Infrastructure Use by Plug-in Electric Vehicle (PEV) owners

Webinar - Infrastructure Use by EVs and Emission Impacts of EVs in TNCs

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Charging infrastructure for PEVs

Home is the most popular charging location among PEV owners using their vehicle for private use only

Public charging infrastructure (shopping complexes, office complexes, etc.) is required to encourage and support the growing PEV market

Public infrastructure is expensive to build and in future we may not be able to build out of congestion

We need to determine the factors that drive demand for charging infrastructure and target policies accordingly

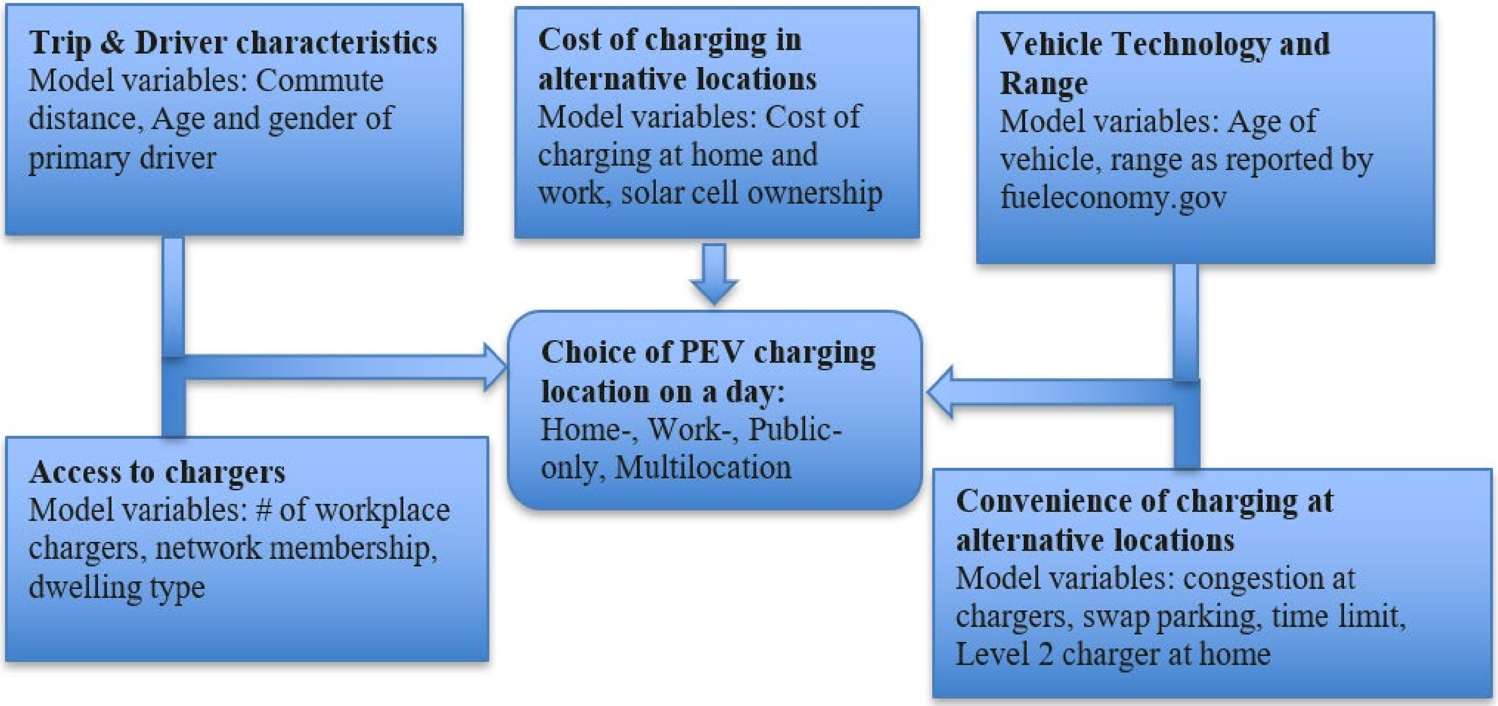
Charging infrastructure use by PEV commuters

Objective of the study: Analyze the factors driving choice of charging location for PEV owners

Study sample: Commuters with access to charging options both at home and work. 1,769 battery electric vehicle (BEV) and 1,432 plug-in hybrid vehicle (PHEV) owners studied.

Method: Structural choice model. Dependent variable: charge @ home, work, public, multiple locations, or not charge

Factors affecting charging infrastructure use



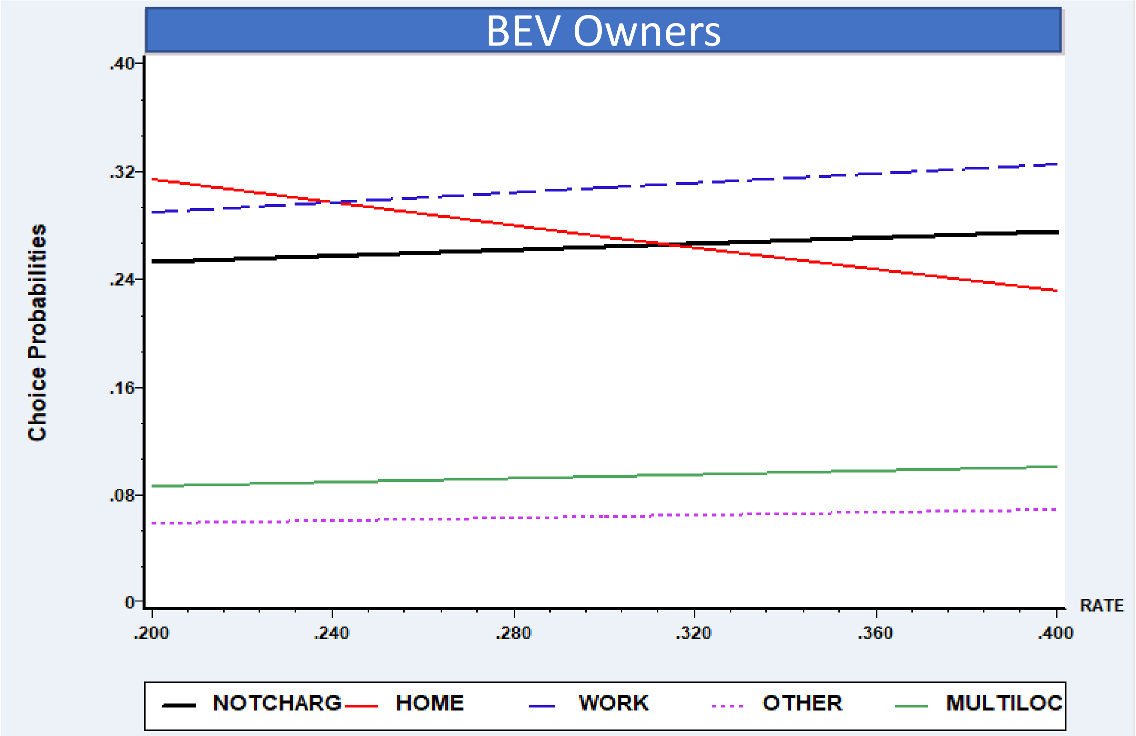
Individual-level heterogeneity modeled in the choice decision:

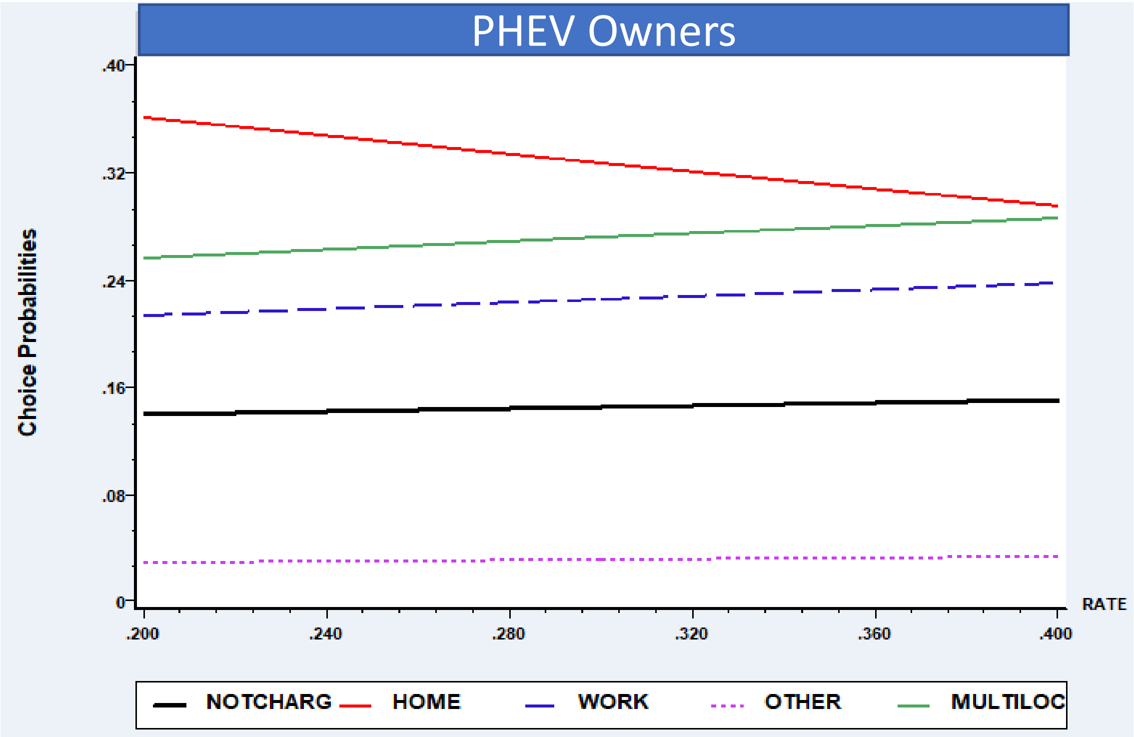
(I) Charge (versus not charge) decisions

