UNIVERSITY OF CALIFORNIA

Understanding the Impact of Local Policies and Initiatives on Plug-In Electric Vehicle Adoption - An In-Depth Study of the Sacramento Region

A Research Report from the University of California Institute of Transportation Studies

Scott Hardman, Postdoctoral Researcher, Plug-in Hybrid & Electric Vehicle Research Center of the Institute of Transportation Studies, University of California, Davis

Nora Jang, Undergraduate Research Assistant, Plug-in Hybrid & Electric Vehicle Research Center of the Institute of Transportation Studies, University of California, Davis

Dahlia Garas, Program Director, Plug-in Hybrid & Electric Vehicle Research Center of the Institute of Transportation Studies, University of California, Davis

March 2019

PROJECT ID: 2018-23 | DOI:10.7922/G2HX19W1

ITS UCDAVIS
INSTITUTE OF TRANSPORTATION STUDIES

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. UC-ITS-2018-23	**2. Government Accession No.** N/A	**3. Recipient's Catalog No.** N/A
4. Title and Subtitle Understanding the Impact of Local Policies and Initiatives on Plug-In Electric Vehicle Adoption - An In-Depth Study of the Sacramento Region		**5. Report Date** March 2019 **6. Performing Organization Code** ITS-Davis
7. Author(s) Scott Hardman, PhD https://orcid.org/0000-0002-0476-7909 Nora Jang Dahlia Garas		**8. Performing Organization Report No.** N/A
9. Performing Organization Name and Address Institute of Transportation Studies, Davis 1605 Tilia Street Davis, CA 95616		**10. Work Unit No.** N/A **11. Contract or Grant No.** UC-ITS-2018-23
12. Sponsoring Agency Name and Address The University of California Institute of Transportation Studies www.ucits.org		**13. Type of Report and Period Covered** Final Report (November 2017 – December 2018) **14. Sponsoring Agency Code** UC ITS

15. Supplementary Notes
DOI:10.7922/G2HX19W1

16. Abstract

The survey project described here is intended to be the beginning of a multi-year project on the effectiveness of various activities in growing consumer interest in purchasing BEVs in the Sacramento region.

This survey in Sacramento shows that engagement in PEVs is moderate, based on the following results: 50% of respondents had seen some PEV-related advertising, mostly on television or in print media; 47% were aware of the California Clean Vehicle Rebate, and 46% aware of the federal tax credit; 40% could correctly name a PHEV, and 50% a BEV; 25% had sought out information on PEVs, mostly through the internet or speaking to car salespeople, friends, or family. Compared to respondents to a 2014 state-wide survey, a higher percentage of respondents to this 2018 Sacramento survey had seen charging stations, and a similar percentage, 3.3%, had actively shopped for a BEV. Ordinal logistic regression modelling indicated that the following factors were associated with having considered purchasing a BEV: being enthusiastic about PEVs, knowing someone by name who owns a PEV, having sought out information on PEVs, knowing how to refuel a PEV, and being familiar with the vehicles. Considering a BEV purchase was not associated with: having seen advertising, being aware of ride-and-drive events, having been in a PEV, having seen chargers, awareness of incentives, or the density of PEVs or charging stations near the respondent's home.

Results suggest that respondents who are interested in BEVs are a self-selecting group whose interest is not the result of promotional activities. Existing efforts to engage the general population not yet had a significant impact on respondents thinking about purchasing a BEV. Future follow-up surveys will be able to track changes in respondent awareness, the impact of various advertising and awareness campaigns, and growing consumer engagement in PEVs over time.

17. Key Words Plug-in hybried vehicles, electric vehicles, surveys, incentives, automobile ownership, policy analysis	**18. Distribution Statement** No restrictions.

19. Security Classif. (of this report)	**20. Security Classif. (of this page)**	**21. No. of Pages**	**22. Price**
Unclassified	Unclassified	42	N/A

About the UC Institute of Transportation Studies

The University of California Institute of Transportation Studies (UC ITS) is a network of faculty, research and administrative staff, and students dedicated to advancing the state of the art in transportation engineering, planning, and policy for the people of California. Established by the Legislature in 1947, ITS has branches at UC Berkeley, UC Davis, UC Irvine, and UCLA.

Acknowledgements

This study was made possible through funding received by the University of California Institute of Transportation Studies from the State of California via the Public Transportation Account and the Road Repair and Accountability Act of 2017 (Senate Bill 1). The authors would like to thank the State of California for its support of university-based research, and especially for the funding received for this project. The authors would also like to thank Joe Klein & Dwight MacCurdy from Sacramento Municipal Utility District (SMUD) for help in obtaining a survey sample for this study. The authors would also like to thank Ken Kurani of the PH&EV Center for developing the questions used in the online questionnaire survey.

Understanding the Impact of Local Policies and Initiatives on Plug-In Electric Vehicle Adoption – An In-Depth Study of Sacramento the Region

UNIVERSITY OF CALIFORNIA INSTITUTE OF TRANSPORTATION STUDIES

March 2019

Scott Hardman, *Postdoctoral Researcher, Plug-in Hybrid & Electric Vehicle Research Center of the Institute of Transportation Studies, University of California, Davis*

Nora Jang, *Undergraduate Research Assistant, Plug-in Hybrid & Electric Vehicle Research Center of the Institute of Transportation Studies, University of California, Davis*

Dahlia Garas, *Program Director, Plug-in Hybrid & Electric Vehicle Research Center of the Institute of Transportation Studies, University of California, Davis*

[page intentionally left blank]

TABLE OF CONTENTS

LIST OF FIGURES

Executive Summary

The project described in this report is intended to provide the baseline assessment for a future, multi-year project to determine the effectiveness of various engagement activities in increasing consumer interest in purchasing plug-in electric vehicles (PEV) in the Sacramento region. As of August 2018, there were approximately 15,000 PEVs in the Sacramento Area Council of Governments (SACOG) area, with close to 8,000 of these in Sacramento County. Compared to San Jose, San Francisco, San Diego, and Los Angeles, Sacramento has a lower percentage of new vehicles for sale that are plug-in hybrid electric vehicles (PHEVs) or battery electric vehicles (BEVs).

Results from the Survey in Sacramento show that engagement in PEVs in the region is moderate, based on the following results: 50% of respondents have seen some PEV related advertising, mostly on television or in printed media; 47% are aware of the California Clean Vehicle Rebate, with 46% aware of the federal tax credit; 40% could correctly name a PHEV, and 50% a BEV; 25% have sought out information on PEVs, with most people using the internet, speaking to car salespeople, or speaking to friends and family; a higher percentage of respondents to the 2018 Sacramento survey than the 2014 state-wide survey indicated having seen charging stations. Despite moderate awareness, only 3.3% of the sample has actively shopped for a BEV, which represents no change compared to a 2014 state-wide survey. Ordinal logistic regression was used to understand the relationship of knowledge, awareness, and other variables to whether respondents have considered purchasing a BEV. Having considered purchasing a BEV was related to being enthusiastic about PEVs, knowing someone by name who owns a PEV, having sought out information on PEVs, knowing how to refuel a PEV, and being familiar with the vehicles. Considering purchasing a BEV was not associated with: having seen advertising, being aware of ride-and-drives, having been in a PEV, having seen chargers, awareness of incentives, or the density of PEVs or charging stations near a respondent's home.

Results suggest that those who are interested in BEVs are still a self-selecting group of respondents whose interest in BEVs was not impacted by any advertising or public outreach programs. Existing efforts to engage those in the general population have yet to have a significant impact on respondents thinking about purchasing a BEV. Future follow-up surveys will be able to track changes in respondent awareness, the impact of various forms of advertising and awareness campaigns, and growing consumer engagement in PEVs over time

Introduction

The Sacramento Area Council of Governments (SACOG) is an association of six county governments, including El Dorado, Placer, Sacramento, Sutter, Yolo, and Yuba. One of the foremost provisions of the SACOG to the region is transportation planning and funding.

In December 2013, the SACOG created the region's first plug-in electric vehicle (PEV) readiness and infrastructure plan to expand the area's PEV ownership. The plan, called TakeCharge, looks at the building codes, zoning codes, and other city planning features that will be transformed by the spread of PEV adoption and charging infrastructure. The second half of the plan looks at the demand of PEVs throughout the region.

The TakeCharge initiative has included a range of actions to encourage PEV awareness, adoption, and wider use (SACOG 2013). For example, TakeCharge has purchased and installed DC Fast Chargers at local grocery stores.

This report examines the annual trends in PEV sales throughout the SACOG region, aggregated by county level, as well as trends in PEV charging infrastructure installation by county, further segregated by infrastructure in disadvantaged versus non-disadvantaged communities.

The purpose of this research is to understand the current level of consumer engagement in PEVs in the Sacramento area. This study can be used as a baseline for future studies. These future studies will include conducting follow-up surveys to measure the impact of current and future activities (e.g., from Electrify America, Sacramento Metropolitan Air Quality Management District (SMAQMD), SACOG, Sacramento Municipal Utility District (SMUD), etc.) in the region designed to nurture the PEV market.

Previous research by Ken Kurani has shown that engagement in California did not change from 2014 to 2017 (Kurani 2017). Despite increasing availability of PEV models, increasing infrastructure, and increasing PEV sales, consumers did not become more engaged in the transition to PEVs. Those that were engaged in 2017 were a similar group of self-selecting consumers as in 2014. Conducting this research in Sacramento will provide a more detailed look at this issue of consumer engagement at a local level.

Much of this report focuses on PEVs which includes PHEVs and BEVs. The model that investigates whether survey respondents purchase consideration focuses only on the consideration to purchase a BEV.

Engaging Consumers in the Transition to a New Technology

Diffusion of innovation theory (Rogers 2003) describes the process of adopting a new technology (Figure 1). The first stage of any transition, and the transition to PEVs, is consumers being aware of the new technology. Next, consumers will begin to become more knowledgeable about it, which includes knowing what the technology is, but having little information about its potential benefits. In these first two stages, consumers rarely expose themselves to the innovation, rather information about the innovation reaches them through

passive communication channels (e.g., advertising, word of mouth, etc.). During the third stage, the persuasion stage, consumers become motivated to find more information about the technology, including the pros and cons of the technology, and, in the case of electric vehicles, the availability of infrastructure and incentives. Next consumers enter the decision stage, where they will consider the pros and cons of the innovation and decide whether they will adopt it or not. Finally, they will adopt the new technology. The process is shown as an inverted pyramid, as at each stage consumers can reject the innovation.

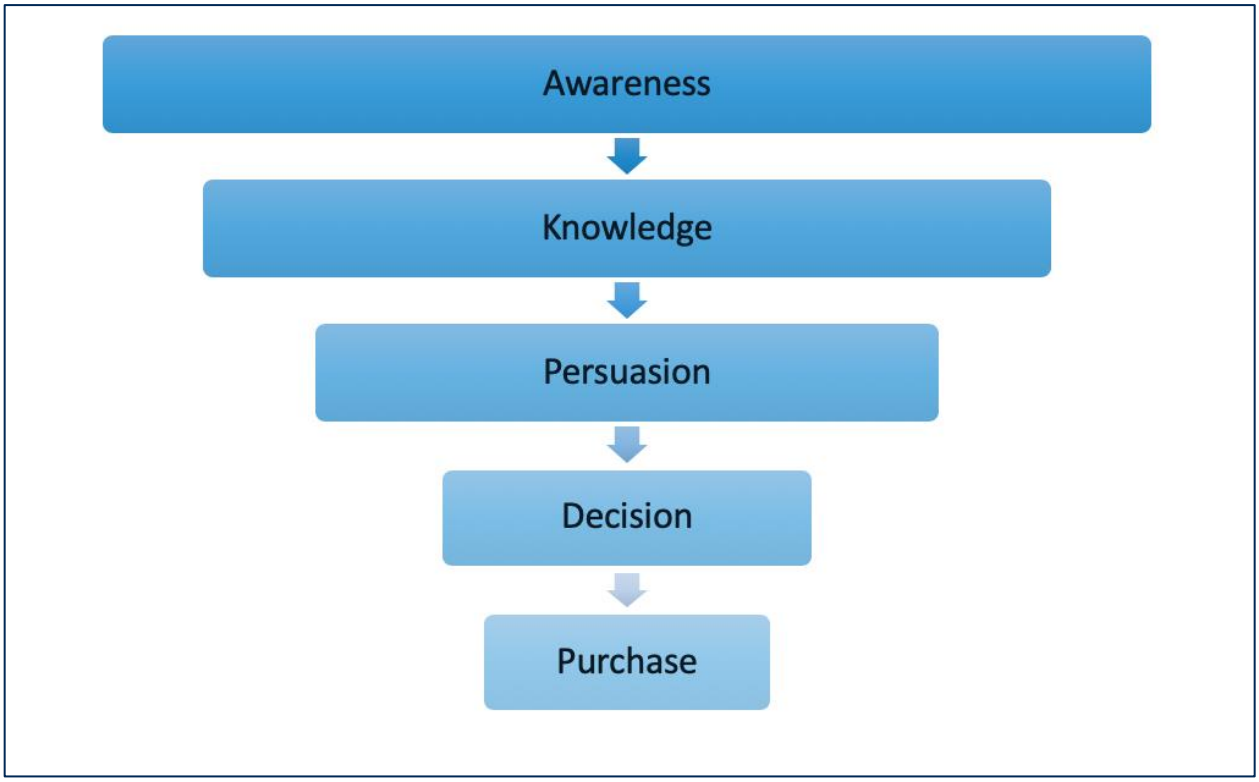

Figure 1. The process of adoption (adapted from Rogers (2003)).

Methods

In this study we used secondary data to build context for a questionnaire survey. Secondary data on the PEV market, PEV availability, infrastructure, and engagement activities was gathered. Subsequently, a questionnaire survey on PEV engagement was administered to residents in the Sacramento region in June–September 2018.

