Equity Impacts of Fee Systems to Support Zero Emission Vehicle Sales in California

June 2016

A Research Report from the National Center for Sustainable Transportation

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National Center for Sustainable Transportation

ITS UC DAVIS INSTITUTE of TRANSPORTATION STUDIES

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U.S. Department of Transportation (USDOT) Disclaimer

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EXECUTIVE SUMMARY

To accelerate the market introduction of zero-emission vehicles (ZEVs, including battery electric and fuel cell electric vehicles) and transitional ZEVs (TZEV, including plug-in hybrid vehicles), customer incentives and subsidies may be needed for many years—until the additional cost to manufacture these vehicles decreases considerably. Currently, California provides $5,000 for the purchase of light duty fuel cell vehicles, $2,500 for battery electric vehicles, and $1,500 for plug-in hybrid electric vehicles, as part of its Clean Vehicle Rebate Project (CVRP-2, 2015), currently funded from revenues collected by the carbon cap and trade program, as well as motor vehicle fees. In FY 2015-2016, the state allocated $75 million for rebates under the program, which was not sufficient to cover the CVRP payments.

This report presents analysis results of potential designs of fee systems for the purchase of new (non-ZEV) vehicles that could help fund California's CVRP. Different CO_2-based fee structures were considered, and the potential incidence of these fees across household groups with different income levels was estimated. The study assesses different fee structures for the given rebate program, but it does not consider alternative rebate systems (only the existing CVRP system), so the term "feebate" is not used, but rather "vehicle fees" to describe the scenarios.

In the scenarios, each income group has been related to the typical California number and types of new light-duty vehicles purchased, including average CO_2 emissions of these new vehicles, to the fees they would pay (individually and as income groups) under the different fee structures. The 2010-2012 California Household Travel Survey data (including 2011-2012 and limited 2013 vehicle models) to explore these relationships, so they are at best only indicative of current and future relationships.

Six different fee structure policy scenarios were developed that apply various vehicle fees depending on a) the CO_2 emissions of individual non-ZEV vehicle models, b) possible adjustments to fees paid by lower income groups, and c) possible adjustment of fees by MSRP. All cases require the same total revenue target raised via these vehicle fees, so they represent six alternative ways to raise a set level of revenues to pay for CVRP rebates. The six fee structure scenarios all appear capable of raising $200 million per year, which is a level that should be sufficient to pay for CVRP rebates for ZEVs, at least through 2018. The presented scenarios all include a $100 minimum fee on those vehicles charged a fee, with varying maximum fees depending on the individual scenario assumptions.

For example, Scenario 1 applies fees to the purchase of all new (non-ZEV or TZEV) vehicles, with fees increasing in proportion to each model's tested fuel economy (converted to CO_2 emissions). Using the $100 minimum fee for purchasing the lowest CO_2-emitting cars results in

$210 high-end fee for the highest emitting cars, which when multiplied across sales of 1.5 million vehicles, reaches the $200 million revenue target. In Scenario 2, the fee was only applied to cars emitting over 250 g CO_2/mile; all cars below this emissions level (mostly hybrid cars) are exempt. In that case, the highest emitting cars are charged a fee of $230. In yet another scenario, fees were only applied to households with annual incomes above $75,000; lower income level households are exempt. This raises the high-end fee to $413. In all, Table 1 summarizes development of the six scenarios and compares them in terms of fees assessed by household income group.

Table 1. Scenario overview

	Scenario Description	Average vehicle fee	Average vehicle fee for households earning < $75,000	Minimum vehicle fee	Maximum vehicle fee	Vehicle fee at 90th percentile	Strengths	Weaknesses
Scenario 1	All vehicles and incomes pay	$144	$143	$120	$210	$158	Lowest max fee	Low income pays same as high income
Scenario 2	Exempt vehicles emitting below 250 g CO_2/mile	$144	$145	$135	$230	$168	Only higher emitting vehicles pay	Top fee higher than if all car CO_2 levels pay; though not many cars are below 250 g CO_2/mile, so not much different
Scenario 3	Exempt households with income below $75,000	$152	$0	$186	$413	$267	Only wealthier households pay	Top fee higher than if all HH's pay; some lower income HH's do buy expensive vehicles
Scenario 4	Exempt households with incomes below $75,000, and vehicles emitting up to 400 g CO_2/mile	$150	$80	$150	$283	$198	Lower income HH's pay for high CO_2 vehicles, but have many choices with no fee	Higher top fee, due to fewer vehicles included
Scenario 5	MSRP-based approach, vehicles pay only if MSRP over $27,000	$150	$99	$193	$583	$390	Those buying below-average priced cars do not pay	Some low price, high CO_2 cars are exempt; high average fee price for those who pay
Scenario 6	MSRP below $27,000 and emit below 400 g CO_2/mile	$150	$111	$215	$519	$352	Below average price, low CO_2 cars exempt	High top fee for those who pay

Main analysis insights:

- For those households buying new cars, both the expenditure level per car and the average CO_2 emissions per car increase substantially from lower to higher income households. Wealthier households buy many more vehicles emitting over 400 g CO_2/mile, although they also buy more vehicles below 200 g CO_2/mile (such as the Toyota Prius).
- To cover CVRP costs of up to $200 million per year (a significant amount more than what was spent in 2015, and within the expected requirements through 2018) the implementation of an average fee, on the order of $140 per non-ZEV/TZEV car will be needed. Alternatively, a flat 0.5% tax on vehicle price would also achieve this.
- The fee for different types of cars with different CO_2 levels, and average fees for different income households varies considerably depending on scenario assumptions.
- Fee structures that exempt very low-CO_2 emitting cars do not change the relative fee incidence on different income households significantly.
- Across the six scenarios, the fee per car purchased can be zero for many households, but can reach nearly $600 for households buying very high CO_2 vehicles. The average fee per household buying a new car does not rise above $150, even for the wealthiest households, with a smaller fee for lower income households in several scenarios.
- Fee levels would need to rise as the target revenue generation exceeds $200 million per year, which may occur from 2019 onward to support higher ZEV/TZEV sales levels.
- Exempting households that earn less than $75,000 per year shifts the average fee for other households from about $150 up to over $200 per vehicle. Combining the $75,000 income exemption with a requirement that vehicle CO_2 be below 400 g CO_2/mile to be exempted results in about a $50 average fee for those lower income households (with some paying nothing and others paying more than $100 per car).
- Exempting vehicles priced (MSRP) less than $16,000 has a relatively small effect, but setting the exemption at an MSRP of $27,000 has a significant effect, since 55% of all new vehicles purchased were below this price. In this case, household average fees rise in direct proportion to income. Also, requiring vehicles to have less than 400 g CO_2/mile does not substantially change this result.
- Overall it appears possible to construct vehicle fee systems that raise $200 million with fairly equal impacts across households of different income levels, or with significantly greater impacts on higher income households, depending on the design. The average fee per vehicle sold would likely be under $150 and the highest fees per vehicle could be kept below $250, depending on design.

Looking out to 2025

- The results in this study, focused on raising $200 million per year, are at most relevant to the CVRP through 2018. After that year and with the current incentive levels, it is likely that as ZEV and TZEV sales rise rapidly, as could the required rebate expenditures. If this occurred, one factor that could become more relevant is the consumer response to higher per-vehicle fees, such as shifts to lower CO_2 vehicles.

- In this project, such potential shifts in vehicle purchases as a result of the six proposed fee structures were not assessed. The highest ratio of vehicle fee to vehicle MSRP in any scenario considered here is about 1.8%, with an average ratio of about 0.5%. This is not expected to trigger a significant shift in vehicle preferences or purchase patterns. However, if revenue requirements rise and fees rise accordingly, analysis of potential purchase shifts related to fee structures could become an important consideration. Purchase shifts tend to help increase the sales of ZEVs and TZEVs since they will receive rebates, while other vehicles would be assessed fees. Future research could consider this dynamic.
- A simplified projection of the fee structures to 2025, assuming slow growth in LDV sales (reaching about 1.8 million in 2025, but with rising ZEV and TZEV sales and market shares as foreseen in the California ZEV mandate, causes an increase in average fees up to over $700 by 2025. This also reflects a decline in the number of vehicles that would be assessed fees, since 22% of vehicles in that year are assumed to be ZEV or TZEV. This estimate is a "ballpark" estimate, since a) the structure of sales and the number of vehicles sold may change dramatically by 2025, and b) fees approaching $1,000 per vehicle may trigger purchase shifts that should be taken into account. A full analysis looking out to 2025 would be much more complex than this study, but would be useful follow-on research.

Potential Future Research

This project has undertaken what could be called first steps of research in investigating possible funding systems for the CVRP. Follow-up research could include a number of activities, including:

- Creating a more detailed projection of California vehicle sales to 2025 by household type, incorporating expected evolution of income and demographic characteristics as well as changing vehicle technologies and potential reductions in new conventional vehicle CO_2 levels.
- Also for a 2025 projection, applying market purchase response functions to changes in vehicle prices, using an appropriate vehicle market model.
- Investigation of other revenue raising concepts and their equity impacts, such as annual registration fees across all owned vehicles (not just new ones) or vehicle in-use fees (e.g. fuel pricing, road pricing or VMT fees) that could be related both to CO_2 emissions and to electric v. non-electric driving.
- Broadening the geographic scope of the work to include other states or national level analysis (such as a national feebate).

Introduction

The State of California is interested in accelerating the penetration of low-carbon vehicles, including zero-emissions vehicles (ZEV) and transitional ZEVs (TZEV). California's ZEV mandate will require 22% of vehicles sold in the state to be ZEV or TZEV by 2025 (ARB-2 2014). Current regulations require 3% of vehicles sold in California to be ZEV or TZEV, which will remain the case through 2017 (ARB-1 2014). Development of this market will require support by vehicle manufacturers, government, consumers, and other stakeholders to help the market reach this point. A key policy to support the ZEV program is the Clean Vehicle Rebate Project (CVRP). This program provides rebates of up to $5,000 per vehicle, and in FY 2015 - 2016 the state allocated $75 million for rebates under the program.

As ZEV sales rise in the future, the funding requirements may also grow, as presented in Figure 1. The figure depicts actual monthly rebate amounts paid from 2011-2015 (CVRP 2016) plus two additional projections extrapolated looking towards three years in the future. One projection is based on the future growth of the total amount of rebates paid, suggesting the need for $15 million in rebate funds. The second projection extrapolated future expenditure of about $13 million, based on projecting BEV and PHEV sales, and then combining the results. A key question is how to continue to fund the program.

