incentives.[16] Mid-Adopters had a slight preference for gas-electric hybrid and gas compact vehicles over EVs. Note that Mid-NSFOs preferred EVs even more than did Early Adopters and were relatively indifferent about all vehicle types. Mid-Adopters also showed moderate to strong interest in the environment, new technology, and EV incentives. Finally, Late Adopters strongly disfavored EVs and EV incentives in general, and cared little about the environment or new technology.[17]

[16] Also see Appendix: Vehicle Preferences, Attitudes, and Demographic Statistics by Segment

[17] As we will discuss later, Late-SFOs care more about design, luxury and comfort in their vehicles, while Late-NSFOs place an emphasis on economy and value in their car purchases. In the long term, we believe Late-SFOs will be more attracted to EVs as more models are introduced and offer the broader design, luxury, and performance attributes that sought by this sub-segment. Late-NSFOs will be incented to adopt EVs as they become a more economical option in the market. This divergence in preference is also evidenced by the differing ratings Late-SFOs and Late-NSFOs placed on gas compact vehicles. Late-SFOs strongly disfavored gas compact vehicles with a rating of 5.17, while Late-NSFOs strongly favored them with a rating of 9.44.

Figure 21 Detailed Market Segment Information

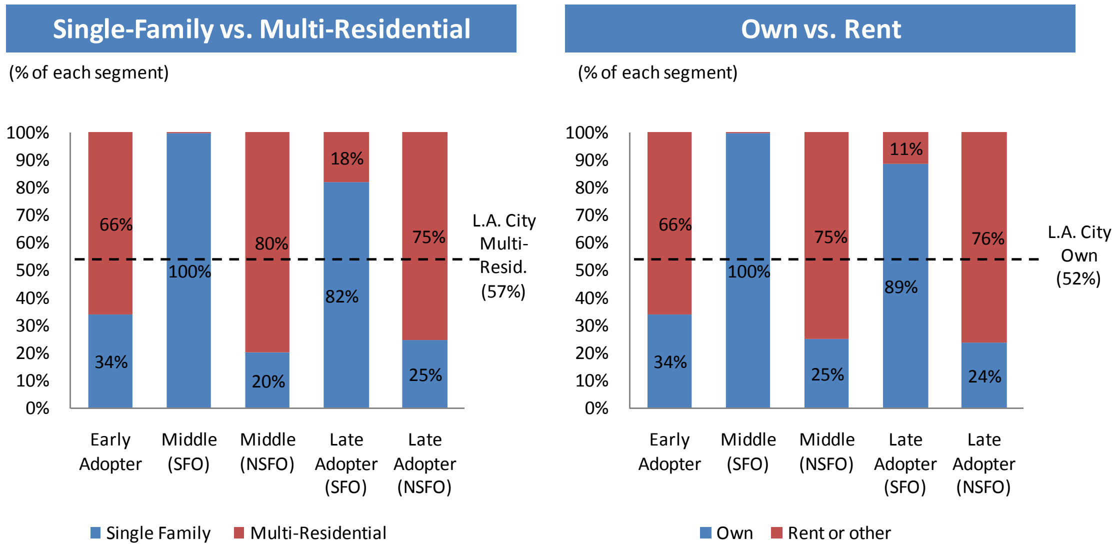
		Early	Mid-Adopters		Late Adopters	
	Sample	Early	Mid-SFO	Mid-NSFO	Late-SFO	Late-NSFO
% of Total	100%	28%	15%	33%	11%	15%
Gas Compact[1]	7.05	4.06	8.33	8.55	5.17	9.44
Gas-electric hybrid[1]	6.71	6.73	7.39	8.84	2.30	4.42
PHEV[1]	5.42	6.96	5.63	7.05	1.51	3.10
BEV[1]	5.85	6.28	5.38	7.65	1.49	3.13

4.2.1 Home Ownership

Comparing home ownership patterns across segments is very important, because the ability to install EV charging equipment at home will vary for those who live in single family homes versus multifamily housing and between those who rent versus own their homes. Renters and dwellers of multifamily housing may face greater obstacles in installing EV charging equipment, as they will likely require additional approval and coordination with landlords and Home Owners Associations (HOAs). As will be discussed later in this paper, approximately 40% of survey respondents who live in multifamily housing or rent say that if charging was not available at home, they would not buy an EV.

A significant percentage of Early to Mid-Adopters are non-single family homeowners who may experience additional challenges with EV charging access at home. Over 65% of Early Adopters live in multifamily housing (compared with 57% of the sample average) and 66% of Early Adopters are renters (compared with 52% of the sample average). Furthermore, 80% of Mid-NSFOs (representing 27% of the overall population) live in multifamily and 75% of Mid-NSFOs (representing 25% of the overall population) are renters.

Figure 22 Key Housing Statistics



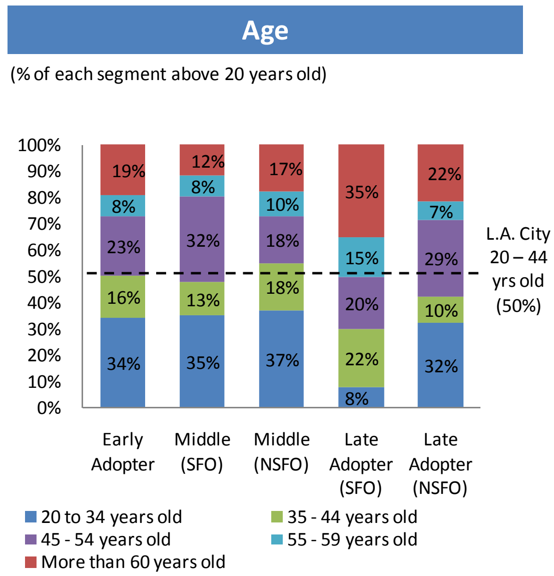
Takeaway #1

In order to support adoption among Early to Mid-Adopters, the City must find ways to facilitate installation of and access to EV charging equipment in multifamily housing and rental properties.

4.2.2 Age, Household Income, Education, and Political Affiliation

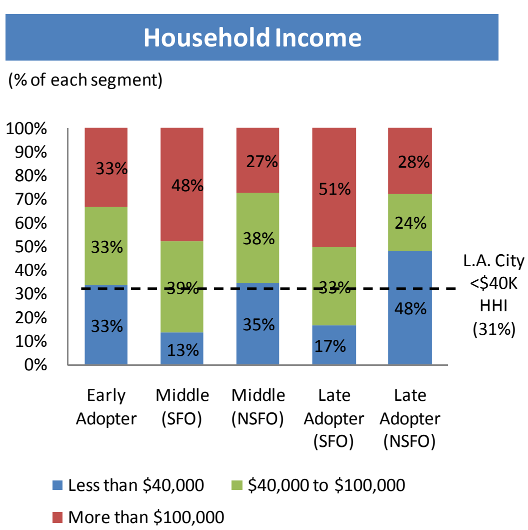
Early to Mid-Adopters are similar to each other in overall age distribution and tend to be younger than the rest of the population. Approximately 50% of Early to Mid-Adopters are between the ages of 20 to 44 (close to the sample average), compared with 30% of Late-SFOs and 42% of Late-NSFOs. Late-SFOs are the oldest among all segments, with 35% of respondents who are age 60 or older and only 8% of respondents who are between 20 to 34 years old. By contrast, Late-NSFOs have a more even age distribution, with 22% of respondents who are above age 60, 29% of respondents who are ages 34 to 54, and 32% of respondents who are ages 20 to 34.

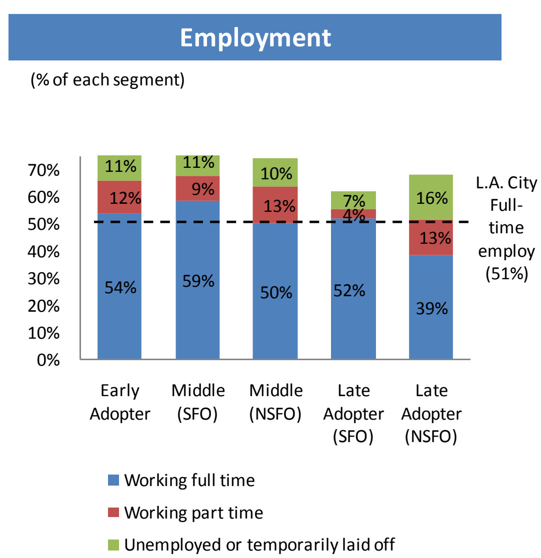
Figure 23 Age Statistics



Mid to Late Adopter segments each break down along household income and employment levels. Mid-SFOs and Late-SFOs have the highest percentage of respondents with more than $100,000 in household income (48% and 51% respectively), while Mid-NSFOs and Late-NSFOs have the least (27% and 28% respectively). Furthermore, Mid-NSFOs and Late-NSFOs have the highest percentage of respondents making less than $40,000 in household income (35% and 48% respectively). The reluctance of Late-NSFOs to purchase EVs may have more to do with low household income and high levels of unemployment. Only 39% of Late-NSFOs are fully employed, compared to the sample average of 51%, and 16% of Late-NSFOs are unemployed, compared to the sample average of 10%.

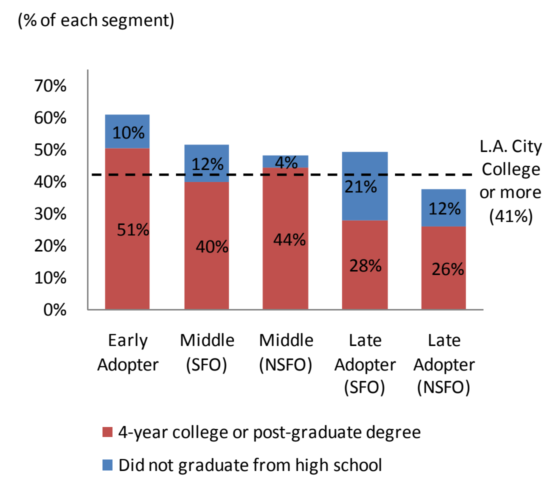
Figure 24 Household Income and Employment Statistics





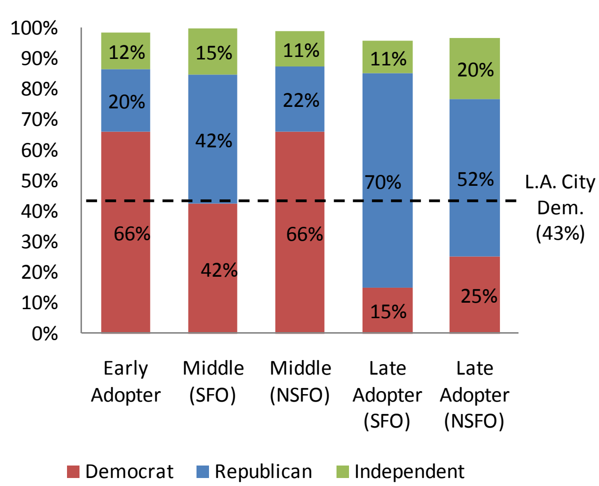
Early to Mid-Adopters tend to be more educated. Over 40% of respondents have a college or post-graduate degree. Late Adopters have a significantly much lower rate of education (28% and 26% for Late-SFOs and Late-NSFOs hold 4-year or post-graduate degrees). Mid-Adopters, in particular, Mid-NSFOs are highly educated. Mid-NSFOs have the second highest rate of college graduates (44%) in the sample and the lowest rate respondents who did not graduate from high school (4%).

Figure 25 Education Statistics



Early to Mid-adopters tend to be more liberal in political affiliation than Late Adopters. Approximately 66% of Early Adopters and Mid-NSFOs and 42% of Mid-SFOs say they are Democrats compared to 43% of the sample average. Late Adopters are more conservative, with only 15% of Late-SFOs and 25% of Late-NSFOs saying they are Democrats and 70% of Late-SFOs and 52% of Late-NSFOs saying they are Republican. While Late Adopters may differ in household income and employment, they share a more conservative political ideology.

Figure 26 Political Affiliation of Respondents



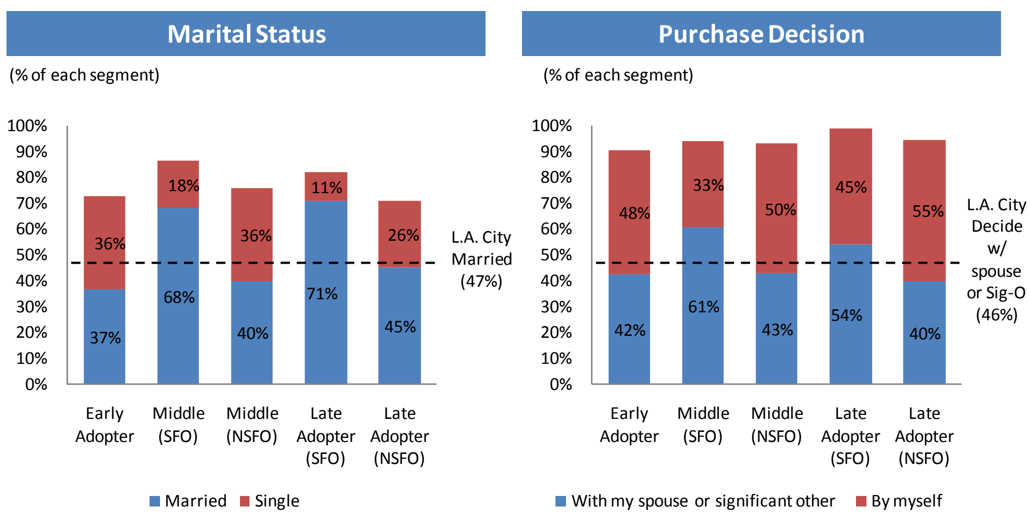
Takeaway #2

Early to Mid-Adopters will likely be younger, more affluent and educated, and politically liberal than Late Adopters.

4.2.3 Vehicle Purchase Decision, Ownership and Preferences

The decision to purchase an EV will be made jointly for many households. Almost 50% of the sample population is married and 46% say they make the decision to purchase a vehicle with their spouse or significant other. While segments that are comprised primarily of non-single family owners are less likely to be married (only 37% of Early Adopters and 40% of Mid-NSFOs are married), they also make joint decisions with a significant other. Segments that are predominantly single family home owners are more likely to be married (68% of Mid-SFOs and 71% of Late SFOs are married) and more likely to make a vehicle purchase decision jointly with a spouse (61% for Mid-SFO and 54% for Late-SFO).

Figure 27 Marital Status and Purchase Decision of Respondents

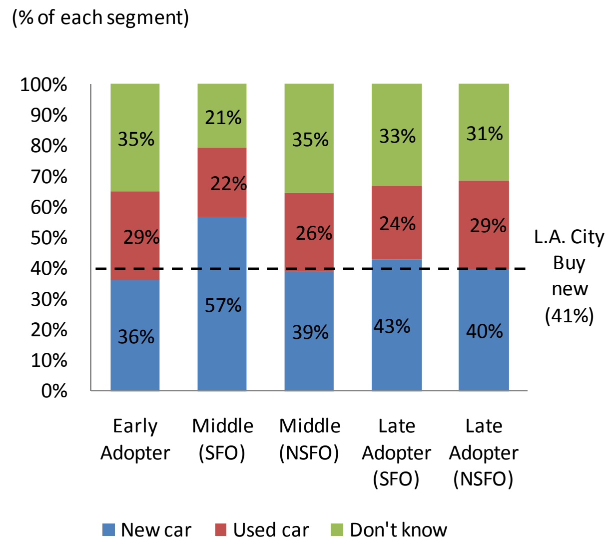


Takeaway #3

For nearly half of the population, the EV purchase decision will be made jointly. It is important to highlight factors that will matter in a joint household purchase decision, such as TCO, safety and reliability.

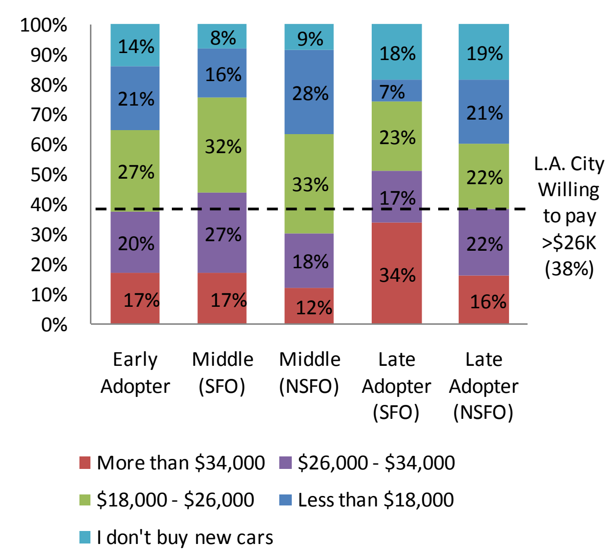
Respondents who are single-family home owners, in particular Mid-SFOs, are more likely to buy new cars. As the primary market for EVs in the next five years will be driven by new car sales, it is important to understand is the likelihood that each segment will purchase a new vehicle. While only 36% of Early Adopters intend to buy a new car (compared to 41% average for the sample), 57% of Mid-SFOs intend to buy a new car.

Figure 28 New vs. Used Car Buying Intention



Tax credits in the short to medium term will be important in attracting at least 30% of Early Adopters and Mid-NSFOs who would not consider paying more than $26,000 for a new vehicle. Only 37% of Early Adopters and 30% of Mid-NSFOs are willing to spend more than $26,000 on a new car, compared to 44% of Mid-SFOs and 51% of Late-SFOs.

Figure 299 Willingness to Pay for a New Vehicle



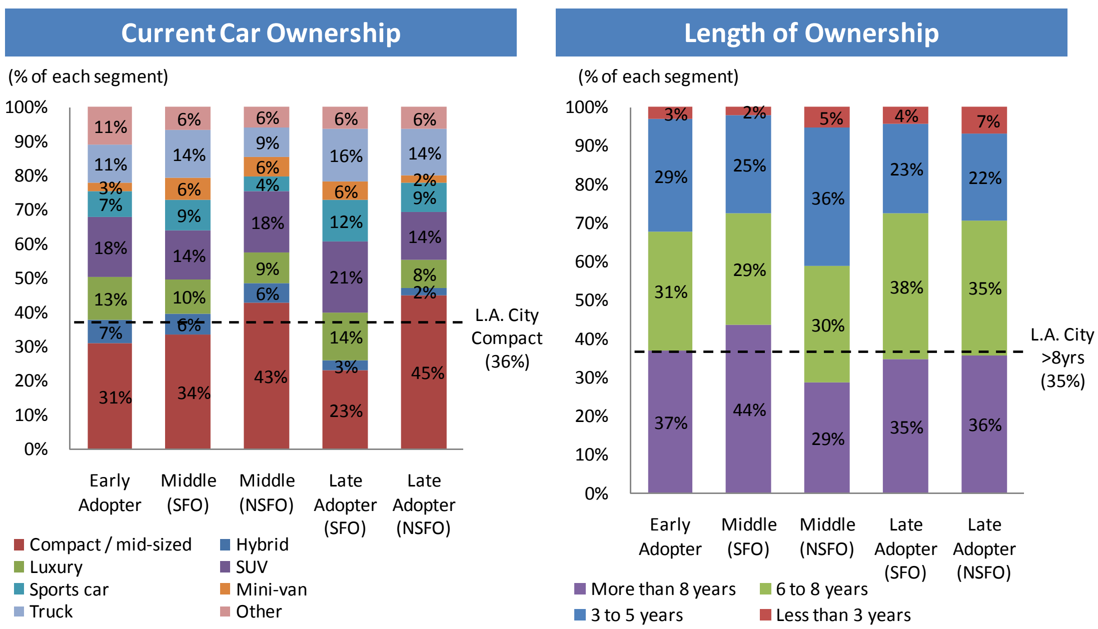
Takeaway #4

Identifying segments that are likely and willing to purchase a new vehicle will help make the case for extending tax credits for an EV purchase. In the near term, tax credits will help attract at least 30% of Early Adopters and Mid-NSFOs who would not consider paying more than $26,000 for a new vehicle.

Respondents' current vehicle ownership helps explain their values, interests, and lifestyle choices. Early to Mid-adopters are twice as likely to drive hybrids as are Late Adopters, indicating a greater appreciation for environmentally friendly cars and fuel economy. Differences in current vehicle ownership among Late Adopters explain each sub-segment's aversion to EVs. Late-SFOs prefer more SUVs, trucks, and luxury cars compared to the rest of the sample, while Late-NSFOs overwhelmingly prefer gas compact vehicles.

Mid-SFOs, which had a highest intent to purchase a new car and second highest willingness to pay amongst all segments, also are most likely to own a vehicle for more than 8 years. This sub-segment is not averse to spending money upfront as long as they are paying for reliability of the vehicle. Increasing perceived reliability and long-term viability of EVs would help attract this Mid-Adopter segment.

