CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Residential Electric Vehicle Charging Program in California

Prepared for: California Energy Commission

Prepared by: AeroVironment, Inc.

Gavin Newsom, Governor

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California Energy Commission

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ACKNOWLEDGEMENTS

California Plug-In Electric Vehicle Buyers

AeroVironment wishes to acknowledge the 1,758 electric vehicle buyers in California who participated in this innovative program. Volunteering their time and homes for this project made possible the significant expansion of Level 2 electric vehicle charging infrastructure throughout the state.

California Auto Dealerships

More than 290 auto dealerships in California assisted with this project. They provided the first contact with residential customers, and performed the eligibility check for the program. They proved essential in explaining the Level 2 electric vehicle supply equipment technology and the process for installation and use to the electric vehicle buyers.

California Energy Commission

One of the survey questions asked of the electric vehicle buyers was whether this program was a significant factor in their decision to purchase an electric vehicle. The overwhelming majority responded yes. This response is a testament to the Energy Commission's vision in launching this program.

PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program, formerly known as the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP). The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and nonroad vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued PON-11-602 to provide funding opportunities under the Clean Transportation Program for alternative fuels infrastructure. In response to PON-11-602, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards August 16, 2012 and the agreement was executed as ARV-12-023 on June 21, 2013.

ABSTRACT

In early 2013, the California Energy Commission awarded $3,707,850 to AeroVironment, Inc. to supply and install free Level 2 electric vehicle supply equipment, also called charging stations, at the homes of qualified electric vehicle buyers in California. The primary goal of the project was to expand electric vehicle adoption in California. AeroVironment worked with automotive dealerships across the state to identify and qualify the electric vehicle buyers. AeroVironment then subcontracted with local electrical contractors to install the equipment.

Electric vehicle supply equipment installations began in June 2013 and ended in August 2014. AeroVironment scheduled data collection to begin six months after installation. In addition to data collection and performance assessment, this report also describes how the residential charger program was launched and implemented.

The project achieved the goal by installing 1,758 pieces of electric vehicle supply equipment, or roughly 23 percent more than the agreement goal of 1,425 units of electric vehicle supply equipment. The project also reduced an estimated 5,000 metric tons of greenhouse gas emissions annually and displaced about 817,200 gallons of gasoline annually.

Keywords: Alternative and Renewable Fuel and Vehicle Technology Program, zero-emission vehicles, electric vehicle supply equipment, battery electric vehicles, plug-in electric vehicles, plug-in hybrid electric vehicles, Level 2 electric vehicle chargers.

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EXECUTIVE SUMMARY

This report describes how AeroVironment, Inc. identified potential electric vehicle buyers for the Level 2 Residential Electric Vehicle Supply Equipment Deployment Program, assessed their eligibility, and supplied and installed the electric vehicle supply equipment in the homes of the 1,758 electric vehicle drivers in the program. AeroVironment used $3,707,850 in grant funds from the California Energy Commission for this program. The electric vehicle supply equipment installed under this program charge a wide spectrum of plug-in electric vehicles that include Nissan LEAF™, Chevy Volt, Toyota Prius plug-in hybrid, Ford Focus, Ford Fusion, Fiat 500e, Daimler Smart, Tesla Model S, and Honda Accord plug-in hybrid.

The 1,758 units of new electric vehicle supply equipment supplied and installed through this project log an estimated 670,000 charging events per year. The electric vehicle supply equipment service logs roughly 22,473,000 miles per year, which results in displacing 817,200 gallons of regular gasoline annually when compared to a 2013 sedan using regular unleaded fuel. This displacement equates to an annual greenhouse gas emissions reduction of nearly 5,000 metric tons.

Feedback from the survey of program participants overwhelmingly stated that this program succeeded in achieving the goals of the program. The final question of the survey asked, “Was the free Level 2 electric vehicle supply equipment charger program a factor in your decision to buy an electric vehicle?” Seventy-two percent of the respondents said, “Yes.”

The goal of this program was to install 1,425 units of Level 2 electric vehicle supply equipment. At the end of the project, 23 percent more or 1,758 have been installed.

CHAPTER 1: Objectives, Planning, and Approach

Project Overview- Goals and Objectives

This project sought to promote adoption of electric vehicles (EVs) in California and expand residential charging in the State.

Goals and Objectives

- Accelerate the commercialization of alternative fuel vehicles and alternative/renewable fuels

EV adoption depends on consumers and positive word-of-mouth relative to their experience. A primary project goal was to make electric vehicle supply equipment (EVSE) home installation positive and seamless.

- Reduce the use of fossil fuels and greenhouse gas (GHG) emissions to help the state achieve its public policy goals

The degree of GHG emission reduction attributable to EVs depends on the grid generation mix. As California has high renewables penetration and high natural gas components in its grid generation mix, it is the ideal environment that makes EVs effective at reducing greenhouse gas emissions from gasoline-powered vehicles. Through this program, consumer adoption of electric vehicles contributed to the reduction of GHG emissions throughout the state.

In 2006, California enacted Global Warming Solutions Act (Assembly Bill 32, Núñez, Chapter 488, Statutes of 2006) to reduce California's GHG emissions. In 2012, Governor Edmund G. Brown Jr. issued Executive Order (EO) B-16-12 ordering state agencies to begin transitioning their fleets away from internal combustion engines that depend on petroleum. The goal is to use zero-emission vehicles (ZEVs) that use no petroleum-based fuel. This project accounted for the displacement of an estimated 817,200 gallons of gasoline and the reduction of 5,000 metric tons of GHG emissions.

- Expand Level 2 residential EV charging and document home charging experience of EV buyers

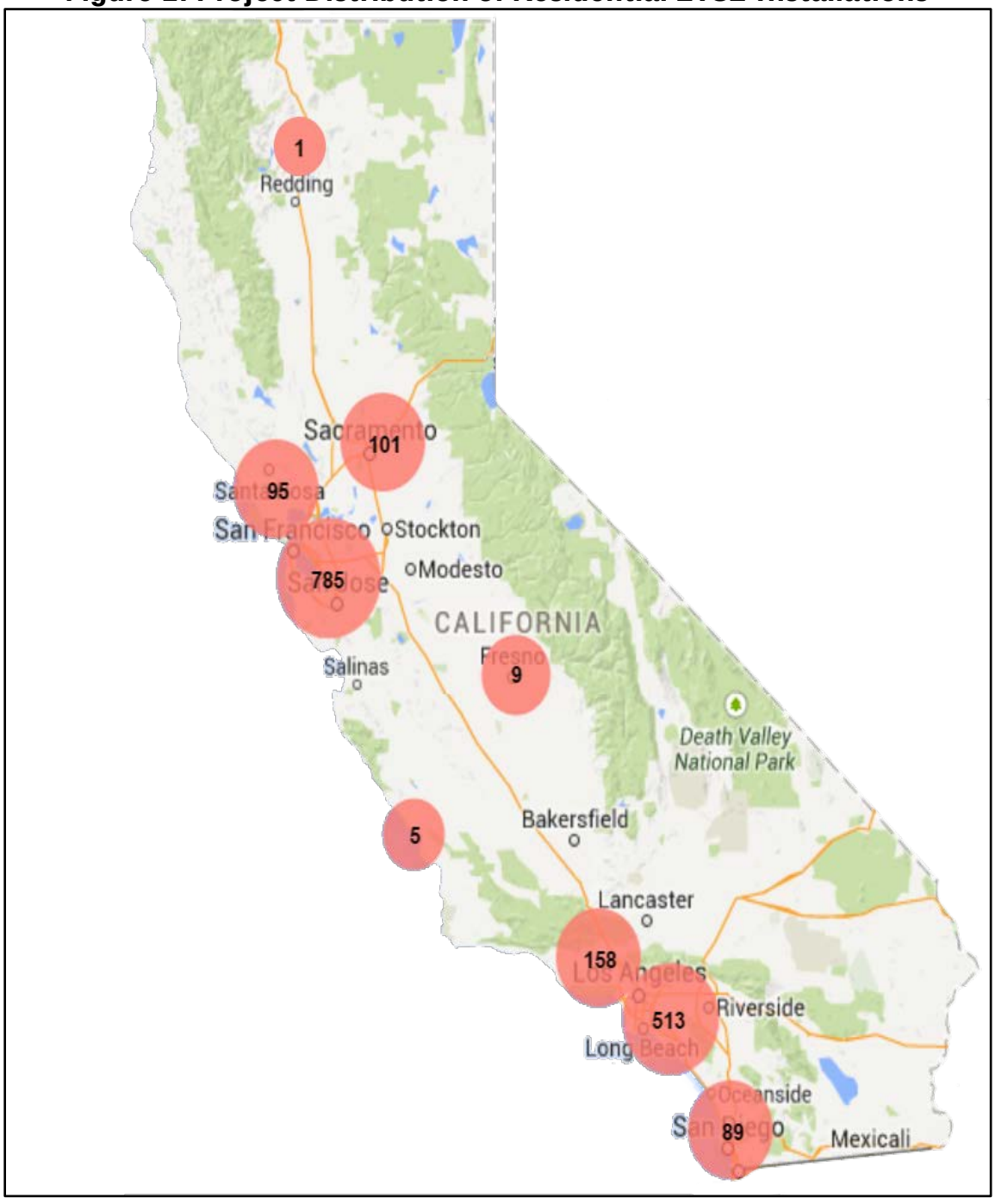
One of the program goals was to provide as many EVSE installations as possible while meeting California Energy Commission program requirements, including data collection.

