Lessons Learned and Evaluation of 2-way Central A/C Thermostat Control System

Demand Response via Thermostat Control

Eileen Egan-Annechino, Consolidated Edison Company of New York, Inc., New York, NY
Joseph S. Lopes, Applied Energy Group, Inc, Hauppauge, NY
Michael Marks, Applied Energy Group, Inc.

ABSTRACT

Consolidated Edison Company of New York, Inc. (Con Edison), in cooperation with the New York State Public Service Commission (NYPSC) and other state agencies, has been working to address their growing summer peak, most recently through control of residential and small commercial Central A/C systems via a two-way system for thermostat control. Con Edison performed an assessment, implemented a pilot program and full-scale rollout of this technology, which communicates with the Central A/C thermostat via two-way pager, and enables features such as confirming feedback, recordable customer overrides, monitoring and thermostat access via internet by both customer and utility, utility control of either thermostat setpoint or duty cycle limit, and collection of hourly runtime and temperature data for virtually all units.

This paper presents background on the program, lessons learned, and impacts from the perspective of both the utility and the participants, including kW impacts and customer satisfaction.

The program was pilot-tested on both residential and small commercial customers, with a residential full-scale rollout of over 10,000 units a small commercial rollout expected for mid-2005. The utility controls the units when system or regional capacity constraints warrant it, can verify participant receipt of control signals, and determine whether and when the participant overrode the control.

Based on hourly runtime, temperature and customer override data, an impact analysis compared the control days with corresponding baseline days. Participants were surveyed to determine their impression of various aspects of the program, including their comfort and overall satisfaction with the program and a report was provided to the NYPSC (Con Edison and AEG, 2004).

Overall, the program was considered successful, achieving sufficient kW impacts to justify its initial cost, and was well received by regulators and participants.

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Introduction

Since the mid-1990's, a number of states have instituted some form of electric utility deregulation for the purpose of increasing competition, with the assumption that it would reduce overall electric costs to consumers and businesses. The results have been mixed, with some aspects improving and some not. One aspect has been an increased volatility in electric commodity costs, since regulated utilities are no longer in the position to absorb fluctuations in fuel prices, nor amortize power plant construction costs over long periods of time. Today's energy commodity brokers and plant owners can now seek the highest price the market can bear -- in many cases, through day-ahead markets, as in New York State. This volatility is particularly true during traditional system critical periods, which are the hottest summer days for most utilities, including the Northeast U.S. and the New York City area. This has resulted in price spikes, such as those that occurred in the San Diego area in 1999/2000[1], and in New York in 1999, each of which caused a large public outcry. New York State Attorney General was concerned enough in a 2001 report to state "Despite the promise that deregulation of electric markets would lower prices, the New York experience has been the opposite"[2].

In an effort to address these issues, regulators and other state agencies have taken action in a number of ways. For example, the New York State Energy Research and Development Authority (NYSERDA) has initiated several programs that fund projects that design, develop and implement demand reduction technology and programs targeting critical utility grid system periods, or "demand response". The Public Service Commission has encouraged -- through mandates and other means – the regulated utility sector to implement such demand response programs. Further, the New York Independent System Operator (NYISO) has several programs that provide incentives for both temporary and permanent demand reduction implementation, including the Emergency Demand Response Program (EDRP) and Special Case Resources (SCR) Installed Capacity (ICAP) Programs[3]. Finally, individual utilities have also offered incentives for demand reduction that addressed local distribution constraints, including Con Edison's "Distribution Load Relief" program"[4].

One of the intended outgrowths of these initiatives is both direct (through, for example, NYSERDA R&D funding) and indirect encouragement of new technology for demand response, which has resulted in a number of new hardware and software systems such as that discussed in this paper. This paper presents background on the design of the program, implementation, lessons learned, and impacts from the perspective of both the utility and the participants, including kW impacts and customer satisfaction.

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[1] PBS *Frontline* Report, "Blackout: What caused the Power Crisis in California" - Timeline of California Energy Crisis http://www.pbs.org/wgbh/pages/frontline/shows/blackout/california/timeline.html; PBS and *The New York Times.* 2001.
[2] McCall, Carl. "Electric Deregulation in New York State: The Need for a Comprehensive Plan", February 2001. Page 3. http://archive.pulp.tc/McCallrpt1.pdf
[3] New York Independent System Operator web site (www.nyiso.org)
[4] Con Edison web site (http://www.coned.com/customercentral/energybusvoluntary.asp) The Distribution Load Relief Program is designed to reduce the strain on T&D lines when Con Edison declares a localized emergency.

Background

One such regulatory-mandated outgrowth of the 1999 New York electric price spikes was initiated by the New York State Public Service Commission (NYPSC) in its December 20, 2000 "Order Requiring Filings and Reports on Utility Demand Response Programs" in Case 00-E-2054, which required that each state utility identify programs for load reductions achievable in the near future (DSM programs). In response to this Order, Con Edison considered a number of programs including those that would be categorized as demand response programs.

