

California Plug-in Electric Vehicle Owner Survey



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OVERVIEW

In the first half of 2012, the California Center for Sustainable Energy (CCSE), in coordination with the California Air Resources Board (ARB), conducted the largest plug-in electric vehicle owner survey in the state's history. Reaching out to more than 2,500 California plug-in electric vehicle owners, CCSE received data from 1,419 unique respondents who provided information on vehicle use, charging behavior, access to public and residential charging infrastructure, fueling costs and household demographics. The data collected by CCSE, in support of the state's Clean Vehicle Rebate Project (www.energycenter.org/cvrp), highlights California's commitment to promoting clean transportation solutions that improve urban air quality, reduce greenhouse gas emissions and offer the state's consumers viable alternatives to conventional gasoline vehicles.

California has firmly established itself as a national and worldwide leader in advanced technology, zero-emission automotive transportation. As of July 2012, Californians own more than 12,000 plug-in electric vehicles, roughly 35% of all plug-in vehicles in the United States. Moreover, approximately 1,000 new plug-in vehicles are being sold in the state every month. Together with the state's clean electricity grid, the growing number of plug-in vehicles in California are a cornerstone of the state's transportation and energy future and represent the highly successful first wave of adoption that is expected to lead to more than one million electric vehicles on California's roads over the next decade.

The results of the statewide CCSE and ARB survey from 1,419 California plug-in electric vehicle owners confirm the early market success as well as the considerable consumer and environmental benefits of electrified vehicles. Some of the highlights from the survey include:

- 89% of owners use their plug-in electric vehicle as their primary car, driving an average of 800 electric-fueled miles per month
- Survey respondents report that roughly two-thirds of plug-in electric vehicle (PEV) charging takes place during off-peak hours (8 p.m. – 8 a.m.). Super-off peak charging (12 a.m. – 6 a.m.) is highest among owners using PEV time-of-use (TOU) electricity rates, which reward owners with lower cost electricity during those hours when the state's electricity grid is most efficient.
- 39% of plug-in electric vehicle owners polled have also invested in home solar energy systems, helping to “fuel” their vehicles with renewable solar energy
- In addition to fueling at home, 71% of plug-in vehicle owners report having access to the state's expanding public and workplace charging infrastructure in order to support the market for plug-in vehicles
- Plug-in vehicle owners report they are willing to pay 40% – 70% more for public charging compared to standard residential electricity rates; they are also prepared to pay 2.5 to 3 times more for “critical need” public charging than they are for daily charging

In addition to these highlights, CCSE has prepared in-depth analyses based on survey results that address three specific topics: (1) access to public charging infrastructure and vehicle owner willingness to pay for public vehicle charging, (2) the link between plug-in vehicle adoption and residential solar ownership and (3) residential charging of plug-in electric vehicles and the use of lower cost time-of-use electricity rates.

Finally, CCSE and ARB, in partnership with other key stakeholders, plan to conduct additional surveys in support of the Clean Vehicle Rebate Project in order to collect valuable data that will help inform the state how best to promote and accelerate the market for plug-in electric vehicles, maximize consumer and environmental benefits and help the state's utilities efficiently integrate these vehicles into the state's electricity grid.

CLEAN VEHICLE REBATE PROJECT

Plug-in Electric Vehicle (PEV) Owner Survey Summary Statistics

Survey population

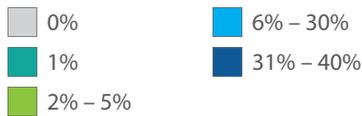
(PEV owners for 6 months or longer as of September 1, 2011)

2,526

Survey respondents

1,419

Distribution of survey respondents



96%



Percentage of survey respondents who are Nissan Leaf owners

California's Plug-in Electric Vehicles

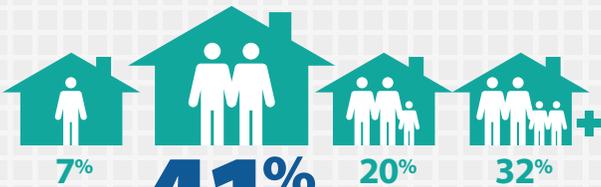
As of July 2012, Californians owned more than 12,000 PEVs, or approximately one of out of every three PEVs in the entire nation. The CVRP issued rebate checks to more than 8,000 of these California vehicle owners, including 5,100 rebates to owners of battery electric vehicles (BEVs) and 2,300 rebates to owners of plug-in hybrid electric vehicles (PHEVs).

40%



71%

of primary PEV drivers are male



41%

of respondents reside in households of two people

29%

20%

PEV vs. conventional vehicle use by activity



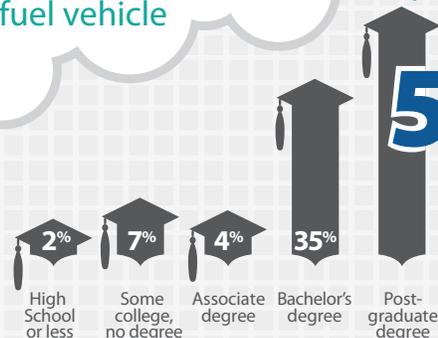
95%

of respondents also own a conventional fuel vehicle



Educational level of respondents

52%



Attitude towards public charging infrastructure

83% expressed varying levels of dissatisfaction with public charging infrastructure

