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Optimizing charging infrastructure buildout for TNC electrification

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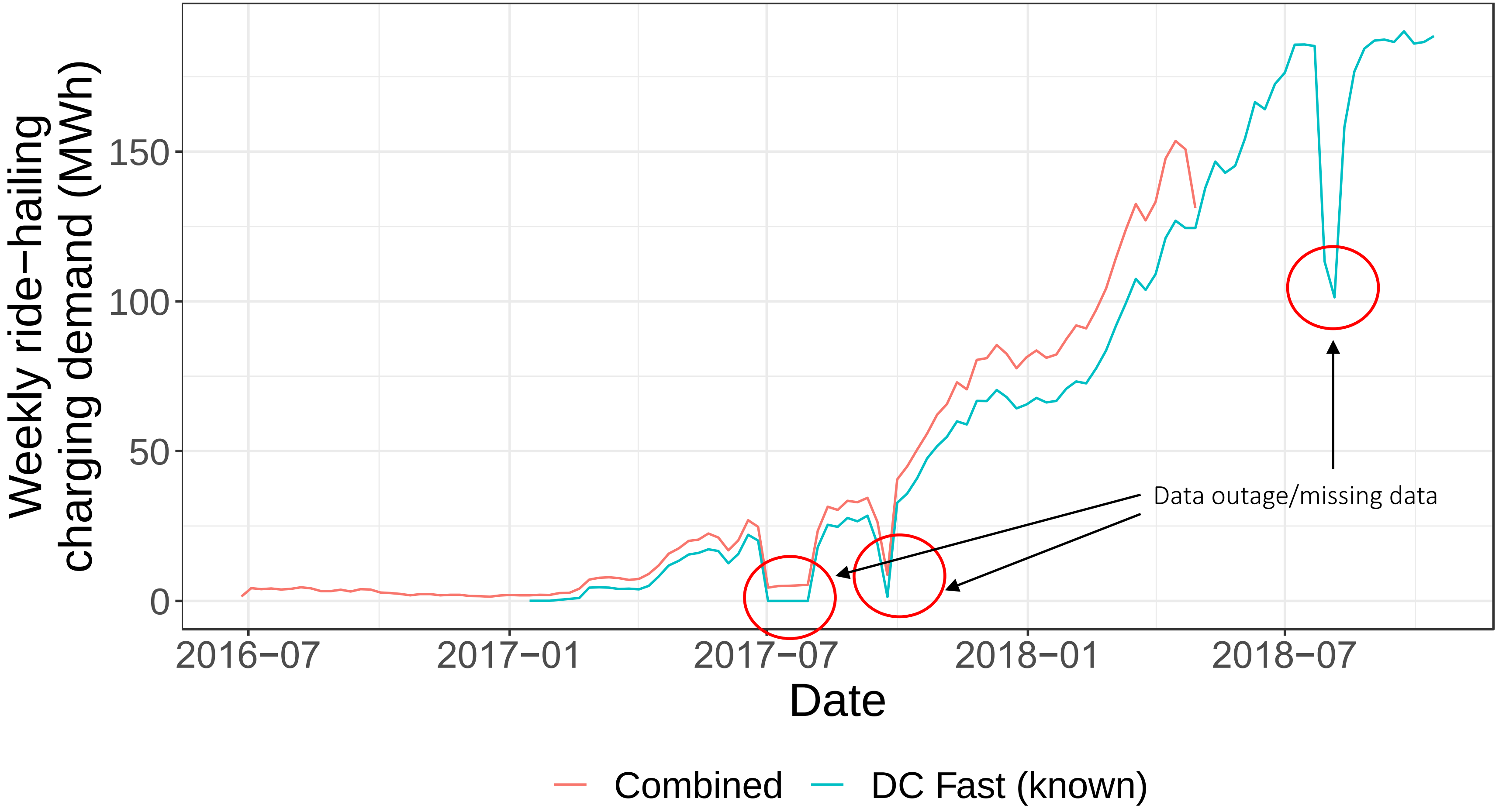
Motivation: TNCs use 35% of non-Tesla public DC fast charging by energy



