2018–2019 California Vehicle Survey

California Energy Commission

CONSULTANT REPORT

Prepared for: **California Energy Commission**
Prepared by: **RSG**

1.1.1.1 California Energy Commission

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ABSTRACT

EXECUTIVE SUMMARY

The Energy Commission is directed by Public Resources Code (PRC) Section 25301 to prepare a forecast of transportation fuel demand. Light duty vehicles compose the largest share of transportation fuel demand, and consumers' choice of light duty vehicle and fuel types is the major determinant of the level and distribution of transportation energy demand. California vehicle survey periodically reassess changes in consumer preferences for different light duty vehicle technology types and uses the results to update the Energy Commission's light duty vehicle choice models for residential and commercial market segments. With growing Zero Emission Vehicle (ZEV) population in California, the 2019 survey included an additional targeted sample of ZEV owners.

Samples

Samples of households, business establishments and ZEV owners were drawn from different sampling frames, resulting in the following:

- Survey invitations were sent to xx households, xx commercial establishments and xx ZEV owners, across California.
- The six regions across California included one specific to the Central valley to ensure representation from different regions across California.
- The survey participants completed a total of xx surveys by households and over 2000 surveys by commercial establishments, including a total of XX residential and commercial ZEV owners.

Questionnaires

Survey questionnaires aimed to collect data on:

- economic and demographic characteristics of the survey participants, such as income, employment & household size, as the key drivers of the light duty vehicle population in California.
- The number and composition of the current vehicles holding and the ones they intend to purchase.
- Stated choice of the vehicle and fuel types from a set of vehicles with hypothetical vehicle attributes, incentives, and refueling/rechanging characteristics.

Results

The survey data was used to estimate the light duty vehicle choice models that capture consumer behavior in different market segments. The results show that:

- Household and business vehicle preferences are different.
- Consumer preferences are different among the households that own one, two or 3+vehicles.
- Households at lower levels of income are more sensitive to both vehicle prices and incentive amounts.
- All market segments show higher preferences for battery electric vehicles.
- ZEV owners are more sensitive to range and more likely to purchases another ZEV vehicle.
- Commercial sector is more sensitive to HOV lane access, and more open to hydrogen vehicles.
- Access to home charging is a significant factor in choosing PEVs.
- In most market segments consumers preferred subcompact, compact and midsize Crossover/SUV to subcompact cars and other vehicles.

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Chapter 1: Introduction

The Energy Commission is directed by Public Resources Code (PRC) Section 25301 to prepare a forecast of transportation fuel demand to assess the need for resource additions, efficiency, and conservation with consideration for all aspects of energy industries and markets essential for the state economy, general welfare, public health and safety, energy diversity, and protection of the environment. PRC Section 25304 specifies that the Energy Commission transportation forecast shall include:

- Assessment of trends in transportation fuels, technologies, and infrastructure supply and demand and the outlook for wholesale and retail prices for petroleum and alternative transportation fuels under current market structures and expected market conditions;
- Forecasts of statewide and regional transportation energy demand, both annual and seasonal, and the factors leading to projected demand growth including, but not limited to, projected population growth, urban development, vehicle miles traveled, the type, class, and efficiency of personal vehicles and commercial fleets, and shifts in transportation modes;
- Evaluation of the sufficiency of transportation fuel supplies, technologies, and infrastructure to meet projected transportation demand growth;
- Evaluation of alternative transportation energy scenarios, in the context of least environmental and economic costs, to examine potential effects of alternative fuels usage, vehicle efficiency improvements, and shifts in transportation modes on public health and safety, the economy, resources, the environment, and energy security; and
- Examination of the success of introduction, prices, and availability of advanced transportation technologies, low- or zero-emission vehicles, and clean-burning transportation fuels, including their potential future contributions to air quality, energy security, and other public interest benefits.

The Energy Commission uses these forecasts and assessments to make recommendations for improving the efficiency of transportation energy use, reduce dependence on petroleum fuels, decrease adverse environmental impacts from transportation energy use, promote economic development, and enhance energy diversity and security.

The Energy Commission prepares the forecast and assessment of transportation fuel demand, the outlook for retail fuel prices, and the analysis of shifts in fuel types, vehicle types, and other factors based on analysis of data collected from different sources. The Energy Commission uses the light duty vehicle choice models that are based on California Vehicle Survey (CVS) data to assess current vehicle ownership, the factors that current and future vehicle owners consider when purchasing a new vehicle, and the

likelihood that they would operate an alternative fuel vehicle or other advanced technology vehicle.

As part of the requirements for the PRC section 25304, the Energy Commission periodically conducts independent surveys of California light duty vehicle (LDV) consumers in both the residential and commercial sectors. Changes in the market conditions, consumer awareness, and technology and manufacturer offerings will change consumer preferences. Repeating the survey allows the Energy Commission to capture the shift in consumer preferences and improve the accuracy of forecasts.

The 2015-2017 vehicle survey included additional targeted sample of 500 plug-in electric vehicle (PEV) owners, in addition to the residential and commercial fleet owner surveys and resulted in the completion of 600 PEV owner surveys in the residential and commercial market segments.

The 2018-2019 vehicle survey builds upon the previous surveys to update consumer preferences. Additionally, it augments the surveys to add targeted samples of the current zero emission vehicle (ZEV) owners to learn about both their preferences and their vehicle use and charging behavior.

1.1 Project Goals

The goals of this survey are to design and conduct both revealed preference (RP) and stated preference (SP) surveys for the household/residential LDV sector and the commercial LDV sector. The survey results were used to update light duty vehicle choice models that are used in generating the LDV fuel demand forecast for the 2021 Integrated Energy Policy Report (IEPR).

The LDV models are designed around levels of vehicle ownership; three categories of vehicle holdings for households and five categories of fleet size for businesses. The survey, therefore, should be a fair representation of California households and businesses in each of these categories.

Both CARB and Fuels and Transportation Division (FTD) cosponsored the survey project managed by Energy Assessments Division (EAD). The project collaboration started prior to the solicitation process, and the project started in 2018, with both CARB and FTD staff participating in the questionnaire design process. Commission worked with two outside entities to complete this project. Resources System Group (RSG) was responsible for the deployment of the survey, while Aspen Environmental Group lead the instrument design and was responsible for building the vehicle choice models. RSG is the author of most chapters in this report, but Chapters 2 and 6 culminates the efforts of RSG, Aspen and the CEC staff.

The survey work is presented in two volumes. Volume one, this report, describes different processes, methods and instruments used in the two phases of the survey, in the following chapters:

- Survey Design
- Survey Pretest
- Main Survey Implementation
- Main Survey Results
- Light Duty Vehicle Choice Models (forthcoming)

Volume two contains the details of design, the actual survey questionnaires, experimental design, survey web pages, survey material and alternative models estimated.

Chapter 2: Survey Design

This survey has seamlessly integrated two types of survey instruments, using two methods, to collect two types of data; (a) demographic and revealed preferences data on current vehicle ownership and replacement, and (b) data on stated preferences in choosing a vehicle to purchase, in two market segments.

This chapter describes the general design of each survey element and instrument; the complete text of the actual survey instruments are displayed in the appendices. The inter-related survey elements discussed here include questionnaires, stated preferences survey instrument, sampling plan, recruitment plan, website design and database design.

2.1 Questionnaire Design

Using the 2015-2017 CVS commercial questionnaire as starting point, CEC, RSG and Aspen teams updated the questionnaires. While the information collected in the 2019 questionnaires is largely consistent with previous versions of the survey, the questions, and question flow, layout, and formatting were updated to make the survey more efficient and easier to complete online.

As in previous iterations of the CVS, the 2019 survey consisted of two questionnaires: one for households and one for commercial fleets. Each of these questionnaires included add-on questions posed only to the ZEV owners in each market segment. Finally, the 2019 survey aimed to improve the accuracy of the self-reported vehicle miles traveled (VMT) by requesting dual odometer readings. Respondents could choose between responding to a short follow-up survey after 2 months, or they could report a previous odometer reading from their maintenance records.

Each survey had two primary components: the revealed preferences (RP) module, which collected information about current vehicle ownership and use behavior, and the stated preferences (SP) module, which collected information about vehicle preferences and future vehicle ownership and use behavior. As in the last two iterations of CVS, respondents could complete the RP and SP survey components in a single session. As a result, separate recruiting and follow-up mailing efforts were not required. Respondents began the survey by completing a series of RP questions about the composition and characteristics of the vehicles they owned and moved on to what they intend to purchase next. The information about the intended vehicle purchase was then used to generate a set of realistic SP experiments in real time as the respondents progressed through the survey. The SP experiments appeared directly following the RP questions, with no observable differentiation in the survey experience from the perspective of respondents.

For a variety of reasons, including continuity, the team adopted a phased approach to developing various parts/sections of the 2019 residential and commercial surveys. The emphasis in phase one of the questionnaire development was on (1) shortening the 2017 survey questionnaires to the degree possible to reduce respondent burden, thereby increasing completion rates, and (2) producing the updated discrete choice experiment (DCE) design. The aspiration for phase one questionnaire development was to limit data collection to what is necessary for updating personal and commercial vehicle choice models, as well as meeting other potential needs. The idea was that, once the phase one questions were completed, the team could determine the overall time and effort it would take for respondents to complete the phase one questionnaire so that the additional phase two questions were designed and added in a way not to overburden the respondents and discourage survey completion.

Some of the questions addressing emerging transportation issues related to alternative travel services/modes, such as ride-hailing and car sharing, were asked in the phase one draft of the questionnaire. At this stage, unless a household member uses a non-car-based mode as the primary mode for a commute trip to work and/or school, or a household vehicle is actively being used to deliver a ride-hailing service, there was no other information collected on the use of travel modes.

In the second phase, new questions were added to complement the phase one questions and better capture the emerging transportation trends, such as autonomous vehicles (AVs) and the intricacies of PEV charging infrastructure.

In addition to introducing new questions, the team provided more context for some of the questions and moved some questions after the choice exercises. Some of the new questions relied on borrowed material from a recent survey conducted by Giovanni Circella, Pat Mokhtarian, Farzad Alemi, and Sung Hoo Kim.

The team weighed advantages and disadvantages of providing context around the comparative costs for vehicle ownership versus using on-demand shared services. On one hand, experience suggests that it is difficult to expect people to give their best responses when they are unsure about costs. On the other hand, many survey studies in the literature appear to ask these types of questions without detailed cost information. But more recently there have been some dedicated DCE studies that manipulate costs.

2.1.1 Residential Survey Questionnaire

The complete residential survey instrument included questions that can be grouped into the following categories:

- **Survey introduction**. Welcome, language preference, password verification, and survey instructions.

- **Survey qualification**. Verify age, residency, and decision-making role, and ask about current vehicle ownership, and intent to purchase a vehicle in the next five years.
- **Household size and names**. Household size and identifying names/nicknames to be used in individual information section.
- **Individual information**. Demographic and travel behavior information for everyone in the household 16 years of age or older. This includes mode choice for work or school commute trips as well as the frequency of Transportation Network Company (TNC) and public transit use.
- **Current vehicle(s)**. Full details for each vehicle in the household (for example, mileage, VMT, primary driver, replacement expectations). The survey also asked whether the vehicle is used to provide TNC services (Uber, Grubhub, etc) and, if so, how many miles are used providing these services.
- **PEV owner questions**. Vehicle charging behavior, use behavior, cost of charging, electric rates used for charging, incentive awareness and influence on choice, and satisfaction information for households with at least one PEV.
- **FCEV owner questions**. Vehicle fueling behavior and infrastructure access, use behavior, cost of fueling, incentive awareness and influence on choice, and satisfaction information for households with at least one FCEV.
- **Next vehicle details.** If respondents are likely to purchase a household vehicle at some point in the future, details about that vehicle transaction including whether it will be a replacement for an existing household vehicle or an additional vehicle, and the expected timeframe for purchase.
- **Consideration Sets**. One departure from prior surveys, as it relates to their next vehicle, was that respondents were asked to identify more than one specific vehicle, if they so were inclined, referred to as "consideration set" elsewhere in the survey.
- **Vehicle trade-off exercises**. Set of eight choice exercises, each containing one SP choice question.
- **Alternative fuel vehicle awareness and consideration**. Measure interest level, awareness and primary concerns relating to ZEV purchasing and future vehicle automation.
- **Dwelling information.** Dwelling type, parking location, and parking cost.
- **Household income**. Current household income and expectations for the next five years.
- **Demographics for non-qualifiers**. Basic demographic questions for respondents that do not qualify to receive a survey incentive (for example, household size, employment, age, gender, ethnicity, education).
- **Dual odometer reading**. In addition to providing the current odometer reading, respondents were given the option to participate in a follow-up survey in two

months to provide a second odometer reading, or to provide an earlier odometer reading from service records.

- **Survey completion incentive and contact info**. Information about how/when respondent will receive their incentive, which was a $15 or $40 gift card for residential and commercial respondents, respectively. Preferred e-mail for incentive delivery.

The final survey questionnaire was translated into Spanish, and respondents had the option of completing the survey in either English or Spanish. Appendix 2-A provides the draft residential survey questionnaire and Appendix 2-E provides detailed description of the SP experiments.

2.1.2 Commercial Vehicle Survey Questionnaire

As with the residential survey, the commercial survey questions, question flow, and formatting were all revised for efficiency and consistency with the residential survey, while preserving most of the survey information content. The qualification section was changed to capture fleets where all the vehicles are used more than 50% of the time for business purposes. The revised survey only captures the number of vehicles used more than 50% of the time for business purposes. The commercial survey—like the residential survey—could be completed in a single sitting without re-contacting for the SP component. From the respondent's perspective, there was no differentiation between the RP and SP survey components when completing the questionnaire.

The commercial fleet owner survey also included a set of questions specific to PEV and FCEV owners and ZEV infrastructure, as well as questions related to autonomous vehicles as described in the residential survey section.

The information collected in the Commercial CVS questionnaire can be aggregated into the following categories:

- **Survey introduction**. Welcome, password verification, and survey instructions.
- **Survey qualification**. Business location(s), business type, number of employees, familiarity with fleet, fleet size, vehicle type ownership, and vehicle purchase intentions.
- **Current vehicle(s)**. Full details for up to five fleet vehicles (e.g., mileage, VMT, primary use, replacement expectations). These vehicles were selected to maximize the coverage of the vehicle types and fuel types in the respondent's fleet. If there were multiple vehicles with the same vehicle and fuel type, then respondents were asked to choose one. The survey also asked whether these selected vehicles could be replaced by TNC services.
- **PEV owner questions**. Vehicle charging and vehicle use behavior, charging behavior, electric rates for charging, incentive awareness and influence on choice, and satisfaction information for commercial fleets with at least one PEV.

- **FCEV owner questions**. Vehicle fueling and vehicle use behavior and infrastructure access, cost of fueling, incentive awareness and influence on choice, and satisfaction information for commercial fleets with at least one FCEV.
- **Next vehicle details.** If respondents are likely to purchase a fleet vehicle at some point in the future, details about that vehicle transaction, including whether it will be a replacement for an existing fleet vehicle or an additional vehicle, and the expected timeframe for purchase.
- **Consideration Sets**. Respondents were given the option to identify more than one specific vehicle, referred to as "consideration set" elsewhere in the survey. This was a change from previous surveys.
- **Refueling capabilities**. Current refueling system information and consideration.
- **Alternative vehicle consideration**. Measure interest level, awareness and primary concerns relating to ZEV purchasing and future vehicle automation.
- **Vehicle trade-off exercises**. Set of eight SP questions.
- **Survey experience**. Survey information resource usage and vehicle terminology understanding.
- **Dual odometer reading.** In addition to providing current odometer reading for up to five fleet vehicles chosen in the "Current vehicle(s)" section, respondents were given the option to participate in a follow-up survey two months later and provide a second odometer reading, or to provide an earlier odometer reading from service records.
- **Survey Completion Incentive and contact info**. Information about how/when respondent will receive his/her incentive. Preferred e-mail address for incentive delivery.

Appendix 2-B provides the draft commercial vehicle questionnaire and Appendix 2-E provides detailed description of the SP experiments.

2.1.3 ZEV Owner Questionnaires

Using the 2015-2017 CVS PEV questionnaire as a starting point, CEC, RSG and Aspen updated the questionnaire with recommended changes. RSG reviewed the changes for feasibility within the existing scope and cost estimate of the proposal. The 2019 ZEV owner add-on questionnaires included more questions specific to ZEV fueling infrastructure in the RP questions and more infrastructure attributes and metrics on the SP instrument. CEC and Aspen were responsible for developing the final questionnaire documents (see Appendix 2-C).

2.1.4 Dual Odometer Reading Follow-Up Survey

Prior surveys included a question on annual VMT, and the participants self-reported the value. To improve the accuracy of reported VMT, the survey team changed the way this information is collected in the questionnaire. Both commercial and residential

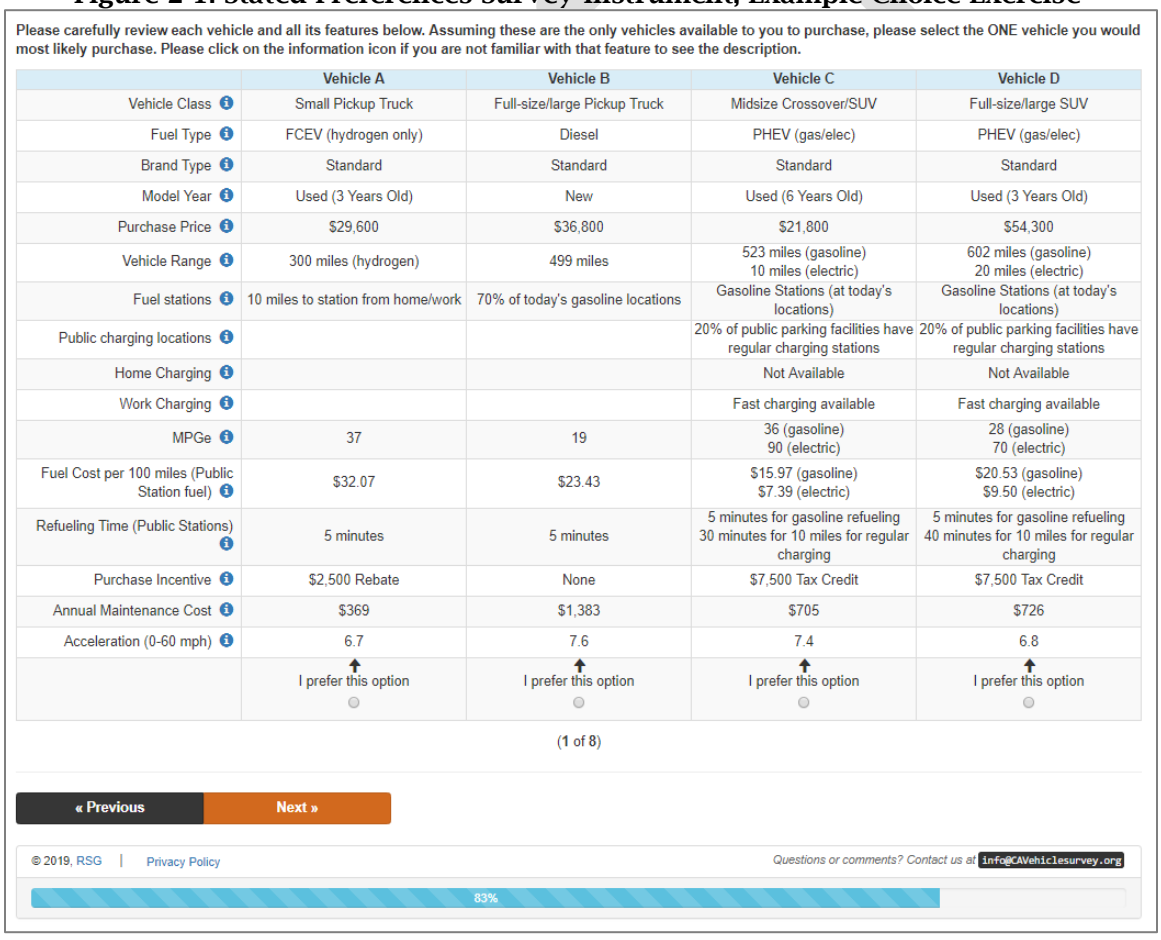
respondents were asked to provide two odometer readings. The first was the current odometer reading for each vehicle. The second was either a past odometer reading from a previous maintenance record, or a future odometer reading to be reported two months later through a brief follow-up survey (Appendix 2-D).

Respondents who provided the second odometer reading were entered into a prize drawing for one of two $50 gift cards.

2.2 Stated Preferences Survey Instrument Design

The survey uses Discrete Choice Experiments (DCE) to solicit stated preferences of the respondents for different class, fuel type, prestige levels and other attributes associated with hypothetical vehicles. The stated preferences survey instrument lists each hypothetical vehicle's attributes, such as price, range, fuel cost per mile and others detailed in Appendix 2-E. An example is shown in Figure 2-1.

Figure 2-1: Stated Preferences Survey Instrument, Example Choice Exercise



Please carefully review each vehicle and all its features below. Assuming these are the only vehicles available to you to purchase, please select the ONE vehicle you would most likely purchase. Please click on the information icon if you are not familiar with that feature to see the description.

	Vehicle A	Vehicle B	Vehicle C	Vehicle D
Vehicle Class	Small Pickup Truck	Full-size/large Pickup Truck	Midsize Crossover/SUV	Full-size/large SUV
Fuel Type	FCEV (hydrogen only)	Diesel	PHEV (gas/elec)	PHEV (gas/elec)
Brand Type	Standard	Standard	Standard	Standard
Model Year	Used (3 Years Old)	New	Used (6 Years Old)	Used (3 Years Old)
Purchase Price	$29,600	$36,800	$21,800	$54,300
Vehicle Range	300 miles (hydrogen)	499 miles	523 miles (gasoline) 10 miles (electric)	602 miles (gasoline) 20 miles (electric)
Fuel stations	10 miles to station from home/work	70% of today's gasoline locations	Gasoline Stations (at today's locations)	Gasoline Stations (at today's locations)
Public charging locations			20% of public parking facilities have regular charging stations	20% of public parking facilities have regular charging stations
Home Charging			Not Available	Not Available
Work Charging			Fast charging available	Fast charging available
MPGe	37	19	36 (gasoline) 90 (electric)	28 (gasoline) 70 (electric)
Fuel Cost per 100 miles (Public Station fuel)	$32.07	$23.43	$15.97 (gasoline) $7.39 (electric)	$20.53 (gasoline) $9.50 (electric)
Refueling Time (Public Stations)	5 minutes	5 minutes	5 minutes for gasoline refueling 30 minutes for 10 miles for regular charging	5 minutes for gasoline refueling 40 minutes for 10 miles for regular charging
Purchase Incentive	$2,500 Rebate	None	$7,500 Tax Credit	$7,500 Tax Credit
Annual Maintenance Cost	$369	$1,383	$705	$726
Acceleration (0-60 mph)	6.7	7.6	7.4	6.8
	I prefer this option	I prefer this option	I prefer this option	I prefer this option

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83%

Each choice experiment includes a set of four hypothetical vehicles, including the reference vehicle that the respondent identified in the set of vehicles s/he would consider for next purchase. A total of eight different vehicle choice sets are presented to each respondent. The vehicle size, fuel type, and age of the reference vehicle were

consistent with what the respondent reported in the RP survey (from the consideration set), with the next three alternatives presented as vehicles of different sizes, fuel types and ages. The remaining attributes varied across the four choices in each choice set and across the eight choice sets presented to respondents. The attribute values enable the respondents to trade-off between different attributes and make a single vehicle choice from the four vehicles in each choice set. The vehicles chosen by the respondent in the eight choice sets capture the respondent's preferences for, and perceived relative importance of, different attributes.

The mix of choice alternatives' attributes, and their levels, are governed by experimental design. The survey team identified the number and types of vehicle attributes in the choice set, and RSG used efficient design (Appendix 2-E) to populate the four hypothetical vehicles, and their attribute values, in each of the eight choice exercises the respondents completed. Weighted draws determined the vehicle class for the three alternatives to the reference vehicle, while their fuel type was based on a random draw with all but one fuel type (flex fuel) having the same draw probability. Flex fuel had a lower draw probability than other fuel types. Other attributes were consistent with vehicle class, fuel type, prestige level and vintage of each vehicle in the choice set. CEC team provided attribute values by class, fuel type, and prestige level for 2015, 2018-2019, 2021-2022 and 2025.

As in previous surveys, the same SP instrument was used for commercial and residential surveys. There were, however, important changes to the design of the discrete choice experiments (DCE), including alternatives, attributes, levels, and algorithms for selecting a reference vehicle and calculating attribute values to present in each experiment. Aspen developed and supplied the new experimental design, which is detailed in Appendix 2-E.

Below are some of the key changes, compared to prior iterations of CVS:

- A single reference vehicle intended for next vehicle purchase was replaced with a set of vehicles the respondents considered (consideration set) for replacement/addition. This resulted in changes to the algorithm used for generating the choice set.
- More details and metrics were added and displayed on ZEV refueling infrastructure.
- Trunk space and number of makes and models were removed from attributes displayed in the SP instrument.
- Prestige level (premium vs standard) was added to the vehicle attributes displayed for different choices in a choice set.
- Two vintage years defined the timing of the intended purchase. As a result some ZEV attribute values changed over time, depending on the year of purchase.

2.3 Sampling Plan

The sampling plan includes identifying the sample population, sampling frame, sample size and sampling methods. The 2019 CVS targets three specific market segments: residential, commercial, and ZEV owners. The differences in these market segments, and their corresponding response rates, require three sampling plans.

