SPP Program Final Report: Additional Control Technologies (ACT) for Small/Medium Commercial Customers

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Report Contents

Executive Summary

The ACT Pilot Program's **objectives** were to:

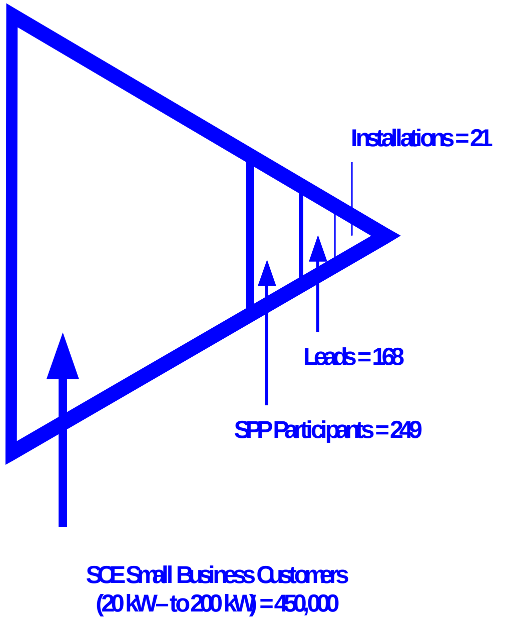
1. Assess the load impacts of an advanced enabling technology—a digital demand control (DDC) device that is compatible with and controlled by the programmable communicating thermostats (PCT) system already deployed to small/medium commercial participants in the State Pricing Pilot (SPP). The DDC can simultaneously control a large number of end-use loads, and therefore can a greater load reduction during Critical Peak Price (CPP) events than the PCT.

2. Assess how small-commercial customers react when offered the DDC device.

The basic research questions addressed in the pilot were:
(1) How much average load reduction over the duration of a CPP event would a DDC device achieve for small/medium commercial customers,
(2) How does this load reduction compare with that achieved by a PCT system acting alone, and
(3) How do customers react when offered the DDC technology, and what are their reactions to the performances of the two types of enabling technologies.

Executive Summary

- Target SCE small/medium commercial participants who are participating in the Statewide Pricing Pilot (SPP) and therefore are served under the CPP tariff and have a Carrier "smart thermostat" system installed as an enabling technology.
- Offer participants an alternative technology (a digital demand control [DDC] device) at no charge. Explain that the DDC will be automatically activated remotely to control both the air-conditioners and additional loads, producing a larger average load reduction during CPP events than the "smart thermostat" system achieves.
- Conduct survey interviews with participants in this pilot to learn their satisfaction with the advanced technology and with the CPP tariff. Also survey other SPP participants to learn their satisfaction with the "smart thermostat" technology and with the CPP tariff.

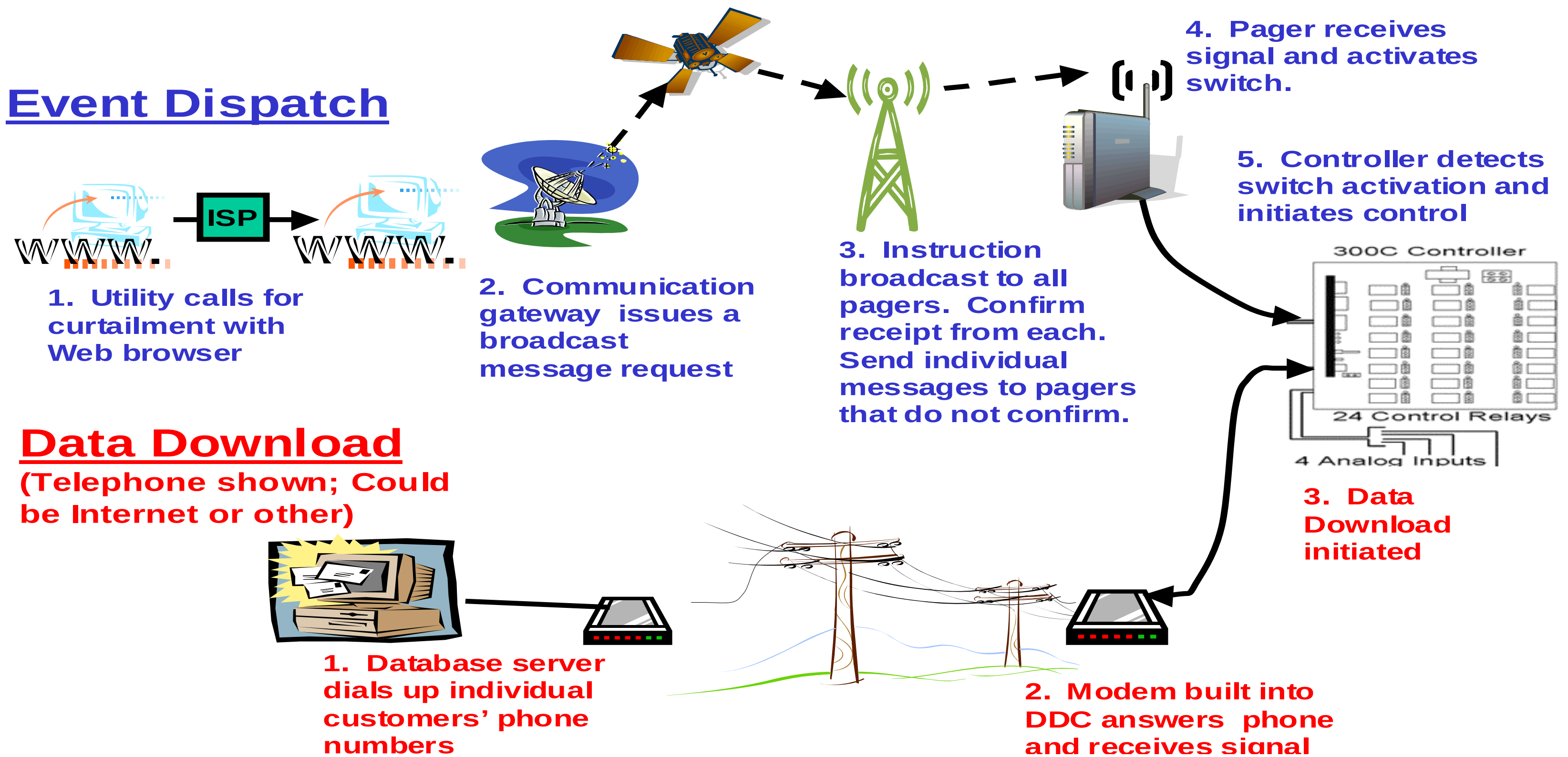


Executive Summary

- The DDC device deployed in this pilot was manufactured by Dencor, Inc. It contains relays that control the operation of major end-use loads (air-conditioning, various refrigeration units, electric water heater). The primary control strategy is to prevent a large number of loads from operating simultaneously by shifting operating times of individual equipment items. Additional reductions are achieved by optionally dimming indoor lighting fixtures.
- The unit has a built-in power meter that constantly monitor total facility power demand. When facility power draw (load) reaches a pre-set level, relays operate to cycle loads such that only a few equipment items operate simultaneously, reducing power demand.
- The DDC is activated when a special pager signal is sent to the receiver that is part of the Carrier "smart thermostat" system located at the customer's facility. The signal specifies the times the CPP event is to begin and it's duration.

Executive Summary

Description of Technology
System Information Linkages in Test Program



Executive Summary

- Aspen contacted small commercial customers who were named on a list of SPP participants provided by SCE.
- Recruitment of host facilities proved to be problematic – decision-makers often were not located at facility and were difficult to contact. A few were out of business. Nearly half the facilities were too small or had too few controllable loads for the DDC device to be a cost-effective technology. However, a diverse group of participants (diverse in terms of both facility type and facility size) were successfully recruited.
- Installations completed:

  2004: 10 (two were not SPP participants)

  2005: 11

  Total: 21

Facility Type	Number
Restaurants	**6**
Retail Stores (No Refr.)	**4**
Office/Manufacturing	**3**
Office/Warehouse	**3**
Grocery Store	**1**
Retail Store (w/Refrigeration)	**1**
Equipment Rental	**1**
Auto Dealer	**1**
Food Catering	**1**
Total	**21**

Executive Summary

- Seven DR control events were called during the late summer of 2005, when the Dencor DDC enabling technology had been installed in 10 facilities with a Carrier “smart thermostat” system (which was being used to dispatch control events at these facilities).
- The average demand reduction achieved by the Dencor DDC system over the seven control events during 2005 was 8.5 kW, which corresponded to 16 percent of the average baseline demand of the facilities being controlled. (Only one control event was on a “hot” (mid-90s temperature) day; the others were on days when the temperatures were in the mid-80s.)
- The amount of reduction varies with daily peak outdoor temperature. The 2-hour control event on a “hot” day produced an average demand reduction of 11 kW (22 percent of baseline demand). We estimate that smart thermostats would have produced an average demand reduction of only 5.5 kW (half as much) at these facilities during this control event.
- “Rebound” (post-event power demand increase) is negligible (less than 0.5 percent of baseline demand).

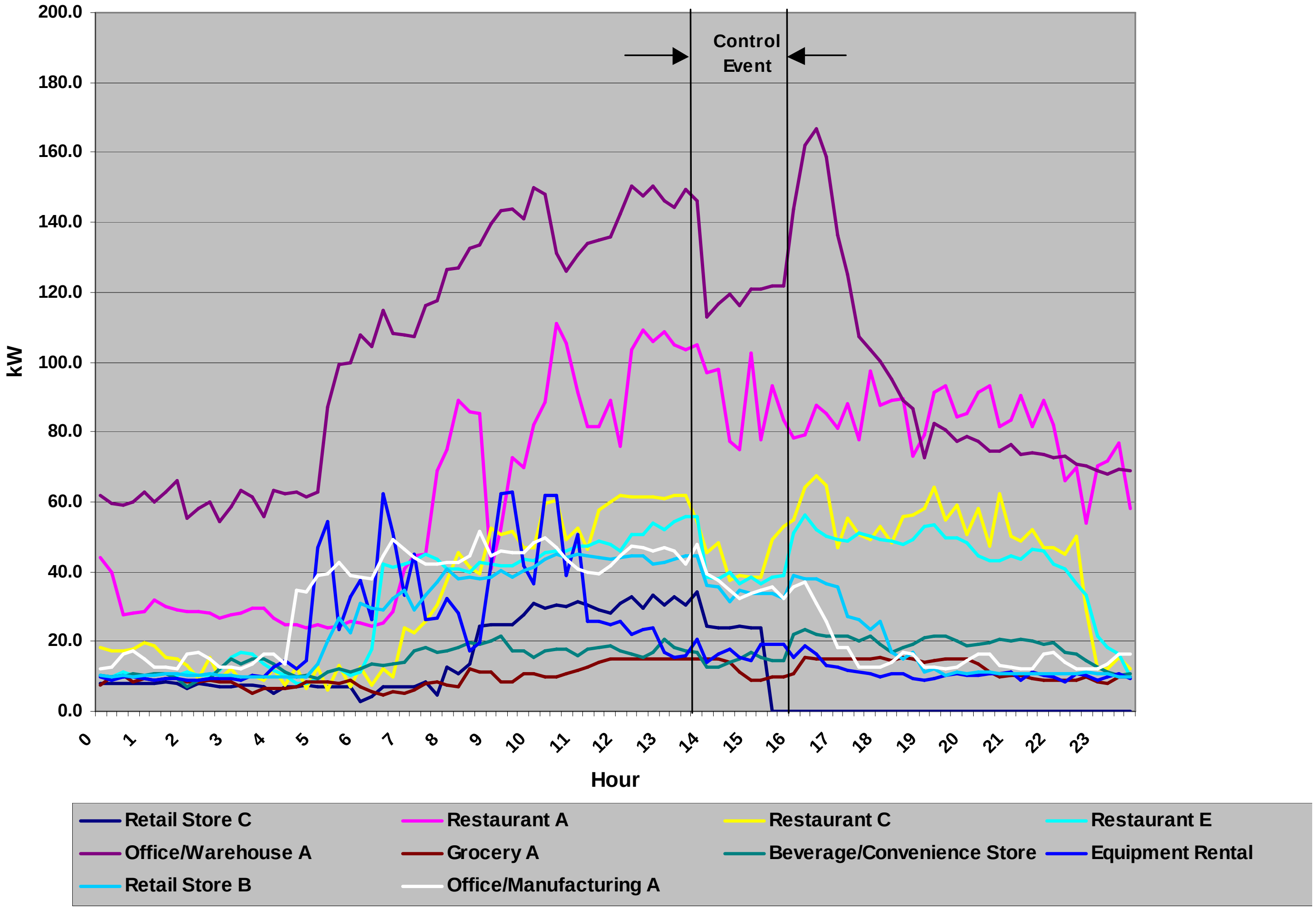
Executive Summary

- The following table shows the average results for the first control event:, 2:00 p.m. to 4:00 p.m.on August 26, 2005.

Customer Name	Baseline Day		Control Day		Adjusted Baseline Demand (kW Avg)	Demand Reduction (kW - %)	
	Noon-2 pm Demand (kW Avg)	2- 4 p.m. Demand (kW Avg)	Noon-2 pm Demand (kW Avg)	2-4 p.m. Demand (kW Avg)			
Retail Store "A"	32.5	33.4	31.8	24.0	32.7	8.7	27%
Limited Serv. Rest. "A"	49.4	49.9	52.3	38.2	52.8	14.6	28%
Restaurant "A"	104.9	105.0	102.1	88.0	102.2	14.2	14%
Beverage Store "A"	17.3	18.4	17.5	14.5	18.6	4.1	22%
Restaurant "B"	60.3	60.5	60.5	43.6	60.7	17.1	28%
Office "A"	45.7	44.7	46.0	35.0	45.0	10.0	22%
Retail Store "B"	36.3	36.4	43.8	33.9	43.9	10.0	23%
Small Grocery "A"	14.8	15.0	15.0	11.6	15.2	3.6	24%
Office "B"	171.6	171.9	147.1	118.8	147.4	28.6	19%
Equipment Rental	21.4	25.7	20.5	16.9	24.6	7.7	31%
		Totals:	**537**	**425**	**543**	**118.6**	**22%**
		Average of 10 Facilities:	**53.7**	**42.5**	**54.3**	**11.9**	**22%**

- The next page contains plots of load data showing the reductions achieved at ten facilities during the CPP event of August 26, 2005.

Executive Summary



Executive Summary

MARKET POTENTIAL

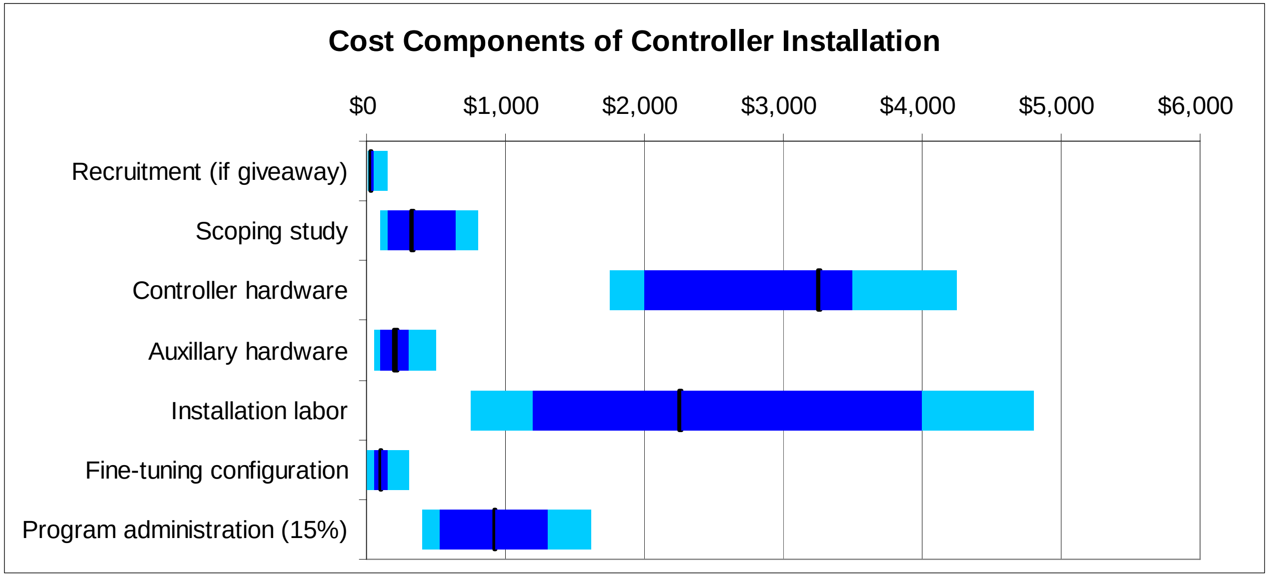
Our analysis indicates that if 50 percent of the small commercial facilities in California with a baseline demand of 45 kW or more installed a DDC enabling technology (Dencor or equivalent), the aggregate reduction during a DR event would be about 1,000 MW. The distribution by facility size range and market penetration is:

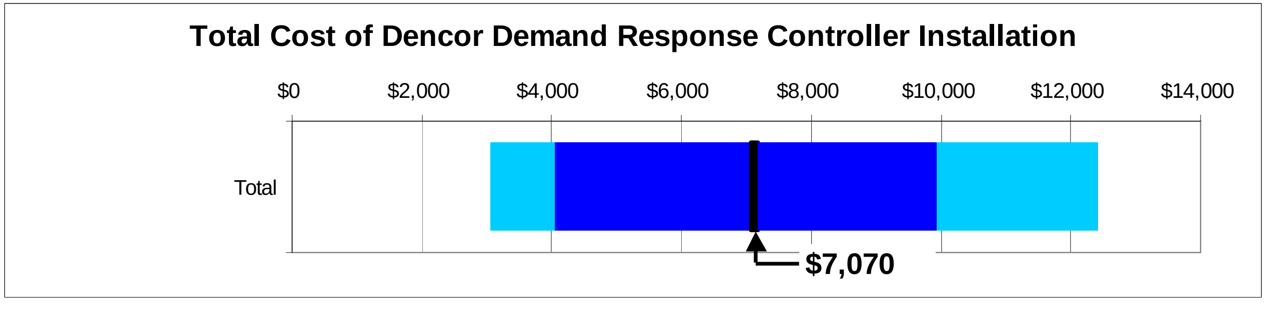
Facility Size Range	Number of Host Facilities	Average Per Facility Demand Reduction (kW)	Demand Reduction (MW) at Indicated Market Penetration		
			50%	25%	10%
151 kW to 200 kW	7,000	37	130	65	26
101 kW to 150 kW	18,000	26	234	117	47
66 kW to 100 kW	35,000	18	315	158	63
45 kW to 65 kW	60,000	12	360	180	72
Total:	**120,000**		**1,039**	**519**	**208**

Executive Summary

- Costs to install the DDC units vary by site. The single biggest cost variable is installation labor, which is most affected by the distance and degree of difficulty in running wires between the controller and the various controlled loads. Other factors that increase installation costs include:
    - Non-standard voltages requiring special transformers
    - Large number of rooftop AC units (resulting in many long wiring runs)
    - High bay ceilings
    - Poor roof access
    - Old or poorly maintained facility and equipment
    - Heavy foot traffic in installation areas
    - Congested work areas
    - Remote location; isolated facility (long travel time).
- On the other hand, obtaining an agreement for installations at a large number of near-identical facilities (i.e., chains) will result in a low cost per kW of reduction.
- The bar charts on the following page indicate the range of installed costs for DDC-based DR enabling technology systems, and the average cost.

Executive Summary





Executive Summary

Aspen has developed the following **conclusions** from the data and other information developed from the pilot program:

1. The pilot has shown that a DDC-based enabling technology:
   - Can consistently reduce the aggregate power demand from a diverse group of small- and medium-size commercial facilities.
   - Sustain these reductions at a near-constant level for the entire 2-hour duration of the tests performed. (Aspen's analysis indicates that the reduction could have been sustained for a longer curtailment duration.)

2. Demand reductions with DDC-based technology:
   - Do not shrink over the course of CPP events.
   - Were larger than PCTs achieve (22% vs. 11% of facility baseline demand).
   - Can be increased to about 26% - 35% if lighting is also controlled.

Executive Summary

3. The estimated average cost to install an advanced technology in a full-scale program that targets only facilities with a baseline summertime afternoon demand larger than about 60 kW is approximately $400 per kW of reduction achieved.
4. A large number of DDC-based technologies are available, and more will become available during 2006.
5. A variety of alternative means for transmitting a control-event signal to the DDC technology, and for retrieving load and other data from the technology, can be used (e.g., pager, Internet, Wi-Fi, WAN, LAN, AMI meters using power-line carrier communications technology).
6. Some DDC technologies feature a variety of customer-desired monitoring capabilities related to facility security and comfort that both: Contribute to making installations cost-effective, and help to ensure that the technology is operable—has not failed or been inadvertently disconnected—when it is needed to reduce demand during CPP events.

Executive Summary

7. Market research indicates that customers will accept advanced enabling technologies – but education will be necessary.
8. Our analysis of the market would indicate there is an order-of-magnitude potential of approximately 1,000 MW demand reduction in this sector at the larger facilities where a DDC-based enabling technology is suitable. This is approximately double the DR at the same facilities that a PCT technology would achieve.

Section 2: Introduction

Section Contents

- Background
- Objectives of the Pilot
- Project Team

Background

- The CEC/CPUC vision for electricity tariffs* calls for widespread use of Critical Peak pricing (CPP) in the residential and small/medium-commercial sectors.
- Under a CPP tariff, customers pay a very high price per kWh (the "CPP") during the 50-100 hours per year when wholesale prices are high or power-supply conditions are critical. The price per kWh is slightly lower during all other hours, making the tariff "revenue-neutral" in that—if the facility's load did not change—the customer's annual electric bill will not change. If the facility's load is reduced during the hours when the CPP is in effect, however, the customer's bill will be decreased.
- Residential and small/medium customers on the CPP tariff cannot be expected to be able to receive a notification when the CPP will be in effect and to take manual actions to reduce electricity usage. Rather, these customers need a reliable and effective "enabling technology" that automatically causes changes to equipment operation to reduce power usage during CPP events.

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* Presentation by Arthur Rosenfeld, CEC Commissioner, at the Utility Energy Forum, Granlibakken Conference Center, May 6, 2005.

Background (continued)

- The CEC and CPUC designed and authorized the state's electric utilities to implement a Statewide Pricing Pilot (SPP) during 2003-2005. The objective of the SPP was to investigate and learn how various customer segments react to alternative CPP tariff designs (i.e., different ratios of the high CPP price to average price, and different event durations).
- SCE recruited a sub-sample from its small/medium commercial customers to participate in the SPP. Most of these customers had an enabling technology, the Carrier programmable communicating thermostat (PCT) system. (If not already installed, participants were provided with these systems.)
- The Carrier PCT can be remotely controlled via a pager signal that causes the temperature setpoint to be raised during CPP events. The air-conditioner then runs less and the facility's average power demand is reduced.
- The CPUC also directed SCE to investigate "additional control technologies" with a subset of SPP participants "within the existing treatment cells, … " This report describes SCE's actions to comply with this directive, and provides the results of the investigation.

Objective of Pilot

The Pilot Program's **objectives** were to:

1. Assess the load impacts of an advanced enabling technology—a digital demand control (DDC) device that is compatible with and controlled by the programmable communicating thermostats (PCT) system already deployed to small/medium commercial participants in the State Pricing Pilot (SPP). The DDC can simultaneously control a large number of end-use loads, and therefore can a greater load reduction during Critical Peak Price (CPP) events than the PCT.

2. Assess how small-commercial customers react when offered the DDC device.

The basic research questions addressed in the pilot were:
(1) How much average load reduction over the duration of a CPP event would a DDC device achieve for small/medium commercial customers,
(2) How does this load reduction compare with that achieved by a PCT system acting alone, and
(3) How do customers react when offered the DDC technology, and what are their reactions to the performances of the two types of enabling technologies.

Project Team

The project team was led by Aspen Systems Corporation (now Lockheed Martin Aspen* – "Aspen")

- Aspen recruited and qualified candidate participants, and then oversaw the installation of the "additional control enabling technology" at qualified facilities that agreed to participate.
- The "additional control enabling technology" was a digital demand controller (DDC) unit manufactured by Dencor, Inc.
- The "outbound" pager network of the Carrier PCT system was used to trigger the DDC unit and cause it to initiate load-reduction control actions.
- Aspen retained Faithco Electrical Corporation to install the DDC units.

* Aspen Systems Corporation was acquired by Lockheed Martin Information Services on January 27, 2006.