With summer-peaking utilities, which encompass most of the United States and include the New York area, air conditioning is the preferred target for demand response. It is somewhat discretionary, highly coincident with summer peaks, which are largely driven by weather, and is growing in saturation, particularly in new residential home developments. Businesses typically have air conditioning – particularly office, retail, restaurant, hotel, and health facilities - for the comfort of their employees and customers. This makes air conditioner control the preferred target for utilities seeking demand response options, and a natural target for Con Edison for their proposed programs in response to the NYPSC Order.

On May 31, 2001, the NYPSC directed Con Edison to implement a direct load control program for residential and small commercial customers. A program called "Con Edison's Central Air Conditioner Pilot Program" was put into action during the summer of 2001, in which residential customers participated[5]. As a result of this pilot program, a full-scale residential program was instituted starting in 2002 called "Con Edison's Central Air Conditioner Program.[6]

In September 2002 Con Edison requested permission to pursue a pilot program for the small commercial market segment utilizing a two-phase approach. The request was approved in October 2002. During the first phase, Con Edison conducted a market assessment of small business demand response programs offered by other utilities for potential load reduction impacts and customer behavior.

Based on the results of the market assessment in Phase I, in 2003 Con Edison requested approval to proceed with Phase II and conduct a pilot program. The "Small Commercial Direct Load Control Pilot Program" (SC-DLC) targeted 2,500 small business customer's thermostats in Brooklyn and Queens, New York with direct load control technology for central air-conditioning. The SC-DLC Pilot Program was approved in December 2003, launched in January 2004 and completed in September 2004.

Program Design

The Program Design was intended to address the NYPSC mandate and meet a number of objectives. Generally, the program had to achieve load reductions that were cost-effective, with significant participation levels, acceptable to customers (including override capability), and could be adequately verified. Specifically, the pilot program objectives included:

<u>Quantitative Objectives</u>

- Measure connected load, including the effects of power factor
- Determine kW load reduction that can be achieved during summer peak load conditions
- Determine the level of customer overrides that can be expected during a curtailment event

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[5] While small commercial customers were eligible, only one signed up. Con Edison then proposed to the NYPSC a pilot program specifically targeted to small commercial customers.

[6] Each program was marketed with the concept of catchy names in news and web site ads designed to attract attention and appeal to its futuristic nature and customer's desire for comfort and efficiency.

Qualitative Objectives

- Evaluate different marketing strategies
- Evaluate customer understanding of the program parameters and willingness to participate in program curtailments
- Determine customer satisfaction with the installation process and the equipment installed
- Assess overall customer satisfaction with the program
- Determine barriers to customer participation
- For businesses, determine the most appropriate customer for program inclusion as measured by billed kW demand

Technology

Given these objectives, Con Edison considered various technologies for this pilot used by other utilities and by Con Edison in the past. This included switches on A/C compressors, which had been the most common type of air conditioner load control during the late 1980's and early 1990's when many utilities, including those in New York State, had aggressive demand-side management (DSM) programs. The selection of the ComfortChoice® Thermostat was made after both switches and "Smart" Thermostat technology were tested in customer homes. Generally, customers did not like the switches and there were communications problems[7]. As a one-way system, switches also would require a sample of homes to be monitored with interval metering (such as data loggers) to enable estimation of impacts and overrides. The customers liked the Carrier thermostats, which were considered more advanced technology and provided a number of features attractive to both customers and the utility, namely:

- The ComfortChoice® thermostat is a state-of-the-art, Energy-Star rated, digital, programmable thermostat that's powered by electricity through low-power typically already provided by existing thermostat wiring. The thermostat replaces the existing one and can control both A/C and heating system. Figure 1 below illustrates the main features.
- It can be programmed by the customer for seven days, four time periods a day, either at the thermostat or remotely (see below).
- Through the EEM Suite© Data Communications system, customers are issued a PIN number that enables them to access their thermostats via the Internet from any location, monitor ambient temperature and change any settings.
- Two-way data communications is accomplished through a public 2-way paging network that sends control signals to the thermostat and can download data from the thermostat via scheduled or ad-hoc commands sent from the EEM Suite System.
- Data stored in the thermostat includes current readings for ambient temperature, setpoint and stored readings for the last 7 days on runtime[8] (minutes per hour of operation), number of starts (change from off to on) and ambient temperature at the thermostat.
- Utility control of the thermostat via the paging network is accomplished by a signal algorithm that can either shut the compressor for a defined percentage of the hour (e.g. 50%, or 30 minutes each hour) or by changing the thermostat setpoint by a defined number of degrees (e.g. raising the setpoint by 4 degrees during A/C operation). The unit fan is not affected by control, so it will continue to operate.

