Title
Connecticut Light and Power C&LM Programs/Residential Load Management Services Program: 2002 Summer and Winter Thermostat Pilot Programs Impact Evaluation Report

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Attachment 2

Connecticut Light and Power
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Residential Load Management
Services Program

2002 Summer and Winter
Thermostat Pilot Programs

Impact Evaluation Report

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Table of Contents

Listing of Tables

Listing of Figures

CL&P Residential Load Management 2002

1 Background

The Residential Load Management Services Program for 2002 built upon the experiences gleaned from previous program years. This program was designed as a departure from traditional direct load control (DLC) programs in which participants may manage their own power bill by electing to control their usage at any time.

1.1 Residential Load Management in 2000: Program Design and Initial Pilot

In the year 2000, the Company initiated an action plan for implementing a residential load management program, comprised of the following six tasks:

1. Market Assessment to determine key parameters for the Residential Load Management Services Program. The objective of this task was to identify program attributes, incentive levels and marketing approaches needed to optimize participation. A total of 578 phone surveys were performed on Connecticut residential customers to inform this task.
2. Technical Assessment to determine key operational parameters for the Residential Load Management Services Program. This task was conducted concurrent with the Market Assessment. RLW performed a technical assessment of twenty different products available for use in a CL&P residential load management program. The assessment concluded with the development of a summary document describing companies with products appropriate for a residential load management trial.
3. Opportunity Analysis of the information gathered in the Market and Technical Assessments. This analysis included a determination of the viability of the residential load management program offering and an initial economic analysis to assess the program's cost-effectiveness. Based on iterations of the economic analysis, a general framework for the program emerged which included identification of the most promising features to optimize the program, such as marketing approaches, communication themes, assumed costs (including incentives) and likely program benefits.
4. Pilot Program Design to develop a comprehensive pilot program design that would rigorously test the implementation of the program and address its researchable issues. The ultimate goal of the pilot program was to reduce the uncertainty associated with the full-scale implementation of the program.
5. Pilot Program Implementation to field-test program delivery with a sample of residential program participants.
6. Verification and Evaluation to assess the ability of the pilot to address the program goals and objectives, highlight the strengths and weaknesses of the pilot approach, and provide a basis for selecting and refining future residential load management offerings.

For the summer of 2000, CL&P participated in Carrier's Comfort*Choice* program for Task 5: Pilot Program Implementation. A total of 47 residential customers participated in this pilot program. The program concept was to replace existing central air-conditioning thermostats with new programmable thermostats that were remote-addressable via an Internet connection. Program administrators maintained the ability to reset participants' thermostat set points for a desired offset in degrees and time duration. The summer of 2000 proved to be unseasonably mild and only four tests were initiated. For Task 6: Verification and Evaluation, analysis of the program on the hottest of these days – 87.8 ºF on August 7th – yielded an average demand reduction of 1.06 kW per participant and a maximum reduction of 1.57 kW. The Carrier pilot showed that residential load management presents a significant number of technical challenges but indeed possesses potential for a measurable reduction in peak demand.

In November 2000, RLW presented results from the Carrier Comfort*Choice* program pilot to CL&P. Because the 2000 pilot started late in the summer and overlapped unseasonably mild temperatures, it was concluded that a subsequent pilot program was warranted to substantiate residential load management potential. A potential vendor list was presented to CL&P by year-end that included a variety of mass-market load management technologies.

1.2 Residential Load Management in 2001: Technology Testing

In January 2001, CL&P and RLW held meetings with four vendors, a utility rate specialist, the manager of NU Metering Services, and C&LM Media Relations to develop residential load management program options for the summer. In early February of 2001, RLW delivered a presentation to CL&P that summarized the lessons learned from the 2000 Carrier pilot and made recommendations on program options for the summer of 2001.

For the summer of 2001, CL&P decided upon a parallel test of three distinct load management technologies: thermostat controls, gateway systems, and manual dispatch devices. A three-way pilot offered CL&P the opportunity to assess the merits and shortcomings of a variety of devices within a single summer. Furthermore, a multifaceted study would be advantageous to the Utility economically via consolidated project management, analysis, and reporting costs.

Thermostat Controls accomplish load management via temperature offset and/or duty cycling of central cooling systems. For a thermostat pilot, CL&P selected the vendor Lightstat and ultimately installed a total of 24 thermostats. These are remote programmable thermostat units that replaced existing air conditioning or heat pump thermostats and receive programming and curtailment signals via a one-way paging network. Both customers and program administrators were able to control the thermostats via a web-page front-end system. Curtailment events were programmed in advance or initiated almost immediately, and the customer retained the power to override curtailments. Since these are direct thermostat replacements, installation was very simple. Interval metering was required in order to validate demand response. The residential Lightstat thermostat pilot yielded average demand savings of 0.54 kW per thermostat with a peak demand impact of 1.17 kW.

Gateway Systems provide modular access to a variety of load management and home service devices within the residence. For a gateway pilot, CL&P selected the vendor muNet and ultimately installed a total of 16 systems with a total of 19 thermostats. This residential gateway interfaced directly with the Utility meter to provide automated meter reading (AMR). In addition, the gateway communicated with thermostats and load control relays inside the home via power line carrier (PLC) or other wireless means. The gateway system employed a live, two-way communications path over a broadband Internet connection to deliver commands to the gateway and strategic data back to Utility. Curtailment events were programmed in advance or initiated immediately, and the curtailed load was validated via built-in AMR. For the muNet pilot, average demand savings were 0.97 kW per thermostat with a peak demand impact of 1.85 kW.