Modeling Approach

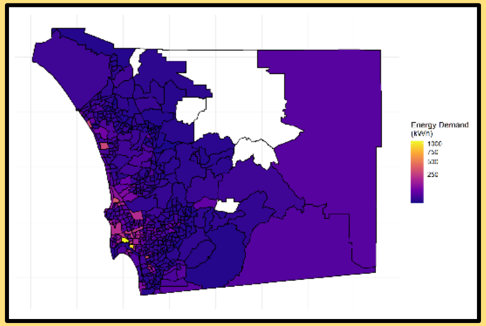
Empirical Trip Data

Uber lyft

Station Attributes

chargepoint EVgo electrify america

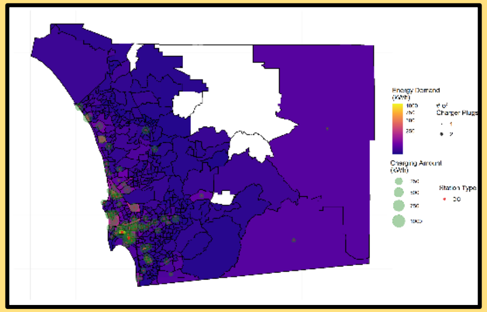
Bootstrap Data to Simulate Demand



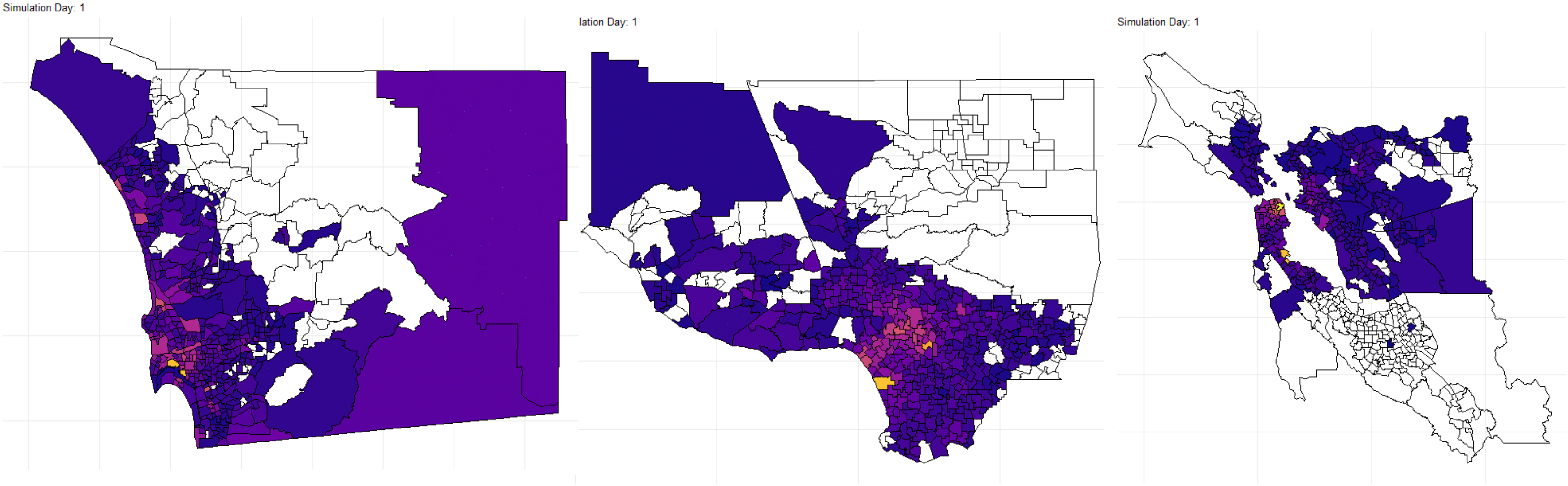
Widespread Infrastructure for Ride-Hailing EV Deployment (WIRED) model