AeroVironment (AV) gathered project data from a customer web portal in conjunction with vehicle dealerships and surveys sent to EVSE customers six months after EVSE installation. Survey response rate was more than 90 percent.

AV was originally awarded $2 million to supply and install 770 EVSE at homes across California. The Energy Commission modified AeroVironment's contract with an additional $1,707,850 to bring the total contract to $3,707,850 to install 1,425 units of EVSE. Working with 290 California vehicle dealerships to identify and qualify prospective EV buyers, AV, and its 28 electrical subcontractors installed 1,758 units of EVSE, or 23 percent more than required

by the agreement. Figure 1 is a map of California that shows the distribution of residential installations performed under this project.

Figure 1: Project Distribution of Residential EVSE Installations



Source: AeroVironment

Project Planning and Approach

Project planning began during the preparation of the proposal in response to PON-12-602. The solicitation limited single application awards to $500,000, which would have limited the effectiveness of a statewide program. To address this, AV submitted 11 regional applications and one catchall application to propose an integrated statewide program. The Energy Commission awarded AeroVironment $3,707,850 to fund a statewide residential EVSE deployment. Figure 2 is a map of California showing the areas of coverage.

Figure 2: Cal Electric: Residential EVSE Deployment Program

Source: AeroVironment

Auto Dealership Signup, EV Driver Identification, and Qualification

The auto dealerships are the first point of contact for EV buyers. AV signed up nearly 290 auto dealerships across California and provided their sales representatives with training for the program. To qualify for the free chargers, prospective EV buyers had to sign up for the EVSE program on the day they bought their EVs at the dealership and had to be California residents. In addition, the monthly EVSE allocation had to be open.

Monthly EVSE Allocation

In the planning phase, AV, together with the Energy Commission, determined that the most equitable distribution of EVSE throughout the program period was to allocate a predetermined number of EVSE units at the beginning of each month. This distribution also allowed the installers to avoid a backlog that would result in an unacceptably long installation schedule to the EV buyer. The program goal was to install the charging equipment within one to two weeks of signup at the dealership. With this installation schedule, a new EV driver would need only to charge with the vehicle cord set for a short period. The alternative plan was to make the entire program allocation available on a first-come, first-served basis. However, this plan would have resulted in many months of installation schedule backlog.

The monthly allocation varied from 110 in the early part of the program to 300 toward the end of the program. Each qualified signup at a dealership reduced the monthly allocation, a remaining balance of which was posted on the program website. The monthly allocation started on the first Tuesday of the month. After about 10 days, the allocation would run out for the month due to high demand. A new allocation started again on the first Tuesday of the succeeding month, until the total program allocation ran out December 31, 2013.

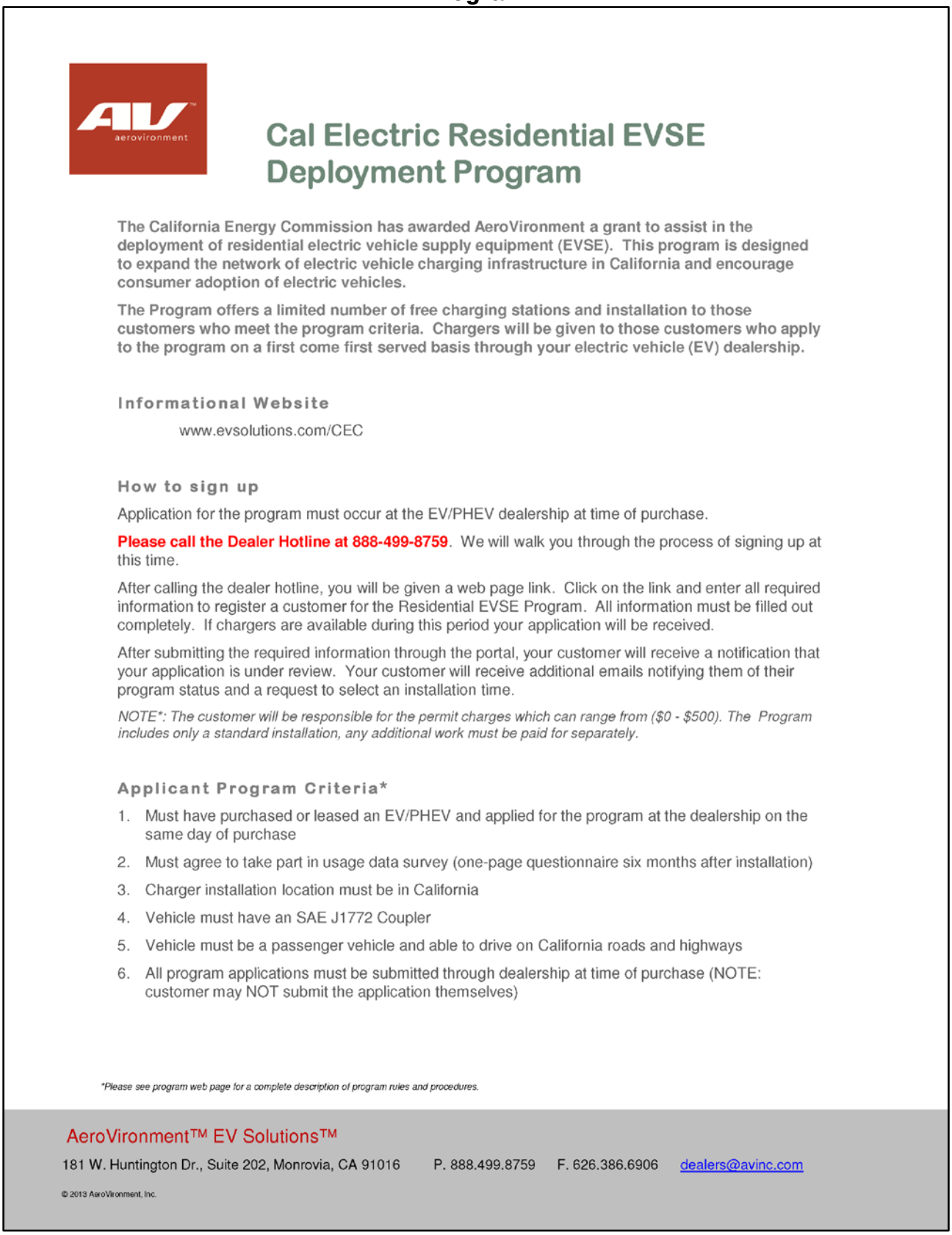
Process

After a prospective EV buyer was qualified at the dealership, buyer information was collected and passed to AV via the web portal. AV collected vehicle purchase verification, vehicle type, and number of electric vehicles planned per household. EV drivers agreed as a condition of program qualification to participate in a survey for data collection.

AV used its customer relationship management (CRM) system to simplify and track installation and reporting. This automated process provided customers with a consistent and user-friendly method to manage the entire process based on their schedule and enabled AV to complete a standard home installation as soon as five days after program signup.

