A Dynamic Programming Approach to Optimal Residential Demand Response Scheduling in Near Real-Time: Application for Electricity Retailers in ERCOT Power Markets

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Abstract

Electricity price volatility in day-ahead and real-time energy markets is a well-documented phenomenon. In the Texas market that we studied, prices sometimes increase by two orders of magnitude in less than 15 minutes. Retail electricity providers (REPs) may seek to protect themselves from these price spikes by scheduling demand response (DR) events that shift load from periods of high prices to lower priced periods. We present a dynamic program (DP) formulation designed to schedule DR events of varying duration across a desired time horizon using internet connected thermostats to shift residential HVAC load. The results presented herein focus on a 24-hour time frame with decisions made every hour. By applying the DP deterministically to historical electricity price and weather data, the load-shifting technique is shown to potentially save REPs $0.5 million to $1.25 million across 50,000 customers per year. Most of these savings come from a few crucial events, further highlighting the usefulness of the DP and the importance of accuracy in the timing of DR events. Due to the uncertainty in electricity prices, we also compute the distribution in savings from DR events using stochastic dynamic programming (SDP) to highlight novel hedging strategies for REPs. Results from this SDP point to longer duration DR events in the evening being the least risky, with additional savings possible through riskier short midday events. To ensure that REPs could apply our DP formulation for use in near real-time decision-making applications, the computation speed was verified to be 20 seconds for 48 stages.