- 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

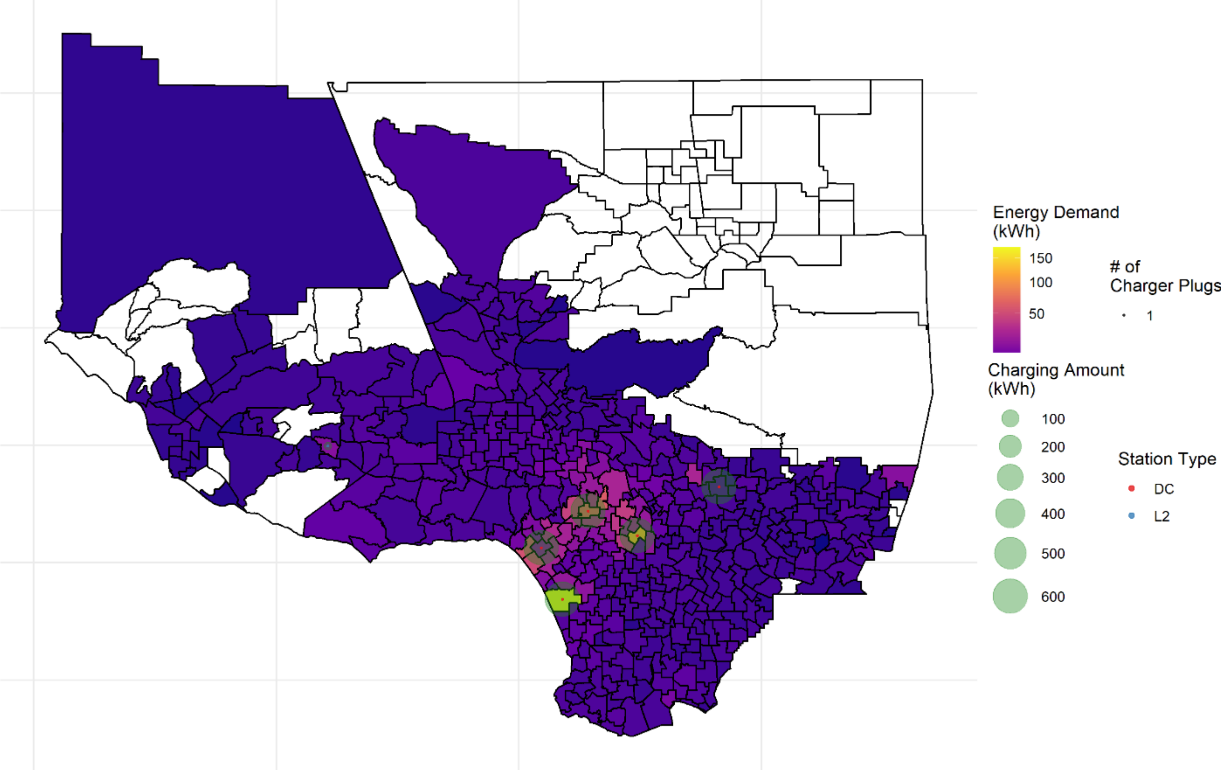


Energy demand for 1000 TNC vehicles operating in San Diego (left), Los Angeles (middle), and the Bay Area (right)

