Plug-in Electric Vehicle (PEV) Charging Infrastructure Assessment Overview, Approaches and Insights

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Research Question

How to model PEV charging infrastructure needs that considers:

1. Current market trends & future scenarios
2. Spatio-temporal heterogeneity
3. PEV adoption rates and penetration
   - Socio-demographic and geographic dispersion
4. Fulfils driving needs
   - Daily averages
   - Long-distance, corridor, inter/intra state travel

Market Trends

Fig. 1 2011-2016 Top 10 PEVs Sold (% Share)

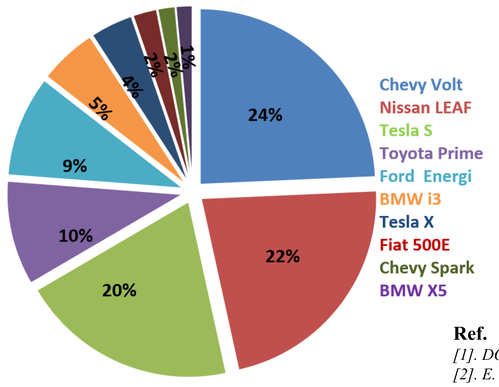
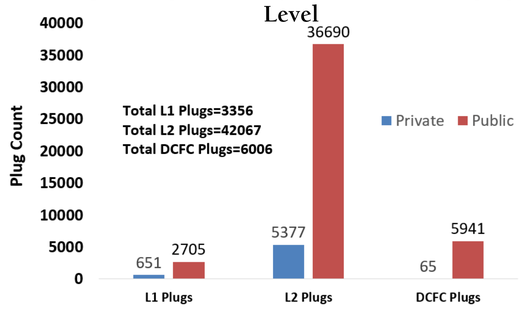


Fig. 2 Plug Counts by Access and Charging Level



Ref.
[1]. DOE Alternative Fuel Vehicle Database as of 12/1/2017
[2]. E. Wood et. al, National PEV Infrastructure Analysis, DOE/GO-102017-5040, Sep. 2017

- ZEV Mandate States: 15.4% of total sales by 2025
- **Infrastructure Readiness, Planning and Assessment is Crucial**

Fig. 3 Top 10 Urban Areas (UA) by Plugs/1000 PEVs

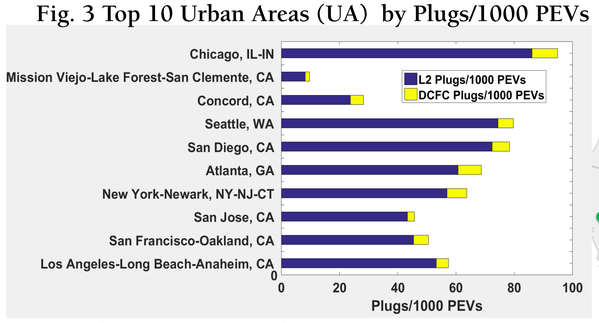
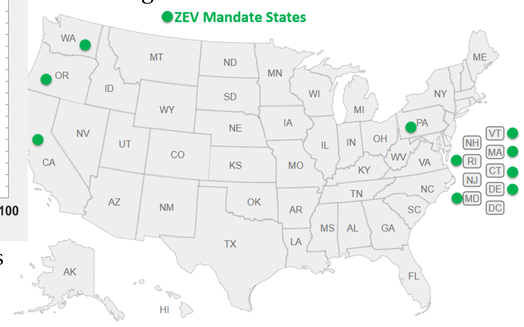


Fig. 4 States with ZEV Mandates



- UA Chicago IL-IN 96 Plugs (L2+DCFC)/1000 PEVs for 9100 PEVs
- UA Los Angeles-Long Beach-Anaheim has 57 Plugs (L2+DCFC)/1000 PEVs for 85500 PEVs

Contemporary Approaches

Fig.5 Contemporary Approaches in Infrastructure Planning

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Illustration: State of CA

Table 1 PEV and Plug Counts (All Available Public and Private Plugs)

Num of Zip Codes Without any Registered PEVs	Num L1 Plugs	Num L2 Plugs	Num DCFC Plugs
80	59	432	93
Num of Zip Codes Without any Plugs	**Num BEVs**	**Num PHEVs**	**Num PEVs**
455	21481	15594	37075

