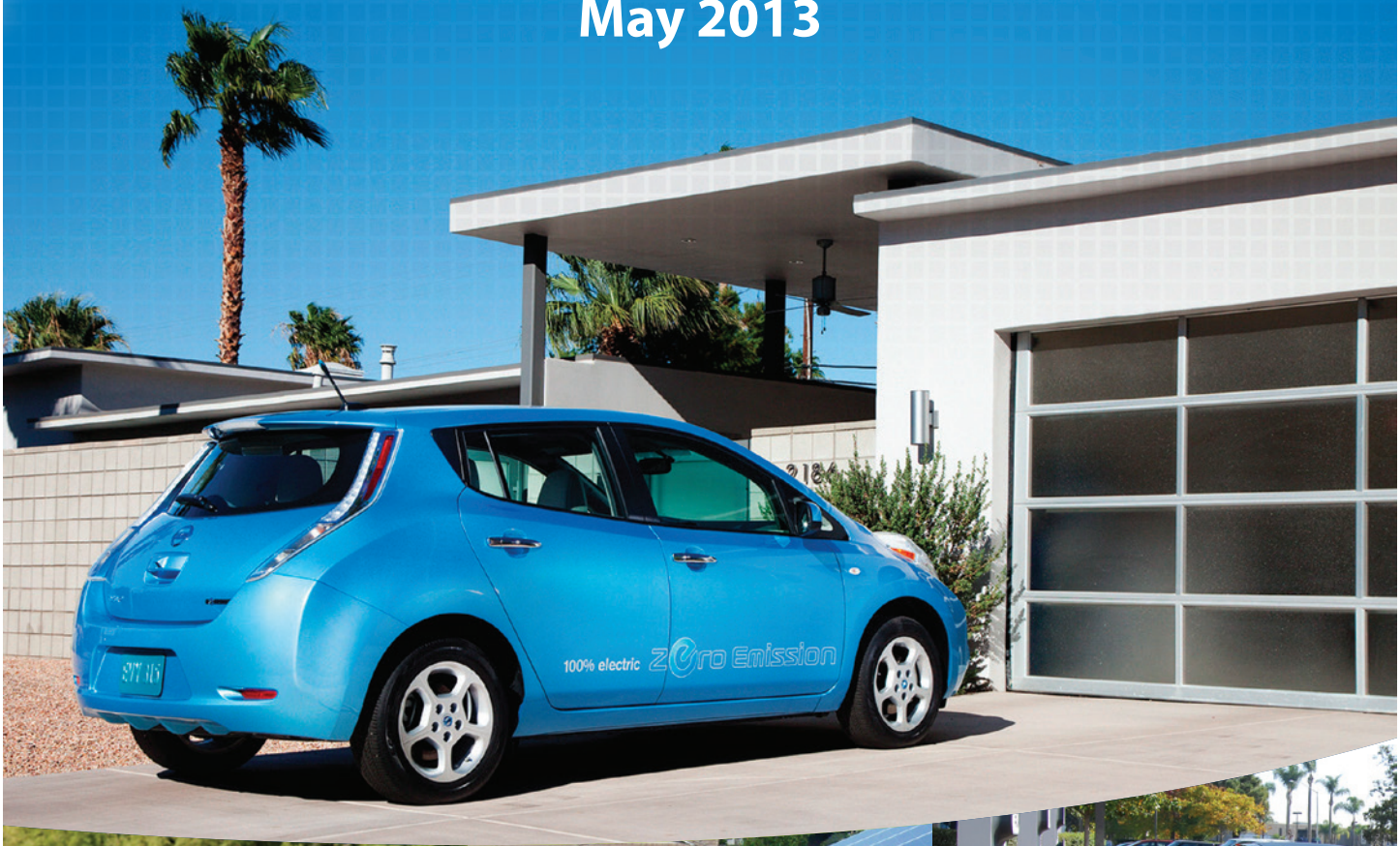
Center for Sustainable Energy® CALIFORNIA

California Environmental Protection Agency
Air Resources Board

California Plug-in Electric Vehicle Driver Survey Results May 2013



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Report Chronology

Round 1 — Issued July 2012
Round 2 — Issued May 2013

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This report was prepared by the California Center for Sustainable Energy (CCSE) as a result of work sponsored by the California Air Resources Board (ARB) through the Clean Vehicle Rebate Project (CVRP). It is available online at **www.energycenter.org/cvrp**.

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OVERVIEW

Roughly 1 of every 40 new cars bought or leased in California during the last three months of 2012 was a plug-in electric vehicle.

The U.S. plug-in electric vehicle market experienced remarkable growth in 2012, with sales tripling that of 2011. This rapid expansion was driven in large part by California, which had more than 22,000 plug-in vehicles (roughly 35% of the U.S. market) on its roads by the end of 2012. This strong market growth was highlighted by the fact that roughly one of every 40 new cars bought or leased in California during the last three months of 2012 was a plug-in electric vehicle. As a result, Californians are now driving more than 15 million electric-fueled miles every month.

The growth in consumer adoption of plug-in electric vehicles in California is supported by the Clean Vehicle Rebate Project (**www.energycenter.org/cvrp**), a consumer incentive program that offers up to $2,500 for the purchase of eligible vehicles. Funded by the California Air Resources Board (ARB), the Clean Vehicle Rebate Project is administered by the nonprofit California Center for Sustainable Energy (CCSE). Since its launch in March 2010, the program has issued over 22,000 rebates and educated more than 100,000 Californians on the availability and benefits of plug-in electric and other clean vehicle technologies.

In an effort to better understand the dynamics of California's growing plug-in electric vehicle market, CCSE, in coordination with ARB, is conducting a longitudinal study of vehicle owners that explores vehicle satisfaction, driving behavior, use of charging infrastructure, motivations for vehicle purchase and household demographics. Since early 2012, CCSE has collected information from 2,039 individual California plug-in vehicle owners and drivers. Overall, these surveys represent the largest and most detailed surveys of plug-in electric vehicle drivers in the nation.

The results of the statewide survey confirm high levels of satisfaction with plug-in vehicles, but also identify significant challenges to broader consumer adoption of the technology. Highlights from the latest survey include:

- The CVRP was identified by 95% of survey respondents as an important motivating factor in their purchase decision.
- 92% of survey respondents reported overall satisfaction with their vehicle purchase and drive their plug-in vehicles an average of 910 miles per month.
- Driver satisfaction with public charging infrastructure remains low, but is improving. Between February and October 2012, satisfaction increased from 17% to 23%.
- 37% of survey respondents reported having access to workplace charging; however, 66% reported using it less than once per week when usage fees were charged.
- Two-thirds of respondents reported a willingness to pay up to $1.00 per hour for occasional public charging, but less than one-third were willing to pay $1.50 per hour.
- Only 16% of respondents reported a willingness to pay up to $1.25 per hour for daily vehicle charging outside the home, but 43% were willing to pay $1.00.
- Although an overwhelming majority of respondents expressed overall satisfaction with their vehicles, 40% were dissatisfied with their electric range and 57% indicated that a range of 150 miles or more would be needed for extreme satisfaction.

Who Are California's Plug-in Electric Vehicle Owners?