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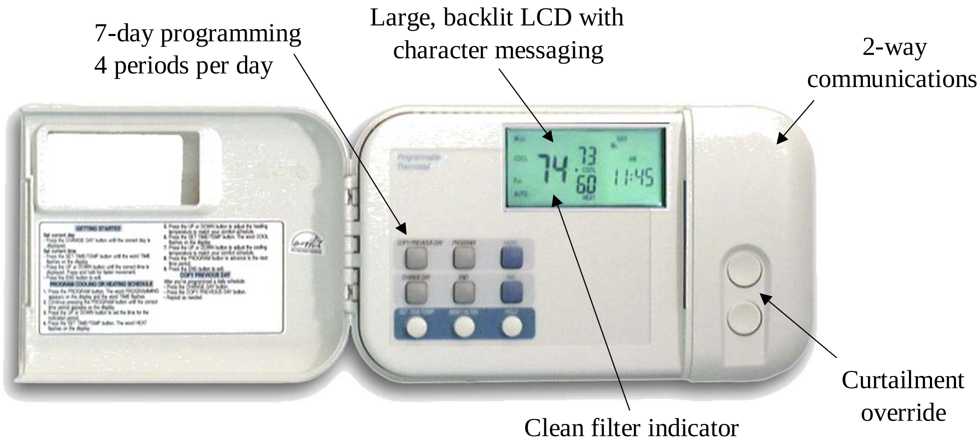
[7] During the switch technology test, communications boards had to be changed out after the paging company was replaced. Signal loss exceeded 20% during the test control event after that, so communications problems were considered not resolved.

[8] Runtime is defined as number of minutes per hour that the thermostat was calling for cooling/heating based on ambient temperature vs. setpoint.

Figure 1 – Thermostat and Control Summary



Program Features

The overall Program Design for both the residential and small commercial air conditioner control programs was basically the same. Customers were offered a free thermostat and a small one-time incentive. For residential participants, the incentive was $25 for each thermostat. For businesses, it was $25 for under six ton units, $50 for 6-9 tons, $75 for 9-12 tons. Multiple thermostats were permitted, with some residential homes having two distinct thermostats (and zones) and many businesses having multiple thermostats (and zones). To date, 14,830 residential thermostats were installed at 12,150 customer locations. For the Commercial Pilot, 2,259 thermostats were installed at 1,678 locations, with 1,546 unique customers.

Under the terms of the participation, prospective participants in the residential program were told that control would be operated only during emergency periods, anticipated to be during hot summer afternoons (between 1-6 pm). There was no specific limit to control events, but historically there were less than 5-10 per year. For the Small Commercial Pilot, for example, Con Edison control events would be accomplished by cycling the compressor off for 30 continuous minutes per hour (i.e., a 50% off-cycle). The utility has the ability to refresh the control event in 2-hour increments. A 50% control strategy was used based on past experience of Con Edison and other utilities in past similar projects and was considered sufficient to balance sufficient impacts without excessive control burden on the customers.[9] Control was to be initiated during NYISO-declared system emergencies (EDRP[10]) or during times of excessive demand on the transmission and distribution system as declared by Con Edison (DLRP[11]). There was also no limit to the number of times that Con Edison could institute load curtailment, but NYISO events have typically been fewer than 5 per year. Participants who were at home or at their business could override the control, which is indicated on the thermostat display, by pressing the override button. This feature is not available remotely. Under the Con Edison programs, there is no penalty for overrides.

[9] Evaluations of Long Island Lighting Company (LILCO)'s 1989-1992 A/C DLC Programs found that a 67% cycling strategy resulted in an excessive number of free riders (customers not using their air conditioning) which resulted in lower average impacts than for the 50% cycling group, reducing the cost-effectiveness of that strategy.
[10] EDRP – Emergency Demand Response Program
[11] DLRP – Distribution Load Relief Program

Recruitment and Participation

Participants were recruited in a number of ways. For both programs, a web site was set up, linked to the Con Edison main site, for information, contact and sign-up information. For the residential pilot and full-scale programs, direct mailing was the primary (and by far the most effective) method, with followup telemarketing also used extensively. In order to limit the scope, billing data analysis was used to narrow the mailing. There were also ads placed in local publications (e.g. Pennysaver) and some citywide newspapers. Through the end of 2004, based on over 22,000 initial requests for participation for the program to date, the method identified as the primary source for participants were as follows:

- Telemarketing 35%
- Direct Mail 25%
- Con Ed sources 11% (web site, bill stuffers)
- Community News 10%
- Friend/Neighbor 8%
- All Other 11% (e.g. city-wide newspaper ads, inserts)

It should be noted that while there is only one primary source indicated, many of these were complementary. Telemarketing following a direct mail letter tends to reinforce the message and close the deal. As of September 30, 2004, a total of 14,427 thermostats had been installed in 11,802 homes and religious institutions. These installations represent over 17 MW of net peak load reduction.

For the Commercial program, a marketing plan was developed based on the target population of small businesses under 50 kW billable demand in the Brooklyn and Queens boroughs of New York City. The primary approach was door-to-door promotion by technically trained bilingual sales staff (marketing representatives). This approach provided distinct advantages, including a turn-key application (completed by marketing rep), face-to-face contact with the decision maker, more efficient installation qualification and scheduling, reference contacts, and smoother backlog control.

The marketing representative explained all aspects of the program including Internet control, utility curtailments, customer support and potential energy savings through the use of a programmable thermostat (they also carried a sample thermostat). If the customer required confirmation of the authenticity of the program, the representative provided the Infoline toll free 800 telephone number to speak with a customer service representative. If the customer was not ready to make a decision during the representative's visit, the representative left a program information sheet with the customer and later followed-up with a telephone call. Direct mailing was also used, as well as followup telemarketing and ads in local publications, the Queens Ledger and (Brooklyn) Greenpoint Star.