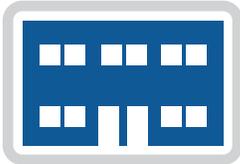


96% of respondents own their home

91% reside in a single-family detached home



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

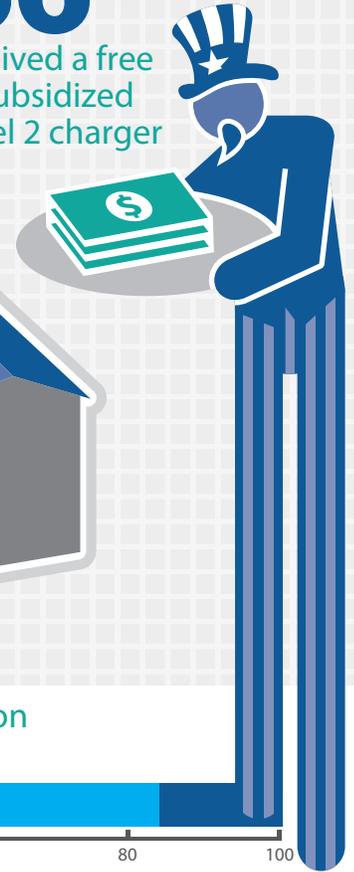


3% reside in an apartment/condominium



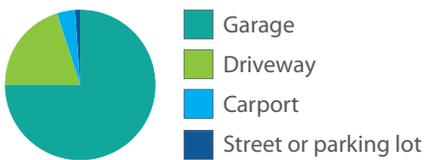
<1% reside in other dwellings

56% received a free or subsidized Level 2 charger

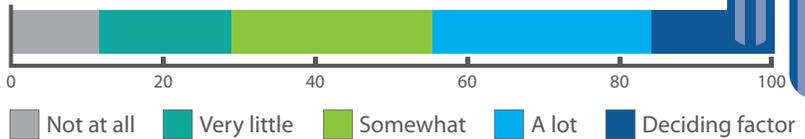


91% have installed a residential charger

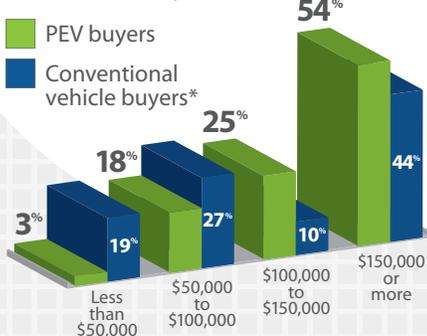
75% of respondents park their vehicle in a garage



Importance of subsidy for decision to purchase a Level 2 charger

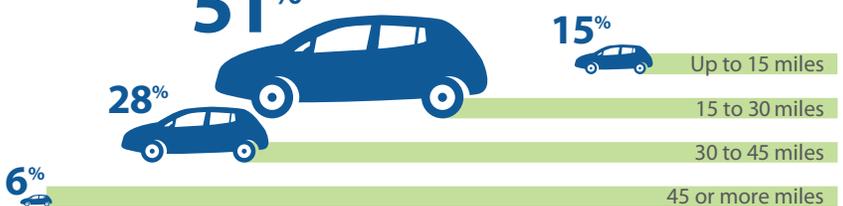


Household income of California new car buyers



*Source: Gil Tan, UC Davis, Plug-in 2012 Conference, July 2012

Average miles driven per day



WILLINGNESS TO PAY FOR ELECTRIC VEHICLE CHARGING

PEV charging infrastructure is growing

A new generation of plug-in electric vehicles (PEVs) is being deployed across the United States thanks to aggressive federal fuel efficiency standards, public subsidies and consumer demand for clean vehicles. To support this growing fleet of PEVs, a number of businesses and public entities are installing charging equipment, referred to as electric vehicle supply equipment (EVSE). These EVSE “hosts” are motivated by a variety of considerations, including a desire to promote their sustainability credentials, attract customers, provide a service for employees and take advantage of current subsidies.¹

The “willingness to pay” questions asked in this survey shed light on how much revenue EVSE site hosts may be able to generate from charging user fees. Currently, most nonresidential EVSE charging is available at no or very low costs to PEV owners, but many EVSE site hosts are planning to collect fees for charging in the near future.

Survey questions

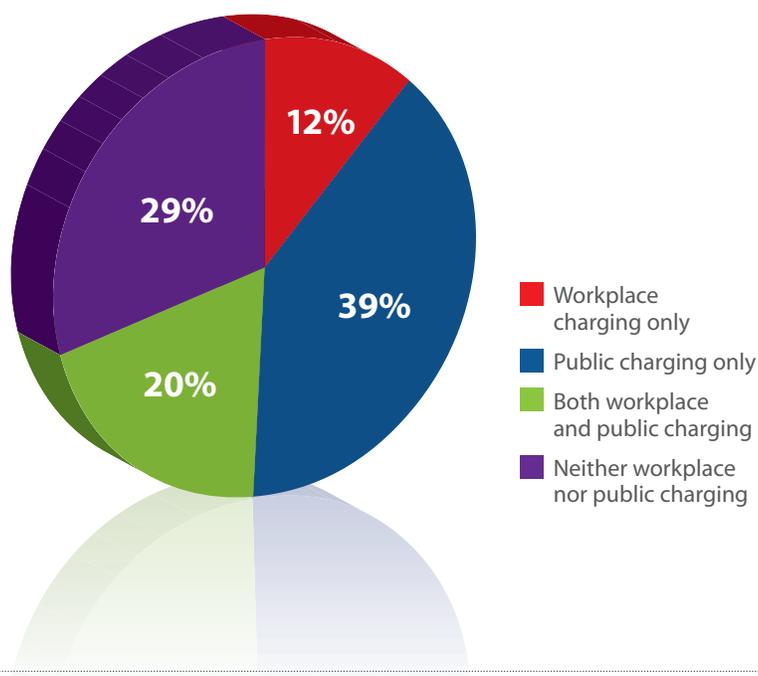
Participants were asked whether or not they had access to workplace and public charging and whether or not they currently pay for charging. They were then asked how much they would be willing to pay. Specifically, PEV owners were asked — for charging at Level 2 and DC fast charging — how much they would pay to charge their PEV under the following “charging needs scenarios”:

- Daily use (charging for regular use)
- Occasional (charging to “top-off” or extend a trip)
- Critical (emergency need to charge to use PEV)

Most PEV owners have access to free charging

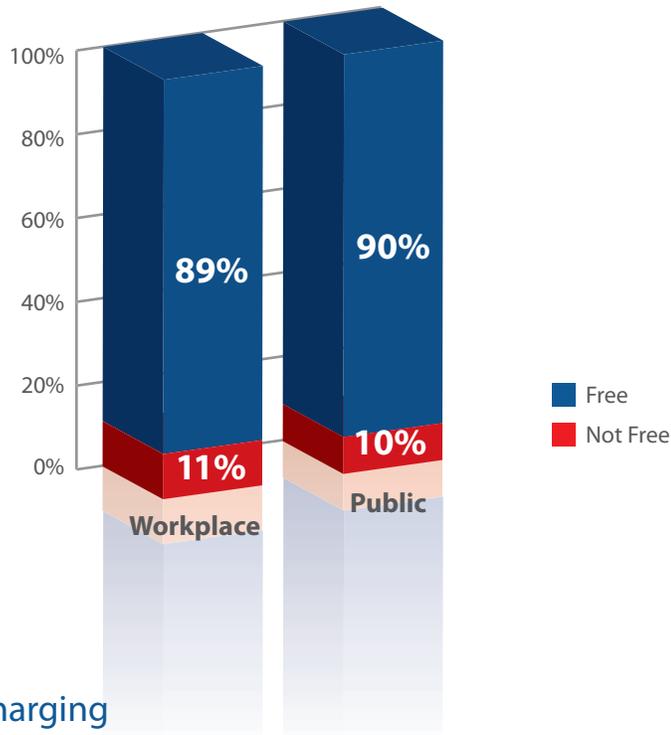
About 70% of respondents reported having access to either workplace or public charging or both (Figure 1). Of these, about 90 percent reported they had access to free charging (Figure 2).

Figure 1. PEV owners’ access to workplace and public charging



¹ May, J.W. and Matilla, M. (2009) *Plugging In: A stakeholder investment guide for public electric vehicle charging infrastructure*. Rocky Mountain Institute. http://www.afdc.energy.gov/afdc/vehicles/electric_charging_public.html

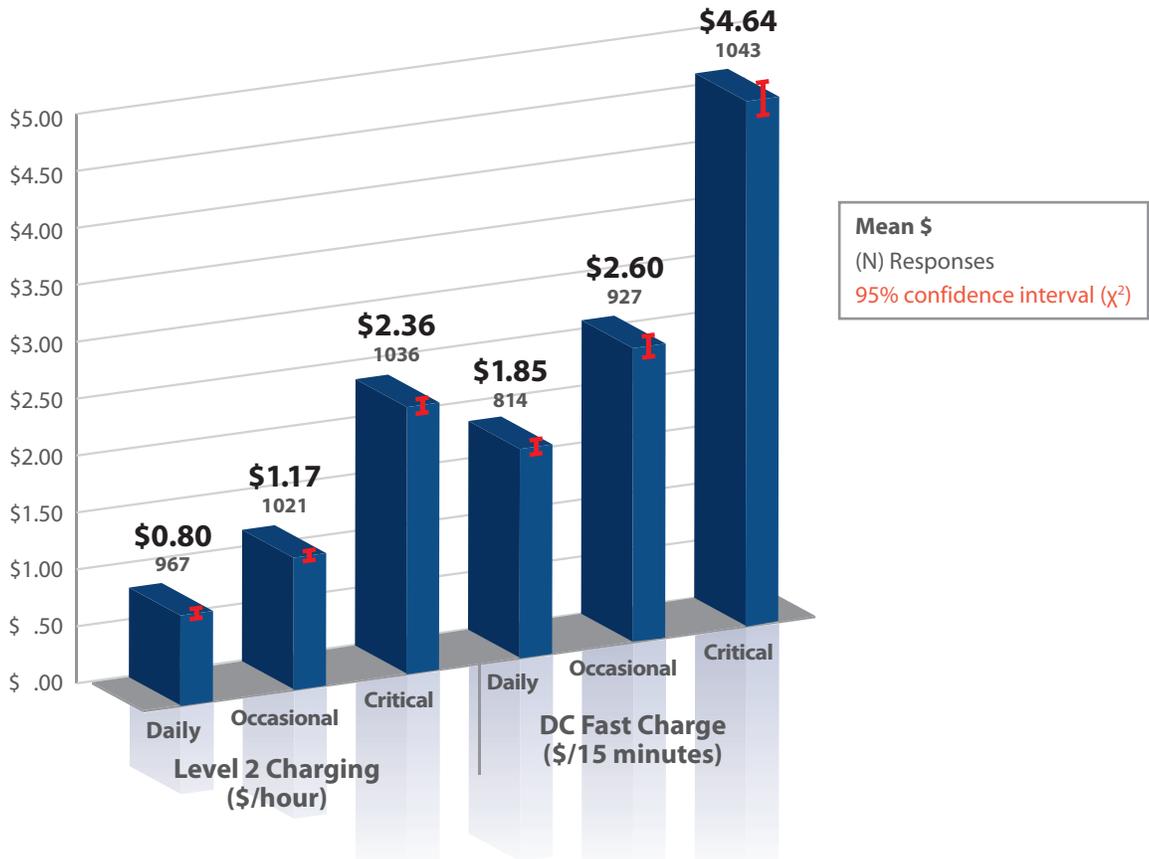
Figure 2. Survey respondents reported cost for use of nonresidential charging



Willingness to pay for PEV charging

Figure 3 shows survey respondents' stated willingness to pay for Level 2 and DC fast charging under different charging scenarios. Most of the PEV owners in this survey (91%) have Level 2 equipment at home, and the 70 percent that have access to public or workplace charging are primarily using Level 2 charging, as very few DC fast chargers have been deployed in California. When interpreting the "willingness to pay" results, it is important to consider that the survey respondents are more familiar with the charging times and capacity associated with Level 2 charging and have little experience with DC fast charging.