Figure 3 is a sample of a program flyer used by dealerships. The CRM of the Web portal featured a dashboard that shows the region of the order process, from site assessment to final inspection as shown in Figure 4.

Figure 3: Dealership Flyer for the Cal Electric: Residential EVSE Deployment Program



Cal Electric Residential EVSE Deployment Program

The California Energy Commission has awarded AeroVironment a grant to assist in the deployment of residential electric vehicle supply equipment (EVSE). This program is designed to expand the network of electric vehicle charging infrastructure in California and encourage consumer adoption of electric vehicles.

The Program offers a limited number of free charging stations and installation to those customers who meet the program criteria. Chargers will be given to those customers who apply to the program on a first come first served basis through your electric vehicle (EV) dealership.

Informational Website

www.evsolutions.com/CEC

How to sign up

Application for the program must occur at the EV/PHEV dealership at time of purchase.

Please call the Dealer Hotline at 888-499-8759. We will walk you through the process of signing up at this time.

After calling the dealer hotline, you will be given a web page link. Click on the link and enter all required information to register a customer for the Residential EVSE Program. All information must be filled out completely. If chargers are available during this period your application will be received.

After submitting the required information through the portal, your customer will receive a notification that your application is under review. Your customer will receive additional emails notifying them of their program status and a request to select an installation time.

NOTE: The customer will be responsible for the permit charges which can range from ($0 - $500). The Program includes only a standard installation, any additional work must be paid for separately.*

Applicant Program Criteria*

1. Must have purchased or leased an EV/PHEV and applied for the program at the dealership on the same day of purchase
2. Must agree to take part in usage data survey (one-page questionnaire six months after installation)
3. Charger installation location must be in California
4. Vehicle must have an SAE J1772 Coupler
5. Vehicle must be a passenger vehicle and able to drive on California roads and highways
6. All program applications must be submitted through dealership at time of purchase (NOTE: customer may NOT submit the application themselves)

*Please see program web page for a complete description of program rules and procedures.

AeroVironment™ EV Solutions™

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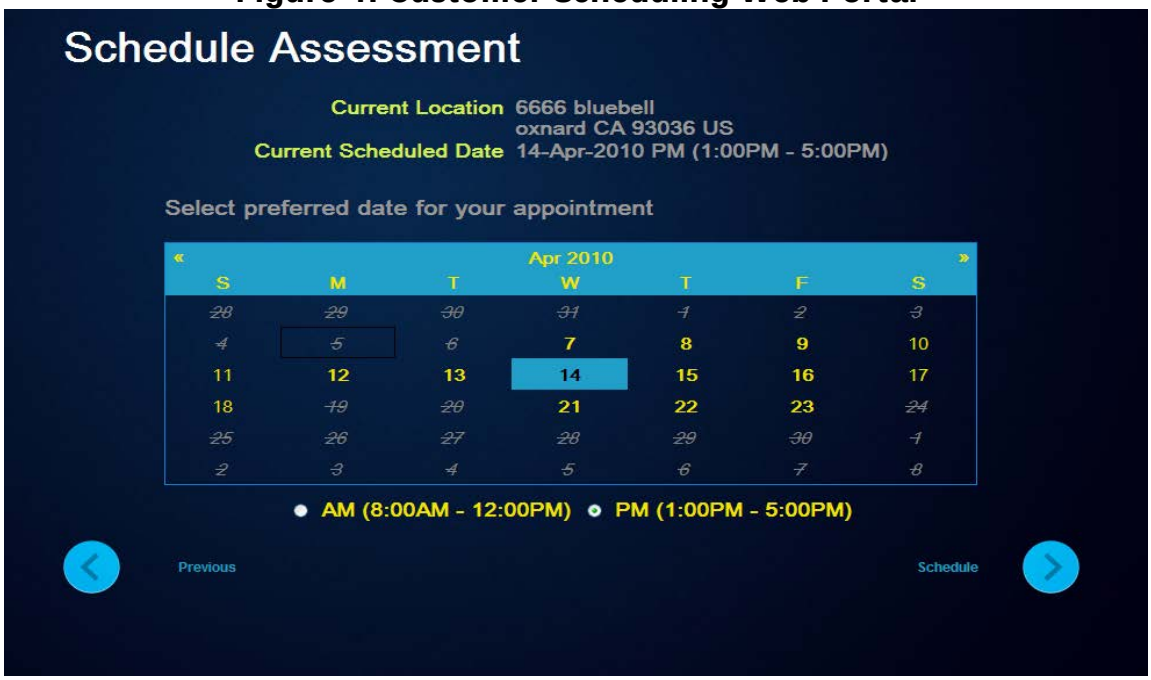
Source: AeroVironment

Figure 4: Customer Scheduling Web Portal

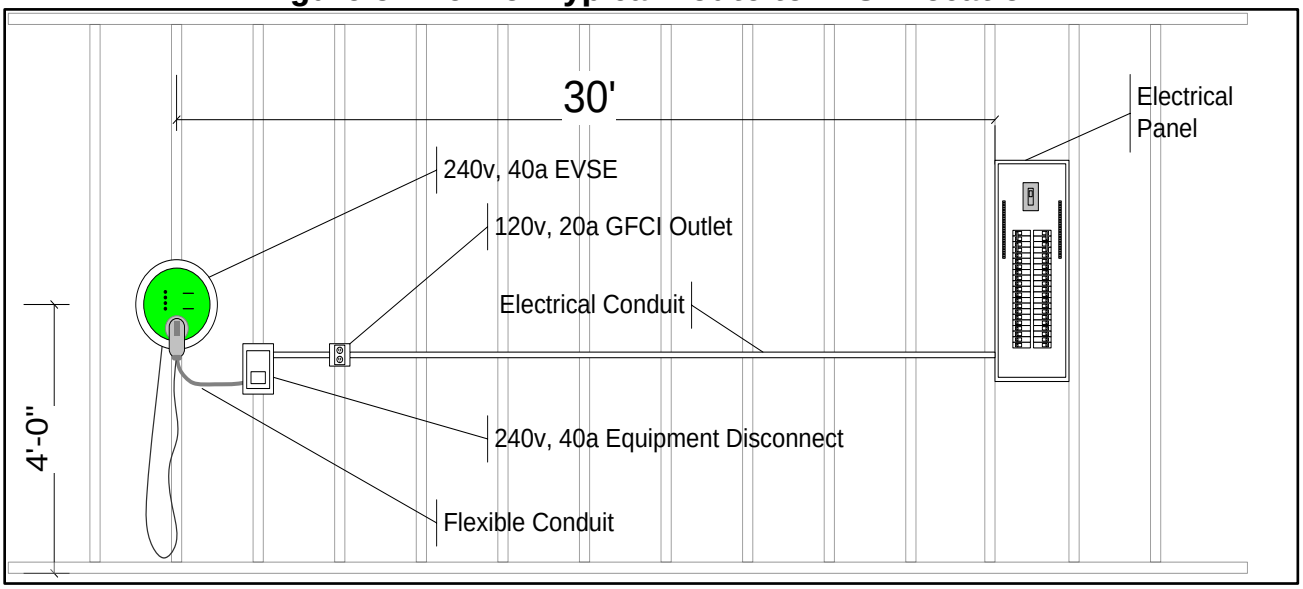


Source: AeroVironment

Installation Planning—the Standard Residential Installation

In a residential setting, an EVSE unit is typically mounted indoors or outdoors on a solid wall (that is, drywall, concrete block, brick, studs, and so forth). AV defined a standard installation as a 30 linear feet electrical run from the electrical panel to the EVSE location, as shown in Figure 5. The panel had to have sufficient space and capacity for the additional 40 ampere (A) circuit breaker and load (typically 200A). Wire runs could be installed through the attic, crawlspace, or exterior and surface-mount conduits.

Figure 5: View of Typical Route to EVSE Location



Source: AeroVironment

Not all EV buyers fell into the standard installation definition. These customers were still eligible for the program but paid AV's contractors the incremental expenses not covered by the standard installation.

