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# First Look at the Plug-in Vehicle Secondary Market

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# FIRST LOOK AT THE PLUG-IN VEHICLE SECONDARY MARKET

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**Abstract**

In most markets in the world there are very few used PEVs. California is one of the first markets to have a significant secondary market - about 5-8% of the almost 200,000 PEVs in California are being used by a second owner. Looking at the market for conventional vehicles, used vehicle sales comprise the clear majority of all transactions while the new vehicle buyers are a small share of the households, making used PEV sales potentially very significant on the market as a whole. As the number of used PEVs grows, the secondary market for PEVs will have an increasing effect as used PEV buyers join new buyers in adopting a new technology.

Can these used vehicles provide environmentally friendly choices to those who do not buy new vehicles? Is range degradation an important factor in the use and purchase of the vehicles? Do the subsidies provided by State, Federal and local authorities pass to the second owner and by how much? This report explores the used PEVs in the market and the motivations behind their purchase and use.

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## Contents

## 1. Background

1.5 million zero-emission vehicles, most of them plug-in electric vehicles, are planned to be on California roadways by 2025. 1.5 million zero-emission vehicles, most of them plug-in electric vehicles, are planned to be on California roadways by 2025. This translates to 1.5 million sales of new vehicles and almost the same number of households purchasing and using a PEV between 2010 and 2025. This encompasses households that purchase a new PEV and drive it for many years as well as households who purchase or lease more than one PEV over the years. Some households will purchase their second or third new PEV while others will buy the used vehicles coming into the market, enjoying the lower price, but lacking some of the incentives available to the new vehicle buyers. In the general car market, two-thirds of all U.S. vehicle purchases are for used vehicles (Edmunds, 2013). Households that purchase their first PEV (whether it is new or used) are incorporating new technology into their life and are part of the social diffusion of the plug-in vehicles in the state. PEV owners with older vehicles, whether purchased new or used, are expected to have reduced performance and effective electric range. On the other hand, they may displace less efficient internal combustion engine (ICE) vehicles used by lower income households.

A relatively defined set of households who purchase new vehicles in California will be the engine of the ZEV deployment, leasing or buying not only the first PEVs, but a second or third PEV in the coming decade, and accelerating the used PEV market. Not every household buys or leases a new vehicle - according to the 2012 Caltrans survey and the 2009 NHTS survey, two thirds of the households surveyed did not purchase a new vehicle in the last 5 years. Some in this group did not purchase any new vehicle and others did it in longer intervals than 5 years. Based on the household current fleet we know that 7% of households purchased 2 or more new vehicles in the last 5 years, which make this group responsible for up to one-third of the new vehicles sold (Figure 1).

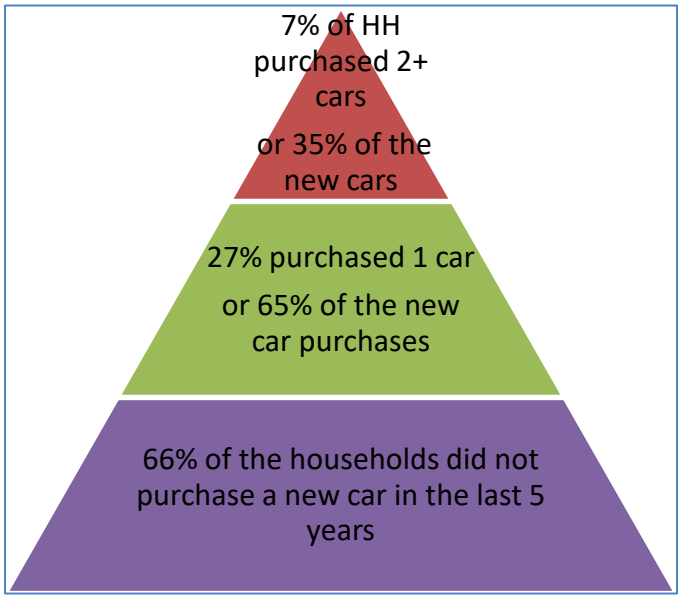


**Figure 1:** New-vehicle-buyers in California

In our 2015 survey that samples the first 5 years of PEV adopters in California we found that about 23% of the households who purchased a 2015 model year PEV are doing it for the second time. Of those, 12% have two PEVs now (In Figure 2, "Have 2+ PEVs") and 13% moved to the secondary market (In Figure 2, "Had a PEV").

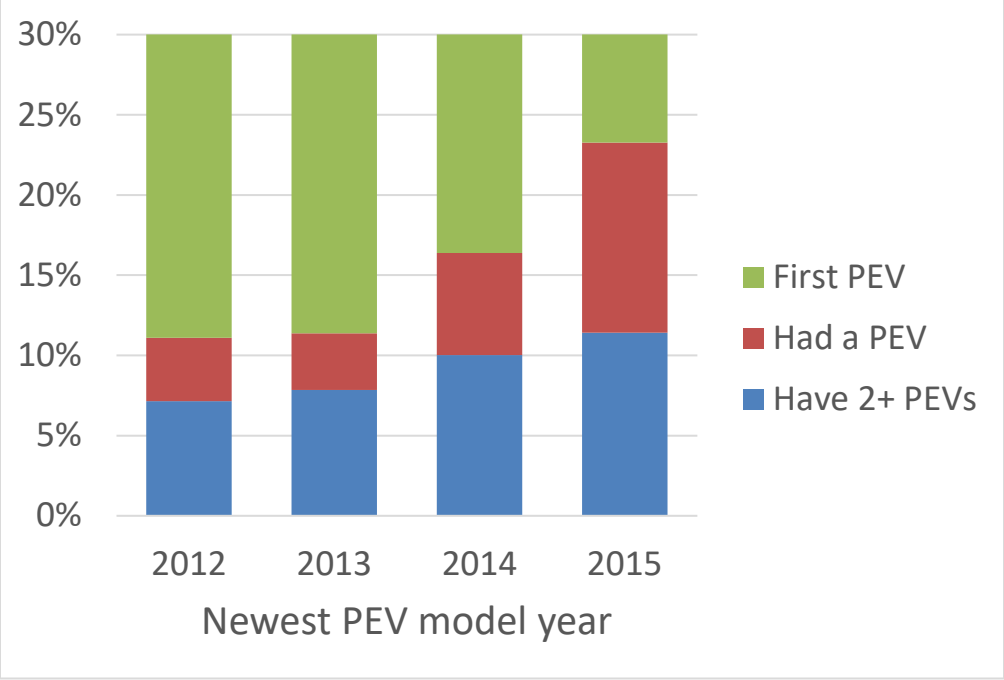


**Figure 2:** Current new PEV Buyers in California by model year

The multi-vehicle buyers, along with the two and three-year lease promotions, are expected to ramp up the market by purchasing a second and third plug-in vehicle and subsequently create a used market by selling their older vehicles. Using the same Californian sample of the 2009 national household travel survey, we expect that about a third of the PEVs will be sold within 5 years of purchase and more than 17% of the PEVs will be sold within 2 years of purchase to second owners.

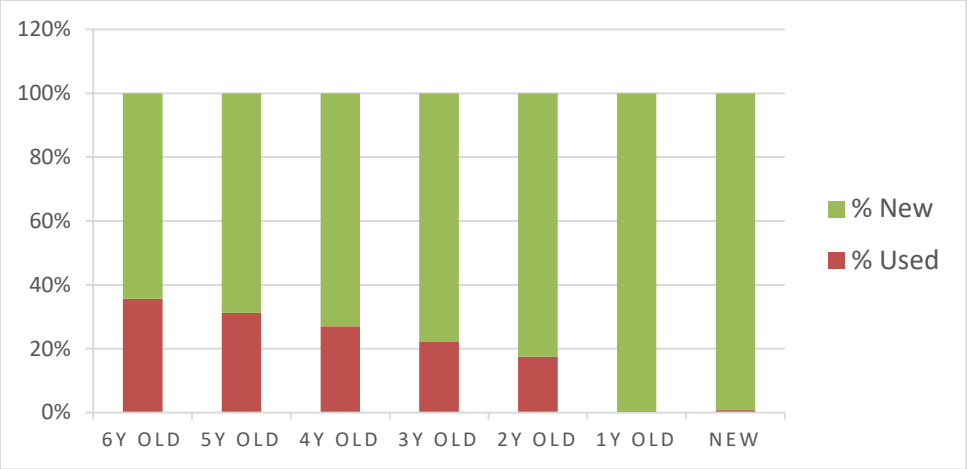


**Figure 3:** Ownership Status by Model Year

In the case of PEVs, we expect higher sales rates than the 2012 survey ICEs resulting from the higher income of the purchasing households PEVs. The buyers of used vehicles face different costs, incentives, and in many cases, exhibit different socioeconomic characteristics. Nevertheless, there are many households that do not purchase new vehicles and have incomes similar to new vehicle buyers as described by the blue line (66% of all households) in Figure 4.

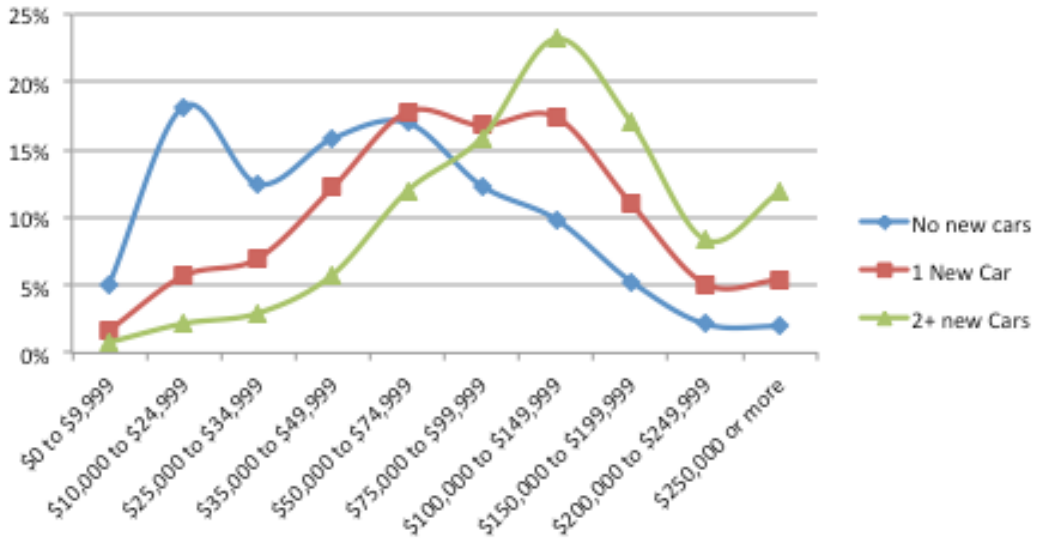


**Figure 4:** Income level of used PEV households by number of new vehicles purchased in the last 5 years

Based on the DMV records from the first half of 2016, we estimate that about 14,000 PEVs were already purchased by a second owner in California, not including second owners who had the vehicle for fewer than 6 months and leasers who purchased their vehicles.

## 2. Literature review

California had one of the first substantial plug-in electric vehicle markets in the world starting in 2011, and therefore the first substantial secondary market starting in 2015. There is no literature on the plug-in vehicle secondary market but we identified several papers that focus on the alternative fuel vehicle secondary market, mainly hybrids, that look at resale value, consumer preference, and the impact on the new market.

The residual value of plug-in cars is a function of consumer perception on reliability and durability as discussed by the national academy report (Brenna et al., 2016) and demonstrated using stated preference survey by Bühler et al. (2011). The secondary market is also heavily impacted by the subsidies and incentives for new vehicles and the impact of similar policies. Studies on the depreciation cost of hybrid vehicles show lower depreciation than regular cars in Japan (Iwata et al., 2016), as well as lower depreciation for vehicles branded as green compared to unbranded hybrid vehicles (i.e a hybrid version of a conventional vehicle) (Majid et al., 2015). Gas prices also have an impact on the secondary market as the change in gas prices in the period between the

original purchase and the secondary purchase reduce the demand for fuel-efficient vehicles (Busse et al., 2013).

The residual value of the vehicles has a strong impact on the ability of the original owner to buy a second plug-in vehicle, according to Fudenberg and Tirole (1998) Furthermore, Benmelech and Bergman (2009) demonstrate the impact of the residual value on wide market when used as collateral. The secondary market influencing the OEMs depends on the durability of the product, as shown by Chen et al. (2013).

