Residential Demand Response to Dynamic Hourly Pricing of Electricity

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Introduction

Dynamic hourly pricing, such as real-time pricing (RTP) or day-ahead pricing (DAP), has been suggested as a tool for incentivizing shifts in electricity consumption. Residential customers are typically charged a flat rate for their electricity – a single price that remains constant for months at a time. Dynamic pricing, on the other hand, allows electricity prices to vary throughout the day, reflecting the prices in the wholesale market for electricity. Exposing residential customers to prices that reflect the marginal cost of generation incentivizes adjustments in consumption patterns. In this study, we consider participant price response to both seasonal average prices and hourly prices of electricity. Furthermore, we allow the price elasticity of demand for electricity to vary by time of day, reflecting daily consumption patterns. Lastly, we investigate participants' price response behavior to determine whether load is shifted to lower-priced periods or reduced overall.

Methods

As checking prices frequently is time-consuming, it is unlikely that participants check prices on a daily basis. Instead, they likely make consumption decisions based on seasonal "rules of thumb." However, when prices are significantly high and participants are aware of the high prices, they likely make further adjustments to their consumption patterns. High Price Alerts (HPA) serve exactly this purpose. Participants are alerted when tomorrow's prices will surpass $0.13/kWh.

To model medium-run (seasonal) price responsiveness, we specify a semi-log demand function using seasonal average hourly consumption and price data for participants and a load research group. To model short-run (hourly) price responsiveness, we employ the Generalized Almost Ideal (GAI) demand system on data from the 28 HPA days that occurred during summer 2008. Consecutive hours are grouped together to form 9 blocks spanning a 24-hour period. The GAI demand system estimates the share of daily electricity expenditures allocated to a given time period as a function of prices for every time period, total daily expenditures, cooling degree hours (CDH), and the previous day's maximum temperature. Our data comes from the Ameren Illinois Power Smart Pricing (PSP) program, a pilot program exposing residential customers to day-ahead hourly prices. Customers sign up for the PSP program on a voluntary basis, and program enrollment now exceeds 10,000 households.

Results

In the medium-run, the hourly price elasticities of demand range from -0.03 to -0.30. These are interpreted as: a doubling of the seasonal average price of electricity during a given hour results in load reductions of 3-30%. In the short-run, the hourly own-price elasticities of demand range from -0.20 to -0.89: a doubling of the hourly price of electricity results in load reductions of 20-89%. Additionally, we estimate the cross-price elasticities, which indicate shifting of load (positive values) or load reductions (negative

values). There is evidence that participants shift load between adjacent periods, but electricity load in non-adjacent periods tends to be complementary in nature. In conclusion, we find that participants generally respond to seasonal average prices, but are even more price responsive on High Price Alert days. Price responsiveness is larger during the daytime hours compared to the overnight hours. Participants respond to high prices by reducing their load, with some of the load being shifted to adjacent or lower-priced periods.