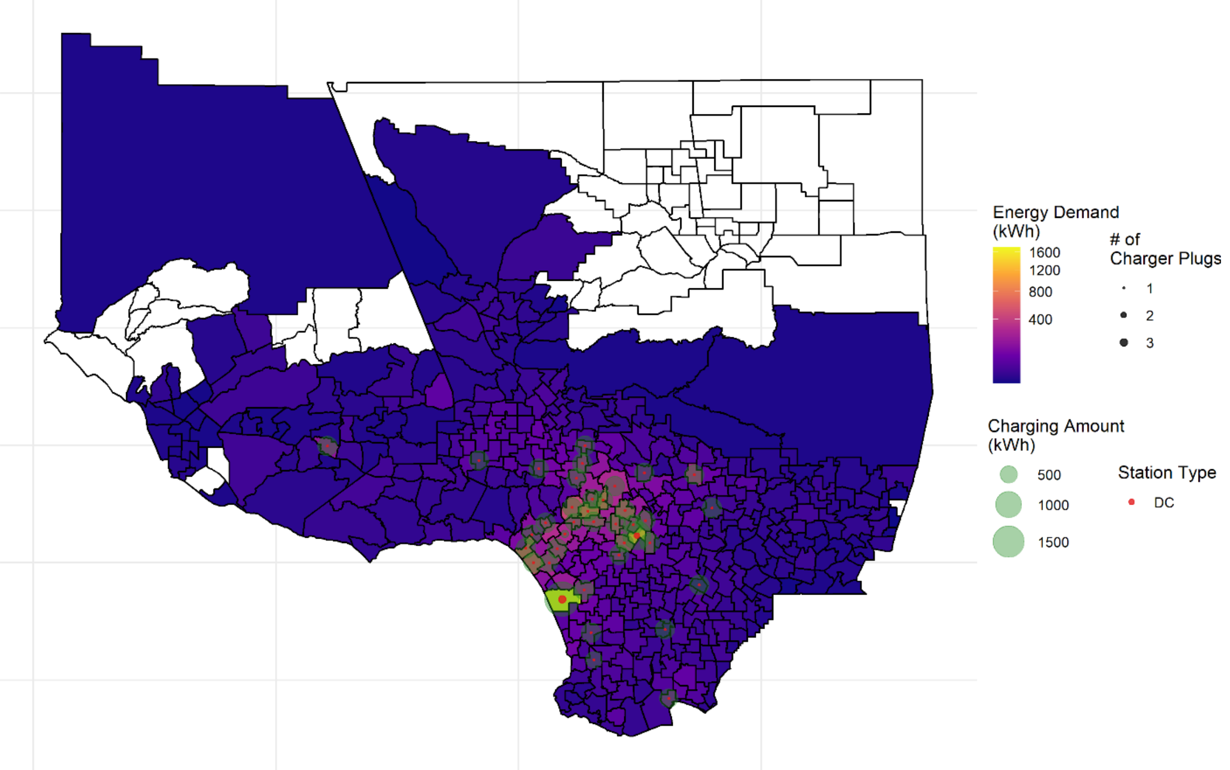
Scenario Runs

- 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

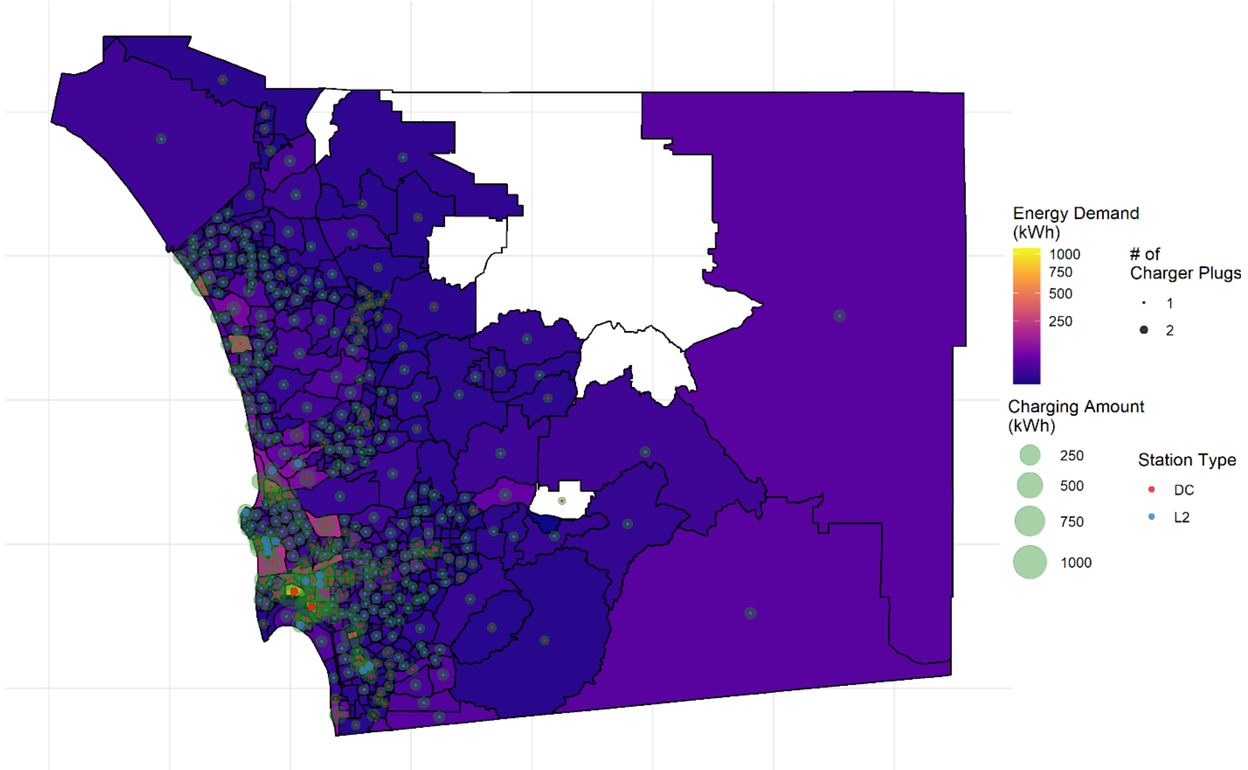