The results from the marketing plan were positive. More than enough leads were generated to meet the participation goal. The door-to-door promotion was successful, generating the majority of the leads (57%) and resulting in very few customers changing their mind after they applied for the program. Direct Letter Mail (23%) and Telemarketing (20%) composed nearly all the remainder.

The result was that the target of approximately 2500 sites was accomplished, broken down by business types as follows:

Table 1 – Participation of Small Commercial Pilot Program by Business Type

Business Type	Customer Sites	% of all sites
Restaurants	392	23.4%
Hard Goods Retailers*	369	22.0%
Food Retailing	164	9.8%
Personal Services	134	8.0%
Financial/Office Based	130	7.7%
Medical/Dental	121	7.2%
Clothing Retailing/Shoes	118	7.0%
Automotive/Transportation	85	5.1%
Consumables Retailers	71	4.2%
Industrial/Assembly/Production	66	3.9%
Schools/Churches	28	1.7%
Total	**1,678**	

**Hard goods retailers include Furniture, Floor Covering, Home Goods, Electronics, Computer Retail, Sporting Goods, Books, Stationery, Jewelry, Optical Goods, Art Dealer, Building Materials, Retail Nurseries, and General Merchandise.*

Installations were coordinated between the information line call center (operated by AEG) and the installation contractor, Honeywell/DMC. Any subsequent issues related to technical problems that prevented installation, repairs, or requests for removal were coordinated the same way. Some of the reasons for "technical turndowns" were:

- Presence of damper systems (incompatible with Carrier system)
- Lack of access
- Wiring constraints
- Heat/Cool thermostat incompatibility
- Unit not operational/equipment condition
- Mounting aesthetics
- No two-way signal (which would prevent internet access)

In 2004, wiring (40%) and dampers (20%) were the most common causes for residential technical turndowns. For commercial, equipment condition (38%), Wiring (34%) and access (22%) were the primary reasons.

Other Customer Features

Each participating customer was provided with materials explaining the operation of the thermostat, a welcome letter, Internet access (PIN number), program website information, Incentive Bonus letter and check. The same website developed for the residential participants was modified to accommodate the commercial participants for the pilot program.

Program Evaluation

In order to determine whether the programs (residential pilot/full-scale and commercial pilot) met their objectives, an evaluation process was incorporated into the overall project planning.

Methodology and Data Collection

The methodology used in collecting data and evaluating the program results consisted of the following components, designed to determine customer satisfaction and understanding of key program aspects, load impacts, and customer overrides:

Survey Data

- Surveys of customers during installation
- Surveys of customers who were declined (technical turndowns)
- Post-season satisfaction surveys

Residential program participants were routinely surveyed as the principal means of monitoring customer satisfaction for each program year. For 2002 and 2003 (the last year a residential survey was conducted since there were no 2004 curtailment events), surveys were mailed to current program participants (all participants in 2002, a random sample of 3,000 in 2003). A total of 1,640 responses were received in 2002 and 1,377 in 2003 and analyzed. The survey was composed of 8-10 questions, involving customer satisfaction with the equipment installed, specifically:

- Customer use and ease of programming the thermostat.
- Customer's perception of the thermostat's user friendliness.
- Whether customers used the override feature during curtailments the past summer.
- Customer use and satisfaction of the Internet feature for the thermostat.
- Customer use/satisfaction with the Con Edison Infoline and after-hours phone service.
- Overall program satisfaction. (2003 only)
- Customer interest in purchasing an outdoor air temperature sensor (2003 only)

For 2004, weekly telephone surveys were completed for 10% of recently-installed customers to determine their satisfaction with the installation process. Additionally, technical turndown customers (customers who could not have the equipment installed due to specific reasons[12]) were all contacted.

Two-Way Transactional Data

The two-way pager system employed for the program enables a number of monitoring and verification (M&V) data collection components that serve to ensure the accuracy of the data and, therefore, impact estimates. For each control signal sent out, a return signal confirms that the unit has received the signal. The two-way signal is virtually 100% effective, confirmed by a test during the installation, but subject to some minimal interference that has been established to be significantly less than comparable RF (radio frequency)-based systems. In some cases, even where signals were confirmed as being received during the installation process, return confirmation signals may not be strong enough to reach the central station, but these are also minimal, on the order of less than 1%. Recovery of runtime data, which requires a much larger packet of data (typically 24 hours of three data

[12] Primary reasons for technical turndowns were inadequate working condition of air conditioning unit or wiring.

items – runtime minutes, number of starts and ambient temperature) is not as complete, but exceeds 90%, and constitutes an unbiased virtually 100% “sample”, much superior to the former process of data collection for one-way systems, where a “small” sample (at most several hundred sites) is monitored. The two-way system also enables generates a signal if the customer overrides, enabling the degree of overrides to be determined instantaneously, although it is typically averaged over each hour of the curtailment.