Clean Vehicle Rebate Project

Survey population

(PEV owners for 6 months or longer as of March 1, 2012)

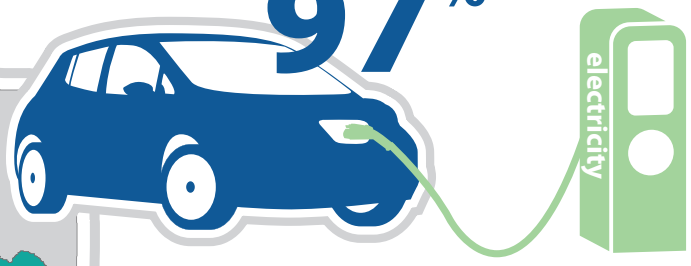
4,329

Survey unique respondents

2,039

California's Plug-in Electric Vehicles (PEVs)

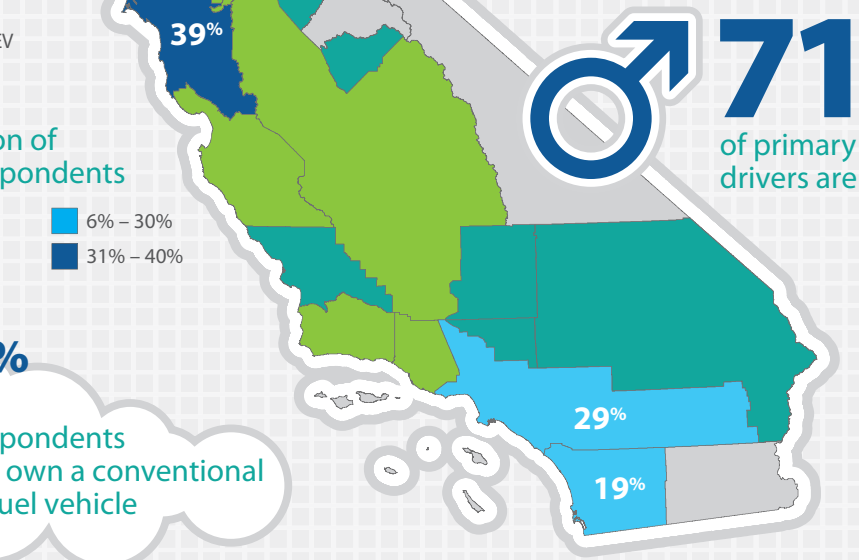
As of March 2013, Californians owned or leased more than 30,000 PEVs, or approximately one out of every three PEVs in the nation. The CVRP issued rebate checks to more than 20,000 of these California vehicle drivers, including 10,750 rebates for battery electric vehicles (BEVs) and 10,250 rebates for plug-in hybrid electric vehicles (PHEVs). Second round survey respondents were exclusively BEV drivers; subsequent survey rounds will include BEV and PHEV drivers.



97%

Percentage of survey respondents who are Nissan Leaf owners

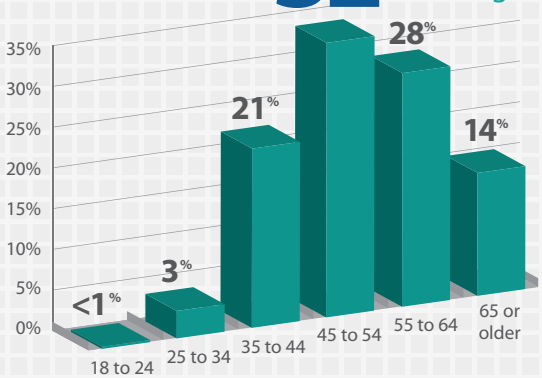
Distribution of survey respondents



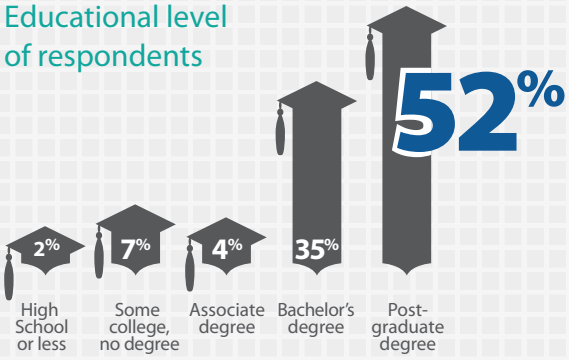
71% of primary PEV drivers are male

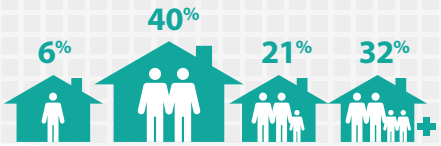
94% of respondents also own a conventional fuel vehicle

32% of respondents are age 45 to 54



Educational level of respondents





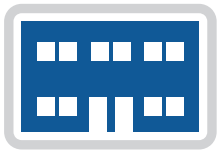
94% of respondents reside in households of two people or more

96% of respondents own their home

90% reside in a single-family detached home

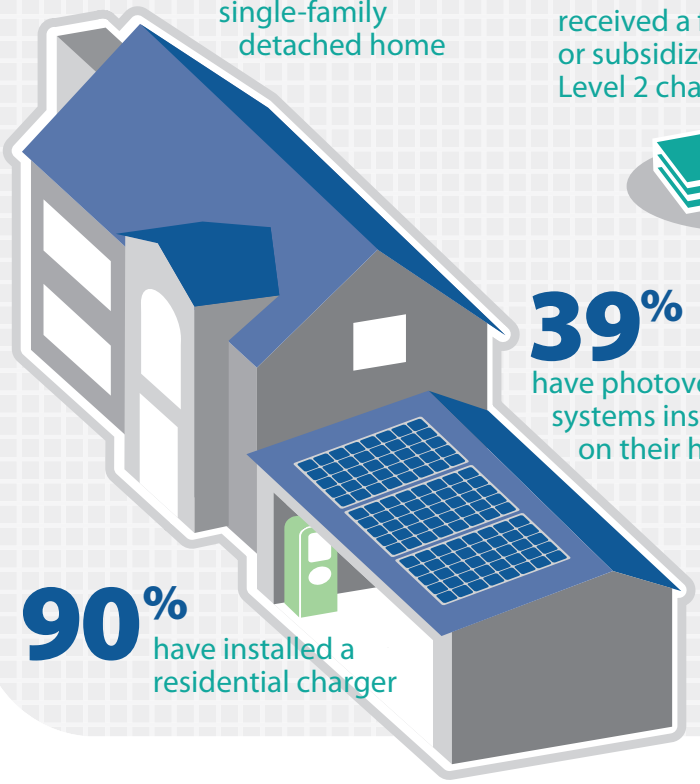
56% received a free or subsidized Level 2 charger

6% reside in a single-family attached home (townhome, duplex, triplex, etc.)



3% reside in an apartment/condominium

1% reside in other dwellings

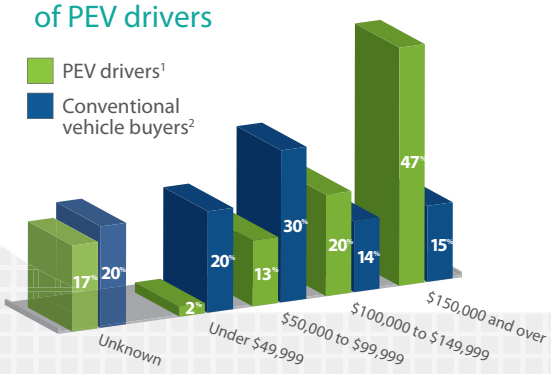


39% have photovoltaic systems installed on their home

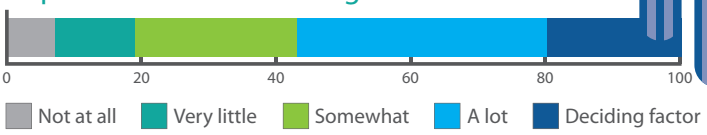
90% have installed a residential charger

71% of respondents park their vehicle in a garage

Household income of PEV drivers



Importance of subsidy for decision to purchase a Level 2 charger



[1] Reported household income for PEV survey respondents CY 2012.

