The Electricity and Transportation Infrastructure Convergence Using Electrical Vehicles

Final Project Report

Power Systems Engineering Research Center

Empowering Minds to Engineer the Future Electric Energy System
The Electricity and Transportation Infrastructure Convergence Using Electrical Vehicles

Final Project Report

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Power Systems Engineering Research Center

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Executive Summary

Electric vehicles (EVs) introduce environmental advantages when compared to conventional gasoline-powered vehicles. They reduce air pollutants and greenhouse gas emissions while contributing to energy security through reduction in oil imports. They can be also utilized to dynamically control the apparent load or contribute to ancillary services. Market penetration of EVs is foreseen to grow significantly in the future. Therefore, the investigation on how EVs, both Plug-in Hybrid Electric Vehicles (PHEVs) and Battery Electric Vehicles (BEVs), can be utilized in an optimal way in both electricity and transportation networks is necessary.

Specifically, this project mainly: a) provides State of Charge (SoC) model that integrates electricity and transportation impact of EVs, b) uses the model to study optimal use of EVs in individual and aggregated mode, and c) shows some practical examples using testbeds for monitoring impact on transformers, participation in ancillary services, and integration of communication and information management for charging stations from multiple vendors.

First, the impact of vehicle movement on SoC is investigated. The relationship between the vehicle’s movement and SoC is simulated and analyzed. An algorithm is proposed to calculate and analyze the optimal velocity during a driving cycle with respect to battery energy consumption. Such algorithm can be inserted in the vehicle imbedded systems and provides the drivers suggestions about the optimal driving speed according to the real-time driving condition and the preset driving cycle.

Second, the design of the proposed communication center between charging infrastructures and its functionality are introduced. The survey results on different charging station vendors are summarized. In addition, database design and data acquisition methods are described, according to the information that each vendor would provide to the customers.

Third, physically based models of various components that are considered to be part of the overall model of the system are presented. These include energy resources such as roof top solar PV, energy storage system in the form of battery systems, etc. and house appliances such as smart dishwasher, refrigerator, and air conditioner. Averaged models of power electronics converters are used to connect various parts of the system together. A demonstration case study of most of these new models is also provided to display the various characteristics of the model. The overall model is managed by a house management system that provides appropriate control for the entire system connected to a distribution transformer. The coordinated control of EVs and PHEVs with other residential resources and the power grid is achieved by real time control utilizing a real time model of the system via state estimation.

Last, a systematic method for an Energy Services Company, particularly one that serves EV load, to participate in a multi-settlement market structure is provided. The challenges in scenario generation in case of EV load are discussed and a data driven approach for generating scenarios is proposed.
Project Publications:


