Advancing Sustainable Urban Mobility: A GIS-Based Multi-Criteria Decision Analysis for Equitable Electric Vehicle Supply Equipment Deployment in Philadelphia

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ABSTRACT:

The transition from traditional fossil fuel vehicles to electric vehicles (EVs) stands out as a pivotal solution to decarbonize the transportation systems and combat the climate crisis. However, the widespread adoption of EVs faces challenges, with one significant obstacle being the expansion of electric vehicle supply equipment (EVSE). The City of Philadelphia's Office of Innovation Technology (OIT) is actively engaged in developing a network of extensive, equitable, and accessible EVSEs as part of its Smart City initiatives. Despite these efforts, the initiative faces a common challenge related to the selection of suitable sites.

In this presentation, we share a geographic information system (GIS)-based multi-criteria decision analysis (MCDA) method that can be used to evaluate the suitability of potential EVSE sites to support the sustainable and equitable deployment of EVSE in Philadelphia. Our MCDA approach considers key criteria ranging from socio-demographic indicators (e.g. driving-age population) to site-specific characteristics (e.g. spatial accessibility of existing EVSEs, availability of public parking garages, and city-wide power grid) and is based on the Analytic Hierarchy Process (AHP). To identify the optimal sites, three MCDA methods – WSM (weighted sum method), PROMETHEE (Method for Organizing Ranking of Preferences for Enrichment), as well as TOPSIS (Technique for Order Preference by Similarity to Ideal Solutions) – are applied and compared.

We implemented our study with open-source R markdown and acquired data from the American Community Survey (ACS), OpenStreetMap, and the US Department of Energy. Specifically, a five-step solution approach is developed for the problem: 1) creating a fishnet for Philadelphia as the spatial unit for analysis and removing any water features, 2) determining and preprocessing criteria, among which we calculated the spatial accessibility of EVSEs using 2SFCA and distance to parking lots using k-nearest neighbor, 3) aggregating criteria into the fishnet, 4) prioritizing the criteria using AHP and finally 5) ranking the potential sites using WSM, PROMETHEE, and TOPSIS.

The results of our MCDAs highlighted several areas in Philadelphia with a pronounced demand for new EVSE. We selected one of those sites in South Philadelphia and proposed a public-private partnership model between Philadelphia's OIT and local grocery stores to install and maintain the EVSEs. We subsequently conducted financial analyses for the cost and revenue of breakdowns and designed a phased implementation of EVSE infrastructure given the current site conditions. Our study highlighted the challenges of agreeing on the input criteria and weighting schemes in MCDA but provided a spatially informed starting point to identify sites for new EVSE that contribute to Philadelphia's sustainable transportation goals while addressing social disparities. It also provides a scalable and replicable model for other cities facing similar challenges in deploying EVSE and

advancing smart city initiatives. More importantly, it emphasized the potential of geospatial analysis in shaping a more climate-smart and equitable future.

The study was conducted collaboratively by graduate students from the Weitzman School of Design and Wharton Business School at the University of Pennsylvania, supervised by Professor Allison Lassiter, and is available as a reproducible repository on GitHub.

KEYWORDS: *multi-criteria decision analysis, Analytic Hierarchy Process, electric vehicle supply equipment, sustainable transportation, smart city, GIS*

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