Removing Free-Ridership through Adaptive Technology Use: An Evaluation of Georgia Power Company's GoodCents Energy Management System

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Abstract

GoodCents Energy Management System (GCEM), an innovative load management pilot program for Georgia Power Company's (GPC) residential customers, introduces a solution to the problem of free-ridership in direct load control programs. GCEM offers customers a free programmable thermostat in return for participation in the pilot load control program, under which GPC periodically cycles the customers' air conditioning units. In addition, the pilot program employs the use of an Adaptive Load Control Algorithm (ALCA), which applies the cycling strategy to appliances' run times rather than to real time. This feature increases potential impacts by virtually eliminating the free-rider element associated with units which escape control by running at a duty cycle lower than the cycling threshold. GCEM is also different from other load control programs in that no cash incentive is given to program participants; the programmable thermostat is the only immediate incentive provided in exchange for participation. This paper analyzes the demand impacts generated by this novel load control program and examines the programmable thermostat's role in its appeal.

GCEM provides an opportunity to evaluate a unique energy management program and the effects of its constituent elements. The ALCA technology's role in removing free-ridership from the program, combined with the energy-saving capabilities of the thermostat, set it apart from traditional direct load control programs. The potential for greater impacts, and by extension, greater program cost effectiveness, will be of interest to other utilities considering modifications to their energy management programs.

Introduction

Background

Georgia Power Company's pilot program, the GoodCents Energy Management System (GCEM), is an ongoing residential direct load program first implemented in 1998 with over 600 participants in the GPC service territory.

GCEM presents two major innovations in the field of direct load control programs. First, the use of an Adaptive Load Control Algorithm (ALCA) introduces a solution to the problem of free-ridership by assigning a separate cycling strategy to each unit based on its duty cycle prior to control. Second, GCEM limits program costs by offering no cash incentive to program participants; customers are given only a free programmable thermostat in return for their participation in the pilot program. In future implementations of the program, customers will be charged a fraction of the thermostat's installation cost in order to ensure that the program passes the Rate Impact Measure (RIM) test.

Scope

This paper includes a brief discussion of the evaluation methods employed in the analysis of GCEM. The results of the analysis are reported, emphasizing demand impacts due to direct load control and energy impacts due to use of the programmable thermostat.

Technology

Traditional load control applies a fixed cycling strategy to the connected load of each appliance, provided that the duty cycle is above a certain threshold at the time of control. Each appliance running at or above the threshold is cycled at a given percentage of its connected load, while each appliance running below the threshold remains unaffected, thereby contributing to program free-ridership.

The ALCA operates by applying the assigned cycling strategy to each appliance's run time rather than to real time. The device observes the duty cycle during the hour preceding control, then applies the cycling strategy to that same proportion of each control hour. This feature increases potential demand impacts by virtually eliminating the free-rider element associated with units which escape control by running at a duty cycle lower than the cycling threshold; control is applied to each consumer, whatever the appliance's duty cycle.

Methodology

Data Collection and Validation

The impact analysis uses whole-premise load data gathered by Georgia Power from a sample of over 300 of its residential customers, both pilot program participants and nonparticipants. Daily temperature data for Macon, GA are used for categorization of daytypes.

The objective of the analysis is to measure separately the impacts of load control and of the programmable thermostat. Since only the program participants have the thermostat, inclusion of the nonparticipant group would introduce the simultaneous observation of both effects. Restricting the demand impact analysis to the participant group makes it possible to evaluate load control effects independent of any thermostat effects.

Conversely, thermostat effects are measured across participants and nonparticipants, using only non-control days in order to avoid inclusion of load control effects in the participants' load profiles.

A stratified sample design is used to select program participants for the metered sample of program participants. The nonparticipant sample is then drawn using a matched pair design. Participants and nonparticipants are matched based upon appliance holdings and demographic variables.

Load data are validated using a complex usage algorithm; problem data are then visually validated. Participants' load profiles are examined for the reported control days. Days showing inconclusive evidence of control are omitted from the list of control days. Control days whose maximum temperature is below 87 degrees are also omitted. As the analysis concentrates on the 3:00 PM to 7:00 PM interval, control periods beginning before 3:00 PM are omitted.

The Day Matching Method

The analysis employs the calculation of demand impacts by the day matching method, whereby program participants' control day load profiles are compared to those from non-control "matching days" with similar weather. These matching days are weekdays chosen on the basis of chronological proximity (no more than a week before or after the control day) and temperature (maximum temperature within two degrees of that of the control day, where possible). Daytypes are defined as follows on the basis of maximum daily temperature:

- "Peak" – temperature values greater than 97 degrees
- "Extreme" – temperature values between 97 and 94 degrees
- "Hot" – temperature values between 93 and 91 degrees
- "Moderate" – temperature values between 90 and 88 degrees.

Calculation of energy impacts compares the non-control day load profiles of participants and non-participants, in order to eliminate any effect of load control upon program participants.