Secondary Data Collection

PEV Market Data

Data from the clean vehicle rebate project (CVRP) was used to estimate PEV registrations in the SACOG region. The CVRP provides data on the number of rebate applicants in each county, which can be used as a proxy for the PEV market. The CVRP also provides data on the proportion of PEV buyers who apply for a rebate, given as a percentage of PEV buyers in each county. These data were used to estimate total PEV registrations in each county.

PEV Availability Data

PEV availability data were taken from online vehicle sales marketplace websites. These websites were used to gather data on PEV availability in San Diego, Los Angeles, San Francisco, and Sacramento regions. Data included new and used plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), fuel cell vehicles (FCVs), and conventional vehicles in each region. The data show the percentage of all new and used vehicles for sale that are PHEVs or BEVs.

The data only include vehicles that were listed on the vehicle marketplace, so they may not include all vehicles for sale. Notably the data do not include the availability of new Tesla BEVs or any certified used Tesla BEVs, because of the automaker's direct sales model. Used Tesla BEVs from other dealers are included in the data. The data is intended to be used as a proxy for PEV model availability in the five counties included in the analysis.

Infrastructure Data

US Department of Energy (DOE) advanced fuel data center (AFDC) data were used for charging infrastructure data. This dataset is one of the most complete publicly available PEV infrastructure datasets, though it does have gaps, including missing the year of installation for a substantial proportion of charging locations and missing locations.

Data on Engagement Activities

The Sacramento EV Association provided data on PEV ride-and-drives, where consumers can test drive and ride in various PEVs, and engagement activities in the region for the years 2016-2018.

Questionnaire Survey

Between June and September 2018 an online questionnaire survey was administered in the Sacramento Region, specifically in the SMUD territory (Figure 2). The territory covers most of Sacramento County and some of Yolo and Sutter counties. Survey recruitment was via postal mail; potential respondents were sent a letter from the Institute of Transportation Studies inviting them to participate in an online survey. The letter provided a URL to the survey and a personal token needed to access the survey. The survey recruitment letter was sent to 46,857 households, of which 1,137 started the survey and 961 completed the survey. For the analysis in this report 847 survey respondents are used as these are households who own at least one vehicle. The distribution of survey respondents in the region can be seen in Figure 2.

The questionnaire survey focused on several topics related to vehicles, electric vehicles (EVs), and awareness, knowledge, and engagement with electric vehicles. The survey contained the following sections:

- Household information (socio-demographics, information on household vehicles and vehicle use, electricity costs, etc.)
- Familiarity with new ways to fuel cars and trucks
- Knowledge of PEVs
- Existing experiences with PEVs
- Attitudes towards PEVs
- Awareness of electric vehicle incentives, including awareness of local incentives and activities
- Consideration of purchasing a PEV (note respondents were asked their consideration to purchase a BEV and PHEV in two separate questions)
- Attitudes towards sustainability

Results in this study are for respondents who completed the survey prior to August 13, 2018, which is when Electrify America began running a national 30-second television advertising campaign. The map below shows the distribution of respondents in the Sacramento region for the 847 completed responses included in this analysis.

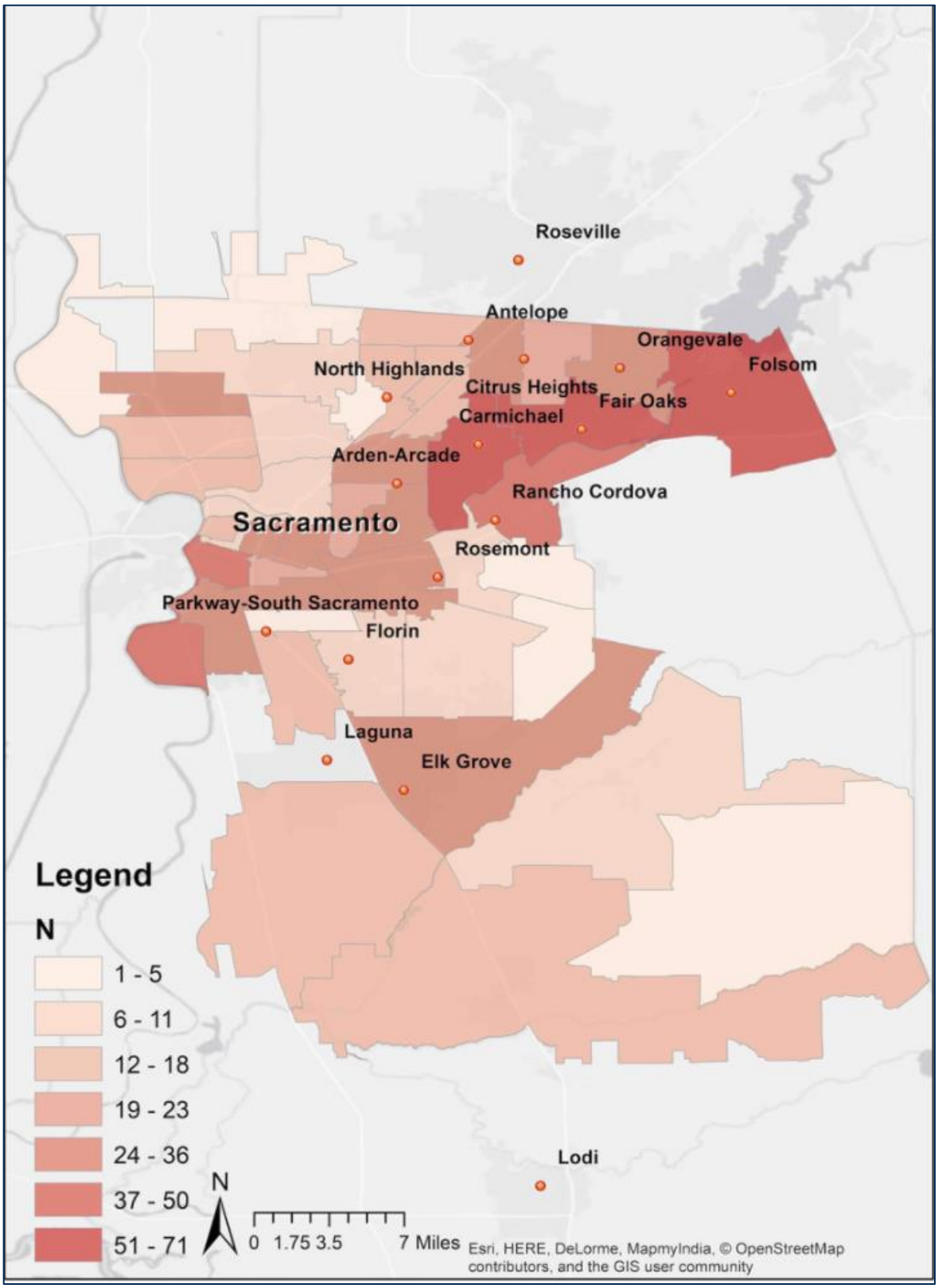

Figure 2. Distribution of respondents by zip code throughout the Sacramento region.

Overview of the PEV Market in Sacramento

In this section, we present data on the PEV market, PEV availability, charging infrastructure, and engagement activities in the SACOG region. These data are used to build a context for the questionnaire survey which is presented in the following section.

PEV Market

Based on registration data, PEV sales throughout the Sacramento region have shown a continual increase annually since 2011 (see Figure 3). In 2017, 8,110 new PEVs were registered in the region. As of August 2018, 6,470 new PEVs were registered, suggesting 2018 sales will be higher than 2017. As of August 2018, based on CVRP data, an estimated 14,581 new PEVs have been registered in the region since 2010. Note that these data do not account for used PEVs being imported into the region or out of the region, or PEV owning households moving in or out of the region.

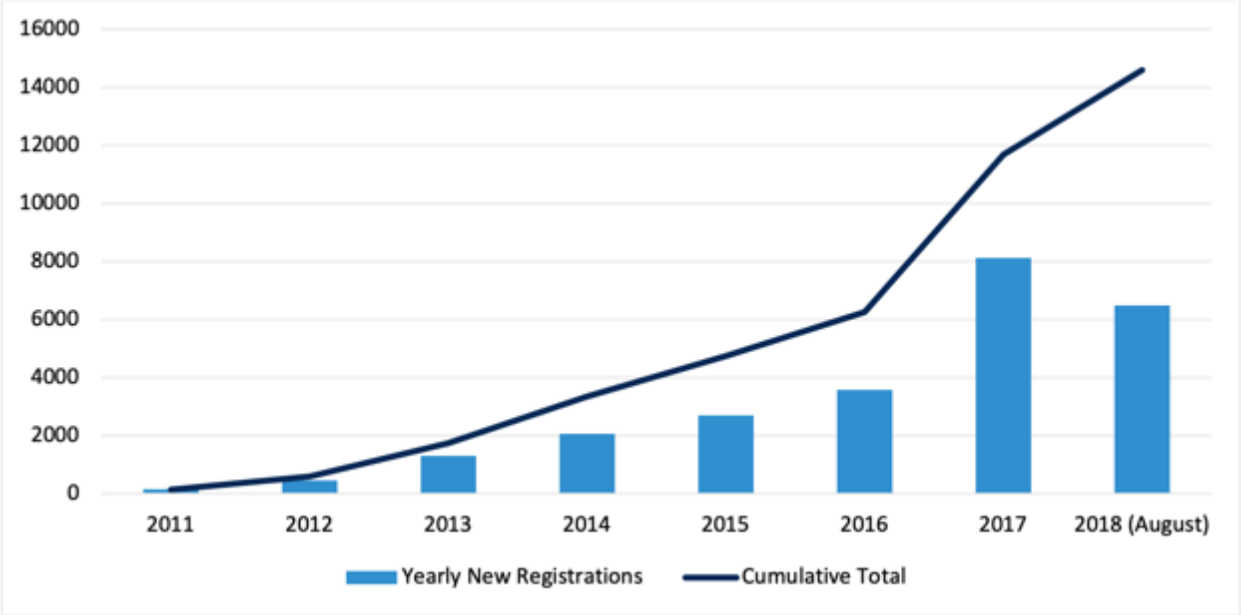

Figure 3. New and cumulative PEV registrations in the SACOG Region 2011-August 2018.

Processing the PEV sales data further, as displayed in Figure 4, demonstrates the sales distribution across area counties. Sacramento County exhibits the highest PEV sales of all the SACOG counties and accounts for 7,742 of all PEV registrations in the region.

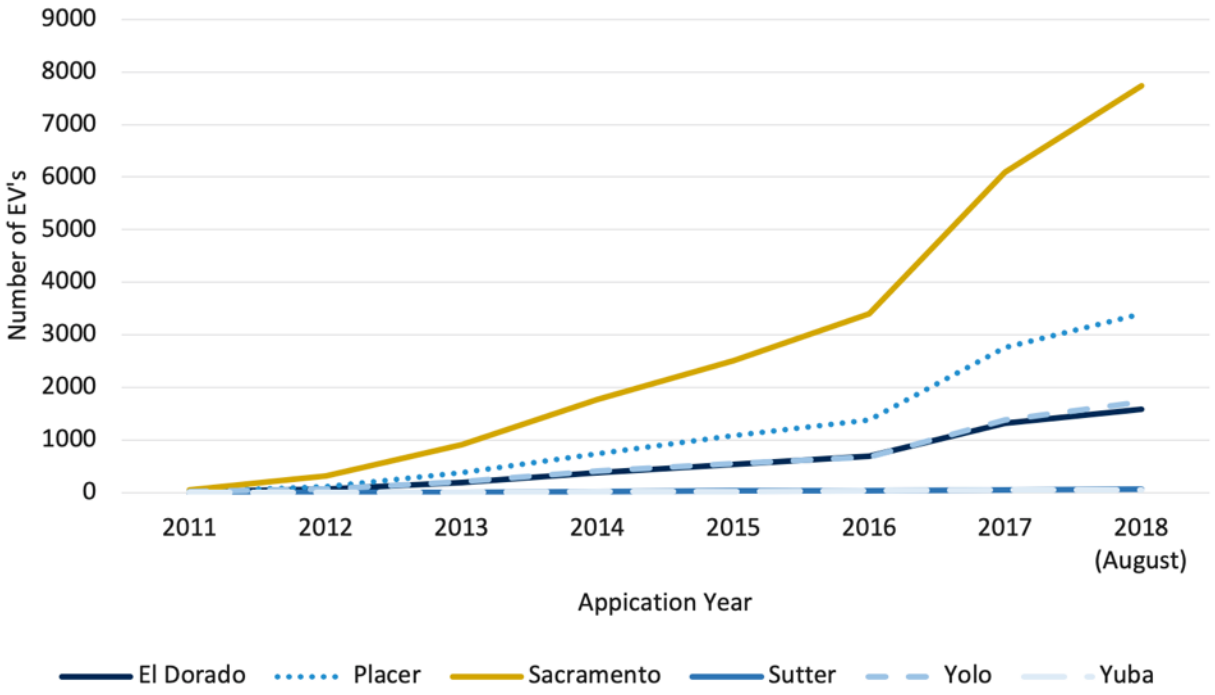

Figure 4. Cumulative PEV registrations in the SACOG Region 2011-August 2018 by county.

Figure 5 and Figure 6 show the number of PHEV and BEV CVRP applicants in each of the SACOG counties. Sacramento county applicants account for more than half of total regional applications for rebates for both PHEVs and BEVs.

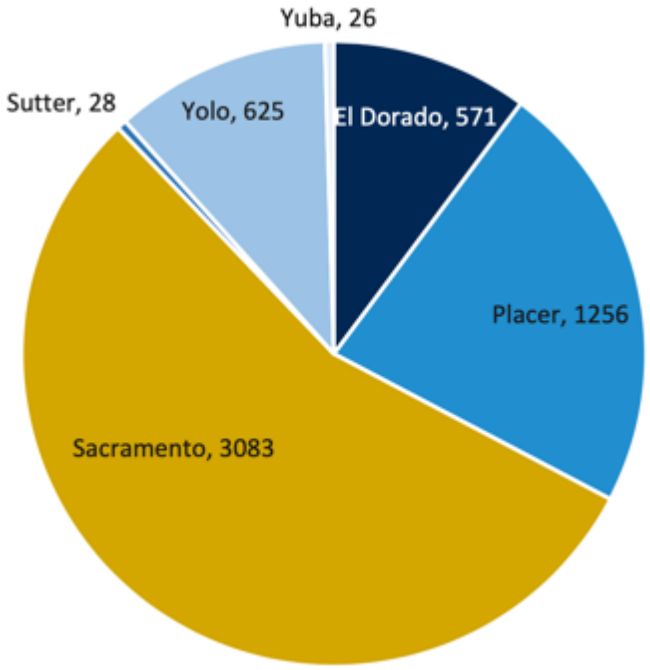

Figure 5. Number of BEV CVRP applicants in each county.