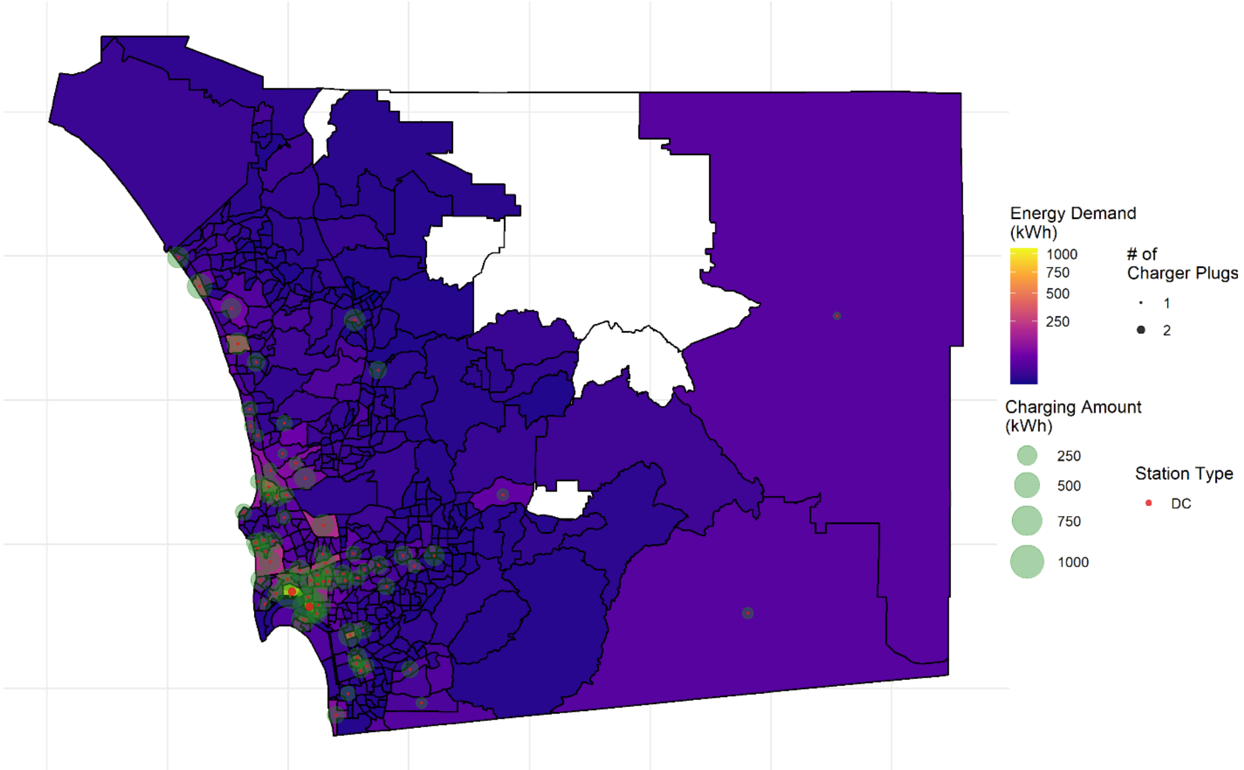
100 TNC vehicles
operating in Los Angeles



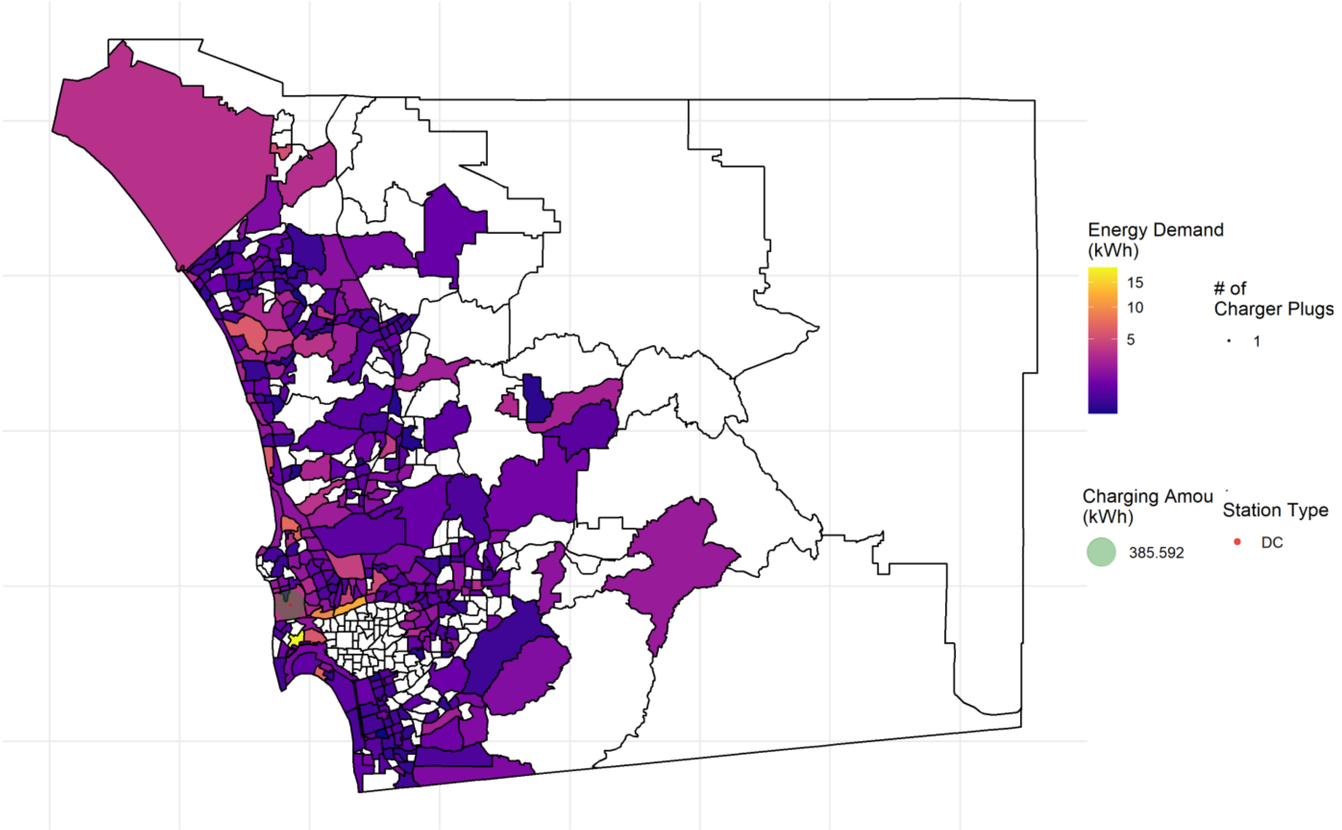
1000 TNC vehicles
operating in Los Angeles