[2] Household income based on California new personal car registrations Jan–Nov 2012 (Source: Polk Inc.)

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CLEAN VEHICLE REBATE PROJECT℠

Source: Survey conducted October 2012 by the California Center for Sustainable Energy
www.energycenter.org

What Drives California's Plug-in Electric Vehicle Owners?

Clean Vehicle Rebate Project

Survey population

(PEV owners for 6 months or longer as of March 1, 2012)

4,329

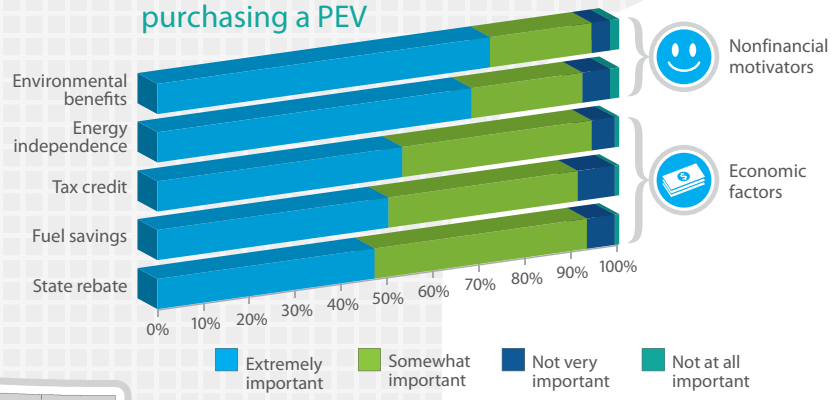
Round 2 respondents

1,202

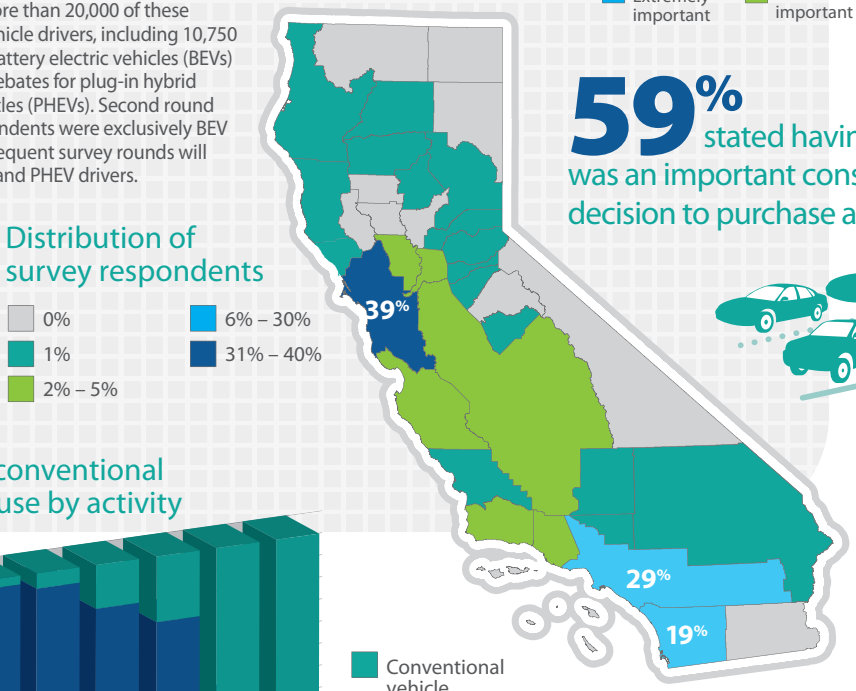
California's Plug-in Electric Vehicles (PEVs)

As of March 2013, Californians owned or leased more than 30,000 PEVs, or approximately one out of every three PEVs in the nation. The CVRP issued rebate checks to more than 20,000 of these California vehicle drivers, including 10,750 rebates for battery electric vehicles (BEVs) and 10,250 rebates for plug-in hybrid electric vehicles (PHEVs). Second round survey respondents were exclusively BEV drivers; subsequent survey rounds will include BEV and PHEV drivers.

Motivation for purchasing a PEV



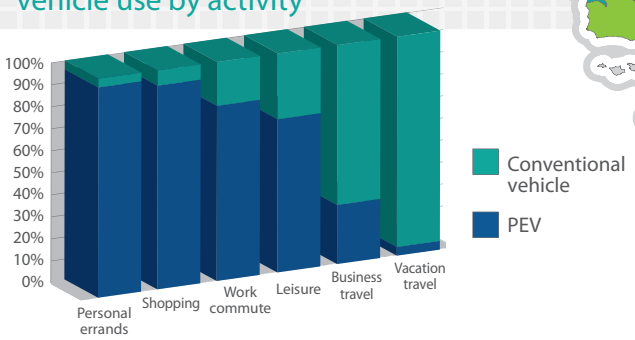
Distribution of survey respondents



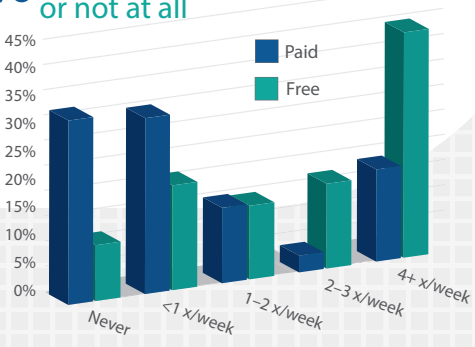
59% stated having HOV lane access was an important consideration in their decision to purchase a PEV

74% of survey respondents display an HOV sticker on their PEV

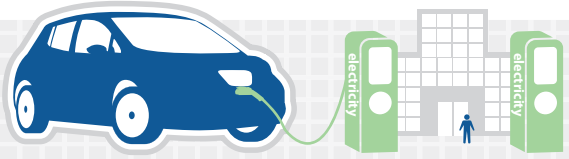
PEV vs. conventional vehicle use by activity



66% For those who pay to charge at work, charge less than once a week or not at all