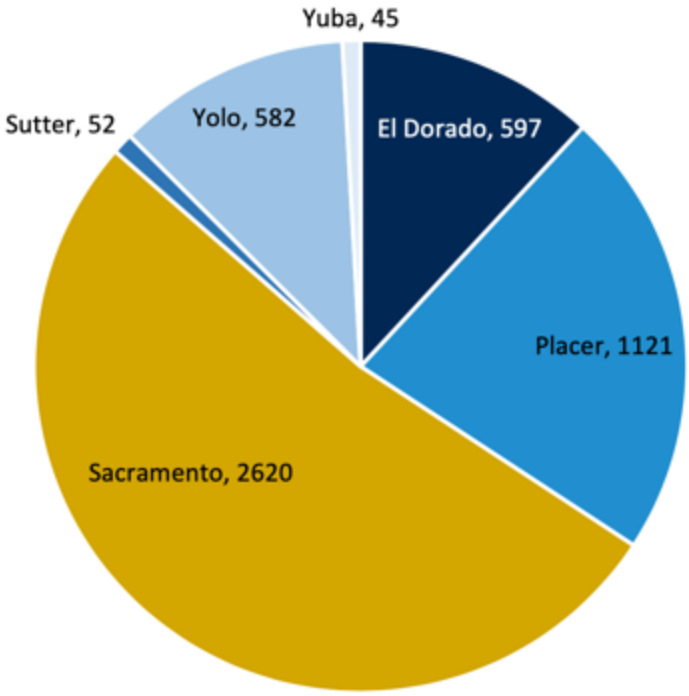

Figure 6. Number of PHEV CVRP applicants in each county.

BEV and PHEV Availability

This section discusses the availability of BEVs and PHEVs in Sacramento as measured by the number of BEVs and PHEVs listed as available for purchase online within a 25-mile radius of the center of the city of Sacramento (and other cities included in the analysis). Figure 7 shows the percentage of new vehicles listed for sale online in Los Angeles, Sacramento, San Diego, San Francisco, and San Jose that are BEVs. Throughout the period of data collection, Sacramento had the lowest percentage of BEVs for sale and San Jose had the highest percentage.

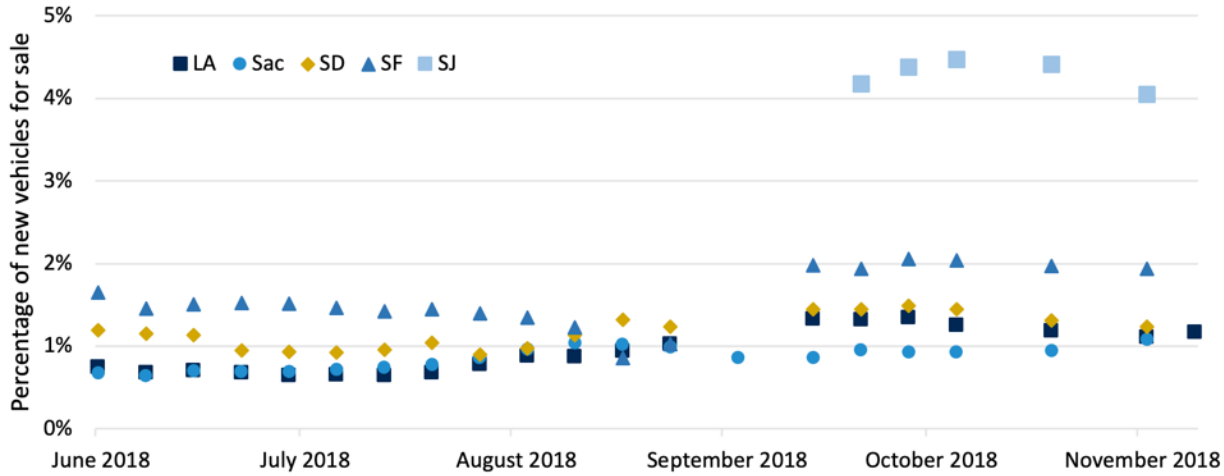

Figure 7. Percentage of new vehicles that are BEV listed as available for purchase in Los Angeles (LA), Sacramento (Sac), San Diego (SD), San Francisco (SF), and San Jose (SJ).

Figure 8 shows the shows the percentage of new vehicles listed for sale online in LA, Sacramento, San Diego, San Francisco, and San Jose that are PHEVs. Again, Sacramento appears to have the lowest percentage of PHEVs for sale in all regions of analysis. Los Angeles and San Jose appear to have the highest percentage of PHEVs for sale.

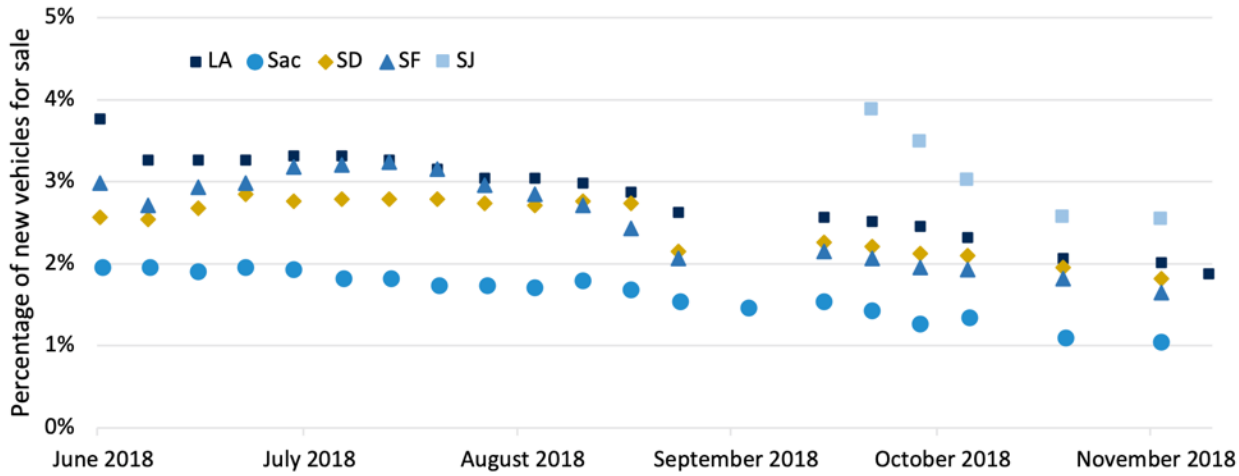

Figure 8. Percentage of new vehicles that are PHEV listed as available for purchase in Los Angeles (LA), Sacramento (Sac), San Diego (SD), San Francisco (SF), and San Jose (SJ).

PEV Charging Infrastructure

Figure 9 illustrates the trending growth in electric vehicle charging infrastructure since 1995. Sacramento has since shown continual growth in PEV charging installations, followed by Yolo and Placer counties. The figure also shows "unknown install date" for charging locations where the installation year is not available. It is possible that many of these charging stations were installed in more recent years with the increasing activity in this area.

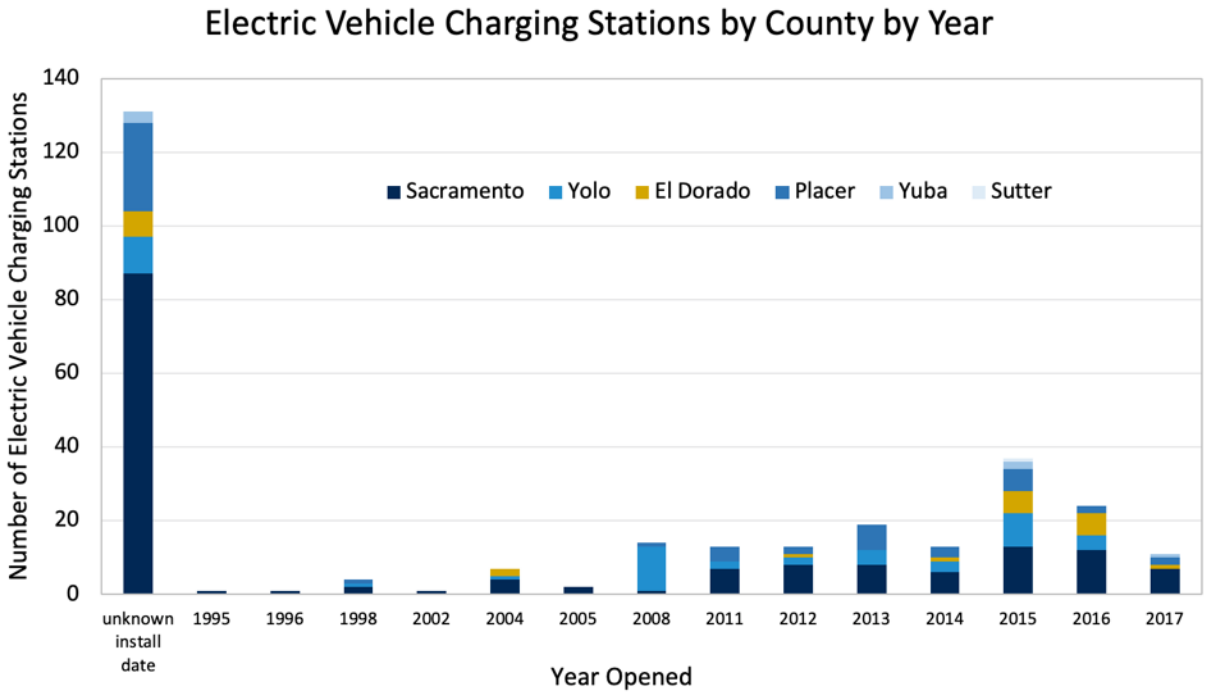

Figure 9. Number of electric vehicle infrastructure installations per year between 1995 to 2017.

Figure 10 shows PEV charging station distribution across the SACOG region, segregated by census block within each county. The Sacramento region contains the most charging infrastructure locations in total, albeit spread across a greater expanse of census block groups. Yolo County shows the greatest consistent spread of PEV charging stations within its census blocks.

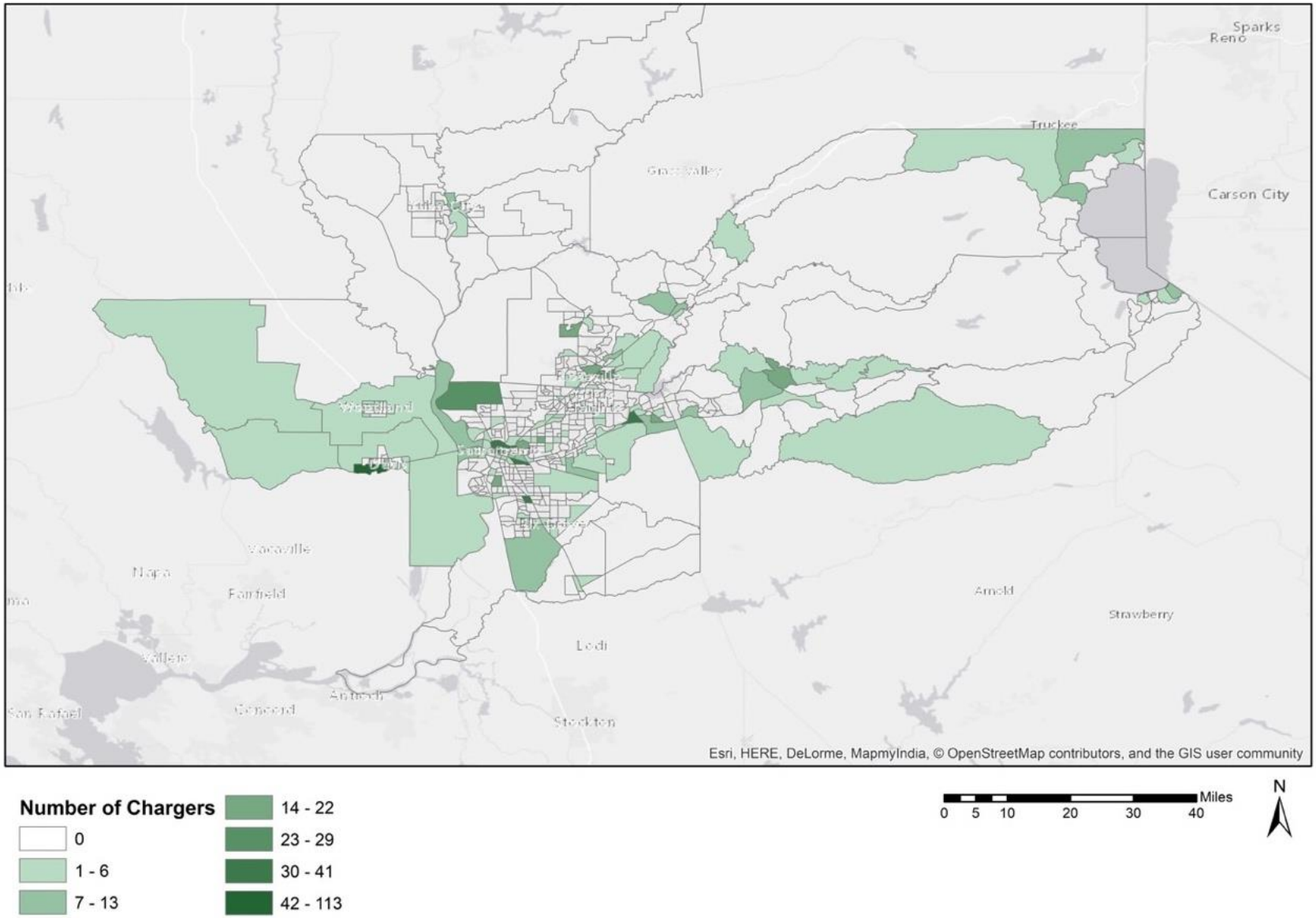

Figure 10. Number of PEV charging stations installed across the SACOG region

Displayed in Figure 11 is the number of PEV charging outlets per county in the SACOG region, further divided by whether the charging station is installed in a disadvantaged community (DAC) census tract[1] or 'non-disadvantaged' community. The bars indicate that Sacramento County has not only the most PEV charging infrastructure out of the SACOG counties, but also the most infrastructure installed in DACs compared to all counties, though Sacramento also has the most DAC census tracts in any of the SACOG counties. Figure 12 shows the location of DACs in the SACOG region, highlighting the concentration in Sacramento county.