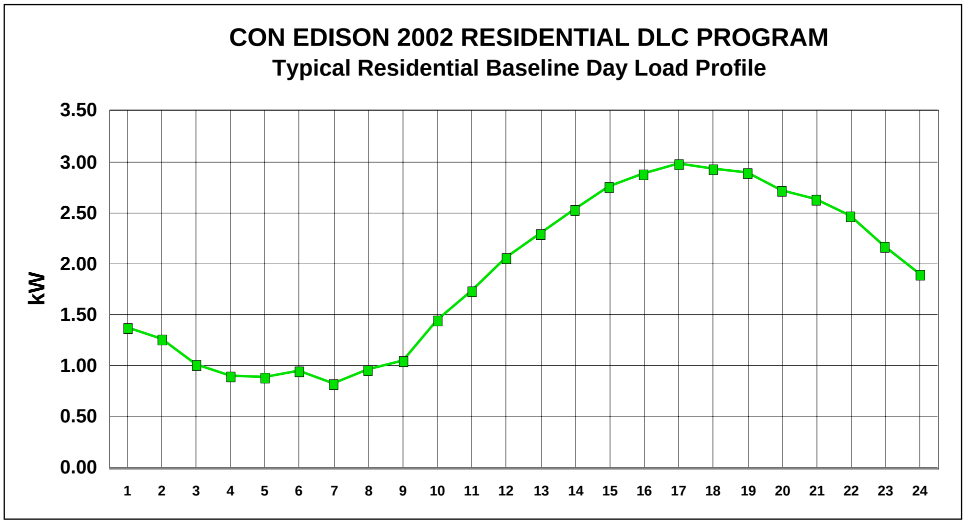
Load Data

- Analysis of runtime data for all participants during curtailment and comparable baseline days (minutes per hour of operation and ambient temperature)
- Analysis of Connected kW and Maximum kW draw during curtailment event days

The key to the load impact analysis methodology is the close matching of a baseline day to each curtailment event day. By definition, a baseline day is the load pattern of the air conditioning units on a non-curtailment day. The baseline day is designed to be a close match to the corresponding curtailment event day in terms of both factors that influence air conditioner load patterns, as well as the actual performance, as measured by the pattern on the baseline day vs. curtailment day during the hours immediately preceding the curtailment period. Key factors that affect the load pattern include weather (temperature, cooling degree days, humidity, wind, cloud cover, prior days’ weather), overall day type (day of week or weekday/weekend, which is more important for commercial than residential), and time of year. From past experience, customers tend to vary (reduce) their tolerance of hot weather and (increase) their use of air conditioning, as the season progresses. Both residential and commercial facilities also have patterns of not being at home, work hours or vacation schedules that dictate that a baseline day be as close to the curtailment day as possible. In this case, historically, NYISO EDRP or Con Edison DLRP event days have been mid-summer (July & August), on weekdays (Monday through Friday), during the afternoon (2 – 6 PM), with temperatures above 90 degrees Fahrenheit.

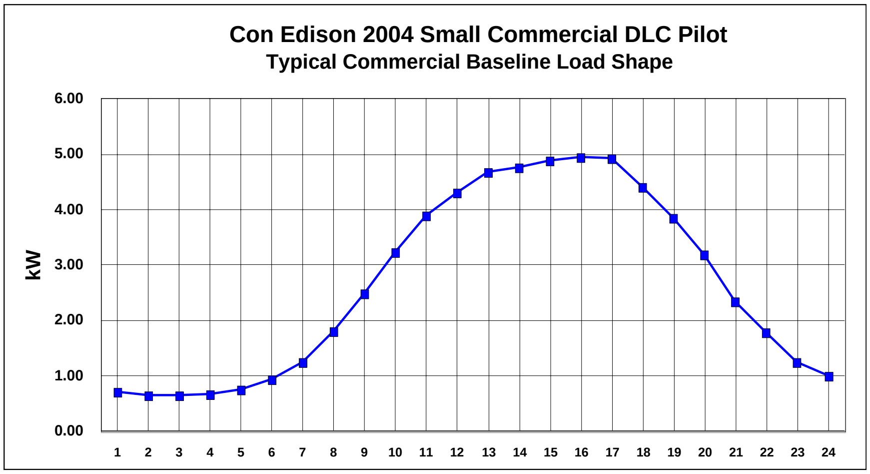
The connected load data for the central air conditioning system (CAC), coupled with the runtime data collected for each unit, can be used to produce a baseline load shape. The baseline load shape will vary for specific customers depending upon the equipment that a customer has, the way in which the equipment was sized for the business that it is installed in and the way in which the customer operates the equipment. Typical baseline load shapes are shown below for residential and commercial sites, represented as net hourly kW load for the air conditioner compressor during a summer day (24 hours) with temperatures over 95 degrees.

Figure 2 – Typical Residential Baseline Central A/C Load Profile



The residential peak load of 2.98 kW represents approximately 75% duty cycle, based on August 13, 2002, a 96 degree day. Given the temperatures, it might have been expected that a higher percentage of units would be on, but the duty cycle is affected by whether the units are on at all – some customers are not home and do not run their units, some have multiple units and an upstairs/bedroom unit may not run during the day.

