Exploring PEV Adoption in California’s Disadvantaged Communities

The National Center for Sustainable Transportation Undergraduate Fellowship Report

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Introduction
Plug-in Electric Vehicles (PEVs), which include both Plug-in Hybrid Electric Vehicles (PHEVs) and Battery Electric Vehicles (BEVs), have many environmental benefits. Because they run either partially or fully on battery power (PHEVs and BEVs, respectively) they emit fewer greenhouse gases and particulates, which can have a significant impact on air quality. However, at present the market share of plug-in vehicles in California is only 3% of the new-vehicle market. To optimize the environmental benefits of these vehicles, they need to be adopted in greater numbers across the state, especially in dense urban areas with high levels of traffic and pollution. However, the median household income of a new-PEV buyer is $200,000, while the median household income for used-PEV buyers is $150,000 (1). In light of the California median household income of $61,818, it is clear that PEVs are purchased mainly by people who are well-to-do, which indicates that geographic areas characterized by high income are likely to have greater concentrations of PEVs than lower-income areas. Despite this underlying logic, there is little published information to quantify the degree of PEV adoption in lower income areas.

During this fellowship, I assisted Gil Tal with research to provide the first look at PEV adoption in disadvantaged communities, which tend to be lower-income than surrounding areas and are disproportionately burdened by pollution. My main activities were formatting and combining different sources of data, conducting GIS analysis, creating maps, and writing a draft of a paper that was submitted to the Transportation Research Board.

Background
Disadvantaged Communities, or DACs, are census tracts designated by the California Environmental Protection Agency (CalEPA) pursuant to SB535 (de Leon, 2012), which mandated that 25% of the funds from the Greenhouse Gas Reduction Fund established by AB 32 (The California Global Warming Solutions Act of 2006) go toward projects that benefit disadvantaged communities. Twenty-five percent of all census tracts in California are DACs, which means that ultimately there are 1,993 DACs of varying size and population. Four groups of factors are considered by the CalEPA in their determination of a DAC: pollution exposure, environmental effects, sensitive populations, and socioeconomic factors (2). Because DACs score in the top 25th percentile on measures within these four groups, in general they can be said to be harder hit by low environmental quality and economic challenges relative to non-disadvantaged census tracts.

There is a comprehensive body of research on the disproportional impacts of vehicular pollution on low-income, minority, and disadvantaged communities. Low-income populations are more likely to be located close to congested roadways, where the associated air pollution increases the incidence of conditions like asthma and cancer (3). Increasing the share of PEVs in a community can address pollution issues by replacing traditional vehicles with cleaner models, but the high cost of purchase for PEVs may be a significant barrier in areas that need pollution mitigation the most. The average household median income across the 1,993 DACs is $41,860,
whereas across non-disadvantaged communities it is $74,690. There are many incentives and rebates available to PEV buyers, and PEVs have lower operating costs because they run on electricity and have fewer mechanical parts. However, the initial purchase price, even considering offsets from incentives, may still be prohibitive.

In this report “disadvantaged community” will be abbreviated as “DAC” and a “non-disadvantaged community” will be denoted as “nDAC”.

**Methods**

In this study we looked at where PEVs owners were concentrated in California and the socioeconomic characteristics of the census tracts they were located in. Because DACs are designated by census tract, we used this spatial unit rather than city or zip code. We use the household as the main social unit of analysis and assume that a PEV owner is equivalent to a PEV-owning household. ArcGIS, Microsoft Excel, and the statistical software JMP were used to prepare and analyze the datasets used in this research.

**Data Sources**

1. Individual (non-business or fleet) applications to the Clean Vehicle Rebate Project provided an approximate number of new-PEV owners per census tract. Though it does not represent every PEV owner in California (not all households apply or are eligible for the rebate), within the first 5 years of the Clean Vehicle Rebate Project, 74% of owners with eligible vehicles applied. Therefore, this dataset provides a look at a majority of new-PEV owners in California up to April 2017, the month that the data was downloaded (N=178,337).

2. Survey data from the Plug-in Hybrid & Electric Vehicle Research Center’s eVMT Project provided more detailed socioeconomic information for a smaller subset (N=9149) of new-PEV owners, such as home location and type, type of PEV purchased or leased, and household income.

3. Household income data was downloaded from the U.S. Census website along with shapefiles of California census tracts. The list of DAC designations and indicator data by census tract was downloaded from the website of the Office of Environmental Health Hazard Assessment.

