

Abstract

Cesar DIAZ LONDOÑO

A Framework for Flexible Loads Aggregation

Smart Grids are integrating renewable generation in their electrical supplies. As a consequence, the fluctuations due to solar radiation and wind speed or direction can produce energy unbalances between supply and demand in the grid. Various Demand Response (DR) programs have been proposed to reduce energy unbalances. Moreover, flexible loads management carried out by an aggregator has been proposed to provide ancillary services in DR by applying optimal methods such as Model Predictive Control (MPC). In this dissertation, an aggregator framework is proposed, developing flexible loads models and direct load control structures able to operate in DR plans and provide ancillary services to the system operator. The aggregator framework is presented considering a methodology for loads to provide ancillary services. Then, this methodology is assessed on three flexible loads, Water Booster Pressure Systems (WBPS), ThermoElectric Refrigeration (TER) units, and Electric Vehicle (EV) charging stations. First, a dynamic model of a WBPS is estimated and tuned with real data, and a WBPS aggregator that is capable of offering spinning reserve services is proposed. Second, a TER unit model is estimated and characterized by experimental data, and a TER aggregator able to provide balancing services such as frequency containment reserve is proposed. Third, a dynamic model of an EV charger is developed, and an EV charger aggregator that looks for minimizing costs while maximizing flexibility is proposed. The EV aggregator can offer spinning reserve services and participate in Day-Ahead and Real-Time markets. Moreover, a specific flexibility definition for EV chargers is formulated. As results, the flexible load aggregators have been validated by simulations fulfilling the ancillary service's response time and the power capacity variations requested by the system operator. Finally, a hierarchical architecture (balancing service provider) able to manage the previous flexible load aggregators is proposed in order to provide different European balancing services in a frequency restoration process.