Figure 30 Current Car Ownership and Length of Ownership

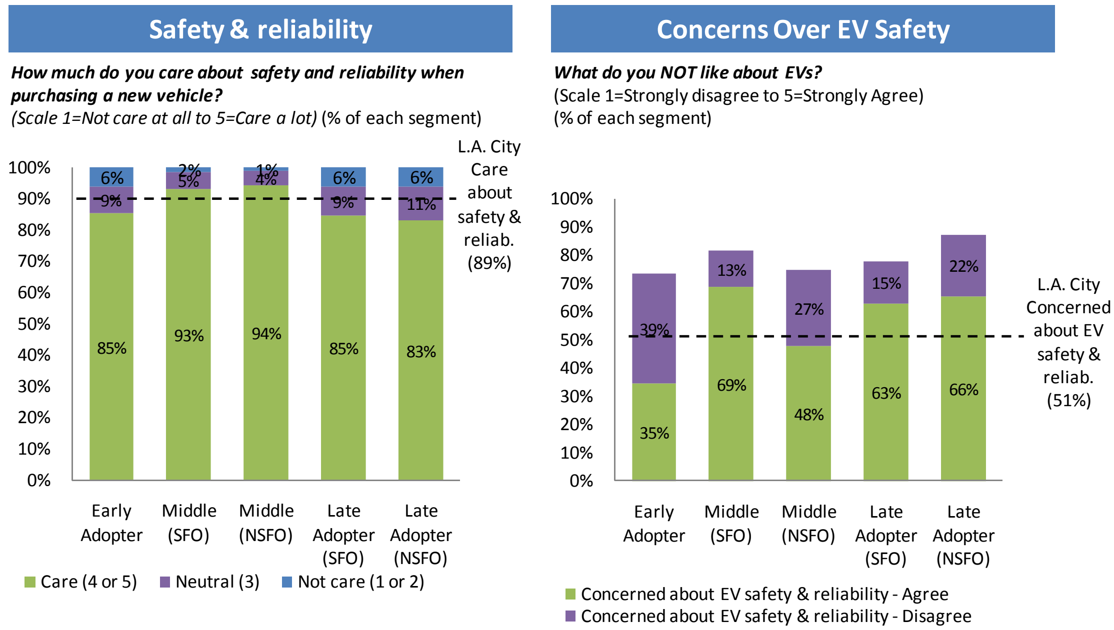


Takeaway #5

Current vehicle ownership helps us understand what might drive each segment's degree of EV preference. Early to Mid-Adopters are twice as likely to be hybrid owners as Late Adopters, who either favor luxury vehicles (Late-SFOs) or care about maximizing economy and value (Late-NSFOs).

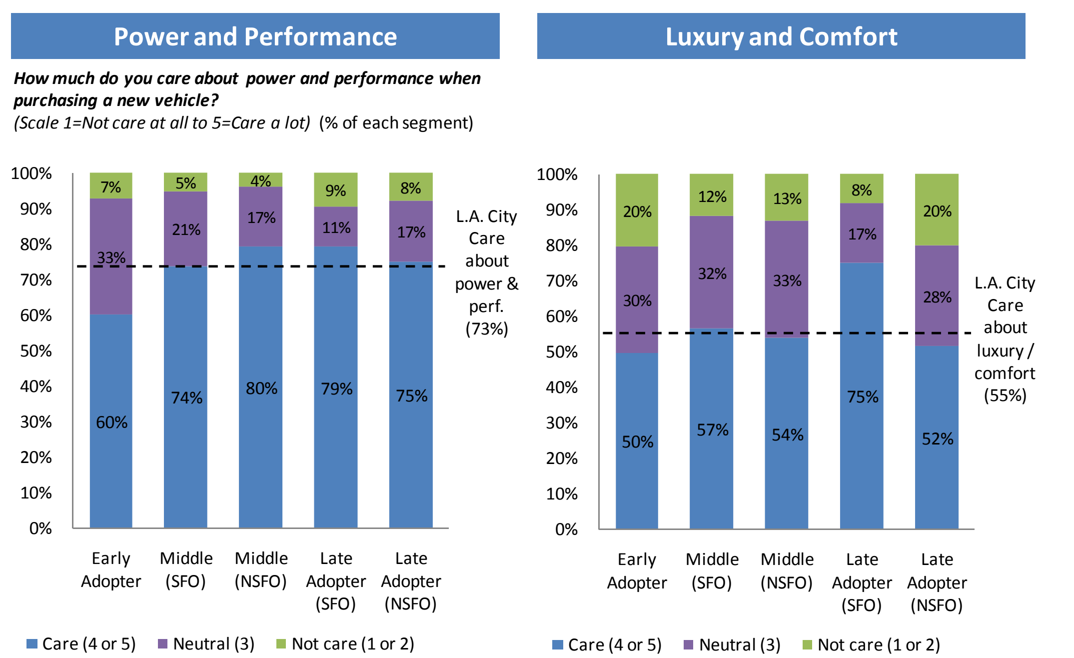
Greater awareness of EV safety and reliability as well as power and performance will help attract interest beyond Early Adopters. While all respondents agree that safety and reliability is important in a vehicle purchase, segments differ in their perception of EV safety. Only 35% of Early Adopters are concerned about the safety of EVs compared to 69% of Mid-SFOs, 48% of Mid-NSFOs, 63% of Late-SFOs, 66% of Late-NSFOs Adopters, and 51% of the sample average.

Figure 31 Concerns about EVs



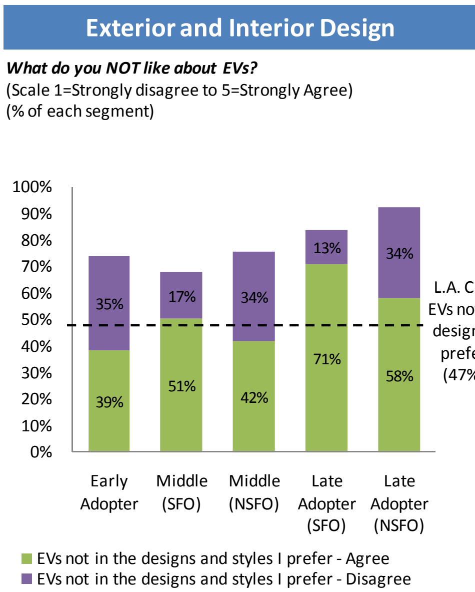
In addition, greater awareness of the power and performance of EVs may also help attract more Mid-Adopters. Only 60% of Early Adopters care about power and performance compared to 74% of Mid-SFOs and 80% of Mid-NSFOs. Late-SFOs care most about luxury and comfort.

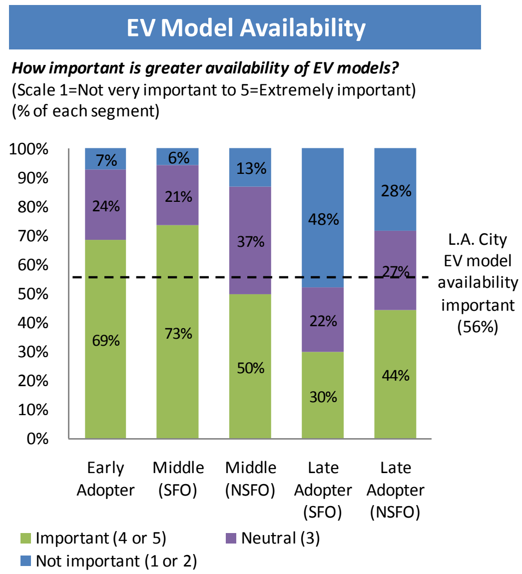
Figure 32 Key Attributes of EV Buying: Power/Performance and Luxury/Comfort



Finally, while Early to Mid-Adopters would like to see more model availability, current EV designs don't deter them from considering EVs as much as they do for Late Adopters.

Figure 33 Key Attributes of EV Buying: Exterior/Interior Design and Model Availability





Takeaway #6

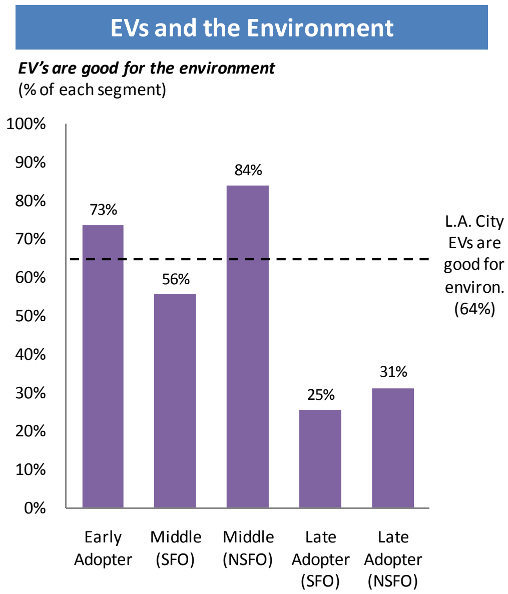
In order for EVs to become more widespread, they must also compete on more traditional metrics of vehicle quality. Greater awareness of EV safety and reliability, as well as their power and performance, will help attract more Mid-Adopters.

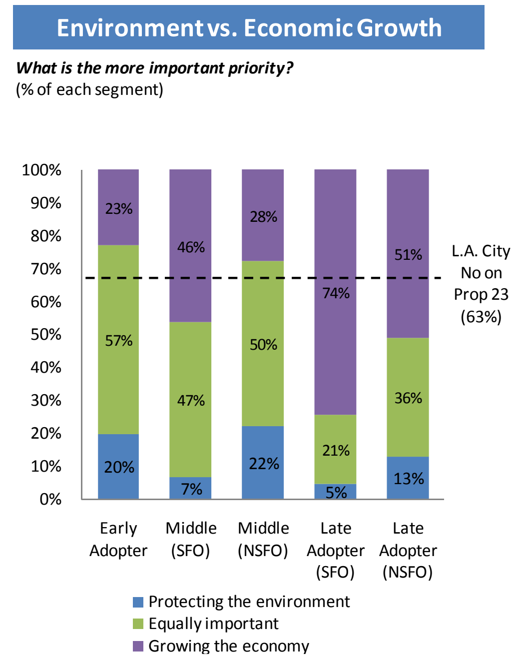
4.3 Drivers of EV Adoption

4.3.1 Attitudes on the Environment and New Technology

Early to Mid-Adopters care more about the environment than do Late Adopters. Over 70% of Early Adopters, 56% of Mid-SFOs, and 84% of Mid-NSFOs agreed that "EV's were good for the environment," compared to 64% for the sample average and only 25% of Late-SFOs and 31% of Late-NSFOs. We also asked respondents what they believed was the more important priority: protecting the environment, growing the economy, or if both were equally important. Over 60% of respondents said that protecting the environment is more or equally important as economic growth. This is similar to the 62% voting no in the City of L.A. on Proposition 23 in November 2010.

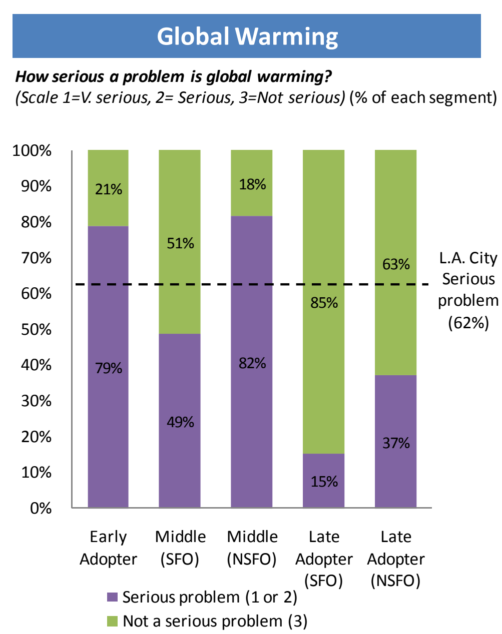
Figure 34 Perception of EVs in Relation to the Environment and Economic Growth

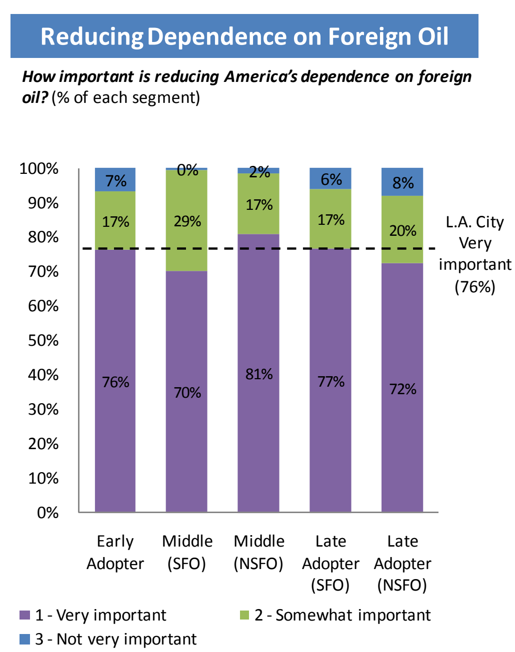




We also asked respondents their views about global warming. Almost 80% of Early Adopters, 49% of Mid-SFOs, and 82% of Mid-NSFOs considered global warming to be a serious problem compared to 62% for the sample average and 15% for Late-SFOs and 37% for the Late-NSFOs. Finally, while attitudes on the environment may diverge, respondents are united on the need to reduce U.S. dependence on foreign oil. This may be an important messaging tool, especially when targeting Late Adopters.

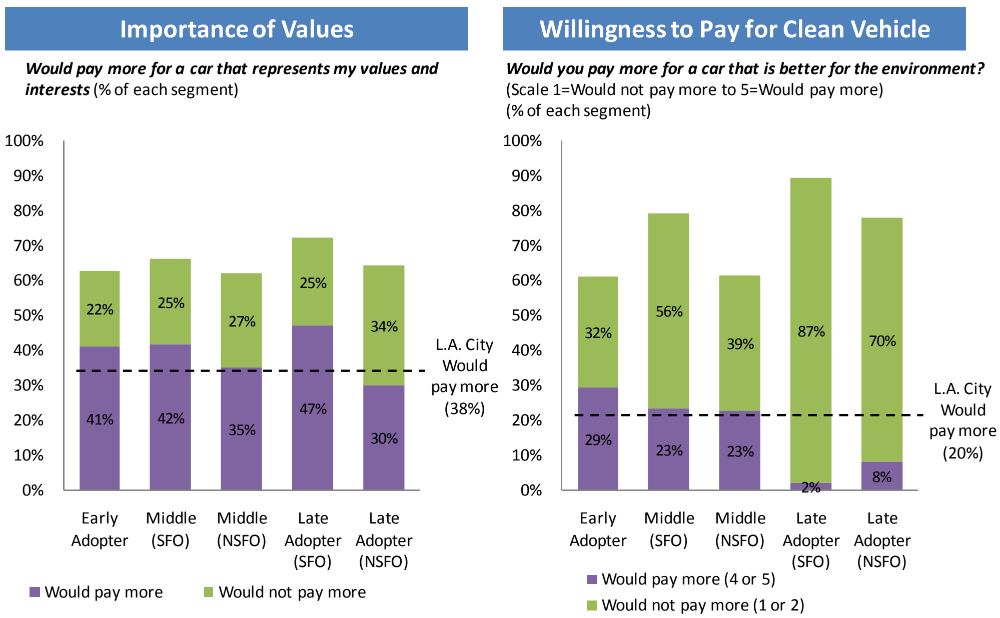
Figure 35 Perceptions of EVs in Relation to Global Warming and Reducing Dependence on Foreign Oil





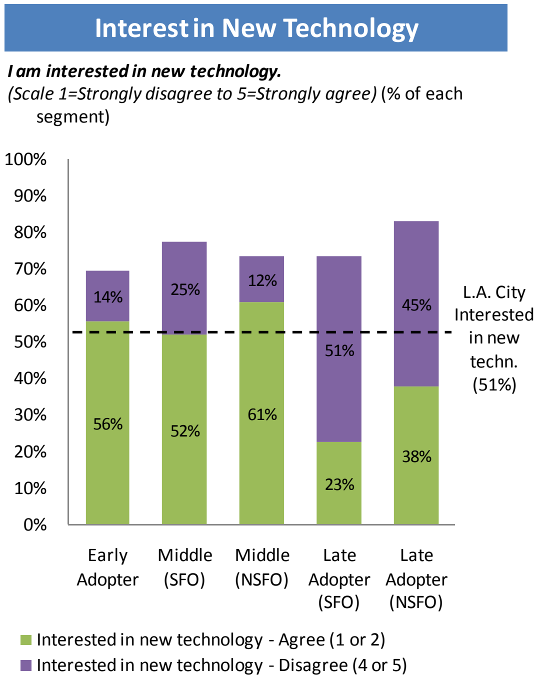
While Early to Mid-Adopters care more about the environment, they do not necessarily want to pay more for a car that is better for the environment. Only 29% of Early Adopters, 23% of Mid-Adopters, 2% of Late-SFOs, and 8% of Late-NSFOs said they would pay more for a car that is better for the environment. Late Adopters would pay more for a car the represents their values and interests, but those interests are not environmental.

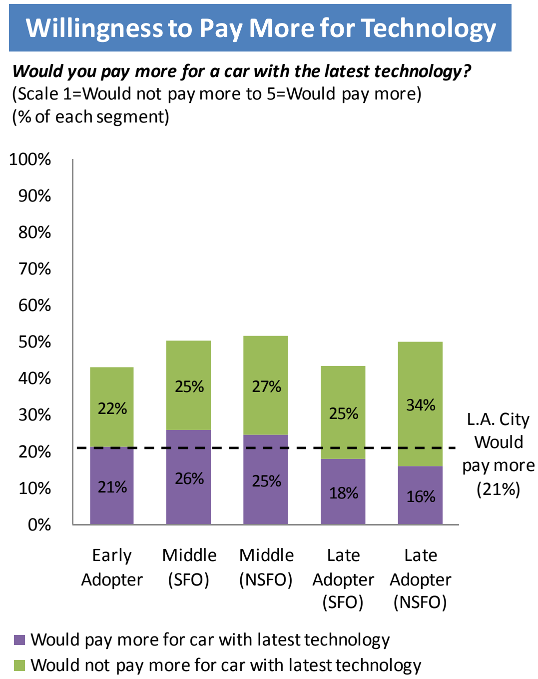
Figure 36 Importance of Values and Willingness to Pay for Clean Vehicle



Similar to attitudes on the environment, interest in new technology among Early to Mid-Adopters does not translate into a willingness to pay more for a car with the latest technology. Early to mid-adopters have significant interest in new technology, with 56% of Early Adopters, 52% of Mid-SFOs, and 61% of Mid-NSFOs indicating their interest in new technology. In comparison, 51% was the sample average and only 23% for Late-SFOs and 38% for Late-NSFOs indicated an interest in new technology. However, when asked whether they are willing to pay more for a car with the latest technology, these numbers go down dramatically and the gap between Early and Late Adopters becomes smaller. Only 21% of Early Adopters, 25% of Mid-Adopters, and 17% of Late Adopters would pay more for a car with the latest technology.

Figure 37 Interest in New Technology and Willingness to Pay More for Technology





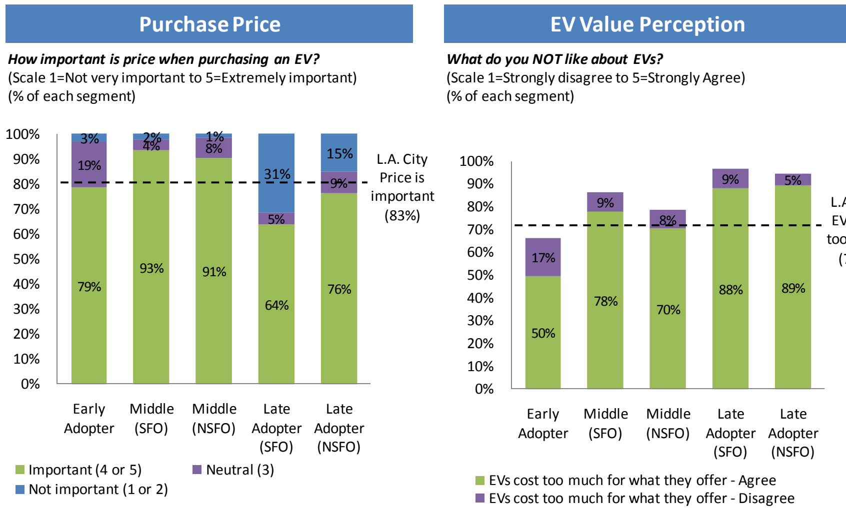
Takeaway #7

Early to Mid-Adopters care more about the environment and new technology than Late Adopters. However, appreciation for the environmental and technology benefits of EV may not necessarily translate into paying more for those values.

4.3.2 Lower Total Cost of Ownership

Mid-Adopters seem to be the most price sensitive EV segment. Over 90% of Mid-Adopters said that purchase price was important, compared to 79% of Early Adopters and 76% of Late-NSFOs. Late-SFOs, the most affluent segment with the greatest preference for luxury vehicles in the sample, were also the least price sensitive, with only 64% replying that purchase price was important. These results would suggest that Mid-Adopters would be most attracted to policy levers designed to lower upfront purchase price.

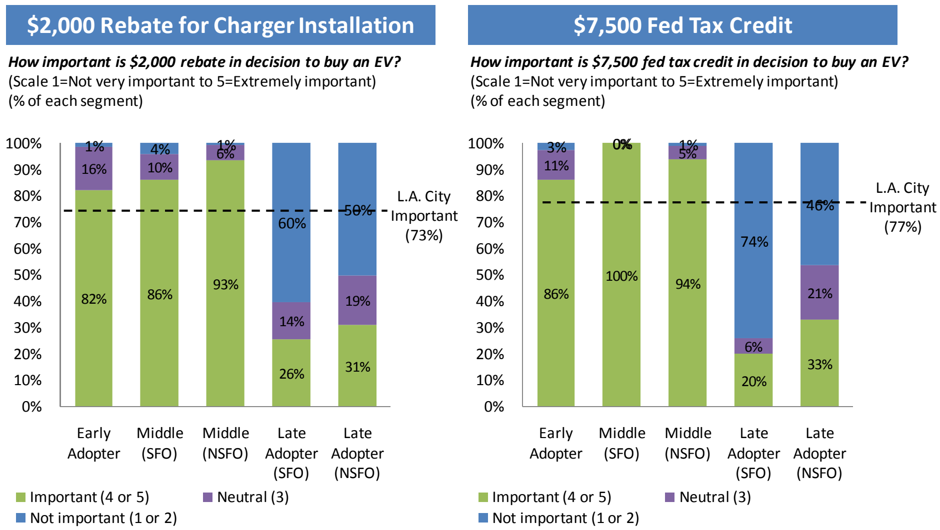
Figure 38 Purchase Price and EV Value Perception



Closing the gap between price and perceived value will be important to attract Mid to Late Adopters. While Mid-Adopters are the most price sensitive segment, Late Adopters perceive the greatest gap between EV price and perceived value. The gap between the price of EVs and their perceived value grows larger among Later Adopters. About 50% of Early Adopters do not like EVs because they believe “EVs cost too much for what they offer”, compared to 78% for Mid-SFOs, 70% for Mid-NSFOs, and 88% for Late-SFOs and 89% for Late-NSFOs.