Figure 3. Stated willingness to pay for Level 2 and DC fast charging under three "charging needs scenarios"



Types of Electric Vehicle Charging Infrastructure

There are three major types of electric vehicle supply equipment (EVSE). Level 1 charging is provided by a normal wall outlet and is rated at 120 volts. Level 2 charging, rated at 208 or 240 volts, often requires special charging equipment but reduces charge time considerably. DC fast charging equipment is considerably more expensive but allows rapid charging.

PEV Charging Station Type	Power
AC Level 1	1.4 kW@12 amps
AC Level 2	3.3 kW@15 amps 6.6 kW@30 amps
DC Fast Charging	25-50 kW@100 amps

Willing to pay a premium over typical electric rates

For daily Level 2 charging, such as that which might take place at a workplace, respondents were willing to pay on average about \$0.80 for one hour of charging. For a 2010 or 2011 Nissan Leaf, an hour of charging provides 3.3 kWh of energy, so \$0.80 per hour corresponds to a cost of about \$0.24 per kWh. In the five largest California utilities, PEV owners pay about \$0.09 – \$0.15 per kWh to charge their PEVs at home during off peak hours (at night) and about \$0.17 – \$0.26 to charge their PEVs on peak (during the day). The average willingness to pay for daily Level 2 charging is thus in line with what PEV owners would pay at home for charging during the day.² Again, it should be noted that the majority of respondents answered this question in the absence of well-established pricing models for public charging infrastructure. This value will likely change as public infrastructure expands and more distinct, clearer pricing models are adopted.

Willing to pay more for occasional and critical charging

Occasional Level 2 charging — such as that which might occur at a retail location — would likely be used by PEV owners to “top off” their batteries and/or extend the range of their trip. Survey respondents expressed a willingness to pay about 50% more for occasional Level 2 charging — \$1.17 per hour on average. For “critical” Level 2 charging, survey respondents would pay about 3 times more than what they would pay for daily Level 2 charging — \$2.36 per hour on average.

Willing to pay more for fast charging

According to the survey, PEV owners are willing to pay a considerable premium for DC fast charging, about double (for 15 minutes of charging) what they would pay for an hour of Level 2 charging across all charging scenarios. A DC fast charger provides about 4 to 15 times more power than a Level 2 charger.

² California Energy Commission statewide electricity rates by utility, class and other data.
www.energyalmanac.ca.gov/electricity/index.html

PLUG-IN ELECTRIC VEHICLES AND SOLAR PV ADOPTION

A key aspect of PEV ownership of interest to the market is the overlap of plug-in electric vehicles and solar photovoltaic (PV) system adoption. This is an important topic given the potentially strong link between the two markets and the implications such a connection could have on utility load and grid infrastructure planning. Potential issues associated with this subset of PEV owners include: PV adoption and its geographic distribution, whether these customers are sizing their PV systems to account for anticipated PEV load, how PV adoption may affect their use of PEV tariffs and how their perception of PV benefits influence charging behavior. This research provides an opportunity to evaluate these questions and enhance our overall understanding of this segment of the PEV market.

High rate of PV adoption among PEV owners

Survey results indicate a strong relationship between PEV and PV ownership. Joint technology adoption among this early cohort is high; 39% of respondents have PV systems installed, and 17% indicated that they are planning to install PV within the next year (Figure 4). To test whether adoption varies by electric service provider, PV ownership rates were compared across the state’s major electric utilities; but, only marginal differences were found. However, when evaluating PV ownership rates by utility type, investor-owned utility (IOU) versus publicly owned utility (POU), we observe that PEV owners located in IOU territories are statistically more likely to adopt PV (Table 1). This could be due in part to the higher electricity rates paid by customers in IOU territories, particularly among those with consumption profiles that drive them into higher tiers.