Incentives and taxes on the original owner have an impact on the residual value. They may lead to a future increase in the supply of used cars on the market and may bring reduction in prices of used cars as demonstrated by Noparumpa et al. (2016). This reduction in price can affect the economy in several ways. Owners of cars suffer damage to their "car equity," as lower resale prices translate into erosion of collateral value. Additionally, car manufacturers may suffer as the presence of used cars affects the pricing ability and sale of future models.

## 3. Research Method

This report is based on an online survey designed and conducted at the UC Davis PH&EV Center. We used DMV records to identify potential used PEV owners and recruited them by mailing a letter with a link to the survey.

### 3.1. SURVEY TOOL

The survey includes questions on household socio-demographic factors, household fleet (Figure 5), and vehicle purchase questions including questions that will allow owners of PEVs to indicate their vehicle preferences (for example: EV range, charging speed, BEV/PHEV, size) and the willingness to pay for those characteristics.

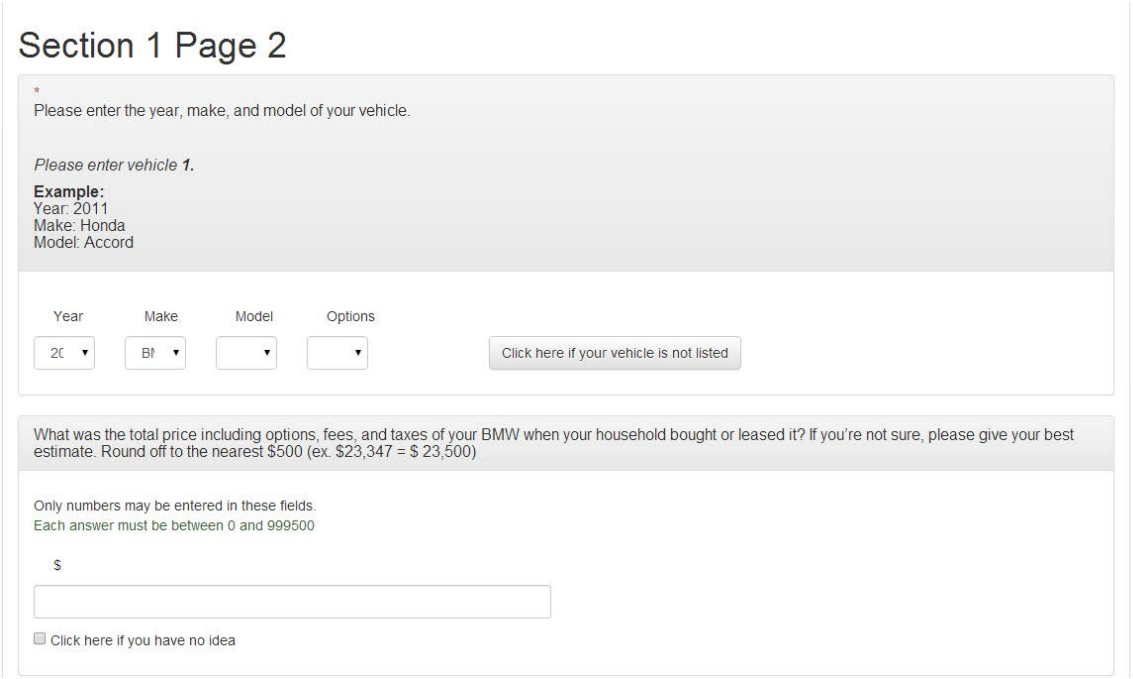


**Figure 5:** Vehicle Selection Survey Tool

We used a web-map survey tool (Figure 6) to collect data on travel behavior and charging activity, both actual and preferred, including the use of HOV lanes. The web-map survey allows users to indicate their origins, destinations, and preferred routes and to indicate preferred charging locations.

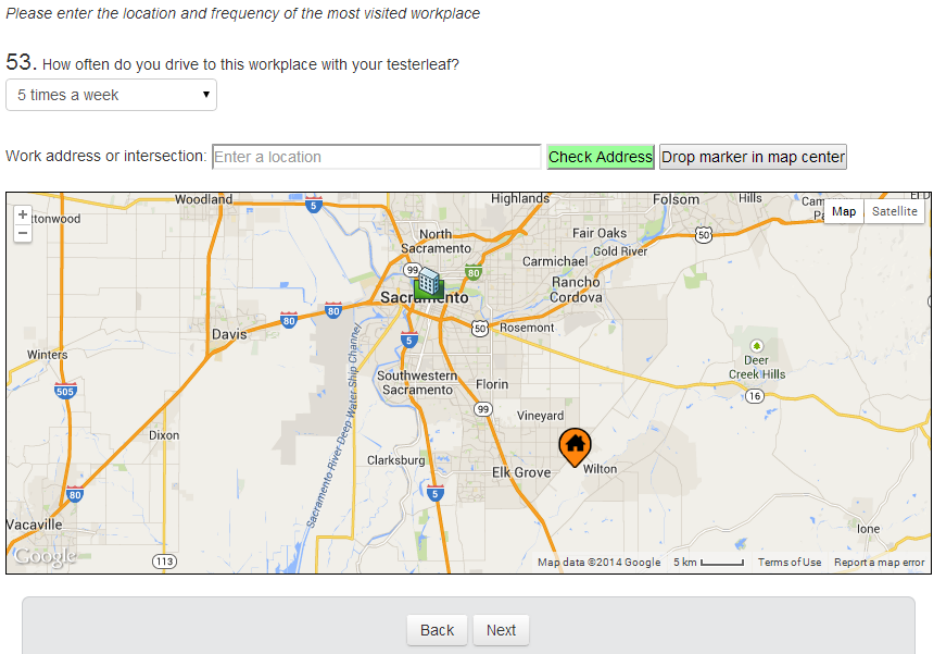


**Figure 6:** Web Map Survey Tool

The survey includes skip-logic to maximize the collected data with minimum survey burden. The questions are based on vehicle type, charging type and vehicle use. Questions on the vehicle purchase process are split based on private party purchase or dealer purchase and based on first time PEV buyers vs. second-time owners.

### 3.2. Survey Sample

Using DMV data from April 2016, the California Air Resources Board constructed a potential population of all used PEV owners in California who had registered a "used" PEV to their household. Potential used PEVs were identified if the vehicle had been transferred more than once and it had an odometer reading greater than 5,000 miles. Over 14,000 potential used PEVs were identified. We sent invitation letters to a randomly selected subsample of 4,700 households. Of those, we had 183 letters that returned because of address problems and 913 who started the survey. 27.6% of the people who started the survey indicated that they don't have a used PEV – in most cases because they purchased or leased the vehicle new and the DMV title transfer did not reflect ownership change. Based on the survey response, who indicated that they are not owners of used PEVs, we estimated that the starting population of used PEVs is about 10,130 households. Out of the valid starts, 82% completed the survey generating 602 usable surveys as described in Figure 7 and 8.

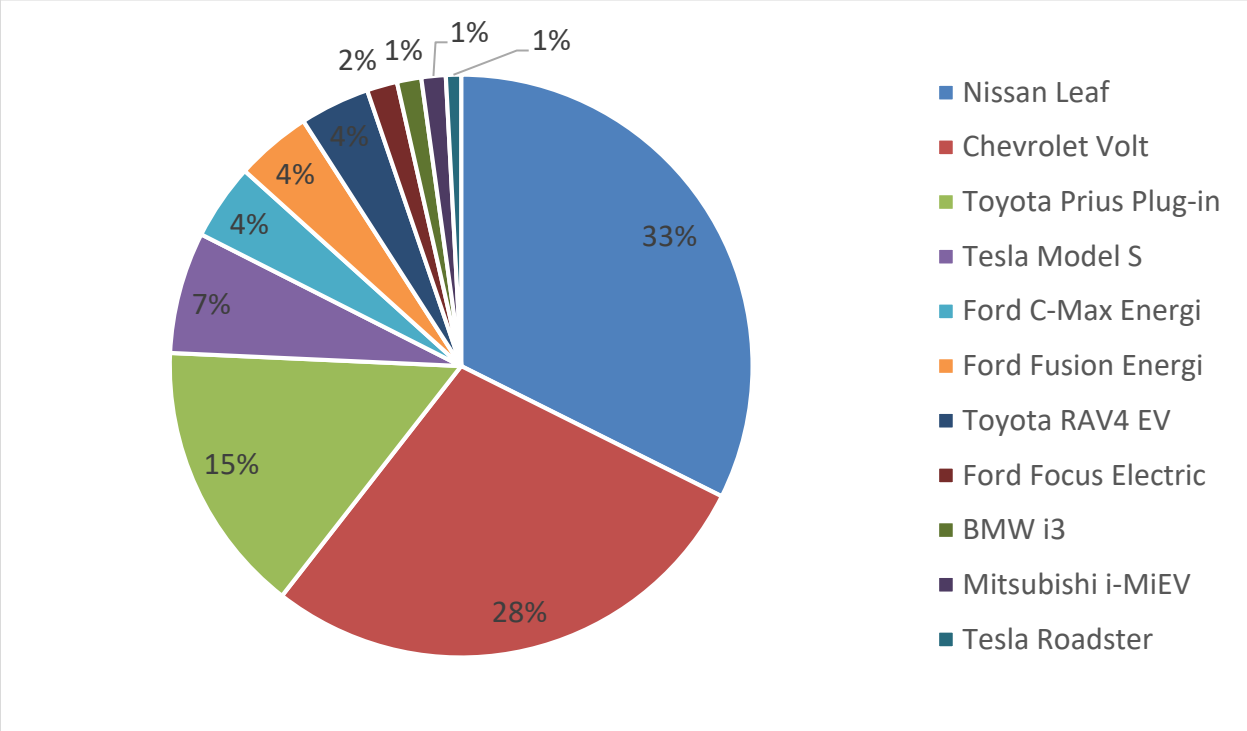


**Figure 7:** Used PEV surveys by vehicle model

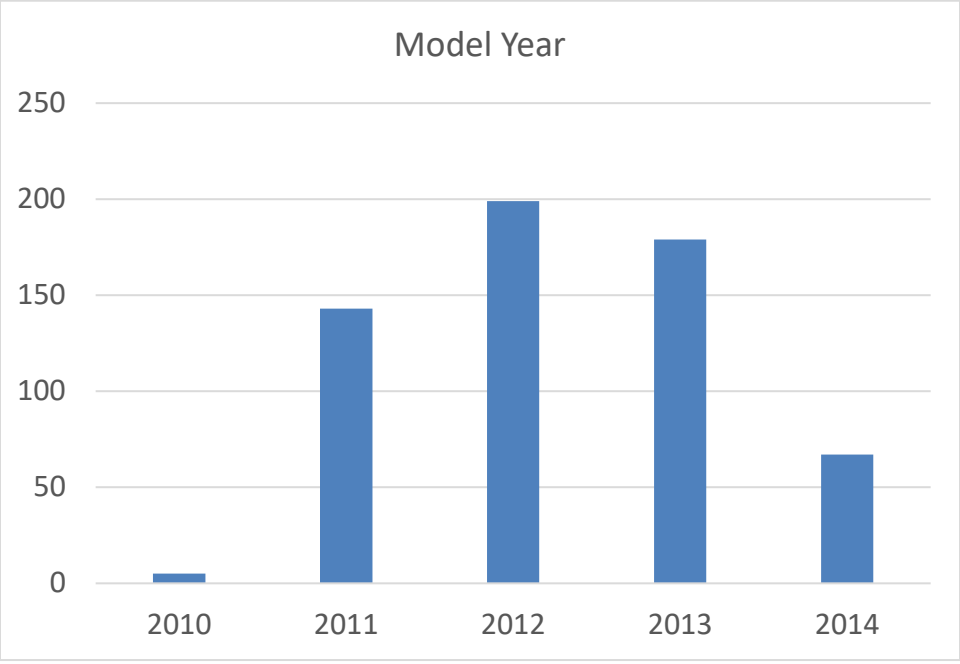


**Figure 8:** Used PEV surveys by model year

Most of the households in the survey owned the vehicle more than 6 months with an average of 15 months and therefore represent mostly buyers in 2015.