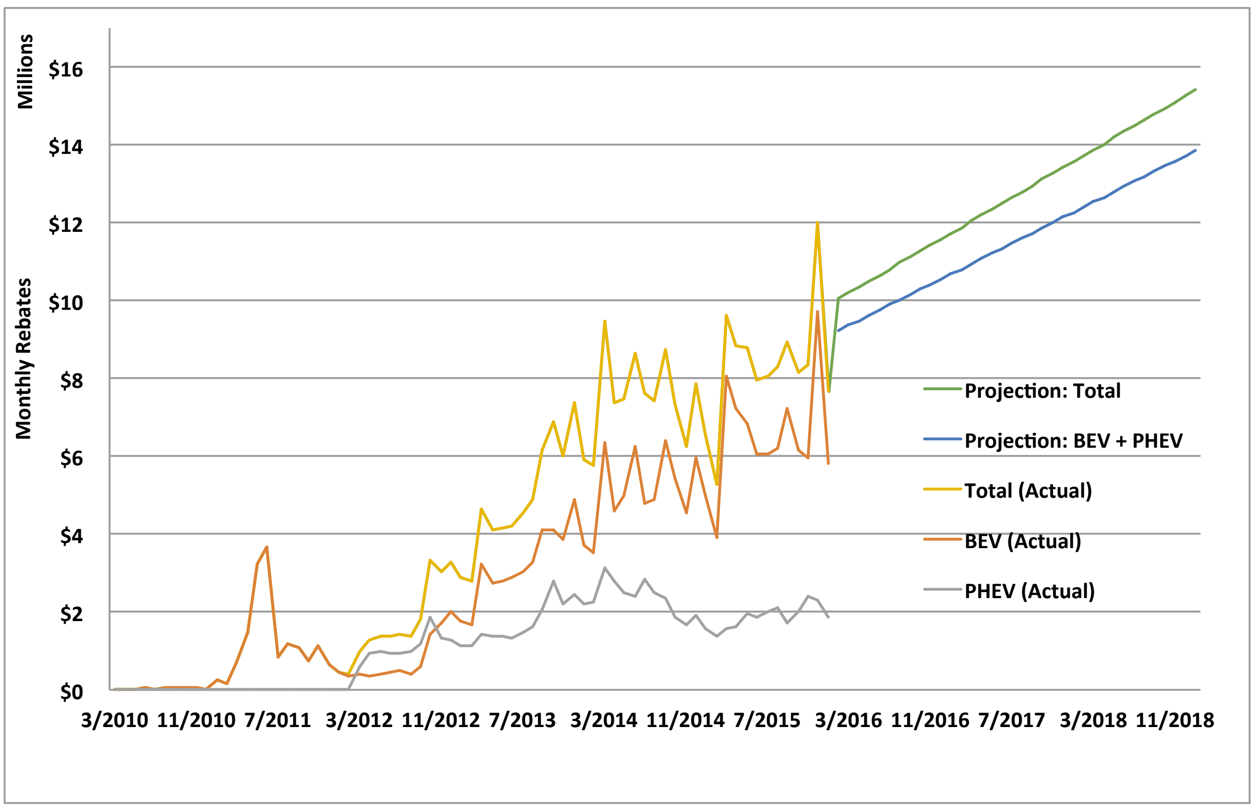

Figure 1: Actual CVRP and potential future rebate monthly payments

One potential mechanism to do this is by applying a fee to the sales of non-ZEV/TZEV vehicles. A fee structure can be a powerful mechanism, since this policy approach can generate a sustainable revenue stream to support the needed incentives and related expenses, and can also directly encourage consumers to buy ZEVs via the price signals they provide in the marketplace. Additionally, fee structures have the potential to address equity implications concerning policy makers about current federal and state incentives, and the funding sources of these incentives.

This study builds on the ITS-Davis feebate study conducted during 2008 to 2010 (Bunch and Greene, 2010) by exploring fee structure scenario alternatives in terms of their impact on different types of vehicles and households in California. This project focuses on a near-term distributional impact analysis of the incidence of different fee structures on different households (broken out by income groups), without looking at more complex fee structure issues such as vehicle manufacturer responses or consumer purchase responses. Further, the data used in this project focuses on the recent new car market (based on 2011-2013 data) and how the different fee structures would impact this market. (A more forward looking analysis, with projections of household income, purchase patterns and ZEV-related fees and rebates out to 2025 could be considered as a follow-on study.)

This report includes a brief review of recent research on feebates and vehicle fee-related policies (particularly the Bunch and Greene (2010) study that included California in its analysis), a review of the relevant California policy context, a snapshot of recent California household characteristics (and income distributional aspects), and an analysis of six different types of potential fee structures based on new car purchases that appear capable of raising enough revenue to fund the CVRP, at least in the short term through 2018. Finally, potential extensions of this analysis are identified, including making projections to 2025 that could be undertaken in a follow-on project.

A Brief Review of Relevant Literature

Many studies have assessed the potential for fee structures to impact vehicle sales, energy use, and CO_2 emissions. Some studies have used modeling approaches (e.g. Bunch and Greene, 2010) and some have assessed existing fee structure programs (mostly in Europe). The current research on fee structures generally suggests that fee systems provide powerful incentives to vehicle purchasers to shift to more efficient, lower carbon vehicles and to vehicle manufacturers to produce such vehicles, as evidence in the United Kingdom (Brand, et al, 2011) and Ireland (Rogan and Dennehy, et al, 2011). Bunch and Greene provide a detailed review in their report; there are also a number of papers on European fee structure systems.

The Bunch and Greene (2010) study is especially relevant for the current project since it covered the California and U.S. light-duty vehicle (LDV) market. Their paper used feebates, a combination of fees and rebates based on vehicle emissions, and determined that a range of different feebates could significantly reduce greenhouse gas (GHG) emissions in California, with other net positive societal benefits such as reduced vehicle lifetime fuel costs. However, implementing a feebate policy only in California will create a system that lacks the leverage to change the production plans of manufacturers significantly, as well as the buying habits and preferences of the rest of the nation. A nation-wide policy has greater potential to reduce CO_2 emissions. Bunch and Greene also found that designing a feebate program to be a revenue neutral system is challenging since it involves predicting purchasing patterns with periodic adjustments to the feebate. They did not look specifically at feebate programs involving ZEVs or the current CVRP program, since their study was undertaken prior to the current CVRP program.

Recent studies in Sweden and Norway proved beneficial in aiding rebates for low-emitting vehicles. Europe tends to favor compact vehicles. However, larger vehicles tend to dominate Sweden's roads. This, along with a European Union directive stating that the average CO_2 emissions for new cars must be less than 200 g CO_2/mile by 2015 and 153 g CO_2/mile by 2021 (European Commission 2015), has motivated Sweden to make changes. Sweden's goal is to have a fossil independent car fleet by 2030 and to be fossil free by 2050. A 2015 Swedish study (Habibi, Hugosson, et al, 2015) based on the 2013 car fleet looked at four different fee structures (referred to as bonus-malus) and ways to incorporate emissions fees as different taxes. Their results show that consumers will not change purchasing decisions based on a fee assessment, and will continue to purchase their vehicle of choice. Sweden also did not achieve their emissions goals. However, the bonus-malus is successful in generating enough money to fund the rebate portion. The study suggests Sweden needs additional policies in order to reach its target emissions goals and find ways to motivate consumers to purchase cleaner vehicles.

Norway faces similar emissions problems since it witnessed an increase in personal vehicles and vehicle miles traveled. Due to these increases, Norway's vehicle emissions are 30% higher than numbers recorded in 1990. A 2014 study looked at Norway's 2007 vehicle registration tax reform (Ciccone 2014), which aims to reduce emissions by disincentivizing high emitting vehicles. Norway does not manufacture any cars, so it must implement policies in order to be effective at reducing vehicle emissions. Norway's emissions tax is at time of purchase, and is most effective because their consumers are typically swayed by price. Previous taxes were based on engine-size, but have been updated to reflect CO_2 emissions. Norway's bonus-malus is politically acceptable because its goal is revenue neutrality. In 2007, the average car emitted 257 g CO_2/mile. Norway successfully reduced emissions of new vehicles by 10 g CO_2/mile when the policy was first enacted in 2007. Researchers estimate this was partially due to a 23% increase in the market share of diesel cars and a 12% decrease in the market share for high-emitting vehicles, as well as improvements in fuel economy.

What is clear is that with the current CVRP purchase incentive program for ZEV and TZEV vehicles, a fee structure overlaid on this could provide: revenues to help pay for the existing incentives, and a stronger incentive for consumers to shift their purchases to lower emitting vehicles with incentives (since more vehicles would also have fees associated with their purchase).

An element missing in Bunch and Greene, as well as other studies, is an analysis of the potential impact of different fee structures on different types of households (in terms of income, purchase patterns, or other characteristics). This project investigates this question and provides an initial analysis of fee structures in the California context, providing a contribution that builds on this previous work.

Current California Policy

California has a range of current policies that incentivize purchasing low-emitting personal vehicles. These include the CVRP and related bills AB 118 and SB 1275, among others.

ARB's Low Carbon Transportation and AQIP (Air Quality Improvement Program) fund the CVRP, which is the current source for plug-in vehicle rebates. For FY 2015-2016, the California Air Resources Board (ARB) allocated $75 million in rebates, and has already run out of funding. CVRP incentives are as follows: ZEVs powered only by a battery (BEVs) and produce no tailpipe emissions qualify for a rebate of $2,500, Fuel Cell Electric Vehicles (FCEVs) receive $5,000, and Plug-in Hybrid Electric Vehicles (PHEVs) receive a $1,500 rebate.

Senate Bill 1275, The Charge Ahead California Initiative, aids lower-income car buyers in their efforts to support the environment and purchase clean vehicles. The bill places a cap on the maximum allowable annual household income eligible for the CVRP. Income thresholds based on tax returns require ZEV rebate eligibility based on single filers earning less than $250,000, $340,000 for head of households, and $500,000 for filing joint, which went into effect in March 2016. Households purchasing FCEVs are not subject to the income cap for the first three years of the bill. Additionally, the law increases the rebate amount for lower-income households by $1,500. Furthermore, SB 1275 gives authority to ARB to decrease rebate amounts as necessary, in order to continue incentivizing clean vehicle purchases. As the ZEV market grows, ARB suggests the rebate amounts will diminish, though incentivizing purchases is important to entice consumers to buy these vehicles in order to meet the ZEV mandate requirements. The vehicle incentive amounts by type of vehicle and household income are shown in Table 2.

Table 2. Summary of CVRP incentive amounts under SB 1275

			Vehicle Type		
	Filing Status	Income Level	FCEVs	BEVs	PHEVs
Increased Rebates for Low/Moderate Income	< 300 percent of federal poverty level (FPL)		$6,500	$4,000	$3,000
Standard Rebate	Individual	300% of FPL to $250K	$5,000	$2,500	$1,500
	Head-of-Household	300% of FPL to $340K			
	Joint	300% of FPL to $500K			
Income Cap	Individual	> $250K	$5,000	Not Eligible	
	Head-of-Household	> $340K			
	Joint	> $500K			

Source: ARB 2015

Analysis Approach

This fee structure analysis focuses not on future potential structures of rebates under the CVRP or related programs, but instead on potential fees on non-ZEV/TZEVs that could be deployed to cover rebate costs under the CVRP. This study also does not estimate market responses to the various fee structures considered, but focuses on assessing and reporting the incidence of the particular fee structures on different types of cars and different household income categories.