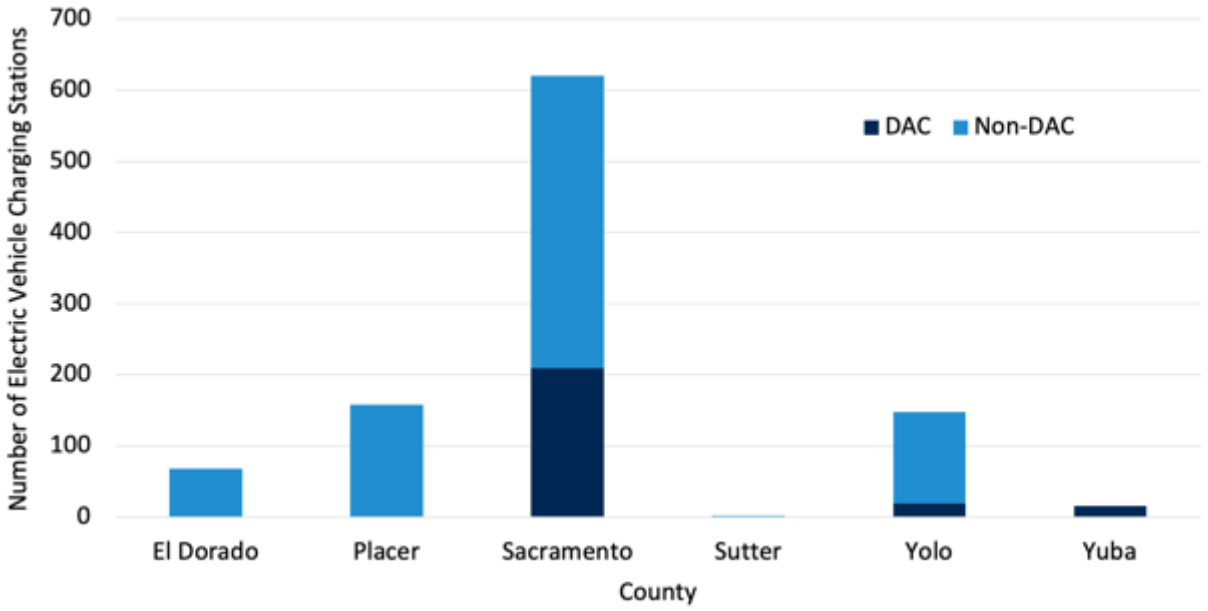

Figure 11. Number of charging stations by disadvantaged and non-disadvantaged community census tracts. (DAC = disadvantaged community).

[1] Four different measures are used to classify disadvantaged communities: exposure to different types of pollutants, environmental indicators, sensitive populations (elderly, young, etc.), and socioeconomic factors (e.g household income) (California Environmental Protection Agency 2014).

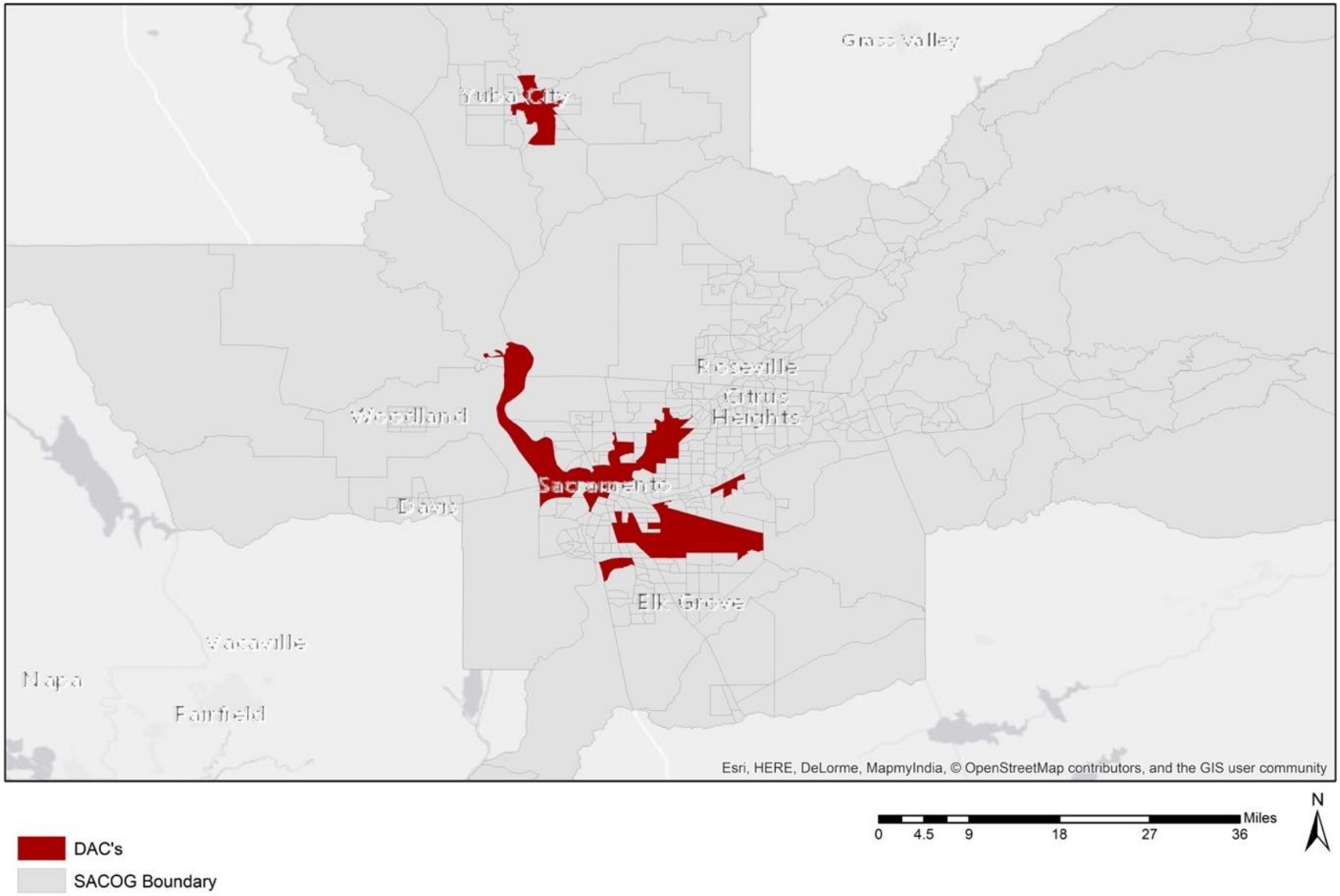

Figure 12. Disadvantaged communities (DACs) in the SACOG region.

Engagement Activities in the Region

Data were collected by the Sacramento Electric Vehicle Association following several ride-and-drive events throughout the greater Sacramento region between 2016 and 2018. As displayed in Figure 13 and Figure 14, the year 2018 consistently shows the highest number of events hosted, as well as the highest number of attendees overall compared to 2016 and 2017. The first events of the year generally took place in the spring months of March or April, and the last events took place in mid- to late-fall between September and November.

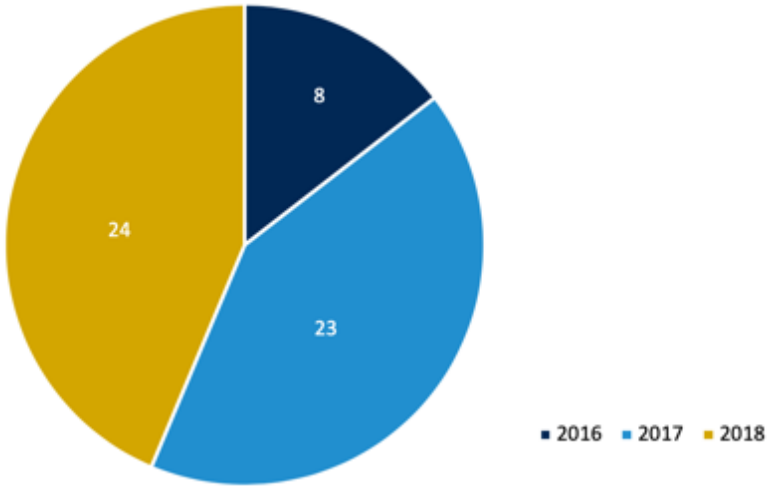

Figure 13. Number of ride and drive events held in 2016, 2017, and 2018 in the Sacramento Region (Source: Sacramento EV Association).

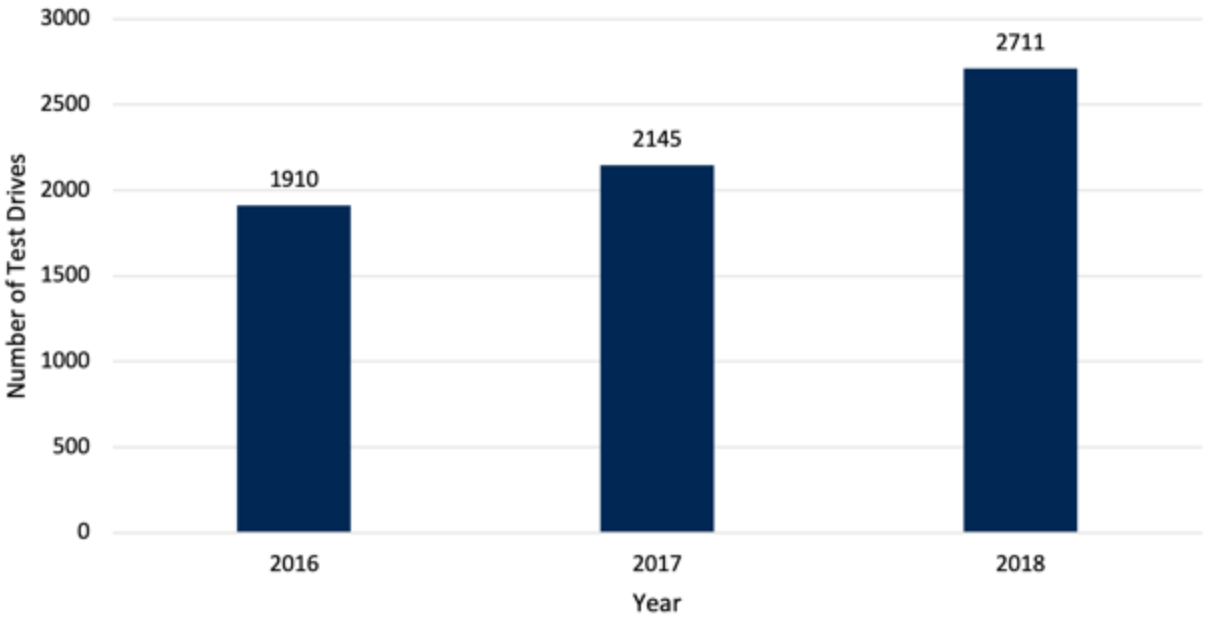

Figure 14. Number of ride-and-drive event attendees from 2016 to 2018.

Questionnaire Survey Results

This section presents results from the questionnaire of residents in the Sacramento Region, it explores respondents socio-demographics, whether they can access charging from home, whether they have sought out information on PEVs, whether they have seen PEV related advertising, their awareness of PEV incentives, their knowledge of PEVs, and whether they have considered purchasing a PEV. Finally, we used an ordinal logistic regression model to understand the relationship between several independent variables and whether respondents had considered purchasing a BEV (not PEV, which would include PHEVs and BEVs).

Sociodemographic Characteristics of Respondents

Figure 15 shows the sociodemographic profile of respondents including: number of vehicles in the household, number of people in the household, house type, whether they own their home, highest level of education, age, and household income.

- Mean number of vehicles in the household was 1.9.
- Mean number of people in the household was 2.1.
- 66.5% of the sample have a university degree (33% college graduate, 32.5% postgraduate degree, 1% some graduate school).
- Mean annual income was $126,617; median income was $110,000.
- 80% of the sample lived in a detached house (also called a single-family home), 12% lived in an apartment or a condo, 8% lived in an attached house (e.g., a row home).
- 80% of the sample owned their home.
- Average age of survey respondents was 55 years old.
- 53% of respondents were male, 46% were female, 1% did not answer.
- 54% of the sample were employed, 39% were retired.