Manual Dispatch devices provide a simple means of notifying customers that the Utility requests voluntary load reduction. CL&P selected Comverge's Customer Alert Device (CAD) as the manual dispatch pilot and installed a total of 46 units. This in-home "Power Watch" alarm extended residential load management programs to customers with window/wall cooling systems. The CAD was ideal for customers who are home during the day or otherwise unwilling to relinquish control. The simple notification devices are equipment blind, meaning they have potential for dispatching a variety of loads such as ranges/ovens, clothes dryers, hot tubs & pool pumps. The simplicity and low cost of these devices enabled the Utility to reach a much larger population, albeit with a lower probability of load response. The CAD is a simple radio-receiver that plugs into the wall, so there is no installation necessary as they may be mailed out and selfinstalled. Metering was required in order to validate demand response. The CAD pilot yielded average demand savings of 0.52 kW each with a peak demand impact of 0.98 kW.

2 Residential Load Management in 2002: Extended Seasonal Test

In 2002, The Connecticut Light and Power Company offered selected households in the Farmington Valley and Stamford area the opportunity to participate in a pilot program designed to enable Internet access to home thermostats. The method tested by CL&P included the installation of a new, high technology Carrier Energy Management Interface (EMi), an Internet-communicating 7-day programmable thermostat, in homes with central air conditioners or heat pumps. With integrated two-way paging to both receive *and send* information, this thermostat was the next-generation device from that employed in CL&P's 2000 pilot program. Using Web-based software developed by Silicon Energy, CL&P communicated with the thermostats remotely over the Internet to increase the current temperature setting during peak demand periods. The air conditioner still was enabled to run during this period, but it operated less frequently due to a higher indoor temperature setting. At any time, homeowners had the ability to override this temperature setting directly from the thermostat or remotely via the Internet. The new two-way paging feature permitted CL&P to track whether or not the thermostat received the signal, as well as collect important feedback on overrides in real time.

Fifty CL&P customers participated in the 2002 residential program. Participating homeowners received an incentive payment and were able to keep the programmable thermostat after the program ends. The pilot research project was designed to help CL&P better understand the energy characteristics and peak load response potential of its residential customers.

3 Evaluation of Program Impacts

Building upon the 2001 analysis, this analysis employed a probabilistic approach to determine the impacts of the thermostat control. The thermostat control analysis had several criteria for the appropriate approach to the estimation of residential interruption savings. These criteria included:

- Adaptable to a dynamic participant list (i.e., the participants may enter or leave the program at any time),
- Adaptable to a dynamic load history. Participant load data is gathered cyclically. A certain number of the entire participant pool is read each day. Accordingly, the source database can be updated daily.
- The analysis (i.e., the software) should be simple to operate. The results were to be written to a file for easy presentation.
- The analysis should determine energy and demand savings for each 15-minute period, as well as for the hourly periods.
- The approach must provide individual as well as pilot group level aggregate results.

A variety of methodologies were tested, including historical load pattern models, matched day approaches, and a probabilistic approach. Each of the approaches was tested for accuracy. The matched day approaches were rejected as a result of poor performance. The various historical load pattern and hybrid approaches were rejected as a result of not being able to achieve the estimate of hourly demand reduction criteria. Regression based approaches performed well for estimating *average* demands, but not peak demands. Actual demands are similar to a step function; that is, for air conditioning load, either the demand is on to some maximum value or off. Accordingly, a regression approach would yield an average of these loads across a certain time period and would result in a muted maximum demand impact value. The probabilistic approach does not use averages but employs actual demands that were experienced by the customer in the derivation of peak demand impacts.

Of all the various methods examined, it was determined that the probabilistic approach achieved the highest accuracy while meeting the various criteria desired for the analysis approach.

There was one difference between the 2001 and 2002 analysis methods. The 2001 program was design for pay-on-performance incentives with rapid metered data transfer and variable monthly incentive payments. As such, without a real-time data source for outdoor temperatures, we were unable to include temperatures in the 2001 models. With a change to flat monthly incentives in 2002, we lifted this constraint and allowed the use of temperatures when choosing appropriate comparison days.

3.1 Data Availability

There was limited availability of metered data with which to assess the summer and winter program impacts of the 2002 Carrier thermostat pilot. A total of thirteen interval-recording meters were installed to monitor the performance of this 50-customer pilot. To express program impacts, evaluators have assumed that impacts from these thirteen customers are representative of all other customers, although there is no statistical basis for drawing that conclusion because they were not randomly selected.

Hourly logs of compressor run-time were not available throughout the entire pilot, so there was no alternative mechanism for validating the thermostat's performance. Part of this project was intended to investigate the statistical relationship between compressor cycling and metered impact from empirical data, but there was insufficient data with which to perform this analysis.

4 Pilot Results

The impact analysis of the pilot activities was performed according to the approach outlined in the preceding section. The events were split into summer and winter pilot groups and analyzed separately. Results are provided in a variety of aggregations compared to several key variables for insight. The data contained in all of the following tables represents accurate analytical findings for the metered sample. Since the metered sample was not statistically selected, one cannot state that the following findings are necessarily representative of the entire pilot program.
Summer Pilot Results

Table 1 provides an event-level summary for the summer Carrier pilot, which included up to thirteen metered participants across eight events. A variety of informational fields are presented along with two key savings parameters: average kW savings and peak kW savings. Average kW savings is the mean kW savings across the duration of the event; it is equivalent to the total kWh savings throughout the event divided by the duration of the event in hours, or the average kWh per hour of curtailment. The peak kW savings is the maximum demand reduction yielded during any one hour period within the event. Each hour of the event was analyzed individually, so this is coincident peak demand savings that represents the maximum hourly impact achieved during the event. For example, on July 24th, thirteen metered participants were curtailed for four hours starting at 3:00 PM. They were sent a signal to increase their temperature setting by 2 degrees, and it was 73 degree outside at the start of the event. A typical household used an average of 0.62 kW less across this curtailment event, with a peak kW reduction of 1.73 in one of the two event hours.