### 3.3. New PEV Comparison Sample

To estimate the price paid for the PEVs purchased new, we use 2014 and 2015 new PEV buyer surveys conducted by our PH&EV center. The surveys allow us to estimate the actual price paid for those vehicles before and after incentives including the incentives that may be paid up to a year after the vehicle purchase such as the state CVRP and the federal tax credit. We used a total of 5,227 purchased vehicles (see Table 1) to estimate both the price of the used vehicle purchased when it was new and the alternatives the used vehicle buyer had when purchasing the vehicle (i.e. what was the price of the same model but not the same year at time of purchase)

*Table 1: New PEV Sample*

| **Model and Year** | **New PEV sample** |
|---|---|
| BMW i3_2014 | 175 |
| BMW i3_2015 | 26 |
| Chevrolet Volt_2011 | 55 |
| Chevrolet Volt_2012 | 109 |
| Chevrolet Volt_2013 | 451 |
| Chevrolet Volt_2014 | 370 |
| Chevrolet Volt_2015 | 39 |
| Ford C-Max Energi_2013 | 235 |
| Ford C-Max Energi_2014 | 149 |
| Ford C-Max Energi_2015 | 15 |
| Ford Focus Electric_2012 | 17 |
| Ford Focus Electric_2013 | 41 |
| Ford Focus Electric_2014 | 86 |
| Ford Fusion Energi_2013 | 115 |
| Ford Fusion Energi_2014 | 239 |
| Ford Fusion Energi_2015 | 27 |
| Mitsubishi i-MiEV_2012 | 16 |
| Nissan Leaf_2011 | 94 |
| Nissan Leaf_2012 | 150 |
| Nissan Leaf_2013 | 546 |
| Nissan Leaf_2014 | 233 |

| | |
|---|---|
| Nissan Leaf_2015 | 107 |
| Tesla Model S_2012 | 81 |
| Tesla Model S_2013 | 388 |
| Tesla Model S_2014 | 232 |
| Tesla Model S_2015 | 34 |
| Toyota Prius Plug-in_2012 | 262 |
| Toyota Prius Plug-in_2013 | 244 |
| Toyota Prius Plug-in_2014 | 455 |
| Toyota RAV4 EV_2012 | 51 |
| Toyota RAV4 EV_2013 | 76 |
| Toyota RAV4 EV_2014 | 109 |

# 4. Results

## 4.1. Used PEV Residual Value

The resale value of used PEVs is a very important factor for the success of the PEV market. OEMs, lease companies, and private owners who plan to buy the next new vehicle strive for high resale value while potential buyers of the used PEVs compare the price to new subsidized PEVs or lower priced ICEs and constantly look for lower prices. Figure 9 describes the up to 6 different price points for the same model and year, in this case a Chevrolet Volt. The first bar is the full price paid for the vehicle based on the average price reported on the new buyers' survey. The second bar represents the MSRP as reported by the OEM and the third is the final price based on the average original price paid minus the reported incentives. The blue bars are based on the used buyer survey based on the purchasing year and reflect the vehicle's age at purchase and other factors such as the limited supply of vehicles purchased used in early years.

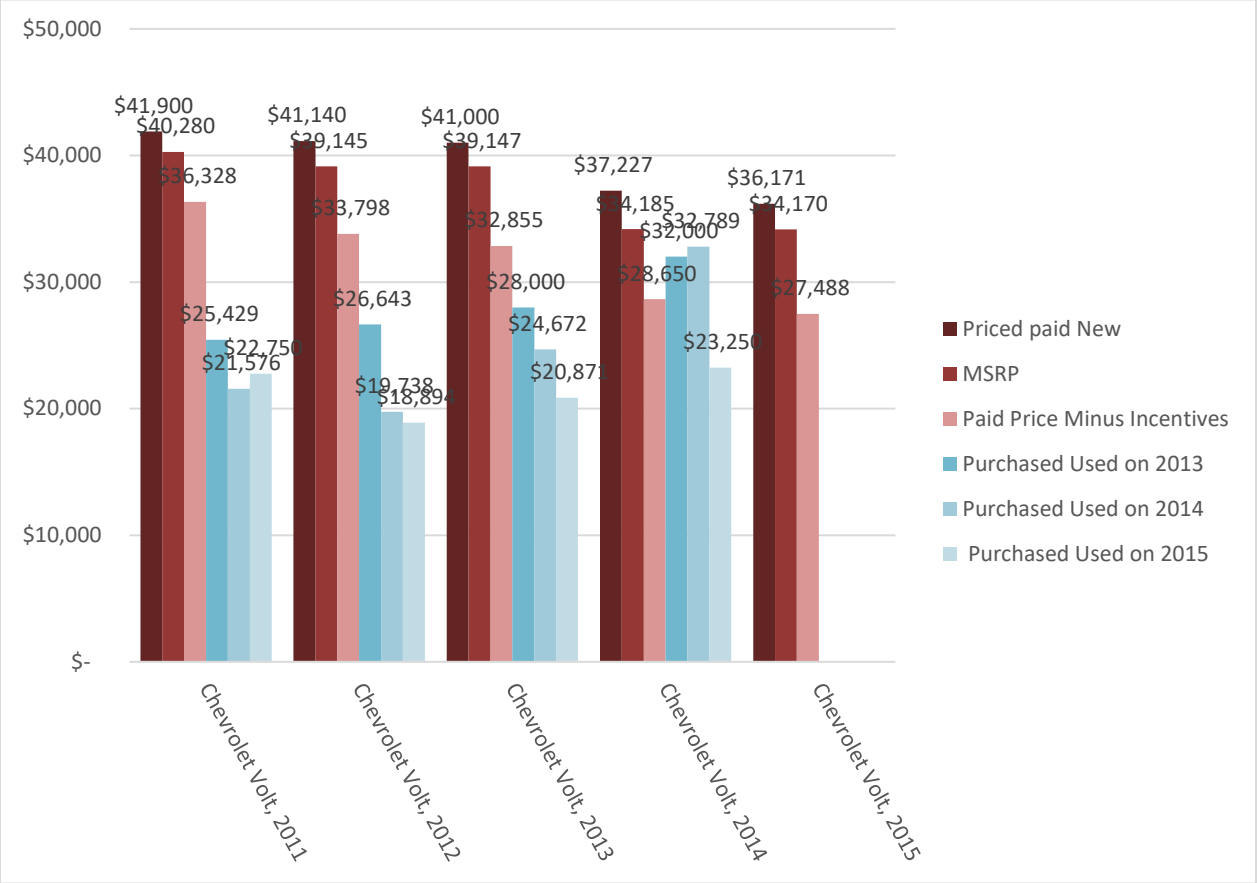


**Figure 9:** Chevrolet Volt price as new and used

Having up to six price points for each vehicle allows us to calculate the average residual value for the sale year based on the original values and the price of a similar vehicle at the time of purchasing the used vehicle. The residual value of a 2012 Volt sold in 2015 from the original seller's perspective (leasing companies, OEM or similar) is based on the resale price in 2015 ($18,894) divided by the original MSRP ($39,145) or 48.2%. The first owner of the vehicle has a different residual value, paying $33,798 on average for the vehicle and selling it for $18,894 or 55.9% of the price paid. The second buyer, has a different perspective when buying the vehicle in 2015. Based on the second buyer's knowledge of incentives, the alternative price for a new 2015 Volt is $27,448 (or up to $34,170 if the buyer assumes zero incentives). In case of full knowledge on the incentives, the price paid for the used vehicle ($18,894) over buying a new one for $27,448 reflects a residual value of 68.8%. Table 2 represents the residual price of 2011 to 2014 model year PEVs sold in 2015 and how these prices compare to the price paid by the original owners of similar vehicles. We only show the prices of vehicles with sample size higher than 24. Overall the lowest

value calculated is 34% for a 2011 LEAF compared to MSRP or 50% of the price of new LEAF in 2015. A one year old Plug-in Prius was sold for 80% of the average prices paid by the original owner or 98% of a 2015 vehicle, which reflect the low availability of 2015 Plug-in Prius in the market and the low availability of HOV lane access stickers at that time.

***Table 2:*** *Used price over new prices*

| | MSRP | Full Price | Price Minus Incentives | Used Price in 2014 | Used Price in 2015 | price minus incentives of a 2015 model | 2015 price over MSRP | 2015 price over Paid as New | 2015 price over new car price |
|---|---|---|---|---|---|---|---|---|---|
| **Nissan Leaf, 2011** | $33,572 | $ 34,990 | $ 26,815 | $ 15,497 | $11,463 | $ 22,779 | **34%** | **43%** | **50%** |
| **Nissan Leaf, 2012** | $36,882 | $ 35,852 | $ 26,564 | | $12,508 | $ 22,779 | **34%** | **47%** | **55%** |
| **Nissan Leaf, 2013** | $31,517 | $ 33,488 | $ 24,380 | | $13,912 | $ 22,779 | **44%** | **57%** | **61%** |
| **Tesla Model S, 2013** | $87,217 | $ 96,732 | $ 87,974 | | $67,338 | $ 105,998 | **77%** | **77%** | **64%** |
| **Ford Fusion Energy, 2013** | $39,235 | $ 41,243 | $ 35,936 | | $25,288 | $ 36,214 | **64%** | **70%** | **70%** |
| **Chevrolet Volt, 2012** | $39,145 | $ 41,140 | $ 33,798 | $ 24,672 | $20,871 | $ 27,488 | **53%** | **62%** | **76%** |
| **Chevrolet Volt, 2013** | $39,174 | $ 41,000 | $ 32,855 | $ 24,672 | $20,871 | $ 27,488 | **53%** | **64%** | **76%** |
| **Ford C-Max Energy, 2013** | $31,665 | $ 35,014 | $ 29,664 | | $22,875 | $ 29,900 | **72%** | **77%** | **77%** |
| **Toyota Prius Plug-in, 2012** | $38,195 | $ 36,211 | $ 32,273 | $ 24,823 | $22,973 | $ 27,951 | **60%** | **71%** | **82%** |
| **Toyota Prius Plug-in, 2013** | $38,704 | $ 34,259 | $ 30,394 | | $24,412 | $ 27,951 | **63%** | **80%** | **87%** |
| **Toyota Prius Plug-in, 2014** | $34,307 | $ 31,726 | $ 27,759 | | $27,525 | $ 27,951 | **80%** | **99%** | **98%** |

A linear regression model was estimated to explore the impact of different factors on the residual price using a subset of 520 vehicles not including Tesla model S and Tesla Roadster (Table 3). We excluded those vehicles because of the different price ranges that create a biased impact on the larger market. As expected, the used PEV price is correlated positively with the original price and negatively with time on the road and mileage. We also notice that PHEV remains on average a 10.3% higher value compared to the MSRP than BEVs, and that PEVs with HOV access stickers receive $1,430 more than PEVs without an HOV sticker.

***Table 3****: Parameter Estimates for price paid when purchasing used PEV*

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 6091.0037 | 2070.067 | 2.94 | 0.0034* |
| PEV Type [electric] | -1958.399 | 241.1654 | -8.12 | <.0001* |
| PEV age when purchased (years) | -2950.497 | 249.7977 | -11.81 | <.0001* |
| HOV Sticker [No] | -715.6517 | 252.7792 | -2.83 | 0.0048* |
| Miles when purchased | -0.101106 | 0.016713 | -6.05 | <.0001* |
| Price paid when new | 0.6887149 | 0.049827 | 13.82 | <.0001* |

Summary of Fit

| | |
|---|---|
| RSquare | 0.602079 |
| RSquare Adj | 0.598208 |
| Root Mean Square Error | 4642.141 |
| Mean of Response | 20814.7 |
| Observations (or Sum Wgts) | 520 |

Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 5 | 1.6759e+10 | 3.3519e+9 | 155.5426 |
| Error | 514 | 1.1076e+10 | 21549476 | Prob > F |
| C. Total | 519 | 2.7836e+10 | | <.0001* |

Lack of Fit

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Lack Of Fit | 472 | 1.0422e+10 | 22080574 | 1.4172 |
| Pure Error | 42 | 654400057 | 15580954 | Prob > F |
| Total Error | 514 | 1.1076e+10 | | 0.0819 |
| | | | | Max RSq |
| | | | | 0.9765 |

The model presented in Table 3 does not reflect the variation in buyer's knowledge perspective and preference. The next section focuses on the households who purchase the vehicle trying to compare the used PEV buyers and the new PEV buyers. We do not currently have a valid comparison to new and used ICE buyers but we can compare general sociodemographic characteristics of this survey to the 2012 California travel household survey.