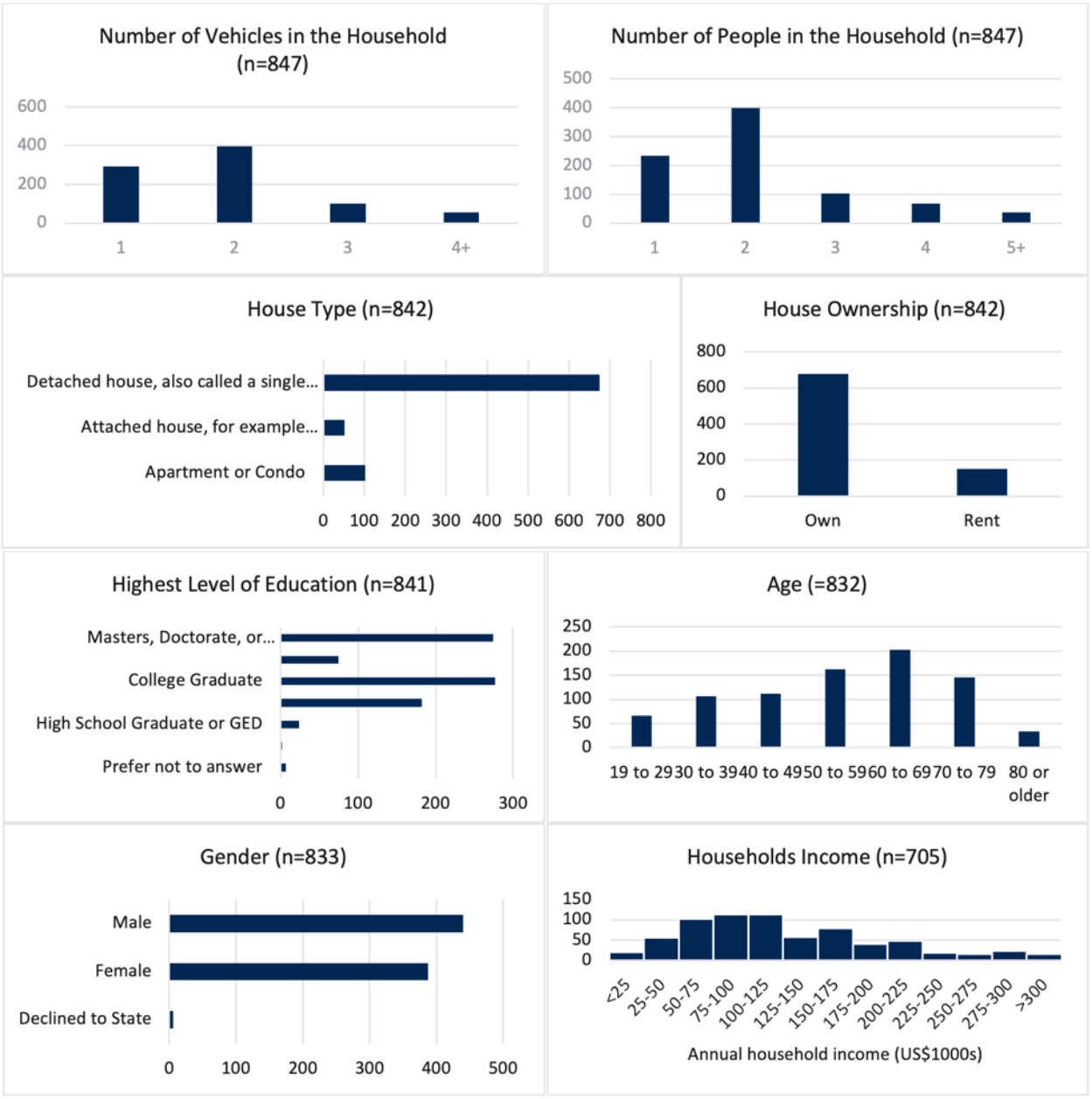

Figure 15. Distribution among survey respondents of number of vehicles and people in the household, house type, house ownership, highest level of education, gender, age, and household income for survey respondents.

Access to Charging from Home

Figure 16 shows the type of parking that respondents used at home, whether they had access to an electrical outlet where they park their vehicle, and whether they had the authority to install a new outlet. Most respondents (86%) parked their vehicle in a garage, carport, or in their driveway. 73.7% had access to a 110v outlet where they parked their vehicle, 27% a 220v outlet, and 1.5% had dedicated electric vehicle supply equipment (EVSE). 21.3% of respondents did not have access to 110v, 220v, or EVSE where they parked their vehicle at home. Of those who did not have charging at home, 35% would be able to install a PEV charger; this left 13.8% of the sample who could not charge a PEV at home and would not be able to install an electrical outlet to charge their PEV.

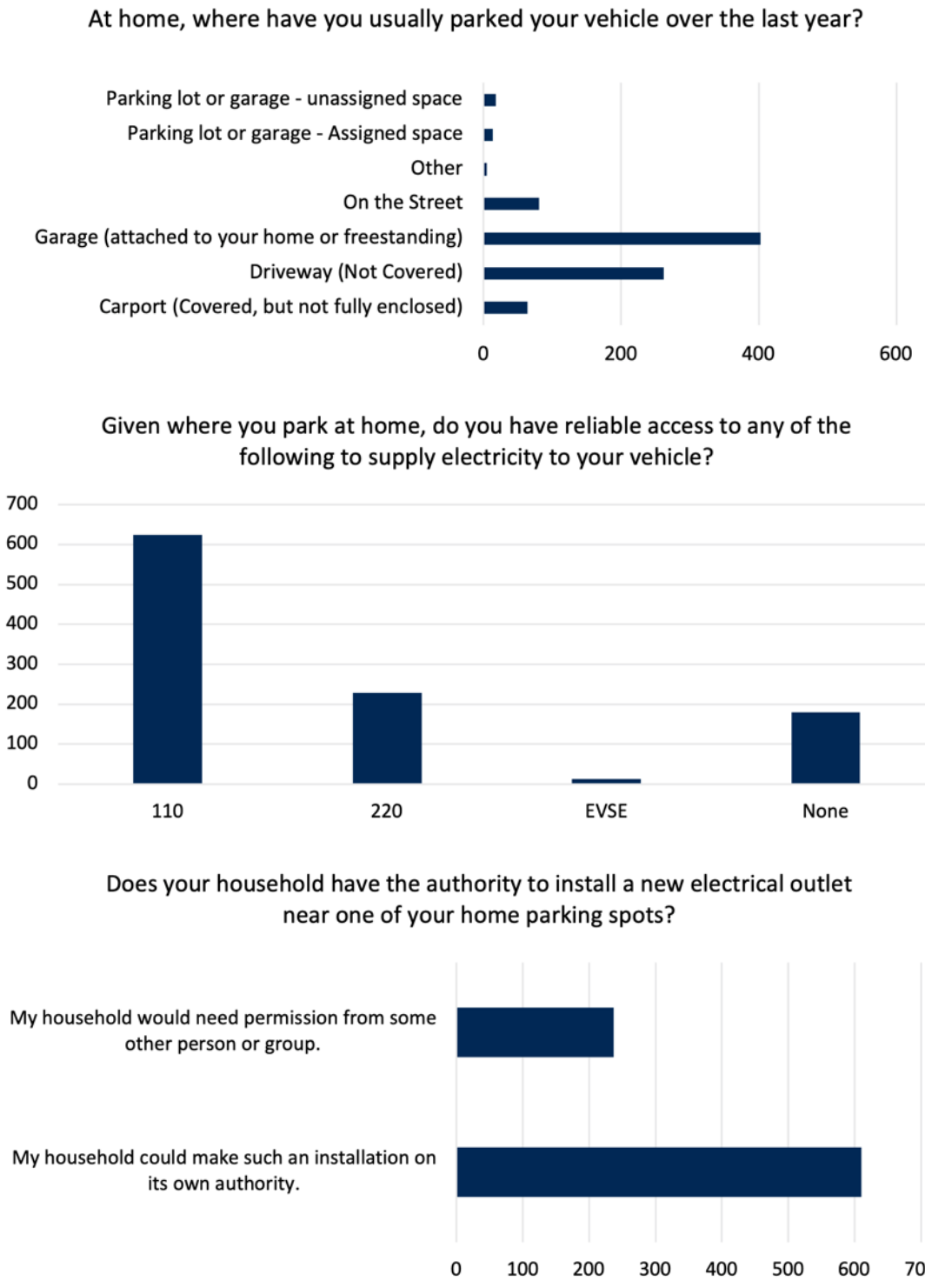

Figure 16. Types of parking respondents used at home, whether they had access to an electrical outlet where they parked, and whether they had the authority to install a new electrical outlet at their home (EVSE = electric vehicle supply equipment) (n=847).

PEV Advertising

Survey respondents were asked whether they are aware of advertising of electric vehicles, education programs, and electric vehicle ride-and-drives in the Sacramento Region. Close to half reported that they had seen advertising, 23% were aware of education programs, and 15.6% are aware of electric vehicle ride-and-drives (Figure 17).

Respondents who reported being aware of advertising of electric vehicles were asked where they had seen this advertising. Most reported having seen this on the television (79%), with print media the next highest source of advertising (68%). Around 40% of respondents reported the source of advertising as social media, billboards, and radio advertising. A smaller proportion of respondents (18.6%) report the source of advertising as coming from when they ride in electric taxis, Uber, or Lyft.

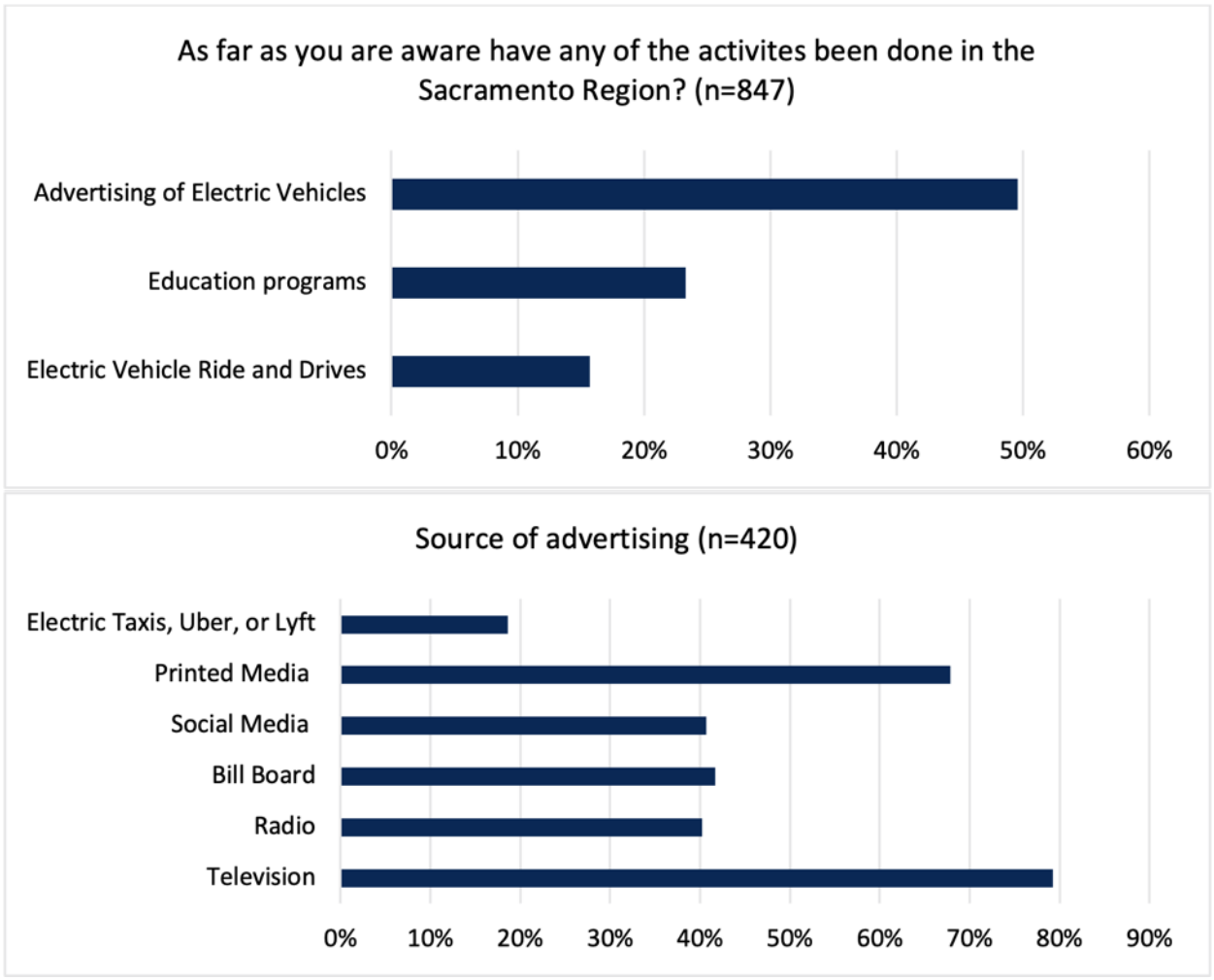

Figure 17. Distribution of respondents aware of different PEV publicity campaigns and, if they saw advertising, the source of that advertising.

Sources of Information for PEVs

Respondents were asked whether they had sought out information on purchasing or leasing electric vehicles. A total of 210 (approximately 25%) had done so. These respondents were asked where they sought this information. Most (160) reported that they used the internet, the next largest proportion asked car salespeople, followed by family and friends.

Those who indicated that they used the internet to find information on electric vehicles were asked to list their sources (in an open text box). Of these, 54 indicated they used Google to search information, 40 used car websites, 17 used Tesla as a source, and 15 used Sacramento Municipal Utility District (SMUD).