(II) Single location vs multiple location

(III) Home vs non-home location (work or public)

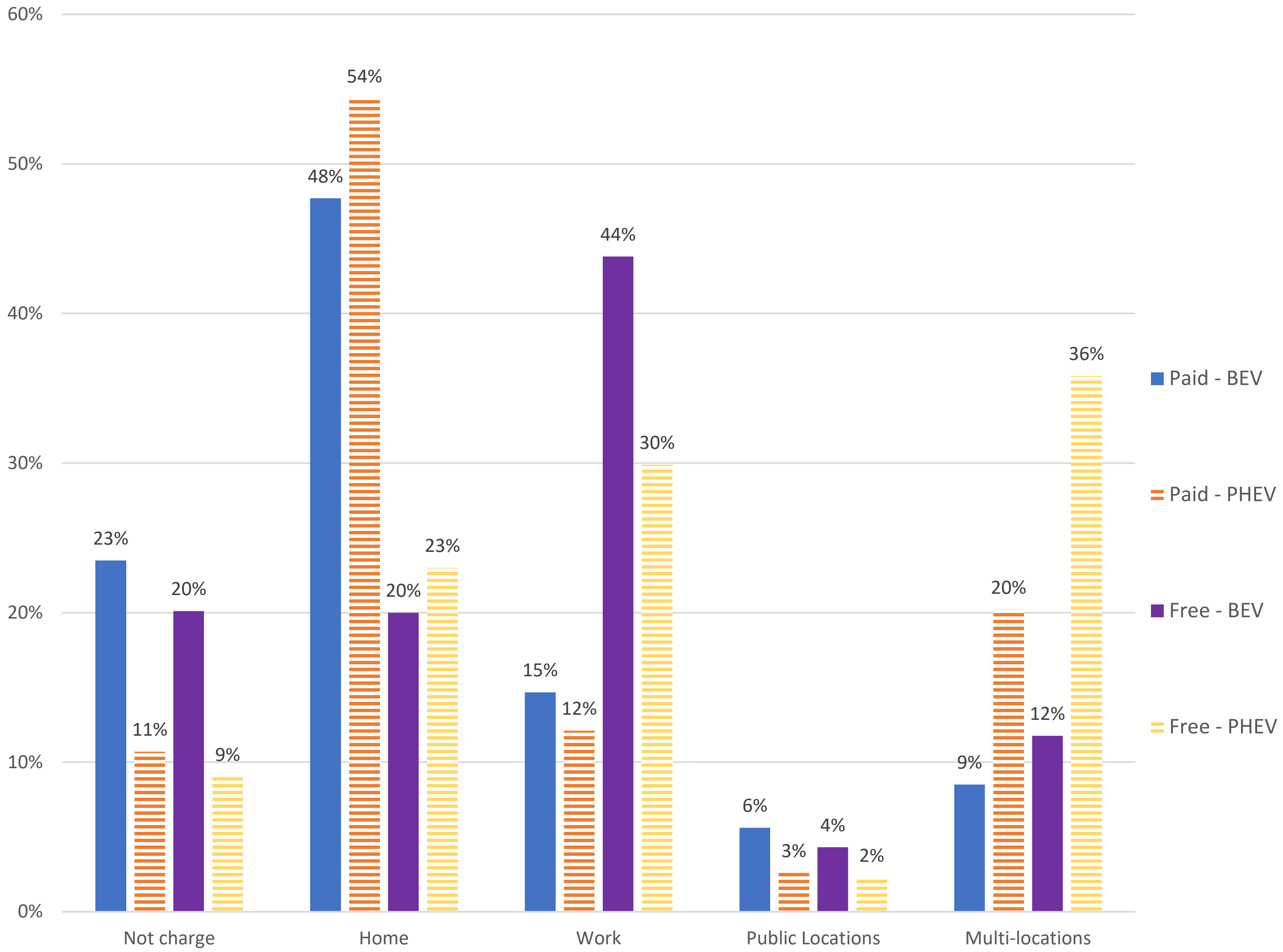
Cost of charging @home





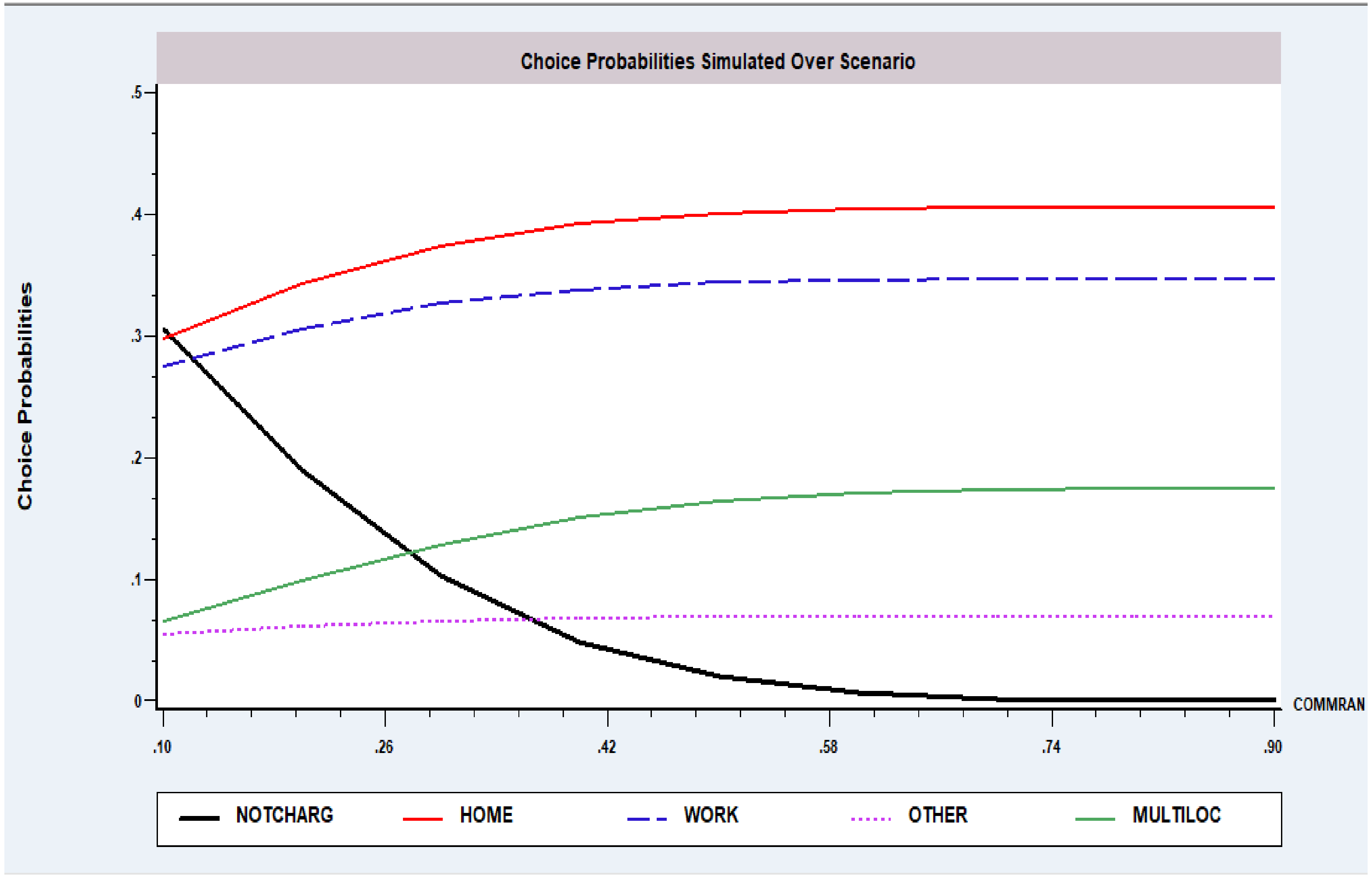
- All else constant, on average, the probability of home charging is 8 percentage point lower if PEV owners face residential electricity rate of 40 cents/kWh compared to 20 cents/kWh.
- PEV commuters may respond by substituting home with workplace charging or by using other vehicles in their household fleet.

