Hawai‘i Natural Energy Institute Research Highlights

Grid Integration

Bidirectional EV Charging Demonstration Project

OBJECTIVE AND SIGNIFICANCE: This project aims to develop, evaluate, and demonstrate the performance of novel algorithms to optimize the charge/discharge of shared fleet vehicles for energy cost minimization. Project results will advance energy research and also inform the university's consideration of options such as the electrification of fleet vehicles, advanced car share applications, integration of distributed renewable energy resources on campus, and the optimal management of campus energy use and cost containment.

BACKGROUND: HNEI's Grid System Technologies Advanced Research Team (Grid*START*) partnered with IKS Co., Ltd. (IKS) on technology development, testing, and demonstration of advanced control of two bidirectional electric vehicle (EV) chargers or hybrid-power conversion systems (H-PCS) on the campus of the University of Hawai‘i at Mānoa (UH). These chargers are located adjacent to the Bachman Annex 6 building (Figure 1). The H-PCS was developed by IKS with support from Hitachi Limited as part of the earlier JUMPSmart Maui smart grid demonstration project, where HNEI was one of the partners.

Figure 1. Location of bidirectional EV chargers.

Two EVs are currently used by designated university personnel in a car-sharing system accessed via a secure web-based car scheduling application developed by HNEI Grid*START*.

PROJECT STATUS/RESULTS: The novel H-PCS control algorithms developed by HNEI first ensures that the shared vehicles for UH personnel use are efficiently assigned and readily available for transport needs. Simultaneously, the autonomous controls deliver ancillary power and energy services through intelligent EV charge and discharge commands, at times allowing the stored energy in the EV batteries to be strategically withdrawn to minimize the overall cost of energy supply to UH campus loads. The autonomous controls may also support the operational needs of the local utility operator (Hawaiian Electric Company) through the supply of grid ancillary services in return for financial compensation.

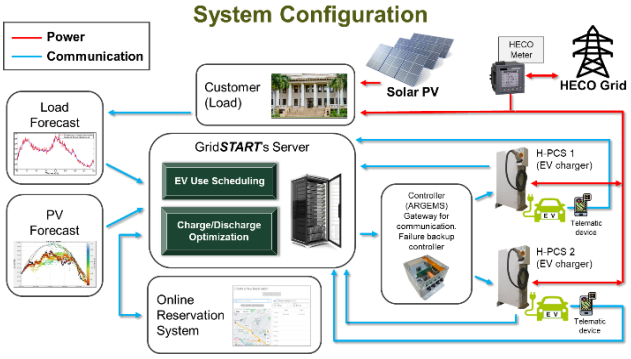

Figure 2. Functional system diagram.

HNEI's novel algorithms also incorporate data fed from state-of-the-art in-house developed forecasts of campus building demand and on-campus solar PV power production. This allows the system to maximize the use of renewable energy as the preferred source for EV charging and supply to building loads while minimizing costly energy purchases from the grid.

Since it became field operational in July 2023, HNEI Grid*START* has made significant progress in enhancing the EV charging management system to maximize EV use and optimize charge/discharging schedules. The team has completed extensive and detailed economic analyses utilizing the scaled load demand of various campus buildings and evaluated alternative EV charging methods. Furthermore, a Machine Learning-based method using bidirectional long short-term memory network (Bi-LSTM) and least square optimization was developed to estimate energy consumption for predetermined EV trips. The team has also extended its ongoing research by developing a software-based tool to conduct techno-economic investment and sizing optimization of home energy systems (rooftop PV with BESS) with calculated financial investment payback and return, showcasing the economic value proposition of incorporating bidirectional EV charging in home applications.

Funding Source: Office of Naval Research

Contact: Leon Roose, lroose@hawaii.edu

Last Updated: November 2024