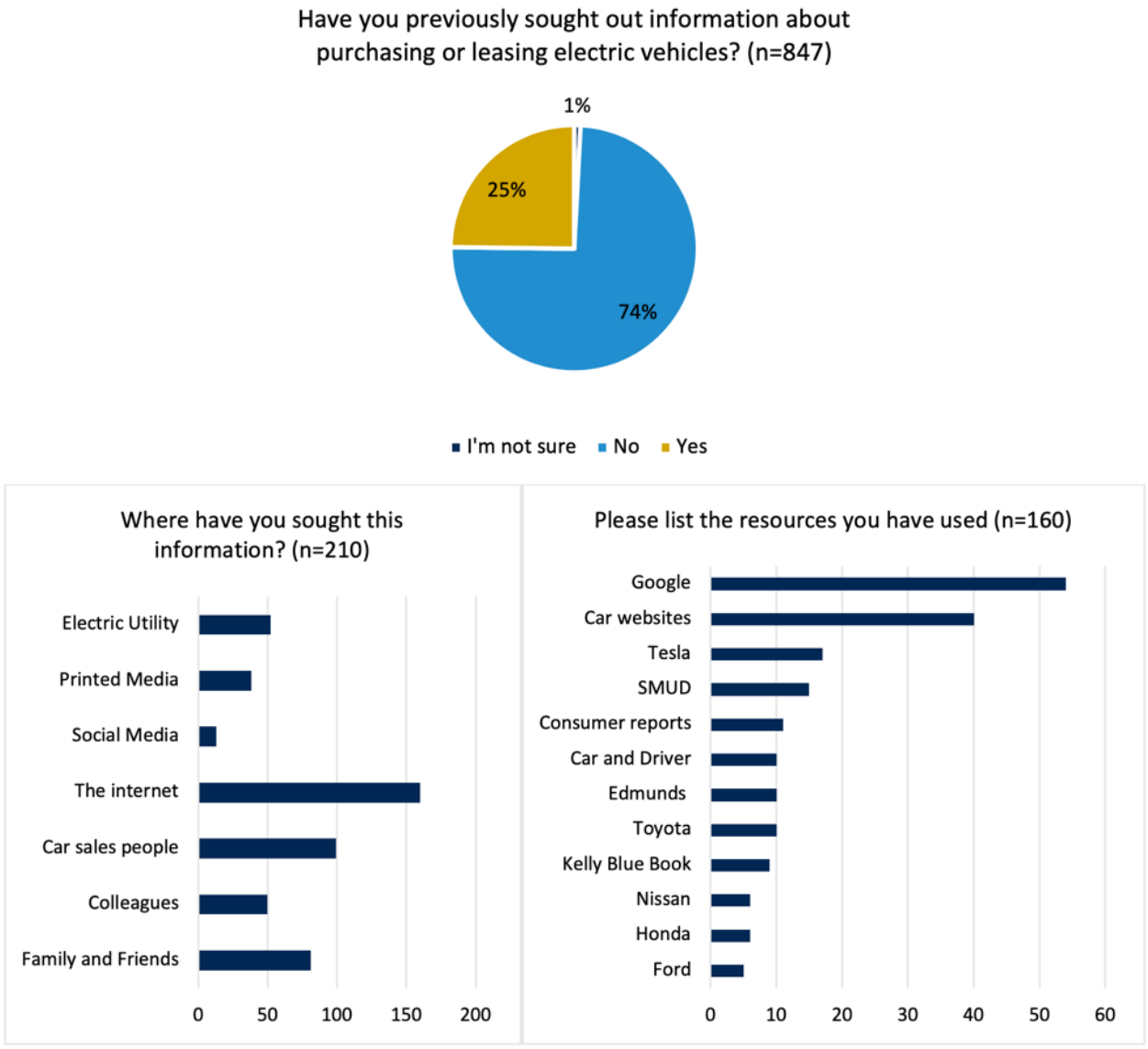

Figure 18. Whether respondents had sought out information on electric vehicles, the source of information, and Internet sources they used.

Awareness of PEV Incentives

Figure 19 shows respondents reported awareness of federal, state, and local incentives. The highest level of awareness was of state incentives (53.7%) (i.e. incentives in any state in the US, not specifically California), followed by California incentives for PEVs (47%), and federal incentives (46%). Awareness of parking incentives was also high (45.6%). Of the respondents, 26.8% reported being aware of incentives provided by their local utility, in this case SMUD.

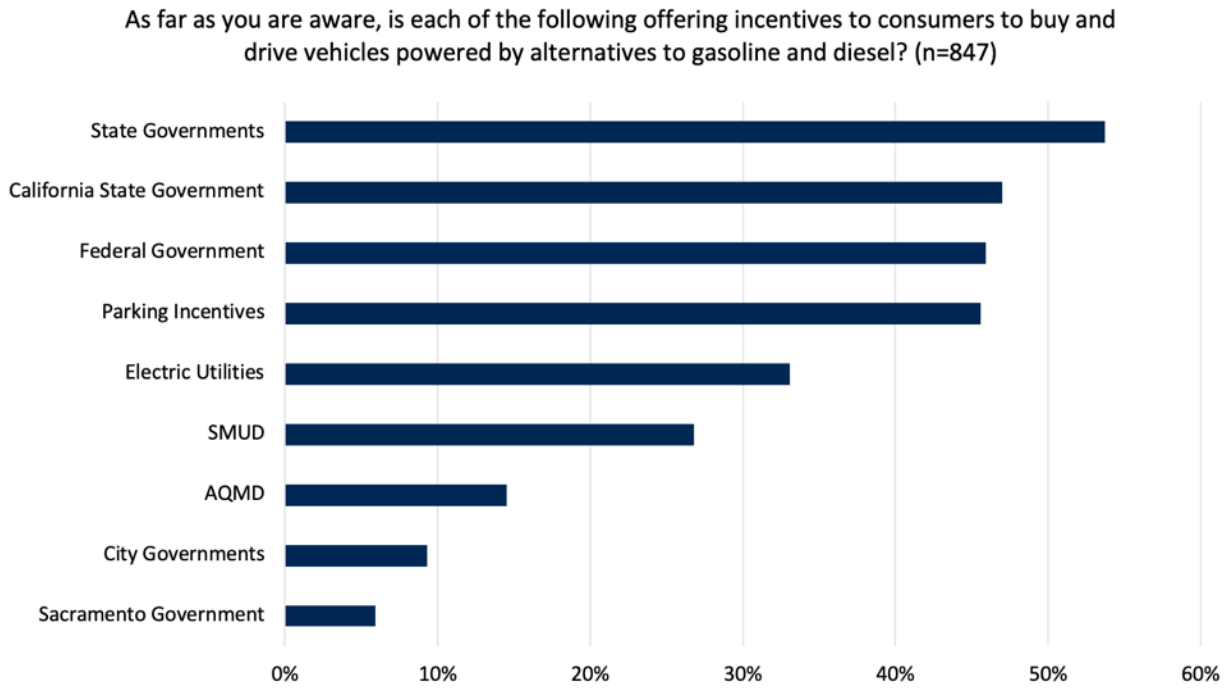

Figure 19. Self-reported awareness of federal, state, and local incentives for PEVs.

Knowledge of PEVs

Survey takers were asked “Are you familiar enough with these types of vehicles to make a decision about whether one would be right for your household?” for internal combustion engine vehicles (ICEVs), hybrid electric vehicles (HEVs), PHEVs, BEVs, and fuel cell vehicles (FCVs). Respondents could drag a slider bar between “No” and “Yes.” Answers are shown in Figure 20. The highest familiarity was with ICEVs, followed by HEVs. This self-reported knowledge shows that respondents are on average less familiar with BEVs and PHEVs, and least familiar with FCVs.

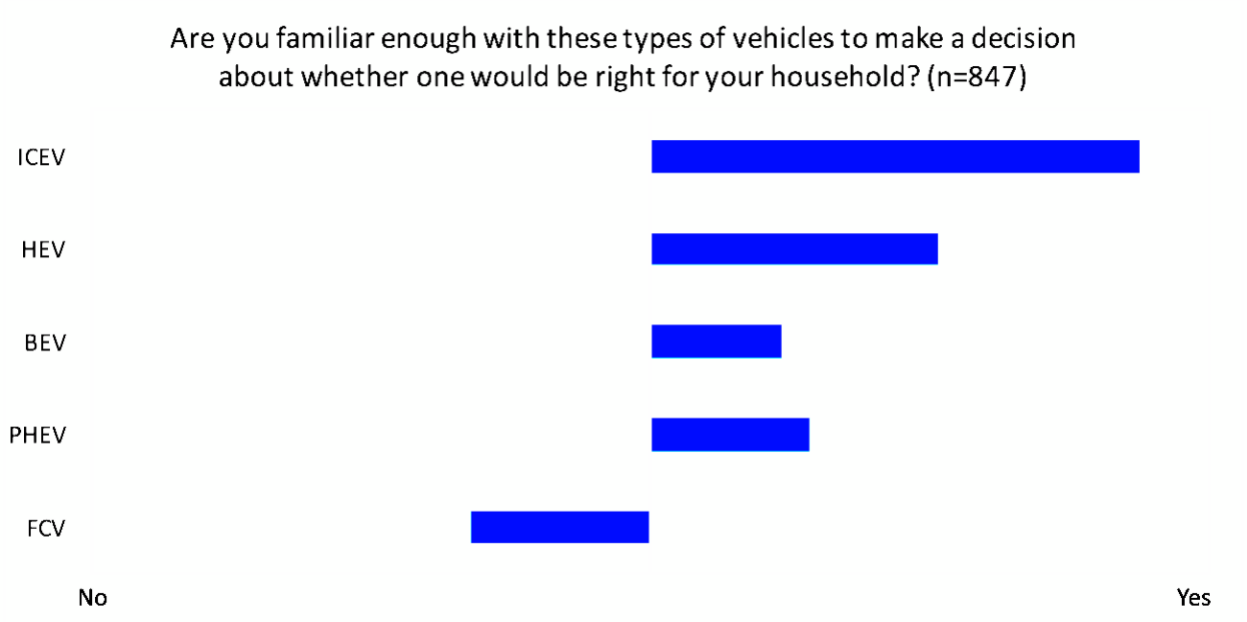

Figure 20. Self-reported familiarity with ICEVs, HEVs, BEVs, PHEVs, & FCVs.

To ascertain whether respondents were knowledgeable about different vehicle types they were first asked how the vehicles were fueled, then were asked to name BEV and PHEV models. Figure 21 shows whether respondents were able to correctly identify how ICEVs, HEVs, BEVs, and PHEVs were refueled. Most respondents knew how to refuel an ICEV, and 87% knew how to refuel a BEV. More confusion exists with HEVs and PHEVs: 77% knew that a PHEV is fueled with both gasoline and plugged in to charge, whereas only 36% know that a HEV is refueled with gasoline and is not plugged in to refuel.

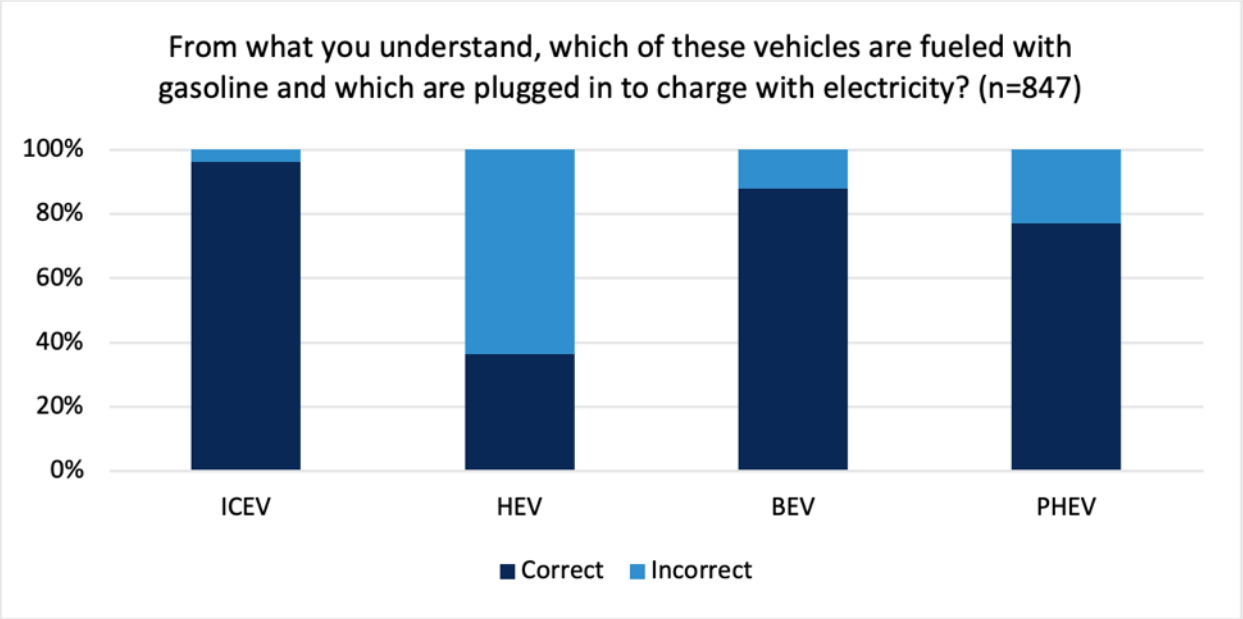

Figure 21. Respondents were asked to indicate how they thought ICEVs, HEVs, BEVs, and PHEVs were fueled. The figure shows the proportion of respondents who could identify the correct fueling method for these vehicles.

Respondents were asked if they can name a PEV for sale in the USA today. If respondents answered "Yes," an open text box was provided for them to enter the make and model of the vehicle. Figure 22 shows those who answered "No" and those who answered "Yes." Those who answered "Yes" but were wrong are in the "Wrong" category, those who answered "Yes" and were right are in the "Right" categories (which also notes popular vehicles that were mentioned).

For PHEVs, 60% could not name a vehicle model or incorrectly named a model. Of the 40% who could name a PHEV for sale in the USA, most either cited the Chevrolet Volt or Toyota Prius Plug-in/Prime, with only 5% of the total sample mentioning other PHEV models.

For BEVs, 50% could not name a vehicle model or incorrectly named a vehicle. Of the 50% who could identify a BEV for sale in the USA, most identified a Tesla (30% of the total sample), with a smaller proportion naming a Nissan Leaf (16%), and just 3% mentioning the Chevrolet Bolt. Other BEV models were mentioned by only 1% of the total sample.