Figure 4. Percent of respondents with a PV system

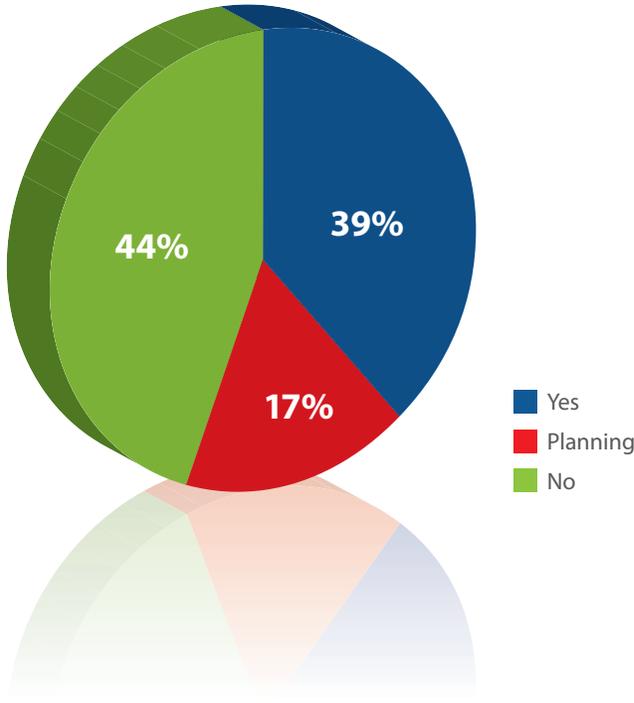


Table 1. PV ownership in IOUs versus POUs

	No PV	PV
IOU	60%	40%
POU	72%	28%

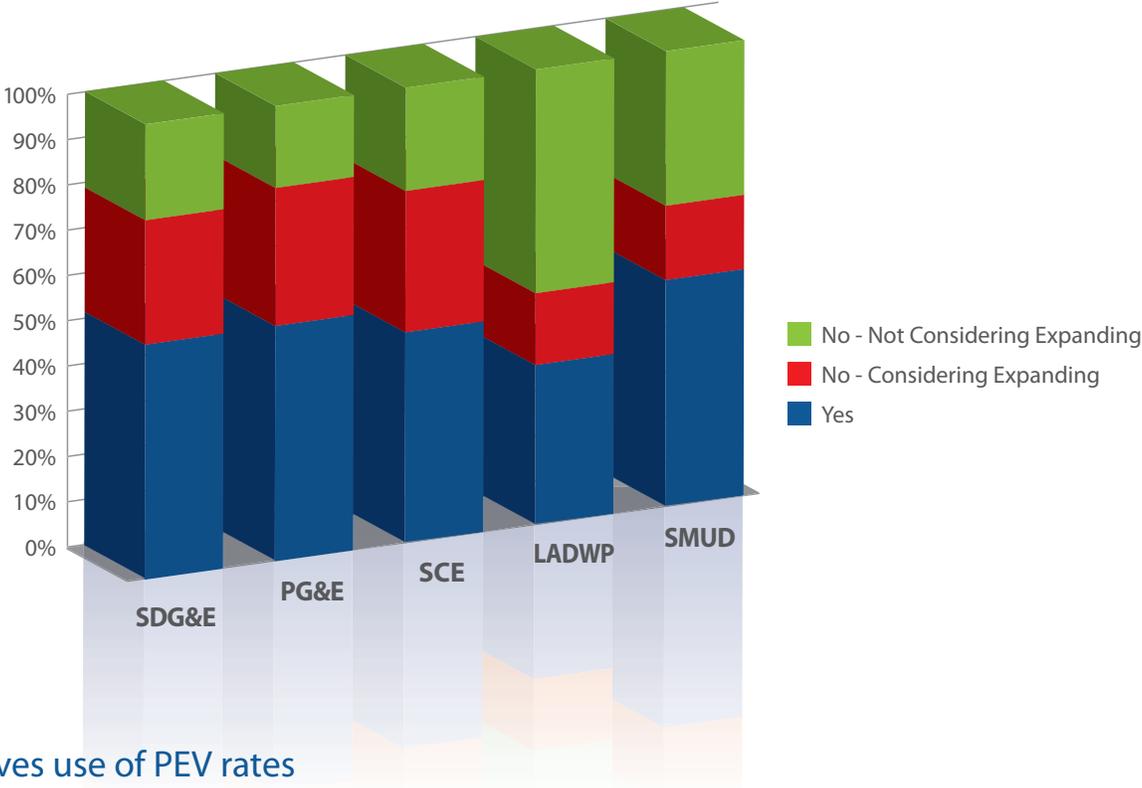
Pearson $\chi^2(1) = 6.6076$ P = 0.010

PEV owners size PV systems to offset PEV load

Respondents who own a PV were asked if their system was sized to reflect anticipated PEV-related load or if they were considering expanding it to reflect this load. As with PV adoption itself, the proportion of customers that sized or are considering

expansion of their systems for PEV load is not significantly different across utility territories (Figure 5). Nor, in this case, is there a significant difference in PV system sizing across utility types (IOU vs. POU). There is, however, a statistically significant difference in the proportion of individuals who are planning to expand their PV system to help offset PEV load versus those that have no plans to expand their PV systems. On average, 60% of respondents who did not initially size their PV system for their PEV state that they plan to expand their system within the coming year.

Figure 5. Respondents who have or are considering sizing PV to offset PEV load by utility



PV ownership drives use of PEV rates

In addition to examining ownership and system sizing characteristics, we also analyzed the extent to which PV customers utilize PEV rates offered by their utility. We found that PV owners were statistically less likely to take advantage of PEV rates than non-PV owners given equal knowledge of rate availability (Table 2). It’s noteworthy to state that the significance holds even in the case of San Diego Gas & Electric (SDG&E) where customers that adopt a PEV rate are given a free residential charging station and have installation costs covered through the federally funded EV Project. This relationship is not, however, universal, as Southern California Edison (SCE), Los Angeles Department of Water and Power (LADWP) and Sacramento Municipal Utility District (SMUD) customers with PV are not significantly less likely to use PEV rates than PEV owners without PV.

Table 2. Use of PEV rates by PV ownership

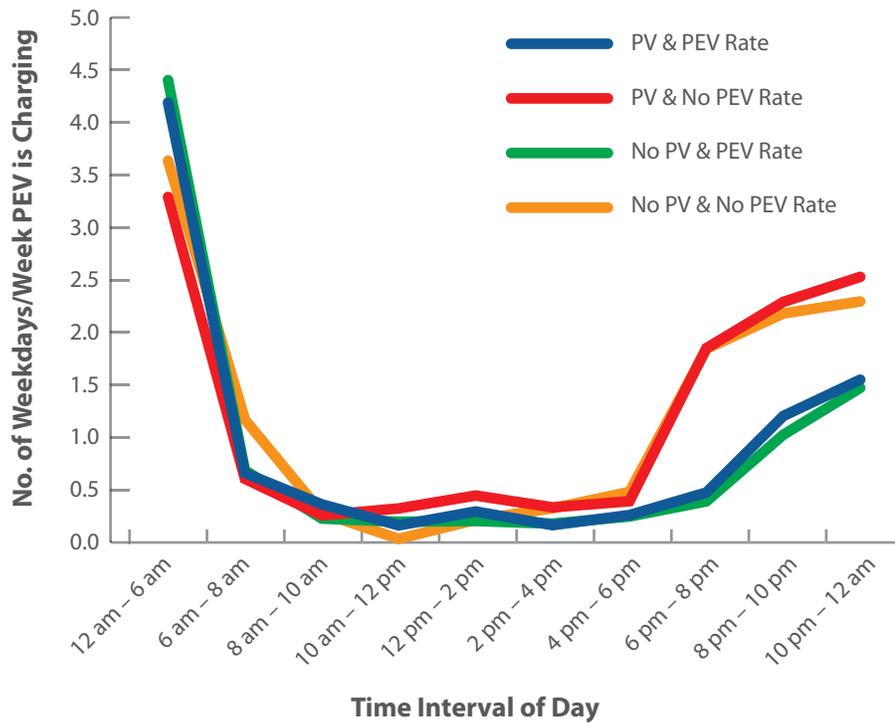
	No PV	PV	Total
Not using PEV Rate	152	162	314
Using PEV Rate	451	208	659
Total	603	370	973