Cost of charging @work



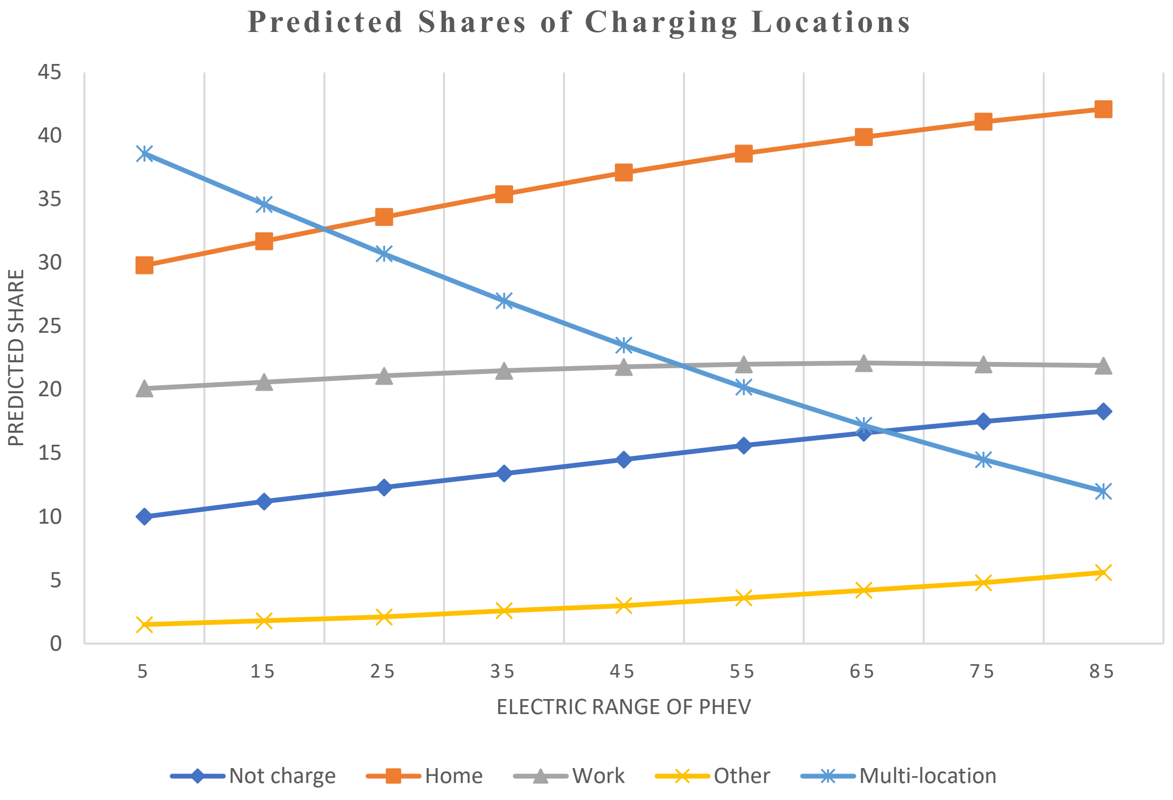
- In the sample, among both groups the share of workplace charging event is substantially higher when free.
- Zero price effect
- All else constant, on average the probability of choosing “workplace” goes up by 9.9 (5.7) percentage points for BEV (PHEV) drivers when workplace charging is free.

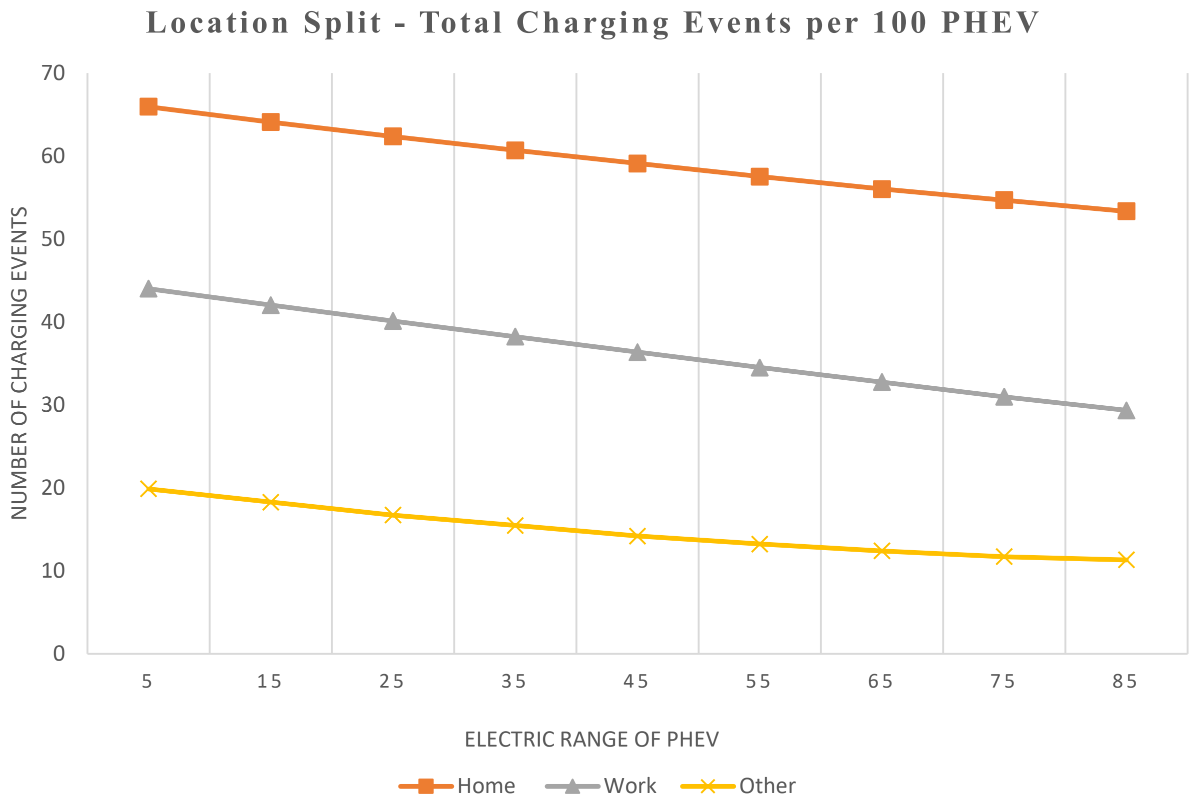
Vehicle Technology: BEV Commuters



- The decision to charge or not is primarily a function of commute distance and range.
- As the ratio of commute distance to range goes up, the need for charging increases.

Vehicle Technology: PHEV Commuters





- With higher e-range, PHEV owners may not need to plug-in multiple times a day to complete their commute

Other factors affecting charging infrastructure use

Factors	Effect on Charging location choice
Driver characteristics	Female drivers of PEVs show a higher likelihood of charging at home than any other location
Access to chargers	Condominiums and apartment dwellers more dependent on non-home locations than residents of detached homes
Convenience of charging @ a location	• Level 2 charger at home raises the probability of home charging by 14 percentage points for BEV owners • Good parking/charging has a strong positive effect on demand for workplace charging

Policy Implications

Demand Drivers	Policy
Residential electricity price	Promoting adoption of special rate plans should encourage charging @ home than in non-home locations
Cost of workplace charging	Free cannot be the long-term plan. Need to develop differential pricing models where PEV owners pay based on the service (e.g. level of charging + parking) received
Access to chargers @ home	Chargers at or near multi-unit dwelling as well as policies incentivizing installation of home chargers can reduce dependence on non-home charging
Vehicle technology	Need to account for changes in charging needs of long-range PEV drivers. Lower need for multiple plug-in events may reduce dependence on public/workplace infrastructure.

