

Plug-in Electric Vehicle Multi-State Market and Charging Survey

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Summary

To understand the PEV market and potential role of the utility companies in supplying electricity for both charging and ramping up the market, more than 4,000 PEV owners were surveyed. These owners included drivers of all major makes and models of PEVs in 11 states (not including California) and the District of Columbia. The survey focuses on the potential impact of the utilities on the ownership experience and includes sections on the purchasing decision, charging behavior, travel behavior, and household socio-demographics. The survey is supplemented by regional data on the local incentives, driving conditions, and market data. The results give a first look at the attitudes, beliefs, and perceptions of PEV owners with regard to the utility role in supporting PEVs and general perspectives on the market.

Keywords: consumers, cost, incentive, sales, utility

1 Introduction

A great deal of research has gone into studying the California market [1], likely as an outgrowth of concentration of plug-in electric vehicle (PEV) sales in California, particularly early sales. However, the California market only includes about 11% of total national vehicle sales. The progress and potential of this larger market for PEVs is the subject of this report. Among the 12 regions studied, there is significant variation in household income, vehicle models preferred, incentives offered, and attitudes towards the role of utilities. This document is one of the first to look at these variations using a single survey instrument of 4,396 PEV owners, making the results directly comparable across the 12 regions studied.

1.1 Plug-In Vehicle Market Background

The PEV sales in the US are strongly influenced by the supply of vehicles offered by the automobile manufacturers, as well as by state regulations and incentives that create wide regional differences in PEV adoption rates, PEV type preference and vehicle usage patterns. The Zero Emissions Vehicle mandate in California motivates automobile manufacturers to sell cars to avoid costly fines while the state incentives, in California and many other states, reduce the purchase price of PEVs. As of February 2016, total vehicle sales top 400,000 in the United States.

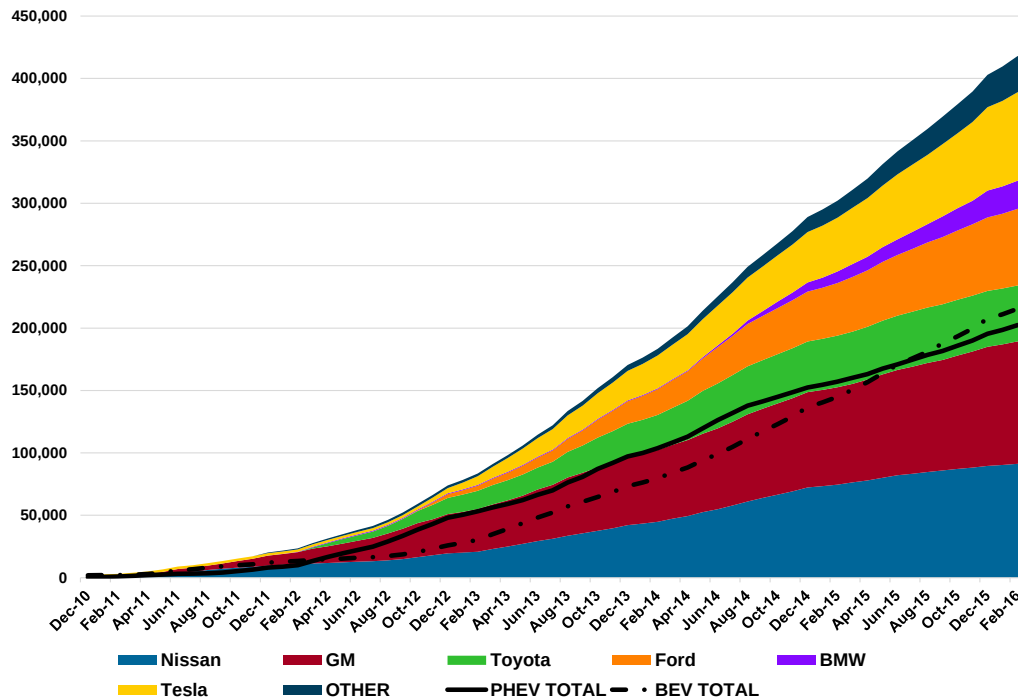


Figure 1: US PEV sales by make through February 2016.

1.2 Survey Tool and Sample

This report is based on a web-based survey developed by the UC Davis Plug-in Hybrid & Electric Vehicle (PH&EV) Research Center to collect data on actual and revealed preference using web-maps and vehicle choice modeling. The recruitment for the survey is based on 17,171 home addresses of PEV owners purchased from IHS Automotive which yielded 16,985 valid potential respondents after accounting for wrong addresses (primarily people who moved without a forwarding address) and households who don't own a PEV. 5,043 of the valid respondents started the survey by opening the recruitment letter and typing the web address and the starting code. An additional 9 users contacted UC Davis to schedule and ultimately complete a phone-based survey. The survey completion rate was over 82% of survey starts or 25.8% of the valid invited population and the median completion time was 25 minutes. Virginia had the highest response rate (32.2%) followed by Colorado (26.4%) and New York had the lowest response rate (22%). When comparing other factors, the people with the oldest model year (2011) had the highest response rate (30.1%), and Volt owners had the highest response rate of all vehicle types (28.9%).