Event Date	Start Time	Duration (hours)	Metered Participants	Temp. Offset	Outdoor Temp.	Savings per Household	
						Avg. kW	Peak kW

7/24/2002	3:00 PM	4	13	2	73	0.62	1.73
7/29/2002	1:00 PM	3	12	3	93	0.74	1.95
8/5/2002	10:00 AM	4	13	1	79	0.29	1.21
8/8/2002	8:00 AM	4	13	2	73	0.31	1.25
8/10/2002	1:00 PM	2	13	3	81	1.23	1.59
8/14/2002	2:00 PM	5	13	2	88	0.55	1.96
8/20/2002	10:00 AM	4	13	3	72	0.56	1.71
9/3/2002	5:00 PM	3	13	3	77	0.44	1.17
Average Summer Demand Response						**0.59**	**1.57**

Table 1 - Summer Pilot Event Summary

Average demand savings ranged from 0.29 kW on August 5th to 1.23 kW on August 10th, while peak demand savings ranged from 1.17 kW on September 3rd to 1.96 kW on August 14th. In aggregate, the average demand response across all summer pilot events was 0.59 kW per hour of curtailment. The mean coincident peak kW impact was 1.57 kW across all summer events.

In an effort to identify key characteristics of high impact events, we examined the demand impacts by a variety of variables that could influence the response. Four key variables were considered: the time of the event, the duration of the event, the ambient temperature during the event, and the temperature offset at the household thermostat. One needs to take special care not to 'over interpret' the following findings, since these aggregated values are based upon just a few events and metered participants. Nonetheless, we will look at the findings for insight on potential influential variables.

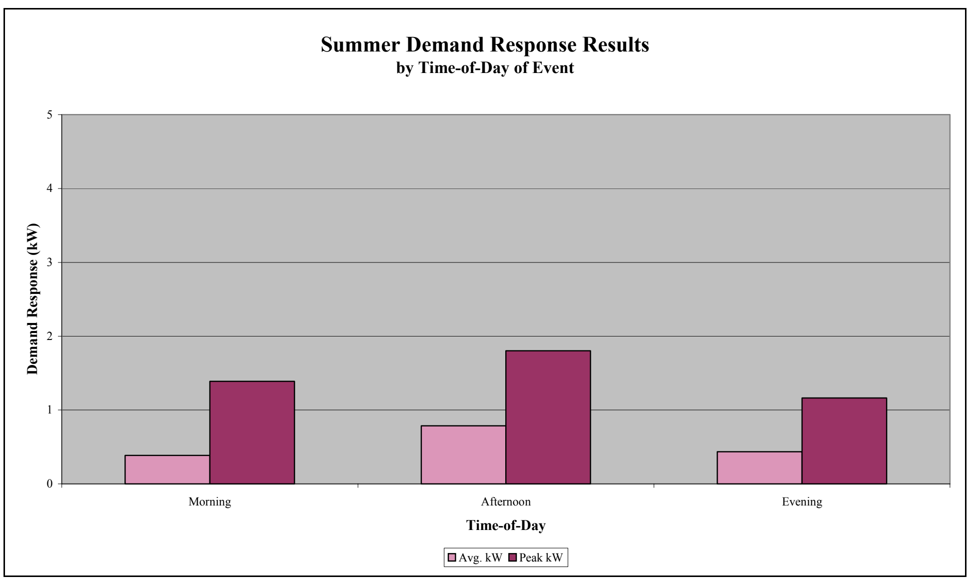

Figure 1 - Summer Demand Response by Time-of-Day

Figure 1 presents the summer demand response by the time of the event. Because the summertime events occurred at seven distinct times, we categorized the times into morning (before noon), afternoon (noon through 4PM), and evening (5PM and later). As might be expected, the largest impacts were realized in the afternoon. During summer afternoons, the average demand response was 0.79 kW, and the coincident peak demand impact was 1.80 kW.

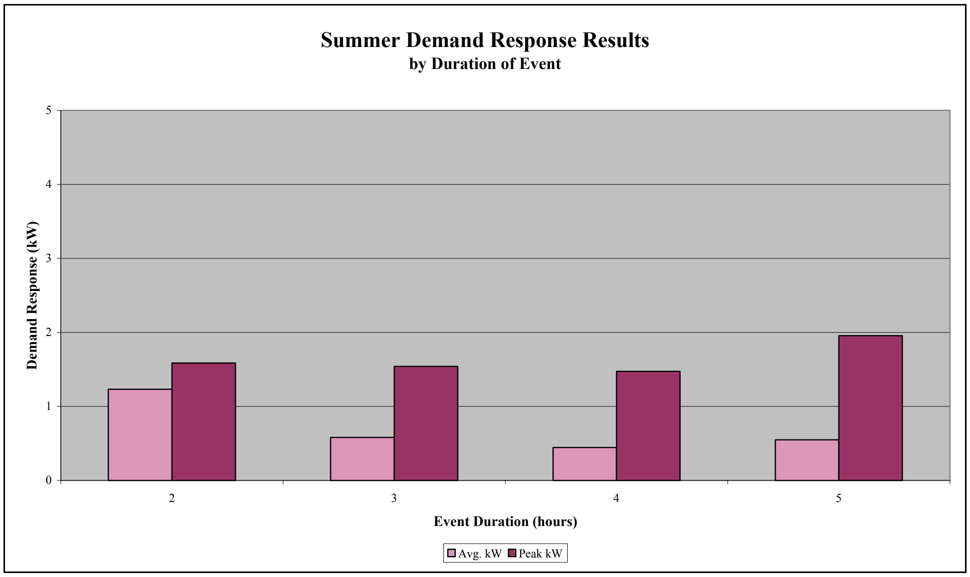

Figure 2 - Summer Demand Response by Duration

Figure 2 presents the summer demand response by the duration of the curtailment event. Events of duration two-hours through five-hours were tested in the summer of 2002. An intuitive trend emerges which shows larger average impacts on shorter duration events. And while the five-hour event shows the largest peak impact, we must keep in mind that the peak kW savings is the largest coincident reduction in any one hour of the event; the five-hour peak kW impact may be influenced by external factors or simple randomness. For events of two-hour duration, the average demand response was 1.23 kW, and the peak demand impact was 1.59 kW. Thermodynamically, we must recognize that event duration is linked to temperature offset as well as ambient temperature. As such, the results by event duration alone are not as significant as those to follow.