This analysis is based on historical data. No projections have been made at this time, though that would be a next phase of the analysis. The goal is to first understand the current and recent nature of vehicle purchases across different household incomes for potential CVRP costs in the next few years, before looking out to 2020 and beyond.

Data used for this analysis was collected from the 2010-2012 California Household Travel Survey (CHTS). There were 42,431 households who completed the survey, divided into 10 income groups, and encompassing over 70,000 vehicles. A subset was created based on new vehicle purchases, encompassing Model Year 2011-2013 vehicles. Some 2013 vehicles are included in this survey since they were available for purchase at the end of 2012. The subset represents about 13% of all CHTS households. Not many TZEVs and ZEVs were sold in these years. As a result, the study focuses on the rest of the vehicle market, and looks at fee structures on these non-TZEVs and non-ZEVs that would raise enough revenue to pay for all the rebates actually distributed by the CVRP. It is estimated to require $200 million (a rough estimate based on previous rebate totals and budgeted payments of $160 million during 2015)[1].

To understand which households are purchasing new vehicles and the kinds of vehicles that are purchased, the study first looked at household incomes of new car buyers, their expenditures on new light-duty vehicles, and the emissions associated with those purchases. The household incomes were self-reported as part of the CHTS, and were not verified.

Figure 2 shows the population distribution of those households participating in the CHTS, weighted by region to denote the state's population, as compared to those households who actually purchased at least one model year 2011-2013 vehicle, based on household income. It also shows the percentage of households within each income group of the CHTS who purchased new vehicles, as well as the percent of new vehicle buyers per income group. The survey includes some Model Year 2013 vehicles, since they were available for purchase at the end of 2012.

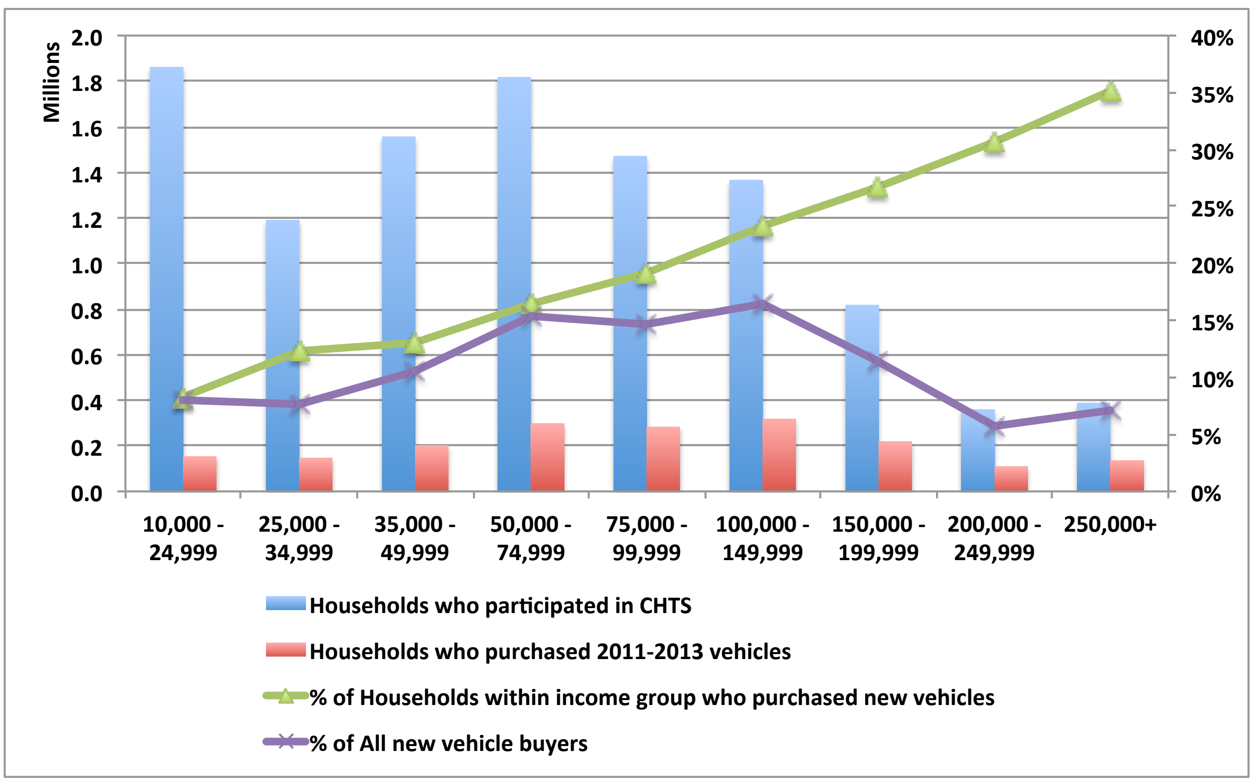

Figure 2. Population representation of new car buyers as compared to overall population

[1] However, in 2015 the final budget allocation was only $75 million, with requests pending for additional funding.

It should be noted that households earning less than $9,999 annually account for a very small share of purchases, and is a bit of a mixed group – some members clearly have access to funds to buy expensive vehicles (e.g. perhaps some are students or households with temporarily low incomes). This group has been dropped from the analysis and is not shown in any figures.

Figure 3 illustrates that households in the $100,000 to $149,999 income bracket buy the most vehicles, though households between $50,000 and $199,999 all buy a relatively large share of vehicles purchased. Households earning less than $75,000 buy approximately 29% of the vehicles, with 71% purchased by households earning more than $75,000. For those households buying new vehicles, both the expenditure level and the average CO_2 emissions increase as household income grows.

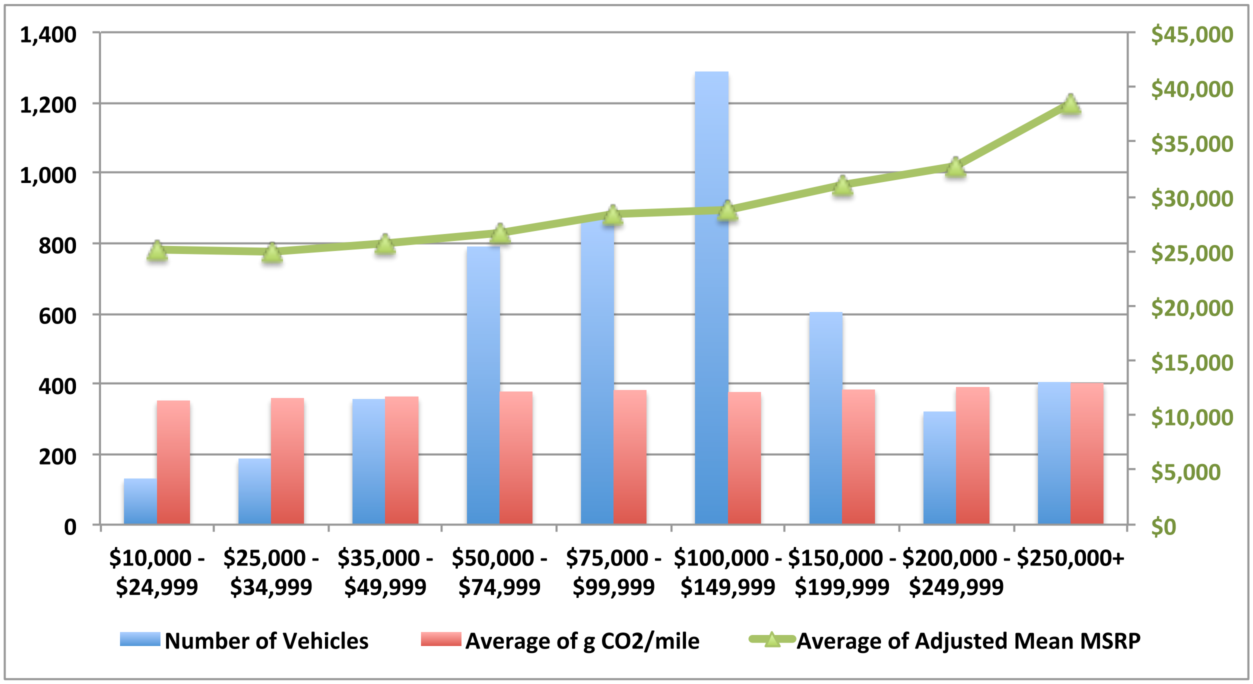

Figure 3. Distribution of new vehicle purchases, CO_2 emissions levels, and purchase expenditures by household income group

At the vehicle level, Figure 4 displays the CO_2 distribution of new 2011-2013 vehicles in the CHTS database across vehicle body types, exhibiting a wide range of emissions. The mean emissions is about 379 g CO_2/mile while the minimum is less than half this, with the Toyota Prius Hybrid emitting 178 g CO_2/mile. At the high end, a few vehicles emit over 500 g CO_2/mile, although 90% of all sales emit below 500 g CO_2/mile. The highest emitting vehicles are trucks, with the Chevrolet Silverado 3500HD peaking out emissions at 925 g CO_2/mile, with other Ram, GMC, Chevrolet, and Ford trucks following closely.

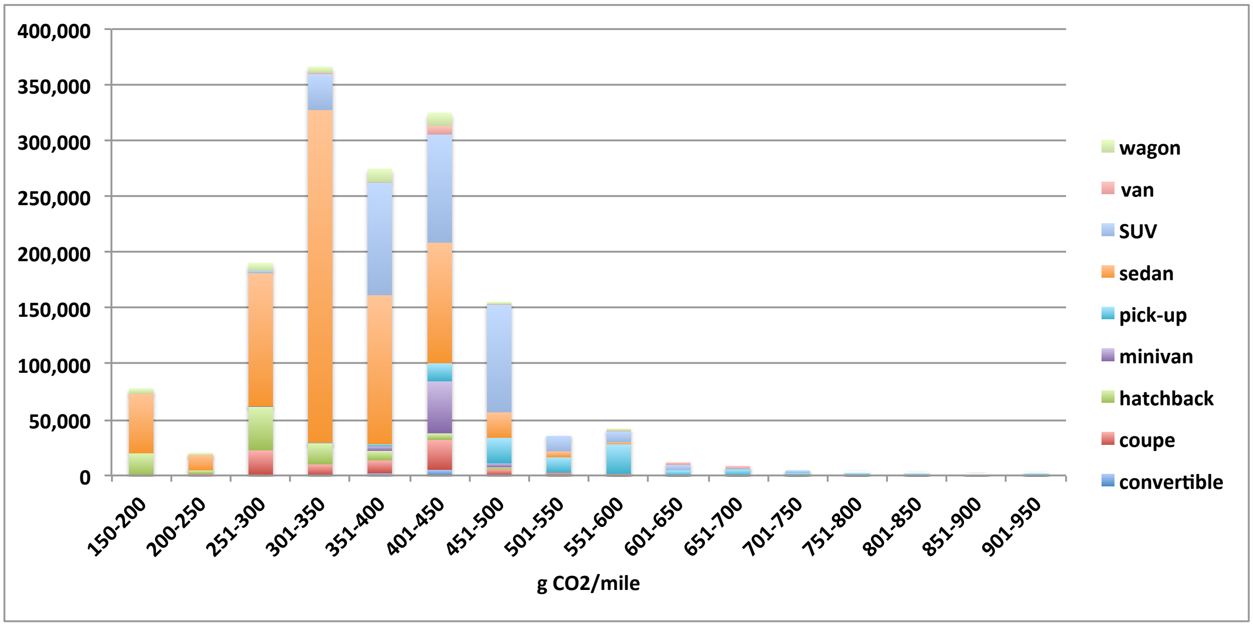

Figure 4. CO_2 characteristics and weighted distribution for new cars, 2011-2013

The expenditure effect, shown in Figure 5, presents the share of purchases by vehicle price (Manufacturer Suggested Retail Price, MSRP) across different household income groups. As income increases, households purchase more expensive vehicles. Edmunds.com data added MSRP values, was linked to the CHTS survey by comparing self-reported vehicle characteristics to the Edmunds information, and then adjusted to 2011 dollars.

