ABSTRACT

The rapid expansion of electric vehicles (EVs) has created an urgent need for efficient, accessible, and resilient public charging infrastructure. While federal and state initiatives are investing heavily in electric vehicle charging stations (EVCSs), the long-term success of this transition depends on a data-driven understanding of user behavior, infrastructure performance, system resilience, and emerging cybersecurity risks. This dissertation addresses these challenges through an integrated framework combining large-scale EVCS data analytics, behavioral modeling, network-based resilience assessment, and cyber-physical simulation to support efficient and resilient EVCS planning.

The first part of this research develops and demonstrates a scalable, real-time framework for collecting and analyzing public EVCS usage data from multiple providers using automated web-scraping pipelines. Applied to 235 stations in Indiana, the framework captures high-resolution spatial and temporal patterns of utilization, revealing that EVCS usage is significantly shaped by station type, built environment, amenities, and sociodemographic context. Machine learning models incorporating spatial heterogeneity explain up to 95% of variation in usage metrics, providing actionable insights for infrastructure deployment and management.

The second part examines how self-selection bias influences user preferences for public EVCS features. Using an ordinal probit switching regression (OPSR) model, the study shows that unobserved individual characteristics, such as attitudes and prior experience, significantly affect both EV adoption and perceptions of charging time. Results indicate that approximately 63% of observed preference differences between EV and non-EV users stem from self-selection rather than ownership effects. Correcting for this bias provides a more accurate understanding of public charging preferences and supports more realistic modeling of future EV adoption.

The third component introduces a network-based framework for assessing the resilience of EVCS infrastructure. By representing EVCSs as weighted spatial networks, the framework evaluates system efficiency under various node-removal scenarios. Findings across twelve U.S. states show that networks are generally robust to random failures but highly sensitive

to targeted disruptions. Integrating travel activity, charging capacity, and land-use data identifies critical stations and regional disparities in resilience, offering a foundation for hazard-informed and geographically adaptive EVCS planning.

The final component simulates a man-in-the-middle (MitM) cyberattack that manipulates online EVCS pricing information. The simulation demonstrates how misinformation targeting a subset of stations can alter driver behavior, degrade charging network performance, and increase overall travel time and energy consumption. These findings underscore the growing vulnerability of EV ecosystems to communication-layer attacks and highlight the importance of cybersecurity measures in maintaining system reliability and public trust.

Collectively, this dissertation contributes a comprehensive, data-driven framework for understanding and enhancing the efficiency, accessibility, and resilience of public EV charging infrastructure. The developed methodologies and insights inform infrastructure providers, policymakers, and planners seeking to design adaptive, secure, and sustainable charging networks that support the continued growth of electric mobility.