### 4.2. PEV Buyers Sociodemographic Characteristics

The survey data focuses only on buyers of used PEVs. We have no data on used ICE buyers. However, according to the 2012 CHTS, new vehicle buyers have on average higher income than used ICE buyers. Figure 11 explores the income distribution of households who purchased a vehicle in the two years prior to the survey and suggests that even though households with higher income are more likely to buy a new vehicle, the number of households who did not purchase a vehicle at all or purchased a used vehicle is much higher. The weighted income of the ICE and PEV household owner population in 2012 is $89,800 for used buyers and $119,400 for new vehicle buyers. Buyers of new PEVs between 2012 and 2014 had an average household income of

$227,000 (median response was $200,000 N=4198 not including Tesla.) Buyers of used PEVs have an average household income of $173,400 with median response of $150,000 (N=481 not including Tesla owners.) Figure 12 explores the average income differences between original owners and second owners. As expected, the income of the used PEV buyers is lower, other than the Prius and the Rav4 used buyers who have income almost as high as the original buyers reflecting the low availability of those models and the high demand for the used PEVs and HOV access stickers.

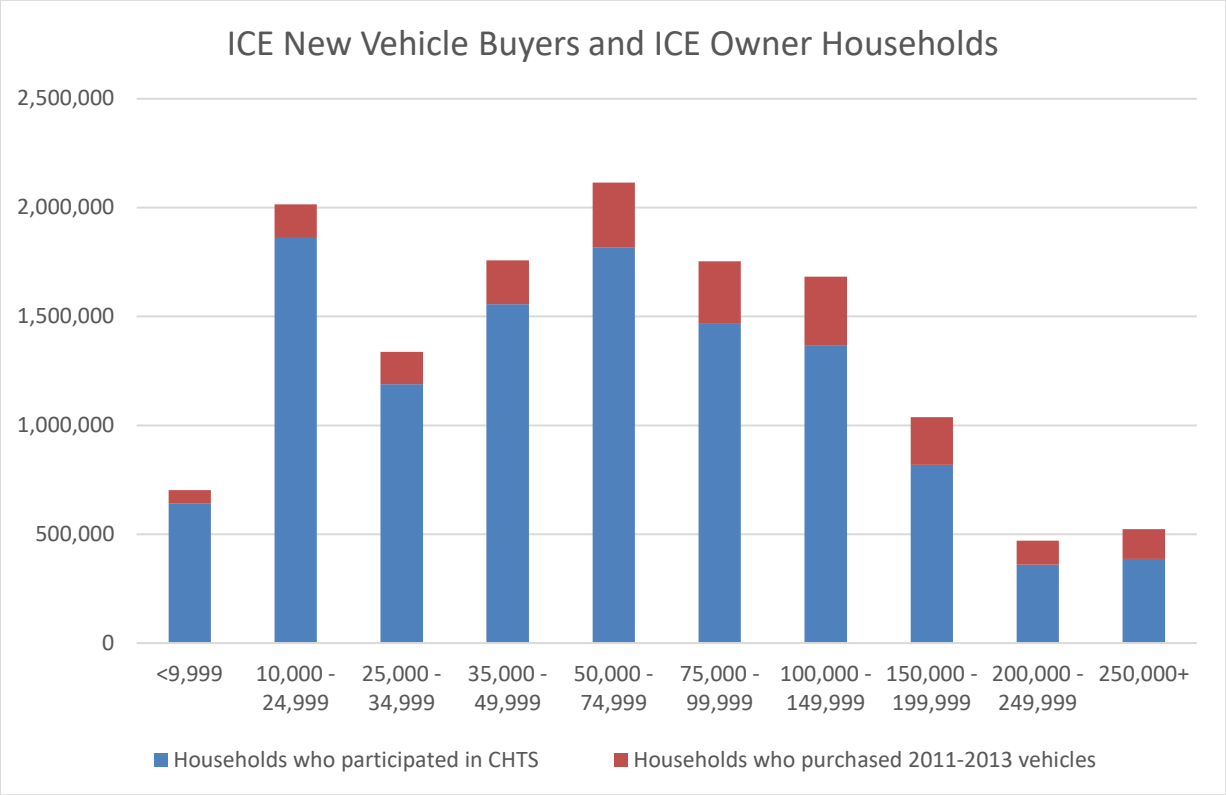


**Figure 11:** CHTS weighted household distribution

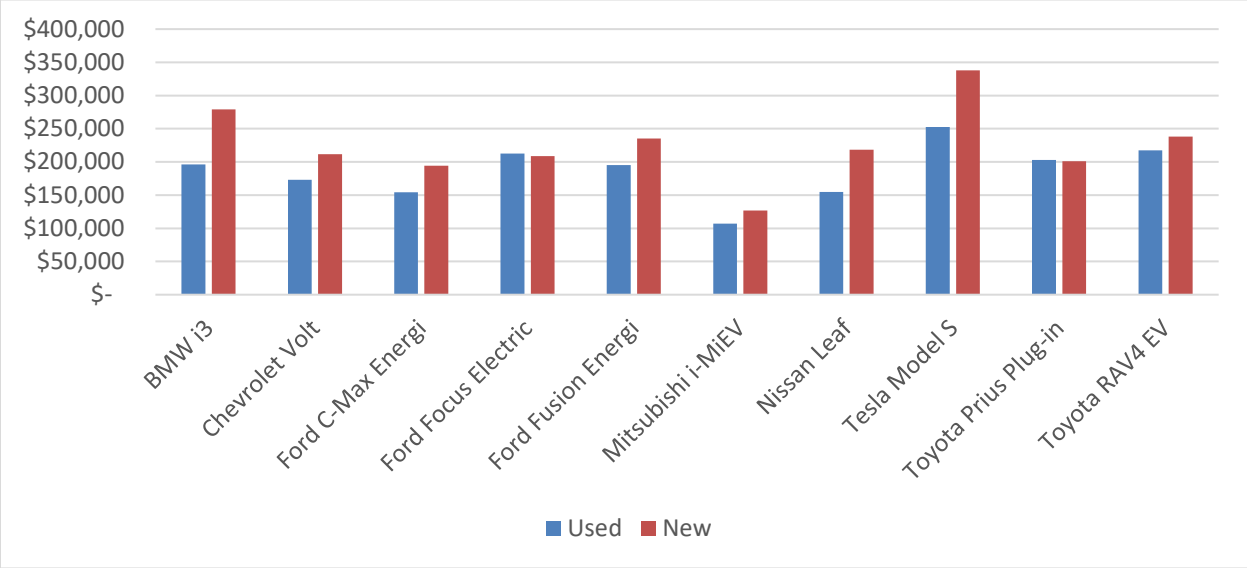


**Figure 12:** Household income of buyers of new and used PEVs

The differences in income may reflect the preference of lower income buyers to purchase a lower priced PEV, but may also reflect changes in preference between 2010 and 2015. We control for the change in price and preference over time by comparing the buyers of different vehicles in the same year. Figure 13 reflects the change over time, as 2013 buyers of new or used Volts had similar income but the average income of Volt buyers, for example in 2014 and 2015, drop faster than that of the new buyers.

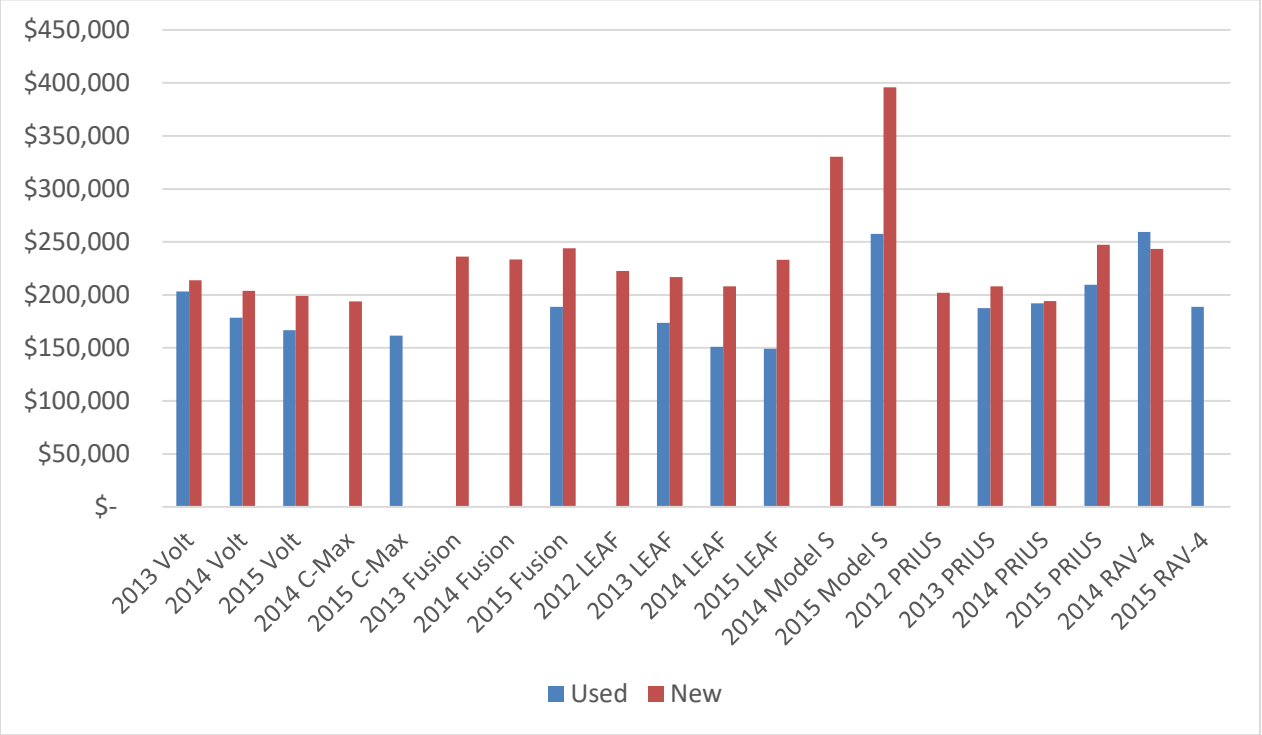


**Figure 13:** Household income of buyers of new and used PEV by vehicle model and purchase year

### 4.3. PEV buyer household fleet and vehicle preference

In order to better understand the household decision to buy a used PEV, we start with exploring the other vehicles in the household. Overall 49% had only used vehicles in their household fleet. 12% had only one used vehicle, and 38% had more than one vehicle all purchased used. On the other hand, 51% purchased new ICE vehicles in the past but elected to buy a used PEV (Figure 14). For almost 8% of the mix of new and used buyers, the used PEV is the second PEV while the first PEV was purchased new. This may reflect a change in habit, buying a new vehicle and not used as no used PEVs were available.

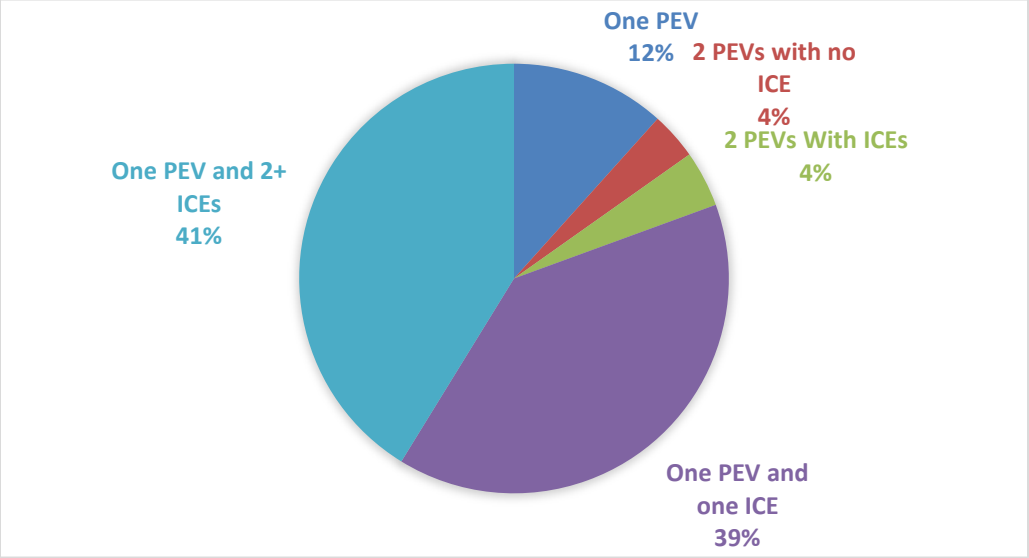


**Figure 14:** Survey Household Vehicles - ICEs and PEVs

### 4.4. Purchase preference

The buyers of used PEVs are early adopters, similar to the buyers of new PEVs. We asked the buyers for their interest in acquiring a PEV when they started the search for a vehicle to purchase and 28% answered that they were only interested in the specific make and model they ended up purchasing, while 33% answered that they were only interested in PEVs and not in ICEs. Only 11% started the search for the new vehicle with only some interest in PEVs and 4% started shopping for an ICE, but converted to a PEV in the shopping process. Asking a similar question on a continuous scale (Figure 15) shows similar patterns.

