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Comfort and Load Control:
It's Getting Hot in Here – But is the Utility to Blame?

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Direct load control (DLC) of air conditioners is an important demand response measure for many utilities.

»The measure cycles air conditioners off for portions of the time during a control event.

»These programs allow the utility to avoid capacity costs and also reduce energy prices by reducing demand.

»Customers may experience discomfort during control events.

»Questions:
- During a prolonged heat wave, how much of that discomfort is due to the control event and how much of it would have occurred anyway?
- How is the control strategy likely to affect comfort and savings?

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A situation in the summer of 2011 provided a controlled experiment to help answer these questions.

»Temperatures soared to 40 C (105 F) degrees over a three day period.

»The air conditioners of one subset of participants were not controlled on one day when the rest were.

»Analysis showed that no statistical difference in perceived comfort levels between the controlled and uncontrolled customers.

»Analysis of the control strategy indicated the adaptive algorithm used was unlikely to affect comfort levels, but would contribute significantly to overall savings.

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The PECO Smart A/C Saver Program is a DLC program for residential customers.

»PECO is the largest electric and natural gas utility in Pennsylvania, serving approximately 1.6 million electric customers and 494,000 natural gas customers in southeastern Pennsylvania.

»The program is based on the installation of digital control units (switches) on qualified residential air conditioners.

»Participants are incented at the rate of $120/year ($30 in each of the four summer months per installed device).

»The PECO Smart A/C Saver switch is controlled via VHF paging networks and only activated at times of high energy usage, during the summer months of June through September.

»Demand response events may occur on summer afternoons, between noon and 8 p.m.

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During control events, participants' air conditioners were controlled using an adaptive algorithm.

»The adaptive algorithm records the compressor runtime, or duty cycle, in the hour before the event, then reduces the duty cycle by half during event hours.

»For example, if the duty cycle was 75% in the hour prior to the event, the adaptive algorithm reduces the duty cycle to a maximum of 37.5% during event hours.

»A simpler algorithm, the simple switch method, caps the duty cycle at 50% during event hours, regardless of whether the air conditioner was running the full hour or not at all.

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On July 21 and July 22, 2011 the PECO service area experienced a record breaking heat wave.

»PECO received many complaints from program participants regarding discomfort from heat.

»PECO asked Navigant to explore how the program was affecting discomfort.

»PECO also asked Navigant to explore the effects of the adaptive algorithm on discomfort and savings.

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PECO did not control all participants during the heat wave.

»The program implementer installed 100 meters on a group of 79 customers for the purposes of measurement and verification (the "M&V Sample").

»PECO called a control event for the **M&V Sample** on Wednesday, July 20, and Thursday, July 21.

»On July 22, the regional transmission organization, PJM, called a control event for utility customers across the region.

»The PECO program manager did not want to control the M&V Sample for the third day in a row out of fear that these customers would drop out of the program and the valuable metering points would be lost.

»Consequently, on Friday, July 22, all program participants **excluding the M&V Sample** experienced an event.