Pearson $\chi^2(1) = 35.4373$ P = 0.000

PEV time-of-use rate adoption determines charging behavior

We observed that customers with PV were notably less likely to take advantage of discounted PEV charging rates if offered; therefore, we ran additional analysis on home charging behavior to call out any differences in charging patterns between PV owners and PEV rate users (Figure 6). The results suggest that although PV ownership may be determinant of PEV rate adoption, it is not a good indicator of charging behavior. Once a customer has selected a PEV rate, their rate selection appears to be a better predictor of charging patterns than the underlying presence of a PV system.

Figure 6. Number of weekdays PEV owners charge at home over different intervals of the day



KNOWLEDGE AND USE OF PLUG-IN ELECTRIC VEHICLE UTILITY RATES

Standard residential electricity rates in California

For over three decades, California utilities have been directed by the state to adopt policies to encourage energy conservation. For residential customers, these policies have resulted in a “tiered” pricing system for household electricity use. Under this system, a set amount of monthly electricity use (termed “baseline” usage) is priced at a low rate. Any electricity consumed above this baseline, however, is priced at a higher rate (in some cases, at a price more than double the baseline price). Because charging a PEV results in additional electricity consumption beyond the allotted baseline amount, the cost of electricity for charging a vehicle at home using a standard residential tiered rate can be much higher than the “average” price normally paid for electricity.

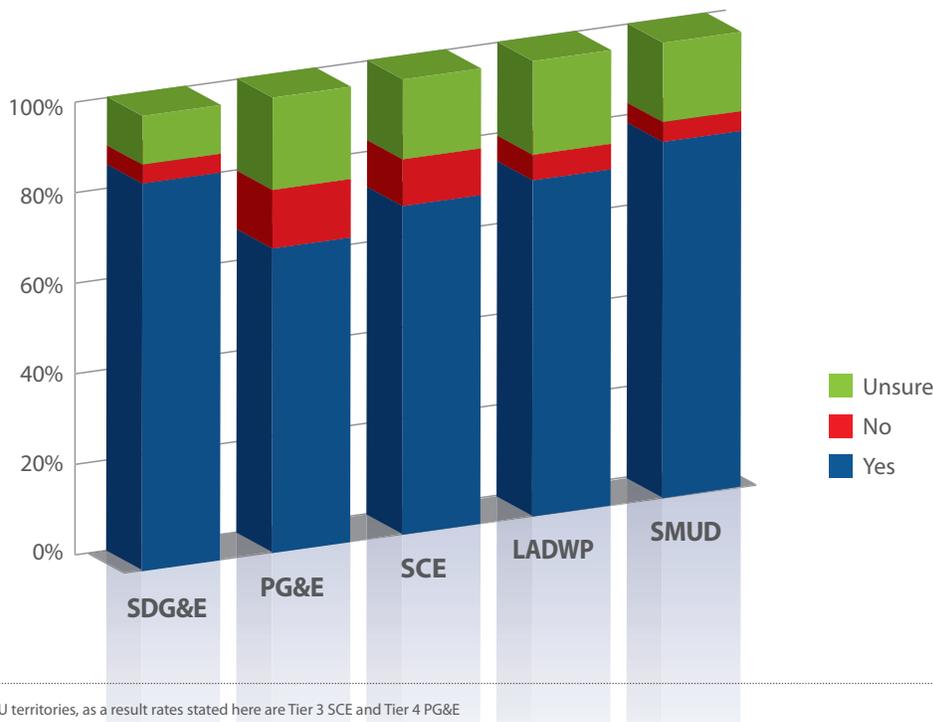
Solution for California PEVs: time of use (TOU) rates

For most PEV owners in California using standard residential electricity rates, the average cost of electricity used to fuel their PEVs could be as high as \$0.24 – \$0.34 per kilowatt-hour (kWh)³ equivalent to \$2.70 – \$4.70 per gallon of gasoline.⁴ Fortunately, utilities across the state are rewarding customers with rates exclusively for PEVs that utilize time-of-use (TOU) pricing. TOU pricing offers cheaper rates during off-peak periods when electricity demand is low and more expensive rates during on-peak periods when there is a greater demand.

Most PEV owners know TOU rates are available to charge their PEV

At the time of the survey, each of the utilities shown in Figure 7 offered TOU rates specifically for charging a PEV. However, consumer knowledge of these rates varied across utilities. PEV owners in the San Diego Gas and Electric (SDG&E) territory were the most aware with 85% of respondents having knowledge of these rates. Among the other utilities represented, an average of approximately 70% of respondents knew that TOU rates were offered. Thus, close to a third of the PEV drivers surveyed were not aware that their individual utility offered lower cost fueling options compared to their standard electricity rate. While consumer knowledge of TOU rates is important, it is also critical to understand if owners are using them.