4. DMV records were used for determining the number of used-PEV owners in California up to June 2016. If a PEV has been transferred to new ownership at least once and has an odometer reading over 5,000 miles, it is considered a used PEV. This dataset is smaller than the CVRP dataset because the used-PEV market is still in the early stages of development (N=9400).

5. A survey of a subset of the DMV used-PEV owners conducted by the PH&EV Center provided detailed socioeconomic information for these households. Participants were asked about factors like home location and type, household income, and vehicle type.
PEV owning households were geolocated and classed by census tract to determine the number of PEVs in each tract. PEV density was then examined in relation to socioeconomic factors, e.g. median household income, percent of households in a census tract with income under $50,000, etc. To simplify analysis, we consider each CVRP application to be equivalent to a PEV-owning household, but recognize that this will be an underestimate of the true number of PEV owners in California. To prevent outliers from skewing estimates of PEV density, we excluded from consideration any census tract that had fewer than 189 households, which is two standard deviations away from the average total households across all census tracts (Mean=1578 households).

**Analysis**

We expected that the high cost of purchase for PEVs would prove prohibitive, and because households in disadvantaged communities tend to have lower incomes than those in non-DACs, there would be a lower concentration of PEVs in these census tracts. Moreover, any PEV-owning households in DACs are likely to be non-representative of most households in the census tract; i.e. they are not likely to have a household income below the median for California ($61,818) and will probably make much more.

**Results**

To determine whether the proportion of PEVs in a census tract is lower than, equal to, or greater than would be expected, it is helpful to have a benchmark proportion that bars all other factors such as income, availability of PEV charging infrastructure, rural vs. urban geography, etc. To find this benchmark, we used the sum of all individual applicants in the Clean Vehicle Rebate Project as a proxy for individual PEV owners in California and divided it by the sum of all households in all California census tracts, retrieved from census data. The calculation yields a value of 1.48%. Therefore, if no outlying factors affected PEV adoption and distribution, 1.48% of households in each census tract should own a PEV.

We find that of all census tracts (DACs and nDACs), 69% have a proportion lower than 1.48%. In DACs alone, 95% have a proportion lower than 1.48%, while only 61% of nDACs have a proportion lower than 1.48%. These statistics, however, do not provide a complete picture: many factors can influence PEV adoption and it would have been extremely unlikely to get an even distribution across the state.

Further analysis shows that the percent of new PEV sales occurring in DACs is lower than it should be to be proportional to the number of households in California that reside in DACs. Though DACs hold 21% of households in California (and represent 25% of all census tracts), only 6.1% of all new PEVs are being sold in DACs. The remainder of new-PEV sales occur in nDACs. The proportion of the used PEV market that exists in DACs is still low in proportion to DAC households (21%), but it is slightly higher than the proportion of the new PEV market. While only 6.1% of new PEVs are purchased by owners who live in DACs, 8.7% of used PEVs are purchased in DACs (See Figures 1 and 2).
We also looked at the proportion of PEVs compared to households in each census tract, which we consider PEV density. Results show that there is a lower proportion of PEVs – fewer PEVs per one-hundred households – in DACs compared with nDACs. This pattern applies to both new PEVs and used PEVs (See Table 1). The pattern is also illustrated in the Los Angeles metropolitan region shown in Figure 3. The lightest areas with the lowest PEV density coincide with the DACs (symbolized in red), while the areas with highest PEV density are nDACs. Finally, the distribution...
of PEV density shown in Figure 4 demonstrates how PEV density tends to be low across all census tracts (which reflects overall low PEV adoption in California), but the longer tail on the nDAC distribution (0, in red) shows how nDACs have more census tracts with higher density relative to DACs.

Table 1. PEV Density Across Census Tracts

<table>
<thead>
<tr>
<th></th>
<th>non-DAC</th>
<th>DAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average of new PEV density (PEVs/HH)</td>
<td>1.65%</td>
<td>0.37%</td>
</tr>
<tr>
<td>Average of used PEV density</td>
<td>0.09%</td>
<td>0.03%</td>
</tr>
<tr>
<td>Maximum new PEV density in a Census Tract</td>
<td>21.70%</td>
<td>3.90%</td>
</tr>
<tr>
<td>Maximum used PEV density in a Census Tract</td>
<td>1.50%</td>
<td>0.40%</td>
</tr>
</tbody>
</table>

Figure 3. New PEV Density Map, Los Angeles
Figure 4. New PEV density comparison conducted in JMP. Red represents nDACs and blue represents DACs.