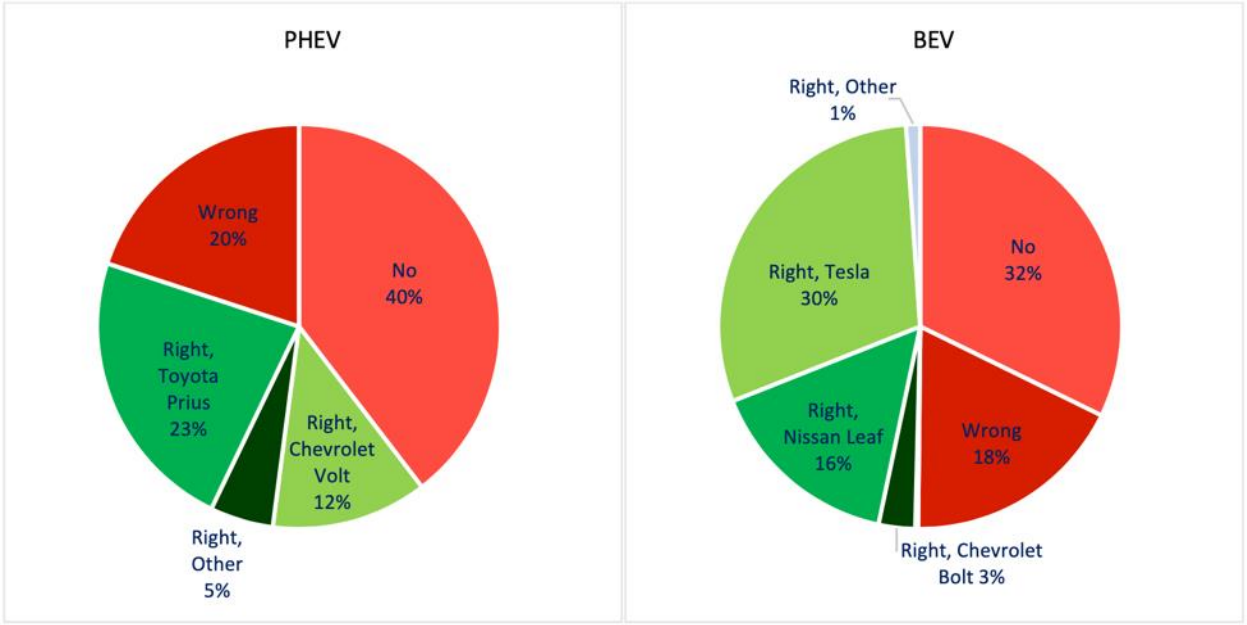

Figure 22. Answers to "Can you name a plug-in hybrid vehicle that is being sold in the US?" and "Can you name a battery electric vehicle that is being sold in the US?" Those who answered "No" are in the "No" category. Those who answered "Yes" but were unable to correctly identify a vehicle are in the "Wrong" category, and all others are in the "Right" categories.

Perceptions of PEVs

Respondents were asked which fuel types they believed would be the most likely to replace gasoline and diesel fuel, with up to three options allowed for each respondent (Figure 23). The most commonly selected fuel type was electricity, indicating most respondents believe PEVs are the most likely vehicles to replace ICEVs.

Next, respondents were given 9 attitudinal statements about electric vehicles, which they could answer by dragging a slider bar between "Strongly Disagree" and "Strongly Agree." Figure 24 shows average responses to this question. On average respondents indicated BEVs are better for the environment and that the vehicles are safe. Respondents were less sure about whether the vehicles are ready for the mass market, believed the vehicles are more expensive to purchase than ICEVs, thought driving ranges are too low, and believed that there are not enough places to recharge a PEV.

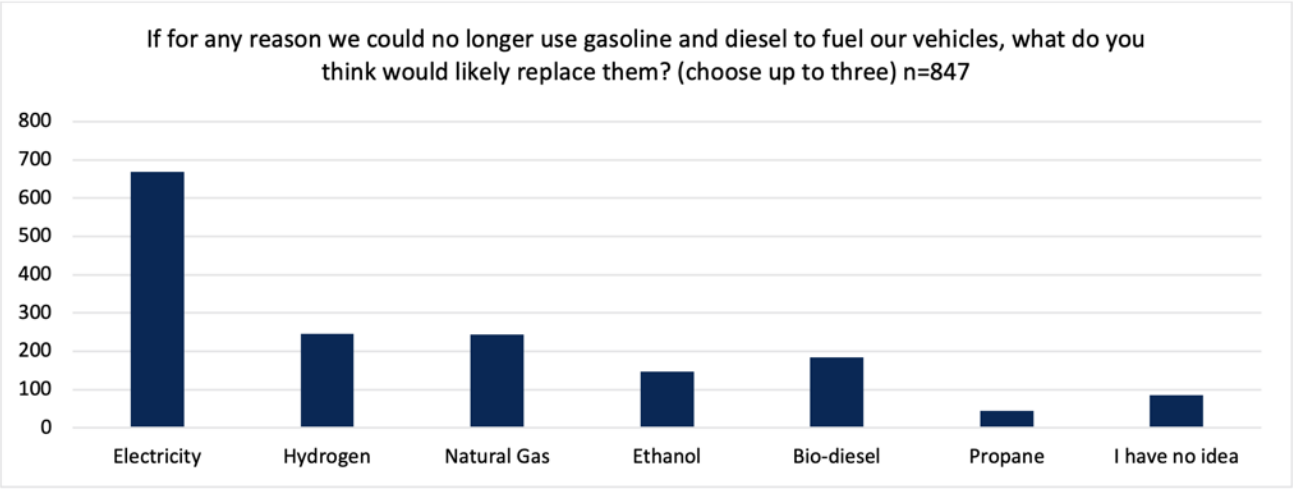

Figure 23. Respondents' thoughts on the fuel type most likely to replace gasoline and diesel fuel.

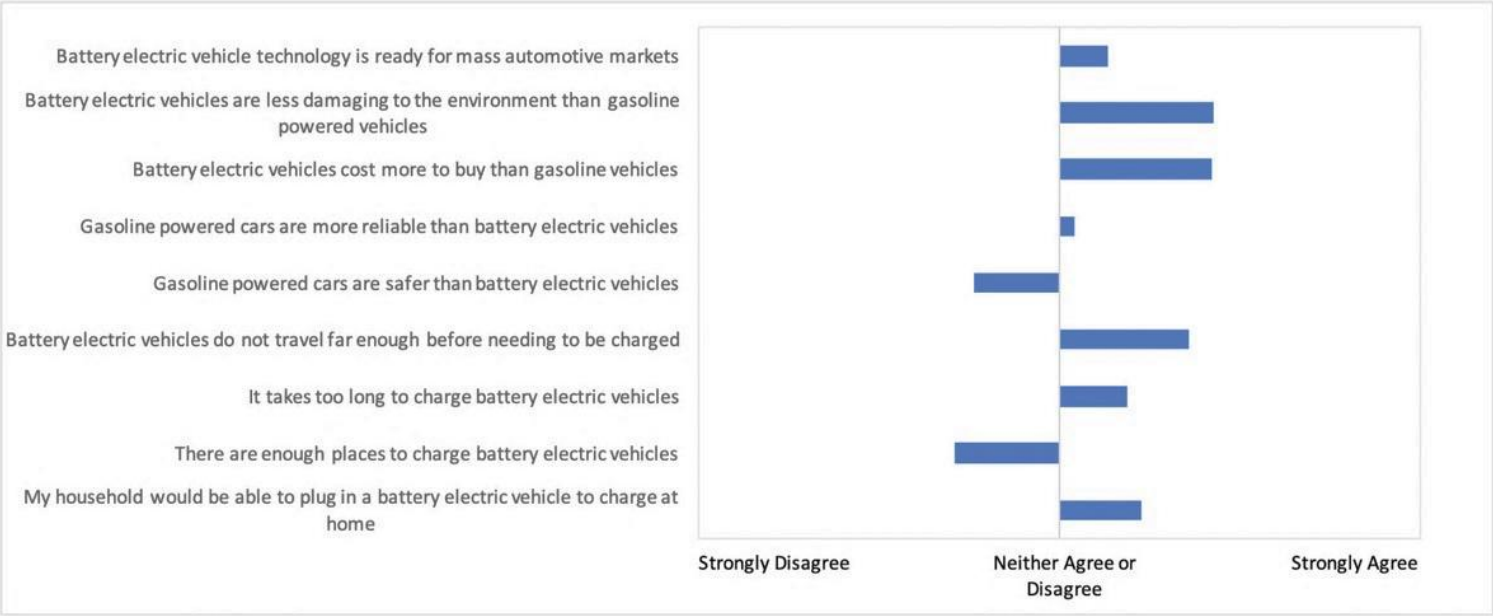

Figure 24. Average responses to 9 attitudinal statements about electric vehicles.

Awareness of PEV Charging Infrastructure

Survey respondents were asked if they had seen any electric vehicle charging spots in the parking garages and lots they use. If respondents had seen charging spots, they could answer "I've seen them at one place," "I've seen them at a few places," or "I've seen them at several places." Figure 25 shows responses to this question for Sacramento in 2018 and for California in 2014. The 2014 data are for car-owning households in California recruited online, the 2018 data are for car owning households in Sacramento recruited via postal mail. The data are not directly comparable as differences could be due to changes in the number of chargers over time, regional differences, or differences in the samples. Nevertheless, in Sacramento in 2018, more respondents reported seeing chargers than they did in 2014 in California, though it is not possible to isolate the cause of this. Respondents who reported seeing PEV chargers were asked whether they had seen them at their place of work. Of the respondents who indicated that they had seen at least one charger, 42% commuted to a workplace where they had also seen electric vehicle chargers (Figure 26).

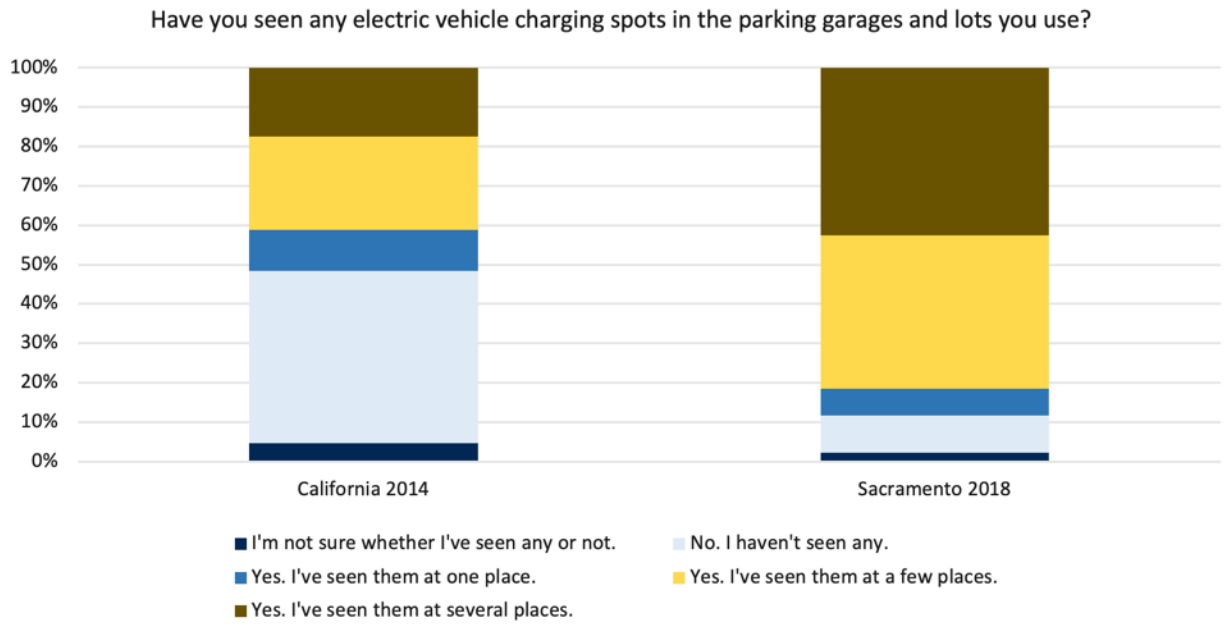

Figure 25. Answers to "Have you seen any electric vehicle charging spots in the parking garages and lots you use?" from the 2014 survey of California and the 2018 survey of Sacramento.

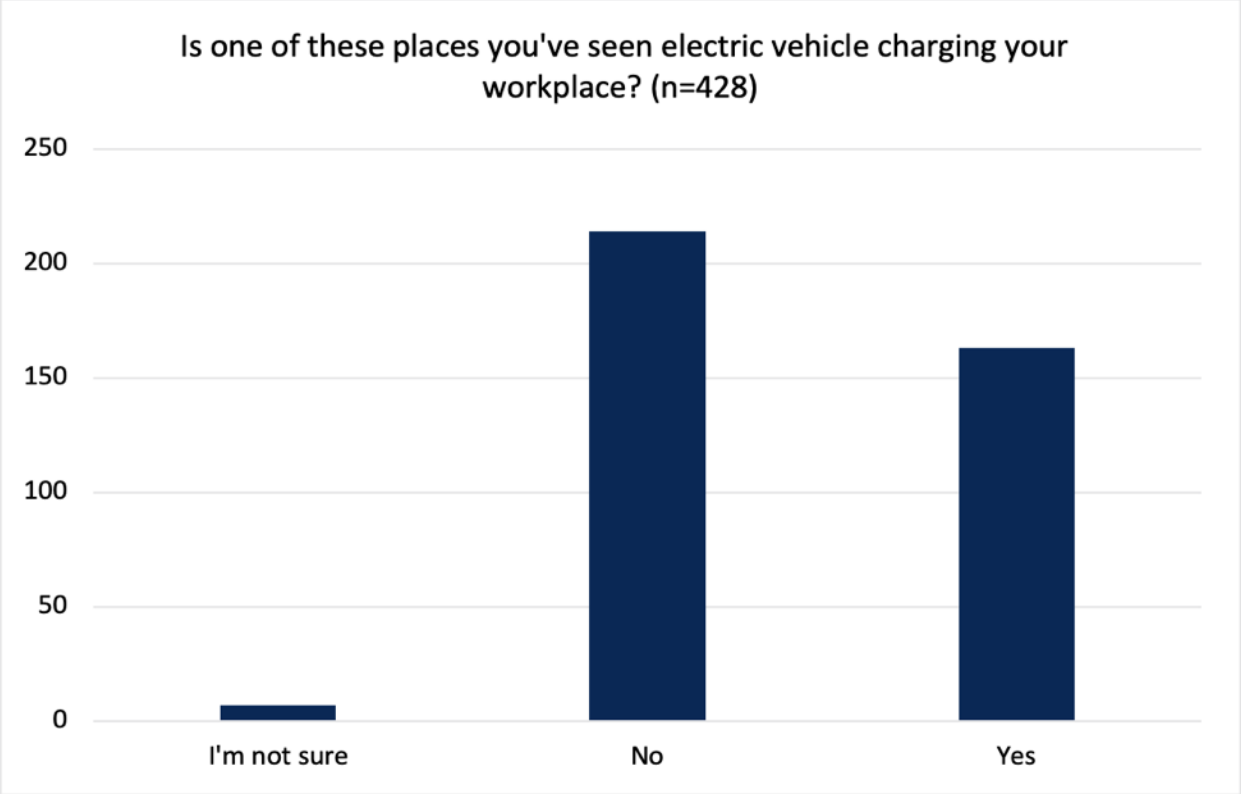

Figure 26. Whether respondents who report seeing a charger have also seen a charger at their place of work (note this question was only asked to respondents who drive to a workplace).