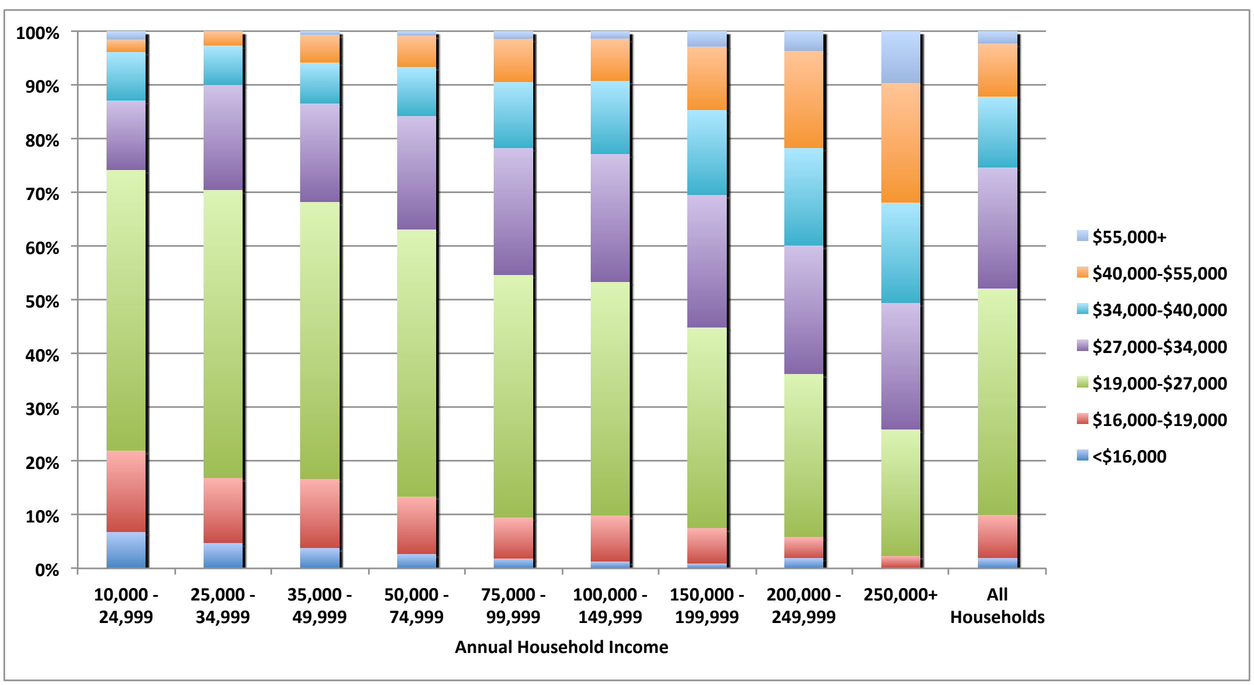

Figure 5. Distribution of new vehicle adjusted MSRP per annual household income

The total MSRP expenditure as a percentage of total household income is displayed in Figure 6. The relationship between vehicle expenditure changes drastically as income increases. The lower income households spend more than their income when purchasing new vehicles. For those households earning less than $75,000, 53% of their income was spent on a new vehicle, whereas households earning more than $75,000 used 21% of their income on a new vehicle. This also assumes the vehicle was paid for in its entirety at time of purchase and ignores the possibility of vehicle financing.

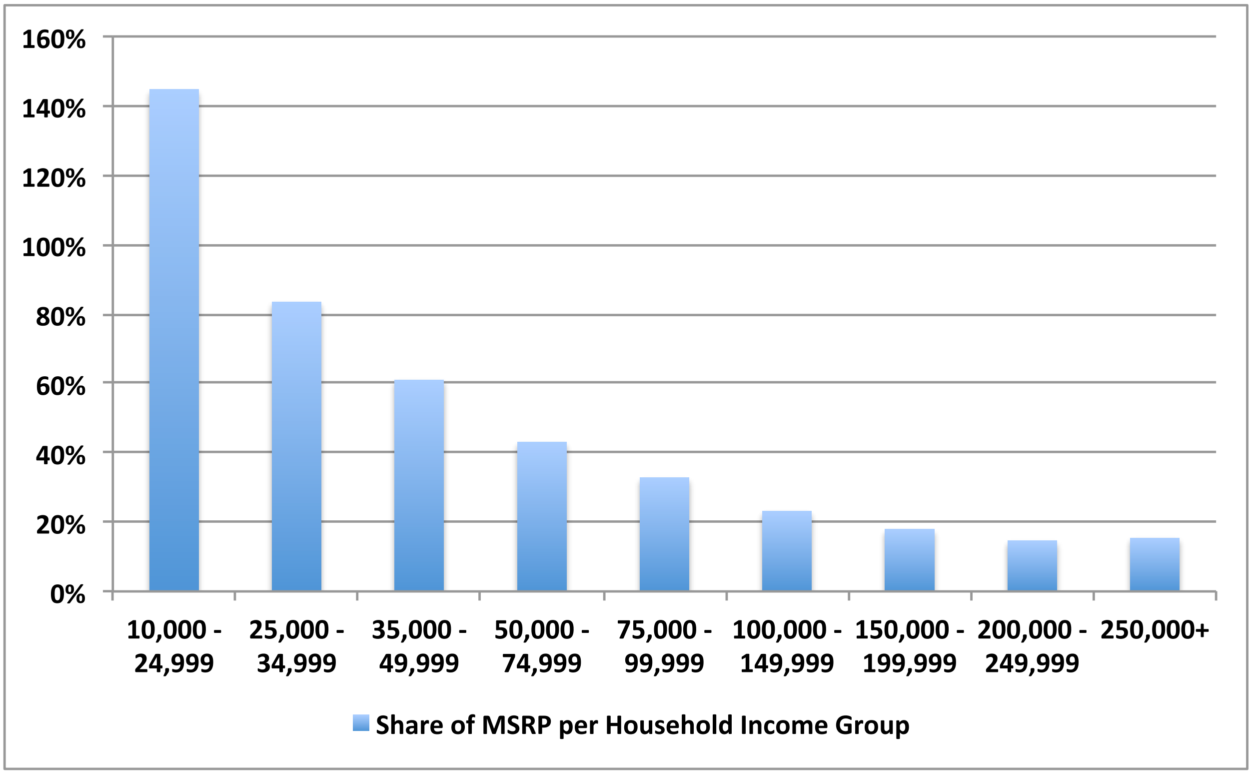

Figure 6. Share of new vehicle expenditure by total income

Figure 7 shows CO_2 emissions distribution from new vehicles, which were assigned to eight different emissions categories. There is a shift from models in the 300-400 g CO_2/mile range into the 400-500 g CO_2/mile range, as household income increases, most visible as income grows above $150,000.

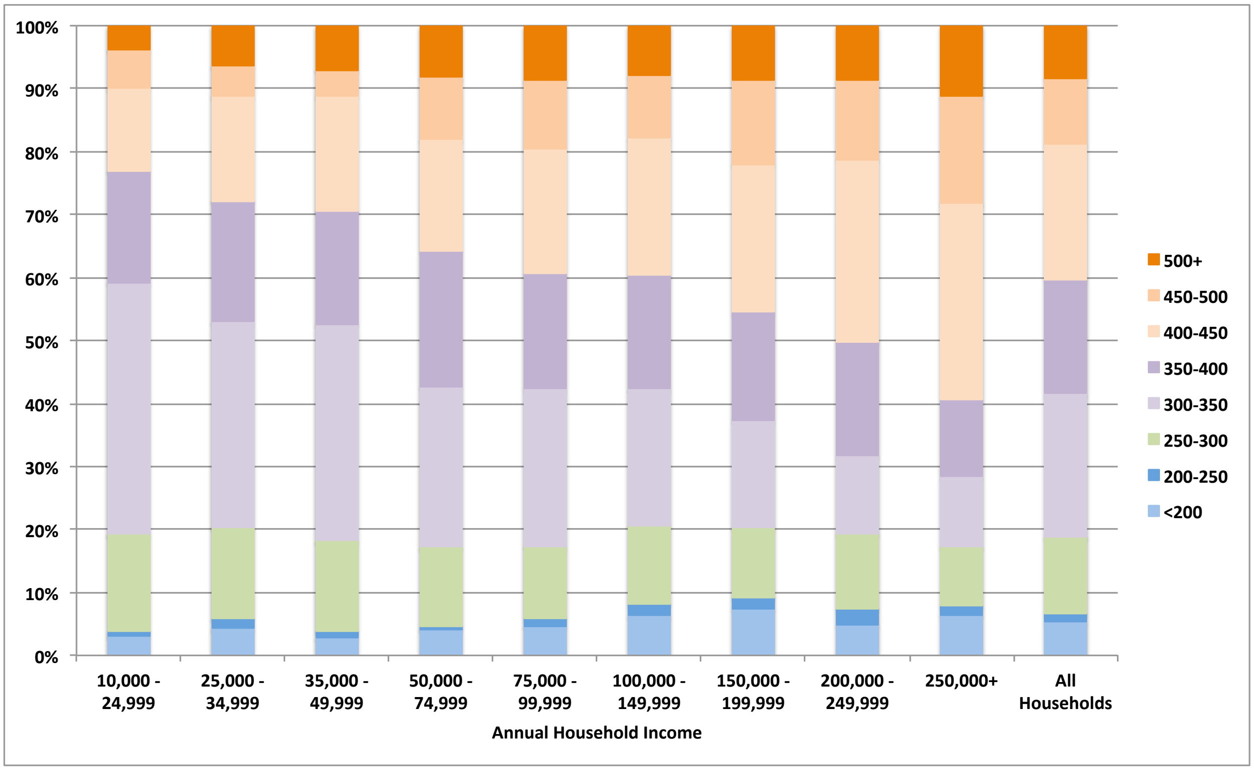

Figure 7. Distribution of vehicle GHG emissions (g CO_2/mile) per annual household income

Also noticeable, in Figure 8, are models emitting less than 250g CO_2/mile per are more common in the higher income households. Households earning less than $75,000 purchase 20% of these low emission vehicles, with the remaining 80% purchased by households earning more than $75,000. However, the net effect on average CO_2 is relatively minor (as shown in Figure 3), since the number of hatchbacks and SUVs increased and pickup trucks decrease in the highest income households.