The distribution of respondents by vehicle type and state in Figure 2 shows significant variation between the states. Michigan has a higher rate of Chevrolet Volt ownership that reflects the higher proportion of American cars in this state, while Georgia has a higher rate of Nissan LEAFs, most likely resulting from the strong state incentives which only applied to BEV purchases.

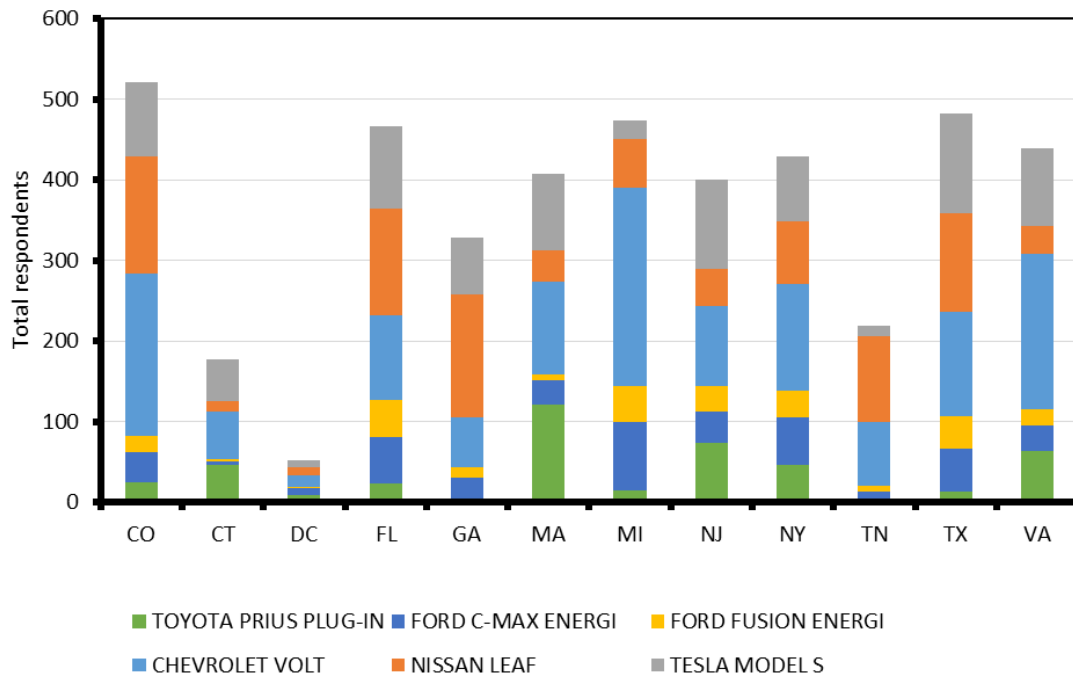


Figure 2: Respondents by vehicle type and state (sample size = 4396)

The IHS Automotive database reflects the fleet in the surveyed state for 2011–mid 2014. The response rate for all years was similar and the final sample had mostly 2013 cars with a small representation of older PEVs or recently purchased vehicles. The sample as presented in Figure 2 includes only Nissan LEAFs and Chevrolet Volts in 2011, with the Toyota Prius Plug-in and Tesla Model S added in 2012 and the Ford Energi vehicles in 2013. The Toyota Prius Plug-in sales dropped in 2014 and with it the response rate for this vehicle.

2 Plug-In Vehicle Owner Socio-Demographics

The early buyers of PEVs have different socioeconomic characteristics than the general population which is expected as new vehicle buyers in general have, for example, higher income than the general population. The median household income was \$150,000, with 9.0% of the PEV owners reporting income higher than half a million dollars per year and 13.8% who declined to state.

The PEV household income by state and vehicle type presented in Figure 3 reveal that Michigan owners have lower income per household at \$136,000 while New Jersey owners have the highest at \$227,000 per household on average. The median income per household reported for these two states in the 2012 US Census [2] is \$45,000 and \$72,000 respectively. While the income of new vehicle buyers is generally higher than the average income, PEV buyers may have an even higher income than conventional new car buyers. Tesla Model S owners, as expected from a >\$70,000 vehicle, have much higher average income than other PEV households ranging from \$300,000 and \$400,000 depending on the region. As one might expect, education levels of PEV buyers were also very different from the general population. 50% of PEV owners had at least a Masters' degree and only 2% didn't complete high school.