2.3.1 Residential Sampling Plan

The residential sector has the largest share of the light duty vehicles on California roads and requires a larger sample size than the commercial survey. Over 90 percent of California households own at least one vehicle, and the key drivers of vehicle population in this market segment are the demographic factors.

Sample Population

Because the Energy Commission forecasting model operates at a household level, the survey population is the number of individual households in the State of California.

Sampling Frame

Prior versions of the survey recruited participants from a sample of California DMV registration data. While this method was efficient and cost-effective, the downside was a lack of zero-vehicle households in the sampling frame which led to an underrepresentation of this population in the final collected data. An alternate Address Based Sampling (ABS) frame is the U.S. Postal Service (USPS) Computerized Delivery Sequence (CDS) File, an electronic database that provides continual updates of all mailing addresses served by USPS, except for general delivery. The CDS File contains address information for all other varieties of addresses, including addresses that receive (or have received) mail delivery, addresses only delivered to on a seasonal basis, vacant addresses, and throwback addresses (addresses not delivered to because of PO boxes).

The response rate for the ABS sample in the 2017 household survey was under 2%, which necessitated augmenting the ABS sample with an online panel sample. To accomplish this, RSG partnered with a private online market research firm which maintained a large and diverse panel of California residents across the state. Panel members are a profiled group of people who agree to participate in research and are rewarded by a proprietary internal incentive structure offered by the online market research firm. Online panel sample accuracy and panel profile is managed through digital fingerprinting, IP-verification, verification questions, and strict reward claims verification process. Approximately one-half of all completed responses in the 2017 CVS came from the online panel.

Matching the survey administration effort in 2017, for the 2019 survey RSG drew residential respondents from two sampling frames: an ABS frame of households in California and an online market research panel sampling frame of individuals in California. ABS was used because of the readily available address information from USPS and the need for geographic representation.

The project team distributed recruitment materials to a total of 40,750 (Table 2-2) addresses from the general household sampling frame from March to July 2019. The addresses were sampled at random from the statewide distribution of households. Invitation postcards and letters were sent to 3,750 households during the March pretest, yielding 169 complete responses. Invitations were sent to an additional 37,000 households during the full survey launch resulting in 1,606 more responses. Four responses were removed during data cleaning, resulting in a final sample size of 1,771.

Respondents were divided into six regions throughout the state, as shown in Table 2-1. Table 2-2 shows geographic distribution of completed ABS surveys.

Table 2-1: Region Definitions

REGION	NAME	COUNTIES INCLUDED
1	San Francisco	Alameda, Contra Costa, Marin, Napa, San Mateo, Santa Clara, Solano, Sonoma, and San Francisco Counties
2	Los Angeles	Los Angeles, Orange, Imperial, Riverside, San Bernardino, and Ventura Counties
3	San Diego	San Diego County
4	Sacramento	El Dorado, Placer, Sacramento, Sutter, Yolo, and Yuba Counties
5	Central Valley	Fresno, Kern, Kings, Tulare, Madera, San Joaquin, Stanislaus, and Merced Counties
6	Rest of State	Alpine, Amador, Butte, Calaveras, Colusa, Del Norte, Glenn, Humboldt, Inyo, Lake, Lassen, Mariposa, Mendocino, Modoc, Mono, Monterey, Nevada, Plumas, San Benito, San Luis Obispo, Santa Barbara, Santa Cruz, Shasta, Sierra, Siskiyou, Tehama, Trinity, and Tuolumne Counties

Table 2-2: Residential Survey—Invitation Distribution and Response by Region from the ABS Frame

REGION	INVITATIONS DISTRIBUTED	COMPLETES	RESPONSE RATE (COMPLETES)

San Francisco	8,545	432	5.1%
Los Angeles	19,024	739	3.9%
San Diego	3,520	161	4.6%
Sacramento	2,760	162	5.9%
Central Valley	3,983	115	2.9%
Rest of State	2,918	161	5.5%
Total	40,750	1,771	4.3%

RSG partnered with Dynata, a private online market research firm, to supplement the address-based sample for the 2019 survey. A total of 1,867 complete responses were obtained through the online panel, 107 during the pretest phase of the project and 1,760 more during the full data collection phase. One response was removed during data cleaning, resulting in a final sample size of 1,866 for the online panel sampling frame.

Table 2-3 shows the results of the residential sampling effort by sampling frame. The targets for each region were derived from the 2017 American Community Survey (ACS) results on the distribution of households across California. The table shows that completed responses approximately match the targeted proportions for each of the six survey regions. The final residential dataset contained 3,637 complete responses, exceeding the target sample size of 3,500.

Table 2-3: Residential Survey—Completes and Targeted Proportion of Completes by Region and Outreach Method

REGION	ABS FRAME COMPLETES	ONLINE PANEL COMPLETES	TOTAL COMPLETES	SHARE OF COMPLETES	TARGETED SHARE OF COMPLETES*
San Francisco	432	378	810	22%	21%
Los Angeles	739	871	1610	44%	46%
San Diego	161	189	350	10%	9%
Sacramento	162	148	310	9%	7%
Central Valley	115	126	241	7%	10%
Rest of State	161	152	313	9%	8%

Total	1,771	1,866	3,637	100%	100%

*Source: 2017 ACS

Sampling Methodology

Households were randomly selected by address. The household population in each county were obtained from the 2017 ACS, 5-year estimates (table 2-4). California counties were then grouped into six distinct geographic regions (table 2-1), and responses were monitored to ensure adequate representation from each of the six regions of interest (table 2-3).

Household Sample Size

The targeted sample size for the household vehicle survey was 3,500 households. At least 1,750 completed responses were proposed to be collected using the ABS frame with postcard and letter reminders, and the remainder to be collected through market research online panel. Based on experience from the 2017 CVS and other household travel surveys, 4% was the anticipated response rate for the ABS mail-based approach in the pretest survey. As mentioned, RSG expected a higher response rate for the current survey compared to the 2015-2017 survey due to the increased incentive and change in invitation process. Based on the anticipated response rate, invitations were to be sent to approximately 44,000 households to achieve the targeted number of complete surveys. The response rate and number of invitations were revised to 4.5%, following the pretest of the survey. The invitations were distributed proportional to the number of households in each region. This distribution of invitations was expected to achieve the target sample size by region presented below in Table 2-4.

Table 2-4: Sample Population and Target Sample Size by Region

Region	Households*	Percent of Total Sample Population	Target Sample Size (Households)
San Francisco	2,636,267	20.9%	731
Los Angeles	5,857,449	46.4%	1,625
San Diego	1,083,811	8.6%	301
Sacramento	848,179	6.7%	235
Central Valley	1,228,773	9.7%	341
Rest of State	962,801	7.6%	267
Total	**12,617,280**	**100.0%**	**3,500**

* Source: 2017 ACS

2.3.2 Commercial Sampling Plan

The commercial survey is different from the residential in almost all elements of the sampling plan. Moreover, there is no universally agreed upon count of business establishments and commercial vehicle population in California. The Energy Commission, Infogroup, and Secretary of State have different counts of business establishments in California, and between CEC and IHS, there are different counts of commercial LDV and distribution by fleet size.

Sample Population

The targeted population for the commercial fleet owner survey is the population of businesses that own and operate light-duty commercial vehicle fleets in California.

Sampling Frame

The sampling frame for the commercial fleet survey is the universe of commercial establishments in California that own light duty vehicles, registered with the California DMV. There was significant discussion on what constituted an appropriate commercial establishment sampling frame. For instance, while CEC staff's processing of DMV vehicle registrations includes all Limited Liability Companies (LLC) in the commercial fleet, not all LLCs engage in the type of business activity that requires purchase of a vehicle fleet specific to business. On the other hand, IHS data on commercial vehicles generally showed a higher percentage of the larger fleet sizes, compared to CEC staff's analysis of DMV data. Another significant question was whether the sampling frame should or could include only the location where the business vehicles were utilized, since typically the DMV registration data only has the address of the business headquarters.

IHS Automotive processes DMV vehicle registration data to assign light-duty vehicles (under 10,000 lbs. gross vehicle weight) to commercial establishments. The IHS Automotive data include basic information for each establishment, such as the number of vehicles and employees, vehicle registration information, and contact information including contact name, address, and phone number. Similar to the residential sample, to augment the data collected from the IHS sampling frame RSG planned to collect a portion of the overall sample targets for the commercial vehicle survey by partnering with Dynata, which maintains panel members that include light duty commercial vehicle fleet managers. However, the pretests proved the commercial incentive changes to be more effective than anticipated. As a result, the final survey included only ABS surveys of commercial fleet owners, using the IHS sampling frame.

The survey recruitment approach is described in more detail later in this chapter. The survey team distributed invitations to 67,500 addresses from the general commercial sampling frame obtained from IHS Automotive between March and July 2019. The addresses were sampled at random, proportional to each of the six California regions' contributions to the state's overall population of commercial vehicle fleets, according to data provided by IHS Automotive. Postcards and letters were sent to 7,500 businesses during the March pretest, yielding 262 completes. An additional 60,000 postcards and

letters were distributed to businesses during the full launch, resulting in 1,737 completes, for an overall total of 1,999 responses. Six responses were removed during the data cleaning process, resulting in a final sample size of 1,993 complete responses for the commercial address-based sampling frame. Table 2-5 presents the distribution of invitations, completes, and response rates by region for the commercial survey address-based sampling frame.

Table 2-5: Commercial Survey—ABS Invitations and Response by Region

Region	Invitations Distributed	Completes	Response Rate (Completes)
San Francisco	9,961	368	3.7%
Los Angeles	38,492	895	2.3%
San Diego	4,607	170	3.7%
Sacramento	3,848	142	3.7%
Central Valley	6,764	248	3.7%
Rest of State	3,828	168	4.4%
Total	67,500	1,993	2.9%

In addition to the six California regions, the commercial addresses were also sampled proportionally to five categories of vehicle fleet sizes. Table 2-6 presents the distribution of invitations, completes and response rates by fleet size for the commercial survey sampling frame.

Table 2-6: Commercial Survey—ABS Invitations and Response by Fleet Size

IHS Fleet Size	Invitations Distributed	Completes	Response Rate (Completes)
1 Vehicle	45,114	818	1.8%
2 Vehicles	8,940	382	4.3%
3–5 Vehicles	6,253	403	6.4%
6–9 Vehicles	3,927	163	4.2%
10+ Vehicles	3,266	227	6.9%
Total	67,500	1,993	3.0%

The pretest phase of the commercial survey collected 54 responses using a research panel sampling frame provided by Dynata. Two responses were removed as a result of data cleaning, contributing an additional 52 responses to the dataset. These 52

responses bring the final commercial sample size to 2,045 responses, exceeding the target sample size of 2,000.

Sample Size

The targeted sample size for the commercial fleet owner survey was 2,000 completed RP and SP surveys. Specific sub-quotas by region, industry, and/or fleet size were developed after the vehicle registration data were obtained. Based on the response rate from the 2015-2017 survey and the changes made to the incentives and invitation process, RSG anticipated a 2% response rate from the IHS sample frame and therefore planned to mail invitations to 70,000 establishments. RSG initially aimed to collect approximately 1,400 completed surveys from the IHS registration sampling frame and 600 completed surveys from Dynata's online panel. Using these proportions, the target sample size by region and fleet size is presented below in Table 2-7.

Table 2-7: Target Sample Size by Region and Fleet Size

Fleet Size	San Francisco	Los Angeles	San Diego	Sacramento	Central Valley	Rest of state	Total
1 vehicle	284	707	138	82	112	96	1,419
2 vehicles	50	120	24	15	25	20	253
3-5 vehicles	37	84	17	12	22	17	188
6-9 vehicles	13	26	5	4	9	6	63
10+ vehicles	16	32	7	6	10	7	77
Total	**400**	**968**	**191**	**118**	**178**	**145**	**2,000**

Sampling Methodology

RSG used a stratified random sampling approach to select commercial establishments for participation in the commercial fleet survey. The sample was stratified by both region (the six regions identified by the Energy Commission and summarized in Table 2-1 above) and by categories of fleet size (1, 2, 3-5, 6-9, and 10+ vehicles). RSG obtained counts of vehicle fleets by region and fleet size for the state of California from IHS Automotive, which are summarized in Table 2-8 below. The counts include commercial on-road registered light duty vehicles up to 10,000 pounds gross vehicle weight.

Table 2-8: Vehicle Fleets by Region and Fleet Size

Fleet Size	San Francisco	Los Angeles	San Diego	Sacramento	Central Valley	Rest of State	Total
1 vehicle	58,150	144,623	28,304	16,691	23,004	19,569	290,341
2 vehicles	10,183	24,556	4,816	2,975	5,090	4,109	51,729
3-5 vehicles	7,623	17,083	3,443	2,407	4,509	3,383	38,448
6-9 vehicles	2,579	5,301	1,120	861	1,762	1,190	12,813
10+ vehicles	3,283	6,541	1,377	1,156	2,083	1,400	15,840
Total	**81,818**	**198,104**	**39,060**	**24,090**	**36,448**	**29,651**	**409,171**

Source: IHS (2019)

Invitations were sent proportionally to the number of fleets in each region and fleet size cell and survey completions will be monitored across these characteristics.

2.3.3 ZEV Sampling Plan

Separate sampling plans were developed for the residential and commercial ZEV owner surveys, with the same market segmentations as in the general surveys. These separate sampling plans augmented the number of ZEV owners that naturally occurred in the general surveys.

Survey Population

The targeted population for the ZEV owner survey was the population of households and business establishments that own and operate at least one light-duty ZEV—either a plug-in hybrid electric vehicle (PHEV), a battery electric vehicle (BEV), or a fuel cell electric vehicle (FCEV) —registered for on-road operation in California. The survey population excluded neighborhood electric vehicles given the significant differences in the design, use, and capabilities of these vehicles compared to standard LDVs.

Sampling Frame

The project team used a separate sampling frame to recruit California residents who own or lease at least one ZEV. Energy Commission staff regularly analyze DMV registration data and distributes light duty-vehicles, including ZEVs, to different ownership types. ZEV vehicles were identified in the database using available vehicle data (e.g. make, model, and year, or fuel type if available). The Energy Commission's complete database of all residential and commercial ZEVs registered in California, as of the end of December 2018, served as the separate sampling frames for residential and commercial ZEV owner surveys. Sampling frames consisted of the household and commercial fleet owners who registered at least one ZEV. RSG used an ABS approach to recruit ZEV owners, but the ZEV owner add-on surveys were also administered to the

household and commercial fleet owners that naturally occurred in the ABS or online panel household and commercial fleet owner surveys.

ZEV Sample Size

The targeted sample size for the ZEV survey was a total of 600 complete RP and SP surveys of commercial and residential ZEV owners, with a minimum sample size of 350 completed residential ZEV surveys. Based on the response rate from the 2017 PEV survey and the changes made to the incentives and invitation process, RSG anticipated a 5% response rate for ZEV sample and therefore planned to mail 11,000 invitations, however, more invitations were sent to residential PEV owners because residential FCEV owners were over sampled.

Sampling Methodology

RSG used a stratified random sampling approach to select residential and commercial ZEV owners for participation in the ZEV owner add-on survey.

For the residential ZEV owner survey, households were randomly selected from the database such that invitations to participate were proportional to the distribution of households with registered ZEVs across the six regions. **Error! Reference source not found.** shows the total number of ZEV owner households and number of invitations distributed to the ZEV sampling frame across the six California regions, along with the number of completed surveys and the response rate based on the number of completed surveys.

Table 2-9: Residential ZEV Survey—Invitation Distribution and Response by Region

Region	ZEV Owner Households*	Invitations Distributed	Complete Surveys	Response Rate (Completes)
San Francisco	122,413	2,739	195	7.1%
Los Angeles	152,764	4,229	312	7.4%
San Diego	25,721	426	38	8.9%
Sacramento	13,411	292	33	11.3%
Central Valley	10,079	169	8	4.7%
Rest of State	13,726	245	25	10.2%
Total	**338,114**	**8,100**	**611**	**7.5%**

*Source: CEC staff analysis of 2019 DMV data

Residential ZEV owner response rates are higher than the general sample and range from 4.7 percent in the Central Valley to a high of 11.3 percent in Sacramento, compared to 2.9 percent and 5.9 percent, respectively, in the general sample.

A stratified random sampling approach was used for the commercial ZEV owner survey, stratified by region. Commercial establishments were randomly selected from the database by region such that invitations to participate were proportional to the distribution of commercial establishments with registered ZEVs across the six regions. Table 2-10 shows the count and percent of commercial ZEV invitations distributed to the ZEV sampling frame across the six designated California regions.

Table 2-10: Commercial ZEV Survey—Invitation Distribution and Response by Region

Region	Commercial ZEV Owners	Invitations Distributed	Completes	Response Rate (Completes)
San Francisco	4,387	2,221	58	2.6%
Los Angeles	8,022	4,471	149	3.3%
San Diego	957	591	21	3.6%
Sacramento	472	233	5	2.1%
Central Valley	449	218	11	5.0%
Rest of State	391	266	11	4.1%
Total	**14,678**	**8,000**	**256**	**3.2%**

Notably the commercial ZEV response rate was highest in the Central Valley, while the residential ZEV owner response rate was lowest for this region.

2.4 Recruitment Plan

Recruitment plans varied by outreach method, but the same plan was used for residential, commercial and ZEV owner surveys. Almost half of the residential and all of the commercial fleet owners and ZEV owners were address based survey (ABS) participants were ABS. The recruitment for ABS survey participants was mail based and carried out in two stages, but the online panel survey participants were recruited via email only.

2.4.1 Recruitment Methodology

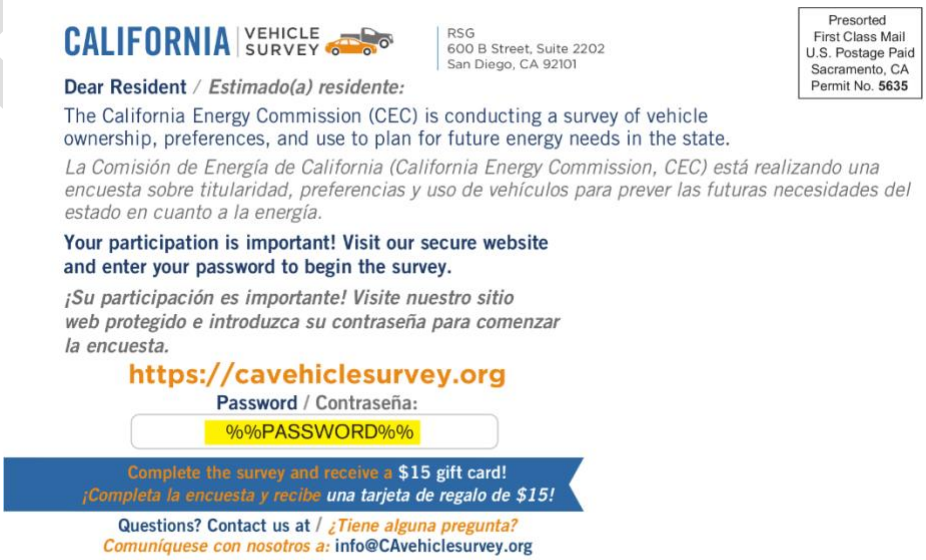
ABS respondents were recruited into the survey using a two staged mail-based approach. First, postcard invitations (4” by 6”) were mailed to adult residents of individual households, or the fleet manager of the commercial establishment. RSG designed a two-sided, full-color postcard to use for the invitation. The postcard contained an introduction to the project, information about the incentives offered for completing the survey, a URL and password to access the survey online, and a project email account that respondents may use to secure any assistance to complete the survey. The URL took the respondents to the survey website where they were able to enter the password printed on the invitation and begin the survey. Figure 2-2 and **Error!**

Reference source not found. show the front and back images of the residential postcard invitation for the 2018-2019 CVS.

The commercial and ZEV owner survey recruitment postcards contained similar information. The information on the residential postcard was provided in both English and Spanish, while the commercial and ZEV postcard invites were only in English.

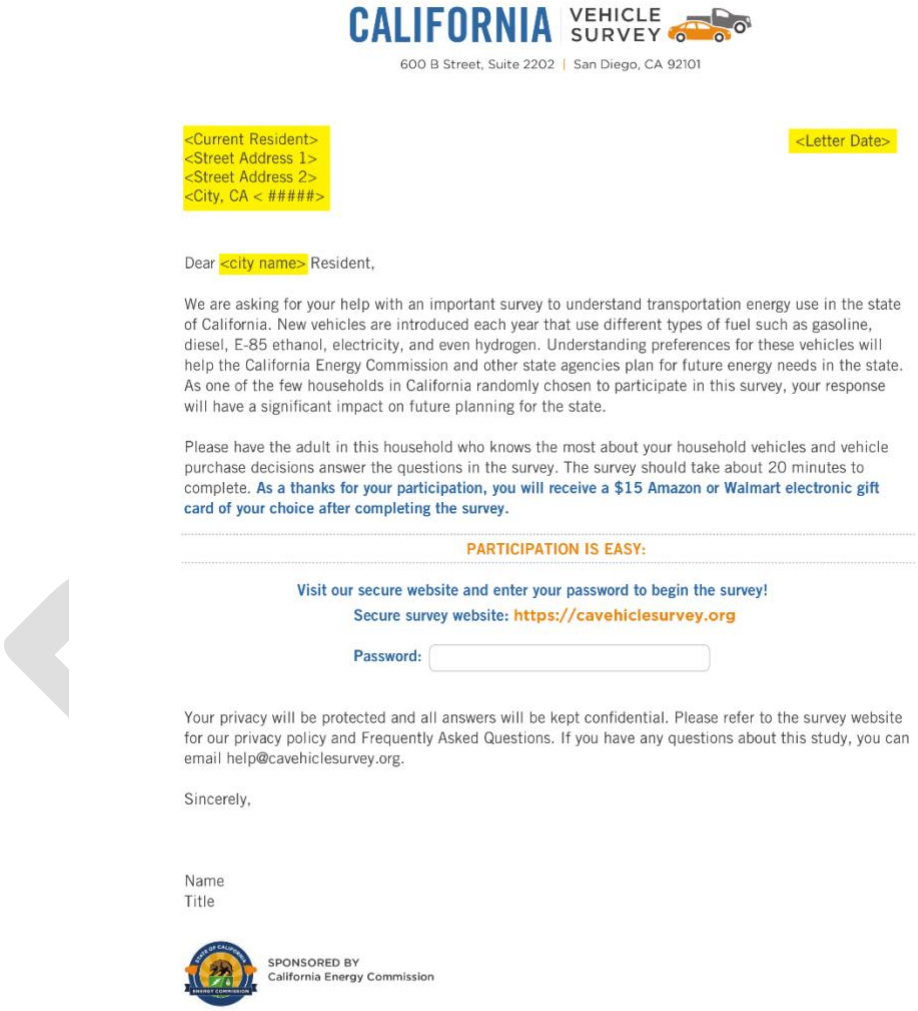
Figure 2-2: 2019 CVS Household Postcard Invitation – Front

Figure 2-3: 2019 CVS Household Postcard Invitation – Back



If the survey was not completed, a reminder letter (Figure 2-4) was sent about one to two weeks after the original postcard invitation. The letters were sealed in custom envelopes that matched the project visual aesthetic and contained a letter with the link to the survey, with the same password as in the postcard, and similar information. RSG has found similar two-stage processes with different invitation types improve participation rates when compared to studies where an initial invitation postcard and a reminder postcard are used.

Figure 2-4: 2019 CVS Household Letter Invitation



CALIFORNIA VEHICLE SURVEY

600 B Street, Suite 2202 | San Diego, CA 92101

<Current Resident>
<Street Address 1>
<Street Address 2>
<City, CA < #####>

<Letter Date>

Dear <city name> Resident,

We are asking for your help with an important survey to understand transportation energy use in the state of California. New vehicles are introduced each year that use different types of fuel such as gasoline, diesel, E-85 ethanol, electricity, and even hydrogen. Understanding preferences for these vehicles will help the California Energy Commission and other state agencies plan for future energy needs in the state. As one of the few households in California randomly chosen to participate in this survey, your response will have a significant impact on future planning for the state.

Please have the adult in this household who knows the most about your household vehicles and vehicle purchase decisions answer the questions in the survey. The survey should take about 20 minutes to complete. **As a thanks for your participation, you will receive a $15 Amazon or Walmart electronic gift card of your choice after completing the survey.**

PARTICIPATION IS EASY:

Visit our secure website and enter your password to begin the survey!

Secure survey website: https://cavehiclesurvey.org

Password:

Your privacy will be protected and all answers will be kept confidential. Please refer to the survey website for our privacy policy and Frequently Asked Questions. If you have any questions about this study, you can email help@cavehiclesurvey.org.

Sincerely,

Name
Title

SPONSORED BY
California Energy Commission

RSG contacted respondents who had started the web survey but did not complete it by using the email that respondents provided in the survey instrument. These respondents received one or two reminder e-mails encouraging them to complete the survey.

All printed materials and online graphics used consistent visual elements, including survey titles and description, color scheme, fonts, logos and picture graphics. The intended effect of this coordination is to connect invitation and reminder materials with the online survey instrument. Survey materials include the invitation postcards and letters, the reminder emails and letters, as well as the survey project website (see Appendix 2-F) and survey web pages (Appendix 2-H). Examples of the outreach materials are presented in Appendix 2-G.

Online panel members were recruited via email sent directly by Dynata. Panelists were able to enter the survey through customized links provided by Dynata, that prevent respondents from taking the survey more than once.

Incentive Plan

Incentives were offered to all respondents who completed the survey. Residential respondents were given the option of receiving a $15 electronic gift card from Amazon or Walmart. Commercial respondents were given the option of receiving a $40 electronic gift card from Amazon or Walmart. Residential and commercial ZEV owner respondents were offered the same incentives as other respondents in each market segment. At the end of the survey, respondents were prompted to choose their preferred gift card option and to provide a valid e-mail address to use for the gift card distribution. RSG then provided them with a gift card access number via email. All respondents were given the option to decline the incentive.

In addition to these gift cards, the respondents who provided a second odometer reading were entered in a $50 gift card prize drawing. Two households and two commercial respondents received $50 gift cards.

Households and establishments recruited through the online market research panel were not eligible to receive the survey incentives, as Dynata uses its own incentive structure, the cost of which is included within their per-complete fee.

Survey Implementation Timing

The full residential CVS was implemented in early June and concluded in early July of 2019. The commercial survey started about two weeks later. Specific tasks conducted during this period included sending survey invitations by mail and e-mail, reminding respondents to complete the survey via e-mail, coordinating weekly incentive processing, and responding to inquiries about the survey via phone and e-mail as necessary.

VMT Data Improvement

To improve the accuracy of reported VMT, the survey team proposed changes to the way this information is collected in the questionnaire. Respondents were asked to provide two odometer readings. The first was the current odometer reading for each vehicle in the household. The second was either a past odometer reading from a previous maintenance record, or a future odometer reading to be reported at some predefined

time in the future, through a short survey instrument (Appendix 2-D). For the respondents who agreed to provide a second odometer reading, RSG sent an email eight weeks after they completed the original survey, and a reminder email after one to two weeks.

2.5 Project Website Design

To implement the survey, RSG developed a project website and a database management plan to accommodate the data obtained from the 2018-2019 CVS instruments. Appendix 2-F displays the screenshots of different pages of the project website.

2.5.1 Project Website

RSG created a public-facing static website to support the 2018-2019 CVS. The website served two primary purposes. First, it provided information to participants and the general public about the 2018-2019 CVS, including the purpose of the study, sponsoring agencies of the study, answers to frequently asked questions (FAQs), information about data privacy, and contact information for questions about the study. Second, it included the online survey instrument for English and Spanish versions of the 2018-2019 CVS for household respondents.

The URL for the project website was https://www.cavehiclesurvey.org. The website used Secure Sockets Layer (SSL) encryption to establish encrypted links between the web server hosted by RSG and the web browser used by respondents to access the website. The project website was programmed to render properly on computers, tablets, and smartphones, and included separate sections, or tabs, for six primary areas of content. The website content was provided in Spanish by including a Google translate option. The primary content areas are described in more detail below.

Content Area 1: Home

The home page was the first page to load after navigating to the project website (https://www.cavehiclesurvey.org). The home page included the project logo, images of alternative fuel vehicles in California and, once the survey recruitment period began, a textbox to enter a password from the recruitment materials and start the vehicle survey.

Content Area 2: About

The second content area described the purpose of the 2018-2019 CVS, the sponsoring agency, and how the data collected from the survey would be used.

Content Area 3: FAQ

The third content area included answers to frequently-asked-questions (FAQs). The questions and answers included in this page are:

What is the California Vehicle Survey all about?

The study is collecting information about the driving and vehicle purchase behavior of residents and businesses in the state of California, including how and how much we

drive, what vehicles we own, what vehicles we intend to purchase, and what impacts our driving and vehicle purchase decisions.

How was I selected to participate?

Invited participants (like yourself) were randomly selected from all the individuals and commercial entities with registered vehicles in the state. The random approach helps us understand the behaviors, current needs, and future needs of all types of households and businesses from different regions in the state.

Why should I participate?

Current data about the behavior and needs of residents and businesses help the California Energy Commission and the State to understand and plan for current and future related energy needs. Your responses have a large impact because yours is one of a small number of households invited to participate in the study.

How will the survey results be used?

Information collected in the study will help the California Energy Commission and the State of California to plan and prioritize future energy-related transportation investments.

Who is sponsoring this study?

The study is sponsored by the California Energy Commission.

How is my personal privacy protected?

All your answers will be kept strictly confidential and will only be analyzed in aggregate with data from all other participating households. A copy of the privacy policy for this study is available here.

Content Area 4: Sponsors

The fourth content area identified the California Energy Commission as the primary study sponsor and included the Commission logo and a link to the Commission homepage at https://www.energy.ca.gov.

Content Area 5: Contact

The fifth content area included contact information for the study and an email link to info@cavehiclesurvey.org. This email account was set up and hosted by RSG and monitored daily. Technical questions about accessing or completing the survey were answered directly by RSG staff. Questions about the overall project or sponsoring agency were forwarded to the Energy Commission Agreement Manager (CAM) and evaluated on a case-by-case basis.

Content Area 6: Privacy Statement

The footer of each screen included a link to the privacy policy, as well as an email address to contact RSG for help completing the survey. The privacy policy indicated that

the survey information provided by respondents will be held confidential by RSG and the CEC pursuant to the California Information Practices Act and non-disclosure agreements with the CEC.

The sixth content area included RSG's privacy statement that covers the following topic areas:

- Who are we and what do we do?
- What type of information do we collect and why?
- What do we do with information we collect?
- How do we protect personal information?

You can find the full privacy statement in volume 2, Appendix 2F.

2.5.2 Survey Instrument

Once the survey recruitment period started, the website homepage included a text box where invited household and commercial respondents could enter the unique password from their postcard or letter and complete the survey using the web-based survey instrument. Appendix 2-H displays screenshots of selected survey web pages.

As in the 2015-2017 CVS, both the RP and SP sections of the survey were incorporated into a single survey instrument. This allowed respondents to move seamlessly and immediately from the RP to the SP section without experiencing any delay. In doing so, RSG had to ensure that RP data was fed in real-time into the SP experiments in selection of a reference vehicle and customized levels based upon the reference vehicle's class and fuel type.

Within the survey, the footer of each screen included a link to a privacy policy, as well as an email address to contact RSG for help completing the survey.

RSG's proprietary web survey technology, rSurvey, was used to create the survey instrument. Among the key features of the rSurvey are multiple ways to ensure data consistency and minimize respondent burden. A few examples include the following:

1. All respondents used the rSurvey interface to ensure that all data undergo the same logic, validation, and real-time checks to reduce respondent burden and error.
2. Metadata collection (as determined by the CEC) permitted passive collection of data such as survey duration (in total and by each question), screen resolution, and browser type (e.g., Chrome or Firefox), default language of web-browser, and more. These data were used to compare participants to the overall population and to identify trends and ensure that rSurvey accommodated all users.
3. All respondents completed both the RP survey and SP survey at the same time, minimizing respondent burden and drop-off between the surveys.
4. rSurvey provided the survey in multiple languages with the ability to switch between languages on any question.

5. Complex logic checks were built into the survey software to avoid illogical responses at the household, person, and vehicle levels. For example, real-time checks were made to identify combinations of vehicle make/model and fuel type that are not actually available on the market, and respondents were asked to reconsider or clarify those responses (e.g., an after-market fuel type conversion was done on the vehicle).
6. Participants who stopped midway through the survey and returned later arrived back at the question they last answered.

RSG defines a complete survey as one where a respondent provides an answer for each data element in the survey. Because the online instrument is designed to fully integrate the RP and SP surveys, only when respondents complete both survey components was the survey considered complete. Because the survey data are entered and validated in real-time using the survey website, there is no missing data or item non-response outside of questions that explicitly allowed the non-response option. Participating respondents who exited the survey without completing each question were not included in the tally for sample size goals. Respondents who started the survey and dropped-out were re-contacted by email to encourage them to complete the survey and were offered help in navigating the survey instrument, if necessary.

The complete instruments were tested by both internal RSG team as well as the CEC, CARB, and Aspen teams in an environment that mimicked actual data collection.

2.6 Database Design

The survey database was developed at the same time as the online survey instrument described above. The survey database was hosted on Microsoft Azure, a secure, enterprise-level, cloud-based SQL environment which provides near 100% uptime and scalability to meet fluctuating server demand. The survey website interacted directly with the database and all responses were input directly by respondents using the survey website in real-time.

The survey database contained fields for every data item in the questionnaire including individual and household or establishment information, vehicle information, stated preference experiments and responses, and ZEV responses (if applicable). Additional data items calculated as part of the survey logic were stored in separate database fields.

A survey dashboard was established to query the database in real time and provide information on the number of completed household, ZEV owner, and commercial establishment vehicle surveys, select tabulations, and other custom information requested by the CAM. The dashboard was made available via a password-protected page on the survey website that was accessible only to the CAM. For the duration of data collection, the dashboard showed the number and percentage of completed surveys obtained along various dimensions, including:

- Region

- Household income (detailed and broad categories, including refusals)
- Household size
- Household workers
- Age category of head of household
- Race/ethnicity, including refusals
- Number of vehicles owned
- Vehicle body type and fuel type (including ZEVs)

Similar data were available for the commercial establishment survey during data collection, but with somewhat different categorizations, such as:

- Region
- Commercial sector (NAICS-based)
- Company size category
- Fleet size category
- Vehicle size/type and fuel type (including ZEVs)

Additional summaries of collected data isolated the ZEV sample, including both household and commercial establishment owners.

Chapter 3: Pretest

The pretests were an important step in the overall study because the 2019 CVS questionnaires and recruitment processes differed in several important ways from past CVS projects. The survey pretests helped the project team evaluate three primary aspects of the study:

1. Changes in the questionnaire content and design from previous surveys.
2. The survey recruitment process and resulting participation rates.
3. The ability of the Stated Preference (SP) data to support the estimation of vehicle choice models.

The pretest was conducted from March to mid-April in 2019. During the pretest period, 358 residential responses and 329 commercial responses were obtained. This section summarizes the approach and outcomes of the pretest for the residential and commercial surveys, including the separate sampling frames used to supplement the zero-emission vehicle (ZEV) owner survey.

Following the pretest, the survey team reviewed the recruitment statistics and the collected data to identify potential opportunities to improve the survey approach. The recommendations for changes to the survey approach, recruitment methods, and questionnaires are provided at the conclusion of each survey pretest section.

The project team also estimated discrete choice models using both the residential and commercial vehicle choice data to ensure that the design and data could support the estimation of the vehicle choice models. While the signs and magnitude of the coefficient estimates were reasonable and intuitively correct, many of the estimates were not statistically significant due to the comparatively small samples sizes collected during the pretest.

3.1 Residential Pretest

The residential survey pretest was administered to California residents using the same two sampling frames discussed previously:

1. a general address-based sampling frame of households in California; and
2. an online market research panel sampling frame of individuals in California.

The targeted sample size for the residential pretest survey was 250 complete surveys, with 150 completes to be obtained from the address-based sampling frame and the remaining 100 completes to be obtained from the research panel sampling frame.

A separate sampling frame was developed to target individuals with a zero-emission vehicle (ZEV) registered in the state of California. This approach was used to ensure the sample of ZEV owners was large enough to evaluate independently in the survey analysis. This section documents the results of the survey administration to the general

residential address-based sampling frame and the online market research panel sampling frame. The results of the residential ZEV sampling frame are documented under the heading *Residential ZEV Pretest*.

3.1.1 Residential Pretest—Address-based Sampling

The project team worked with Marketing Systems Group (MSG) to select a random sample of household addresses within the state of California. MSG maintains an address-based sampling frame built using the USPS Computerized Delivery Sequence File (CDS), which MSG licenses. The ABS frame contains over 135 million residential addresses covering nearly 100% of households in the US. For the purposes of this survey, the 58 counties in California were grouped into six distinct geographic regions (Table 3-1), and responses were monitored against household counts for each region obtained from the 2017 American Community Survey (ACS) to ensure adequate representation from each of the six regions of interest.

Table 3-1: Study Regions

Region	Counties
San Francisco	Alameda, Contra Costa, Marin, Napa, San Mateo, Santa Clara, Solano, Sonoma, San Francisco
Los Angeles	Los Angeles, Orange, Imperial, Riverside, San Bernardino, Ventura
San Diego	San Diego
Sacramento	El Dorado, Placer, Sacramento, Sutter, Yolo, Yuba
Central Valley	Fresno, Kern, Kings, Tulare, Madera, San Joaquin, Stanislaus, Merced
Rest of State	Alpine, Amador, Butte, Calaveras, Colusa, Del Norte, Glenn, Humboldt, Inyo, Lake, Lassen, Mariposa, Mendocino, Modoc, Mono, Monterey, Nevada, Plumas, San Benito, San Luis Obispo, Santa Barbara, Santa Cruz, Shasta, Sierra, Siskiyou, Tehama, Trinity, Tuolumne

The survey team estimated the response rate for the proposed address-based recruitment to be 4% on average, with some variation expected by region. This assumed response rate implied that 3,750 invitations would need to be distributed across the state to achieve the pretest sample size target of 150 complete surveys. Table 3-2 presents the distribution of households across the six regions along with the corresponding number of invitations distributed to households in each region.

Table 3-2: Residential Pretest—Sampling Plan

Region	Households		Invitations Distributed	
	Count	*Percent*	*Count*	*Percent*
San Francisco	2,636,267	21%	781	21%
Los Angeles	5,857,449	46%	1,750	47%
San Diego	1,083,811	9%	324	9%
Sacramento	848,179	7%	255	7%
Central Valley	1,228,773	10%	370	10%
Rest of State	962,801	7%	270	7%
Total	**12,617,280**	**100%**	**3,750**	**100%**

Source: 2017 American Community Survey 5-year estimates.

3.1.2 Residential Pretest—Research Panel Sampling

The project team worked with Dynata, a global online sampling and digital data collection company, to obtain the remaining 100 pretest survey responses. Qualifying panel members were recruited via email sent directly by Dynata. Panelists entered the survey through customized links that controlled survey access and recorded survey status. The responses from the research panel were targeted and monitored across the same six regions presented in Table 3-1 above.

3.1.3 Residential Pretest—Summary of Recruitment and Data

The residential pretest collected complete surveys from 273 respondents, including 166 from the address-based sampling frame and 107 from the online panel sampling frame (Table 3-3). The number of complete surveys for both sampling frames exceeded the sample size targets for the pretest.

Table 3-3: Residential Pretest—Targeted Completes and Actual Completes by Sampling Frame

Sampling Frame	Targeted Pretest Surveys	Actual Pretest Surveys
Address-based	150	166
Online panel	100	107
Total	**250**	**273**

Table 3-4 presents the distribution of completed surveys by region for each sampling frame compared to the targeted proportion of completes. The research panel sampling frame closely matches the targeted sampling proportions, while the address-based sampling frame has higher representation in the San Francisco and Sacramento regions and a lower representation in the Los Angeles region compared to the targeted sampling proportions. The discrepancy in the regional distribution of responses is a result of variation in response rates by region.

Table 3-4: Residential Pretest—Distribution of Complete Surveys by Region

Region	Address-based Responses	Online Panel Responses	Total Responses	Households
San Francisco	28%	20%	25%	21%
Los Angeles	42%	49%	44%	46%
San Diego	7%	8%	7%	9%
Sacramento	10%	8%	9%	7%
Central Valley	8%	9%	9%	10%
Rest of State	5%	8%	6%	7%

Source: 2017 American Community Survey 5-year estimates.

Table 3-5 presents the counts of postcards distributed, completes, dropouts, disqualifications, total logins, and response rate (number of completes/number of postcards distributed) by region for the address-based sampling frame. Dropouts are respondents who began, but did not complete, the survey, while disqualifications represent respondents who were disqualified from participating in the survey based on their responses to the qualification questions. Response rates varied by region, with the highest rate of completion in the Sacramento region and the lowest rate in the Rest of State region.

During the survey pretest, 209 respondents from the general residential sampling frame entered the online survey and 166 completed the questionnaire. This represents a completion rate of 4.4%, which was slightly higher than the assumed 4% completion rate for the pretest.

Table 3-5: Residential Pretest—ABS Response Summary by Region

Region	Invitations	Completes	Dropouts	Disqualifications	Total Logins	Response Rate (Completes)
	Count	*Count*	*Count*	*Count*	*Count*	*Percent*
San Francisco	781	46	9	1	56	5.9%
Los Angeles	1,750	69	11	1	81	3.9%
San Diego	324	11	7	0	18	3.4%
Sacramento	255	17	1	0	18	6.7%
Central Valley	370	14	1	1	16	3.8%
Rest of State	270	9	1	0	10	3.3%
Unknown	0	0	4	6	10	N/A
Total	**3,750**	**166**	**34**	**9**	**209**	**4.4%**

Table 3-6 presents the counts of completes, dropouts, disqualifications, and logins by region for the residential online research panel sampling frame. During the survey test administration phase, 158 respondents from the research panel sampling frame entered the residential survey; of these respondents, 107 completed the questionnaire.

Table 3-6: Residential Pretest—Online Research Panel Response Summary by Region

Region	Completes	Dropouts	Disqualifications	Total Logins
	Count	*Count*	*Count*	*Count*
San Francisco	21	1	2	24
Los Angeles	52	14	6	72
San Diego	8	0	0	8
Sacramento	8	1	0	9
Central Valley	10	2	1	13
Rest of State	8	5	1	14
Unknown	0	4	15	19
Total	**107**	**26**	**25**	**158**

Of the 34 respondents who were terminated from the survey, 14 indicated they do not participate in the household decision-making process when acquiring a new vehicle, 8 did not meet the minimum age requirement, 7 were not a resident of the state of California, and 5 did not enter a qualifying California ZIP Code.

Of respondents who partially completed the survey, 19 dropped out at the household vehicle details section. Figure 3-1: Residential Pretest—Dropout Locations shows the eight most common drop out locations for the survey pretest.

Figure 3-1: Residential Pretest—Dropout Locations

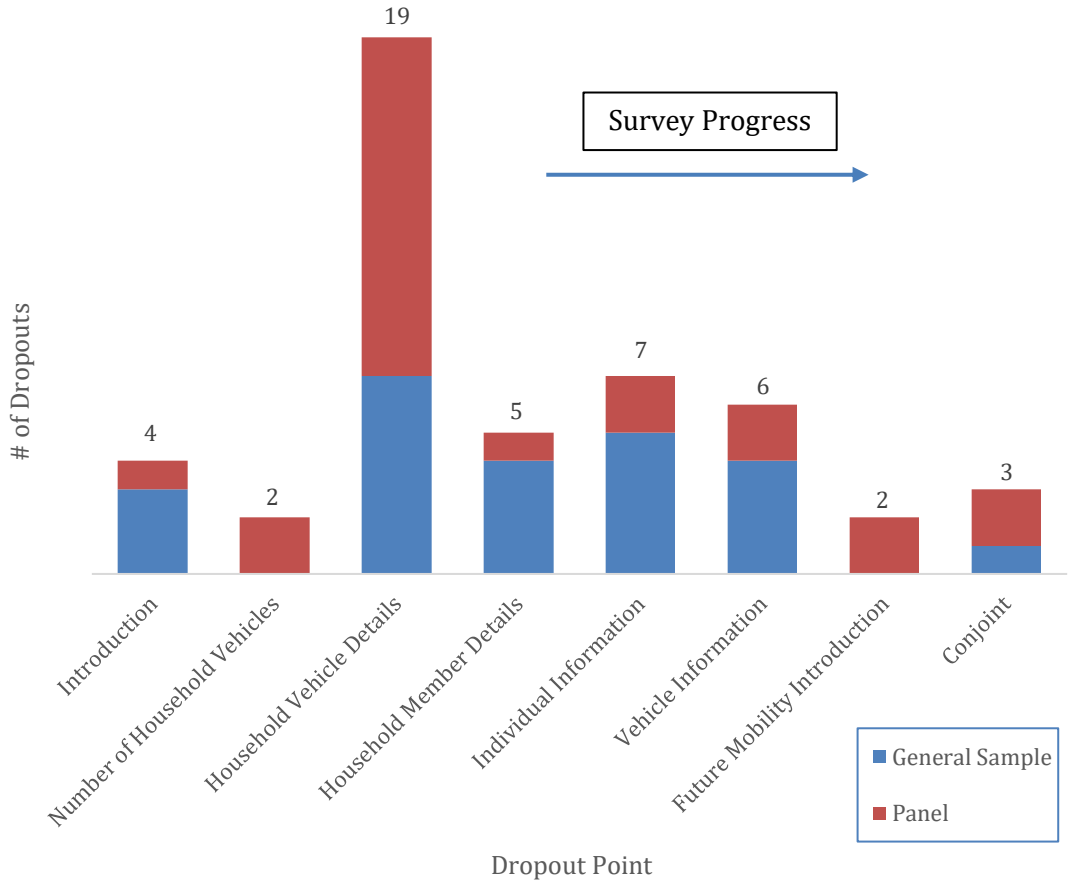


Table 3-7: Residential Pretest—Survey Completion Time Statistics shows survey completion time statistics for the 273 respondents who finished the survey. The median completion times are relatively long, but not unexpected considering the length and complexity of the questionnaire. The median completion time for research panel respondents was approximately 33% faster than respondents recruited through the address-based sampling frame.

Table 3-7: Residential Pretest—Survey Completion Time Statistics

Survey Duration	ABS Duration (minutes)	Online Research Panel Duration (minutes)
Minimum	10	7
5th Percentile	16	8
Median	33	22
95th Percentile	136	56
Maximum	4433	78

Table 3-8: Residential Pretest—Number of Household Vehicles summarizes the number of vehicles owned at the household level for each sampling frame. Vehicle ownership at

the household level from the survey approximately matches the distribution of household vehicle ownership in California.

Table 3-8: Residential Pretest—Number of Household Vehicles

Number of Vehicles	ABS		Research Panel		ACS*
	Count	*Percent*	*Count*	*Percent*	*Percent*
0 Vehicles	2	1%	5	5%	7%
1 Vehicle	55	33%	52	49%	31%
2 Vehicles	66	40%	42	39%	37%
3 Vehicles	29	17%	6	6%	16%
4 or more	14	8%	2	2%	8%
Total	166	100%	107	100%	100%

*Source: 2017 American Community Survey 5-year estimates.

Residential Pretest—Incentives

Incentives were offered to all respondents recruited through the address-based sampling frame who completed the survey. Online research panel respondents were incentivized directly by Dynata using a proprietary compensation system.

Address-based respondents were given the option of receiving a $15 gift card from Amazon.com or Walmart. Table 3-9 shows the distribution of incentive choices across the sample. A technical error during t 30 respondents who completed the survey from being ableil address to receive the incentive. Seventeen of these respondir e-mail address at an earlier point in the survey or contacted the so about their gift card, while the remaining 13 did not enter an email address and were unable to be contacted or awarded their gift card.

Table 3-9: Residential Pretest—Incentives

Gift Card Selection	Count	Percent
Selected Amazon	118	70%
Selected Walmart	31	19%
No Prize—Survey Error	13	8%
Declined	4	2%
Total	**166**	**100%**

Residential Pretest—Respondent Feedback

Upon completing the questionnaire, 88 respondents left comments in open-ended text boxes provided during the survey. A few respondents indicated that the number of options presented in the stated preference experiments was confusing or difficult to process. A handful of respondents remarked that the questionnaire was too long or took too much time to complete. No other common themes were identified that would indicate widespread survey comprehension or completion challenges.

Residential Pretest—Recommended Changes to Survey Instruments and Procedures

- The project team corrected the technical error related to the incentive distribution but otherwise recommended making no changes to the residential survey instrument.
- The observed pretest completion rate of 4.4% was slightly higher than the 4% completion rate targeted for the full residential survey. The project team recommended making minor adjustments to the sampling plan to reflect the observed response rate in the calculation of survey invitations for the full launch.

3.2 Residential ZEV Pretest

It was expected that the natural incidence of ZEV owners in the general California population would be too low to achieve a sufficient sample size for the ZEV owner section of the survey questionnaire. As a result, the project team developed a separate sampling plan for both residential and commercial ZEV owners to achieve the necessary sample size for analysis. A separate set of questions was administered within the regular questionnaire to residential and commercial respondents who own or operate one or more ZEVs. The following section describes the test administration results of the residential ZEV sampling frame. The targeted sample size for the residential ZEV pretest was set at 30 complete surveys.

3.2.1 Residential ZEV Pretest—Sampling

The survey population for the ZEV owner survey was all households in California with at least one registered light-duty ZEV—either a plug-in hybrid electric vehicle (PHEV), a battery electric vehicle (BEV), or a fuel cell electric vehicle (FCEV). The sampling frame for the ZEV survey was the vehicle registration database of all ZEVs registered in the state of California.

The team estimated the response rate for the proposed address-based recruitment to be 5% on average, with some variation expected by region. This assumed response rate implied that 600 invitations would need to be distributed across the state to achieve 30 complete surveys. **Error! Reference source not found.** presents the distribution of ZEV-owner households across the six regions along with the corresponding number of invitations distributed to households in each region.

Table 3-10: Residential ZEV Pretest—Sampling Plan

Region	PEV Owner Households		PEV Invitations Distributed		FCEV Owner Households		FCEV Invitations Distributed	
	Count	*Percent*	*Count*	*Percent*	*Count*	*Percent*	*Count*	*Percent*
San Francisco	121,141	36%	120	40%	1,258	31%	100	33%
Los Angeles	150,157	45%	141	47%	2,550	62%	180	60%
San Diego	25,466	8%	20	7%	104	3%	6	2%
Sacramento	13,279	4%	10	3%	132	3%	7	2%
Central Valley	10,014	3%	3	1%	13	0%	2	1%
Rest of State	13,674	4%	6	2%	51	1%	5	2%
Total	**333,731**	**100%**	**300**	**100%**	**4,108**	**100%**	**300**	**100%**

Source: California Energy Commission and California Department of Motor Vehicles.

