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Electric vehicle park-charge-ride programs: A planning framework and case study in Chicago

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ABSTRACT

In suburban areas, combining the use of electric vehicles (EV) and transit systems in an EV Park-Charge-Ride (PCR) approach can potentially help improve transit accessibility, facilitate EV charging and adoption, and reduce the need for long-distance driving and ensuing impacts. Despite the anticipated growth of EV adoption and charging demand, PCR programs are limited. With a focus on multi-modal trips, this study proposes a generic planning process that integrates EV infrastructure development with transit systems, develops a systematic assessment approach to fostering the PCR adoption, and illustrates a case implementation in Chicago. Specifically, this study develops a Suitability Index (SI) for EV charging locations at parking spots that are suitable for both EV charging and transit connections. SI can be customized for short-term and long-term planning scenarios. SI values are derived in Chicago as an example for (1) commuter rail stations (for work trips), and (2) shopping centers near transit stops as potential opportunities for additional weekday parking and EV charging (for multi-purpose trips/MPT). Furthermore, carbon emissions and vehicle miles travelled (VMT) across various travel modes and trip scenarios (i.e., work trips and MPT) are calculated. Compared to the baseline of driving a conventional vehicle, this study found that an EV PCR commuter can reduce up to 87% of personal VMT and 52% of carbon emissions. A more active role of the public sector in the PCR program development is recommended.

1. Introduction

First and last mile accessibility can often be a challenge for transit riders, especially for suburban commuters. Park-and-ride (P&R) design supports multi-modal trips, facilitates transit uses, improves accessibility to stations, and promotes systems services (Duncan, 2010; Noel, 1988; Parkhurst, 1999; Spillar, 1997; Stieffenhofer et al., 2015). Combining the use of electric vehicles (EV) and transit in an EV Park-Charge-Ride (PCR) approach can further reduce reliance on petroleum vehicles, thereby reducing greenhouse gas (GHG) emissions. Such a multi-modal trip also reduces the need for long-distance driving and thus promotes EV adoption.

The promotion of EV adoption and increasing EV uses necessitates the support of adequate charging infrastructure. Currently the EV charging siting prioritizes home and work locations (Frades, 2014; Francfort and Brion Bennett, 2015). The limitations of home charging (e.g., cost and exclusivity) and work-place charging (e.g., no change in the number of vehicles on road) suggest that alternative locations deserve further consideration. The adoption and implementation of PCR programs, despite the anticipated benefits for both EV adoption and transit uses, are still limited. Concerns often involve both EV charging infrastructure availability and existing P&R capacity, as well as financial resources and policy support. A few metropolitan areas (e.g., Los Angeles, Boston, San

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Diego, Seattle, New York City, and St. Paul/Minneapolis) have led the implementation of PCR projects. However, the planning process, siting criteria, and performance measures have not been systematically documented. An integrated approach to promoting EVs in multi-modal trips that include improved transit accessibility is needed for future transportation plans. It can also be a potential strategy for EV Community Readiness planning, which has been supported by the U.S. Department of Energy (DOE) as part of the Clean Cities program in 2011 and highlights charging infrastructure as a major planning component (Frades, 2014).

The aim of this study is to provide new policy insights into PCR planning. While the existing EV charging infrastructure has often been driven by the private sector to facilitate EV adoption, this study promotes transit uses and EV adoption at the same time. With a focus on multi-modal trips, this study explores opportunities related to parking spots that are suitable for both EV charging and transit connections, either on site or in proximity to transit stations. Besides transit stations, large shopping centers are identified as a potential opportunity to provide additional capacity for weekday parking and EV charging.

Distinct from the existing EV programs that solely focus on commuting trips or shopping trips (Frades, 2014; NYSERDA, 2012), this study takes into account both work trips and multi-purpose trips (MPT) that include shopping activities on commuting trips and are expected to reduce total vehicle miles travelled (VMT) and generate environmental benefits (Duncan, 2016).

In addition, this study will focus on suburban areas, where multi-modal trips tend to be most applicable due to limited transit accessibility, driving-alone rates and personal VMT for commuting trips are high (Cao, 2009; Yang, 2005), and vehicle related emissions associated with development density and urban form tend to be higher than in urban areas (Hong and Shen, 2013). Long-distance commuters have turned to the P&R service to avoid driving on congested freeways especially during the peak hours (Auerbach and Rueter, 2017).