Section 3: Description of Enabling Technology

Contents

- System Components
- System Configuration
- Key Features
- Typical Installation

System Components

The enabling technology system deployed in this pilot had two components:

- The Dencor 300C digital demand control (DDC) unit.
- The DR event-dispatching communications linkage (paging network) portion of Carrier Corporation's *ComfortChoice* PCT system.*

The Aspen team arranged with Carrier representatives for an additional pager signal to be dispatched to the Carrier input/output (I/O) module already installed at each facility participating in the SPP. The special pager signal informed the I/O modules when the CPP was to begin and end. During this interval, the I/O module activated an auxiliary relay that the Aspen team had installed at the same time as the DDC unit. The auxiliary relay then caused the DDC unit to implement its pre-programmed actions to reduce facility power usage.

The Dencor digital demand control (DDC) unit reduces a facility's peak demand by (1) continuously sensing the total facility demand; (2) comparing the actual demand with a preset demand target; and (3) if actual demand rises to the preset target, temporarily interrupting the operation of equipment to prevent further load increases.

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* The Carrier PCT system was used in this pilot to initiate control events, but a wide variety of other communications linkages could instead be used in future deployments.

System Components (continued)

More specifically, the Dencor DDC limits a facility's peak electric power demand by:

- Preventing certain equipment from running continuously when intermittent operation will have no adverse consequences.
- Preventing equipment that cycles "on" and "off" from cycling in a purely random fashion, which sometimes results in all or most equipment operating simultaneously and produces a high power demand.

End-Use equipment items controlled at various facilities are:

- Air-conditioning Units (both single-stage and dual-stage)
- Refrigeration Units: Walk-in Coolers and Freezers, Cabinet-Type Coolers and Freezers, Ice-Makers
- Domestic Water Heaters
- Interior Lighting Fixtures (when dimming can be done inexpensively).
- Anti-sweat heaters on refrigerated cases.

Each equipment item controlled by a relay is assigned an operational priority. Maximum "off" times and minimum "on" (or run) times can also be assigned for each relay. A relay that controls an electric water heater is typically assigned a low priority, which means it can be turned off for a period of an hour or more.

System Components (continued)

Air-conditioning units are typically given a low priority, but are permitted to be “off” for only about 10 to 15 minutes at a time. Experience shows that refrigeration equipment can be off for 15 to 20 minutes without the temperature of stored food rising by more than a few degrees, if at all.

Selection of end-use equipment to be controlled is guided by three considerations:

- Equipment that has a significant power draw, so the relay actions result in meaningful savings.
- Equipment operation can be interrupted or shifted in time without consequences. (This requirement typically rules out most equipment associated with small/medium-business manufacturing operations.)
- Occupant comfort not be sacrificed, and the quality of any food items or other products whose quality is potentially affected by temperature changes.

The DDC unit continuously monitors temperatures associated with controlled equipment and uses these data to temporarily suspend control of the monitored load if a temperature rises to a pre-selected “trigger-point.” More specifically, when the controlled load is the refrigeration system or air conditioner, the temperature within the refrigerated or conditioned space is continuously monitored.

System Components (continued)

If the temperature should rise to a preset level, control is automatically suspended until the temperature is reduced to below the set point. This prevents degradation of food quality, ice-cream softening, or occupant discomfort. .

The DDC unit continuously monitors the electric power being used by the facility, and also monitors up to three temperatures associated with controlled equipment. These data are stored in an internal memory.

The Dencor DDC has internal memory that stores a record of loads, control actions, and monitored temperatures. These data elements can be periodically downloaded via a telephone, cable, or wireless modem and associated communications link. This communications link can also be used to remotely program the unit and to change target set points.

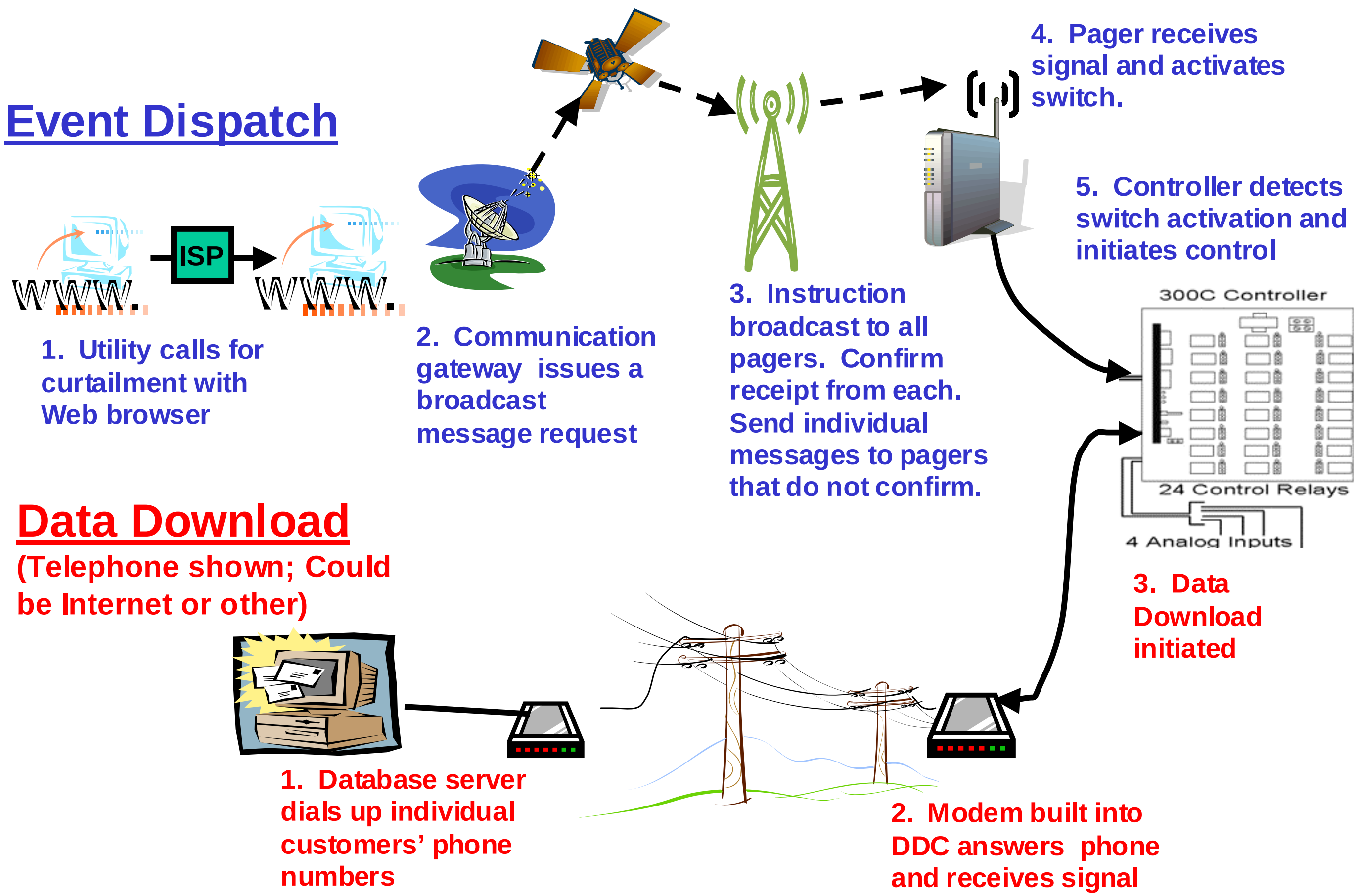
System Components (continued)

In the pilot program conducted for SCE, three days of load and temperature data were up-loaded from the DDC units after control events by means of the unit's built-in telephone modem. (The modem had been connected to a shared phone line at each facility during the installation process.)

These data were then analyzed to determine the magnitude of load reduction that had occurred during the CPP periods.

The diagram on the next two pages show how the various components interacted to initiate load reductions by the DDC installed at a participating facility. Note that if the Carrier PCT system is not available to initiate control actions, the telephone modem can be employed as an alternate means. The following page shows some of the other communications linkages that can be used to activate Dencor DDC units. The final page in this section shows a typical installation.