Figure 3 – Typical Commercial Baseline Central A/C Load Profile



The commercial peak load of about 5.0 kW represents a peak duty cycle of approximately 84%, estimated for a 95 degree day in 2004. The mitigating factor for duty cycle for commercial is primarily multiple units, since overlapping zones may result in overall oversizing of total unit capacity. Unlike residential, units are not typically voluntarily off, since the facility is assumed to be occupied and requiring air conditioning. For the load data impacts, the calculation is as follows:

1. Obtain run time data (duty cycle[13]) for participants for baseline and control days.
2. Select baseline days comparable to control days, primarily from Cooling Degree days, using Central Park weather. Compute weather adjustment for baseline, if necessary.
3. Multiply baseline day run times for each hour and participant by weather adjustment, capped at 100% run time for any given hour, if necessary, where an exact match of baseline to curtailment day does not exist, based on analysis of loads for 1-3 hours prior to the control period.
4. Multiply hourly run times (Controlled Duty Cycle[14] and Baseline Duty Cycle[15]) by estimated connected kW draw. The kW draw is based on nameplate data for all participants adjusted for spot metering from a randomly selected sample of units. The spot metering included the use of a power meter/power harmonics analyzer, which measured voltage, sign wave, harmonics, power, wattage, and power factor[16]. This will result in kW per hour for both baseline and control days.
5. Subtract control day average kW from baseline day average kW to produce impacts for each hour during control period.
6. Multiply per-unit impacts by number of units under control.

[13] Duty cycle - defined as the fraction or percent of time per defined interval (e.g., one hour) that the AC compressor was running. For example, a duty cycle of 0.75 (75%) means that the CAC compressor was operating for 45 minutes that hour.
[14] Controlled Duty Cycle includes the effects of customers who overrode the control.
[15] Baseline Duty Cycle is similar to the Controlled Duty Cycle from the perspective of selecting similar days (e.g., weekdays) with similar temperature conditions (e.g., over 90 degrees).
[16] The spot metering resulted in a 15% reduction of nameplate connected load. This reduction includes the effect of power factor.

Evaluation Results

Survey Results

The results of the residential technical turndown surveys showed that virtually 100% of customers who could not be installed (surveys were attempted on all) were "very satisfied", with an average of 4.99 out of 5 rating, with 1 being "Very Dissatisfied" to 5 for "Very Satisfied". Virtually the same results were found for the Commercial Pilot Program. The results of the 2002 overall program satisfaction survey conducted on over 1,600 residential participants were as follows[17]:

- Over two-thirds (73%) of the respondents were "very satisfied" with the quality of the equipment installed and an additional 21% were "somewhat satisfied". The average rating by the respondents was 1.9 with 1 being "very satisfied" and 4 being "very dissatisfied".
- Over 82% of respondents have used the programming features on their thermostats, with over 80% rating the programming "easy" and over 86% rating the thermostat "user friendly".
- Approximately 27% of respondents used their thermostat to override the curtailment event
- The website was used by 12% of respondents. About half of the users (49%) have accessed the website between 2-4 times. Most users (89%) rated the website as user friendly or better.
- 11% of respondents called the info line, with 88% rating it as responsive or better. 5% of respondents have used the after-hours service with 88% rating the service as responsive or better.

Two additional questions were asked in the 2003 Survey:

- Nearly all respondents (92%) reported that they were satisfied with the program. Of those, 56% reported being "very satisfied".
- Approximately one-third of respondents, (32%), were interested in purchasing outdoor temperature sensors (7% definite and 25% probably).

For the Commercial Program, an overall program satisfaction survey was conducted after the 2004 summer period, which included a test control day on September 13, since there were no NYISO or Con Edison critical days. A total of 300 responses were collected from the total program participant population of 1,546 unique customers. Key findings for the survey questions are as follows:

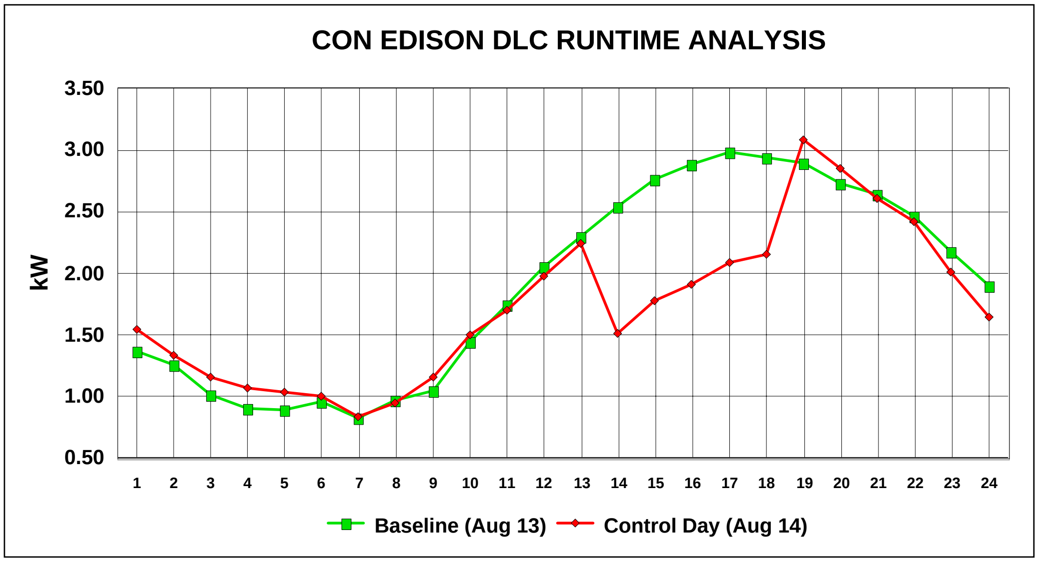
- The vast majority (90%) were satisfied with the overall program and quality of the thermostats.
- Approximately two-thirds of the respondents (67%) stated that the main reason for participation was to help conserve energy, while 18% stated it was to receive the free thermostat.
- More than half of the respondents (61%) reported using the programming features of the thermostat and 80% of these respondents reported that the programming features were an important part of the thermostat.
- Additionally, 84% of the respondents using the programming features stated that the thermostat was easy to program.
- Of the 14% of respondents who used the Internet feature, approximately 80% felt it was an important feature of the program.
- Approximately 11% of the respondents used the program Infoline and more than 70% of these respondents felt the Infoline was helpful in answering their questions and concerns.
- Approximately 4% of the respondents have used the after-hours phone service and more than 67% of this group rated the service as "responsive".
- Slightly more than a quarter of the respondents (26%) were aware that a test curtailment event had occurred during the summer, and more than half (62%) of these respondents stated that they had overridden the test curtailment event.