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This situation provided the evaluators with a natural experimental design.
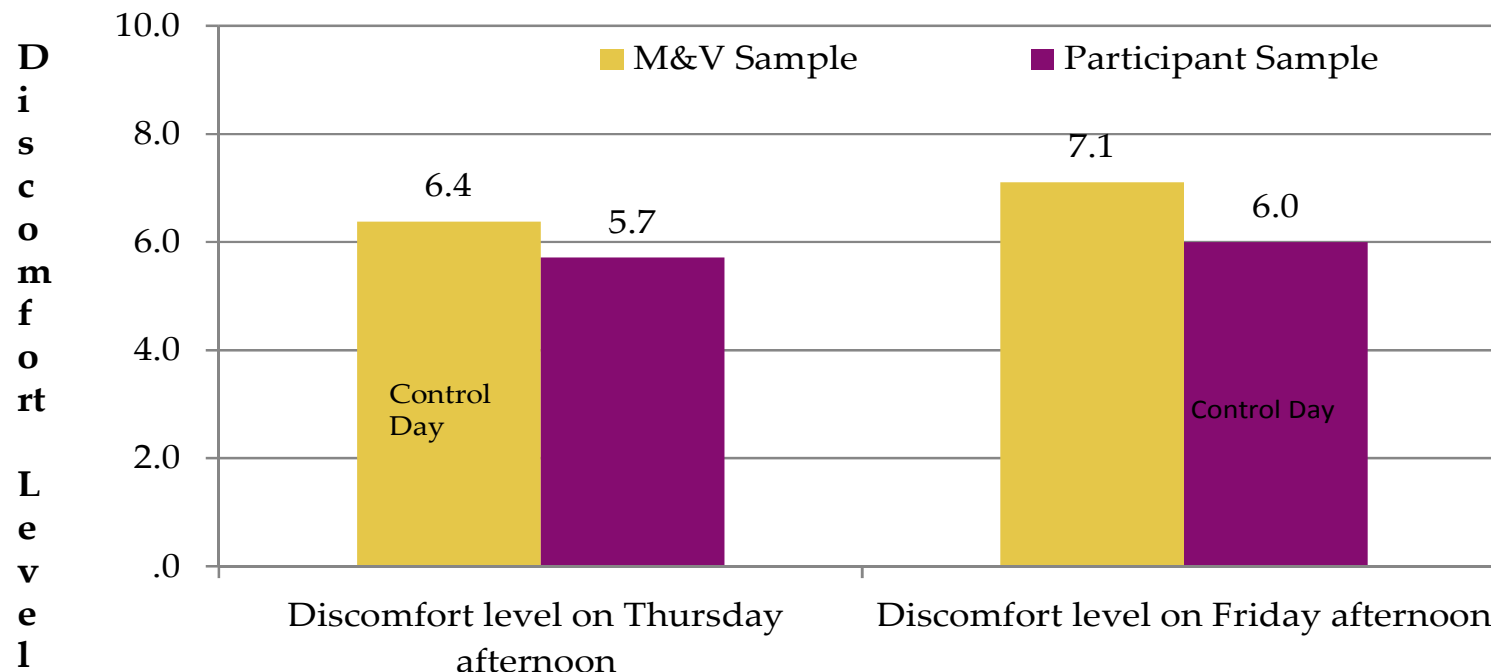
»Navigant conducted a survey, shortly after the heat wave, of two groups:

      1.   46 customers in the M&V Sample and

      2.   260 other participants ("the Participant Sample")

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Discomfort levels were not significantly related to control event.