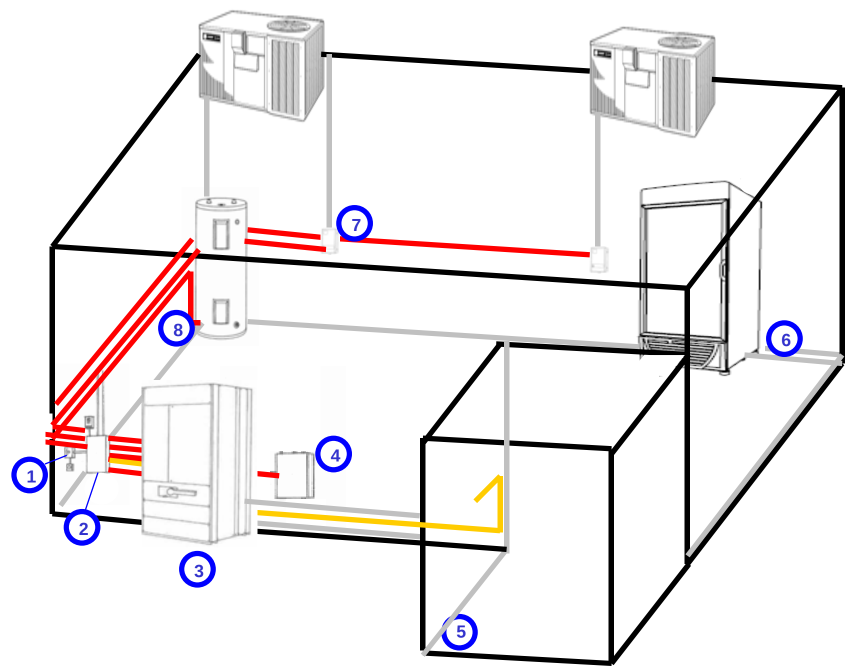
System Configuration



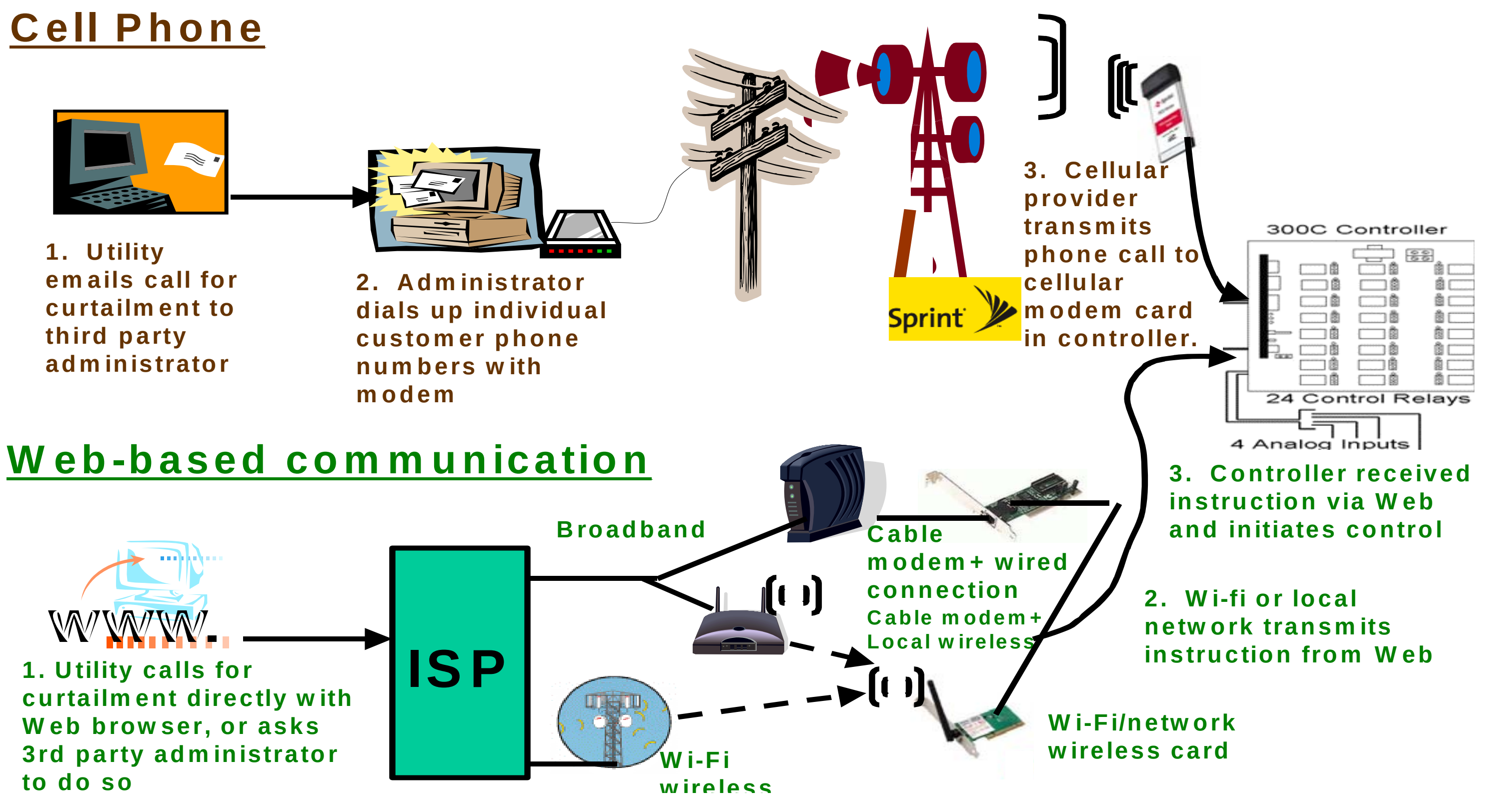
System Configuration (Continued)

1. Wireless signal receiver & switch, or modem or internet connection
2. Dencor controller
3. Distribution panel, including main service with 3 CTs and relay for dedicated plug circuit & walk-in
4. Lighting control panel (light fixtures not shown)
5. Walk-in cooler with thermostat monitor
6. Novelty cooler or other controllable plug load on dedicated circuit
7. One- or two-stage thermostats for rooftop air conditioners
8. Water heater with two elements

New control wiring
New monitor wiring

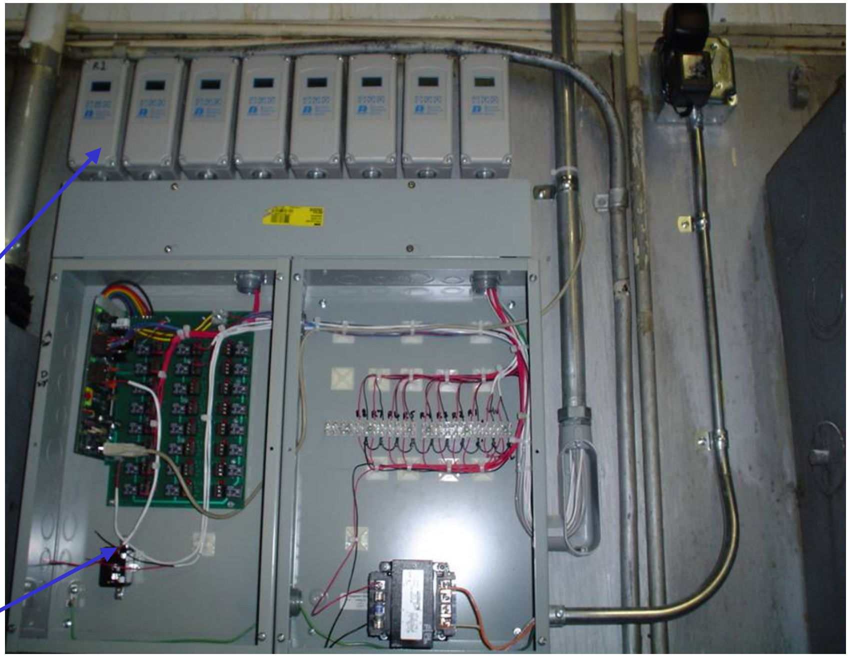


Alternative Two-Way Communications Linkages



Typical Installation

The photograph on the right shows a typical installation of a 24-relay Dencor DDC unit at a food distribution warehouse. It shows the Dencor 24-relay unit with the override thermostats mounted on top.



Override Thermostats

Dencor 24-Relay DDC Unit

Section 4: Recruiting and Qualifying Host Facilities

Contents

Overview of the Process

The process of recruiting and qualifying host facilities began with a telephone call to a customer on the list of candidates. The ensuing conversation sought to:

- Confirm that a Carrier PCT system is currently installed.
- Establish that the facility was likely to have a minimum of 10 kW of controllable load.
- Convey an explanation of the purposes of the pilot and the benefits of participating.
  - In Year One (2004) this included a sharing-savings approach (i.e., partially controlling end-use loads at non-CPP-event times and fully controlling these loads during CPP events
  - In Year Two (2005), load control occurred only during CPP events.
- Schedule an appointment with interested customers.

Overview of the Process (Continued)

The site inspection and Scoping Study were performed by an Aspen engineer to establish that:

- There is at least 10 kW of controllable load.
- DDC installation costs would not be excessive.
- The customer was willing to provide access to a telephone line.
- The customer wanted to proceed with installation of the DDC unit.

