Knowing Your Limits: Application of Censoring Distributions to Impact Estimation for a Residential Air Conditioner Direct Load Control Program

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Direct load control programs are used by many utilities as a means of reducing system capacity requirements at times of peak. These and related programs to reduce peak loads are currently of renewed interest in many U.S. markets. Estimating design-condition impacts for such programs typically requires modeling, to project monitoring data from observed temperature conditions to average demand at hypothetical design temperatures in the absence of control.

The impact evaluation of Public Service Electric and Gas Company's Direct Load Control Program utilized metering data from a random sample of participating homes, 48 monitored during 1997 and another 56 monitored during 2000. During both these summers, no cycling was conducted during extreme weather. Of interest from the analysis was the magnitude of capacity reduction that would have been available during extreme conditions if it had been needed. This design-condition reduction defines a capacity credit from the PJM power pool.

In this analysis, duty cycle (fraction of time on) was modeled using Tobit regression models familiar from econometric applications. The model appropriately treats duty cycle as resulting from an underlying linear relationship between temperature or weighted temperature–humidity index (WTHI) and the desired cooling level, truncated at zero (no cooling) and one (continuous operation). The impact analysis recognizes that the truncation creates asymmetry in the random variation of duty cycle around the fitted model. As a result, impacts at a given temperature are not based simply on the average duty cycle estimated for that temperature, but also take into account the distribution of duty cycles above and below the controlled level.

For each study participant and time of day, a Tobit model was fit to relate duty cycle to ambient air temperature or WTHI. The Tobit analysis was used to estimate for each sample customer as a function of time of day and weather both the probability that the customer's duty cycle would exceed the control threshold, and the expected savings due to cycling given that the threshold was exceeded. Combining these estimates gave the demand savings, which were averaged over customers to provide program savings per customer by time period. The increase in connected load with increasing temperature or WTHI was also determined and included in the impact calculation.

Depending on time of day and design weather condition, impacts estimated were on the order of 1 kW per participant with 90 percent confidence bounds in the neighborhood of ±10 percent of the estimate.

Analysis of the metering samples provides impacts that would occur if all switches receive the transmitted dispatch signals and respond as intended. Signal tower performance was tested using a mobile bank of working switches to map signal receipt through the service territory. Results were used to target transmitter tower improvements after the 1997 study. Improved transmitter performance was confirmed by the 2000 study based on tests of switches in place for a cluster sample of 300 participating customers. In all, this study is the most comprehensive direct load control evaluation to date in its treatment of duty cycle, connected load, and signal-receipt rates.