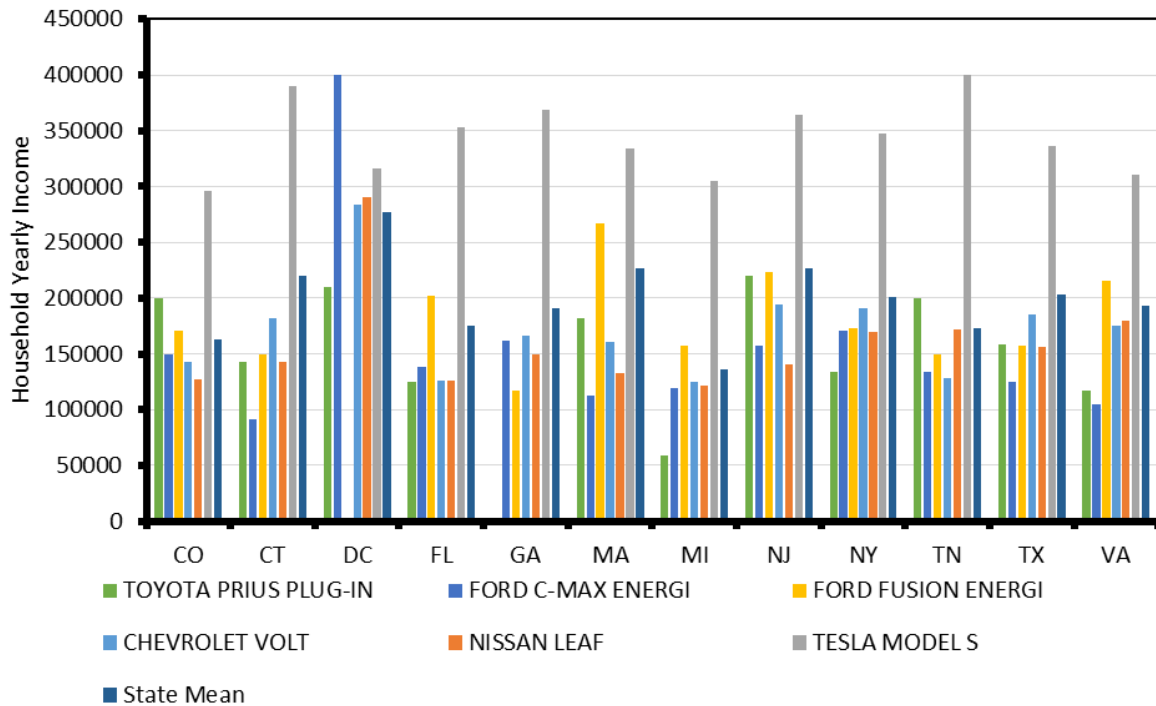


Figure 3: Household reported yearly income by state and vehicle type

3 The Role of Incentives

PEV buyers are early adopters who are willing to purchase or lease a car with new technologies and very little market history. They are also willing to pay higher prices relative to conventional technologies. Nevertheless, the total number of buyers who are willing to pay the full price of these vehicles without government incentives may be very low.

Survey respondents were asked, which incentives (of those available to the buyer) were not necessary to this purchase. Table 1 summarizes the results. The monetary incentives have the highest impact of all incentives. Workplace charging is the most important non-monetary incentive for all vehicles, though for Tesla it's less important and for the Toyota Prius Plug-in the charging benefit is strongly correlated with the parking benefit.

Table 1: Necessity of incentives by vehicle type

	Federal tax	State rebate	Local rebate	Workplace charger	Dedicated Parking	HOV	EVSE subsidy
TOYOTA PRIUS PLUG-IN							
Necessary	51%	11%	8%	15%	11%	11%	7%
Not Necessary	26%	10%	8%	17%	20%	17%	10%
Not Applicable	23%	79%	84%	68%	68%	72%	83%
FORD C-MAX ENERGI							
Necessary	58%	12%	6%	13%	7%	9%	11%
Not Necessary	26%	14%	7%	23%	26%	18%	16%
Not Applicable	16%	74%	87%	64%	66%	73%	73%
FORD FUSION ENERGI							
Necessary	52%	9%	8%	17%	6%	11%	9%
Not Necessary	22%	14%	7%	25%	32%	20%	15%
Not Applicable	26%	77%	85%	58%	62%	69%	76%
CHEVROLET VOLT							
Necessary	67%	16%	4%	15%	7%	7%	14%
Not Necessary	18%	12%	8%	32%	31%	23%	25%
Not Applicable	15%	72%	88%	54%	62%	70%	62%
NISSAN LEAF							
Necessary	71%	33%	3%	19%	7%	8%	17%
Not Necessary	16%	15%	8%	31%	39%	32%	28%
Not Applicable	13%	52%	89%	49%	55%	61%	55%
TESLA MODEL S							
Necessary	49%	15%	2%	7%	7%	8%	5%
Not Necessary	47%	21%	8%	32%	36%	31%	17%
Not Applicable	4%	64%	90%	61%	57%	60%	77%

4 Driving Behavior

The yearly mileage driven was estimated based on the odometer reading reported by PEV owners divided by the number of months since buying the car multiplied by 12. Figure 4 shows the driving intensity per model and model year for vehicle/year combinations with a sample size larger than 40. Nissan LEAF owners reported a driving intensity of about 9,600 miles per year and the longer-range Tesla Model S has a driving intensity of 12,000 miles per year.

The limited range of the BEVs is only one limiting factor for the vehicle use. Lease agreements with limited yearly miles may also reduce the annual mileage, for both BEVs and PHEVs, when the penalty costs of driving over the lease agreement mileage limit pushes users to other cars in the household. A leased Chevrolet Volt, for example (Figure 5) is driven 2,800 fewer miles per year than a purchased Chevrolet Volt. This trend is similar for all PHEVs but is reversed for the Nissan LEAF. It is unclear from the survey results why this difference between leased and purchased Nissan LEAFs occurred, but based on other studies the researchers have two hypotheses. First, concerns about battery life may reduce the miles driven for drivers who expect to own the vehicle for a long time. Second, it is possible that the mileage difference reflects self-selection

since households who plan to drive less purchase the Nissan LEAF in order to have it for a longer time while leasers plan on a shorter ownership period with higher miles.

