Californias
Advanced Clean Cars
Midterm Review

Appendix B:
Consumer Acceptance of Zero Emission Vehicles and Plug-in Hybrid Electric Vehicles

January 18, 2017

California Environmental Protection Agency
Air Resources Board

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I. Key Findings

The zero emission vehicle (ZEV) regulation has been designed to accelerate commercialization of ZEV technology. While the ZEV regulation has been effective in generating product development and initial vehicle supplies, fleet transformation to near- or pure-ZEVs also requires consumers to demand and ultimately purchase these products. This appendix describes staff analysis using a variety of data sources on market trends, consumer acceptance, and the potential for market growth of plug-in hybrid electric vehicles (PHEV), battery electric vehicles (BEV), and fuel cell electric vehicles (FCEV) in California and states that have adopted California's ZEV regulation under Section 177 of the Clean Air Act (Section 177 ZEV States) compared to other regions.

Since 2010, the market of ZEVs and PHEVs has developed from just a single vehicle model to 25 models offered by 14 manufacturers at the beginning of 2017. Although market shares have been relatively constant in recent years, as of June 2016, almost 450,000 ZEVs and PHEVs have been sold in the United States (U.S.), with California and Section 177 ZEV States accounting for about 60 percent of those sales.[1] Although some models were initially only available for sale in states with a ZEV regulation, the market has also proliferated to other states in the U.S. and other countries, with a total of two million BEVs and PHEVs expected to be sold globally by the end of 2016.[2] Compared to conventional hybrid electric vehicles (HEVs), BEVs and PHEVs have developed and diversified much more rapidly.

Regional variation in sales trends may be the result of uneven exposure to ZEVs and PHEVs at dealerships, which appears to be lower in Section S177 ZEV states,[3] or through auto manufacturer advertising.[4] Overall sales volumes are also affected by vehicle pricing, which can vary by state as a result of purchase incentives. The top 50 best-selling models of the 300 light-duty vehicle models offered in model year 2016 and almost 90% of all new vehicles sold during the first eight months of 2016 start at a base price of less than $35,000, with the largest volume of vehicles having a starting manufacturer suggested retail price (MSRP) between $20,000 and $24,999. In comparison, only when factoring in up to $10,000 worth of government incentives do ZEVs and PHEVs prices become competitive with conventional vehicle prices. Furthermore, dealers appear to be transacting ZEVs and PHEVs at prices close to starting MSRP, meaning that government incentives are resulting in effective prices paid by consumers substantially more discounted than those typically offered for conventional vehicles during the negotiation process.

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[1] See Section III.A for historic and current sales trends.

[2] Carrington 2016. Damian Carrington. October 13, 2016. *The Guardian*. “Electric cars set to pass 2m landmark globally by end of 2016” https://www.theguardian.com/environment/2016/oct/13/electric-car-sales-set-to-pass-2m-landmark-globally-by-end-of-2016.

[3] See Section III.A.3 for dealership availability analysis.

[4] NESCAUM 2016. Northeast States or Coordinated Air Use Management. October 2016. EV Marketing Analysis. http://www.zevstates.us/wp-content/uploads/2016/10/Marketing-effort-092216.pdf.

Multiple studies reveal a low but slowly increasing level of ZEV technology awareness and knowledge in California and throughout the U.S. and other studies show that increasing knowledge and exposure to these vehicles results in lasting, positive impressions. Among current ZEV and PHEV drivers, vehicle test drives served as influential information sources. Already over 10% of recent buyers (or lessees) are driving their second (or subsequent) ZEV or PHEV. The majority of households purchasing these vehicles have had no prior experience with any alternative fuel or hybrid technology.[5] However, in general these households exhibit other characteristics conducive to ZEV and PHEV ownership, such as additional household vehicles, the ability to charge at home (or the ability to make changes to their residence that would allow for home-charging), and often the ability to charge at work.

During this initial stage of the market, many current ZEV and PHEV consumers were motivated to select their vehicle based on environmental benefits or a desire for the newest technology, though saving money overall or on fuel specifically is also a strong motivator. Purchase incentives and other complementary policies from assorted entities have also played an important role in supporting the emerging market by reducing the cost of purchasing or operating this new technology to the consumer.[6] For example, workplace charging serves a dual role in supporting the market by providing consumers with assurances on charging away from home while also providing opportunities for increasing electric vehicle miles traveled.

However, until production costs fall sufficiently to more closely match with conventional vehicle prices, the future development of the market without continued incentives will be uncertain as purchase price remains a primary concern of potential consumers. Conversely, fuel cost savings have been a primary motivator for consumers to purchase a ZEV or PHEV, but continued relatively low gasoline prices in the near-term will reduce interest if vehicles do not provide counteracting appeal. Compounding this issue, some consumers may spend more to operate their plug-in electric vehicle (PEV, meaning any type of electrified vehicle with a plug) than they would a conventional vehicle if utilities are not offering (or consumers are not aware of) supportive electricity rates for vehicle charging.[7]

Despite these challenges, additional growth in the ZEV and PHEV market is possible with continued action to increase product diversity, consumer awareness, and infrastructure deployment. More than 70 different ZEV and PHEV platforms are projected within the next five model years,[8] though continued increases in overall market shares of ZEVs and PHEVs will require multiple successful models. The new vehicle market is highly competitive and diversified; even today's best-selling model of any technology does not account for more than four percent of total new light-duty vehicle sales in California or the U.S.[9] Nonetheless, given the

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[5] See Section III.C.1 for current ZEV consumer characteristics.
[6] See Section III.C.2.d for discussion on the role of incentives and Appendix E for addition complementary policies discussion.
[7] See Section III.C.1.e.iii for usage of EV rates and Section III.C.4.b for energy price impacts on operating costs.
[8] See Section IV.A for future model availability.
[9] See Section III.A.2.e for light-duty vehicle market shares.

large proportion of leases, many consumers will be returning to the market within two to three years and among all these current drivers, more than 90% report they would replace their current vehicle with another ZEV or PHEV and about half would be willing to pay additionally for greater all-electric range. While the majority of consumers would remain with their existing technology, there are slightly more consumers who would switch from a PHEV to BEV than the reverse, and the projected BEV offerings with greater all-electric range (often at lower price points) may further intensify this difference.[10]

Finally, an emerging secondary market for ZEVs and PHEVs demonstrates demand for these vehicles, even in areas without regulatory requirements or purchase incentives. Combined with the new vehicle market, additional sales will continue to support development, production and supply of ZEV technologies that sustains employment and investments in California's automotive sector, while also spurring growth in battery manufacturing, infrastructure planning and construction, as well as electricity and renewable energy production. Such increases can also have spillover effects in other economic sectors.

[10] See Section IV.B.1 for future purchase behavior of current ZEV and PHEV consumers.

II. Introduction and Background

Fleet transformation to near- or pure-zero emission vehicles (ZEV) requires not only auto manufacturers to develop and produce such vehicles, but also consumers to demand and ultimately purchase these products. Demand will be dependent on consumer awareness of the vehicles being offered as well as their characteristics – most notably vehicle price, available incentives, driving range, and the cost and convenience of recharging/refueling – and how consumers value these attributes. Additional factors, such as dealership availability and product diversity may also influence the rate at which market shares may grow. This appendix describes consumer acceptance, sales trends, and pricing trends of plug-in hybrid electric vehicles (PHEV), battery electric vehicles (BEV), and fuel cell electric vehicles (FCEV) in California and states that have adopted California's ZEV regulation under Section 177 of the Clean Air Act (Section 177 ZEV States).[11]

The first part of the appendix describes the market landscape to date, which includes model offerings and regional availability, sales by region, vehicle availability on dealer lots, vehicle prices, awareness of ZEV (meaning BEV and FCEVs) and PHEV products among the general public, as well as attitudes and characteristics of existing PHEV and ZEV drivers. This discussion informs the following section of the appendix on the potential for market shares of these technologies to grow in the long term beyond current levels. Additionally, this appendix shows evolving consumer attitudes towards new vehicle technologies and provides indications of continued market growth based on future purchase behavior from both existing and prospective drivers. An emerging secondary market of PEVs also supports the possibility for developing a sustainable new vehicle market for electrified vehicles. Lastly, this appendix concludes with an overview of the broader economic implications for California that could result from increased ZEV and PHEV adoption to levels needed to comply with the ZEV regulation.

II.A. Data Sources

Staff analysis utilized an assortment of data sources. These include a combination of: freely available internet resources; subscription-based internet resources; licensed data from commercial vendors; data collected through state administered programs, including surveys to recipients of state vehicle rebate programs; ARB-sponsored research contracts; and assorted peer-reviewed publications and publicly available reports from external parties, such as media outlets, auto manufacturers, or other organizations. Some of these data sources are used for multiple analyses. Additional details on sources relied upon for original staff analyses are included in Section VII. A complete list of references is available in Section VI.

III. Recent Market Development and Current Status

Since its inception, the ZEV regulation has been designed to accelerate commercialization of ZEV technology. During the 1990s and early 2000, manufacturers produced and marketed a limited quantity of ZEVs, primarily distributed in California.[12] The ZEV and PHEV market has developed considerably since the reemergence of commercially available vehicles with these

[11] Through Section 177 of the Clean Air Act, nine states have adopted California's ZEV regulation: Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont. These nine states are commonly referred to as the Section 177 ZEV states.

[12] Examples: 1996-1999 General Motors (GM) EV1, 1997-2003 Toyota RAV4 Electric Vehicle.

technologies in late 2010. This section reviews staff's current understanding of market trends, consumer awareness about ZEVs and PHEVs, and consumer acceptance and attitudes towards these vehicles. The first portion of this section summarizes historic and current sales trends with respect to model offerings, dealership availability, and vehicle pricing. As new products in the marketplace, with varying degrees of behavioral changes required for fueling these vehicles, the next portion of this section assesses consumer awareness and understanding of these vehicles. Next, this section discusses current PHEV and ZEV driver characteristics, as well as purchase motivations and barriers among both existing and prospective consumers alike. Finally, this section concludes with a review of current PHEV and ZEV driver experiences and attitudes towards their vehicles that may inform their future purchase behavior.

III.A. Historic and Current Sales Trends

This section focuses on the current wave of ZEV and PHEV sales, which began in 2010 with the introduction of the model year (MY) 2011 Chevrolet Volt, followed soon after by the MY2011 Nissan LEAF. The market of ZEVs and PHEVs has since developed to 25 models offered by 14 manufacturers at the beginning of 2017. In addition to ZEV and PHEV model availability, market shares, and sales volumes, it discusses regional differences between California, the Section 177 ZEV states and the rest of the United States, as well as provides comparisons between other technology types. Although market shares have been relatively constant in recent years, as of June 2016, almost 450,000 ZEVs and PHEVs have been sold in the U.S., with California and Section 177 ZEV States accounting for about 60 percent of those sales, roughly evenly divided between ZEVs and PHEVs in all regions. Although some models were initially only available for sale in states with a ZEV regulation, the market has also proliferated to other states in the U.S. and other countries. Compared to conventional HEVs, BEVs and PHEVs have developed and diversified much more rapidly and manufacturers have announced numerous future additional models that will continue to diversify consumer choices of PHEVs and ZEVs. Based on the current light-duty vehicle market structure, expanding ZEV and PHEV sales will likely require consumers to embrace multiple models.

To evaluate whether regional sales variation reflects differences in consumer access to vehicles, data on vehicle model inventories of PEVs and various comparable models from dealerships across major metropolitan areas were collected and analyzed. These data show a significant difference between PEVs and other conventional vehicles offered within the same city by the same manufacturer, with greater volumes of a comparable model available than the PEV. Differences in availability across cities show that some consumers could be less exposed to PEV technology when shopping for a new vehicle. While manufacturers do not seem to vary incentives offered at the dealership level across regions for the same vehicle models, they do seem to offer different incentives for different technology types.

Retail and transaction prices of ZEVs and PHEVs are also evaluated relative to the overall light-duty vehicle market to assess the extent to which past sales trends are the result of pricing strategies. The top 50 best-selling models of the 300 light-duty vehicle models offered in model year 2016 and almost 90% of all new vehicles sold during the first eight months of 2016 start at a base price of less than $35,000, with the largest volume of vehicles having a starting MSRP between $20,000 and $24,999. In comparison, only when factoring in up to $10,000 worth of government incentives do ZEVs and PHEVs prices become competitive with conventional vehicle prices. Furthermore, dealers appear to be transacting ZEVs and PHEVs at prices close to starting MSRP, meaning that government incentives are resulting in effective prices paid by consumers substantially more discounted than those typically offered for conventional vehicles during the negotiation process.

Understanding these trends helps to inform: 1) how the market has developed over time; 2) whether a sustainable market is developing; and 3) how the market may develop in the future.

III.A.1. Model Availability

Currently in the U.S., there are approximately 300 passenger car and light-duty truck models available, and the ZEV and PHEV market represents a small, but growing, number of this overall total number of vehicle models. [13] The market has grown from one PHEV model in 2010 to 25 models of PHEVs, BEV, and FCEVs offered by 14 manufacturers at the beginning of 2017. The total number of ZEV and PHEV models available from each manufacturer in the U.S. by calendar year (CY) is shown in Figure 1. The ZEV portion includes BEVs and FCEVs, while the PHEV portion includes PHEV models that are TZEV-certified[14] and also BEVx[15] models.

Table 1 provides a more detailed listing of the available ZEV and PHEV models and also provides some perspective on manufacturers' past success in launching new models. This table is an update to a table from the 2011 ZEV Regulation Initial Statement of Reasons(ISOR),[16] which cataloged current and announced ZEV and PHEV models known at the time of the propose rulemaking. With the exception of the General Motors “TBD” FCEV and the Mitsubishi Outlander PHEV,[17] every model has been released in the U.S. market. There have been ten additional models released that were not anticipated prior to the 2012 Advanced Clean Cars (ACC) rulemaking.

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[13] WardsAuto data. See Section VII.E for further details.

[14] PHEVs are classified in two categories: transitional zero emission vehicles (TZEV), which must meet super ultra-low-emission vehicle (SULEV) exhaust emission standards, provide an extended warranty on emission control systems, and have zero evaporative emissions in order to qualify for credits under California’s ZEV regulation, and non-TZEV PHEVs, which do not qualify to earn credits.

[15] A BEVx is a vehicle powered predominantly by a zero emission energy storage device, able to drive the vehicle for more than 75 all-electric miles on the urban dynamometer driving schedule (UDDS), and also equipped with a backup auxiliary power unit (APU), which does not operate until the energy storage device is fully depleted and whose range does not exceed that of the all-electric mile range, and meeting super-ultra-low-emission vehicle (SULEV) standards.

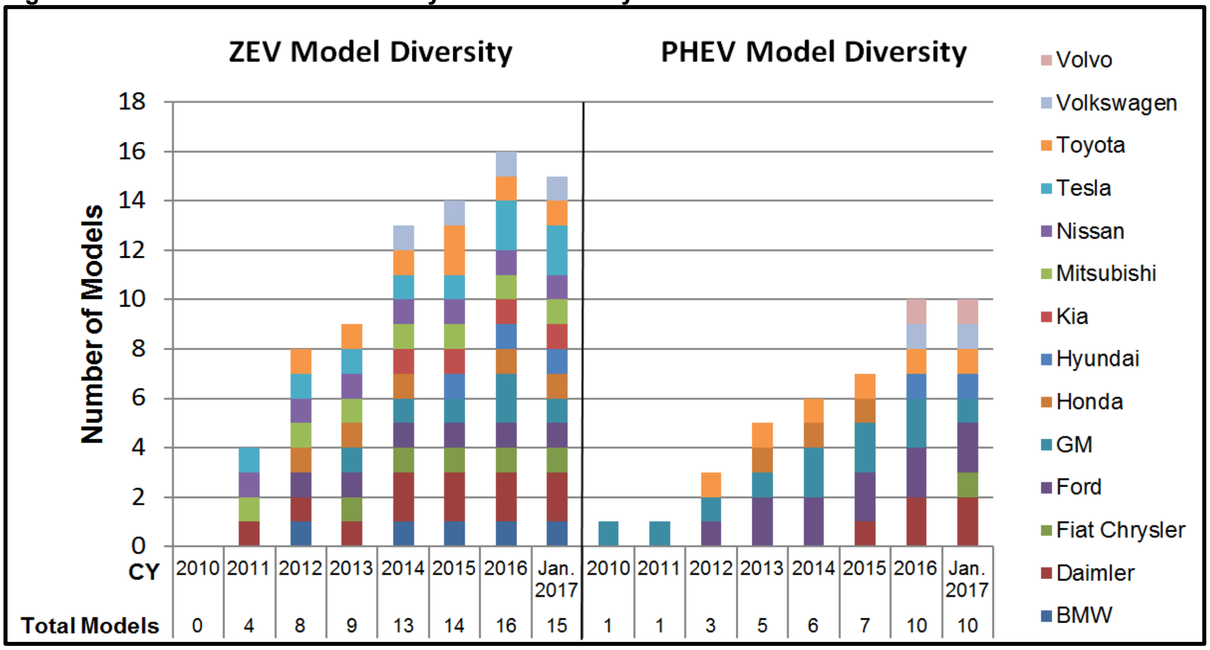
[16] ARB 2011. California Air Resources Board. December 7, 2011. Initial Statement of Reasons: 2012 Proposed Amendments to the California Zero Emission Vehicle Program Regulations. https://www.arb.ca.gov/regact/2012/zev2012/zevisor.pdf.

[17] The Mitsubishi Outlander is currently available in outside of the United States but expected to launch in the U.S. in 2017.

Table 1 - Past and Current ZEV and PHEV Models

Models Projected in the 2011 ZEV ISOR					
OEM	**Model**	**Type**	**ISOR Projected**	**Actual Release/ Initial Region**	**2017 Availability**
BMW	ActiveE	BEV	2011	2012, CA and S177	Discontinued
	i3	BEV	2013	2014, All States	All States
	i3 REx	BEVx	2013	2014, All States	All States
	i8	PHEV	2014	2014, not TZEV	All States
FCA	500e	BEV	2012	2013, CA Only	CA and OR
Ford	CMAX	PHEV	2012	2012, All States	All States
	Focus EV	BEV	2011	2012, All States	All States
	Transit Connect	BEV	in prod	2011, CA and S177	Discontinued
GM	ELR	PHEV	unknown	2014, All States	Discontinued
	Spark	BEV	2012	2013, CA and OR	Discontinued
	Volt	PHEV	in prod	2010, All States	2nd gen, All States
	TBD	FCEV	2015	n/a	n/a
Honda	Fit EV	BEV	2012	2012, CA and S177	Discontinued
	~~TBD~~ Accord	PHEV	2012	2013, CA and S177	Discontinued
	Clarity	FCEV	in prod	2010, CA Only	2nd gen, CA only
Hyundai	Tucson	FCEV	2015	2014, CA Only	CA Only
Mercedes-Benz	~~TBD~~ B-Class	BEV	2012	2014, CA and S177	All States
	F-Cell	FCEV	in prod	2011, CA Only	Discontinued
	smart fortwo ED	BEV	in prod	2011, All States	All States
Mitsubishi	iMiEV	BEV	in prod	2011, All States	CA and S177
	Outlander	PHEV	2013	n/a	Expected 2017
Nissan	LEAF	BEV	in prod	2010, All States	All States
Tesla	Model S	BEV	2012	2012, All States	All States
Toyota	Prius Plug-in	PHEV	2012	2012, CA and S177	2nd gen, All States
	Rav4 EV	BEV	2012	2012, CA Only	Discontinued
	Scion iQ	BEV	2012	2013, CA Only	
	~~TBD~~ Mirai	FCEV	2015	2015, CA Only	CA Only
VW	~~e-up!~~ e-Golf	BEV	2013	2014, CA and S177	All States
Additional Models Not Projected					
FCA	Pacifica	PHEV	n/a	2017, All States	All States
GM	Bolt	BEV	n/a	2016, CA and OR	All States
Ford	Fusion	PHEV	n/a	2013, All States	All States
Hyundai	Sonata	PHEV	n/a	2015, CA Only	All States
Kia	Soul EV	BEV	n/a	2014, CA Only	CA and S177
Mercedes-Benz	C350e	PHEV	n/a	2016, CA and S177	All States
Mercedes-Benz	S550e	PHEV	n/a	2015, CA and S177	All States
Tesla	Model X	BEV	n/a	2016, All States	All States
Volvo	XC90	PHEV	n/a	2015, All States	All States
VW	A3 e-Tron	PHEV	n/a	2015, CA Only	All States

Figure 1 - ZEV + PHEV model diversity CY2010-January 2017[18]



Manufacturers have announced numerous future additional models that will continue to diversify consumer choices of PHEVs and ZEVs. Section IV.A of this appendix and Section I of Appendix C both provide a more detailed discussion of these future product offerings.

III.A.2. U.S. ZEV and PHEV Sales

Figure 2 shows annual U.S. sales of ZEVs and PHEVs for calendar year 2011[19] through June 2016. There have been 447,000 cumulative ZEV and PHEV sales (224,000 ZEV and 223,000 PHEV) in the U.S. from calendar year 2011 through June 2016.[20] From calendar year 2011 to 2014, sales of ZEVs and PHEVs across the U.S. grew steadily, but flattened for 2015 and 2016. Relative to total light-duty vehicles (LDV) sales, ZEV and PHEV market shares from 2013 to 2016 have remained relatively constant. Currently, ZEV and PHEV sales comprise approximately 0.7% of U.S. LDV sales, with sales typically divided evenly between the two vehicle categories. Total U.S. ZEV and PHEV sales fell by 3% from calendar year 2014 to 2015, however this lag appears to be primarily due to PHEV sales, which fell by 13% from 2014 to 2015. By contrast, ZEV sales increased slightly from 2014 to 2015, by 6%. Total ZEV and PHEV sales have been higher by approximately 12% for the first half of calendar year 2016 relative to the same period in 2015; while PHEV sales increased more than 40%, ZEV sales declined by approximately 8%.

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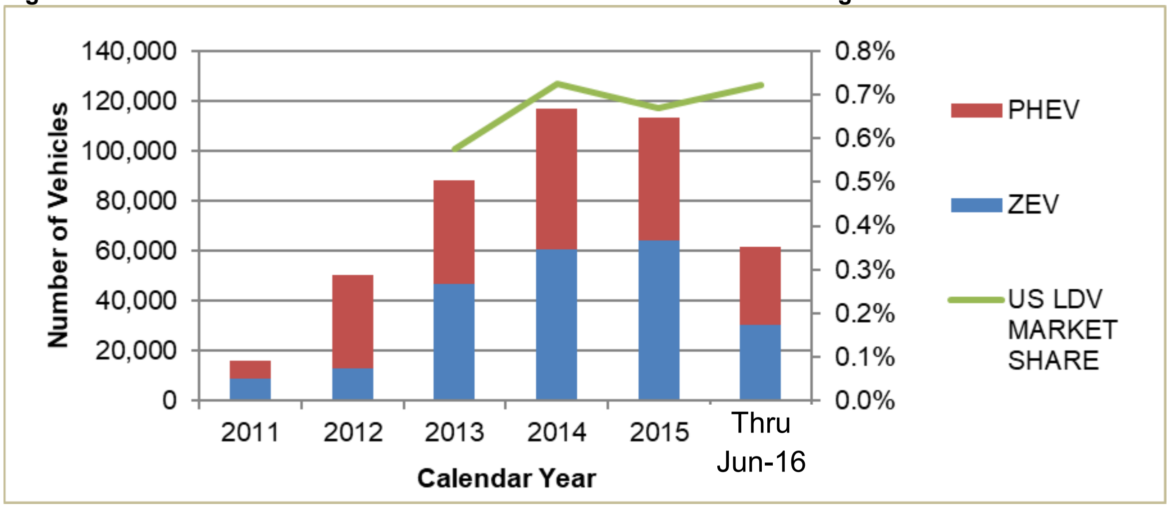
[18] For data source see sections VII.B Experian Automotive data and VII.E WardsAuto data.
[19] As was previously discussed in model availability, the current wave of ZEV and PHEV sales actually began in calendar year 2010, however, this analysis beings with 2011 because the Dashboard data used in this analysis starts with sales from January 2011. DMV data show 2010 volumes to be minimal. See Sections VII.A and VII.C for additional details on data sources.
[20] Dashboard data.

Figure 2 - Total U.S. ZEV and PHEV sales and market share CY2011 through June 2016[21]



Note: PHEVs include TZEV and non-TZEV certified PHEVs, as well as BEVx.

According to California DMV data of vehicles registered as of April 2016, non-TZEV PHEVs (PHEVs not certified to the TZEV standards) sold between 2011 and 2015 made up approximately 2% of total PEV and FCEV sales or 6% of the PHEV sales in California.[22] While this is a relatively small percentage of the overall sales of new PEVs and FCEVs, more recent registrations suggest that this ratio has begun to shift. Non-TZEVs sold in California during the first four months of 2016 account for approximately 6% of the total PEV and FCEV sales and 12% of PHEV sales. Most of this shift results from the introduction of the BMW X5 PHEV, which accounts for more than 45% of the non-TZEV sales in California through April 2016. Other non-TZEV PHEVs include BMW's i8 and 330e, as well as the Porsche Cayenne and Panamera S E-Hybrids. In general, these PHEVs have the requisite all-electric range necessary to qualify as TZEVs,[23] however, they either do not meet the accompanying SULEV emissions requirements and/or do not provide a 15 year/150,000 mile extended warranty on the vehicle's emission system. Although non-TZEVs do not earn ZEV regulation credits, additional modifications to these vehicles may allow them to qualify as TZEVs in future model years.

While ZEV and PHEV sales have not increased in the last two years, these trends are consistent with the overall passenger car segment, as most of the growth in light-duty vehicle sales stem from increases in light truck sales (which include pickup trucks, sport utility vehicles, crossover vehicles, and vans). Out of the 23 ZEV and TZEV models sold during the first half of 2016, 20 offerings fall within the passenger car segment. Between 2014 and 2015, passenger cars sales fell by 2.5%, while total U.S. light-duty truck[24] sales increased by 12%. Over those same years, passenger car sales in California increased by 6%; however, light-duty truck sales were also very strong, growing by 19%. For the first half of calendar year 2016, passenger car sales decreased by 7% in the U.S. and also declined by 4% in California. Light-duty truck sales

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[21] Dashboard data.
[22] Average sales of non-TZEVs from calendar year 2011 through April 2016.
[23] TZEVs must have a minimum 10 miles AER on UDDS.
[24] Trucks and truck based vehicles, such as SUVs, with a gross vehicle weight rating (GVWR) of less than 8,500 lbs.

continued to grow, increasing by 1.3% and 13% during the first half of 2016 in the U.S. and California, respectively.

III.A.2.a. Comparison to HEV Market

The conventional hybrid electric vehicle market emerged during the early 2000s, with Toyota's Prius leading the way, and often serves as an analog to the emerging PEV market. This comparison may seem appropriate given the fact that both markets seek to overcome the challenge of introducing consumers to electrified vehicle platforms, however, there have been significant differences in sales trends and vehicle availability between the two markets. To better understand market trends for PEVs, staff compared the current PEV market with the early years of the HEV market. Figure 3 shows the number of HEV models available in the U.S. from each manufacturer from calendar year 2000 to 2015. By 2015, there were 11 manufacturers offering a total of 47 different HEV models with the number of HEVs appearing to have stabilized in recent years.

Figure 3 - HEV model diversity by manufacturer CY2000-2015[25]

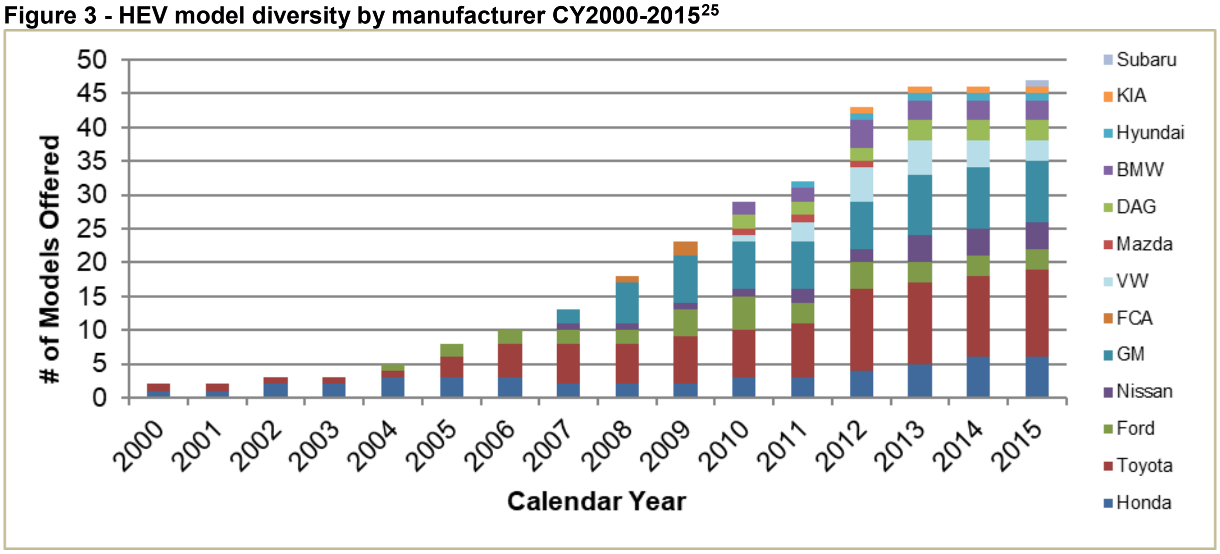

Figure 4 uses a combination ZEV and PHEV model counts discussed in section III.A.1 and AFDC data for HEV model counts to provide a direct comparison of the number of models available in the early years of the ZEV and PHEV market to the similar market phase of the HEV market. The HEV market started with two manufacturers each offering a single product, and over the first seven years of model availability grew to offer to total of seven models. Over the same period of time, the ZEV and PHEV market grew to offer a total of 26[26] ZEV and TZEV models, with an additional seven PHEV models that are not TZEV certified. The HEV market, by contrast, did not offer 26 models until more than ten years after its introduction. Additionally, the HEV market has never shown the same level of manufacturer diversity as the majority of the available HEV models were marketed primarily by three manufacturers: General Motors, Honda, and Toyota. Therefore, while the HEV market trajectory may illustrate one path for an electrified

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[25] For data source see section VII.J AFDC HEV sales data.

[26] The analysis for this HEV market comparison was done on a calendar year basis, and 26 models were offered for sale within calendar year 2016.

platform to be introduced into the market, it is not a direct comparison for the PEV market, which has developed and diversified much more rapidly.

Figure 4 - Early market model diversity by technology type[27]

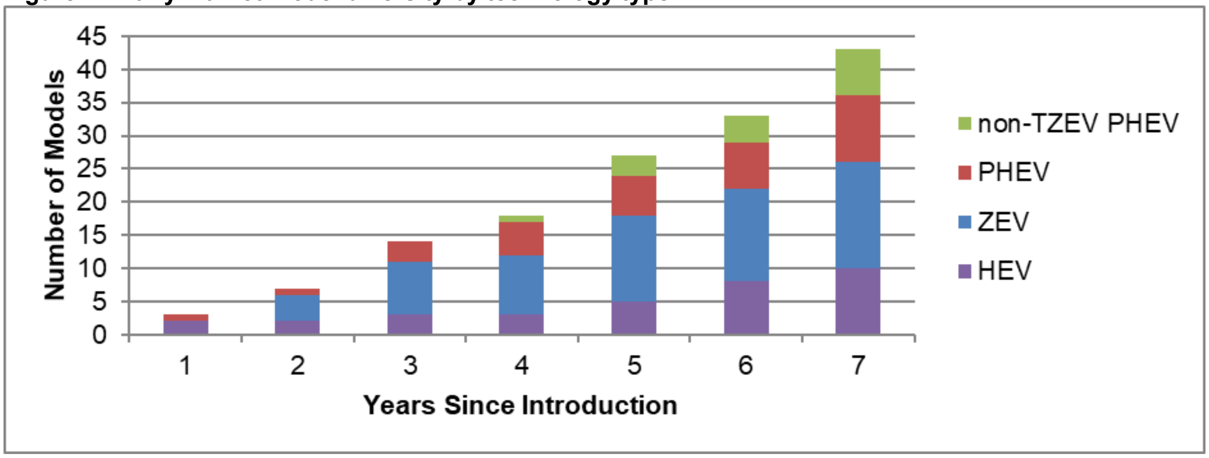

Figure 5 shows annual U.S. HEV sales volumes (left y-axis) and market share (right y-axis) by manufacturer. Figure 6 compares ZEV and PHEV sales to HEV sales data over the first six years of the respective technologies being available. These two graphs further illustrate the fact that HEV sales have been (and continue to be) dominated by only a few manufacturers, while ZEV and PHEV sales have only grown more diverse over time. Figure 5 shows Toyota producing approximately 68% of all new HEV sales in the US and accounting for 1.6% of total U.S. LDV sales in 2015. By comparison, Tesla had the largest percentage of ZEV or PHEV sales in the U.S. for calendar year 2015 at 21%, which only accounted for 0.13% of total U.S. LDV sales.

Both vehicle markets showed similar sales trends over the first five years of model availability, with ZEV and PHEV sales reaching around 0.6% and HEV sales reaching 0.5% of total U.S. LDV sales. The HEV sales data shows a significant jump in sales between years five and six, where sales jumped from 0.5% to 1.24%, a large portion of this increase resulting from a single manufacturer. As discussed in section 0, ZEV and PHEV sales dropped by 3% between years five and six, or from 2014 to 2015. While ZEV and PHEV sales have been higher for the first half of 2016, the ZEV and PHEV market seem unlikely to sharply increase in 2016 as the HEV market did between 2004 and 2005, however several new model introductions or redesigns have the possibility of dramatically increasing sales in 2017.

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[27] The HEV model counts did not distinguish between non-PZEV certified HEVs that do not qualify for credits under the ZEV regulation through MY 2017 and those HEVs that do qualify for credits; therefore it was necessary to include non-TZEV certified PHEVs in this part of this analysis.

Figure 5 - HEV annual U.S. sales volumes by manufacturer CY2000-2015[28]

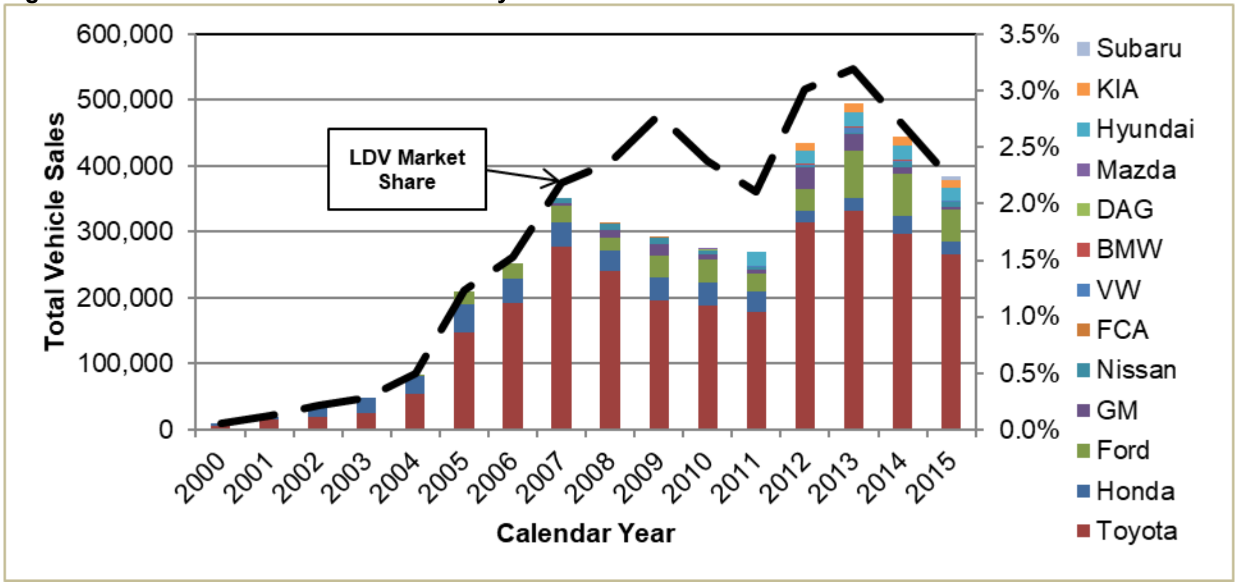
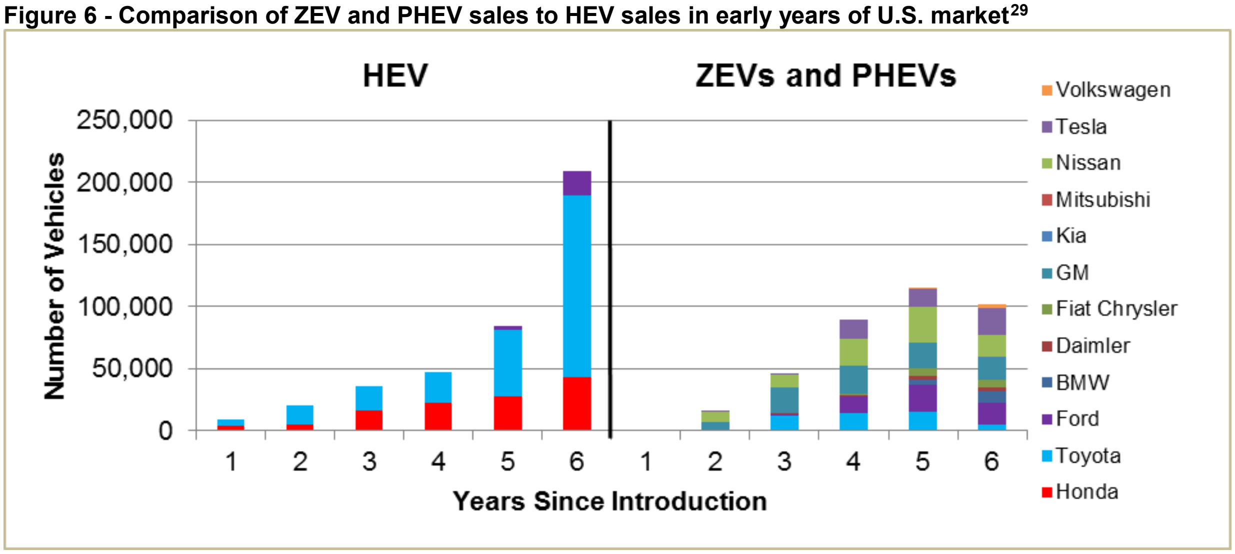


Figure 6 - Comparison of ZEV and PHEV sales to HEV sales in early years of U.S. market[29]



III.A.2.b. Comparison of CA/S177/U.S. Sales Trends

California has the largest PEV (and FCEV) market in terms of volume and market share in the U.S. In addition to a long history of the ZEV regulation, California and the nine Section 177 ZEV states have adopted several complementary policies to support the ZEV and PHEV market. Some manufacturers have also been distributing these vehicles outside of states where they would earn regulatory compliance credits (Rest of the U.S); sales trends in these states provide insights into consumer acceptance of ZEV and PHEV technologies in the absence of potential regulatory market distortions. Evaluating sales trends in all three regions can also help assess

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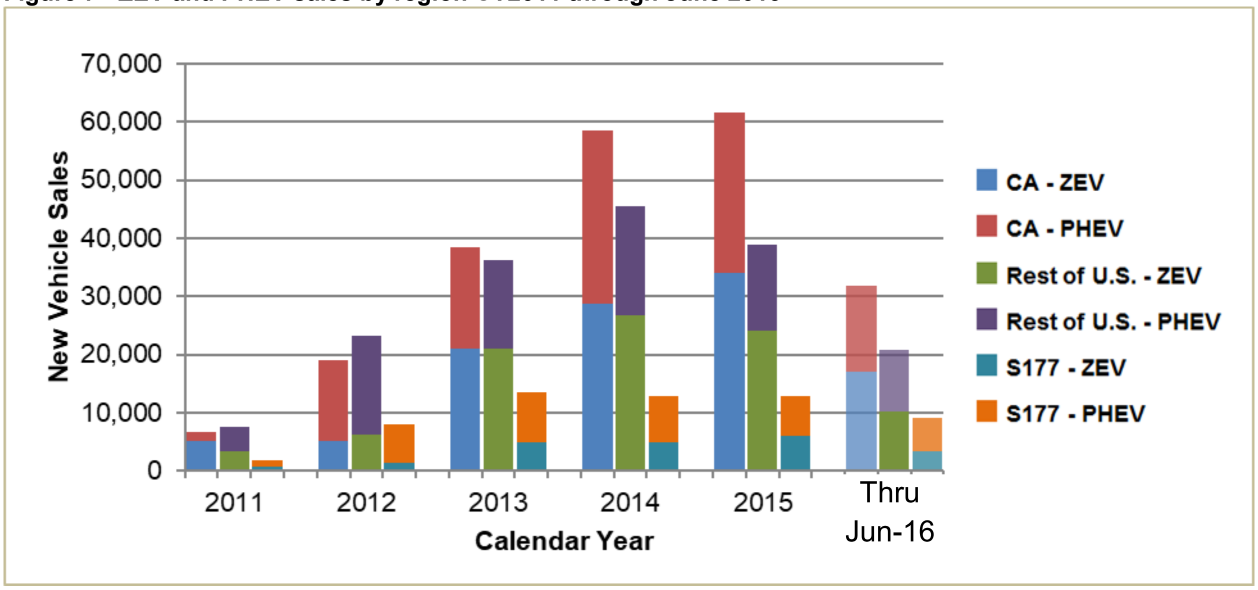
28 AFDC HEV sales data.

29 For ZEV and PHEV sales data source see Section VII.B Experian Automotive data; for HEV sales data source see Section VII.A AFDC HEV sales data.

progress towards achieving economies of scale that can contribute to vehicle cost reductions. This section uses Dashboard data to evaluate differences in sales trends between the three geographic regions: California, the Section 177 ZEV states, and the Rest of the U.S., which includes the remaining 40 states and the District of Columbia.

Figure 7 directly compares sales between the three U.S. regions. California comprised approximately 12% of total U.S. new LDV sales from 2013 through June 2016, while the Section 177 ZEV states accounted for approximately 17% of sales and the Rest of U.S. region accounting for the remaining 71%.[30] While both ZEV and PHEV sales declined in the Rest of U.S. region from 2014 to 2015, sales of ZEVs have remained fairly constant across every region and have actually increased in California and the Section 177 ZEV states. The reduction in total U.S. ZEV and PHEV sales from 2014 to 2015 resulted from the drop in sales of PHEVs in every region, with the largest drop of 22% occurring in the Rest of U.S.

Figure 7 - ZEV and PHEV sales by region CY2011 through June 2016[31]



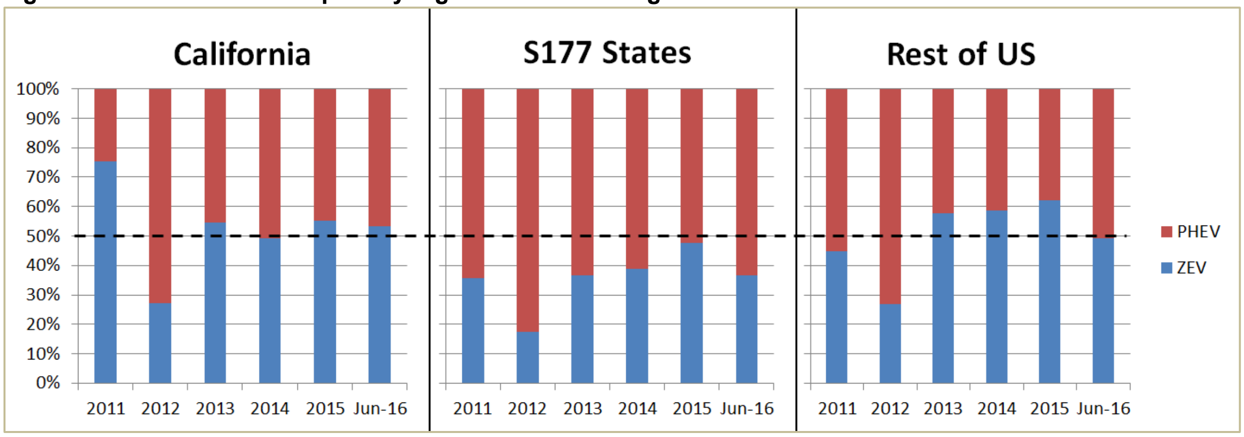
Total U.S. ZEV and PHEV sales for the first half of 2016 increased 12% compared to the first half of 2015 (11% California, 2% Rest of U.S., and 51% in the Section 177 ZEV states). This increase in ZEV and PHEV sales is consistent with that of the overall LDV market which grew by 2.8% in California and 2.1% in the entire U.S. for the first half of 2016 over the same time period for 2015.[32] Taking a closer look at this national increase, sales of PHEVs grew in every region over this time span (24% California, 55% Rest of U.S., and 96% in the Section 177 ZEV states). While sales of ZEVs have increased in California (2%) and the Section 177 ZEV states (9%), sales have fallen in the Rest of U.S. by 25%.

However, within each time period, Figure 8 shows sales about evenly split between PHEVs and ZEVs across all of the regions, with California and the Rest of U.S. region showing a slight bias

[30] Dashboard data.
[31] Dashboard data.
[32] Dashboard data.

toward ZEVs. For Section 177 ZEV states, these technology splits vary depending on the region analyzed: Oregon's sales tend to align more with California, whereas the Northeast Section 177 ZEV states tend to favor PHEVs.

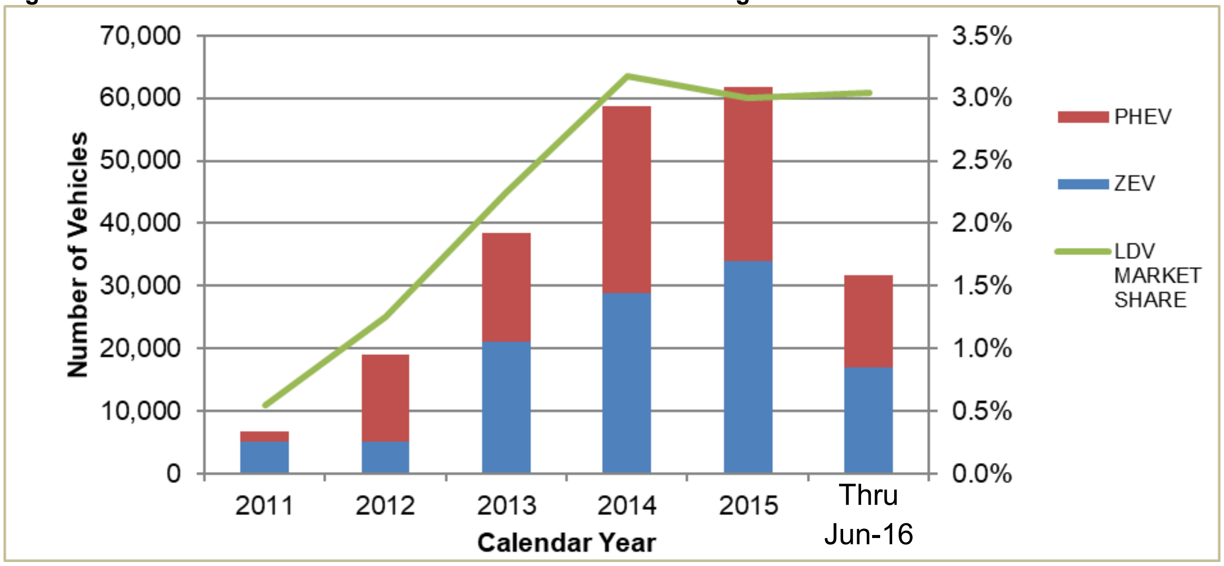
Figure 8 - ZEV/PHEV sales splits by region CY2011 through June 2016[33]



In California, there have been 216,000 cumulative ZEV and PHEV sales (111,000 ZEV and 105,000 PHEV) from the beginning of calendar year 2011 through June 2016. California accounts for approximately 48% of cumulative ZEV and PHEV sales in the U.S. during this time period, with approximately 50% of total U.S. BEV sales and 47% of total U.S. PHEV sales. Figure 9 shows that ZEV and PHEV sales grew steadily from calendar year 2011 through 2014, but appear to have stagnated recently. While ZEV and PHEV sales grew by approximately 5.2% from 2014 to 2015, the overall market share has remained at approximately 3% of California LDV sales for 2015 and the first half of 2016. Taking a closer look at the different vehicle technologies, ZEV sales have grown 18% and now account for approximately 1.6% California's LDV sales, whereas PHEV sales declined 7% between 2014 and 2015, and now account for approximately 1.4% of California LDV sales, down from a high of 1.6% in 2014.

[33] Dashboard data.

Figure 9 - California ZEV and PHEV sales volumes CY2011 through June 2016[34]

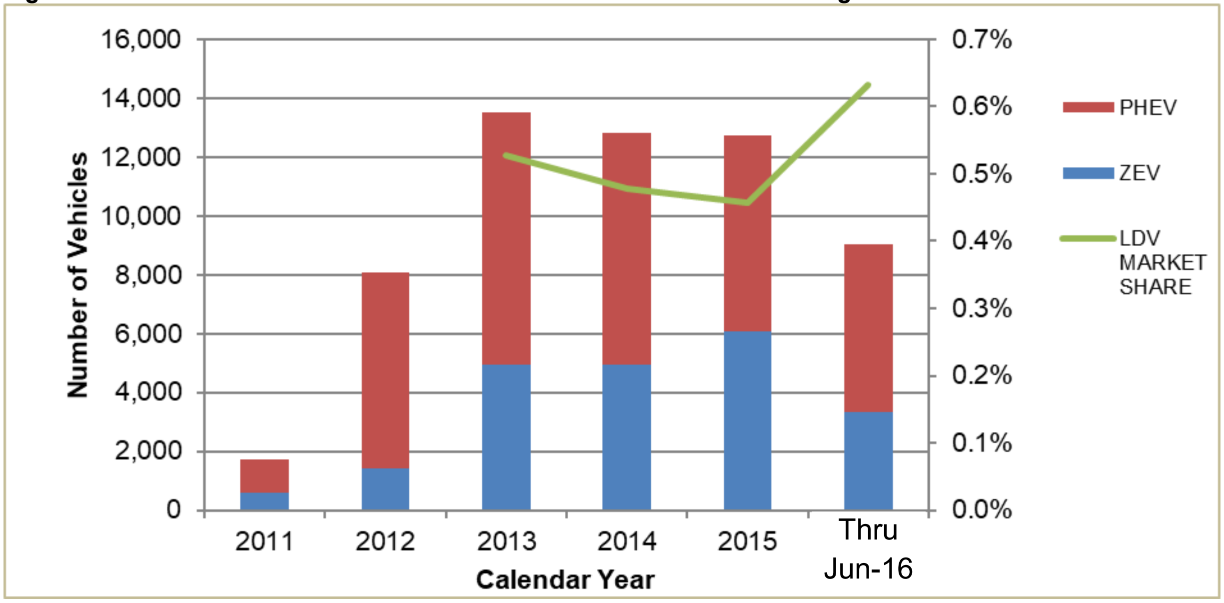


The Section 177 ZEV states have accounted for approximately 13% (58,000) of cumulative ZEV and PHEV sales in the U.S. from 2011 to June 2016, 11% (21,300) of cumulative U.S. ZEV sales and 18% (36,500) of cumulative PHEV sales. As shown in Figure 10, sales of ZEVs and PHEVs in the Section 177 ZEV states grew rapidly in the first three years, but remained flat at approximately 0.5% of total LDV vehicle sales in those states from calendar year 2013 through 2015. During that same time period, ZEV sales increased slightly to 0.2% of Section 177 ZEV state LDV sales. By contrast, PHEV sales, which started around 0.3% in 2013, fell to around 0.2% of Section 177 ZEV state LDV sales in 2015. Despite these past trends, sales of ZEVs and PHEVs are up to 0.6% in the Section 177 ZEV states for the first half of 2016, the highest levels to date for that region.

The Rest of U.S. region comprised 39% (172,000) of the total cumulative ZEV and PHEV sales in the U.S. from 2011 through June 2016, 41% (91,600) of cumulative ZEV sales and 36% (81,000) of cumulative PHEV sales. Sales in the Rest of U.S. region peaked in 2014 with 26,700 ZEVs and 19,000 PHEVs, which represents a total of 0.4% of the LDV sales for that region. However, these sales fell by 15% from 2014 to 2015, and for the first half of 2016 accounted for approximately 0.3% of regional LDV sales, with sales fairly evenly split between the two technologies.

[34] Dashboard data.

Figure 10 - Section 177 State ZEV and PHEV sales volumes CY2011 through June 2016[35]



III.A.2.c. Total Annual Volumes

This section looks at new ZEV and PHEV registrations from Experian Automotive data to better understand how individual vehicle model sales are driving the overall market and to provide a better picture of which vehicles contributed most of the 3% decrease in U.S. ZEV and PHEV sales between calendar year 2014 and 2015. Figure 11 and Figure 12 show California registrations from calendar year 2011 through 2015 (the last complete year of sales data by model available); California's ZEV sales totaled approximately 33,000 and PHEV sales totaled 25,000 in 2015. The three best-selling ZEV models in California (e.g. Tesla Model S, Nissan LEAF, and Fiat 500e) combined made up just over 66% of the total ZEV sales in calendar year 2015. The best-selling PHEV models, which were the Chevrolet Volt, the Ford Fusion and the BMW i3 REX, combined made up 70% of PHEV sales. With the exception of the FIAT 500e, California's top-selling PEV models are all distributed in other states as well and models that are only distributed to California are low volume.

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[35] Dashboard data.

Figure 11 - Annual California ZEV new registrations by model CY2011-2015[36]

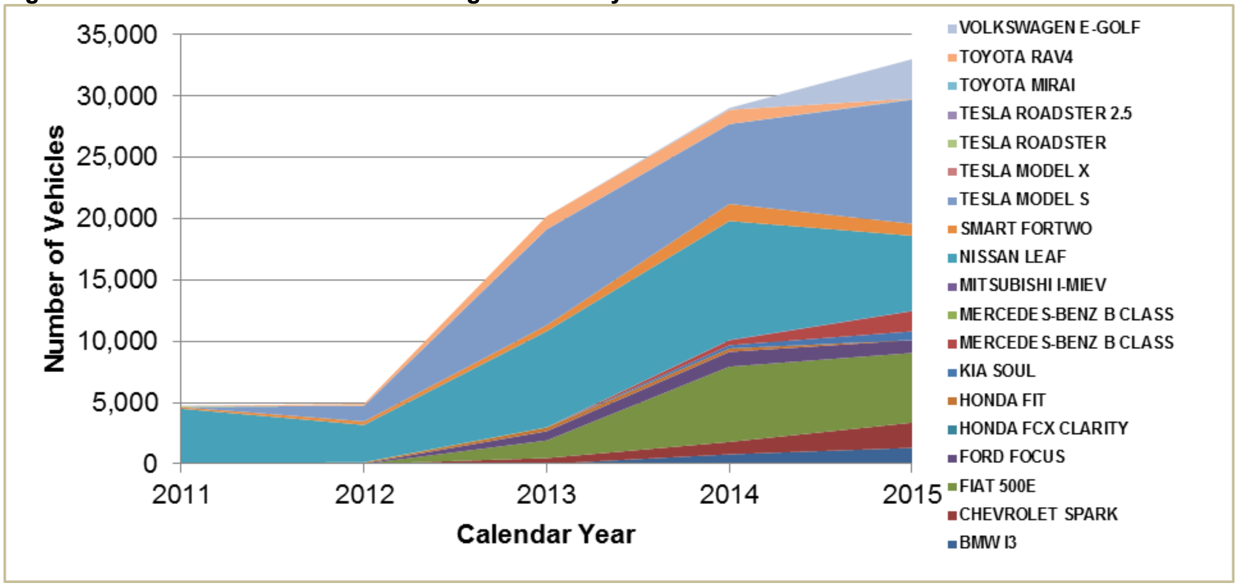
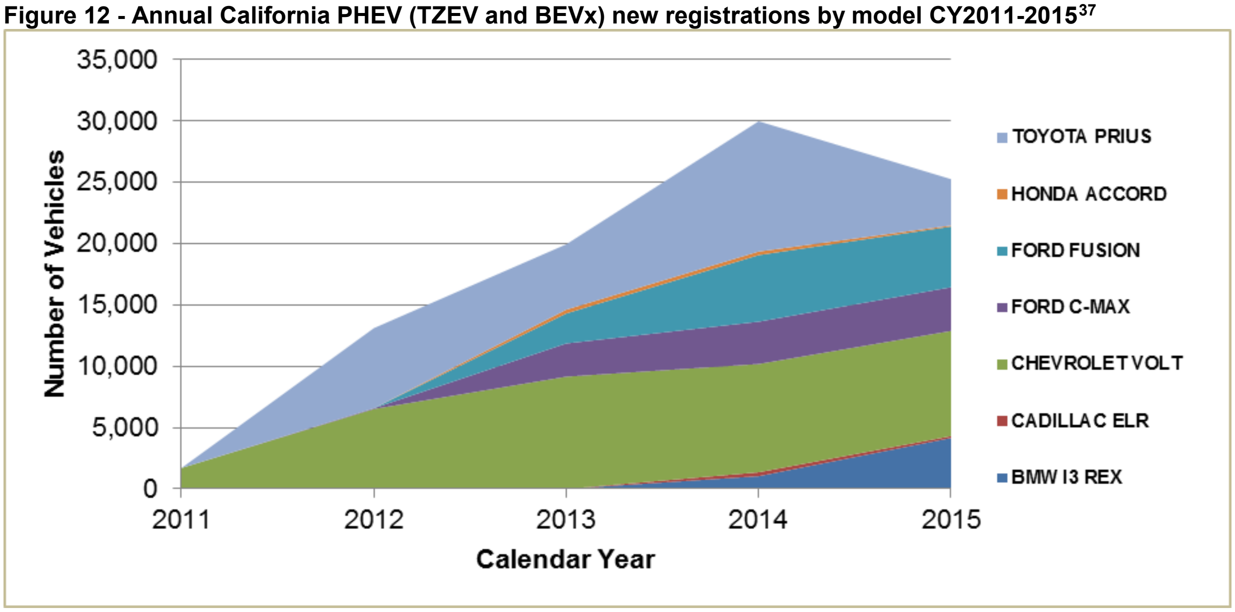


Figure 12 - Annual California PHEV (TZEV and BEVx) new registrations by model CY2011-2015[37]



The Section 177 ZEV state ZEV and PHEV sales by model are shown in Figure 13 and Figure 14, respectively. For calendar year 2015, these nine states had combined ZEV and PHEV sales of approximately 11,500 (5,900 ZEVs and 5,600 PHEVs). Combined sales for the top three selling ZEV models in this region, the Model S, the Nissan LEAF, and the Chevrolet Spark, was 74%. The Volt, Fusion, and C-Max are the three best-selling PHEVs, accounting for a combined 72% of PHEV sales in calendar year 2015 in that region.