Preliminary Results

Preliminary results of the impact analysis are presented in the following pages. Demand impacts are large, as expected, and energy savings due to the thermostat are also in the expected direction. A comparison between impacts on "peak" and "hot" days yields a logical, if seemingly counterintuitive, result.

Demand Impacts

Table 1 presents demand impacts in percentage terms. Peak-hour demand impacts owing to load control are significant and, as expected, increase with temperature. Load control demand impacts for the hour of 5:00 to 6:00 PM average 55 percent for "peak" days, as defined above. The corresponding demand impacts for "extreme" and "hot" days during the same interval averaged 53 percent and 41 percent, respectively. Intuitively, one would expect higher demand impacts during hotter weather when cooling units are running near or at capacity.

For comparison, calculations were made to estimate demand impacts using a 65 percent control strategy, but with the conventional load control technology described above. Demand impacts under the conventional technology are 23 percent for "peak" days.

There were no "moderate" days during which control included the 5:00 to 6:00 PM interval; for "moderate" days, demand impacts for the 4:00 to 5:00 PM interval are included in Exhibit 1 for comparison.

Table 1. Demand Impacts by Daytype (percent)

	Peak	**Extreme**	**Hot**	**Moderate**
Control Interval	**(>97 degrees)**	**(94-97 degrees)**	**(91-93 degrees)**	**(88 to 90 degrees)**
4:00 - 5:00 PM	--	--	--	47%
5:00 – 6:00 PM	55%	53%	41%	--

Effects of Temperature Difference

Figure 1 demonstrates the effect of a 65 percent cycling strategy for a "peak" day. Control begins at 4:00 PM and ends at 7:00 PM, during which time demand impacts of up to 59 percent are observed. The load profile reaches its maximum at 8:00 PM, during the snapback following control, generating energy payback equal to 1.5 percent of the total daily energy consumption over the three hours following control. (Note that the load profile is generated from whole-premise data; end uses other than the controlled appliance contribute to the observed total load shape.)

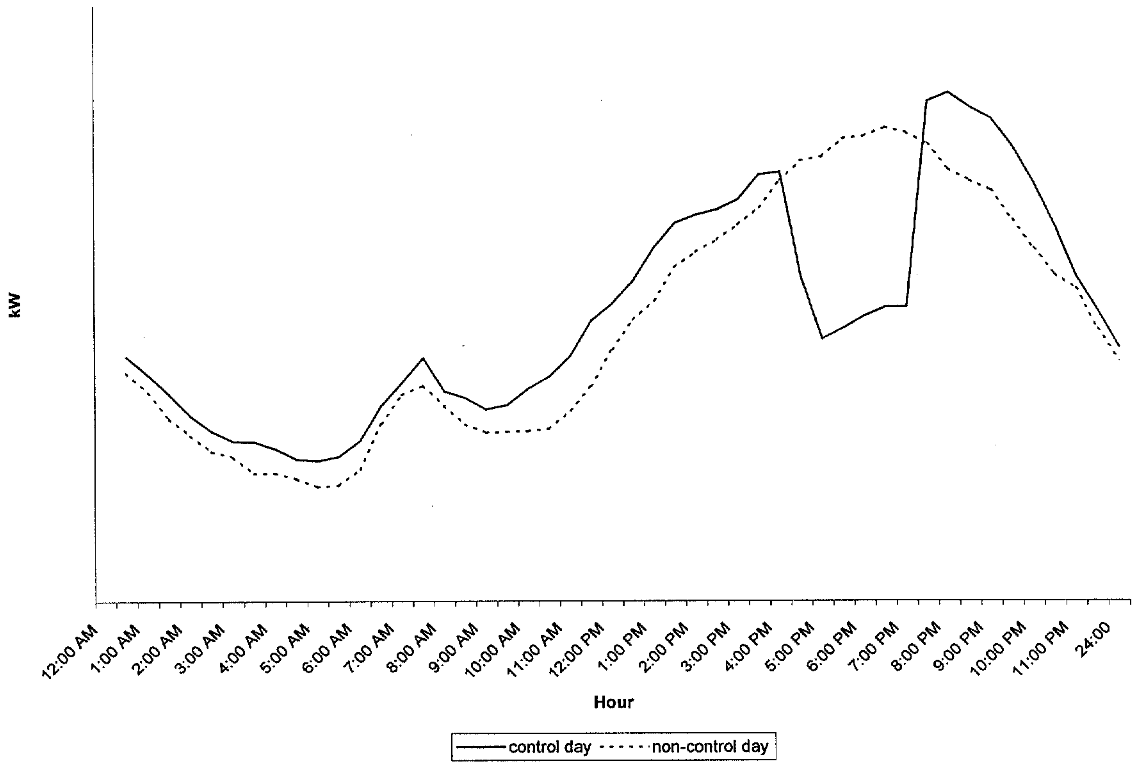

Figure 1. Comparison of Participants during Control and Non-Control. Peak Days (>97°F): Control from 4:00 PM to 7:00 PM (Sample size = 320)

Figure 2 presents the load profile associated with a 65 percent cycling strategy applied to a "hot" day. In comparison to the "peak" day case shown in Figure 1, impacts are small; demand impacts are no larger than 41 percent. Payback, however, is much larger for the "hot" day than for the "peak" day; during the three hours following control, energy recovered through payback accounts for 2.6 percent of the total daily energy consumption. (This comparison of payback-related energy impacts holds true in the absolute as well as in percentage terms.)