The following section reviews current practice of PCR in the U.S., identifies the gaps in practice, and discusses the rationale of this proposed research. Section 3 advocates for an active role of the public sector in the integrated EV-Transit design and introduces a generic planning model for siting EV charging. To implement the proposed planning process, this study develops a Suitability Index (SI) for EV charging station siting in connection to transit stations, discusses anticipated impacts of implementing the integrated EV-Transit programs, and quantifies the environmental impacts of anticipated travel behavior changes in an activity-based approach. Case implementation results for Chicago were presented in Section 4. Based on derived SI ratings, the most desirable locations at commuter rail stations (for work trips) and shopping centers near transit stops (for MPT) are identified in short-term and long-term planning scenarios. Carbon emissions are estimated and compared across various travel modes in two trip scenarios (i.e., Work-Trip and MPT). In its conclusion in Section 5, this study discusses the need of policy support and additional research to promote and implement an integrated EV-Transit design efficiently.

2. Literature review and research hypotheses

Access to charging infrastructure is a critical barrier for potential EV buyers (Barter et al., 2015; Egbue and Long, 2012). Investments in EV charging stations are necessary for the promotion and adoption of increased EV usage (Block et al., 2015; Namdeo et al., 2014; Schroeder and Traber, 2012; Von Kaenel, 2016). However, which comes first has been the subject of some debate. Kansas City, for example, has taken a proactive approach to EV infrastructure planning. Kansas City Power & Light (KCP&L) launched a $20 million project in 2015 to install 1000 charging stations to serve as a catalyst model (Canon, 2017; KCP&L, 2017). The hope is “if you build it, they will come” (Siegel and Hsu, 2017). Within one year of project implementation, 613 charging stations were installed and EV ownership grew from about 400–500 EVs to over 1200 (Von Kaenel, 2016). The Kansas metro area is now one of the fastest-growing EV markets in the country (Von Kaenel, 2016; Smith, 2017).

The idea of integrating EVs with public transit is not novel. In the 1990s, electric station cars were promoted by some regions, mostly in the west coast and the New England area. The commuter can pick up a shared EV at a transit station, drive to work or home, and return the car to the station. The business model was expected to facilitate transit use for commuting trips, reduce the number of vehicles on the freeway, relieve space constraints for parking, and mitigate air emissions from driving (Barth and Shaheen, 2002; Shaheen et al., 2004). The assessment of pilot projects confirmed the anticipated benefits; the fleet-sharing model was also found to have reduced the travel cost for commuters (Cervero et al., 1994; Nerenberg et al., 1999). However, the willingness-to-pay of station car users may not fully cover the operational expenditures of the program, which tend to be heavily subsidized by governmental funds. The past experience suggests a critical role of public support and the need of supplemental programs in addition to funding.

Although the pilot programs of electric station cars were not widely adopted, a few regional PCR programs have been implemented recently. Three cases are summarized in this section: Los Angles (first program in the U.S.), Boston (with environmental impact evaluation), and New York City (most comprehensive information accessible online).

Los Angeles pioneered America’s integration of EV charging with public transit systems. The Los Angeles County Metropolitan Transportation Authority (Metro) installed the EV chargers at five transit stops in 2013. As regional demand increased, Metro expanded its EV charging program to 62 charging units at 15 stations in 2017 (LA Metro, 2017). Membership is required to utilize the EV charging stations and it costs $1 per hour to charge the EV and has a $3 cap per charge. Parking fees are waived in lieu of a charging fee (LA Metro, 2017). The highest concentration of EV chargers are located at Union Station, a major commuter rail and public transit hub.

The Massachusetts Bay Transportation Authority (MBTA) installed 30 EV chargers at Park and Ride lots at MBTA stations as part of an energy efficiency program and customer service initiative. MBTA acknowledges that EV chargers at transit stations are promoted as a tool or asset for the public, rather than a final solution to combating environmental degradation. In 2016, approximately 4488 charges at transit stations dispensed 420,132 kWh of electricity and prevented approximately 17,697 kg of GHG emissions. (MBTA, 2017).