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[36] Experian Automotive data.
[37] Experian Automotive data.

Figure 13 - Annual Section 177 ZEV State ZEV new registrations by model CY2011-2015[38]

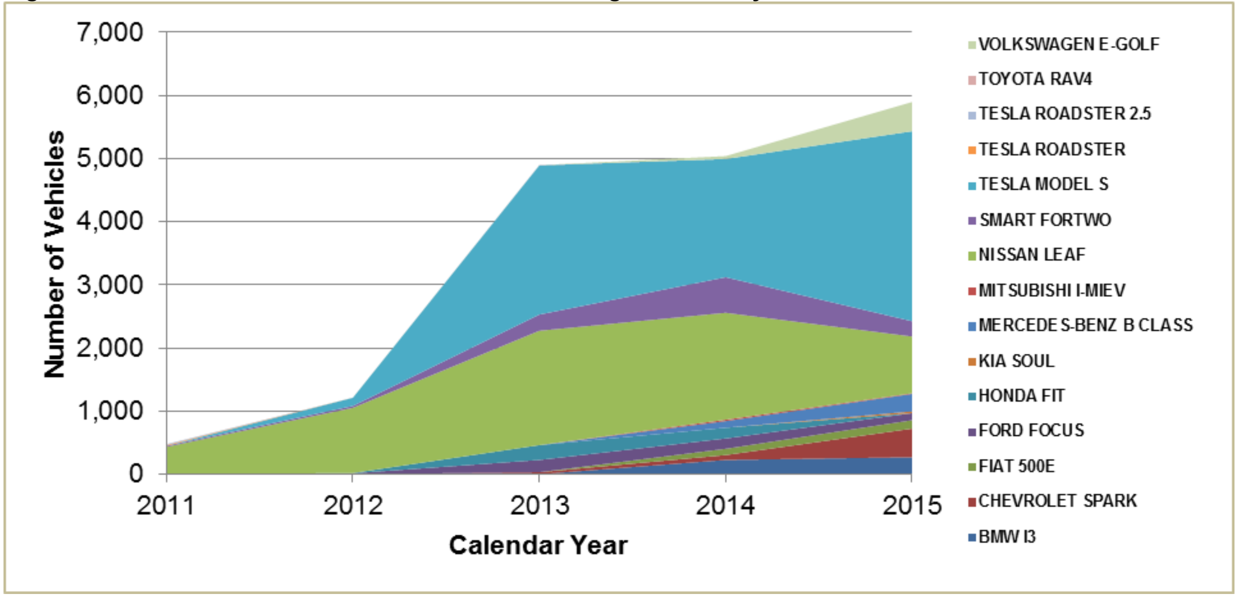
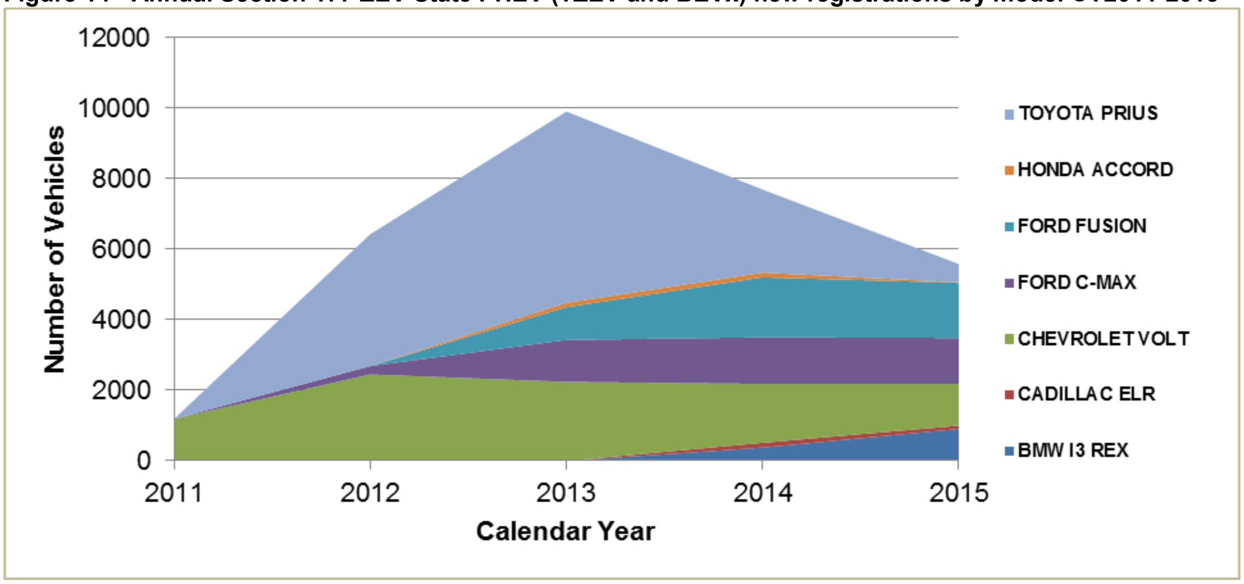


Figure 14 - Annual Section 177 ZEV State PHEV (TZEV and BEVx) new registrations by model CY2011-2015[39]



For calendar year 2015, combined ZEV and PHEV sales in the Rest of U.S. region totaled just over 35,000 vehicles. The three best-selling ZEV models for this region were the Nissan LEAF, the Tesla Model S and the BMW i3, which comprised 95% of all ZEV sales. Similar to the Section 177 ZEV States region, the Volt, Fusion, and C-Max are the three top-selling models, which likewise accounted for around 75% of the PHEV sales in the Rest of U.S. region.

Table 2 summarizes the three best-selling ZEV and PHEV sales from each region for calendar year 2015. This table additionally includes each model's regional market share within its given

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[38] Experian Automotive data.
[39] Experian Automotive data.

technology type (ZEV or PHEV) and the market share for the combined ZEV and PHEV market. This table data highlights that there are approximately five models (Tesla Model S, Nissan LEAF, Chevrolet Volt, Ford Fusion Energi, and Ford C-Max Energi) which currently constitute the majority of ZEV and PHEV sales in the U.S. Only Nissan sells the majority of its volume outside of states with a ZEV regulation and except for Tesla, the market shares of the remaining auto manufacturers has generally become more concentrated in California or Section 177 ZEV States over time. Given the previous discussion in Section III.A.2.a showing more diversity in the ZEV and PHEV market then during a similar stage of the HEV market, additional product options may increase the likelihood of meeting consumer preferences and requirements that can facilitate greater adoption of these new vehicle technologies.

Table 2 - Top ZEV and PHEV new registrations by region[40]

Region	Technology Type	Make	Model	Regional Market Share by ZEV Type	Regional Market Share of Total ZEV and PHEV Sales
California	ZEV	TESLA	MODEL S	31%	17%
	ZEV	NISSAN	LEAF	19%	11%
	ZEV	FIAT	500E	17%	10%
	PHEV	CHEVROLET	VOLT	34%	15%
	PHEV	FORD	FUSION	20%	9%
	PHEV	BMW	I3 REX	16%	7%
Section 177 ZEV States	ZEV	TESLA	MODEL S	51%	26%
	ZEV	NISSAN	LEAF	15%	8%
	ZEV	VOLKSWAGEN	E-GOLF	8%	4%
	PHEV	FORD	FUSION	28%	14%
	PHEV	FORD	C-MAX	23%	11%
	PHEV	CHEVROLET	VOLT	21%	10%
Rest of the U.S.	ZEV	NISSAN	LEAF	49%	32%
	ZEV	TESLA	MODEL S	41%	26%
	ZEV	BMW	I3	5%	4%
	PHEV	CHEVROLET	VOLT	38%	13%
	PHEV	FORD	FUSION	20%	7%
	PHEV	FORD	C-MAX	20%	7%

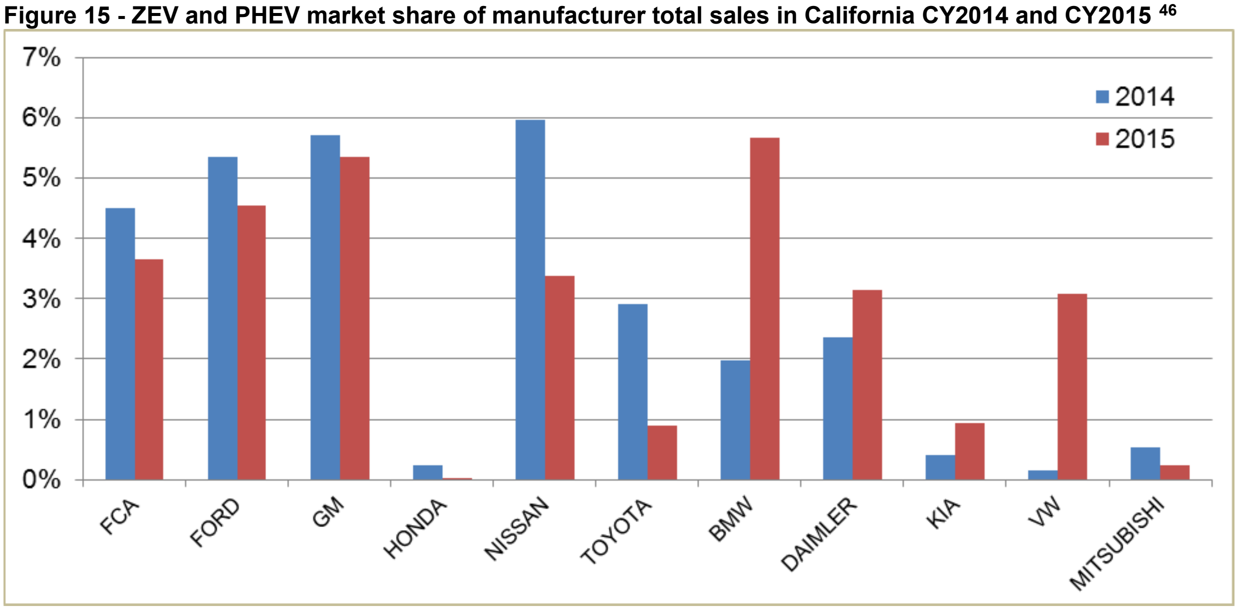
As shown in Figure 12 and Figure 14 the sharp decline in PHEV sales in California and the Section 177 ZEV States described in section III.A.2.b resulted primarily from two vehicles being discontinued in 2015: the Toyota Prius and the Honda Accord. The Prius Plug-in was the best-selling PHEV in both California and the Section 177 ZEV states in calendar year 2014. Sales of all the other PHEV models in both California and the Section 177 ZEV states were fairly flat from 2014 to 2015. Based on Figure 11 and Figure 13, the ZEV models that decreased in sales from 2014 to 2015 are either vehicles that have been on the market for a while, such as the Nissan LEAF and the Smart ForTwo Electric, or were discontinued in 2015, such as the RAV4 EV.

[40] Experian Automotive data.

III.A.2.d. ZEV and PHEV Market Share of OEM Total LDV Sales

Figure 15 shows ZEV and TZEV market shares based on each OEM's individual California LDV sales volumes for calendar year 2014 and 2015. In California, overall ZEV and PHEV sales (including TZEV and non-TZEV certified PHEVs) were approximately 3% the total LDV market during this time period.[41] However, the ZEV and PHEV market share for each OEM is more variable. Year-over-year market shares fell for each of the six largest manufacturers (FCA, Ford, GM, Honda, Nissan, and Toyota); only in the case of GM did total ZEV and PHEV market shares decline because of an increase in overall sales volumes. In contrast, PEV market shares increased for the next four manufacturers[42] despite the increase in overall sales. These trends may be a function of the fact that the larger manufacturers introduced products in 2012 and 2013, and by 2015 were transitioning to their next generation products. For example, General Motors announced the new Volt at the Detroit Auto Show in January 2015[43] and released it later that year as a 2016 MY vehicle. Toyota also announced plans to discontinue the Prius Plug-in in May 2015[44] and will be releasing the Prius Prime PHEV by the end of 2016.[45] Meanwhile, the four smaller manufacturers released their ZEV and PHEV products in this timeframe, and as a

Figure 15 - ZEV and PHEV market share of manufacturer total sales in California CY2014 and CY2015 [46]



[41] Dashboard data.

[42] Hyundai is not included in Figure 15 because the Experian Automotive data used to create this graph did not include sales data for the Hyundai Tucson FCV.

[43] Moss 2015. Darren Moss. January 12, 2015. Article. *Autocar.* "Chevrolet Volt unveiled in Detroit." http://www.autocar.co.uk/car-news/motor-shows-detroit-motor-show/2015-chevrolet-volt-unveiled-detroit.

[44] Berman 2015. Brad Berman. May 01, 2015. *Plug-in Cars*. "Toyota Halts Production of Prius Plug-in Hybrid Until Late 2016." http://plugincars.com/toyota-stops-production-current-prius-plug-hybrid-130691.html.

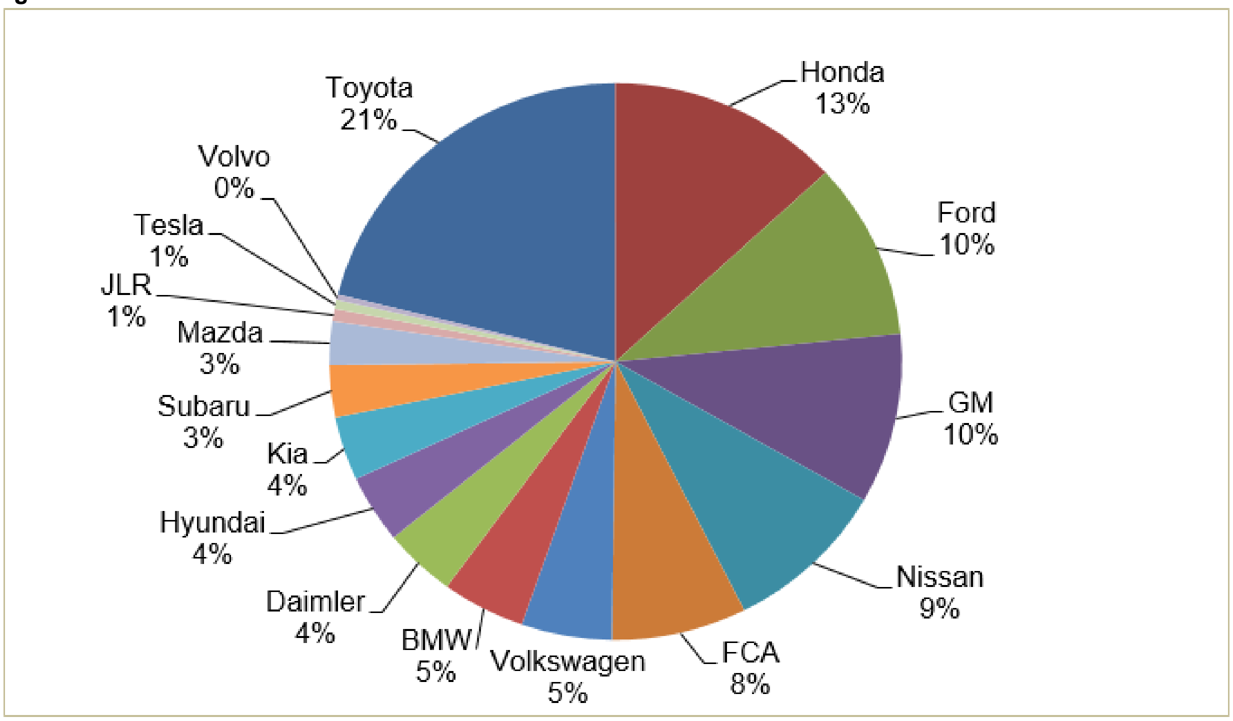
[45] http://www.toyota.com/priusprime/

[46] ZEV and TZEV sales based on Experian Automotive data, total manufacturer sales volumes based on CNCDA Quarterly Report.

result 2014 reflects only a partial year of sales. For example, the Kia Soul EV was announced in early 2014 as a 2015 MY vehicle[47] and BMW released the i3 in early 2014.

Additionally, although ZEV and PHEV market shares for some of the largest manufacturers may be below those of the smaller manufacturers, when factoring in their total California market shares shown in Figure 16, their total volumes of ZEVs and PHEVs may still be greater. While market shares are relevant for regulatory compliance, total volumes of ZEVs and PHEVs are also important for increasing consumer exposure to these products and generating scale economies for cost reductions.

Figure 16 - Manufacturer market shares in California for CY2015[48]



III.A.2.e. Building ZEV and PHEV Market Shares in the Context of the Entire Light-Duty Vehicle Market

This section provides additional context for how individual vehicles and vehicle segments contribute to the overall California and U.S. LDV market for calendar year 2015 to illustrate which segments provide the greatest opportunities for ZEV and PHEV models. Additionally, current *model* shares show that no single model accounts for more than 4% of the total market, which indicates that an expanded and sizeable ZEV and PHEV market requires consumers to embrace multiple models.

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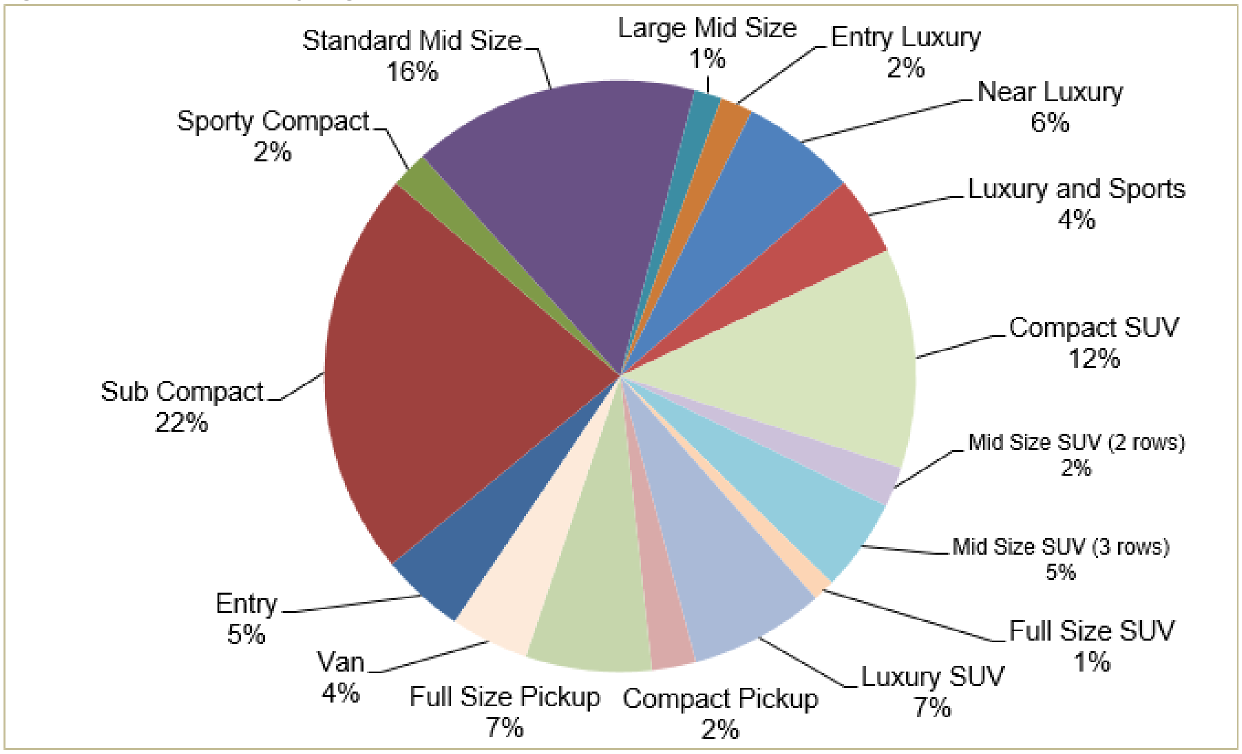
[47] Voelcker 2014. John Voelcker. February 6, 2014. *Green Car Reports*. "2015 Kia Soul EV Electric Car Unveiled At Chicago Auto Show." http://www.greencarreports.com/news/1090170_2015-kia-soul-ev-electric-car-unveiled-at-chicago-auto-show.

[48] CNCDA 2016.

California market shares for each vehicle segment are shown in Figure 17. More than half of new light-duty vehicles sold are passenger cars body styles (darker colors) as opposed to light trucks (lighter colors). The two largest segments – subcompact and standard midsize passenger cars – contribute more than one-third of sales and are also the segments in which many ZEVs and PHEVs are currently offered (and more are expected in the future).[49] Within the light truck category, compact SUVs (often built on unibody chassis similar to passenger cars and may also be included in a manufacturer's passenger car fleet for performance standard averages) comprise the largest segment and is the segment in which many future PHEV and ZEV offerings are expected.[50]

Figure 17 - Market share by segment in California CY 2015[51]



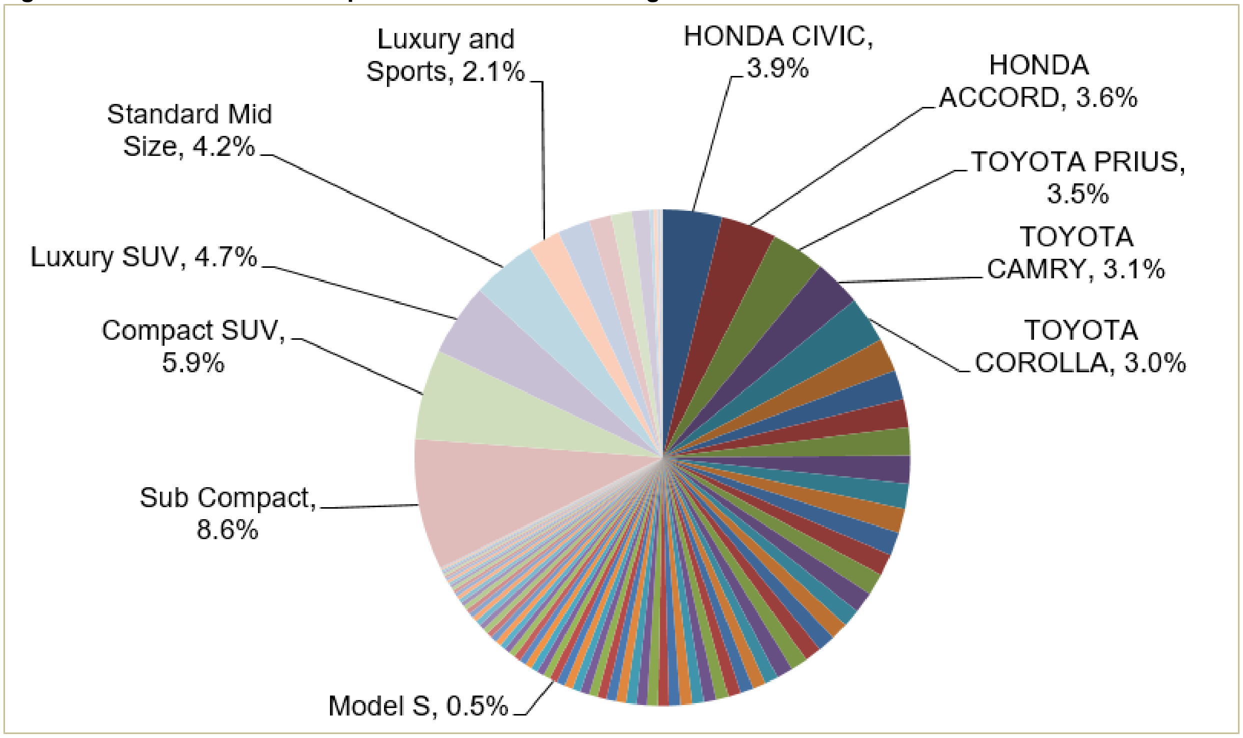
Note: Darker colors represent passenger car segments, lighter colors represent light-truck segments.

For context, Figure 18 shows the five best-selling individual vehicle models within each segment in California. The five best-selling vehicles overall are all passenger cars and comprise just over 17 percent of all new light-duty vehicles sold. At about 10,000 units, Tesla's Model S was the best-selling ZEV or PHEV in California in calendar year 2015 and the third best-selling model in the Luxury and Sports segment (the only ZEV or PHEV model to rise to be within the top five in its class). However, relative to the roughly two million light-duty vehicles sold in the state in

[49] Based on DOE/EPA Fuel Economy Guide MY 2016 vehicle classification, http://www.fueleconomy.gov/feg/pdfs/guides/FEG2016.pdf.
[50] See Section IV.A for discussion on future model availability.
[51] CNCDA Quarterly Reports. See Section VII.K for further data source details.

2015, the Model S represents a total market share of 0.5% (around the 50th percentile among all of the segment leaders).

Figure 18 - Market shares of top 5 models within each Segment in California CY 2015 [52]



As the California sales data do not include all available models, Figure 19 uses U.S. vehicle sales data from WardsAuto to calculate the overall market share for each of the 300 models offered for sale in 2015. [53] Similar to the California market, only the top-selling vehicle, the Ford F-Series (which includes a large assortment of variants) exceeds four percent of the market, and even the fifth best-selling model, the Toyota Corolla, comprises only two percent of total sales. In California, the top three best-selling vehicle models in calendar year 2015 were all passenger cars (i.e. Honda Civic, Honda Accord, and Toyota Prius). By contrast, the top three best-selling vehicle models in the U.S. were all light-duty trucks (i.e. Ford F-Series, Chevrolet Silverado, and Ram 1500). Within both markets the top three vehicles combined total approximately 11% of the total LDV market.

Of the 300 models, the top 10 percent of models account for about 50 percent of all light-duty vehicle sales in the U.S. with each of these models exceeding 1 percent overall market share. The remaining half of the market is comprised of the remaining 90 percent of models, many of which are relatively low volume. More than half of all models have 0.25 percent market share or less; however, even models with 0.1 percent market share in the U.S. represent 16,000 units.

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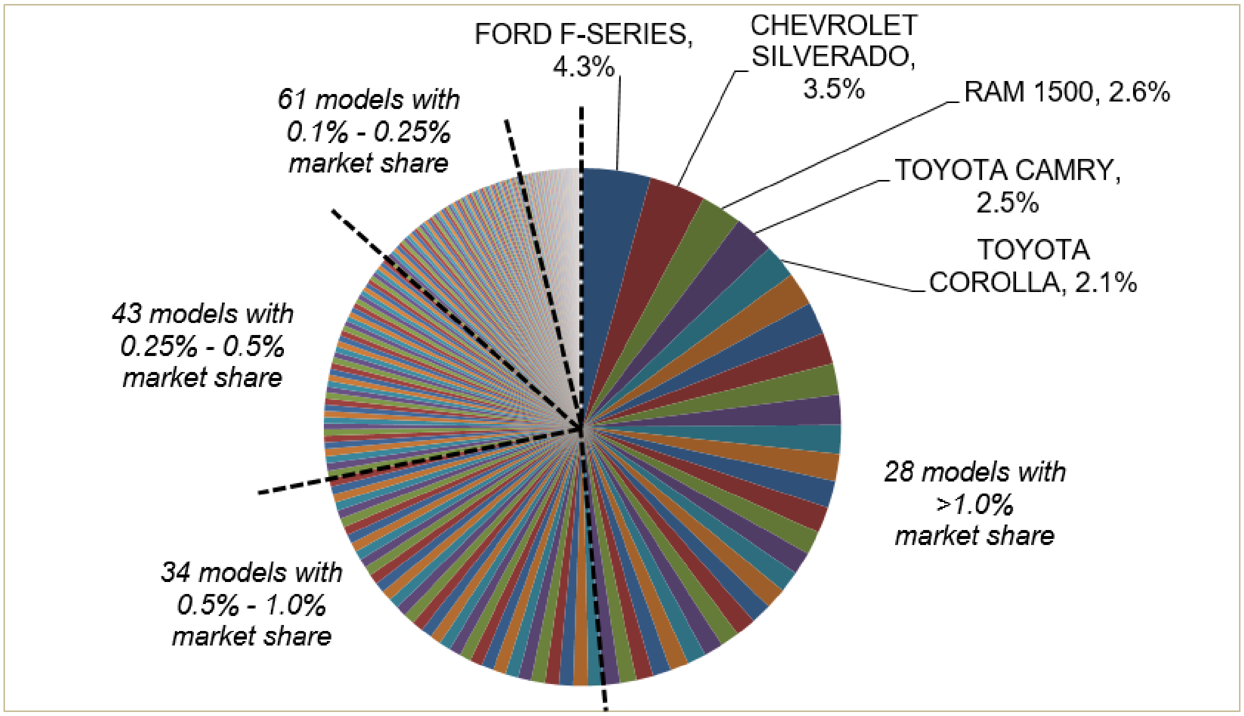
[52] CNCDA Quarterly Reports.

[53] Exotic models such as very high-end luxury or performance vehicles were excluded, e.g. Rolls Royce, Ferrari, etc.

While current market shares for individual ZEV and PHEV models are relatively low, they are similar to those of many of their conventional technology counterparts.

Figure 19 - Market share of 300 conventional, PHEV, and ZEV models in U.S. CY2015[54]

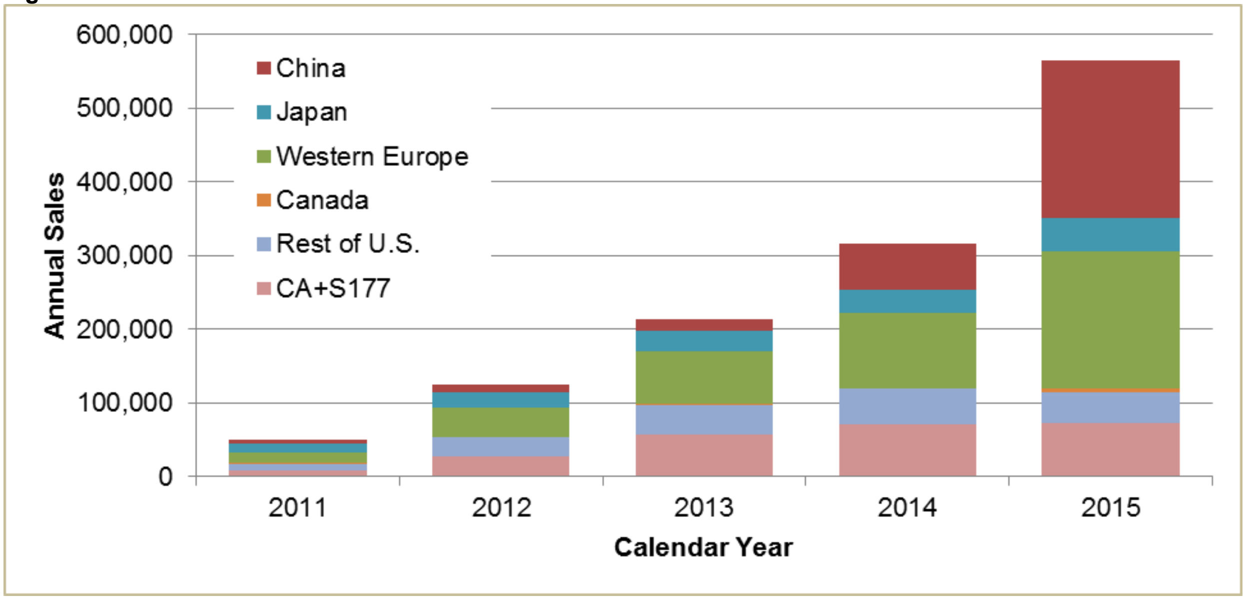


III.A.2.f. Global Sales Volumes of PEVs

Combining the U.S. PEV sales volumes from the previous sections with global PEV sales volumes[55] the global PEV market has increased steadily since 2011, reaching over 500,000 units in 2015. However, as shown in Figure 20, recently this growth has been concentrated in regions outside of the U.S., though cost reductions from economies of scales occur regardless of location. In 2015, China had the highest PEV sales followed closely by Western Europe; California with the Section 177 ZEV States most recently ranks as the third largest PEV market, surpassing the volumes in Japan and Canada combined. It is expected that the total global PEV market will surpass a cumulative 2 million vehicles by the end of 2016.[56]

[54] WardsAuto data.
[55] DOE, 2016b. U.S. Department of Energy. March 28, 2016. Fact of the Week #918. "Global Plug-in Light Vehicle Sales Increased by About 80% in 2015." http://energy.gov/eere/vehicles/fact-918-march-28-2016-global-plug-light-vehicle-sales-increased-about-80-2015.
[56] Carrington 2016.

Figure 20 - Global PEV sales CY2011-2015[57]



III.A.3. Dealership Vehicle Availability

One question posed by stakeholders is whether low numbers of PEVs on dealer lots across the Section 177 ZEV states helps to explain their sales rates relative to California's. Vehicle availability at dealerships can help explain what potential consumer might encounter in terms of how many choices are available when purchasing a vehicle. In contrast to model availability discussed in Section III.A.1, this analysis evaluates select PEVs (as well as comparable vehicle models) available on dealer lots, over a period of time, across specific cities. Even if a manufacturers distributes certain models for sale in a particular city or state, physical vehicles may not be available on dealer lots for customers to see and test drive.[58]

One 2016 study asserted that more PEV models are available in California compared with the rest of the U.S. and all automakers could improve their availability of PEVs and the number of models available at dealership, especially outside of California.[59] Staff recognizes one of the highest selling PEVs in the Section 177 ZEV states is the Tesla Model S, which is not sold at any dealership, but through online orders and sales. However, all manufacturers with a current pure-ZEV obligation offer vehicles for sale through a traditional network of dealers.

Inventory data was collected from all dealerships within each city once a week via Edmunds.com. The following major metropolitan cities were chosen to be representative of the larger state: Boston, New York City, Albany, Baltimore, Los Angeles, Portland (OR), and

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[57] DOE 2016b and Experian Automotive data.
[58] See Section III.B.5 for more information on the effectiveness of test drives on PEV purchase decisions.
[59] Reichmuth and Anair 2016. David Reichmuth and Don Anair. August 2016. Union of Concerned Scientists. "Electrifying the Vehicle Market: Evaluating Automaker Leaders and Laggards in the United States." http://www.ucsusa.org/sites/default/files/attach/2016/08/Electrifying-Vehicle-Market-full-report.pdf.

Table 3 - PEV models and comparable vehicles by manufacturer

Manufacturer	PEV model	Comparable vehicle model	Comparable sales model	Best-selling passenger car
BMW	i3	i3 REx	M235	328
GM	Volt	Cruze*	Corvette	Cruze
Ford	Fusion Energi	Fusion Hybrid	Focus ST	Fusion
	C-MAX Energi	C-MAX Hybrid	Focus ST	Fusion
Nissan	LEAF	Versa	Juke	Altima

* The Chevrolet Cruze is both the best-selling and comparable vehicle model to the Volt.

Table 4 - Average daily number of vehicles on dealership lots from October 2015 to May 2016 (with number of dealership carrying each vehicle)

	PEV Model	PEVs available (dealerships)	Comparable vehicles available (dealerships)	Comparable sales models available (dealerships)	Best-selling PC models available (dealerships)
Boston	i3	13 (4)	38 (5)	32 (5)	201 (5)
	Volt	33 (14)	28 (16)	29 (14)	28 (16)
	Fusion Energi	32 (16)	50 (21)	14 (18)	328 (24)
	C-Max Energi	17 (15)	46 (23)	14 (18)	328 (24)
	Leaf	22 (15)	62 (14)	81 (15)	582 (15)
New York City	i3	6 (6)	43 (14)	69 (17)	464 (17)
	Volt	29 (30)	69 (31)	81 (33)	69 (31)
	Fusion Energi	196 (28)	67 (28)	20 (25)	1005 (33)
	C-Max Energi	55 (26)	14 (16)	20 (25)	1005 (33)
	Leaf	6 (9)	134 (34)	101 (37)	2652 (38)
Albany	i3	0	1 (2)	6 (2)	59 (2)
	Volt	3 (3)	10 (3)	7 (3)	10 (3)
	Fusion Energi	7 (5)	25 (8)	4 (5)	105 (9)
	C-Max Energi	4 (5)	4 (4)	4 (5)	105 (9)
	Leaf	3 (3)	27 (4)	21 (4)	227 (4)
Baltimore	i3	5 (4)	17 (5)	30 (6)	138 (6)
	Volt	15 (14)	57 (16)	51 (15)	57 (16)
	Fusion Energi	52 (13)	76 (16)	27 (15)	337 (16)
	C-Max Energi	32 (12)	29 (16)	27 (15)	337 (16)
	Leaf	18 (10)	163 (13)	43 (13)	520 (13)
Los Angeles	i3	41 (14)	101 (14)	94 (14)	603 (14)
	Volt	186 (17)	61 (17)	87 (17)	61 (17)
	Fusion Energi	491 (18)	174 (19)	71 (19)	580 (19)
	C-Max Energi	96 (18)	140 (18)	71 (19)	580 (19)
	Leaf	83 (16)	720 (16)	87 (16)	1346 (16)
Portland	i3	5 (2)	22 (2)	17 (2)	65 (2)
	Volt	24 (10)	17 (9)	25 (9)	17 (9)
	Fusion Energi	90 (8)	43 (13)	14 (10)	108 (15)
	C-Max Energi	42 (9)	37 (11)	14 (10)	108 (15)
	Leaf	70 (6)	77 (6)	20 (6)	159 (6)
Seattle	i3	23 (3)	34 (3)	38 (3)	108 (3)
	Volt	10 (12)	19 (14)	26 (15)	19 (14)
	Fusion Energi	105 (12)	61 (14)	31 (15)	234 (15)
	C-Max Energi	38 (12)	88 (15)	31 (15)	234 (15)
	Leaf	74 (7)	31 (7)	26 (7)	183 (7)

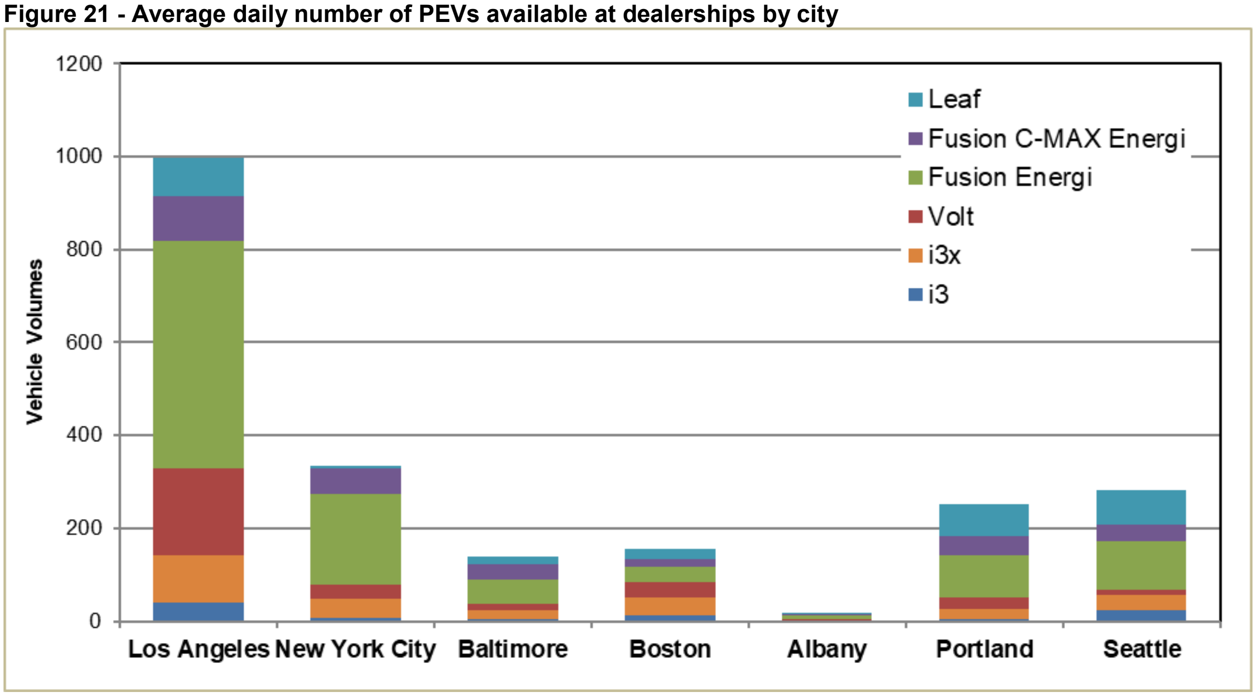
Seattle. Note that Washington is not a Section 177 ZEV state, but was included as a comparable city in order to analyze the potential effect of the ZEV regulation. Staff also analyzed some non-PEV models to provide context for the way in which a given manufacturer/dealer stocks vehicles. For each PEV chosen, a comparable vehicle (in terms of segment class), a vehicle with similar sales volumes, and the best U.S selling passenger car for that manufacturer was studied, shown in Table 3. Table 4 summarizes the average number of vehicles available in each city and vehicle type, as well as the number of dealerships carrying each model in (parentheses). These numbers were then averaged over the six month period, resulting in an average daily “snapshot”.

Analyzing these data on inventories among dealerships that offer PEVs compared to comparable vehicle models, there is a difference between cities and manufacturers. In Los Angeles, all dealerships carry the PEV and comparable vehicles. Baltimore, Portland and Seattle dealers have PEVs available at most dealerships across all manufacturers. Boston BMW, GM and Nissan dealers carry PEVs at their dealerships, but Ford dealers offer limited PEVs and only at some dealerships. In New York City, only the GM and Ford dealers have similar dealership availability between the PEV model and other comparable vehicles. Nissan and BMW dealers do not carry as many the PEVs on their lots, which may translate to low sales.

III.A.3.a. PEV Availability

Using data from Table 4 on average daily PEV availability, Figure 21 shows the average number of PEVs available at dealership lots for each city. This figure illustrates the significant difference in availability between Los Angeles and all other cities for these select PEVs.

Figure 21 - Average daily number of PEVs available at dealerships by city



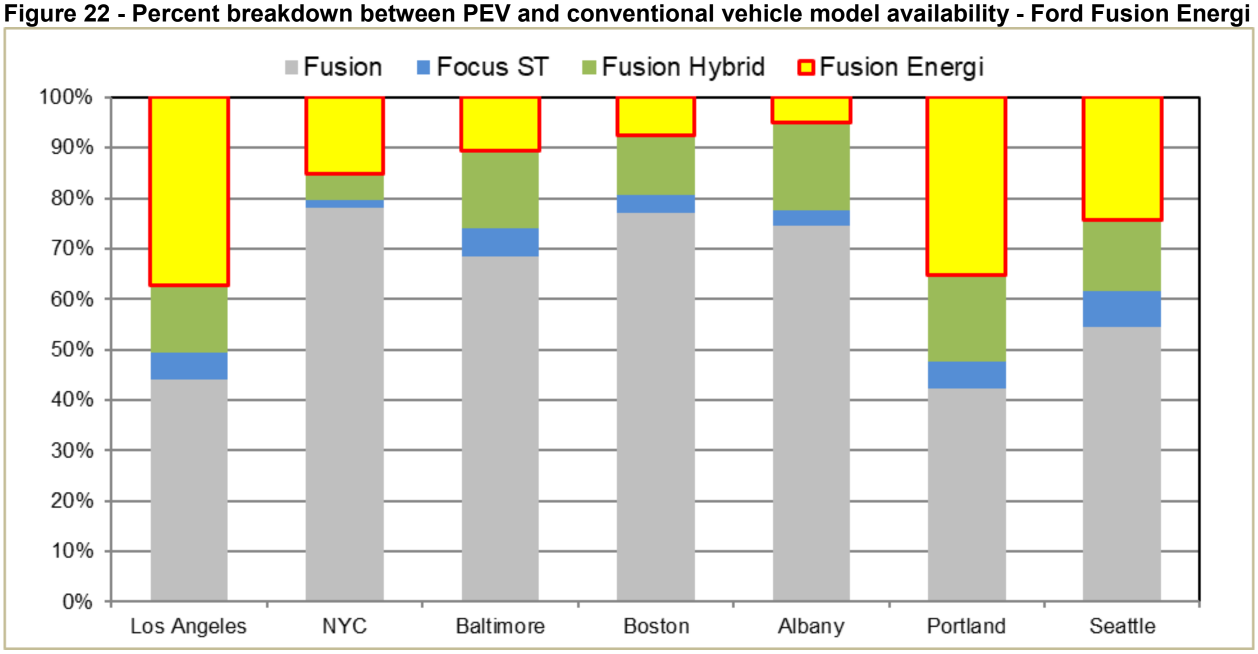
According to these data, it does appear that PEVs are less available in pure volume in Section 177 ZEV state cities than in Los Angeles, California. However vehicle volumes have not been normalized for new vehicle sales within each of the cities. For reference, New York City, Boston and Baltimore have similar PEV market shares per capita,[60] but New York has more models available on dealer lots, especially the Ford products.

III.A.3.b. PEV and Comparable Vehicle Availability

To help further explain PEV availability at the dealership, staff analyzed availability for comparable vehicles for each model. For each city and PEV, staff developed a “target fleet” to compare the number of vehicles across cities. This “target fleet” consists of the PEV of interest, all the comparable models, and the best-selling vehicle. Staff looked at each PEV (presented in subsequent figures), but for simplicity, have provided an example first with the Ford Fusion Energi (PHEV).

Figure 22 shows the relationship between the Ford Fusion Energi and its comparable vehicles (Ford Fusion Hybrid, Focus ST and Fusion) and how this relationship differs between cities. In Los Angeles, PEVs comprise a larger percentage of the "target fleet," though Portland and Seattle exhibit similarly higher percentages of PEVs that are greater than those in the northeast states.

Figure 22 - Percent breakdown between PEV and conventional vehicle model availability - Ford Fusion Energi



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[60] Lutsey et al. 2015. Nic Lutsey, Stephanie Searle, Sarah Chambliss, and Anup Bandivadekar. July 2015. The International Council for Clean Transportation. *Assessment of leading electric vehicle promotion activities in United States cities.* http://www.theicct.org/sites/default/files/publications/ICCT_EV-promotion-US-cities_20150729.pdf.

Figure 23 - Percent breakdown between PEV and conventional vehicle model availability

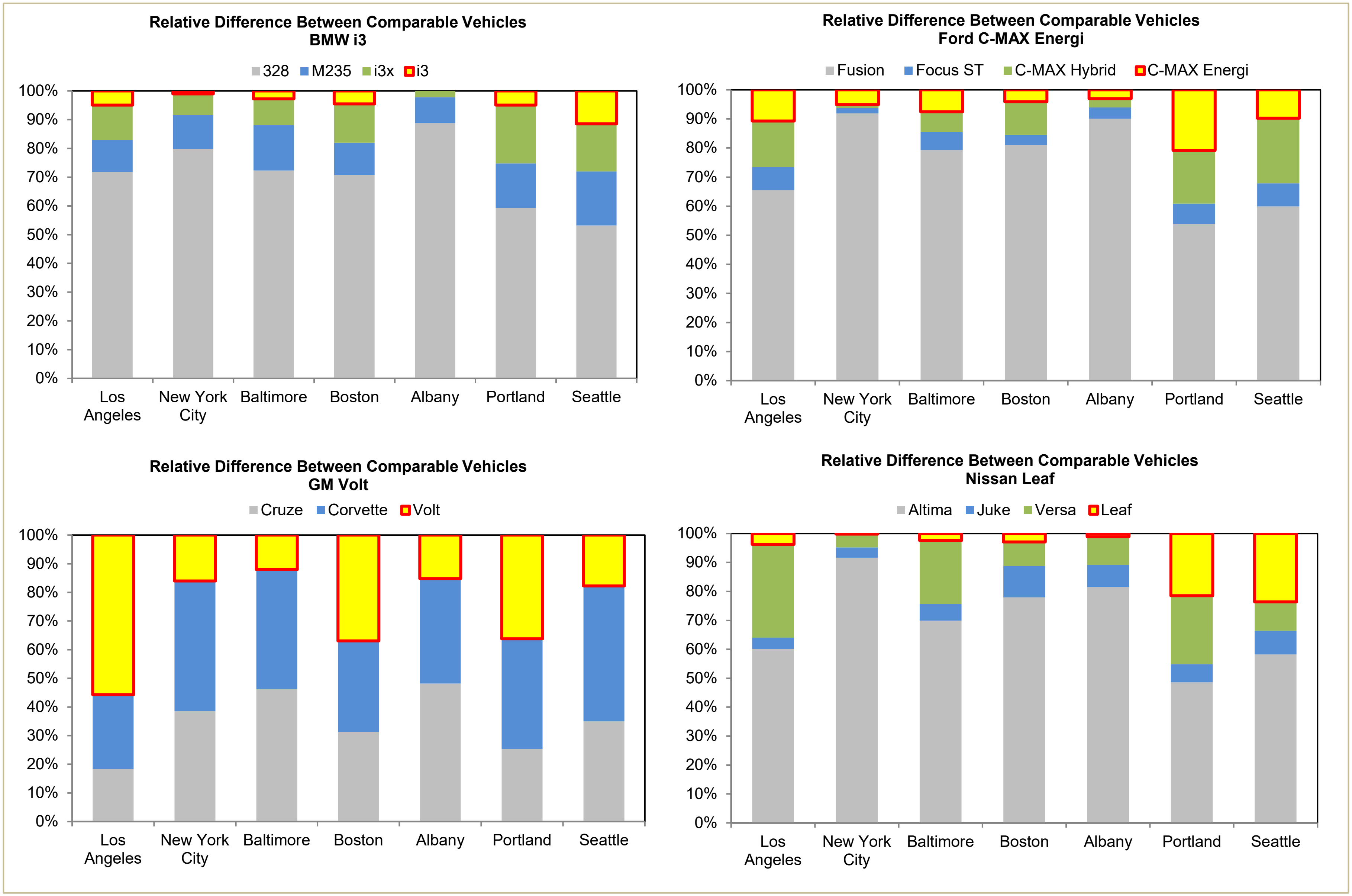

Figure 23 shows the remaining four PEVs and their comparable vehicles. Note for BMW, the dealership lots in Portland and Oregon have relatively more BMW i3 and i3 REX models when compared to other cities. Even though the Chevrolet Volt is available in all 50 states across the U.S., there are significantly greater numbers available on dealer lots in California, though Boston and Portland are close behind. For the Nissan Leaf, California dealers offer similar vehicle inventory volumes as Portland and Seattle, however Portland and Seattle Leaf sales make up a larger portion of sales for this "target fleet".

It is difficult to fully analyze dealer availability without knowing city sales numbers to accurately compare market size with dealer inventory. However, these data show a significant difference between PEVs and other conventional vehicles offered within the same city by the same manufacturer. For example, BMW offers the M235 in much higher volumes (and relative percent) compared to the i3 or the i3x. However, for BMW this trend is the same for all the cities analyzed. GM, however, offers the Volt (which is the highest selling PHEV in the U.S.) as a much larger proportion of overall sales in each city. Differences in availability across cities show that some consumers could be less exposed to PEV technology when shopping for a new vehicle.

The Union of Concerned Scientists also conducted their own study investigating this topic.[61] They concluded that most drivers would have difficulty locating an electric vehicle at a dealership outside of California. Many more models are offered for sale in California, 24 in CY2015 compared to 14 in any other state and over half the sales of the most popular electric vehicles occurred in California. Focusing on availability on the dealer lots from January to June 2015, they found stark differences in dealer availability on the lots with Baltimore having only 10% of the vehicles available in Oakland after adjusting for relative car ownership.

III.A.4. New Vehicle Manufacturer Suggested Retail Prices of ZEVs and PHEVs

As discussed in Appendix C, incremental vehicle costs of ZEVs and PHEVs are anticipated to remain well above the cost of conventional vehicle technology in the near term. These higher costs are likely to be passed onto consumers and reflected in part or in whole in the price of new vehicles. Under the dealer franchise business model, consumers do not necessarily pay the price that is suggested by the auto manufacturer, as dealers have flexibility to negotiate prices and may also have incentives offered by the manufacturer that can be passed onto customers. For example, in 2015, the average MSRP of a midsize car was $27,000 but the average transaction price was just below $24,000.[62] Nonetheless, the manufacturer suggested retail price (MSRP) generally reflects auto manufacturer pricing expectations and serves as a benchmark for consumers and lenders on a vehicle's value.

Pricing data for the nearly 300 models[63] offered in MY2016 were assembled from a combination of Wards data, auto manufacturer websites, and other third-party auto buying guides. A vehicle

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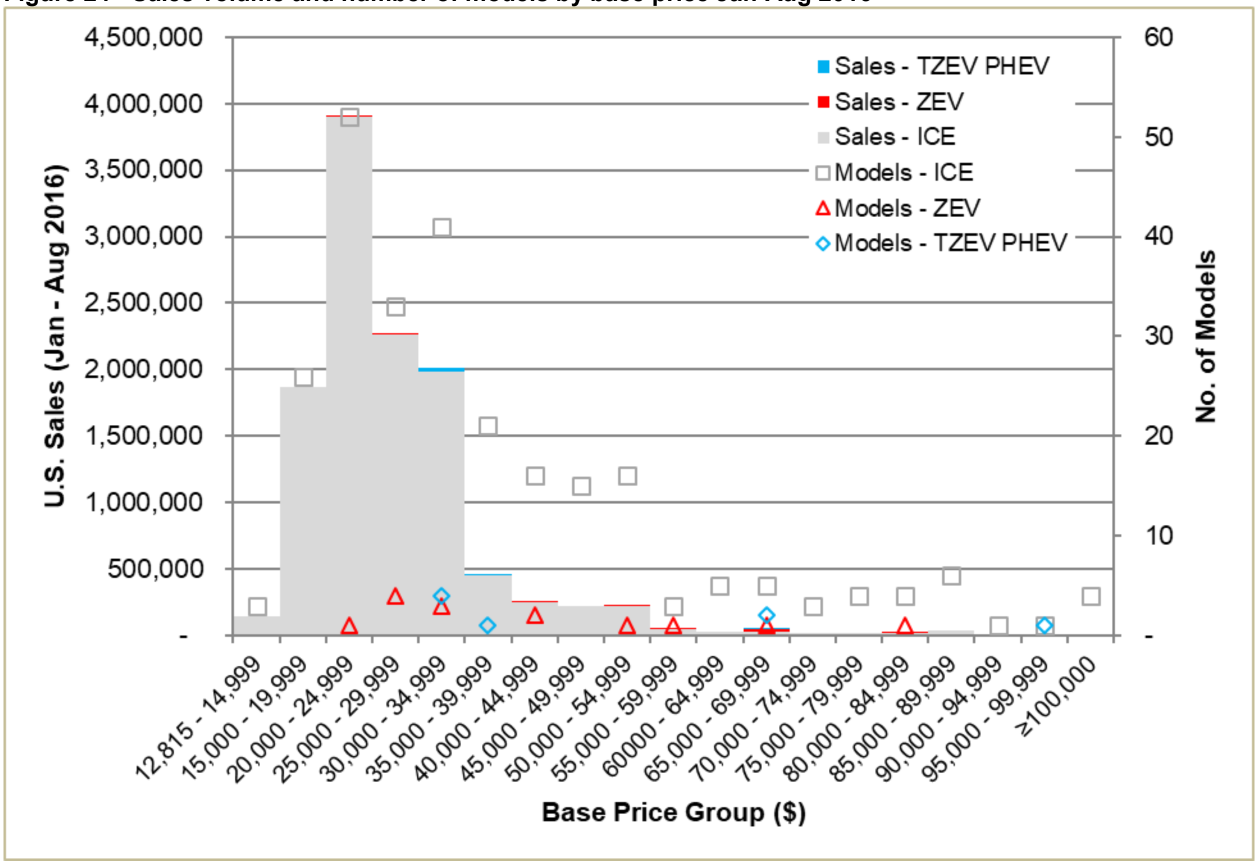
[61] Reichmuth and Anair 2016.
[62] NADA 2016b. National Automotive Dealers Association. Q2 2016. White Paper: An Updated Pricing Approach for New Vehicle Financing. http://business.nada.com/2016Q2Whitepaper.
[63] Exotic models such as very high-end luxury or performance vehicles were excluded, e.g. Rolls Royce, Ferrari, etc.

model may have a wide variety of MSRPs given that they often come with optional, higher priced engine configurations, accessories, and amenities. The base prices analyzed here reflect the starting MSRP and destination fee for each model, with ZEVs and PHEVs itemized separately. Only when factoring in up to $10,000 worth of government incentives do ZEVs and PHEVs prices become competitive with conventional vehicle prices. However, average starting prices for BEVs with ranges of less than 200-miles are $3,000 less than PHEVs without any government incentives. Meanwhile, at the dealership level, PHEVs appear to receive greater incentives from manufacturers than BEVs, though not well-beyond those offered on conventional vehicles. These two pricing factors combined may account for the relatively constant and even market share split between the two technologies.

Staff used January to August 2016 U.S. sales volumes for each of these models to estimate a sales-weighted base price distribution. As shown as shaded bars in Figure 24, the majority of all new vehicles sold start at a base price of less than $25,000 and vehicles are most frequently

Figure 24 - Sales volume and number of models by base price Jan-Aug 2016[64]



sold with starting prices ranging from $20,000-$24,999. The top 50 best-selling models and almost 90% of all new vehicles sold start at a base price of less than $35,000. The colored points denote the number of different models of each powertrain type that are offered in each price category. The number of models offered in each price category roughly follows the

[64] WardsAuto data and manufacturer websites.

distribution of U.S. sales in each category, with the $20,000-$24,999 price range also offering the greatest number of model choices. However, the higher average volume per model for this popular price range also suggests that the number of models is not solely responsible for the higher sales volumes, as this category also includes some of the market's best-selling models.