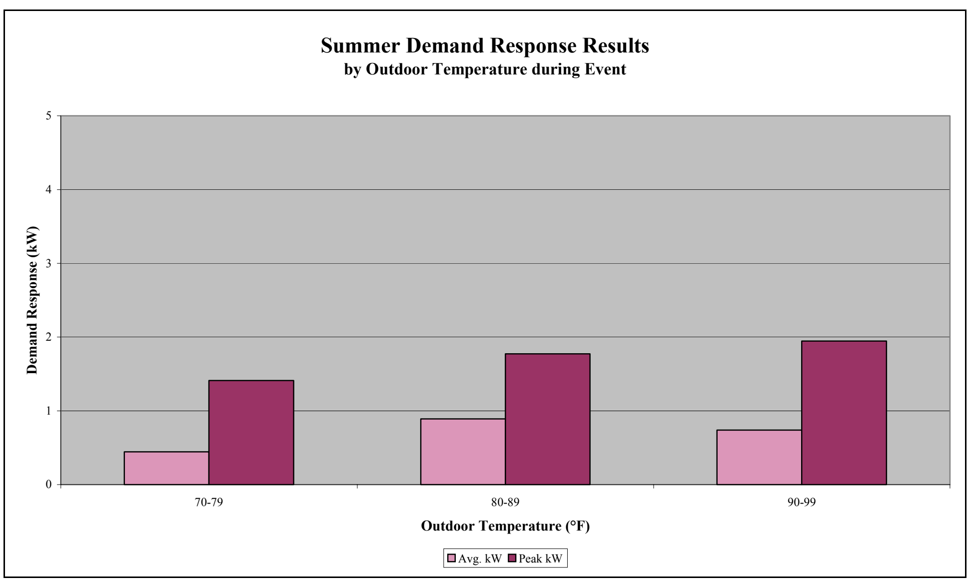

Figure 3 - Summer Demand Response by Outdoor Temperature

Figure 3 presents the summer demand response by the outdoor temperature at the onset of the event. Because the summertime events occurred at a broad array of ambient temperatures, we categorized the temperatures into ten-degree bins. Again, an intuitive trend emerges which shows larger impacts at higher ambient temperatures. At temperatures above 90 degrees, the average demand response was 0.74 kW, and the peak demand impact was 1.95 kW. The average demand response for the 80-to-89 degree temperature bin is actually higher at 0.89 kW, which suggests that any day above 80 degrees may be a good candidate for residential thermostat-based load response in our climate.

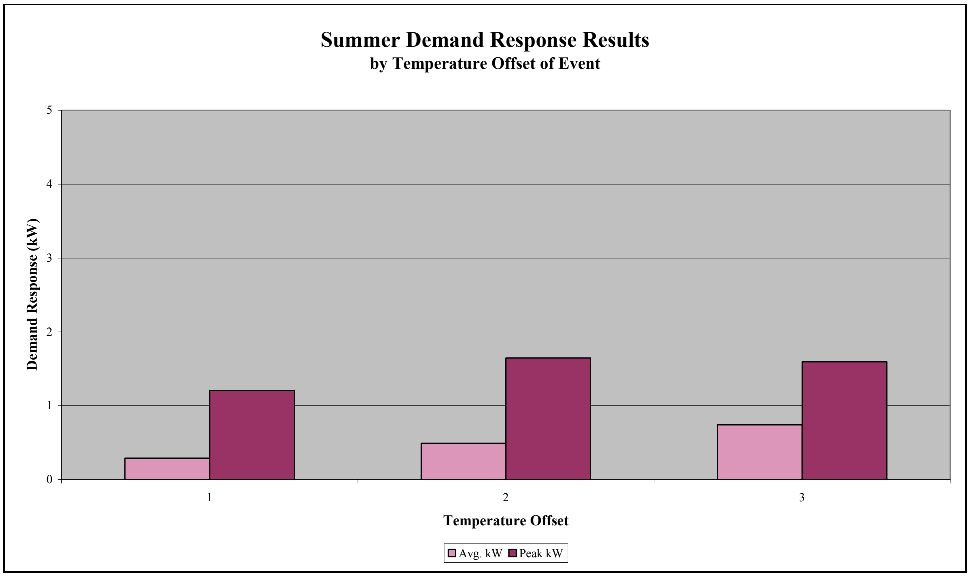

Figure 4 - Summer Demand Response by Temperature Offset

Figure 4 presents the summer demand response by the temperature offset imposed on the thermostat. Since the offset relates to the sustainability of the event, we see that average and peak impacts correlate to the number of degrees the thermostat was raised. Whereas a one-degree offset yielded an average 0.29 kW impact, a three-degree offset yielded an average impact of 0.74 kW.

4.1 Winter Pilot Results

Table 2 provides an event-level summary for the winter Carrier pilot, which included up to eight metered participants across eight events. A variety of informational fields are presented along with two key savings parameters: average kW savings and peak kW savings.

Event Date	Start Time	Duration (hours)	Metered Participants	Temp. Offset	Outdoor Temp.	Savings per Household	
						Avg. kW	Peak kW
3/15/2002	5:00 PM	1	7	5	50	1.38	1.38
3/18/2002	6:00 PM	3	7	3	35	0.54	1.61
3/22/2002	6:00 PM	4	8	1	29	0.05	0.32
3/28/2002	7:00 AM	4	7	3	35	1.35	3.39
4/6/2002	7:00 PM	2	8	5	40	0.83	1.64
4/11/2002	5:00 AM	4	8	2	46	1.81	4.94
Average Winter Demand Response						**0.99**	**2.22**

Table 2 - Winter Pilot Event Summary

Average demand savings ranged from only 0.05 kW on March 22nd to 1.81 kW on April 11th, while peak demand savings ranged from 0.32 kW to 4.94 kW on the same days. In aggregate, the average demand response across all winter pilot events was 0.99 kW per hour of curtailment. The mean coincident peak kW impact was 2.22 kW across all events.