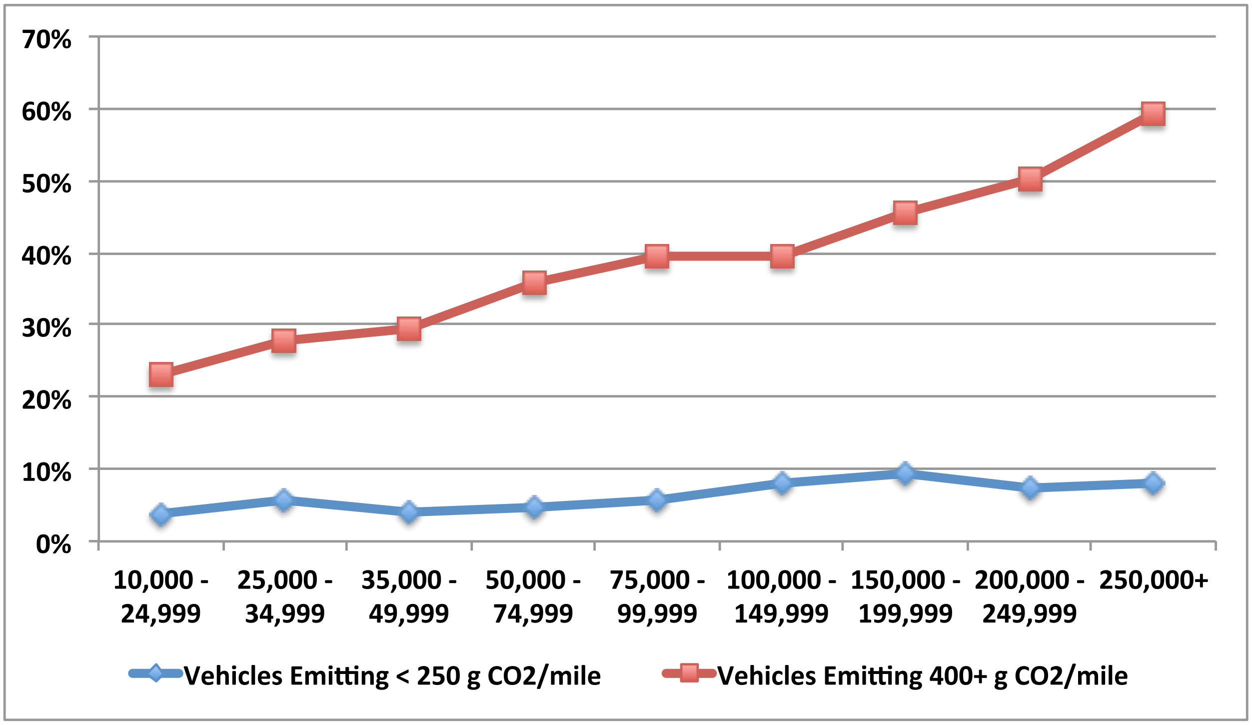

Figure 8. Share of new vehicles emitting less than 250 g CO_2/mile and more than 400 g CO_2/mile by households income

Vehicles emitting less than 250 g CO_2/mile encompass hybrids, BEVs, and PHEVs. Figure 9 shows that as household income increases, so does the trend in purchasing PHEVs, hybrids, and BEVs.

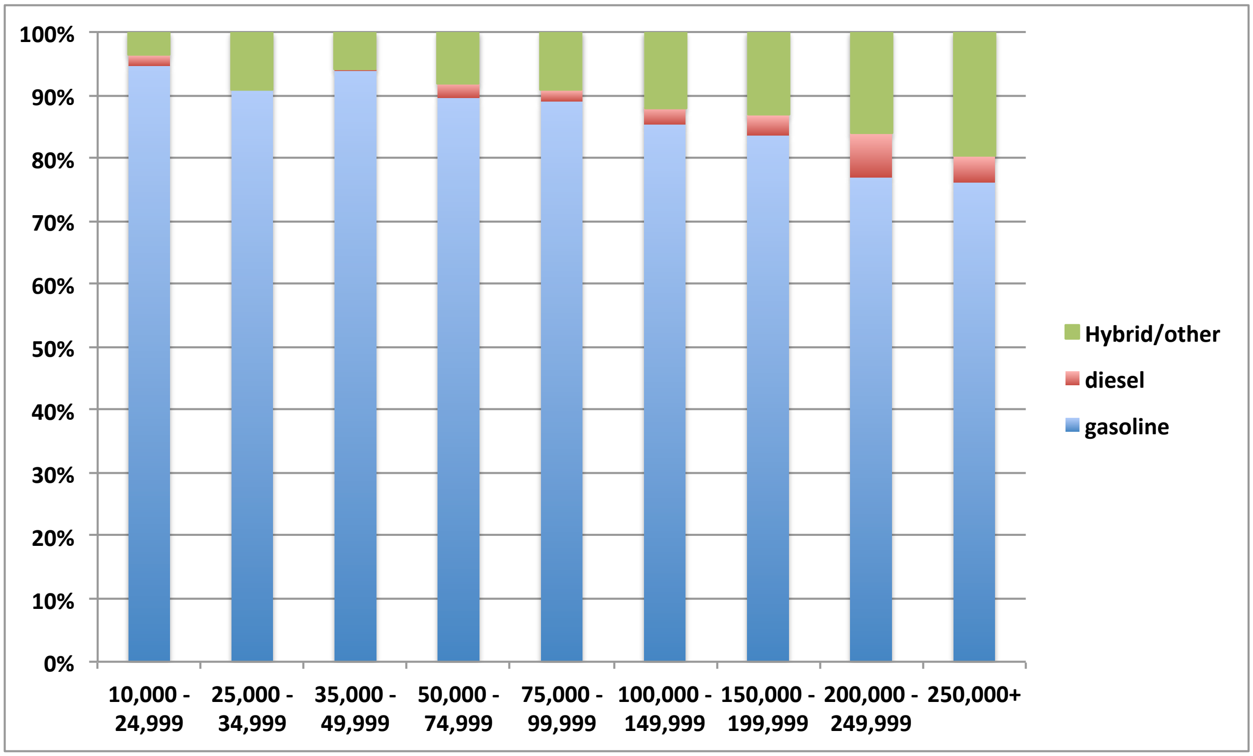

Figure 9. Share of new vehicle types purchased by household income

Figure 10 presents the distribution of household income among those who recently purchased ZEVs or TZEVs, received a rebate through the CVRP program, and participated in a CVRP survey. On average, about 80% of these households had incomes greater than $100,000 and 40% had incomes above $200,000, much higher than the percentage of all new car buyers in a similar period. Comparing the CVRP data to the CHTS new car buyers, households with incomes greater than $100,000 purchased about 66% of the ZEVs or TZEVs and about 29% had incomes above $200,000. About 34% of the CHTS new car buyers had incomes less than $100,000.

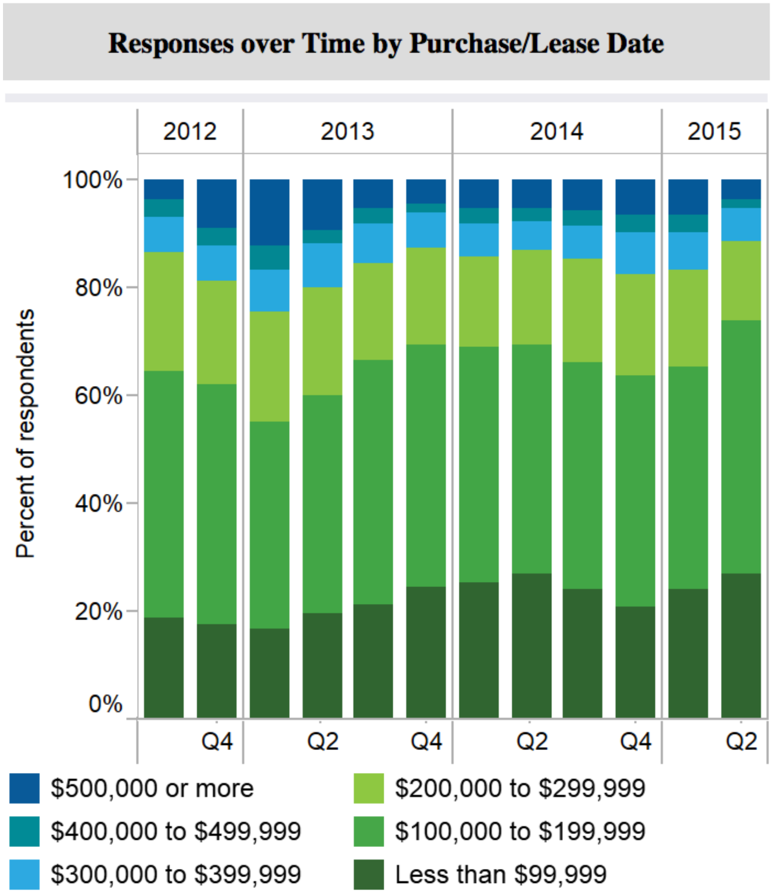

Figure 10. Annual household income based on a subset of respondents who received rebates between September 1, 2012 – May 31, 2015. Source: California CVRP 2015

Finally, Figure 11 shows the breakdown of new car sales by body type per income group for model years 2011-2013. As shown, households in the $100,000 to $150,000 income category purchased a strong plurality of new LDVs. Even much lower income households, such as $35,000 to $50,000, purchased a significant number of new LDVs. Figure 11.b shows the distribution of sales is remarkably stable across income categories, with a slight trend toward more sport utility vehicles (SUVs) and fewer sedans, as income moves from the lower to higher brackets. Looking at the split between households earning below and above $75,000, the higher income households purchased 74% of the SUVs (25% purchased by lower income households) and 68% of sedans (32% purchased by the lower income households). Also, the average vehicle emissions for each body type are noted, which tend to increase as income grows.