Permit costs were not eligible for reimbursement as set by Energy Commission program requirements. Thus, the EV buyers paid for local permits. Amounts varied by jurisdiction from $0 to $400.

According to the program plan:

- EV buyers signed up on the same day (monthly allocation permitting) with the auto dealership where they purchased the EV.
- They scheduled their installation.
- AV's electrical contractor installed the EVSE within one to two weeks.
- The local inspector signed off.
- The EV buyer signed off, completing the process.

CHAPTER 2: Project Implementation

AV began EVSE installations in June 2013 and completed 1,758 installations by August 2014 following the process listed in Chapter 1. Figure 6 shows representative pictures of home EVSE installations performed under this project.

Figure 6: Residential EVSE Pictures

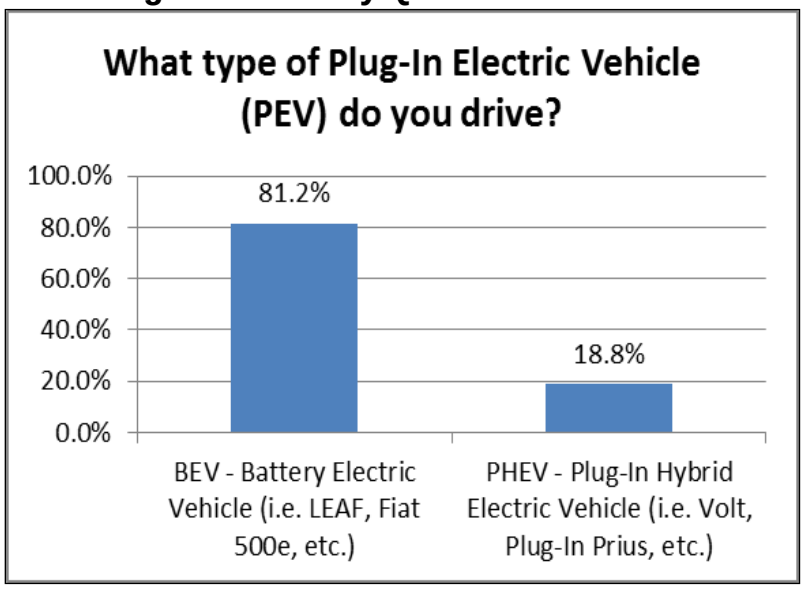
Source: AeroVironment

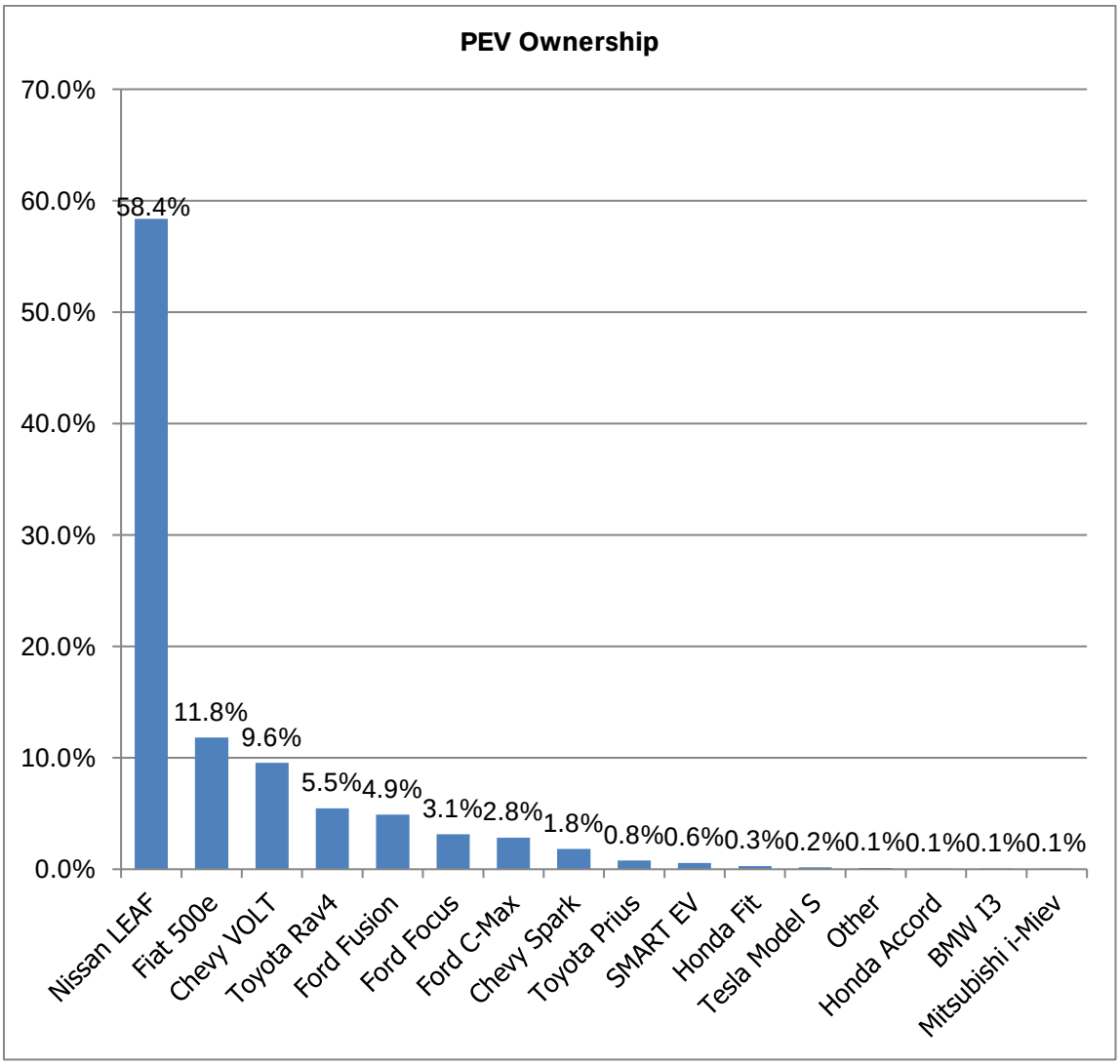
Data Gathering

As part of the program eligibility requirement, EV drivers agreed to participate in an online survey six months after installation of their EVSE. The section lists the results of this survey. Out of 1,758 survey queries sent, 1,580 responded, a response rate of 90 percent. This subsection presents the survey questions and results.

1. Do you drive an electric-only vehicle or a plug-in hybrid vehicle?
    a. BEV—Battery Electric Vehicle (i.e. LEAF, Fiat 500e, etc.)
    b. PHEV—Plug-In Hybrid Electric Vehicle (i.e. Volt, Plug-In Prius, etc.)