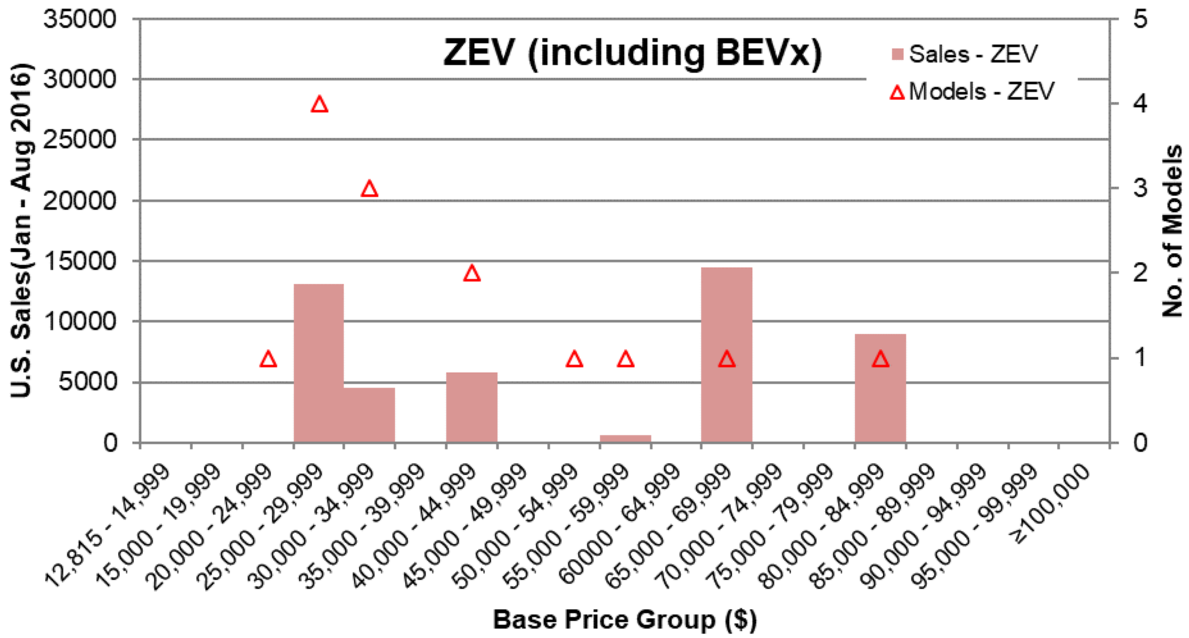
To focus more closely on the trends of ZEVs and PHEVs, Figure 25 shows these powertrains in isolation. The figure illustrates that the lower bound sales price for ZEVs with significant sales volumes is lower than that for PHEVs, falling in the $25,000-$29,999 range. However there are also substantial volumes in the upper price ranges, making the sales more distributed across price categories, even though the model offerings are more concentrated at the lower price ranges. The lower bound for PHEVs falls in the $30,000-$34,999 range, which is about $10,000 more than the mode for ICEs (previous shown in Figure 24), and the vast majority of PHEVs sold are in this price range. Although 30 percent more ZEVs were sold during this period than PHEVs, it is not clear whether a greater number or diversity of PHEV models across price ranges would increase overall PHEV market shares even if they were offered at lower price points.

Current government purchase incentives can reduce the price of a new ZEV or PHEV to be more similar to new ICEs. While federal tax credits depend on individual consumers' tax situations[65] and state incentives vary in amount and eligibility, Figure 26 illustrates sales volume and model counts for ZEV and PHEV prices adjusted to include federal and California state incentives.[66] When accounting for these incentives, there are now ZEVs available in the two lowest price categories. Only when factoring in up to $10,000 worth of government incentives does the ZEVs and PHEV price distribution become similar to the overall (mostly ICE) market, though the median price occurs in the $25,000-$29,999 range which is higher than the median price for ICEs. Some of this price increase may result from these vehicles having more features included as standard equipment similar vehicles with conventional powertrains might include as optional. Nonetheless, these price differences are relatively consistent with the higher technology costs for the different technologies that are discussed in Appendix C.

[65] Federal tax credit for purchases are claimed directly by the consumer on federal income tax returns and are not refundable in the case of the credit value exceeding an individual's tax liability, however tax credits are claimed by the title holder for leases. Federal tax credit varies based on battery size.

[66] California state incentives assumed to be $2500 for all BEVs and $1500 for all PHEVs and do not include the additional rebates for low and moderate income households. Other state rebate incentives are of similar amounts. See Appendix E for more details. Some local government agencies also offer additional purchase incentives.

Figure 25 - ZEV and PHEV sales volume and number of models by base price Jan-Aug 2016



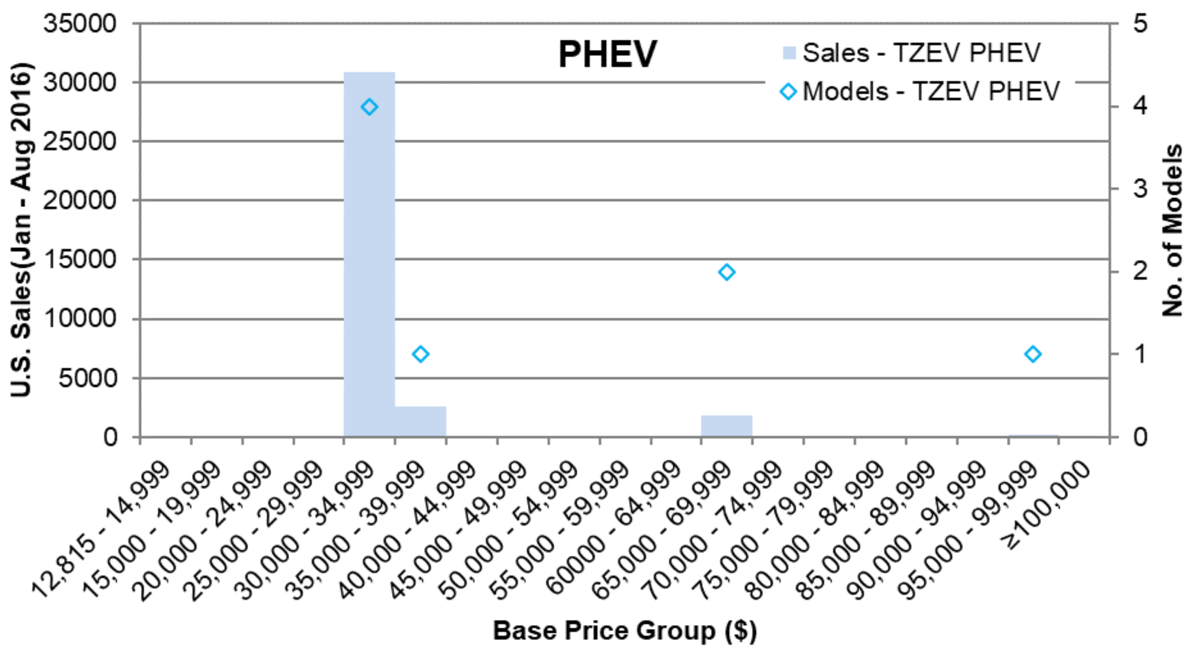
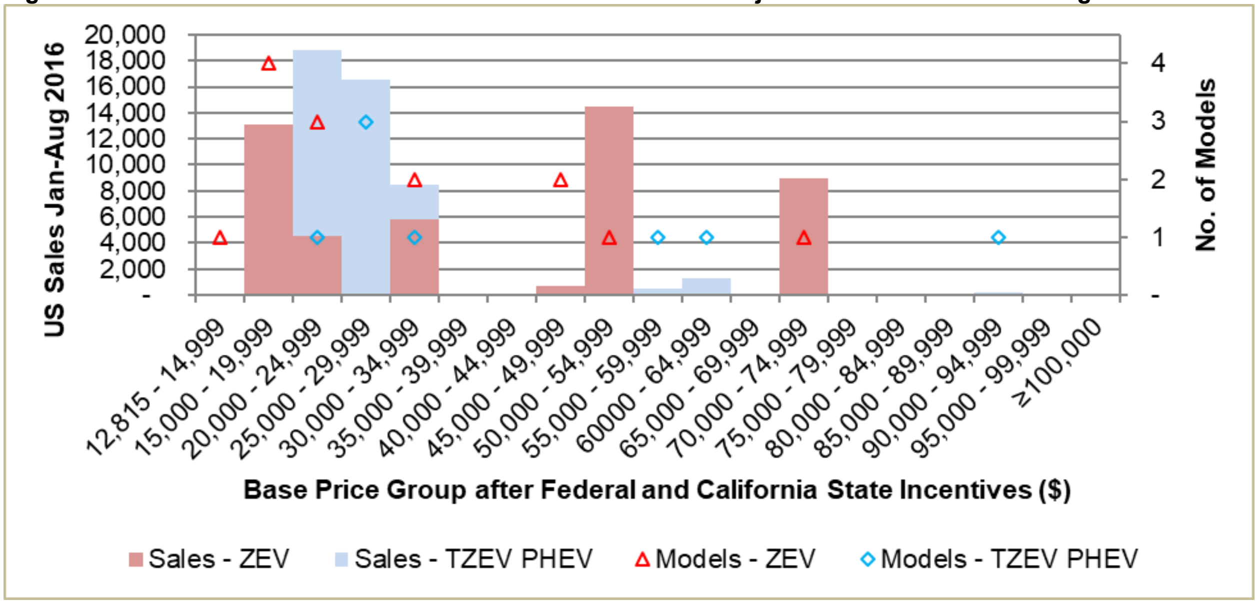


Figure 26 - ZEV and PHEV sales volume and number of models adjusted for incentives Jan-Aug 2016



Comparing the two columns in Table 5 shows that federal tax incentives and California-specific rebates reduce the base price of BEVs, PHEVs, and FCEVs by around $10,000, $7,000, and $13,000, respectively. Even after these price reductions, ICE base prices are lower than the sales-weighted average prices of all ZEVs and PHEVs. The average base price of passenger car ICEs is around $25,000, while the average base price for ICE light trucks is just under $30,000.

BEV prices have a bimodal distribution, which represents two distinct price groups of BEVs: higher-priced BEVs (BEV200+) and the remaining BEVs (BEV<200). The average price for BEV<200 vehicles (around $23,000) is only competitive against the average price of passenger ICEs ($25,000) after both the federal and state purchase incentives. Even after omitting the higher priced performance PHEVs that are not TZEV-eligible, PHEVs are offered at higher prices than BEV<200s with or without incentives.

Table 5 - U.S. sales-weighted MSRP with and without purchase incentives

	Sales-weighted Average MSRP	
Technology Type	**Without purchase incentives**	**Assuming CA + US purchase incentives**
All BEVs	$53,500	$43,500
BEV<200	$33,300	$23,300
All PHEVs	$43,000	$36,300
TZEV-certified PHEVs	$36,300	$29,300
FCEVs	$58,700	$46,100
All ICEs	$27,600	-
Passenger Cars	$24,600	-
Light Trucks	$29,500	-

III.A.4.a. New vehicle transaction prices of PEVs

Rarely do consumers pay the exact MSRP with franchised dealers. While both MSRP and transaction prices have be increasing with time for the industry as a whole, in 2011 the actual transaction price was 93% of the MSRP and by 2015 had fallen to 91%.This reduction has been fueled in part by consumer cash incentives offered by auto manufacturers. At a vehicle segment level, the change in the ratios has been more pronounced, with small and compact cars that were previously in the mid-90% falling to be on par with the industry average in 2015. Meanwhile, midsize car segment started at the industry average in 2011 and has since fallen to 88%.[67]

Analyzing the purchase price of MY2015 PEVs currently registered in California Department of Motor Vehicle (DMV) records in April 2016 shows that on average, the transaction price of PEVs ranges from 98% for BEVs[68] to 103% for PHEVs of starting MSRP. Note that the DMV information does not always include MSRP for additional options or upgrades to the base model. For example, while it is possible to differentiate between the two trim levels of a Ford Fusion Energi PHEV, it is not possible to differentiate between the base Titanium version and the "fully-loaded" version, which would add an additional $6,700 to the MSRP. To the extent that consumers are opting for any additional features that would increase MSRP, the transaction price ratio would decline, which would reflect discounts provided by the dealer and/or manufacturer. Additionally, federal or state incentives can also reduce the ultimate price paid by the consumer, effectively further lowering this ratio, even though the dealer would transact at closer to MSRP. Assuming the same incentive values used for Figure 26, Figure 27 shows how the incentives lower the adjusted transaction price-MSRP ratio to 65% for BEVs and 84% for PHEVs. These results suggest that dealers and manufacturers are providing similar levels of discounts for ZEVs and PHEVs as they typically do for conventional vehicles, however the additional incentives provided by government is resulting in even lower costs for consumers.

To explore additional pricing trends, staff analyzed the Experian Automotive dataset to compare differences in prices of new leased and purchased PEVs from 2011 to 2015 for the 10 states that report purchase price data.[69] As the Experian Automotive dataset does not provide purchase prices for California, the median transaction price of MY 2015 vehicles found in the California DMV registration data and the Experian Automotive data were compared to ensure comparability (see Table 6). The comparison suggests that California vehicle prices is generally somewhat higher, which can either reflect differences in the trim levels or options purchased and/or the availability of additional state incentives that can offset this higher price.

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[67] NADA 2016b.

[68] Excludes Tesla vehicles where are not sold under a dealer franchise business model. By default, the transaction price to MSRP ratio will always be 1.

[69] There are ten states in the Experian Automotive data that are listed as providing purchase price data: Colorado, Kentucky, North Carolina, North Dakota, New Mexico, Ohio, Oklahoma, Texas, Virginia, and West Virginia.

Figure 27 - Ratio of California MY 2015 PEV transaction prices (assuming federal and state incentives) compared to MSRP[70]

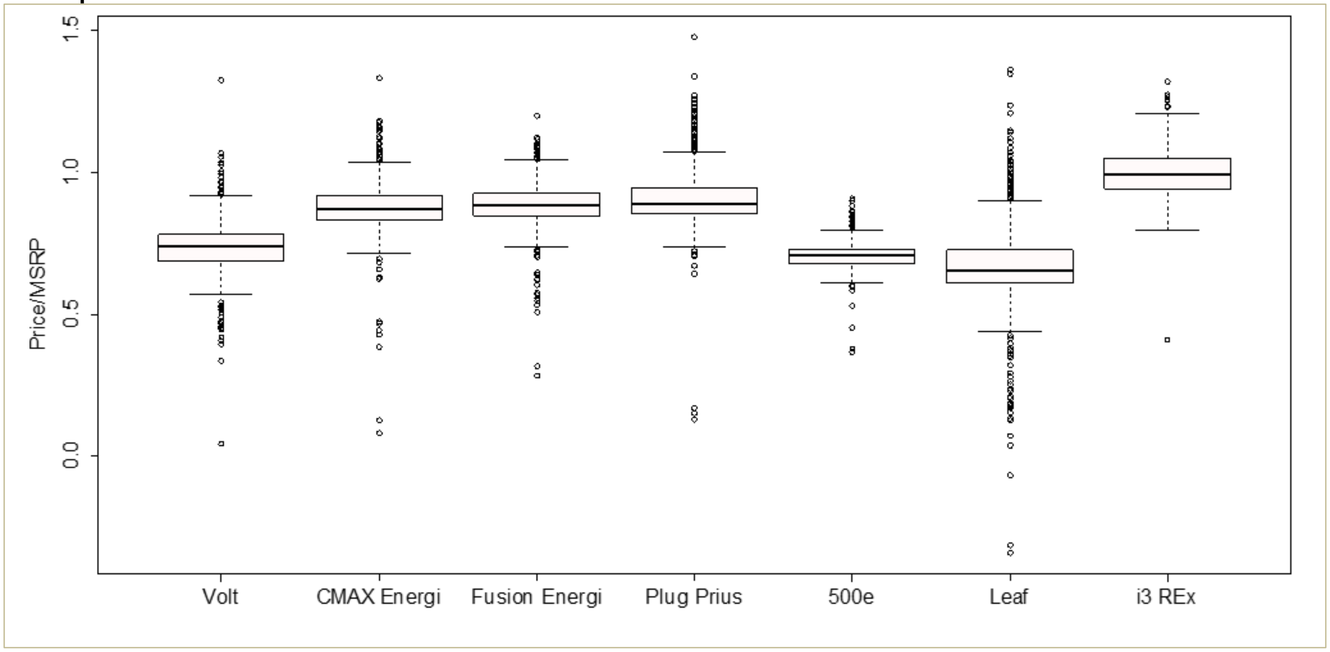


Table 6 - California DMV vs Experian Automotive MY2015 transaction prices

	Median CA DMV Price ($)	Median Experian Automotive Price ($)	Difference ($)
BMW i3	42,100	40,070	2,030
Chevrolet Volt	34,300	33,350	950
Ford CMAX Energi	33,100	33,100	0
Ford Fusion Energi	37,300	33,598	3,702
Nissan LEAF	28,900	25,123	3,777
Tesla Model S	95,300	96,200	-900
Toyota Prius Plug-in	30,700	30,596	104

For new vehicles in the ten states that reported prices, staff ran a regression of price on whether a vehicle is leased and additional control variables, including vehicle model, purchaser race and income, dealership location, and the month and year of the transaction.[71] The results from the regression indicate that when controlling for some demographic, geographic, and time variables,

[70] CA DMV data.
[71] Specifically, the regression takes the form of:

$$Price_{it} = \beta_0 + \beta_1 Lease_i + \gamma' X_{it} + \epsilon_{it}$$

Where subscript *i* denotes a specific vehicle and *t* denotes a specific month and year the vehicle was transacted. Price is the reported purchase price, Lease is an indicator for whether the vehicle was leased of purchased. X is a set of control variables including race indicators, income, the state the dealer was located in, and the year and month of purchase. To omit price outliers, the regression restricts the data to vehicles with a listed purchase price greater than $1,000 and less than $150,000.

that a leased PEV has a purchase price that is $7,400 lower than that of a purchased PEV. This difference is statistically significant at the 1% level. Additionally, the coefficients on the year and month of purchase control variables indicate how the average purchase price on PEVs, after controlling for model, lease status, dealer location, race, and income, suggest a downward trend in the purchase price over time. This downward trend could be a factor of both decreases in MSRP over time or a decrease in overall transaction prices through manufacturer discounts. Four models have lowered their starting MSRP from initial release to 2015, and accordingly the distribution of transaction prices for these models has also fallen. The regression also suggests that on average, wealthier individuals pay more for vehicles.

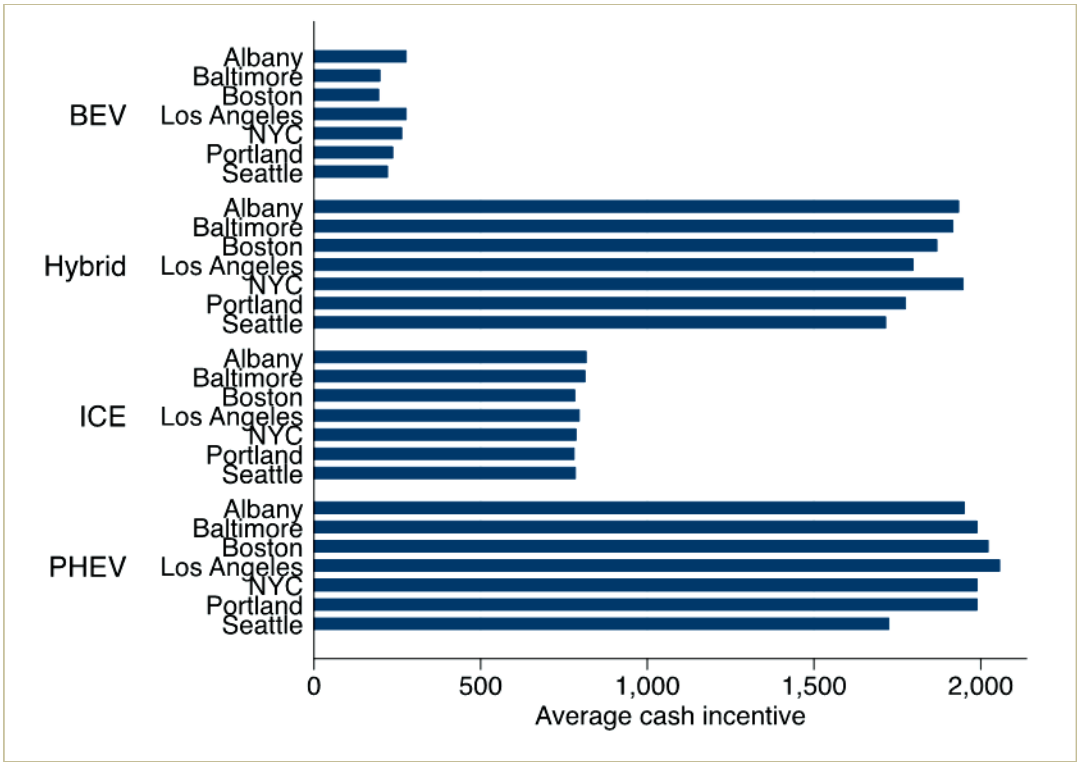
III.A.4.b. Dealer incentive data analysis

To evaluate whether price differences may result from differential incentives offered by auto manufacturers for dealers to promote with consumers, staff collected data from AutoNews[72] for cash incentives offered between February 2016 and August 2016 for the same regions and vehicle models included in the dealership vehicle availability analysis described in Section III.A.3. The data suggest manufacturers offer similar incentives for the same technology type across regions. However, manufacturers offer different incentives for the different technology types.

Figure 28 shows the average incentives offered by technology type and region. Overall, BEVs appear to receive lower incentives than the other technologies, while PHEVs receive the highest level of incentives. The BEVs in the data (BMW i3, Ford Focus Electric, and Nissan LEAF) had $0 cash incentive for the majority of the sample period, while the PHEVs (Chevrolet Volt, Ford CMAX Energi, and Ford Fusion Energi) and HEV models have larger cash incentives than comparable ICEs produced by those manufacturers. One potential explanation for this difference is that government incentives tend to be higher for BEVs than PHEVs, which reduces the need for manufacturers to provide equivalent incentives. Additionally, as previously discussed, MSRPs for PHEVs are higher on average than those of BEV<200s, which may result in a greater need to offer additional incentives at the dealership level.

[72] See Section VII.F for data description of AutoNews data.

Figure 28 - Manufacturer incentives by city and technology type Feb-Aug 2016[73]



III.B. Consumer Awareness and Knowledge of ZEVs and PHEVs

In order for consumers to purchase or lease a ZEV or PHEVs, they must first be aware that these vehicles are available in the market today. The National Research Council's Report, "Overcoming Barriers to Deployment of Plug-in Electric Vehicles," finds that lack of knowledge about both PEV benefits and offerings poses a barrier to mainstream adoption.[74] Additionally, advertising expenditures in 2015 for select PEV models is highly variable across regions and manufacturers.[75] This section summarizes ARB-sponsored research by UCD along with independent surveys and reports from Morpace, the National Renewable Energy Lab (NREL), Consumer Federation of America (CFA), Public Policy Institute of California (PPIC), and others that examine awareness and knowledge of ZEVs and PHEVs among new car buyers and general consumers in California and the rest of the U.S.

The results of these independent studies all reveal confusion and low levels of ZEV and PHEV awareness about the different PEV and FCEV technologies. For example, fewer than half of the respondents from two surveys – one by UCD and the other by NREL – were able to name a specific PEV model and even fewer a BEV. Results from the PACE survey similarly reveal a low level of awareness of basic facts regarding PEVs and FCEVs. For instance, fewer than half of the respondents reported knowing that BEVs do not have a gasoline engine; only two-fifths reported knowing that PHEVs could be refueled at any gasoline station, and only a third

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[73] AutoNews data.
[74] TRB and NRC 2015. Transportation Research Board and National Research Council. 2015. *Overcoming Barriers to Deployment of Plug-in Electric Vehicles*. Washington, DC: The National Academies Press. doi: 10.17226/21725.
[75] NESCAUM 2016.

reported knowing that FCEVs are refueled at hydrogen fueling stations. In addition, UCD, NREL and CFA studies have determined that those who are more knowledgeable about PEVs are more interested in acquiring one compared with those who are less knowledgeable. Furthermore, results from CFA surveys indicate that consumers are becoming more interested in acquiring PEVs, although the NREL surveys did not observe this increase. This section also discusses reports that analyze the effects of behind the wheel experience on attitudes towards PEVs. Results reveal that exposure to PEVs through ride and drive events or car-sharing programs seem to result in lasting, positive impressions and serve to be one of the most influential information sources for helping consumers decide on a PEV. Second to a vehicle test drive, another PEV driver is the other most influential information source for new buyers to choose a PHEV or BEV.

III.B.1. UC Davis 2015 Survey of New Car Buyers' ZEV Valuation

This ARB-funded research project, completed in April 2016,[76] collected information on the decision-making process and factors influencing the choices of new light-duty vehicle purchasers in California, focusing on the barriers and motivations for purchasing near-zero and zero emission vehicles. The study was designed to: measure consumer awareness, knowledge, experience and valuation of ZEVs and PHEVs; analyze consumer decision making regarding ZEV and PHEV purchase decisions; and compare consumers in California with consumers in other states, especially Section 177 ZEV States.

The vast majority (95% in California and 96% in overall sample) of the vehicles owned by survey respondents are fueled by gasoline. While many respondents claim to be "familiar enough with [ZEVs and PHEVs] to make a decision about whether one would be right for their household," their familiarity was not gained from actual experience driving PHEVs, BEVs, FCEVs, or even HEVs (see Figure 29). Measured on a scale from -3 (none at all) to 3 (extensive driving experience), and excluding those who scored themselves as unsure or declined to answer, the mean scores for California respondents are all negative (HEVs, -1.14; BEVs, -1.97; PHEVs, -2.10; and FCEVs, -2.28) and the 75th quartile score for PHEVs, BEVs, and FCEVs varies from -1.77 (BEVs) to -2.73 (FCEVs). In short, within the realistic accuracy of the survey, more than three-fourths of this sample of California new car buyers had no driving experience with PHEV, BEVs or FCEVs. This result holds for respondents from the other states as well. It is also worth noting that despite an additional ten years in the market, survey respondents are also indicating limited familiarity with HEVs.

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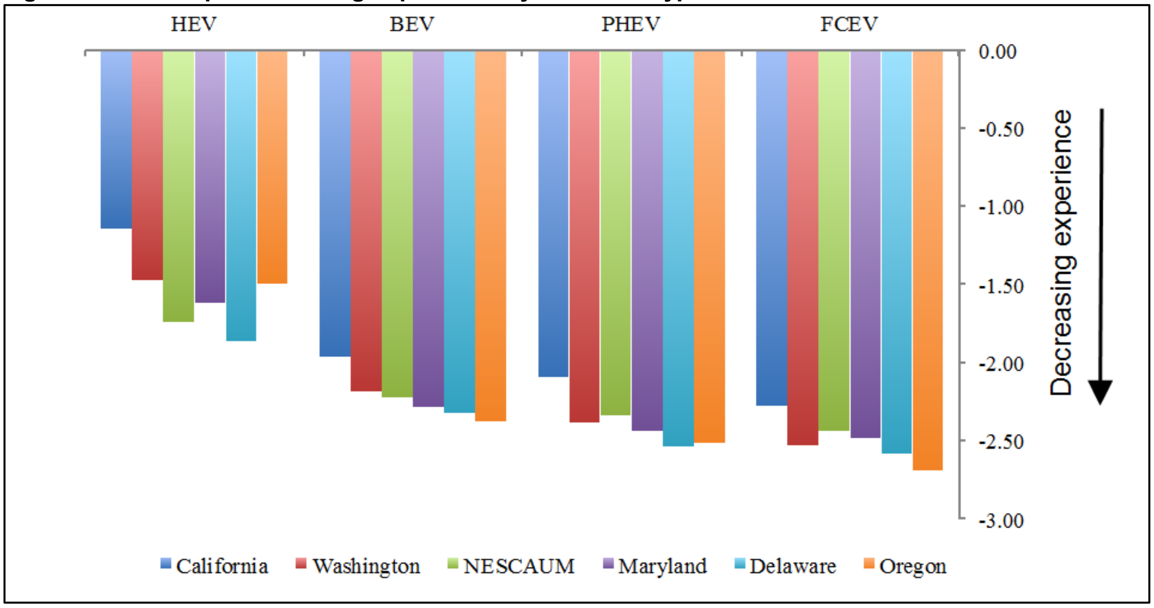
[76] Kurani, et al. 2016. Kurani, K., N Caperello, and J. Tyree Hageman. 2016. "New Car buyers' valuation of zero-emission vehicles: California" Final Report for ARB contract 12-332. https://www.arb.ca.gov/research/apr/past/12-332.pdf.

Figure 29 - Self-reported driving experience by drivetrain type[77]



Note: A score of -3 represents no experience at all, 3 represents extensive driving experience. Excludes unsure or declined to state.

The measures of prior consideration show new car buyers in California were more likely than those in the other study states to have already purchased, shopped for, or at least gathered information on PEVs and FCEVs. Yet even in California, new car-buyers' valuations of ZEVs and PHEVs were largely unformed. As shown in Figure 30, almost half (49%) of this sample of California new car buyers was aware of ZEV and PHEV purchase incentives from the federal government, while only one-third reported they were aware that California offers ZEV and PHEV purchase incentives.[78] California's percentages were the highest in any state in the study and well above the average across all states (44% federal and 18% state). Respondent awareness of incentives offered by other entities, (e.g., cities, utilities, or manufacturers), is comparable to or lower than their awareness of state government incentives. Despite marketing of PEVs and deployment of PEV charging infrastructure since 2010, as well as federal, state, and local incentive programs for PEV purchase and use, 77% of respondents representing new car-buying households in California have yet to seriously consider a PEV for their household; 92% have yet to ask themselves the same question about FCEVs.

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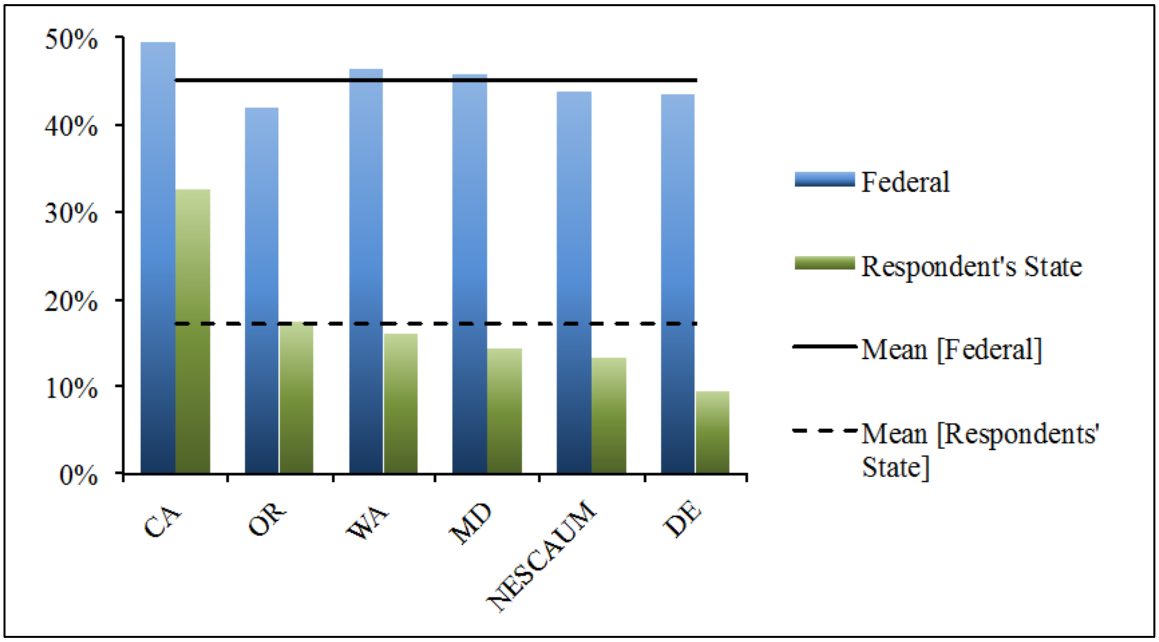
[77] Kurani, et al. 2016.
[78] At the time the survey was administrated, over 85,000 rebates had been awarded to PEV and ZEV drivers through California's Clean Vehicle Rebate Project beginning in 2010, totaling over $180 million in incentives, https://cleanvehiclerebate.org/eng/rebate-statistics. See Appendix E for additional incentives available in California and Section 177 ZEV States.

Figure 30 - Percentage of new car buyer respondents aware of the federal and state ZEV and PHEV purchase incentives[79]

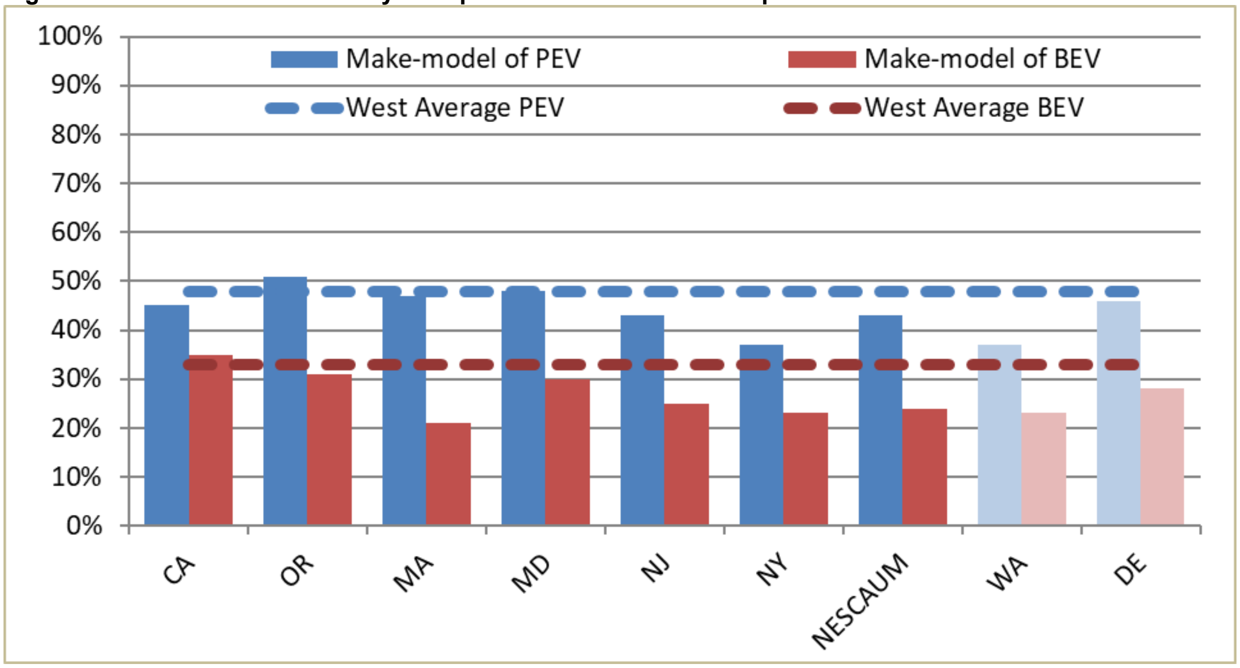


More than five years after PEV marketing started in California, two-thirds of respondents—who as new car buyers have searched for information about cars, been on new car lots, and purchased a vehicle during this period—could not name a BEV for sale in the U.S., as shown in Figure 31. Of those in California who could name a BEV for sale, 95% named one of only two of the earliest BEVs commercially available: a Nissan LEAF and a Tesla Model S. Lack of understanding of the differences between BEVs, PHEVs, and HEVs is a likely explanation for why respondents named PHEVs when asked for makes and models of BEVs. Fewer respondents from other states were able to name a BEV model than those from California, although in Oregon, Maryland, Massachusetts, and Delaware a slightly higher fraction of respondents were able to name a PEV model than those from California.

The conclusion that most California new car-buyers have yet to even consider ZEVs or PHEVs was reinforced by the interviews conducted in California, Oregon and Washington, in which it was clear that most respondents formulated their first ZEV and PHEV valuations in the process of completing their survey and interview. Overall, awareness of HEVs, PEVs, and FCEVs was so low that it is reasonable to assume most new car buyers' assessments prior to completion of the survey were based largely on ignorance. But without more effective dissemination of information about the availability and the technology of ZEVs and PHEVs, most California new car buyers will not have an opportunity to form a positive valuation.

[79] Kurani, et al. 2016.

Figure 31 - Percent of new car buyer respondents able to name a specific PEV or BEV model[80]



Note: Darker bars represent states or regions with a ZEV regulation.

III.B.2. Morpace Powertrain Acceptance and Consumer Engagement Surveys

ARB licensed the use of the complete respondent data for the 2015 administration of the syndicated Powertrain Acceptance and Consumer Engagement (PACE) survey conducted by Morpace to better understand new vehicle owners nationwide to assess their awareness and perception of alternative powertrain technologies as well as their household characteristics and other attitudes.

According to the 2015 PACE Survey, consumer knowledge and awareness of alternative fuel technologies is low. Respondents indicated that 45% "own/have owned or know very well" a BEV, which is similar to the 44% for PHEVs. However, direct questions about knowledge of technologies indicated very low rates of understanding. Only 2% of respondents claimed they knew of all the facts presented for both BEVs and separately for PHEVs. Only 53% indicated they were aware that BEVs used only an electric motor. Even fewer (50%) indicated knowing there are zero exhaust emissions associated and fewer (45%) knew there is no gasoline engine in a BEV (see Figure 32). For PHEVs, only 45% of respondents reported knowing that PHEVs use both an electric and a gasoline engine (see Figure 33). Respondents seemed to be the least aware of basic facts regarding FCEVs, with less than a third reporting they knew those vehicles only emit water (see Figure 34). Evaluating based on regions, respondents in California or Section 177 ZEV states were not uniformly more informed about any technology than respondents in the rest of U.S.

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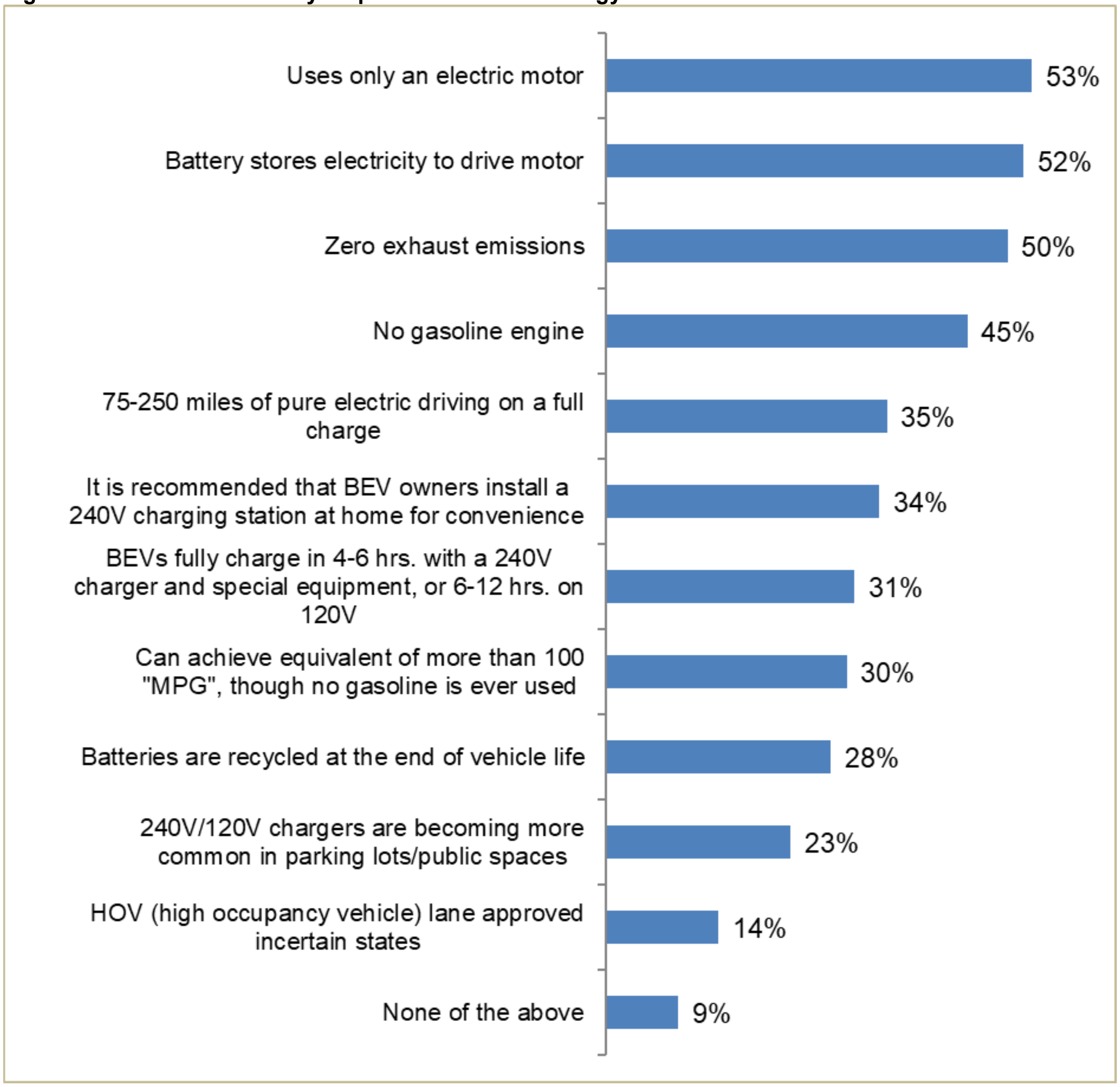
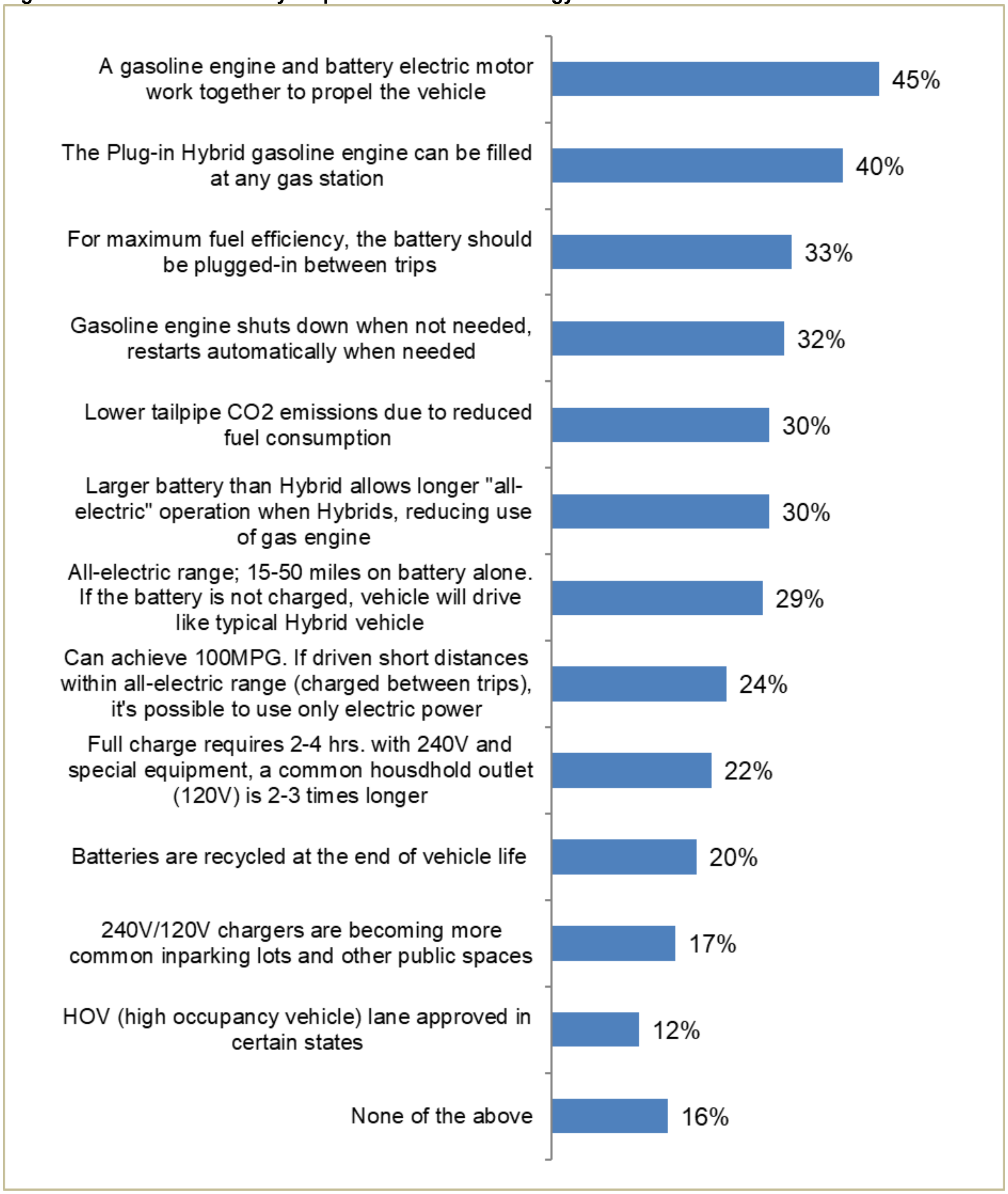
[80] Kurani, et al. 2016.

Figure 32 - 2015 PACE Survey respondent BEV technology awareness[81]



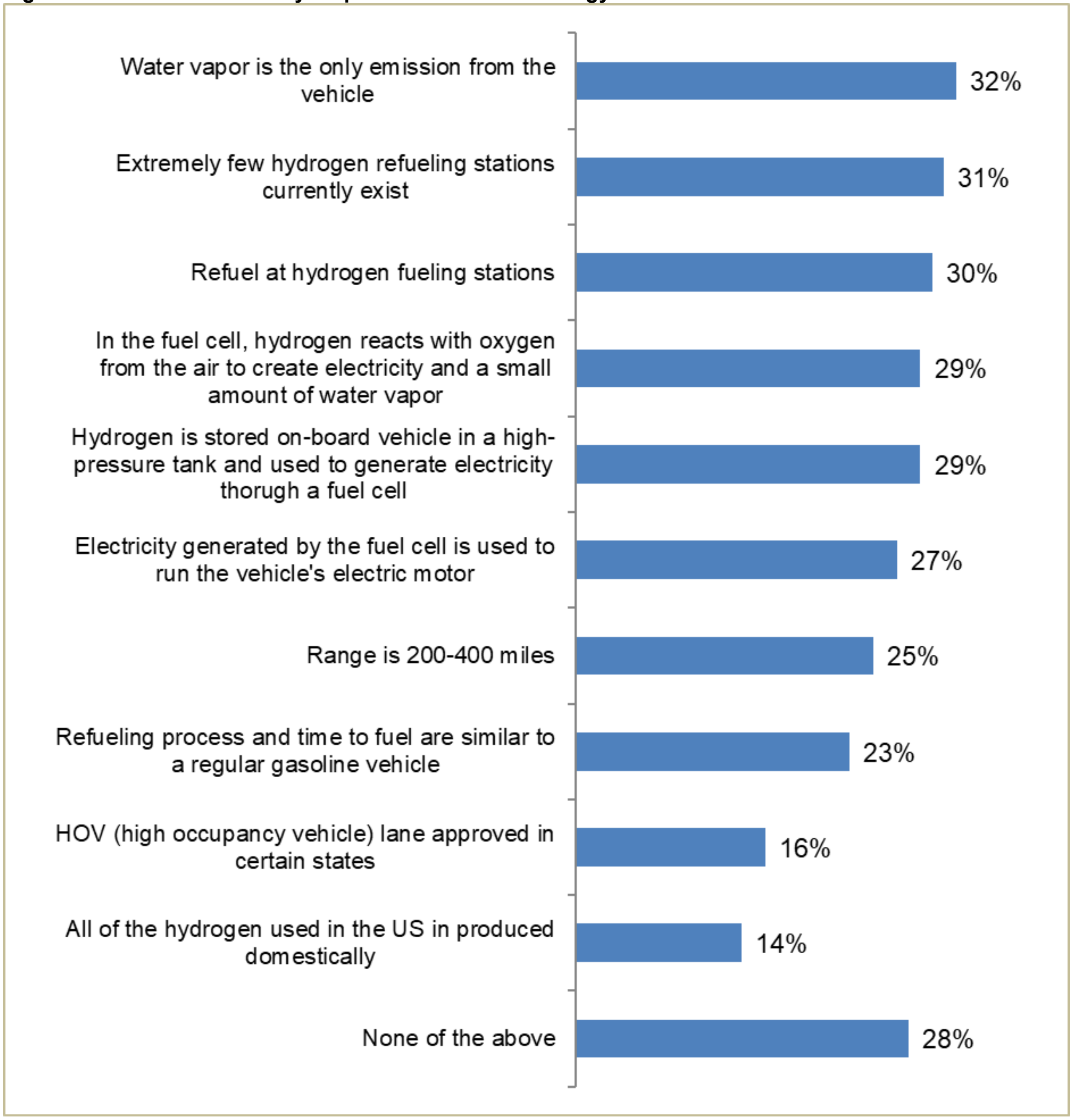
[81] 2015 PACE Survey. See Section VII.I for further details on this survey.

Figure 33 - 2015 PACE Survey respondent PHEV technology awareness[82]



[82] 2015 PACE Survey.

Figure 34 - 2015 PACE Survey respondent FCEV technology awareness[83]



According to the 2015 PACE survey results, there is some evidence that overall awareness is improving slowly over time. Respondents showed small percentage improvements relative to (a separate set of respondents to) the 2014 PACE Survey in the fraction that indicated “know something about what it does” or “Own/have owned or know very well” for all technologies, largely as a result of gains in the portion of respondents owning or knowing very well (see Figure 35).

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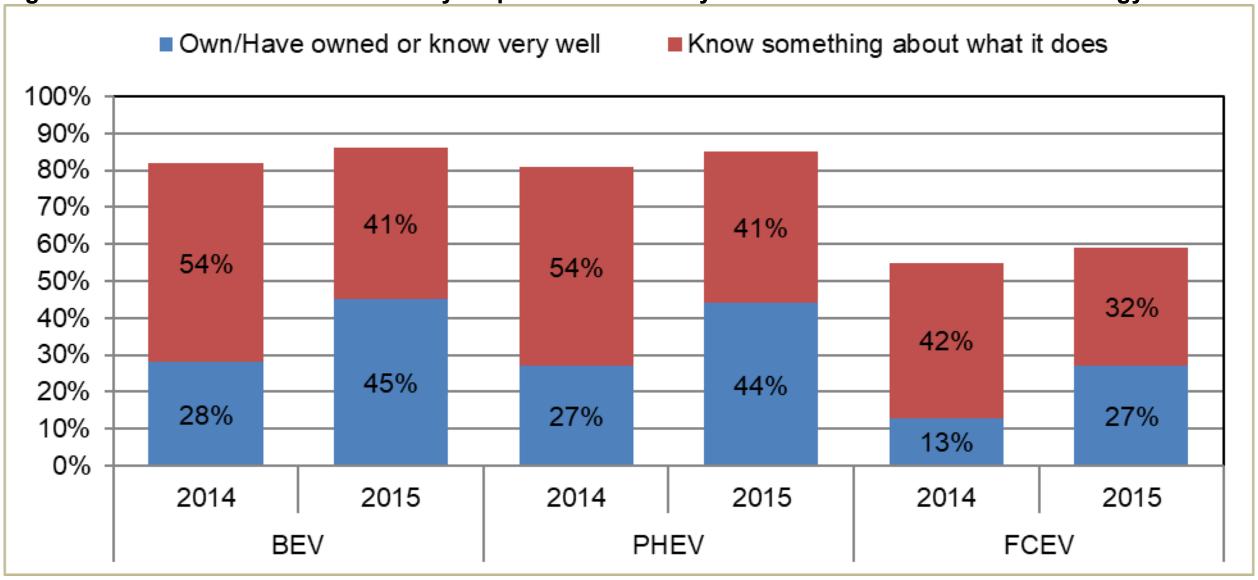
[83] 2015 PACE Survey.

Figure 35 - 2014 and 2015 PACE Survey respondent familiarity with alternative drivetrain technology[84]



Consumer perceptions play a significant role in forming consumer purchase decisions, though sometimes these perceptions may be based upon incorrect information. Figure 36 compares respondent perceptions of BEVs, PHEVs, and FCEVs along the same list of vehicle features. Participants rated BEVs more positively for environmental benefits, fuel economy, cost to refuel or charge vehicle, and newest technology. In contrast, more view BEVs negatively than positively on all other attributes, but especially for driving range, time required to refuel or charge, towing/hauling capacity, and acceleration/passing capability, and dependability and reliability. Although some of these perceptions may reflect today's BEV characteristics, for example currently only one BEV offers any towing capability and driving range of most BEVs is less than 100 miles per charge, others are more subjective and may be based on incorrect or outdated information. Respondents rated the same features more positively for PHEVs as they did for BEVs. The PHEV attributes viewed most negatively are time required to refuel or charge, driving range, convenience of refueling or charging, acceleration/passing capability, and towing/hauling capacity. While these relative ratings are similar for both types of PEVs, both the positive and negative ratings are generally lower in magnitude, suggesting that consumers are more ambivalent towards PHEVs than BEVs. Perceptions of FCEVs differ more dramatically from those of PEVs. The attribute with the strongest positive association for FCEVs is the fact that it is the newest technology, which may in turn result in the strongest negative associations being purchase price and ability to find qualified mechanics for servings. Although positive perceptions outweigh negative ones for environmental benefits and fuel economy, these are similar in magnitude to the perceptions of PHEVs, which were lower than those of BEVs.

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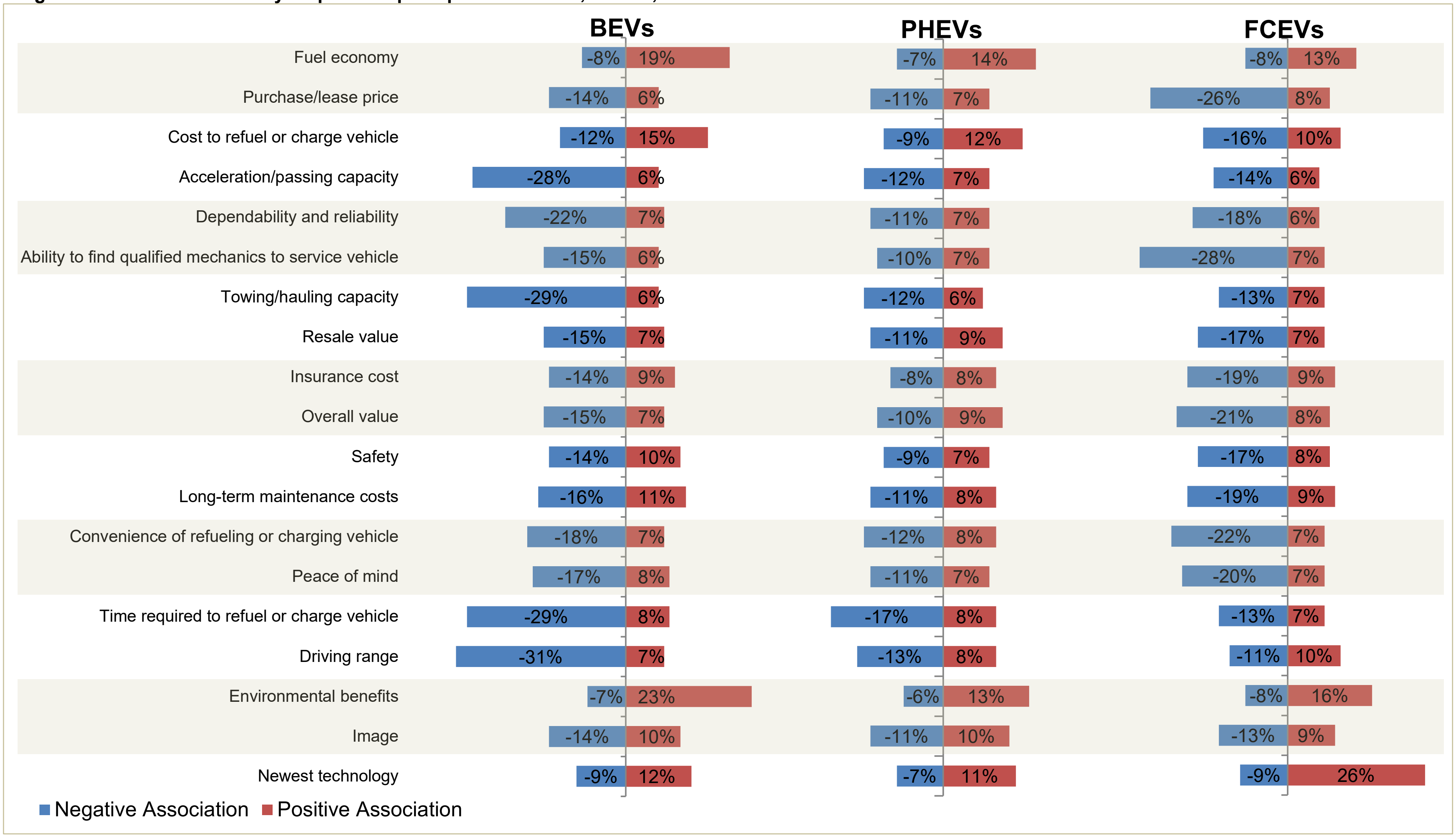
[84] PACE Surveys.

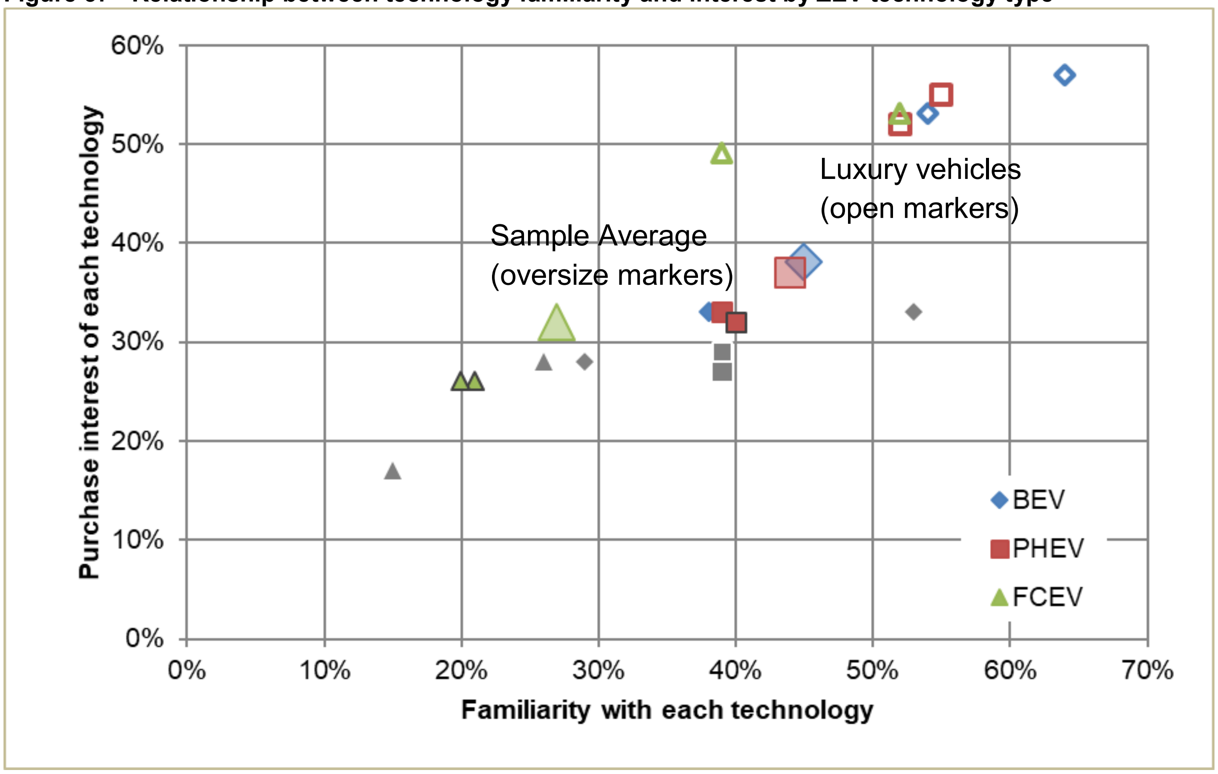
Figure 36 - 2015 PACE Survey respondent perceptions of BEVs, PHEVs, and FCEVs[85]



[85] 2015 PACE Survey.