If all conditions were satisfied, an installation appointment was scheduled.

NOTE: Several of the facilities were less than ideal in that load magnitude was marginal or installation costs were projected to be high. (The sample of SPP participants represented a broad spectrum of small commercial facilities, most of which are too small for the Dencor DDC to be an economic enabling technology. The preferred minimum acceptable magnitude of controllable load is 30 kW.)

Issues Encountered During Recruitment

The following issues were encountered during the recruitment of host facilities:

- Customers did not understand demand charges in general or CPP rate in particular.
- Many customers did not have T-stats installed and others that did had bad experiences with T-stat installation.
- Many customers with T-stats found them difficult to program and were reluctant to install EMS which they saw as more complex.
- Some customers had satisfaction issues with SCE unrelated to pilot which made them disinterested in pilot.
- Several customers selected for pilot had no significant controllable loads (i.e., lighting only, under 5-KW total, etc.).
- Several customers had not seen energy bill reductions they had anticipated… none of them realized rate helped defer additional costs as much as reduce existing billing levels.

Issues Encountered During Qualification

The following issues were encountered during the qualification of host facilities:

- Many customer sites did not have significant controllable loads.
- The majority of the load for many larger customers (100KW+) was not controllable (i.e., printing press, compressed air, manufacturing equipment, etc.).
- Several facilities had large distances between end-use equipment and the DDC unit, making installation very costly.
- Most customers required some explanation of their rates and how CPP and enabling technology would benefit them before agreeing to participate.
- Most initial customer contacts required additional facility personnel involvement (i.e – facilities manager, president, etc.) to make decision.
- Several facilities had special installation requirements (high ceilings, concrete or steel walls, long wiring runs) that required special planning.

Recruiting Participants - 2004

- In mid-July SCE provided to Aspen a list of 51 small commercial customers who were also SPP participants.
- To train installers, during August two installations were made at restaurants that were not SPP participants.
- Recruitment of SPP participants proved to be problematic – decision-makers often were not located at facility and were difficult to contact. Eight installations were completed during the September to November period.

Recruiting Participants – 2004 (continued)

Disposition of the 51 candidate SPP facilities

- 8 facilities: Installed enabling technology.
- 4 facilities: Decision-maker contacted and facility found to be suitable, but decision-maker declined to participate.
- 16 facilities: Decision-maker contacted but facility found to be unsuitable (small loads or expensive installation because long wiring runs needed).
- 23 facilities: Unable to contact decision-maker.

Recruiting Participants - 2005

- SCE provided a list of 89 small-commercial SPP participants.
- Recruitment of participants in the pilot continued to be problematic – decision-makers often were not located at facility and were difficult to contact. A large fraction of facilities were not ideally suitable for the Dencor enabling technology because they had small power demands. Some facilities no longer were in the SPP.
- Eleven additional installations were completed during the July to November period.

Recruiting Participants – 2005 (continued)

Disposition of the 89 candidate SPP facilities

- 8 facilities: Installed enabling technology in 2004.
- 11 facilities: Installed enabling technology in 2005.
- 10 facilities: Decision-maker contacted and facility found to be suitable, but decision-maker declined to participate.
- 15 facilities: Sites with scoping study performed but nor chosen for installation
- 37 facilities: Facility found to be unsuitable (no “smart thermostat,” small loads, or expensive installation because long wiring runs needed or facility in a remote location).
- 4 facilities: Unable to contact decision-maker.
- 4 facilities: No current telephone listing.

Section 5: Description of Host Facilities

Contents

- Host Facilities Types and Sizes
- End-Uses Controlled

Host Facilities Types and Sizes

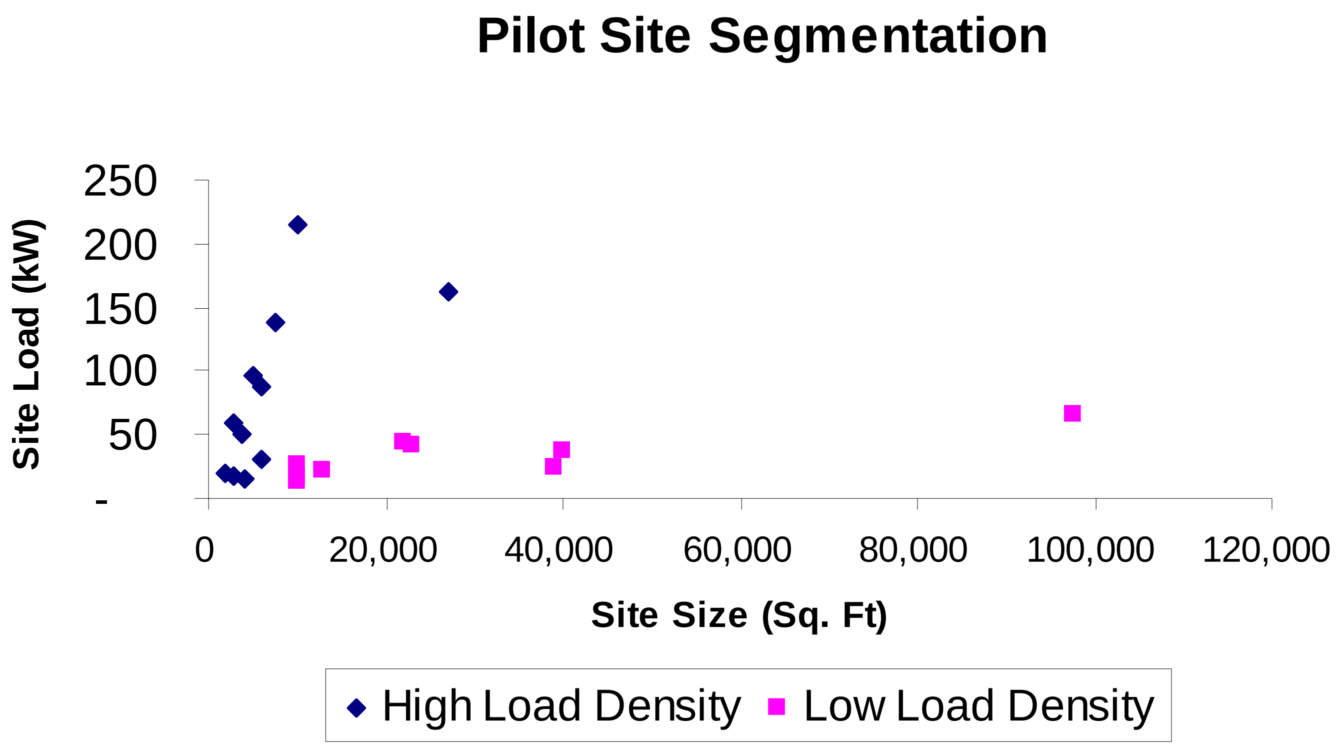
Site No.	Facility Type	Sq. Ft.	Lvls	kW	W/Sf
1	Office/Manufacturing	39,000	2	25	0.6
2	Office/Warehouse	97,500	2	67	0.7
3	Service/Retail - Office schedule	40,000	2	37	0.9
4	Retail	10,000	1	13	1.3
5	Office/Warehouse	13,000	2	23	1.7
6	Office	10,000	2	18	1.8
7	Retail	23,000	2	42	1.8
8	Office/Manufacturing	22,000	1	43	2.0
9	Office/Warehouse	10,000	2	26	2.6
10	Grocery - Small	4,000	1	15	3.9
11	Retail	6,000	2	30	5.0
12	Office/Warehouse	27,000	2	162	6.0
13	Beverage store with coolers	2,800	1	17	6.1
14	Restaurant - Casual sit down	2,800	1	17	6.1
15	Coffee Shop	2,000	1	21	10.3
16	Restaurant - Fast food	3,800	2	50	13.1
17	Auto Dealer	6,000	2	87	14.6
18	Restaurant - Casual sit down	7,600	1	139	18.3
19	Restaurant - Casual sit down	5,000	1	96	19.2
20	Restaurant - Fast food	2,800	1	59	21.0
21	Food Catering	10,000	1	214	21.4

Host Facilities Types and Sizes

The plot of kW and floorspace shown on the next page clearly indicates that there are two distinct groups of facilities:

- Those with a high load density (mainly restaurants and the small grocery where there is refrigeration equipment in addition to air conditioning and lighting).
- Those with low load density, which means there is not much equipment to be controlled, and the equipment that can be controlled is distributed around the facility, necessitating long wiring runs.