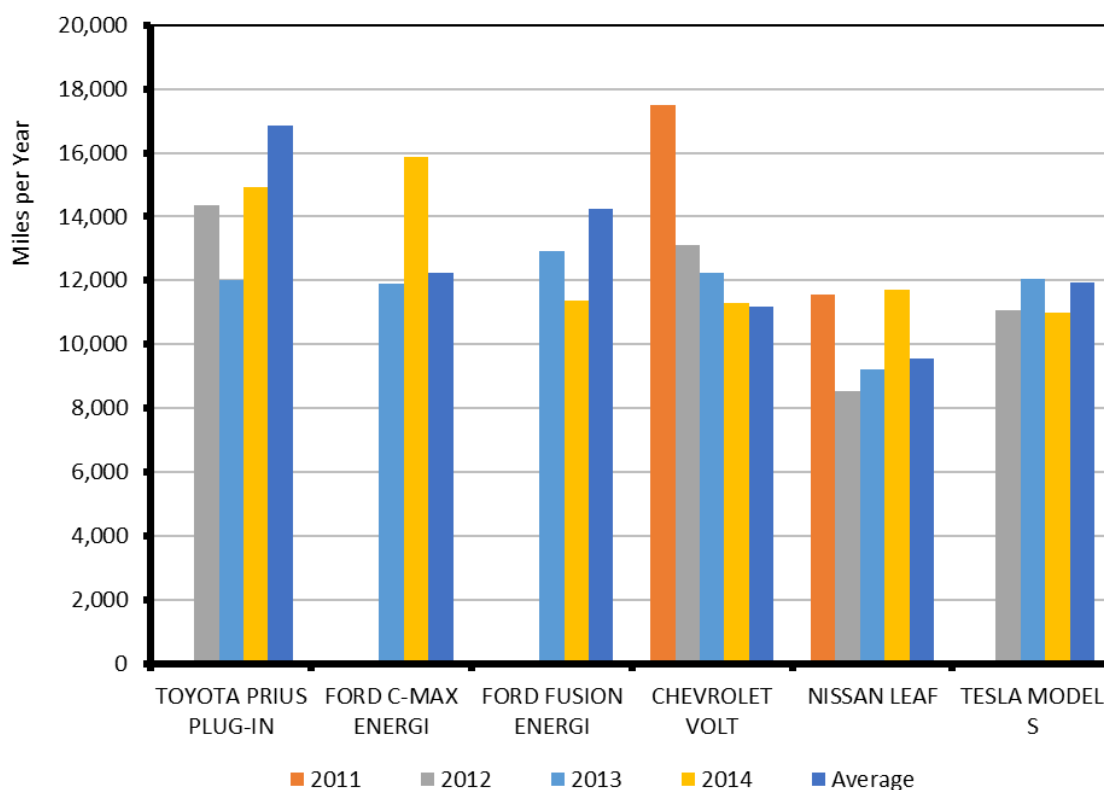


Figure 4: Yearly miles per vehicle and model year

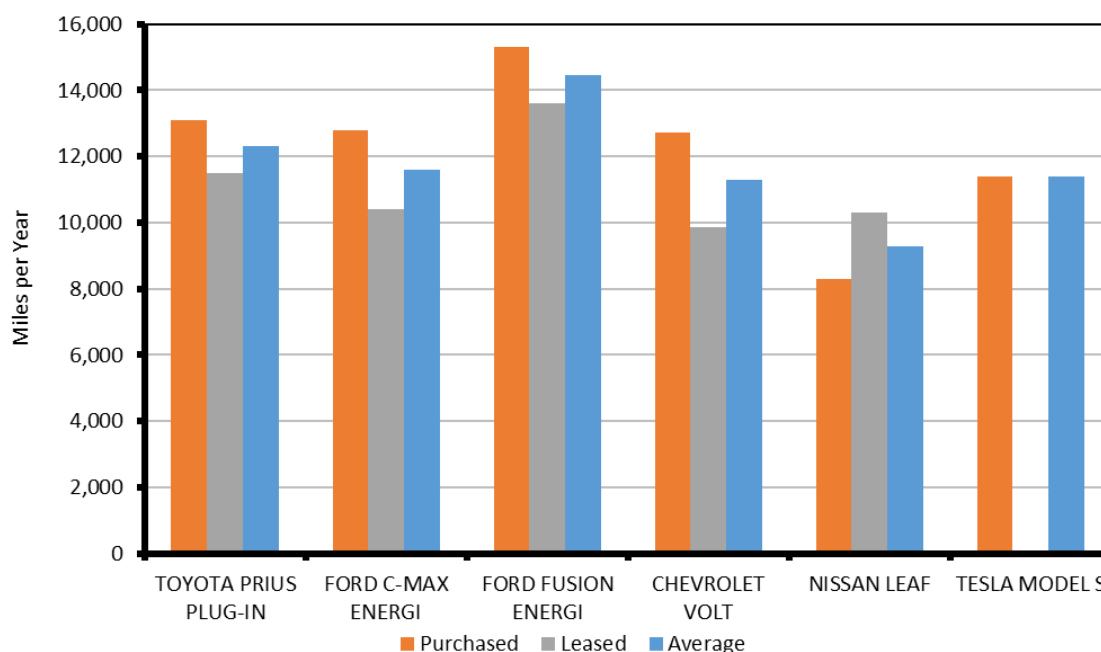


Figure 5: Yearly miles per vehicle by purchase category

Of the PEV owners surveyed, 59.5% commute regularly with their PEV. The number one commuter is the Nissan LEAF (65%) while only about half of the Ford C-MAX owners commute with their car.

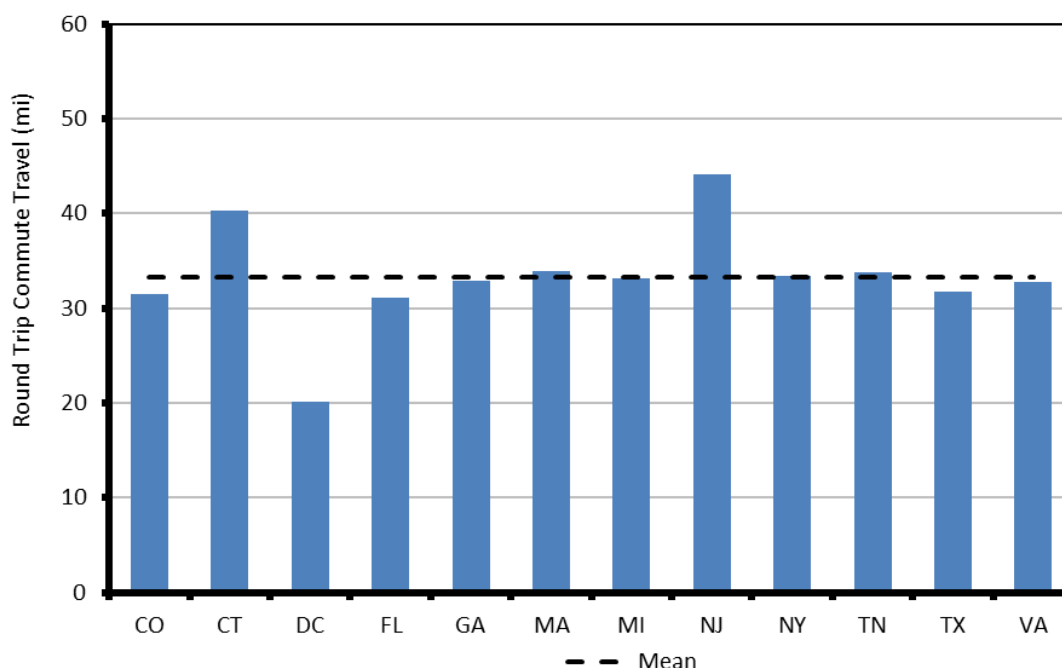


Figure 6: Daily commute travel by state

Location also has important impact on PEV commute share as almost 70% of the Virginia and Georgia owners commute with their car. In DC, only 49% of the owners commute by car as many likely commute by transit. The 52% commute share measured in Florida may reflect an older population (average age of survey despondence in Florida is 59 vs 56 sample average) of PEV owners with lower commute needs (Figure 6).

5 Charging Behavior

Very few PEV owners who finished the survey reported that they are not plugging in their car (at least once in the last 30 days). More people may not charge their vehicle, but they may be less likely to start and complete a long survey. Most users (57%) report charging only at home while 40% use home and public locations including work charging (Figure 7). 2% of the users use only public charging either as a result of having no charging option at home or due to public charging being free and sufficient for their travel needs.