Respondents indicated some interest in making their next vehicle either a ZEV or PHEV, which appears to be correlated with both their current vehicle segment and their familiarity with the technology type. Figure 37 plots familiarity (defined as reporting own(ed)/know very well what it does) against purchase interest (defined as probably or definitely interested in purchasing) for each vehicle technology based on the respondents' current vehicle type. In general, the points all fall along the diagonal, demonstrating strong correlation. Luxury vehicle owners (open markers) appear to have the greatest familiarity and interest in all three ZEV technologies. Among the non-luxury vehicle owners, familiarity and interest in FCEVs was lower than for PEVs, potentially a reflection of the current limited FCEV offerings.

Figure 37 - Relationship between technology familiarity and interest by ZEV technology type[86]



Key: Oversized marker represents total sample; open markers represent respondents currently driving a luxury car, CUV, or SUV; solid, colored markers represent respondents currently driving non-luxury car, CUV, or SUV; solid, gray markers represent respondents currently driving minivan or pickup truck.

However, this relationship may not hold at the regional level. Statistical tests (X^2 statistic) comparing California to Section 177 ZEV states to the rest of U.S. reveal differences in interest between regions, but no difference in levels of understanding of PEV and FCEV technologies.

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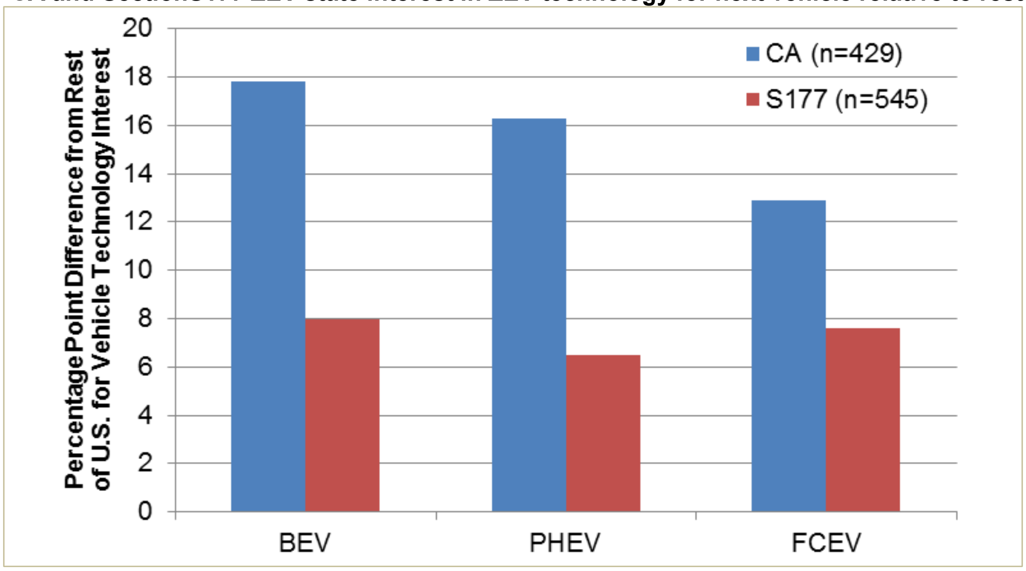
[86] 2015 PACE Survey.

As shown in Figure 38, purchase interest in BEVs among California respondents is 18 percentage points greater than for the rest of the U.S. while interest is ten percentage points greater in Section 177 ZEV states. In both regions, interest in BEVs is slightly greater than for PHEVs. Purchase interest in FCEVs revealed the same trend across regions but with slightly less interest in California in spite of the fact that there retail hydrogen refueling infrastructure is only available in California at this time.

Figure 38 - CA and SectionS177 ZEV state interest in ZEV technology for next vehicle relative to rest of U.S.[87]



III.B.3. NREL CARAVAN Surveys

A National Renewable Energy Lab (NREL) report investigated consumer attitudes toward PEVs.[88] The report was based on a February 2015 CARAVAN survey conducted by the Opinion Research Corporation, which sampled 1,015 households selected to be representative of the U.S. The survey has a margin of error of ± 3% at the 95% confidence level. Overall, almost half (48%) of respondents were able to name a specific PEV model, with the most commonly named models being the Chevrolet Volt (20%), the Toyota Prius Plug-in (18%), the Tesla Model S (14%), and the Nissan Leaf (10%). By far the most exposure respondents had with PEVs was seeing one in parking lots (49%), followed by sitting in a PEV (16%), driving a PEV (5%), and having a neighbor with a PEV (5%). Only 18% of respondents were aware of PEV charging infrastructure at their work or other locations they frequented, with only 10% of respondents passing these locations regularly.

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[87] 2015 PACE Survey.
[88] Singer 2016. Mark Singer. January 2016. National Renewable Energy Laboratory. *Consumer Views on Plug-in Electric Vehicles – National Benchmark Report.* http://www.nrel.gov/docs/fy16osti/65279.pdf.

Table 7 - Summary of NREL CARAVAN Survey findings about consumer awareness

Awareness/Exposure Metric	Percent of Respondents
Model Availability Awareness: Ability to name a specific PEV model	48%
Infrastructure Awareness: Not aware of any charging stations at work or near stores	79%
PEV Exposure: Driving a PEV Sitting in a PEV Neighbor with PEV Seen one in parking lots	 5% 16% 5% 49%

III.B.4. Consumer Federation of America Surveys

The Consumer Federation of America commissioned the Opinion Research Corporation to conduct national surveys on consumer attitudes towards PEVs. The surveys were administered in August of 2015[89] and 2016[90] via landline and cell phone with 1,009 and 1,007 adult Americans completing the survey, respectively. The margin of error reported was ± 3%. Results indicate that interest in acquiring a PEV has increased between 2015 and 2016, rising from 31% to 36%. Results from the 2015 survey show that most Americans (54%) have a positive view of EVs. Both surveys revealed that the more consumers know about PEVs, the more positive their attitudes towards them and the more likely they are to consider acquiring one. However, only 6% reported knowing a great deal and 21% reported knowing a fair amount about PEVs in 2015. Results from the 2015 survey reveal that older respondents and males with higher education levels and higher incomes reported knowing more about PEVs and were more likely to express an intention to purchase. In contrast, results from the 2016 survey indicate young adults are the most interested in PEVs, with 50% of 18-34 year olds saying they would consider buying a PEV. In 2016, over half (55%) of survey respondents who reported knowing a great deal about PEVs were interested in buying one, while only 22% of those who reported no knowledge of PEVs also expressed interested in buying one.

III.B.5. Effect of behind the wheel experience and more information

When non-PEV consumers are exposed to PEVs evidence suggests they become more interested in acquiring them. The impact of exposure to PEVs through participation in ride and

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[89] CFA 2015. Consumer Federation of America. . October 29, 2015. Knowledge Affects Consumer Interest in EVs, New EVs Guide to Address Info Gap. http://consumerfed.org/press_release/knowledge-affects-consumer-interest-in-evs-new-evs-guide-to-address-info-gap/.

[90] CFA 2016. Consumer Federation of America. September 19, 2016. New Data Shows Consumer Interest in Electric Vehicles Is Growing. http://consumerfed.org/press_release/new-data-shows-consumer-interest-electric-vehicles-growing/.

drive events and carsharing programs has been shown to have a positive effect on attitudes towards PEVs and increase interest in PEV adoption.[91,92,93]Additionally, the effect of educating consumers on fuel costs of different vehicle technologies using their own commuting patterns has also been shown to improve opinions of PEVs and interest in acquiring a PEV.[94] However, it should be noted that drivers who attend ride and drive events and participate in carsharing may not be representative of the "average" consumer.

The Plug-in Electric Vehicle Collaborative (PEVC) held six ride and drive events coupled with surveys before and after the test drive and a follow up survey 3-6 months after the test drive.[95] These events were held throughout California between August and November 2015. The pre- and post-drive surveys were completed by a total of 365 (pre) and 350 (post) respondents, while 53 participated in the follow-up survey. Analysis of the survey responses indicates that 76% of participants were more likely to consider acquiring a PEV after test driving one, with participants slightly preferring a BEV (40%) over a PHEV (36%). The follow-up survey determined that an average of 15% of the ride and drive participants had purchased or leased a PEV 3-6 months after the ride and drive event. A further 14% of all participants are still planning to acquire a PEV. On average, 55% and 38% of participants reported that the test drive was very important and somewhat important part of their decision to consider purchasing or leasing a PEV.

Similarly to PEVC's ride and drive surveys, the Metropolitan Transportation Commission (MTC) held ride and drive events coupled with surveys in the San Francisco Bay Area between May and October 2014.[96] A total of 1,483 and 1,386 participants completed the pre- and post-drive surveys with 266 completing the follow-up survey at least two months after the event. A total of 79% of participants reported that test driving a PEV improved their overall opinion of electric vehicles. Results from MTC's ride and drive surveys show that immediately after the test drive respondents rated all of the eight dimensions comparing PEVs to conventional gasoline vehicles higher, with statistical significance, than before the test drive. The PEV dimensions that most improved between the pre- and post-survey were driving performance/handling (39% vs 57%), appearance (31% vs 48%), and overall quality (48% vs 63%). Participation in the ride and drive events also resulted in statistically significant reductions in the impact of tested potential barriers to owning a PEV that. These barriers tested included cost of purchase, limited driving range, difficulty finding a charging station on the road, concerns about the vehicle running out of electricity on the road, time it takes to recharge vehicle, and difficulty charging a vehicle at

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[91] PEVC 2016. Plug-In Electric Vehicle Collaborative. February 29, 2016. Best. Ride. EVer! Final Report. http://www.pevcollaborative.org/sites/all/themes/pev/files/PUBLIC_PEVC%20Best.Ride.EVer%21%202015%20Final%20Report.pdf.

[92] McLarney and Sarles 2014. T. McLarney and R. Sarles, True North Research: Encinitas, CA. *Experience Electric - The Better Ride: campaign evaluation report, in Prepared for the Metropolitan Transportation Commission*.

[93] Shaheen, et al. 2015. S. Shaheen, E. Martin, and A. Bansal. 2015. Transportation Sustainability Research Center, UC Berkeley. *Zero- and low-emission vehicles in U.S. carsharing fleets impacts of exposure on member perceptions*. http://tsrc.berkeley.edu/sites/default/files/ZEV%20Whitepaper_FINAL_0.pdf.

[94] Sanguinetti, et al. 2016. Angela Sanguinetti, Michael A. Nicholas, Gil Tal, Matthew Favetti. 2016. Institute of Transportation Studies, University of California, Davis, Working Paper UCD-ITS-WP-16-01. *EV Explorer: Evaluating a Vehicle Information Tool*. https://itspubs.ucdavis.edu/wp-content/themes/ucdavis/pubs/download_pdf.php?id=2569.

[95] McLarney and Sarles 2014.

[96] McLarney and Sarles 2014.

home. Furthermore, 68% of survey participants reported being more likely to purchase a PEV after test driving one. The follow-up survey indicates that 11% of all ride and drive participants purchased or leased a PEV following their attendance at the event with the vast majority stating their test drive at the event positively impacted their decision to acquire a PEV. It is worth noting that not all of the positive impacts on perceptions of PEVs persisted months after the ride and drive event. For example, the percentage of participants that rated the PEV range as somewhat worse or much worse than a conventional gasoline vehicle went from 50% immediately after the test drive to 78% a few months after.

Carsharing is another avenue to expose consumers to PEV technologies. One study that investigated the effect of PEV carsharing on subsequent ownership found this exposure positively influenced customer perceptions and increased propensity to acquire a PEV, especially among younger people and women.[97] Control and experimental groups consisting of a total of 3,662 carsharing members were surveyed between November, 2014 and February 2015 throughout the U.S. The control group was comprised of carsharing members who had not used the PEVs available to them, while the experimental group consisted of those that had used PEVs. However, 60% of all members of the experimental group had previous experience with a PEV either as a driver or passenger. Members of the control group indicated they would have liked to have used the PEVs through their carsharing program, but had not due to these vehicles not being available for reservations, either because others were using them, they were not in locations convenient to the users, or users did not know what these vehicles look like. Overall, over 40% of the experimental group reported that their desire to own a PEV was greater or much greater now as a result of their exposure through carsharing. Members of the experimental group were more likely to recommend driving and buying these vehicles over the control group. These differences were found to be statistically significant. Furthermore, members that used PEVs more often had a better opinion of ZEVs as well as a greater desire to own them. When asked what type of vehicle they expect to acquire next, 5% and 12% and of the experimental group reported they would acquire a PHEV or BEV, respectively. In contrast, 3% and 9% of the control group indicated they would acquire a PHEV or BEV as their next vehicle. Notably, those in the experimental group reported an increase of 3% and 9% for those who would acquire a PHEV or BEV and a 24% decrease of those that would acquire a gasoline vehicle next compared to before they participated in a carsharing program.

In addition to experience behind the wheel, simply giving consumers more information on PEVs also increases their interest in acquiring one. A study analyzed the effect of providing information on fuel costs of different vehicle technologies for specific commuting patterns on attitudes regarding PEVs.[98] The EV Explorer[99] is an informational, map-based on-line tool that allows users to compare fuel costs for different vehicles based on their own commuting patterns, local fuel prices, and charging opportunities. A total of 108 participants were asked

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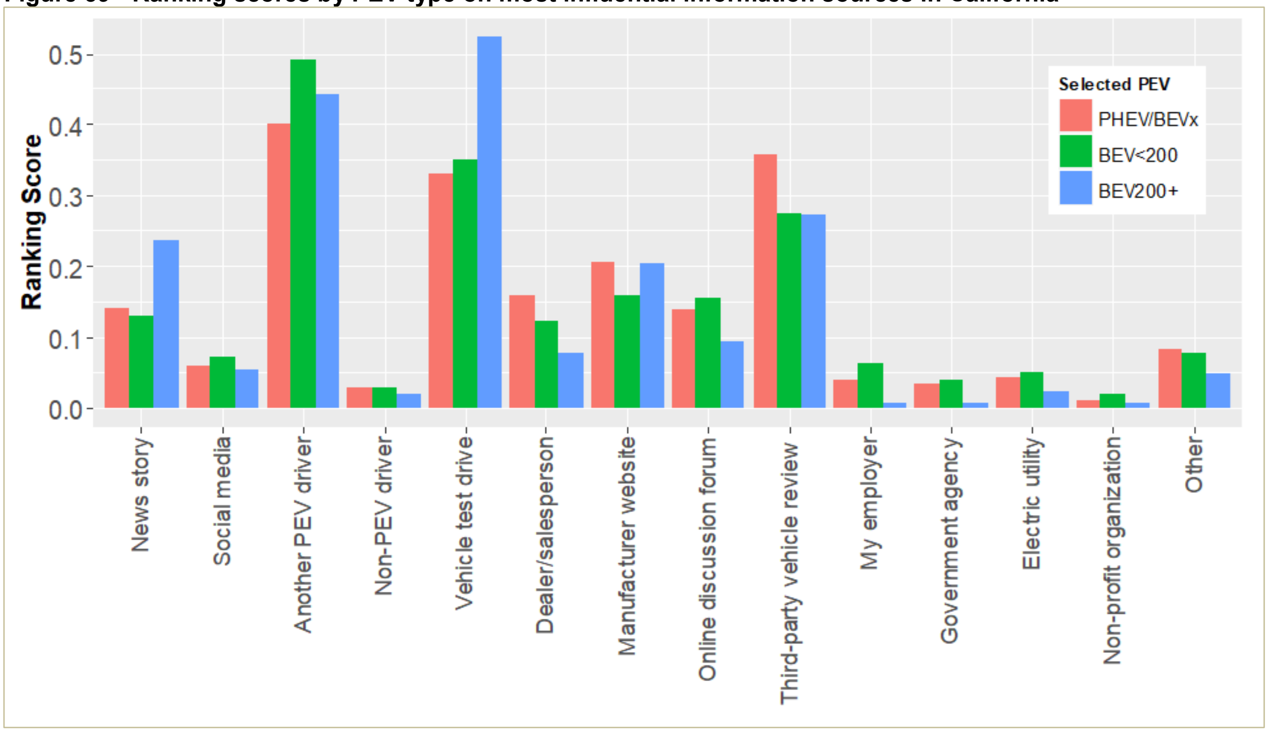
[97] Shaheen, et al. 2015.
[98] Sanguinetti, et al. 2016.
[99] University of California, Davis. "EV Explorer" http://gis.its.ucdavis.edu/evexplorer/.

questions before and after utilizing the EV Explorer tool. Participants reported a significantly greater intention to acquire a PEV after using EV Explorer.

These findings are consistent with survey results of current PEV drivers in California who reported on information sources that are most influential in their purchase decisions. Figure 39 shows that vehicle test drives rank among the highest influential information source for all PEV types, and as the most influential for BEV200+ drivers. Other PEV drivers and third-party reviews also ranked high as influential information sources. Although the survey does not ask directly about where test drives occur, these results support outreach efforts like ride and drive events featuring other "real life" PEV drivers as effective marketing mechanisms. Extended test drives or pre-purchase rental programs may also help to further develop the PEV market.

Figure 39 - Ranking scores by PEV type on most influential information sources in California[100]



III.C. Current ZEV consumer purchase behavior

New car buyers have a wide array of models from which to choose, only a small fraction of which are currently available with ZEV technology. Understanding the purchase motivations of past and recent buyers will be important for developing strategies to accelerate the market. To date, consumers have been varied in the degree to which financial, environmental, or performance attributes have influenced their choices, however the majority of households purchasing these vehicles have had no prior experience with any alternative fuel or hybrid technology. Favorable characteristics, such as their access to charging and other household vehicles, as well as a variety of incentives further help to enable PEV ownership. Workplace charging also serves a dual role in supporting the market by providing consumers with

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[100] CVRP results, Jun2015-Sept2016. See Section VII.G.1 for further details on CVRP survey.

assurances on charging away from home while also providing opportunities for increasing electric vehicle miles traveled. Finally, as a new technology, dealerships or retail stores serve significant roles in providing education to customers; however, the newness and constantly evolving marketplace creates challenges in keeping sales representatives up to date. This section describes staff's findings related to current PEV[101] consumer purchase behavior and experiences in both California and Section 177 ZEV states.

III.C.1. ZEV Purchaser Characteristics

This section largely draws upon survey results administered to recipients of California's, Connecticut's, and Massachusetts' state incentive programs[102] to describe who is currently driving ZEVs and PHEVs, the characteristics of their households, and the circumstances under which these vehicles were acquired. A few higher level aggregate data sources provide a more complete picture of the overall market, though with less granularity. Combined, these two approaches produce insights into what factors both enable and motivate the choice of a PEV, which in turn informs how the market may be developing and how consumers may respond to market changes in the future as well as how to appeal to a broader customer base.

III.C.1.a. Purchase or Leased Vehicles

Leasing provides consumers with an opportunity to experience electric-drive technology with relatively less commitment and generally lower monthly payments than outright purchase (and financing) of a PEV. The nature of leasing means that fleet turnover will be accelerated as most lease terms last 24 to 36 months, rather than the typical ownership period of five to seven years for the purchase of a new vehicle. However, with pre-paid mileages usually ranging from 10,000 to 15,000 annual miles, consumers with high travel demand may opt for purchases over leases.

The CVRP application data show different purchase and lease rates among the different PEV technologies and over time. Overall, the majority of BEV<200s and BEVxs have been leased (83% each), while half (50%) of the PHEVs have been purchased, and the majority of BEV200+s (83%) have been purchased.[103] However, as shown in Figure 40, the trend over time among all PEV technologies has been an increase in the share of leases. For instance, only 30% of BEV<200s were leased in 2011, while the fraction jumped to 94% in the first four months of 2016. Similarly, 33% of PHEVs were leased in 2012 increasing to 76% in 2016.

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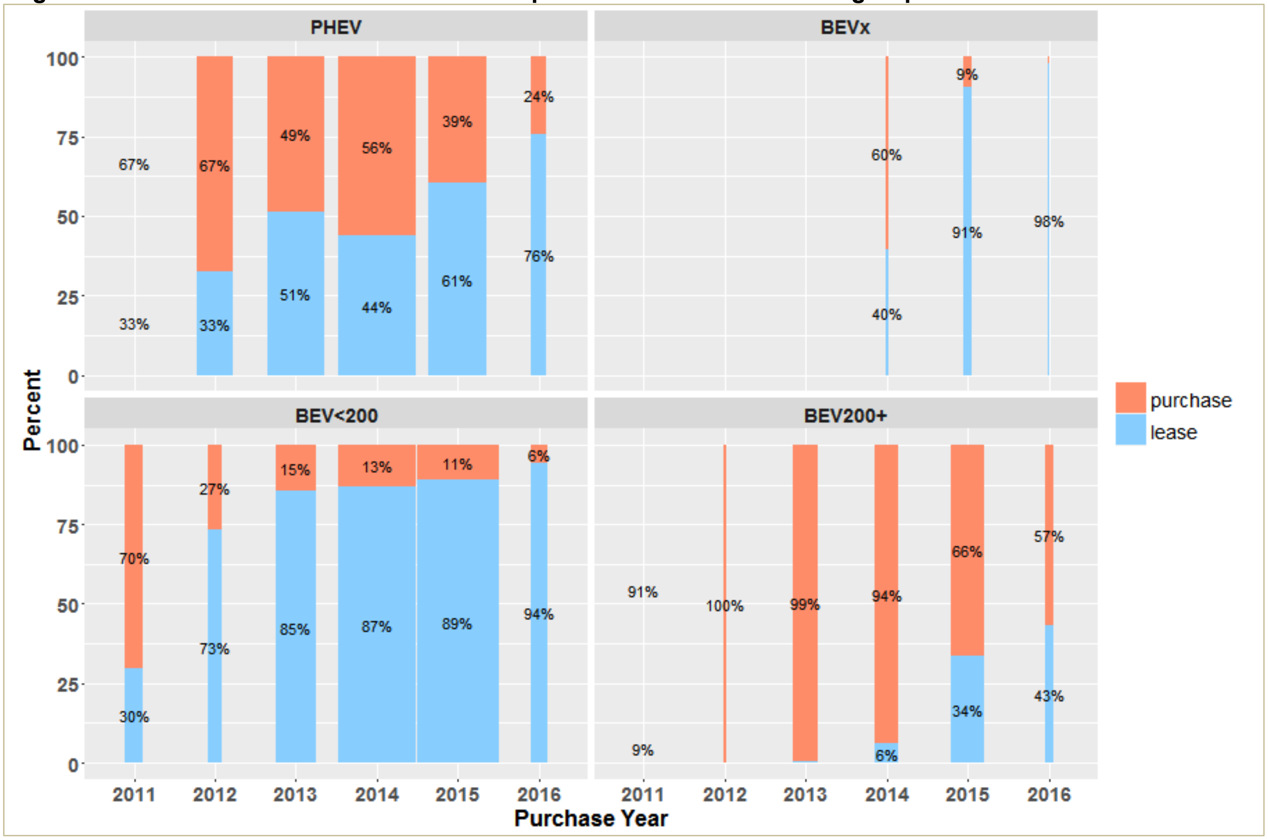
[101] Currently, there are only around 500 FCEVs in California and fewer than 100 survey responses. Therefore, FCEV demographics were not included in this section.
[102] See Section 0 for descriptions of the California Clean Vehicle Rebate Project (CVRP) surveys, the Connecticut Hydrogen and Electric Automobile Purchase Rebate (CHEAPR), and the Massachusetts Offers Rebates for Electric Vehicles (MOR-EV).
[103] Note that Tesla initially did not offer vehicles for lease, which may contribute to their high purchase rates.

Figure 40 - Percent of CVRP rebated vehicles purchased and leased through April 2016[104]



Note: Column widths are proportional to number of rebates granted for each PEV type and purchase year

Eligibility for California's vehicle rebate requires applicants to lease their vehicles for at least 30 months, and therefore these survey results exclude any lessees who may have leased their vehicles for a shorter time period. As a result, the lease indicator in the Experian Automotive data shows a slightly higher fraction of lessees of all PEV types for transactions from 2011 to 2015 in California. Table 8 shows the lease fraction for California, the Section 177 ZEV states and the rest of U.S. Although the relative ranking of PEV types that are most frequently leases is consistent across the three regions, California's market shows a higher fraction of leases for all categories.

Table 8 - Percent of leases within each region for each PEV type for 2011-2015 registrations[105]

PEV Type	CA	Section 177 ZEV States	Rest of U.S.
PHEV	51%	46%	48%
BEVx	82%	54%	58%
BEV<200	86%	66%	64%
BEV200+	16%	6%	12%

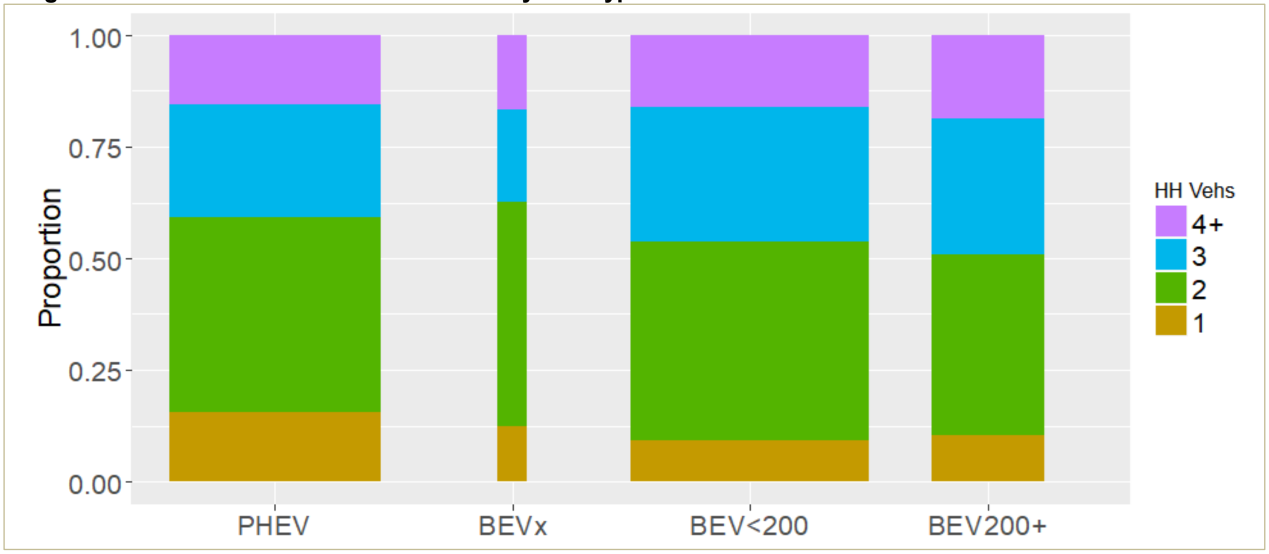
III.C.1.b. Number of Household Vehicles

The majority of 2015 and 2016 CVRP recipient respondents have more than one vehicle in the household. As shown in Figure 41 respondents in single-vehicle households are more likely to

[104] CVRP Rebate data.
[105] Experian Automotive data.

have a PHEV than the other types of PEVs, however the vast majority of PHEV drivers have at least one other household vehicle.

Figure 41 - Number of household vehicles by PEV type in California[106]

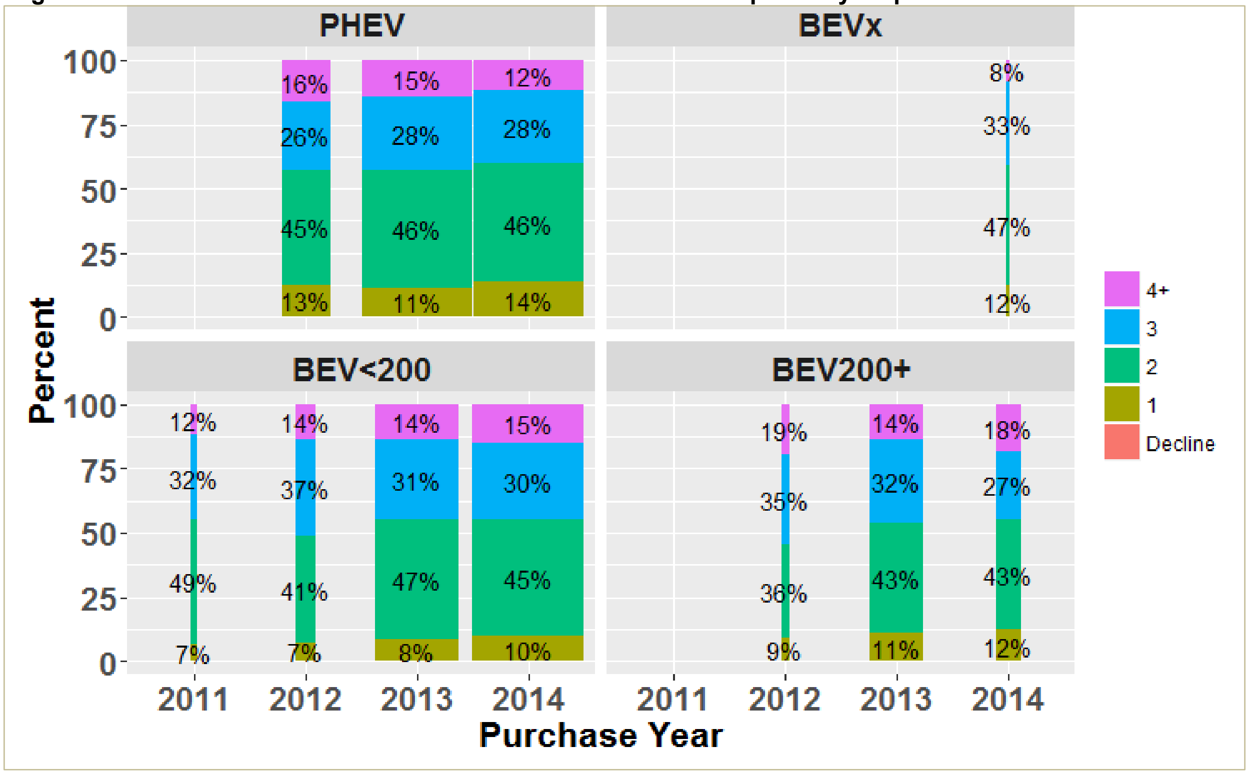


Note: Column widths are proportional to the number of respondents in each PEV category.

California's Ownership survey respondents represent a cross-section of the cumulative PEV drivers with over six months of experience with their vehicles and acquired their vehicles prior to 2015. As shown in Figure 42, less than 13% of these respondents belong to a single-vehicle household. Overall, only a slightly higher percentage of PHEV households are single vehicle households (13%) compared with BEV<200 households (9%). Despite potential range or infrastructure limitations, nine percent is a non-trivial fraction of single-vehicle households who drive BEV<200s. A similar percentage of BEV200+ households only have one vehicle (11%) compared to PHEV households. These trends are fairly similar across different PEV models, and the percentage has slightly increased with purchase year.

[106] CVRP results, Jun2015-Sept2016.

Figure 42 - Household number of vehicles of California Ownership Survey respondents[107]



Note: Column widths are proportional to number of rebates granted for each PEV type and purchase year

III.C.1.c. Replacing or Adding Vehicles

Given the high lease rates discussed in Section III.C.1.a, whether vehicles are acquired as a replacement vehicle or additional to a household's fleet can influence vehicle usage and future purchase behavior. Leased vehicles that are added without a new driver to the household may have a lower likelihood of being replaced (immediately) upon expiration of the lease while replacement vehicles may have a greater likelihood of resulting in repeated leases. The majority of all CVRP, CHEAPR[108] and MOR-EV[109] recipients shown in Figure 43 replaced a vehicle with the rebated PEV. In CA, PHEVs, BEVx, and BEV200+ replaced household vehicles at similar rates (70 - 74%). Similarly in Massachusetts, PHEVs, BEV200+ and BEVx were acquired as replacement vehicles at roughly the same rates (76 - 80%). In California and Massachusetts BEV<200s replaced a vehicle 63% of the time. In Connecticut, PHEVs were replacement vehicles in 85% of instances compared with 58% for BEV<200s.

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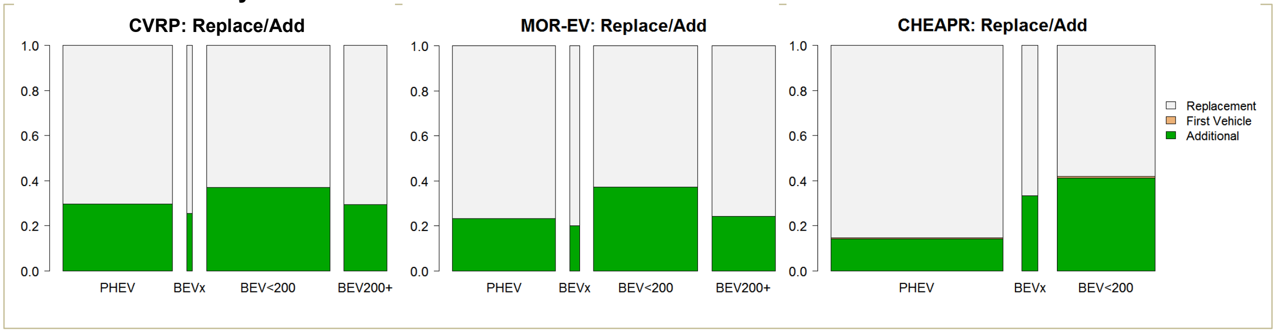
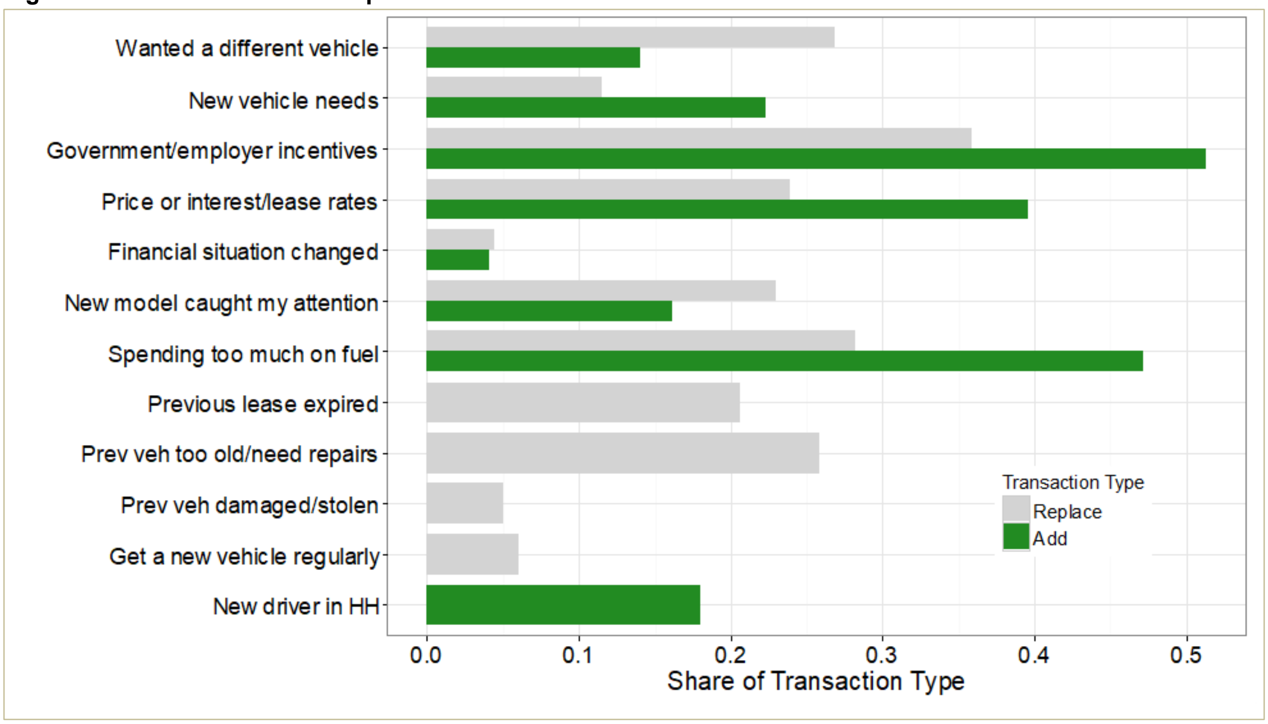
[107] Ownership results. See Section VII.G.4 for details about California's ownership survey.
[108] See Section VII.G.2 for details about Connecticut's CHEAPR incentive program survey.
[109] See Section VII.G.3 for details about Massachusetts' MOR-EV inventive program survey.

Figure 43 - Fraction of PEV rebated that were a replacement or additional vehicle based on CVRP, MOR-EV, and CHEAPR Surveys[110,111,112]



Note: Column widths for each state are proportional to the number of respondents in each PEV category.

Figure 44 - Reasons for vehicle purchase/lease now in California[113]



Note: Single, taller bars reflect reasons exclusive to each transaction type. Bars will sum to more than 1 given respondents were permitted to select more than one reason.

Reasons for replacing or adding a vehicle can be further analyzed when looking at California buyers, as shown in Figure 44. For both replacing and adding households in the 2015-2016 timeframe, government or employer incentives are most commonly cited as motivating the timing of their recent transaction, suggesting that consumers may be concerned about the longevity of existing incentives such as tax credits or rebates. Additionally, both types of

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110 CVRP results, Oct 2013-Nov 2015.
111 MOR-EV results.
112 CHEAPR results.
113 CVRP results, Jun2015-Sept2016.

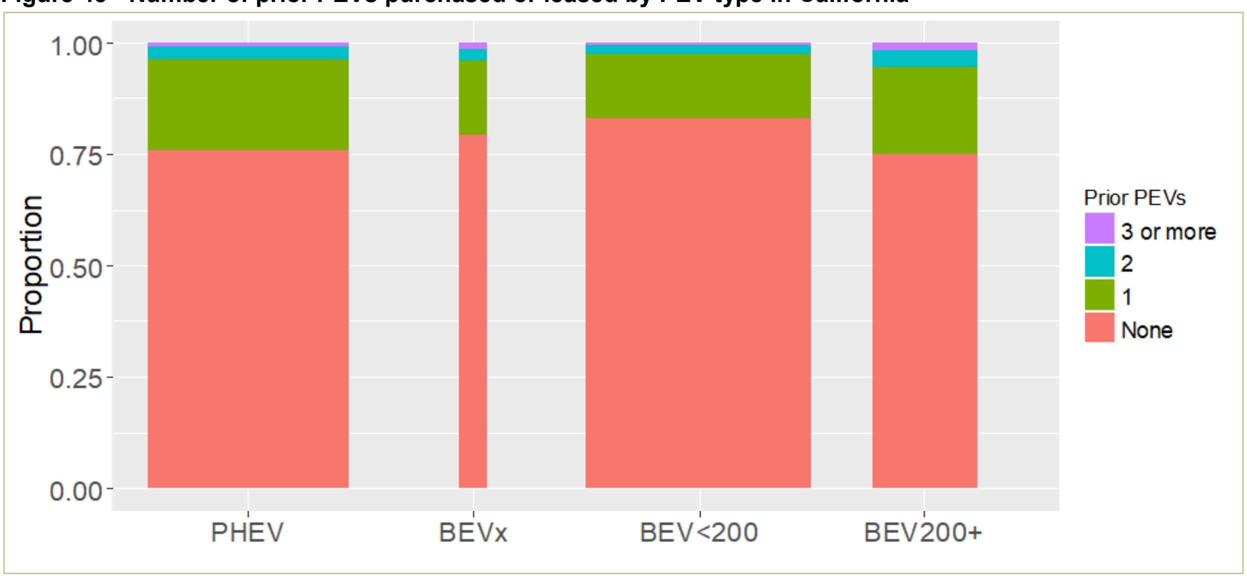
households frequently noted spending too much on fuel. Appealing prices or low interest/lease rates were more often cited for adding households than replacing households, rather than changes in consumer tastes or needs. Pricing strategies thus do help to expand the market. About half of the replacement transactions were out of "necessity" such as vehicles becoming too old or unreliable, leases expiring, or being damaged in accidents.

III.C.1.d. Prior ownership of alternative fuel vehicles

Approximately 80% of respondents to the 2015-2016 CVRP survey report that their household is purchasing or leasing their first PEV. Despite notions that consumers will need to ease their way into greater degrees of vehicle electrification, these results suggest that many drivers are willing to take the plunge into full electrification without any transition.

As shown in Figure 45, those acquiring BEV<200s are the group with the highest proportion of respondents new to PEVs; this also represents the PEV type with the largest number of respondents and greatest market share. Those acquiring PHEV, BEVx, and BEV200+ are all more likely to have had some prior PEV experience, though mostly having only one previous PEV. In the case of PHEVs, the launch of the redesigned Chevrolet Volt during this survey period likely temporarily magnifies the number of experienced PEV drivers, though still nearly 70% of Chevrolet Volt respondents reported this to be their first PEV. Furthermore, among those new to PEVs, only 17% are transitioning from HEVs, either reporting that their PEV replaces an HEV or that another vehicle in their household is an HEV.

Figure 45 - Number of prior PEVs purchased or leased by PEV type in California[114]



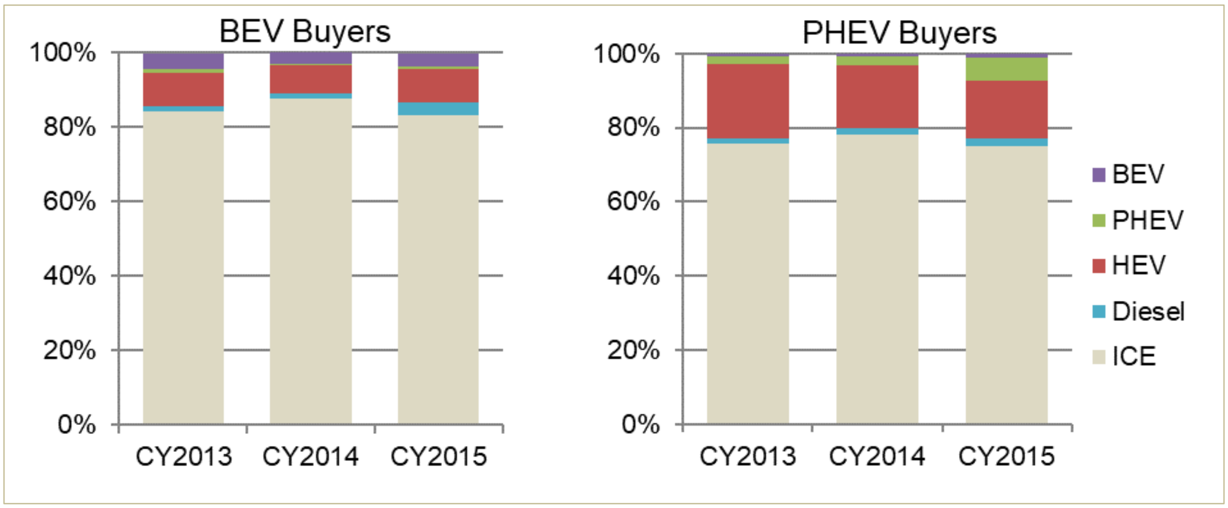
Note: Column widths are proportional to the number of respondents in each PEV category.

Nationally, the National Automobile Dealers Association (NADA) analyzed vehicle disposal data including new and used vehicle retail transactions from over 7,500 automotive franchises in the

[114] CVRP results, Jun2015-Sept2016.

United States and Canada originating from J.D. Power's Power Information Network® (PIN).[115] As shown in Figure 46, results reveal that 85% of consumers who purchased BEVs between 2013 and 2015 disposed of a gasoline powered vehicle followed by an HEV (8%). Similarly, 77% of PHEV consumers replaced a gasoline vehicle followed by 18% replacing an HEV over these three years. An average of 3.5% of BEV consumers replaced another BEV, with another 0.7% of BEV consumers replacing a PHEV; PHEV consumers had similar replacement levels. Although all these percentages have been relatively stable over the three years studied, the percentage of PHEV consumers that have replaced a PHEV has increased from 1.8% in 2013 to 6.4% in 2015 which seems to have offset the decline in PHEV consumers replacing an HEV. In contrast, no consumers have replaced a BEV with an HEV and only 0.1% have replaced a PHEV with a conventional hybrid.

Figure 46 - Replaced technology type for BEV and PHEV purchases CY2013-2015[116]



III.C.1.e. Charging Locations

Given that PEV recharging/refueling may be different from conventional vehicles, understanding where current PEV drivers are able to charge their vehicles and the cost of this charging provides more insights into who is buying PEVs and why. Additionally, infrastructure availability is useful for gauging how the market is penetrating to different consumer groups and the benefits of policies that facilitate infrastructure deployment that can help to expand the market.

III.C.1.e.i. Home charging

The ability to charge at home is one of the advantages of PEV ownership. Correlated to home parking, over 90% of recent PEV consumers in California can and do charge at home. The larger the battery pack, the more often the household is using faster charging speeds (240V, level 2) at home, as shown in Figure 47 (light and dark blue). The majority of PHEV, BEVx, and

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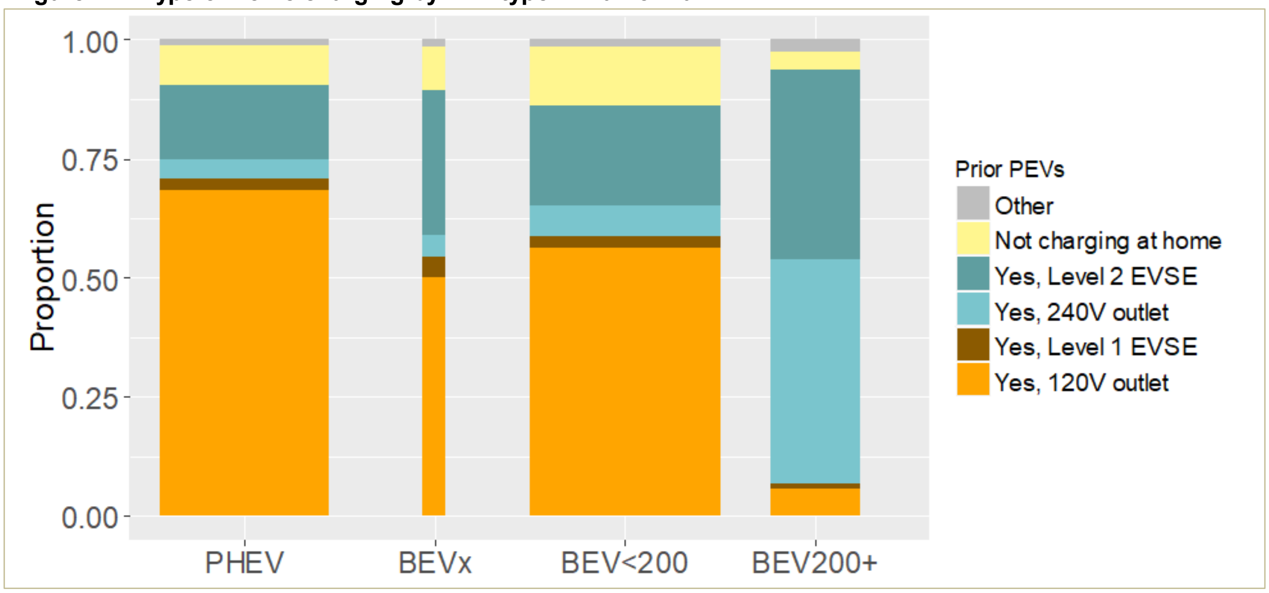
[115] NADA 2016a. National Automobile Dealers Association. April 2016. *Alternative Powertrains: Analysis of Recent Market Trends & Value Retention.* http://img03.en25.com/Web/NADAUCG/%7B49f71c70-31ef-4af9-870b-aeac4c6245bd%7D_201604_Alternative_Powertrains.pdf.

[116] NADA 2016a.

BEV<200 respondents are relying on slower charging speeds (120V, level 1), of whom only about one-third do not believe faster charging to be necessary to meet their needs. However, the remaining respondents indicate costs, complexity, or authority as renters or members of homeowners associations as reasons for not installing level 2 charging and may benefit from public policy to address these issues. In contrast, the overwhelming majority of current BEV200+ drivers are able to charge at home at level 2 speeds. Assuming home will be the predominant location for charging in the future, these results may foreshadow future needs for PEV drivers to increase their home charging speeds as more larger battery vehicles are introduced that accommodate longer daily drive cycles (or allowing less frequent charging, especially in multi-PEV households).

Figure 47 - Type of home charging by PEV type in California[117]



Note: Column widths are proportional to the number of respondents in each PEV category.

This higher charging speed will likely result in some additional cost for some future purchasers of longer range PEVs. Among those using outlets, 80% of respondents reported not needing any upgrades at all to be able to charge at home. As shown in Figure 48, installing level 1 or 2 outlets is typically less expensive than installing a full charging station (electric vehicle service equipment or EVSE) due to the lower material cost. Regardless of the type of upgrade, though, residential charging infrastructure has been added at a median cost of less than $1000; with outlets being installed at a median cost of $600 and EVSEs procured and installed at a median cost of $900.

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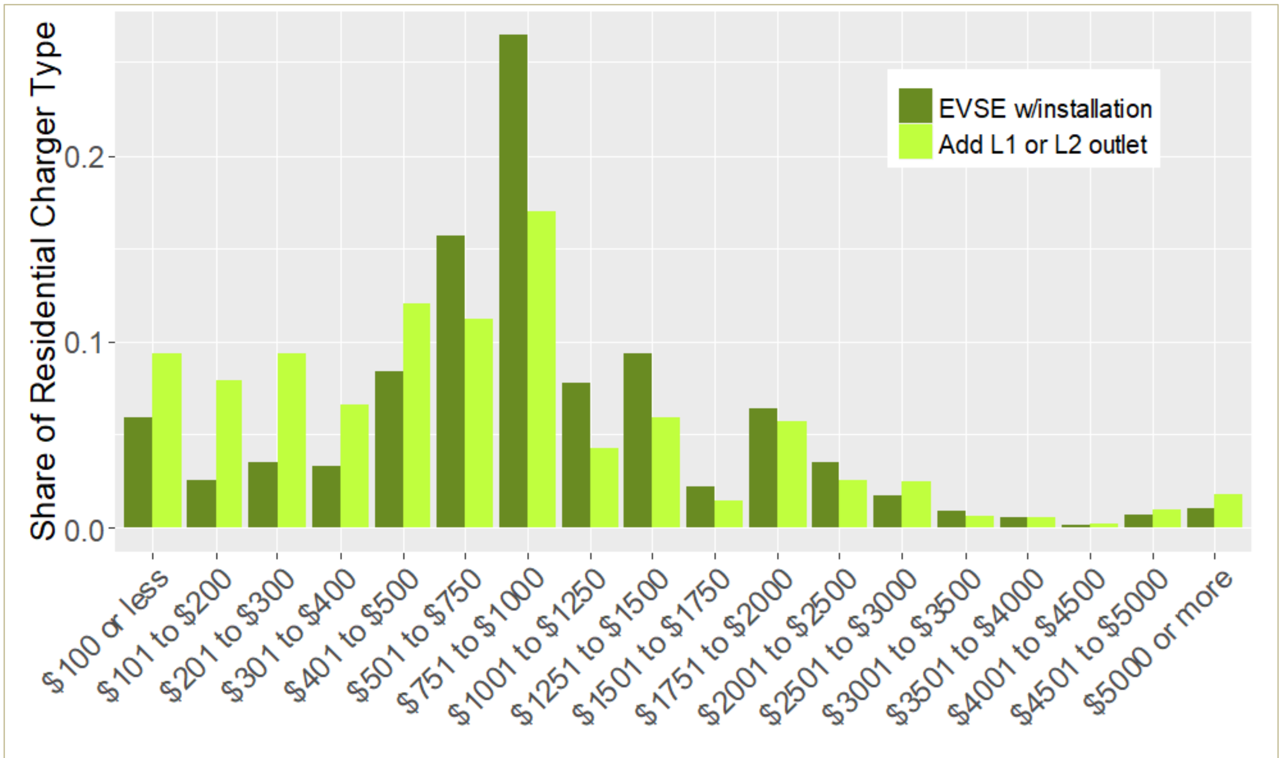
[117] CVRP results, Jun2015-Sept2016.

Figure 48 - Distribution of infrastructure costs for residential charging in California 2015-2016.[118]



Note: Bars of each color sum to 1.

III.C.1.e.ii. Workplace charging

Workplaces can serve as "second showrooms" for employees to learn about new vehicle technologies from their colleagues and a number of employers have joined initiatives such as the U.S. DOE's Workplace Charging Challenge to provide their employees with opportunities to charge their vehicles while at work. In addition to assisting with workforce retention, workplace charging can increase the electric vehicle miles traveled (eVMT) of PEVs, especially for those consumers whose commute distances exceed the all-electric range of their vehicles. When workplace charging is available for free, this can serve as an incentive for employees. However, even when only paid charging is offered, the availability of infrastructure can still enable PEV adoption for those who are not able to charge at home, or provide the necessary comfort or flexibility for using a PEV for more than just commuting purposes. In the future, workplace charging may also be important for vehicle grid integration and balancing electrical loads that incorporate a greater share of renewable energy sources.

California PEV consumers tended to have more access to workplace charging (39-49% depending on PEV type) compared to Massachusetts consumers (28-36%), especially the BEV<200 (47% vs 34%) and BEVx (49% vs 30%) drivers. The number of respondents not working/working from home was fairly similar among both states across PEV types except for for BEV200+ consumers (19% CA vs 26% MA).

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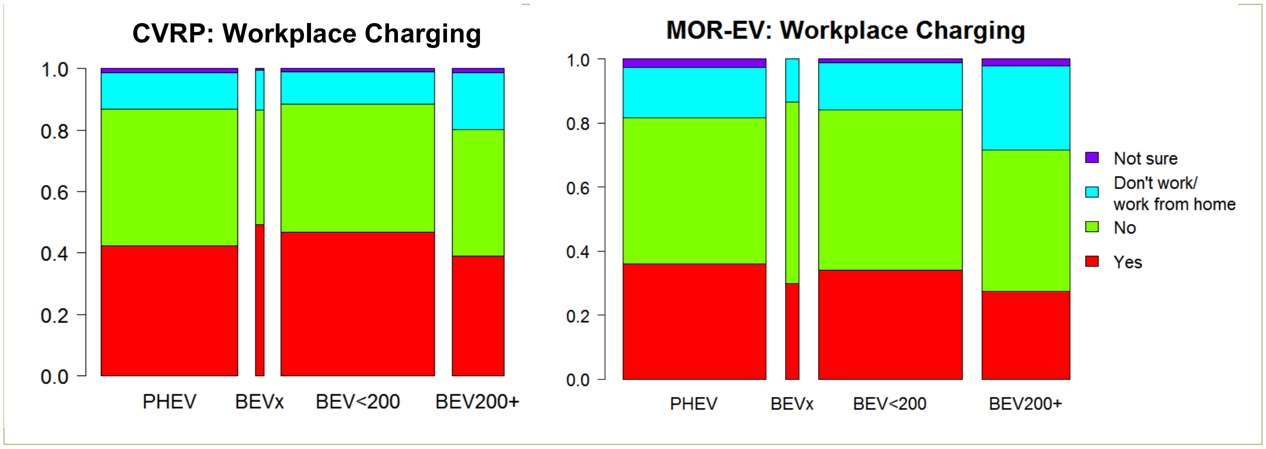
[118] CVRP results, Jun2015-Sept2016.

Figure 49 - Workplace charging availability for CVRP and MOR-EV Survey respondents[119,120]



Note: Column widths for each state are proportional to the number of respondents in each PEV category.

The majority of PEV drivers in California who have access to workplace charging (about one-quarter of the entire sample) are able to charge for free, which contributes to lowering total vehicle ownership costs and is consistent with other survey results showing free charging more generally to be an important incentive. Additional to battery size, frequency of workplace charging usage also seems to be correlated to whether access if free or paid. When workplace charging is provided for free, usage is much more frequent than when drivers must pay (though specific costs are not collected) as shown in Figure 50 and Figure 51.

This finding would support the use of pricing to manage charging congestion at workplaces and elsewhere. Although future increases in battery sizes may suggest a reduced need for infrastructure away from home, still roughly 40 percent of BEV200+ drivers reported using workplace charging at least once a month even when paid. So while charger types, configurations, pricing and ratios will continue to evolve, the need for workplace charging infrastructure will likely remain, especially for drivers without access to home charging, and existing infrastructure investments will continue to serve PEV drivers in the future.

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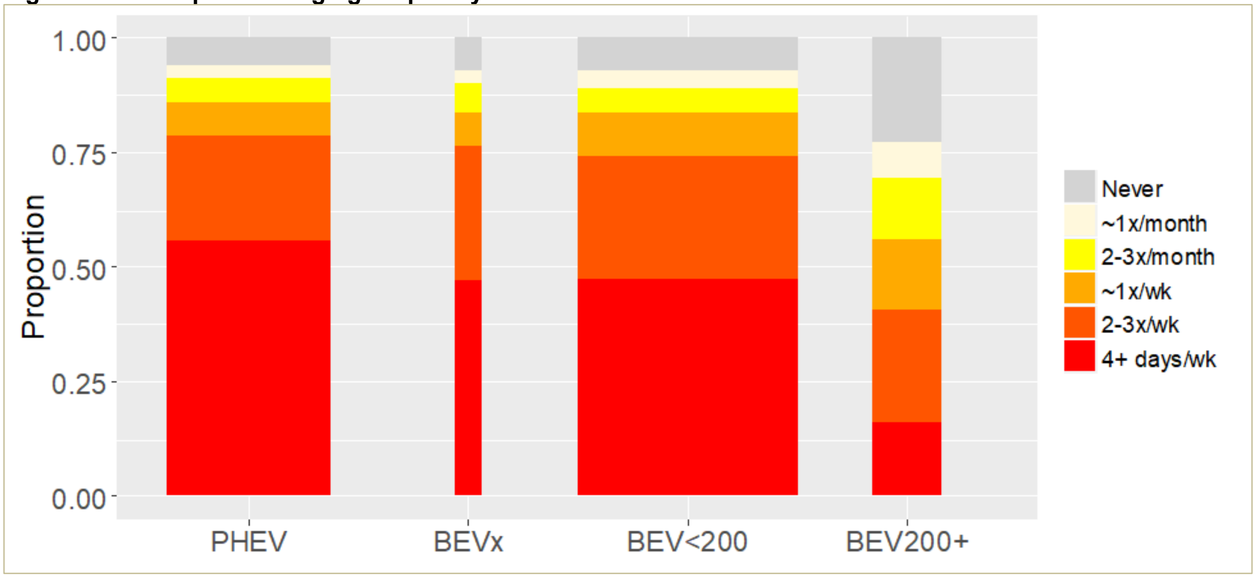
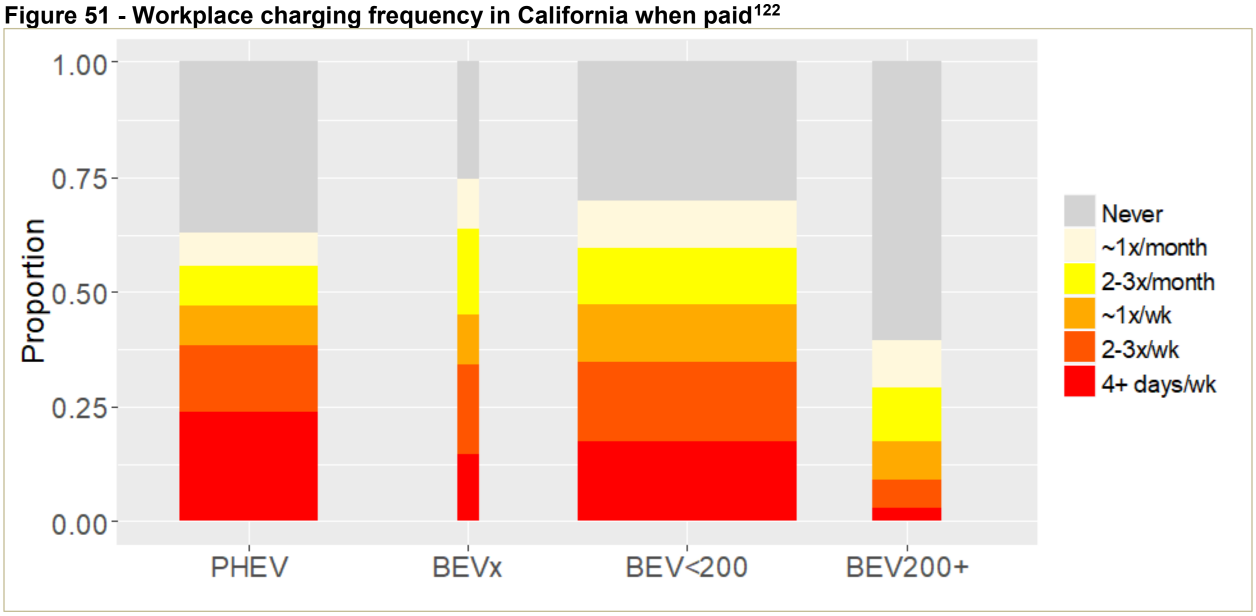
[119] CVRP results, Oct 2013-Jun 2016.
[120] MOR-EV results.