Early to Mid Adopters are more receptive to monetary incentives that lower TCO, while incentives are not enough to sway Late Adopters. Only 26% of Late-SFOs and 31% of Late-NSFOs consider the $2,000 rebate for charger installation important in their decision to buy an EV, compared with the sample average of 73%. Only 20% of Late-SFOs and 33% of Late-NSFOs consider the $7,500 federal tax credit important, compared with the sample average of 77%.

Figure 39 Perception of Monetary EV Incentives

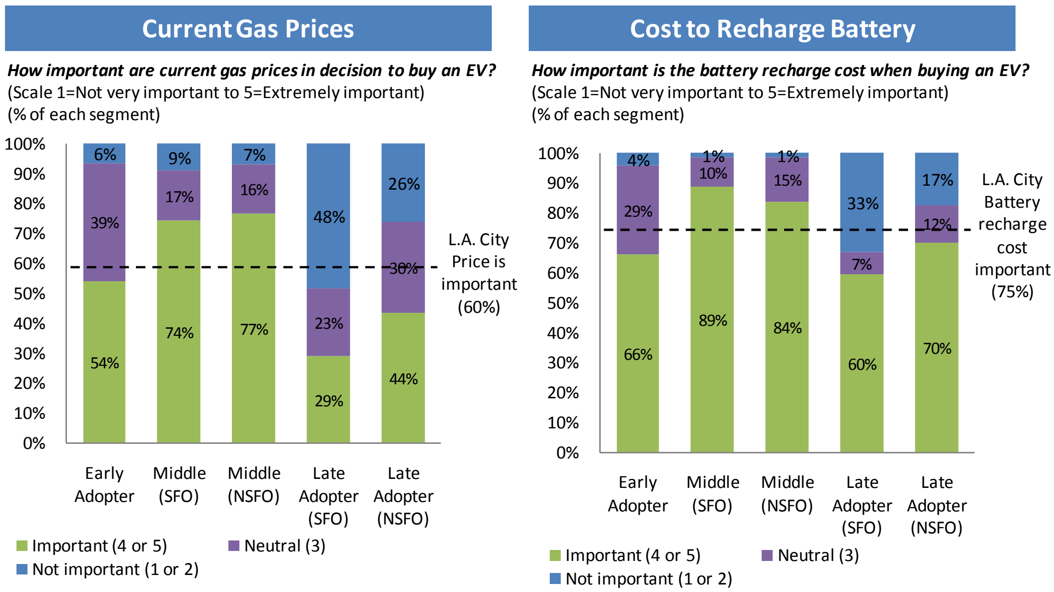


Takeaway #8

Mid to Late Adopters will be more attracted to EVs as either one of two things happen: decrease in purchase price or increase in perceived value. While ways to significantly lower purchase price for EV consumers may be limited for the City, it may have an important role to play in elevating the perception of EV value through public-private education campaigns and initiatives. Specifically, the City can emphasize environmental benefits, reducing U.S. dependence on foreign oil, safety and reliability of EVs, and other incentives.

Higher gas prices will help sway more Mid-Adopters to EVs. In addition to being the most sensitive to upfront purchase price, Mid-Adopters also care most about lowering ongoing fuel costs. Seventy-four percent of Mid-SFOs and 77% of Mid-NSFOs consider current gas prices to be an important factor to consider when buying an EV compared to 60% for the sample average, only 54% for Early Adopters, 29% for Late-SFOs and 44% for Late-NSFOs.

Figure 40 Gas Price and Battery Recharge Cost Perception

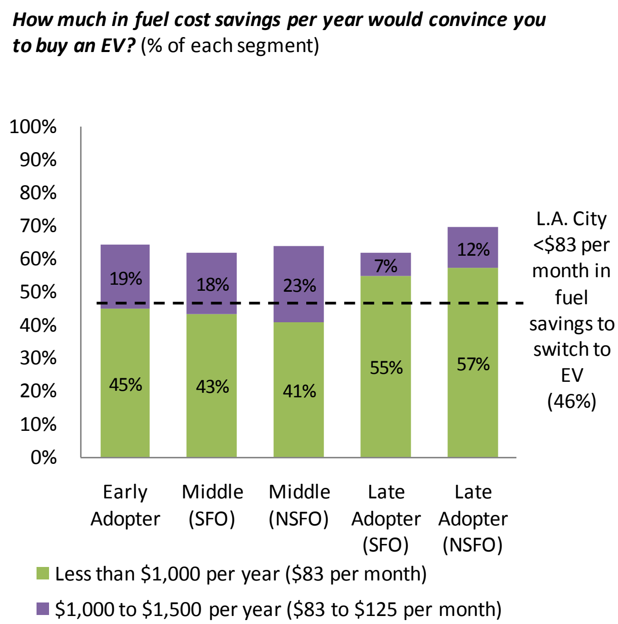


A competitive EV rate structure that is well-communicated will be critical to raising the perceived value of EVs amongst Mid-Adopters. While the City may not have the ability to affect gas prices, it can deliver fuel savings through a competitive rate structure that lowers battery charging costs. Almost 90% of Mid-SFOs and 84% of Mid-NSFOs care about battery recharge cost, compared with 75% of the sample average and 66% of Early Adopters, 60% of Late-SFOs and 70% of Late-NSFOs. Note that it is important not only to formulate a pricing scheme that delivers lowers TCO, but to communicate that value clearly to the public to raise the perceived value of EVs.

Policies to lower TCO should be targeted and timed to attract Mid-Adopters, as Early Adopters are less sensitive to TCO. Early Adopters seem to be driven less by TCO considerations as they are by their views on the environment and preference for new technology. Slightly over 50% of Early Adopters say current gas prices are important to consider when buying an EV, which is below the 60% average for the sample. Additionally, 66% of Early Adopters say battery recharge cost is important, below the 75% average for the sample.

Delivering $83 per month in fuel cost savings per month may be enough to convince 46% of the population to buy (or at least consider) an EV.

Figure 41 Fuel Cost Saving Incentive to Switch



Takeaway #9

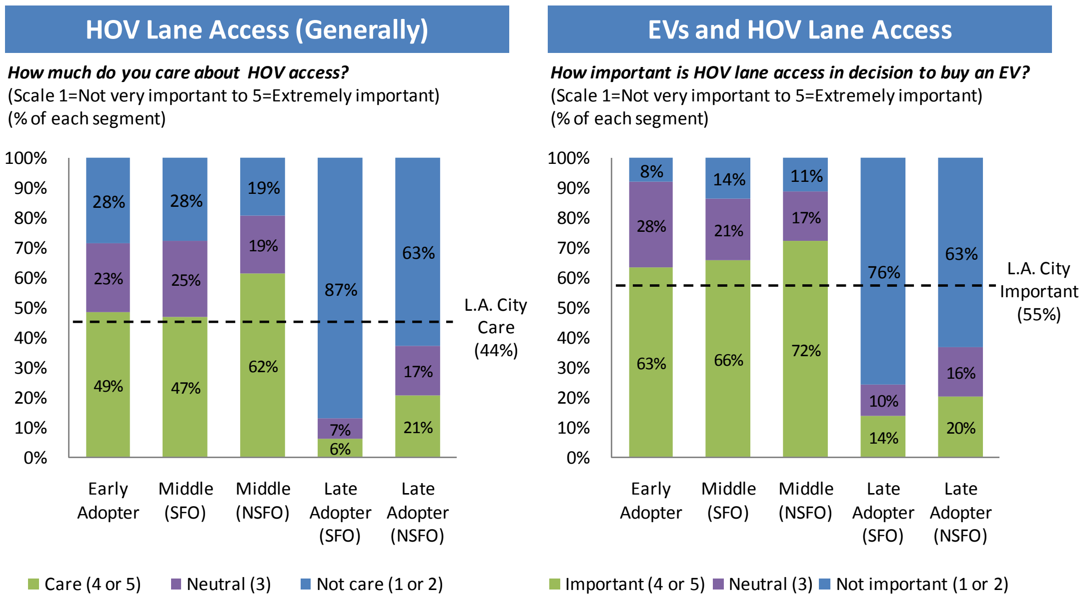
A clear and easy EV rate structure can help deliver and communicate the fuel cost savings to Mid-Adopters. An $83 monthly fuel savings may be enough to convince 46% of the population to buy (or at least consider) an EV.

4.3.3 Traffic Avoidance and Parking Privileges

4.3.3.1 HOV Lane Access

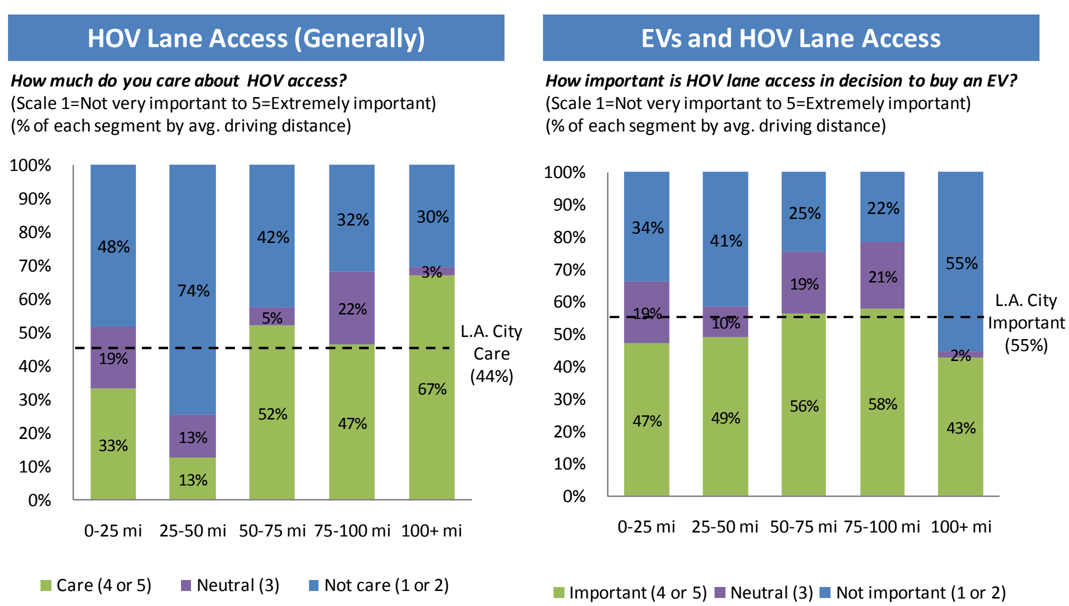
HOV lane access for EVs will be an attractive incentive for Mid-Adopters. While HOV lane access is important in general for Early to Mid-Adopters, HOV lane access becomes much more important when considered as an incentive for an EV purchase. HOV lane access could be an effective incentive for Mid-NSFOs. The survey indicates that 62% of Mid-NSFOs, 47% of Mid-SFOs, and 49% of Early Adopters care about HOV lane access in general. When asked how important HOV lane access would be in their decision to buy an EV, 63% of Early Adopters, 68% of Mid-SFOs, and 72% of Mid-NSFOs say that HOV lane access would be important. By contrast, only 14% of Late-SFOs and 20% of Late-NSFOs consider HOV lane access to be important in their decision to buy an EV. Late Adopters place less importance on EV incentives overall.

Figure 42 Attitudes toward HOV Lane Access and its Relation to the EV Purchase Decision



Respondents who drive more per day on average care more about HOV lane access, particularly in the context of buying an EV. Almost 60% of respondents who drive an average of 75 to 100 miles per day said HOV lane access is important in their decision to buy an EV, compared to 56% of drivers who drive 50 to 75 miles per day, 49% of drivers who drive 25 to 50 miles per day, and 47% of drivers who drive 0 to 25 miles per day. Respondents who drive more than 100 miles per day, however, are least likely to believe HOV lane access is important at 43%. This is likely due to concerns over the limited range of EVs.

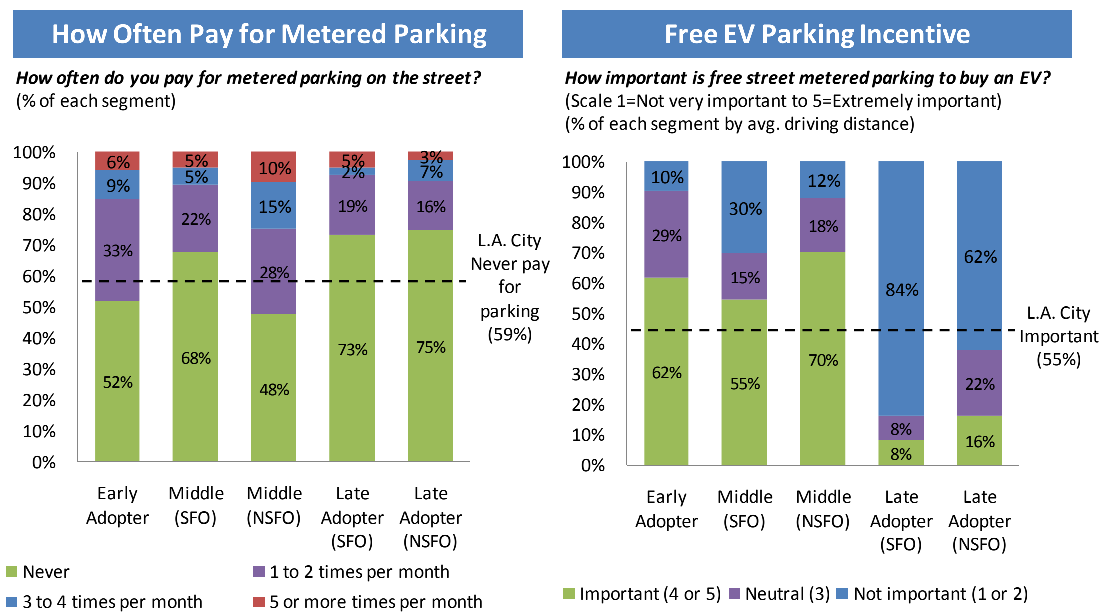
Figure 43 HOV Lane Access and EV Purchase Decision Broken Down by Commuting Distance



4.3.3.2 Free Parking

Free parking may not prove to be a good incentive to attract incremental EV demand, as most L.A. drivers do not use metered street parking. While there is strong interest in the free EV parking incentive, there are strong reasons to question whether it would create incremental demand for EVs due to the low usage of metered street parking among respondents. A majority across the segments stated they use metered street parking for less than two hours a month: 85% of Early Adopters, 90% of Mid-SFOs, and 76% of Mid-NSFOs. Almost 60% of respondents said they never pay for parking.

Figure 44 Free Parking Frequency and its Incentive Power In the EV Purchase Decision



Takeaway #10

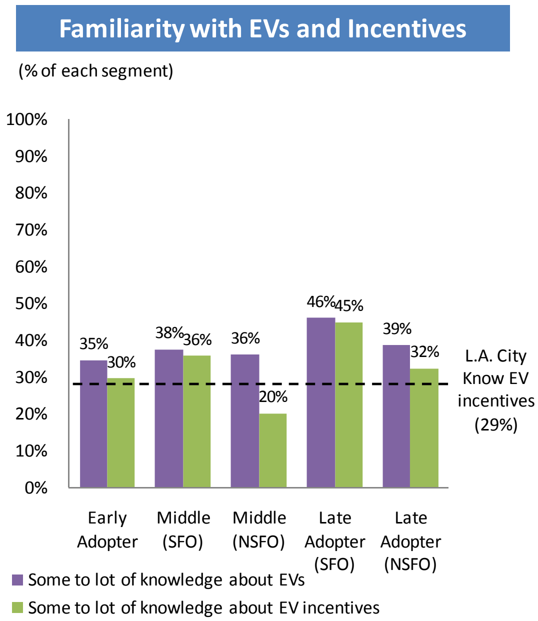
Free HOV lane access will be an effective tool to attract Mid-Adopters to purchase EVs. However, free EV street parking will be less effective, as few people currently use metered street parking.

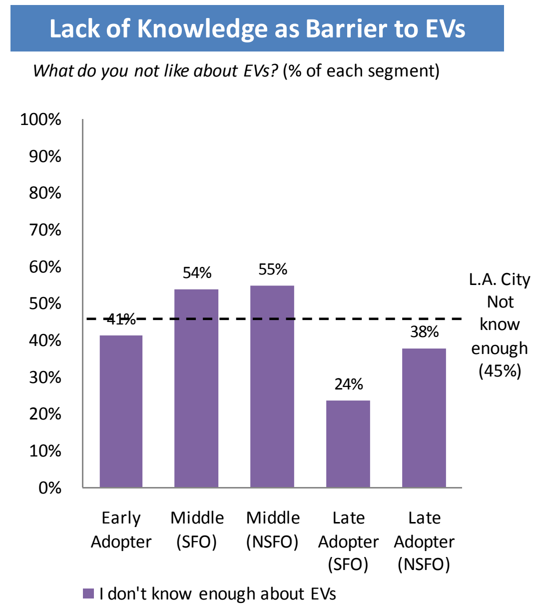
4.4 Potential Barriers to EV Adoption

4.4.1 Knowledge of EVs and EV Incentives

In general, there is a low level of knowledge about EVs and EV incentives. Only 37% of the sample said they had knowledge about EVs and only 29% of respondents were aware of available EV incentives. Mid-NSFOs were the least knowledgeable about EV incentives. Early to Mid-Adopters (who showed greater interest in EVs) stated they had less knowledge about EVs and EV incentives than Late Adopters (in particular, Late-SFOs, 46% of whom said they were knowledgeable about EVs and EV incentives). Lack of knowledge about EVs and EV incentives could be a major deterrent for many would-be adopters, in particular Mid-Adopters. Greater education and information about EV incentives would be most useful to Mid-Adopters, since 54% said that lack of knowledge was an obstacle in considering purchasing an EV.

Figure 45 Familiarity with EVs and Incentives





Takeaway #11

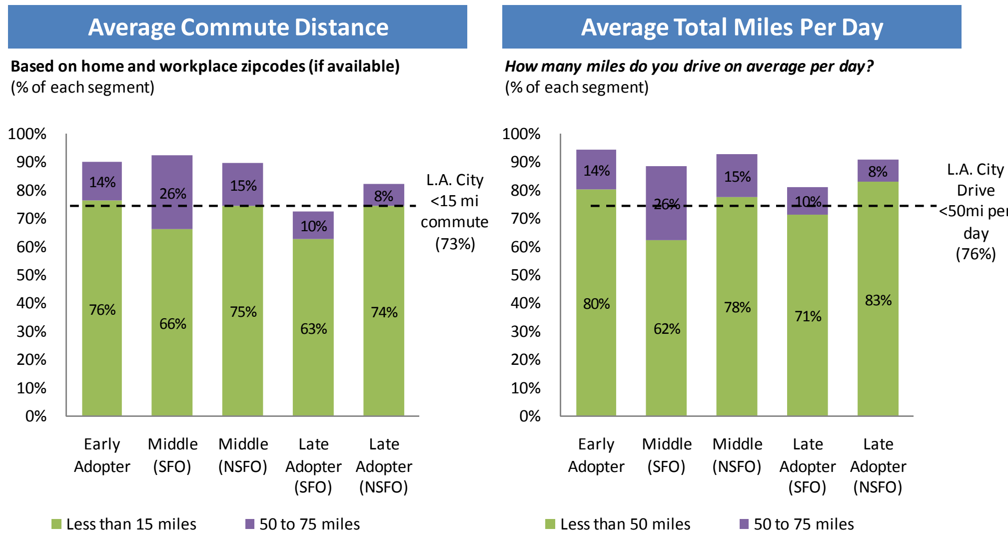
The lack of knowledge about EVs and available incentives is a barrier for adoption, particularly among Mid-Adopters.

4.4.2 Range Anxiety

4.4.2.1 Actual Range Requirements of L.A. Drivers

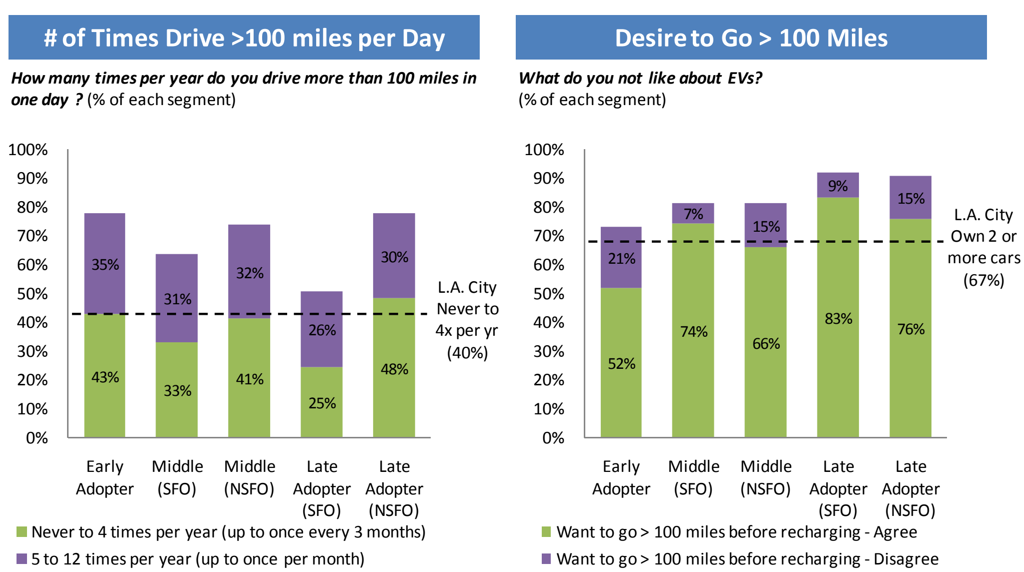
Over 70% of Los Angeles commuters drive under 30 miles round-trip. Even accounting for follow-on and non-commute driving, 76% of trips are less than 50 miles per day. In order to understand the true range needs of L.A. residents, we asked two questions. First, we asked respondents for the zip codes of their home and destinations (work, school) and calculated the average commute distance. We learned that 73% of commutes are less than 15 miles each way. We also asked how many miles respondents drive on average and 76% of respondents said they drive 50 miles or less per day.