[17] A similar survey of 1,377 participants conducted in 2003 produced virtually identical results.

Load Impacts

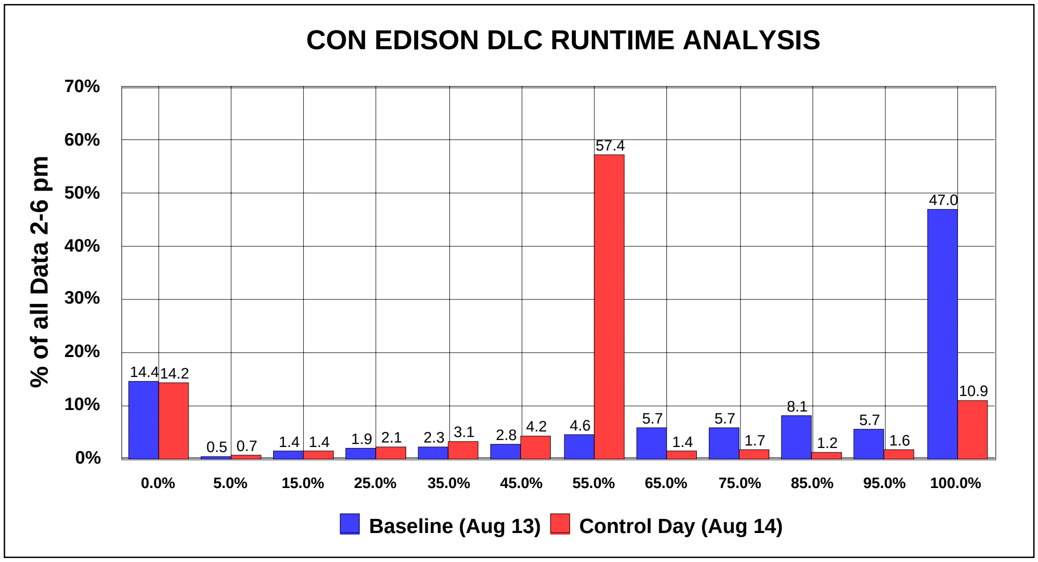
For the residential program, based on an actual 2002 curtailment on August 14, 2002, a 95 degree day, the figure below illustrates the comparison between the curtailment day and a comparable baseline day (August 13, a 96 degree day). The total impact estimate for that day is approximately 1.1 kW per unit for the approximately 1,200 participants on that day.

Figure 4 - Curtailment Day Load Impact Analysis for 2002 Residential Participants



Of additional interest is the distribution of duty cycles among the thermostats. As indicated in the figure below, on both the baseline and control days, about 14% of all units were off (considered free riders in that they were not using their A/C). On the Baseline day, 47% of units ran at 100% duty cycle ("flat out"), replaced by the bunching of the units around the 50% duty cycle level (the maximum allowed) on the control day. Others exceeding that level would be assumed as overrides.

Figure 5 - Distribution of Duty Cycles for Baseline vs. Control Day (2002 Residential)



For the Small Commercial Pilot Program, the following table summarizes the results of the 2004 impact evaluation. Since there were no control days called by the NYISO, a test day (September 13, 2004) was used to confirm overrides and system operation, and the actual runtimes from three hot days during the summer were used as the basis for a regression model to simulate impacts on a 95 degree day.