There is, however, a higher concentration of lower-priced PEVs in DACs. For example, while only 2.6% of Tesla Model S owners (one of the most expensive PEVs) reside in DACs, 57.9% of Ford Fusion Energi owners (a less expensive plug-in hybrid) live in DACs. The average price for a PEV paid in nDACs was $43,240, and in DACs it was $39,197. This indicates that PEV owners in DACs tend to prefer slightly less expensive vehicles.

Upon examination of socioeconomic data for PEV owners across California, it becomes clear that most new-PEV buyers in DACs have high incomes and tend not to be representative of the average household within the census tract. Only 3.3% of new-PEV owners (and only 0.6% of Tesla owners) had a household income of $50,000 or lower. However, the average household income of a new-PEV owner in a DAC was $135,102 compared with $153,175 in a nDAC. This difference was found to be statistically significant, but new-PEV owners in DACs are still firmly in the high-income range.

Examining the type of home PEV owners live in is an interesting factor, because it is easier for people to charge a PEV if they live in a detached, single family home rather than an apartment, which may not have an accessible charger in the most convenient parking. A high majority of PEV owners in DACs and nDACs live in detached homes, but there is a greater share of apartment dwellers in DACs. In DACs, more PEV owners rent their homes than own them, whereas in nDACs there are more owners than renters.
Potential for Further Study
My faculty mentor and I are currently comparing the proportion of PEV owners to total households in all census tracts and the proportion of PEV owners to *high income* households (incomes >$100,000) in all census tracts. The expectation is that while the [PEV/HH] proportion should be greater in nDACs than in DACs, reflecting the higher concentration of PEVs in nDACs, the [PEV/high income HH] proportion should be similar across DACs and nDACs, reflecting our finding that most PEV buyers in nDACs have high incomes. However, we are not finding clear results from our analysis and will continue to examine the data.

Additionally, we will be using the eVMT survey data to look at whether the importance of incentives differs across new-PEV buyers in DACs and nDACs. Incentives like the Federal Tax Credit for PEVs and the Clean Vehicle Rebate offered in California can significantly offset the cost of a PEV, but not necessarily at the time of purchase. Therefore, these incentives may not be as helpful for low- to moderate-income prospective buyers. It would also be interesting to find out whether previous knowledge about available incentives differs in DACs and nDACs, and how much of a part it plays in the decision to buy a PEV.

Finally, thus far we have considered only the binary of DACs and nDACs, but it may be useful to know how well specific indicators predict PEV density, such as poverty, education level, unemployment, or population at risk characteristics. The California EPA provides data that details what percentile each DAC belongs to for all nineteen indicators\(^1\).

Discussion
Analyzing the new and used PEV markets in California confirms that PEVs are not being adopted in DACs to the same degree as in non-disadvantaged communities. When they are adopted, it is almost always by households with high incomes. However, the PEVs being purchased in DACs tend to be less expensive models and the incomes of the buyers tend to be slightly lower than those of buyers in nDACs.

PEV adoption needs to increase across California, but special focus should be placed on disadvantaged communities because of the environmental benefits of reducing the number of traditional vehicles on the road. Maturation of the PEV market may reduce the cost of this technology in time, but policies that incentivize the use of electric vehicles will also be crucial for expanding adoption in low- or middle-income sectors of the population. The finding that a slightly larger portion of the used PEVs on the market are found in DACs compared to new PEVs is a reason to be hopeful – as the used PEV market grows, there may be more reasonably priced PEV options available to those with moderate income. If the transition from traditional vehicles to clean vehicles is to have significant effect on greenhouse gas reductions, PEVs cannot only be

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\(^1\) There are 19 indicators in total used by CalEnviroScreen 2.0, the tool developed by CalEPA that calculates indicator values and then ranks census tracts to determine the top 25%. The census tracts in the top 25\(^{th}\) percentile are designated as DACs. See [https://oehha.ca.gov/calenviroscreen/indicators](https://oehha.ca.gov/calenviroscreen/indicators) for more information.
attainable for the wealthy. Improving the accessibility of clean transportation technology will require further exploration of this topic moving forward.

References

2. California Environmental Protection Agency. Learn more about the indicators that make up CalEnviroScreen. 2016, Available at: [https://oehha.ca.gov/calenviroscreen/indicators](https://oehha.ca.gov/calenviroscreen/indicators)