Figure 46 Commuting Patterns



The desire to travel more than 100 miles is rooted less in average daily need than in a desire for flexibility. According to 40% of respondents, trips over 100 miles occur about four times a year. Early, Mid, and Late Adopters do not vary significantly in their need to drive more than 100 miles in one day. However, the segments do vary in their desire to go more than 100 miles before recharging. More than half of the Early Adopters said they do not like EVs because of the 100mile BEV range, compared to 74% of Mid-SFOs, 66% of Mid-NSFOs, 83% of Late-SFOs, and 76% of Late-NSFOs. This suggests that perceived concerns over limited BEV range is rooted less in actual range needs, but in a desire for flexibility to travel over 100 miles without the need to recharge. While Early Adopters may be more willing to adapt their driving behavior to accommodate the range, Mid to Late Adopters may have less willingness to adjust their behavior.

Figure 47 Long-Distance Travel Patterns



Takeaway #12

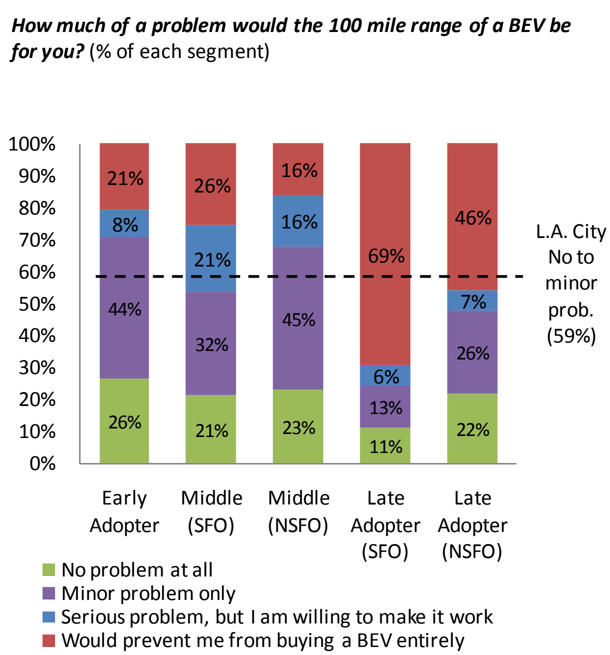
Actual driving patterns and range needs of L.A. residents make EVs highly suitable for the majority of day-to-day commutes and urban travel (76% of total driving is under 50 miles per day; 40% drive more than 100 miles in one day less than 4 times per year).

- BEVs with a 100-mile range is a realistic possibility for most drivers in L.A.—even accounting for reduced range in urban terrain. However, there is a disconnect between actual and perceived range needs. Greater education regarding true range needs of L.A. residents and how EVs can be integrated into actual driving patterns will help mitigate range anxiety for much of the population.
- If 30 to 50 miles of range is enough for over 70% of L.A.'s population, 4 to 6 hours of Level I charging per night may be enough to meet the needs of the majority of L.A. drivers.

4.4.2.2 Policy Options to Mitigate Perception of Range Anxiety

The City can undertake three initiatives to help meet the desire to travel more than 100 miles. First, it can help shape the perceived need—and hence the desire—to own a vehicle with extended range. Early to Mid-Adopters are more comfortable and are willing to accommodate to the 100 mile range limitation than Late Adopters. Most Early Adopters (70%) said the 100-mile range of BEVs is not an adoption barrier, compared to 53% of Mid-SFOs, and 58% of Mid-NSFOs. However, 69% of Late-SFOs and 46% of Late-NSFOs state that the 100-mile range limit of BEVs would prevent them from buying an EV. Furthermore, 21% of Mid-SFOs and 16% of Mid-NSFOs consider the range limitation to be "a serious problem," but are "willing to make it work".

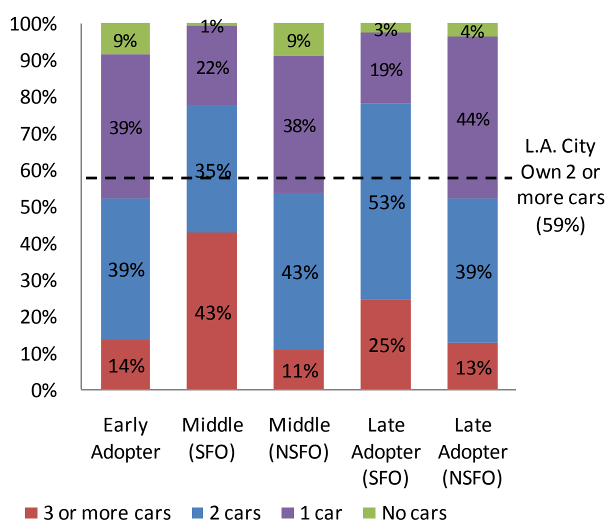
Figure 48 BEV 100 Mile Range Limitation



The number of Mid-Adopters who are concerned about the 100-mile range but are willing to work around the range limitations was higher than expected. Part of this might be due to the fact that survey respondents were carefully primed by being asked how many miles they drove per day on average, how many times per year they drove more than 100 miles in one day, and reminded that if they owned multiple cars, they could use the non-EV for extended trips. We would have had to ask the question before and after priming to test the effect of priming itself, but the results (post-priming) may suggest the importance of shaping perception of true range needs.

Position the EV as an additional vehicle for households with multiple vehicles. Households with multiple vehicles may have the greatest opportunity to accommodate an EV because of the flexibility provided by multiple vehicle options. L.A. is especially suited for EV ownership, with 59% of respondents saying the own two or more vehicles. The SFO segments in particular have higher rates of multiple car ownership per household. Almost 80% of Mid-SFOs and Late-SFOs have two or more cars. Note that of all segments, Mid-SFOs are especially well-positioned for EV ownership, with the highest rate of access to three or more cars.

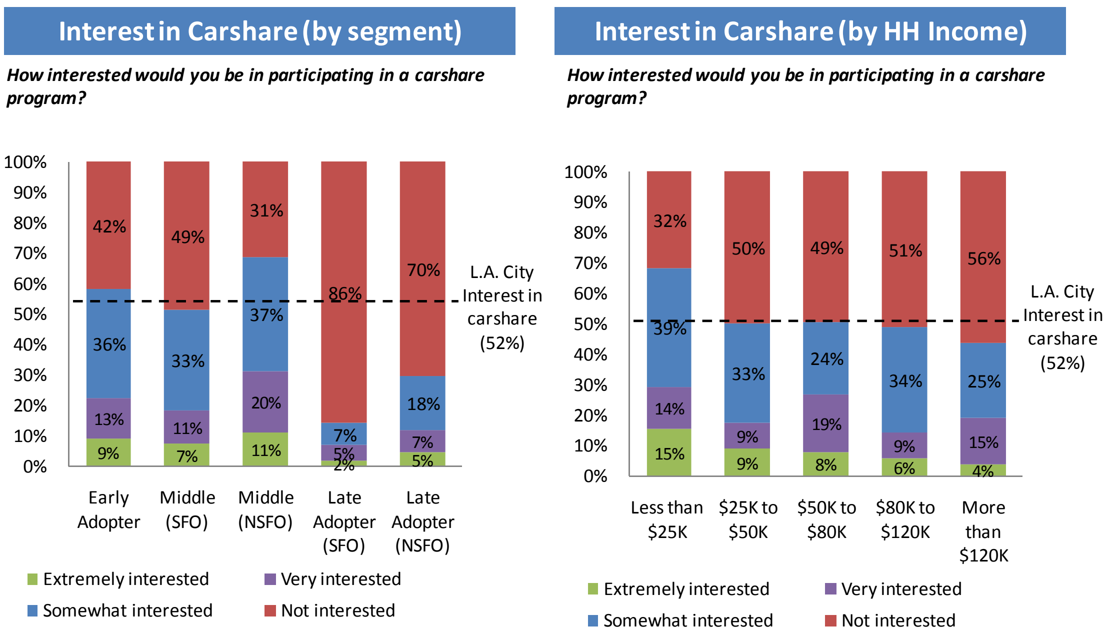
Figure 49 Cars per Household



Finally, car share may be a viable and economical option to provide greater range flexibility for L.A. drivers in the context of EV ownership. Early to Mid-Adopters showed significant interest in car share. Over 50% of sample respondents expressed interest in car share. There were difference is the interest levels among the population segments: 68% of Mid-NSFOs said expressed interest, compared with 58% for Early Adopters and 51% of Mid-SFOs. Late Adopters were largely not interested in car share, with 86% of Late-SFOs and 70% of Late-NSFOs saying they were not interested. There is an opportunity to shape opinions on car share among Early to Mid-Adopters, with 36% of Early Adopters, 33% of Mid-SFOs, and 37% of Mid-NSFOs saying they are "somewhat interested" in car share. This suggests that initiatives to demonstrate the relevance, convenience, and cost-effectiveness of car share, especially in the context of supplementing EV ownership, might help drive preference for EVs among these segments.

Furthermore, introduction of EVs via car share programs in lower income communities may be effective, as lower income households show the greatest interest in car share. Almost 70% of households earning less than $25,000 per year stated interest in car share, compared to 52% of the sample average. This group also had the highest rate of those who responded they were "somewhat interested", suggesting that there is opportunity to attract them to car share with the right incentives and information.

Figure 50 Interest in Car Share by Segment and Household Income



Takeaway #13

While L.A. drivers may not require extended range, they desire the flexibility—especially Mid to Late Adopters. Measures that will help meet this desire include:

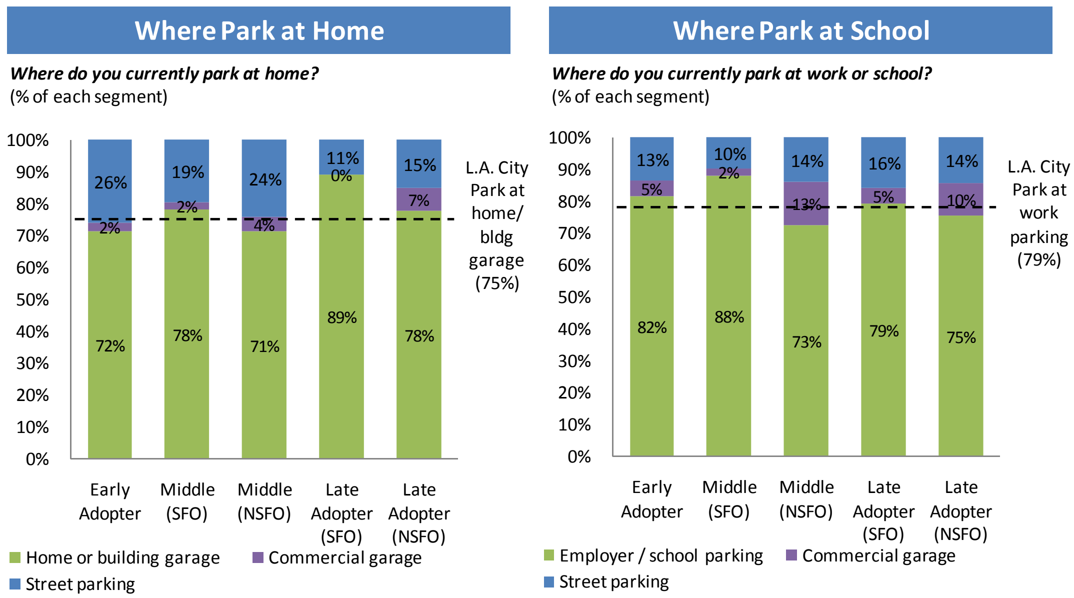
- Positioning the EV as an additional household vehicle.
- Facilitating wider and convenient access to car share (for those limited times per year one travels more than 100 miles per day).
- HOV lane access will help make EVs attractive to Mid-Adopters.

4.4.3 Access to EV Charging

4.4.3.1 Need for Public Sources of EV Charging

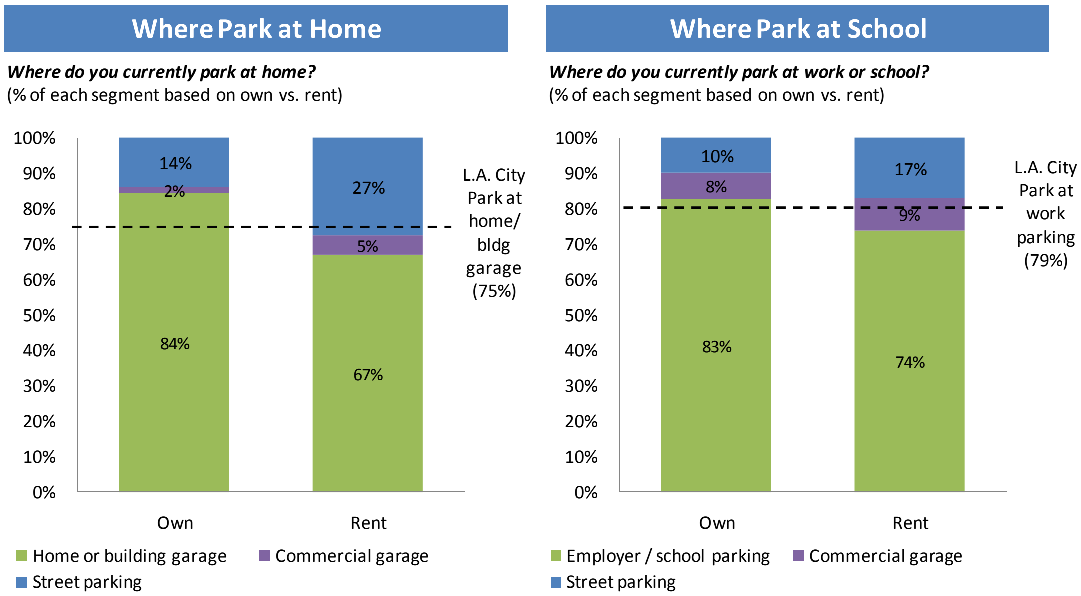
Access to charging options outside the home or parking garage will be important for the 25% of L.A.'s population who park on the street. The segments with the greatest preference for EVs are also most hindered by their lack of access to a home or parking garage where they can recharge their EVs. About 26% of Early Adopters, 19% of Mid-SFOs, and 24% of Mid-NSFOs park on the street at home. Only 11% of Late-SFOs and 15% of Late NSFOs park on the street. Respondents were more likely to have dedicated parking at work or school, which suggests that workplace charging could partially make up for the lack of charging access in a home garage. Only 13% of Early Adopters, 10% of Mid-SFOs, and 14% of Mid-NSFOs park on the street at work or school.

Figure 51 Parking Patterns at Home and at School/Work



The lack of access to parking in a home or building garage is exacerbated for renters. Nearly twice as many renters (27%) park on the street while at home than owners (14%). Renters are also more likely to park on the street at work (17%) than owners (10%). Tenants who are interested in EVs must coordinate and incentivize landlords to install charging equipment. Twenty-seven percent of renters cannot install home charging infrastructure because they don't have access to a parking space in their building.

Figure 52 Parking Patterns at Home and at School/Work Broken Down by Rent/Own



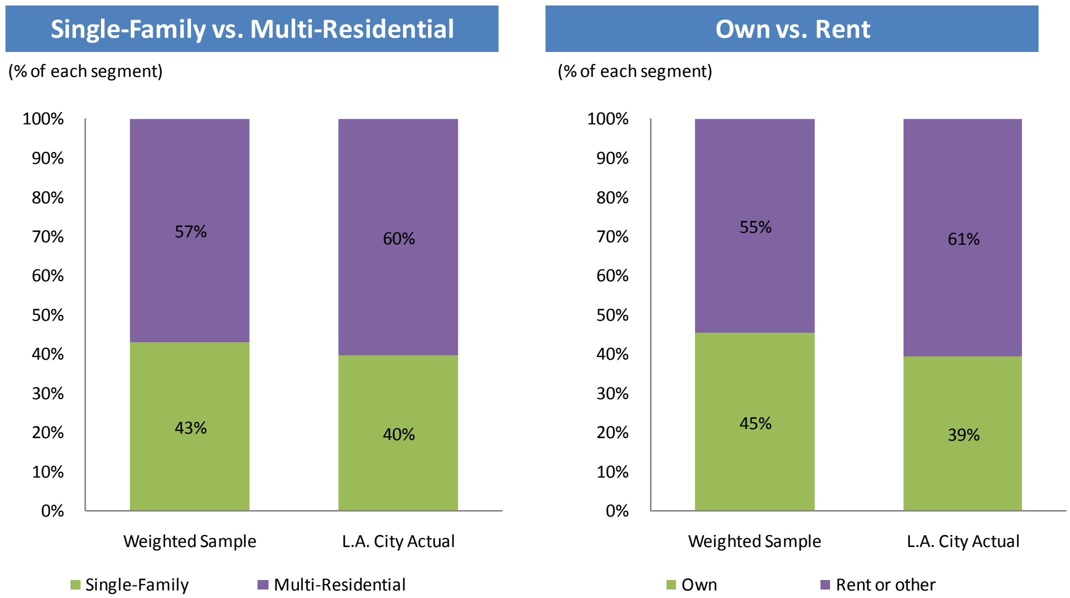
Takeaway #14

Access to public EV charging sources (i.e. commercial garages, office buildings, shopping areas) will be important for 25% of the population that rely on street parking at home and will not have a dedicated EV charger at home.

4.4.3.2 Charging in Multifamily Housing

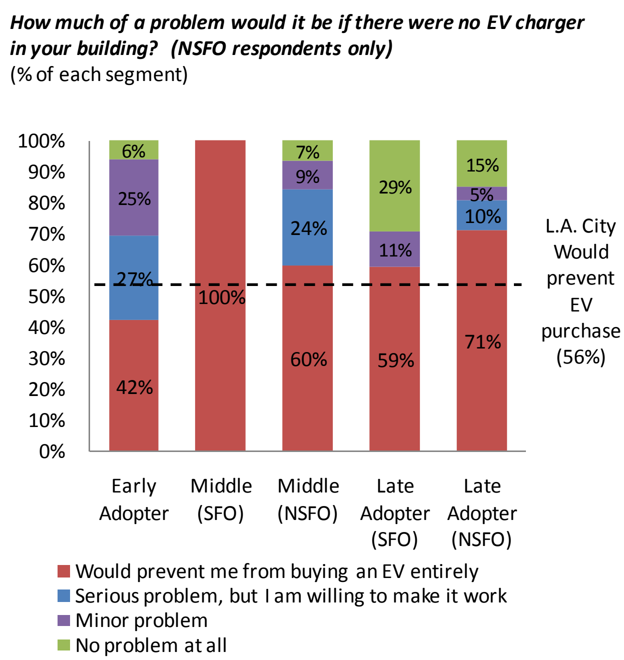
Increased access to charging infrastructure will be important to make EV ownership possible for renters and residents of multifamily housing, who make up 62% of LA's population. Otherwise, 40% of respondents stated they would be unable to purchase an EV. The sample was weighted to match Los Angeles' demographic and homeownership rates. This revealed that 70% of the sample (non-single family homeowners) would have problems coordinating the installation of charging equipment.

Figure 53 Key Housing Statistics for the Weighted Sample and L.A. City Actual



The lack of charging equipment would prevent 56% of NSFOs from purchasing an EV. (This figure is 53% for the sample that matches L.A. target demographics and home ownership). Even 42% of Early Adopters, the most enthusiastic segment, said that lack of EV charging equipment would prevent them from buying an EV. The problem is considerably worse for Mid to Late Adopters. Nearly all Mid-SFOs and 60% of Mid-NSFOs, as well as 59% of Late-SFOs and 71% of Late-NSFOs state they would not purchase an EV without access to a home charger.

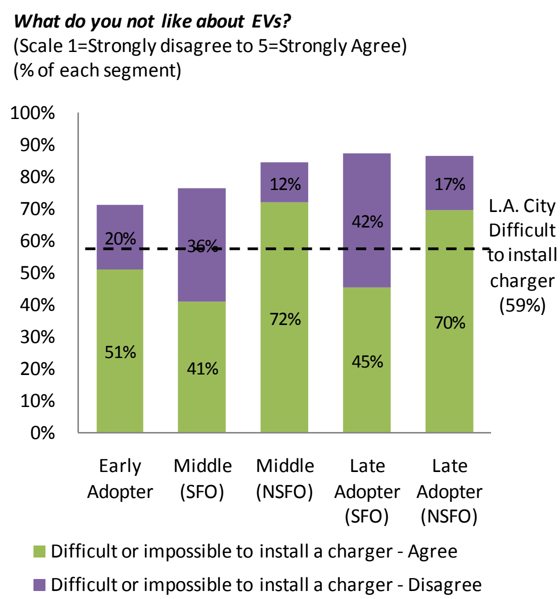
Figure 54 Non-Single Family Owners Preference to Buy an EV without Charging Availability by Segment



In total, 39% of the trimmed weighted sample[18] would be prevented from buying an EV if they could not install an EV charger at home, i.e. problems with landlords or Homeowner Associations (HOAs) over EV home charging equipment. Unfortunately, 59% of survey respondents perceived they would have difficulties in the charger installation process. This would imply that nearly 25% of the total sample would not buy an EV due to perceived difficulties with charger installation.[19]

Improving access to EV charging will be critical for certain Mid to Late segments, especially for the 72% of Mid-NSFOs and 70% of Late-NSFOs who believe that it would be difficult or impossible to install an EV charger in their home or building. One might argue that respondents may not know how difficult the process will be until they experience it. However, it is alarming to know that 59% already perceive a problem. This perception may preclude them from ever considering the possibility of an EV purchase or the installation of charging equipment at home.

