| **DOCKETED** |
|-----------------|-----------------|
| **Docket Number:** | 20-IEPR-02 |
| **Project Title:** | Transportation |
| **TN #:** | 234210 |
| **Document Title:** | Presentation - Optimizing charging infrastructure buildout for TNC electrification |
| **Description:** | S4.1A Alan Jenn, UC Davis |
| **Filer:** | Raquel Kravitz |
| **Organization:** | Institute of Transportation Studies University of California Davis |
| **Submitter Role:** | Public Agency |
| **Submission Date:** | 8/3/2020 4:08:38 PM |
| **Docketed Date:** | 8/3/2020 |
Optimizing charging infrastructure buildout for TNC electrification

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Motivation: TNCs use 35% of non-Tesla public DC fast charging by energy
Modeling Approach

Empirical Trip Data
- Uber
- lyft

Bootstrap Data to Simulate Demand

Station Attributes
- ChargePoint
- EVgo

Widespread Infrastructure for Ride-Hailing EV Deployment (WIRED) model

- Reduce costs to charge and downtime (traveling and charging) of drivers
- Meets energy requirements for trips provided throughout the day

Infrastructure Deployment Results
Simulating energy demand from Uber/Lyft data

Energy demand for 1000 TNC vehicles operating in San Diego (left), Los Angeles (middle), and the Bay Area (right)
Scenario Runs

• California locations:
  • San Diego county, Greater Los Angeles, San Francisco Bay Area

• Number of vehicles in operation
  • 100, 1000, 10000

• Weighting parameters
  • Value of minimizing travel to charging stations
  • Value of minimizing charging time

• Behavior of overnight charging
Highlights: More vehicles, more chargers

100 TNC vehicles operating in Los Angeles

1000 TNC vehicles operating in Los Angeles
Highlights: Increasing value of charge time
Highlights: Maximize overnight charging
What is the value of reducing time to travel?

- There is a clear gain in adding chargers to reduce travel time for drivers.

- After a certain point, increasing chargers and costs are to address other issues (e.g. charging time, meeting demand).
Discussion

• Finalizing the development of the WIRED model will allow deep exploration of other scenarios (e.g., Clean Miles Standard projections, etc.)

• The model can integrate existing stations, this will allow for coupling with other infrastructure development models (EVI-Pro2, Roadtrip, EV Toolbox)

• Future steps will address heterogeneity of use between the public and TNC specific EVs
Chargers must serve aggregate demand profiles

Average daily energy demand for 100 TNC vehicles operating in San Diego over 3 months

Average daily energy demand for 1000 TNC vehicles operating in San Diego over 3 months
Infrastructure deployment model

\[
\begin{align*}
\min_{x_{i,r}^{\text{install}}, x_{i,r,s}^{\text{chrgAmt}}} & \sum_{i} \sum_{r} x_{i,r}^{\text{install}} c_{i}^{\text{stationCost}} \\
& + \sum_{i} \sum_{r} \sum_{s} \left( x_{i,r,s}^{\text{chrgAmt}} c_{i}^{\text{chrgPrice}} + w_{1} c_{s}^{\text{energyDemand}} c_{r,s}^{\text{travelTime}} x_{i,r,s}^{\text{chrgAmt}} + w_{2} x_{i,r,s}^{\text{chrgAmt}} / c_{i}^{\text{chrgRate}} \right)
\end{align*}
\]

• Objective function:
  • Installation cost of charging station
  • Cost to driver for charging
  • Weighting value for where charging happens and the time it takes to travel there
  • Weighting value for how long it takes to charge
Infrastructure deployment model constraints

\[
\sum_{i} \sum_{r} \sum_{s} x_{i,r,s}^{\text{chrgAmount}} - \sum_{s} c_{s}^{\text{energyDemand}} \geq 0
\]

\[
\left( x_{i,r}^{\text{install}} + c_{i,r}^{\text{existing}} \right) c_{i}^{\text{chrgRate}} \cdot 12
- \sum_{s} x_{i,r,s}^{\text{chrgAmount}} \geq 0; \ \forall i, r
\]

\[
\sum_{i} \sum_{r} x_{i,r,s}^{\text{chrgAmount}} - c_{s}^{\text{energyDemand}} \geq 0; \ \forall s
\]

- Total charging demand must be fulfilled
- Charging in each period cannot exceed charging capacity
- Allocate charging to original demand locations