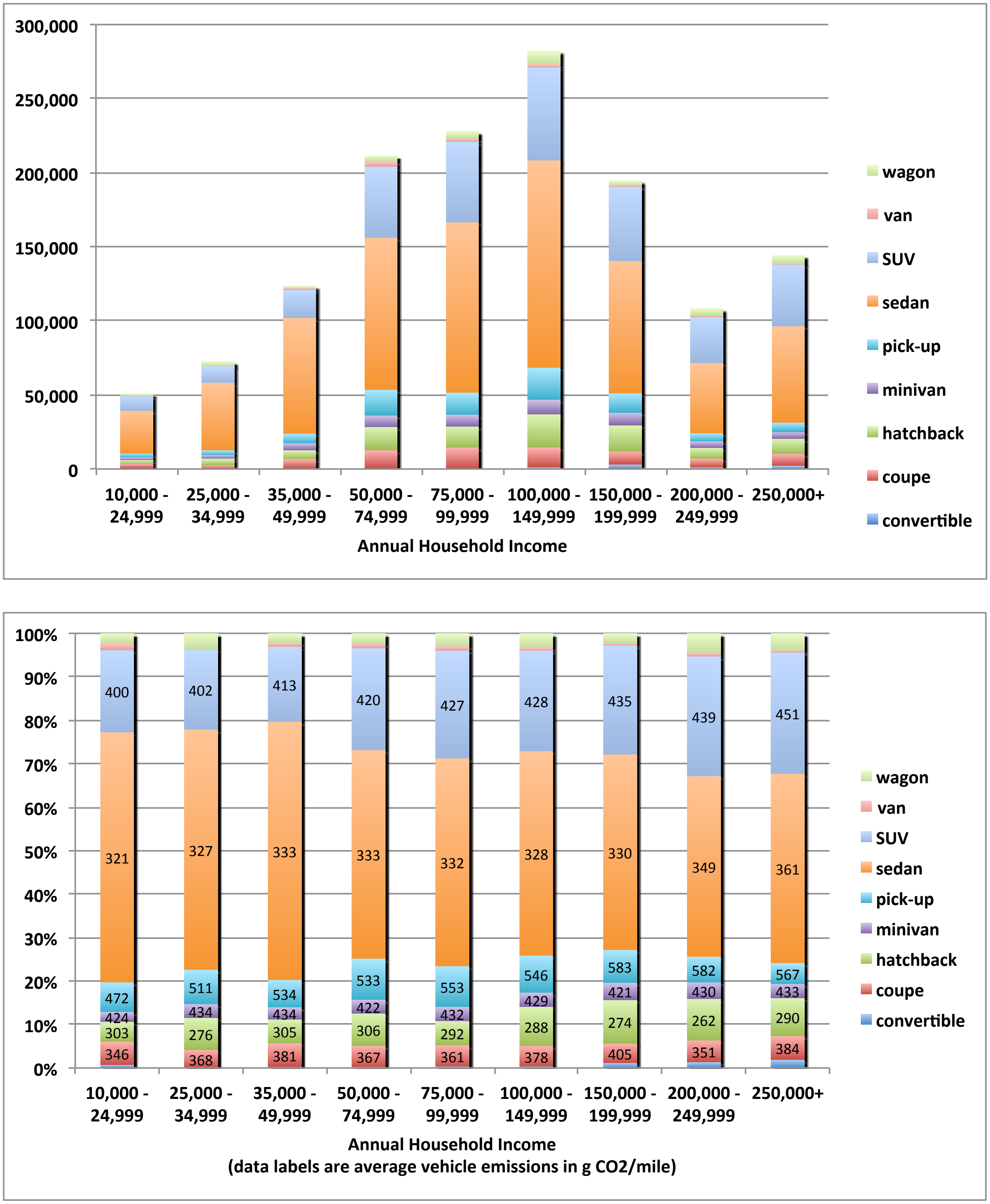

Figure 11. Distribution of sales broken out by (a) new car body types by household income group and (b) as percentages for each group

Analysis of Alternative Fee Structures

As described above, the data analyzed represents vehicle sales between 2011 and 2013, and the characteristics of the households that bought these vehicles. The funds generated are based on the total paid CVRP incentives. Various types of vehicle fee structures were developed to explore the impact on equity while excluding low income or below average-priced vehicles, based on CO_2 emissions. The analysis observes how these fees would be distributed across households, given the household income and vehicle sales distributions in the CHTS.

A simple calculation reveals that if all non-ZEV buyers paid the same fee, this fee would be about $140 per vehicle. Building off this simple scenario, two broad types of CO_2-based fee structures were examined. Scenario 1 requires all non-ZEV purchasers to pay a fee differentiated by vehicle CO_2. Scenario 2 exempts purchasers of cars emitting below 250 g CO_2/mile level from paying any fee - effectively a “donut hole” structure since PHEVs receive a rebate under the CVRP.

A household income scenario is also included in the analysis to test the effect of excluding lower income households, where only households earning more than $75,000 per year pay any fee when buying a car (Scenario 3). The $75,000 annual income threshold was selected, as it separated CHTS new car buyers into about equal halves. Further, in Scenario 4, only those households that earn more than $75,000 annually and purchase a vehicle emitting more than 400 g CO_2/mile pay a fee.

It would be difficult to add income verification to the fee process, so MSRP scenarios are the second best option to reduce the burden on lower income buyers. In Scenarios 5 and 6, vehicle MSRP played a role in determining which households pay a fee. This was to examine whether exempting vehicles with MSRP less than $27,000 would place less of a burden on lower income households, and whether it has an effect on fees paid by other households. This threshold was established because it is below $29,000, the average-priced vehicle in the data set.

The combination of these variants created six separate scenarios, as shown in Table 3. Scenario 4 and 6 assessed all vehicles emitting over 400 g CO_2/mile a fee, regardless of income or MSRP. The typical vehicles excluded based on emitting less than 250 g CO_2/mile are a mixture of hybrids, some of which are the Honda Civic hybrid, Toyota Prius, Smart for 2, among others. Common vehicles emitting over 400 g CO_2/mile include minivans, SUVs, and pick-up trucks. Those cars emitting over 400 g CO_2/mile include 76% of the vehicles for income groups earning above $75,000.

Table 3. Fee structure scenarios considered

Scenario Description	CO_2	Income	MSRP
Scenario 1	All pay	All pay	All pay
Scenario 2	Vehicles emitting less than 250 g CO_2/mile are exempt	----	----
Scenario 3	---	Exempt households with income below $75,000	---
Scenario 4	Vehicles emitting less than 400 g CO_2/mile are exempt	Exempt households with income below $75,000	---
Scenario 5	---	---	Exempt vehicles with MSRP below $27,000
Scenario 6	Vehicles emitting less than 400 g CO_2/mile are exempt	---	Exempt vehicles with MSRP below $27,000

In all scenarios, the goal is to generate $200 million in revenue for the CVRP rebates, with a minimum fee of $100 per new vehicle, for those vehicles that incur a fee. The $200 million per year should be sufficient to cover CVRP costs over the next 3 years, before higher total revenue streams may be needed as a result of increased ZEV sales requirements (which will be addressed in a later phase of this analysis that looks out to 2025). The minimum $100 per vehicle reflects the idea that any amount below this is more nuisance than useful revenue collector.

In order to generate the target $200 million in each of the six scenarios, the maximum fee paid for the highest CO_2 vehicles was adjusted higher or lower (thus affecting the slope of the fee schedule and the fee paid for all cars) as needed to achieve the targeted revenue. The CO_2 emissions starting fee and the income levels of households exempt from the fee were also adjusted up or down depending on the scenario.

It is important to note at this time, that the possibility the fees will in any way alter the choices people make of which vehicle to purchase was not considered. Excluding consumer choice is a major simplification, since the application of vehicle purchase fees will likely affect the car models that people purchase. However, as will be seen below, the levels of fee necessary to generate the target revenues constitute 0.5% of the vehicle cost, and are low enough that consumer purchase shifts in response are small and can perhaps be neglected. At higher fees (needed for higher revenue targets and as less non-ZEV/TZEV vehicles are sold), this assumption will become more unrealistic. This issue will be further explored in a later phase of study.

Results

Figure 12 shows the main results, including Scenarios 1 and 2, where all household income levels are subject to paying a fee, Scenarios 3 and 4, where incomes levels above $75,000 play a role in determining which households pay any fee, and Scenarios 5 and 6, where MSRP above $27,000 play a role in determining fees.

Several implications of the results are apparent. First, if all households are subject to pay and all non-plug-in vehicles (non-PEVs) are subject to a fee, an average fee of around $140 per household is very constant across household income groups, because the average CO_2 emissions of the purchased vehicles per group is similar. This low fee is translated to about 0.6% of the yearly income of a $25,000 new car buyer to 0.06% of the yearly income of a $250,000 new car buyer. Exempting vehicles with emissions below 250 g CO_2/mile does not change this distribution, as the share of those vehicles is low for all income groups.

This leads to Scenarios 3 and 4. In Scenario 3, households with incomes below $75,000 do not pay, and the burden shifts to higher income households. The average fees those households paying shifts to over $200 per vehicle. Scenario 4 also has this income threshold and adds an additional exemption for vehicles emitting below 400 g CO_2/mile, resulting in about a $50 average fee for those lower income households.

Scenarios 5 and 6 both are MSRP-focused. Scenario 5 exempts vehicles with MSRP below $27,000, while Scenario 6 adds an additional exemption that those vehicles with MSRP below $27,000 must also emit below 400 g CO_2/mile. This has a significant effect since 55% of the vehicles have an MSRP below $27,000. These scenarios may better allocate the burden on the different income groups, as the vehicle MSRP may be a stronger indicator than reported income for the household economic situation. Adding the emissions requirement in Scenario 6 does not drastically change the outcome. The average fees per household take on a linear effect, with fees increasing as income increases.