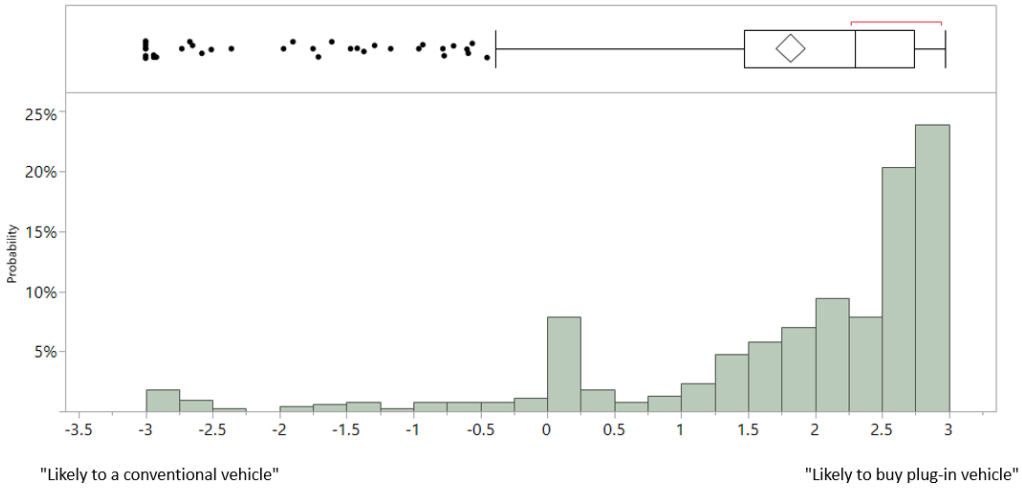


**Figure 15:** Likely to buy ICE or PEV

When asked about the probability of buying a used vehicle or a new vehicle, 67% of the respondents answered that they were more likely to buy a used vehicle while only 15% take into equal consideration buying a new or used vehicle, though 18% are more likely to buy new.

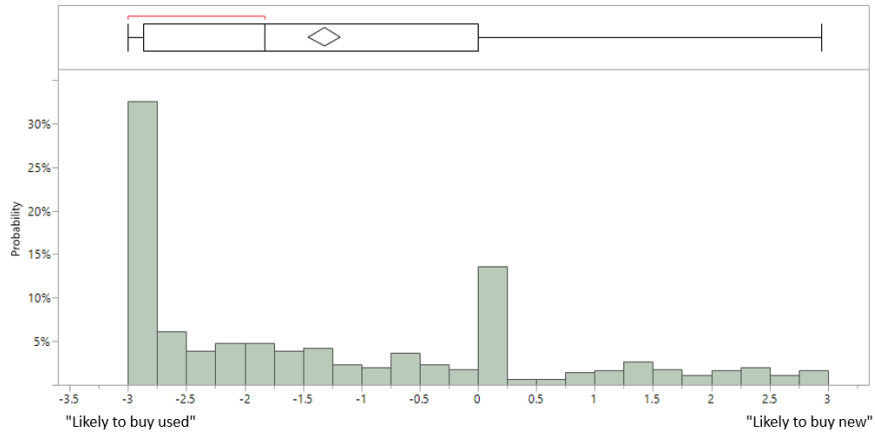


**Figure 16:** Likely to buy new or used

When combining the two questions together we find no linear correlation between the two questions as most buyers are in the used PEV group, but we do notice that our sample does not include potential buyers of new ICEs who end up buying used PEVs (Figure 17).

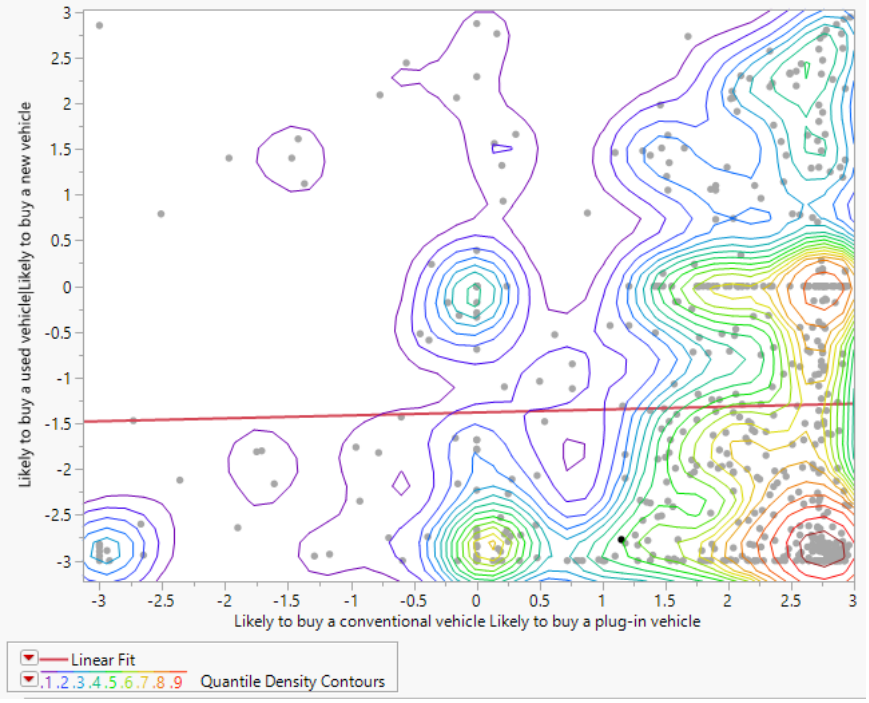


**Figure 17:** Density map of likely to buy new or used over likely to buy ICE or PEV

Overall, early adopters of used PEVs were in the market for a used PEV and in more than 28% of the cases, for a specific PEV. Only 3.9% started the purchase process not interested in PEVs (Figure 18)

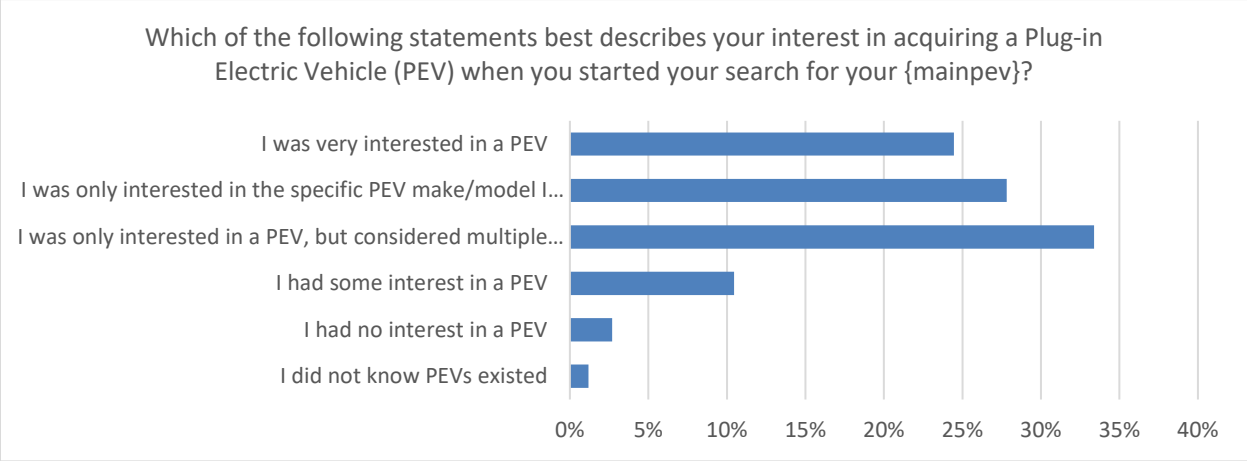


**Figure 18:** Interest in PEV when starting the purchase process

As presented in section 3.1, the price paid for a used PEV varied as a factor of the vehicle characteristics and the purchase timing. Next, we will explore the potential impact of the buyer attributes. We compared the price of a used PEV to that of a similar new vehicle at the time of purchase after subtracting purchase incentives and subsidies, but not all buyers were informed about the price difference between the MSRP and the actual price of a new PEV as those incentives are not available for used PEV buyers. 40.5% of the used PEV buyers had no knowledge about the federal tax credit for the purchase of a PEV with higher awareness rates for the PEVs eligible for the maximum $7,500 (Figure 19)

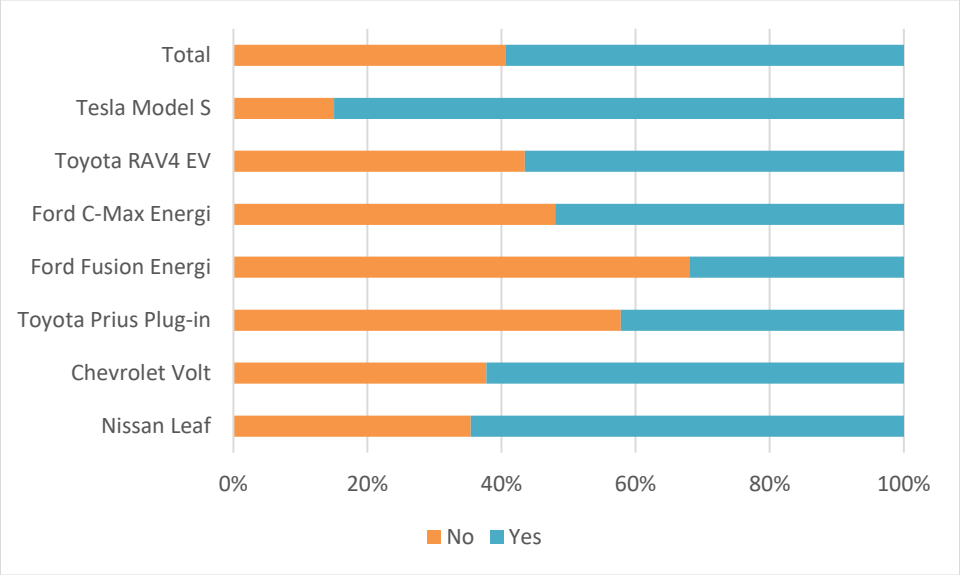


**Figure 19:** Knowledge about the potential federal incentive

The knowledge about the federal incentives was higher for purchasers in 2013 when most used PEVs were purchased after only a year or two on the road and lower in 2014-2015 (Figure 20)

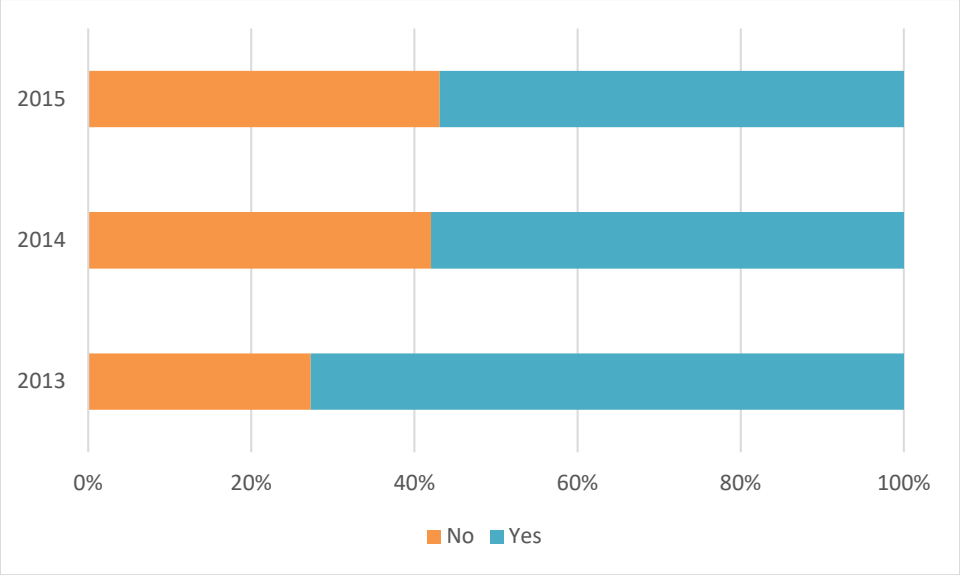


**Figure 20:** Knowledge of the Federal Tax credit by purchase year

We found that vehicle dealerships, even those that sell the same brand as new PEVs, were not improving the probability of knowing about the federal tax credit (Figure 21).