Host Facilities Types and Sizes



End-Uses Controlled

The electricity end-uses controlled by the Dencor DDC units were:

- Air Conditioning: Controlled at all facilities (Total of 84 rooftop units, 2 to 20 tons capacity).
- Refrigeration: Controlled at restaurants and grocery (Total of 27 coolers, freezers, or ice-makers).
- Domestic Water Heaters: Controlled at only five facilities (other facilities did not have an electric water heater).
- Lighting: Controlled at only one facility.

Section 6: Installation Activities and Costs

Contents

- Overview of the Process
- Photographs
- Factors Affecting Installation Costs
- Future Installation Costs
- Installation Best Practices

Overview of the Process

- **Perform Scoping Study to:**
  1. Determine suitability of site (adequate controllable load, reasonable installation costs, etc.)
  2. Develop installation plan and notify installer of any special installation requirements
- **An Aspen engineer and FaithCo electricians installed the Dencor DDC, connecting it to:**
  1. Control 5 - 12 end-use loads;
  2. Monitor key temperatures (e.g., room, walk-in cooler, freezer case); and
  3. Measure the instantaneous total power load of the facility. (Power readings, temperature, and relay-state are stored in an internal memory.)
  4. A telephone modem connection, to permit the DDC to be remotely programmed and also enables stored load and temperature data to be remotely downloaded to a master database.
- **The Aspen engineer programmed the DDC unit and conducted a commissioning test.**

Photographs

Alternative to prior page (choose one or other). Prior page has benefit of showing inside of Dencor and scale with person, disadvantages of having EMCS panel being too prominent for its importance, and having less wiring in place.

Main Distribution Panel

Wiring to CTs in main panel

Wiring for control relays

Leads to temperature monitoring in cases

Dencor Controller

Factors Affecting Installation Costs

Factors that tended to increase installation costs:

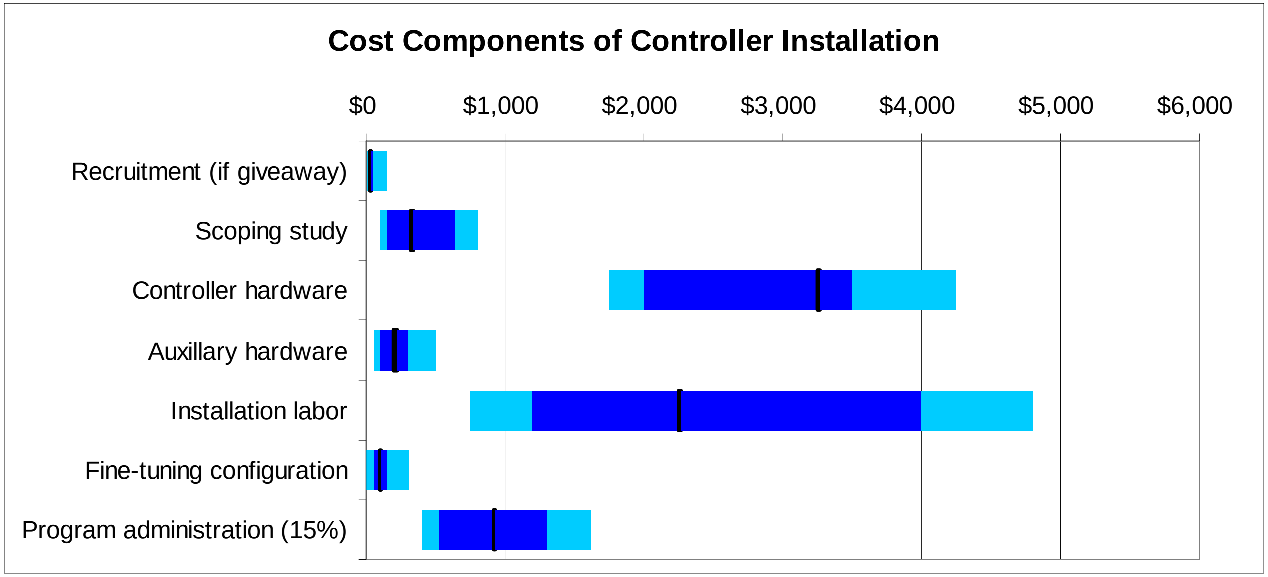
- Large distances between meter and end-use equipment (e.g., large warehouse with small office area)
- Non-standard voltages requiring special transformers
- Large number of rooftop AC units
- Poor roof access
- Concrete or steel walls between meter and end-use equipment, requiring drilling
- Old or poorly maintained facility and end-use equipment
- Heavy foot traffic in installation areas
- High bay ceilings
- Congested work areas
- Remote location; isolated facility (long travel time).

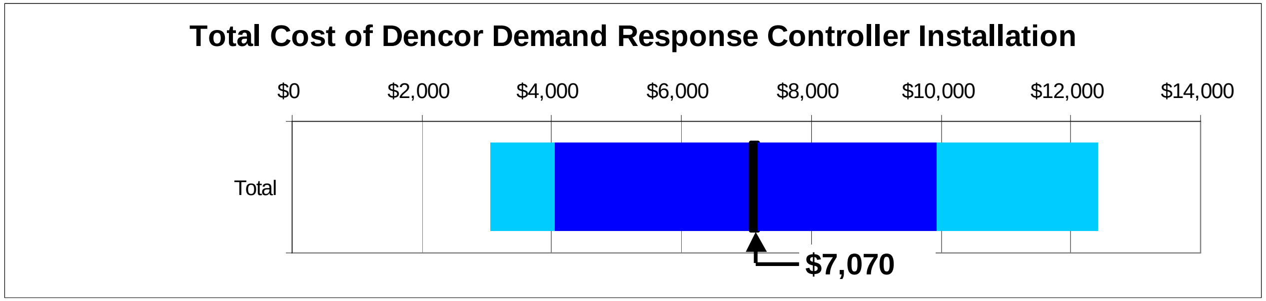
Factors Affecting Installation Costs (continued)

Factors that tended to keep installation costs low:

- Perform Scoping Study prior to Installation.
- All end-uses near meter (minimize wiring runs).
- Standardized facility layout (i.e., chain stores and chain restaurants).
- Large number of 1-kW to 10-kW end-use loads.
- Multiple phone lines (avoid sharing with an active phone).
- Minimal business activity in installation areas during business hours.

Installation Costs During the Pilot





Installation Best Practices

- **Choose installation sites that minimize installation times and maximize load reduction**
  - Convenience stores and Grocery stores
  - Other Retail stores with significant refrigeration end-uses
  - Restaurants
  - Large Retail stores w/o refrigeration
  - Single-tenant Office buildings
  - Facilities w/dimmable lighting fixtures
- **Avoid Facilities with small controllable loads:**
  - Any facility with less than 30 KW of controllable load
  - Manufacturing and repair facilities where air-conditioned space is small and large production-related equipment operates sporadically
  - Multi-tenant facilities
- **Perform scoping study prior to installation and identify any special installation requirements before installer arrives**
  - Long wiring runs
  - Hours of heavy foot traffic
  - High ceilings
  - Special installation concerns (concrete or metal walls for drilling)
  - High ceilings
- **Make sure customer fully understands installation requirements.**

Section 7: Procedure for Calculating DR Results

After each event, Aspen remotely downloaded 4 days' of demand and temperature data for each facility via the phone modem. The following four-step procedure was then used to estimate the baseline load for each facility and for each 2-hour control event:

- Identify a day when the average demand over the noon to 2:00 p.m. period was within 5 percent of the average demand over the same period on the control-event day. (Closely similar average demand indicated that business activities and outdoor temperature were also similar.) Designate this the Baseline Day for a given facility.
- Calculate the unadjusted baseline for each facility as the average demand over the 2:00 to 4:00 p.m. period on the facility's Baseline Day.
- Normalize the baseline demand by multiplying the unadjusted value by the ratio of the average demand during the Noon to 2:00 pm period on the event day by the average demand over the same time period on the Baseline Day.
- Finally, calculate the load reduction as the difference between the average demand over the 2:00 to 4:00 p.m. period on the control day and the adjusted baseline value.