37% of survey respondents had access to workplace charging

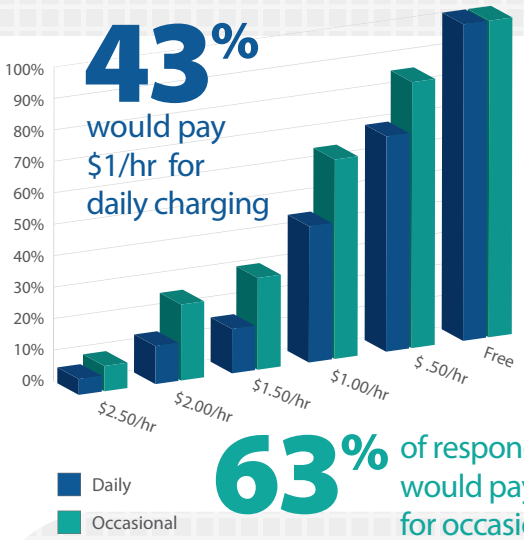


Of those who reported having workplace charging

82% had access to it for free

Willingness to pay for Level 2 charging

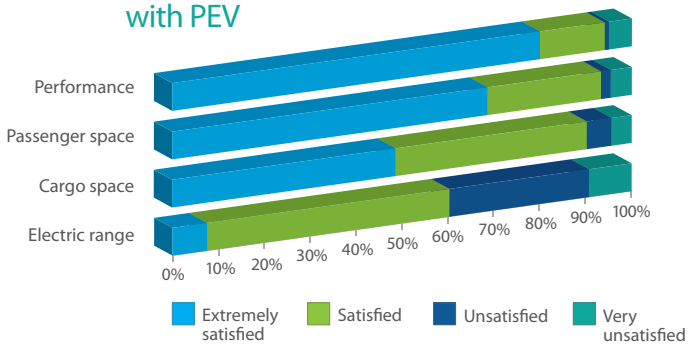
43% would pay $1/hr for daily charging



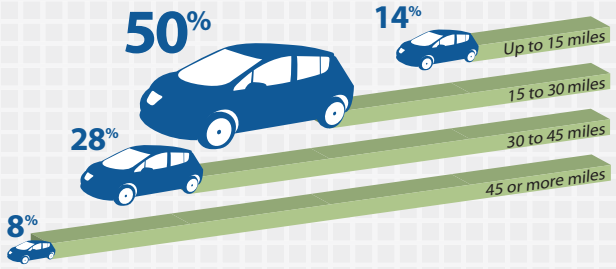
63% of respondents would pay $1/hr for occasional charging

92% expressed overall satisfaction with their PEV

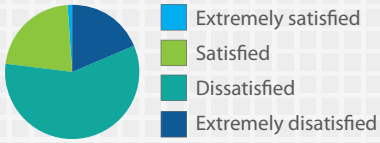
Satisfaction with PEV



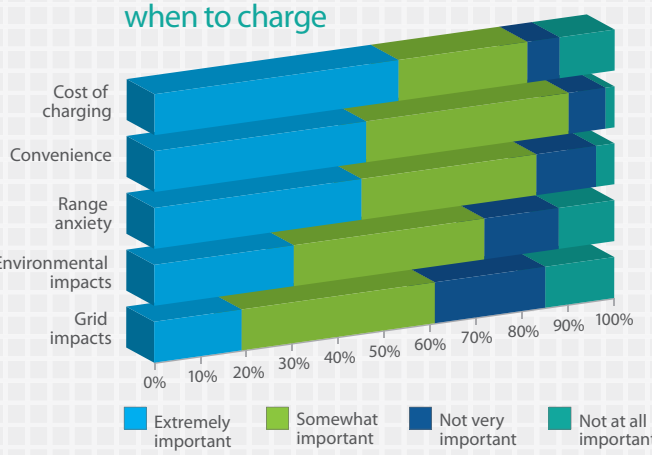
Average miles driven per day



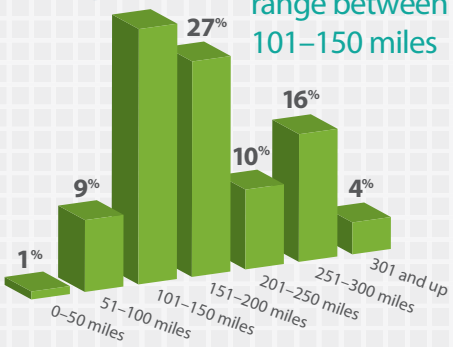
77% expressed varying levels of dissatisfaction with public charging infrastructure



Factors determining when to charge



32% of respondents desired an electric range between 101–150 miles



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Source: Survey conducted October 2012 by the California Center for Sustainable Energy
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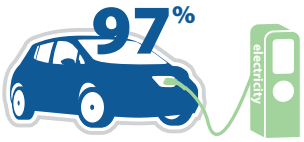


Percentage of survey respondents who are Nissan Leaf owners

Nissan Leaf drivers dominate the Round 1 and Round 2 survey populations, with fully 97% of survey respondents being Leaf owners or lessees. Although more than 2,000 Chevrolet Volts were sold or leased in California prior to March 2012, these drivers were not represented in the Round 1 and 2 survey populations because the Volt was ineligible for the CVRP prior to this date. Between March and September 2012, more than 1,200 Volt owners applied for and received a rebate from the CVRP. These drivers will be part of the Round 3 survey population.

The Toyota Prius Plug-in Hybrid has always been eligible for the CVRP, but was not available to consumers in significant numbers until March 2012. Approximately 1,800 Prius Plug-in owners applied for and received a rebate from the CVRP prior to September 2012 and will subsequently be part of the Round 3 survey population.

SURVEY ANALYSIS

2,611 responses (2,039 unique respondents) have been collected thus far.

The California Plug-in Electric Vehicle Driver Survey is administered semiannually to CVRP recipients. Detailed information on purchasing motivations, charging behavior, vehicle use, access to public and residential charging infrastructure, fueling costs and other data are collected from California plug-in electric vehicle (PEV) drivers who have owned or leased a PEV for a minimum of six months.[1] To date, CVRP surveys have included only plug-in electric vehicles. Fuel cell vehicles will be included in future CVRP survey efforts when those vehicles become commonly available.

As of October 2012, two rounds of the CVRP survey had been administered (see Table 1), with the survey population divided into cohorts based on CVRP application receipt date. Cohort 1 is defined as CVRP applicants who applied for a CVRP rebate from March 2010 through August 2011. Cohort 2 is defined as CVRP applicants who applied for a rebate from September 2011 through February 2012. Cohort sizes and survey respondents by cohort are given in Table 1. A total of 2,611 respondents (2,039 unique) participated in the first two rounds of the survey, with 572 respondents participating in both rounds.

Table 1. Survey Populations, Cohorts and Total Respondents

	Survey Populations			Survey Respondents		
	Cohort 1	Cohort 2	Total	Cohort 1	Cohort 2	Total
Round 1 Survey: February 2012	2,526	—	2,526	1,409*	—	1,409
Round 2 Survey: October 2012	2,526	1,803	4,329	819	383	1,202

* 1,419 complete responses were received for Round 1 of the survey; however, due to a change in the use of application receipt dates in the survey design, 10 respondents were removed from Cohort 1.

Vehicle Satisfaction and Use

PEV drivers expressed high levels of satisfaction with their vehicles, both overall and across a variety of specific characteristics, with the highest ratings for performance and passenger space (Figure 1). In contrast to these favorable ratings, nearly 40% of PEV drivers expressed some level of dissatisfaction with their vehicle's all-electric range. When asked what all-electric range would result in extreme satisfaction, 57% of respondents expressed a desired range of 150 miles or greater (Figure 2). This is nearly double the Nissan Leaf's EPA rated range of 78 miles and exceeds the rated range of nearly all battery electric vehicles currently on the market (Table 2).

[1] In order to determine eligibility to participate in the survey, CVRP application receipt date is used as a proxy for the vehicle purchase date. Therefore, the length of ownership may vary due to a lag between the actual vehicle purchase date and CVRP application date.

Despite the large discrepancy in desired versus rated all-electric range, the actual average vehicle use of survey respondents was 28.9 miles per day, which coincides with the daily driving habits of non-PEV drivers with similar demographics.[2] Only 8% of PEV drivers log more than an average of 45 miles per day (Figure 3), which corresponds to 16,400 miles per year or greater.

The actual average vehicle use of survey respondents was 28.9 miles per day.