3.2.2 Residential ZEV Pretest—Summary of Recruitment and Data

In the four weeks after the pretest invitations were distributed, 104 respondents from the residential ZEV sampling frame entered the survey, with 85 of these respondents completing the questionnaire. This indicated a substantially higher response and completion rate than was found in the general residential sampling frame. Table 3-11 presents the incidence of completed surveys and the count of dropouts and disqualifications. The overall completion rate was 14.2%, with the highest rate of completion in the Sacramento area and the lowest rate in the Central Valley region.

Table 3-11: Residential ZEV Pretest—Response Summary by Region

Region	Invitations	Completes	Dropouts	Disqualifications	Total Logins	Response Rate (Completes)
	Count	*Count*	*Count*	*Count*	*Count*	*Percent*
San Francisco	220	29	7	0	36	13.2%
Los Angeles	321	47	9	2	58	14.6%
San Diego	26	3	0	0	3	11.5%
Sacramento	17	4	0	0	4	23.5%
Central Valley	5	0	0	0	0	0%
Rest of State	11	2	0	0	2	18.2%
Unknown	0	0	1	0	1	0%
Total	**600**	**85**	**7**	**2**	**104**	**14.2%**

Figure 3-2 shows the eight most common locations in the survey where respondents dropped out during the pretest. The highest incidence of dropouts occurred at the vehicle information questions.

Figure 3-2: Residential ZEV Pretest—Dropout Locations

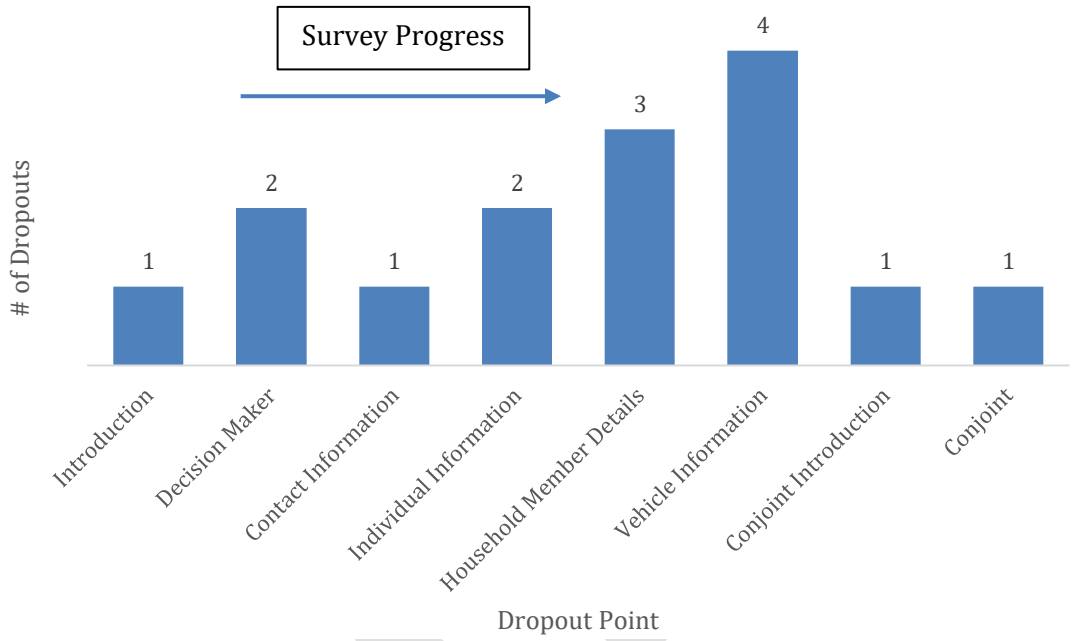


Table 3-12 shows survey completion time statistics for the remaining respondents who finished the survey. Overall, the median completion time was longer than the median time of respondents in the general sampling frame. This was because most respondents in the ZEV sampling frame also completed the additional ZEV questionnaire nested within the general residential survey.

Table 3-12: Residential ZEV Pretest—Survey Duration

Minutes	Survey Duration
Minimum	11
5th Percentile	19
Median	39
95th Percentile	271
Maximum	27,494

Most respondents included in the ZEV sampling frame reported owning at least one ZEV and completed the ZEV portion of the questionnaire. Of the 85 respondents from the ZEV sampling frame who completed the questionnaire, 34 reported owning at least one plug-in electric vehicle and 41 reported owning at least one hydrogen vehicle, while 11 respondents indicated they did not currently own a ZEV. In addition, some of the respondents from the general ABS and online research panel sampling frames reported owning a ZEV. Of the 273 respondents from the general sampling frames who completed the study, 12 reported owning one or more ZEVs. As a result, 87 total respondents completed the ZEV portion of the questionnaire during the residential pretest. Table 3-13 shows household-level ZEV ownership for the general sampling

frame and the ZEV-owner sampling frame combined. Overall, 24% of the residential pretest sample reported owning a ZEV.

Table 3-13:Household-Level Vehicle Type Ownership (All Respondents)

Vehicle Type	Ownership	
	Count	***Percent***
PHEV	21	6%
BEV	35	10%
FCEV	41	11%
Do Not Own PHEV/BEV	272	76%
Total Respondents	**358**	**--**

Note: Some respondents reported owning more than one type of ZEV

Residential ZEV Pretest—Incentives

Incentives were offered to all respondents who completed the survey. Respondents were given the option of receiving a $15 electronic gift card from Amazon.com or Walmart. Table 3-14 shows the distribution of incentive selection. A technical error in the survey prevented ten respondents who completed the survey from being able to confirm their e-mail address to receive the incentive. Three of these respondents had entered their e-mail addresses at an earlier point in the survey and were sent gift cards, while the remaining seven respondents did not enter their e-mail addresses and were unable to be contacted to receive their incentive.

Table 3-14: Residential ZEV Pretest—Incentives

Gift Card Selection	Count	Percent
Selected Amazon	68	80%
Selected Walmart	9	11%
No Prize—Survey Error	7	8%
Declined	1	1%
Total	**85**	**100%**

Residential ZEV Pretest—Recommended Changes to Survey Instruments and Procedures

The observed pretest completion rate of 14.2% was significantly higher than the estimated completion rate of 5%. The project team recommended decreasing the number of residential ZEV invites to achieve the desired sample size targets. The team recommended no changes be made to the residential ZEV survey questionnaire or instrument.

3.3 Commercial Pretest

The commercial survey was administered to the population of California fleet managers using two sampling frames:

1. a general commercial sampling frame of businesses with at least one registered vehicle in California from IHS Automotive, and
2. online market research panel sampling frame of commercial fleet managers in California.

The targeted sample size for commercial pretest survey was 200 complete surveys, with 150 completes to be obtained from the address-based sampling frame and the remaining 50 completes to be obtained from the research panel.

As in the residential survey, a separate sampling frame was used to target commercial establishments with a zero-emission vehicle (ZEV) registered in the state of California to purposefully oversample the number of ZEV owners in the dataset. This section documents the results of the survey administration to the general commercial sampling frame and the online market research panel sample. The results of the commercial ZEV sampling frame are documented in a subsequent section.

3.3.1 Commercial Pretest—Address-based Sampling

The project team worked with IHS Markit (IHS) to select a random sample of commercial establishments with light-duty (under 10,000 lbs. gross weight) vehicles registered the in the state of California. IHS maintains a vehicle database built using vehicle registration data from the California Department of Motor Vehicles (DMV) and classifies each vehicle as residential or commercial based on information about the entity to which the vehicle is registered. IHS is also able to estimate the number of light-duty vehicles registered to each establishment, providing a count of establishments by fleet size. The IHS frame contains every vehicle registered in California and is updated on a monthly basis.

The commercial pretest sampling frame was stratified by the six study regions described in **Error! Reference source not found.** above, as well as by five fleet size categories. Table 3-15 presents the distribution of establishments by fleet size and region as provided by IHS.

Table 3-15: Commercial Pretest—Distribution of Commercial Fleets by Fleet Size and Region

Region	Fleet Size					Fleet Size Distribution
	1 Vehicle	2 Vehicles	3–5 Vehicles	6–9 Vehicles	10+ Vehicles	
San Francisco	14%	2%	2%	1%	1%	20%
Los Angeles	33%	5%	4%	1%	2%	45%
San Diego	7%	1%	1%	0%	0%	9%
Sacramento	4%	1%	1%	0%	0%	6%
Central Valley	7%	1%	1%	1%	1%	11%
Rest of State	6%	1%	1%	0%	0%	9%
Region Distribution	**70%**	**12%**	**10%**	**3%**	**4%**	**100%**

Source: IHS Automotive.

The team estimated the response rate for the proposed commercial address-based recruitment to be 2% on average, with some variation expected by region and fleet size. To achieve the desired pretest sample size of 150 address-based sampling completes, RSG distributed 7,500 survey invitations to commercial establishments in March and April of 2019. RSG intentionally over-sampled larger fleet sizes and smaller regions for the pretest. Table 3-16 presents the distribution of postcards by fleet size and region for the commercial pretest.

Table 3-16: Commercial Pretest—Distribution of Survey Invitations by Fleet Size and Region

Region	Fleet Size					Total Distribution
	1 Vehicle	2 Vehicles	3–5 Vehicles	6–9 Vehicles	10+ Vehicles	
San Francisco	7%	3%	3%	2%	2%	**17%**
Los Angeles	9%	5%	5%	3%	3%	**24%**
San Diego	5%	3%	3%	1%	1%	**12%**
Sacramento	7%	3%	3%	2%	2%	**17%**
Central Valley	7%	3%	3%	2%	2%	**17%**
Rest of State	5%	3%	3%	1%	1%	**12%**
Region Distribution	**40%**	**20%**	**20%**	**10%**	**10%**	**100%**

3.3.2 Commercial Pretest—Research Panel Sampling

The project team worked with Dynata to obtain the remaining 50 pretest survey responses. Qualifying panel members were recruited via email directly by Dynata. Panelists entered the survey through customized links that controlled survey access and recorded survey status. The responses from the research panel were targeted and monitored across the same stratification segments presented in Table 3-16 above.

3.3.3 Commercial Pretest—Summary of Recruitment and Data

The commercial pretest collected complete surveys from 316 respondents, including 262 from the ABS frame and 54 from the online research panel sampling frame (Table 3-17Table 3-20). The number of complete surveys for the address-based sampling frame was substantially greater than the 150 expected completes for the pretest phase of the study.

Table 3-17: Commercial Pretest—Targeted Completes and Actual Completes by Sampling Frame

Sampling Frame	Targeted Pretest Surveys	Actual Pretest Surveys
ABS	150	262
Online Research panel	50	54
Total	**200**	**316**

Table 3-18 presents the counts and percentages of completed commercial surveys by region. The table compares the ABS figures to the targeted proportion of completes as specified in the sampling plan for the pretest launch.

Table 3-18: Commercial Pretest—Completes by Region

Region	ABS			Online Research Panel	
	Completes	Share of Completes	Region Target	Completes	Share of Completes
	Count	*Percent*	*Percent*		
San Francisco	48	18%	17%	17	31%
Los Angeles	36	14%	24%	28	52%
San Diego	37	14%	12%	1	2%
Sacramento	53	20%	17%	2	4%
Central Valley	42	16%	17%	3	6%
Rest of State	46	18%	12%	3	6%
Total	**262**	**100%**	**100%**	**54**	**100%**

Table 3-19 summarizes the fleet size reported by 316 fleet managers who completed the survey and compare these figures to the targeted share.

Table 3-19: Commercial Pretest—Completes by Fleet Size

Vehicle Fleet Size	ABS			Online Research Panel	
	Completes	Share of Completes	Fleet Size Target	Completes	Share of Completes
	Count	*Percent*	*Percent*	*Count*	*Percent*
1 Vehicle	43	16%	40%	5	9%
2 Vehicles	27	10%	20%	6	11%
3–5 Vehicles	59	23%	20%	5	9%
6–9 Vehicles	36	14%	10%	1	2%
10 or More Vehicles	97	37%	10%	37	69%
Total	**262**	**100%**	**100%**	**54**	**100%**

Table 3-20 presents the incidence of completed surveys and the count of dropouts and disqualifications. Survey dropouts are respondents who began the survey but left the questionnaire before finishing, and disqualifications represent cases where respondents were disqualified from participating in the study based on their responses to the qualification questions. The observed completion rate was 3.5%, with the highest rate of completion in the Rest of State area (5.1%) and the lowest rate of completion (2.0%) in the Los Angeles region.

Table 3-20: Commercial Pretest—ABS Response Summary by Region

Region	Invitations	Completes	Dropouts	Disqualifications	Total Logins	Response Rate
	Count	*Count*	*Count*	*Count*	*Count*	*Percent*
San Francisco	1,300	48	6	9	64	3.7%
Los Angeles	1,800	36	10	14	60	2.0%
San Diego	900	37	8	4	49	4.1%
Sacramento	1,300	53	8	16	78	4.1%
Central Valley	1,300	42	12	6	61	3.2%
Rest of State	900	46	11	8	66	5.1%
Unknown	N/A	0	38	20	58	N/A
Total	**7,500**	**262**	**93**	**77**	**436**	**3.5%**

Table 3-21 presents the counts of completes, dropouts, disqualifications, and logins by region for the commercial research panel sampling frame. During the survey test administration phase, 159 respondents from the research panel sampling frame entered the commercial survey and 54 completed the questionnaire.

Table 3-21: Commercial Pretest—Online Research Panel Response Summary by Region

Region	Completes	Dropouts	Disqualifications	Total Logins
	Count	*Count*	*Count*	*Count*
San Francisco	17	0	4	24
Los Angeles	28	2	13	72
San Diego	1	0	2	8
Sacramento	2	0	0	9
Central Valley	3	1	2	13
Rest of State	3	0	2	14
Unknown	**0**	5	85	19
Total	54	**8**	**108**	**159**

Of the 185 respondents who were disqualified from taking the survey, about a third were disqualified because they indicated there were no light-duty vehicles at their location, another third of respondents were disqualified because they indicated they were not a vehicle decision maker at their organization, and approximately one-quarter of disqualified respondents indicated that their type of organization was a car rental company, a taxicab company, or a government agency.

Figure 3-3 shows the locations in the survey where respondents dropped out of the questionnaire; majority of respondents dropped out in the introduction page and decision maker page at the beginning of the survey.

Figure 3-3: Commercial Pretest—Dropout Locations

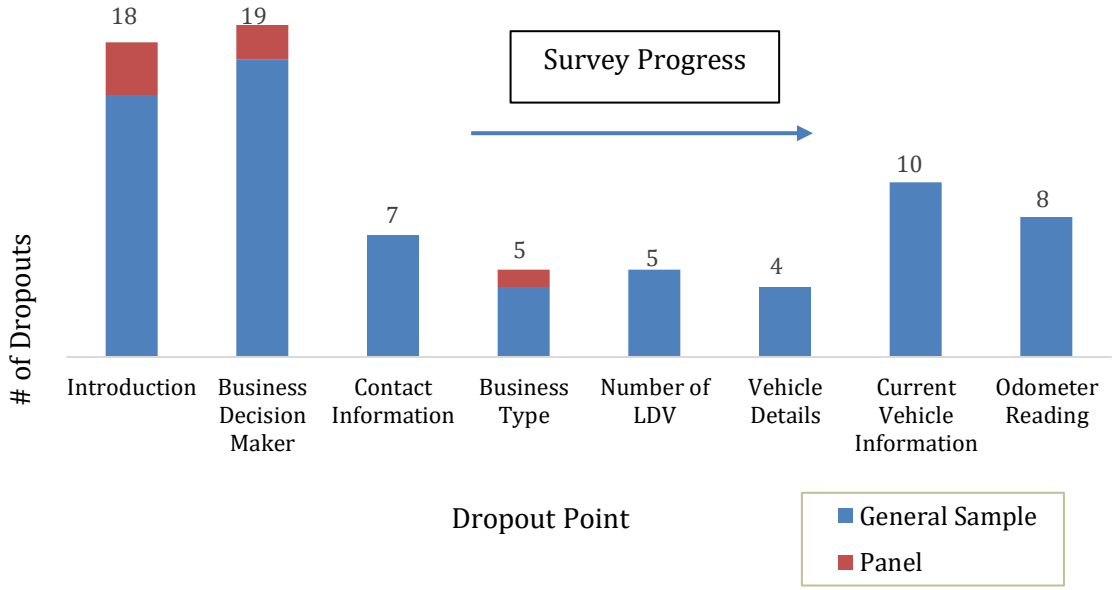


Table 3-22 shows the duration statistics for the 262 ABS frame respondents and 54 online research panel respondents who completed the questionnaire. As with the residential survey, the median completion times are relatively long, but not unexpected considering the length and complexity of the questionnaire. The median completion time for research panel respondents was approximately 64% faster than respondents recruited through the address-based sampling frame.

Table 3-22: Commercial Pretest—Completion Time Statistics

Minutes	ABS	Panel
Minimum	5	5
Maximum	24,559	54
Median	36	13

Commercial Pretest—Incentives

Commercial fleet respondents recruited through the ABS frame were offered an incentive of a $40 gift card to Amazon.com or Walmart. Table 3-23 shows the distribution of survey incentive choices. Research panel respondents were incentivized directly by Dynata using a proprietary compensation system.

Table 3-23: Commercial Pretest—Incentives

Gift Card Selection	Count	Percent
Selected Amazon	203	77%
Selected Walmart	44	17%
Declined	15	6%
Total	**262**	**100%**

Commercial Pretest—Respondent Feedback

Upon completing the questionnaire, 66 respondents left comments in an open-ended text box provided on the last survey screen. Several comments expressed interest in alternative fuel vehicles to use in the future. A few respondents commented that they felt the survey was too lengthy and one respondent commented that the fleet size question was confusing.

Commercial Pretest—Recommended Changes to Survey Instruments and Procedures

- The observed pretest completion rate of 3.5% was greater than the 2.0% completion rate estimated for the full commercial survey. The team recommended eliminating the online research panel sampling frame for the full launch and using the address-based sampling frame to achieve the target of 2,000 commercial surveys.
- A significant number of respondents reported a large number of LDVs owned and operated at their locations. RSG conducted follow-up phone calls to survey respondents who reported large fleet sizes and concluded that a number of respondents reported inaccurate fleet sizes as a result of confusion related to this section of the questionnaire. The survey team simplified the commercial fleet size questions to reduce confusion and collect more accurate fleet size data.

3.4 Commercial ZEV Pretest

It was expected that the natural incidence of ZEV owners in the general California commercial establishment population would be too low to achieve a sufficient sample size for the ZEV owner section of the survey questionnaire. As a result, the project team developed a separate sampling plan for commercial ZEV owners to achieve the sample size desired for analysis. The following section describes the test administration results of the commercial ZEV sampling frame. The targeted sample size for the residential ZEV pretest was 20 complete surveys.

3.4.1 Commercial ZEV Pretest—Sampling

The team estimated the response rate for the proposed address-based recruitment to be 4% on average, with some variation expected by region. This assumed response rate implied that 500 invitations would need to be distributed across the state to achieve 20 complete surveys. Table 3-24 presents the distribution of ZEV-owner establishments across the six regions along with the corresponding number of invitations distributed to establishments in each region.

Table 3-24: Commercial ZEV Pretest—Sampling Plan

Region	ZEV Owner Establishments		Invitations Distributed	
	Count	*Percent*	*Count*	*Percent*
San Francisco	4,387	30%	144	29%
Los Angeles	8,022	55%	286	57%
San Diego	957	7%	21	4%
Sacramento	472	3%	19	4%
Central Valley	449	3%	14	3%
Rest of State	391	3%	16	3%
Total	**14,678**	**100%**	**500**	**100%**

Source: California Energy Commission and California Department of Motor Vehicles.

3.4.2 Commercial ZEV Pretest—Summary of Recruitment and Data

During the test phase of the commercial survey, 47 respondents from the commercial ZEV sampling frame entered the survey and 13 completed the questionnaire. Table 3-25 presents the incidence of completed surveys and the counts of dropouts and disqualifications. The overall completion rate was modest (2.6%), with the only completes in San Francisco and Los Angeles.

Majority of the respondents who were terminated from the survey were disqualified for indicating that their business location did not have any commercial vehicles, or their organization was a car rental company, a taxicab company or a government agency.

Table 3-25: Commercial ZEV Pretest—Response Summary by Region

Region	Invitations	Completes	Dropouts	Disqualifications	Total Logins	Response Rate (Completes)
	Count	*Count*	*Count*	*Count*	*Count*	*Percent*
San Francisco	144	3	0	4	7	2.1%
Los Angeles	286	10	4	5	19	3.5%
San Diego	21	0	1	1	2	0.0%
Sacramento	19	0	0	2	2	0.0%
Central Valley	14	0	0	0	0	0.0%
Rest of State	16	0	0	1	1	0.0%
Unknown	0	0	13	3	16	
Total	**500**	**13**	**18**	**16**	**47**	**2.6%**

Figure 3-4 shows the eight most common locations in the survey where the 18 respondents who started without finishing dropped out from the questionnaire. The highest incidence of dropouts occurred at the question that asked about if they were the vehicle decision maker in their organization.

Figure 3-4: Commercial ZEV Pretest—Dropout Locations

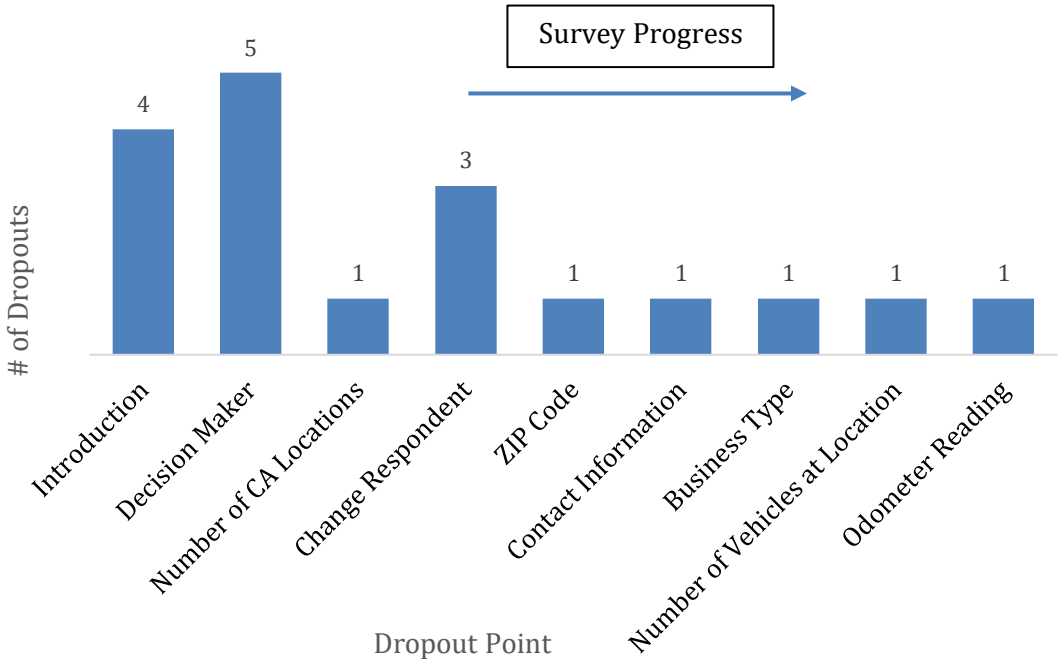


Table 3-26 summarizes the reported fleet size of the 13 fleet managers who completed the survey from commercial ZEV sampling frame. Most respondents reported having ten or more vehicles in their fleet.

Table 3-26: Commercial ZEV Survey—Fleet Size

Household Vehicles	Completes	Share of Completes
	Count	***Percent***
1 vehicle	3	23%
2 vehicles	1	8%
3–5 vehicles	2	15%
6–9 vehicles	0	0%
10+ vehicles	7	54%
Total	**13**	**100%**

Of the 13 fleet managers who were recruited using the ZEV sampling frame and completed the survey, only five reported owning at least one ZEV. Of the 316 fleet managers who were recruited using the ABS and online research panel commercial sampling frame and completed the survey, 22 reported owning at least one ZEV. As a result, 27 total respondents completed the ZEV portion of the questionnaire during the commercial vehicle pretest. Table 3-27 shows commercial establishment-level ZEV ownership for the general sampling frame and the ZEV-owner sampling frame combined. Overall, 8 percent of the commercial pretest sample reported owning a ZEV.

Table 3-27: Commercial ZEV Pretest—Establishment-level ZEV Ownership (All Commercial Respondents)

Vehicle Type	Ownership	
	Count	*Percent*
PHEV	21	6%
BEV	8	2%
FCEV	4	1%
Do Not Own PHEV/BEV	302	92%
Total Respondents	**329**	

Note: Some respondents reported owning more than one type of ZEV

Commercial ZEV Pretest—Incentives

Incentives were offered to all respondents who completed the commercial establishment ZEV survey. Respondents were given the option of receiving a $40 electronic gift card from Amazon.com or Walmart. Table 3-28 shows the distribution of survey incentive choices for respondents recruited through the commercial ZEV sampling frame.

Table 3-28: Commercial ZEV Pretest—Incentives

Prize Selection	Count	Percent
Selected Amazon	9	69%
Selected Walmart	4	31%
Declined	0	0%
Total	**13**	**100%**

Commercial ZEV Pretest—Recommended Changes to Survey Instruments and Procedures

The observed pretest completion rate of 2.6% was considerably lower than the anticipated rate of 4%. An evaluation of the survey disqualification locations, dropout locations, and respondent comments indicated that many vehicle records included in the commercial ZEV sampling frame may have been registered to residential individuals as opposed to commercial establishments. The project team worked with the Energy Commission staff to revise the commercial ZEV sampling frame, including the classification of residential and commercial registration records. The project team also recommended increasing the number of invitations to compensate for the lower than anticipated response rate.