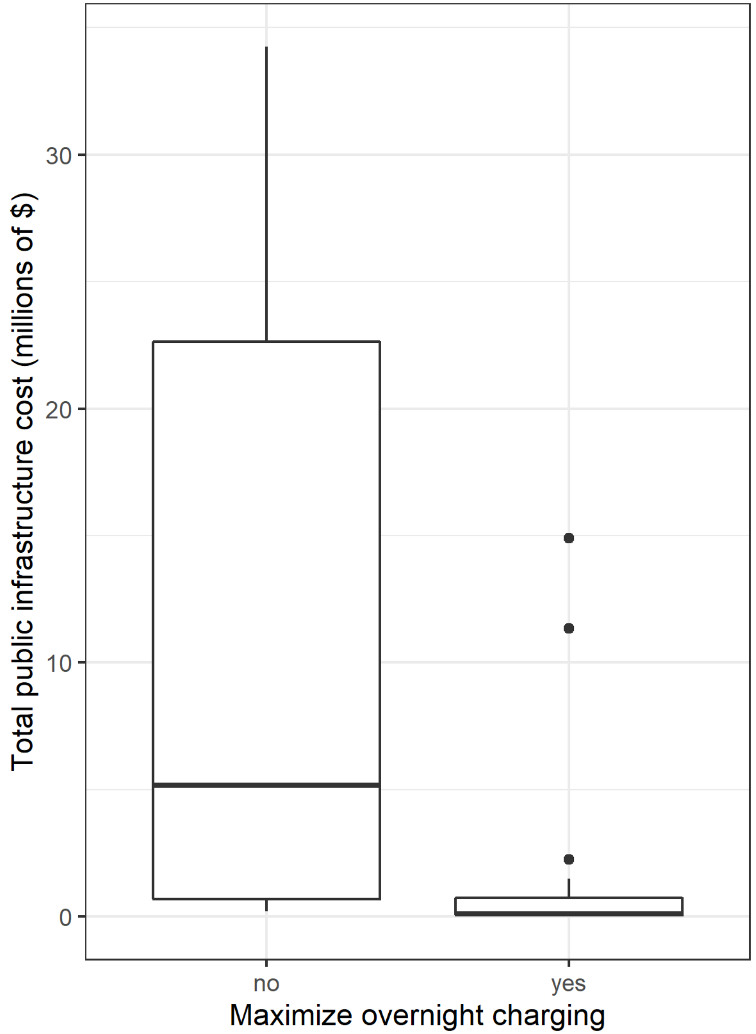
Highlights: Increasing value of charge time