Figure 7. Knowledge of PEV TOU rates



³ 86% of respondents are located in one of the three IOU territories, as a result rates stated here are Tier 3 SCE and Tier 4 PG&E

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. $[(1/(m/kWh)) \times (\$/kWh) \times (mpg)]$

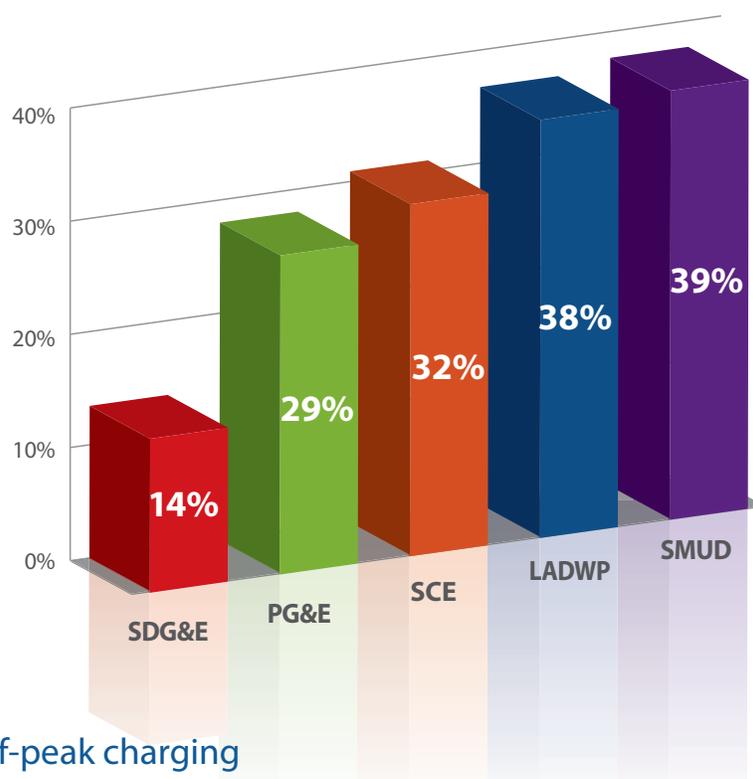
About half of PEV owners are not on a TOU rate

About half of PEV owners polled reported not using a TOU rate to charge their vehicle. As previously mentioned, charging a PEV on a standard rate can result in higher costs compared to the lower rates offered via TOU pricing. However, approximately 50% of vehicle owners not using a TOU rate polled are also owners of residential solar photovoltaic (PV) systems. Because of net metering regulations in California for residential PV systems, many households with solar PV may not be subject to higher tiered pricing when charging their vehicles at home.

About a third of early adopter PEV owners likely paying high prices for PEV charging

As Figure 8 shows, the percentage of drivers that are not on a PEV TOU rate and do not have PV systems ranges from 14% in SDG&E's territory to 39% in the Sacramento Municipal Utility District territory. Excluding San Diego, approximately a third of all PEV drivers surveyed across the state are charging their vehicle using a standard residential rate and are likely paying high prices to do so. Taking into consideration the extra electricity consumption that a PEV requires, these drivers may be charging their vehicle at prices as high as \$0.24 – \$0.34 per kWh⁵ or the equivalent of \$2.70 – \$4.70/gallon.

Figure 8. PEV survey respondents (nonsolar owners) charging on a standard rate



Economic benefits of off-peak charging

Low-cost fueling is one of the biggest benefits of charging a PEV using TOU rates. The San Diego region has both the highest awareness and utilization of PEV TOU rates in the state, likely the result of extensive outreach conducted by SDG&E in support of a CPUC-approved experimental PEV TOU study. Additionally, participants in SDG&E's study receive free installation of a utility-grade submeter that allows access to TOU pricing. As a result, PEV drivers on these TOU rates in the San Diego region pay the equivalent of about \$0.90 – \$1.90/gallon, or 42% – 59% less than nonsolar PEV owners charging on a standard rate.⁶ While lower cost fueling is one direct benefit of TOU rates, there are also environmental benefits to charging a PEV during off-peak periods.

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

⁵ This value is based on PEV drivers charging during super off-peak periods at 0.07-0.14\$/kWh compared to \$0.24-0.34 (Tier 3 SCE and 4 PG&E).

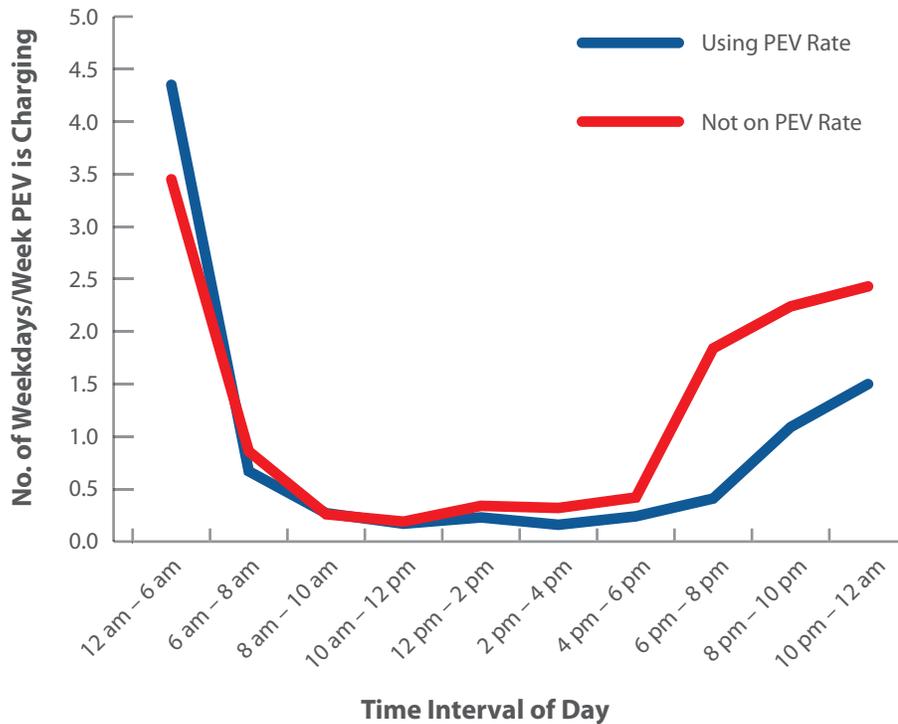
⁶ Ibid.