Chapter 4: Main Survey Implementation

This section discusses the recruitment and implementation of the full survey instrument. Tasks included refining the survey questionnaires, instruments, and recruitment plan based on the outcomes of the pretest, as well as recruitment of the full survey sample for the residential and commercial sectors. As previously discussed, the project team set overall sample size targets of 3,500 residential surveys, 2,000 commercial surveys, and 600 completed ZEV-owner surveys across both sectors.

After the survey pretest was completed, the project team incorporated recommended changes to the survey design and sampling plan. The project team also refined the questionnaire prior to the full survey launch to address issues identified during the pretest. The final residential and commercial survey materials can be found in the Task 4 report, while a description of the survey pretest and recommend changes can be found in the Task 5 report.

4.1 Residential Survey

The full residential CVS was implemented in early June and concluded in early July of 2019. Specific tasks conducted during this period included sending survey invitations by mail and e-mail, reminding respondents to complete the survey via e-mail, coordinating weekly incentive processing, and responding to inquiries about the survey via phone and e-mail as necessary.

Residential Survey—Changes to Survey Content

The residential pretest conducted in March and April of 2019 was generally found to be successful and no major challenges were identified in terms of the survey questionnaire or the sampling and recruitment methodology, as described in Chapter 3. As a result, the project team did not recommend any changes to the residential survey before proceeding with the full data collection phase of the survey.

Residential Survey—Changes to Survey Recruitment

The sample size target for the full residential survey was 3,500 responses, with 1,750 to come from the ABS frame and the remaining 1,750 to come from the online market research panel sampling frame. The pretest phase of the residential survey collected 273 responses, including 166 from the address-based sampling frame and 107 from the research panel sampling frame. After reviewing the data, these responses were found to be valid and useable toward the final target sample size. Therefore, the minimum number of completes to be collected during the full data collection phase was 3,227, including 1,584 from the address-based sampling frame and 1,643 from the research panel sampling frame.

Residential Survey—Changes to Address-based Sampling

The address-based sampling completion rate of 4.4% observed during the pretest phase of the residential survey was slightly higher than the expected response rate of 4%. Using this revised response rate, the project team estimated approximately 36,000 invitations would need to be sent to collect the remaining 1,584 responses from the address-based sampling frame. The team adjusted the number of invitations to 37,000 to provide a response rate buffer.

The 37,000 invitations were distributed across the six study regions proportional to the number of households in each region. **Error! Reference source not found.** shows the updated address-based sampling plan and the projected number of completes based on the observed response rate from the pretest administration, by region.

Table 4-1: Residential Survey—Revised Address-based Sampling Plan

Region	Invitations Distributed	Projected Completes (4.4%)
San Francisco	7,764	342
Los Angeles	17,274	760
San Diego	3,196	141
Sacramento	2,505	110
Central Valley	3,613	159
Rest of State	2,648	117
Total	**37,000**	1,628

Respondents recruited into the survey using the address-based sample were contacted using a two staged mail-based approach. First, a postcard invitation (4" by 6") was mailed to adult residents of individual households. The postcard contained an introduction to the project, information about the incentives offered for completing the survey, a URL and password to access the survey online, and a project email account that respondents could contact for assistance with accessing or completing the survey. The information on the postcard was provided in both English and Spanish.

A reminder letter was mailed to households one to two weeks after the original postcard invitation. The letters were sealed in custom envelopes to match the project visual aesthetic and contained a letter on project letterhead with information about the survey and a link and password for the online instrument. The information on the letter was also provided in English and Spanish.

All printed materials and online graphics used consistent visual elements, including survey titles and description, color scheme, fonts, logos and picture graphics. The intended effect of this coordination was to connect invitation and reminder materials with the online survey instrument.

After the invitations were distributed, respondents who started the web survey but did not complete it were contacted by email using the address that respondents provided in

the survey instrument (if applicable). These respondents received one or two reminder e-mails encouraging them to complete the survey. Examples of the outreach materials are presented in Appendix 2-G.

Residential Survey—Changes to Research Panel Sampling

RSG worked with Dynata to collect the remaining 1,643 survey responses required to achieve the overall sample target of 1,750 completed surveys from the online research panel sampling frame.. Panel respondents were sampled at the regional level to meet the geographic sampling objectives of the survey. **Error! Reference source not found.** shows the targeted percentage of completed surveys and the projected numbers of completed surveys, by region.

Table 4-2: Residential Survey—Revised Online Research Panel Sampling Plan

Region	Target Percent	Projected Number of Completed Surveys
San Francisco	20%	329
Los Angeles	48%	789
San Diego	8%	131
Sacramento	6%	99
Central Valley	11%	181
Rest of State	7%	115
Total	**100%**	1,643

4.2 Commercial Survey

Data collection for the full-launch commercial survey began in early June and concluded in late June of 2019. Specific tasks conducted during this time included sending survey invitations, reminding respondents to complete the survey via e-mail, coordinating weekly incentive processing, and responding to inquiries via e-mail as necessary.

Commercial Survey—Changes to Survey Content

The project team recommended that changes be incorporated into the full-launch survey after the commercial survey pretest. These recommended changes are described in Chapter 3 and were designed to improve the overall user-friendliness and clarity of the survey.

The survey team simplified the questions relating to commercial fleet size and composition to eliminate respondent confusion and obtain more accurate fleet size results. The question that asked about the number of light duty vehicles by fuel and vehicle type owned by the company was reworded so the respondent would have a better understanding of what was being asked.

Aside from these changes to survey content, the full-launch survey matched the pretest survey for commercial respondents.

Commercial Survey—Changes to Survey Recruitment

The pretest phase of the commercial survey collected 316 responses, including 262 from the address-based sampling frame and 54 from the online research panel sampling frame. After reviewing the data, these responses were found to be valid and useable toward the final sample size target of 2,000 commercial responses.

The address-based sampling recruitment effort for the pretest resulted in an average completion rate of 3.5%, significantly higher than the expected rate of 2%. Because of the higher response rate, the project team revised the sampling plan to exclusively use address-based sampling to collect the remaining 1,684 responses.

Commercial Survey—Changes to Address-based Sampling

The number of survey invitations distributed to commercial establishments in each region was updated to maximize the number of invitations within the available project resources. The initial sampling plan, consisting of 70,000 postcards and letters distributed in population-proportionate numbers by fleet size and region, was adjusted downward to 60,000 invitations. **Error! Reference source not found.** shows the number of invitations that were distributed by fleet size and region.

Table 4-3: Commercial Survey—Revised Address-based Sampling Plan

Region	1 Vehicle	2 Vehicles	3-5 Vehicles	6-9 Vehicles	10+ Vehicles	Total
San Francisco	6,079	1,074	686	459	363	8,661
Los Angeles	25,754	4,550	2,906	1,943	1,539	36,692
San Diego	2,602	460	294	196	155	3,707
Sacramento	1,788	316	202	135	107	2,548
Central Valley	3,835	678	433	289	229	5,464
Rest of state	2,055	363	232	155	123	2,928
Total	42,113	7,441	4,753	3,177	2,516	60,000

As with the residential survey, respondents recruited into the commercial survey using the address-based sampling approach were contacted using a two-stage mail-out process. First, a postcard invitation (4” by 6”) was mailed to the business owner, fleet manager, or other individual responsible for making vehicle fleet purchase decisions at the establishment. The postcard contained an introduction to the project, information about the incentives offered for completing the survey, a URL and password to access the survey online, and a project email account that respondents could contact for assistance with accessing or completing the survey. The information on the commercial postcard was provided in English only.

A reminder letter was mailed to households one to two weeks after the original postcard invitation. The letters were sealed in custom envelopes to match the project visual aesthetic and contained a letter on project letterhead with information about the survey and a link and password for the online instrument.

All printed materials and online graphics used consistent visual elements, including survey titles and description, color scheme, fonts, logos and picture graphics. The intended effect of this coordination was to connect invitation and reminder materials with the online survey instrument.

Respondents who started the web survey but did not complete it were contacted by email using the address that respondents provided in the survey instrument (if applicable). These respondents received one or two reminder e-mails encouraging them to complete the survey.

Examples of the outreach materials are presented in Appendix 2-G.

4.3 ZEV Survey

No changes were made to the ZEV-specific portion of the questionnaire following the pretest. The project team adjusted the sampling plan based on the observed response rates from the pretest. The targeted sample size for the ZEV survey was 600 total completes across both residential and commercial sectors. Because there are fewer ZEVs registered to commercial establishments than individuals in the State of California, the project team weighted the target number of completes more heavily toward the residential sector. The final sample size targets set for the ZEV survey were 350 completes from the residential sector and 250 completes from the commercial sector.

The project team used an address-based sampling approach to recruit ZEV owners similar to the sampling approach used for the general residential and commercial surveys. The sampling frame was a complete database of all residential and commercial ZEVs registered in California as of December 2018.

4.3.1 Residential ZEV Survey—Changes to Sampling

The residential ZEV survey completion rate of 14.2% observed during the pretest was significantly higher than the expected completion rate of 5%. The observed response rate of 14.2% indicated the remaining residential survey completes would require approximately 2,500 invitations to achieve.

This allowed the team to distribute more invitations than would be necessary to collect the minimum sample size target of 350 responses. In particular, the team sampled FCEV owners more aggressively to increase the number of FCEV responses in the dataset. **Error! Reference source not found.** shows the count and percent of invitations distributed to the residential ZEV sampling frame across the six designated California regions

Table 4-4: Residential ZEV Survey—Revised Sampling Plan

Region	PEV		FCEV		Total	
	Invitations Distributed	Percent	Invitations Distributed	Percent	Invitations Distributed	Percent
San Francisco	1,702	36%	817	30%	2,519	34%
Los Angeles	2,174	46%	1,734	63%	3,908	52%
San Diego	333	7%	67	2%	400	5%
Sacramento	184	4%	91	3%	275	4%
Central Valley	154	3%	10	0%	164	2%
Rest of State	203	4%	31	1%	234	3%
Total	4,750	100%	2,750	100%	7,500	100%

4.3.2 Commercial ZEV Survey—Changes to Sampling

The observed commercial ZEV completion rate of 2.6% in the pretest was lower than the expected rate of 4%. Using the observed response rate of 2.6%, the project team estimated approximately 7,500 invitations would be required to obtain the minimum sample size of 250 complete surveys. **Error! Reference source not found.Error! Reference source not found.** shows the count and percent of invitations distributed to the commercial ZEV sampling frame across the six designated study regions. The 125 invitations sent to establishments with registered FCEVs represent nearly all of the FCEV establishments contained in the California DMV registration database.

In addition to adjusting the number of invitations to account for the observed response rate, the project team reviewed and revised the ZEV sampling frame. An evaluation of the survey disqualifications, dropout locations, and respondent comments indicated that some vehicle records included in the commercial ZEV sampling frame may have been registered to residential individuals as opposed to commercial establishments. The project team revised the commercial ZEV sampling frame, including the classification of residential and commercial registration records, to minimize potential classification errors before selecting records for the full recruitment effort.

Table 4-5: Commercial ZEV Survey—Revised Sampling Plan

Region	PEV		FCEV		Total	
	Invitations Distributed	Percent	Invitations Distributed	Percent	Invitations Distributed	Percent
San Francisco	2,057	28%	20	16%	2,077	28%
Los Angeles	4,090	55%	95	76%	4,185	56%
San Diego	566	8%	4	3%	570	8%
Sacramento	210	3%	4	3%	214	3%
Central Valley	204	3%	2	2%	206	3%
Rest of State	248	3%	0	0%	248	3%
Total	7,375	100%	125	100%	7,500	100%

4.4 Incentive Plan

Residential and commercial respondents were offered survey completion incentives in the form of an Amazon.com or Walmart gift card with a value of $15 value for residential respondents and a value of $40 for commercial respondents. At the end of the survey, respondents were prompted to choose their preferred gift card option and to provide a valid e-mail address to use for the gift card distribution.

The incentive distribution for both surveys is discussed in more detail below.

Residential Survey—Incentives

Error! Reference source not found. presents the incentive selection for all residential ABS frame respondents. Those respondents recruited through the research panel were incentivized separately by Dynata using a proprietary compensation system. Four percent of eligible residential respondents chose to decline the survey incentive.

Table 4-6: Residential Survey—Incentive Distribution

Incentive Status	Count	Total Percent	Eligible Percent
Dynata Compensation	1,759	45%	N/A
Selected Amazon.com	1,675	43%	79%
Selected Walmart	369	9%	17%
Declined Incentive	87	2%	4%
Total	**3,890**	**100%**	**100%**

Commercial Survey—Incentives

Error! Reference source not found. shows incentive selection for all commercial respondents. Three percent of eligible commercial respondents chose to decline the survey incentive.

Table 4-7: Commercial Survey—Incentive Distribution

Incentive Status	Count	Total Percent	Eligible Percent
Selected Amazon.com	1,573	80%	80%
Selected Walmart	330	17%	17%
Declined Incentive	69	3%	3%
Total	**1,972**	**100%**	**100%**

4.5 Data Processing and Quality Assurance

The data validation and coding for both the RP and SP phases of the survey were conducted in real time through the survey instrument. This real-time validation was possible because the 2018–2019 CVS was conducted entirely online. Respondents were required to provide a valid answer for each question before proceeding, eliminating item nonresponse and ensuring that each survey was completed in its entirety.

Data Validation

Several mechanisms for validating survey data were built into the residential and commercial surveys:

1. Respondents reported the number of vehicles owned or leased by their households or commercial establishments during the screening section of the questionnaire. To ensure accuracy, the provided vehicle number was compared with the number of vehicles that a respondent reported later in the survey. If the totals did not match, respondents were reminded to enter the details of the same number of household vehicles reported earlier in the survey.
2. Respondents reported the details of future vehicles they intended to purchase as replacement or additional vehicles for their households or commercial establishments. When a respondent indicated that he or she intended to purchase multiple replacement or additional vehicles within a similar timeframe, he or she was prompted to report which vehicle would be purchased first. This information enabled the project team to validate the information respondents provided about their next vehicle purchases.
3. Limitations were placed on the range of numbers respondents could enter when reporting numerical information throughout the survey to ensure that responses were reasonable. For example, respondents could only enter a current vehicle mileage between zero and 500,000 miles. Respondents could also only enter a vehicle purchase price between $500 and $300,000. Entries outside of these ranges were either not allowed or prompted a warning text box that asked respondents to confirm the quantity entered.

Data Cleaning

The project team collected a total of 4,253 residential responses and 2,309 commercial responses during all phases of data collection, including the pretest and the full survey launch. The data were screened for outliers to ensure that all observations in the data analysis represented realistic household information, establishment information, and vehicle details. Variables evaluated for data cleaning included survey response time, inconsistent or irrational choice experiments, extreme values for self-reported commercial fleet sizes, and irrational or non-sensical open-ended comments. A total of 5 residential and 8 commercial respondents were removed during the data cleaning process, resulting in final datasets of 4,248 residential respondents and 2,301 commercial respondents.

The project team also reviewed household-, person-, and vehicle-level information provided by respondents and cleaned or flagged variables as necessary. Inconsistencies between vehicle make, model year, vehicle type, and fuel type were identified, flagged, and cleaned as necessary.

Commercial Data Coding

Commercial respondents were asked to provide their company's industry in an open-ended text box. These responses were classified according to the North American

Industry Classification System (NAICS), available from the US Census Bureau. NAICS codes are the standard used by federal statistical agencies in classifying business establishments for the purposes of collecting, analyzing, and publishing statistical data related to the US business economy.

Each commercial survey response was classified according to the 2017 NAICS database. Respondents were manually associated with the NAICS code that best matched their stated business type, per NAICS code specifications. Some responses were unable to be classified because of vague or inconsistent entries. These codes were used to segment businesses into three industry groups for the purposes of modeling. The groups are described in the Section 5.2 of Chapter 5.

4.6 Reporting and Data Deliverables

RSG developed a live survey tracking page so the project team could monitor the progress of the residential and commercial data collection efforts in real time. The tracking page was accessible via a website address and included information on the number of respondents who completed, began, and were disqualified from the survey on each day of data collection. The tracking page also included average survey completion times and basic response tabulations for both surveys.

The final coded and cleaned datasets were provided to the Energy Commission to develop the system of choice models to support forecasts of transportation-related energy use in the state of California. The final residential and commercial datasets are summarized in more detail in the Section 5.2 of Chapter 5.

Chapter 5: Survey Results

This section presents summary statistics for the full CVS data collection phase, and the results presented here are based on a final dataset of 4,248 residential responses (including 611 residential zero-emission vehicle (ZEV) owners) and 2,301 commercial responses (including 256 commercial ZEV owners). This section documents the results of the administration of both the residential and commercial surveys and presents these results separately for each survey's general sampling frame and ZEV sampling frame.

5.1 Residential Survey

The 2018-2019 California Vehicle Survey collected responses from 3,637 households in California. A separate sampling effort that targeted zero emission vehicle (ZEV) owners collected an additional 611 responses. A subsequent section of this task report provides additional analysis of the residential ZEV sampling frame.

The general residential survey was administered to the public using two sampling frames:

1. A general address-based sampling frame of households in California; and
2. An online market research panel sampling frame of individuals in California.

The survey recruitment approach is described in more detail in Chapter 2.

Residential Survey—Recruitment and Response

Error! Reference source not found. shows the results of the residential sampling effort by sampling frame. The table shows that completed responses approximately match the targeted proportions for each of the study's six regions. The final residential dataset contained 3,637 complete responses, exceeding the target sample size of 3,500.

Table 5-1: Residential Survey—Completes and Targeted Proportion of Completes by Region and Outreach Method

Region	General Sampling Frame	Online Panel Completes	Total Completes	Share of Completes	Targeted Share of Completes*
San Francisco	432	378	810	22%	21%
Los Angeles	739	871	1610	44%	46%
San Diego	161	189	350	10%	9%
Sacramento	162	148	310	9%	7%
Central Valley	115	126	241	7%	10%
Rest of State	161	152	313	9%	8%
I don't know	1	2	3	0%	0%
Total	**1,711**	**1,866**	**3,637**	**100%**	**100%**

Source: 2017 American Community Survey 5-year Estimates

Error! Reference source not found. shows the counts of log-ins, disqualifications, partial completes, and the total completes for the address-based and research panel sampling frames. The total number of completes shows all general sample respondents who completed the survey before data cleaning, as well as the final number of completes after data cleaning as described in Section 4.5 of Chapter 4.

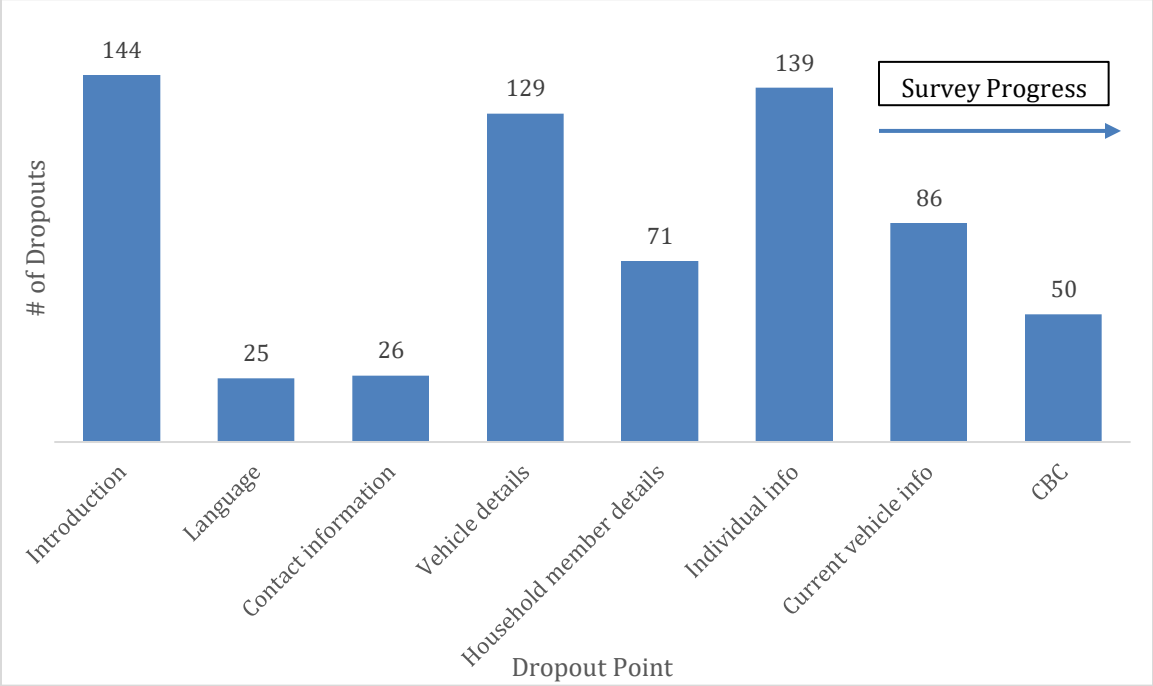
Table 5-2: Residential Survey—Response Summary

	Address-based Sampling Frame	Online Research Panel	Total
Invitations	40,750	N/A	N/A
Total Log-ins	2,553	2,854	5,407
Disqualifications	74	275	349
Partial Completes	704	712	1,416
Initial Completes	1,775	1,867	3,642
Final Completes	1,771	1,866	3,637

Of those respondents who were disqualified from the survey, the most common reason for being disqualified was not participating in the household decision-making process for acquiring a new vehicle (53% of disqualified respondents), followed by not residing in the State of California (26% of disqualified respondents).

Error! Reference source not found. shows the eight most common dropout locations for general sample residential respondents. Dropouts are defined as respondents who began, but did not complete, the survey. Respondents were most likely to drop out of the survey on the first screen, which introduced the study and provided an estimate of the time required to complete the questionnaire. Other questions with elevated dropout rates were those that asked about detailed household and vehicle information. These questions were among the most demanding of the survey, where a higher incidence of dropouts was expected. Respondents dropped out at 37 additional locations throughout the survey, but these locations accounted for smaller fractions of overall survey dropouts.

Figure 5-1: Residential Survey—Dropout Locations (All Respondents)



Residential Survey—Respondent Demographics and Summary Statistics

This section summarizes the primary demographic, household characteristics, and vehicle data from the 3,637 residential respondents. The survey collected respondent demographics such as home ZIP Code, age, and household information.

Error! Reference source not found. shows age categories for respondents and compares this information with the 2017 ACS five-year estimates, which are available from the US Census Bureau[1]. Half of respondents fell in the 35-to-64-year-old age category. Respondents under the age of 18 were not eligible to participate in the survey.

Table 5-3: Residential Survey—Respondent Age

Age Category	Count	Percent	ACS Percent
18 to 34	477	13%	32%
35 to 64	1,834	50%	50%
65 or older	1,326	36%	18%
Total	**3,637**	**100%**	**100%**

Source: 2017 American Community Survey

Error! Reference source not found. shows household size for all residential respondents compared against the 2017 ACS five-year estimates. Of the residential

[1] Available at: https://www.census.gov/programs-surveys/acs/

respondents, 44 percent of respondents live with one other person and 28 percent live alone. Larger households are underrepresented in the final dataset.

Table 5-4: Residential Survey—Household Size

Household Size	Count	Percent	ACS Percent
1 person (I live alone)	1,005	28%	24%
2 people	1,598	44%	30%
3 people	496	14%	17%
4 or more people	538	15%	29%
Total	**3,637**	**100%**	**100%**

Source: 2017 American Community Survey

Error! Reference source not found. shows household income for all residential respondents, in comparison with the 2017 ACS five-year estimates. The median reported annual household income was in the $75,000–$99,999 range.

Table 5-5: Residential Survey—Annual Household Income

Annual Household Income	Count	Percent	ACS Percent
Less than $10,000	58	2%	5%
$10,000 to $24,999	231	7%	12%
$25,000 to $34,999	215	6%	8%
$35,000 to $49,999	332	10%	11%
$50,000 to $74,999	559	17%	16%
$75,000 to $99,999	557	17%	12%
$100,000 to $149,999	659	20%	16%
$150,000 to $199,999	334	10%	8%
$200,000 or more	382	11%	11%
Prefer not to answer	310	-	-
Total	**3,637**	**100%**	**100%**

Source: 2017 American Community Survey

Error! Reference source not found. summarizes household vehicle ownership for residential respondents and compares this information to the 2017 ACS five-year estimates. Thirty-nine percent of all households reported having one vehicle and 39 percent of households reported having two vehicles.

Table 5-6: Residential Survey—Household Vehicles

Household Vehicles	Count	Percent	ACS Percent*
0 vehicles	109	3%	7%
1 vehicle	1,430	39%	30%
2 vehicles	1,421	39%	37%
3 or more vehicles	677	19%	26%
Total	**3,637**	**100%**	**100%**

*Source: 2017 American Community Survey

The 3,528 residential respondents with at least one vehicle reported basic information on a total of 6,597 household vehicles that they currently own or lease. **Error! Reference source not found.** shows the vehicle types for all household vehicles. Midsize cars and compact cars were the most common vehicle types, comprising 44 percent of all household vehicles.