»Navigant asked survey respondents: "What was your discomfort level, on a scale of 0 to 10 where 0 is no change in comfort and 10 is extremely uncomfortable?" The scale in this question, 0 to 10, increases as discomfort rises.
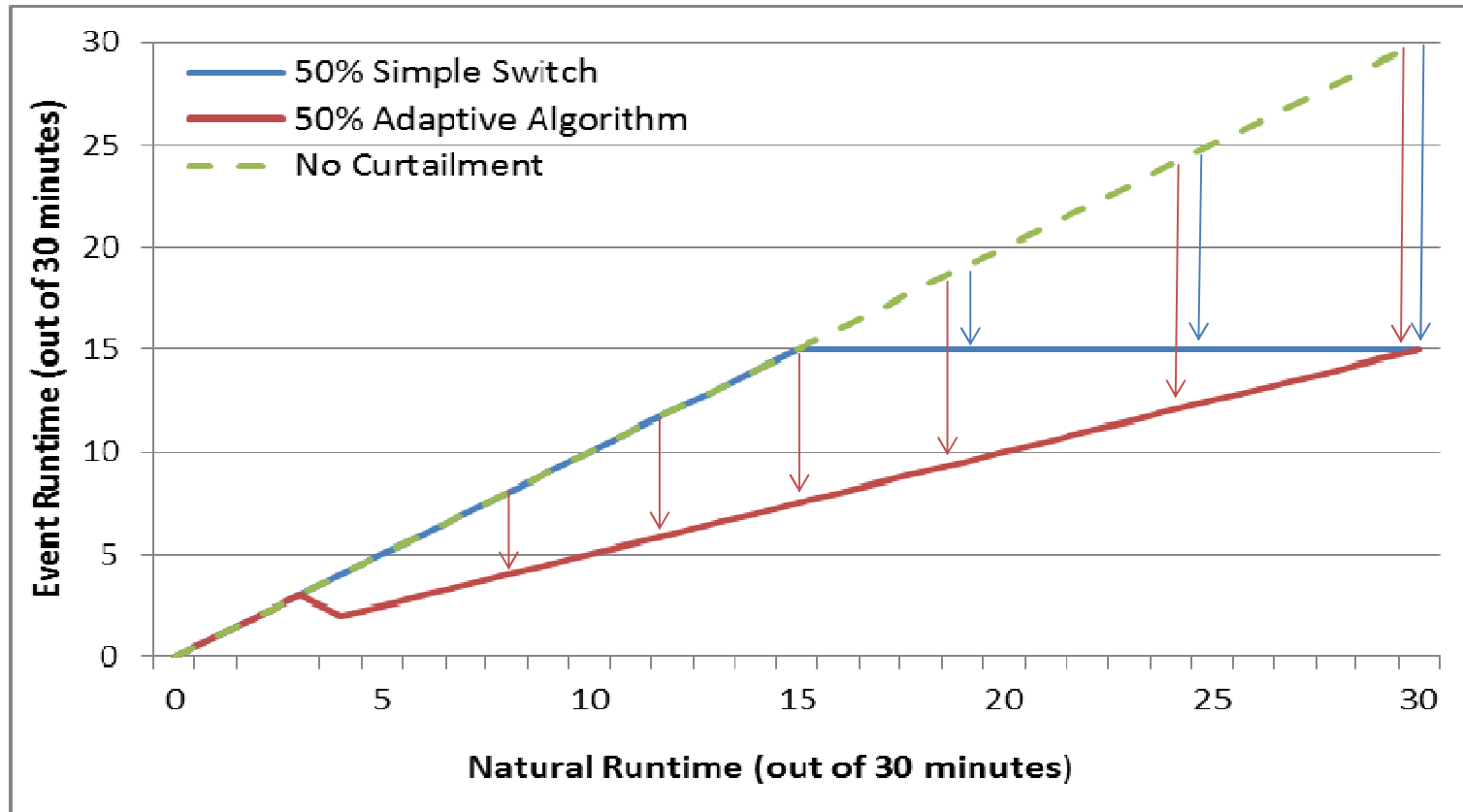
»**None of these differences are statistically significant**.

Source: Navigant analysis.

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The adaptive algorithm in use during the control event provides significant savings over a comparable simple switch method when the AC is not running at full capacity.

Source: Navigant analysis.

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Navigant employed regression analysis to predict the natural duty cycle for each unit during the event hours

»Navigant compared the summer 2011 savings, which included milder periods, from the adaptive algorithm to the savings that would have occurred with the simple switch method.

»Navigant calculated average per unit savings of 0.738 kW from the adaptive algorithm, while the simple switch would have reduced savings by 0.275 kW, or approximately 37%, under the same conditions.

»During more extreme weather conditions such as the recent heat wave, Navigant expects minimal difference between savings and comfort from the two methods, based on the reduced differences in event run-time as natural run-time grows longer.

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The analysis showed DLC control has little influence on customer comfort during a heat wave.

»Customers in the two samples are very similar in their comfort levels, in how they program their thermostats and in how they reacted to the two heat wave days.

»Navigant believes there is no evidence for treating the M&V Sample differently from the Participant Sample during an event.

»Knowledge of the event appears to increase discomfort during the event, especially for those customers in the M&V Sample.

- There is a fine line to walk here.
- PECO has a responsibility to meet the needs of customers who want to know when control events are happening but, overall, customer satisfaction is best served by keeping event information knowledge low key.

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The adaptive algorithm provides significant savings relative to a simpler algorithm when natural duty cycles are significantly less than 100%.

» As natural duty cycles approach 100%, as we would expect during extreme weather conditions, the two algorithms are likely to provide similar savings.

» It is unlikely that the adaptive algorithm would have a significant effect on comfort during heat waves.

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