TIP 337: Home Battery System for Cybersecure Predictive Energy Efficiency and Demand Response

**Context**

Residential buildings present a significant but challenging opportunity for grid operations. Homes comprise over 90% of a utility’s customers and in aggregate are both the largest energy-consuming sector and the driving force behind most utilities’ peak loads. In many markets, the residential sector has the largest contribution to the peak load, much more so than during off-peak times.

Utilities often approach the residential demand response (DR) problem solely by providing financial incentives. Pricing mechanisms include direct load control (DLC) programs, rebates, and various dynamic pricing schedules, including time-of-use (TOU) and real-time pricing (RTP). Additional DSM programs usually entail pamphlets distributed with information on recommended behaviors for energy savings. These techniques often produce fewer savings than anticipated and for only a limited duration.

Aggregation of distributed energy resources promises some relief, but has yet to achieve significant adoption. Specifically, a number of adoption barriers exist – cost of implementation, perception of utilities circumventing homeowner preferences such as comfort, operating cost and technical hurdles in managing many small distributed loads, data privacy, and cybersecurity, to name a few.

**Description**

The full scope of this project, led by National Renewable Energy Laboratory (NREL) is to develop and demonstrate an innovative Home Battery System which provides electric energy storage and conversion, along with self-learning adaptive control signal outputs for appliances and reliable predictions for residential demand response. The team will develop and perform preliminary validation of critical infrastructure protection (CIP) requirements on the Home Battery System. The work will result in improved understanding of the system performance and cost tradeoffs. The project will make substantial progress toward a marketable product, but may not result in a market-ready Home Battery System product.

Major tasks for the project are:
- Development of control platform architecture and data model
- Development of Homeowner Preference Input methodologies
- Development of advanced, self-learning controls for individual appliances, and hierarchical control methods for the whole-home, enabling optimal operation to deliver comfort alongside demand response
- Development of hardware including: Home Battery System, controller and DR-ready appliances
- Laboratory demonstration of the Home Battery System, along with several connected appliances, to deliver reliable forecasts and whole-home demand response without significant homeowner impacts
- Cybersecurity (CIP) integration and validation
- Reporting on the project’s results and outcomes

**Why It Matters**

For BPA, the Home Battery System can support a distributed energy resource available for grid services including balancing, contingency and regulation; thus reducing demands on the hydro system. For the homeowner and utilities this project will facilitate energy efficiency through advanced learning controls and by enabling higher utilization of renewable energy (i.e. avoidance of curtailment).

The flexibility of the Home Battery System will allow utilities to call either INC or DEC services with a variety of timescales and durations. Managed properly, this can be a valuable part of system congestion management.

The learning controls will accommodate grid DR requests, and when no event is underway they will optimize for energy savings in order to maximize the cost benefit to the homeowner. In this way, operation of the Home Battery System will operate to maximize operating efficiency of the home most of the time, while being available for grid needs whenever called.

**Goals and Objectives**

This project aims to develop a Home Battery System integrated with advanced control algorithms for cybersecure energy efficiency and demand response. The system is expected to provide highly available and reliable DR resources while maintaining comfort and energy efficiency in a home.

**Deliverables**

This project will provide documentation of all software records and schematics.

A final report will be complied covering all the technical details and lessons learned.
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**Project Start Date:** October 1, 2015

**Project End Date:** March 31, 2017

**Reports & References**

**Funding**
- Total Project Cost: $2,500,000
- BPA Cost Share: $1,250,000
- BPA FY2016: $500,000

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