Doctor of Business Economics: Business Engineering

A data-driven approach for the planning of electric vehicle charging infrastructure

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Abstract

Electric Vehicles (EVs) have a great potential to reduce greenhouse gas emissions, improve air quality, and reduce the noise pollution generated by traffic in cities. An important obstacle for their large-scale adoption is the availability of sufficient charging infrastructure. Developing a widespread network of public charging stations is essential to address this barrier, especially in cities where many residents live in multi-unit dwellings without access to private home charging.

This dissertation presents new tools that policy makers and charging point operators can use in the location planning of public charging infrastructure in urban areas. Location plans are typically developed in a two-step approach, in which first the demand for public charging is *predicted*, and second the locations of where to install new stations are *optimized*. In this dissertation, particular focus is given on how the use of data-driven methods, i.e., relying on observed charging transactions from existing stations, can improve this approach.

Analyzing the demand for charging is an essential part when planning infrastructure. Chapter 2 demonstrates how observed charging data in combination spatial variables can be used to predict demand. The chapter discusses how the model's spatial accuracy, time horizon, and metric that is used to represent demand affect the predictive performance. In addition, by comparing the demand predictions with an external dataset of citizen requests for charging stations, the limitations of solely relying on observed charging data are highlighted. Chapter 3 continues to explore the use of charging data by conducting a detailed analysis into *who* (i.e., which EV driver) charges *where* (i.e., at which station). This revealed the existence of 'overflow dynamics', i.e., EV drivers that divert to alternative stations when a preferred station is fully occupied. Identifying these dynamics can be a valuable input when expanding the charging infrastructure. Finally, given that today's observed behavior may not be realistic for the future population of EV drivers, chapter 4 presents a simulation model to analyze how EV charging behavior affects the use of public charging infrastructure. This allows to simulate how a different compositions of the EV driver population could impact the utilization rate, charging convenience, and energy consumption of the existing charging network.

As the available space in cities is scarce and installing charging stations is expensive, policy makers and charging point operators should carefully consider where to install charging infrastructure. Chapter 5 presents a model to optimize the locations of new charging stations by balancing the expected usage of these stations and the coverage of the charging network. In addition, by modeling the marginal value that each additional station brings to the already existing infrastructure, this chapter is applicable at different stages of 'market maturity' of the existing charging network.

An important contribution of this dissertation is that the usefulness and limitations of observed charging data is demonstrated. One should always consider that charging stations are not ubiquitous in the city, nor do they have unlimited capacity available to measure demand. Nonetheless, this thesis presents how such data can contribute to the location planning of public charging infrastructure.