Table 2 - Simulated 50% Cycling for 95 degree Control Day

Number of installations at end of pilot program = 2,259	Hr. End 2 P.M.	Hr. End 3 P.M.	Hr. End 4 P.M.	Hr. End 5 P.M.	Average
Per unit kW load reduction (without overrides, with line losses)	2.180	2.267	2.300	2.284	2.258
Total kW load reduction	4,924	5,120	5,195	5,160	5,100
Cumulative overrides from September 13, 2004	6.30%	17.60%	12.60%	17.60%	13.50%

Mathematically, the impact, averaged for the 2 – 6 PM period, was calculated as follows:

Duty Cycle Reduction = Baseline Duty Cycle$_i$ - Controlled Duty Cycle$_i$

.382 ***.826*** ***.444***

*Multiply duty cycles by estimated connected load with line losses (**5.91 kW**)*

*Per Unit kW Reduction$_i$ = Baseline kW$_i$ * Control Day kW$_i$:*

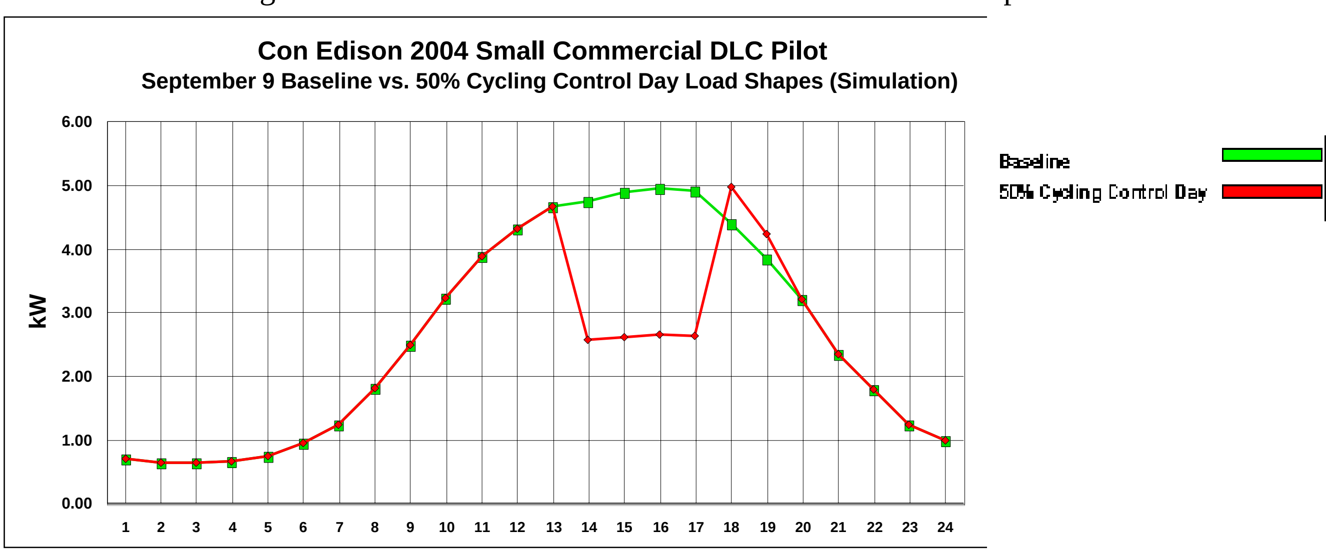
2.258 ***4.886*** ***2.629***

*Total kW Reduction$_i$ = Per Unit kW Reduction$_i$ * Number of Units*

5,100 ***2.258*** ***2,259***

The following Figure illustrates the kW load comparison between the baseline simulated 95 degree day and the modeled curtailment day:

Figure 6 - Small Commercial DLC Pilot Simulated Load Impacts



Conclusions

The Program can be considered a success, both from Con Edison's perspective, having achieved significant load reduction cost-effectively without adverse impact on the participants, which were a sufficient number to create a significant total impact that can be used as an effective tool for Con Edison and the NYISO to respond to critical load availability and price events during summer peak periods.

In terms of participation, the most significant element of the new technology used for the program, and a key factor in the successful recruitment, has been the customer features, specifically the new programmable thermostat and the novelty of access via the Internet. Customers can achieve significant benefits on their own through the use of the programming features (which have not been evaluated) and the flexibility that the Internet access provides that divert the focus from the utility control aspect.

The Residential DLC Program has continued to meet its goals and objectives; Con Edison has continued to expand this program since the 2002 Pilot. Additional installations are being proposed through 2007.

A specific report on the evaluation of the Small Commercial Pilot Program was provided to the NYPSC early in 2005, and included the following recommendations:

- With the estimated 2.3 kW per commercial installation load reduction (before overrides), coupled with the fact that the cost per installation at commercial sites was about the same as for Residential sites, it is clear that the commercial program should be expanded to a full-scale program, and expanded throughout Con Edison's service area.
- The eligibility criteria should be expanded to include sites over 50 kW, up to 100 kW, which should double the potential participants. During the marketing effort, it was found that medium commercial customers with higher billed demands also had compatible air-conditioning equipment. These customers would also likely have larger HVAC equipment with greater air-conditioning tonnage requirements and thus increase the average per participant kW impact. Based on other programs, which AEG has evaluated, an average increase of 20% or 0.5 kW impact per thermostat could be expected from this change.
- Door-to-door promotion should be the focal point of a small commercial DLC Program marketing plan, since it was the most effective marketing strategy. The approach resulted in better explanation to customers, better pre-qualification to ensure HVAC equipment compatibility and overall condition, more sign-ups per customer contact than direct mail or telemarketing and reduced technical turndowns and deactivated leads.
- Alternative incentive offers should be considered, including a fixed "thank you" amount and also an option for incentives for only customers that agree not to override the control.

References

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