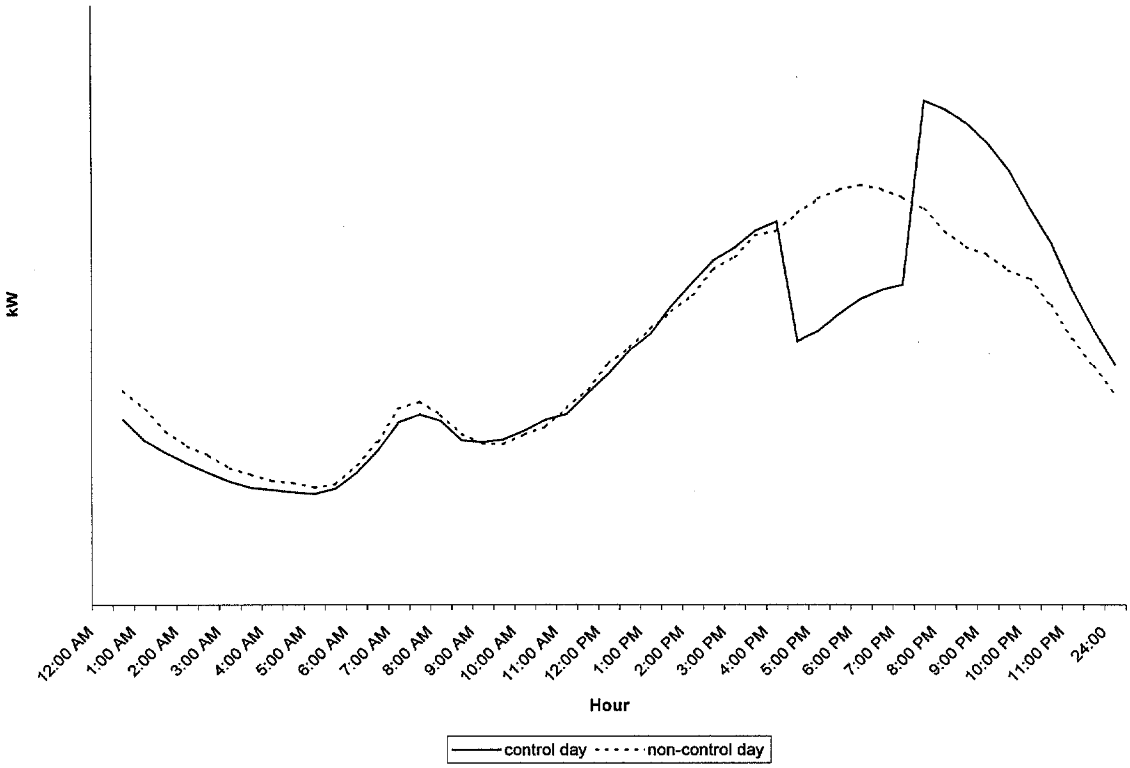

Figure 2. Comparison of Participants during Control and Non-Control, Hot Days (91°-93°F): Control from 4:00 PM to 7:00 PM (Sample size = 1,638)

While the hottest days result in the largest control-related demand impacts, the largest payback-related demand impacts are realized during milder weather. This somewhat counterintuitive result obtains because, in extremely hot weather, air conditioners are operating near capacity during afternoon hours. After control, these units resume running at capacity, representing only a small increase over their previous demand level. On milder days, when the units are running at only partial capacity prior to control, the post-control snapback represents a larger increase in demand.

Energy Impacts

Table 2 presents aggregate energy impacts by month. The percentages reported are lower bounds of the differences between program nonparticipants' average monthly energy consumption and that for participants. The savings are modest in percentage terms but are consistently of the expected sign – program participants saved energy each month using the programmable thermostat. It is worth re-emphasizing that these calculations do not include the difference in energy use that owes to load control.

Table 2. Average Monthly Energy Savings (percent)

Month	Percent Difference from Nonparticipants
July	4.9%
August	0.3%

September	2.3%
TOTAL	2.6%

Conclusions

The preliminary results of this analysis support the assertion that use of ALCA can provide greater demand impacts for direct load control programs by offering a solution to free-ridership. The methods of analysis employed here, separating out the effects of ALCA from the effects of the programmable thermostat with which it operates, reveal demand impacts which compare favorably with those of traditional load control programs.

The programmable thermostat used by program participants shows potential for energy bill savings on the part of consumers. From the utility's point of view, the thermostat offers an alternative to a direct cash transfer as an incentive to participate in the program.