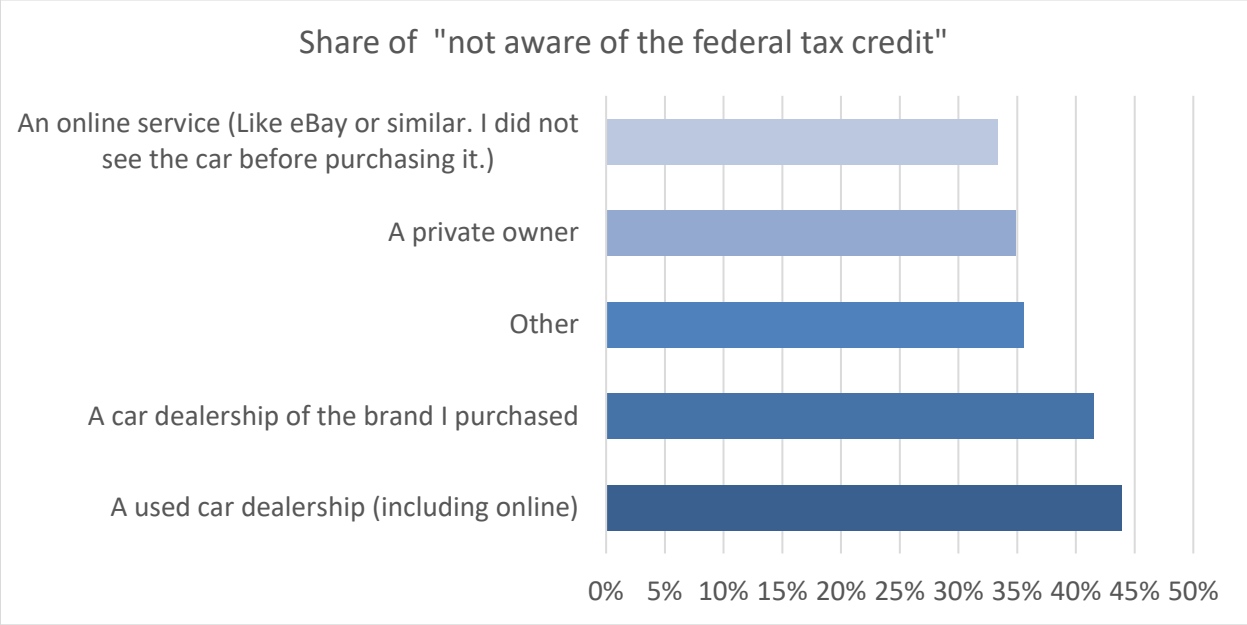


**Figure 21:** Knowledge of the Federal Tax credit by purchase location

The knowledge about the California PEV Clean Vehicle Rebate is lower than the knowledge about the federal tax credit which reflects the lower value of the state incentive. Only 45% of the used PEV buyers knew that if they bought a new vehicle they could receive a $1,500 to $2,500 rebate from California. Figure 20 shows a very low knowledge level for the shorter-range PHEV, perhaps because of the lower value and purchasing motivation that may be focused on HOV access and better MPG, not the plug-in capabilities.

Used PEV buyers had a long list of concerns ranking range, price and charging infrastructure as the top three (Figure 22).

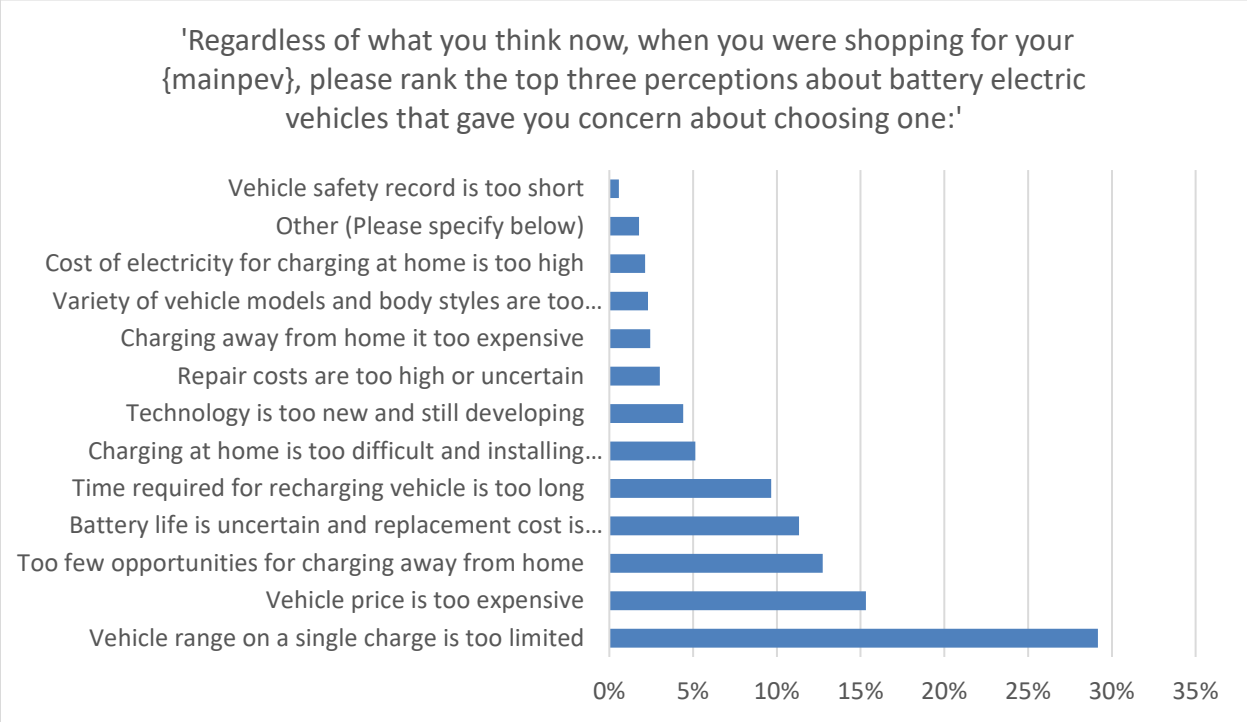


**Figure 22:** Initial perspectives on PEVs

Regardless of the initial perspectives, 77% of used PEV buyers would repeat their purchase if they needed to do it again and only 3% would not buy a PEV after their experience with one. 9% would buy a new vehicle if they needed to do it again, maybe as result of the additional knowledge on potential incentives (Figure 23).

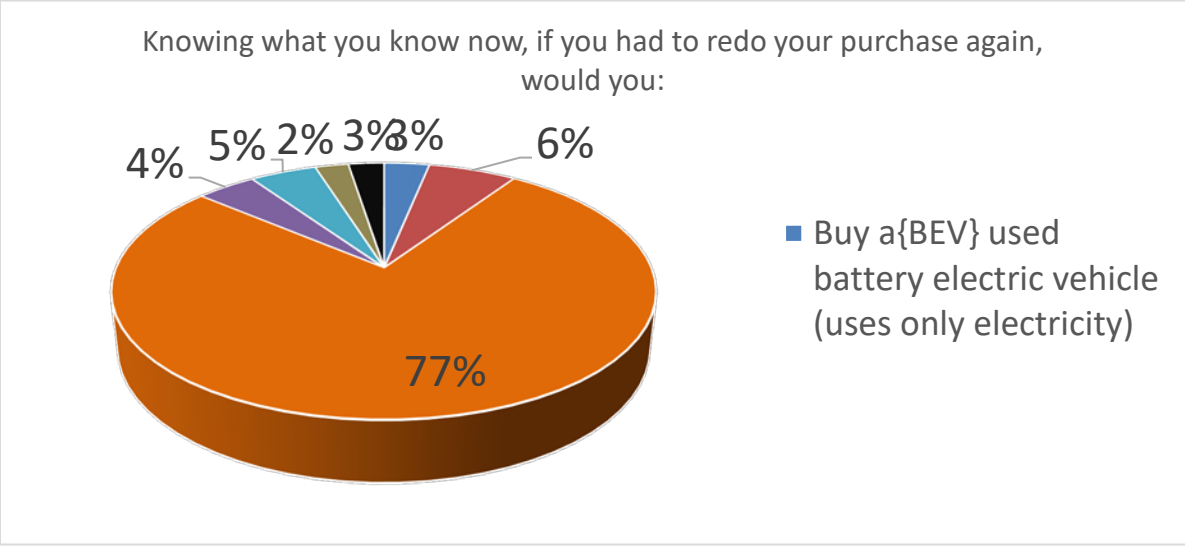


**Figure 23:** Would you purchase the PEV again?

The average odometer reading of used PEVs at the time of purchase was 23,400 miles. As described above, most of these vehicles entered the used PEV market after 2-3 years of usage by the original owner. The median odometer reading was 21,500 miles, with 90% of the vehicles having less than 40,000 miles as shown in the CDF plot (Figure 24).

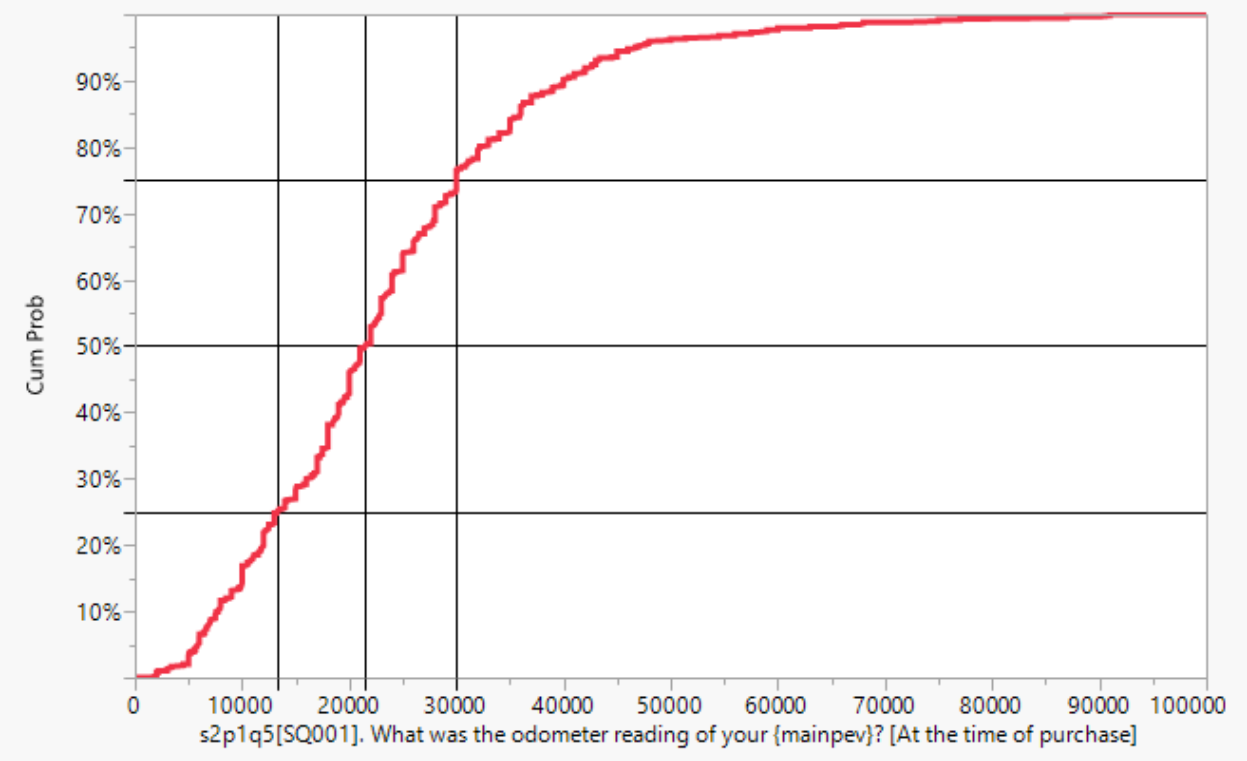


**Figure 24:** Odometer reading at purchase

The vehicles being relatively new and having low mileage is reflected in awareness about the battery condition as only 15% report a capacity lower than 90% of the original (Figure 25), and most buyers did not check the battery condition other than asking the seller (Figure 26).