Figure 50 - Workplace charging frequency in California when free[121]



Note: Column widths are proportional to the number of respondents in each PEV category.

Figure 51 - Workplace charging frequency in California when paid[122]



Note: Column widths are proportional to the number of respondents in each PEV category.

III.C.1.e.iii. Residential electricity rates for PEV charging

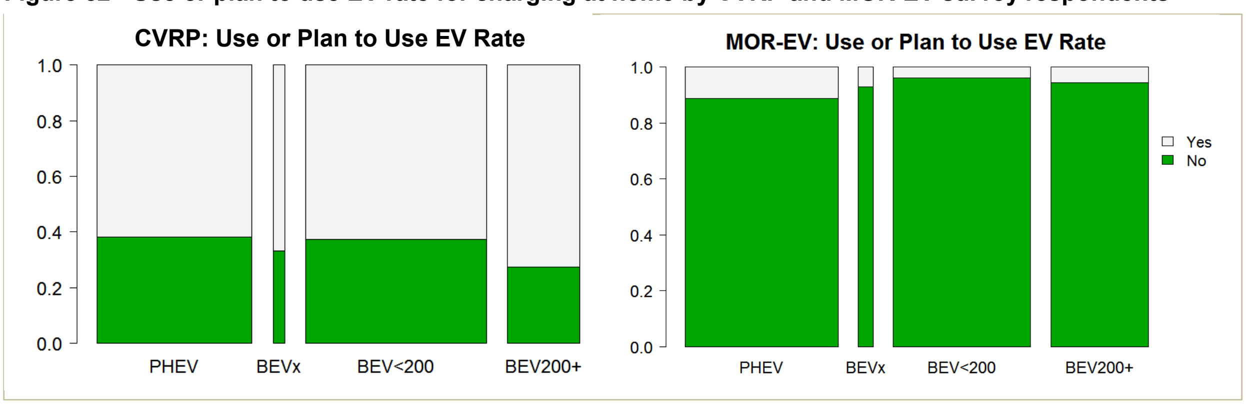
While electric-drive technology is inherently more energy efficient than internal combustion engines, operating cost savings will not be realized for PEVs if electricity prices are too high. While some employers, retailers, municipalities, and auto manufacturers offer free charging at

[121] CVRP results, Jun2015-Sept2016.
[122] CVRP results, Jun2015-Sept2016.

various locations, home remains the predominant location for vehicle charging. In California, electric utilities have been somewhat more progressive in offering reduced electricity prices for PEV charging during off-peak hours. These EV time-of-use (TOU) rates can potentially encourage PEV adoption by allowing PEV drivers to charge their vehicles at certain times when electricity rates are lower. As a result, some consumers may still have lower PEV operating costs than those driving conventional vehicles even during times of low fuel prices. Gauging the share of drivers aware of these charging discounts helps utilities and their regulators to improve their outreach. Additionally, if a significant portion of drivers are aware of the EV rates but are not electing to use them, this could suggest modifications to the rate structures may be needed to support further PEV market growth.

More than 60% of California respondents use or plan to use an EV electricity price rate for charging at home. However, in Massachusetts more than 89% of consumers do not use or do not plan to use EV rates and this likely reflects that Northeast utilities are only beginning to offer charging discounts. Vehicles with larger battery packs have the potential to benefit more from adopting a special utility rate for charging their PEV at home as they have the ability to consume the most electricity at discounted rates (and offset higher rates for other household consumption). However, actual electricity consumption will depend on (electric) vehicle miles traveled, which in turn determines the financial benefit of adopting an EV or TOU rate. As a result, opting into a reduced rate for EV charging is only somewhat correlated to battery size. In Massachusetts, more PHEV consumers use or plan to use EV rates than BEV<200 consumers (11% vs 4%) while in California similar proportions of PHEVs and BEV<200 drivers use EV rates for charging at home (62% vs 63%). Interestingly, although Ford C-MAX and Fusion Energi PHEVs have the same battery capacity, Fusion drivers in California have opted into EV rates in larger numbers, suggesting other influencing factors.

Figure 52 - Use or plan to use EV rate for charging at home by CVRP and MOR-EV survey respondents[123,124]



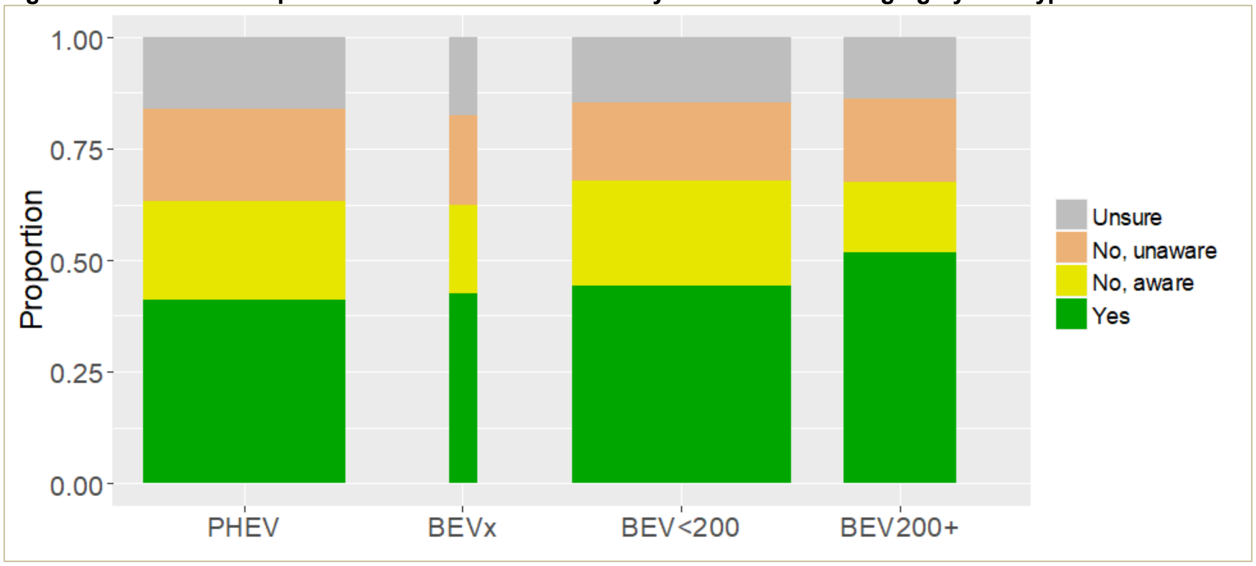
Note: Column widths for each state are proportional to the number of respondents in each PEV category.

As shown in Figure 53, about one-fifth of recent California consumers were aware of an EV rate offered by their utility but have elected to remain with their existing residential rate, presumably

[123] CVRP results, Oct 2013-Jun 2016.
[124] MOR-EV results.

because this rate would not provide financial benefits based on their household's electricity consumption patterns. About another fifth of respondents are unaware of any EV rate. Although in some cases, consumers with municipal utilities may not have EV rates available to them, the vast majority of respondents have their electricity provided by one of the three investor-owned utilities (IOU) that do offer EV (or TOU) rates.

Figure 53 - Share of adoption/awareness of reduced utility rates for PEV charging by PEV type in California[125]

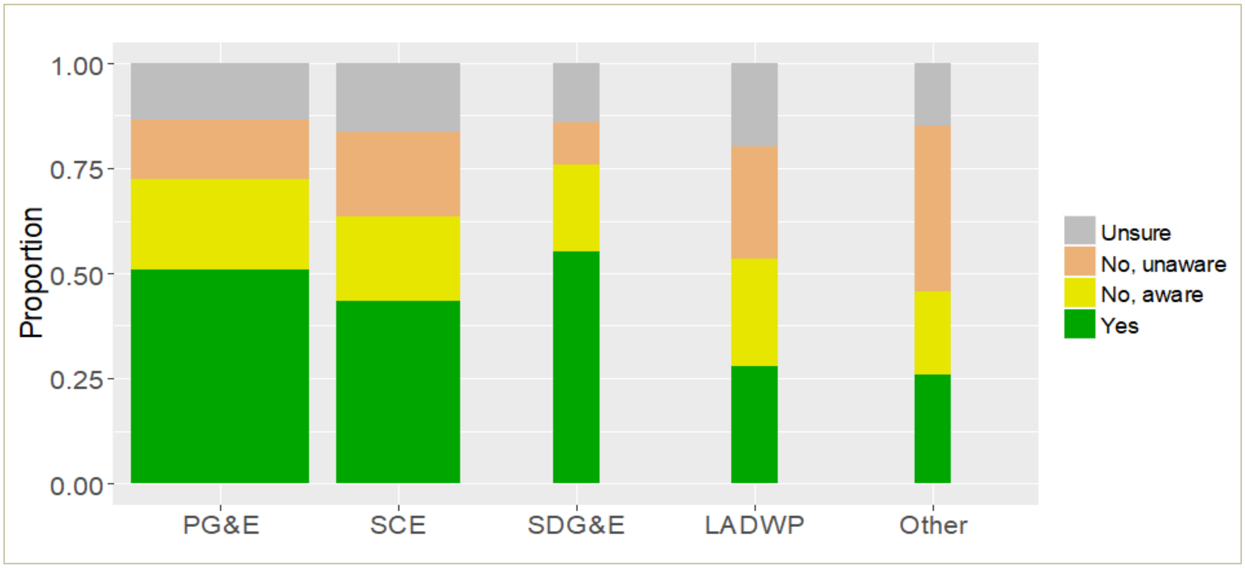


Note: Column widths are proportional to the number of respondents in each PEV category.

Figure 54 shows adoption/awareness levels across utilities in California to be more variable. Similar fractions are unsure of whether they are charging using any discounted rates, but there are larger differences in the other categories. Within the segments aware of EV rates, opt-in rates are higher within IOUs; while territories like San Diego Gas and Electric (SDG&E) have the highest proportion of BEV200+ respondents that may be skewing these results, the vehicle market shares in Southern California Edison (SCE) and Los Angeles Department of Water and Power (LADWP) are similar, suggesting that the rates themselves (or their various conditions, such as separate meter requirements or TOU parameters) account for the differences.[126]

[125] CVRP results, Jun2015-Sept2016.
[126] See Appendix E for discussion of residential electricity prices in California.

Figure 54 - Share of adoption/awareness of reduced utility rates for PEV charging by utility in California[127]



Note: Column widths are proportional to the number of respondents in each utility.

III.C.1.f. Residence

The ability and motivation for most current PEV drivers to charge at home, as discussed in the previous section, may be related to the attributes of their residence. Specifically, consumers who own their own homes have greater autonomy to make modifications to allow for home charging; the type of residence will also affect access to electricity at vehicle parking locations; and the presence of photovoltaic solar panels (which itself is likely correlated to home ownership) may affect motivations to charge at home from an environmental or financial perspective. At this stage of the market, the majority of PEV consumers appear to be those for whom home charging is easiest. Broadening the market to other segments, such as renters of multi-unit dwellings will likely require additional policy interventions to provide more opportunities for these consumers to charge, either with additional infrastructure deployment or agreements with local charging station hosts to allow nearby residents to charge overnight. However, increases in vehicle range, faster onboard vehicle charging speeds, and the proliferation of DC fast charging stations can also facilitate adoption among those who do not have access to home charging if vehicle charging becomes more similar to gasoline refueling.[128]

III.C.1.f.i. Rent/own

Home ownership increases the probability that a consumer would have the authority to install or upgrade electrical equipment that would allow for or improve home PEV charging. This authority is not automatic as some home ownership associations may have restrictions on renovations that would be visible from outside the property. However, interior upgrades would likely not be prohibited, and in all cases, ownership increases the probability that the consumer will remain at that location in the mid- or long-term, so any investments to the residence will be less likely to

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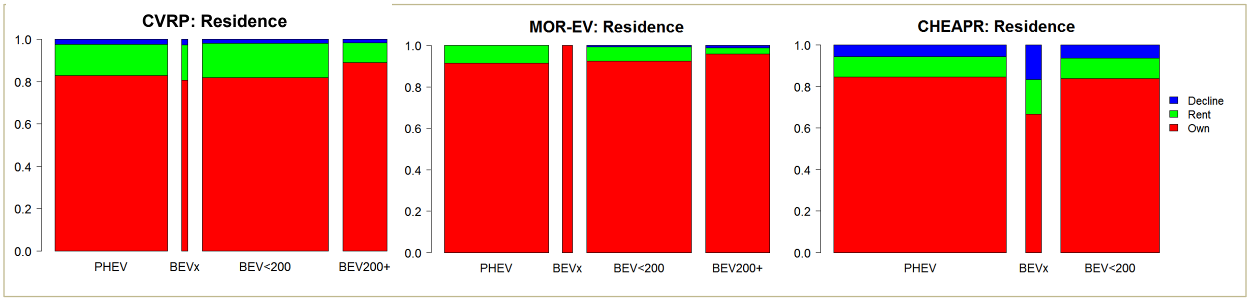
[127] CVRP results, Jun2015-Sept2016.

[128] Hydrogen fuel-cell electric vehicles can also offer gasoline-like refueling but data on these drivers is currently too limited for analysis.

be stranded. To date, a large majority of PEV consumers own their own residence, with minimal variation between the different PEV types or regions, as shown in Figure 55. These trends may be correlated to residence type as well as household income levels.

Figure 55 - Percentage of respondents that rent or own their residence based on CVRP, MOR-EV, and CHEAPR Surveys[129,130,131]

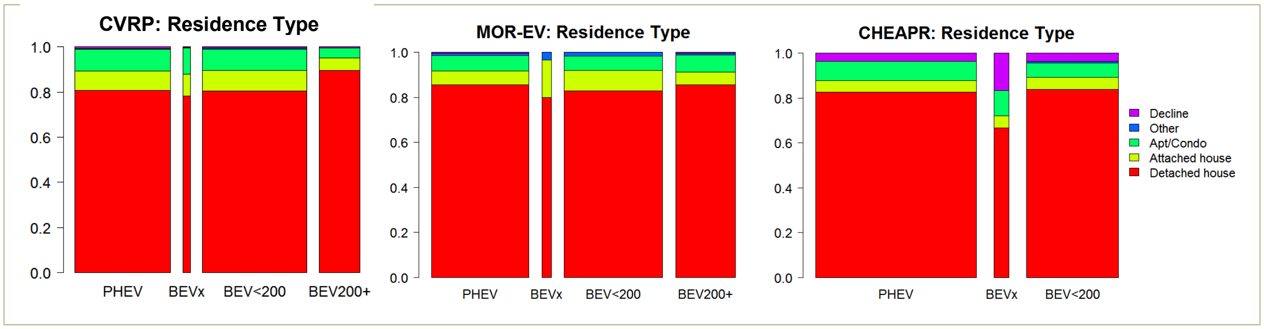


Note: Column widths for each state are proportional to the number of respondents in each PEV category.

III.C.1.f.ii. Residence type and home parking

PEVs offer the possibility of convenient charging when charging is available at home. The availability of home charging is highest when consumers have off-street parking available at their residence, which in turn is correlated to their type of residence. Most PEV consumers tend to live in detached single family homes, as shown in Figure 56. It is worth noting a few PEV models that were more prevalent among those that lived in an apartment/condo or attached housing. In Connecticut, both Ford Enegi models and the BMW i3 were acquired slightly more by apartment/condo residents, suggesting that the additional gasoline powertrain provides needed flexibility. In Massachusetts, the Fusion Energi, BMW i3 REx, Smart Fortwo, and VW e-

Figure 56 - PEV driver residence types based on CVRP, MOR-EV, and CHEAPR Surveys[132,133,134]



Note: Column widths for each state are proportional to the number of respondents in each PEV category.

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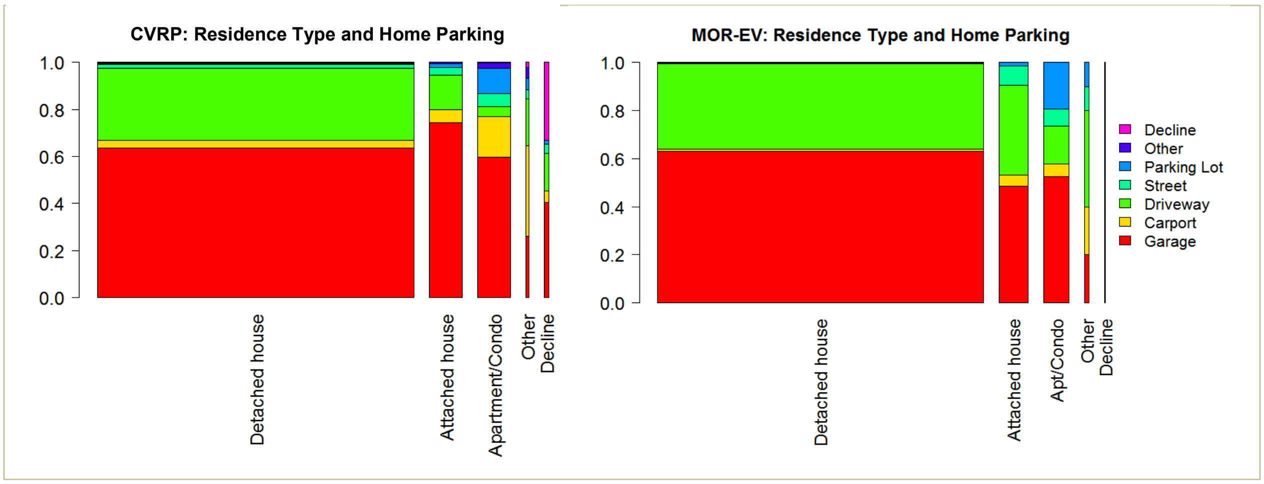
129 CVRP results, Oct 2013-Nov 2015.
130 MOR-EV results.
131 CHEAPR results.
132 CVRP results, Oct 2013-Jun 2016.
133 MOR-EV results.
134 CHEAPR results.

Golf are among those found living in attached houses and apartments/condos. In California, the Toyota Prius Plug-in, Fiat 500e, Ford C-MAX Energi, and Nissan Leaf were more likely to be acquired by those living in attached houses and apartments/condos.

Combining the residence type of current PEV consumers with the parking location at home in California and Massachusetts, Figure 57 shows the majority live in detached houses but the distribution between parking in a garage and the driveway is similar. Surprisingly, the share of those parking in driveways exceeds 30% in both states. California PEV consumers living in attached houses and apartments or condominiums were more likely to have a garage to park their vehicle in than those in Massachusetts (74% and 60% vs 48% and 53%). Carports were also much more likely to be present in California than Massachusetts PEV residences. A similar

Figure 57 - PEV driver home parking type and residence type based on CVRP and MOR-EV Surveys[135,136]



Note: Column widths for each state are proportional to the number of respondents in each residence type.

proportion of respondents in both states live in multi-unit dwellings where they may not have dedicated parking for their PEV, such as in a parking lot or on the street, though a small fraction of both BEV and PHEVs consumers are seemingly able to manage; at this stage of the market, PHEVs do not seem to be favored by those living in apartments or condos more so than BEVs.

III.C.1.f.iii. Solar panels at your residence

The presence of solar panels that produce electricity at a residence informs both the emissions impact of PEV usage as well as the potential charging behavior of these consumers. While households that are motivated by environmental reasons to purchase a PEV may similarly be motivated to install solar panels, the presence of these panels may have also motivated their purchases as PEV operating costs could be lower if solar panels are already present at the residence. Alternatively, the extent to which a PEV purchase motivates the installation of solar panels demonstrates the co-benefits of PEV market expansion for emission reductions in the electricity sector.

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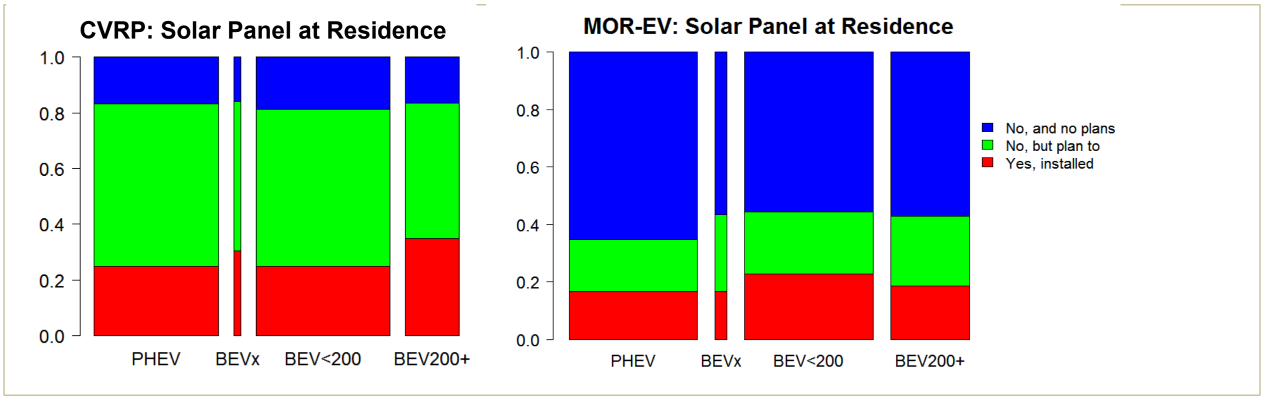
[135] CVRP results, Oct 2013-Nov2015.
[136] MOR-EV results.

As shown in Figure 58, higher percentages of California PEV consumers have installed (25-35%) and planned to install (48-58%) solar panels in their home within the next year compared to those from Massachusetts (17-23% and 18-27%). Similar shares of PHEV and BEV<200 consumers in California had solar panels installed at their home (~25%), whereas more BEV<200 than PHEV consumers did in Massachusetts (23 vs 18%). California BEV200+ consumers were the most likely (35%) to have solar panels installed across all vehicle technologies in these two states. In contrast, a higher percentage of BEV<200 (23%) consumers had solar panels installed than BEV200+ (19%) consumers in Massachusetts.

Figure 58 - Solar panels at residence of PEV drivers based on CVRP and MOR-EV Surveys[137,138]



Note: Column widths for each state are proportional to the number of respondents in each PEV category.

III.C.1.g. Comparison to current conventional new car buyers

At around 80%, the lease rates of PEVs are considerably higher than occur in the overall new vehicle market where leases comprised about 23% of new vehicle transaction at the end of 2010 and have climbed to about 33% by the end of 2015.[139] PEV households also tend to have more household vehicles than the more general new car buying population, where about one-third of households have only one vehicle[140] compared to the roughly 10% of single-vehicle PEV households.

Based on the UCD New Car Buyers Study, three-fourths of respondents in states sampled (73%) report they own their home, 26% rent, and approximately 1% lease or have some other arrangement. The PEV respondents to surveys in California, Connecticut, and Massachusetts show higher levels of home ownership than in the broader new vehicle market. Potentially related to these home ownership levels, at least 80% of PEV households live in a detached house, compared to the approximately 70% among overall households in California and Section 177 states (see Figure 59).

Finally, Figure 60 shows that about 70% of new car-buying Californians and only 45% of Massachusetts consumers park at least one vehicle in a garage or attached carport at their

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[137] CVRP results, Oct 2013-Jun 2016.
[138] MOR-EV results.
[139] NADA 2015b. National Automotive Dealers Association. NADADATA 2015. https://www.nada.org/WorkArea/DownloadAsset.aspx?id=21474839497.
[140] 2015 PACE Survey.

residence. However, among PEV drivers in these two states, the share of parking in a garage or carport is similar around 60%. It is possible that garage parking is more important for PEV ownership in New England than it may be in more temperate California. Alternatively, California PEV drivers may be able to be more reliant on workplace or public infrastructure that reduces the need for charging at home and the associated garage parking.

Figure 59 - Residence type among new car buyers by state[141]

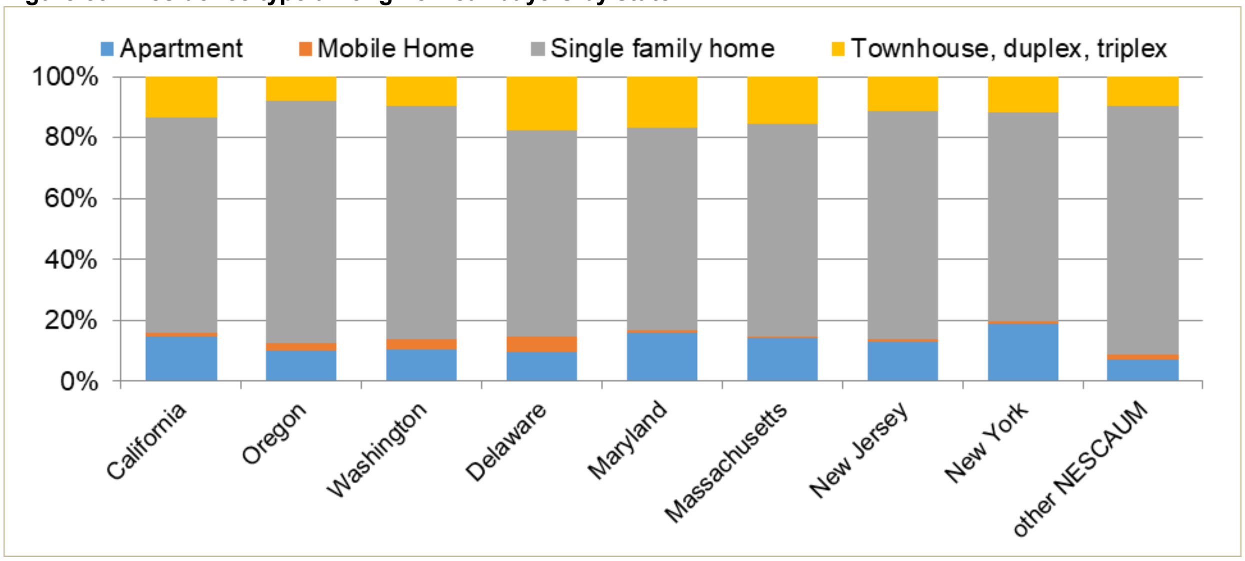
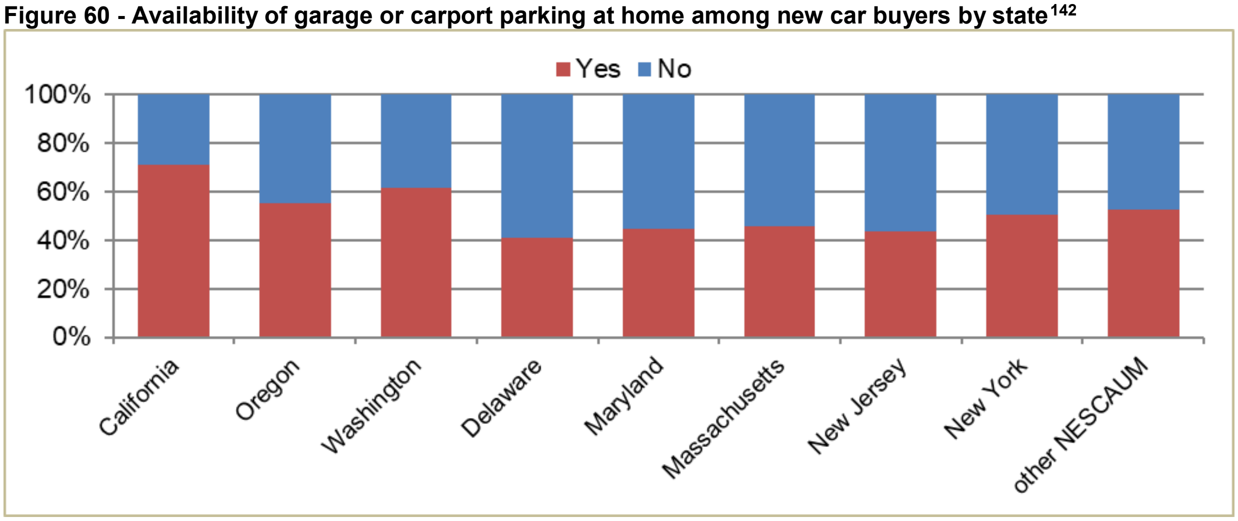


Figure 60 - Availability of garage or carport parking at home among new car buyers by state[142]



III.C.2. ZEV Purchase Motivations

Understanding existing drivers' motivations for choosing a PEV is important for developing effective outreach materials and campaigns to build upon existing market shares. Consistent with surveys of new car buyers describing their motivations for (hypothetically) choosing a ZEV and PHEV, survey results of actual PEV drivers show that motivations can be varied, ranging

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141 Kurani, et al. 2016.
142 Kurani, et al. 2016.

from financial or environmental benefits to vehicle performance. Additionally, given the current subsidies and incentives devoted to encouraging PEV and FCEV adoption, measuring their role in the purchase decision will inform how their future sunset might affect market development. Infrastructure, particularly at home, also plays an important role in enabling a PEV purchase, though as PEVs increase their vehicle range, infrastructure on the way to destinations will become increasingly important to consumers.

III.C.2.a. Conventional new car buyer motivations for ZEVs and PHEVs

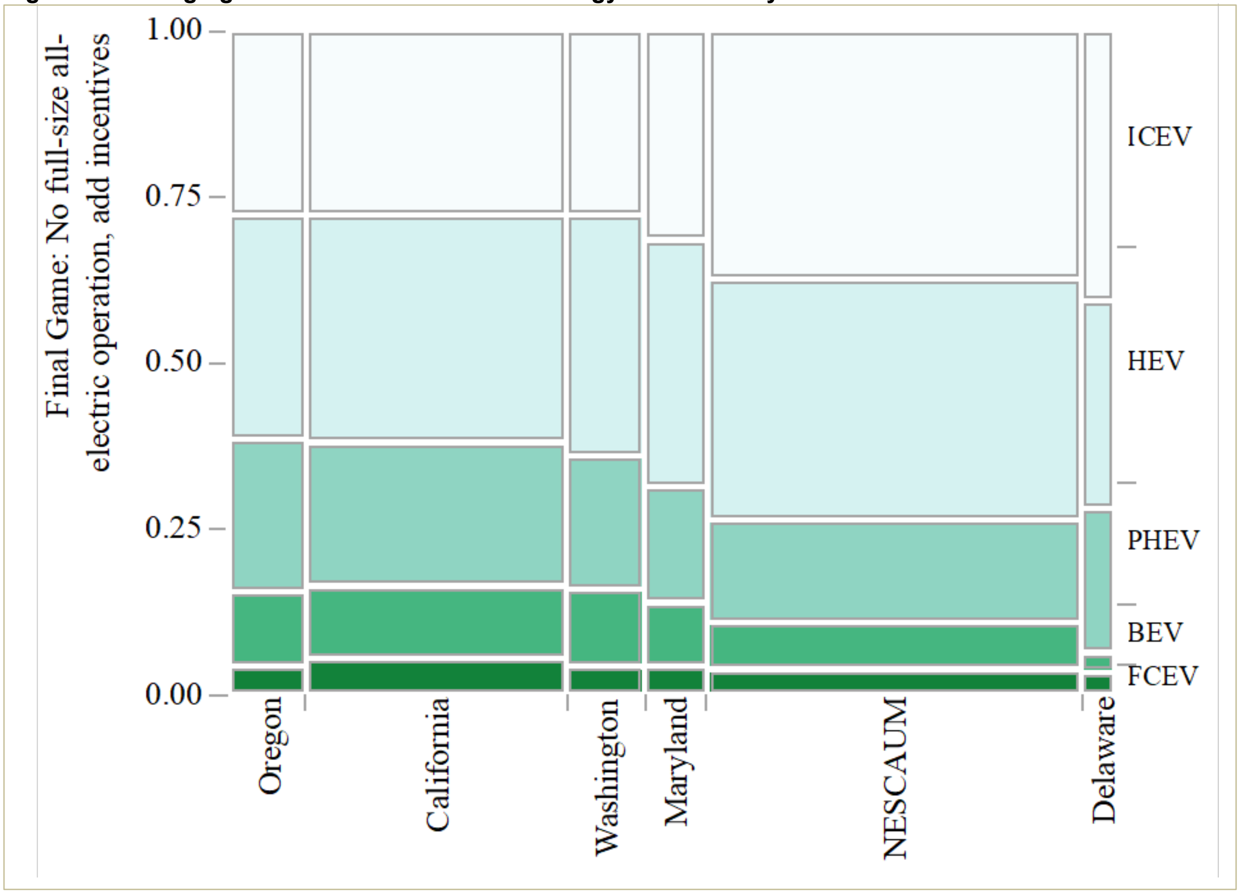
Returning to the ARB-funded research project on new car buyers, positive or negative consumer valuation was expressed by survey respondents' stated preferences for a plausible next new vehicle.[143] During the design game, respondents were asked to design a plausible next new vehicle for purchase assuming varying costs for different vehicle technologies, with and without certain incentives. ZEV valuation was determined by the vehicle drivetrain type selected by respondents during the survey's vehicle design game. Vehicle drivetrain types included: internal combustion engine (ICE), HEV, BEV, PHEV, or FCEV. Once (partially) informed about ZEV and PHEV technologies, a substantial share (38%) of survey respondents valued them positively.

Within this overall context of generally low levels of prior experience or consideration of PEVs and FCEVs, 38% of the California sample had a sufficiently positive valuation to design a PHEV (21%), BEV (11%), or FCEV (6%) as their next new vehicle, as shown in Figure 61. The California sample was more likely than respondents from most other study states to design their next new vehicle to be a PEV or FCEV. Household factors associated with positive valuation of ZEVs and PHEVs by respondents include:

- Prior consideration of PEVs or FCEVs—to the extent they have searched for related information or visited a vehicle dealership;
- Higher familiarity with all drivetrain types;
- Greater experience driving HEVs, PEVs, or FCEVs;
- Access to home charging/fueling infrastructure;
- Favorable assessments of the comparative safety and reliability of PEVs compared to ICE vehicles;
- Concern that air pollution is both a regional threat and a personal risk.

[143] Kurani, et al. 2016.

Figure 61 - Design game results of vehicle technology valuations by state[144]



Motivations for designing PEVs or FCEVs were assessed on a scale from 0 = not at all important to 5 = very important. Respondents were presented with a list of 17 possible motivations derived from prior research. However, respondents were restricted to spend a maximum of 30 points summed across all 17 items. Because not all respondents spent the maximum number of points, an "average" score for any individual item is the total number of points spent by all respondents, divided by the number of respondents, and divided again by the number of items. The resulting mean motivation score for the California sample is 1.38. Any item scoring higher than this is interpreted as having a "high" score. The highest scoring motivations for positive valuation are listed in Table 9 as well as the percent of respondents assigning the maximum five points to each of these motivations.

The highest-rated self-reported motivations for positive valuation of PEVs or FCEVs were a mix of private and pro-social factors including: fuel cost savings, interest in new technology, home charging convenience, and reducing climate change, air pollution, oil imports, and payments to oil producers. Saving money (in this case, restricted to fuel cost savings) is not often at the top of the list of ZEV motivations in academic papers, policy discussions, and market analyses. However, 41 percent of respondents who design a ZEV give the maximum number of possible points to saving money on fuel costs (and two-thirds assign two or more points)—possibly

[144] Kurani, et al. 2016.

revealing a “partial rationality” that apportions costs to different categories and treats them separately from and possibly even differently than vehicle purchase costs.

Table 9 - Highest-scoring motivations of new car buyers *for* designing a PEV or FCEV[145]

Motivations for Designing a PEV or FCEV	Mean	% 5 pts.
To save money on gasoline or diesel fuel	2.91	41.0
I'm interested in the new technology	2.39	29.8
It will reduce the effect on climate change of my driving	1.87	23.0
It will reduce the effect on air quality of my driving	1.84	20.5
It will reduce the amount of oil imported to the United States	1.55	16.7
I'll pay less money to oil companies or foreign oil producing nations	1.52	17.0
It will be fun to drive	1.49	14.6
It will be safer than gasoline or diesel vehicles	1.47	15.6
Mean Motivation Score	*1.38*	

Households who have the infrastructure to charge or fuel at home and those with higher familiarity with all drivetrain types and greater experience driving HEVs, PEVs, or FCVs were more likely to have a higher ZEV or PHEV valuation. Similarly, households with more favorable assessments of the comparative safety and reliability of PEVs, and the driving range per charge/fueling and charging, and fueling times of ZEVs were more likely to design such vehicles. Households who are more concerned that air pollution represents both a regional threat and a personal risk are also more likely to design ZEVs. Households who have already considered purchasing a ZEV—to the extent they have searched for information, visited a vehicle dealership, or may drive one already—have higher valuations of ZEVs.

Based on their vehicle designs, most respondents appeared uninterested in PEVs or FCEVs (at least at this point in time). Motivations against designing such vehicles were assessed by a process similar to that used to identify motivations for designing them. The global mean score for all motivations against ZEVs was 0.96. California respondents’ highest-scoring self-reported motivations against designing a PEV or FCEV as their next new car are listed in Table 10, sorted from high to low by their mean score. The top self-reported reasons for negative valuation of PEV or FCEV were: limited access to vehicle charging facilities; vehicle purchase price; vehicle range; and lack of familiarity with vehicle technologies. Many of the respondents’ highly rated motivations against designing a ZEV are connected to the newness of the vehicles. Arguably other motivations against, such as the high initial purchase price and distance per charge or fueling, may also belong to what the researchers characterize as “teething problems of new technology.” This is not to dismiss the on-the-ground importance of these concerns, but to note that consumers’ concerns may be ameliorated with each new generation of technology, with continued market growth and infrastructure deployment, and with continued accumulation of experience and information by consumers.

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[145] Kurani, et al. 2016.

Table 10 - Highest-scoring motivations of new car buyers *against* designing a PEV or FCEV[146]

Motivations Against Designing a PEV or FCEV	Mean	% 5 pts.
Limited number of places to charge or fuel away from home	2.52	37.0
Cost of vehicle purchase	2.08	30.2
Distance on a battery charge or tank of natural gas is too limited	1.82	24.9
I’m unfamiliar with the vehicle technologies	1.73	23.0
Concern about electricity, e.g. blackouts and overall supply	1.48	17.8
Can’t charge vehicle with electricity or fuel with hydrogen at home	1.46	20.7
Concern about time needed to charge or fuel vehicle	1.39	16.3
Cost of maintenance and upkeep	1.23	15.0
Concerns about batteries	1.01	10.7
Cost to charge or fuel	0.99	10.4
I’m waiting for technology to become more reliable	0.97	10.4
Mean motivation score	*0.96*	

Following-up with some survey respondents during in-person interviews in California, Oregon, and Washington, the long list of motivations to not design a PEV or FCEV, that is, the list of concerns that most respondents have about these vehicles, is itself a barrier. Many people simply have too many questions, certainly too many for financial purchase incentives alone to overcome. The misunderstandings and lack of knowledge of PHEVs, BEVs, and FCEVs and the inability to accurately distinguish between these technologies may be the most important finding of the interviews. Interviews revealed that the PHEV design concepts of charge-depleting and charge-sustaining operation as well as all-electric vs. assist (blended) modes caused considerable confusion. Much of the confusion crosses from HEVs to PHEVs to BEVs: interviewees spoke of choosing “assist” PHEV designs rather than “all-electric” PHEV designs because they were afraid of being stranded when the PHEV battery was discharged. (When in actuality, at such a moment, the ICE in a PHEV would continue to power the vehicle.) Some respondents still wrongly believe that HEVs have to be plugged in.

While most of those who do not design a PEV or FCEV may be motivated by multiple concerns, fewer seem outright resistant. When asked about whether they have already considered PEVs or FCEVs, only 15% of the CA sample replied they have not and would not consider buying a PEV, 25% an FCEV, and 12% neither a PEV nor FCEV.

Similarly, a UCLA new car buyer survey, conducted in 2014, is being analyzed as part of the ARB-sponsored UCLA ZEV Sales Factors study to identify potential consumer segments for PEVs. The study’s analysis of stated preference data of 1,261 potential new-car buyers estimates respondents’ valuation of vehicles of different drivetrain types (but with otherwise comparable attributes). Although there is a portion of respondents who have negative valuations and a low likelihood of selecting a PEV as a future vehicle purchase, other segments have a more positive valuation of PEVs, particularly those who have environmentalist and early adopter tendencies and who live in single-family homes. Additionally, another larger segment who do

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[146] Kurani, et al. 2016.

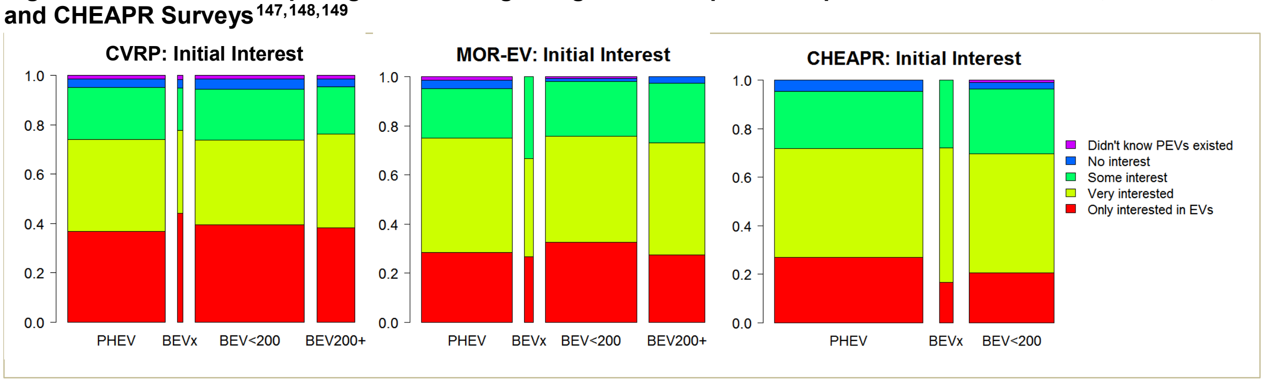
not live in single-family homes and who live near HOV lanes have a positive valuation of PHEVs, but not BEVs.

Building on the UCLA survey work, the study is also exploring PEV incentive policy design variations in order to estimate how vehicle technology preferences – combined with consumer income and incentive levels – could impact incentive program outcomes such as cost-effectiveness, allocative equity and total program cost. The UCLA study's simulation of rebate program designs indicates that the CVRP policy in force in 2015, (offering $1,500 for PHEVs and $2,500 for BEVs), was effective, increasing the virtual market share of PEVs by about 7% over a reference scenario without CVRP incentives.

III.C.2.b. Initial Interest in PEVs among current PEV drivers

At this phase of the market, the majority of consumers began their shopping process already very interested or exclusively interested in a PEV, and a relatively small minority began without knowing about these vehicles or having no interest. Only between 2-4% of California consumers across all models reported no interest in an EV prior to purchasing one, whereas 0-10% and 0-12% of Massachusetts and Connecticut consumers had no initial interest (see Figure 62). Although PHEVs do not have the range or infrastructure limitations of BEVs that might allow them to appeal to a broader population at this time, there is not an appreciable difference in the initial interest (or lack of interest) between the different PEV technologies.

Figure 62 - Interest in acquiring a PEV at beginning of vehicle purchase process based on CVRP, MOR-EV, and CHEAPR Surveys[147,148,149]



Note: Column widths for each state are proportional to the number of respondents in each PEV category.

Overall, although general interest is similar across the states, purchasers in Connecticut and Massachusetts were less resolved (as measured by only interested in an EV) on their PEV purchase. Over two-thirds of all California, Massachusetts, and Connecticut state rebate recipients were only interested or very interested in a PEV when they shopped for their PEV. California had the highest "only interested in EVs" respondents compared with Massachusetts and Connecticut (>37% vs 33%, and 27%). Among those in California interested only in PEVs, more than half were only interested in the specific model they selected; this was true even for those with no prior PEV ownership, i.e. not replacing a vehicle whose lease was expiring.

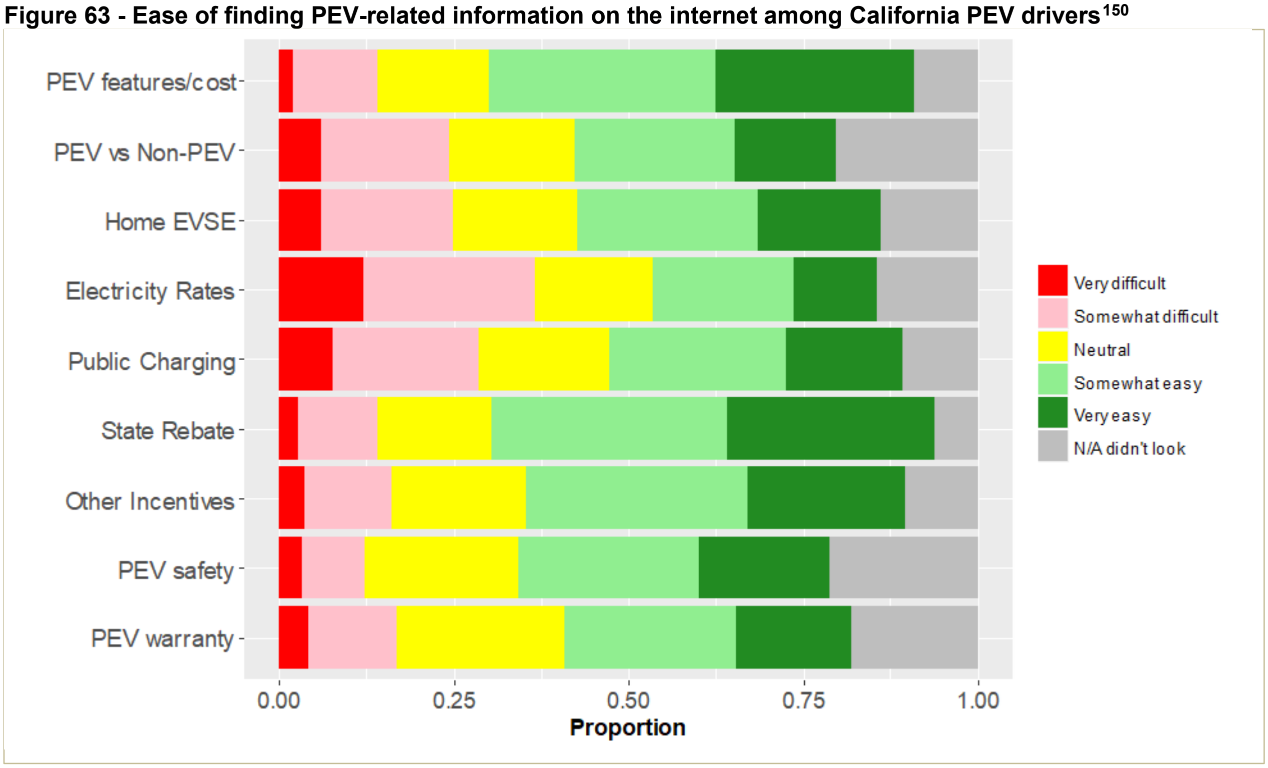
[147] CVRP results, Oct 2013-Nov 2015.
[148] MOR-EV results.
[149] CHEAPR results.

However, not surprisingly, commitment to PEVs at the start of the shopping process is strongest among those with three or more prior PEVs.

Related to initial interest is the type of information that was sought prior to a PEV selection. Recent California PEV drivers were asked to rate the ease of finding information on PEV-related topics on the internet during their shopping process. As shown in Figure 63, over one-third of respondents rated finding information about home electricity rates somewhat or very difficult to find. Residential electricity rates are highly variable, even within the same utility territory, and despite some utilities providing generic, on-line cost calculators, these do not necessarily incorporate individualized usage history and actual subscribed rates to provide more accurate customized estimates.

A large proportion of respondents did not look for information on the internet about safety or warranties. Although they maybe have sought this information from dealer representatives rather than searched on-line, these relatively higher proportions suggest less consideration of these factors in their PEV decision. Similarly high proportions did not seek information to compare PEVs to non-PEVs, which likewise supports the finding that many respondents began their shopping process intent on a PEV.

Figure 63 - Ease of finding PEV-related information on the internet among California PEV drivers[150]



III.C.2.c. Primary PEV Purchase Motivations

Existing consumers of PEVs at this stage of the market can be roughly categorized as motivated by three major factors: environmental benefits, savings, and technology. These

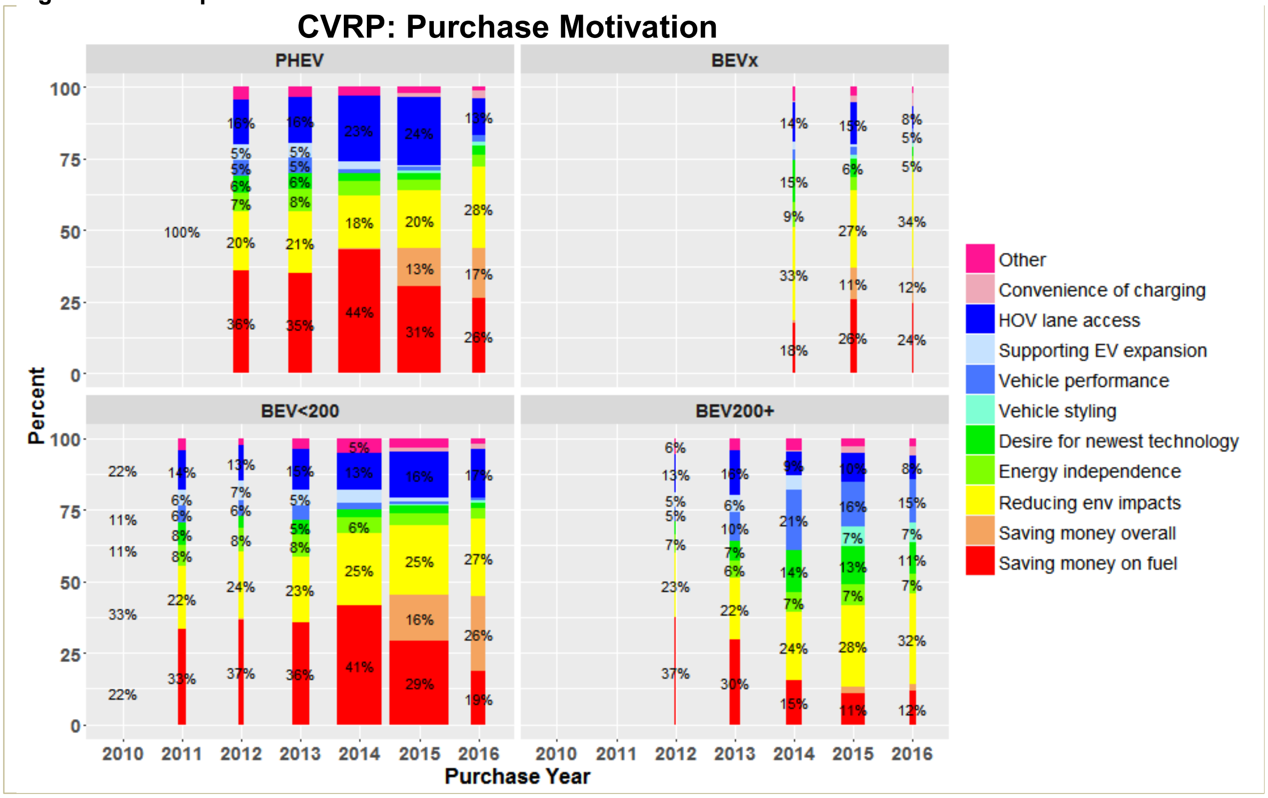
[150] CVRP results, Jun2015-Sept2016.

results are consistent with sentiments of conventional new car buyers discussed in Section III.C.2.a on their potential motivations for purchasing a ZEV or PHEV. As shown in Figure 64, the top three motivations reported by CVRP survey respondents for acquiring a PEV were saving money on fuel, reducing environmental impacts, and HOV lane access. Before the introduction of the “saving money overall” response in the CVRP survey version of 2015, the percentage reporting that saving money on fuel was their top motivation reached a high of 44% and 41% for those who acquired their PHEV or BEV<200 in 2014. The combined fraction of PHEV and BEV<200 respondents most motivated by saving money on fuel or overall (available only in 2015 and 2016) was similar to those reporting that saving money on fuel was their top motivation in 2014. It could be that as fuel prices have decreased, PHEV and BEV<200 consumers have become less motivated to save money on fuel (through their vehicle purchases), although these trends are confounded by modifications to the survey response options.

California PHEV, BEV<200, and BEV200+ consumers have become more motivated to reduce their environmental impacts over time, which may be correlated to declining fuel prices and additional consumers not selecting a PEV for savings motivations. Purchase motivations based on HOV lane access peaked across PHEV, BEVx, and BEV200+ California PEV consumers in 2015. PHEV respondents were the most motivated by HOV lane access among those who acquired their vehicle in 2015. This finding coincides with reaching the limit of single-occupant HOV lane access decals for PHEVs and BEVx in late 2015. In contrast, there was a slight increase in the fraction of BEV<200 respondents being motivated by HOV lane access in early 2016.

As shown in Figure 64 and Figure 65, the most common motivations for acquiring a PEV among all three states were to save money on fuel and reducing environmental impacts. Overall, BEV<200 consumers across the three states were slightly more interested in reducing their environmental impacts than PHEV owners were. California's BEV<200 consumers were more interested in saving money on fuel than on reducing their environmental impacts (33% vs 25%) in contrast with consumers in Massachusetts (27% vs 38%) and Connecticut (35% vs 38%), suggesting that California's BEV<200 market has begun to expand to more mainstream

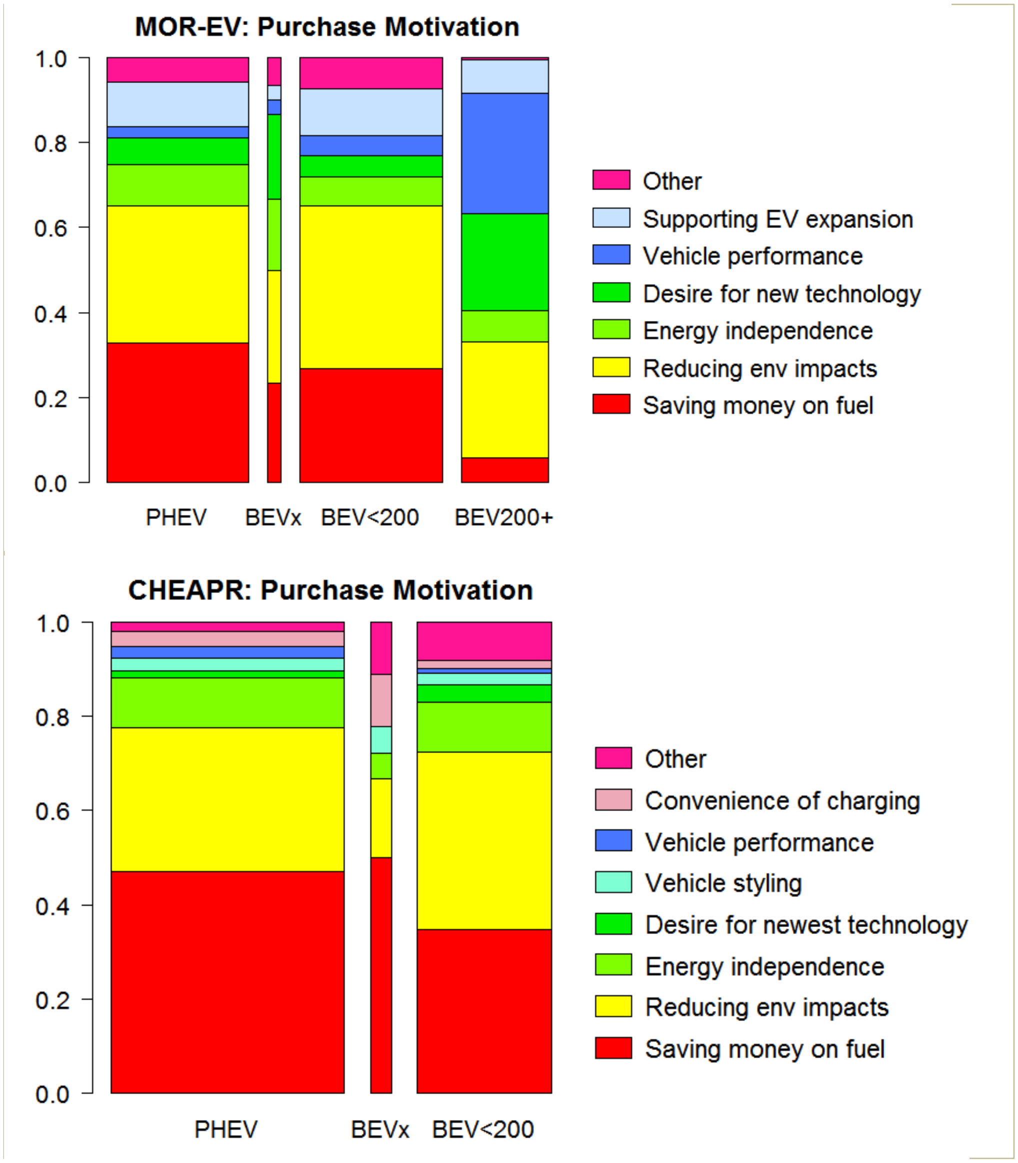
Figure 64 - PEV purchase motivations over time in California[151]



Note: Column widths are proportional to number of rebates granted for each PEV type and purchase year. Lighter shading indicates response option was not present for all survey administrations.

