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Research Results

Evaluation of Electric Vehicle Charging Station Deployment

Evaluated and assessed charging infrastructure networks for electric vehicles that also involves driving behavior modeling.

Planning, Policy and Programming

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Project Title:
Evaluation of Electric Vehicle Charging Station Deployment

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WHAT IS THE NEED?

The transportation sector is accountable for more than 20% of CO2 emissions worldwide and about 30% in the U.S. To reduce greenhouse gas (GHG) emissions, electric vehicles (EVs) are widely discussed as alternatives to conventional internal combustion engine vehicles. Their potential benefits include, but are not limited to, relatively lower operating and maintenance costs, as well as, reduced or no dependence on gasoline. However, there still exist several bottlenecks blocking the rapid development of EVs, such as the high cost of EV batteries, lack of charging infrastructure, and shortage of battery range. Without accessible charging infrastructure, it is never possible for drivers to be convinced to adopt EVs. Therefore, strategically locating charging stations with driver behavior considerations is an essential step towards EV mass adoption.

WHAT WAS OUR GOAL?

The goal of this study was to determine charging station locations and charger installation with uncertain customer coverage and equivalently uncertain EV adoptions, by developing a tool that optimizes the design of a network of charging stations. Using the model, the researchers would input data of different regions to determine where the charging stations should be located and estimate the corresponding costs. By varying the inputs of the model, they could perform scenario analysis that sheds light on whether the innovative solution is economical under different conditions.

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WHAT DID WE DO?

Inspired by previous studies, and in order to reveal the travel patterns of individual drivers, the researchers gathered real-time vehicle trajectory data of 46,765 taxis in Beijing, China, for two months in 2014. By applying the "big data" mining techniques, they simulated drivers' travel and recharging behavior to quantitatively depict the relationship among the electrification rate of vehicle miles traveled (eVMT) by plug-in hybrid electric vehicles (PHEVs), battery range of PHEVs, and public charging station deployment plans. In order to increase eVMT and based on the simulation results, the researchers provide policy guidelines for public charging infrastructure deployment planning, including the locations of public charging stations, the number of chargers at each station, and the types of chargers to deploy.

The project yielded three major documents: (1) a summary of the findings from the literature review and fact gathering task, which provide a better understanding of the overall problem and the factors that would affect the locations of the EV charging stations; (2) a discussion of the formulation of the model and the development of the solution algorithms; and (3) the project's final report.

WHAT WAS THE OUTCOME?

This study found that:

- When the public charging infrastructure is not sufficient, facilitating home charging is a promising way to increase eVMT, especially for the high range PHEVs.
- Without changing the total power of charging stations, introducing an appropriate number of fast chargers will contribute to increased eVMT, but replacing all slow chargers with fast chargers may not necessarily increase eVMT.
- Breaking the charging stations into smaller ones and spatially distributing them will increase eVMT, but its marginal effect becomes relatively small after the number of stations exceeds the best case scenario of the number of public stations.
- Adopting an intelligent charging guidance system can increase the electrification rate of VMT by around 0.027.

These results contribute to ongoing efforts by number agencies and organizations to address EV infrastructure needs to optimize EV adoption.

Future research would involve extending the simulation framework by adopting more sophisticated models to track the state of charge (SOC) of PHEVs. Another future study would investigate how to design the intelligent charging guidance system to improve eVMT. For instance, besides navigating PHEVs to currently available chargers, the researcher team could explore adding additional features into the guidance system, such as making reservations for charging, and predicting the utilization levels of charging stations in the future.

WHAT IS THE BENEFIT?

The project results in the development of a model that provides a robust design for the charging station network, and conducted experiments and scenario analysis to test if the charging station solution is economical under different conditions. The results provide important insights on the sustainability of future transportation systems based on EVs.

Designing a robust charging station network will facilitate the adoption of EVs as the network has to be designed and put in place before the vehicles are introduced in full scale. Widespread use of EVs can have several benefits for California, especially regarding energy usage. For example, by enabling better use of California's energy grid by charging

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the vehicles during off-peak periods, which results in better utilization of electricity-generating infrastructure, and in the case of the developing smart grid in California, vehicle batteries can be used to store energy at periods of low demand and then fed back to the grid at peak periods, which mitigates the need of peaking plants. Furthermore, electric vehicles will protect California's drivers from volatile gas prices.

LEARN MORE

The final report can be viewed at:
http://escholarship.org/uc/item/2rr92202

IMAGES

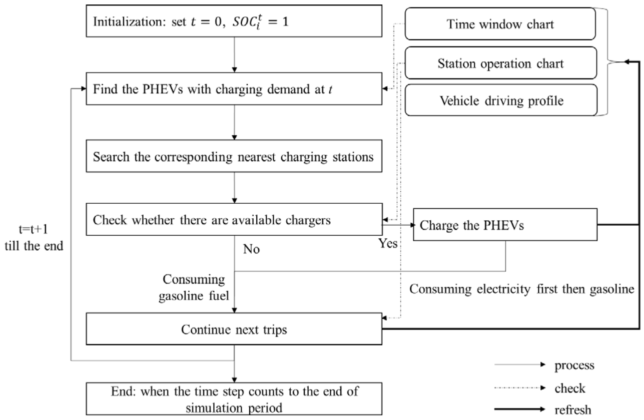

FIGURE 1: Simulation model flow chart

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