Figure 55 Attitude Towards Charging Installation Difficulty



Takeaway #15

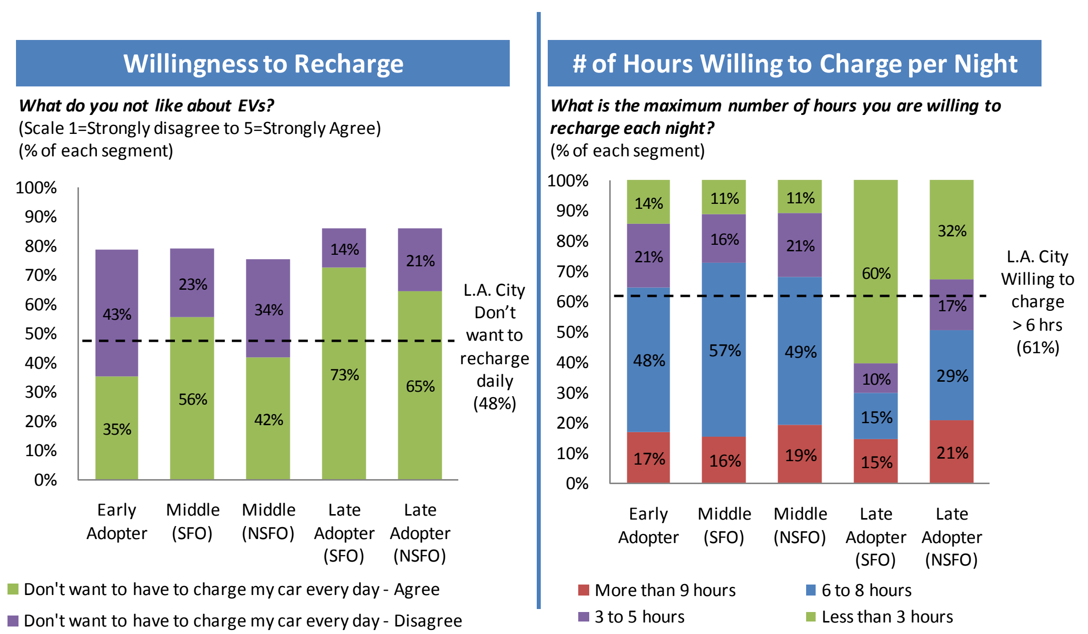
Facilitating access to EV charging in multifamily housing and rental homes will be critical to attracting Early to Mid-Adopters. Without policies to address the multifamily housing problem, we estimate that nearly 25% of the entire L.A. market would not buy an EV due to perceived difficulties with charger installation.

[18] 39% = 56% of NSFOs who would not purchase without an EV charger at home x 69% NSFOs in the sample. This is also 39% for the untrimmed sample that matches L.A.'s home ownership rates. 53% of NSFOs who would not purchase without an EV charger at home versus 74% NSFOs in the sample.
[19] 23% = 39% of the trimmed weighted sample who would be prevented from buying an EV x 59% of survey respondents who believed installing an EV charger would be difficult or impossible

4.4.3.3 *Policy Options to Support Charging*

Framing the charging experience that will support the true range needs of the majority of L.A. drivers will attract Mid to Late Adopters who are less interested in daily recharging for long periods. Almost 50% of the sample indicated that they do not want to charge their car every day. Early Adopters and Mid-NSFOs are more willing to adjust to the daily recharging, if necessary. Only 35% of Early Adopters and 42% of Mid-NSFOs do not want to recharge every day. However, Late Adopters and Mid-SFOs are less inclined to accommodate daily recharging. Over 55% of Mid-SFOs, 73% of Late-SFOs and 65% of Late-NSFOs do not want to recharge every day. Furthermore, 61% of the sample is willing to charge more than six hours. Most Early to Mid-Adopters are willing to charge six to eight hours (48% of Early Adopters, 57% of Mid-SFOs, and 49% of Mid-NSFOs), while Late Adopters are less eager to charge for long periods (70% of Late-SFOs and 49% of Late-NSFOs want to charge for less than 5 hours).

Figure 56 Attitude Towards Recharging

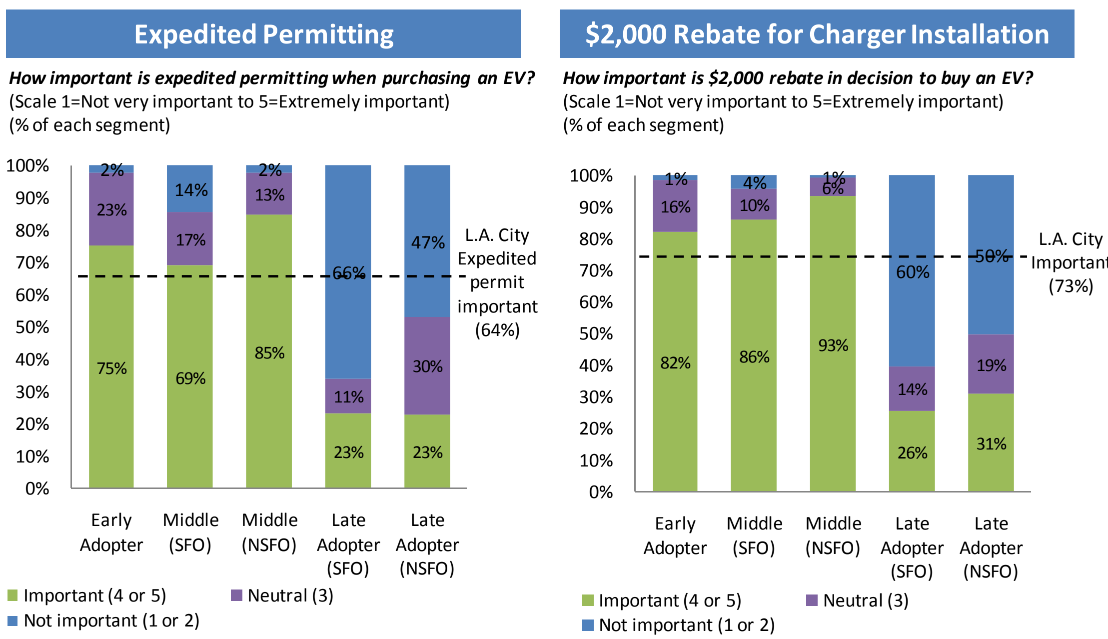


However, for over 70% of L.A. drivers who commute less than 30 miles per day (round-trip), there are multiple options to accommodate their charging preferences. The relative disinclination to recharge daily and the desire for shorter charging time might seem like a barrier for EV adoption. However, presenting the charging schedule that would be realistically required by the majority of L.A. drivers would help attract more Mid to Late Adopters. The relatively short trips made by most LA drivers means many may not have to recharge daily, which is important for Mid to Late Adopters who do not wish to find a charging source daily. Alternative charging schedules would work to meet their range needs. Most L.A. drivers can either charge for 6 to 8 hours of Level II recharge every 2 to 3 days or rely on 3 to 4 hours of Level II recharge every day.

Mid-adopters (NSFO) are particularly interested in incentives facilitating charger installation. Continued support for the following incentives will foster greater adoption amongst the shapeable majority:

- **Expedited permitting that reduces EV installation permit approval from two weeks to one day proved to be important for Early to Mid-Adopters.** About 75% of Early Adopters, 69% of Mid-SFOs, and 85% of Mid-NSFOs consider expedited permitting to be important, compared with 64% of the sample average, 23% of Late Adopters.
- **$2,000 rebate for charger installations are even more important when buying an EV for Early to Mid-Adopters.** Compared with a 73% sample average, 82% of Early Adopters, 86% of Mid-SFOs, and 93% of Mid-NSFOs consider the $2,000 rebate for charger installation to be important.

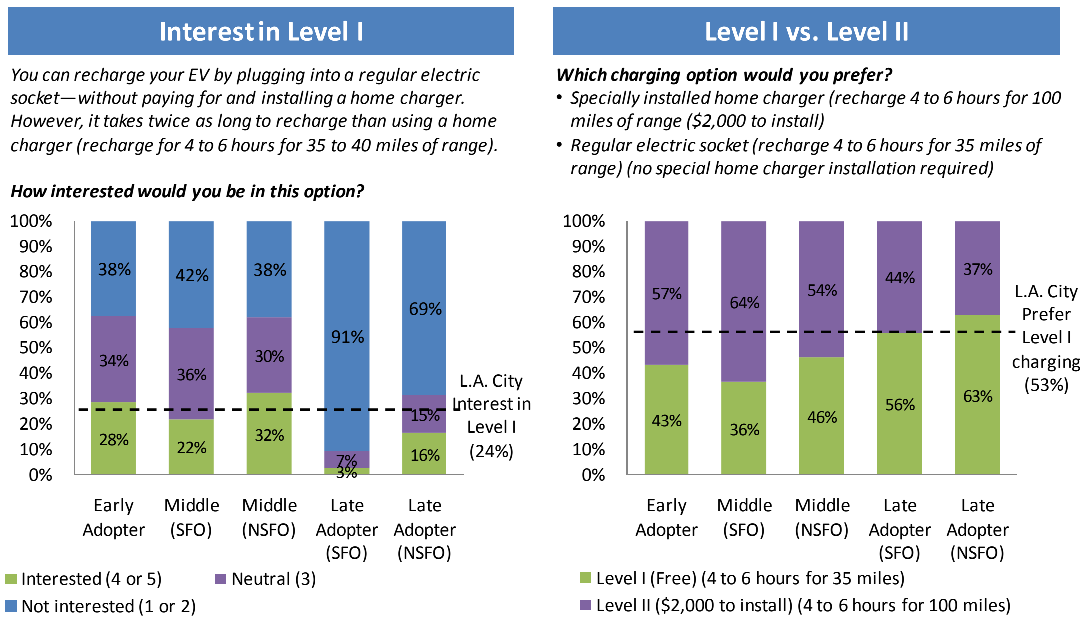
Figure 57 Attitude Towards Expedited Permitting and Charger Rebate



Finally, Level I charging may be a realistic option to support and incent greater widespread adoption among non-single family homeowners and Mid to Late Adopters. Given limited driving distances of the majority of L.A. residents, Level I charging may be a realistic opportunity for early to mid-adopters—especially when charger installation might be difficult. There is some interest in Level I charging among Early to Mid-Adopters. Level I charging uses a regular electrical socket and doesn't require installation of a special home charger installation, but takes twice as long to charge than other charging equipment (four to six hours for 35 to 40 miles of range). Early Adopters are interested in Level I charging at a rate of 28%, compared to 22% of Mid-SFOs, 32% of Mid-NSFOs, and a 24% sample average. Also promising is that a significant portion of the population remains neutral about Level I. With more education about how Level I might be enough to support the majority of L.A. drivers' range needs, a significant portion of the 34% of Early Adopters, 36% of Mid-SFOs, and 30% of Mid-NSFOs who remain neutral might consider Level I charging a viable option.

When given a choice between charging for 4 to 6 hours for 100 miles of range using a specially installed home charger at $2,000 installation cost (Level II) vs. charging for 4 to 6 hours for 35 miles of range with no home charger installation required (Level I), respondents preferring Level I increased dramatically. Preference for Level I charging increased to 43% of Early Adopters, 36% of Mid-SFOs, and 46% of Mid-NSFOs, compared with 53% of the sample, 56% of Late-SFOs and 63% of Late-NSFOs. This suggests not only that Level I charging is a viable option for L.A. residents, but also that the City can present the charging options in such a way to increase Level I adoption.

Figure 58 Interest in Level I and Level II and III Charging



These results are not to suggest that Level I should become the charging standard over Level II. Level I may be a time and cost-effective interim measure for a significant portion of L.A.'s population, given the difficulties of installing Level II equipment. Level I charging may help non-single family homeowners or neighborhoods such as Silver Lake that have significant EV interest, but have older buildings and anticipate costly upgrades needed for Level II charging. The City and DWP should further study how it can support widespread Level I charging.

Takeaway #16

The City has several policy options at its disposal to support EV charging:

- Continue to offer EV charger installation incentives, including expedited permitting and $2,000 charger installation rebate
- Educate drivers on alternative charging schedules. Most L.A. drivers can either charge for six to eight hours every two to three days on Level I, or for three to four hours daily on Level II. Facilitate Level I charging among non-single family homeowners and Mid to Late Adopters

5. EV Strategic Options for Los Angeles

5.1 Introduction

Concurrent to understanding what EV adoption may look like for the city of Los Angeles, we looked to other cities to understand the public policy options that Los Angeles should consider. This work stream is a largely qualitative examination of the incentives that other major cities around the world are enacting or seriously considering to increase EV adoption. The goal is to help answer:

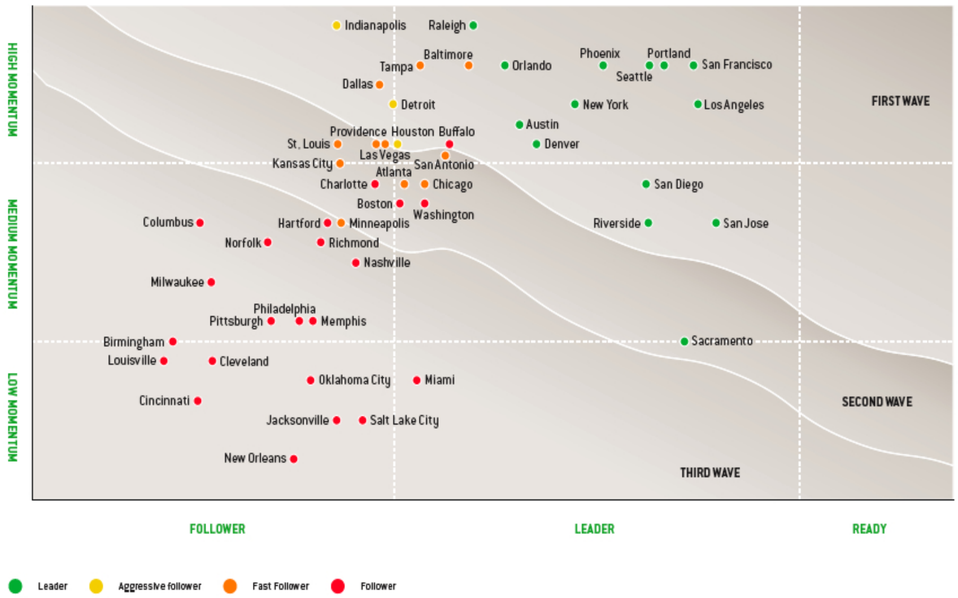
- What are the best public policy options to incentivize EV adoption?
- What are other cities doing to incentivize EV adoption, and what is L.A.'s position?
- Are these policies applicable and feasible for L.A.?

Cities around the world are experiencing the deployment of electric vehicles, many in 2010. In the European nations, generous monetary incentives are in effect to incentivize EV adoption. In the United States, ECOtality was granted $230 million to implement "The EV Project." This three-year project will deploy nearly 15,000 charging stations in 16 select cities in America, including Los Angeles. The ultimate objective of The EV Project is to "take the lessons learned from the deployment of these first 8,300 EVs, and the charging infrastructure supporting them, to enable the streamlined deployment of the next 5,000,000 EVs."[20]

Cities are at various stages of development of a support system, whether or not they are a part of the EV Project. A combination of factors affects the level of development for each city as well, including the roll-out timeline from Original Equipment Manufacturers (OEMs), city context, and public funding. The Rocky Mountain Institute conducted a preliminary analysis in 2010 of the EV-readiness in various U.S. cities:[21]

[20]The EV Project, "Overview," The EV Project website, http://www.theevproject.com/overview.php, accessed September 2010.
[21]Project Get Ready, "Report: Electric Vehicles in America," Project Get Ready website, http://projectgetready.com/resources/electric-vehicles-in-america, accessed September 2010.

Figure 59 Rocky Mountain Institute 2010 analysis of EV leadership



To identify a comprehensive menu of policy options for L.A., we selected comparable and relevant cities to conduct "mini case studies." We selected cities with commuting and demographic profiles comparable with those of Los Angeles and leaders in EV policy initiatives accessible to our team.

5.2 Methodology

Our approach in selecting cities was to funnel down from the largest cities in America. We took the major U.S. cities by population, including C40 cities (a coalition of cities that have committed to making climate change). With this set of cities, we selected criteria for evaluating demographics and commuting patterns for comparability purposes.

Demographic criteria included:[22]

- Average Residential Density (households per acre)
- Median Household Income

Commuting patterns included:

- Average Autos per Household
- Average Annual Household Gasoline Expenses (2008 gas prices)
- CO2 per Household from Household Auto Use (metric tons per household)
- Transit Ridership (% of commutes)
- Travel time to work (minutes)

[22] Center for Neighborhood Technology, "Housing & Transportation Affordability Index," Center for Neighborhood Technology website, http://htaindex.cnt.org/, accessed October 2010.

The initial results were as follows:

Figure 60 Initial results of city selection

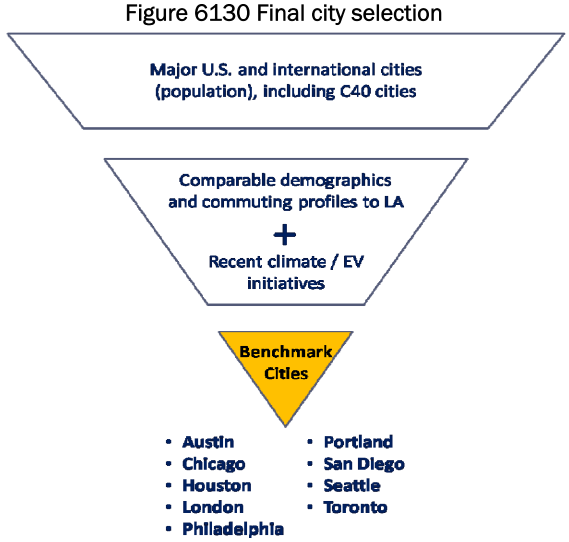
Demographics	LA*	CHI*	HOU*	PHI*	MIA	NYC*	SF	SEA	PHX	PORT	DAL	BOS
Avg Residential Density (HH/acre)	9.5	11.0	4.7	9.0	9.0	47.0	17.0	5.9	4.5	5.0	5.1	9.0
Median HH Income	42,189	51,680	44,655	47,536	35,966	45,053	63,297	52,804	44,752	47,077	48,364	55,183
Commuting	**LA***	**CHI***	**HOU***	**PHI***	**MIA**	**NYC***	**SF**	**SEA**	**PHX**	**PORT**	**DAL**	**BOS**
Avg Autos per HH	1.4	1.6	1.6	1.5	1.4	0.8	1.4	1.8	1.6	1.6	1.6	1.8
Avg Annual HH Gasoline Expenses (2008 Gas Prices)	2,903	3,512	3,402	3,343	2,899	2,010	3,478	3,939	3,768	3,958	3,547	3,497
CO_2 per HH from HH Auto Use (metric tons/HH)	6.0	7.5	8.5	7.7	6.8	4.5	6.7	8.4	23.0	8.4	8.4	7.8
Transit Ridership (% of Workers)	11%	13%	6%	12%	9%	49%	20%	9%	3%	6%	5%	14%
Travel time to work (minutes)	29.0	32.0	28.8	29.0	29.9	39.0	29.3	27.2	26.0	24.4	27.8	28.9

Blue = High
Orange = Low
*C40 city

LA & Comparables (LA, CHI, HOU, PHI, MIA) — Dense & Transit (NYC, SF) — Sparse & Private Auto (SEA, PHX, PORT, DAL)

Four of the cities were comparable to Los Angeles: Chicago, Houston, Philadelphia, and Miami. Of the remaining cities, we kept San Francisco, Seattle, and Portland based on their leadership and reputation in promoting climate change. Finally, the client requested four additional cities based on interest and accessibility: Austin (to replace Miami), San Diego, Toronto, and London. Nine cities were selected as a reasonable number given the duration of the project. The final selection was as follows:

Figure 6130 Final city selection



After identifying the cities, our approach was to conduct interviews with officials and relevant stakeholders within each city to understand the types of incentives and policies for EV adoption. This process depended on connections made by officials in the City of Los Angeles each benchmark city; accessibility was a very important piece of this work stream.