[151] CVRP results, Oct2016-Sept2016.

Figure 65 - Purchase motivations from MOR-EV and CHEAPR survey respondents[152,153]



Note: Column widths for each state are proportional to the number of respondents in each PEV category.

consumers. Nonetheless, reducing environmental impacts has also been an important factor for drivers across PEV types. And even for those who select another primary factor, reducing environmental impacts is still an important factor in their decision, just not *the most* important.

Finally, there appears to be an emerging group concentrated within the BEV200+ category but also in other PEV types who have a desire to have the newest technology, and arguably are motivated by more typical factors that influence a conventional vehicle purchase such as performance and styling, comfort, etc. Although the BEV200+ category currently includes only

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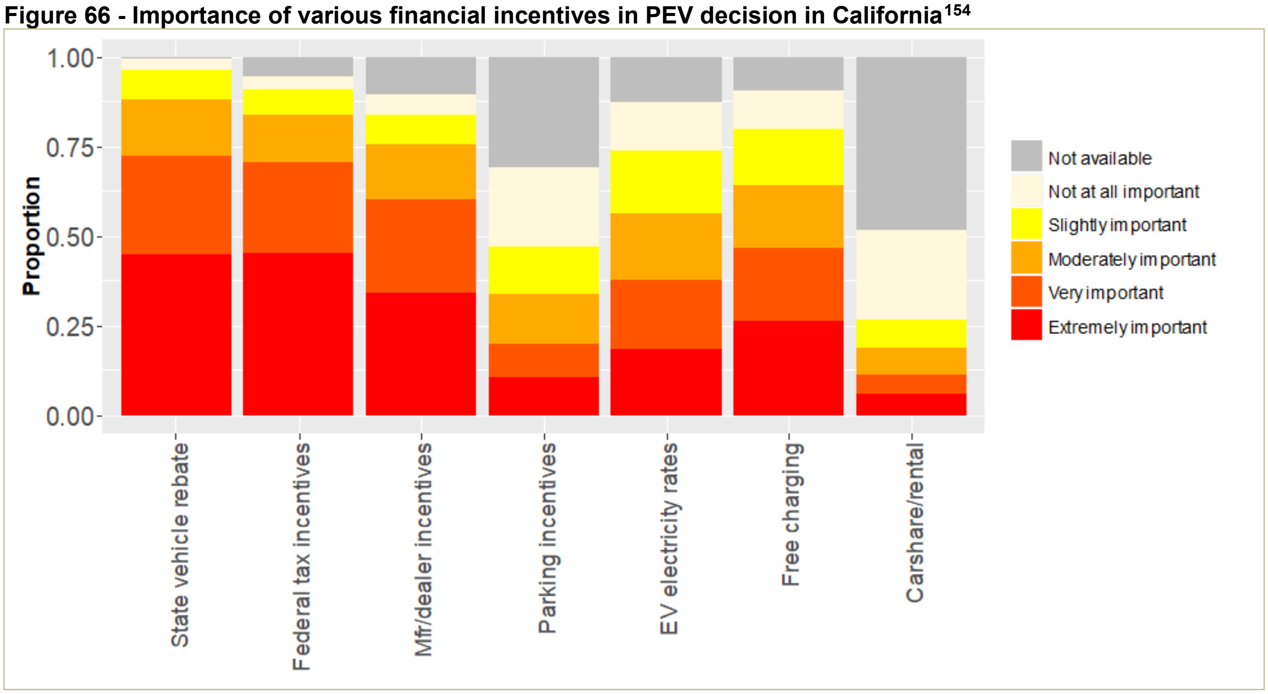
152 MOR-EV results.
153 CHEAPR results.

Tesla premium models and may be correlated to Tesla's brand image, this does suggest the potential for PEVs to be attractive to a different consumer base provided that the vehicle can also provide satisfactory attributes. While BEV200+ consumers in California were most motivated by reducing environmental impacts, those in Massachusetts were most motivated by vehicle performance, which may foreshadow future consumer response to longer-range BEVs. As additional vehicle offerings become available in this PEV category at lower price points, this result will need to be re-evaluated.

III.C.2.d. Role of Incentives

In a nascent market, incentives can play an important role in offsetting incremental costs while government incentives also offer legitimacy to new product types. As previously discussed in Section III.C.1.c both replacement and additional PEV transactions in California were partially spurred by incentives offered by government and/or auto manufacturers. Figure 66 suggests that one-time monetary incentives related to the initial purchase appear to be more important to a purchase decision than ongoing incentives accrued through vehicle usage and operation. As only those Californians who received a state vehicle rebate are invited to complete the survey, the sample is slightly skewed and the importance of the state vehicle rebate may be overstated. However, the importance of the state rebate is similar to that of the federal tax credit, which

Figure 66 - Importance of various financial incentives in PEV decision in California[154]

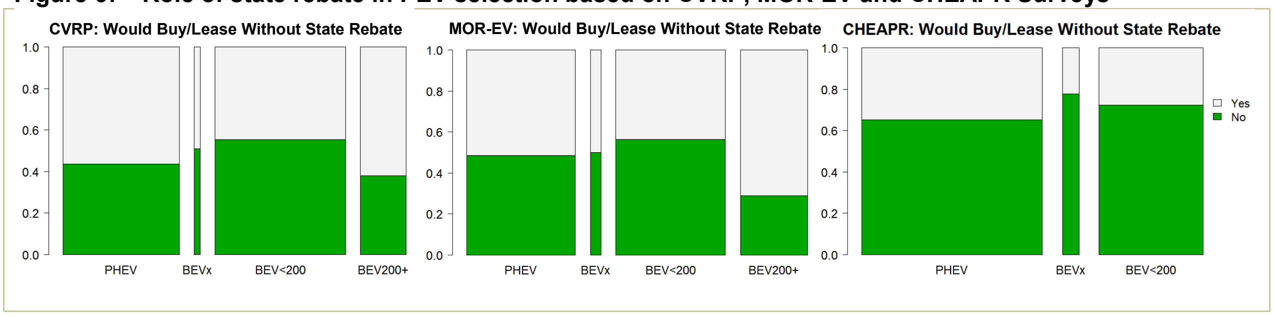


[154] CVRP results, Jun2015-Sept2016.

academic studies estimate as driving over 30% of PEV sales nationwide.[155] Although the amount of the federal tax credit may be three to five times the amount of the state rebate, studies[156] have shown that upfront payment incentives appear to be more effective than deferred payments like tax credits, which may counteract the strict difference in dollar benefits. Indeed, it may be the combination of all of these incentives that motivates a consumer, where the whole is greater than the sum of each of the individual incentives.

Nonetheless, when asked about their purchase decision in the absence of a state vehicle rebate, overall less than 40% would have purchased their exact same vehicle anyway. Generally, PHEV consumers are more likely to have bought or leased their vehicle without the state rebate compared to BEV<200 consumers. This could be a reflection of the state rebates typically being smaller for PHEVs than BEVs (while federal tax credits can be equivalent). These distributions are consistent with when survey respondents in California, Connecticut, and Massachusetts are asked more generally whether or not they would have purchased their PEV without a state rebate, as shown in Figure 67. However, it is also important to note that all other incentives are assumed to remain available and should any of those be eliminated, the role of the state rebate would likely shift.

Figure 67 - Role of state rebate in PEV selection based on CVRP, MOR-EV and CHEAPR Surveys[157,158,159]



Note: Column widths for each state are proportional to the number of respondents in each PEV category.

While some respondents may be overstating the impact of the rebates given a desire to appease the survey administrators (who are also the rebate administrators), the variation in responses between the PEV types suggests that there may still be relative differences in effectiveness of a state rebate in the context of other available incentives. For example, those motivated by environmental reasons may be less sensitive to a purchase incentive than those who were most interested in saving money on fuel. A follow-up question in the California survey on likely actions in the absence of a state rebate supports the general notion that this incentive

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155 Tal and Nicholas 2016a. Gil Tal and Michael A. Nicholas. "Exploring the Impact of the Federal Tax Credit on the Plug-in Vehicle Market." *Transportation Research Record: Journal of the Transportation Research Board*. Issue 2572, pp 95-102. https://trid.trb.org/view.aspx?id=1392922

156 Examples include Beresteanu, A. and S. Li (2011). "Gasoline prices, government support, and the demand for hybrid vehicles in the United States." International Economic Review 52(1): 161-182. Diamond, D. (2009). "The impact of government incentives for hybrid-electric vehicles: Evidence from US states." Energy Policy 37(3): 972-983. Gallagher, K. S. and E. Muehlegger (2011). "Giving green to get green? Incentives and consumer adoption of hybrid vehicle technology." Journal of Environmental Economics and Management 61(1): 1-15.

157 CVRP results, Oct 2013-Nov 2015.

158 MOR-EV results.

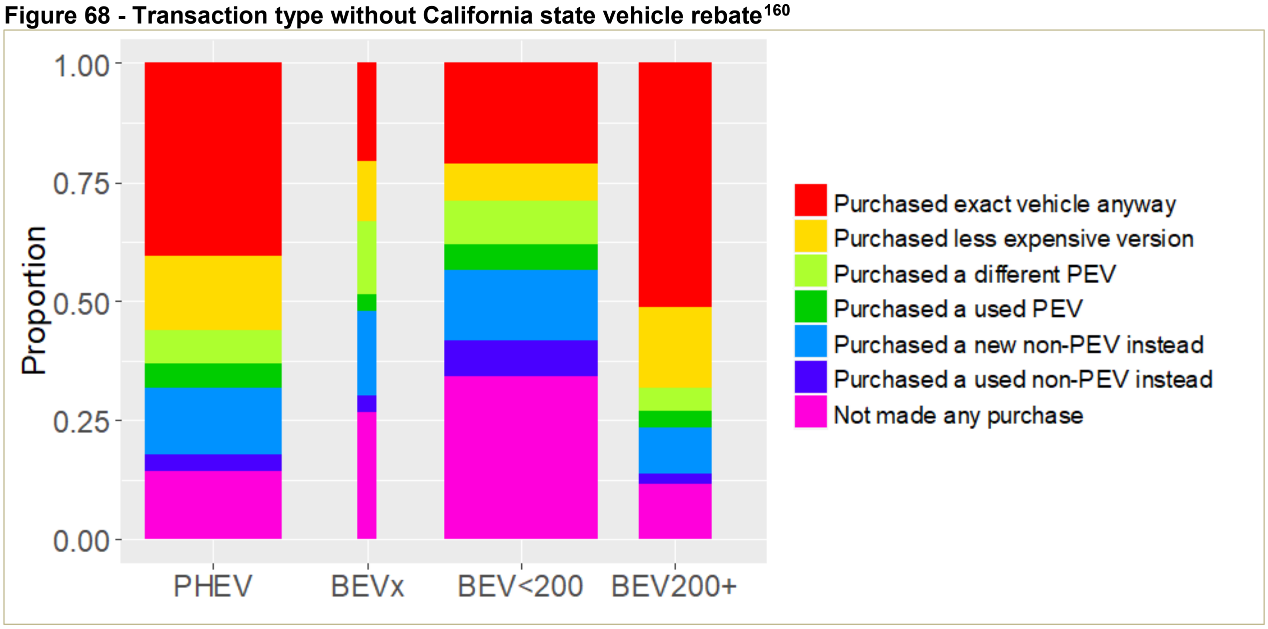
159 CHEAPR results.

is helping to increase the size of the PEV market. Figure 68 shows that in California without a rebate, over half of the BEV<200 respondents report that they either would not have made any purchase or would have purchased a new or used non-PEV instead. Although the portion of PHEV, BEVx and BEV200+ respondents who would not be part of the market is smaller than that of BEV<200s, the rebate is nonetheless still expanding the market for these PEV types as well.

The UCLA ZEV Sales Factors Study is exploring the relationship between HOV lane access and PEV purchases. Using registration data for 2010-2013 and Caltrans data on HOV lane miles, the research team is examining the relationship between HOV lane miles (within a 30 mile radius of a census tract). Preliminary results indicate that HOV lane proximity is correlated with PEV sales in the area, suggesting that some PEV purchases are motivated by single-occupancy access to HOV lanes. The researchers estimated that incremental PEV sales of two, four and 10 PEVs per census tract are attributable to access to 20, 40 or 140 miles of nearby HOV lanes, respectively. These results are consistent with survey results of California PEV drivers' attitudes about this incentive.

As discussed in Section III.C.2.c, about 15% of California respondents reported their primary motivation for selecting a PEV was to gain access to the HOV lane without the requisite number

Figure 68 - Transaction type without California state vehicle rebate[160]



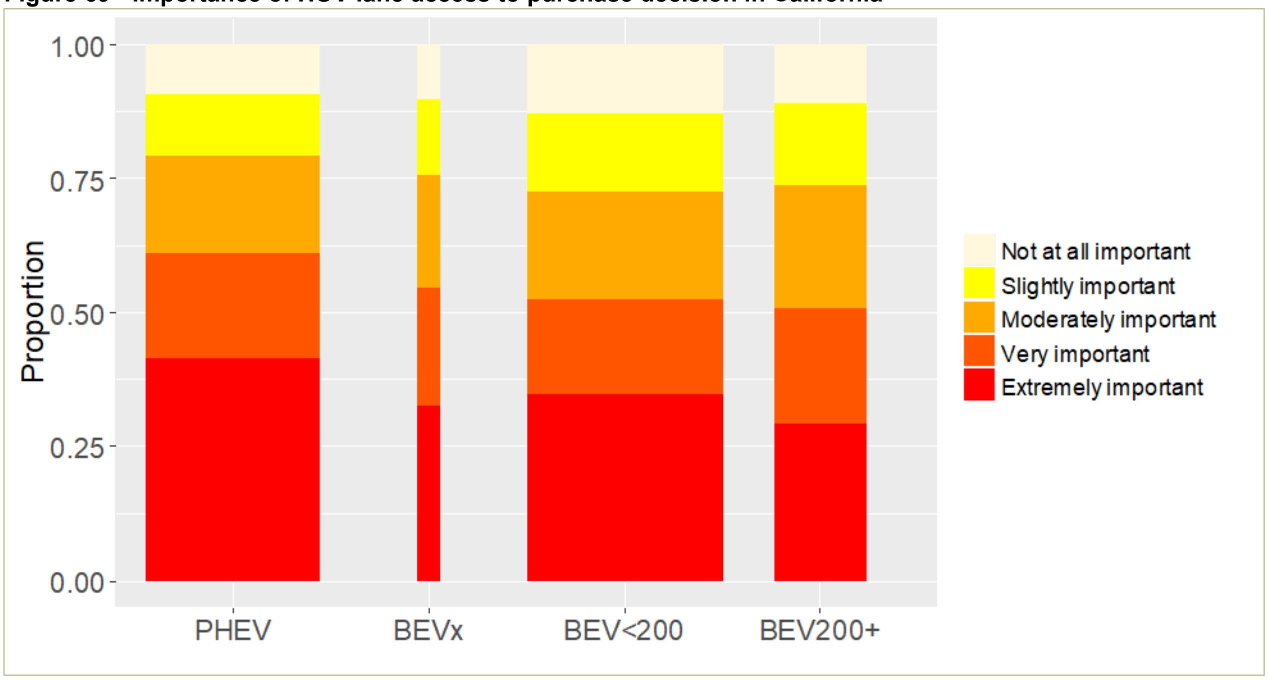
Note: Column widths are proportional to the number of respondents in each PEV category.

of passengers, as is currently allowed through legislation until January 1, 2019. Although seemingly less important than the vehicle rebate or federal tax credit, the ratings of this non-monetary incentive are of similar importance to that of manufacturer and dealer incentives, and

[160] CVRP results, Jun2015-Sept2016.

Figure 69 shows the importance of HOV lane access to be inversely proportion to battery size, which is consistent with the fractions shown previously in Figure 64 indicating that HOV lane access was their primary motivation for purchasing a PEV. As might be expected, these rankings are correlated to the frequency respondents use this incentive, with PHEV drivers overall using the HOV lane access incentive the most. These results may reflect the range limitation of similarly priced BEV<200s and the greater travel demand of PHEV drivers that make HOV access more beneficial. However, they also suggest that PHEV sales to date have been more influenced by the HOV access incentive and the expiration of this incentive will likely affect the future mix of PEV sales.

Figure 69 - Importance of HOV lane access to purchase decision in California[161]



Note: Column widths are proportional to the number of respondents in each PEV category.

III.C.2.e. Role of infrastructure in purchase decision

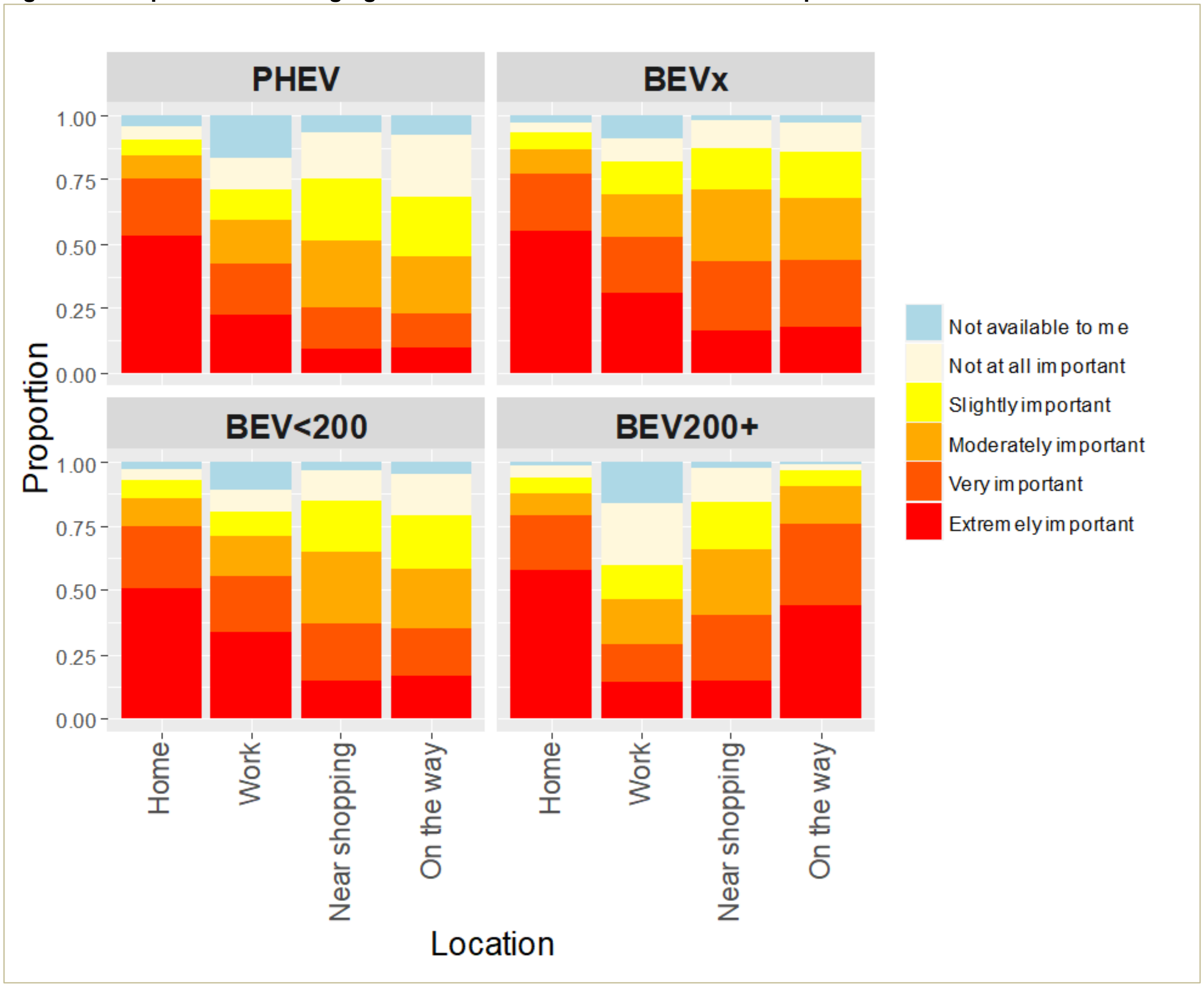
Concerns about infrastructure, particularly away from home, is often noted by new car buyers as a barrier, though current PEV drivers mostly have access to charging at home and to a lesser degree at their workplaces (see Section III.C.1.e) and additional infrastructure continues to be deployed (see Appendix D). Consistent with the UCD New Car Buyers Study, the ability to charge at home appears to be universally important.

As shown in Figure 70, the relative importance of infrastructure at home, work, near shopping/friends/family/transit, and on the way to other destinations between PHEV, BEVx, and BEV<200 drivers are quite similar, with work being the second most important location and the remaining two locations about equal to each other. For the decision to purchase PHEVs and BEVxs, the flexibility to use gasoline results in less dependence on charging near or on the way

[161] CVRP results, Jun2015-Sept2016.

to other, non-work or home destinations. The availability of workplace charging was most important for BEV<200 drivers in their purchase decision, least important for BEV200+ drivers, and of intermediate importance for PHEV and BEVx drivers. However, as shown previously in Figure 50 and Figure 51, PHEV drivers reported charging at work most frequently and BEV200+ drivers reported the least frequent workplace charging. This finding highlights the dual role that

Figure 70 - Importance of charging at different locations in California PEV purchase decisions[162]



Note: Column widths are proportional to number of respondents in each PEV category.

workplace charging serves to support the PEV market – one to promote adoption by providing consumers with assurances on locations away from home to charge and a second that increases vehicle miles traveled powered by grid electricity, reducing environmental impacts and displacing petroleum consumption.

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[162] CVRP results, Jun2015-Sept2016.

Additionally, in the 2015 Ownership survey, PHEV drivers were more likely than BEV drivers (of all battery sizes) to disagree with the statement "there are enough places to charge my PEV." Interestingly, BEV200+ drivers appear to be distinct in their ranking of charging on the way to destinations as being nearly as important as home charging, and are slightly more satisfied with the coverage of the charging network. Whether these sentiments are specific to Tesla's Supercharger network or transferrable to other BEV200+'s will be evaluated as more BEV200+'s enter the market. Nonetheless, the introduction of ever longer range BEVs will increase the reliance on these "layover" charging stations (presumably with faster charging) to broaden the market.

III.C.2.f. Other Studies

A survey of 3,236 early PEV consumers throughout the U.S. that participated in the EV Project[163] asked about motivations for purchasing or leasing a PEV. The highest-ranking response was "[P]EVs are energy efficient and cheaper in the long run than gasoline vehicles", followed closely by "[P]EVs are environmentally friendly and reduce greenhouse gas emissions." The lowest-scoring motivation was related to HOV lane access, perhaps because HOV lanes are not available throughout the U.S.

For comparison with the California, Massachusetts and a Connecticut survey results, a study of Norwegian PEV owners reported that consumers were generally satisfied with their vehicles.[164] Less than 1% and 2% of these consumers stated they would not buy their BEV or PHEV again. The three most frequent reasons given by PEV owners who said they would buy a PEV again were economy of use, environmental performance, and future-proof technology. In addition, BEV owners who will purchase another BEV also said free usage of toll roads would be a motivation. This incentive is not available to PHEV owners in Norway.

III.C.3. Role of dealers

All auto manufacturers with a current ZEV obligation use a dealer franchise business model to retail their vehicles.[165] Less than 10% of PEV consumers in California[166] or Massachusetts[167] report that a sales representative tried to discourage a PEV purchase.[168] This holds true across time, PEV types, models, and whether at a traditional dealership or at a retail store. Among these consumers, the most common reasons provided by sales representatives was the incremental price of the PEV (sometimes in relation to fuel savings), the vehicle range relative to driving needs, and a lack of inventory or long wait time for product delivery. Nevertheless, dealers serve as the point of contact for consumers and understanding the dealership

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163 INL 2015. Idaho National Laboratory. February 2015. "How Do The EV Project Participants Feel About Their EVs?" https://avt.inl.gov/sites/default/files/pdf/EVProj/EVProjectParticipantsAndTheirEV.pdf.

164 Figenbaum and Kolbenstvedt 2016. E. Figenbaum and M. Kolbenstvedt. 2016. *Learning from Norwegian Battery Electric and Plug-in Hybrid Vehicle Users: results from a survey of vehicle owners.* Oslo, Institute of Transport Economics, Norwegian Centre for Transport Research.

165 Tesla Motors, which currently does not have a ZEV requirement, sells direct to customers through retail stores.

166 CVRP results, Oct2013-Jul2015.

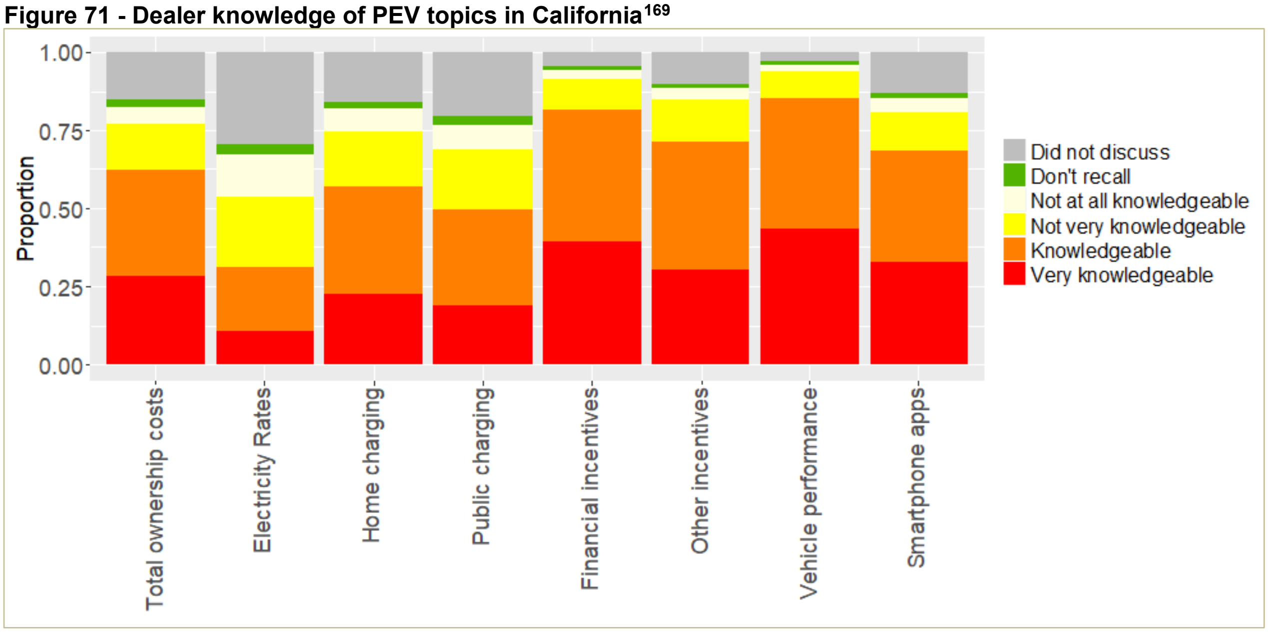
167 MOR-EV results.

168 There may have been more consumers who were convinced not to select a PEV and are therefore omitted from the survey population. 10% is thus a minimum estimate.

experience of existing customers may help to explain current sales trends or help to improve future market growth.

As dealers serve important intermediary roles between automakers and consumers, gauging their knowledge on various PEV topics can help to improve dealer-oriented outreach materials and the customer experience in the showroom. Based on the California results shown in Figure 71, dealer representatives are most knowledgeable about topics related to the vehicles themselves and less knowledgeable about charging aspects. Potentially this is a reflection of the complexity and variability within each topic. Vehicle-related topics such as performance will be limited to perhaps a few trim levels, while financial incentives are generally fixed for each vehicle model, so this type of information can be confined to fact sheets or other easily referenced documents.

Figure 71 - Dealer knowledge of PEV topics in California[169]



In contrast, residential electricity rates are much more complicated and can differ for drivers of the same PEV based on utility, usage, metering options, and whether they have solar panels installed at their home, which means there is no single "one-size-fits-all" answer that can be provided by all dealer sales representatives. Similarly, public charging locations that will be relevant to a potential PEV driver will vary based on their individual travel patterns and dwell times. With continued investments from both public and private entities, training dealer salespeople to know where upwards of 4,200 public charging stations are located is impractical, though promoting infrastructure websites or smartphone apps, such as U.S. DOE's Alternative Fuels Data Center portal, to dealer representatives may be a more effective method of ensure consumers are provided with the latest information.

In addition to improving training or outreach materials to educate sales representatives, dealerships could also adjust the services they provide intended to create or assist new PEV

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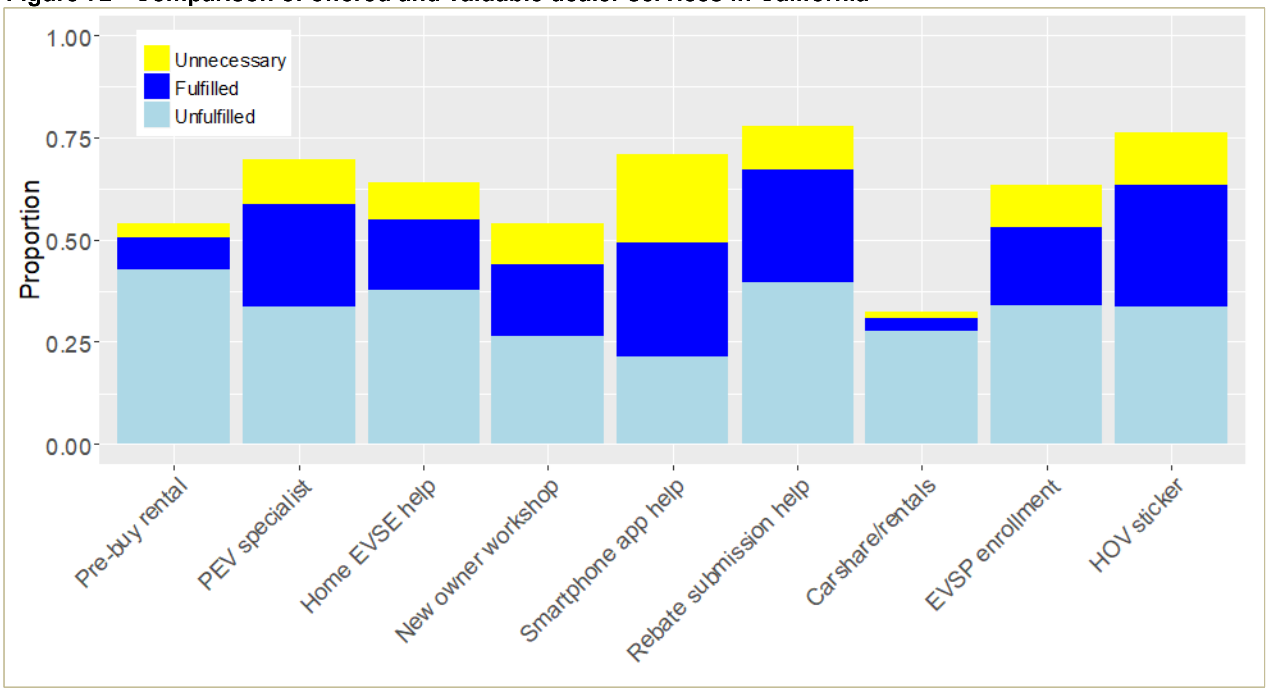
[169] CVRP results, Jun2015-Sept2016.

drivers as there appears to be a mismatch between those that are received and those that respondents report to be valuable. Figure 72 shows that more often than not, California respondents are not offered services that they think would have been valuable. The areas in dark or light blue represent the total portion of respondents who value a particular service, with those in the dark blue area also receiving this service (Fulfilled). Whether or not received, assistance with applying for CVRP (Rebate submission help) is the service that is most valued, followed by assistance applying for an HOV sticker, and then a PEV specialist to answer questions about the vehicle or additional services. However, the most often reported service that would be valuable that was not provided (light blue area) is an extended test drive or pre-

Figure 72 - Comparison of offered and valuable dealer services in California[170]



Note: Unnecessary indicates a service was offered that a respondent did not rate as valuable. Fulfilled indicates a service was offered that a respondent did rate as valuable. Unfulfilled indicates a respondent rated a service as valuable but was not offered it. The remainder, not shown, reflects respondents who did not rate the service as valuable nor was it offered to them.

purchase rental. As not all dealers may be able to offer this service, there may be a role for other entities to develop these programs. Those actually receiving services are represented by the two upper dark blue and yellow areas, with those receiving a service they deemed not valuable shown in yellow (Unnecessary). Assistance setting up vehicle smartphone apps appears to be the service deemed unnecessary most often, though many other respondents found this service to be helpful, which likely reflects variation in customer needs rather than suggests that dealers should discontinue certain services. Overall, one- to two- fifths of

[170] CVRP results, Jun2015-Sept2016.

respondents believe they would have benefited from a dealer service that was not offered to them (Unfulfilled).

III.C.4. Purchase Barriers

As discussed previously in Section III.C.2.a, self-reported reasons for negative valuations of ZEVs and PHEVs among new car buyers include limited access to vehicle charging facilities, vehicle purchase price, vehicle range, and lack of familiarity with vehicle technologies which mirror initial concerns during the shopping process of existing PEV drivers. While incentives and other policies may help consumers to overcome some of these concerns, others require further technological advances to satisfy customer requirements within acceptable price points.

III.C.4.a. Initial Concerns about Choosing BEVs

In California's CVRP Consumer survey, BEV and PHEV drivers alike are asked to rank their top three concerns about BEVs during the shopping process. As shown in Figure 73, all PEV drivers express concern about BEV vehicle ranges which uniformly had the highest ranking score[171] regardless of the PEV type ultimately selected. For current BEV drivers, this question was posed as reasons they were concerned about choosing a BEV, though these concerns were somehow alleviated or not so overwhelming as to prevent them from ultimately selecting a BEV. Not surprisingly, those with a BEV200+ were not as concerned about range as <BEV200 drivers. For current PHEV (and BEVx) drivers, this question was posed as reasons that they decided against a BEV; with the highest score of all the PEVs for vehicle range, the range offered by BEVs is presumably insufficient to meet the travel needs of current PHEV drivers. Both of these results suggest that as longer range BEVs are introduced into the market, this will ease concerns over BEV adoption, potentially transforming some existing PHEV drivers into BEV drivers, as well as appealing to a broader customer base. These findings on existing PEV drivers are consistent with the opinion of the general public, 56% of whom state they would need a minimum electric range of 300 miles in order to consider a BEV.[172]

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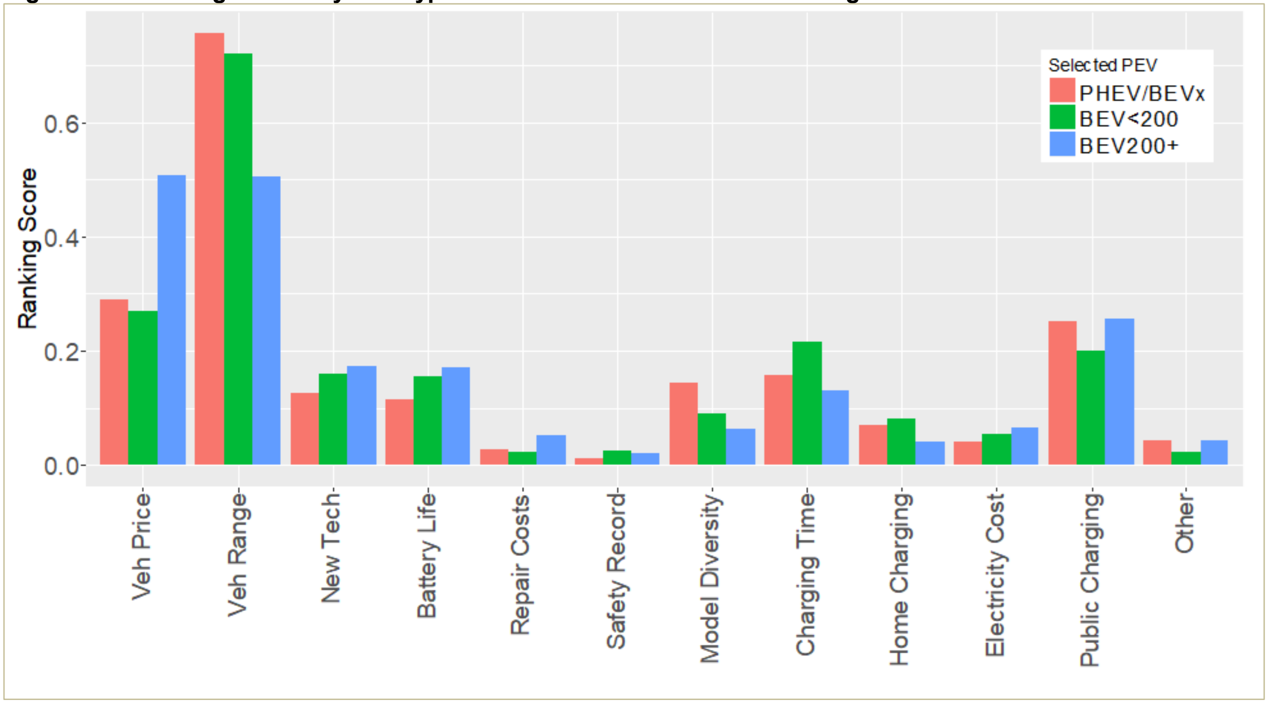
[171] To facilitate comparisons between the different PEV types, ranking scores were computed to factor in both the number of respondents including a concern in their top three list as well as its position within this list. Ranking scores are calculated by assigning a score to each ranking, summing the scores for each factor, and then dividing by the total number of rankings. For instance, the number of PHEV respondents ranking vehicle price #1 is multiplied by 3, #2 by 2, and #3 by 1; these are then summed and this total is divided by the total number of PHEV respondent rankings.

[172] Singer 2016.

Figure 73 - Ranking scores by PEV type on initial concerns about choosing a BEV in California[173]



Although the results shown here suggest that that high electricity costs were not major concerns to most respondents, those results did show limited public charging infrastructure to be a possible barrier. Combining this with the results shown previously in Figure 63 where over one-quarter of respondents found it somewhat or very difficult to find information about "Locations, use and payment of charging away from home" would suggest the need for improving or centralizing the on-line presence of public charging locations and details, especially as more infrastructure is deployed in the future. Although experienced PEV drivers may have knowledge of and access to numerous websites, smartphone apps, and even in-vehicle navigation systems to locate nearby charging stations, market development may be hindered if prospective buyers have difficulty accessing information that can alleviate perceptions of limited public infrastructure.

Vehicle pricing will also be important to growing the market. The only current BEV200+ offerings are classified as luxury vehicles, and these drivers rank high prices as almost concerning as vehicle range. Even though non-luxury BEVs are more moderately priced, vehicle prices are often still one of the top three concerns among PHEV and BEV<200 respondents. However, as discussed previously in Section III.A.4 and III.C.2.d, an assortment of incentives offered by governments, automakers, and dealers are able to partially address this concern.

Rounding out the top three is concerns over a lack of public charging infrastructure. Despite continual investments from a variety of providers, the perception, if not reality, is that opportunities to charge away from home are too limited. Even for longer range BEV200+ drivers whose battery capacity may cover most daily driving needs, the current charging

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[173] CVRP results, Jun2015-Sept2016.

network seems insufficient. This finding would support further expansion of the public charging network.

Interestingly, attributes associated with new technology, such as continuing developments, uncertainty about battery life, safety records, or repair costs, are not as concerning to respondents of current PEV drivers. Likewise the logistics and cost of charging at home did not appear to be barriers to these respondents. Potentially at this stage of the market, many PEV drivers could be categorized as "early adopters" interested in new technology whose lifestyles are easily compatible with PEV ownership.

III.C.4.b. Effects of Energy Prices on PEV Operating Costs

Fuel savings have been one of the main selling points for PEVs and a potentially large contributor to reducing the total cost of ownership for these vehicles. Especially during periods of high fuel prices, PEVs provide consumers with an opportunity to decouple from the volatility of global oil markets. For the FY2016-2017 Funding Plan for Low Carbon Transportation and Fuels Investments and the Air Quality Improvement Program, ARB staff explored the potential relationship between fuel prices and demand for state vehicle rebates in California. While BEV rebate applications increased for ZEVs in 2015 despite lower gasoline prices, monthly PHEV rebate applications were generally lower than those for the prior year, though staff was not able to establish a direct relationship.

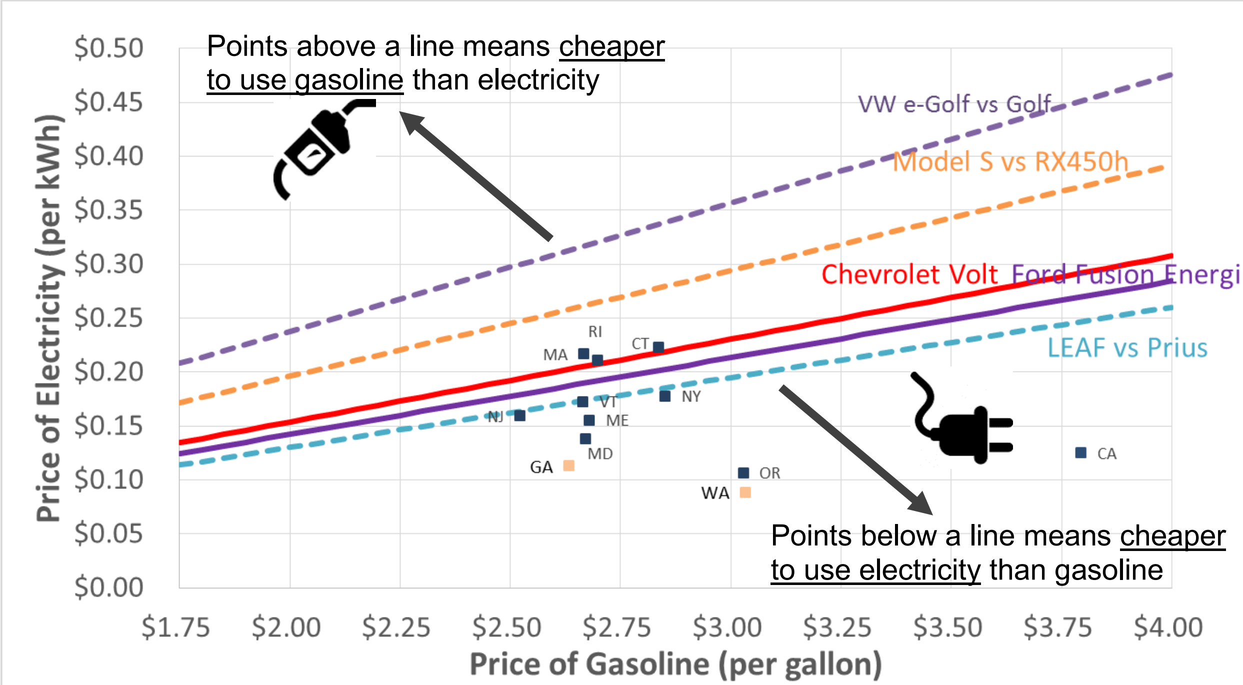
Preliminary results of the UCLA ZEV Sales Factors Study suggest that PEV purchases are positively associated with the price of gasoline. Evaluating California registration data for new and used plug-in electric and hybrid electric vehicles purchased from December 2010 through October 2015 and gasoline price data from Gas Buddy, a county-scale analysis found that a $1 increase in gasoline price (from $3 to $4), is associated with a more than 200 percent increase in average monthly PEV sales, but stopped short of attributing any causal impact to gasoline price changes. The analysis also indicates that the association between gas prices and PEV sales is stronger in the less wealthy inland areas of the state.

However, while electricity prices may be more stable and predictable over time, they can be highly variable across and even within regions.[174] Consumers considering whether to purchase a PEV have multiple cost calculators available, either from utilities, government agencies, automakers, and others. Depending on the consumer's vehicle choices and residential electricity rates, though, a PEV is not universally the lowest operating cost option.

Figure 74 shows how varying energy prices in different states compare relative to the operating costs of certain vehicle choices. The lines in the figure represent the breakeven points where the operating costs for the vehicles labeled in the corresponding color would be equivalent for

[174] See Appendix E for discussion of residential electricity prices in California.

Figure 74 - Comparison of PEV average operating costs across select states in CY2015[175]



Notes: Solid lines show PHEV operating costs using either gasoline or electricity. Dashed lines show BEV operating costs compared to specified ICE or HEV. Dark blue squares indicate states with ZEV regulations.

either energy source, i.e. the cost of driving a PEV one mile using electricity would be the same as driving the same vehicle (if PHEV) or comparable vehicle (if BEV) using gasoline. The solid lines represent PHEVs where the operating costs are based on the vehicle efficiencies of the same vehicle using either fuel. The dashed lines represent BEVs, where the operating costs are based on the electricity efficiency (Wh/mi) of the BEV and the gasoline efficiency (miles per gallon) of an ICE or HEV. The efficiency of BEVs is less variable than that of ICEs so the main reason for the variation between these lines is due to the different fuel economies of the comparison vehicles.

The points plotted on this chart show the average 2015 prices of gasoline and electricity for various states, the dark blue points representing California and Section 177 ZEV States, and the light orange points representing other states with high PEV market shares. When gasoline prices are high and electricity prices are low, the lower right-hand quadrant of this chart, consumers will save money driving with electricity rather than gasoline. In contrast, when gasoline prices are low and electricity prices are high, the upper left-hand quadrant of this chart, operating a vehicle with gasoline will be less expensive than using electricity. The distance of the points from the lines reflect the sensitivity of consumers in each state to fluctuating energy prices. In California or Oregon, gasoline prices can fall, moving the point towards the center of

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175 Vehicle efficiencies used combined label values for MY2016 from fueleconomy.gov. Electricity prices are state averages for April 2015 from the Energy Information Administration, Table 5.6.A, https://www.eia.gov/electricity/monthly/current_year/june2016.pdf. Gasoline prices are state averages for May 2015 from http://www.gasbuddy.com/USA [Accessed May 13, 2015].

the graph, however so long as electricity prices remain stable, or through time-of-use or discounted PEV charging rates, consumer savings are relatively assured. In contrast, many northeast states have relatively high electricity prices that place them above some of the breakeven lines, where choosing a PEV would not necessarily result in fuel savings unless they have access to discounted PEV charging rates or free charging at work or elsewhere. For many of these other states, being so close to the breakeven lines makes them more sensitive to falling gasoline prices. For PHEVs, this figure also illustrates a market challenge if the *same vehicle* would not result in fuel savings from not charging. As discussed in Appendix G, the charging behavior of PHEV drivers is highly variable and may in part be determined by energy prices.

III.C.5. Current ZEV and PHEV Consumer Attitudes

Understanding current ZEV consumers' attitudes towards their PEVs is important for assessing how different vehicle models may or may not be succeeding in the market. These first-hand experiences will shape their future purchase decisions and inform how the market may develop in the future. This section explores results from the California Ownership Survey as well as other independent surveys, which show that the majority of current PEV owners and lessees are satisfied by their experiences with the technology. While many existing PEV drivers could be considered early adopters, there are still improvements they would like to see in their next PEV, such as increased range, faster charging, and ability to charge wirelessly, and auto manufacturers incorporating these features into future products may be able appeal to a broader consumer base.

III.C.5.a. PEV Ownership Survey Results

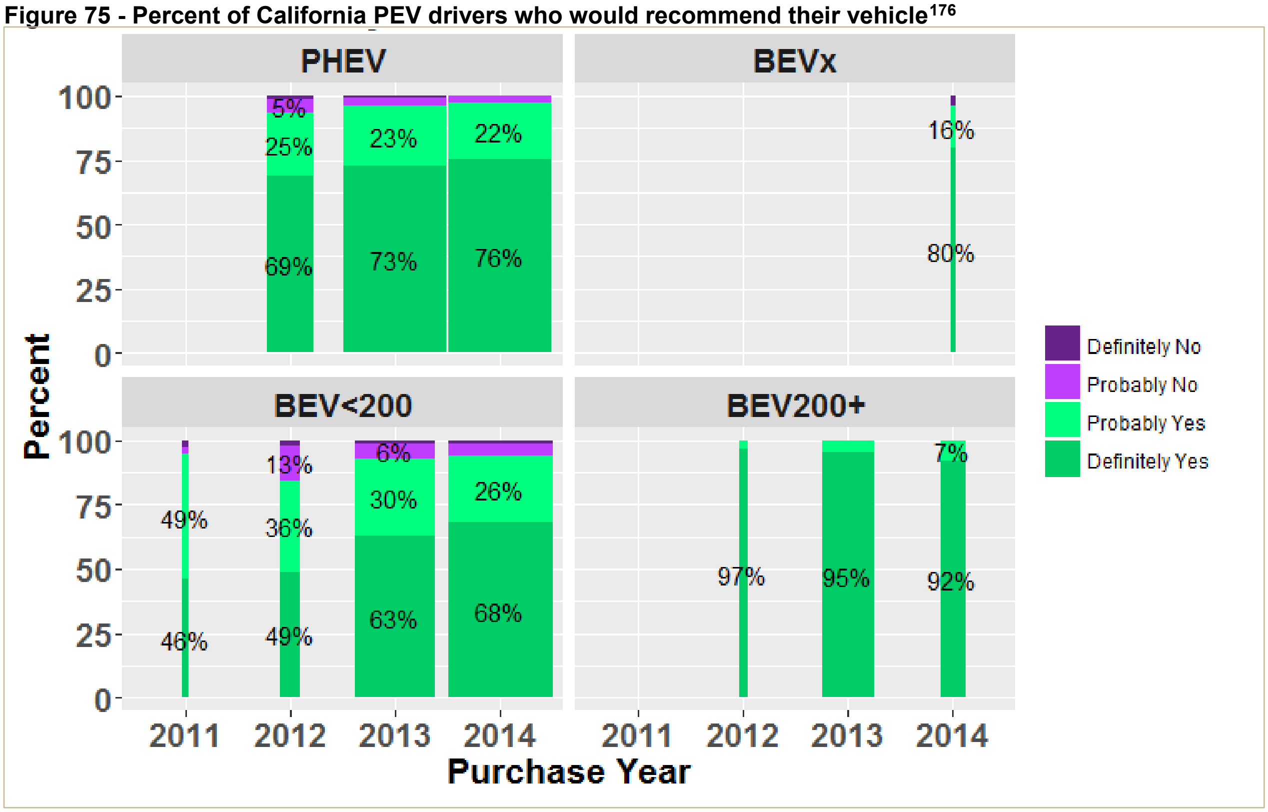
As described in Section VII.G.4, the Ownership Survey sampled a random subset of PEV consumers stratified across time starting with early (2011) and ending with more recent (2014) PEV consumers in California, for a total of 6,500 completed responses. Overall, 98% of respondents still had the PEV for which they received the state rebate and the few who no longer have their PEV generally purchased their PEV prior to 2013. Almost all of those who no longer had the PEV for which they received the state rebate reported having a different PEV instead, and less than 0.2% of respondents indicated not having any PEV. Not surprisingly, respondents of older PEV model years are more likely to no longer have the rebated PEV, but rather a different PEV. For example, 8% of the 2011 model year BEV<200 owners had a different PEV when completing the survey. Of those who no longer had their rebated PEV, 13 had their leases expired, 45 sold/traded it in or ended lease early, 10 had their vehicle damaged/stolen and 15 had other reasons.

III.C.5.a.i. Recommending a PEV

PEV owners were satisfied with their vehicle as over 92% of respondents would probably or definitely recommend their specific PEV model. Virtually all of the BEV200+ consumers would probably or definitely recommend their vehicle, as would 96% of PHEV and 93% of BEV<200 consumers. Given that many prospective PEV drivers rely on the opinion of existing PEV drivers, these high levels of recommendation are important for continued market growth. As shown in Figure 75, as the market has matured, both PHEV and BEV consumers have become more likely to definitely recommend their specific PEV model, which may be correlated to the continued improvements auto manufacturers have made to vehicles between full redesigns.

This increasing trend is especially encouraging as more recent purchasers are less likely to be considered "early adopters" and potentially more typical of conventional vehicle buyers. Relatedly, the percentage of respondents who would not recommend their PEV to someone they know looking for a new car is lower for more recent purchasers. However, even those who did not like their vehicle would still recommend a different PEV to someone they know looking for a new car. A follow-up question was asked of the 265 respondents who would probably and definitely not recommend their PEV specific model: of these, only 21% and 32% probably or definitely would not recommend a *different* PEV model than the one they owned, which represents about 1% of the overall survey population.

Figure 75 - Percent of California PEV drivers who would recommend their vehicle[176]



Note: Column widths are proportional to number of respondents for each PEV type and purchase year.

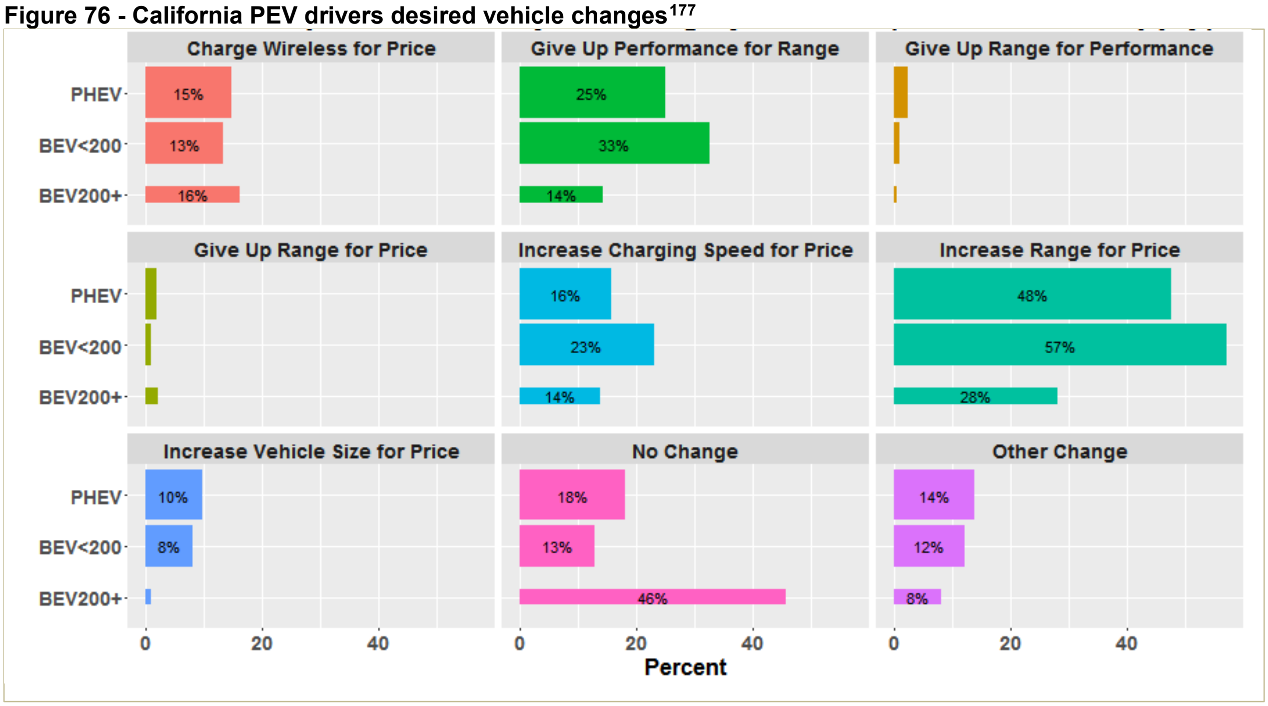
III.C.5.a.ii. Improving PEVs

All respondents were asked either "how would you change your PEV" (for current PEV drivers) or "what changes would have allowed you to consider keeping your PEV or acquiring another?" (for prior PEV drivers) These questions allowed respondents to check multiple answers among this list: 1) give up power/acceleration for greater electric range, 2) give up electric range for greater power/acceleration, 3) give up electric range for lower price, 4) increase electric range for higher price, 5) increase vehicle size for higher price, 6) increase charging speed for higher price, 7) ability to charge wirelessly for higher price, 8) I wouldn't change anything about my PEV, and 9) other.

[176] Ownership results.

Although some drivers are content with their vehicles as-is, many PHEV and BEV<200 consumers seem dissatisfied with the all-electric range of their vehicle. Figure 76 shows all PEV drivers, including some BEV200+ drivers, would be willing to pay for additional range, either in the form of a higher vehicle price or by giving up power or acceleration. Conversely, few respondents were willing to sacrifice range for improving performance or reducing purchase price. Additionally, the most common "other" response was to increase the range without increasing the price. The next most common changes PEV owners would make to their vehicles are to increase charging speed and have the ability to charge wirelessly for a higher price. These findings suggest that future offerings that offer these features or improved attributes will increase the likelihood of existing PEV drivers purchasing another PEV or recommending PEVs to other consumers.

Figure 76 - California PEV drivers desired vehicle changes[177]



Note: Bar heights are proportional to number of respondents for each PEV type.