Emissions Benefits of Electric Vehicles in Uber and Lyft

Alan Jenn, PhD

Assistant Director

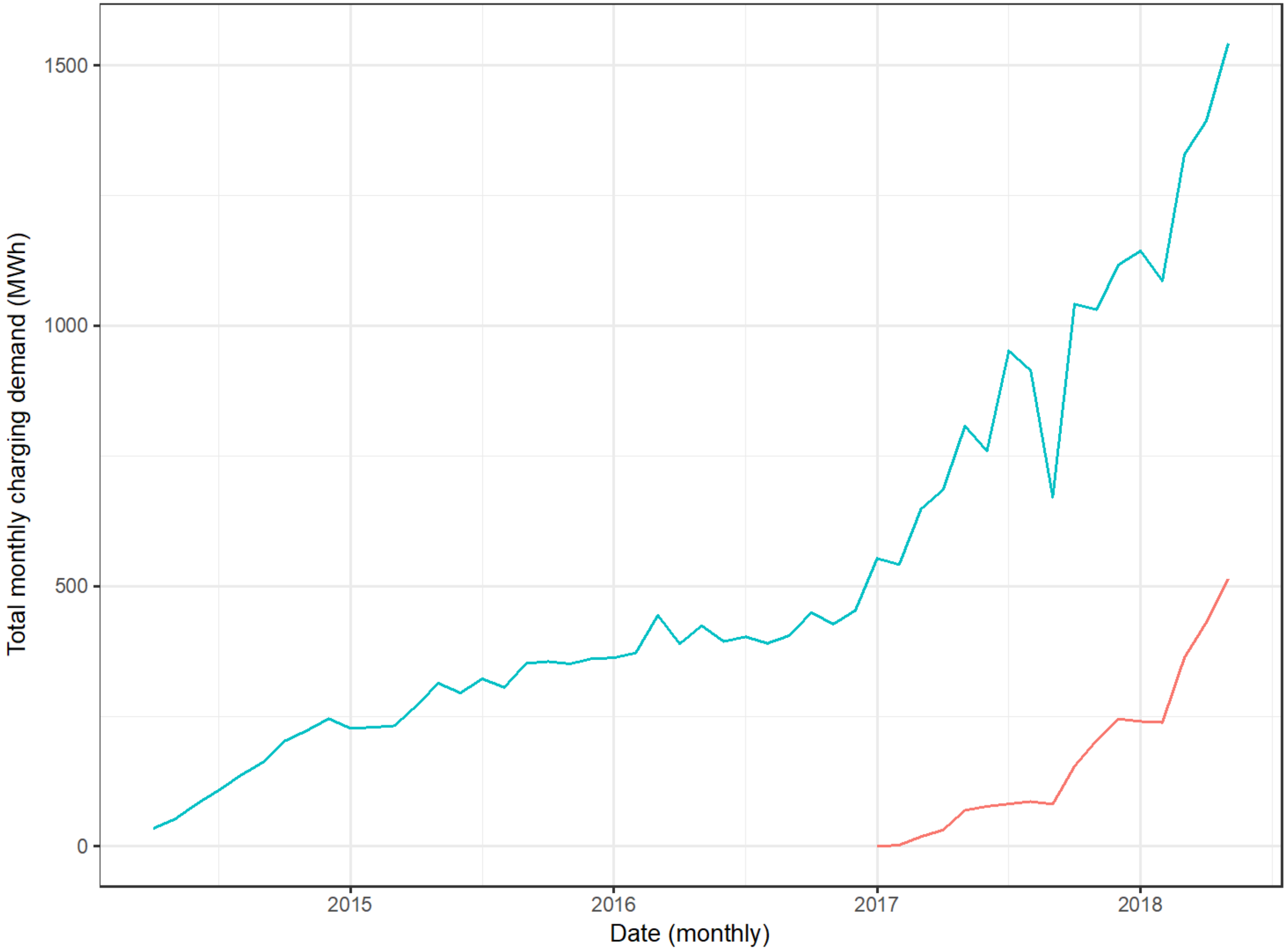
Institute of Transportation Studies

Electrifying vehicles in Uber/Lyft

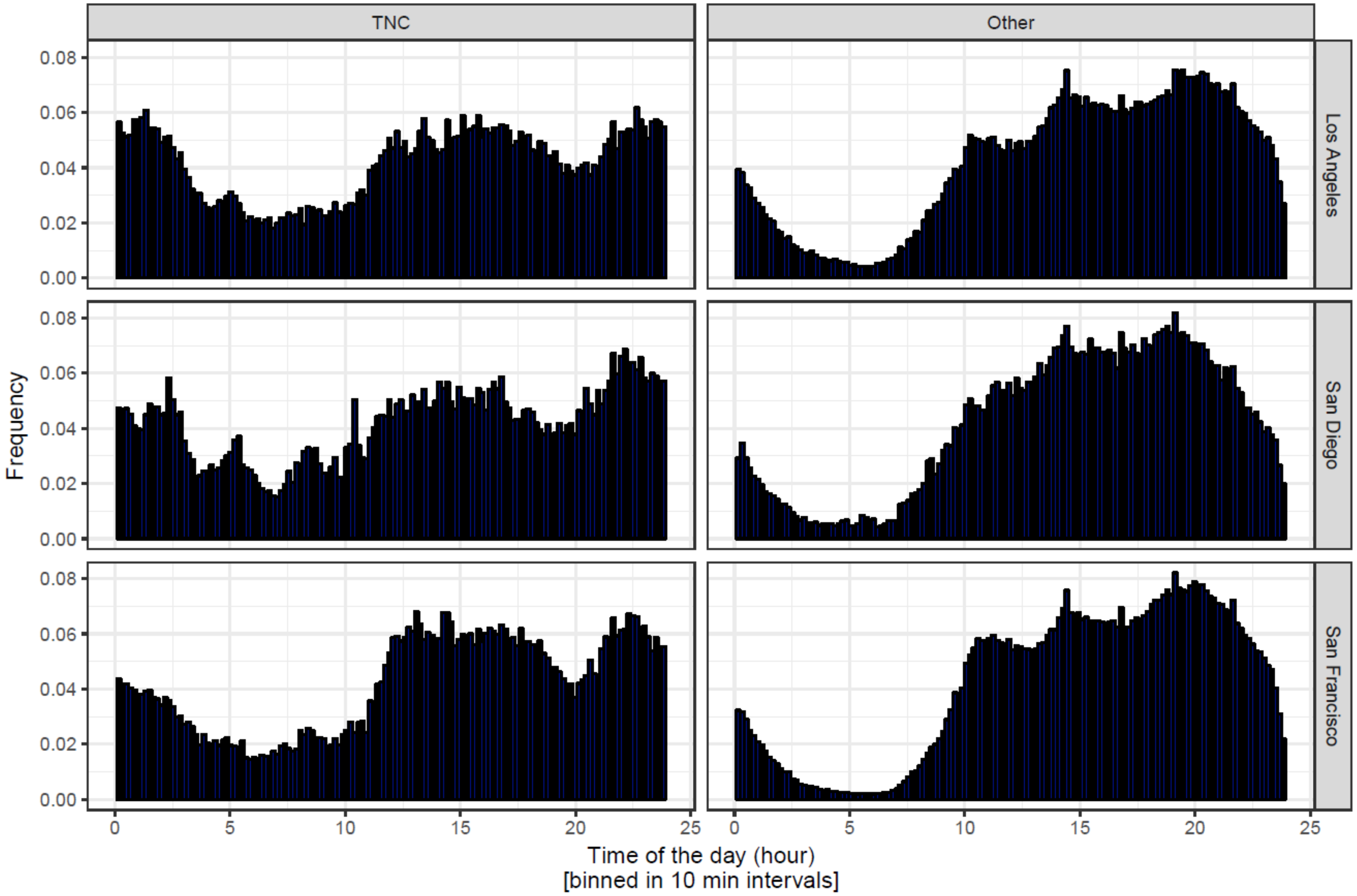
Fast growth of electric vehicles in ride-hailing services has led to important considerations on supporting new technologies in these services:

- What are the benefits of EVs in ride-hailing?
- Are EVs able to provide the same service as conventional gas vehicles?
- What are the financial barriers for drivers to adopt this technology?
- How much charging infrastructure is required to support EVs with travel and charging patterns of ride-hail?

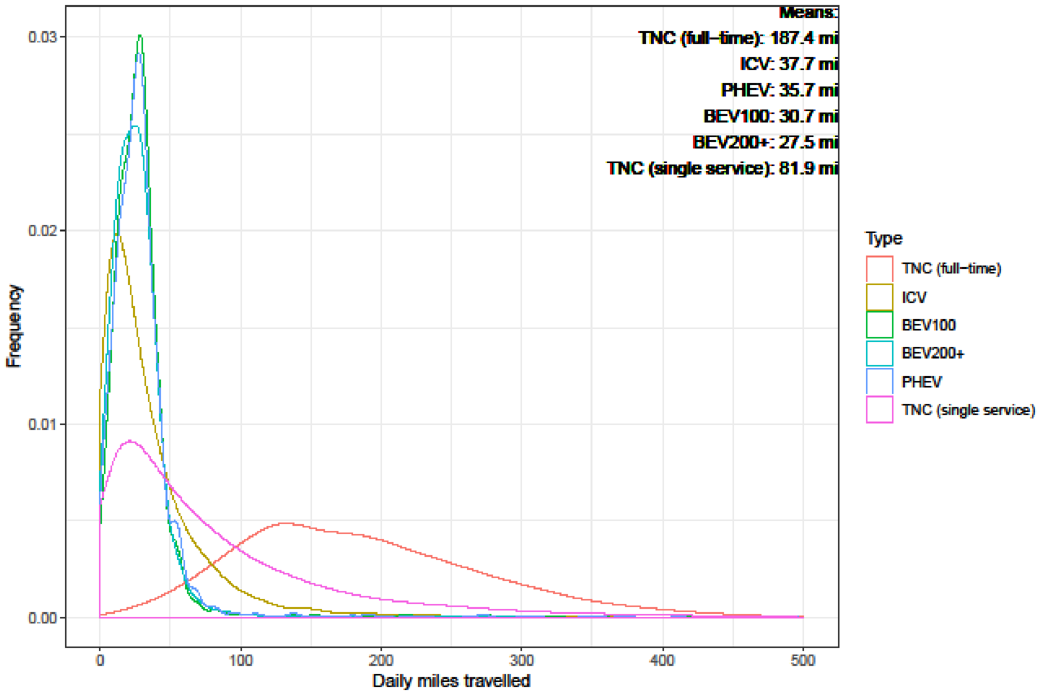
TNCs use 35% of non-Tesla public DC fast charging