In an effort to identify key characteristics of high impact events, we examined the demand impacts by a variety of variables that could influence the response. Four key variables were considered: the time of the event, the duration of the event, the ambient temperature during the event, and the temperature offset at the household thermostat.

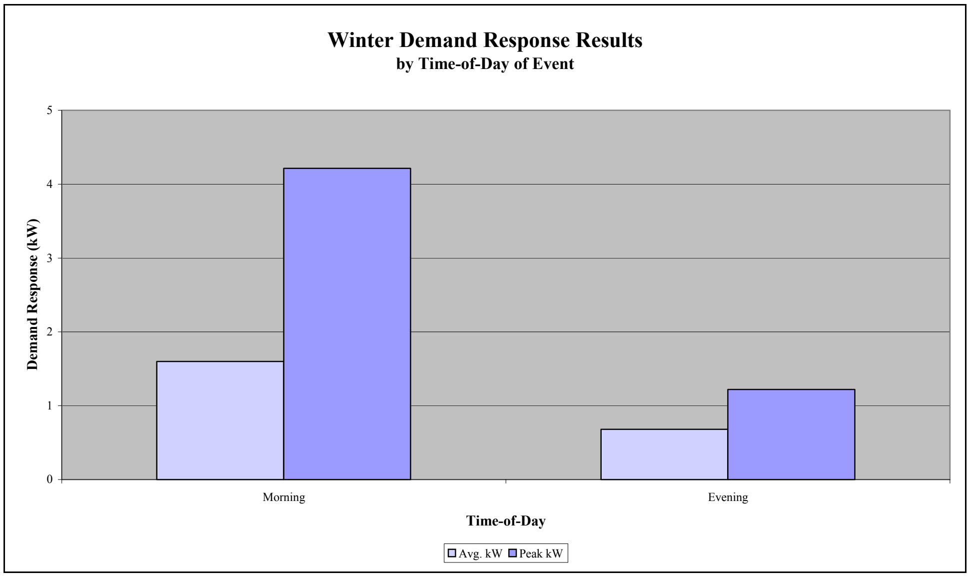

Figure 5 - Winter Demand Response by Time-of-Day

Figure 5 presents the winter demand response by the time of the event. Because the wintertime events occurred at seven distinct times, we categorized the times into morning (before noon), afternoon (noon through 4PM), and evening (5PM and later). There were no afternoon curtailment events in the winter season. During winter mornings, the average demand response was 1.60 kW, and the coincident peak demand impact was 4.21 kW.

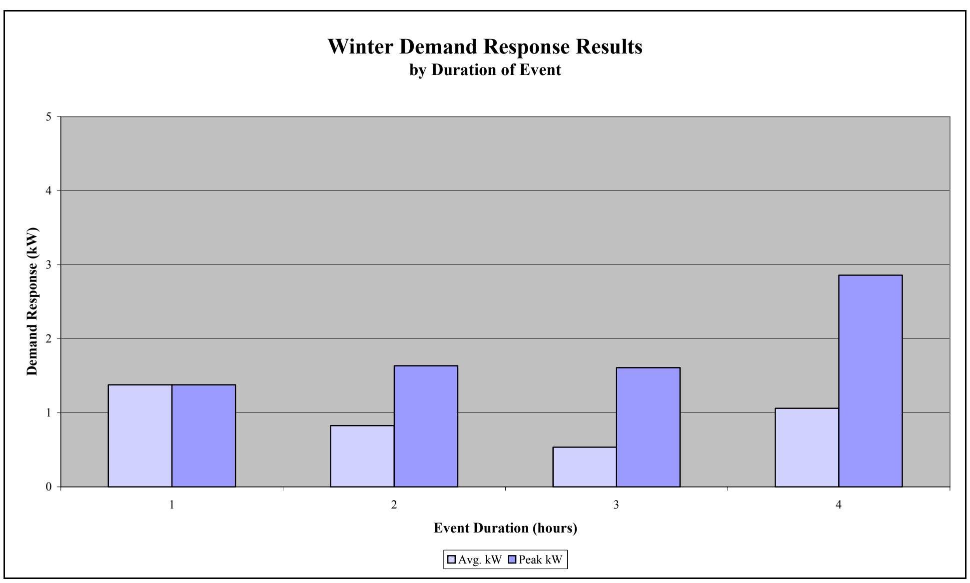

Figure 6 - Winter Demand Response by Duration

Figure 6 presents the winter demand response by the duration of the curtailment event. Events of duration two-hours through five-hours were tested in the winter of 2002. A trend emerges which shows larger average impacts on shorter duration events. And while longer events show larger peak impacts, this is probably more of a function of the larger temperature offset on longer duration events. For events of one-hour duration, the average (and hence coincident peak) demand response was 1.38 kW.