Table 5-7: Residential Survey—Vehicle Type

Vehicle Type	Count	Percent
Subcompact car	348	5%
Compact car	1,277	19%
Midsize car	1,649	25%
Large car	242	4%
Sports car	328	5%
Subcompact cross-over	724	11%
Compact cross-over/SUV	385	6%
Midsize cross-over/SUV	595	9%
Full-size/large SUV	143	2%
Small van	201	3%
Full-size/large van	50	1%
Small pickup truck	214	3%
Full-size/large pickup truck	441	7%
Total	**6,597**	**100%**

Error! Reference source not found. shows the distribution of fuel type for all reported household vehicles. A majority (86%) of household vehicles use gasoline for fuel, with hybrid (gasoline) comprising 7% of all vehicle fuel types.

Table 5-8: Residential Survey—Fuel Type

Fuel Type	Count	Percent
Gasoline	5,650	86%
Hybrid (gasoline)	477	7%
Plug-in hybrid electric vehicle (PHEV)	88	1%
Diesel	106	2%
Battery electric vehicle	147	2%
Fuel cell electric vehicle (FCEV)	3	0%
Gasoline - ethanol flex fuel vehicle (E85 FFV)	122	2%
Compressed natural gas (CNG) vehicle	4	0%
Total	**6,597**	**100%**

Residential Survey—Alternative Technology

Levels of agreement were measured for seven statements to gauge drivers' preferences and concerns regarding autonomous vehicles. **Error! Reference source not found.** through **Error! Reference source not found.** show responses to these statements for ZEV owners, non-ZEV owners and for all residential respondents. In general, ZEV owners were more receptive to autonomous vehicle technology than non-ZEV owners.

Figure 5-2: Residential Survey—Autonomous Vehicles Statement #1

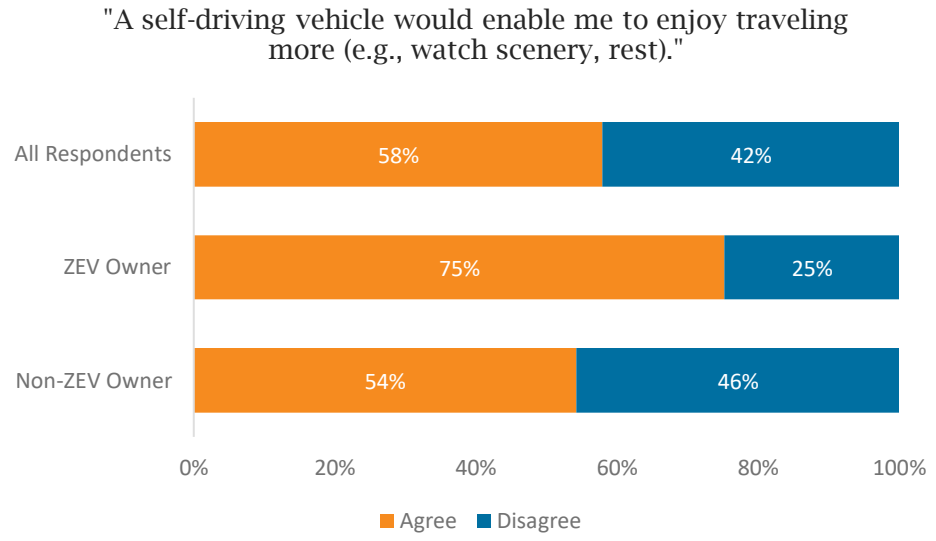


Figure 5-3: Residential Survey—Autonomous Vehicles Statement #2

"I would miss the joy of driving and being in control."

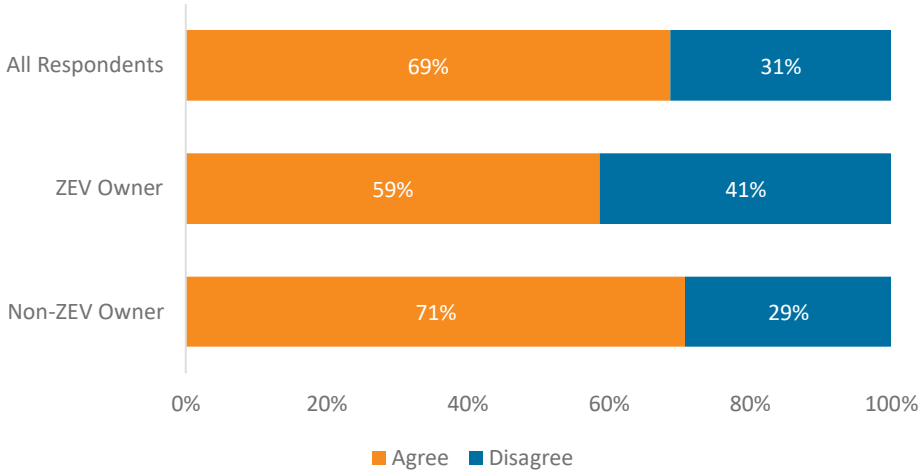


Figure 5-4: Residential Survey—Autonomous Vehicles Statement #3

"I would accept longer travel times so the self-driving vehicle could drive at a speed low enough to prevent unsafe situations for pedestrians and bicyclists."

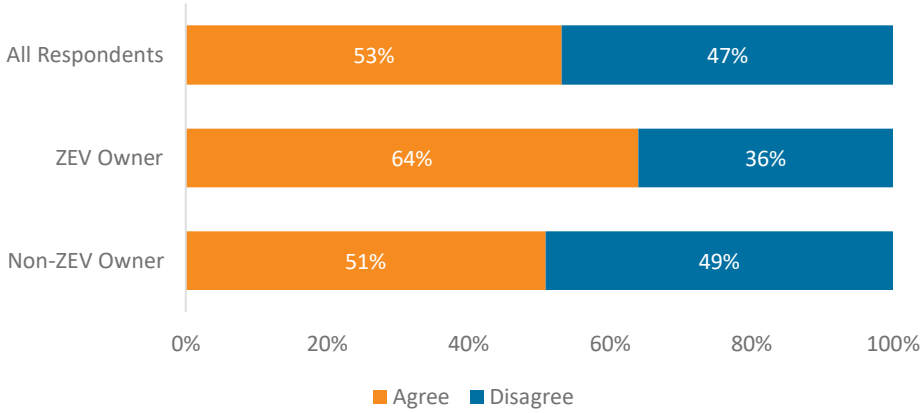


Figure 5-5: Residential Survey—Autonomous Vehicles Statement #4

"I do not see a need for self-driving vehicles."

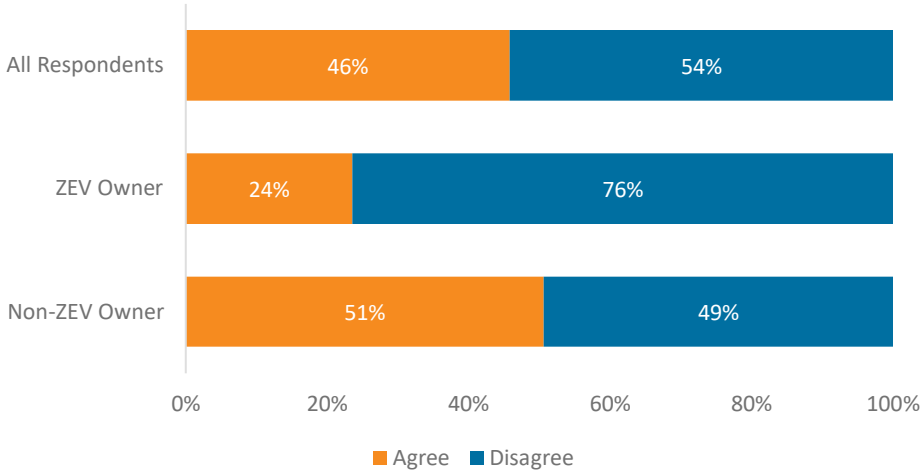


Figure 5-6: Residential Survey—Autonomous Vehicles Statement #5

"I would reduce my time at the regular workplace and work more in the self-driving car."

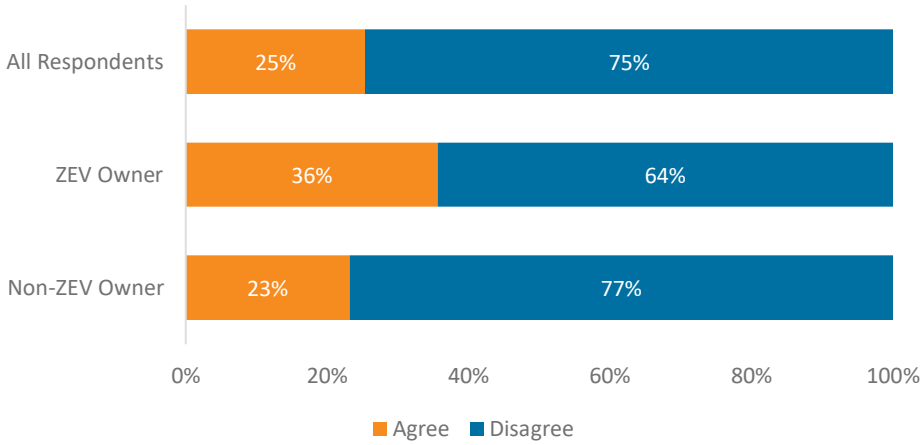


Figure 5-7: Residential Survey—Autonomous Vehicles Statement #6

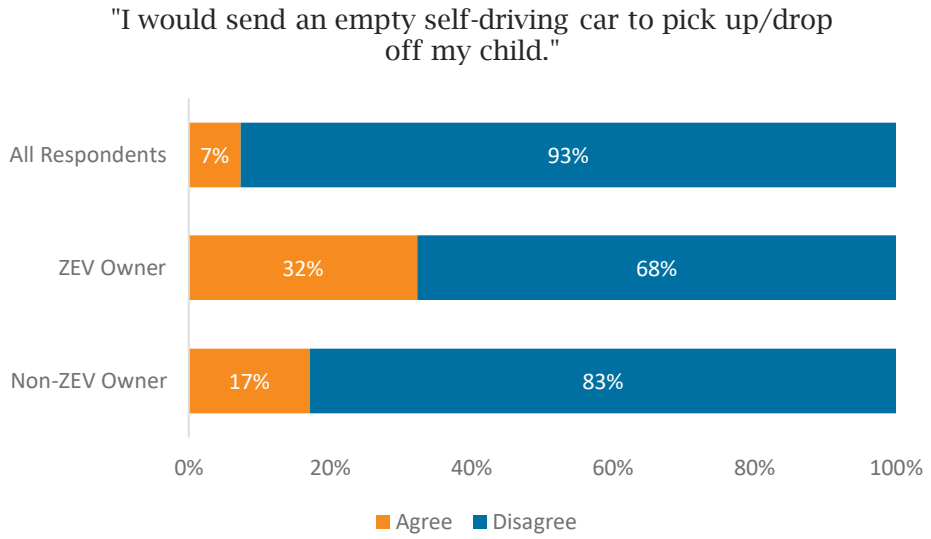
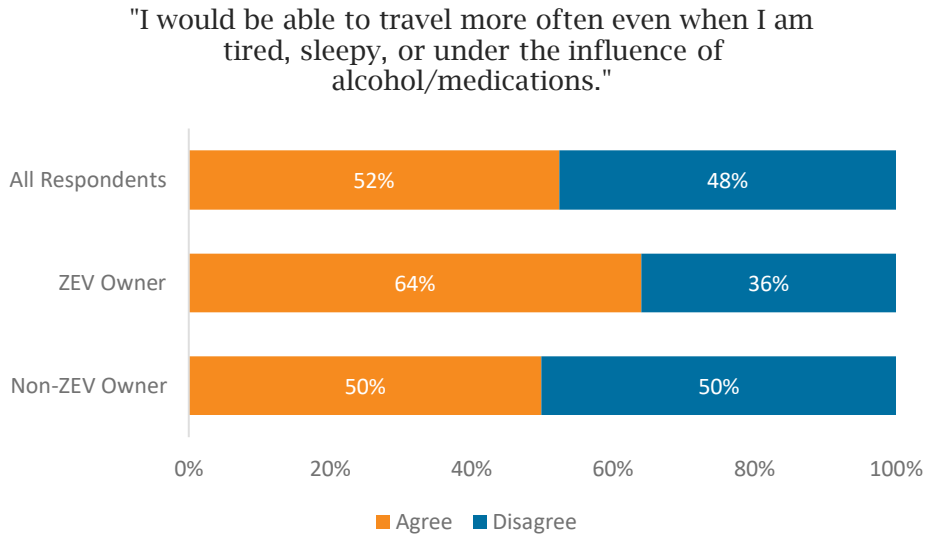


Figure 5-8: Residential Survey—Autonomous Vehicles Statement #7



Respondents were also asked about their current and expected future use of solar panels at home. Thirty-one percent (31%) of ZEV owners and 12% of non-ZEV owners indicated that they currently had solar panels installed on their permanent residence. Of those respondents who did not report having solar panels at home, 30% of ZEV owners and 16% of non-ZEV owners indicated that they planned to purchase solar panels for their permanent residence within the next five years.

5.2 Commercial Survey

This section documents the results of the survey administration for the general commercial sampling frame. A subsequent section of this task report provides additional analysis for the commercial ZEV sampling frame.

The commercial survey was administered to the California fleet managers using two sampling frames:

1. a general commercial sampling frame of businesses with at least one registered vehicle in California from IHS Automotive, and
2. an online market research panel sampling frame of business fleet managers in California.

The survey recruitment approach is described in more detail in Chapter 2.

Commercial Survey—Response

Error! Reference source not found. shows the results of the commercial sampling effort by sampling frame. The table shows that completed responses approximately match the targeted proportions for each of the study's six regions.

Table 5-9: Commercial Survey—Completes and Targeted Proportion of Completes by Region and Recruitment Method

Region	Address-based Sampling Completes	Online Research Panel Completes	Total Completes	Share of Completes	Targeted Share of Completes*
San Francisco	368	17	385	19%	20%
Los Angeles	895	26	921	45%	45%
San Diego	170	1	171	8%	9%
Sacramento	142	2	144	7%	6%
Central Valley	248	3	251	12%	11%
Rest of State	168	3	171	8%	9%
I don't know	2	0	2	0%	0%
Total	**1,993**	**52**	**2,045**	**100%**	**100%**

*Source: IHS Markit

Error! Reference source not found. and **Error! Reference source not found.** show the percent and targeted percent of all commercial completes by fleet size and by region. While the regional distribution aligns well with sampling targets, the fleet size distribution under-represents one-vehicle fleets and over-represents the larger fleet sizes. This is primarily due to a discrepancy between the fleet size estimate provided by IHS Automotive and the actual fleet size reported by survey respondents. For example, of the 1,993 respondents who completed the survey from the IHS Automotive sampling frame, 1,324 (66%) were identified as one-vehicle fleets by IHS. However, only 818 respondents (41%) reported having a one-vehicle fleet.

Table 5-10: Commercial Survey—Completes by Fleet Size and Region

Fleet Size by Region	San Francisco	Los Angeles	San Diego	Sacramento	Central Valley	Rest of State	Total
1 Vehicle	8%	20%	3%	2%	4%	3%	**40%**
2 Vehicles	3%	10%	1%	1%	2%	1%	**19%**
3–5 Vehicles	3%	9%	2%	2%	3%	1%	**20%**
6–9 Vehicles	2%	3%	1%	1%	1%	1%	**8%**
10+ Vehicles	2%	4%	1%	1%	2%	1%	**13%**
Total	**19%**	**45%**	**8%**	**7%**	**12%**	**8%**	**100%**

Table 5-11: Commercial Survey—Targeted* Completes by Fleet Size and Region

Fleet Size by Region	San Francisco	Los Angeles	San Diego	Sacramento	Central Valley	Rest of State	Total
1 Vehicle	14%	33%	7%	4%	7%	6%	**70%**
2 Vehicles	2%	5%	1%	1%	1%	1%	**12%**
3–5 Vehicles	2%	4%	1%	1%	1%	1%	**10%**
6–9 Vehicles	1%	1%	0%	0%	1%	0%	**3%**
10+ Vehicles	1%	2%	0%	0%	1%	0%	**4%**
Total	**20%**	**45%**	**9%**	**6%**	**11%**	**9%**	**100%**

*Source: IHS Markit

Error! Reference source not found. shows logins, disqualifications, partial completes, and the number of completes for the address-based sampling frame and the research panel sampling frame. The total number of completes shows all respondents who completed the survey before data cleaning, as well as the final number of completes after data cleaning as described in Chapter 4.

Table 5-12: Commercial Survey—Response Summary

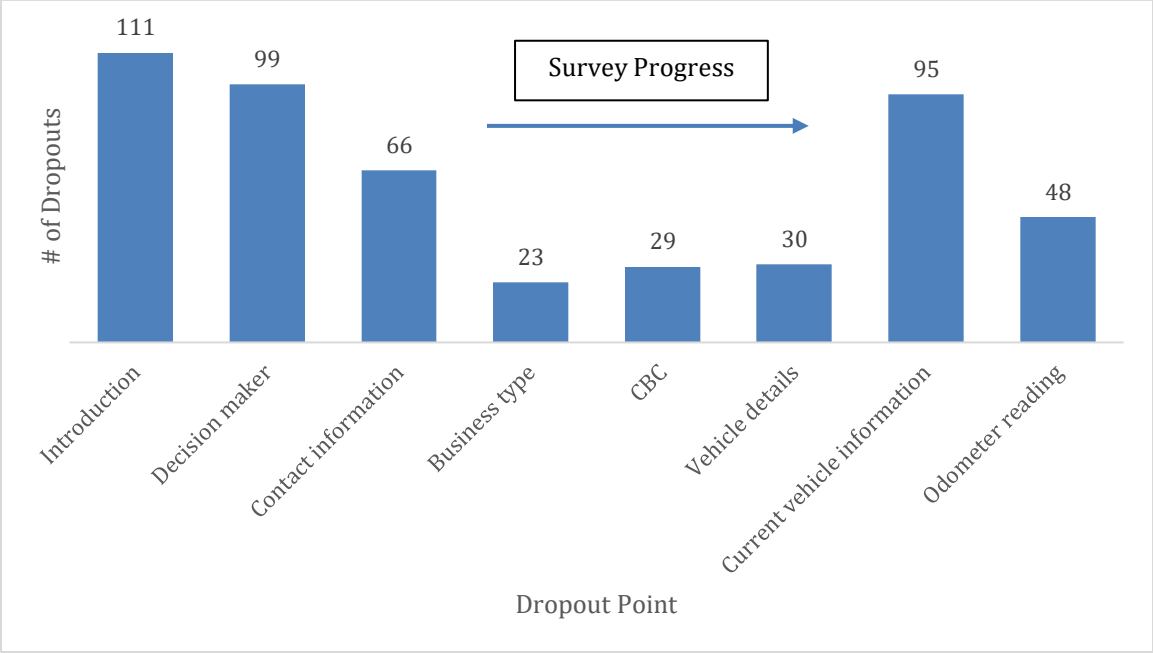
	Address-based Sampling	Research Panel	Total
Invitations	67,500	N/A	N/A
Total Log-ins	3,738	172	3,910
Disqualifications	1,013	108	1,121
Partial Completes	726	10	736
Initial Completes	1,999	54	2,053
Final Completes	1,993	52	2,045

The most common reason for disqualification from the commercial survey was entering a ZIP code outside of California (42% of disqualified respondents), followed by not owning any vehicles used for business at least 50% of the time (27% of disqualified respondents).

Error! Reference source not found. shows the eight most common dropout locations for commercial respondents who started the survey but did not complete it.

Respondents dropped out at 46 additional locations throughout the survey, but each of these locations account for only a small number of dropouts.

Figure 5-9: Commercial Survey—Dropout Locations



Commercial Survey—Summary Statistics

This section presents summary information about the 2,045 respondents in the final commercial dataset. **Error! Reference source not found.** shows the types of organizations reported by commercial respondents. The majority (59%) of commercial respondents were employed by for-profit companies.

Table 5-13: Commercial Survey—Organization Type (Select all that apply)

Organization Type	Count	Percent
For-profit organization	1,212	59%
Non-profit organization	175	9%
Religious organization	82	4%
None of the above	620	30%
Total	**2,045**	

Commercial respondents were asked to report the number of company business locations in California. **Error! Reference source not found.** shows the number of business locations in California for all commercial respondents. Seventy-eight percent of respondents reported working for a business or organization that operates from a single location in California.

Table 5-14: Commercial Survey—Business Locations in California

Business Locations in California	Count	Percent
1 Location	1,587	78%
2 Locations	187	9%
3–5 Locations	145	7%
6–9 Locations	48	2%
10–19 Locations	31	2%
20 or more Locations	47	2%
Total	**2,045**	**100%**

Table 5-15 shows the total number of employees based at respondents' self-reported places of work. More than half (51%) of respondents reported working at their given location with fewer than 10 employees.

Table 5-15: Commercial Survey—Number of Employees

Number of Employees	Count	Percent
Fewer than 10	1,051	51%
10–99	840	41%
100–999	144	7%
1,000 or more	10	0%
Total	**2,045**	**100%**

Commercial respondents were asked to describe the industry most closely associated with their organization and were matched with a category in the NAICS based on this description. The respondents were grouped into three sets of industries, as displayed in Table 5-16. Approximately 3% of responses could not be classified due to ambiguity or incomplete information provided by the respondent.

Table 5-16: Commercial Survey—Industry Groupings

Industry Group	Responses	Industries Included
Group 1	672	Agriculture, Forestry, Fishing, and Hunting
		Mining, Quarrying, and Oil and Gas Extraction
		Utilities (i.e., Electric, Gas, Water)
		Construction
		Manufacturing
Group 2	356	Wholesale Trade
		Retail Trade
		Transportation and Warehousing
Group 3	947	Information (i.e., Communications, Information Services, Publishers, Telecommunications)
		Finance and Insurance
		Real Estate and Rental and Leasing
		Professional, Scientific, and Technical Services (i.e., Lawyers, Engineering, Marketing)
		Management of Companies and Enterprises
		Administrative and Support and Waste Management and Remediation Services
		Educational Services (i.e., Schools, Colleges, Universities)
		Health Care and Social Assistance
		Arts, Entertainment, and Recreation
		Accommodations and Food Services
		Public Administration
		Repair Service
		A/O Professional, Scientific, and Technical Services Mentions
Unclassified	70	N/A
Total	2,045	N/A

The 2,045 commercial respondents reported detailed information on a total of 4,808 vehicles that their commercial establishments owned or leased. Table 5-17 shows the vehicle types, and

Table 5-18 shows the vehicle fuel types for all commercial vehicles by the three industry groups. Among vehicles owned by these respondents, 3% were PHEVs and 12% were BEVs.

Table 5-17: Commercial Survey—Vehicle Type by Industry Group

Vehicle Type	Group 1		Group 2		Group 3		Unclassified		Total	
	Count	*Pct.*	*Count*	*Pct.*	*Count*	*Pct.*	*Count*	*Pct.*	*Count*	*Pct.*
Subcompact car	13	1%	26	3%	29	1%	1	1%	**69**	**1%**
Compact car	39	2%	45	6%	115	6%	6	4%	**205**	**4%**
Midsize car	73	4%	39	5%	178	9%	18	11%	**308**	**6%**
Large car	14	1%	9	1%	33	2%	7	4%	**63**	**1%**
Sports car	8	0%	6	1%	13	1%	3	2%	**30**	**1%**
Subcompact cross-over	43	2%	39	5%	116	6%	5	3%	**203**	**4%**
Compact cross-over/SUV	31	2%	17	2%	64	3%	3	2%	**115**	**2%**
Midsize cross-over/SUV	77	4%	44	6%	144	7%	12	8%	**277**	**6%**
Full-size/large SUV	60	3%	33	4%	56	3%	5	3%	**154**	**3%**
Small van	78	4%	64	8%	213	10%	7	4%	**362**	**8%**
Full-size/large Van	219	12%	176	22%	399	19%	34	22%	**828**	**17%**
Small pickup truck	115	6%	41	5%	172	8%	6	4%	**334**	**7%**
Full-size/large pickup truck	1,008	57%	244	31%	558	27%	50	32%	**1,860**	**39%**
Total	**1,778**	**100%**	**783**	**100%**	**2,090**	**100%**	**157**	**100%**	**4,808**	**100%**

Table 5-18: Commercial Survey—Fuel Type by Industry Group

Fuel Type	Group 1		Group 2		Group 3		Unclassified		Total	
	Count	*Pct.*	*Count*	*Pct.*	*Count*	*Pct.*	*Count*	*Pct.*	*Count*	*Pct.*
Gasoline	1,339	75%	606	77%	1,711	82%	115	73%	**3,773**	**78%**
Hybrid (gasoline)	30	2%	33	4%	68	3%	6	4%	**137**	**3%**
Gasoline - ethanol flex fuel vehicle (E85 FFV)	58	3%	31	4%	98	5%	8	5%	**195**	**4%**
Plug-in hybrid electric vehicle (PHEV)	17	1%	9	1%	29	1%	5	3%	**60**	**1%**
Diesel	311	17%	92	12%	153	7%	18	11%	**574**	**12%**
Compressed natural gas (CNG) vehicle	4	0%	1	0%	2	0%	4	3%	**11**	**0%**
Full electric vehicle	17	1%	8	1%	25	1%	0	0%	**50**	**1%**
Hydrogen vehicle (FCEV)	2	0%	1	0%	1	0%	0	0%	**4**	**0%**
Other Fuel	0	0%	2	0%	3	0%	1	1%	**6**	**0%**
Total	**1,778**	**100%**	**783**	**100%**	**2,090**	**100%**	**157**	**100%**	**4,811**	**100%**

5.3 Residential ZEV Survey

The project team used a separate sampling frame to recruit California residents who own or lease at least one ZEV, as documented in previous chapters. The survey population for the residential ZEV owner survey was all individual households in

California with at least one registered light-duty ZEV—either a plug-in hybrid electric vehicle (PHEV), a battery electric vehicle (BEV), or a fuel cell electric vehicle (FCEV). The survey population excluded neighborhood electric vehicles given the significant differences in the design, use, and capabilities of these vehicles compared to standard LDVs.