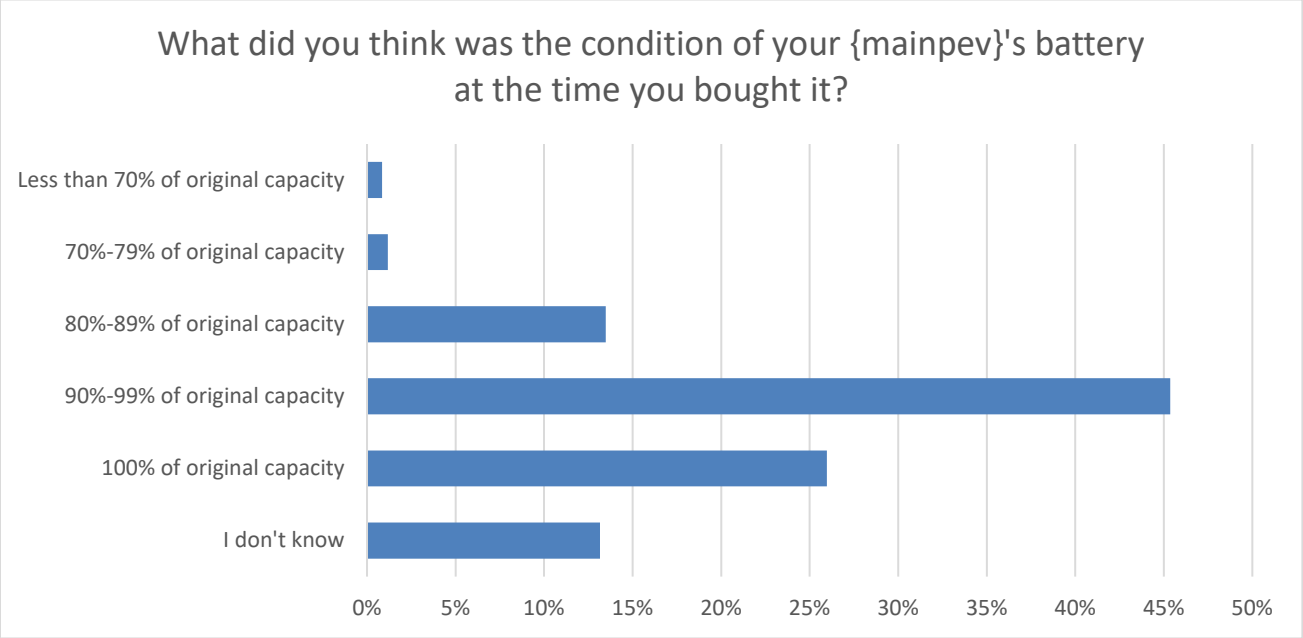


**Figure 25:** Battery condition at purchase

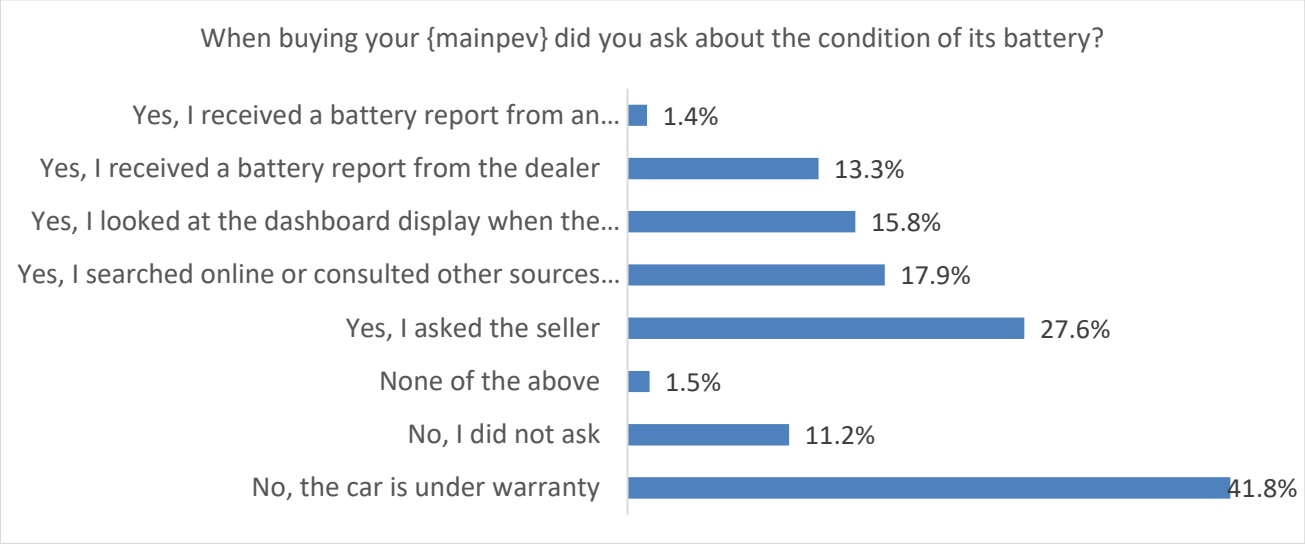


**Figure 26:** Asked about battery condition

## 4.5. Vehicle Usage

We estimated the vehicle usage based on the reported odometer reading at the time of vehicle purchase, the time of survey, and the number of months of reported ownership. We excluded outliers with less than 1,000 or over 50,000 miles per year and owners who report lower accuracy than 3,000 on their odometer report. The results, in Table 4, suggest high usage of the used PHEVs

with the median higher than 15,000 for the Ford Fusion.

*Table 4: Used PEV Annual miles*

| PEV | N | Mean | Std Dev | Median | New PEV Median |
|---|---|---|---|---|---|
| Ford Fusion Energi | 25 | 17839 | 9336 | 15692 | 12600 |
| Toyota Prius Plug-in | 89 | 15584 | 9376 | 13678 | 12700 |
| Ford C-Max Energi | 24 | 14412 | 7696 | 12621 | 10800 |
| Tesla Model S | 38 | 14403 | 9490 | 12798 | 11200 |
| Chevrolet Volt | 167 | 13611 | 7126 | 12000 | 10800 |
| Toyota RAV4 EV | 23 | 9929 | 7323 | 8075 | 10500 |
| Nissan Leaf | 188 | 8649 | 6233 | 7836 | 9400 |

When comparing usage of the used and new PEVs (data from UCD eVMT survey data) in the last two columns of Table 4, one can see that used PHEVs are driven more than their new PHEV counterparts, but used BEVs (other than the long-range Tesla) are driven less. When comparing charging behavior (Figure 27) we see that many of those high usage PHEVs are being used as hybrid vehicles only or being plugged in less than 5 times per month. As expected, the Prius with the short-range battery has the greatest percentage of respondents that are not plugging in regularly (more than 30%), with 18% not plugging in at all.

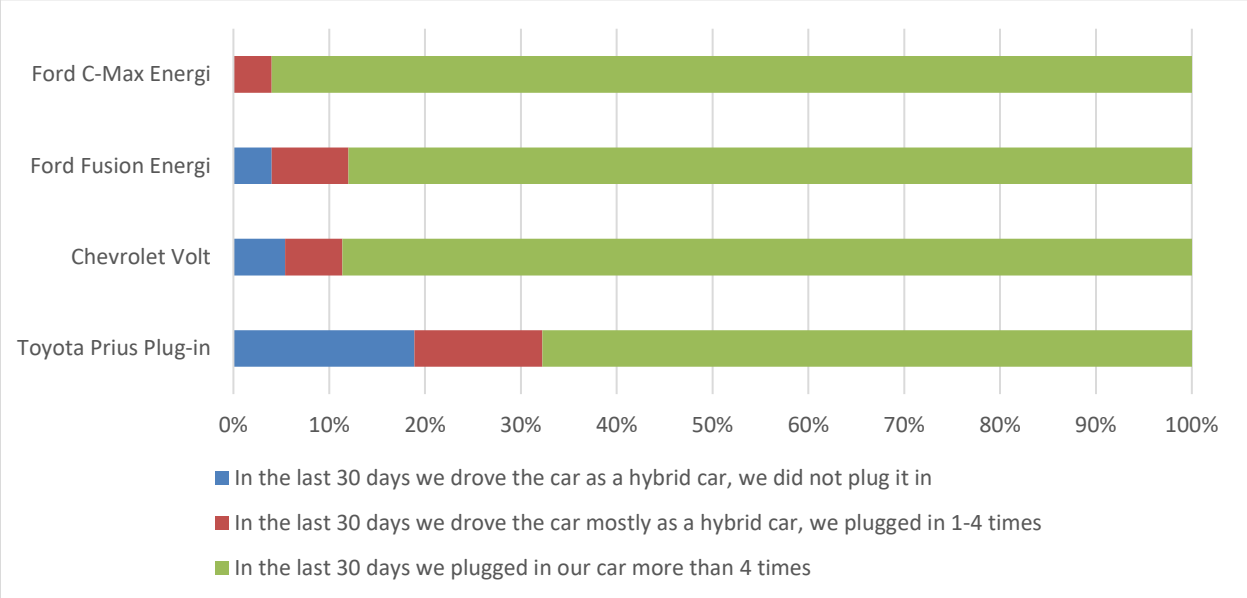


**Figure 27:** Not plugging in at all or less than 4 times a month

Additionally, it helps to compare the used PEV consumers to the original owners. In the eVMT project recruitment survey, we used a similar question and as shown in Figure 28 the original owners are more likely to plug in their car, even in 2016 with low gas prices.

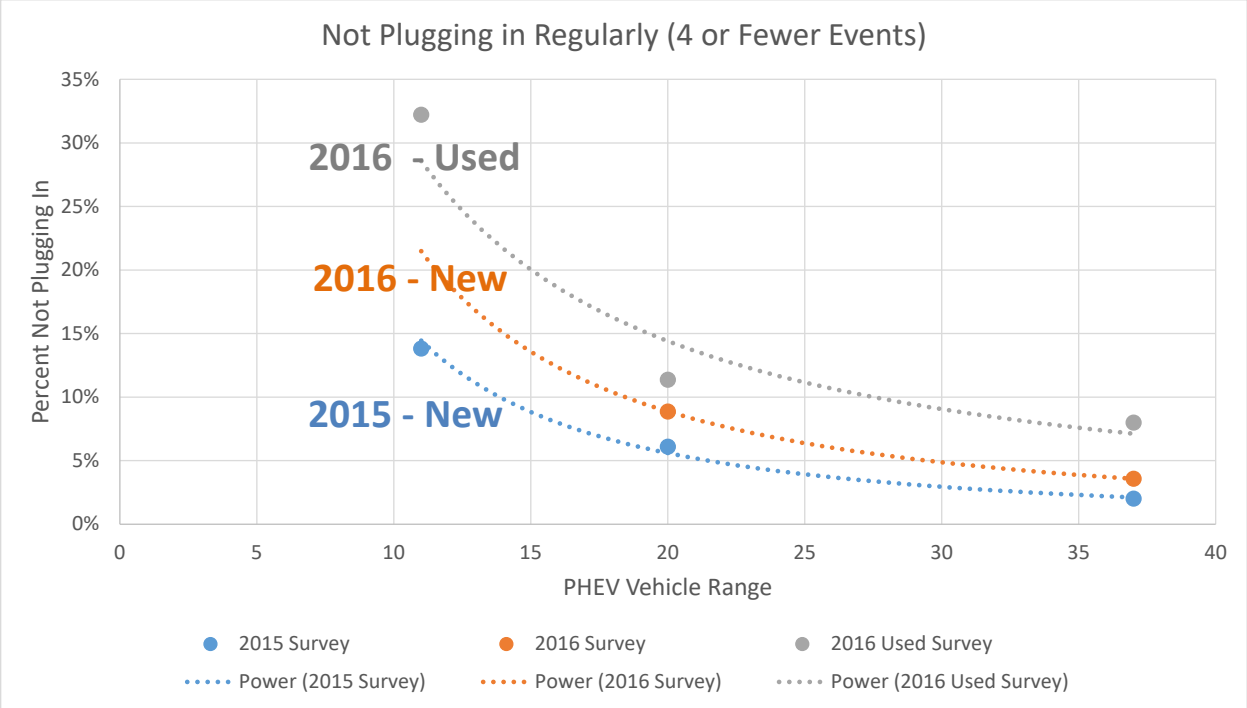


**Figure 28:** Percent of survey respondents rarely plugging in as a function of PHEV electric range

As the benefit of plugging in is limited by vehicle range and battery capacity, some users don't bother plugging in. We show results from 3 different surveys. The results are consistent with the premise that increasing vehicle electric range in PHEVs increases the likelihood of plugging in. Also, the plugging in of PHEVs with short ranges is vulnerable to gasoline prices and second owner user engagement.