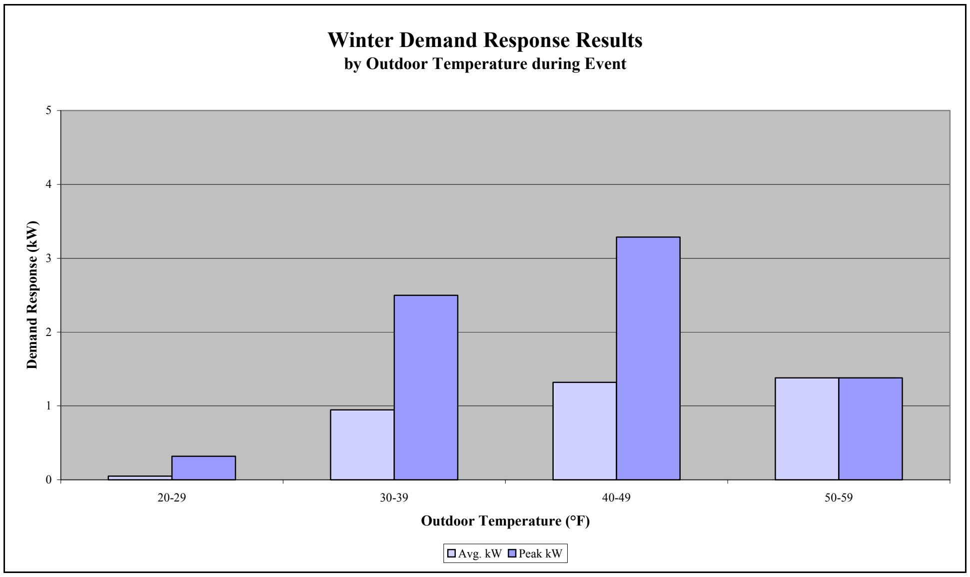

Figure 7 - Winter Demand Response by Outdoor Temperature

Figure 7 presents the winter demand response by the outdoor temperature at the onset of the event. Because the wintertime events occurred at a broad array of ambient temperatures, we categorized the temperatures into ten-degree bins. The results are somewhat counterintuitive for a heating system curtailment, as the graphic shows larger average kW impacts at higher ambient temperatures. March 22nd was the only event under 30 degrees, and the performance for the event was extremely poor for unknown reasons. Events in the 40-to-49 degree range showed the best performance with an average demand response of 1.32 kW and a coincident peak demand impact of 3.29 kW.

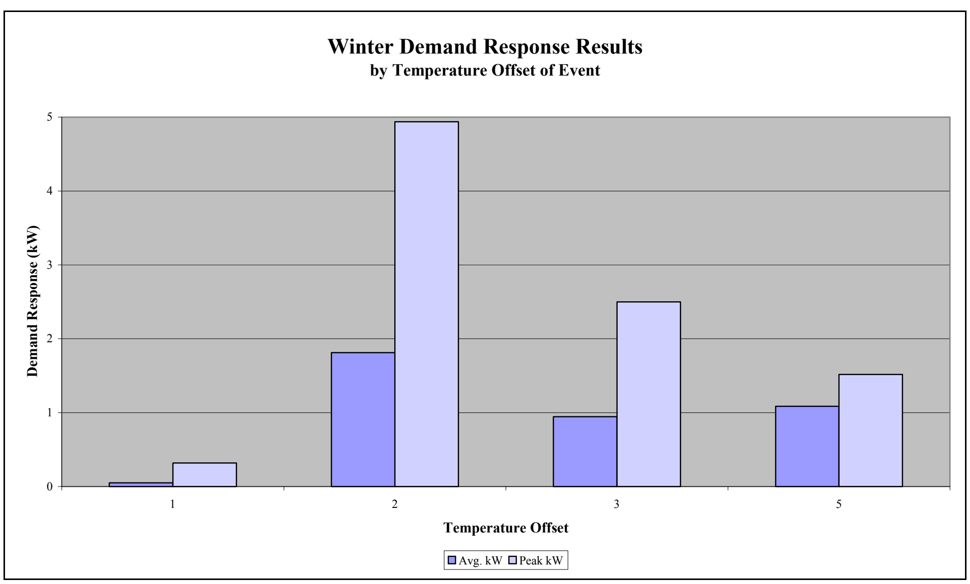

Figure 8 - Winter Demand Response by Temperature Offset

Figure 8 presents the winter demand response by the temperature offset imposed on the thermostat. There was only one event with a two-degree offset, and those results are particularly high and may be anomalous. The three-degree and five-degree offset results are based upon two events each and are probably reasonable.

4.2 Deadbeats and Overrides

While the preceding results represent the aggregate impact of all metered participants, there are two particular circumstances in which demand response is not expected for some customers. Sometimes the vendor was unable to communicate with some of the devices during the curtailment events. The dispatch signal requests an acknowledgement of command receipt, but if an acknowledgement is not sent, then it is categorized as a 'deadbeat' device. As seen in Table 3, 2% of the devices in the winter pilot and 19% of the devices in the summer pilot were inaccessible. It is unclear what the reason for the significant disparity is between the two seasonal pilots, but it is suggestive of a technology problem such as network congestion or signal interference. In total, 9% of the devices did not receive their curtailment instructions.

The second circumstance in which demand response is not expected is when customers override the curtailment command. CL&P research has concluded that the ability to 'opt-out' is a valued feature of a residential load management program. As evidenced by Table 3, 10% of customers in the winter pilot overrode their thermostat settings during a curtailment event, compared with 14% in the summer pilot.

Event Date	Start Time	Confirmed Devices	Deadbeat Devices		Active Devices	Event Overrides		Curtailed Devices	
			#	%		#	%	#	%
2/28/02	3:30 PM	41	2	5%	39	2	5%	37	90%
3/1/02	11:00 AM	43	0	0%	43	4	9%	39	91%
3/6/02	2:00 AM	43	0	0%	43	1	2%	42	98%
3/7/02	9:00 AM	41	2	5%	39	3	8%	36	88%
3/9/02	1:00 PM	43	0	0%	43	4	9%	39	91%
3/13/02	8:00 PM	42	1	2%	41	2	5%	39	93%
3/15/02	5:00 PM	41	2	5%	39	2	5%	37	90%
3/18/02	6:00 PM	43	0	0%	43	7	16%	36	84%
3/22/02	6:00 PM	42	1	2%	41	12	29%	29	69%
3/28/02	7:00 AM	40	3	8%	37	4	11%	33	83%
4/6/02	7:00 PM	42	1	2%	41	6	15%	35	83%
4/11/02	5:00 AM	41	0	0%	41	4	10%	37	90%
Winter Subtotal		502	12	2%	490	51	10%	439	87%
7/24/02	3:00 PM	41	7	17%	34	2	6%	32	78%
7/29/02	1:00 PM	39	9	23%	30	6	20%	24	62%
8/5/02	10:00 PM	42	6	14%	36	5	14%	31	74%
8/8/02	8:00 AM	41	7	17%	34	4	12%	30	73%
8/10/02	1:00 PM	41	7	17%	34	4	12%	30	73%
8/14/02	2:00 PM	36	6	17%	30	8	27%	22	61%
8/20/02	10:00 AM	38	10	26%	28	3	11%	25	66%
9/3/02	5:00 PM	42	8	19%	34	5	15%	29	69%
Summer Subtotal		320	60	19%	260	37	14%	223	70%
Grand Total		822	72	9%	750	88	12%	662	81%

Table 3 - Curtailment Summary with Deadbeats and Overrides

In total, 81% of the load management devices actively participated in the 2002 events. Participation was higher in the winter season with 87% of the devices contributing. Deadbeat devices were significantly more prevalent in the summer pilot and influenced a net participation rate of 70%.