After gaining access to each city, extensive secondary research would be conducted for each city to understand the different context and background for that city. The context is considerably important because it provides an understanding of how much support a city is willing and able to provide for the EV initiatives. We have chosen a few key contextual categories for this study, including:

- **Climate affiliation** – refers to alliances and programs in which the city participates. The "EV Project" is a nationwide effort to support electric vehicle adoption by providing significant monetary incentives. This program is currently being rolled out by ECOtality in 16 selected cities and has a total of $230M in funding.
- **Political affiliation** – provides information of city's mentality towards spending and willingness to deploy resources to EV adoption
- **Utility and whether it is owned by city** – determines if the city has more levers for EV adoption
- **State-level incentives** (rebates, HOV access) – outlines state-level context for EV adoption
- **Climate & EV Goals** – illustrates city's approach towards climate change

After a reasonable amount of secondary research was conducted for background, a "lay of the land" interview with the city official, including questions about:

- Monetary incentives (e.g., rebates, tax waivers)
- Non-monetary incentives (e.g., priority parking, HOV access)
- Unique ideas

Necessary follow-up with each city was based on priority areas selected by our client. These deep dives focused on a few agreed-upon areas that were more relevant to Los Angeles, including:

- Charger permitting & installation process
- Public charging installation plan
- City rebates & monetary incentives
- City procurement commitments

The results of the interviews were "mini case studies" of cities around the United States and the world that illustrated the strategic direction and state of implementation of those cities with regard to climate change and EV-specific initiatives. The intent of these studies is for Los Angeles to understand the overall strategy behind policies, evaluate where it is positioned, and learn about specifics in the priority areas and from thought leaders. A peripheral benefit for Los Angeles would be the new relationships and strengthening of relationships between the observed cities and Los Angeles.

5.3 Ten Cities at a Glance

After conducting 16 interviews with stakeholders in nine cities, we found that the context of each city strongly guided the initiatives/programs that were enacted. Per the initial "lay of the land" interviews, the results were as follows:

Table 11 Policy options across comparison cities

	LA	HOU	POR	LON	SEA	PHI	CHI	AUS	SD	TOR[1]
Owns utility?	√				√			√		√
MONETARY POLICIES / INCENTIVES										
EV rebate/credit (state-level)	√		√	√		√	√		√	
Charger rebate/credit	√		√					√	√	
Free / discounted parking				*			*			
Discounted home charging									√	
Free public charging		*	*	*					*	
Sales tax waivers										
NON-MONETARY POLICIES / INCENTIVES										
HOV access	√	√							√	
Designated/priority parking		√		*	√	√	√			
Streamlined permitting	√	√	√	√	√	√		√	√	
# L3 public chargers in place			√				√		√	
Queue jumps	√								√	
"Clean taxi" priority										
Carshare partnership			√	√	√	√	√		√	
Building code changes	√			√	√				√	

* Regional decision [1]Has not started implementation as of February 2011

5.4 *Emerging Themes*

During the course of exploring policy options in the various cities around the US and internationally, some general themes emerged.

- EV strategy alone is not equivalent to sustainability. Many cities believe that electric vehicles are only a small portion of climate action and sustainability policymaking. While electric vehicles are zero/low emissions vehicles that benefit the environment in the automobile genre, transportation methods go beyond cars. Public transit, bicycling, and walking often have reduced environmental impacts, and many cities such as Portland and Seattle will not support EVs to the point where EVs reduce share for those modes.

- U.S. cities are still in early stages of implementation; published strategies are not necessarily indicative of implementation status. As this is the first big push for electric vehicles in thirty years, the amount of coordination and planning is tremendous for a successful roll-out. Cities are polarized between not over-committing (largely due to the unsuccessful roll-out thirty years ago) and supporting mass adoption. Published documents generally reflect the vision and not the actual state of implementation.

- Many cities are streamlining the permitting and installation process for charger installation. One key finding is that permitting and installation are the not the same thing. Some cities see it as similar due to the limited role of the city, but from a consumer perspective, receiving approval for a home charger and actually installing the charger in the home are two very different processes. Many cities are taking action to reduce the time it takes to receive a city permit for EV home chargers. Many cities have developed online portals where permits are approved the same day it is submitted (Seattle, Houston). Secondly, in terms of installation, the variance between cities is much larger. Many cities have not even considered installation a part of their role and will defer the responsibility to the consumer. The consumer is therefore responsible for understanding the coordinating process and informing all relevant parties. In these cases, consumer education is vital in supporting the mass adoption of EVs. Some cities such as Seattle have developed education materials to facilitate this process. Portland has developed a process of conducting spot inspections (via Oregon's minor label program) where one of ten installations is inspected.

- Charging access for multifamily housing is only relevant in some cities but has remained largely unexplored. For the cities where residents of multifamily housing are a relevant demographic for EV purchases, the process of permitting and installing a charger in an accessible and convenient location is a difficult issue. Most cities have not developed a streamlined process that coordinates the multiple parties: Homeowner Associations, landlords, builders and developers, the City, the utility, contractors, and OEMs. From our research, San Diego is the farthest along in this process, with ECOtality and SDG&E serving as central points of contact for coordinating installation. As the EV Project concludes and ECOtality phases itself out of the process, it will be especially important for cities to take responsibility in planning a sustainable, streamlined permitting and installation process.

- Cities that are farther along not only have strong ECOtality teams, but have actively involved utilities. In this stage of development where demand is uncertain, utilities have the tools to evaluate supply-side issues and manage demand with pricing. ECOtality can serve coordination and planning efforts in these initial phases of EV deployment, but utilities can facilitate long-term sustainable EV charging. SDG&E, PGE, and Austin Energy have taken the initiative in getting heavily involved in planning for EV deployment. They have established rates and public education materials to ease the burden on the consumer. Coordination between the utility and the city will be important in making educated policy decisions that can be properly supported by the utility.

- At the time of the survey, there had been outreach from public sector to private sector. Cities have not engaged in discussions with large employers that may support demand by providing public charging during the day. Other companies that may purchase EV fleets have not been targeted either. Rather, private companies have been promoting EVs on their own initiative (e.g., Whole Foods in Austin, Hertz EV rentals). A public-private sector partnership may prove beneficial in supporting EV adoption by providing charging infrastructure and fleet purchases, creating more public awareness and interest.

- There are little/no monetary incentives at the city level. Most monetary rebates are at the state and federal level and account for a significant portion of the cost of an electric vehicle. The EV Project also made EV charging infrastructure heavily discounted or free for its constituent cities. The types of monetary incentives available at the city level are generally free parking (at a regional level) or a waived registration fee. Austin Energy is an exception, with a $1,500 rebate for EV chargers.

- Cities are leveraging car share programs to promote EVs. Because of the public accessibility factor, car share programs are extremely popular with many cities. Some receive funding to assist with purchase of EV fleets and chargers (London, Chicago, Philadelphia), and others have partnerships where EV owners can charge their EV in ZipCar parking lots (Portland).

- Direct Current (DC) fast charging is a polarizing topic. Because standards are not yet in place for the DC connector, there is uncertainty in the roll-out of this charging method. Some cities are tabling this option, other cities have installed infrastructure and will retrofit the connector when standards emerge, and the rest of the cities are rejecting this idea. Many are enthusiastic that fully charging a car in 20-30 minutes will satisfy customer needs and will deploy infrastructure along freeways and high-traffic areas (Seattle, San Diego). Other cities believe that 20-30 minutes is unrealistic in satisfying customer demands for "fast" charging and are wary of investing in this technology (Austin).

- Currently there is low consumer knowledge and little/no marketing. Very few cities have developed education materials for consumers and marketed them. Seattle and San Diego seem to be the only cities that have developed public marketing materials that are readily accessible by residents. Seattle's "Client Assistance Memos (CAMs)" are a unique feature that the city has undertaken in prior years to educate their public on various processes. SDG&E has posted high-level process flows on their website for EV buyers in search of installing a home charger. As cities formulate and solidify EV-related processes, consumer-facing documentation will be essential in supporting EV adoption.

5.5 Options for Los Angeles

With federal and state funding for EV purchases and charging infrastructure, EV demand exceeding supply in the next few years, and involvement of key stakeholders such as the Department of Water and Power, Los Angeles is in a great position to become an EV city leader. From exploring EV policy options in cities worldwide, understanding what consumers want, and projecting supply and demand in the next ten years, we have triangulated to a few choice options for Los Angeles. Considerations in evaluating and implementing such program include **applicability** to the city and **feasibility** in implementation. Programs that are both applicable and feasible to Los Angeles are the areas that should be strongly considered as top priorities.

Increase consumer education and marketing. Based on the survey results for Los Angeles, all customer segments revealed an overall lack of knowledge about electric vehicles and incentives, especially within the Middle Adopters segment. Almost half of the respondents reported that this lack of knowledge is a barrier to purchasing an EV. Consumer education is instrumental in addressing this issue and removing the knowledge barrier will help consumers adopt this new product. The city can help bridge the knowledge gap to help alleviate uncertainty about what EVs are, how they operate, how to purchase an EV, the purchase and installation process for home chargers, and the support resources available. The marketing aspect is also important in driving adoption by the shapeable majority. The EV brand, environmental and technological image, and prestige are aspects in which OEMs have already invested, and the City can leverage this brand platform to support those marketing efforts. Feasibility is therefore fairly high in this area, as developing educational and marketing materials will not require massive investments or infrastructure. Los Angeles can look to Seattle and San Diego as benchmark cities in developing useful and succinct consumer-facing materials.

Increase multifamily housing charging availability. Increased charging access for multifamily housing opens an entire segment of the Los Angeles population to the EV market. In terms of applicability, the survey confirms that multifamily housing customers are a large part of the shapeable majority – namely, the Mid-Adopters – and could dramatically increase the adoption rate of EVs. As opposed to some other cities worldwide, multifamily housing residents are a very relevant demographic for potential EV owners in Los Angeles. The survey further states that Mid-Adopters (NSFO) are particularly interested in incentives facilitating home charger installation, confirming the need for increased charging availability to multifamily housing. The EV projection model currently has a significant demand constraint due to the lack of availability of home charging for multifamily housing customers. Alleviating this constraint could increase EV adoption to more than 13% of car sales by 2020. In terms of feasibility, this initiative will require considerable resources to engage all the stakeholders of multifamily housing, including landlords, Homeowner Associations, property managers, residents, builders and developers, OEMs, contractors, and others. San Diego is the most advanced city in this area of development and would be a great potential partner for Los Angeles. The City should strongly consider partnering with San Diego to develop different ways to provide access to multifamily housing residents.

Streamline permitting & installation process with an actively involved utility. As the amount of EV purchases increases in the next few years, it will be important for the City to create an efficient process for the permitting and installation of home charging equipment. As opposed to the experimental processes currently undertaken in these nascent stages of EV deployment, mass EV adoption will warrant an engaged City and utility to make this initiative successful. From the survey, expedited permitting is very important to early and mid-adopters in Los Angeles. From the multiple city research, cities that are farther along in supporting EV adoption all have actively participating utilities, if not utilities that are altogether leading the effort. SDG&E, Portland General Electric, and Austin Energy are utility leaders in paving the way for EV adoption. They have established processes, published consumer education materials, developed EV pricing, and have engaged in serving the EV purchaser. Permitting demands should be addressed within the same day, and Los Angeles can look to Seattle and Houston for a model to expedite requests. Installation is more difficult due to the level of coordination, but exploring programs such as those in Portland, Austin, and San Diego may prove beneficial and relevant. Mostly importantly, since Los Angeles owns the DWP, an additional level of control and tighter coordination foster greater feasibility for the City to meet these consumer demands.

6. Recommendations

Based on our analysis of the L.A. EV market, we recommend that the Mayor and the City Council, the Department of Water and Power (DWP), and other stakeholders within City Government consider some or all of the following initiatives to incentivize greater EV adoption in the City of Los Angeles. These recommendations will be especially useful in attracting the shapeable majority of potential customers.

- The Mayor's Office (in conjunction with OEMs and non-profit organizations) should lead a public education campaign to highlight the following aspects of EV ownership:
    - Availability of EV incentives
    - EV safety and reliability
    - Adequacy of EV range to accommodate actual range needs of most drivers
    - Total Cost of Ownership (TCO) savings potential of EVs
    - Convenience and non-intrusiveness of the charging experience

  Specifically, the Mayor's Office might consider some or all of the following initiatives:
    - Private-public test-drive events (in all neighborhoods) with EV and charging equipment companies and DWP
    - Social and traditional media campaign
    - High-profile public relations events by the Mayor

- DWP is in the best position to affect ongoing (if not upfront) TCO and can do much to shape consumer understanding of EV-related cost-savings. Specifically, DWP should consider the following initiatives:
    - Conduct a pricing study to craft a rate plan for EV charging that is competitive, incentivizes desirable off-peak charging, and is easy to understand and communicate. This may require price / electricity rate experiments to understand pricing structure. The DWP should consider a wide range of options, including an interruptible EV rate.

    - Conduct a revenue analysis to consider the impact of alternative pricing schemes on overall demand. The survey indicated that mid-adopters would react to DWP pricing incentives (that are well communicated and easy to understand). Mid-Adopters currently perceive a large gap between price and perceived value of EVs, and place emphasis on ongoing battery costs in their decision to buy an EV. DWP might also consider transferring anticipated revenue gains from an EV customer (on a discounted basis) via either an upfront rebate or a forward contract to purchase the battery (for storage and reuse by DWP).

    - Offer an online interactive tool for prospective EV drivers that quantifies TCO savings (upfront and on-going) and reduced carbon footprint based on respondent's driving patterns, anticipated charging times, and electricity rate plan preferences. Such a tool should also be designed to gain valuable information gain about market attitudes, preferences, and concerns about EV ownership.

- The Mayor and the City Council should consider policies designed to increase access to at-home and public charging infrastructure, including:

    - Policies to expand access to EV charging in multifamily housing and rental properties. Incentivize commercial and residential real estate developers, landlords and HOAs, and

EV charging equipment companies to improve the charger installation process for renters.

    - Increase understanding of the factors which drive electric vehicle charger installation costs in multifamily buildings. Consider reserving a number of $2,000 rebates for charger installations in multifamily settings, and collecting high quality data from these installations.

    - Policies to increase public charging network in office buildings, shopping malls, and curbside charging.

    - Offer and facilitate Level I charging in the near term.

- Consider greater access to car share around high-density areas in the city, and in particular, in low-income neighborhoods. A limited EV car share or trial program (via a private-public partnership) may also serve as an opportunity to understand driving and charging patterns.

- Finally, the Mayor and the City Council should continue to offer or advocate for monetary and non-monetary incentives for EV drivers (except free parking), in order to attract the shapeable majority. In particular:

    - Advocate for EV priority lanes and zones, and the continuation of key monetary incentives including the proposed federal $7,500 point of purchase refund and the $5,000 California tax credit.

    - Streamline the permitting process down to two weeks and continue to offer the $2,000 charger installation rebate in order to reach Mid-Adopters.

    - However, free street-side metered parking will not be an effective policy tool to increase greater EV purchases.

7. Appendices

7.1 L.A. EV Market Survey

Thank you very much for taking our survey on the Electric Vehicle (EV) market in Los Angeles.

1. Are you currently in the market to purchase a vehicle?

   - Yes
   - No

2. If not, when do you expect to buy your next vehicle?

   - Less than 1 year
   - In 1 year
   - In 3 years
   - In 5 years or more

3. When deciding on which car to buy, with whom do you make the decision?

   - By myself
   - With my spouse or significant other
   - With my parents or relatives

4. Will you buy a new or used car?

   - New car
   - Used car
   - Don't know

5. How much would you be willing to spend for a new car?

   - I don't buy new cars
   - Less than $18,000
   - $18,000 - $26,000
   - $26,000 - $34,000
   - $34,000 - $42,000
   - More than $42,000

6. How much do you care about the following when purchasing a new car?
(Scale 1=I do not care at all to 5=I care a lot)

Not care at all ⟷ Care a lot

Sticker price	1	2	3	4	5
Maintenance cost	1	2	3	4	5
Gas mileage	1	2	3	4	5
Performance and power	1	2	3	4	5
Safety and reliability	1	2	3	4	5
Exterior and interior design	1	2	3	4	5
Advanced technology and electronics	1	2	3	4	5
Pollution / environmental impact	1	2	3	4	5

7. What type of car(s) does your family own?

- Compact / mid-sized sedan
- Hybrid
- Luxury
- SUV
- Sports car
- Mini-van
- Truck
- Other

[Note to Polimetrix: Please enable multiple selections]

8. How long do you expect to own a car before replacing it?

- Less than 3 years
- 3 to 5 years
- 6 to 8 years
- More than 8 years

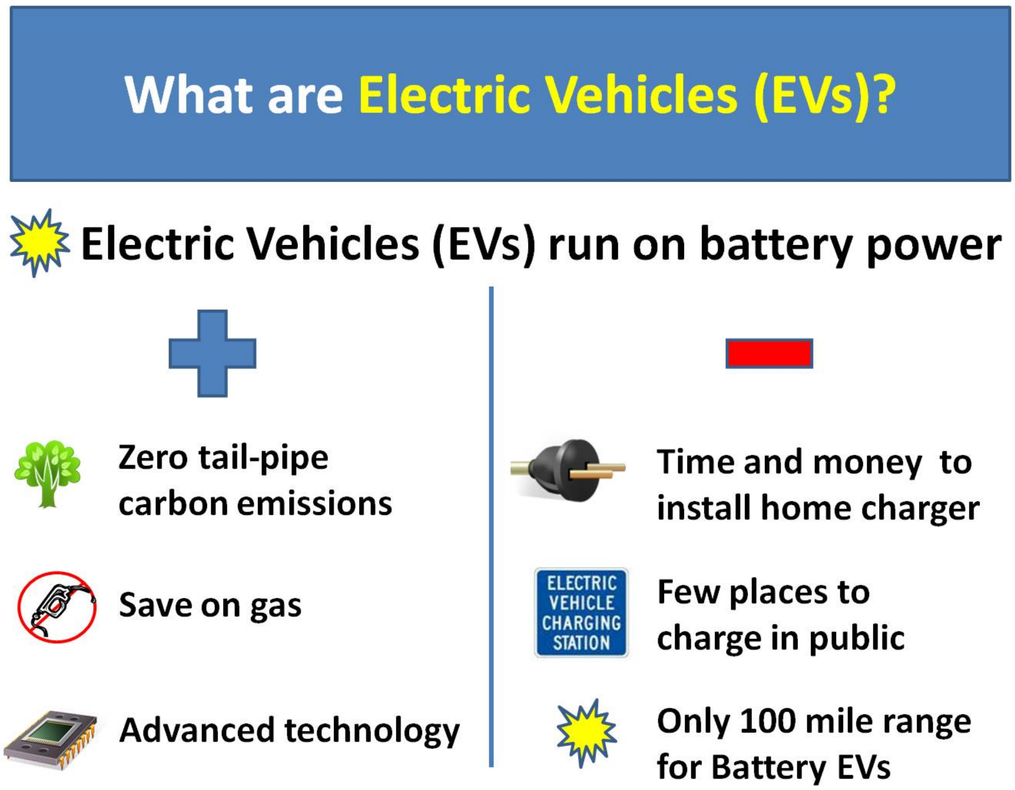
9. How much do you know about electric vehicles (EVs)?

- No knowledge
- Little knowledge
- Some knowledge
- Lot of knowledge

10. How much do you know about government incentives to buy electric vehicles (EVs)?

- No knowledge
- Little knowledge
- Some knowledge
- Lot of knowledge

11.



26. How much more would you pay for the following cars?
(Scale 1=Would not pay more to 5=Would pay a lot more)

	Would not pay more				Would pay a lot more
A car that is better for the environment	1	2	3	4	5
A car with the latest technology	1	2	3	4	5

27. What is the more important priority?

- Protecting the environment
- Growing the economy
- Equally important

28. How serious a problem do you think global warming is?

- Very serious
- Somewhat serious
- Not very serious
- Not sure

29. Assume the following:

Gas prices INCREASE to
$5.00 per gallon

How much more likely would you be to consider an EV for your next car purchase? (Scale 1=strongly disagree to 5=strongly agree)

Not more likely ⟷ A lot more likely

1	2	3	4	5

12.

How far can I go in my
Battery EV?

Battery EV → **All battery power** → **100 miles**

Most people drive less than 100 miles per day

If your household has more than 1 car, you can use the EV for short trips and the non-EV for longer trips

13. How many miles do you drive per day on average?

- Less than 25 miles
- 25 to 50 miles
- 50 to 75 miles
- 75 to 100 miles
- More than 100 miles

14. How many times per year do you drive more than 100 miles in a day?

- Never
- 1 to 4 times per year
- 5 to 8 times per year
- 9 to 12 times per year
- More than 12 times per year

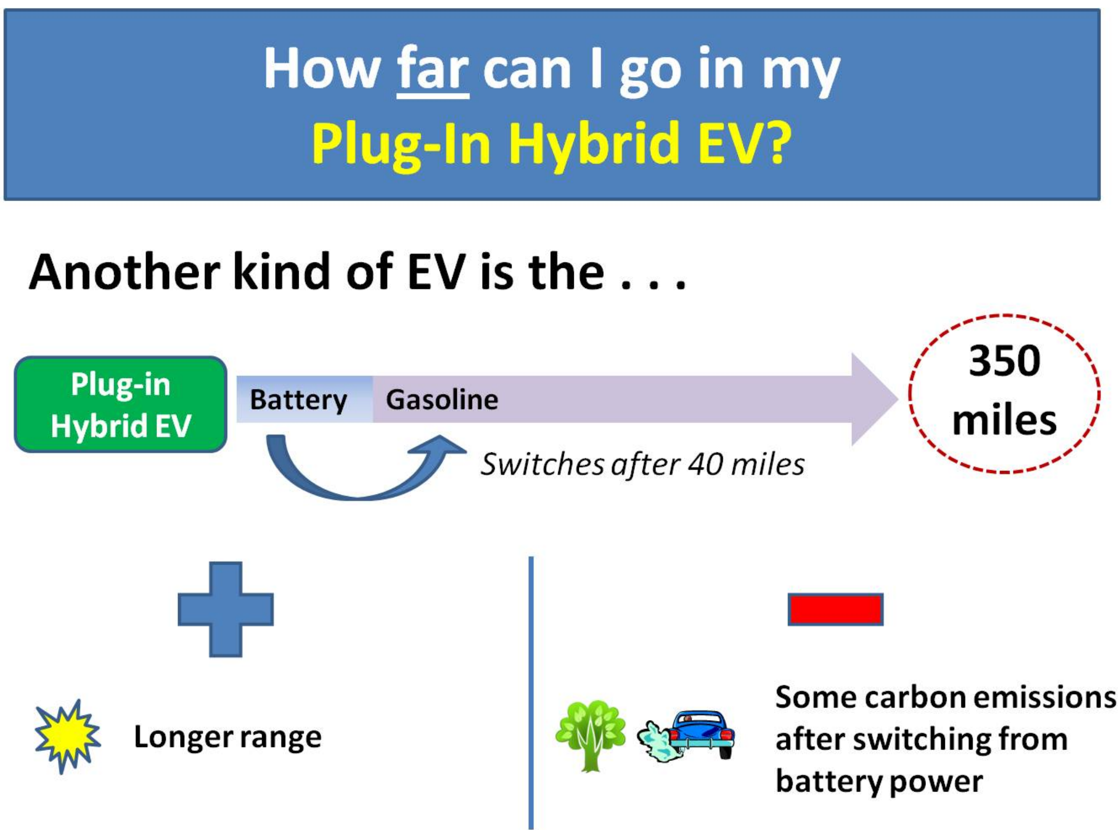
15. How many cars do you own in your household?