Figure 7: Survey Question 1 Results

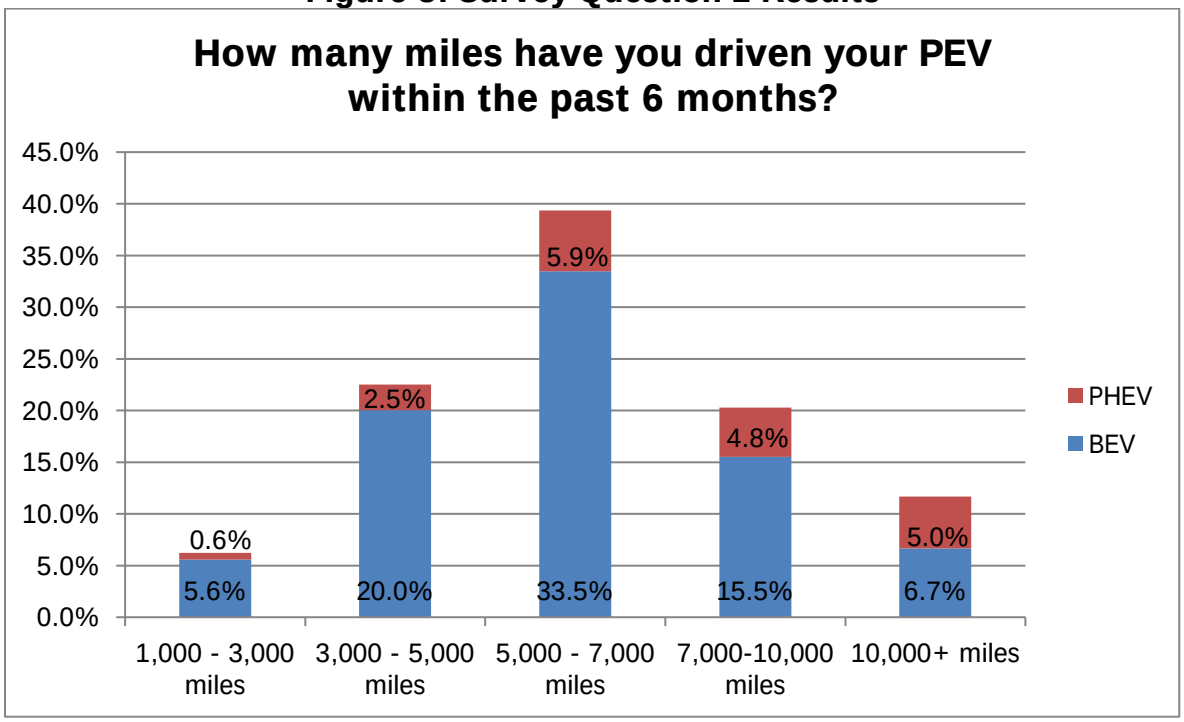




Source: AeroVironment

2. How many miles have you driven your PEV within the past 6 months?
    a. 1,000–3,000 miles
    b. 3,000–5,000 miles
    c. 5,000–7,000 miles
    d. 7,000–10,000 miles
    e. 10,000+ miles

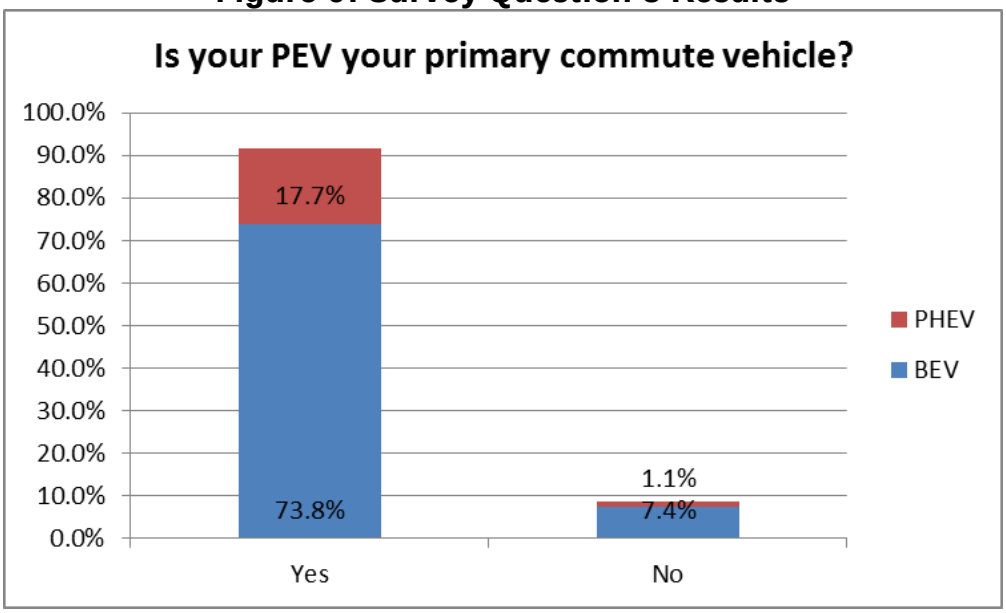
Figure 8: Survey Question 2 Results



Source: AeroVironment

3. Is your PEV your primary commute vehicle?
    a. Yes
    b. No

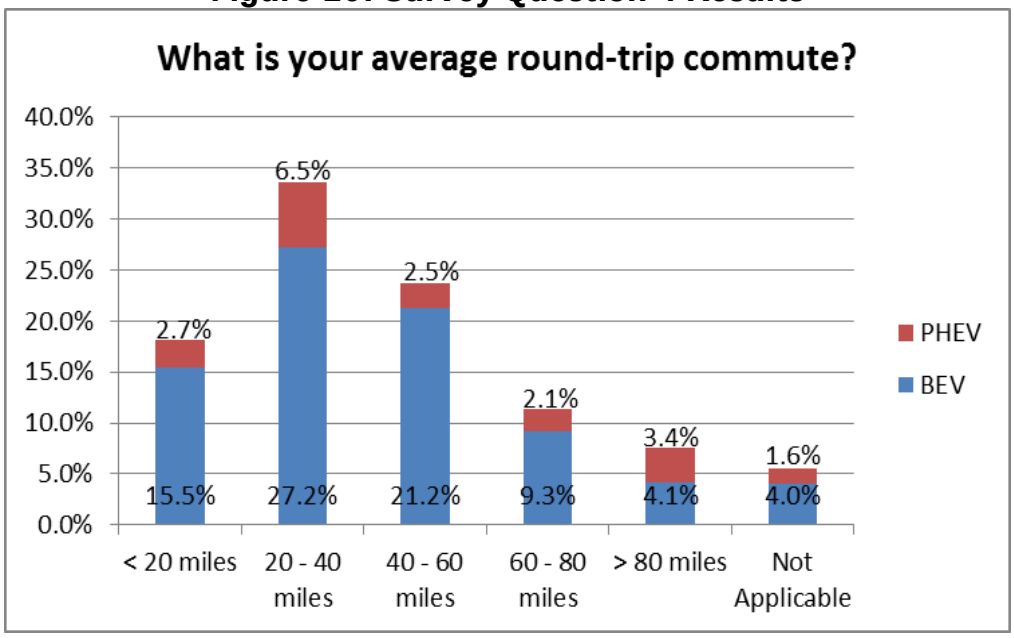
Figure 9: Survey Question 3 Results



Source: AeroVironment

4. What is your average round-trip commute?
    a. <20 miles
    b. 20-40 miles
    c. 40-60 miles
    d. 60-89 miles
    e. >80 miles
    f. Not Applicable

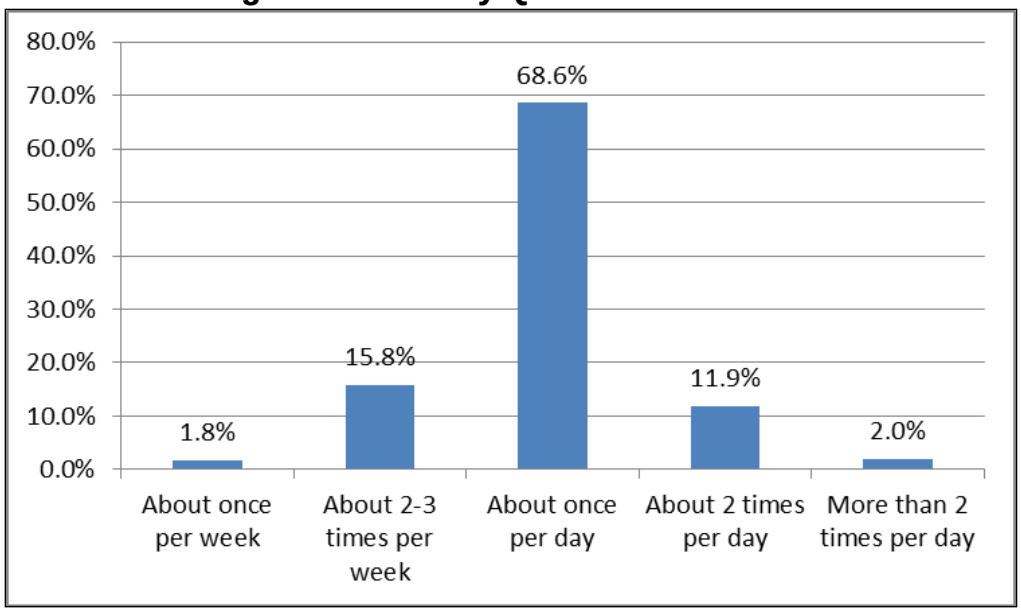
Figure 10: Survey Question 4 Results



Source: AeroVironment

5. How often do you plug in your vehicle to charge?
    a. About once per week
    b. About 2-3 times per week
    c. About once per day
    d. About 2 times per day
    e. More than 2 times per day