Figure 1. Overall Satisfaction with PEV & Vehicle Characteristics

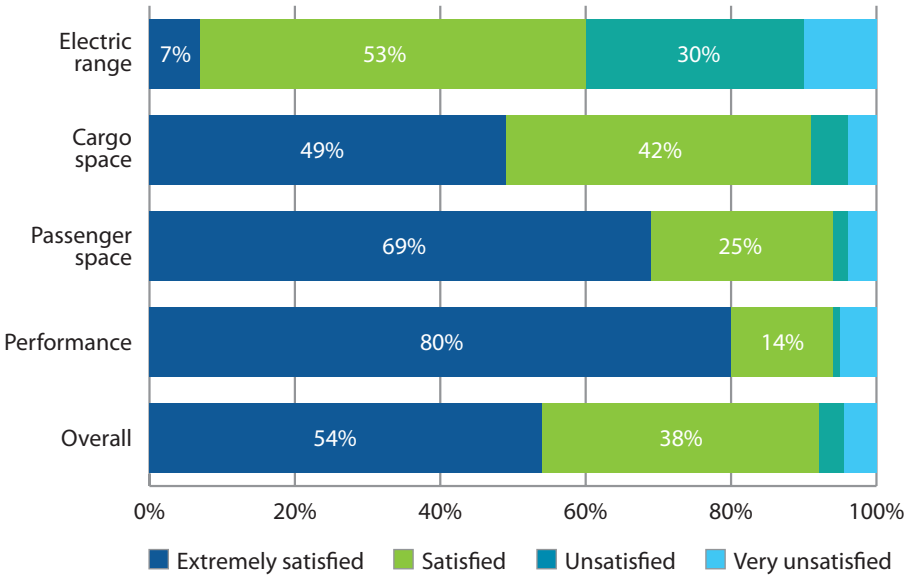
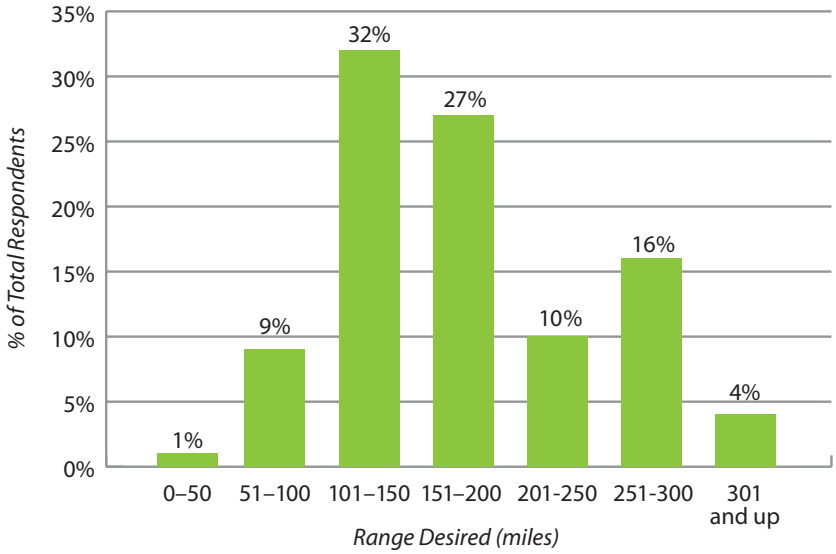


Figure 2. All Electric Range Desired for Extreme Satisfaction



[2] Federal Highway Administration: Average Annual Miles per Driver by Age Group, http://www.fhwa.dot.gov/ohim/onh00/bar8.htm. Using the weighted average of daily driving based on the gender and age distribution observed in the survey population respondents, the expected average daily miles driven is 31 miles/day.

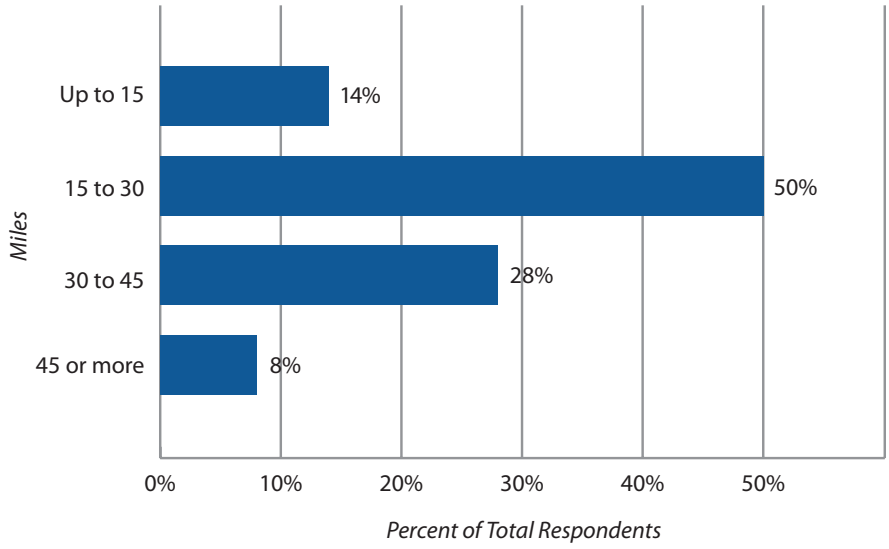
Table 2. Partial List of CVRP Eligible Vehicles

Vehicle	Electric Range*
Ford Focus Electric	76 miles
Honda Fit EV	82 miles
Mitsubishi i-MiEV	62 miles
Nissan Leaf	78 miles
Smart ED	68 miles
Tesla Model S (85 kWh battery)	265 miles
Toyota RAV4 EV	103 miles

*EPA estimates, actual range may vary

Only 8% of PEV drivers log more than an average of 45 miles per day, which corresponds to 16,400 miles per year or greater.

Figure 3. Average Miles Driven Daily

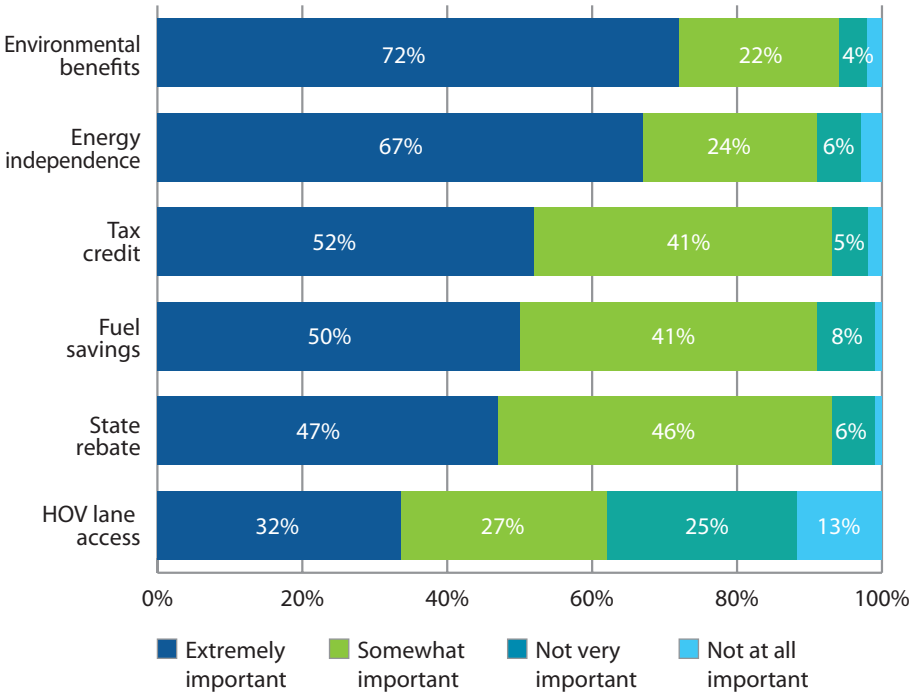


Ownership Motivation

In order to better understand the motivations for plug-in electric vehicle adoption, respondents were asked to rate the importance of various factors in their decision to purchase a PEV (Figure 4). Of these factors, environmental benefits were rated as the most important motivation for purchasing a PEV, with 72% of respondents describing it as "extremely important." This was followed closely by energy independence with 67% of respondents rating it as "extremely important." Interestingly, HOV lane access was rated as an important motivation factor by only 59% of respondents; however, 74% reported displaying an HOV sticker on their vehicle.