- 0 cars
- 1 car
- 2 cars
- 3 or more cars

16. How much of a problem would the 100 mile range of a Battery EV be for you?

- No problem at all
- Minor problem only
- Serious problem, but I am willing to make it work
- Would prevent me from buying a Battery EV entirely

17.



18. In what zipcode do you live? ____________

19. If you commute, what is the zipcode of where you work or go to school?
(If you don't know, write the neighborhood) _________________

20. Where do you currently park at home?

- Home or building garage

- ○ Commercial garage
- ○ Street parking
- ○ I don't have a car

21. Where do you currently park at work or school?

- ○ Employer / school parking lot or garage
- ○ Commercial garage
- ○ Street parking
- ○ I don't have a car
- ○ I don't commute to work / school

22. How often do you pay for metered parking on the street?

- ○ Never
- ○ 1 to 2 times per month
- ○ 3 to 4 times per month
- ○ 5 to 6 times per month
- ○ More than 7 times per month

23. How much would you care about the following incentives when buying an EV?
(Scale 1=I do not care at all to 5=I care a lot)

Not care at all ⟷ Care a lot

 HOV lane access	1	2	3	4	5
 Free EV-only street parking	1	2	3	4	5

24. Do you own or rent your home?

- ○ Own
- ○ Rent

25. Do you live in a multi-residential or single-family home?

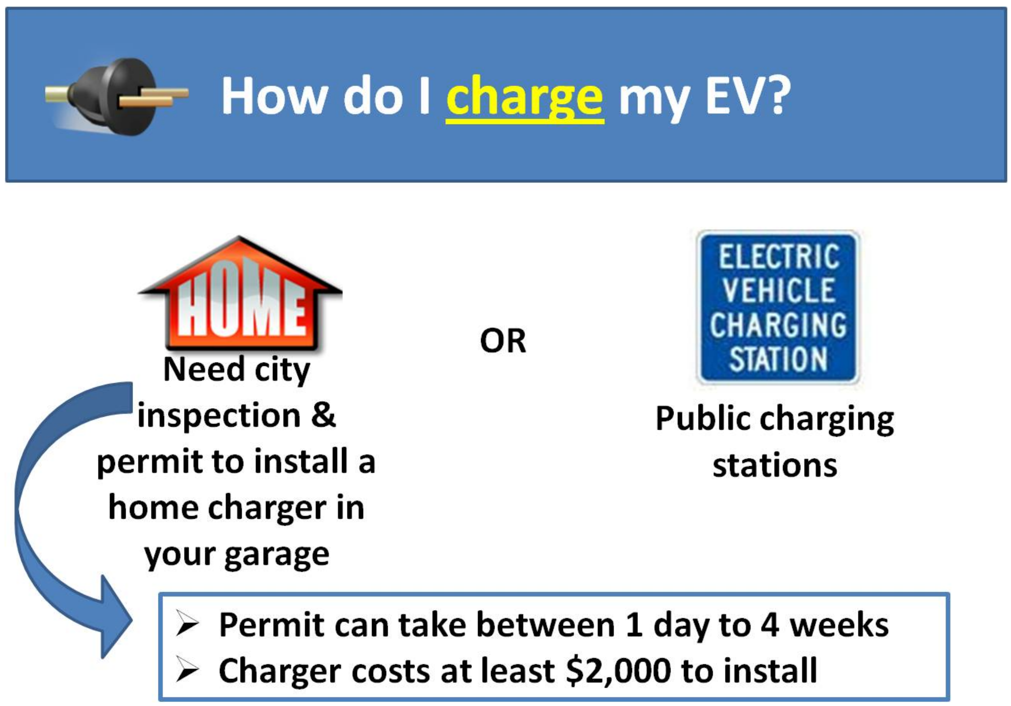
- ○ Single-family
- ○ Multi-residential

Survey splits into (2) branches at this point:

Branch 1 – Single Family Owned (SFO)

Branch 2 – Non-Single Family Owned (NSFO)

26.



How much would you care about the following incentives for driving an EV? (Scale 1=I do not care at all to 5=I care a lot)

Not care at all ↔ Care a lot

Express 1-day permit for charger installation	1	2	3	4	5
Free charger installation	1	2	3	4	5

27. How long would you be willing to plug in your vehicle to recharge each night?

- Less than 3 hours
- 3 to 5 hours
- 6 to 8 hours
- 9 to 11 hours
- More than 11 hours

30. What do you like about EVs?
(Scale 1=Strongly disagree to 5=Strongly agree)

	Strongly disagree	⟷			Strongly agree
EVs are good for the environment	1	2	3	4	5
I am very interested in new technology	1	2	3	4	5
I want to save on gas	1	2	3	4	5

31. What do you NOT like about EVs?
(Scale 1=Strongly disagree to 5=Strongly agree)

	Strongly disagree	⟷			Strongly agree
EVs cost too much for what they offer	1	2	3	4	5
It will be difficult or impossible to install a charger in my home or building	1	2	3	4	5
I don't want to have to charge my car every day	1	2	3	4	5
I want to go more than 100 miles before recharging	1	2	3	4	5
EVs do not come in the designs and styles I prefer	1	2	3	4	5
I'm concerned about their safety and reliability	1	2	3	4	5
I don't know enough about them	1	2	3	4	5

32. Suppose that you and your family were buying a car today.

How important would the following factors be in when buying an EV?
(Scale 1=Not very important to 5=Very important)

Not very important ⟷ Very important

Price of EV	1	2	3	4	5
Range of EV	1	2	3	4	5
Environmental benefits	1	2	3	4	5
Current gas prices	1	2	3	4	5
Cost to recharge battery	1	2	3	4	5
More auto companies offer greater variety of EV models	1	2	3	4	5

33. How important would the following incentives be in when buying EV?
(Scale 1=Not very important to 5=Very important)

Not very important ⟷ Very important

$2,000 cash back for home charger installation	1	2	3	4	5
Express 1-day home charger permitting	1	2	3	4	5
HOV lane access incentive	1	2	3	4	5
Free EV street parking incentive	1	2	3	4	5

28. Suppose that you and your family were buying a car today.

How would you rate your preference for each of the following cars, on a scale of 0 to 10? (0=Dislike a lot to 10=Like a lot)

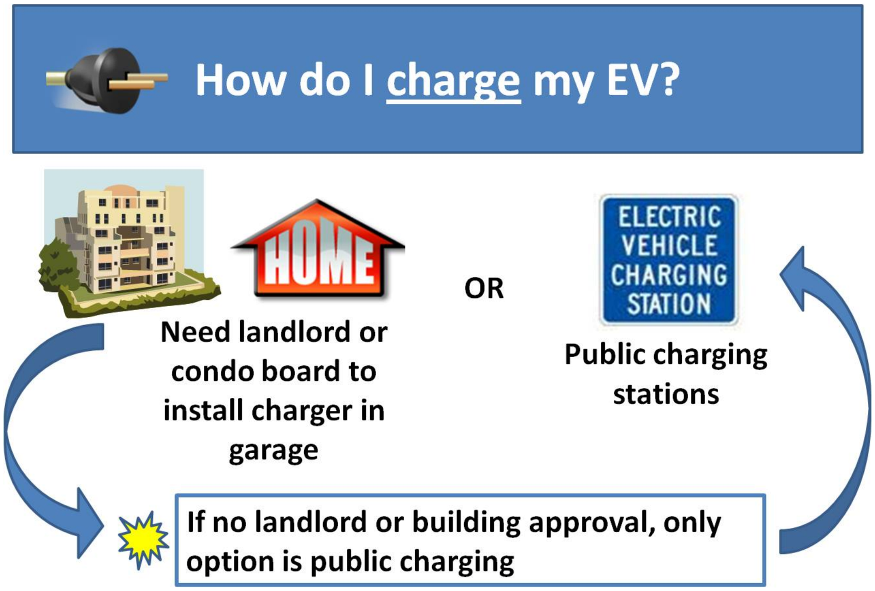
Gas prices INCREASE to
$5.00 per gallon

	Price	Range	Environment	Home Charger Installation	Government Incentives
Gasoline Compact Car	$19,000	350 miles			
Hybrid	$24,000	350 miles			
Battery EV	$36,000	100 miles		FREE charger installation + 1 DAY for permit	ACCESS OK CLEAN AIR VEHICLE CALIFORNIA HOV lane access + FREE Free EV-only street parking
Plug-In Hybrid EV	$42,000	350 miles		FREE charger installation + 1 DAY for permit	ACCESS OK CLEAN AIR VEHICLE CALIFORNIA HOV lane access + FREE Free EV-only street parking

[1 of 16 randomly selected SFO profiles]

[Branch 2 - Questions for Non Single-Family Owned]

26.



If you were thinking about buying EV, how much of a problem would it be if there was no EV charger in your home or building garage?

- No problem at all
- Minor problem
- Serious problem, but I am willing to make it work
- Would prevent me from buying an EV entirely

29. How long would you be willing to plug in your vehicle to recharge each night?

- Less than 3 hours
- 3 to 5 hours
- 6 to 8 hours
- 9 to 11 hours
- More than 11 hours

34. What do you like about EVs?
(Scale 1=Strongly disagree to 5=Strongly agree)

Strongly disagree ⟷ Strongly agree

EVs are good for the environment	1	2	3	4	5
I am very interested in new technology	1	2	3	4	5
I want to save on gas	1	2	3	4	5

35. What do you NOT like about EVs?

(Scale 1=Strongly disagree to 5=Strongly agree)

Strongly disagree ⟷ Strongly agree					
EVs cost too much for what they offer	1	2	3	4	5
It will be difficult or impossible to install a charger in my home or building	1	2	3	4	5
I don't want to have to charge my car every day	1	2	3	4	5
I want to go more than 100 miles before recharging	1	2	3	4	5
EVs do not come in the designs and styles I prefer	1	2	3	4	5
I'm concerned about their safety and reliability	1	2	3	4	5
I don't know enough about them	1	2	3	4	5

36. Suppose that you and your family were buying a car today.

How important would the following factors be when buying an EV?
(Scale 1=Not very important to 5=Very important)

Not very important ⟷ Very important					
Price of EV	1	2	3	4	5
Range of EV	1	2	3	4	5
Environmental benefits	1	2	3	4	5
Current gas prices	1	2	3	4	5
Cost to recharge battery	1	2	3	4	5
More auto companies offer greater variety of EV models	1	2	3	4	5

37. How important would the following incentives be in when buying an EV?
(Scale 1=Not very important to 5=Very important)

Not very important ⟷ Very important					
$7,500 federal tax credit	1	2	3	4	5
$5,000 CA state tax credit	1	2	3	4	5
$2,000 cash back for home charger installation	1	2	3	4	5
Express home charger permitting	1	2	3	4	5
HOV lane access incentive	1	2	3	4	5
Free EV street parking incentive	1	2	3	4	5

27. Suppose that you and your family were buying a car today.

    How would you rate your preference for each of the following cars, on a scale of 0 to 10?
    (0=Dislike a lot to 10=Like a lot)

Gas prices DECREASE to
$2.50 per gallon

	Price	Range	Environment	Home Charger	Government Incentives
Gasoline Compact Car	$19,000	350 miles			
Hybrid	$24,000	350 miles			
Battery EV	$20,000	100 miles		Charger NOT AVAILABLE in your garage	HOV lane access + Free EV-only street parking
Plug-In Hybrid EV	$26,000	350 miles		Charger NOT AVAILABLE in your garage	HOV lane access + Free EV-only street parking

[1 of 16 randomly selected NSFO profiles]

Thank you very much for taking our survey. We deeply appreciate your time and effort.

7.2 L.A. EV Market Conjoint Profiles

Single Family Owned Profiles							
SFO Card	Price (BEV)	Price (PHEV)	HOV	Parking	Install time	Charger cost	Gas Price
1	$36K	$42K	HOV	Parking	1 day	$0	$5.00
2	$36K	$34K	No HOV	No parking	2 weeks	$0	$2.50
3	$28K	$26K	No HOV	No parking	1 day	$2,000	$5.00
4	$28K	$26K	HOV	No parking	2 weeks	$2,000	$2.50
5	$28K	$34K	No HOV	Parking	1 day	$2,000	$2.50
6	$36K	$42K	HOV	No parking	1 day	$2,000	$2.50
7	$36K	$26K	No HOV	No parking	2 weeks	$0	$2.50
8	$20K	$34K	HOV	No parking	2 weeks	$2,000	$5.00
9	$36K	$34K	HOV	Parking	2 weeks	$2,000	$5.00
10	$20K	$34K	No HOV	No parking	1 day	$0	$5.00
11	$28K	$42K	HOV	No parking	2 weeks	$0	$5.00
12	$20K	$42K	No HOV	Parking	2 weeks	$2,000	$2.50
13	$28K	$34K	HOV	Parking	2 weeks	$0	$2.50
14	$20K	$26K	HOV	Parking	1 day	$0	$2.50
15	$36K	$26K	No HOV	Parking	2 weeks	$2,000	$5.00
16	$28K	$42K	No HOV	Parking	2 weeks	$0	$5.00

Non-Single Family Owned Profiles						
Non-SFO Card	Price (BEV)	Price (PHEV)	HOV	Parking	Home charging	Gas Price
1	$20K	$26K	HOV	Parking	Not available	$2.50 per gal
2	$28K	$34K	No HOV	No parking	Not available	$5.00 per gal
3	$28K	$26K	HOV	Parking	Not available	$5.00 per gal
4	$20K	$42K	HOV	No parking	Available	$5.00 per gal
5	$20K	$34K	HOV	No parking	Available	$5.00 per gal
6	$20K	$26K	No HOV	No parking	Not available	$5.00 per gal
7	$20K	$42K	No HOV	Parking	Not available	$2.50 per gal
8	$28K	$26K	No HOV	Parking	Available	$5.00 per gal
9	$36K	$34K	No HOV	No parking	Not available	$2.50 per gal
10	$28K	$26K	No HOV	No parking	Available	$2.50 per gal
11	$28K	$34K	HOV	Parking	Available	$2.50 per gal
12	$36K	$26K	HOV	No parking	Available	$2.50 per gal
13	$36K	$34K	HOV	Parking	Not available	$5.00 per gal
14	$20K	$34K	No HOV	Parking	Available	$2.50 per gal
15	$28K	$42K	HOV	No parking	Not available	$2.50 per gal
16	$36K	$42K	No HOV	Parking	Available	$5.00 per gal

7.3 Survey Sample by Polimetrix[23]

Out of 4,775 invitations that were sent out, 2,282 panelists started the survey (a response rate of 43.4%) and 2,282 panelists 2,072 completed the survey (a completion rate of 90.8%). The respondents were all members of Polimetrix's opt-in Internet panel. Invitations are emailed to qualified panelists by a process called "turbosampling" and panelists are rewarded "Polling Points" for each survey they complete. Polling Points can be redeemed for various rewards, but the standard equivalent is that 100,000 points can be redeemed for $100. Respondents to the L.A. EV Market Survey were rewarded 500 points (the standard reward for relatively short surveys). Invitations are sent out for currently fielding surveys every half hour based on current completes and the length of the field period, which gives slow-to-respond panelists time to respond (rather than taking the first set who show up). Targeted populations are defined for each survey, which range from very generic general populations to more specific populations (like LA residents for this survey).

Survey Panel Data. The PollingPoint panel, a proprietary opt-in survey panel, is comprised of 1.6 million U.S. residents who have agreed to participate in YouGov's Web surveys. At any given time, YouGov maintains a minimum of five recruitment campaigns based on salient current events. Panel members are recruited by a number of methods and on a variety of topics to help ensure diversity in the panel population. Recruiting methods include Web advertising campaigns (public surveys), permission-based email campaigns, partner sponsored solicitations, telephone to Web recruitment (RDD based sampling), and mail to Web recruitment (Voter Registration Based Sampling). The primary method of recruitment for the PollingPoint Panel is Web advertising campaigns that appear based on keyword searches. In practice, a search in Google may prompt an active PollingPoint advertisement soliciting opinion on the search topic. At the conclusion of the short survey respondents are invited to join the PollingPoint panel in order to receive and participate in additional surveys. After a double opt-in procedure, where respondents must confirm their consent by responding to an email, the database checks to ensure the newly recruited panelist is in fact new and that the address information provided is valid. Additionally, YouGov augments their panel with difficult to recruit respondents by soliciting panelists in telephone and mail surveys.

Sampling and Sample Matching. Sample matching is a methodology for selection of "representative" samples from non-randomly selected pools of respondents. It is ideally suited for Web access panels, but could also be used for other types of surveys, such as phone surveys. Sample matching starts with an enumeration of the target population. For general population studies, the target population is all adults, and can be enumerated through the use of the decennial Census or a high quality survey, such as the American Community Survey. In other contexts, this is known as the sampling frame, though, unlike conventional sampling, the sample is not drawn from the frame. Traditional sampling, then, selects individuals from the sampling frame at random for participation in the study. This may not be

[23] This explanation of the survey sampling methodology was provided by Delia Bailey from Polimetrix in an e-mail dated March 1, 2011.

feasible or economical as the contact information, especially email addresses, is not available for all individuals in the frame and refusals to participate increase the costs of sampling in this way.

Sample selection using the matching methodology is a two-stage process. First, a random sample is drawn from the target population. We call this sample the target sample. Details on how the target sample is drawn are provided below, but the essential idea is that this sample is a true probability sample and thus representative of the frame from which it was drawn. Second, for each member of the target sample, we select one or more matching members from our pool of opt-in respondents. This is called the matched sample. Matching is accomplished using a large set of variables that are available in consumer and voter databases for both the target population and the opt-¬-in panel. The purpose of matching is to find an available respondent who is as similar as possible to the selected member of the target sample. The result is a sample of respondents who have the same measured characteristics as the target sample. Under certain conditions, described below, the matched sample will have similar properties to a true random sample. That is, the matched sample mimics the characteristics of the target sample. It is, as far as we can tell, "representative" of the target population (because it is similar to the target sample). When choosing the matched sample, it is necessary to find the closest matching respondent in the panel of opt-¬-ins to each member of the target sample.

Polimetrix employs the proximity matching method to find the closest matching respondent. For each variable used for matching, we define a distance function, d(x,y), which describes how "close" the values x and y are on a particular attribute. The overall distance between a member of the target sample and a member of the panel is a weighted sum of the individual distance functions on each attribute. The weights can be adjusted for each study based upon which variables are thought to be important for that study, though, for the most part, we have not found the matching procedure to be sensitive to small adjustments of the weights. A large weight, on the other hand, forces the algorithm toward an exact match on that dimension.

Sampling Frame and Target Sample. YouGov constructed a national sampling frame from the 2007 American Community Survey, including data on age, race, gender, education, marital status, number of children under 18, family income, employment status, citizenship, state, and metropolitan area. The frame was constructed by stratified sampling from the full 2007 ACS sample with selection within strata by weighted sampling with replacements (using the person weights on the public use file). Data on voter registration status and turnout were matched to this frame using the November 2008 Current Population Survey. The target sample of 500 Los Angeles metropolitan area residents was selected with stratification by age, race, gender, education, and with simple random sampling within strata.

7.4 Survey Weighting by Polimetrix[24]

Since matching is approximate, rather than exact, and response rates vary by group. The sample of completed interviews normally shows small amounts of imbalance that can be corrected by post-stratification weighting.

Raking, first proposed by Deming and Stephan (1940), adjusts an initial set of weights to match a known set of population marginals, using a method of iterative proportional fitting (see Bishop, Fienberg and Holland, 1975 for details). In this procedure, the weights are adjusted sequentially to match the marginal distribution of each weight variable. The process proceeds until all marginals are matched. It does not require any information about the joint distribution of the variables (though, if these data are available and believed to be important, they can be employed by defining a marginal distribution involving a cross-¬-classification of two variables).

We calculated post-stratification weights by raking the completed interviews to known marginals for the general population of Los Angeles city from the 2009 American Community Survey for the following variables: age, race, gender, education, income, own/rent status, and single family/multi-family residence. Political party affiliation marginals for Los Angeles county residents were obtained from January and March 2010 Public Policy Institute of California statewide surveys.

We weighted the survey data results, in order to match the population of the City of Los Angeles as closely as possible.[25] However, the weights were trimmed in order to avoid sacrificing statistical robustness. Matching L.A. City target marginals exactly with untrimmed weights would have resulted in 2% of the sample being given over 50% of total weightings. The weighted sample remains slightly more affluent and educated, more married, more White and less Latino, more politically conservative and has a slightly higher percentage of single-family residents and home owners than the City of Los Angeles.