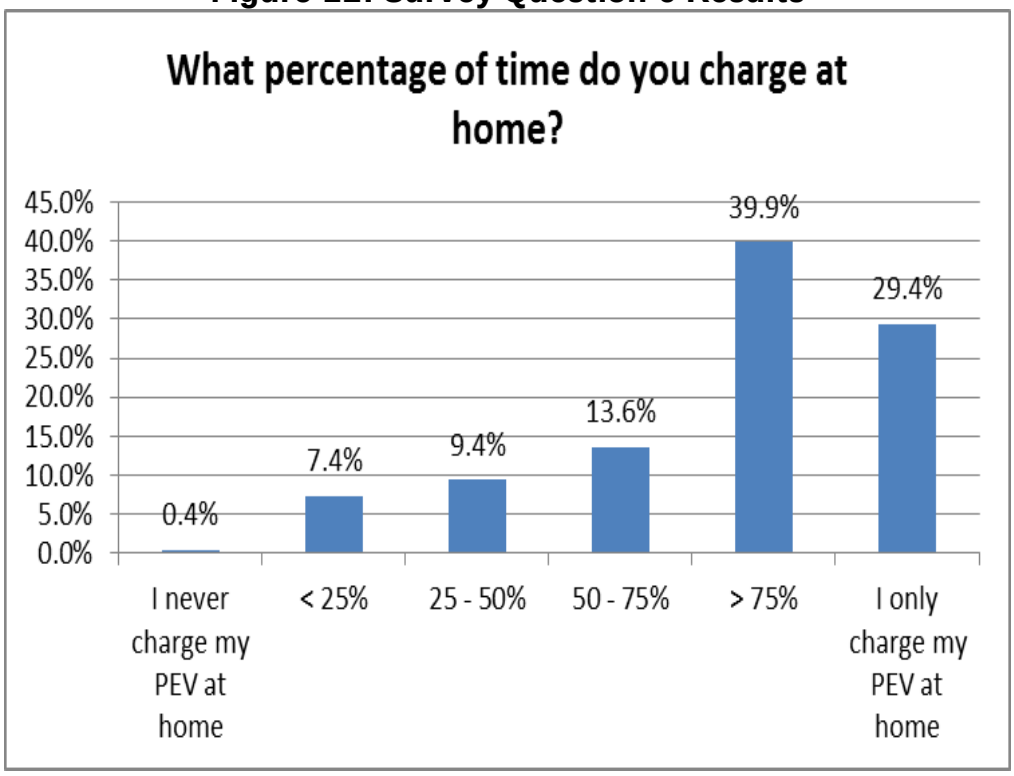
Figure 11: Survey Question 5 Results



Source: AeroVironment

6. What percentage of the time do you charge at home?
    a. I never charge my PEV at home
    b. < 25%
    c. 25-50%
    d. 50-75%
    e. > 75%
    f. I only charge my PEV at home

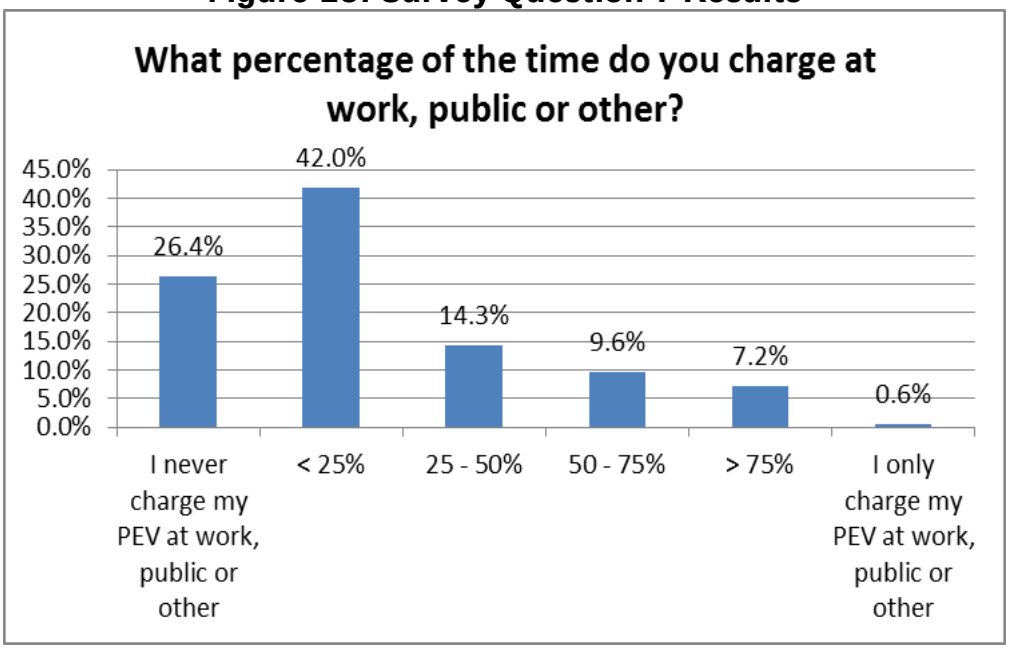
Figure 12: Survey Question 6 Results



Source: AeroVironment

7. What percentage of the time do you charge at work, public, or other?
    a. I never charge my PEV at work, public, or other
    b. < 25%
    c. 25-50%
    d. 50-75%
    e. > 75%
    f. I only charge my PEV at work, public, or other.

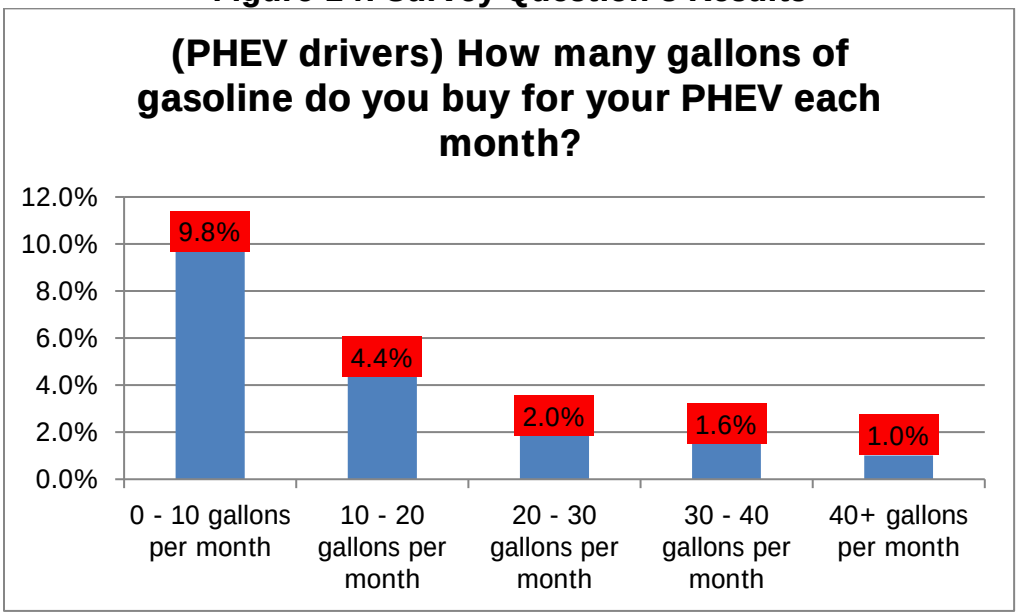
Figure 13: Survey Question 7 Results



Source: AeroVironment

8. (PHEV drivers) How many gallons of gasoline do you buy for your PHEV each month?
    a. 0-10 gallons/month
    b. 10-20 gallons/month
    c. 20-30 gallons/month
    d. 30-40 gallons/month
    e. 40+ gallons/month