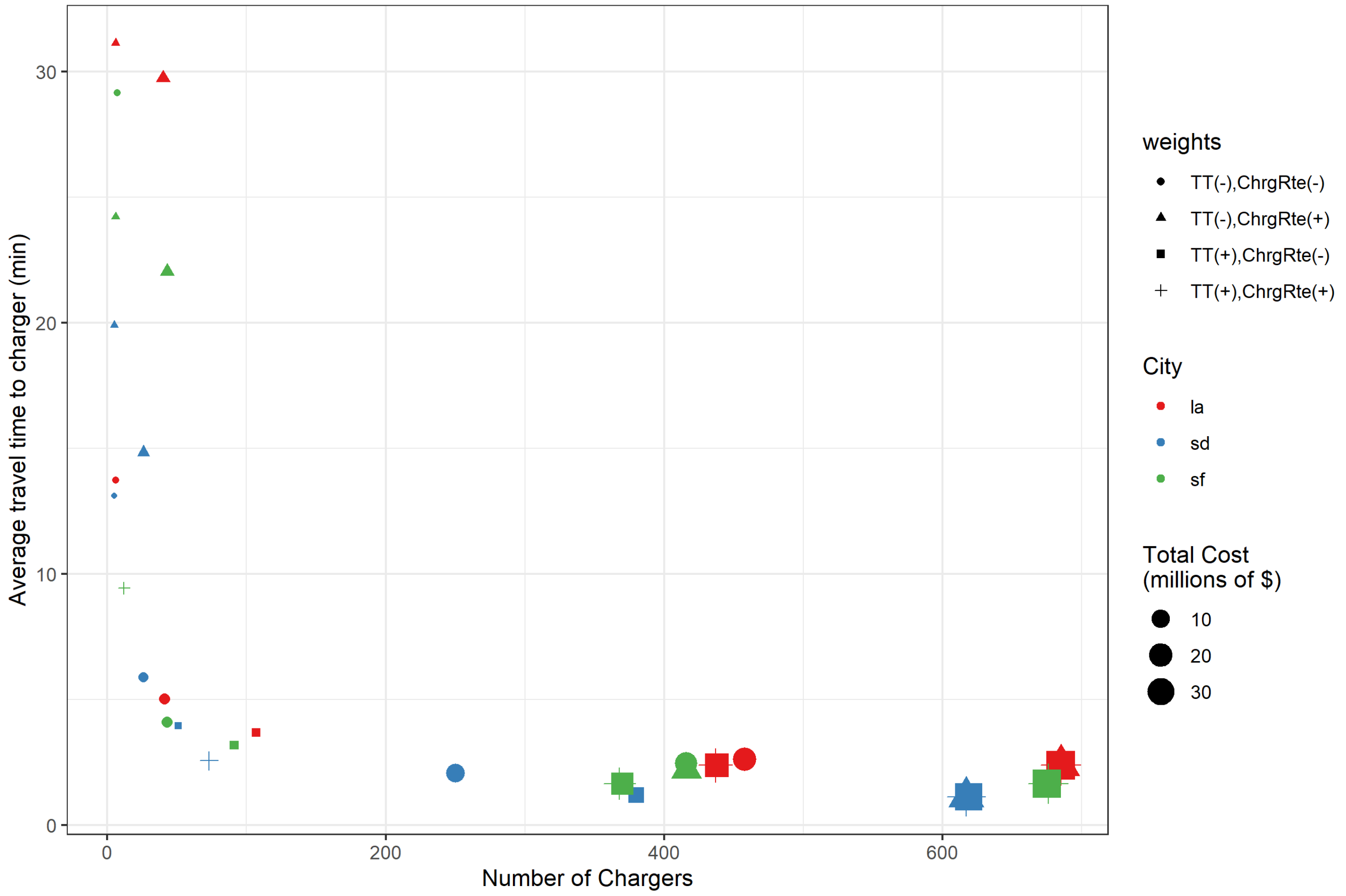
Highlights: Maximize overnight charging





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

Contact

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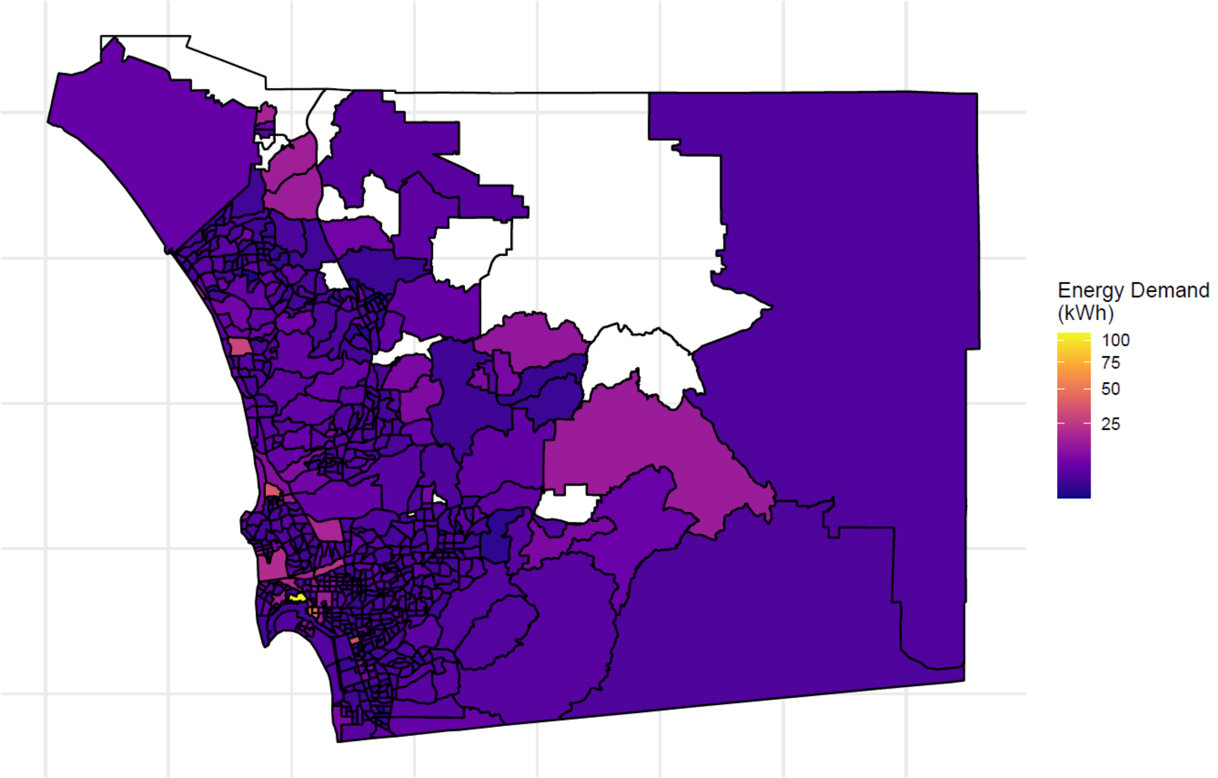
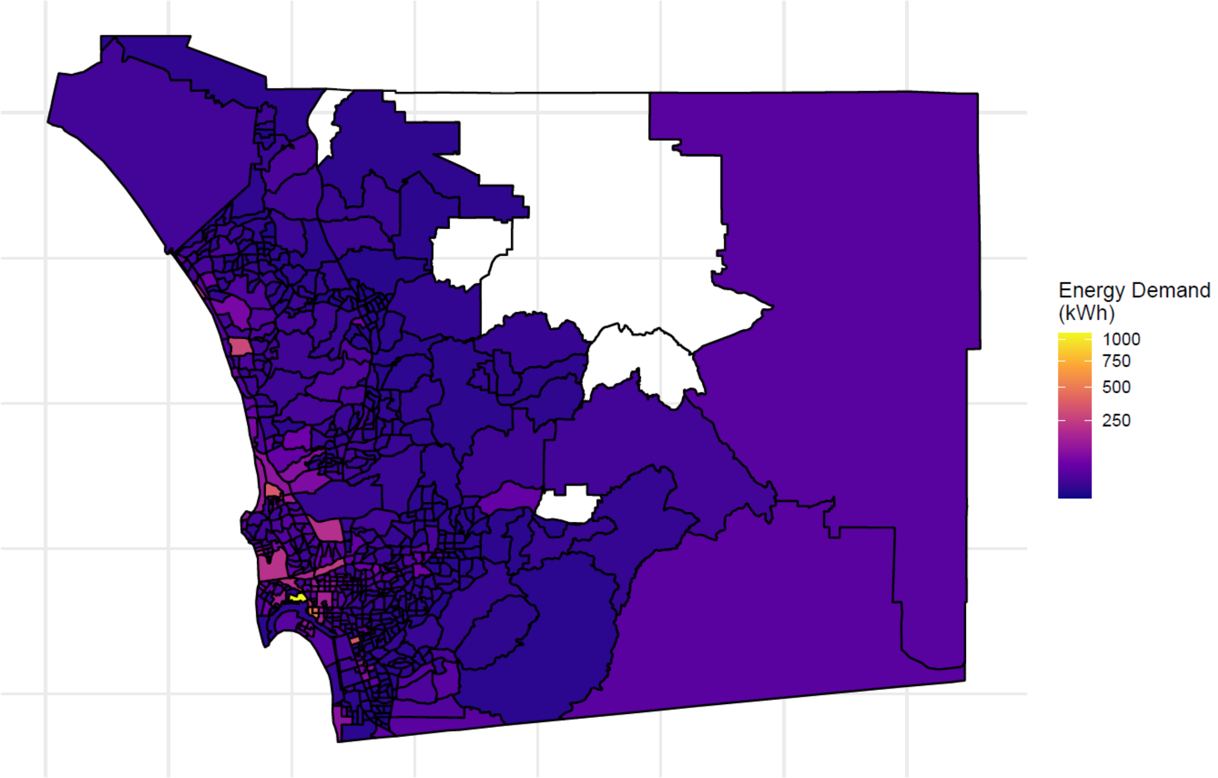
Chargers must serve aggregate demand profiles



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

$$\min_{x_{i,r}^{\text{install}},\, x_{i,r,s}^{\text{chrgAmt}}} \sum_i \sum_r x_{i,r}^{\text{install}} c_i^{\text{stationCost}}$$

$$+\sum_i \sum_r \sum_s \left(x_{i,r,s}^{\text{chrgAmt}} c_i^{\text{chrgPrice}} + w_1 c_s^{\text{energyDemand}} c_{r,s}^{\text{travelTime}} x_{i,r,s}^{\text{chrgAmt}} + w_2\, x_{i,r,s}^{\text{chrgAmt}} / c_i^{\text{chrgRate}} \right)$$

- 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