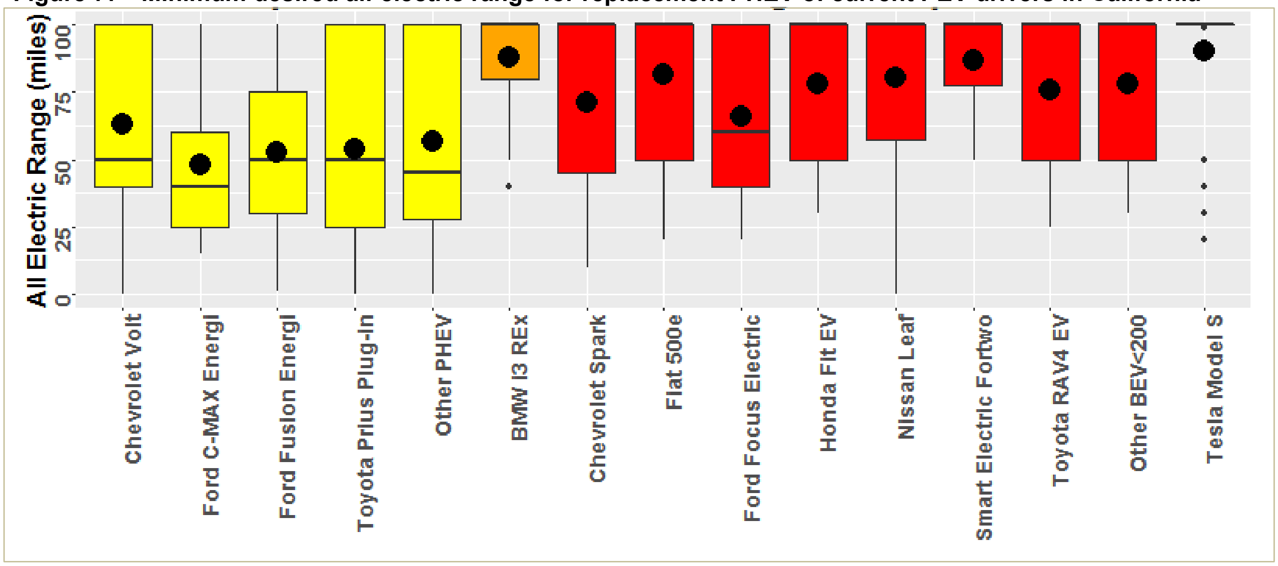
III.C.5.a.iii. Minimum all-electric range for replacement PHEV

Respondents who indicated a PHEV as their replacement vehicle were subsequently asked the *minimum* all-electric range they would require. Responses were capped at 100 miles given known PHEV market offerings at the time when the survey was administered. Consistent with the desire for increased range, Figure 77 shows the distribution of ranges for a replacement PHEV based on the respondent's current PEV model. Current PHEV owners reported wanting their replacement PHEV to have a median between 40-50 miles of all-electric range, and the median desired range for replacement PHEVs far exceeds the all-electric range of their existing model. In contrast, current BEV drivers want even more all-electric range in a replacement PHEV than current PHEV drivers. In fact, the median range desired by almost all BEV<200

177 Ownership results.

respondents was 100 miles, or the maximum allowed response, suggesting that they are not willing to sacrifice the all-electric range provided by their BEV but wanting the added flexibility/utility of the additional range provided through gasoline. Whether additional BEV model offerings with greater all-electric range at lower price points would alter these selections remains a topic for future research.

Figure 77 - Minimum desired all-electric range for replacement PHEV of current PEV drivers in California[178]



Note: Circles indicate mean range desired, horizontal line indicates median range (median is at 100 if not shown).

III.C.5.b. Other surveys of PEV consumers

Independent surveys from UCD and Consumer Reports further support that PEV consumers are satisfied with their purchases.

A 2015 survey of current PEV owners in California was conducted via internet by researchers at UCD.[179] Results reveal that PEV owners are loyal to the technology as evidenced by their repeated purchase/lease of PEVs. The percentage of respondents that reported having two PEVs in their household at the time of the survey increased steadily as a function of newest PEV model year acquired, going from about 7% to 12% for those who purchased a MY2012 compared to MY2015 PEV. Furthermore, the percentage of respondents that reported previously owning/leasing a PEV in addition to their current one also increased as a function of PEV model year acquired, reaching 13% for MY2015 PEVs. In other words, 23% of those who have a MY2015 PEV are repeat PEV owner/lessees.

The 2015 Annual Auto Survey conducted by Consumer Reports determined PEVs were the top three ranked vehicles based on owner satisfaction for use as commuter vehicles.[180] In total,

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[178] Ownership results.
[179] Tal and Nicholas 2016b. Gil Tal and Michael A. Nicholas. 2016. First Look at the Plug-in Vehicle Secondary Market - Working Paper. UCD-ITS-WP-16-02. Institute of Transportation Studies, University of California Davis.
[180] Linkov 2015. Jon Linkov. December 29, 2015. Consumer Reports. "The Most Satisfying Commuter Cars." http://www.consumerreports.org/cars/the-most-satisfying-cars-for-commuting.

over 230,000 responses were obtained from Consumer Reports subscribers who owned vehicles less than three years old. The top three vehicles rated were the Tesla Model S, Chevrolet Volt, and Nissan Leaf among all types of vehicles, including conventional gasoline vehicles and HEVs.

IV. Long-term Consumer Acceptance Potential

While future market shares of ZEVs and PHEVs are unknown, product offerings, technological advancements consumer attitudes, and economic conditions are certain to change. Although the longevity of existing incentives or future energy prices remain uncertain, the potential exists for consumer acceptance to increase well beyond today's levels. The diversity and improvements of future products are likely to appeal to a broader consumer base especially when combined with continuing complementary policies such as outreach and awareness campaigns (see Appendix E) and infrastructure deployment (see Appendix D). By model year 2021, more than 70 unique models are anticipated to be available by all auto manufacturers combined. These vehicles will be offered at a variety of generally lower price points and many will also provide over 200 miles of all-electric driving range, addressing two of the main attributes that current consumers often perceive as barriers to considering a ZEV. The emergence of a secondary market of ZEVs and PHEVs also provides greater opportunities for consumers to experience these kinds of vehicles. Added to these new consumers are the existing, satisfied drivers who are likely to purchase or lease subsequent vehicles, as well as continue to inform others of the benefits of electrified driving.

IV.A. Future model availability

In section III.A.1, Table 1 lists historic ZEV and PHEV model availability and also the 25 models (15 ZEV and 10 TZEV) currently available at the beginning of 2017. As discussed in Appendix C, the number of new ZEV and PHEV models is expected to grow rapidly to 80 total vehicle offerings available for the 2021 model year. With that model growth, the vehicle offerings are expected to become more diverse in terms of the vehicle segment, size classification, and all-electric range options. Greater diversity of available ZEV and PHEV models are more likely to meet the demands of a greater number of consumers with more varied requirements. The vehicles listed in Table 11 are new, additional models expected to be released in the coming year alone.

Table 11 - Expected ZEV and PHEV Models to be Released in 2017

ZEV Type	OEM	Model	Vehicle Segment
BEV	Daimler	Smart ForFour Electric	PC
	Hyundai	Ioniq BEV	PC
	Tesla	Model 3	PC
TZEV	Daimler	Mercedes-Benz GLC350e	LDT
	Hyundai	Ioniq PHEV	PC
	Kia	Optima PHEV	PC
	Mitsubishi	Outlander PHEV	LDT
	Volvo	V90 PHEV	PC
	Volvo	S90 PHEV	PC

In addition to these upcoming new vehicles, manufacturers have made announcements regarding a number of current models that will either be refreshed or receive a battery upgrade in the next year. These include the refreshed MY2017 Smart ForTwo,[181] as well as the MY2017 Ford Focus EV and BMW i3, both of which will have a projected all-electric EPA label range of approximately 100 miles.[182,183] By 2017 every transitioning LVM that will be subject to LVM status starting in 2018 will be offering at least one ZEV and one PHEV model, and by 2019 every manufacturer will be producing at least one ZEV or PHEV model regardless of volume status.

Table 12 provides an overview of the ZEV and PHEV models by expected EPA size classification and the technology type that are expected to be available by MY2021, showing a total of 80 ZEV and TZEV vehicle offerings across almost every EPA size classification and vehicle technology. This chart is similar to the Current and Future ZEV/TZEV Models by Model Year figure in Section II.B.4 of Appendix C. This analysis relies on publicly available news articles about expected future models and is consistent with information provide by manufacturers during meetings with ARB staff. Notable within this table is the introduction of the new the fuel-cell plug-in electric vehicle (FCPEV) technology type. With the planned launch of the GLC F-Cell,[184] Mercedes-Benz will combine the long driving range and short fueling time of a FCEV with the convenience of vehicle charging at home to enable shorter electric trips like a PHEV.

Table 12 - ZEV and TZEV Model offerings available by MY2021

	Vehicle Technology Type				
EPA Size Classification	**BEV**	**BEVx**	**FCEV**	**FCPEV**	**PHEV**
Pickup					
Minivan					1
Standard SUV	2				7
Small SUV	9		1	1	11
Large Car	2				2
Mid-Size Car	7		2		13
Compact Car	2				7
Subcompact Car	3	1			
Two-Seater	1				
Unknown Size Passenger Car	5		1		2
Total	*31*	*1*	*4*	*1*	*43*

181 Meiners 2016. Jens Meiners. September 2016. Car and Driver. "2017 Smart Fortwo Electric Drive." http://www.caranddriver.com/news/2017-smart-electric-drive-official-photos-and-info-news.
182 Fink 2016. Greg Fink. April 19, 2016. Car and Driver. "2017 Ford Focus Electric Aims for 100 with Additional Range." http://blog.caranddriver.com/2017-ford-focus-electric-to-get-100-mile-range/.
183 Siler 2016. Steve Siler. May 2017. Car and Driver. "2017 BMWi3: Now with More Electric Range." http://www.caranddriver.com/news/2017-bmw-i3-revealed-more-range-leads-the-updates-news.
184 Daimler AG 2016. "Under the microscope: Mercedes-Benz GLC F-CELL: The fuel cell gets a plug" http://media.daimler.com/marsMediaSite/en/instance/ko/Under-the-microscope-Mercedes-Benz-GLC-F-CELL-The-fuel-cell-.xhtml?oid=11111320.

In addition, a number of auto manufacturers have announced widespread electrification of their portfolios to support their own corporate sustainability goals to reduce the environmental impacts of their products. For example, the Ford Motor Company has publically announced that it is investing $4.5 billion to develop electric vehicles, which will allow them to bring 13 electrified vehicles to market by 2020, including a small SUV BEV with 300 miles of all-electric range.[185] In addition, they have committed to have some amount of electrification, including ZEVs, PHEVs, and HEVs, in at least 40% of their product offerings in that same timeframe.[186] Daimler recently unveiled its EQ concept at the Paris Auto Show, which will serve as the basis for a family of BEVs, and has also announced plans to invest $1 billion into battery technology to power those vehicles.[187,188] Volvo has similarly announced plans to electrify their entire range of vehicles.[189] Volkswagen group has announced plans to electrify vehicles across their entire family of product offerings. Volkswagen expects battery-powered vehicles to account for approximately 25% of new vehicle sales by 2025,[190] and at the Paris Auto Show unveiled the IQ concept,[191] which utilizes their new MEB platform, a modular vehicle platform for a range of electric vehicles. At the 2015 LA Auto Show, Audi of America President, Scott Keogh, announced that 25% of vehicles sold by Audi in the U.S. will be electrified vehicles by 2025.[192] In addition to the unveiling of the Mission E at the end of 2015, a range-topping long-range performance BEV, Porsche announced plans to invest 700 million euros into their production facilities to accommodate the production of electric vehicle components.[193] The future of the ZEV and PHEV market is rapidly evolving, and with a range of new companies releasing vehicles in the next few years, consumers will have increasingly more vehicle choices to continue transforming the light-duty fleet and commercializing ZEV technology.

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[185] Ford 2017. January 3, 2017. " Ford Adding Electrified F-150, Mustang, Transit by 2020 in Major EV Push; Expanded U.S. Plant to Add 700 Jobs to Make EVs, Autonomous Cars." https://media.ford.com/content/fordmedia/fna/us/en/news/2017/01/03/ford-adding-electrified-f-150-mustang-transit-by-2020.pdf.

[186] Migliore 2015. Greg Migliore. December 10, 2015. AutoBlog. "Ford invests $4.5 billion to build more electric cars." http://www.autoblog.com/2015/12/10/ford-electric-vehicle-investment/

[187] Taylor 2016. Michael Taylor. September 29, 2016. AutoBlog. "The Mercedes-Benz Generation EQ concept will span a full line of Tesla fighters." http://www.autoblog.com/2016/09/29/mercedes-benz-generation-eq-concept-paris-official/

[188] Lambert 2016. Fred Lambert. October 12, 2016. Electrek. " Daimler plans to invest over $1 billion in batteries to support its electric vehicle plans." https://electrek.co/2016/10/12/daimler-plans-to-invest-over-1-billion-in-batteries-to-support-its-electric-vehicle-plans/.

[189] Krok 2016. Andrew Krok. April 21, 2016. Road/Show by CNET. "Volvo to electrify its entire fleet, will release battery-electric vehicle in 2019." https://www.cnet.com/roadshow/news/volvo-to-electrify-entire-fleet-battery-electric-vehicle-2019/.

[190] Ziegler 2016. Chris Ziegler. June 16, 2016. The Verge. "Volkswagen wants to have 30 new electric models on the road by 2025." http://www.theverge.com/2016/6/16/11952816/volkswagen-electric-car-plans-30-battery-powered-vehicles.

[191] Kane 2016. October 2016. InsideEVs. "Volkswagen I.D. At The Paris Motor Shor – Photos & Videos." http://insideevs.com/volkswagen-d-paris-motor-show-photos-videos/

[192] Audi 2015. November 18, 2015. "Audi declares at least 25% of U.S. sales will come from electric vehicles by 2025." https://www.audiusa.com/newsroom/news/press-releases/2015/11/audi-at-least-25-percent-u-s-sales-to-come-from-electric-2025

[193] Porsche 2015. December 4, 2015. "Green light for Mission E." https://newsroom.porsche.com/en/products/porsche-mission-e-concept-study-iaa-e-mobility-12066.html

IV.B. Future consumer purchase behavior

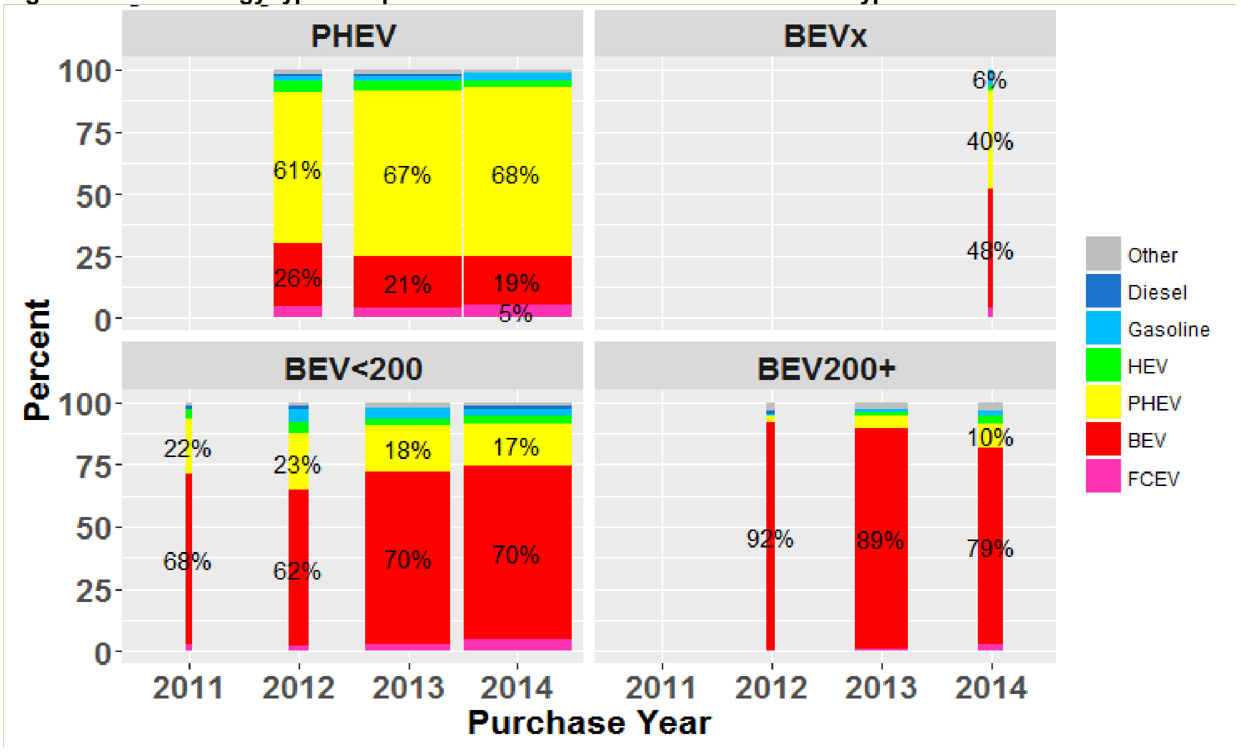
Additional ZEV and PHEV model availability and diversity address the supply-side of the market. Consumers will also need to demand these products at increasing rates for the ZEV and PHEV markets to grow. This section describes the segments from which additional sales can be derived. Although awareness and interest in ZEV technologies is increasing, additional sales are not guaranteed and collective action from government and industry will be needed to support this growing market.

IV.B.1. Current ZEV and PHEV drivers

Current ZEV and PHEV drivers are one of the most certain segments of the market to purchase ZEVs and PHEVs in the future. As previously discussed in Section III.C, this consumer base is already familiar with the technology; likely to already have access to supporting infrastructure; has demonstrated an interested in new technology; likely to have leased their vehicle and thus needing a replacement within a few years; and is largely satisfied with the vehicle technologies. Multiple studies suggest that over 80% of current PEV drivers are likely to be repeat buyers.

California's 2015 Ownership Survey asked over 6,000 current PEV drivers the technology type they would select if needing to replace their vehicle suddenly. Respondents tended to select the specific vehicle technology they currently have, as shown in Figure 78. This is especially true for BEV200+ owners as 86% of them reported they would acquire another BEV to replace their current one, though it should be noted that this percentage has decreased from 92% for those who purchased or leased their vehicle in 2012 to 79% for those who did in 2014. In contrast, the percentage of BEV<200 respondents who would replace their vehicle with another BEV has increased starting from 62% for those who acquired their vehicle in 2012 to 70% for those who did in 2014. A similar increase was observed in PHEV respondents who would replace their vehicle with another PHEV from 60% to 68% over the same purchase years. These increases suggest improving experiences for newer model year vehicles. Overall, slightly more PHEV owners would change to a BEV than BEV<200 owners would change to a PHEV (21% vs 18%). Interest in FCEVs seems greater among PHEV drivers, which may be a result of having greater travel demand needs that are better suited for longer-range FCEVs or a correlation to Toyota's PHEV and FCEV offerings.

Figure 78 - Technology type of replacement vehicle based on current PEV type in California[194]



Note: Column widths are proportional to number of respondents for each PEV type and purchase year.

Nationally, over 3,000 of the EV Project[195] participants were surveyed in June 2013 by Idaho National Lab researchers.[196] Results reveal that the overwhelming majority (96%) of participants of the EV Project would also replace their PEV with another PEV. Specifically, 81% of Leaf owners would replace their Leaf with another BEV and 15% would replace it with a PHEV. Similarly, 70% of Volt owners would replace their Volt with another PHEV, while 27% would replace it with a BEV.

Ford commissioned a survey of 10,000 PEV owners through Plug Insights.[197] The results of this survey indicate that 92% of BEV owners and 94% of PHEV owners plan to acquire another PEV in the future. Similar to other studies, more BEV owners plan to acquire another BEV, while more PHEV drivers plan to switch to a BEV. The survey also found that 73% of PHEV owners who have a second vehicle that is powered by gasoline plan to replace it with either a PHEV or a BEV.

Finally, the 2015 PACE survey sampled 136 PHEV drivers, 138 BEV drivers, and 154 HEV drivers. Asked about their future purchase interest, summarized in Figure 79, almost 90% of BEV drivers stated they would most likely purchase another BEV and only a small fraction would purchase a PHEV. In contrast, more PHEV owners reported they will consider a BEV

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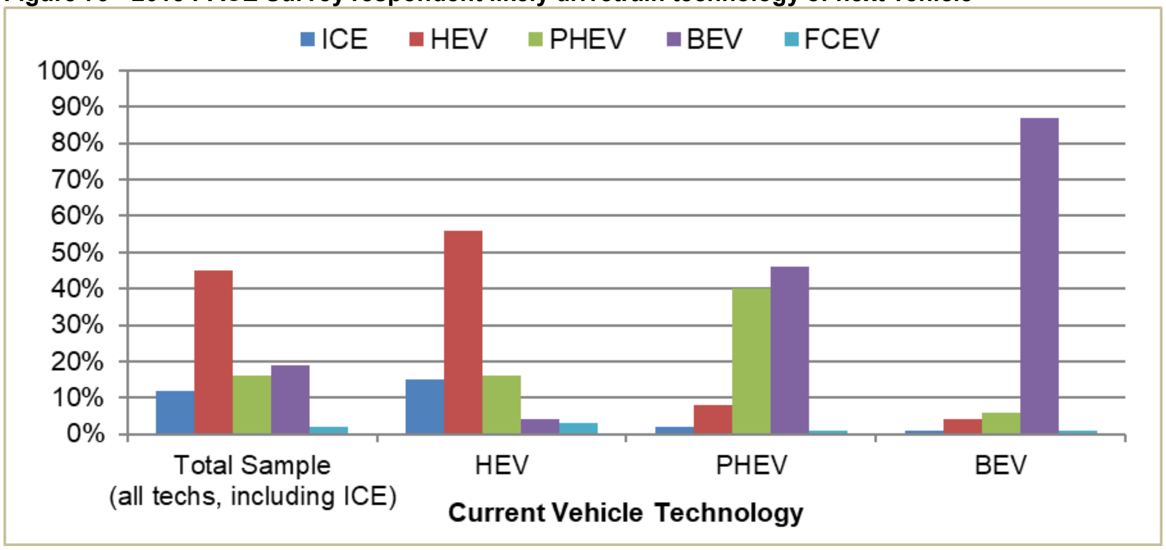
194 Ownership results.
195 See Appendix G for EV Project description.
196 INL 2015.
197 Casey 2015. Tina Casey. August 9, 2015. CleanTechnica. "10,000 EV Drivers Can't Be Wrong... But They Can Be Different." https://cleantechnica.com/2015/08/09/ct-exclusive-interview-10000-ev-drivers-cant-wrong-can-different/.

than a PHEV for their next vehicle (46% vs 40%). Less than 10% of BEV or PHEV drivers would consider an ICE or HEV, and had less interest in FCEVs than the overall sample. HEV drivers expressed the greatest interest in FCEVs though largely were interested in remaining with HEV technology.

Figure 79 - 2015 PACE Survey respondent likely drivetrain technology of next vehicle[198]



IV.B.2. Conventional new car buyers

Reliance on existing ZEV and PHEV drivers to purchase additional vehicles will not be sufficient to create the market growth that is necessary. Reaching long-term goals will require a more widespread consumer base to adopt these technologies, meaning current consumers without ZEVs or PHEVs will need to convert one or more of their household vehicles prior to 2025. Stated interest or intentions to purchase a ZEV or PHEV in the future is not a precise or definitive predictor of future sales as consumer tastes and needs – as well as product offerings – are continually changing. However, interest can be nurtured into consideration or intention with dedicated effort and expressions of interest gauge the potential demand for products should they be delivered for an acceptable price and with the requisite features. This section describes various studies that assessed interest among predominantly conventional vehicle buyers in California and Section 177 ZEV states in potentially purchasing a ZEV or PHEV.

IV.B.2.a. UC Davis 2015 Survey of New Car Buyers' ZEV Valuation

Section III.B.1explains ARB's contracted study with UC Davis on new car buyers' valuation of ZEV and PHEV technologies. ZEV and PHEV valuation is assessed in a design game, which corresponds most closely to present reality, showing how new car buyers value ZEV technology, its attributes, and whether they would be willing to pay for such technology. In the final game, respondents were presented a scenario in which BEVs were not available in full-size body styles, though federal, state, and local incentives were offered. In this scenario, 38% of CA

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[198] 2015 PACE Survey.

respondents designed their next new vehicle to be a PHEV (21%), BEV (11%), or FCEV (6%).[199] Comparable totals in the other states surveyed range from a low of 24% (New Jersey) to a high of 38% (Oregon) of respondents who design their next vehicle to be a ZEV or PHEV.

Extrapolating to a population level estimate, this subset of the sample of new car-buying households in CA represents nearly 1.5 million similar households in CA and 3.3 million similar households for all of the survey regions combined. These estimates were calculated by combining data from several sources and estimating the total number of households that are represented by UC Davis survey respondents who designed a ZEV or PHEV in the final design game. These calculations are summarized in Table 13. The result is that over three million households across the states studied —who already spend the income, wealth, or credit needed to buy new cars— sufficiently value the idea of a ZEV or PHEV to design one as their household's next new vehicle.

[199] Kurani, et al. 2016.

Table 13 - Population estimates of new car buying households with positive PEV or FCEV valuations[200]

State/Region	Total Number of Households[1]	Share of Households with Vehicle available[1]	Percent of Households that Buy New Vehicles[2]	Percent of Respondents that Designed a PEV or FCEV	Population Estimate (x1,000)
Oregon	1,522,988	92%	33%	38.7%	181
California	12,617,280	92%	33%	38.1%	1,476
Washington	2,645,396	93%	33%	35.9%	295
Maryland	2,155,983	91%	33%	31.4%	204
Delaware	339,046	94%	33%	28.0%	30
New York	7,255,528	70%	33%	27.9%	474
Massachusetts	2,538,485	87%	33%	27.7%	205
New Jersey	3,188,498	88%	33%	23.7%	222
NESCAUM	16,078,204	81%	33%	26.6%	1,151
Total[3]					*3,337*

1. US Census http://www.census.gov/quickfacts/table/HSG010214/00 and American Community Survey. Figures are as of July 1, 2014.
2. Based on a survey in November 2014 by UCD of all car-owning households in California the subset estimated to meet the definition of new car buyers used in this study.
3. Total does not double count Massachusetts, New York, and New Jersey as part of NESCAUM.

IV.B.2.b. Union of Concerned Scientists Survey

The Union of Concerned Scientists surveyed 1,200 drivers to assess their perception of PEV policy and potential barriers to PEV adoption.[201] The survey was conducted online from April 1 - April 8, 2016. Respondents were selected from drivers over 18 years of age who live in California, Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York, or Pennsylvania. Additionally, participants had to either have off-street parking with access to an electrical outlet or a plug-in electric charger at home; did not need a vehicle for towing and hauling; and had a maximum vehicle capacity requirement of five passengers. The results of the survey revealed that 35% of the participants in the Northeast states would consider a PEV for their next vehicle purchase or lease and 55% of participants expressed interest in PEV technology. Comparatively, 54% of consumers in California would consider a PEV for their next purchase or lease and 65% of consumers are interested in EV technology.

The study highlighted areas which influenced consumers' perception of EVs. For both regions, the top attributes of a PEV among those who would consider a PEV for their next vehicle purchase were: lower purchase prices, being able to drive 200 miles on a fully charged battery, and more charging infrastructure in parking lots and shopping centers. Survey respondents in

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[200] Kurani, et al. 2016. The second through fourth columns estimate the number of households that meet the definition of "households who acquire new vehicles," that is: respondent households that had —at the time of the survey— acquired a new vehicle since January 2008. The fourth column —Buy new vehicles, %— is an estimate based on data for California only, thus the estimates for all other states and regions assume this percentage in other states is similar. Taking the product across each row produces the Population Estimate in the sixth column.
[201] UCS and CU 2016. Union of Concerned Scientists and Consumers Union May 2016. Electric Vehicle Survey Methodology and Assumptions: Driving Habits, Vehicle Needs, and Attitudes toward Electric Vehicles in the Northeast and California. http://www.ucsusa.org/sites/default/files/attach/2016/05/Electric-Vehicle-Survey-Methodology.pdf

the Northeast states indicated the low number of charging stations seen while traveling as a one of the major concerns of owning an EV. California respondents noted a desired 200 mile travel range as the top concern. Respondents in both CA and the Northeast states cited providing a tax credit or rebate for the purchase or lease of plug-in electric vehicles, incentives for businesses to install charging stations, and a more streamlined process for installing charging stations at multi-dwelling housing units, as their top three areas of public policy that need improvement.

IV.B.2.c. Public Policy Institute of California Surveys

The Public Policy Institute of California's surveys on "Californians & the Environment" conducted in 2015 and 2016 included some questions on PEVs.[202,203] In contrast to the UCD study which was an internet-based survey that only surveyed new car buyers, the PPIC surveys were conducted entirely on landline telephones and cellphones and were based on a representative sample of California adults. A total of 1,702 and 1,704 California residents completed the survey in July 2015 and 2016, respectively. A ±3.5% margin of error was reported. Results reveal that nearly half of the respondents (48% and 47%) in 2015 and 2016 have seriously considered getting a PEV as their next vehicle. In addition, younger Californians were more likely to report they have seriously considered getting a PEV (55%) than Californians age 55 and older (34%). The overall percentages are significantly higher than those from other surveys (20-24% based on NREL study and 31-36% based on CFA) perhaps because of the California-only sample, which could be argued has a more mature PEV market. However, the UCD study also reported a lower percentage of California new car buyer participants willing to design a ZEV or PHEV (38%) compared to the fraction of PPIC survey respondents willing to consider a PEV. Furthermore, a greater percentage of PPIC survey respondents reported they already had a PEV in 2016 (8%) than in 2015 (5%), which are both generally higher than PEV fleet or market shares during those years. These differences could be due to the difference in sampling methodologies or question framing.

IV.B.2.d. Other Surveys

Two additional surveys are broader in nature, but do include some measures of future purchase intentions from mostly current ICE or HEV drivers US-wide. The 2015 NREL Caravan Survey discussed in Section III.B.3 reported that compared to traditional gasoline vehicles, 52% of respondents stated PHEVs were just as good or better while 45% of respondents said the same for BEVs. 24% of respondents would consider a PHEV for their next vehicle and 20% would consider a BEV, though a smaller percentage reported they expect to purchase or lease a PHEV (2%) or a BEV (2%). Consideration was higher for both PEV types when respondents were aware of PEV charging stations, were able to name a specific model, or planning a new vehicle (as opposed to used) as their next purchase. Additionally, 51% of respondents reported they were willing to pay some incremental costs for PEVs: 14% would be willing to pay over

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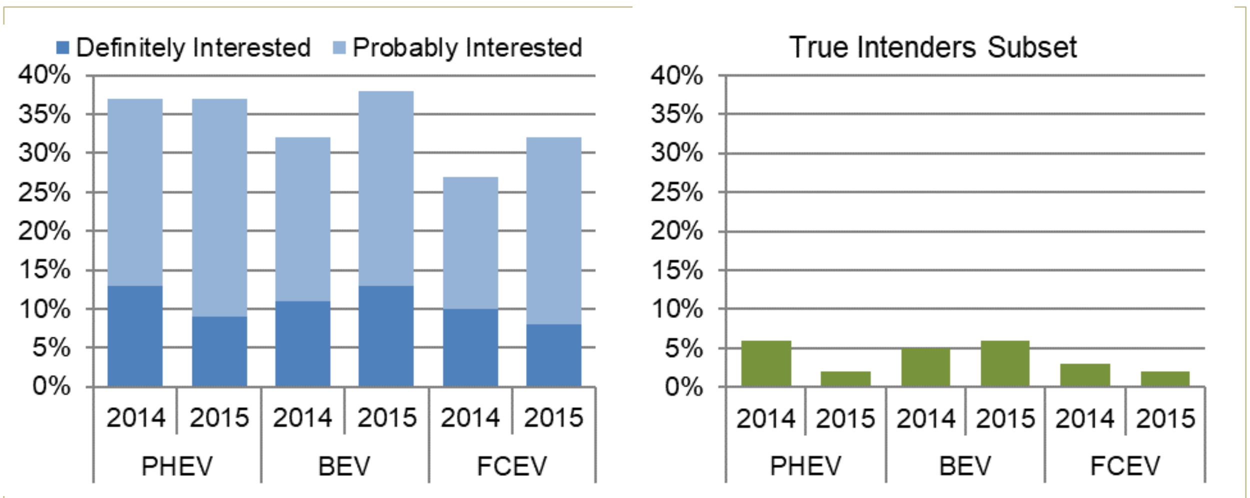
[202] PPIC 2015. Public Policy Institute of California. July 2015. *Californians & the Environment: PPIC Statewide Survey*. http://www.ppic.org/content/pubs/survey/S_715MBS.pdf.
[203] PPIC 2016. Public Policy Institute of California. July 2016. *Californians & the Environment: PPIC Statewide Survey*. http://www.ppic.org/content/pubs/survey/S_716MBS.pdf.

$9,000 and 17% would be willing to pay $4,000-5,000, and 20% not willing to pay more than $4,000.[204] The NREL CARAVAN survey was repeated with 1,008 respondents in February 2016.[205] Preliminary results indicate little movement in PEV attitudes between 2015 and 2016. While the fraction of respondents that expected to consider a PEV as their next vehicle was similar between both years, the percent that expected to purchase a PEV increased from 2% in 2015 to 3-4% in 2016.

Morpace's 2014 and 2015 PACE Surveys shows similar national trends, shown in Figure 80, with the addition of gauging interest in FCEVs. In general, interest levels are higher than the fraction of respondents categorized as "true intenders" based on their responses to other questions. Compared to the 2014 PACE Survey, interest in FCEVs and BEVs rose while PHEV interest remained constant. Between these two surveys, the fraction of true intenders remained similar for ZEVs but fell by four percentage points for PHEVs. However, in the 2015 results, the sum of true intenders of ZEVs and PHEVs total 10%.

Figure 80 - 2014 and 2015 PACE Survey respondent interest in ZEVs or PHEVs as next vehicle purchase[206]



IV.B.3. Future Incentives

As discussed in section III.C.2.d and Appendix E, the current ZEV and PHEV market has benefited from a host of incentives and complementary policies that have contributed to sales trends observed to date. However, the continuation of some of these incentives into the future is uncertain.

The federal tax credit is one of the most important incentives offered to consumers for purchasing their PEV. This credit has been especially effective for lessees as it is factored into the vehicle price used for calculating lease payments, which avoids any delay in claiming the

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[204] Singer 2016.
[205] Davis, et al. 2016. Stacy C. Davis, Mark Singer, and Yan Zhou. June 8, 2016. Oak Ridge National Laboratory. *Transportation Data Program: A Multi-Lab Coordinated Project.* http://energy.gov/sites/prod/files/2016/06/f33/van016_davis_2016_o_web.pdf.
[206] 2014 and 2015 PACE Surveys.

credit until filing federal tax returns as well as ensures even those consumers without a large tax liability benefit from the full value of the tax credit. Also described in Appendix E, the Qualified Plug-in Electric Drive Motor Vehicle Tax Credit varies by the capacity of the vehicle's battery pack, awarding a $2,500 credit for vehicles with a five kilowatt-hours (kWh) battery and an additional $417 credit per kWh up to a maximum of $7,500. The tax credit begins phasing out for each manufacturer when its nationwide sales of qualified PEVs reach 200,000 vehicles. Based on historic sales rates, staff estimates at least four manufacturers would reach this threshold prior to 2025. Leading manufacturers General Motors and Nissan would reach this threshold first in 2022 followed by Ford and Tesla, though increasing sales of existing vehicles and introduction of new products would likely accelerate this timeline. The $8,000 federal tax credit for FCEVs will expire on December 31, 2016. Neither tax credit is being discussed in Congress for an extension.

In California, sufficient funding for the state purchase rebate remains a perennial uncertainty. Recent modifications to program eligibility requirements by the state legislature may reduce the occurrence of waiting lists but current incentive funding collected through AB8 will sunset in 2023. Incentive programs in Section 177 ZEV States described in Appendix E have also faced funding shortages at times and may not necessarily keep pace with future demand.

Additionally, high-occupancy vehicle (HOV) lane access by single-occupancy ZEVs and PHEVs has been an effective incentive in five states, including California. As discussed in Section III.C.2.c, access to HOV lanes has been one of the frequently cited primary motivations for acquiring a PEV, especially PHEVs. Current California state law granting access for these vehicles sunsets on January 1, 2019, though federal law allows for provisions to be extended to 2025.

As sales of ZEVs and PHEVs grow, local government or employer incentives, whether directly related to vehicle purchase or more indirectly through free or discounted parking and/or charging can also play a role in supporting and developing the market. How these individual entities may modify these incentives will further change the future landscape for new car buyers. However, the extent to which any phase-out of incentives creates challenges for forthcoming products will depend on the rate at which incremental technology costs decrease and vehicle attributes improve that increase consumers' willingness to pay for ZEVs and PHEVs.

IV.C. The Secondary ZEV Market

A used PEV market is quickly emerging as the higher lease rates for PEVs are resulting in a large influx of vehicles entering this market. For context on the overall secondary market, according to California New Car Dealers Association Quarterly Reports, between 2012 and March 2016, there have been over three million used vehicles of model years 2009 and newer (e.g., similar to the model years of used PEVs) sold in California of all technology types or about half the number of all new vehicles sold during this time.[207] Typically, only about one-third of

[207] CNCDA Quarterly Reports.

California and U.S. households purchase or lease a new vehicle at least every 5 years.[208] According to Edmunds,[209] the second quarter of 2016 saw the highest average prices in the used vehicle market ever ($19,367), which they attributed to a high fraction (58%) of the used vehicles sold in franchises being less than three years old and a heavier light truck mix that tends to retain higher values. Despite these recent higher prices, over the last three years the resale values of used vehicles have been decreasing due to the increased preference for leasing, which continues adding newer used vehicles into the secondary market.[210] Edmunds reported that the average residual value among all vehicle classes less than three years old sold in the second quarter of 2016 was 64%, down from a high of 70% in 2012.

This section explores what is currently known about the secondary ZEV market, beginning with ARB-sponsored research. This on-going study has estimated the size of the secondary PEV market in California to be about 10,000 vehicles or 5-8% of all PEVs on the road.[211] About half of used PEV households surveyed have only purchased used vehicles in the past. Surprisingly, 12% of used PEV owners surveyed had no other vehicle in their household besides their single used PEV. The majority (86%) of used PEV owners were satisfied with PEV technology and would either repeat their purchase or opt for a new PEV instead. However, the average household income of used PEV owners was found to be fairly high ($173,400). With time, though, the growing secondary PEV market has the potential to enable more households to purchase and benefit from driving PEVs.

A staff analysis of Experian Automotive data is also included in this section followed by discussion of external reports focused on the secondary PEV market. Not only do the majority of PEVs sold as new vehicles in California tend to stay in state as used vehicles, but California is also a net importer of used PEVs. Growing pains associated with developing a market for this new technology are evident with low average residual values. However, there are signs that demand for used ZEVs has been increasing, which indicate a possible sustainable used ZEV market. For example, used PEVs on average are not lingering on the market and used models such as the Tesla Model S have lower depreciation than other gasoline-powered vehicles in the same vehicle segment.

IV.C.1. UC Davis Secondary PEV Market Research Project

Because the PEV secondary market is still so new, there are few research studies that have analyzed its health. ARB is sponsoring a UCD research project titled “The Dynamics of Plug-in Electric Vehicles in the Secondary Market and their Implications for Vehicle Demand, Durability, and Emissions”.[212] Researchers are employing surveys and analyzing used vehicle transaction data to evaluate the impact of factors such as battery life, energy prices, infrastructure

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[208] Tal and Nicholas 2016b.
[209] Edmunds 2016. Edmunds.com. Q2 2016. *Used Vehicle Market Report*. http://static.ed.edmunds-media.com/unversioned/img/car-news/data-center/2016/aug/used-car-report/used-car-report-q2.pdf.
[210] The National Automobile Dealers Association (NADA) found that in the first eight months of 2016 the lease share of new vehicles reached 31%, compared to just 24% three years earlier.
NADA 2016c. National Automotive Dealers Association. Q3 2016. *Value Discovery: How Automotive Brand Affects Used Vehicle Prices*. http://www.autonews.com/assets/pdf/UCG_AN_Q3WhitePaper_16-NA-1061.pdf.
[211] Tal and Nicholas 2016b.
[212] See Section VII.L for more details on ARB-contracted research.

availability, attributes and prices of vehicle offerings, and economic conditions, on the demand and prices of used PEVs and on their usage. The project is also evaluating whether the secondary market is expanding access to PEVs to a wider array of consumers than the new PEV market. Both parts of this project are currently ongoing and are expected to be finalized in 2017. Preliminary results from this project are discussed in the next two subsections.

IV.C.1.a. Secondary PEV Owner Survey

The goal of surveying used PEV buyers was to identify the socioeconomic characteristics and purchase motivations of used PEV buyers, and to understand how these vehicles are being driven and charged. Of the over 14,000 potential used PEV owners/lessees in California identified through the DMV database, 4,700 were randomly selected to receive survey invitation letters. About 28% of those who started the survey indicated that they did not have a used PEV. Scaling the potential used PEV population based on this percentage yields about 10,000 actual used PEV owners/lessees in California. A total of 602 self-identified used PEV owners/lessees completed an internet-based survey May-June 2016.[213] Results from a survey of new PEV owners that was conducted by the same research team was used for comparison.

Analysis of the self-reported purchase price, excluding the 121 responses from Tesla owners, shows that used PEV prices were correlated positively with the original purchase price and negatively with vehicle age and mileage. Used PHEVs maintained an average retention value (resale value relative to new MSRP) that is 10 percentage points higher than used BEVs. Additionally, used PEVs with a high occupancy vehicle (HOV) lane access sticker sold for $1,430 more than used PEVs without the sticker. Most of these used PEVs were purchased after 2-3 years of usage by the original owner. The self-reported median odometer reading of the used PEVs at the time of purchase was 21,500 miles (mean 23,400 miles). For a further discussion of estimated annual miles driven and charging behavior of used PEV survey respondents see Appendix G.

Nearly half of the respondents (49%) have only previously purchased used vehicles for their household. In addition to one used PEV, most respondents also have one (39%) or two (41%) ICE vehicles in their household. Yet, 12% of the used PEV respondents belong to a single PEV household, another 4% are from a two-PEV household, and a further 4% have two PEVs plus at least one ICE vehicle. Used PEV buyers tend to be interested in acquiring a PEV at the start of their shopping process: 28% of respondents reported they were only interested in the specific make and model they ended up purchasing, 33% were only interested in PEVs, and 24% were very interested in a PEV.

The survey also revealed that 86% of used PEV owners are satisfied with PEV technology. Over three quarters (77%) of the respondents would repeat their purchase if they had to do it again, while 9% would opt for a new PEV instead of a used one. In contrast, only 3% of respondents reported they would not purchase another PEV. When asked about the condition of their used PEV battery at the time of purchase, a little over a quarter of the respondents reported that it had 100% of original capacity, 45% reported it had 90-99% of its original

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[213] Tal and Nicholas 2016b.

capacity, and 13% reported it had 80-89% of its original capacity. About 13% did not know the condition of their battery at the time of purchase.

Used PEV-owning households have relatively high incomes compared to conventional vehicle consumers, though lower incomes than new PEV-owning households. The mean household income reported by used PEV owners is $173,400 (median of $150,000) versus a mean of $227,000 (median of $200,000) as reported by new PEV owners in a 2015 survey. The exceptions are the owners of used Toyota Prius Plug-in, the Ford Focus Electric, and the Toyota RAV4 EV which have more similar household incomes compared to new owners of these PEV models. UCD researchers explained this could be due to the low availability of the Ford Focus Electric and Toyota RAV4 EV and the high demand for used PEVs with HOV access stickers. For comparison, UCD researchers note that the average household income from the 2012 California Household Travel Survey was $89,800 for households with older vehicles versus $119,400 for households with new vehicles.

IV.C.1.b. Used Vehicle Transaction Data Analysis

Manheim data analyzed to date by UCD researchers is included in this section to understand the demand of used PEVs in California. Manheim is a wholesale vehicle auction company with 62 exchanges in North America whose primary buyers are vehicle dealerships. The preliminary data analyzed consists of all transactions in the United States from January 2014 through July 2015 excluding Alaska, Hawaii, and Pennsylvania.[214] Each transaction record contains vehicle information (vehicle identification number (VIN), vehicle make, model, and model year), odometer reading, transaction price, and auction origin and destination states. The Manheim data analyzed includes transactions of all PEVs (n=9,685) in the U.S., and 50% of HEVs and "comparable" ICEs transactions in California, and 10% of HEVs and "comparable" ICEs transactions in the rest of the U.S. A total of 63,923 HEV transactions are included in the data analyzed. The "comparable" ICEs (n=250,914) were limited to the Ford Focus, Honda Civic, Nissan Sentra, and Toyota Corolla. It should be noted that Manheim exchanges do not include Tesla vehicles.

Auctioned Nissan Leafs account for nearly two-thirds of all used PEV transactions in this dataset with the remaining being an assortment of non-LEAF BEVs and PHEVs. Of vehicles terminating in California, the average auction price of used PEVs was about $1,000 less than the average auction price of used HEVs but over $4,000 higher than that of used comparable ICEs vehicles during this period. Auctioned Nissan Leaf vehicles terminating in California during this time were cheaper than those terminating elsewhere in the United States, with an average price in California about $600 lower than in all other states. In contrast, the non-Leaf PEVs auctioned in California received higher average prices by about $1,000 to $3,000 than those in other states. The average auction price of HEVs fell between the average price of Leaf and Non-Leaf PEVs, with similar prices in other states. For comparison, there was limited regional variation in the average auction price of comparable ICE vehicles. However, the age of the vehicles may play a role since the average model year of all PEVs auctioned is two years newer (2012.3) than the average of HEVs (2010.2) and three years newer than that of

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[214] Personal communication with Dr. David Rapson, October 3, 2016.

comparable ICE vehicles (2009.0). The effect of vehicle age on auction prices is still being explored. In addition, the effect of mileage on auction prices is also being investigated.

Preliminary results suggest that over three-fourths of all vehicles auctioned by Manheim in California remain within the state, with 76% of PEVs, 84% of HEVs and 88% of comparable ICEs. California had a similar net inflow of PEVs and comparable ICE vehicles, suggesting similar demand for these vehicle technologies. In contrast, California experienced a net outflow of HEVs through the Manheim exchanges between 2014 and the first half of 2015, indicating there was greater demand for these vehicles in other states during this period, potentially due to California consumers shifting from HEVs to PEVs.

IV.C.2. Migration of Used PEVs and Comparable Vehicles

The Experian Automotive data[215] provides another approach for ARB staff to evaluate the migration of used PEVs, which contains the vehicle identification number (VIN) for all PEV transactions—new and used—for the entire country. A total of almost 38,000 used PEVs were identified based on a unique VIN occurring in the data two or more times between 2011 and 2015.[216] About 60% of these used PEVs were PHEVs, of which another two-thirds were Chevrolet Volts. Of the 40% used PEVs that are BEVs, almost 80% of these are Nissan Leafs. As the first entrants to the PEV market, Volts and Leafs comprise about 70% of the entire used PEV market and these two models will strongly influence current trends.

As shown in Table 14, the majority of used vehicles, regardless of technology, generally stay within their originating region which supports continued promotion of PEVs within regions. About the same fraction of PEVs remain in California according to both the Experian Automotive and Manheim results. Of the PEVs originating in California, a greater share was transferred to Other States than other gasoline-only technology types, suggesting that there is higher demand for (or limited supply of) used PEVs in these states. Likewise, for PEVs originating in Section 177 ZEV states, a sizeable share was transferred to Other States and at a greater rate than gasoline-only vehicles are transferred.

Table 14 - Origin and destination regions for used vehicles in CY2011-2015[217]

		Destination					
		PEVs			ICEs/HEVs		
		California	S177 ZEV States	Other States	California	S177 ZEV States	Other States
Origin	California	10,850 (76%)	417 (3%)	3,077 (21%)	18,623 (91%)	911 (4%)	1,012 (5%)
	S177 ZEV States	436 (9%)	2,149 (46%)	2,117 (45%)	237 (1%)	19,728 (92%)	1,508 (7%)
	Other States	1,347 (7%)	1,709 (9%)	15,691 (84%)	722 (4%)	5,008 (29%)	11,328 (66%)

[215] For data description, see Section VII.B on Experian Automotive data.
[216] Note that this method also includes owners who move from one state to another and must re-register the same vehicle; these vehicles will appear as a used vehicle transaction even though vehicle ownership has not transferred.
[217] Experian Automotive data.

Note: Percentages of each vehicle technology type by origin are shown in parentheses.

Regardless of ZEV regulatory status, the presence of incentives for both new and used vehicles may distort typical migration patterns for used vehicles as states with new PEV purchase incentives may have lower demand for used PEVs, while states with used PEV purchase incentives may attract a disproportionate share of used vehicles. Table 15 details the states offering new and/or used PEV purchase incentives between CY2013 and 2015. In some states, incentives may only be offered for a particular type of PEV however all would reduce the initial purchase price of the vehicle. Note as well that all states offering used PEV incentives also offer new PEV incentives.

Table 15 - States offering new and used PEV purchase incentives in CY2013, 2014, or 2015

New PEV Purchase Incentive States
ZEV states: California, Connecticut, Maryland, Massachusetts, New Jersey, Vermont **Non-ZEV states:** Colorado, District of Columbia, Georgia, Illinois, Louisiana, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Washington, West Virginia
Used PEV Purchase Incentive States
ZEV states: California, New Jersey **Non-ZEV states:** Colorado
State without PEV Purchase Incentives
ZEV states: Maine, New York, Oregon, Rhode Island **Non-ZEV states:** Alabama, Alaska, Arizona, Arkansas, Delaware, Florida, Idaho, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, South Dakota, Virginia, Wisconsin, Wyoming

Note: Purchase incentives include state tax credit, rebate (sometimes in conjunction with scrappage requirement), or sales tax exemption.

Based on used vehicle transactions occurring between January 1, 2013 and December 31, 2015, Table 16 further distinguishes the flow of vehicles between the states based on their ZEV regulation status and availability of purchase incentives. In California, the net outflow of PEVs is largely driven by the export of BEVs, however, these vehicles are only a fraction of the total used PEVs originating from the state. California is different from the two other states offering both new and used PEV incentives, which show a small net inflow of all types of vehicles, potentially reflecting the counteracting forces of the two incentive types. While a net outflow might be expected from states with incentives on only new PEV purchases, this is observed only in states with a ZEV regulation. States without a ZEV regulation, but offering new PEV incentives, show a net inflow of both types of PEVs. Likewise, among states without any purchase incentives, those states without a ZEV regulation have a net inflow of PEVs that is of the opposite direction of the flow of conventional vehicles. Overall, the net effects are small relative to the population of used vehicles, however there appears to be the emergence of demand in a secondary market reflected by the net inflow of used PEVs to states without ZEV regulations and/or purchase incentives.

Table 16 - Flow of vehicles by PEV type and state incentive categories in CY2013-2015[218]

			New PEV Purchase Incentives		New and Used PEV Purchase Incentives		States Without PEV Purchase Incentives	
	Flow	**California**	**S177 States**	**Non-S177 States**	**S177 States**	**Non-S177 States**	**S177 States**	
BEV	**In**	823	282	2,031	47	204	530	1,875
	Out	-2714	-265	-1,248	-23	-166	-439	-875
	Net	**-1,891**	**17**	**783**	**24**	**38**	**91**	**1,000**
PHEV	**In**	927	1,012	2,280	178	134	611	2,474
		-706	-1,174	-2,097	-163	-102	-978	-2,349
	Net	**221**	**-162**	**183**	**15**	**32**	**-367**	**125**
All PEV	**In**	1,750	1,294	4,311	225	338	1,141	4,349
	Out	-3,420	-1,439	-3,345	-186	-268	-1,417	-3,224
	Net	**-1,670**	**-145**	**966**	**39**	**70**	**-276**	**1,125**
ICE/ HEV	**In**	922	6,113	1,236	2,306	4	2,384	1,540
	Out	-1,826	-1,751	-3,354	-266	-2	-2,652	-2,612
	Net	**-904**	**4,362**	**-2,118**	**2,040**	**2**	**-268**	**-1,072**

Note: Green shading means net imports and red means net exports.

Whether there is any significance to the presence of a ZEV regulation or incentives to these migration patterns is unclear, as these states are not entirely contiguous. To explore whether used PEV migration is driven by geographic factors, the states were categorized into regions according to Table 17.

[218] Experian Automotive data.

Table 17 - State categorization of regions

CA		Mountain		Southwest	
California	CA	Colorado	CO	Arizona	AZ
Pacific		Idaho	ID	New Mexico	NM
Oregon	OR	Montana	MT	Oklahoma	OK
Washington	WA	Nevada	NV	Texas	TX
Hawaii	HI	Utah	UT		
Alaska	AK	Wyoming	WY		
North Central		**North Atlantic**		**Southeast**	
Illinois	IL	Connecticut	CT	Alabama	AL
Indiana	IN	Delaware	DE	Arkansas	AR
Iowa	IA	District of Columbia	DC	Florida	FL
Kansas	KS	Maine	ME	Georgia	GA
Michigan	MI	Maryland	MD	Kentucky	KY
Minnesota	MN	Massachusetts	MA	Louisiana	LA
Missouri	MO	New Hampshire	NH	Mississippi	MS
Nebraska	NE	New Jersey	NJ	North Carolina	NC
North Dakota	ND	New York	NY	South Carolina	SC
Ohio	OH	Pennsylvania	PA	Tennessee	TN
South Dakota	SD	Rhode Island	RI	Virginia	VA
Wisconsin	WI	Vermont	VT	West Virginia	WV

Generally at least half of all used BEVs and PHEVs remain in their originating region. Despite some BEV models being available exclusively in California and/or Oregon, these models comprise less than 4% of California's exports. The Nissan Leaf, which is distributed nationally, comprised the bulk of California's BEV exports as well as the majority of imports to the Northeast region. Although vehicles might be expected to migrate between nearby regions, Table 18 shows that the largest portion of BEVs originating in California are imported into the Southeast region. In contrast, Table 19 shows that PHEVs are imported into the Southeast region at only about a tenth of the rate. Two factors likely contribute to this pattern: 1) the overall supply of "native" used BEVs in the Southeast region is less than half that of "native" used PHEVs; 2) at the same time, Georgia offers HOV lane access for single-occupancy BEVs only and recently discontinued state purchase incentives on new BEVs. This finding suggests that complementary policies that apply to used vehicles (including usage-based incentives) will also be important for retaining the emission benefits generated by PEV adoption.

Table 18 - Origin and destination region of used BEVs in CY2011-2015[219]

		Destination Region							
		CA	**South-west**	**Mountain**	**North Central**	**Pacific**	**North Atlantic**	**South-east**	***Grand Total***
Origin Region	**CA**	4,413	364	366	312	475	249	966	*7,148*
	Southwest	292	562	68	67	61	40	140	*1,230*
	Mountain	120	59	288	15	40	4	8	*534*
	N. Central	72	51	26	494	10	36	92	*781*
	Pacific	151	55	121	21	2,002	10	21	*2,381*
	N. Atlantic	114	24	17	70	14	399	170	*808*
	Southeast	100	87	31	135	18	143	1,113	*1,627*
	Grand Total	*5,265*	*1,202*	*917*	*1,114*	*2,620*	*881*	*2,510*	*14,506*

Table 19 - Origin and destination region of used PHEVs and BEVxs in CY2011-2015[220]

		Destination Region							
		CA	**South-west**	**Mountain**	**North Central**	**Pacific**	**North Atlantic**	**South-east**	***Grand Total***
Origin Region	**CA**	6,434	149	152	154	192	53	62	*7,196*
	Southwest	88	827	41	71	25	31	64	*1,147*
	Mountain	47	49	410	65	31	23	60	*685*
	N. Central	352	201	134	3,363	71	467	565	*5,153*
	Pacific	71	17	22	22	992	3	15	*1,142*
	N. Atlantic	263	94	77	790	52	2,178	646	*4,100*
	Southeast	113	131	37	328	31	797	2,424	*3,861*
	Grand Total	*7,368*	*1,468*	*873*	*4,793*	*1,394*	*3,552*	*3,836*	*23,284*

IV.C.3. Enhanced Fleet Modernization Program (EFMP) and Plus-Up Pilot Program

Another source of used vehicle pricing data comes from California's Enhanced Fleet Modernization Program (EFMP) and Plus-Up Pilot Program that incentivizes households to replace scrap older, higher-polluting vehicles.[221] Pricing and financing terms for replacement vehicles are collected from program participants, which provide early data on trends of ZEV and PHEV resale values compared to other technologies. In the first fifteen months of the EFMP and EFMP Plus-Up pilot program (July 1, 2015 through September 30, 2016), 1,411 vehicles were replaced in the South Coast and San Joaquin Valley air districts. Over 80 percent of the

[219] Experian Automotive data.
[220] Experian Automotive data.
[221] See Section VII.H for more details on EFMP.

vehicles replacements are categorized as used vehicles.[222] Table 20 shows the breakdown of purchase price and financing by replacement vehicle technology type for the subset of used vehicles. The most common replacement vehicle technology by far was conventional hybrid (40%), with an average purchase price of almost $20,000. The average price of a PHEV was similar to that of HEVs, which is about $3500 more than a conventional vehicle. BEV average purchase prices (mostly Nissan LEAFs) are about $4,000 lower than conventional vehicles and $7,500 lower than PHEVs or HEVs.

Table 20 - Used vehicle price and financing of EFMP replacement vehicles (July 1, 2015 through September 30, 2016)

Vehicle Technology	Max EFMP Incentive	Count	Purchase Price		Loans		Average Interest Rate (%)
			Average	Standard Deviation	Count	Average Amount	
BEV	$9,500	197 (17%)	$12,685	$3,374	99	$4,300	6.7
Conventional	$4,000	177 (15%)	$16,735	$4,152	167	$12,639	8.3
Hybrid	$7,000	455 (40%)	$19,870	$4,168	421	$12,845	7.4
Minivan	$4,000	10 (1%)	$20,092	$4,157	10	$13,991	8.6
PHEV	$9,500	309 (27%)	$20,099	$3,260	264	$10,983	6.4
Total		*1148*	*$18,217*	*$4,703*	*961*	*$11,430*	*7.2*

IV.C.4. Other Analyses

Analysis of over two million used vehicle model year 2013-2015 transactions between January and May, 2016 by iSeeCars.com revealed that the fastest-selling used vehicles among all technologies were BEVs.[223] Used BEVs stayed in the market an average of 29.2 days in 2016, a decrease of 8 days compared to the same period in 2015. Between 2015 and 2016, used BEVs decreased in price the most an average of 15.2% or $3,830. Used conventional hybrids were the second fastest selling vehicle technology, remaining on the market an average of 38.2 days, which is a decrease of 5 days compared with 2015. The average decrease in price between 2016 and 2015 for used HEVs was 3.7% or $889. Used PHEVs were the third fastest selling vehicle technology, staying in the market an average of 40.7 days, a decrease of 2 days compared to 2015. The average decrease in price year-over-year for used PHEVs was 5.1% or $1,214. Used gasoline vehicles remained on the market the longest, averaging 42.5 days. The average price of used gasoline vehicles decreased by 1.0% or $242 between the two years.

More specifically, iSeeCars.com found the Toyota Prius Plug-in, Nissan Leaf, and Tesla Model S to be the three fastest selling used vehicle models among all used vehicles regardless of technology. The Toyota Prius Plug-in was the fastest selling vehicle with an average of 19.7 days on the market, which is over two times faster than the average light-duty vehicle. During the same time period in 2015, the used Prius Plug-in remained on the market double the time, an average of 38.1 days. This halving of the number of days on the market for the used Prius

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[222] Used vehicles are defined based on having odometer readings greater than 5,000 miles and whose model year is at least one year greater than the purchase year.
[223] Lee 2016. Thomas Lee. July 18, 2016. iSeeCars.com, "Fastest-Selling Used Cars." http://blog.iseecars.com/2016/07/18/fastest-selling-used-cars/.