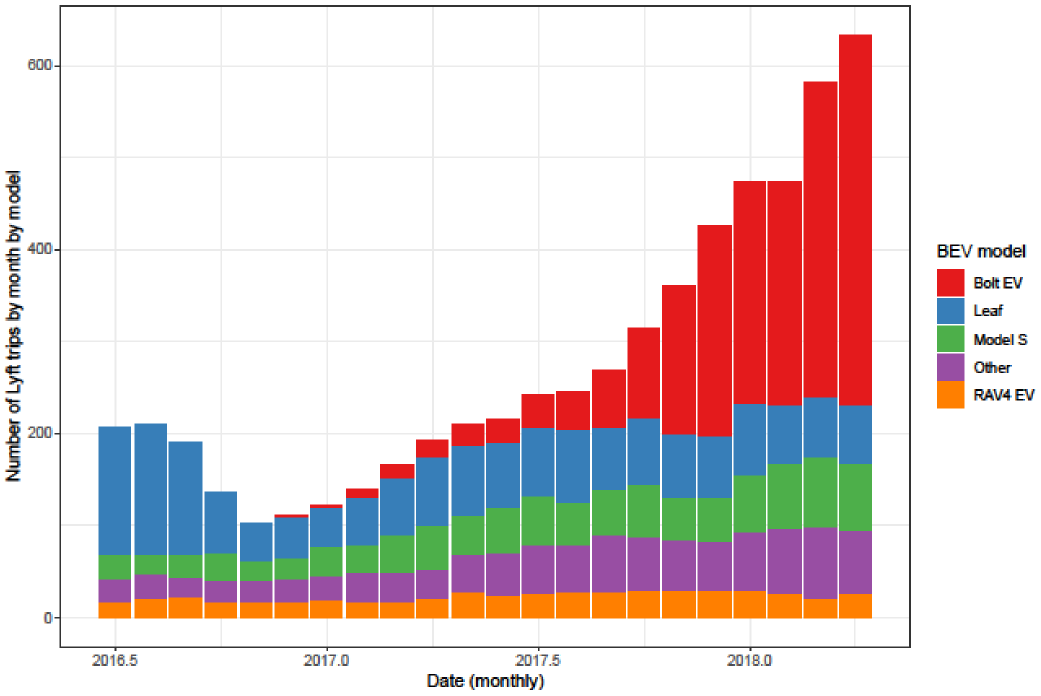


TNC charging behavior is quite different



Ride-hail driving and EV range – a critical relationship





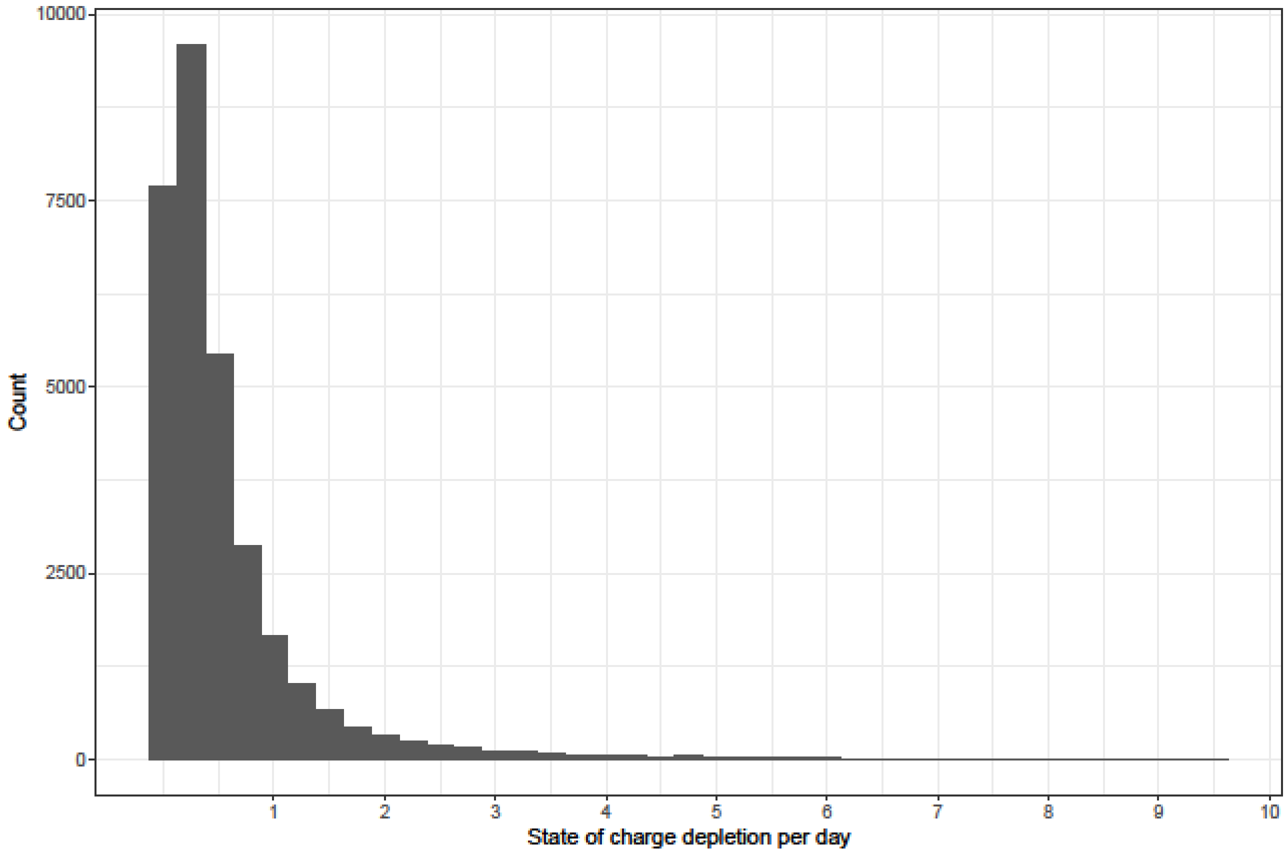
Even given travel behavior (left), the types of electric vehicles (right) has a strong bearing on capability of vehicles meeting the travel patterns of ride-hail vehicles.

How much SOC do drivers use in a day?

For a single day, about 85% of vehicles use less than the full range of the battery

15% exceeding the range of the battery indicates that a non-trivial portion of vehicles *must* charge during the day to fulfill their behavior

From a perception standpoint, this may help to explain observed behavior for why drivers try to keep their SOC topped out

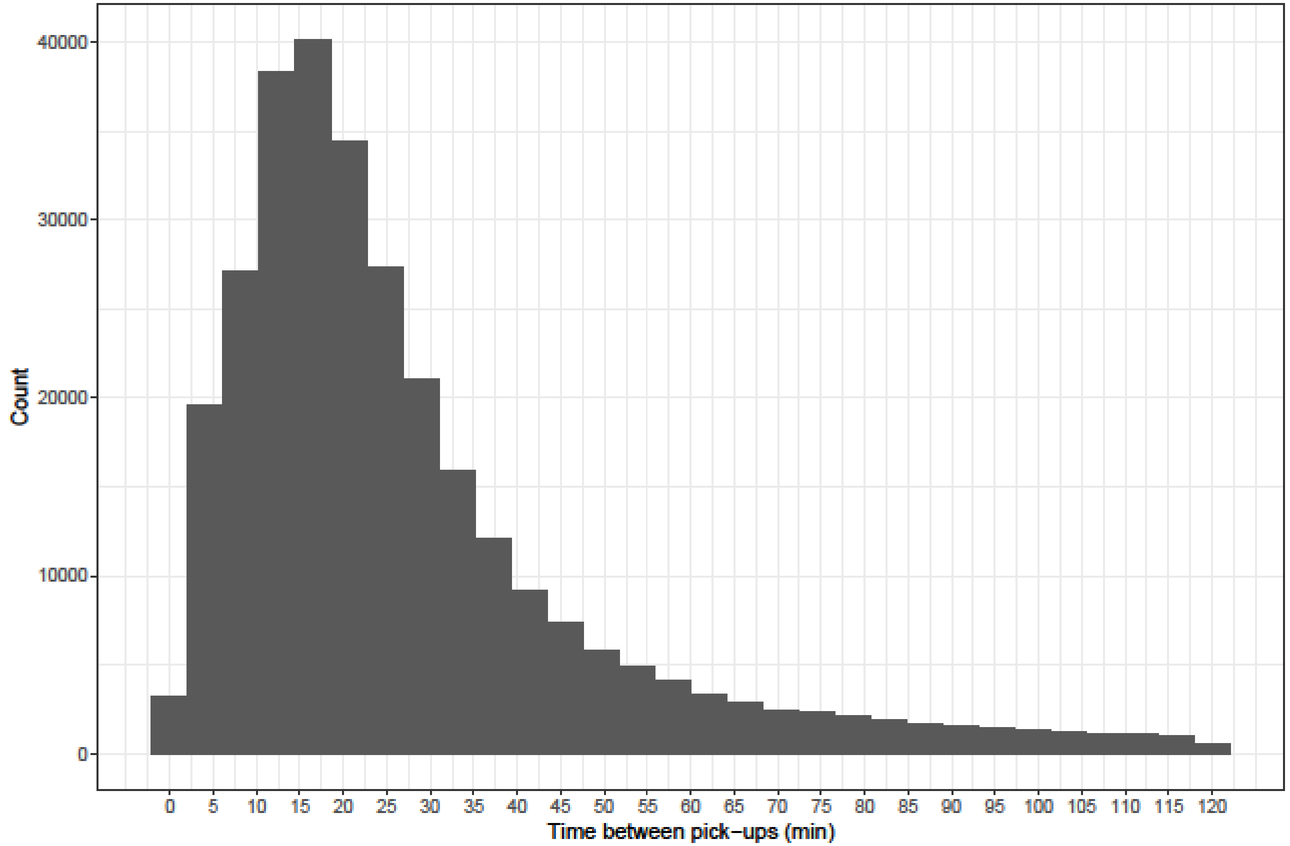


Capability of EVs to charge between rides

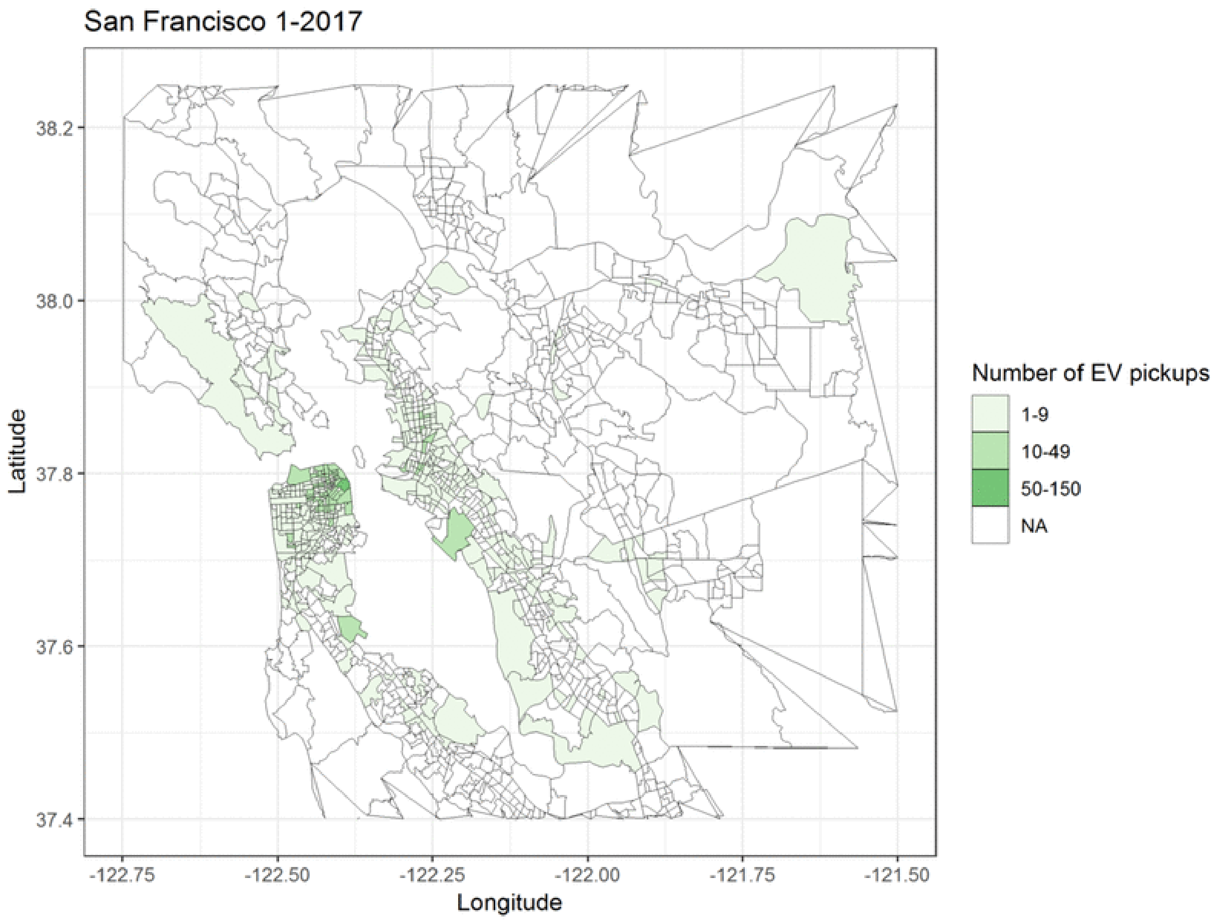
Figure shows the amount of time between the *starts* of each pickup—this means each time includes: the trip, the wait time, and the amount of time to drive to pickup the next passenger