Environmental benefits were rated as the most important motivation for purchasing a PEV

Figure 4. Importance of Motivations on Vehicle Purchasing Decision

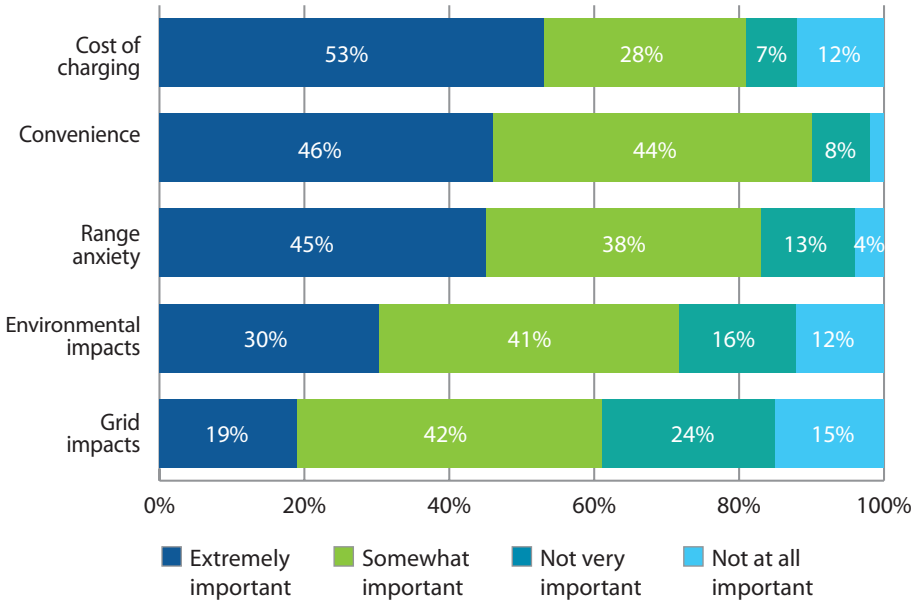


Vehicle Charging

The three most important factors in determining when respondents charge are cost, convenience and range anxiety.

The three most important factors in determining when respondents charge are cost, convenience and range anxiety, rated as "extremely important" by 53%, 46% and 45% respectively (Figure 5). Among the lowest ranked determinants of when owners charge their vehicles are environmental and grid impacts, ranked as "extremely important" by 30% and 19% of owners respectively. The relatively low rating of environmental impacts is surprising given how highly drivers rated environmental benefits as a motivating factor in their vehicle purchase (Figure 4). This discrepancy may suggest a lack of awareness among PEV owners regarding the environmental impacts of when and how vehicles are charged. Consequently, though messaging designed to influence charging behavior should continue to focus on cost as a prime motivator, given PEV owners' expressed interest in environmental benefits, communication strategies could be developed to influence charging behavior based on nonmonetary concerns, including environmental impacts and effects of PEV charging to the electricity grid.

Figure 5. Importance of Factors Determining When PEV Drivers Charge

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Get in.
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Residential Charging

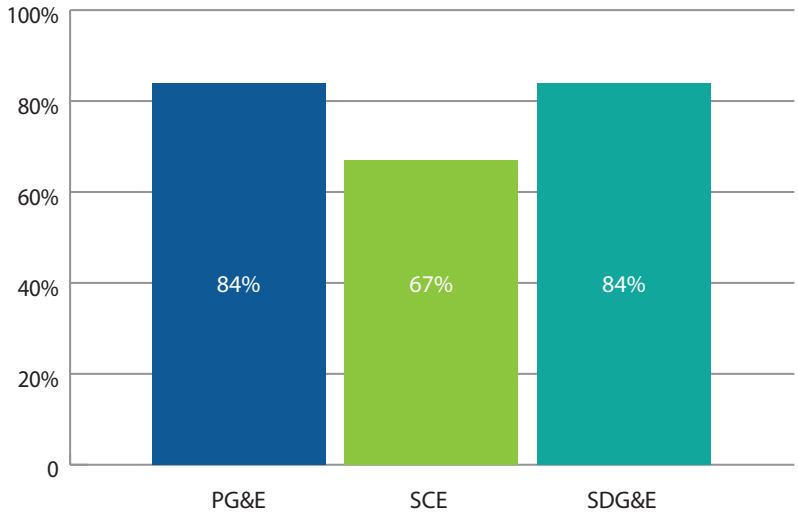
The majority of early PEV adopters in California are using TOU electricity rates to charge their vehicles.

For PEV owners in California using standard residential electricity rates, the average cost of electricity used to fuel their PEVs can be as high as $0.24–$0.34 per kilowatt-hour (kWh),[3] equivalent to $2.70–$4.70 per gallon of gasoline.[4] However, lower costs are available because utilities across the state are providing customers with rates exclusively for PEVs that utilize time-of-use (TOU) pricing.

TOU pricing offers cheaper rates during off-peak hours when electricity demand is low and more expensive rates during on-peak hours when there is a greater demand for electricity.

As shown in Figure 6, the majority of early PEV adopters in California are using TOU electricity rates to charge their vehicles.

Figure 6. Survey Respondents (nonsolar owners) Using TOU Rates for Vehicle Charging



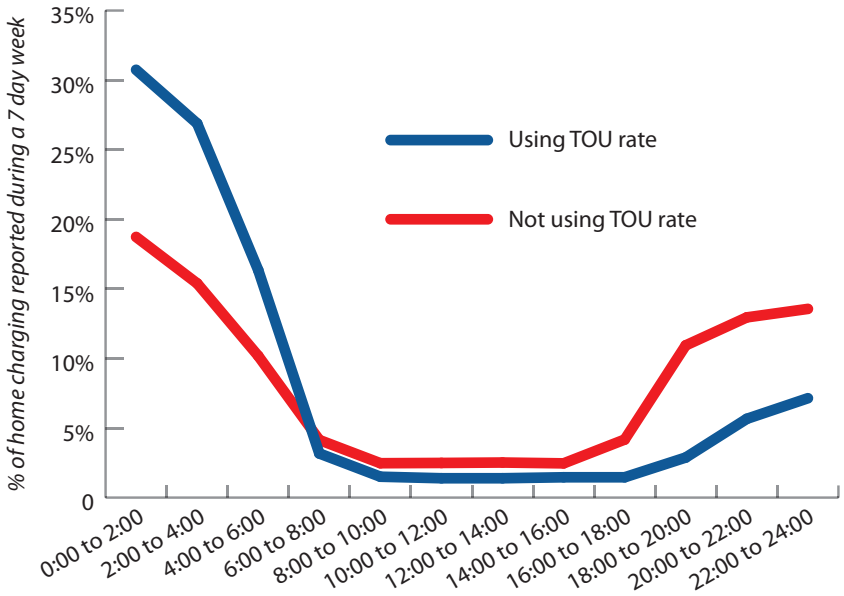
[3] Range of prices sourced from Tier 3 and Tier 4 tariff schedules for PG&E and SCE.
[4] Range of assumptions for equivalent pricing calculation: PEV efficiency of 3.25 mi/kWh AC, Tier 3 and higher electricity rates of 0.24-0.34$/kWh, conventional vehicle efficiency of 36-45 mpg. [(1/(m/kWh)) x ($/kWh) x (mpg)].