Plug-in was attributed by iSeeCars.com to the high demand and limited supply of HOV carpool lane stickers since the maximum number of PHEVs allowed to get a sticker was reached in late 2015 coupled with a 17% drop in average price between 2015 and 2016 ($22,945 versus $19,057). The Nissan Leaf was the second-fastest selling used vehicle on the market in 2016 going from 38.7 days in 2015 to 24.3 days in 2016. The price paid for the Leaf dropped by $2,219 between 2015 and 2016. iSeeCars.com explains that the high demand for the used Leaf likely came from its low average price of $12,533, which makes it one of the most affordable used vehicles on the market overall. The Tesla Model S was the third-fastest selling vehicle in the study spending an average of 26.1 days on the market, likely due to its relatively high demand and limited supply and 17% price decrease from 2015 to 2016.

While ICEs typically depreciate 45% to 50% in three years, some suggest BEVs, except for the Tesla Model S, depreciate 60% to 75% in the same time period.[224] In contrast, the Model S depreciates about 40% in its first three years, which is more similar to conventional vehicles. Possible factors given by Nerdwallet that affect depreciation values include worry about battery degradation over time, new model introductions with longer driving ranges and other features, unknown battery replacement costs, the impact of federal and state incentives for new ZEVs, and the preference towards the newest features of early adopters.

Analysis of used vehicle transaction data between 2012 and August 2016 previously published by Autolist[225] reveals that the Tesla Model S has the slowest depreciation rate in its vehicle segment, even when compared to leading gasoline-powered vehicles. For example, a Model S with 50,000 miles typically depreciates 28% of its original value while comparable large luxury gasoline vehicles, such as the Mercedes-Benz S-Class, Porsche Panamera and BMW 7 Series, with the same mileage depreciate about 40%. In contrast, other PEVs tend to depreciate at a faster rate than their gasoline-powered competition. For vehicles with 50,000 miles, the comparable gasoline vehicles, such as the Toyota Corolla, Honda Civic, Toyota Prius (hybrid), and Ford Focus, depreciate about 25%, while the Chevrolet Volt and Nissan Leaf depreciate about 43% and 59% of their original value.

In 2015, the National Automobile Dealers Association (NADA) calculated the retention values of used PEVs using a three-month (March-May 2015) average of NADA's average trade-in value divided by the vehicle's MSRP.[226] The published retention values do not include any include any federal, state or dealer incentives. Overall, results reveal that used PEVs overall have a lower retention value compared to gasoline-powered vehicles. As shown in Table 21, the retention of one year old PEVs ranges from 83.1% for the Tesla Model S to 34.9% for the Mitsubishi i-MiEV. For comparison, NADA notes that the one year old retention averages for gasoline powered luxury large, mid-size and compact vehicle segments fells between 70.1%

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[224] O'Dell 2016. John O'Dell. September 9, 2016. Nerdwallet.com. "Used Plug-In Cars Could Be a Bargain." https://www.nerdwallet.com/blog/loans/auto-loans/used-electric-cars-bargain/.

[225] Autolist 2016. Autolist.com. Used Tesla Model S Listings for Sale in San Francisco, CA accessed September 2016. https://www.autolist.com/tesla-model+s-san+francisco-ca#sort_filter=distance:asc&section=ev-depreciation-analysis.

[226] NADA 2015a. National Automotive Dealers Association. April 2015. *Used Car Guide Perspective: Electric Vehicle Retention Report Card*. http://img03.en25.com/Web/NADAUCG/%7B413f55a5-807f-4b2e-8310-48cd4aeb40da%7D_April_2015_NADA_Perspective.pdf.

and 62.7%. Therefore, the Model S and the Porsche Panamera S-E maintain higher retention values than the average of the large luxury vehicle segment. Because the top two PEVs with lowest depreciation value are luxury vehicles, the Model S and Porsche Panamera S-E, NADA suggests their strong retention values are predicated on demand for owning a vehicle with cachet and exclusivity. The Model S continued to maintain a higher retention value among two and three year old models (71.1% and 57.2%) compared with the average of the luxury large segment (57.8% and 49.5%). The two PEV models that consistently have the highest depreciation are the i-MiEV and the Nissan Leaf. The three year old retention values of mainstream PEVs ranges from 47.6% to 20.6%, while that of comparable gasoline powered vehicles is greater than 46.2%. NADA explains the low retention value of PEVs through range

Table 21 - PEV retention value percentages by model year calculated in 2015[227]

PEV	Model Year 2014 Retention %	Model Year 2013 Retention %	Model Year 2012 Retention %	ARB-calculated Model Year 2012 Retention % using after-incentive MSRP
Tesla Model S	83.1	71.1	57.2	64.5
Porsche Panamera S-E	78.4			
Toyota RAV EV	71.3	55.8	47.6	59.3
Honda Accord Plug-in	69.8			
Toyota Prius Plug-in	68.8	53.6		
Ford Fusion Energi	62.7	46		
BMW i3	61.4			
Cadillac ELR	57.5			
Chevrolet Volt	56.1	35.8	31.3	40.4
Ford C-Max Energi	53.7	42.2		
Fiat 500e	50.1	42.1		
Chevrolet Spark EV	47.2			
Mercedes-Benz B-Class	47.1			
Ford Focus Electric	46.5	34.9	31.8	42.4
Smart Fortwo Electric	45.8	38.2		
Nissan Leaf	43.5	36.5	25.3	34.8
Mitsubishi i-MiEV	34.9		20.6	30.9
Average Comparable ICE	*63-70*	*54-58*	*46-50*	*NA*

and technology concerns, as well as stiff competition from highly efficient and lower cost gasoline powered vehicles. However, adjusting MY2012 MSRPs to reflect federal and state incentives that would have been available for these vehicles when new and recalculating the retention values shows PEVs to be more similar to conventional vehicles. Reducing MSRPs by

[227] NADA, 2015a. Incentives assumed include $7500 federal tax credit and $2500 state rebate for BEVs and $1500 state rebate for Chevrolet Volt

up to $10,000 increases retention scores by about 10 percentage points. Low retention values are thus partially a reflection of government purchase incentives.

V. Economic Impacts of ZEVs and Advanced Technology Vehicles

California's ZEV market exhibits signs of growth throughout the supply chain of the automotive industry. As discussed in SectionIII.A.2, new ZEV sales in California were nearly seven times higher in 2015 than in 2011, which far exceeds the growth rate of the new light-duty vehicle market for the same period.[228] Increased ZEV sales continue to help California meet statewide environmental and economic goals by improving public health, safety, and general consumer welfare. The development, production and supply of ZEV technologies also sustain employment and investments in California's automotive sector, while spurring growth in battery manufacturing, infrastructure planning and construction, as well as electricity and renewable energy production.[229] Research has shown that a faster penetration rate of ZEVs in California increases wages across various industries in the state, particularly for lower- and middle-income households that earn under $40,000 a year.[230] The same research also found that the spillover effects associated with ZEV adoption increase jobs in nearly all economic sectors, implying that accelerated ZEV adoption creates more opportunities in occupations with higher wages.

California's ZEV market growth coincides with the state's general economic recovery, making it difficult to isolate the contribution of ZEV adoption to job growth in the state. Still, as organizations such as CALSTART and the Advanced Energy Economy Institute (AEEI) have emphasized, growth in the broader clean technology industry has expanded the network of manufacturers, suppliers, and producers of advanced energy and fuels. The AEEI describes advanced energy as encompassing technologies, services and energy sources that are clean and secure in the long-run, including "energy efficiency, demand response, energy storage, natural gas electric generation, solar, wind, hydro, nuclear, electric vehicles, biofuels and smart grid." Results from AEEI's 2016 California Advanced Energy Employment Survey showed that jobs related to advanced energy grew by 18% in 2015, six times faster than the growth of statewide employment across all industries.[231] AEEI estimates that there are currently 142,000 jobs in advanced energy production and 19,000 jobs in advanced grid technologies. Looking forward, the AEEI expects California's advanced energy jobs to grow by 8% in 2016, and CALSTART projects that the state's ZEV manufacturing industry will employ more than 25,000

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[228] Total CA LDV Sales are obtained from the CNCDA Quarterly Reports and Dashboard data.

[229] This section mostly focuses on the direct impacts of adopting advanced technology vehicles; there are additional indirect and induced economic benefits at the state and national level that are not discussed here. One of these benefits is improvements in energy security. Given that passenger vehicles account for around 70% of transportation oil consumed nationally, the electrification of light-duty vehicles in California and in the U.S. is expected to reduce the country's reliance on foreign petroleum imports.

[230] Roland-Holst 2012. David Roland-Holst. September 2012. Department of Agricultural and Resource Economics, University of California, Berkeley. *Plug-in Electric Vehicle Deployment in California: An Economic Assessment*. https://are.berkeley.edu/~dwrh/CERES_Web/Docs/ETC_PEV_RH_Final120920.pdf.

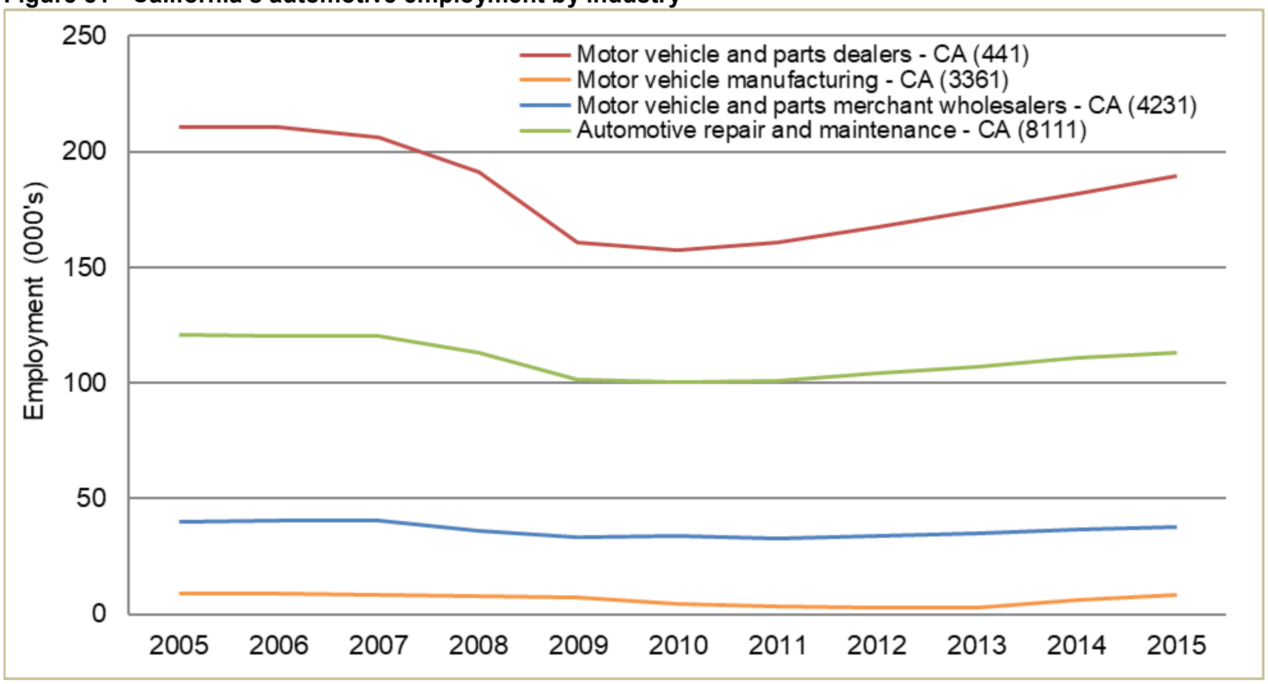
[231] AEE 2016. Advanced Energy Economy. 2016. *Advanced Energy Jobs in California: Results of the 2016 California Advanced Energy Employment Survey*. Prepared by BW Research Partnership. http://info.aee.net/advanced-energy-jobs-in-california-2016

workers by 2020.[232] These job-growth estimates are consistent with California's long-term plans for widespread electrification of the state's transportation system. This section discusses the employment and investment benefits associated with developing the ZEV and advanced technology vehicle market in California.

V.A. Automotive Sector's Recovery

The latest employment levels shown in Figure 81 for California's broader motor vehicle manufacturing industry are approaching pre-recession levels, while jobs in motor vehicle body, engine, and parts manufacturing have also been recovering in recent years. These observations are consistent with trends in the automotive industry at the national level, which show employment numbers for motor vehicle and parts manufacturers, suppliers, and dealers are returning to levels observed before the 2008 recession.[233]

Figure 81 - California's automotive employment by industry[234]



California maintains a unique position as a driver of innovation and environmental regulations, fostering growth of light- and heavy-duty ZEV manufacturers in the state and in the nation. While a number of companies are considering ZEV manufacturing prospects in California, Tesla Motors, a prominent electric vehicle manufacturer, intends to grow its 9,000-employee

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[232] CALSTART 2016. August 2016. *California's Clean Transportation Technology Industry: Time to Shift into High Gear.* http://www.calstart.org/Libraries/Policy_Documents/California_s_Clean_Transportation_Technology_Industry_-_2016.sflb.ashx.

[233] DOL 2016. U.S. Department of Labor. September 2016. Automotive Industry: Employment, Earnings, and Hours. http://www.bls.gov/iag/tgs/iagauto.htm.

[234] BLS Quarterly Census of Employment and Wages (Preliminary data for 2015) http://www.bls.gov/cew/.

workforce in the state to more than 15,000 before 2018.[235] Still, as shown in Figure 81, motor vehicle manufacturing accounts for a relatively small share (approaching 9,000 jobs) of California's larger automotive sector's employment base. Parts dealers and automotive repair and maintenance workers make up an overwhelming majority of jobs in the sector, accounting for around 189,000 and 113,000 jobs, respectively, in 2015. Parts wholesalers also account for a sizable share of jobs in the auto sector, showing steady employment numbers over the past decade (in the mid 30,000's). A recent report by Next 10 shows that clean technology investments in California have increased considerably after 2013, particularly for transportation-related projects.[236] California accounted for around two-thirds of all clean technology investments made in the U.S. in 2015. This statistic is unsurprising considering California's share of all venture capital investments in the country exceeded two-thirds in 2015. However, as noted by the Next 10 report, venture capital investments are just one of the diversified financing instruments that are being used in the clean technology space. Other funding resources include private and public grants, loans, and equity. While national clean technology investments increased by $14.5 billion (5%) between 2014 and 2015, they grew by $9.8 billion (35%) in California over the same period. Clean technologies for transportation applications received the largest share of venture capitalist investments in 2015, both nationally (47%) and in California (60%).

V.B. ZEV and Advanced Technology Vehicle Jobs

Growing public- and private-sector interests for deploying new vehicle technologies, and the increasing stringencies of vehicle emission standards, are contributing to ZEV and PHEV sales in California. These sales may grow existing auto sector jobs and create opportunities for new businesses and innovations in related industries. New ZEV-related manufacturing jobs are expected to stem directly from vehicle, parts, and battery manufacturers, but businesses that enable ZEV and PHEV adoption (such as alternative fuel producers and suppliers, charging infrastructure providers; vehicle and grid software developers; utility providers; etc.) will also likely see considerable gains in employment. While the production and operation of ZEVs and PHEVs will stimulate economic growth, in the long-run there may also be job losses in industries with occupations closely tied to the manufacturing, supplying, and servicing of conventional vehicles. Jobs related to the oil and gas industry (extraction, transportation, refining, etc.) may also decrease as petroleum use is reduced due to a suite of transportation and fuel standard measures. In view of these counteracting economic effects, studies have sought to estimate the

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[235] CALSTART 2016 report on the clean transportation technology industry (CTTI) tracks more than 300 California companies that are transforming the state's economy through advances in clean energy technology, manufacturing, distribution, and related services. Daily Kanban obtained information from Tesla Motor's CAEATFA (California Alternative Energy and Advanced Transportation Financing Authority) application, showing that production activities for Tesla's Model 3 will increase employment in California by 5,600 jobs. They also found that Tesla plans to build manufacturing sites in California for supplying component materials that are currently provided by non-California suppliers. (Niedermeyer 2016. Edward Niedermeyer. October 4, 2016. Daily Kanban. "10 True Facts from Tesla's Model 3 CAEATFA Application." http://dailykanban.com/2016/10/10-true-facts-teslas-model-3-caeatfa-application/)
[236] Next 10 2016. June 2016. Prepared by Beacon Economics. *California Green Innovation Index, 8th edition*. http://next10.org/sites/next10.org/files/2016-california-green-innovation-index-1.pdf.

net impact of ZEV and PHEV adoption on jobs, accounting for how much these vehicles both accelerate and slow job growth across different economic sectors.

Using various methodologies and assumptions, studies have provided estimates of the net job growth stimulated by further deployment of ZEVs and PHEVs through 2030. The following tables adapted from an International Economic Development Council report summarize the estimates provided by some reports on the net job impacts of adopting advanced technology vehicles more broadly, in California and in the United States.[237] The outlined studies indicate that the number of jobs created by adopting advanced technology vehicles would more than offset the job losses. Although the scenarios and assumptions behind each study vary, their results suggest that harmonized fuel economy and GHG standards will generate considerable employment benefits by 2030, ranging from 38,000 to 236,000 net jobs in California and 129,185 to 1.9 million net jobs in the U.S. As a leader in ZEV adoption, California accounts for a sizable share of the net job gains estimated for the nation. Note that forecasts are sensitive to assumptions about future policy adoption, technology development, investor confidence, infrastructure deployments, and other factors.

Among reports that have estimated job growth impacts of advanced technology vehicles in California, a 2012 UC Berkeley study on plug-in electric vehicle deployment and a 2011 Next 10 study are notable.[238,239] The UC Berkeley study used the Berkeley Energy and Resources (BEAR) model to forecast economic impacts of three policy scenarios of varying levels of PEV deployment. The baseline conditions for the modeling exercise assumed that California continues with current State PEV deployment commitments and post-1990 Federal fuel economy standards. Two scenarios were then analyzed where PEV deployment increases by 15.4% and 45%, respectively, in addition to the baseline by 2030. The resulting net jobs estimated under these assumptions ranged between 50,000 and 100,000 across all sectors in 2030.

The Next 10 study estimated net job impacts for 2025 by assessing a range of fuel economy standard stringencies. One of the analyzed policy scenarios assumed that California's emission standards and 2016 Low Carbon Fuel standards would remain the same through 2025. The estimated net jobs under this scenario were around 38,000 by 2025, which is in a comparable range to the 50,000 net jobs estimated for 2030 by the UC Berkeley study under similar assumptions. However, Next 10 also analyzes the impacts of the following increases in Federal economy standards: (1) Fuel economy standards increased by 4% annually between 2017-2025 (37 mpg federal average; 46 mpg new vehicle standard); (2) Fuel economy standards increased by 6% annually between 2017-2025 (43 mpg California fleet average; 54 mpg new vehicle standard); (3) Fuel economy standards increased by 6% annually between 2017-2025 (52 mpg

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[237] IEDC 2013. International Economic Development Council. 2013. *Creating the Clean Energy Economy: Analysis of the Electric Vehicle Industry.* http://www.iedconline.org/clientuploads/Downloads/edrp/IEDC_Electric_Vehicle_Industry.pdf.
[238] Roland-Holst 2012.
[239] Roland-Holst 2011. David Roland-Holst. May 2011. Department of Agricultural and Resource Economics, University of California, Berkeley. *Driving California's Economy: How Fuel Economy and Emissions Standards Will Impact Economic Growth and Job Creation.* Research Paper No. 1103011. http://next10.org/sites/next10.org/files/Final_vehicle_efficiency_report.pdf.

California fleet average; 54 mpg new vehicle standard) and assumes that the standard pushes development of new state-of-the-art vehicle technology. These different scenarios yield (1) 158,000 jobs; (2) 205,000; and (3) 236,000 by 2025.

Table 22 - Net job growth estimates for California from adopting advanced technology vehicles

Source	Estimate Year	Net Jobs in California(#) All Sectors
UC Berkeley (2012)	2030	50,000 - 100,000
Next 10 (2011)	2025	Resulting from CA standards: 38,000 Resulting from Federal standards: 158,000 – 236,000

At the national level, four studies that estimated the net job impacts of adopting advanced vehicle technologies are summarized in Table 23. Due to the wide range in scale and scope of scenarios analyzed, the net job impacts estimated across these studies ranged from 11,000 in 2020 to 1.9 million in 2030. The UC Berkeley (2009)[240] study evaluated three adoption scenarios with varying gas prices and PEV subsidies. The base case assumed low gas prices that gradually increased to $4 per gallon by 2030. A second scenario considered high gas prices above $5.50 per gallon. Finally, the third scenario assumed that the private sector absorbs costs associated with consumer adoption (operator-subsidized). In this scenario, a subsidy of 3 cents per mile is used in addition to existing $7,500 federal tax credit. In 2030, these three scenarios resulted in 130,000; 315,000; and 350,000 national jobs across all sectors, respectively.

[240] Becker et al. 2009. Thomas Becker, Ikhlaq Sidhu, and Burghardt Tenderich. August 2009. Center for Entrepreneurship & Technology, University of California, Berkeley. *Electric Vehicles in the United States: A New Model with Forecasts to 2030.* http://globaltrends.thedialogue.org/wp-content/uploads/2014/12/Electric-Vehicles-in-the-United-States-A-New-Model-with-Forecasts-to-2030.pdf.

Table 23 - Net job growth estimates for the United States from adopting advanced technology vehicles

Source	Estimate Year	Net Jobs in the United States (#) All Sectors
UC Berkeley (2009)	2030	130,000 - 350,000
Blue Green Alliance/ ACEEE (2012)	2030	570,000
Electrification Coalition (2010)	2030	Total: 1.9 million Manufacturing: 560,000 Motor vehicle parts: 106,000 EV electric & electronic parts suppliers: 112,000 Travel & tourism: 276,000 Professional services: 73,000
National Resources Defense Council (2010)	2020	11,000 - 32,000 Estimates include employment changes in the supply chain of manufacturing sector and indirectly impacted non-manufacturing jobs

The Blue Green Alliance/ACEEE (2012)[241] also published a study showing that different federal fuel economy and GHG standard would yield around 570,000 net jobs across all sectors in 2030. The study used ACEE's Dynamic Energy Efficiency Policy Evaluation Routine (DEEPER) model to evaluate impact of August 2012 Federal standards. Assumptions were made about the incremental cost of new vehicles; financing costs to consumers; changes in energy demand; fuel savings and reallocations; administrative costs to government.

The largest job impact estimates for advanced technology vehicle adoption were made by Electrification Coalition.[242] For 2030, this report estimated that 1.9 million net jobs across various sectors would be gained as a result of a wide range of adoption scenarios and policies recommended by the Electrification Coalition in the 2009 Electrification Roadmap. The University of Maryland's Inforum LIFT economic forecasting model was used to assess the impacts of the following specific policies: increasing ZEV and PHEV purchases; deploying charging infrastructure and upgrading utility IT to support electrified transportation; accelerating

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[241] Busch, et al. 2012. Chris Busch, John Laitner, Rob McCulloch, and Ivana Stosic. June 2012. Gearing Up: Smart Standards Create Good Jobs Building Cleaner Cars. https://www.bluegreenalliance.org/wp-content/uploads/2016/08/062812-GearingUp_Final.pdf.

[242] Electrification Coalition 2010. Electrification Coalition. April 2010. *Economic Impact of the Electrification Roadmap*. http://www.electrificationcoalition.org/sites/default/files/SAF_1249_EC_ImpactReport_v06_proof.pdf.

domestic electric vehicle battery production and purchase; and supporting auto manufacturers to equip and prepare auto production plants for manufacturing electric vehicles. An important assumption made by this study was that 75% of passenger VMT would be electric by 2040. Table 23 details the various sectors where the estimated net job impacts would be distributed.

Focusing more on near-term 2020 impacts, the National Resources Defense Council examined the economic impacts of policies that encourage domestic production and improved vehicle economy.[243] The study analyzed three main scenarios that assumed 25%, 50%, and 75% of total technology value are produced domestically, corresponding to Low, Medium, and High retention of total job benefits. Considering the appeal of non-PEVs when oil dependence decreases, and accounting for non-US jobs that may be created with PEV adoption, the study estimated that net job impacts would range from a low of 11,000 to a high of 32,000 by 2020.

The number of vehicles sold in California affects demand for workers in the auto sector's supply chain. This relationship holds with ZEV and PHEV sales as well, which have slowly grown over the past seven years. One factor in the growth of ZEVs and PHEVs hinges on consumer valuations of fuel savings relative to the cost of purchasing a vehicle. Although gas prices have been low since the 2014 drop in global crude oil prices, long-term projections indicate they will increase steadily through 2040.[244] Meanwhile, over the next few decades, the incremental price difference between a ZEV or PHEV compared to a conventional vehicle is expected to decrease as manufacturers leverage research, scale economies, technology improvements, and other innovations in their production processes.[245] Assuming that actual vehicle sales align with the vehicle projections of the minimum compliance scenario, employment for all auto dealers would increase, while creating jobs in the rest of the supply chain (motor vehicle and battery manufacturers; parts dealers, suppliers, and wholesalers; auto repair and maintenance workers; etc.). To the extent that new, ZEV-related jobs created from increasing ZEV and PHEV manufacturing and sales may offset job losses from traditional ICE vehicle production and sales, the increasing ZEV and PHEV market share requirements could result in a significant net positive impact on employment in the auto sector and related industries. Future work will quantify the demand and the supply-side effects of production input prices, labor capacity, and other factors to estimate the net job impact of increasing market shares for ZEV and PHEV sales.

V.C. ZEV and Advanced Technology Vehicle Investments

California's automotive industry maintains strong ties with the state's engineering and technology firms. This link is particularly important for ZEV and PHEV adoption and infrastructure deployment, as production relies heavily on advancements in battery, fuel cell,

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[243] Baum and Luria 2010. Alan Baum and Daniel Luria. March 2010. *Driving Growth: How Clean Cars and Climate Policy Can Create Jobs*. Prepared for the National Resources Defense Council, United Auto Workers and Center for American Progress. http://www.nrdc.org/energy/files/drivinggrowth.pdf.
[244] AEO's 2015 reference-case projections indicate that motor gasoline prices will approach $4/gallon in 2040. The reference case is modeled after the 2014 global oil market.
[245] See Appendix C for additional cost estimates.

and grid technologies. Large multinational technology companies as well as existing auto manufacturers have demonstrated growing interests in developing autonomous vehicle technologies and advanced safety features that are well-suited for electric vehicle systems and platforms. More broadly, the conglomeration of high-tech software and hardware firms in California has spurred innovations in engine, battery, and vehicle parts research, development and production. Tesla Motors, for example, is planning to advance its battery packs, electric motors, and gearbox technologies along with other R&D efforts at its headquarters in Palo Alto.[246] Engineering and manufacturing firms based in California are also able to share or license their new products to other companies, which may lead to new developments in other related sectors. For example, the development of hydrogen infrastructure is supported by firms like Quantum Technologies that produces hydrogen tanks and dispensers and FasTech that performs hydrogen station testing and commissioning. Table 24, adapted from CALSTART's report on California's Clean Transportation Technology Industry, highlights some of the private sector's investment plans and commitments that can support further development of ZEV and PHEV technologies or infrastructure.

Table 24 - California-based private sector investment plans and commitments

Company	Plans and Investments
AeroVironment	- Manufacturer of EVSE and power cycling and test systems for electrification equipment. - Operate and manage a network connected - Participant in Nissan's No Charge to Charge program.
ChargePoint	- Working with BMW and Volkswagen to expand EV charging network to connect east and west coasts while ensuring there are sufficient charging corridors within both coasts
eMotorWerks	- Manufacturer of smart charging devices for home use
Faraday Future	- Plans to manufacture electric cars
Google	- Significant investments in autonomous vehicles - Potential partner with existing OEM
Greenlots	- Solutions for payment, network management, and installation and support of EV charging networks - Partnership with Kia for KIA Chargeup
Karma Automotive	- Electric car development plans - Employee investments (100 engineers)
Lucid Motors (formerly Atieva)	- Electric car development plans - Produced all-electric prototype van (Edna)
Polyplus	- Leader in advanced battery technology development - Developed and patented the protected lithium electrode (PLE)
Tesla Motors	- Plans to increase 9,000-employee workforce in the California to more than 15,000 before 2018 - Plans to build manufacturing sites in California for supplying component materials that are currently provided by non-California suppliers

[246] Niedermeyer 2016.

Public sector investments have also played a critical role in enabling the development, production, and adoption of advanced vehicle technology in California. FirstElement Fuel plans to build at least 19 hydrogen filling stations in California with assistance from over $30 million in grants as well as additional loans from Honda and Toyota. HyGen and Stratos Fuel have received over $6 million and $2 million, respectively, in grant awards to support the construction and operation of four more hydrogen stations in California.

Additionally, U.S. DOE's Vehicle Technologies Office is a leader in funding battery-related research and development, investing over $1 billion since 1992, to address challenges of ZEV technologies. [247] These challenges include battery development and manufacturing costs, technology barriers for electric drivetrains, and broader issues with the public's awareness of ZEVs. Reducing the cost of batteries and improving their efficiency are paramount factors in improving the affordability of ZEVs and PHEVs. U.S. DOE's research support has also played an important role in lowering the costs of transportation fuel cells by 50% reduction since 2007 and DOE recently stated its plans to invest $30 million to help fuel cell and hydrogen technologies continue growing.[248] Other notable public sector financing resources for growing the ZEV and PHEV markets include grants and subsidies from the American Recovery and Reinvestment Act, as well as financing and tax incentive programs availed by the California Alternative Energy and Advanced Transportation Financing Authority.

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[247] DOE 2016c. U.S. Department of Energy. October 5, 2016. "Revolution…Now Rewind: Revving up the Electric Vehicle Market." http://energy.gov/eere/articles/revolution-now-rewind-revving-electric-vehicle-market.

[248] DOE 2016d. U.S. Department of Energy. October 5, 2016. "DOE Announces $30 Million Investment in Hydrogen and Fuel Cells as Industry Continues Unprecedented Growth Rates." http://energy.gov/eere/articles/doe-announces-30-million-investment-hydrogen-and-fuel-cells-industry-continues.

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VII. Data Source Descriptions

Staff analysis utilized an assortment of data sources. Each data source is described briefly below. Some data sources are used for multiple analyses. Only sources relied upon for original staff analysis are discussed in this section.

VII.A. Alliance of Automobile Manufacturers ZEV Sales Dashboard ("Dashboard data")

This data, referred to as "Dashboard data" in this document, was recorded manually from the Alliance of Automobile Manufacturers' publically available website ZEVFacts.com.[249] This site contains information for consumers on ZEV technology, background on the ZEV regulation, and a ZEV sales dashboard. The dashboard displays statewide cumulative and monthly ZEV sales figures for every state in the U.S. starting from January 2011 through the present.[250] Data for the ZEV sales dashboard is populated using information from a third party vendor that tracks new vehicle registrations across the US.

Dashboard data is aggregated by BEV, FCEV and PHEV technologies. The PHEV sales data includes sales of both TZEV and non-TZEV certified PHEVs as well as range-extended battery electric vehicles (BEVx). The dashboard omits sales of the Honda Fit EV, Honda FCX Clarity, and the BMW ActiveE, all of which were marketed in limited quantities prior to MY 2014 and all of which have since been discontinued. In addition to monthly sales figures, the dashboard displays light-duty vehicle (LDV) market share for each vehicle technology from calendar year 2013 through the present, which was used to approximate total statewide monthly LDV sales figure for each state.

VII.B. Experian Vehicle and Consumer Demographic data ("Experian Automotive data")

ARB licensed data from Experian Information Solutions, Inc., referred to as "Experian Automotive data" in this document, related to new and used vehicle registrations of BEVs, FCEVs, and PHEVs as well as "comparable" gasoline-only HEVs and ICE vehicles. The data set includes a total of 1 million observations for vehicles transacted from January 2011 through December 2015. Each observation provides details on vehicle characteristics, including vehicle identification number (VIN), purchase characteristics, and owner demographics. Some observations also include purchase price information, though generally only for registrations in states that have not adopted the ZEV regulation. Almost all BEV, FCEV, and PHEV registrations – both new and used – in the U.S. are included, regardless of vehicle seller. A random sampling of new and used comparable ICEs and HEVs drawn from California, Section 177 ZEV states, and states providing purchase price information comprise the remainder of the observations.

VII.C. California Department of Motor Vehicles Registration data ("DMV data")

California's Department of Motor Vehicles (DMV) provides ARB with periodic updates of BEV, FCEV, and PHEV registrations in California, referred to as "DMV data" in this document. These updates reflect the on-road statewide vehicle populations of each of the models. As opposed to cumulative new vehicles sales, these populations account for vehicle migrations and scrappage that may occur over time, though migration and scrappage is fairly minimal for recently

[249] http://www.zevfacts.com/sales-dashboard.html
[250] Most recent sales data is typically two months behind the current calendar month (i.e. Sales data for June is updated at the end of August).

purchased vehicles. DMV data were used to determine survey samples and provide additional detail on vehicle counts when other data sources were incomplete.

As vehicle license fees are based on a vehicle's value, registration records also include vehicle purchase prices, which represent the transaction price for new vehicles when a vehicle has not been transferred. Registration records also include the original base list price of the vehicle series, which is interpreted as the starting manufacturer suggested retail price of a vehicle model.

VII.D. Dealer Inventory data from Edmunds.com ("Edmunds.com Inventory data")

Data accessed through an application programming interface (API) on dealer inventory was collected once a week from Edmunds.com over a period of six months from October 15, 2015 through May 25, 2016. Parameters collected included vehicle specifications, dealer information, and inventory, including unique VIN. Inventory data was queried within a 30-mile radius of the seven U.S. cities shown in Table 25. Almost all of the cities are located in California or a Section 177 ZEV State and were selected based on their populations according to the 2010 U.S. Census. For comparison, inventory data was also collected from Seattle because while not a Section 177 ZEV State, Washington has had strong ZEV and PHEV sales and inventory may be transferred from neighboring Oregon.

The most centrally located ZIP code was chosen for each city. New Jersey was excluded from the analysis because the largest city by population, Newark, falls within the 30 mile search radius of New York City, the largest city in New York State. Staff chose the city of Albany to help explore whether there are regional differences within a given state.

Table 25 - Cities and Zip Codes Used for Dealer Inventory Queries

	City	State	ZIP code (radius=30 miles)
1	Los Angeles	CA	91423
2	Boston	MA	02118
3	Baltimore	MD	21201
4	New York	NY	10019
5	Albany	NY	12206
6	Portland	OR	97212
7	Seattle	WA	98102

Inventories the vehicles listed in Table 26 were collected. PEVs with national distribution as well as three kinds of comparison vehicles: “Comparable Vehicle,” represents the vehicle within a manufacturer’s vehicle lineup that most closely approximates the PEV model in terms of body size and style, or identical models with differing drivetrains whenever possible.; “Comparable Sales Volume” vehicles were chosen with similar national sales volumes to the PEV model; and "Best Selling Passenger Car" represents the *passenger car* within a manufacturer's portfolio with the highest national sales volume in 2015. In some cases, the same vehicle may represent multiple comparison vehicles.

Table 26 - Vehicle Models Used for Dealer Inventory Queries

Manufacturer	PEV Model	Comparable Vehicle	Comparable Sales Volumes	Best Selling Passenger Car
BMW	i3	i3x	M235	328
Ford	Fusion Energi	Fusion Hybrid	Focus ST	Fusion
Ford	C-MAX Energi	C-MAX Hybrid	Focus ST	Fusion
GM/Chevrolet	Volt	Cruze	Corvette	Cruze
Nissan	LEAF	Versa	Juke	Altima

While the data is extensive, it is possible that every dealer (and subsequent vehicle inventories), may not be included on the website. Although the data collected may not contain every vehicle in the dealership inventory, the data analyzed is a good representation of dealership availability for the regions.

VII.E. Ward's Automotive Data Center ("WardsAuto data")

Ward's Automotive maintains a paid subscriber-only section on their website, www.wardsauto.com that includes access to copyrighted, downloadable datasheets on a wide array of vehicles-related statistics, such as vehicle model year offerings, including specifications such as size class and manufacturer suggested retail prices, as well as manufacturer-reported nationwide monthly or annual sales of vehicle models. Data originating from these datasheets are referred to as "WardsAuto data" and form the basis for estimating sales volumes by varying manufacturer suggested retail price categories in the United States.

VII.F. Automotive News Data Center ("AutoNews data")

Automotive News maintains a paid subscriber-only data center through their website, www.autonews.com, that includes a searchable database on incentives offered by auto manufacturers (via dealers) for specific vehicle makes and models over time. The data include cash rebate amounts on purchases, discounted financing terms for borrowers, and other available discounts (e.g military personnel or recent college graduate discounts). This data, referred to as "AutoNews data" in this document, was recorded manually on a monthly basis from February to August 2016 based on searches for the ZIP codes listed in Table 25 of both ZEV and non-ZEV vehicle models offered by BMW, GM, Ford, Nissan, and Toyota shown in Table 27; although data for all auto manufacturers are available, these five manufacturers were queried based on distributing PHEVs and ZEVs nationwide, or having a best-selling vehicle.

Table 27 - Vehicles included in new vehicle dealer incentive analysis

Manufacturer	Model	Technology Type	Number of MY and Trim Level Combinations
BMW	2 Series	ICE	2
BMW	228i	ICE	1
BMW	320i	ICE	4
BMW	328d	ICE	4
BMW	328i	ICE	4
BMW	330e	ICE	2
BMW	330i	ICE	1
BMW	335i	ICE	3
BMW	340i	ICE	2
BMW	i3	BEV (and BEVx)	3
BMW	M2	ICE	1
BMW	M235i	ICE	2
BMW	M3	ICE	1
Ford	C-Max Energi	PHEV	2
Ford	C-Max Hybrid	HEV	2
Ford	F-150	ICE	106
Ford	Fiesta	ICE	1
Ford	Focus	ICE	26
Ford	Focus Electric	BEV	2
Ford	Fusion Energi	PHEV	5
Ford	Fusion Hybrid	HEV	10
Ford	Fusion	ICE	23
GM	Corvette	ICE	7
GM	Cruze	ICE	16
GM	Cruze Diesel	Diesel	1
GM	Equinox	ICE	2
GM	Volt	PHEV	5
Nissan	Altima	ICE	18
Nissan	Juke	ICE	6
Nissan	LEAF	BEV	7
Nissan	Maxima	ICE	1
Nissan	Versa	ICE	15
Toyota	Camry	ICE	3
Toyota	Camry Hybrid	HEV	3

VII.G. Clean Vehicle Rebate Programs and Surveys

California, Massachusetts, and Connecticut all offer rebates for new vehicle purchases of PHEVs and ZEVs. Program eligibility varies by state, though the Center for Sustainable Energy (CSE) administers all three programs.[251] Basic information on all of California's Clean Vehicle Rebate Project (CVRP) recipients, such as date of purchase, rebated vehicle including VIN, recipient's utility, and lease information is referred to as "CVRP rebate data." Rebate statistics are also available publicly through the Rebate Statistics Dashboard at:

- California: https://cleanvehiclerebate.org/eng/rebate-statistics
- Connecticut: http://ct.gov/deep/cwp/view.asp?a=2684&q=565018&deepNav_GID=2183
- Massachusetts: https://mor-ev.org/program-statistics

Each of these states has also been surveying their rebate recipients about their purchase motivations, purchase experience, and household characteristics. Based on current market shares of PHEVs and ZEVs, data sources of general new car buyers include only a limited number of actual drivers of these vehicles, making data sources focused specifically on these technologies more valuable. Table 28 summarizes the response rates for each PEV type.

Table 28 - Summary of CA, MA, CT rebate program survey responses

Vehicle Technology	CA CVRP Recipients	CA CVRP Survey Responses	CA Response Rate	MA MOR-EV Recipients	MA MOR-EV Survey Responses	MA MOR-EV Response Rate	CT CHEAPR Recipients	CT CHEAPR Survey Responses	CT Response Rate
PHEV	51,452	9,792	19.0%	963	313	32.5%	422	196	46.4%
BEVx	1,755	514	29.3%	-	30	-	75	18	24.0%
BEV<200	52,062	10,997	21.1%	804[252]	345[253]	42.9%[254]	161	112	69.6%
BEV200+	18,015	3,847	21.4%	703	193	27.5%	N/A	N/A	N/A
All	123,284	25,150	20.4%	2,470	851	34.5%	658	326	49.5%

Additionally, a cross-section of California rebate recipients was surveyed in April-May 2015 to learn about their PEV experience and attitudes to date. When analyzing these survey results, the vehicle technology categories were broken down into: PHEV, BEVx, BEV<200 (BEVs with less than 200 mile electric range), and BEV200+ (BEVs with more than 200 mile electric range). Details from these four surveys are discussed below.

VII.G.1. California Clean Vehicle Consumer Survey ("CVRP results")

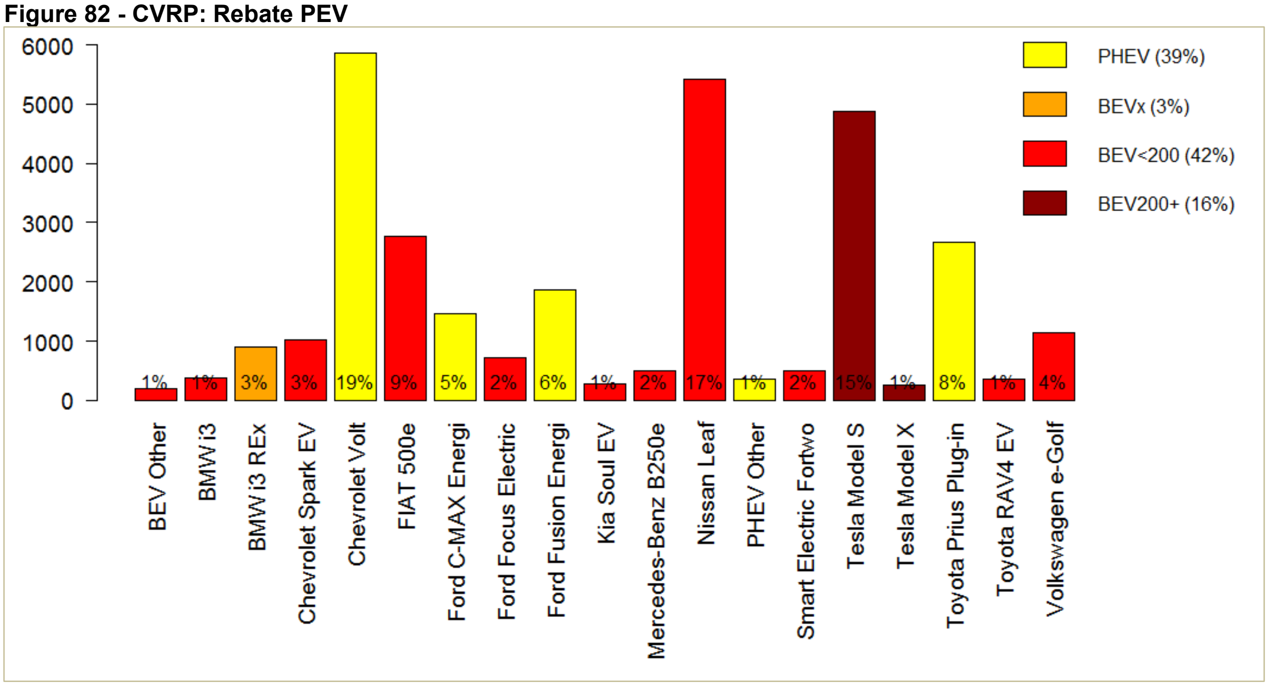
For the duration of California's CVRP program,[255] rebate recipients have been invited to complete a voluntary, on-line survey about their PEV purchase. Early rebate recipients were

[251] Additional details on these complementary policies can be found in Appendix E
[252] This number includes BEVx rebate recipients
[253] To be consistent with MOR-EV program guidelines, this number includes BEVx survey respondents
[254] This number includes BEVx in the response rate
[255] A complete description of California's CVRP is included in Appendix E.

invited to complete the survey following at least a six month ownership period, but beginning in 2014 rebate recipients were invited on a rolling basis as their rebate applications are received/approved, which generally occurs shortly after the vehicle has been purchased. Over time, the survey questionnaire has been revised periodically, though some questions have remained unchanged. Thus, some results presented are based on different sample periods and sample numbers, as noted. The results reported in this document are referred to as "CVRP results." Total responses cover invitations distributed to participants who purchased their vehicles between April 2010 and mid-June 2016. Although a limited number of FCEV drivers have been receiving rebates since the beginning of the CVRP, the survey was not designed to capture their purchase motivations and experiences until July 2016; to date, total responses from FCEV drivers are not sufficient for analysis.

Due to the small sample size for some PEV models, "other" categories were made by combining models that had fewer than 150 responses. The "Other BEV" category consists of BMW 1 Series Active E (n=12), CODA (n=5), Th!nk City (n=6), Tesla Roadster (n=20), Honda Fit EV (n=112), and Mitsubishi i-MiEV (n=48). The "Other PHEV" category comprises Audi A3 e-tron (n=86), Cadillac ELR (n=94), Honda Accord Plug-In (n=90), Hyundai Sonata Plug-in (n=69), Mercedes-Benz S-Class 550e (n=8), and Volvo XC90 T8 (n=15).

Figure 82 - CVRP: Rebate PEV



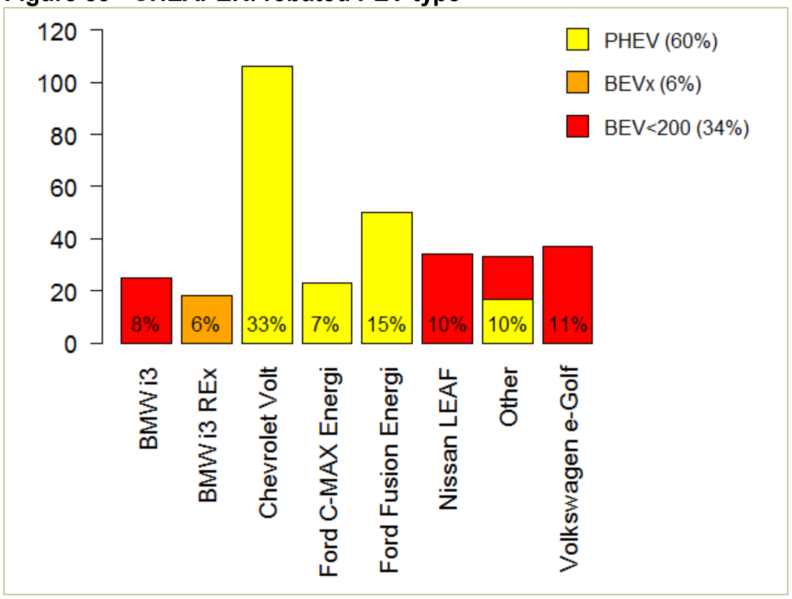
VII.G.2. Connecticut Hydrogen and Electric Automobile Purchase Rebate ("CHEAPR results")

For the duration of the CHEAPR program,[256] rebate recipients have been invited to complete a voluntary, on-line survey about their clean vehicle purchase.

[256] Full description of the CHEAPR program found in Appendix E.

PEV models with fewer than 10 total responses were combined to form the “Other” category, which includes the PHEVs Audi A3 e-tron (n=3), Hyundai Sonata Plug-in Hybrid (n=5), and Toyota Prius Plug-in Hybrid (n=9); and BEVs Ford Focus Electric (n=7), Kia Soul EV (n=1), Mercedes-Benz B-Class (n=4), and Smart Fortwo (n=4).

Figure 83 - CHEAPER: rebated PEV type



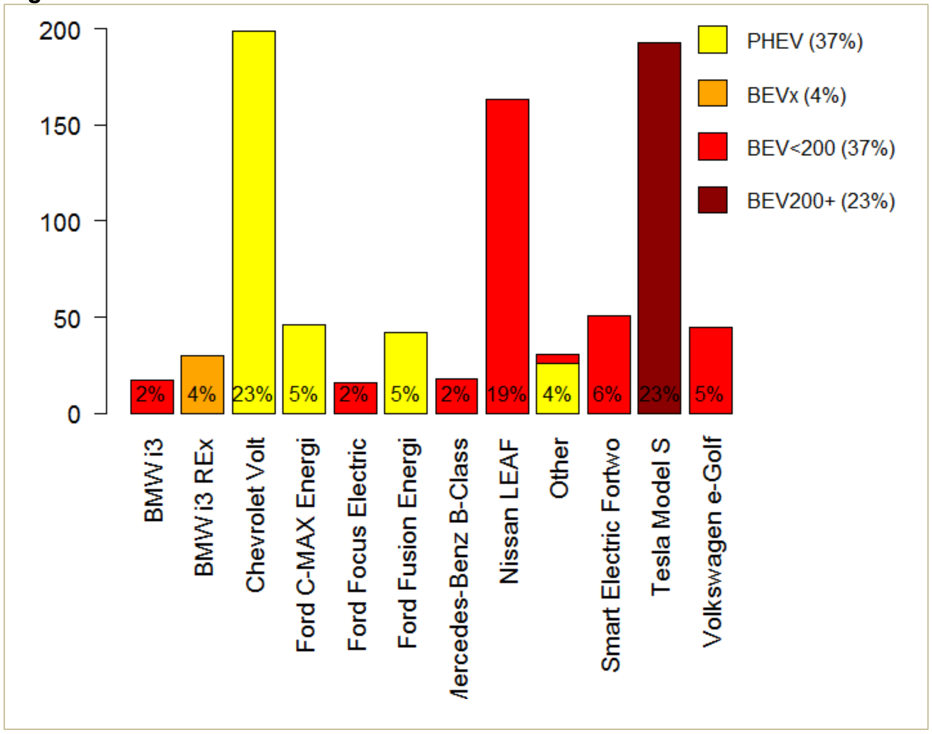
VII.G.3. Massachusetts Offers Rebates for Electric Vehicles ("MOR-EV results")

For the duration of the MOR-EV program,[257] rebate recipients have been invited to complete a voluntary, on-line survey about their clean vehicle purchase.

Some models were combined to form the “Other” category if the total responses per model were fewer than 10. The Other PHEVs includes BMW i8 (n=6), BMW X5 xDrive40e (n=2), Cadillac ELR (n=8), Porsche Cayenne S E-Hybrid (n=1), and Toyota Prius Plug-in (n=9). The Other BEVs includes Honda Fit EV (n=2) and Mitsubishi i-MiEV (n=3).

[257] Full description of the MOR-EV program found in Appendix E.

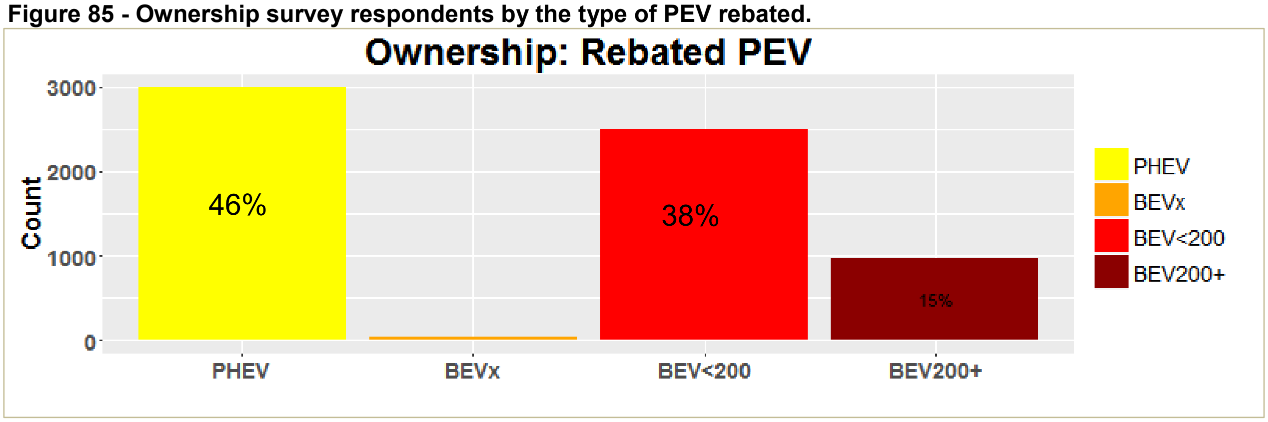
Figure 84 - MOR-EV: Rebated PEV



VII.G.4. California PEV Ownership Survey ("Ownership results")

The PEV Ownership Survey was administered between April and May 2015 by CSE on behalf of ARB. A total stratified random sample of 20,000 non-fleet CVRP recipients was invited to participate via email. All PEV owners invited had their vehicle registered with the California DMV as of October 2014. The goal of the survey was to understand the attitudes of individual owners or lessees of PEV consumers who had their vehicle for more than 6 months to ensure that they had sufficient time and experience with their vehicles to inform their responses. The sample chosen was stratified across counties and model years beginning with PEV purchased in 2011 to approximate the California population of PEVs. The overall response rate was 33% and the distribution of respondents' initial PEV types is shown in Figure 85. Note that a small

Figure 85 - Ownership survey respondents by the type of PEV rebated.



number of respondents no longer had the vehicle for which they received a rebate but this did not disqualify them from completing the survey. Overall, 46% of respondents originally had a PHEV followed by 38% with a BEV<200 and 15% with a BEV200+ and the overwhelming majority of all respondents bought or leased a PEV in 2013 or 2014. See Table 29 for a complete breakdown of respondents by PEV model and purchase year.

Table 29 - Ownership survey respondents by PEV model and purchase year

PEV	2011	2012	2013	2014	All
Chevrolet Volt	0	243	595	365	1,203
Ford C-MAX Energi	0	11	186	125	322
Ford Fusion Energi	0	0	151	188	339
Toyota Prius Plug-in	0	288	269	526	1,083
Other PHEV	0	0	23	30	53
BMW i3 REx	0	0	0	49	49
Chevrolet Spark	0	0	51	76	127
Fiat 500e	0	0	139	321	460
Ford Focus Electric	0	29	57	73	159
Honda Fit EV	0	8	38	26	72
Nissan Leaf	73	165	460	523	1,221
Smart Electric Fortwo	0	0	44	63	107
Toyota RAV4 EV	0	19	143	106	268
Other BEV<200	1	7	12	54	74
Tesla Model S	0	88	604	282	974
All	74	858	2,772	2,807	6,511

Note: shading represents PEV technology: yellow = PHEV, orange = BEVx, red = BEV<200, and dark red = BEV200+.

VII.H. Enhanced Fleet Modernization Program and Plus-Up Pilot Program

The Enhanced Fleet Modernization Program (EFMP) and Plus-Up pilot program, currently implemented in the South Coast and San Joaquin Valley air districts, started in July of 2015. The program provides incentives to low income residents living in or near disadvantaged communities to scrap their older, higher-polluting vehicles and replace them with fuel-efficient conventional or advanced technology cars. The incentive amounts depend on each applicant's household income and choice of replacement vehicle.[258] The price, mileage, and loan terms for the replacement vehicles used for analyzing the price of PEVs in the secondary market in these air districts come from the vehicle sales contracts, which the vehicle dealers submit to the districts directly.

VII.I. Powertrain Acceptance & Consumer Engagement survey ("PACE Survey")

Morpace first administered their Powertrain Acceptance & Consumer Engagement (PACE) survey in 2009 and has repeated this syndicated survey annually starting in 2013. ARB has

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[258] See https://www.arb.ca.gov/msprog/aqip/ldv_pilots/efmp_plus_up_faq.pdf for program details.

licensed the use of the complete respondent data for the 2013, 2014, and 2015 administrations. The 2015 PACE survey was administered between October 29 through December 1, 2015 to an online panel of new vehicle owners nationwide to assess their awareness and perception of alternative powertrain technologies as well as their household characteristics and other attitudes. The survey includes a total of 2,138 new car buyers, of which 136 drive PHEVs, 138 drive BEVs, and 154 drive HEVs.

The sample was weighted to be representative of vehicle segment/class distributions. 54% of respondents were male, 83% Caucasian, 79% married, 87% reside in single family house, 88% own their home, and over 70% had a college degree. The median age of respondents was 40 years old with a median annual income was $90,000 and a median household size of three. The weighted sample size of the study along with the sample sizes for each of the vehicle segments and by powertrain is shown in Table 30.

Table 30 - Morpace 2015 PACE Study Sample Sizes

Segment	Sample Size
Traditional Engines	1710
Mainstream Car	502
Luxury Car	286
Mainstream CUV/SUV	444
Luxury CUV/SUV	183
Pickup Truck	191
Minivan	104
Alternative Powertrains	428
Hybrid Electric Vehicle (HEV)	154
Plug-in Hybrid Electric Vehicle (PHEV)	136
Battery Electric Vehicle (BEV)	138
Total Sample	*2138*

VII.J. Alternative Fuels Data Center ("AFDC HEV sales data")

The U.S. Department of Energy's Alternative Fuels Data Center (AFDC) website provides analysis of U.S. alternative fuel vehicle sales. Data used by AFDC for analysis is gathered from public sources and available for download. Specifically, ARB staff downloaded HEV sales data, accessed at the AFDC website,[259] and referred to as "AFDC HEV sales data" in this document, which consists of HEV sales numbers from calendar year 1999 through 2015 for the US. This data serves as the basis for the number of HEV model offerings during this time period.

VII.K. CNCDA's California Auto Outlook Report ("CNCDA Quarterly Reports")

The California New Car Dealer Association (CNCDA) posts quarterly California Auto Outlook reports available through their website.[260] These reports provide data on individual manufacturer's California vehicle sales trends. Data on manufacturer's 2012 through 2015 annual new vehicle sales was gathered manually from this report. This data, referred to as

[259] DOE, 2016a. United States Department of Energy. January 2016. "Maps and Data – U.S. HEV Sales by Model." http://www.afdc.energy.gov/data/10301.
[260] http://www.cncda.org/Auto_Outlook.asp

"CNCDA Quarterly Reports," was used to determine statewide manufacturer market shares as well as estimates of vehicle segment shares and overall statewide market shares of best-selling vehicle models.

VII.L. ARB-contracted research

ARB's Research Division funds a number of extramural research projects on air pollution and climate change as part of the Board's Annual Research Plan. Research projects must first be approved by the board-appointed Research Screening Committee (RSC), comprised of eleven scientists and engineers from academia, government, or industry, before funding is awarded by the Board. Final reports are also reviewed and approved by the RSC before they are published following project completion on the projects' webpages. Three recent research contracts are relevant to assessing the PHEV and ZEV markets discussed in this appendix include:

- "New Car Buyer's Valuation of Zero-Emission Vehicles," Contract 12-332, University of California, Davis (UCD) (with additional funding from the Northeast States for Coordinated Air Use Management or NESCAUM), https://www.arb.ca.gov/research/single-project.php?row_id=65166, referred to in this document as "UCD New Car Buyers Study"

- "Examining Factors that Influence ZEV Sales in California," Contract 13-303, University of Los Angeles (UCLA), https://www.arb.ca.gov/research/single-project.php?row_id=65197, referred to in this document as "UCLA ZEV Sales Factors Study"

- "The Dynamics of Plug-in Electric Vehicles in the Secondary Market and their Implications for Vehicle Demand, Durability, and Emissions," Contract 14-316, University of California, Davis (UCD), https://www.arb.ca.gov/research/single-project.php?row_id=65236, referred to in this document as "UCD Secondary Market Study"