We find that most drivers have one or two "sessions", clusters of time in a day that they provide service

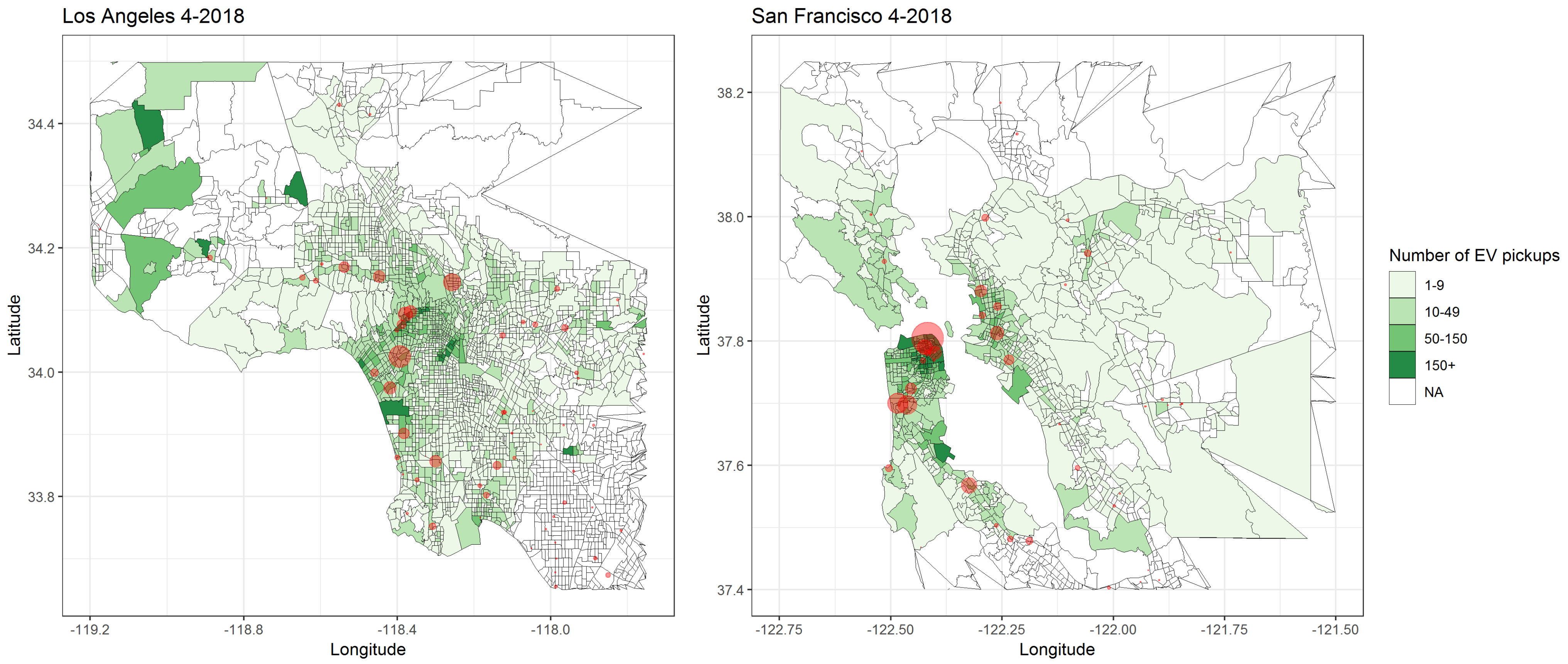
Not large opportunities for slower charging in between trips for individual sessions



Growth of TNC EVs and their public infrastructure use has been rapid



Are chargers located where they are needed?



TNC infrastructure model (on-going work)

$$\min_{wrt: x^{chrg}_{ijtr}, x^{loc}_{jrt}, x^{inf.inst}_{ir}} \sum_{ijtr} x^{chrg}_{ijtr} \sum_{jrot} x^{loc}_{jrt} x^{loc}_{jrt-1} c^{trav.time}_{ro}$$

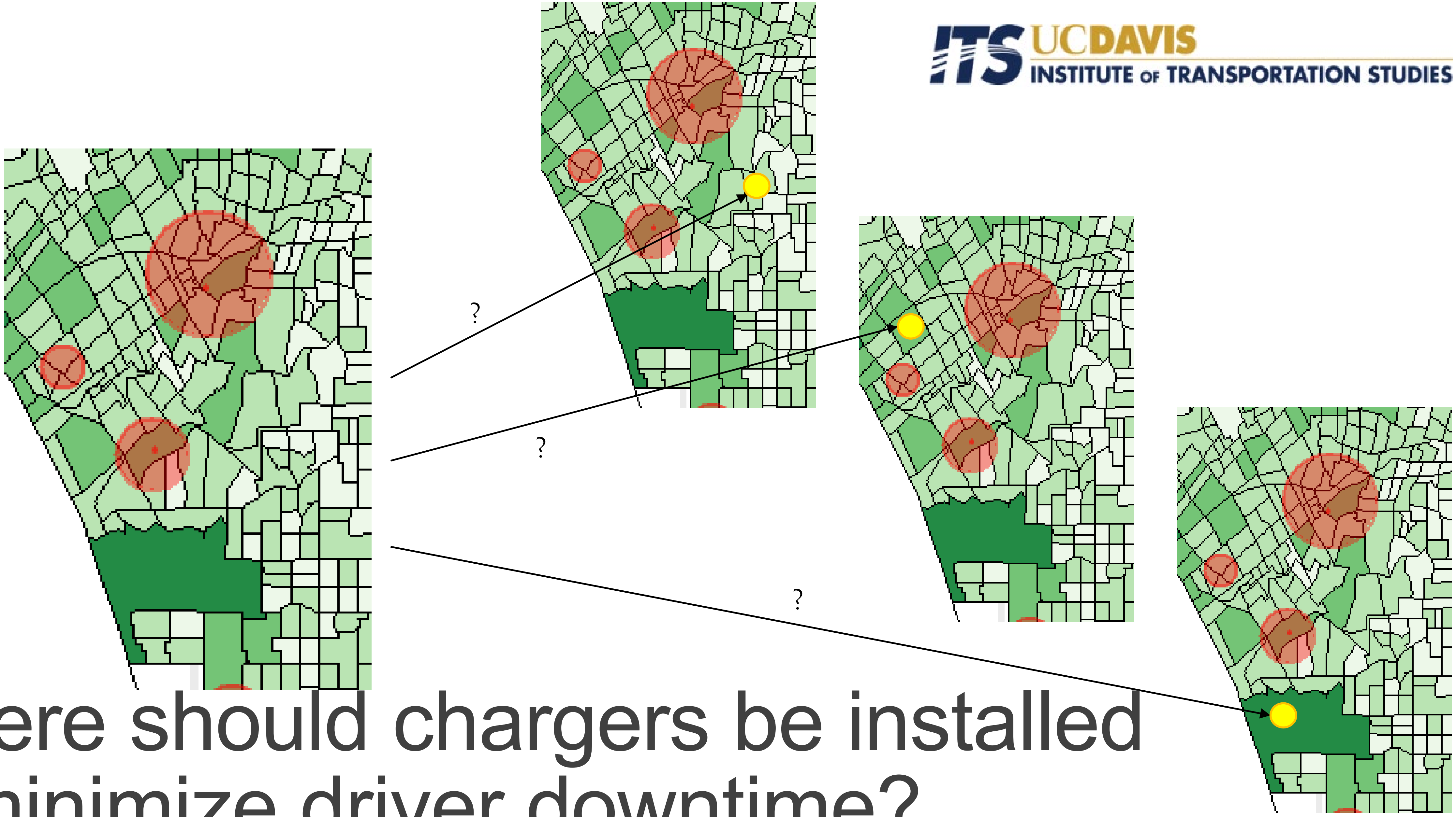
$$\sum_{ij} x^{chrg}_{ijtr} \leq \sum_{i} x^{inf.inst}_{ir} + c^{inf.exist}_{ir}, \forall rt$$

$$\sum_{j} c^{daily.mi}_{j} \leq \sum_{ijtr} x^{chrg}_{ijtr} c^{mi.per.hr}_{i}$$

$$\sum_{ir} x^{inf.inst}_{ir} c^{cost}_{i} \leq c^{budget}$$

$$\sum_{ir} \left(x^{chrg}_{ijtr} + c^{travel}_{jrt} \right) \leq 1, \forall jt$$