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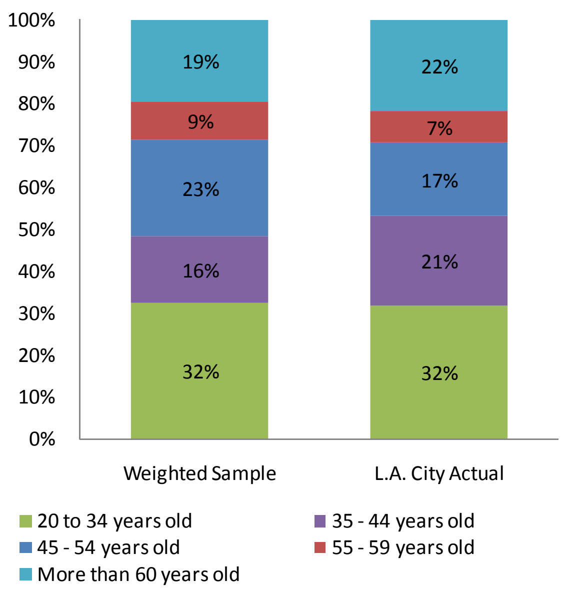
[24] This explanation of the survey weighting methodology was provided by Delia Bailey from Polimetrix in an e-mail dated March 1, 2011.

[25] Target race, age, education, and home ownership data for the City of Los Angeles were taken from the 2009 Annual Community Survey by the U.S. Census. Target political affiliation data for the L.A. County was taken from the Public Policy Institute of California (PPIC) Statewide Survey (March 2010).

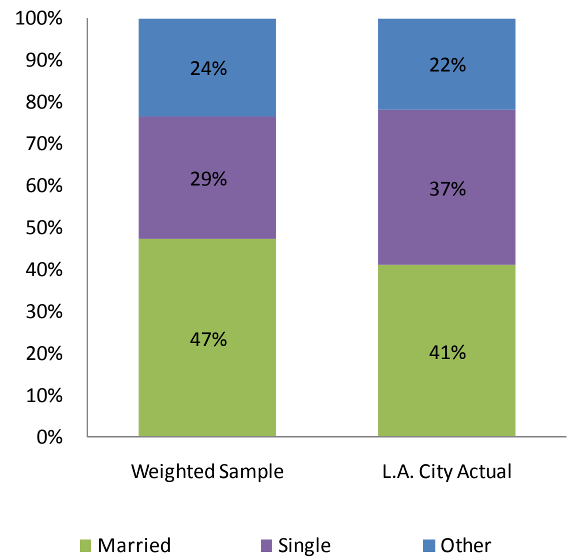
Age

(% of each segment)



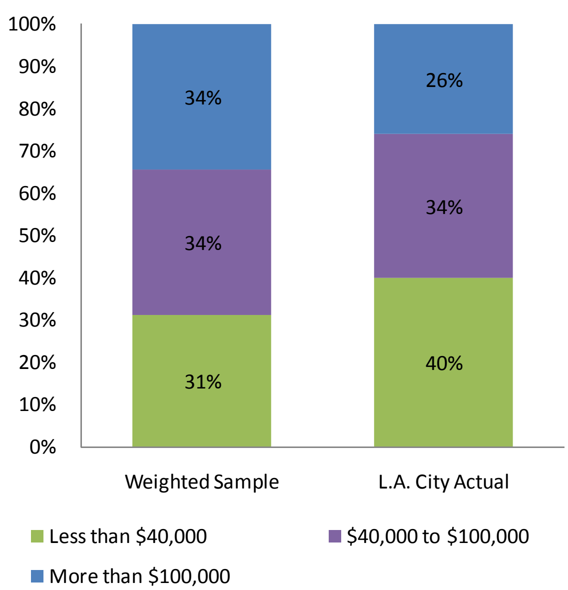
Marital Status

(% of each segment)



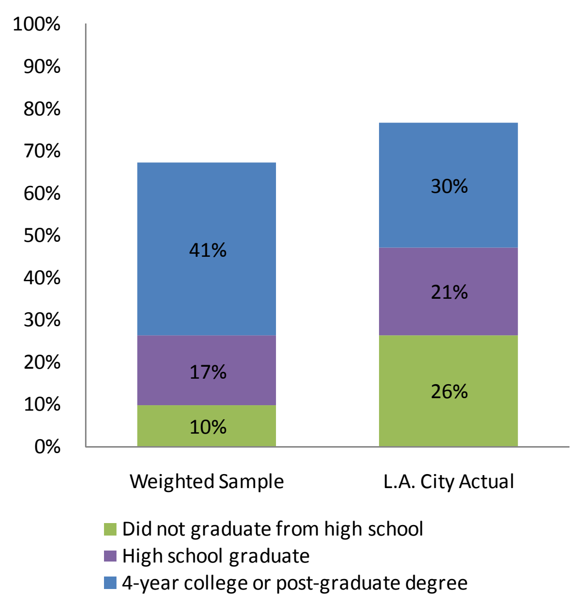
Household Income

(% of each segment)



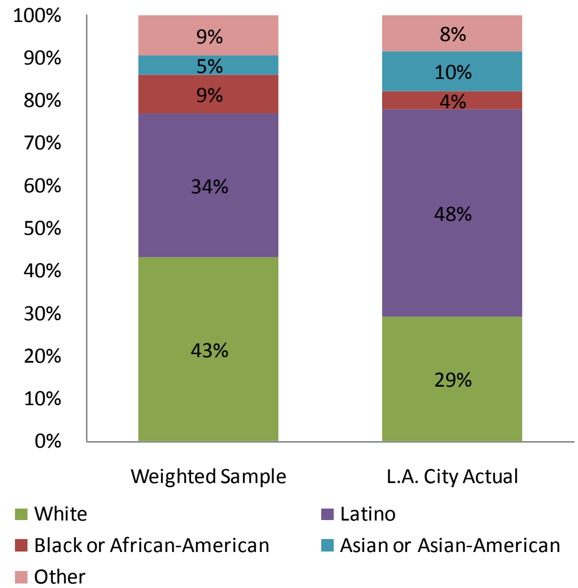
Education

(% of each segment)



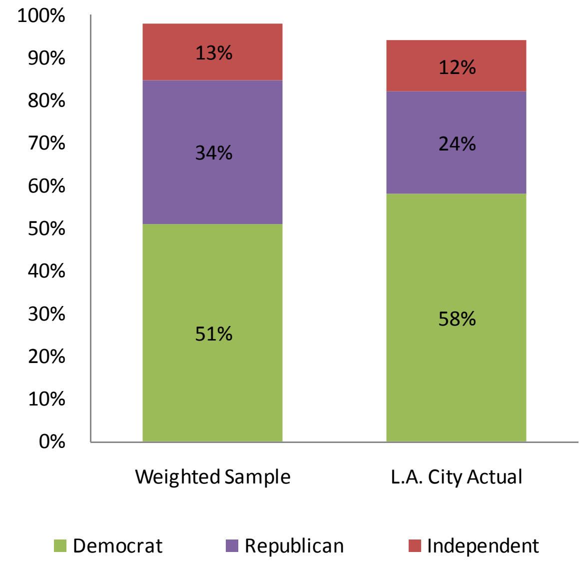
Race

(% of each segment)



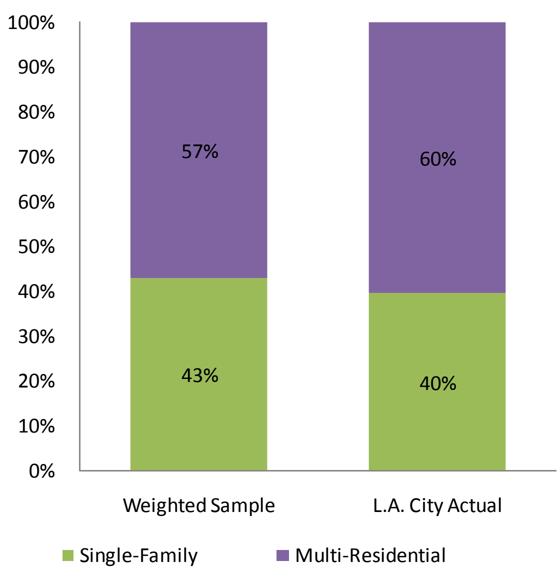
Political Affiliation

(% of each segment)



Single-Family vs. Multi-Residential

(% of each segment)



Own vs. Rent

(% of each segment)

We also assume that certain attitudes, preferences and behavior that influence EV adoption will remain consistent along demographic lines. In other words, we assume that residents of the City of Los Angeles and the L.A. Metro Area that share similar demographics (age, race, political affiliation, home ownership type) would not differ significantly in their car ownership patterns and preferences, driving and parking behavior, and their attitudes on the environment, energy, and new technology.

7.5 Vehicle Preferences, Attitudes, and Demographic Statistics by Segment

		Early	Mid-Adopters		Late Adopters	
	Sample	Early	Mid-SFO	Mid-NSFO	Late-SFO	Late-NSFO
% of Total	100%	28%	15%	33%	11%	15%
Gas Compact[1]	7.05	4.06	8.33	8.55	5.17	9.44
Gas-electric hybrid[1]	6.71	6.73	7.39	8.84	2.30	4.42
PHEV[1]	5.42	6.96	5.63	7.05	1.51	3.10
BEV[1]	5.85	6.28	5.38	7.65	1.49	3.13

			Early	Mid-Adopters		Late Adopters	
	L.A. City[1]	Sample	Early (28%)	Mid-SFO (15%)	Mid-NSFO (33%)	Late-SFO (11%)	Late-NSFO (15%)
Multi-Resid.	60%	57%	66%	0%	80%	18%	75%
Rent	61%	55%	66%	0%	75%	11%	76%
HH Income (>$100K)	26%	34%	33%	48%	27%	51%	28%
Education (College+)	30%	41%	51%	40%	44%	28%	26%
Age (20-34)	32%	32%	34%	35%	37%	8%	32%
Ideology (Liberal)	51%	58%	66%	42%	66%	15%	25%

		Early	Mid-Adopters		Late Adopters	
	All	Early (28%)	Mid-SFO (15%)	Mid-NSFO (33%)	Late-SFO (11%)	Late-NSFO (15%)
Environment[1]	64%	73%	56%	84%	25%	31%
Technology[2]	51%	56%	52%	61%	23%	38%
Safety/Reliab[3]	89%	85%	93%	94%	85%	83%
Power/Perform[4]	73%	60%	74%	80%	79%	75%
Luxury/Comfort[5]	55%	50%	57%	54%	75%	52%

[1] What do you like about EVs? EVs are good for the environment.
[2] What do you like about EVs? I am interested in new technology.
[3] Care about safety & reliability when purchasing a new vehicle
[4] Care about power and perf. when purchasing a new vehicle
[5] Care about luxury and comfort when purchasing a new vehicle

	All	Early (28%)	Mid-SFO (15%)	Mid-NSFO (33%)	Late-SFO (11%)	Late-NSFO (15%)
		Early	Mid-Adopters		Late Adopters	
Price sensitivity[1]	83%	79%	93%	91%	64%	76%
Perception of EV value gap[2]	71%	50%	78%	70%	88%	89%
Tax credit[3]	77%	86%	100%	94%	20%	33%
Gas savings[4]	77%	80%	84%	89%	40%	63%
Charger rebate[5]	73%	82%	86%	93%	26%	31%
Fuel savings to switch to EV[6]	46%	45%	43%	41%	55%	57%

[1] How important is price when buying an EV?
[2] What do you not like about EVs? EVs cost too much for what they offer
[3] $7,500 fed tax credit for EV purchase is important when buying an EV.
[4] What do you like about EVs? I want to save on gas.
[5] $2,000 rebate for charger install is important when buying an EV.
[6] $1K/yr ($83/mth) in fuel savings would convince me to buy an EV.

	All	Early (28%)	Mid-SFO (15%)	Mid-NSFO (33%)	Late-SFO (11%)	Late-NSFO (15%)
		Early	Mid-Adopters		Late Adopters	
Difficulties in charger install[1]	59%	51%	41%	72%	45%	70%
Charging[2]	48%	35%	56%	42%	73%	65%
Range anxiety[3]	67%	52%	74%	66%	83%	76%
Level I vs. Level II[4]	53%	46%	36%	43%	56%	63%

[1] What do you not like about EVs? Difficult or impossible to install a charger
[2] What do you not like about EVs? I do not want to charge my car every day
[3] What do you not like about EVs? Want to go >100mi w/o recharge
[4] Prefer [Level I charging] over [Level II].

	All	Early	Mid-SFO	Mid-NSFO	Late-SFO	Late-NSFO
		Early	Mid-Adopters		Late Adopters	
HOV lane access[1]	55%	63%	66%	72%	14%	20%
Free parking[2]	55%	62%	55%	70%	8%	16%
Expedited install[3]	64%	75%	69%	85%	23%	23%
Charger rebate[4]	73%	82%	86%	93%	26%	31%
Tax credit[5]	77%	86%	100%	94%	20%	33%

[1] HOV lane access is important in decision to buy an EV.
[2] Free parking is important in decision to buy an EV.
[3] Expedited permit for charger installation is important when buying an EV.
[4] $2,000 rebate for charger installation is important when buying an EV.
[5] $7,500 fed tax credit for EV purchase is important when buying an EV.

7.6 Projected Green Car Market Share by Los Angeles Zip Code

	Single Family Owners			Multi-Unit and Renters		
Zip Code	Hybrid	BEV	PHEV	Hybrid	BEV	PHEV
90001	55.5%	23.1%	21.3%	57.4%	25.1%	17.6%
90002	55.3	23.2	21.4	57.2	25.2	17.6
90003	55.4	23.3	21.4	57.1	25.3	17.6
90004	55.4	23.1	21.5	57.7	24.7	17.6
90005	56.1	22.8	21.1	58.0	24.6	17.3
90006	55.9	23.0	21.1	57.5	25.1	17.4
90007	54.6	23.7	21.6	56.1	26.0	17.9
90008	54.3	23.7	22.1	56.5	25.5	18.0
90010	55.2	23.2	21.6	57.4	24.9	17.7
90011	55.6	23.2	21.2	57.3	25.2	17.5
90012	56.3	22.8	20.9	57.9	24.8	17.3
90013	54.2	24.0	21.8	55.6	26.4	18.1
90014	54.9	23.6	21.5	56.2	26.0	17.8
90015	56.0	23.0	21.0	57.5	25.0	17.4
90016	54.4	23.7	21.9	56.5	25.6	17.9
90017	56.1	23.0	20.9	57.5	25.1	17.4
90018	55.2	23.3	21.5	57.1	25.2	17.7
90019	54.5	23.5	22.1	57.0	25.1	17.9
90020	55.5	23.1	21.4	57.6	24.9	17.5
90021	54.1	24.0	21.8	55.4	26.5	18.1
90023	55.3	23.3	21.5	57.1	25.2	17.7
90024	54.6	23.1	22.3	58.2	24.1	17.7
90025	54.6	23.2	22.3	58.0	24.2	17.7
90026	53.6	24.0	22.5	56.1	25.7	18.2
90027	53.7	23.8	22.5	56.4	25.4	18.2
90028	54.3	23.8	22.0	56.2	25.8	18.0
90029	54.9	23.4	21.7	56.9	25.3	17.8
90031	55.1	23.3	21.6	57.2	25.1	17.7
90032	55.5	23.0	21.5	57.9	24.6	17.5
90033	55.7	23.1	21.2	57.4	25.1	17.5
90034	54.4	23.4	22.2	57.5	24.7	17.8
90035	55.6	22.7	21.7	58.8	23.8	17.4
90036	54.7	23.1	22.2	58.2	24.1	17.7
90037	55.4	23.3	21.3	57.0	25.4	17.6
90038	54.3	23.7	22.0	56.4	25.6	18.0
90039	53.9	23.5	22.5	57.2	24.8	18.0
90041	55.8	22.5	21.7	59.1	23.6	17.3
90042	55.0	23.1	21.9	57.9	24.5	17.6
90043	54.3	23.6	22.1	56.8	25.3	17.9
90044	55.1	23.4	21.5	56.9	25.3	17.7
90045	56.7	21.9	21.4	60.5	22.6	16.9
90046	54.1	23.5	22.3	57.1	25.0	18.0
90047	54.8	23.4	21.8	57.1	25.1	17.8
90048	54.2	23.3	22.5	57.8	24.4	17.9
90049	55.8	22.2	22.0	60.4	22.5	17.1
90056	55.2	22.6	22.2	59.4	23.2	17.4
90057	56.3	22.8	20.9	57.8	24.9	17.3
90058	55.1	23.4	21.5	56.8	25.5	17.7
90059	55.4	23.3	21.3	57.1	25.3	17.6
90061	55.4	23.1	21.4	57.4	25.0	17.6
90062	55.1	23.3	21.6	57.0	25.3	17.7
90063	55.2	23.2	21.5	57.3	25.0	17.6
90064	55.1	22.7	22.2	59.1	23.4	17.5
90065	55.3	23.0	21.8	58.2	24.3	17.5
90066	54.9	23.0	22.1	58.2	24.2	17.6
90067	56.3	22.1	21.6	60.4	22.6	17.0
90068	53.9	23.4	22.7	57.6	24.4	18.0
90069	54.1	23.4	22.5	57.6	24.5	17.9
90071	54.3	23.7	22.1	56.6	25.5	18.0
90077	56.7	21.4	21.8	62.2	21.2	16.7

	Single Family Owners			Multi-Unit and Renters		
Zip Code	Hybrid	BEV	PHEV	Hybrid	BEV	PHEV
90210	57.5%	21.3%	21.2%	62.0%	21.5%	16.5%
90211	56.3	22.2	21.5	60.0	23.0	17.0
90212	56.2	22.2	21.6	59.9	23.0	17.1
90230	55.2	22.8	22.0	58.6	23.8	17.5
90232	54.5	23.2	22.3	57.9	24.3	17.8
90245	58.3	21.1	20.6	62.2	21.6	16.3
90247	57.2	22.2	20.6	59.3	23.7	16.9
90248	56.6	22.3	21.1	59.4	23.5	17.0
90272	56.4	21.7	21.9	61.5	21.7	16.8
90290	53.1	23.4	23.5	58.2	23.7	18.1
90291	53.4	23.8	22.9	56.9	24.9	18.2
90292	55.3	22.6	22.1	59.4	23.2	17.4
90293	56.4	22.0	21.5	60.4	22.6	17.0
90302	55.1	23.3	21.7	57.3	25.0	17.7
90402	55.7	22.1	22.2	60.6	22.2	17.2
90501	58.3	21.4	20.3	61.2	22.4	16.4
90502	57.8	21.6	20.6	61.0	22.5	16.6
90710	57.6	21.7	20.7	60.7	22.7	16.6
90717	58.6	21.2	20.3	61.7	22.0	16.3
90731	56.9	22.3	20.9	59.3	23.7	17.0
90732	57.8	21.4	20.8	61.6	21.9	16.5
90744	56.1	22.7	21.2	58.5	24.2	17.3
90810	57.2	22.0	20.8	59.8	23.3	16.9
91040	58.9	21.0	20.1	62.1	21.8	16.1
91042	59.3	20.9	19.8	62.2	21.8	16.0
91214	58.7	20.9	20.5	62.7	21.2	16.1
91303	56.6	22.4	21.0	59.1	23.8	17.1
91304	57.8	21.6	20.6	60.9	22.5	16.6
91306	57.3	21.9	20.8	60.3	23.0	16.8
91307	58.0	21.2	20.8	61.9	21.7	16.4
91311	58.1	21.3	20.6	61.7	21.9	16.4
91316	56.5	22.2	21.3	59.8	23.2	17.0
91324	57.5	21.7	20.8	60.8	22.6	16.6
91325	57.0	22.0	21.0	60.2	23.0	16.8
91326	58.8	20.7	20.5	63.1	20.9	16.0
91331	56.3	22.6	21.2	58.8	24.0	17.2
91335	56.9	22.1	21.0	59.7	23.4	16.9
91340	56.6	22.4	21.0	59.1	23.8	17.1
91342	57.2	21.9	20.9	60.2	22.9	16.8
91343	57.1	22.0	20.8	59.9	23.2	16.9
91344	58.6	21.0	20.4	62.2	21.6	16.2
91345	57.2	21.9	20.9	60.3	22.9	16.8
91352	57.1	22.1	20.8	59.6	23.5	16.9
91356	57.1	21.8	21.1	60.7	22.6	16.8
91364	57.3	21.5	21.3	61.7	21.7	16.6
91367	57.1	21.8	21.1	60.7	22.5	16.8
91401	55.5	22.9	21.6	58.3	24.2	17.5
91402	56.7	22.4	20.9	58.9	24.0	17.1
91403	55.8	22.4	21.7	59.6	23.2	17.2
91405	55.8	22.9	21.3	58.0	24.6	17.4
91406	56.4	22.5	21.1	59.0	23.9	17.1
91411	55.4	23.0	21.7	58.0	24.4	17.5
91423	55.5	22.6	21.9	59.2	23.5	17.4
91436	56.8	21.7	21.5	61.3	22.0	16.8
91504	58.2	21.2	20.6	61.7	21.9	16.4
91505	56.6	22.2	21.3	59.8	23.1	17.0
91601	55.2	23.1	21.7	57.8	24.6	17.6
91602	55.5	22.7	21.7	58.7	23.9	17.4
91604	55.1	22.7	22.2	59.0	23.5	17.5
91605	56.3	22.6	21.1	58.6	24.2	17.2
91606	55.9	22.8	21.3	58.2	24.4	17.4
91607	55.5	22.8	21.7	58.5	24.1	17.4

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