Residential ZEV Survey—Response

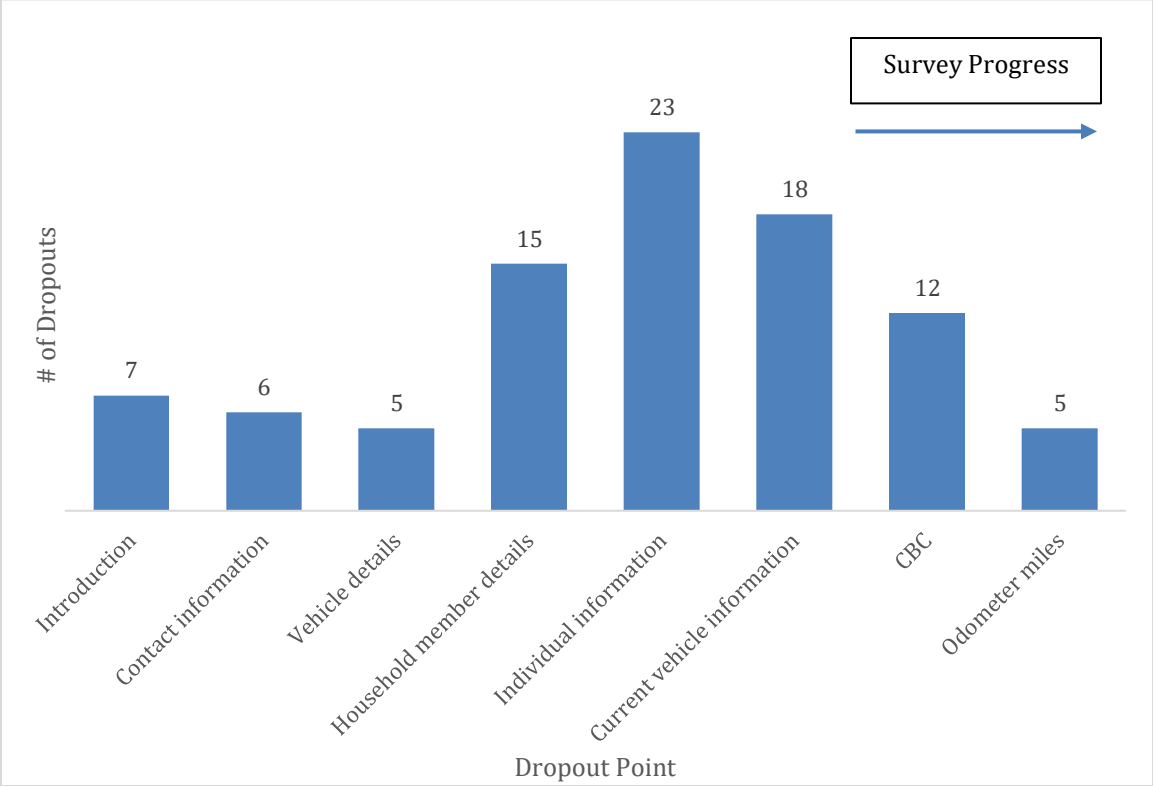
Table 5-19 shows logins, disqualifications, partial completes, and the total number of completes for the residential survey's ZEV sampling frame.

Table 5-19: Residential ZEV Survey—Response Summary

Invitations	8,100
Total Logins	759
Disqualifications	17
Partial Completes	131
Initial Completes	611
Final Completes	611

Error! Reference source not found. shows the eight most common dropout locations for all residential respondents recruited from the ZEV sampling frame who dropped out of the survey before completing it. Respondents were most likely to drop out from the survey while reporting information about individuals in their household and while answering questions about each household vehicle. These locations were among the most detailed and demanding sections of the survey, where a higher incidence of dropouts was expected. Respondents from the ZEV sampling frame dropped out at 30 additional locations throughout the survey, but these locations accounted for smaller fractions of overall survey dropouts.

Figure 5-10: Residential ZEV Survey—Dropout Locations (Residential ZEV Sampling Frame)



Residential ZEV Survey—Respondent Demographics

Table 5-20, **Error! Reference source not found.**, and **Error! Reference source not found.** show number of household vehicles, household size, and annual household income for respondents recruited through the ZEV sampling frame. In general, respondents from the ZEV sampling frame were more likely than average CA households to own multiple vehicles, live in larger households, and have higher annual household incomes.

Table 5-20: Residential ZEV Survey—Number of Household Vehicles

Number of Household Vehicles	Count	Percent	ACS Percent
0 Vehicles	3	0%	7%
1 Vehicle	99	16%	30%
2 Vehicles	292	48%	37%
3 or more Vehicles	217	36%	26%
Total	**611**	**100%**	**100%**

Table 5-21: Residential ZEV Survey—Household Size

Household Size	Count	Percent	ACS Percent
1 person (I live alone)	85	14%	24%
2 people	269	44%	30%
3 people	97	16%	17%
4 or more people	160	26%	29%

Total	**611**	**100%**	**100%**

Table 5-22: Residential ZEV Survey—Annual Household Income

Income	Count	Percent	ACS Percent
Less than $9,999	1	0%	5%
$10,000 to $24,999	4	1%	12%
$25,000 to $34,999	6	1%	8%
$35,000 to $49,999	22	4%	11%
$50,000 to $74,999	39	7%	16%
$75,000 to $99,999	58	11%	12%
$100,000 to $149,999	120	22%	16%
$150,000 to $199,999	96	18%	8%
$200,000 or more	200	37%	11%
Prefer not to answer	65	-	-
Total	**611**	**100%**	**100%**

Residential ZEV Survey—Summary Statistics

The residential ZEV questionnaire asked respondents about their reasons for owning a PHEV, BEV, or FCEV and the details about when, where, and how they charge or fuel their vehicles and the types of facilities they use.

While 611 respondents were recruited through the ZEV sampling frame, not all of them reported owning a ZEV. Of the 611 respondents who completed the survey through the ZEV sampling frame, 67 did not report currently owning a ZEV and were not eligible to complete the ZEV-specific questions. However, some respondents recruited through the general sampling frame reported owning at least one ZEV. **Error! Reference source not found.** shows all respondents who own a ZEV by outreach method.

Table 5-23: Residential ZEV Survey—Completes by Outreach Method

Outreach Method	Count	Percent
ZEV Sampling Frame	544	72%
Online Research Panel	51	7%
Residential ABS Frame	160	21%
Total	**755**	**100%**

In total, 18% (n=755) of the final set of residential survey respondents completed the residential ZEV questionnaire. **Error! Reference source not found.** shows the count and percent of total ZEV owner households and of completed residential PHEV, BEV, FCEV, and all ZEV surveys, by region.

Table 5-24: Residential ZEV Survey—Completes by Region

Region	ZEV Owner Households		Completed PHEV Surveys		Completed BEV Surveys		Completed FCEV Surveys		Total	
	Count	*Percent*	*Count*	*Percent*	*Count*	*Percent*	*Count*	*Percent*	*Count*	*Percent*
San Francisco	122,413	36%	54	31%	103	37%	86	28%	243	32%
Los Angeles	152,764	45%	77	45%	97	35%	186	61%	360	48%
San Diego	25,721	8%	18	10%	27	10%	10	3%	55	7%
Sacramento	13,411	4%	14	8%	17	6%	14	5%	45	6%
Central Valley	10,079	3%	2	1%	9	3%	0	0%	11	1%
Rest of State	13,726	4%	8	5%	22	8%	8	3%	38	5%
I don't know	0	0%	0	0%	3	1%	0	0%	3	0%
Total	**338,114**	**100%**	**173**	**100%**	**278**	**100%**	**304**	**100%**	**755**	**100%**

Residential ZEV Survey—Plug-in Electric Vehicle Respondent Results

Residential respondents with a plug-in electric vehicle (either a PHEV or a BEV) were asked whether they had purchased home charging equipment, upgraded their electrical system, or used a combination of these approaches to enable them to charge their electric vehicle at home. About 88% of PHEV respondents and 90% of BEV respondents indicated that they had installed home charging equipment.

Next, PEV respondents were asked a series of questions about their vehicle charging behavior for a specific PEV from their household fleet. If a respondent reported owning more than one PEV of the same fuel type, the respondent was asked to focus on the PEV for which they were the primary driver. If a respondent reported owning a PHEV and a BEV, they were asked to focus on the BEV. On average, respondents spent 16 cents per kilowatt-hour charging their PEVs at home.

Error! Reference source not found. shows the charger type used for PHEV, BEV, and all residential PEV owners. Respondents selected all technologies that they had used to charge their vehicles over the past month. Level 1 and Level 2 chargers were the most commonly selected technologies. Level 1 chargers were more commonly selected by PHEV owners, while Level 2 chargers were more commonly selected by BEV owners.

Table 5-25: Residential ZEV Survey—Charging Technologies Used (Select all that Apply)

Charger Type	PHEV Owner		BEV Owner		Total	
	Count	*Percent*	*Count*	*Percent*	*Count*	*Percent*
Level 1: A standard (120V) household outlet	95	83%	57	34%	152	54%
Level 2: A 240V outlet used for faster charging	29	25%	136	80%	165	58%
DC Fast Charger: A high voltage charger found at public charging stations	6	5%	3	2%	9	3%
Total	**114**	**N/A**	**170**	**N/A**	**284**	**N/A**

Error! Reference source not found. through 8 show PEV respondents' typical charging frequencies by time of day during weekdays, and **Error! Reference source not found.**

through **Error! Reference source not found.** show PEV respondents' typical charging frequencies by time of day during weekends. During both weekends and weekdays, PEVs are charged most frequently overnight.

Figure 5-11: Residential ZEV Survey—Charging Frequency on Weekday Mornings (7 am to noon)

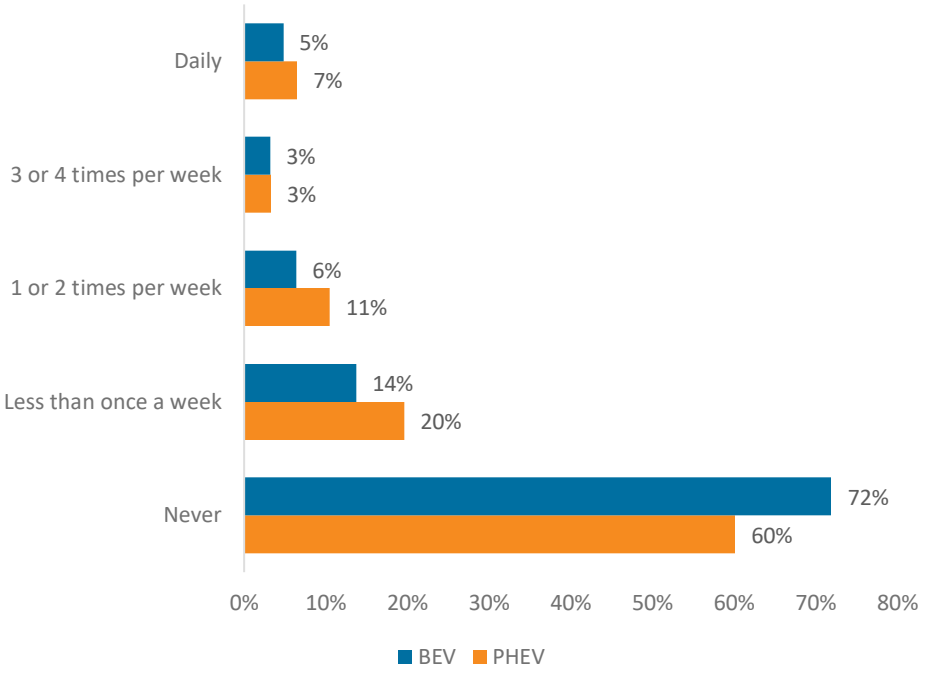


Figure 5-12: Residential ZEV Survey—Charging Frequency on Weekday Afternoons (noon to 6 pm)

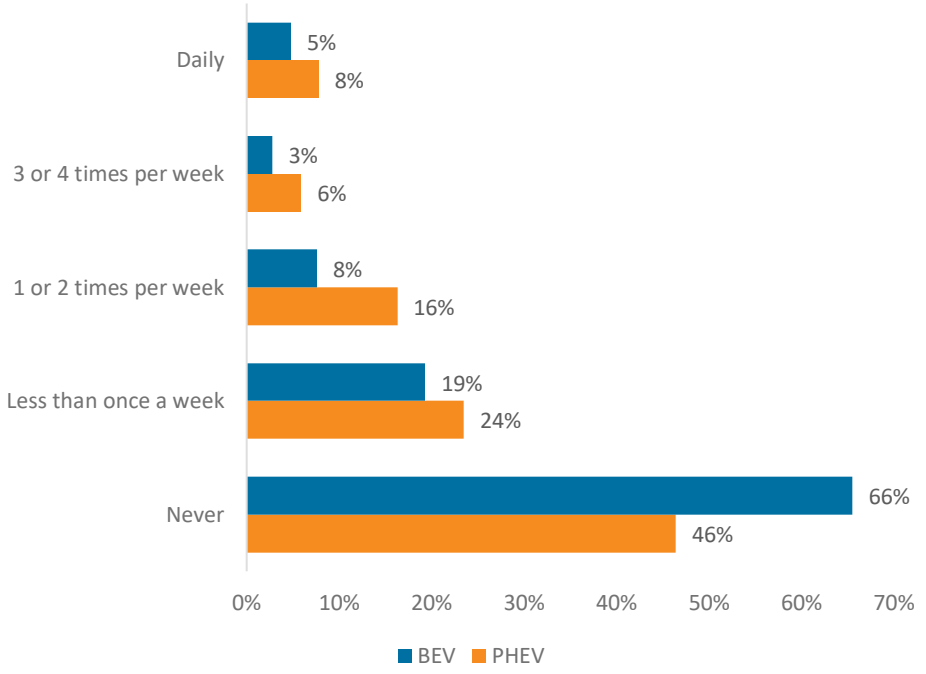


Figure 5-13: Residential ZEV Survey—Charging Frequency on Weekday Evenings (6 pm to 11 pm)

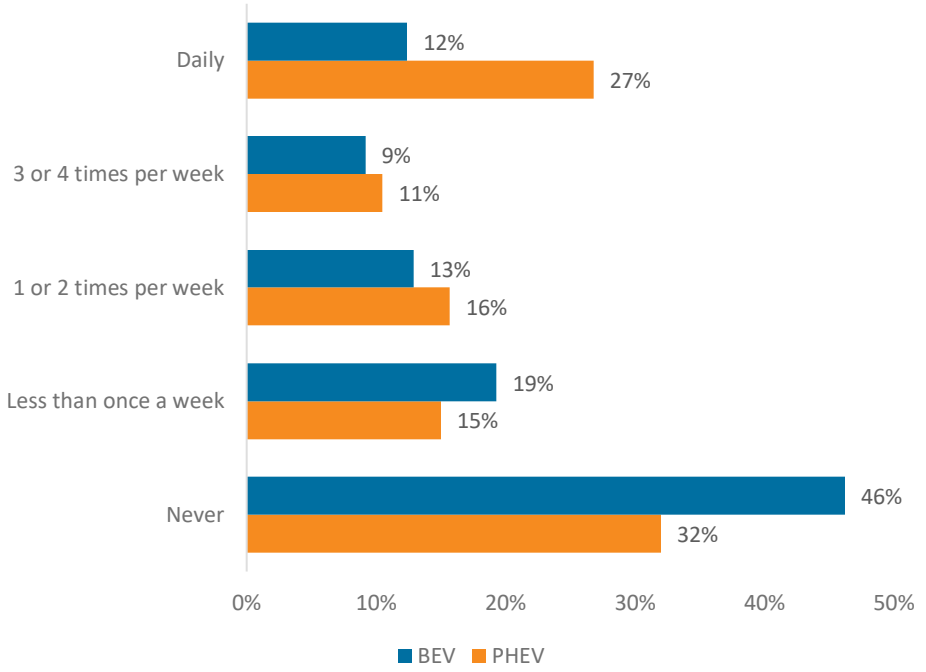


Figure 5-14: Residential ZEV Survey—Charging Frequency on Weekday Nights (11 pm to 7 am)

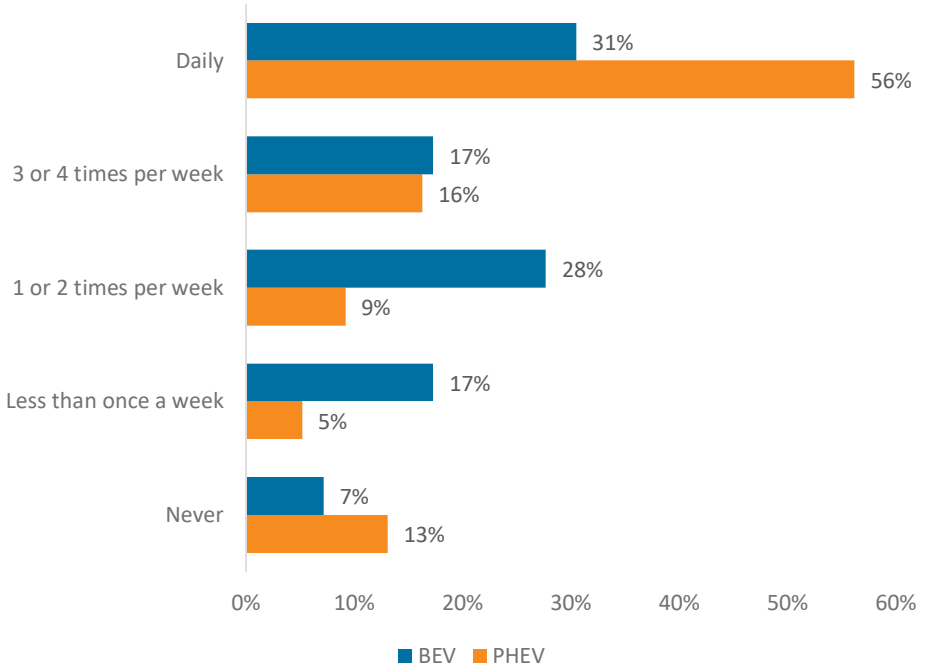


Figure 5-15: Residential ZEV Survey—Charging Frequency on Weekend Mornings (7 am to noon)

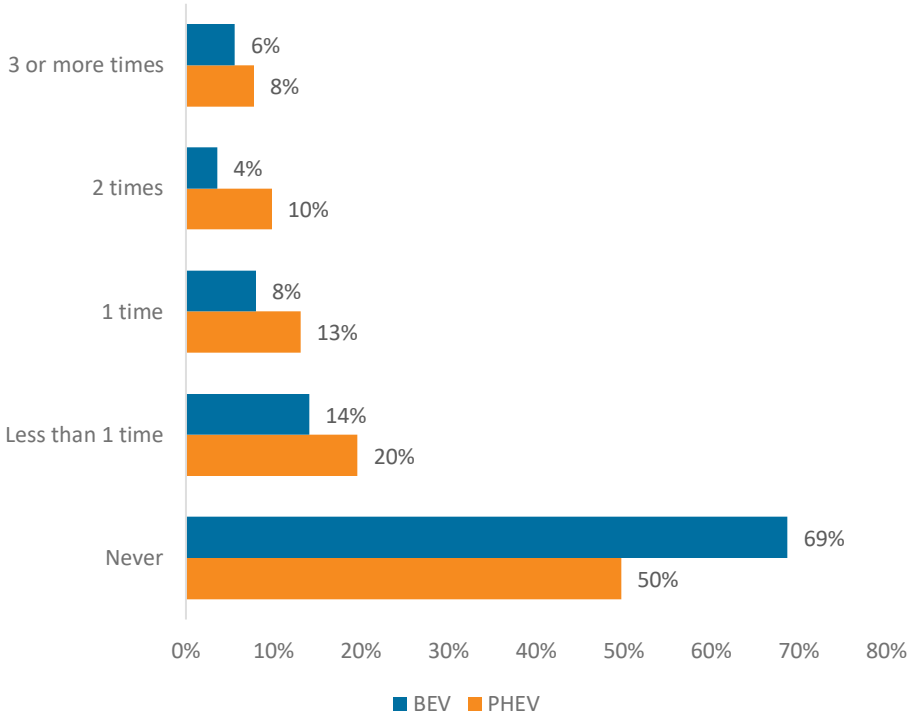


Figure 5-16: Residential ZEV Survey—Charging Frequency on Weekend Afternoons (noon to 6 pm)

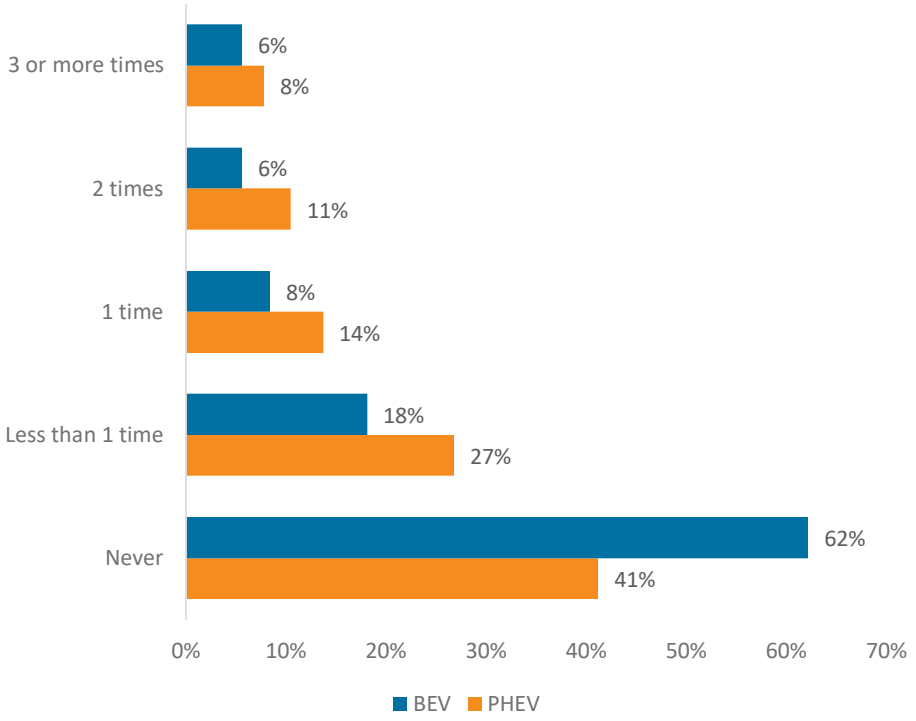


Figure 5-17: Residential ZEV Survey—Charging Frequency on Weekend Evenings (6 pm to 11 pm)

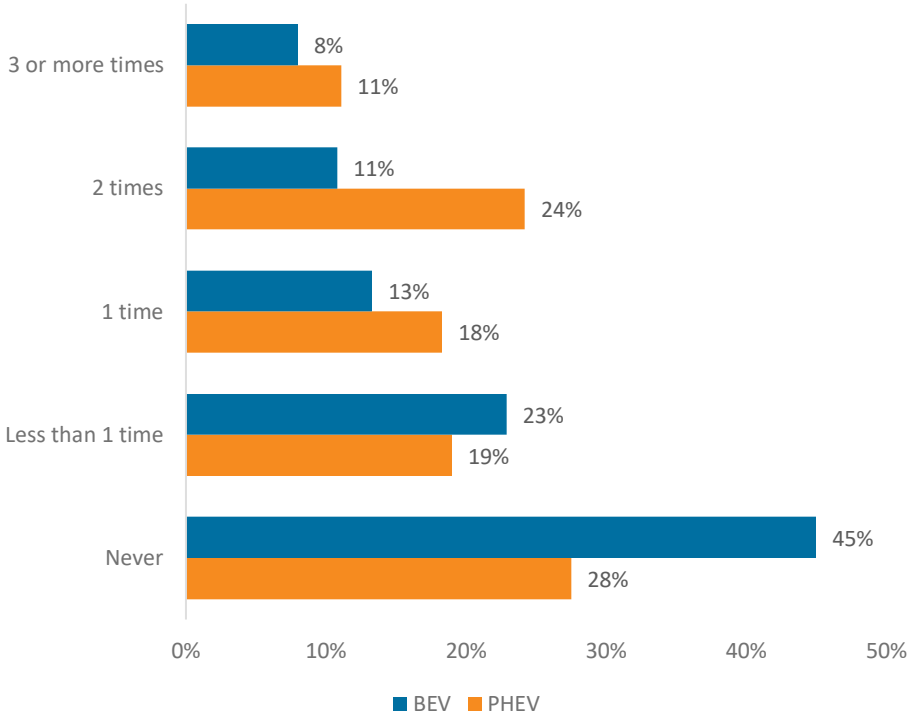
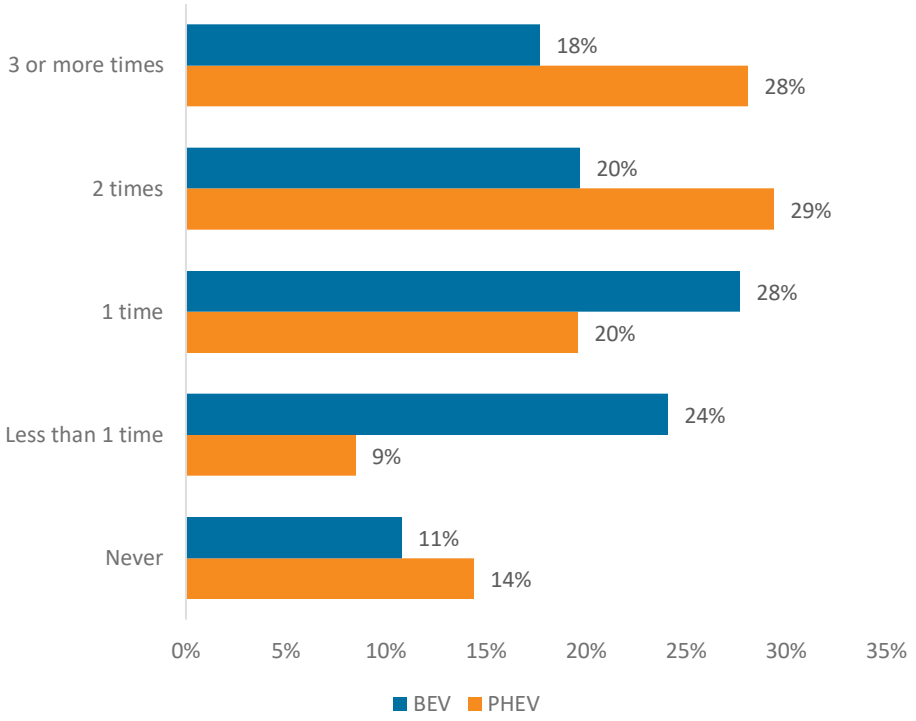