- How do we minimize downtime for TNC drivers?
  - We developed a mixed-integer program optimization model
  - Currently populating with empirical data

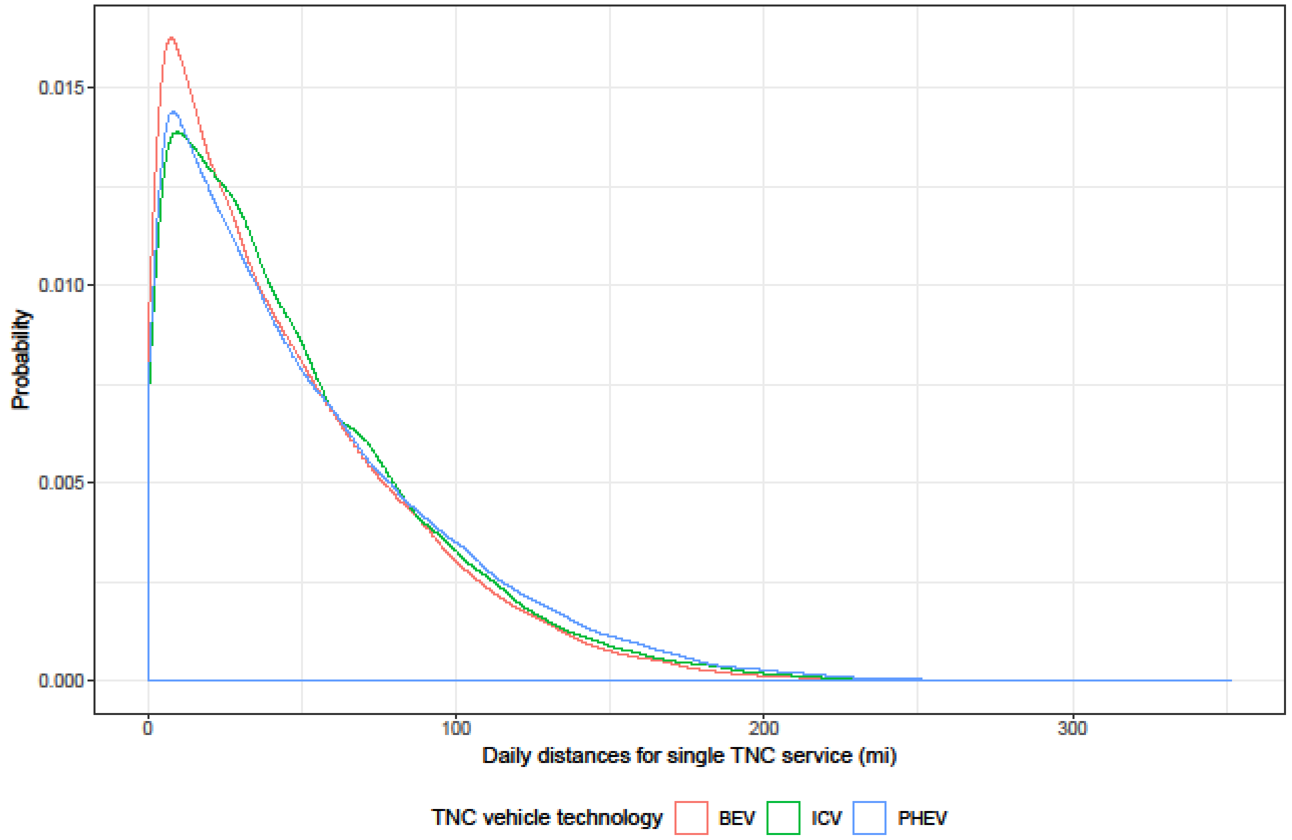


Where should chargers be installed to minimize driver downtime?

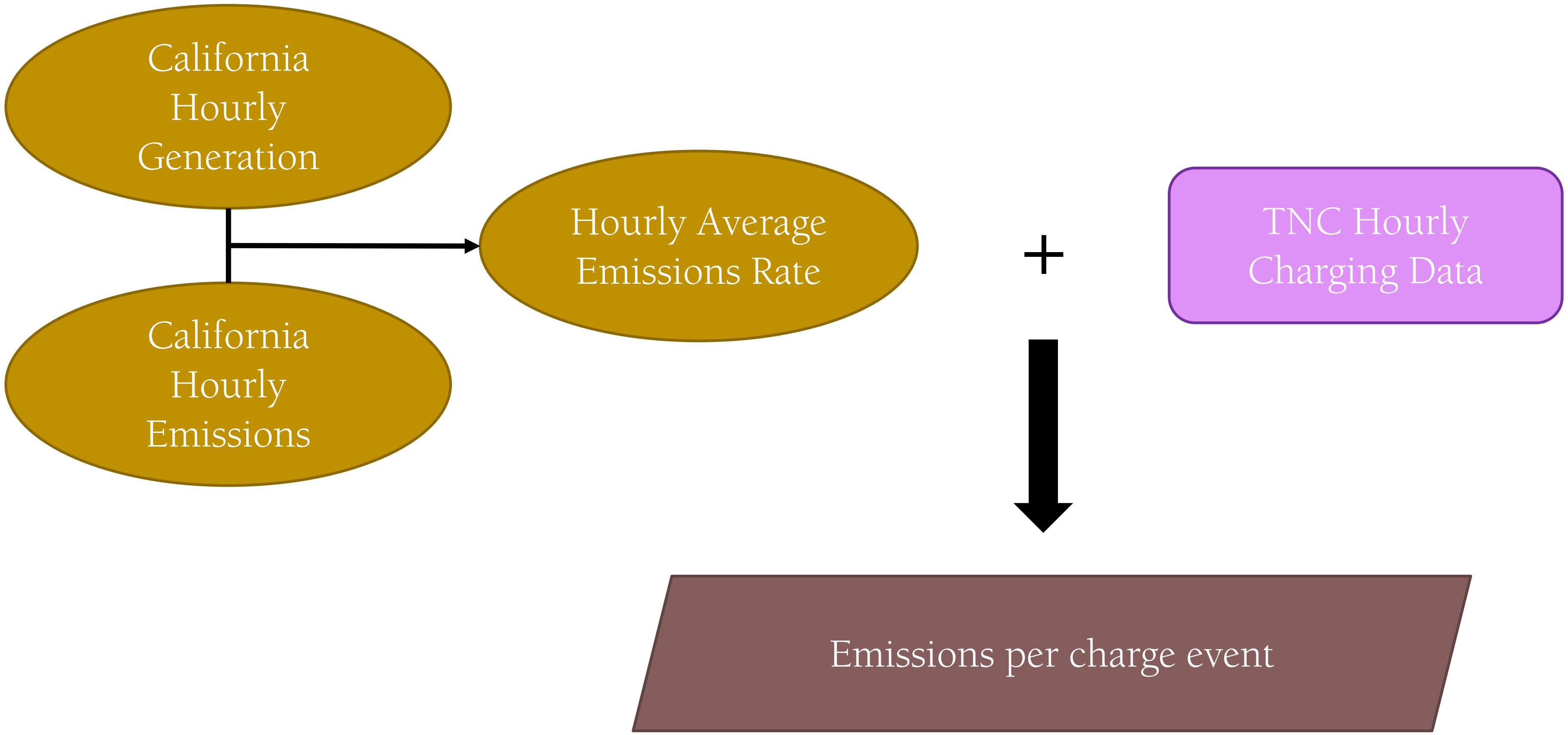
Does current infrastructure prevent EVs from providing adequate service?

Despite the issues listed above, we find no statistical difference in the number of trips and the distance travelled everyday.

We don't know whether this holds true for locations. Are EVs providing services in the same places as gas vehicles?