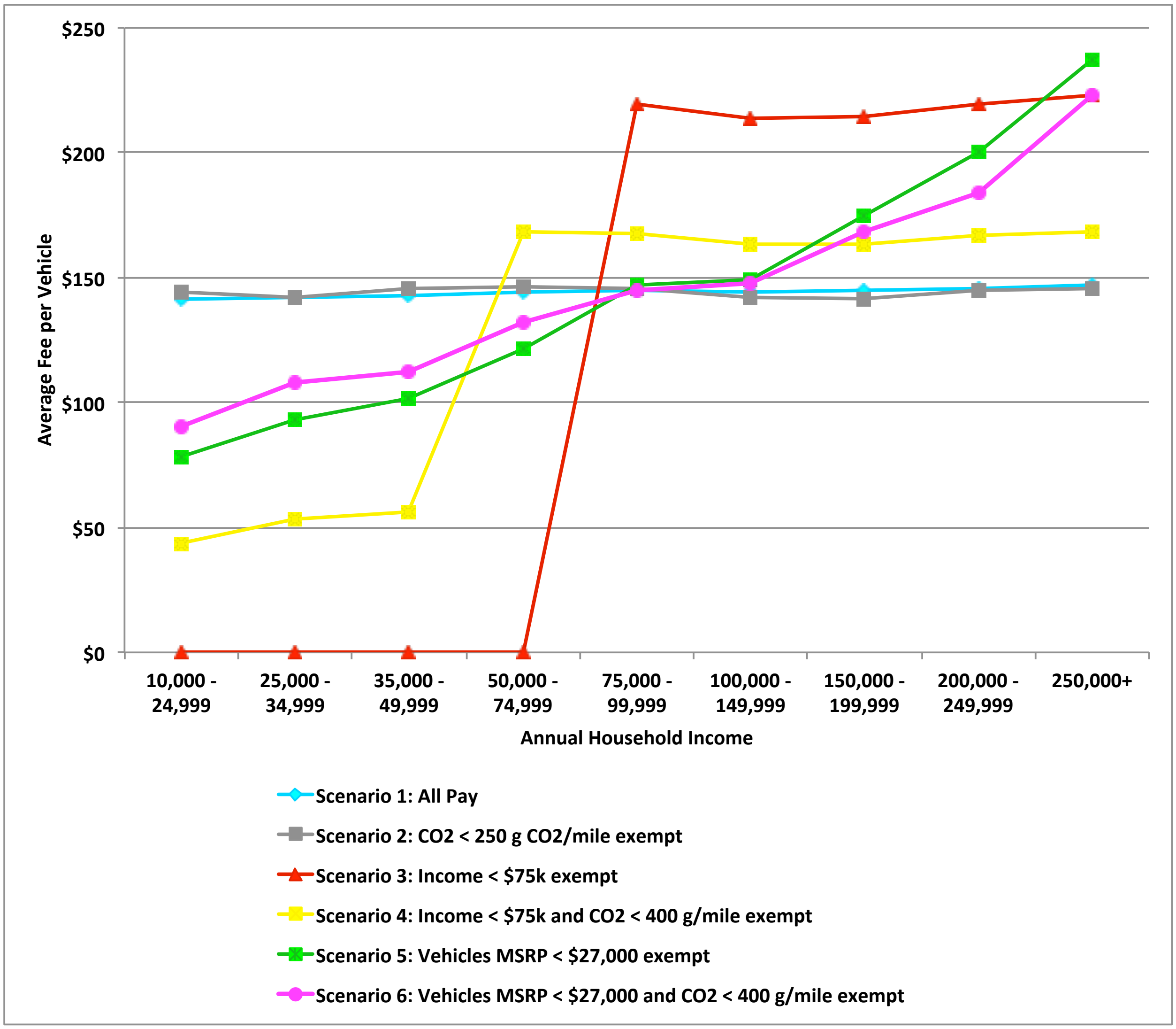

Figure 12. Average fee per vehicle per annual household income

The full distribution of fee levels as a function of vehicle CO_2 levels is shown in Figures 13-15 below. Figure 13 compares Scenario 1, where the fee starts at 177 g CO_2/mile (the best non-PHEV) to Scenario 2, where the fee starts at 250 g CO_2/mile (exempting 7% of the new vehicles). With the fee starting at 177 g CO_2/mile, the fee needs to rise to about $210 for the highest emitting vehicles and the fee needs to be about $160 for the highest emitters (500 g CO_2/mile) to generate the needed $200 million. Thus the revenue can be raised with 0.62% of households paying more than $200 when purchasing a vehicle. With only cars above a minimum of 250 g CO_2/mile paying a fee, the upper limit rises from $208 to about $228 and the fee for cars at 500 g CO_2/mile is about $170.

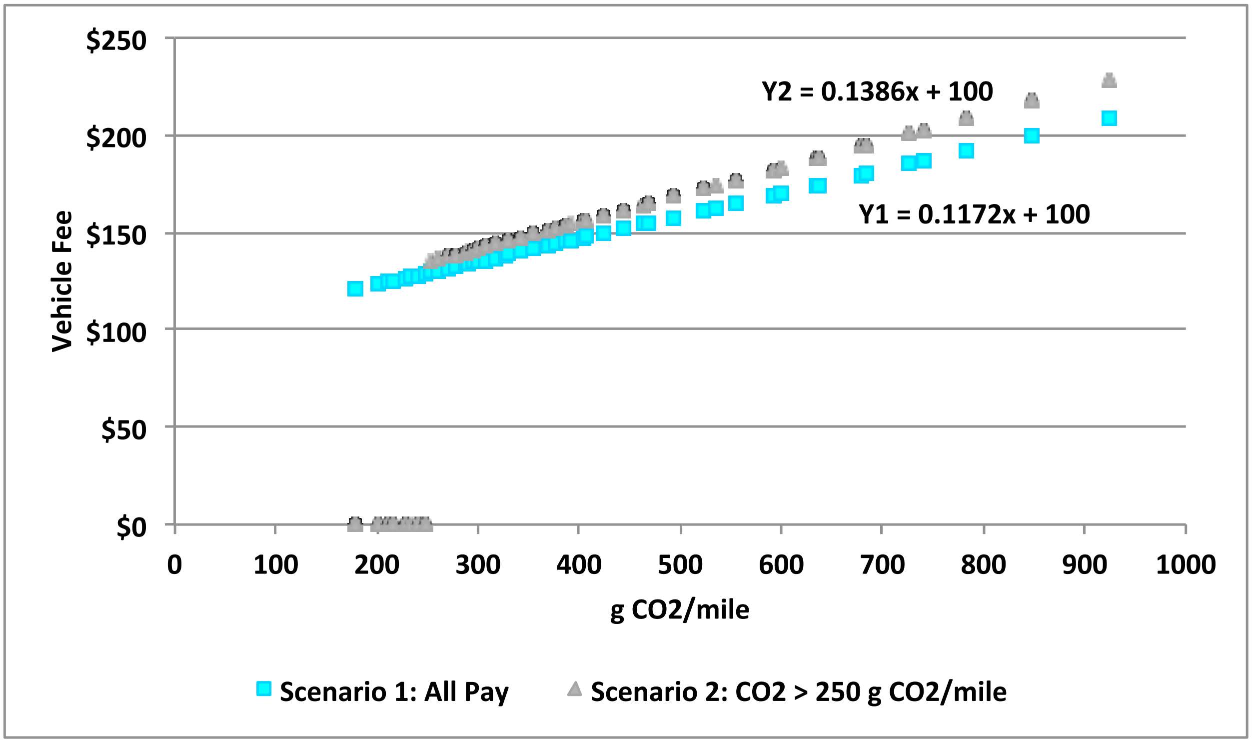

Figure 13. Emissions comparison for Scenarios 1 and 2

The second set of scenarios, in Figure 14, uses households income as a distinguishing factor. Those households earning above $75,000 to pay a fee, as long as their vehicle is not considered a high-emitter. For example, Scenario 3 has fees ranging from $186 to $413. For those purchasing cars at 500 g CO_2/mile, Scenario 1 has a fee of about $200, while Scenario 3 generates a fee of $270. Scenario 4 excludes those vehicles that emit below 400 g CO_2/mile and have an annual income less than $75,000, thus decreasing average fees for this scenario. For those purchasing cars at 500 g CO_2/mile, the fee drops to about $200. Since Scenario 3 exempts households solely on income, it thereby exempts many high CO_2 vehicles bought by those households.

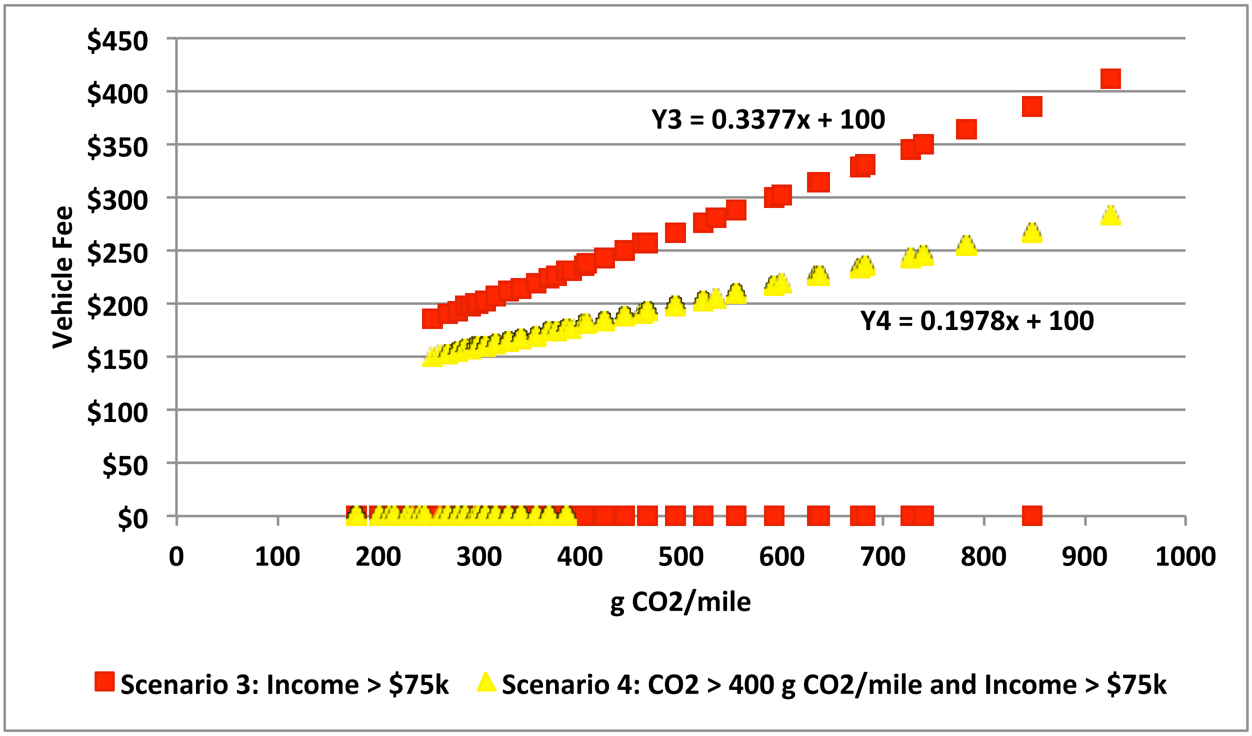

Figure 14. Emissions comparison for Scenarios 3 and 4, based on annual household income

An alternative to exempting households based on income is one based on vehicle MSRP. The final two scenarios, Scenarios 5 and 6 (Figure 15) use a vehicle fee exclusion if the MSRP is less than $27,000, representing 55% of the vehicles in the CHTS. Scenario 5 only looks at price, and it is evident that this allows high-emitting vehicles to avoid paying a fee. Therefore, a restriction can be added to also exempt vehicles emitting less than 400 g CO_2/mile from paying a fee, as demonstrated in Scenario 6. When all vehicles costing below $27,000 are exempt, the highest fee on remaining vehicles rises to $583. With an exemption limit at the 400 g CO_2/mile, the maximum fee drops to $519.