Consideration of Purchasing a BEV

Respondents were asked whether they had considered buying a BEV for their household. They were able to answer this question in the six following ways:

1. "Have not--and would not--consider buying a BEV"
2. "Have not considered buying a BEV, but maybe some day"
3. "Idea occurred, but no real steps taken"
4. "Started to gather information but not serious"
5. "Actively shopped for BEVs"
6. "I (we) already have, or have had, a BEV"

Option 1 is for those not considering a BEV and unlikely to ever buy an electric vehicle. Option 2 is for those who have never thought about buying a BEV until taking the survey, but maybe would consider one in the future. Option 3 is for those who have thought about it but have taken no real steps in making a purchase. Option 4 is for those who have started to gather some information about BEVs and purchasing one but have not gotten serious about the purchase yet. Option 5 is for those who are actively shopping for a BEV, which may include test driving the vehicles. Option 6 is for those who already own or have previously owned a BEV. For

BEV markets to continue to grow, the group of people who have thought about purchasing BEV needs to grow. This includes those who have had the idea but not taken steps toward a purchase (option 3), gathered information (option 4), or actively shopped for a BEV (option 5). Figure 27 shows responses to this question from a 2014 survey of California by Ken Kurani, and the 2018 survey of Sacramento. As was previously mentioned the data are not directly comparable as differences could be due to changes over time, regional differences, or differences in the samples. Nevertheless, the percentage of respondents who were considering purchasing a BEV was not greater in Sacramento in 2018 than in the entire state of California in 2014, which suggests little progress has been made in engaging respondents in the transition to BEVs in the region.

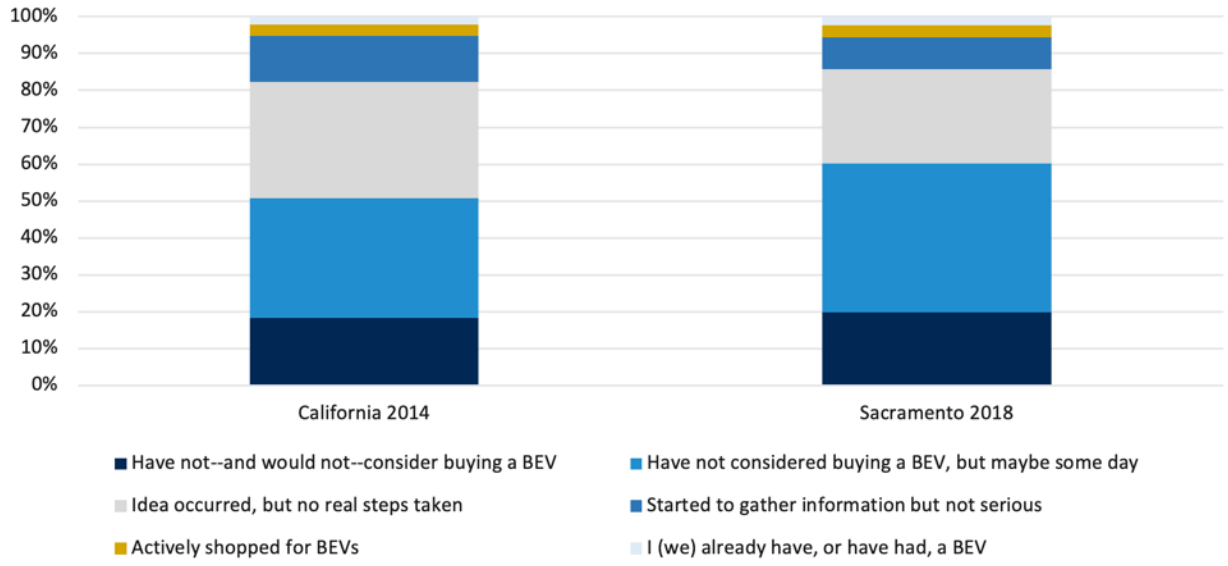

Figure 27. Answers to "Have you considered buying a BEV for your household?" from the 2014 California statewide survey and the 2018 Sacramento survey.

Understanding Consideration to Purchase a BEVs

We performed an ordinal logistic regression model to identify factors related to whether respondents were considering purchasing a BEV. The model specifically focused on BEVs for the dependent variable, not PEVs which would include PHEVs. Some independent variables in the model are for PEVs (i.e. BEVs and PHEVs). The model used four ordinal categories as the dependent variable. These categories were taken from the possible responses shown in Figure 27:

1. "Have not and would not consider buying a BEV", the base scenario in the model.
2. "Have not considered buying a BEV, but maybe some day", referred to as "Maybe"
3. "Idea occurred, but no real steps taken", referred to as "Idea occurred"
4. "Actively shopped for a BEV" or "Started to gather information but not serious", referred to as "Gathered info or test driven"

The model aims to understand what factors are related to whether respondents have considered purchasing a BEV; either by having "Actively shopped for BEVs" or "Stated to gather information but not serious". The independent variables in the model included socio-demographic information, variables that measure PEV knowledge, those that measure awareness of incentives and advertising, and whether respondents have sought out information on PEVs. The model also includes attitudinal factors generated using responses to the questions in Figure 24. The attitudinal statements were used to generate three factors that capture respondents' overall attitudes towards electric vehicles. The three factors were Skeptical, Reluctant, and Enthusiastic.

Table 1 shows the results of this model. The model had a p-value of <0.001 and an unadjusted R^2 of 0.22, suggesting it has explanatory power. The model found the factors "Skeptical" and "Reluctant" were negatively correlated with the ordinal dependent, the factor "Enthusiastic" was positively correlated. These results suggest that those who have considered purchasing a BEV are less skeptical, less reluctant, and more enthusiastic about the vehicles. Self-reported familiarity with PEVs also had a significant positive correlation with the dependent variable. This indicates those who believe they are more familiar with the technology are more likely to be considering purchasing the vehicles. Other independent variables positively correlated with considering BEV purchase were: correctly knowing how a BEV is refueled; knowing a PEV owner by name; having sought out information on PEVs; and the number of sources of this information used. The only socio-demographic variable with a significant correlation was age, which had a negative correlation, suggesting younger respondents are more likely to consider purchasing a PEV. The ability to charge a PEV from home was almost significant (p-value 0.052).

The model shows the following factors are not significantly related to whether respondents were considering purchasing a PEV: whether they had seen advertising, their awareness of ride-and-drives, whether they had been in a BEV, whether they had seen charging stations, and whether they were aware of incentives. Neither the density of PEV charging stations nor the density of PEVs in respondents' home zip code significantly correlated with consideration of purchasing a PEV.

The model indicates that the most important predictors of whether respondents were considering purchasing a PEV were attitudinal variables, whether they themselves have sought out information on PEVs, whether they knew how to refuel a PEV, and whether they knew a PEV owner by name. These results suggest that existing efforts to encourage consumers to purchase a PEV do not have a significant impact on purchase considerations. The model supports the idea that the consumers who are purchasing or thinking about purchasing PEVs are a small group of early adopters whose interest in the vehicles is self-motivated and not impacted by the external factors (i.e. awareness and engagement activities) that were assessed.

The lack of significance of advertising and ride-and-drives does not mean they cannot impact PEV sales but that their impact could not be detected by this study, perhaps due to having too small an impact on the market at present. They may serve to move consumers from the

persuasion stages to the purchase stages, but may be less effective at moving people to the awareness or knowledge stage, where more people may be affected.

Table 1. Ordinal logistic regression model for whether respondents have considered purchasing a BEV (*<0.05, **<0.01, *<0.001).**

	Estimate	Std Error	p-value
Intercept [Gathered info or test driven]	-4.0738	0.4848	<0.001***
Intercept [Idea occurred]	-1.6274	0.4543	<0.001***
Intercept [Maybe]	1.0097	0.4521	0.0255*
Skeptical Factor	-0.5117	0.1038	<0.001***
Reluctant Factor	-0.5084	0.1022	<0.001***
Enthusiastic Factor	0.7273	0.1107	<0.001***
Age	-0.0128	0.0053	0.0160*
Gender	0.2224	0.1702	0.1913
Know a PEV owner by name	0.4403	0.1843	0.0169*
Number of PEV information sources used	0.9133	0.0999	<0.001***
Number of PEV advertising sources seen	0.0007	0.0471	0.9881
Awareness of ride-and-drives	0.1965	0.2419	0.4167
Been in PEV	-0.1701	0.1935	0.3794
Seen chargers	0.3380	0.2211	0.1263
Know how to refuel a BEV	0.5922	0.2566	0.0210*
Have access to charging at home	0.4079	0.2106	0.0528
Have high-occupancy vehicle (HOV) lanes on commute	-0.1270	0.1621	0.4334
Annual vehicle miles traveled (VMT)	-6.00E-06	1.21E-05	0.6206
Number of PEV incentives aware of	0.0061	0.0630	0.9228
Familiarity with BEVs	0.0999	0.0380	0.0086*
Household Income	2.37E-07	1.23E-06	0.8474
Density of PEVs on home zip code	0.0235	0.0324	0.4673
Density of charging stations in zip code	-0.0066	0.0041	0.1097
		p-value	<0.001***
		R^2 (U)	0.22

Summary

Engagement in PEVs in Sacramento appears to be moderate. Of the survey respondents, 50% indicated having seen PEV advertising; 25% had gathered information on PEVs; 47% were aware of the California rebate; 46% were aware of the federal tax credit; 72% were able to identify how a PHEV is refueled and 87%, how a BEV is refueled; 40% could name a PHEV for sale in the US, and 50% could name a BEV. The proportion of respondents who were aware of infrastructure was higher in this 2018 Sacramento survey than in a 2014 California survey. Despite moderate engagement in the region, only 3.3% of respondents indicated they had actively shopped for a BEV, which was not substantially different from the percentage in the 2014 California survey.

An ordinal logistic regression model showed no relationship between considering the purchase of a BEV and any of the following: seeing advertising; awareness of ride-and-drives; having been in a PEV; having seen chargers; awareness of incentives; infrastructure density; or PEV density in respondents' home location. These findings suggest that these factors have yet to have a measurable impact on PEV purchase consideration in the population surveyed.

Considering the purchase of a BEV is related to being enthusiastic about BEVs, having sought out information on the vehicles, knowing a PEV owner by name, knowing how to fuel a PEV, and being familiar with the vehicles. This suggests that those who have considered purchasing a BEV are doing so due to a pre-existing interest in the vehicles, not due to external influences. It appears BEV shoppers are still a self-selecting group, as was first discussed by Kurani (Kurani 2017).

To continue to engage consumers, and to engage more consumers in the transition of PEVs different approaches will be needed at different stages of the adoption process shown in Figure 1. According to the regression model knowing someone who owns a PEV by name has a significant relationship with consideration to purchase a PEV, this may mean word of mouth effects are having an impact on PEV sales. Word-of-mouth is often important in the later stages of the adoption process, it doesn't always generate awareness but can help consumers decide to purchase an innovation or not. To engage consumers in the early stages, particularly the awareness and knowledge stage, mass and traditional media may be more important. The locality of information is also important at each stage. According to Rogers, more local information sources are important in the later stages, and more cosmopolitan sources are important in the earlier awareness and knowledge stage.

Based on the results of this study and generalizations made in diffusion-of-innovation theory, it appears that when consumers conduct research in the persuasion and decision phase, the right conditions must exist to help convince them to adopt a PEV. The significance of knowing someone by name who owns a PEV may suggest that local sources of information are available to perspective PEV buyers. The available incentives and infrastructure in the region may also help consumers decide to purchase a PEV. Perhaps what is lacking is larger scale activities to engage consumers in the transition from general awareness to specific knowledge and consideration. The recent advertising campaigns for PEVs that several entities (e.g., Veloz,

Electrify America, Plug-In America, etc.) have begun may have an impact on the consideration to purchase a BEV. The survey in this study was administered before these recent campaigns, so does not measure the potential impact of these campaigns.

Future Research

Future research should include investigating which factors are related to consumers' consideration to purchase an electric vehicle (Figure 27). This will include understanding any relationship between considering the purchase of a PEV and several independent variables, including awareness of incentives, awareness of electric vehicle promotion activities (advertising, ride-and-drives), knowledge of electric vehicles (how they are fueled, vehicle models), having seen charging stations in the region, and other variables (including socio-demographics). This analysis may be conducted using a regression model to investigate any statistical relationships.

The study results described here can serve as a baseline for comparison of future measurement of awareness of PEVs and engagement with the PEV market.

The ordinal logistic regression model described in this report will be further developed into a paper for publication in a Journal in 2019.

The researchers hope that external funding can be obtained to continue this questionnaire survey in 2019 and beyond to track progress in the region and to gain a better understanding of which outreach and advertising activities work to help consumers transition to PEV consideration, and which do not.

References

California Environmental Protection Agency, 2014. Approaches to Identifying Disadvantaged Communities. , (August).

Kurani, K., 2017. What if you held a transition to electric-drive and no one knew?

Rogers, E.M., 2003. *Diffusion of Innovations* 5th Editio., New York: Free Press.

SACOG, 2013. PEV Implementation: Plug-in electric vehicle (PEV) readiness and infrastructure plan.