A User-Driven Deployment Plan of Dynamic Charging Systems for EVs

Duc Minh Nguyen

King Abdullah University of Science and Technology

IEEE SusTech 2021

King Abdullah University of Science and Technology | CEMSE Computer, Electrical and Mathematical Sciences and Engineering

Abstract

In a future of sustainability with electric vehicles (EVs) as the major means of green transportation, new efficient charging solutions such as *dynamic charging systems*, i.e., electrified roads that charge EVs (wirelessly) while driving, will become the main driving force behind the green transformation in every modern city. In this poster, we introduce a statistical framework to guide the deployment of charging roads in metropolitan cities and measure theirs impact on urban commuting trips.

Introduction

- **Green transportation plays a key role in a future of sustainability**
- **EVs are at the heart of sustainable transportation**:
  - Reduces our reliance on fossil fuels and cuts down on polluting emissions
  - Improves public health and creates economic growth
- **To facilitate the application of EVs, we need efficient charging facilities:**
  - Long charging time of charging stations impedes changes in customers' behaviors.
  - Driving range anxiety prevents car manufactures from producing affordable EV models, since batteries accounts for a large part of the EVs cost.

For EVs to be adopted by the majority, beside regular EV charging stations, we need *dynamic charging systems*, i.e., solutions to charge EVs (wirelessly) while driving.

- *Dynamic charging* technology has been thoroughly researched and demonstrated by research institutes and automotive, utility and infrastructure companies such as Renault (France), Scania AB (Sweden), Qualcomm, WiTricity (US).

Renault is preparing to test the technology in freeway and city conditions at test sites in France, aiming to fully incorporate the technology in its vehicles by 2030.

Photo: Qualcomm

Dynamic charging enables **longer** driving distance, **less** charging time, and **reduced** EV costs.

- To prepare for the application of dynamic charging systems, we investigate the **optimal strategies for deploying the systems** and measure **its contribution to commuting trips**.

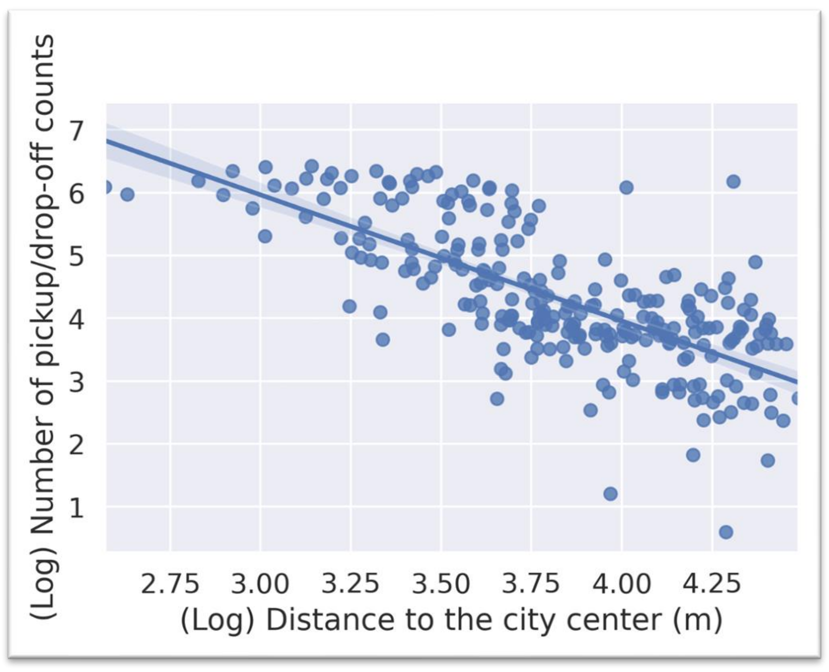
- **Implications:** **E**ssential for a realizable future of green transportation with EVs
  - For urban planners, city policymakers, utility and infrastructure companies: equip with a tool to guide EV infrastructure planning
  - For car manufacturers: design EV models with batteries suitable for city trips

Analysis

- We introduce a statistical framework to guide the deployment of charging roads in metropolitan cities and measure theirs impact on urban commuting trips.
- We model the road systems in urban cities using **inhomogeneous Manhattan Poisson Line Process,** assuming that drivers always choose the shortest route and maximize the time spent on charging roads.

A picture of the grid-like road systems in Manhattan, New York city. Similar road patterns are also found in modern cities such as Chicago, Vancouver, Barcelona.

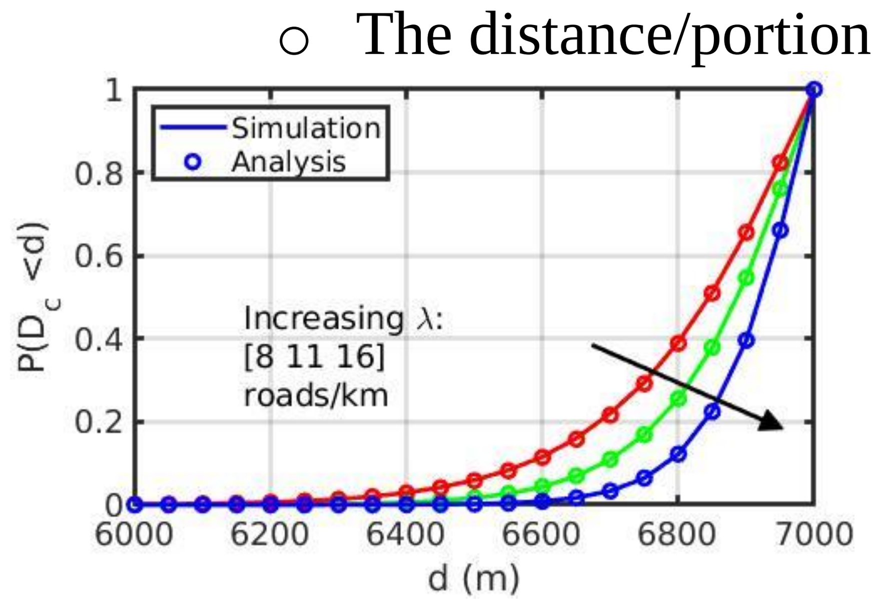
- We observe that to maximize the utilization of charging roads, they should be deployed following the traffic and road distribution.



From 6-month trip records data of yellow taxis in New York city in 2019, we found that the number of pickups/drop-offs follows a power-law distribution in terms of the distance to the city center.

Data source: NYC Taxi and Limousine Commission

- We propose that the charging roads be deployed following a *power-law distribution* from the city center.
- Then, for various scenarios of trips across the city, we report **statistical measures of the deployment effect** of dynamic charging systems in terms of two metrics:
  - The distance to the nearest charging road
  - The distance/portion of traveling on charging roads



The distribution of the charging distance, i.e., D_c, on a 7km trip across the center of cities with different road densities, i.e., λ, when the source (non-charging) and destination (charging) roads are parallel

References

[1] D. M. Nguyen, M. A. Kishk, and M.-S. Alouini, "Modeling and Analysis of Dynamic Charging for EVs: A Stochastic Geometry Approach," IEEE Open Journal of Vehicular Technology, vol. 2, pp. 17-44, 2021.