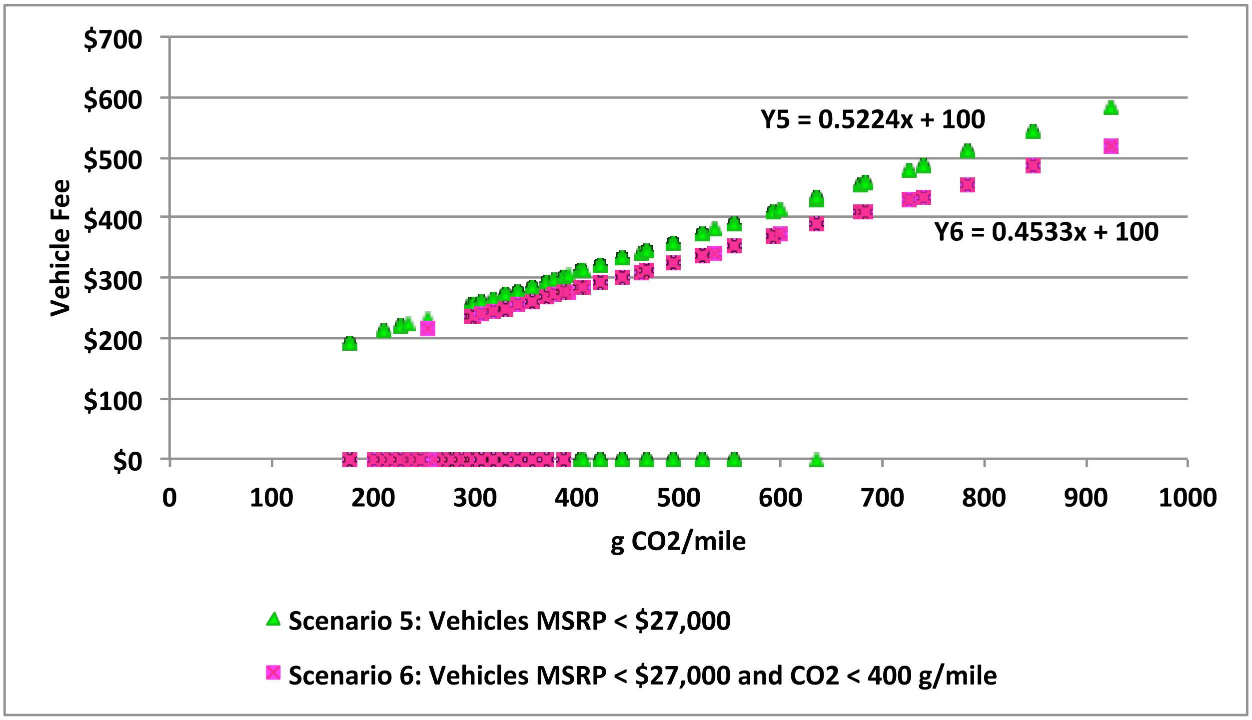

Figure 15. Emissions comparison for Scenarios 5 and 6, based on vehicle MSRP

Table 1 shows a summary of all six scenarios, outlining the average and top vehicle fees and a short description of strengths and weaknesses of each approach. Of course, many more cases and scenarios could be created, but these provide a rough idea of how some different, and potentially important, approaches compare.

Summary of Findings and Policy Implications

The foregoing alternative fee structure analysis for raising $200 million to pay for the CVRP yields a number of insights in terms of fee requirements, impacts across households, and for policy making in this area. These include:

- To raise $200 million with a vehicle fee system, the average fee would be a low percentage of average vehicle prices in 2016 (e.g. around $140 out of $30,000+ average vehicle price, less than 0.5%). It also is not a significant share of income for most households that buy a new car.
- It should be possible to continue incentivizing ZEV and TZEV purchases under the CVRP program with a relatively small ($140) average fee on non-eligible vehicles.
- By focusing the fee on vehicle CO_2 emissions, this can send a signal to buyers of those vehicles regarding the CO_2 impacts of their purchases. However, varying fee structures by household income or vehicle MSRP can have a significant impact on the distribution of fees across household income levels.

- Excluding vehicles emitting under 250g CO_2/mile has a small impact on the average fees for vehicles emitting above 250 g CO_2/mile, but may be an important element to offer consumers some zero fee options and highlight which models achieve this.
- Fee structures may create price differentials for the same model vehicle, depending on the engine configuration (gasoline or PHEV). This was not explored in this study.
- For those lower income households buying a new car, a large share of their income appears to be needed for this (neglecting financing options to spread out costs over time). Such households may be quite sensitive to incentive schemes for purchasing cleaner vehicles.
- Any incentives or fee systems should include this information as part of the car window sticker so it is obvious at time of sale.
- In the future, there will be less non-ZEV/TZEV vehicles sold, as ZEV/TZEV sales increase, so the fee levels per non-ZEV/TZEV will need to increase (apart from increasing as the total numbers of incentivized vehicles increases).
- As vehicle technologies advance, fuel economy will increase and CO_2 emissions will decrease. This would impact the CO_2 thresholds indicated in this study. Fees that automatically adjust with the average CO_2 levels of new cars will help maintain revenue streams.
- When excluding by income, as in Scenario 3, 33% of new cars with average MSRP of $25,500 and average emissions of 367 g CO_2 /mile are exempt from paying a fee.
- Excluding less than average MSRP, like Scenario 5, allows the higher income households, which makes up 63% of this group (or about one-third of all new car buyers), to be exempt from paying a fee, but reduces policy complications and may be better correlated with purchasing power.
- Assessing fees on vehicles emitting over 400 g CO_2/mile may be an important message, but may add additional burden on households who require bigger vehicles. This research did not take into account family size.
- A combination of some scenarios may be better than the individual 6 presented.

Looking toward 2025

Although a detailed analysis of future market evolution, incentive expenditures on ZEVs and TZEVs, related revenue needs and possible fee structures are beyond the scope of this report, a few simple projections and calculations are provided here. Additional research in this area represents an important potential follow-up study.

Using ARB's previous projection from the California Vision 2012, based on EMFAC (ARB's Emissions Factors for mobile sources database), LDV sales are projected to increase from about 1.6 million in 2015 to nearly 1.8 million in 2025, an overall increase of 8% (comprised of about a 7% increase in car sales and 12% in light truck sales), as seen in Figure 16.

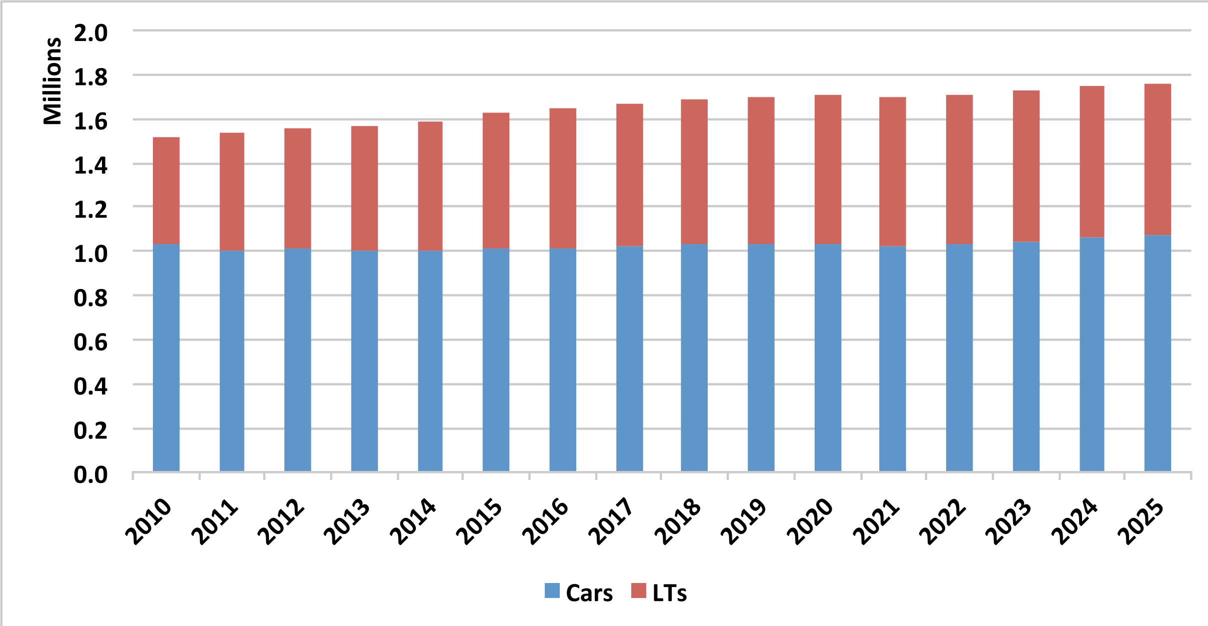

Figure 16. Car and light truck sales projection. Source: CA Vision, 2012 model runs

Table 4 outlines the ZEV and TZEV sales requirements from 2018 to 2025. If today's CVRP rebate levels remained the same through 2025, the table shows the total amount of rebates that would be required to fulfill these purchases. It is estimated that $178 million in rebates would be issued in 2018, thus the $200 million targeted revenue amount in the fee structure scenarios would still be sufficient. After 2018, revenue requirements would rise rapidly, reaching nearly $400 million in 2020 and close to $1 billion by 2025. If the market structure of vehicle sales remained the same as today (though with many more ZEVs and thus fewer non-ZEVs to charge fees from, in the context of increasing vehicle sales), and without taking into account a range of possible market responses, our simple calculation is that the average vehicle fee required to pay for the CVRP rebates would rise to close to $500 per vehicle.

Table 4. Projection of CVRP Rebates based on Program targets and projected vehicle sales

Model Years	ZEVs Required	Projected LDV sales (Vision 2.0) (millions)	ZEV Rebates (millions)	Average fee per non-ZEV purchased to pay for rebates
2018	2%	1.58	$79	$51
2019	4%	1.61	$161	$104
2020	6%	1.62	$244	$160
2021	8%	1.64	$327	$217
2022	10%	1.66	$414	$278
2023	12%	1.68	$503	$341
2024	14%	1.70	$594	$407
2025	15%	1.72	$644	$441

(Note: Total rebates based on $2,500 per vehicle for ZEVs through 2025.) Research Next Steps

Potential Future Research

This project has undertaken what could be called first steps of research in investigating possible funding systems for the CVRP. Follow-up research could include a number of activities, including:

1) Creating a more detailed projection of California vehicle sales to 2025 by household type, income and/or demographic characteristics, and linking this projection to the ZEV sales requirements along with potential required funding for CVRP. This should also take into account changing vehicle technologies and potential reductions in new conventional vehicle CO_2 levels. Taking into account such changes will enable a better forward-looking analysis of different fee structures, in the context of rising program budget needs and changing demographics and market environments.
2) Also for a 2025 projection, applying market purchase response functions to changes in vehicle prices, such as by using the MA3T model (a market simulation model called Market Acceptance of Advanced Automotive Technologies) or another model. As fee and rebate levels per vehicle rise, the likelihood of a significant consumer response would also rise, and thus should not be neglected. In fact, consumer response to fees and rebates could strengthen the ZEV program by helping increase demand for ZEV and TZEV sales and decreasing funding requirements, a potentially important dynamic.
3) Investigation of other revenue raising concepts and their equity impacts, such as in-use fees (e.g. VMT fees) that could be related to electric v. non-electric driving.
4) Broadening the geographic scope of the work to include other states or national level analysis (such as a national feebate).

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