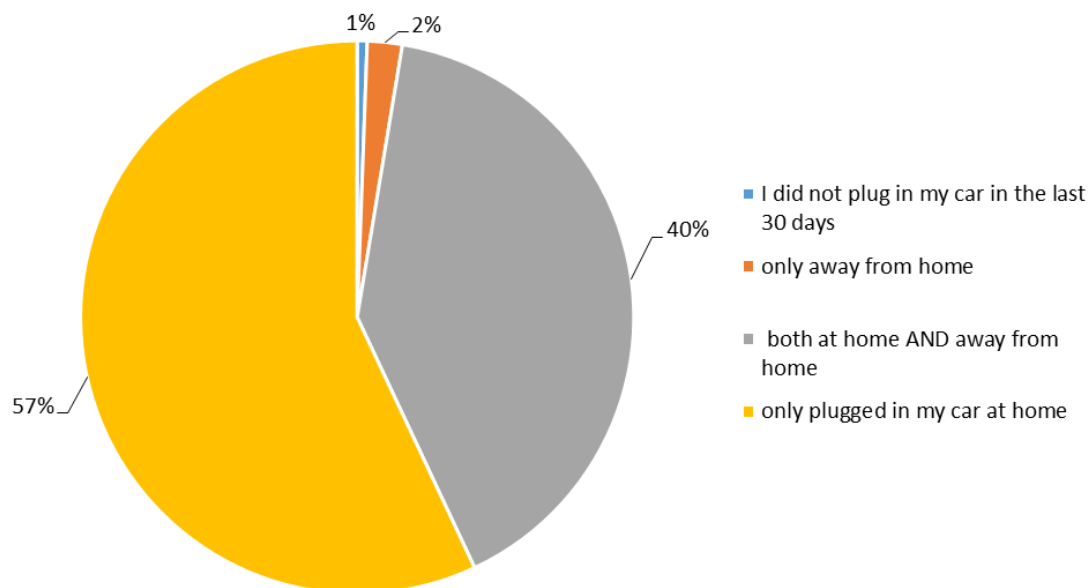


Figure 7: Charging location (last 30 days)

Teslas had the greatest time away from home. Probably due to their free charging network- but even with that taken into account, 49% only plugged in their car at home.

Home charging is the main charging option for most users but the rate varied from 1 to 9 kW. Half of the respondents report using Level 2 (240V) at home, although most of those are the Nissan LEAF and Tesla Model S owners. Of drivers using 120 V charging at home, most left the convenience cord at home plugged in at all times, precluding the chance to use it in public. Most users start charging right away when they plug in the vehicle but about 20% use a timer to shift load to off peak hours. There is a high correlation between use of a timer and being on a time of use (TOU) rate. 35% of the households on a TOU rate use a timer at home, as expected, but at the same time 13% of the flat rate users did so without any financial benefit.

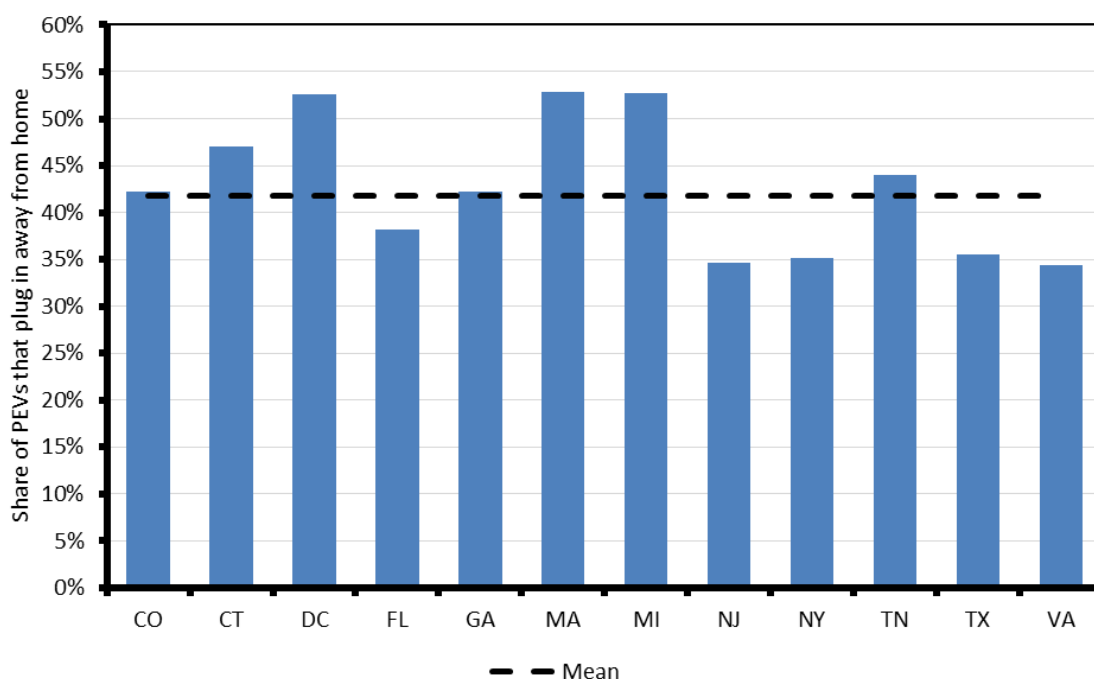


Figure 8: Share of plug-in vehicle that used away from home charging in the last 30 days