Time-of-Use Rates and Vehicle Charging Behavior

Figure 7 summarizes the self-reported charging behavior of survey respondents for charging their PEV at home. As can be seen, PEV owners utilizing TOU rates report fewer charging events in the 4 p.m. to midnight period. This data indicates that PEV owners are reacting to the price signals associated with TOU rates by programming their vehicles to begin charging when electricity is least expensive.

Owners using a TOU rate to charge their PEV are much more likely to plug in during off-peak periods.

Figure 7. Charging Behavior of Owners on a TOU Rate vs. Non-TOU Rate



Environmental Benefits of Off-peak Charging

Electricity is generated from a mix of sources — hydroelectric, natural gas, nuclear, renewables and coal. In California, the number one source of electricity generation is from power plants that burn natural gas. Moreover, these natural gas power plants account for nearly 100% of the marginal, or additional, electricity consumed in the state as new electrical loads are added, such as from PEV charging. However, natural gas power plants vary widely in levels of efficiency, from as low as 31.5% to as high as 51.8% efficient,[5] with the less efficient power plants used during peak periods of electricity consumption. Compared to PEVs charged during daytime peak periods, PEVs charged in California in off-peak periods reduce greenhouse gas emissions 15%–50%.[6]

[5] California Air Resources Board, *Detailed California-Modified GREET Pathway for California Average and Marginal Electricity*, pg. 10 (http://www.arb.ca.gov/fuels/lcfs/022709lcfs_elec.pdf).
[6] McCarthy, Ryan W. and Christopher Yang (2009), *Determining Marginal Electricity for Near-term Plug-in and Fuel Cell Vehicle Demands in California: Impacts on Vehicle Greenhouse Gas Emissions.* Journal of Power Sources 195 (7), 2099–2109.

Residential Charging Stations

Approximately 90% of respondents reported having a dedicated Level 2 (240 V) residential vehicle charger. Of those that own a charger, 56% indicated the purchase and/or installation of the charging equipment was subsidized. Respondents who purchased their vehicles prior to September 2011 (Cohort 1) were statistically more likely to have a Level 2 charger than those who purchased their vehicles between September 2011 and February 2012 (Cohort 2).

Table 3. Adoption of Level 2 Residential Chargers Based on Vehicle Purchase Date

Level 2 Charger Installed	Cohort 1	Cohort 2
Yes	1,500	320
No	136	63
Percentage with L2 charger	**91.7%**	**83.6%**

p-value = 0.000

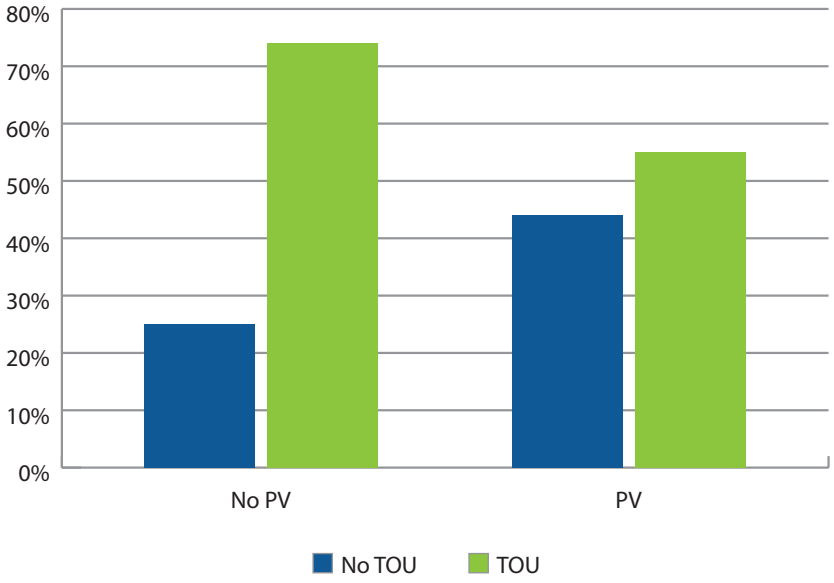
This difference is notable given that major residential Level 2 charger incentive programs, such as the EV Project, remained active throughout this period. However, additional analysis revealed no significant difference between cohorts in the proportion of residential Level 2 adopters that received a monetary incentive.

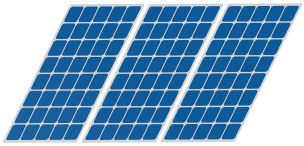
Table 4. Distribution of Free/Subsidized Level 2 Residential Chargers by Vehicle Purchase Date

Received free or subsidized Level 2 charger	Cohort 1	Cohort 2
Yes	938	206
No	562	114
Percentage of L2 chargers that received subsidy	**62.5%**	**64.4%**

p-value = 0.534

Figure 8. Adoption of EV Time-of-Use (TOU) Rates by PV and Non-PV System Owners





PEV Adoption and Residential Solar Power

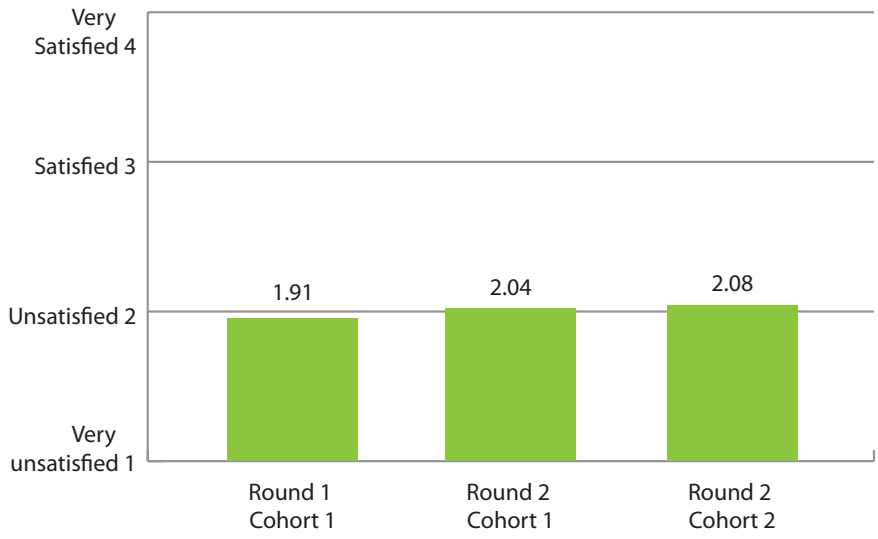
The pairing of renewable energy technologies remained an important element in the early PEV population (vehicles purchased prior to March 2012), with nearly 39% of PEV drivers owning residential solar PV systems and 53% of those stating that their systems were sized to meet the additional load from their PEV. Furthermore, of those respondents who did not have solar PV installed, more than 17% expressed a strong interest in adopting the technology in the near future. It also remains true that those with PV are less likely to adopt EV time-of-use rates (Figure 8).