Fig.6 Regression Between Total PEVs and Plugs
Num zip codes = 1669

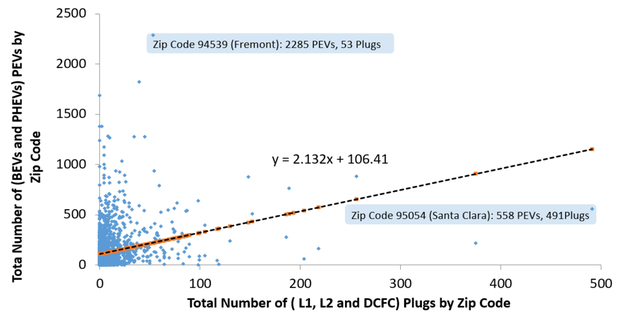
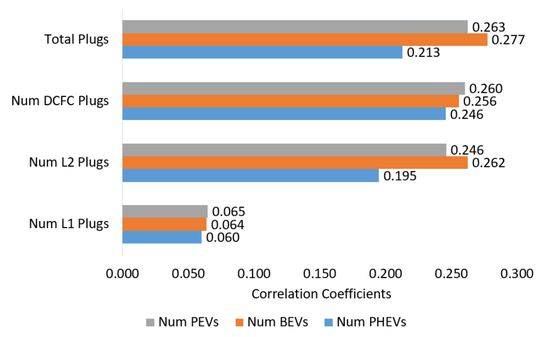


Fig.7 Correlation Between Types of PEVs and Plugs



- Looking at outliers: influence of charging location, housing attributes (single or multiunit dwelling, densities), workplace charging initiatives **WHY?**
- At zip code level, 95th percentile Plugs Per 1000 PEVs = 45
  - Influencing Factors **WHAT?**
- State level aggregated correlation vs. variance at a spatially explicit level **HOW?**
- **Quantify probability of access** to a charging station
  - Socio-demographics, travel behavior, and vehicle adoption

Ref.
[3]. State of CA Clean Vehicle Rebate Program Data as of 12/1/2017
[4]. DOE Alternative Fuel Vehicle Database as of 12/1/2017

Assuming Average Urban Driving

- Majority of studies assume representative DVMT as average urban driving (~40 miles, 4 trips)
- Missing: the tail of daily VMT (short trips and long-distance) ; intraday dwelling time variations ; type of day, type of road network

Fig. 8 % of Cars Parked (2009 NHTS)

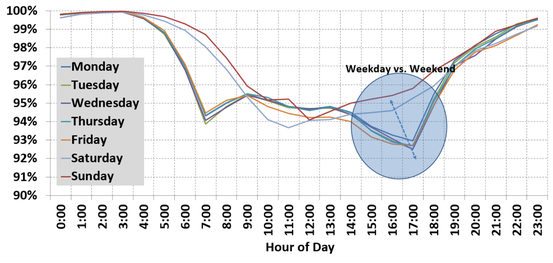
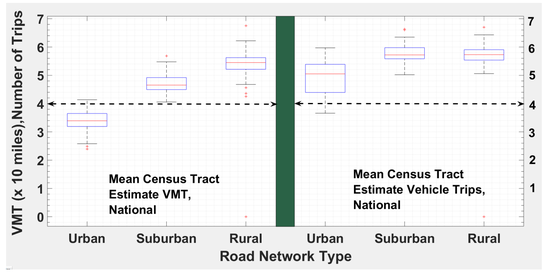


Fig. 9 Average VMT and Trips by Road Type



- Differences due to population density, dwelling unit splits
  - home or public/workplace dominant charging decision
  - **Design infrastructure for peak demand or nominal demand or coverage?**

Next Steps

1. Integrate travel data (NHTS, CHTS etc.), DOE AFDC and end-use household level energy consumption survey data
2. Econometric modeling of access to charging infrastructure probability at household level
   - HH heterogeneity, socio-economics, and demographics, existing PEV and infrastructure
3. Explore trade-offs between complexity, fidelity, and explicitness
4. Capture the trajectory of PEV adoption and infrastructure build out for future scenarios
5. Evaluate charging behavior impacts on charging infrastructure needs and power grid
6. Integrate transportation sector with energy

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