Figure 14: Survey Question 8 Results

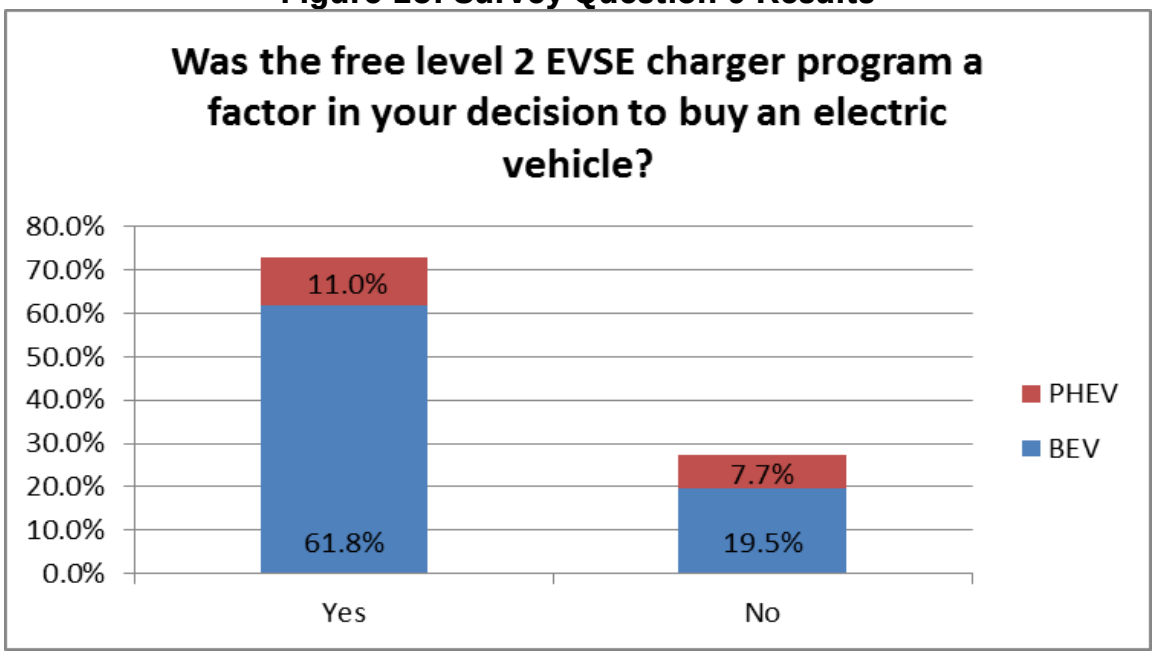


Source: AeroVironment

The 18.8 total percentage in Figure 14 is for PHEV drivers only. BEV drivers accounted for the other 81 percent.

9. Was the free Level 2 EVSE charger program a factor in your decision to buy an electric vehicle?
    a. Yes
    b. No

Figure 15: Survey Question 9 Results



Source: AeroVironment

The results from Question 9 show that overall 72 percent of project drivers were motivated to purchase EVs by the CEC free charger program. The breakdown between BEV and PHEV drivers is also of interest. Only 59 percent of PHEV drivers were influenced by the CEC free charger program in their PHEV purchase. In contrast, 76 percent of BEV drivers said the CEC program positively influenced their BEV purchase. This difference might be expected considering BEVs have larger batteries, which means the BEV drivers would find a Level 2 EVSE more essential than a PHEV driver who might be satisfied with just plugging in to a 120 volt (V) outlet overnight.

Number of Residential Vehicles Fueled

A total of 1,758 residential EVSE installed under this program service the same number (or more) of home EVs.

Number of Days Vehicles were Fueled

EVs typically charge daily.

Number of Charging

Based on survey results in Section 2.3, the number of annual charge events resulting from this project is about 670,000.

Maximum Capacity of the New Fueling System

The EVSE installed under this project were rated at 30A 208/240 volts alternating current (V_{AC}). The maximum capacity at 240 V_{AC} is 7.2 kilowatts (kW).

Gallons of Gasoline Displaced

According to survey results, the 1,758 PEVs in this program will travel roughly 22,473,000 miles annually. According to fueleconomy.gov[1], this number will result in annually displacing approximately 817,200 gallons of regular gasoline (when comparing a 2013 Nissan Leaf to a 2013 Chevrolet Impala using regular unleaded fuel).

Emissions Reductions

Emissions reductions, as with gasoline displaced, were based on 22,473,000 annual PEV miles traveled. The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model was used to calculate greenhouse gas, non-methane hydrocarbons, oxides of nitrogen, non-methane hydrocarbons plus oxides of nitrogen, particulates, and formaldehyde.

The GREET software was developed by Argonne National Laboratory. This analysis used the GREET version 1-2014 using standard inputs for California grid mix and California reformulated gasoline.

Emissions Reductions Results

- Greenhouse gas (GHG)–5,000 metric tons
- Nonmethane hydrocarbons (VOCs)–6.0 metric tons
- Oxides of nitrogen (NO_x)–4.1 metric tons
- Nonmethane hydrocarbons plus oxides of nitrogen (VOCs and NO_x–10.1 metric tons
- Particulates (PM_{10} + $PM_{2.5}$)–0.52 metric ton
- Formaldehyde–0.81 metric tons

[1] Fuel economy website https://www.fueleconomy.gov/

Table 1: GREET 1-2014 Emission Factors

	Electric Vehicle				ICE Vehicle, Cal. Gasoline			
	g/mile				g/mile			
Item	Feedstock	Fuel	Vehicle Operation	Total	Feedstock	Fuel	Vehicle Operation	Total
Total Energy	172	1,224	1,330	2,726	127	935	3,932	4,995
Fossil Fuels	169	948	1,030	2,147	121	854	3,670	4,645
Coal	2	126	136	264	3	19	0	22
Natural Gas	154	822	893	1,870	75	625	0	700
Petroleum	13	1	1	14	43	210	3,670	3,923
Water Consumption	0.01	1.18	0.00	1.20	0.07	0.19	0.00	0.25
CO2 (w/ C in VOC & CO)	11	130	0	141	-12	61	302	350
CH4	0.312	0.011	0.000	0.323	0.319	0.234	0.011	0.563
N2O	0.001	0.001	0.000	0.002	0.000	0.015	0.007	0.022
GHGs	21	131	0	152	-2	72	304	373
VOC: Total	0.017	0.005	0.000	0.022	0.012	0.108	0.170	0.290
CO: Total	0.042	0.060	0.000	0.102	0.026	0.072	2.866	2.963
NOx: Total	0.057	0.090	0.000	0.147	0.092	0.118	0.121	0.331
PM10: Total	0.003	0.011	0.018	0.032	0.006	0.013	0.026	0.044
PM2.5: Total	0.001	0.008	0.005	0.014	0.006	0.008	0.012	0.025
SOx: Total	0.022	0.088	0.000	0.110	0.045	0.105	0.005	0.154
BC Total	0.008	0.009	0.001	0.018	0.008	0.007	0.002	0.017
OC Total	0.000	0.002	0.001	0.003	0.002	0.002	0.006	0.010

Source: Argonne National Laboratory

Sample Calculation

1,000 miles of EV travel equates to 152g/mi x 1000 miles = 0.152 metric tons

1,000 miles of ICE (internal combustion engine) travel equates to 373g/mi x 1000 = 0.373 metric tons

GHG reduction = 0.373-0.152 = 0.221 metric tons/1,000 miles

Formaldehyde Calculation

The GREET model does not list formaldehyde emissions. However, formaldehyde emissions were estimated using a factor of 20 percent of nonmethane organic gases (NMOG or VOC) from the following study to calculate ICE vehicle portion:

Brinkman, Norman, Michael Wang, Trudy Weber, and Thomas Darlington. May 2005. *Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems—A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions.* Argonne National Laboratory.

Formaldehyde for the EV portion is a subset of VOC. However, this is a small number relative to the ICE vehicle emissions. Thus, the VOC emissions were assumed to represent formaldehyde emissions.

Formaldehyde = 0.29 x 0.2 (ICE) – 0.022 = 0.036g/mi

Duty Cycle

Residential EVs typically charge daily.

Jobs and Economic Development

EV and EVSE manufacturing creates jobs. The installations have, at the minimum, provided temporary jobs and contributed to increasing revenues for companies engaged in the manufacture and installations of EVSE.

This project resulted in $1,399,510 or 38 percent of grant funding, to be paid to 28 in-state electrical contractors. These contractors are all small businesses.