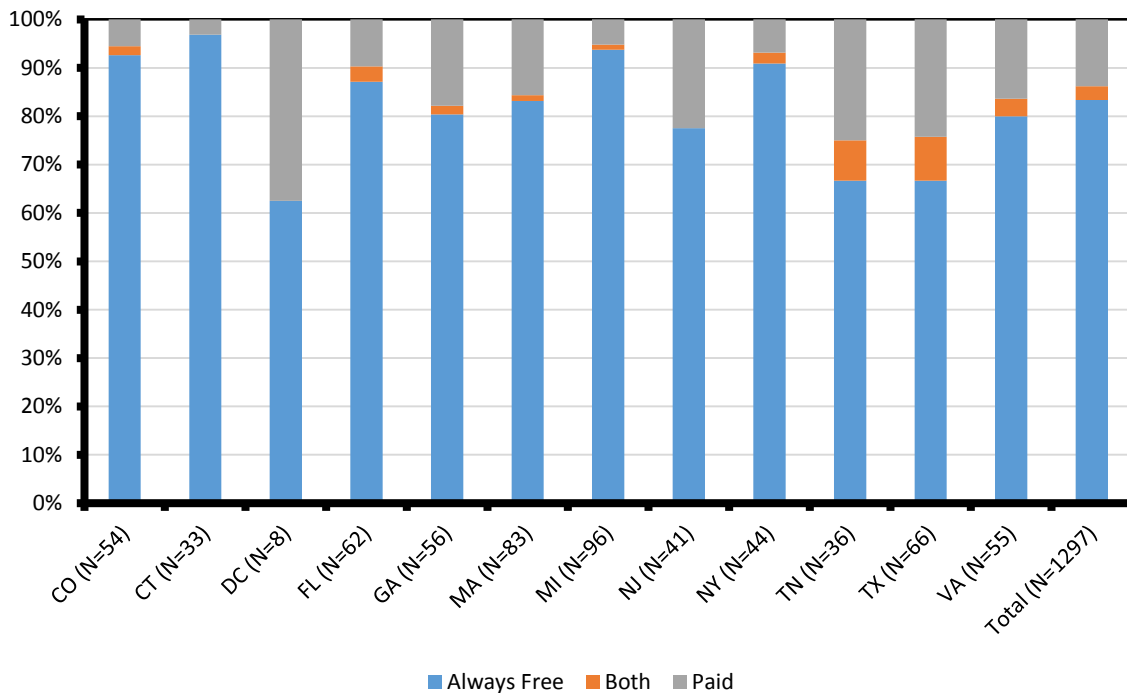


Figure 9: Is your charging Free?

More than 63% of public charging in the US are free of charge[3] but in each state some portion is paid and we expected this share to grow with the PEV market. States that were part of the EV Project or similar Federal funded charging infrastructure tend to have more paid workplace charging while states where workplace charging was mostly installed by employers have higher rates of free charging. Washington DC shows high level of paid charging (Figure 9) but the sample is too small to draw conclusions.

6 Utility Role

The utility companies had very low impact on the purchasing decision for PEV owning households (Figure 10). Only 5% responded in the affirmative to the question of whether their utility company had any role in purchasing their PEV, and of that 5%, almost half of those used the utility website while others used more traditional venues such as brochures or phone.

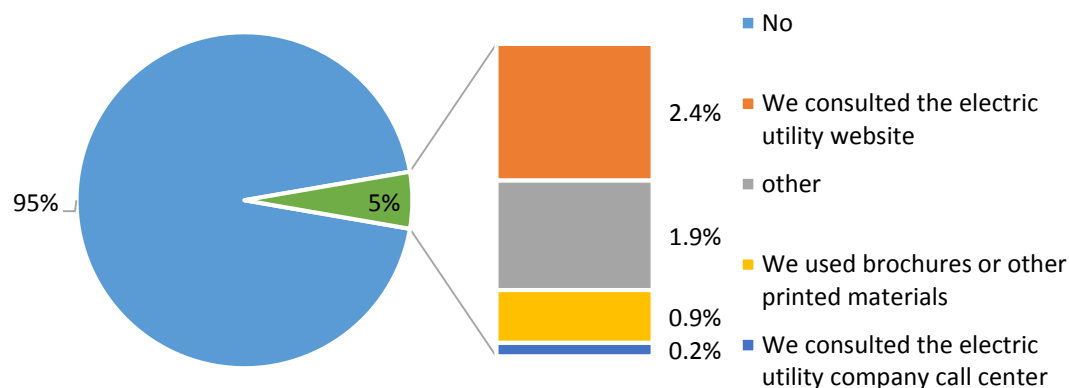


Figure 10: Did your utility company have any role in purchasing your plug-in vehicle?

The survey indicates that utility companies contact 2.9% of the PEV buyers after purchasing their car. The primary reasons for contact were to offer better rates and subsidies for EVSE. Just 6% of the PEV owners (175 households) reported that they have a separate meter for the PEV. The survey found that most customers are on a flat rate while 18% are on a time of use rate. Even among PEV owners, 16% don't know their rate structure. 3% of respondents or 79 households use the EV rate for the whole household, although these responses may consist of few actual cases and may include reporting errors.

PEV buyers see a much more active role for the utilities in two main locations: home and public charging. The users see the role of the utility in education and helping to optimize their usage. To reduce cost they also look for help in charger installation both at home and in public locations, however only 40% of PEV owners asked their utility about options for discounted electricity. Despite the fact that only 36% identified public charging as a role for utilities (Figure 11), a separate question on who should install public charging indicates that utilities are among the parties most expected to have a role in installing public chargers. Furthermore, a majority of respondents would rather see the utility broker demand response versus a private entity.