The variability of the override percentage across the curtailment events warranted further investigation. The 29% override on March 22nd and 27% override on August 14th seem anomalous. In an effort to identify factors that may be influencing the elevated override behavior on these days, the following table was generated which contains event dates, override rates, and suspected drivers of this effect.

Event Date	Start Time	Active Devices	Event Overrides #	Event Overrides %	Temperature Offset (°F)	Duration (hours)	Outdoor Temp. (°F)
2/28/02	3:30 PM	39	2	5%	2	2	38
3/1/02	11:00 AM	43	4	9%	2	4	38
3/6/02	2:00 AM	43	1	2%	2	4	36
3/7/02	9:00 AM	39	3	8%	4	2	48
3/9/02	1:00 PM	43	4	9%	3	3	49
3/13/02	8:00 PM	41	2	5%	2	3	43
3/15/02	5:00 PM	39	2	5%	5	1	50
3/18/02	6:00 PM	43	7	16%	3	3	35
3/22/02	6:00 PM	41	12	29%	1	4	29
3/28/02	7:00 AM	37	4	11%	3	4	35
4/6/02	7:00 PM	41	6	15%	5	2	40
4/11/02	5:00 AM	41	4	10%	2	4	46
Winter Subtotal		490	51	10%			
7/24/02	3:00 PM	34	2	6%	2	4	73
7/29/02	1:00 PM	30	6	20%	3	3	93
8/5/02	10:00 PM	36	5	14%	1	4	80
8/8/02	8:00 AM	34	4	12%	2	4	73
8/10/02	1:00 PM	34	4	12%	3	2	81
8/14/02	2:00 PM	30	8	27%	2	5	88
8/20/02	10:00 AM	28	3	11%	3	4	72
9/3/02	5:00 PM	34	5	15%	3	3	77
Summer Subtotal		260	37	14%			

Table 4 - Curtailment Summary with Possible Override Influences

We theorized that some characteristic(s) of the March 22nd and August 14th curtailment events influenced their high override rates. Specifically, we suspected participation to drop as the perceived negative effects of participation rise. As evidenced by Table 4, we note that the two highest override rates in each seasonal pilot possess the two most extreme outdoor temperatures. Other variables such as event start time, temperature offset, and event duration appear not to correlate with the override rate.

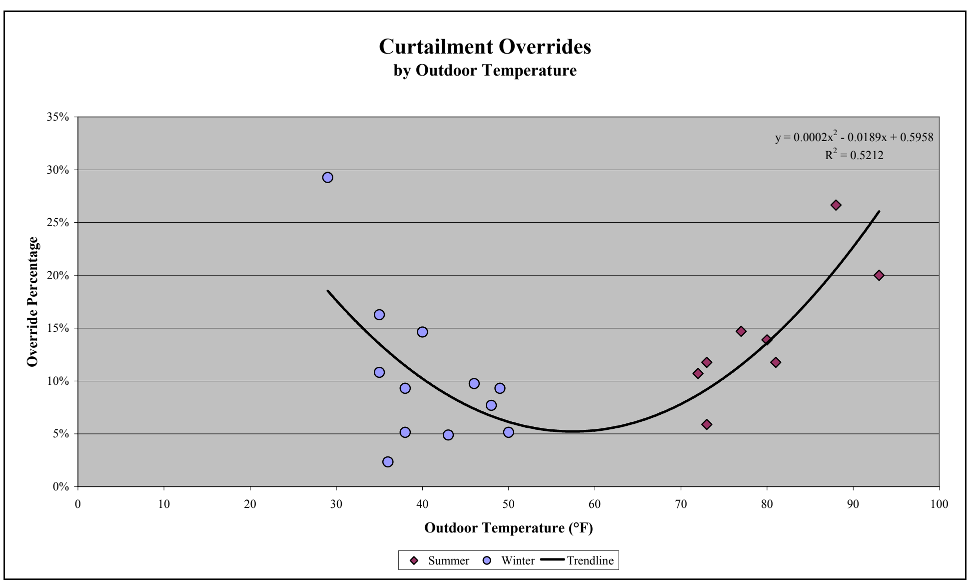

Figure 9 - Curtailment Overrides by Outdoor Temperature

Figure 9 presents a scatter plot of override percentage against outdoor temperature. A reasonable trend emerges from these twenty data points that shows a higher percentage of overrides at extreme outdoors temperatures. As evidenced by the trend line equation and R^2 term, a parabolic curve fits the relationship with moderate precision. The data supports one's intuitive expectation that overrides will increase with outdoor temperature in a summer program.

5 Conclusions and Recommendations

Overall, the impacts from the 2002 Carrier project were consistent with prior similar efforts. Table 5 constructs a weighted average of the four CL&P summer residential thermostat pilots to date.

