I. Introduction

- **Problem**: The management of electric vehicle (EV) loads in a Real-Time price market area with Distr. Net. Cong. Inf.

- **Motivation**: EV load management achieves cost savings by (i) Charging at low cost times (ii) selling regulation service & assisting intern. Ren. Gen., and (iii) avoiding distr. congestion.

II. Cost Structure of Energy Grid

- Cost 60%
- Cost 25 - 35%
- Cost 5 - 10%

III. Energy Markets

- **Regulation Service Clearing Price**: Opportunity cost for $Q_t^R - u_t^R$, plus RS price offer $u_t^R$, relative to clearing price, $P_t^R$.

IV. Energy Service Company

- **Contracts with EV owners** to manage charging of EV batteries plugging in at several feeders.
- **Access to local congestion constraint information**, namely the maximal additional load that may be applied along a specific feeder without stressing the transformer and other distribution hardware tolerances.
- **Smart interface** measures and communicates in real-time aggregate features that determine clearing prices in related (i.e., co-optimized) energy and reserve markets.

V. Decision Support Model

- **ESCo participates in wholesale power market** for both energy and reserve capacity transactions (e.g., regulation service (RS)) where commands are sent by ISO in 5-8 second intervals, full reserve deployment response capability is required within 1-2 minutes.
- **RS can be provided by controlling the time of switching on and off battery chargers under the ESCo’s control**.

VI. Computational Results

- **Solution approach adopted** was a deterministic (optimal open loop feedback control) approximation based on inclusion of robust (e.g., worst case) contingencies.

- **Four period look-ahead model calibrated to represent a low voltage residential feeder servicing approximately fifty households. ERCOT website provided Consumption profiles and hourly wholesale market energy and RS clearing prices.**

VII. Conclusions and Future Work

- Preliminary results indicate that smart management of EV charging can (i) help with renewable generation intermittency, (ii) result in cost substantial EV charging savings, and (iii) mitigate distribution congestion.

- Promising research directions include (i) decision support algorithm improvements such as coupling across feeders, policy evaluation through Monte Carlo Simulation (fluid approximation), and robust optimization analysis, and (ii) more accurate distr. net. variable cost & congest. modeling.

Related publication