



## ABSTRACT

Infrastructure for Plug-in Electric Vehicle (PEV) Charging is expensive to build. Also, and like road congestion, we may not be able to "build out of congestion".

Modeling the choice of charging infrastructure of more than 3000 PEV drivers, we find that:

- PEV drivers are cost-sensitive in their choice of charging location and tend to substitute toward workplace charging when they pay a higher electricity rate at home, more so when workplace charging is free.

- Having a Level 2 charger at home increases the probability of home charging by 18 percentage points.

These results indicate that policies encouraging households to adopt special rate plans and install Level 2 chargers at home can help lower the need for public charging infrastructure. Also, it may help deal with the problem of congestion if commuters with charging facility at home do overnight charging while the workplace chargers are available for apartment dwellers and renters who are more dependent on non-home charging infrastructure.

## BACKGROUND

There is a need for public charging infrastructure to support the PEV adoption target of California.

Early 2018, Pacific Gas & Electric (PG&E) launched the EV Charge Network Program with a budget of 130 million whereby it will partner with businesses and other charging network companies to install 7500 chargers in apartment complexes and workplace. Other utilities in California have similar programs.

Policy makers often have limited information on what drives demand for charging locations.

Understanding the drivers of demand will allow informed planning of future investments in infrastructure and allocation of limited funds.

## REFERENCES

- Hardman, S. et al (2018),
- Li, S. et al (2017)
- Nicholas, Michael, "Ensuring Driving on Electricity Is Cheaper Than Driving on Gasoline," (2018).
- Faktra, J. et al (2013)

# Demand drivers for Plug-in Vehicle Charging Infrastructure

Debarjya Chakraborty, Jae Hyun Lee, Gil Tal  
 Plug-in Hybrid & Electric Vehicle Research Center  
 Institute of Transportation Studies, UC Davis  
 STEPS Symposium, Dec. 11-12, 2018

## RESEARCH QUESTION

Question: What are the drivers of demand for a charging location?

Objective: Identify the drivers and their importance in the choice decision. Also, provide an overview of policy opportunities to allow more informed allocation of limited funds in building a charging infrastructure.

## DATA & METHODOLOGY

### PH&EV Center eVMT Survey- 2016 & 2017:

Participants with at least one EV were recruited based on Department of Motor Vehicles (DMV) registration data using a random sampling procedure.

In total, 7,979 households were chosen after consultation with the California Air Resource Board (CARB) staff.

For the purpose of the study, we focus on the charging decision of 3,201 commuters with access to workplace charging. We consider their weekday charging behavior.

Respondents asked about their 7-day charging history: location and kind of charger

- Respondents could say Y/N to the following options: Level 1 home, Level 2 home, Level 1 work, Level 2 work, DC Fast charger work, Level 1 non-work, Level 2 non-work, DC Fast charger non-work.

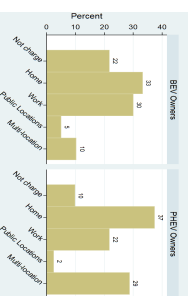


Figure 1: Distribution of weekday charging location choice of EV and PHEV commuters

For both BEV and PHEV drivers home is the most popular location followed by work.

**Estimation method:** Structural model of choice of charging location.

**Dependent variable:** On weekday 'd' charge at home, work, public locations, a combination of the above three (multi-location) or not charge.

**Demand Drivers (controls):** Electricity price at home (cents/kWh), access to Level 2 charger @ home, workplace charging infrastructure characteristics like the cost of charging (free/paid), number of chargers and congestion, access to public networks, demographic characteristics of the primary driver.

## EFFECT OF DEMAND DRIVERS

Economic drivers of choice of location

- Electricity price at home differs significantly across utilities in California and also depends on whether the household is on a special EV rate or not.
- A 10% increase in electricity price at home leads to a 3% decrease in demand. (Inelastic demand)
- Free workplace charging increases the probability of choice of workplace charging by 19%

Non-economic factors driving the choice of location

- Access to Level 2 charger @ home: increases P (Home) by 18% (5%) and reduces P (Work) by 19% (9%) for BEV /PHEV owners
- Solar cell @ home: Increases P (home) by 1.8% and reduces P (no charge) by 2.6% for BEV owners. For PHEV commuters P (home) increases by 4% and P (work) reduces by 5%.
- Dwelling type: Apartment dwellers are more dependent on workplace charging.
- Congestion at the workplace: Insignificant effect for BEV drivers. For PHEV drivers P(work) reduces by 2%
- Access to Public Charging networks: Increases P (public) by 3% and reduces P(home) and P(work) for BEV owners.
- Vehicle Range: Ownership of long range BEV and PHEVs reduces P(home) and P(work) while increasing P(public) and P(no charge)
- Demographic Characteristics: Female drivers are less likely to charge anywhere but home.

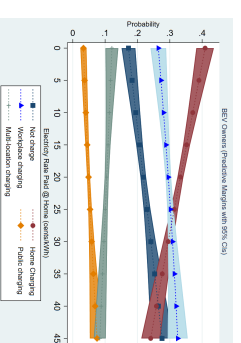


Figure 2: Predicted probability of Choice of Charging Location by Electricity Rate paid at Home

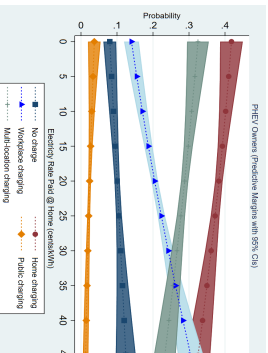


Figure 2: Predicted probability of Choice of Charging Location by Electricity Rate paid at Home

## POLICY IMPLICATIONS

| Result  | Policy Implication  |
|---|---|
| Access to Level 2 charger at home encourages home charging. Reduces the probability of charging at workplace and public locations   | Incentives to households for Level 2 installation at home can help reduce the need for expensive investment in building public infrastructure as well as reduce congestion at charge points in the future.                |
| For every 100 BEV /PHEV drivers, if each one has a Level 2 charger at home there will be 19 (6) less workplace charging events  |   |
| PEV drivers who are apartment dwellers are more dependent on workplace charging.  | Building charging infrastructure at the workplace and near multi-family apartments can encourage adoption and usage of PEV's among renters and apartment dwellers.  |
| Roof-top solar increases the probability of home charging   | Incentives promoting adoption of rooftop solar can lower the need for public infrastructure by encouraging charging at home. Also, lower electricity cost implying a lower cost per mile and encourage overall PEV usage. |
| <b>Role of Electricity and Infrastructure Pricing</b>   |   |
| High electricity price at home disincentivize charging at home and increases the probability of not charging. Not charging can imply low usage of the PEV. High electricity price at home also encourages shifting charging demand to workplace especially if the latter is free. | Programs encouraging households to sign up for special rate plans can encourage PEV usage and help more optimal usage of public infrastructure.   |
| For every 100 BEV /PHEV drivers, compared to the scenario when workplace charging is paid, we will have two times more events if it is free. The shift is mostly from home charging   | Investment in workplace charging infrastructure is important for encouraging adoption and PEV usage. However, free is not sustainable. It may lead to congestion of infrastructure in the future.                         |

## CONCLUSIONS

Cost sensitivity of PEV drivers implied both their response to home electricity price and free vs paid workplace charging indicates that optimal pricing policies for home and work can help reduce future investment needs for public infrastructure and reduce risks of congestion.

In addition to pricing policies, Incentives that promote adoption of Level 2 charger at home and other complementary technology like rooftop solar can also reduce the need for costlier public infrastructure