

ABSTRACT

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Title: Evaluating the Potential of Truck Electrification and Implementation of Electric Vehicle Technology from a User and Agency Perspective

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Although the trucking industry is entering an era of significant alterations in powertrain technologies, including the transition to electric trucks, this sector seems to be resistant to electrification. However, electrifying trucks can lead to large societal as well as private benefits. The overall goal of this dissertation was to create a framework to better inform policy making and enhance electric vehicle (EV) preparedness in the trucking industry through the examination of two interrelated elements: (a) the adoption of electric trucks and (b) the appropriate implementation of electric truck technology. These two elements cover the user perspective, which is not adequately studied, and the agency perspective, which is pivotal in the decision-making process. Specifically, this study addressed the following research questions: (i) What are the factors that affect the purchase decisions of truck fleet managers or owners for electric trucks? (ii) What is the ranking of and interrelationships between the barriers to the adoption of electric trucks? (iii) What location criteria should be considered for the strategic implementation of emerging charging solutions such as dynamic wireless charging (DWC) in a freight transportation network and where should this technology be located based on these criteria, and (iv) What is the impact of electric truck adoption on highway revenue and potential of alternative funding mechanisms to recover the revenue loss?

To examine the adoption of electric trucks, a stated preference survey was designed and distributed online to truck fleet managers/owners in the U.S., gathering 200 completed responses. Using an ordered probit model with random parameters to account for unobserved heterogeneity, this study found that the purchase intentions of truck fleet managers are affected by three main groups of factors: trucking firm and truck fleet characteristics (such as trucking firm revenue and fleet size), behavioral factors/opinions regarding electric trucks (such as organization's social responsibility, cost to charge, perceived availability of charging infrastructure), and awareness of innovative charging technologies. Factors related to the trucking segment, truck fleet composition, and truck annual mileage had mixed effects on truck fleet managers' purchase intentions, that attested to the heterogeneity in truck fleet managers' perspectives. The perspectives of truck fleet

managers were further explored using a multi-criteria decision-making technique, the Grey-DEMATEL method, which provided invaluable feedback on the barriers to electric truck adoption. Among other findings, this study highlighted that electric truck adoption would be accelerated if stakeholders focused on the barriers related to the business model, product availability, charging time, and governmental support. Moreover, a subgroup analysis was performed, showing that when addressing the barriers to electric truck adoption, electric truck adopters and non-adopters may not be viewed as one homogenous group.

This dissertation further proposed a multi-criteria decision-making spatial approach for the deployment of DWC for electric trucks, which can overcome certain barriers to electric truck adoption, such as charging time. Four categories of location criteria were identified: demand-related, cost-related, EV-related, and other criteria. The framework was demonstrated using the case of Indiana, U.S., which is among the leaders in the trucking industry. It was concluded that the most suitable locations for DWC lanes were on interstates that are characterized by high truck traffic. Furthermore, the most suitable locations were near airports and ports and away from EV charging stations. The optimal locations were not strongly affected by distance from intermodal facilities, military bases, planned construction/preservation projects, and floodplains.

Lastly, this dissertation developed a data-driven framework to quantify the impact of electric truck adoption and estimate the optimal fee for each truck to recover the revenue loss. Using the market penetration levels estimated using the survey data collected, it was found that the average annual fuel tax revenue loss for Indiana is approximately \$349M. To maintain the same tax revenue per vehicle, annual fees ranging from \$969 (in 2021) to \$1,243 (in 2035) for single unit trucks and \$6,192 to \$7,321 for combination trucks would be needed over the analysis period. To address public relations problems from implementing EV fees, this study also identified and discussed alternative mitigation measures: a vehicle-miles-traveled fee and a pay-as-you-charge fee.

In summary, this dissertation contributes to the body of literature by providing significant insights regarding the perspectives of truck fleet managers for electric trucks as well as a comprehensive list of all the location criteria for DWC. The study frameworks and findings can be used by policymakers, transportation agencies, and other major stakeholders of the EV ecosystem to frame certain strategies to accelerate electric truck adoption, identify the most suitable locations for charging infrastructure, better understand the impact of electric trucks on the highway revenue and serve as a reference to support decision making and develop EV roadmaps.