Electrification of personal transportation can push job creation in a host of industries. More efficient cars require more sophisticated technology, which are designed and produced by adding workers to the auto industry. Many of these jobs would be in industrial sectors closely tied to auto manufacturing, advanced batteries, and research and development.

In the long run, drivers who switch to electric vehicles will have more disposable income to spend for housing, entertainment, and other services. This increased spending in other sectors will stimulate the economy and enhance job creation.

Electric vehicles at homes are generally charging late in the evening, overnight, and in the early morning, when there is excess generation capacity in the grid. A major portion of energy generated during this period comes from renewable sources, such as wind. This use of renewable resources allows utilities to forego the use of power plants that are needed only to satisfy peak demand. Operating costs, and therefore utility rates, are reduced.

Renewable Energy at the Facility

Many homes where the chargers were installed have rooftop solar arrays. The project did not track these data.

Source of the Alternative Fuel

California electrical utilities provided the electrical power for the charging stations. Based on 2013 data from the U.S. Energy Information Administration, in California, 60 percent of electricity generated comes from natural gas, 12 percent from hydroelectric, and 9 percent from nuclear. Wind and geothermal each account for 7 percent. Biomass and solar represent 3 percent and 2 percent, respectively.

Energy Efficiency Measures

Although, the project did not track energy efficiency measures at the homes, California EV owners are now benefitting from rate plans to help them manage their EV energy costs. PG&E for example, offers two EV rate plans. The first option incorporates EV charging costs in the total household electric bill. The second option has the in-home charging station on a separate meter to keep EV charging costs separate from the rest of the home. The price per kilowatt-hour (kWh) is based only on the time of day electricity is used—peak, partial-peak and off-peak.

CHAPTER 3: Assessment of Project Success

Electric vehicles produce less tailpipe emissions per mile than conventional vehicles, even taking into account power-plant emissions. These vehicles contribute to a cleaner commute and lower carbon footprint. Plug-in electric cars are more efficient and require less energy to run than internal combustion engine vehicles.

Electric vehicles contribute to energy independence. Most of the resources used to power the grid are locally sourced, with nearly 20 percent of the power generated from renewable energy sources like wind and solar. When an EV driver fuels his or her vehicle, the driver is purchasing 100 percent American-made energy instead of the imported oil that powers most conventional vehicles today.

Electric cars lower household fuel expenses compared to gasoline. On average, electricity costs 25 to 50 percent the cost of a gasoline gallon equivalent. The household may save more by choosing an electric vehicle rate plan that gives lower rates for charging at night, when the costs of electricity are lower.

AeroVironment was initially awarded $2 million to supply and install 770 units of EVSE at homes across California. The Energy Commission increased AeroVironment's grant by $1,707,850 to bring the total funding to $3,707,850 to install 1,425 units of EVSE. Working with 290 California vehicle dealerships to identify and qualify prospective EV buyers, AeroVironment and its 28 electrical subcontractors installed 1,758 units of EVSE, or 23 percent more than required by the grant.

AeroVironment gathered project data from its customer web portal, from the vehicle dealerships, and via surveys sent to EVSE customers six months after EVSE installation. Survey response was more than 90 percent. Seventy-two percent of respondents said that the free EVSE was a factor in their decision to purchase an electric vehicle. The split between BEV and PHEV drivers positively influenced was 76 percent versus 59 percent, respectively.

This project will contribute to displacing an estimated 817,200 gallons of gasoline and reduced GHG emissions by 5,000 metric tons annually.

CHAPTER 4: Conclusions and Recommendations

Conclusions

This project has achieved the goal of promoting the adoption of battery-electric vehicles by expanding Level 2 charging in the residential sector. It has contributed to the electrification of the transportation sector, reduced GHG emissions by an average of 5,000 metric tons annually, and displaced 817,200 gallons per year of gasoline. The 22,473,000 total miles traveled by the EV drivers who participated in this program, or an average of about 12,780 miles traveled per driver, is more than the oft-stated national average of 12,000 miles per year for all passenger vehicles. This number is significant because it demonstrates that EV drivers consider their vehicles as their primary mode of transportation and not just a secondary option to an internal combustion engine vehicle. The project also contributed to job creation with 38 percent of grant funds going to 28 electrical contractors, which are all small businesses.

Recommendations

This project achieved and even exceeded the related goals. A primary project objective was to promote electric vehicle adoption by making Level 2 charging available in the homes of EV buyers and making procuring and installing a Level 2 EVSE seamless and convenient. Additional funding for similar incentive programs is highly recommended.

GLOSSARY

AEROVIRONMENT, INC. (AV) is an American technology company in Monrovia (Los Angeles County) and Simi Valley (Ventura County) that is involved primarily in energy systems, electric vehicle systems, and unmanned aerial vehicles.

ALTERNATIVE AND RENEWABLE FUELS AND VEHICLE TECHNOLOGY PROGRAM (ARFVTP)—Created by Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007), the program with an annual budget of about $100 million supports projects that develop and improve alternative and renewable low-carbon fuels, improve alternative and renewable fuels for existing and developing engine technologies, expand transit and transportation infrastructures, establish workforce training programs, conduct public education and promotion, and create technology centers, among other tasks.

BATTERY-ELECTRIC VEHICLE (BEV)—A battery-electric vehicle, pure electric vehicle, only-electric vehicle, or all-electric vehicle is a type of electric vehicle that uses chemical energy stored in rechargeable battery packs. BEVs use electric motors and motor controllers instead of internal combustion engines for propulsion.

CUSTOMER RELATIONSHIP MANAGEMENT (CRM)—Refers to all strategies, techniques, tools, and technologies used by enterprises for developing, retaining, and acquiring customers.

ELECTRIC VEHICLES (EV)—Vehicles that derive all or part of the related power from electricity supplied by the electric grid. They include all-electric vehicles and plug–in electric vehicles.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)—Also called EV charging station, is an element in an infrastructure that supplies electric energy for the recharging of plug-in electric vehicles.

GREENHOUSE GASES (GHG)—any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halogenated fluorocarbons (HCFCs), ozone (O_3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

GREENHOUSE GASES, REGULATED EMISSIONS, AND ENERGY USE IN TRANSPORTATION (GREET) is a full life-cycle model sponsored by the Argonne National Laboratory (U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy). It fully evaluates energy and emission impacts of advanced and new transportation fuels, the fuel cycle from the well to the wheel and the vehicle cycle through material recovery and vehicle disposal need to be considered. It allows researchers and analysts to evaluate various vehicle and fuel combinations on a full fuel-cycle/vehicle-cycle basis.

HYDROCHLOROFLUOROCARBONS (HCFC) **-** Compounds containing hydrogen, fluorine, chlorine, and carbon atoms. Although ozone depleting substances, they are less potent at destroying stratospheric ozone than chlorofluorocarbons (CFCs). They have been introduced as temporary replacements for CFCs and are also greenhouse gases.

HYDROFLUOROCARBONS (HFCs) - compounds containing only hydrogen, fluorine, and carbon atoms. They were introduced as alternatives to ozone depleting substances in serving many

industrial, commercial, and personal needs. HFCs are emitted as by-products of industrial processes and are also used in manufacturing. They do not deplete the stratospheric ozone layer, but they are greenhouse gases

INTERNAL COMBUSTION ENGINE (ICE)—the ignition and combustion of the fuel occurs within the engine itself. The engine then partially converts the energy from the combustion to work.

METRIC TON - a unit of mass equal to 1000 kilograms.

PARTICULATE MATTER (PM) - Unburned fuel particles that form smoke or soot and stick to lung tissue when inhaled. A chief component of exhaust emissions from heavy-duty diesel engines.

PLUG-IN ELECTRIC VEHICLE (PEV) is a general term for any car that runs at least partially on battery power and is recharged from the electricity grid. There are two different types of PEVs to choose from—pure battery-electric and plug-in hybrid vehicles.

PLUG-IN HYBRID ELECTRIC VEHICLE (PHEV)—PHEVs are powered by an internal combustion engine and an electric motor that uses energy stored in a battery. The vehicle can be plugged into an electric power source to charge the battery. Some can travel nearly 100 miles on electricity alone, and all can operate solely on gasoline (similar to a conventional hybrid).