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,⁷ 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%.⁸

Utilization of TOU rate & impact on charging behavior

Owners using a TOU rate to charge their PEV are much more likely to plug in during off-peak periods. Figure 9 summarizes the self-reported charging behavior of survey respondents for the average weekday. As can be seen, PEV owners utilizing TOU rates report fewer charging events during on-peak and off-peak hours, notably in the 4 p.m. to 8 p.m. on-peak and the 8 p.m. to midnight off-peak periods. This data indicates that PEV owners are reacting to the price signals associated with TOU rates by charging less during the on-peak and off-peak periods when electricity is more expensive.

Figure 9. Charging behavior of owners on a TOU rate vs. not on a TOU rate



⁷ 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)

⁸ 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

ABOUT THE CLEAN VEHICLE REBATE PROJECT

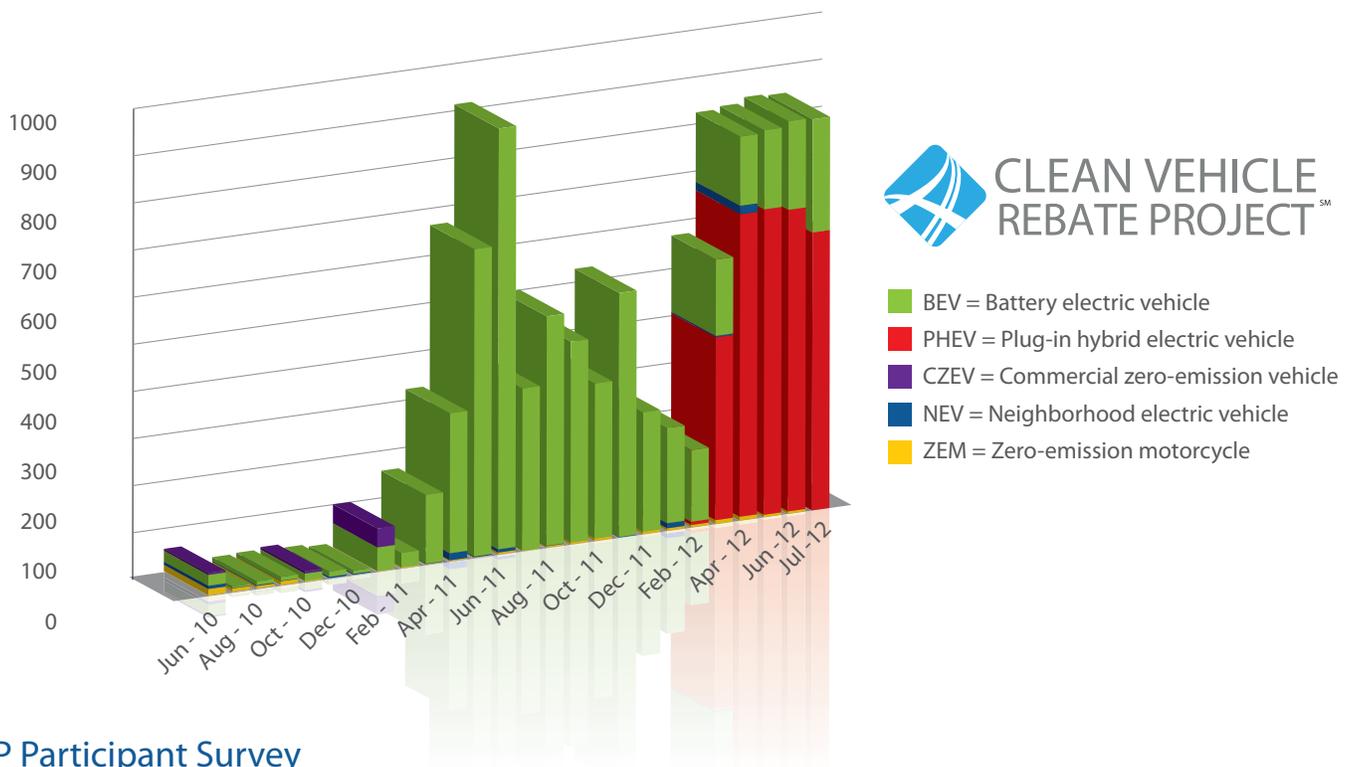
Overview

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.

Funding for CVRP is provided through the California Air Resources Board (ARB) 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 has managed the Project since launching the program in March 2010.

Approximately \$23 million in CVRP funds were distributed to more than 8,000 Californians from March 2010 to July 2012. Project funding for fiscal year 2012 – 2013 is expected to exceed \$20 million. Throughout 2011, the majority of CVRP rebates were distributed to owners of a single vehicle model, the Nissan Leaf. However, with the introduction and eligibility of plug-in hybrid electric vehicles (PHEVs) in early 2012, such as the low-emission package Chevrolet Volt and the Toyota Plug-in Prius, a greater level of vehicle and manufacturer diversity within the project was achieved.

Figure 10. CVRP rebates by vehicle type through July 2012



CVRP Participant Survey

The information gathered from respondents to the CVRP participant survey provides valuable data regarding first-adopter demographics, charging behavior, vehicle usage, consumer satisfaction and utilization of charging infrastructure. This information, as well as data gathered through follow-on surveys, will help California achieving its goal of bringing 1.5 million zero-emission vehicles to the state by 2025.

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.