Year	Pilot	Installed Thermostats	Average kW	Peak kW
2000	Carrier	47	0.77	1.11
2001	Lightstat	24	0.54	1.17
2001	muNet	19	0.97	1.85
2002	Carrier (summer)	13	0.59	1.57
Weighted Average (by Thermostat)			**0.73**	**1.32**

Table 5 - Summary of CL&P Summer Residential Thermostat Programs

Prior to inclusion of the 2002 Carrier results, the mean demand response per household was 0.75 kW per hour and 1.28 kW peak. The 2002 results served to drive down the average kW value and improve the peak kW response slightly. One should recognize that the analytical methodologies have evolved across these three program years, so direct comparison is not entirely appropriate, particularly for peak kW results. Also, when we consider that the summer 2002 Carrier project had a high percentage of condominium participants versus single-family detached homes in the other programs, the average kW results are well within performance expectations.

Technical Product Issues

In past residential load management tests, technology issues were common. The new Carrier two-way system seems to have overcome some of the past problems, including installation complexity, device reliability, and ease of administration. However, the 9% unacknowledged curtailment signals - and particularly the disparity between 2% winter deadbeat and 19% summer deadbeat devices - raises concerns about the ongoing reliability of communications over this medium. In addition, the vendor will need to ensure consistent and reliable transfer of hourly cycling logs in order for the technology to facilitate impact validation in a larger scale program.

A Business Plan for Load Management

Northeast Utilities would benefit from the development of a strategic plan and corresponding business strategy to guide its decision on which pricing platforms, technology, and program design options to pursue. A formal business plan would serve to integrate the information gathered in trials into a coherent assessment of the prospects for competitive load management programs. A basic financial model that defines the stream of benefits and costs associated with this enterprise would serve as the starting point. The model would be parameterized with the current best estimates of costs/benefits and simulations would identify the key drivers of program success, which in turn would serve as design criteria for future program efforts. In this manner, the results of each pilot or program would contribute to establishing the value of a growing portfolio of load management pricing products and enabling technologies, and guide enterprise investment decisions in how to capture this value in evolving electricity markets.

Expand Research and Testing

A number of parties have expressed concern as to the potential for acceptance of load management in the residential market. Residential pilot program marketing and recruiting has indeed proved challenging over the past three years, yet once 'found', participants have expressed remarkable interest, patience, and resiliency to load management - temperature control in particular. It remains to be seen whether these participants are typical of the residential population or are they 'early adopters', environmentally conscious, or particularly charitable homeowners. A market assessment in 2000 surveyed 578 Connecticut homeowners and found that 65% of them were likely to participate in a load response program. CL&P may wish to expand upon this research, to get more reliable participation rates in light of the override issues, deadbeat signals, and unclear monetary incentive for customers. A significantly larger load management pilot is required to see if residential load response can deliver.

A considerably larger thermostat test is needed to establish the level of diversified demand reduction that is attainable from a full-scale residential load management program. Air conditioning compressors are cyclic devices that start and stop in response to temperature swings inside a home. Since compressor cycles are measured in minutes not hours, the collective load response from a group of residential air conditioners is extremely hard to predict. As such, the aggregate results from recent pilot studies with 50 sample points may not accurately reflect a real installed base of hundreds or thousands of residential customers. The large electrical variability of residential air conditioner kW in conjunction with the fairly low probability that compressor operation will be coincident warrants a study of no less than 300 customers per analysis dimension. To wit, regulators in other jurisdictions around the country are specifying sample sizes in the order of several thousand residential customers to accurately depict the expected demand response of a real-world program. These large pilots enable utilities to study multiple program characteristics with precision, e.g. operate one sub-sample with a two-degree temperature offset and another with four-degree, or curtail one sub-group for only one hour at a time and another for extended durations. Such information from the 2002 and prior pilots is strictly anecdotal with their extremely small, non-statistical samples.

Choose Technologies Wisely

In theory, RLW supports the concept of developing a toolkit of load management tools and services to serve CL&P's residential load management needs. Remote addressable thermostats capable of dispatching central air conditioning or heating load could be one of the primary tools. These thermostats are amongst the simplest and most-effective load control devices available in the residential market. Research has demonstrated that residential customers are more receptive to load management via temperature control because it guarantees them a certain level of comfort compared to traditional direct load control switches. Recent technological advances have expanded application of remote temperature control to window/wall air conditioners. Residential gateway systems are expensive, complex and less mature, but should not be dismissed entirely because it extends the reach for load control and value-added services deeper into the home. In 2001, CL&P tested a low-tech alert device that could be used to request customers who are home during peak periods to manually reduce electric usage. Resist selecting one particular device or methodology for residential load response. All of these load management devices may remain in the CL&P toolkit if device selection is guided by an established cost/benefit test.

Know Thy Enemy

A successful demand response program attains its impacts when they are needed most. But the critical bane of any voluntary curtailment program is that they are inherently disruptive to participants. As such, program designers would be wise to identify the factors that reduce load response and devise means of neutralizing them. In this impact evaluation, we discovered a notable and quantifiable relationship between curtailment overrides and outdoor temperature. If 90 degrees is a threshold for steep degradation of summer load response, one could envision the establishment of premium incentives for these circumstances. Alternatively, if this is found to be an insurmountable barrier, the participant base may need to be expanded significantly in order to yield results at high ambient temperatures.

Pursue Verification and Metering Alternatives

Verification metering remains a challenge with residential load management programs. Monitoring power consumption on the customer-side of the meter is expensive, intrusive, and time-consuming. Interval metering products for utilities are ever evolving, and NU's metering department is constantly working to test products to achieve the needs of revenue billing, load research, and advanced customer services. Wireless automated meter reading (AMR) recording meters are currently being tested at CL&P and may facilitate the validation of demand response in a load research sample. Hourly cycling data from curtailment thermostat technologies is a promising means of validating demand impact, especially in larger scale projects, but it has yet to be seen whether vendors can reliably provide this data to curtailment service providers for validation.

In small quantities, it is necessary statistically to install interval metering on all customers to properly validate the demand response. For larger populations, interval metering can be installed on a sample of program participants. The validation of program impacts can be contained to even smaller interval-metered samples if used in conjunction with a larger sample of hourly A/C compressor cycling logs. For accurate and reliable results, future studies must be designed statistically and data availability rates must improve.