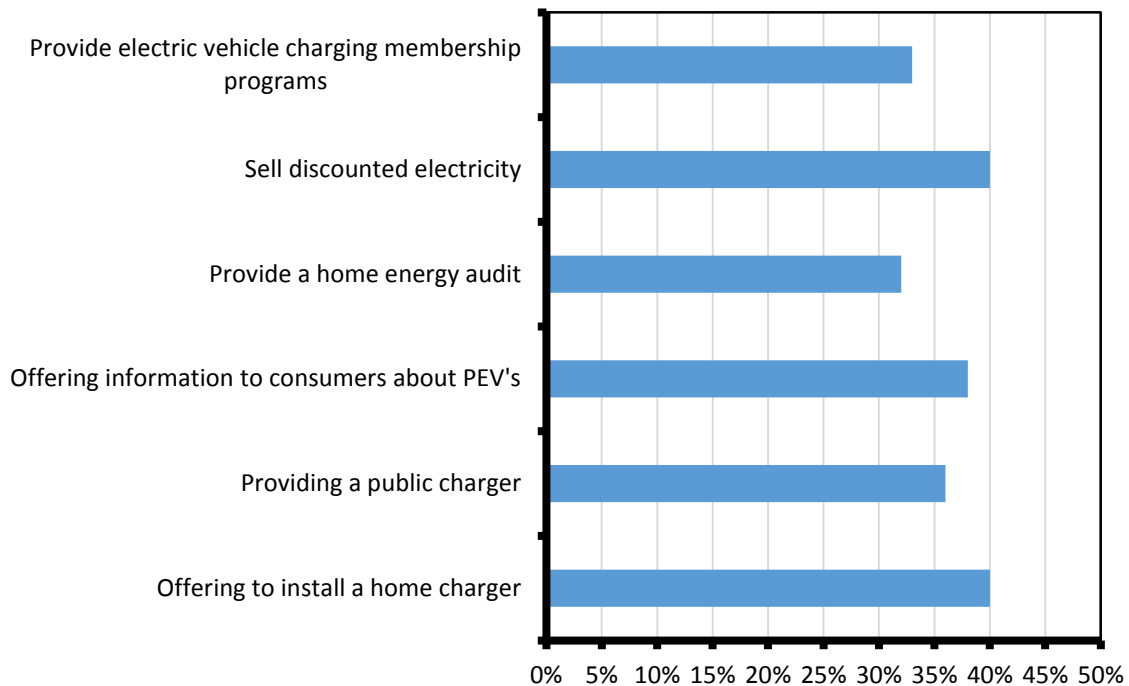


Figure 11: Should any of the following be the role of the utility company?

7 Conclusions

The growth of the PEV market poses an opportunity and a potential challenge for utility companies. Early adopters studied in this survey are not likely to contact their utility company when buying a PEV and are in most cases going to charge their vehicle when arriving at home in the afternoon or late evening. Free public charging is also expected to shift users to daytime charging as demonstrated by users who are not charging at home even with the current nascent public charging network. The demand for electricity due to PEV charging will likely be small in the near future but with market growth and a potential shift to bigger batteries and faster chargers, PEVs without load management may significantly add to demand at specific locations and times.

Incentives played a large role in the purchasing behavior of PEVs. The federal incentive was applicable to all and was the most important of all the incentives. In some states such as Georgia, the large state incentive for BEVs was very important as well. The importance of incentives differed by vehicle model and vehicle preferences differed by region. Currently, only a very small percentage of respondents indicated that the utility played a role in their purchase decision. About 60% had flat rate pricing and 18% had time of use rates, leaving 16% of PEV owners in this survey who did not know what type of electrical rate they used. As most PEV households were not educated on best practices, utilities and users can benefit from such a program, including ways to shift loads to off-peak hours by offering demand response and education to users on timer usage.

While current PEV buyers did not interact much with their local utility, they do envision a few roles for the utility in charging infrastructure. At home they would like better guidance on how to optimize their usage to reduce their bills. Approximately 40% also see a role for the utility to install EVSEs at home and in public. Lastly a majority of respondents would rather see the utility broker demand response versus a private entity. All of this indicates that utilities may play an important role in ramping up the PEV market by educating potential buyers on the benefit of electric driving and by supporting public charging infrastructure.

References

- [1] Tal, Gil and Michael A. Nicholas (2013) Studying the PEV Market in California: Comparing the PEV, PHEV and Hybrid Markets. [*EVS27 International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium*](#), 1 – 10.
- [2] http://www.socialexplorer.com/tables/ACS2012_5yr/R10824208
- [3] <http://chargedevs.com/newswire/free-fuel-over-63-of-public-pev-charging-stations-in-the-us-are-free-to-use/>

Authors



Jamie Dunkley is a Data Analyst/Scientist at EPRI. She received her BS in Environmental Engineering at MIT and her Masters and PhD in Civil and Environmental Engineering at Stanford University. Her current projects include transformer loading analysis, electric vehicle tracking studies and mapping current and future electric vehicle charging infrastructure.



Dr. Tal works primarily within the Plug-In Hybrid & Electric Vehicle (PH&EV) Center, in the Institute of Transportation Studies at University of California Davis. His Recent work focuses on exploring the overall demand for EVs in the United States and China. Dr. Tal contributing significantly to the siting and design of electric vehicle (EV) charging stations in California, and the impact of infrastructure on EV performance. As part of this research, Dr. Tal has produced methodological innovations in on-line travel surveys and in EV charging location modeling that include GIS-based tools that are used by state and regional planners in California and other states.