Public Charging

Satisfaction with public charging infrastructure, although still low, noticeably improved since the first round of the PEV survey

Satisfaction with public charging infrastructure, although still low, noticeably improved since the first round of the PEV survey and is significant across multiple levels of analysis. Satisfaction among those who purchased their vehicle prior to September 2011 (Cohort 1) showed a significantly greater level of satisfaction from the first to the second round of the survey (p-value=0.000). In addition, satisfaction with public infrastructure is higher for Cohort 2 respondents than that expressed by Cohort 1 respondents during their first six months of ownership (p-value=0.0001). This data indicates that vehicle owner attitudes have not only improved over time, but that the attitudes of recent car buyers are less negative than those expressed by the first adopters of PEVs.

Figure 9. Satisfaction with Public Infrastructure Over Time for Cohort 1



When viewed in the context of public charging infrastructure deployment, these results are not surprising. Between the first and second survey rounds, California added 880 Level 2 charging points at 355 new public charging locations, increasing from 1,178 points at 598 public locations to 2,058 points at 953 locations. The level of dissatisfaction may continue to decrease in subsequent rounds of the survey as the number of public chargers increases.

ABOUT THE CLEAN VEHICLE REBATE PROJECT

The Clean Vehicle Rebate Project (CVRP) provides cash incentives to individuals, businesses and others throughout California for the purchase or lease of battery electric, plug-in hybrid electric and fuel cell electric vehicles. CVRP rebates range from $1,500 to $2,500 for highway-capable passenger vehicles.

The California Air Resources Board (ARB) provides funding for CVRP via revenue from vehicle and vessel registration and smog abatement fees, with project funding legislated through 2015. Each year, ARB conducts a competitive solicitation process to select a CVRP administrator. The California Center for Sustainable Energy (CCSE) has managed the project since its launch in March 2010.

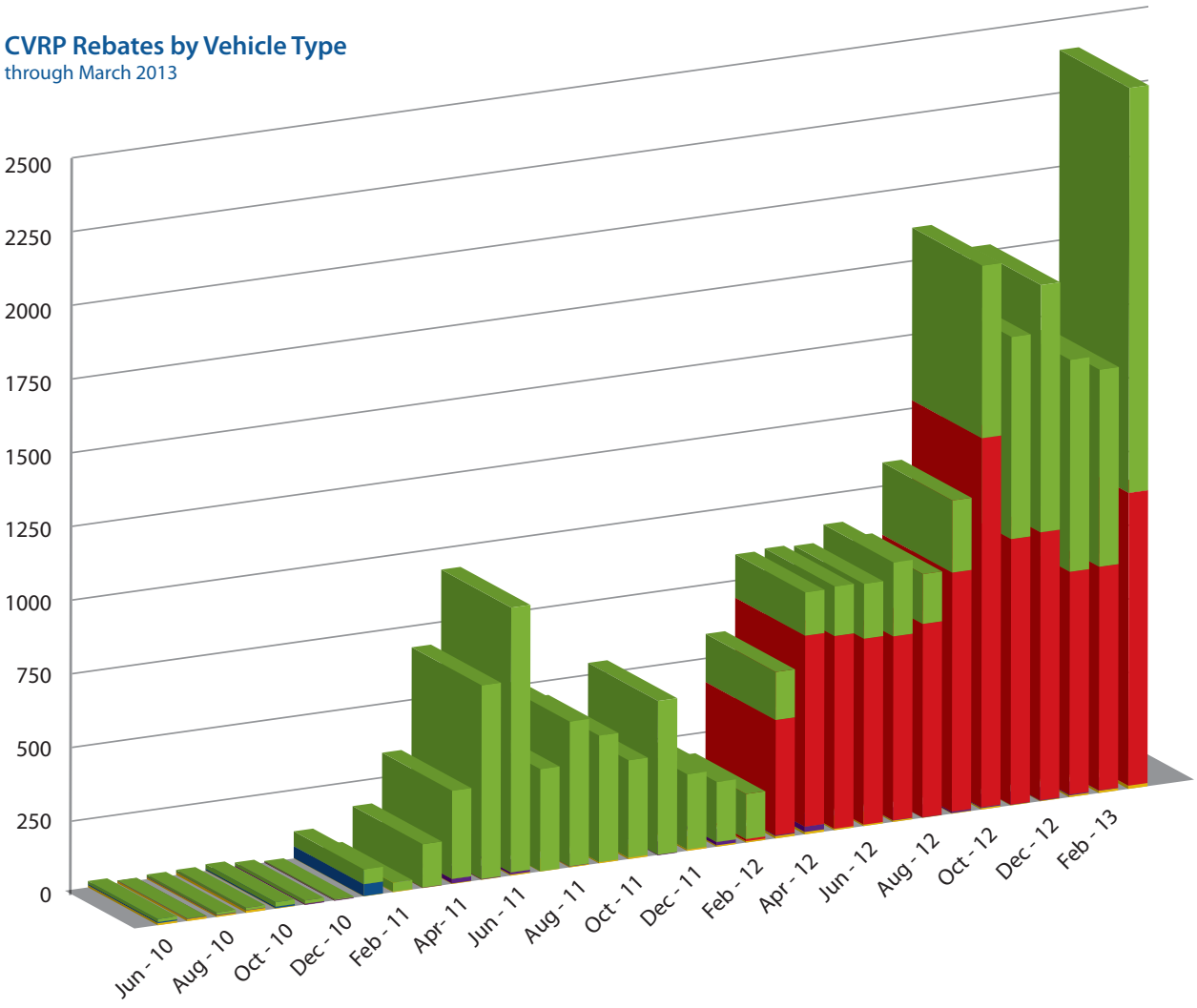
The CVRP distributed approximately $46 million to more than 20,000 Californians from March 2010 to March 2013.

CLEAN VEHICLE REBATE PROJECT℠

- BEV = Battery electric vehicle
- PHEV = Plug-in hybrid electric vehicle
- CZEV = Commercial zero-emission vehicle
- NEV = Neighborhood electric vehicle
- ZEM = Zero-emission motorcycle

CVRP Rebates by Vehicle Type

through March 2013



Vehicle Rebate Statistics

CCSE provides several online tools that leverage the CVRP database. These tools provide a wide spectrum of information about the adoption and use of clean vehicles in California, including detailed vehicle purchasing trends such as geographic distribution of rebated vehicles.

The CVRP Statistics online tool allows users to view rebate awards on a time series by type of vehicle and provides the option to filter the data by regional air district, local utility, county, ZIP code and owner type. Although the data only documents rebated vehicles, it provides valuable information regarding general adoption in California. The data is of particular interest to city planners, vehicle manufacturers, utility managers and others involved with transportation issues, plug-in electric vehicle readiness planning and air quality control. This information is on the CCSE website, and the data is available for download. **www.energycenter.org/projectstatistics**

Further Information

This brief summarizes selected results of an ongoing study of PEV drivers in California. For more information on additional findings, visit **www.energycenter.org/cvrp** or contact research@energycenter.org.

The **California Center for Sustainable Energy® (CCSE)** operates where energy and climate policies and the marketplace converge — providing integrated consumer education and incentive programs as well as facilitating research and program guidance for regional and state sustainable energy planning and policymaking.

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