Figure 5-18: Residential ZEV Survey—Charging Frequency on Weekend Nights (11 pm to 7 am)



Residential ZEV Survey—Fuel Cell Electric Vehicle Respondent Results

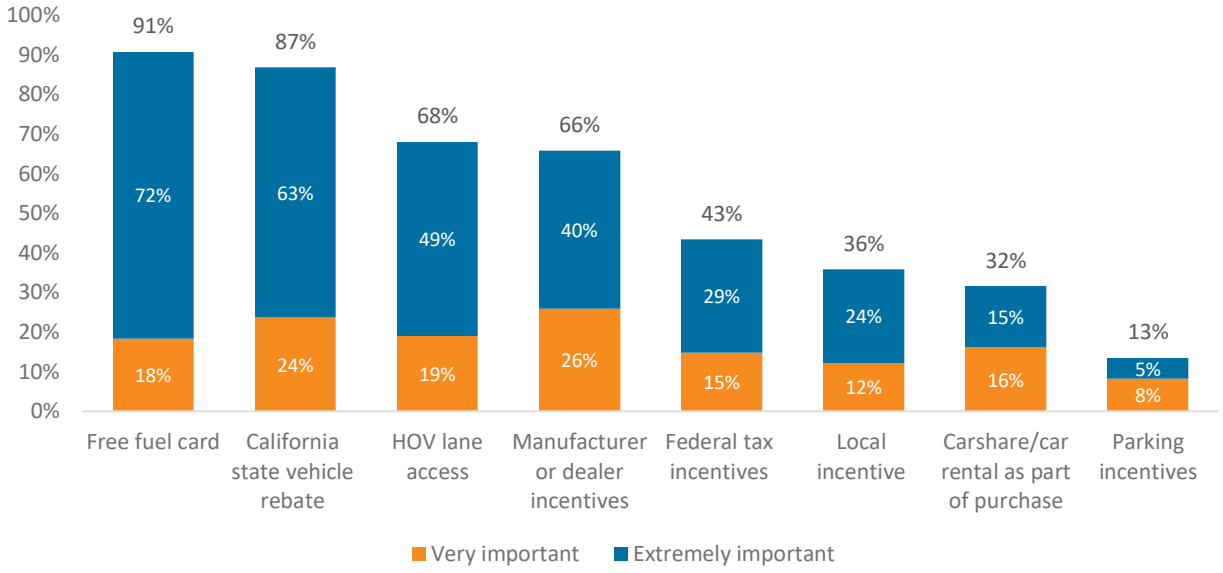
Residential FCEV respondents answered a separate set of questions about their FCEV vehicle. Approximately two-thirds (65%) of FCEV respondents owned a subcompact Toyota Mirai, approximately one-third (34%) of FCEV respondents owned a midsize Honda Clarity, two respondents owned a Hyundai Tucson and one respondent owned a Hyundai Nexo.

FCEV respondents were asked about their vehicle refueling behavior. Two-thirds (67%) of respondents said that they rarely or never have to wait to access a hydrogen pump. Over half (51%) said they have a refueling station conveniently located near their home, and 35% have a refueling station conveniently located near their work. Once they have access to a pump, it takes respondents 6.7 minutes on average to refuel their FCEV. The majority (80%) of respondents have used multiple hydrogen pumps in the last month, but due to concerns about hydrogen station availability, 77% of respondents have had to use an alternate travel mode since owning their FCEV.

Respondents were then asked about the fuel costs associated with their FCEV. Ninety-seven percent of FCEV respondents use a special fuel card provided by the dealership to pay for their hydrogen fuel. Comparing their FCEV to a similar gasoline vehicle, 41% consider a gasoline vehicle much more convenient to refuel, and 35% consider a gasoline vehicle much less expensive to refuel.

FCEV respondents were asked if they were aware of a variety of incentives available to purchasers of FCEVs, and if so, how important those incentives were in their decision to purchase a FCEV. **Error! Reference source not found.** shows the portion of incentives that respondents indicated as “very important” or “extremely important”. Overall, purchase incentives were more important to FCEV buyers than PEV buyers.

Figure 5-19: Residential ZEV Survey—Importance of FCEV Purchase Incentives



5.4 Commercial ZEV Survey

The project team used a separate sampling frame to recruit California commercial fleet owners with at least one ZEV, as documented in previous chapters. The survey population for the commercial ZEV owner survey was all commercial establishments in California with at least one registered light-duty ZEV—either a PHEV, BEV, or FCEV.

Commercial ZEV Survey—Response

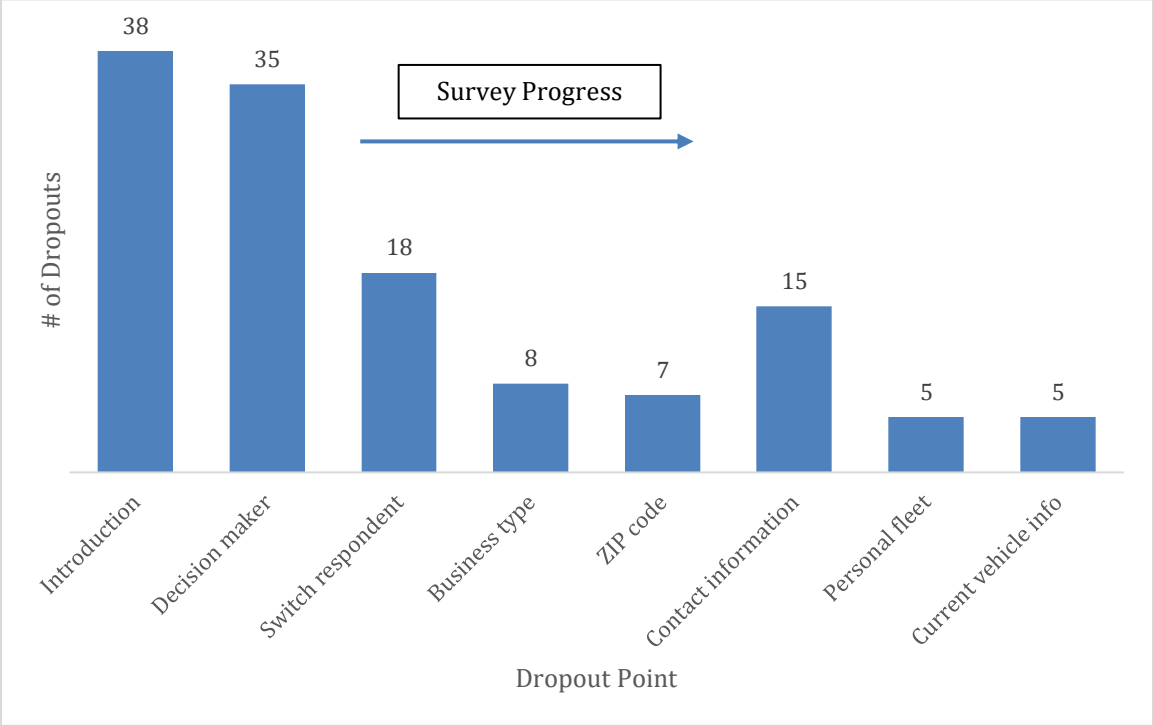
Table 5-26 shows log-ins, disqualifications, partial completes, and the total number of completes for the commercial survey's ZEV sampling frame.

Table 5-26: Commercial ZEV Survey—Response Summary

Invitations	8,000
Total Log-ins	546
Disqualifications	109
Partial Completes	181
Initial Completes	256
Final Completes	256

Error! Reference source not found. shows the eight most common dropout locations for all commercial respondents recruited from the ZEV sampling frame who dropped out of the survey before completing it. Respondents dropped out at 23 additional locations throughout the survey, but each of these locations account for only a small number of dropouts.

Figure 5-20: Commercial ZEV Survey—Dropout Locations (Commercial ZEV Sampling Frame)



Commercial ZEV Survey—Summary Statistics

A separate questionnaire was administered to commercial respondents whose establishments own or operate a ZEV. The questionnaire asked these respondents about their main reasons for owning a PHEV, BEV, or FCEV and the details about when, where, and how they charge their vehicles and the types of facilities they use. In total, 12% of commercial survey respondents completed the ZEV questionnaire.

While 256 respondents were recruited through the ZEV sampling frame, not all of them reported owning a ZEV. Seventy respondents recruited to the survey through the ZEV sampling frame did not report currently owning a ZEV and were not eligible to complete the ZEV-specific questions. However, 90 respondents recruited through the general ABS frame and the online research panel sampling frame reported owning a ZEV. **Error! Reference source not found.** shows all commercial respondents who reported a ZEV by outreach method.

Table 5-27: Commercial ZEV Survey—Completes by Sampling Frame

Sampling Frame	Count	Percent
ZEV Sampling Frame	186	67%
ABS Frame	75	27%
Online Research Panel Sampling Frame	15	5%
Total	**276**	**100%**

Error! Reference source not found. shows completed commercial ZEV surveys, by region, for PHEV, BEV, and FCEV owners. Four respondents owned both a PEV and FCEV and were asked to complete a set of questions for each fuel type.

Table 5-28: Commercial ZEV Survey—Completes by Region

Region	Completed PHEV Surveys		Completed BEV Surveys		Completed FCEV Surveys		Total Respondents	
	Count	*Percent*	*Count*	*Percent*	*Count*	*Percent*	*Count*	*Percent*
San Francisco	27	25%	39	23%	3	23%	62	22%
Los Angeles	60	56%	94	55%	9	69%	156	57%
San Diego	7	6%	13	8%	0	0%	20	7%
Sacramento	2	2%	5	3%	0	0%	7	3%
Central Valley	9	8%	12	7%	0	0%	19	7%
Rest of State	3	3%	8	5%	1	8%	12	4%
Total	**108**	**100%**	**171**	**100%**	**13**	**100%**	**276**	**100%**

Note: Total adds to more than 276 because respondents completed surveys for each type of ZEV in their fleet.

Error! Reference source not found. shows completed commercial ZEV surveys by self-reported vehicle fleet size, for PHEV, BEV, and FCEV owners.

Table 5-29: Commercial ZEV Survey—Completes by Fleet Size

Fleet Size	Completed PHEV Surveys		Completed BEV Surveys		Completed FCEV Surveys		Total Respondents	
	Count	*Percent*	*Count*	*Percent*	*Count*	*Percent*	*Count*	*Percent*
1 Vehicle	35	32%	86	50%	6	46%	127	46%
2 Vehicles	16	15%	39	23%	3	23%	58	21%
3-5 Vehicles	11	10%	24	14%	0	0%	34	12%
6-9 Vehicles	10	9%	8	5%	1	8%	16	6%
10+ Vehicles	36	33%	14	8%	3	23%	41	15%
Total	**108**	**100%**	**171**	**100%**	**13**	**100%**	**276**	**100%**

Note: Total adds to more than 276 because respondents completed surveys for each type of ZEV in their fleet.

Commercial ZEV Survey—Plug-in Electric Vehicle Respondent Results

Commercial PEV respondents were asked whether their companies had purchased charging equipment or completed upgrades to enable them to charge their electric vehicles. More than half (56%) of PEV respondents indicated that their companies had arranged for charging equipment.

PEV respondents were also asked a series of questions about their vehicle charging behaviors. On average, PEV respondents indicated they spent 38 cents per kilowatt-hour charging their PHEVs or BEVs. **Error! Reference source not found.** and **Error! Reference source not found.** show how frequently commercial respondents charge their PEVs during the week and on weekends, respectively.

Figure 5-21: Commercial ZEV Survey—Weekday Charging Frequency

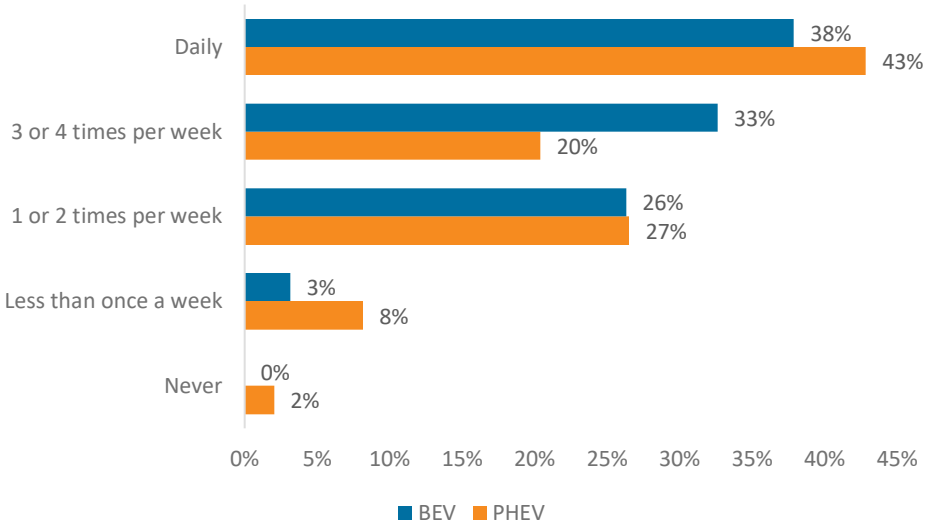
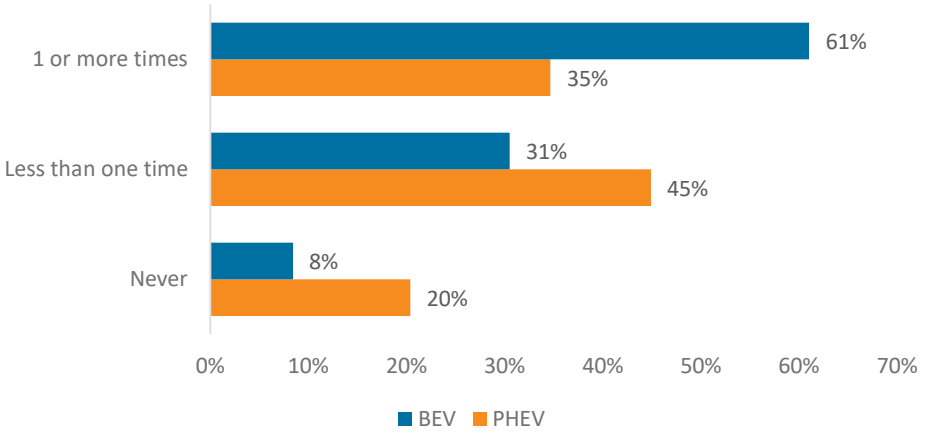


Figure 5-22: Commercial ZEV Survey—Weekend Charging Frequency



Error! Reference source not found. and **Error! Reference source not found.** show the time of day that commercial respondents charge their PEVs during the week and weekend, respectively. In general, BEVs are charged overnight more frequently than PHEVs.

Figure 5-23: Commercial ZEV Survey—Weekday Charging Times

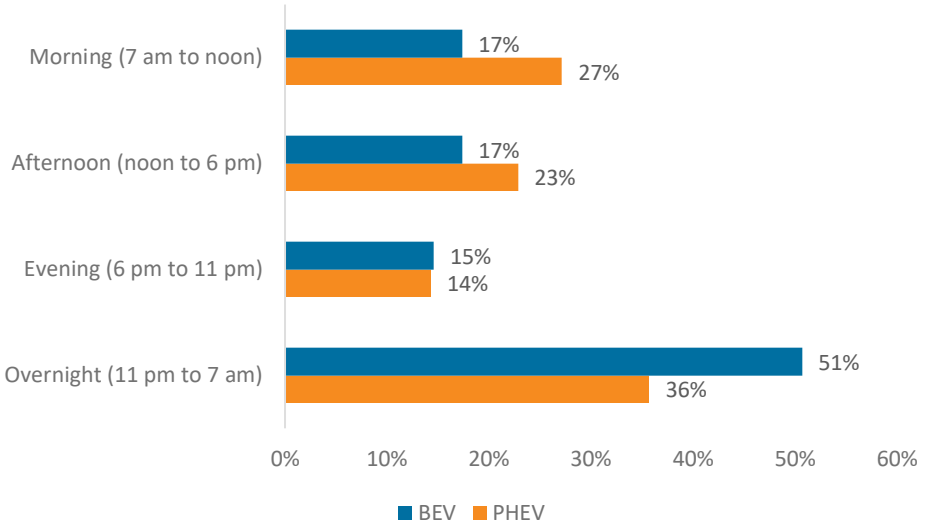
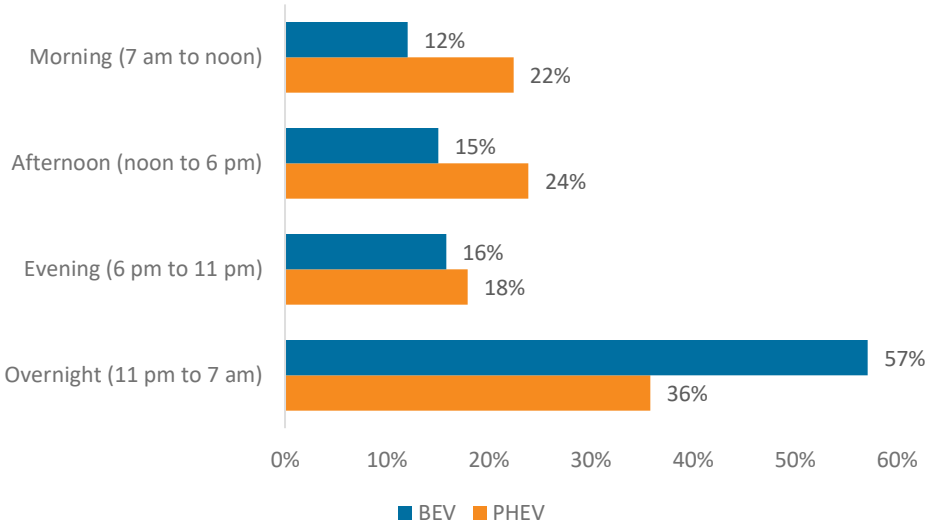


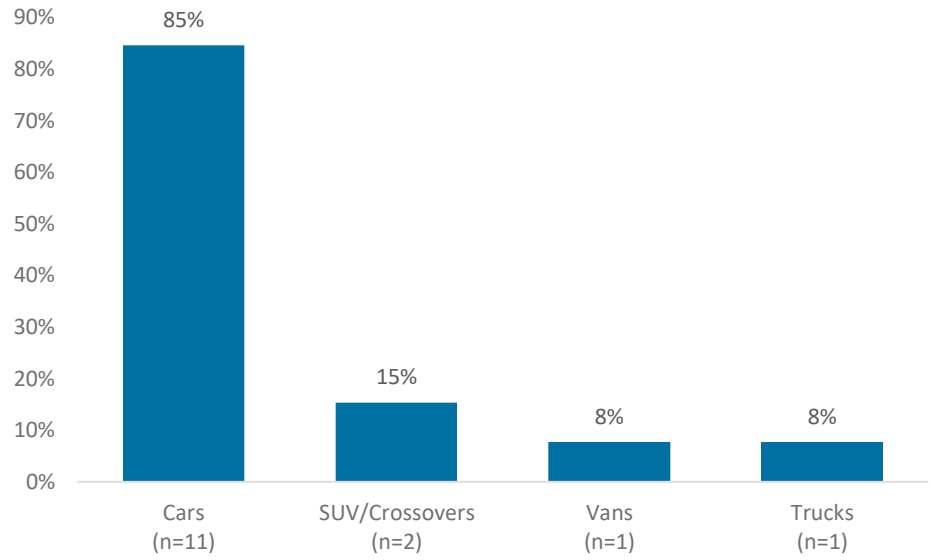
Figure 5-24: Commercial ZEV Survey—Weekend Charging Times



Commercial ZEV Survey—Fuel Cell Electric Vehicle Respondent Results

Commercial FCEV owners and operators answered a separate set of questions about their FCEVs. Thirteen commercial respondents indicated they had one or more FCEVs in their fleet. Because of the very small sample size, care needs to be taken in interpreting and extrapolating the results. **Error! Reference source not found.** shows the types of FCEVs owned by commercial respondents.

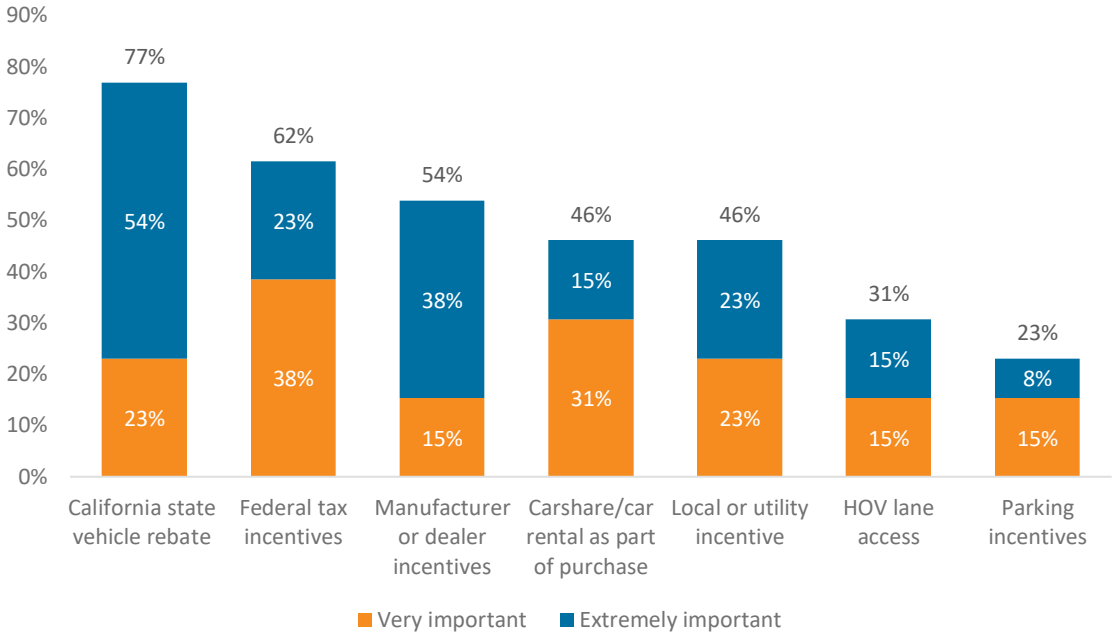
Figure 5-25: Commercial ZEV Survey—FCEV Vehicle Types



FCEV respondents were then asked a series of questions about their refueling behaviors. Eight of the thirteen FCEV respondents reported having hydrogen refueling capabilities on-site or at a company-owned location. Six respondents reported they do not pay for hydrogen fuel, four respondents reported paying by the kilogram, and three respondents did not know if they paid for hydrogen fuel. Of those who paid for hydrogen fuel, the cost ranged from $10 to $17 per kilogram. Of the 11 respondents who use off-site fuel stations eight reported using multiple hydrogen stations in the past month.

FCEV respondents were also asked if they were aware of a variety of incentives available to purchasers of FCEVs, and if so, how important those incentives were in the respondent's decision to purchase their FCEV. **Error! Reference source not found.** shows the portion of incentives that respondents indicated as "very important" or "extremely important".

Figure 5-26: Commercial ZEV Survey—Importance of FCEV Purchase Incentives



ACRONYMS

Acronyms	Original Term
2017 IEPR	*2017 Integrated Energy Policy Report*
BEV	Battery electric vehicle
CARB	California Air Resources Board
California ISO	California Independent System Operator
CCA	Community choice aggregator
CPUC	California Public Utilities Commission
CHP	Combined heat and power
CVC	Commercial Vehicle Choice
CVS	California Vehicle Survey
DMV	California Department of Motor Vehicles
DOE	U.S. Department of Energy
DOF	California Department of Finance
Energy Commission	California Energy Commission
EV	Electric vehicle
FCEV	Fuel cell electric vehicle
GWh	Gigawatt-hour
IEPR	*Integrated Energy Policy Report*
kW	Kilowatt
kWh	Kilowatt-hour
LDV	Light duty vehicle
MW	Megawatt
PEV	Plug-in electric vehicle
PHEV	Plug-in hybrid electric vehicle
PFCEV	Plug-in fuel cell electric vehicle
PVC	Personal Vehicle Choice
VMT	Vehicle miles traveled
ZEV	Zero-emission vehicle (BEV, PHEV, FCEV, PFCEV)

REFERENCES

Dillman, D., J. Smyth and L. Christian, Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method, John Wily, 2014