44% of our sample plugged in only at home. Over 50% of the shorter-range PHEV drivers (of those who plugged in) plugged in only at home. We saw more public (out of home) charging for the BEVs and the longer-range Volt. Fewer than 10% of all households charge away from home only, while most the vehicles that are used as plug-in vehicles are being charged both at home and out of home (Figure 29).

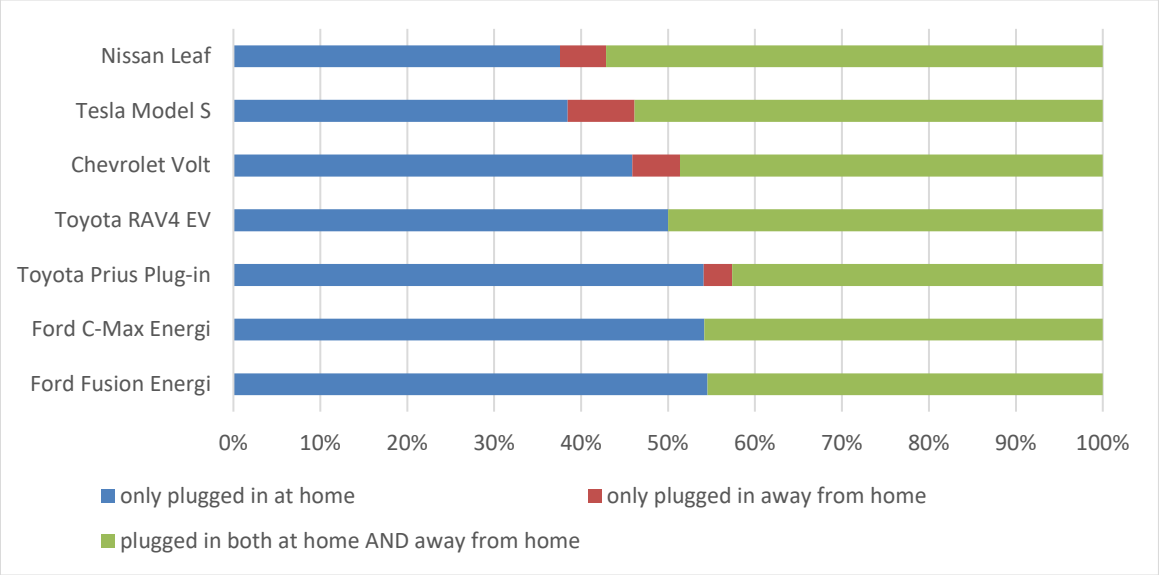


**Figure 29:** Charging location in the last 30 days

Figure 30 and Figure 31 show that second owners have similar levels of level 2 EVSEs at home despite a lower level of installation support. Some of the original owners received the EVSEs as part of the Federal EV project, from the OEMs or government subsidies. We see a few more converted L2 chargers with the seconed owners but a statistically similar total number of L1 use. All households who did not charge at all in the last 30 days report having L1 availability at home.

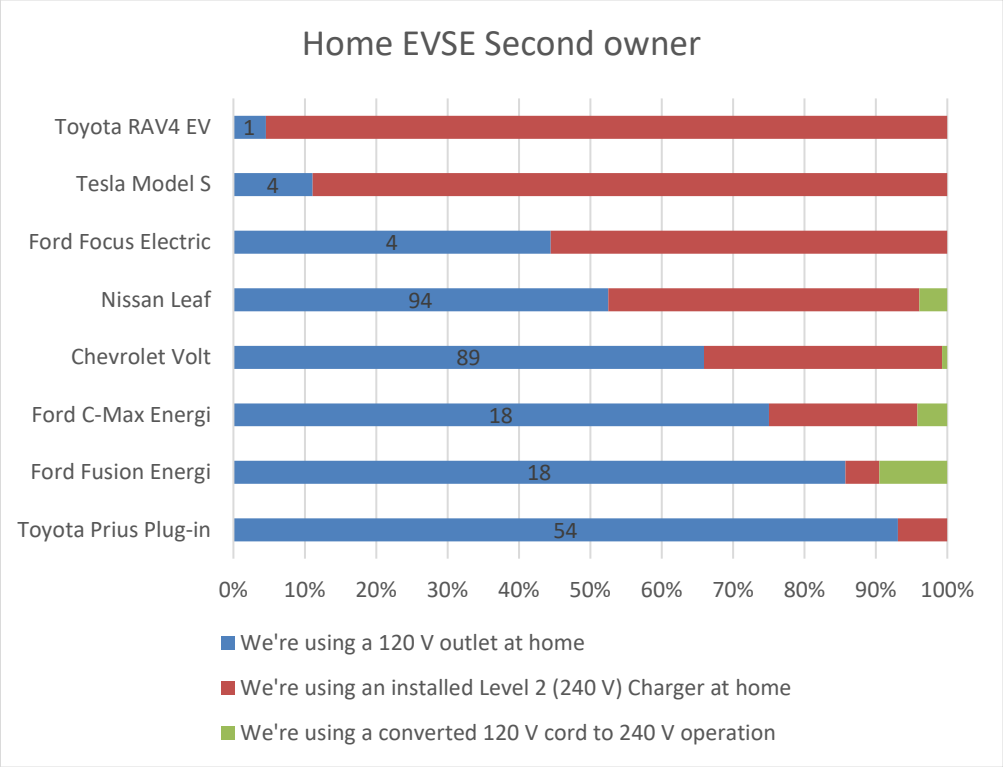


**Figure 30:** Second Owner- Charging at home

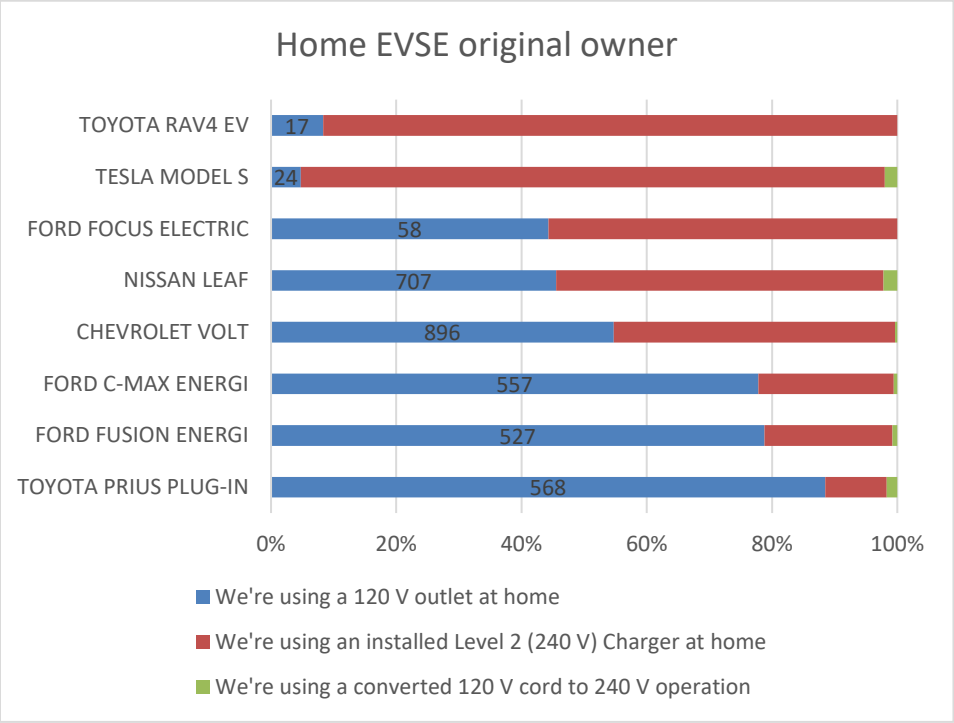


**Figure 31:** First Owner - Charging at Home

In Figure 32 we present the primary reason people did not install a charging station at home. Most PHEV owners reported that it is not necessary. We see 7% who reported that they are not authorized to install and 11% who report that it is too expensive. A policy that subsidizes EVSEs for second owers would benefit up to half of the buyers.

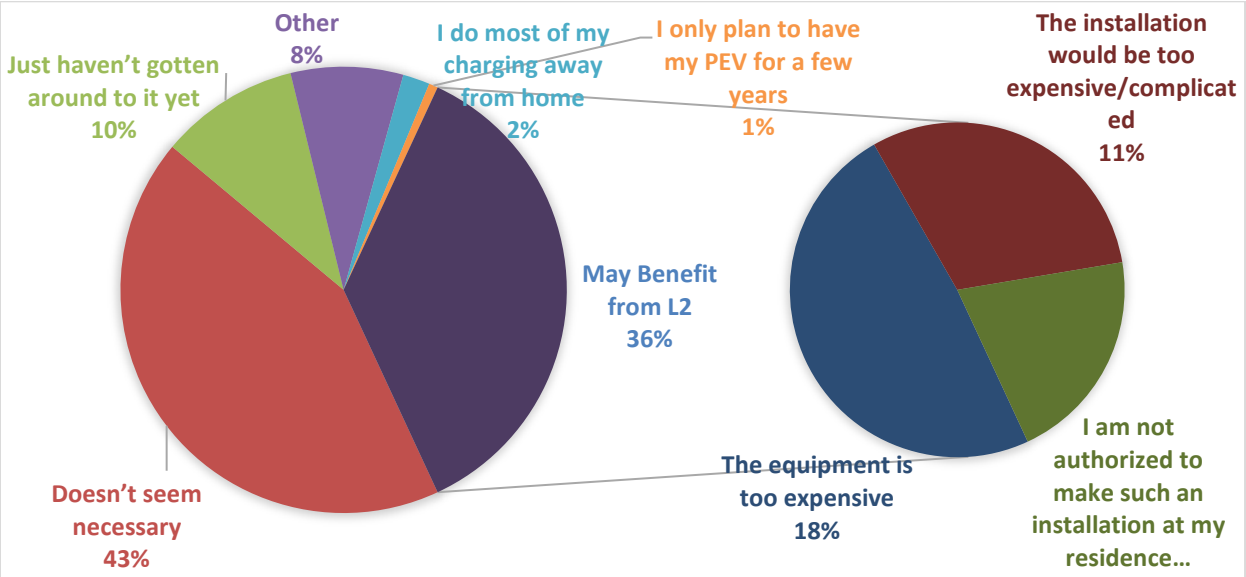


**Figure 32:** Reasons not to install charging station at home

## 5. Conclusion

Overall, buyers of used PEVs purchased a vehicle they had planned to buy and had learned about that was relatively new with low mileage, and in most cases under warranty, for a relatively low price. This may not be the case in the future, when the PEV market will contain more and older vehicles with high mileage that are over the battery and powertrain warranty limit. Used PEV buyers are more utilitarian than new PEV buyers as reflected by their high driving need but they may be less committed to electric driving; they do not always plug in their vehicle. As shown in our price analysis, HOV stickers have a high impact on the price paid and they may be negatively co33rrelated with charging behavior.

This draft research suggests a limited analysis based on the survey results and will be followed by a full report.

## 6. Acknowledgment/Disclaimer

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