Plug-in electric vehicles and the electricity grid

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Overview of work

1. Grid Optimized Operation Dispatch (GOOD) model
   a. Future emissions modeling
   b. Extreme fast charging effects
   c. Autonomous, shared, electric future

2. Charging effects on local distribution infrastructure

3. Transportation network company infrastructure demand
GOOD model features

• The GOOD model is an economic dispatch model that simulates the operation of the entire US electricity grid
  • Generator level resolution
  • Exogenous capacity expansion through 2040
  • Includes transmission constraints at a sub-state level
  • Ramping constraints included by fuel type
  • Measures emissions for \( \text{CO}_2, \text{NO}_x, \text{CH}_4, \text{SO}_x, \) and \( \text{N}_2\text{O} \)
Project 1a: Understanding future grid emissions impacts from PEVs

- Charging management will be critically important for smoothing grid operation.
Smart charging is not created equal

- Grid optimized charging to reduce costs will differ in timing in different regions
- Smart charging doesn’t mean cleaner charging
Project 1b: Understanding extreme fast charging (XFC)

• The “gas station” model: eliminating range anxiety by providing PEVs the ability to charge in about the same amount of time as a gas car
• This requires 350+ kW chargers, which will have large impacts on the grid
• How does this affect grid operation at the generator/transmission level?
• What are the emissions associated with their usage?
Charging behavior simulations

- Bootstrapped simulation of charging behavior (based on real, not modeled data)
Preliminary results

- We are able to observe how generation is used to meet a BAU case versus high adoption of XFC
Project 1c: A potential 3-Revolutions future

• Estimate the costs and benefits on the transportation and power systems of integrating millions of plug-in electric vehicles

• By accounting for charging profile and load flexibility within personally owned EV fleet as well as future fleets of shared automated EVs (SAEVs) serving mobility on-demand
3 Revolutions

• The 3 R’s:
  • Electric vehicles
  • Shared mobility (pooling, think Uber and Lyft)
  • Autonomous vehicles

• How will the combination of these “revolutions” affect the transportation sector?
Project 2: PEV charging effects on local distribution infrastructure

• Sloan Foundation funded 2-year research project
• Support from California Energy Commission, California Public Utilities Commission, and major utilities (SMUD, PG&E, SCE)
• What are the impacts of PEV charging and EVSE infrastructure on the distribution grid in California?
PEV charging demand

• Work by PhD student Xinwei Li

• Builds off the EV Toolbox but upgrading with:
  • Non-work commute trips from CHTS weighted by Streetlight data
  • Pricing behavior models
  • Optimization routine that provides choices for installation accounting for needs of drivers

• EV adoption will employ data simulated from the EV Toolbox
Impact on distribution infrastructure

• Work by PhD student Jake Highleyman

• Employs data from utilities for distribution infrastructure requirements at the circuit and substation level

• Optimizes placement of EVSE while accounting for distribution constraints and costs
Coupling with DER

• Work by PhD candidate Kelsey Fortune
• Just launching this portion of the project
• What are the synergistic opportunities of coupling with distributed energy resources including:
  • Rooftop solar
  • Residential storage
  • Community choice aggregators
Project 3: The TNC Dark Horse

• SB 1014 – The California Clean Miles Standard passed last year which will require TNCs to reduce their per-passenger mile emissions

• One large strategy will be electrification of

• This likely has a tremendous impact on charging service providers’ business models and on local grid infrastructure
Growth of charging demand in California is massive
Coupling demand and infrastructure
Many opportunities and challenges:

1. Leveraging charging management
2. Better understanding of impacts on distribution grids as well as opportunities for synergy
3. Highly uncertain future from the three revolutions
Questions?