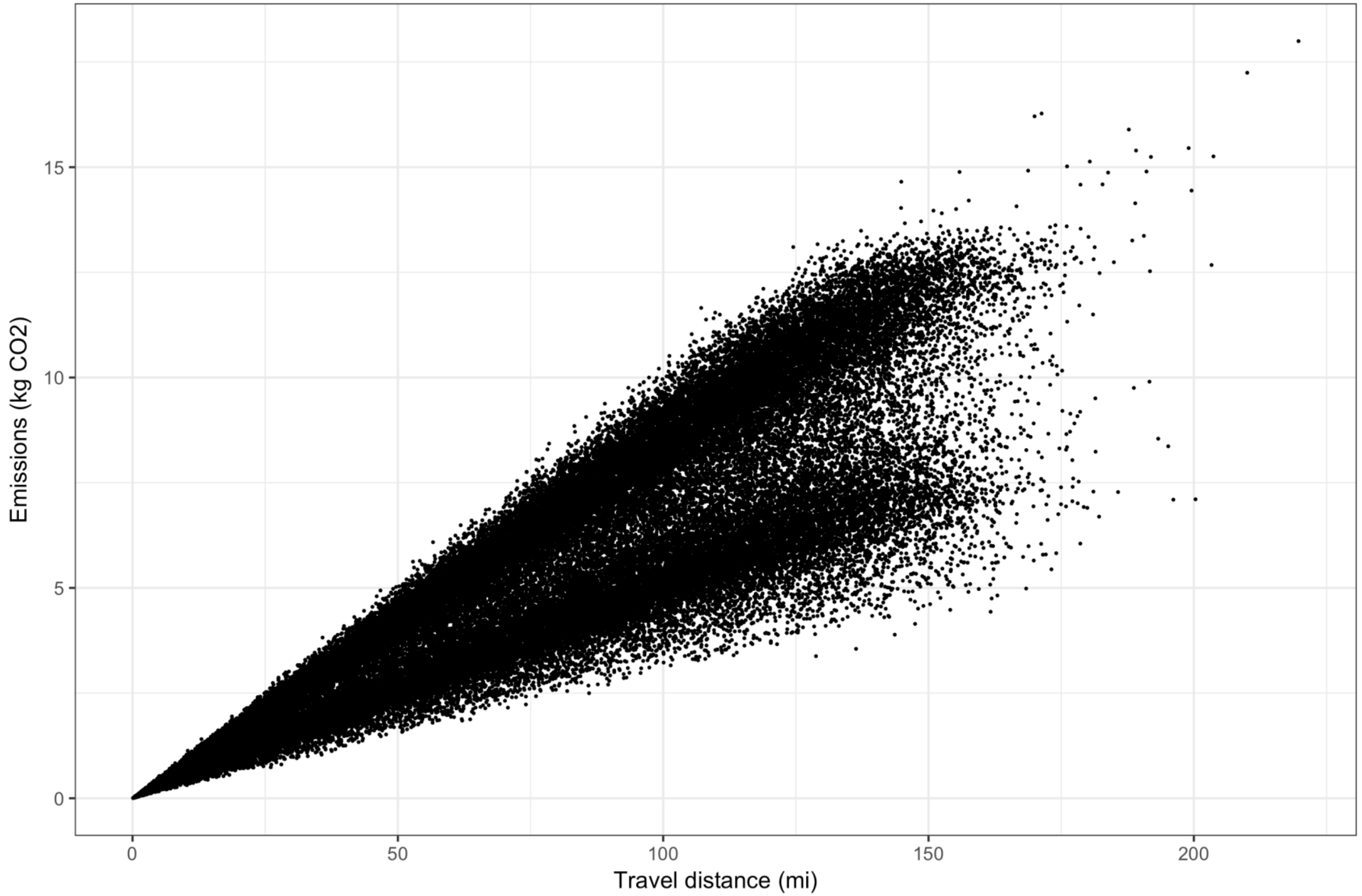
Modeling emissions of TNC EVs



Emissions associated with TNC charging events

For every individual vehicle charging record, the associated emissions can be calculated

The variation in emissions for a given travel distance is due to range in hourly emissions at any given charging time



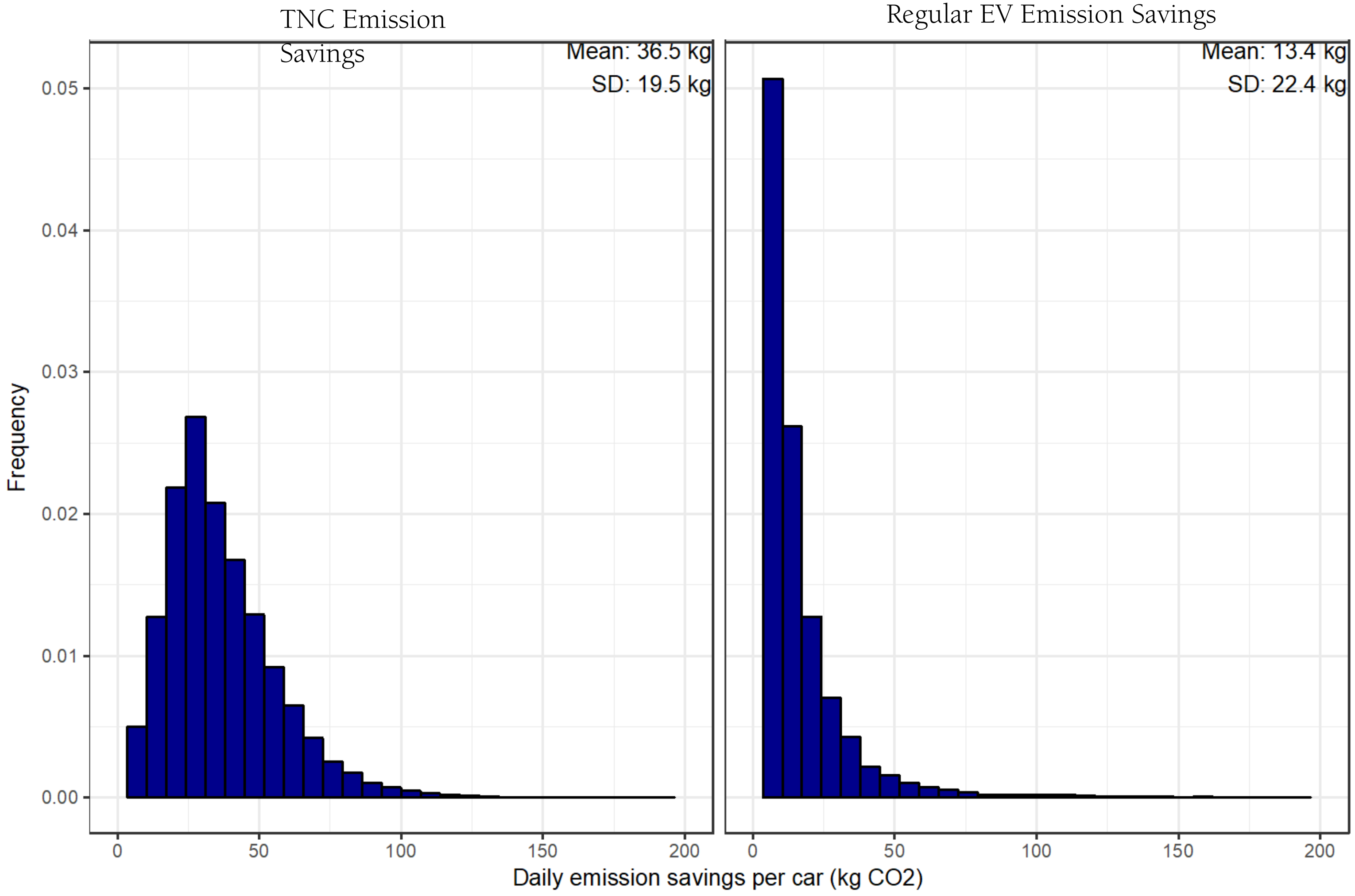
Comparative emission savings

TNC EV emission savings is the difference between:

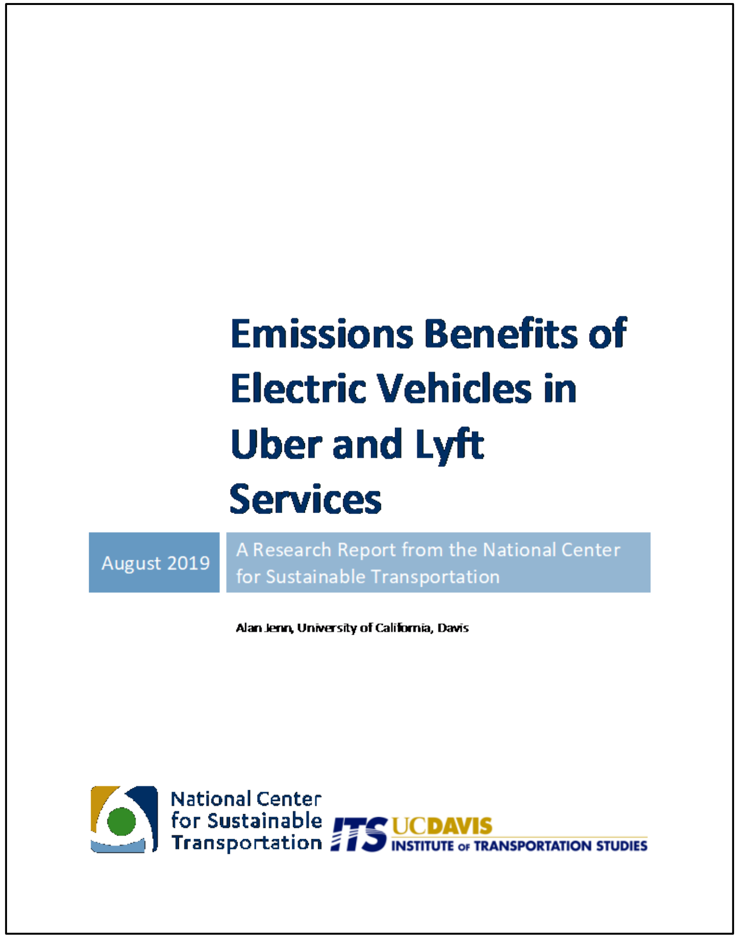
- EV – calculated as before
- ICV – based on empirical vehicles

Regular EV emission savings is the difference between:

- ICV – actual trip data from CHTS with corresponding fuel efficiencies
- EV – assumed highest efficiency (28 kWh/100 mi) and lowest emission rates (180 g/kWh)



Findings from NCST report



Emissions Benefits of Electric Vehicles in Uber and Lyft Services

August 2019

A Research Report from the National Center for Sustainable Transportation

Alan Jenn, University of California, Davis

National Center for Sustainable Transportation

ITS UCDAVIS INSTITUTE of TRANSPORTATION STUDIES

Report was released in August 2019. Two main findings:

1. Growth in EVs has been startlingly rapid
2. Emissions benefits are much larger for TNC vehicles

https://escholarship.org/uc/item/15s1h1kn

Ongoing work

Using trip-level data to observe charging potentials:

- How much SOC is used and how much charging opportunity is there between specific trips, how many future trips can charging events support?
- Distance between pickup locations and charging infrastructure: what is the time it takes to travel to chargers?
- Trade-off between fewer and farther DC fast chargers versus larger number and closer Level 2 chargers

Economics of charging in TNCs, large opportunity/barrier for service providers