Section 8: Demand Reduction Results

Contents

- Summary of DR Results
- Composite Facility Curtailment Profile
- Individual Facility Curtailment Profiles

Summary of DR Results

- Seven DR control events were called during the late summer of 2005, when the Dencor DDC enabling technology had been installed in 10 facilities with a Carrier “smart thermostat” system (which was being used to dispatch control events at these facilities).
- The average demand reduction achieved by the Dencor DDC system over the seven control events during 2005 was 8.5 kW, which corresponded to 16 percent of the average baseline demand of the facilities being controlled. (Only one control event was on a “hot” (mid-90s temperature) day; the others were on days when the temperatures were in the mid-80s.)
- The amount of reduction varies with daily peak outdoor temperature. The 2-hour control event on a “hot” day produced an average demand reduction of 11 kW (22 percent of baseline demand). We estimate that smart thermostats would have produced an average demand reduction of only 5.5 kW (half as much) at these facilities during this control event.
- “Rebound” (post-event power demand increase) is negligible (less than 0.5 percent of baseline demand).

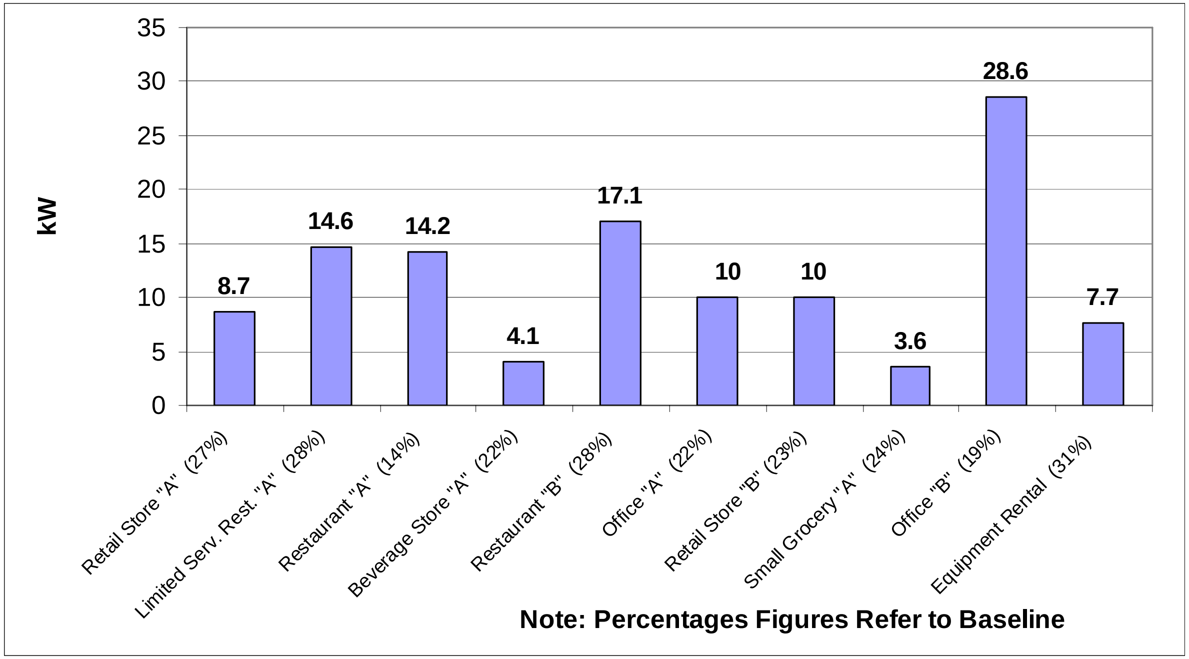
Summary of DR Results (continued)

- The following table shows the results for the first control event:, 2:00 p.m. to 4:00 p.m.on August 26, 2005.

	Baseline Day		Control Day				
Customer Name	**Noon-2 pm Demand (kW Avg)**	**2- 4 p.m. Demand (kW Avg)**	**Noon-2 pm Demand (kW Avg)**	**2-4 p.m. Demand (kW Avg)**	**Adjusted Baseline Demand (kW Avg)**	**Demand Reduction (kW - %)**	
Retail Store “A”	32.5	33.4	31.8	24.0	32.7	8.7	27%
Limited Serv. Rest. “A”	49.4	49.9	52.3	38.2	52.8	14.6	28%
Restaurant “A”	104.9	105.0	102.1	88.0	102.2	14.2	14%
Beverage Store “A”	17.3	18.4	17.5	14.5	18.6	4.1	22%
Restaurant “B”	60.3	60.5	60.5	43.6	60.7	17.1	28%
Office “A”	45.7	44.7	46.0	35.0	45.0	10.0	22%
Retail Store “B”	36.3	36.4	43.8	33.9	43.9	10.0	23%
Small Grocery “A”	14.8	15.0	15.0	11.6	15.2	3.6	24%
Office “B”	171.6	171.9	147.1	118.8	147.4	28.6	19%
Equipment Rental	21.4	25.7	20.5	16.9	24.6	7.7	31%
		Totals:	**537**	**425**	**543**	**118.6**	**22%**
		Average of 10 Facilities:	**53.7**	**42.5**	**54.3**	**11.9**	**22%**

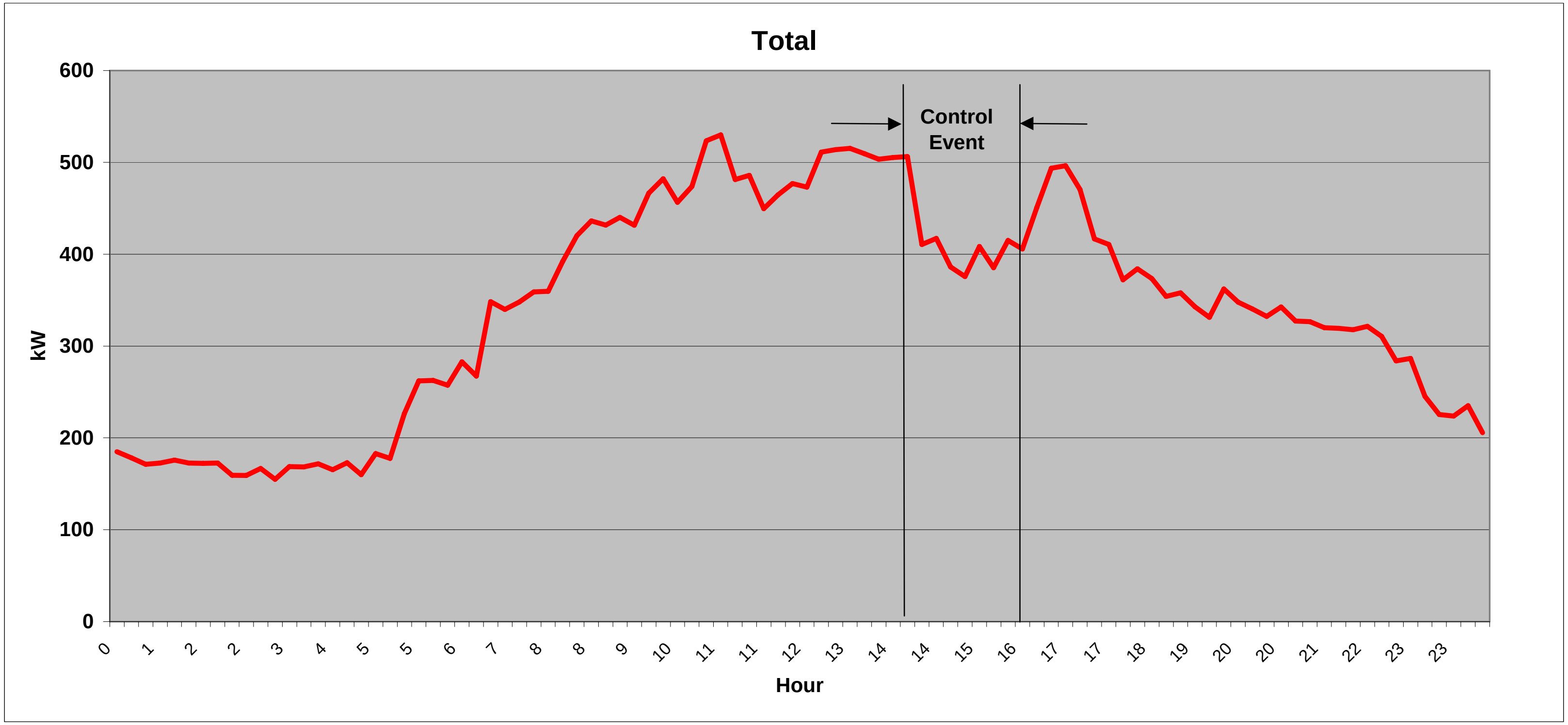
- The next page shows a plot of these data.

Summary of DR Results (continued)

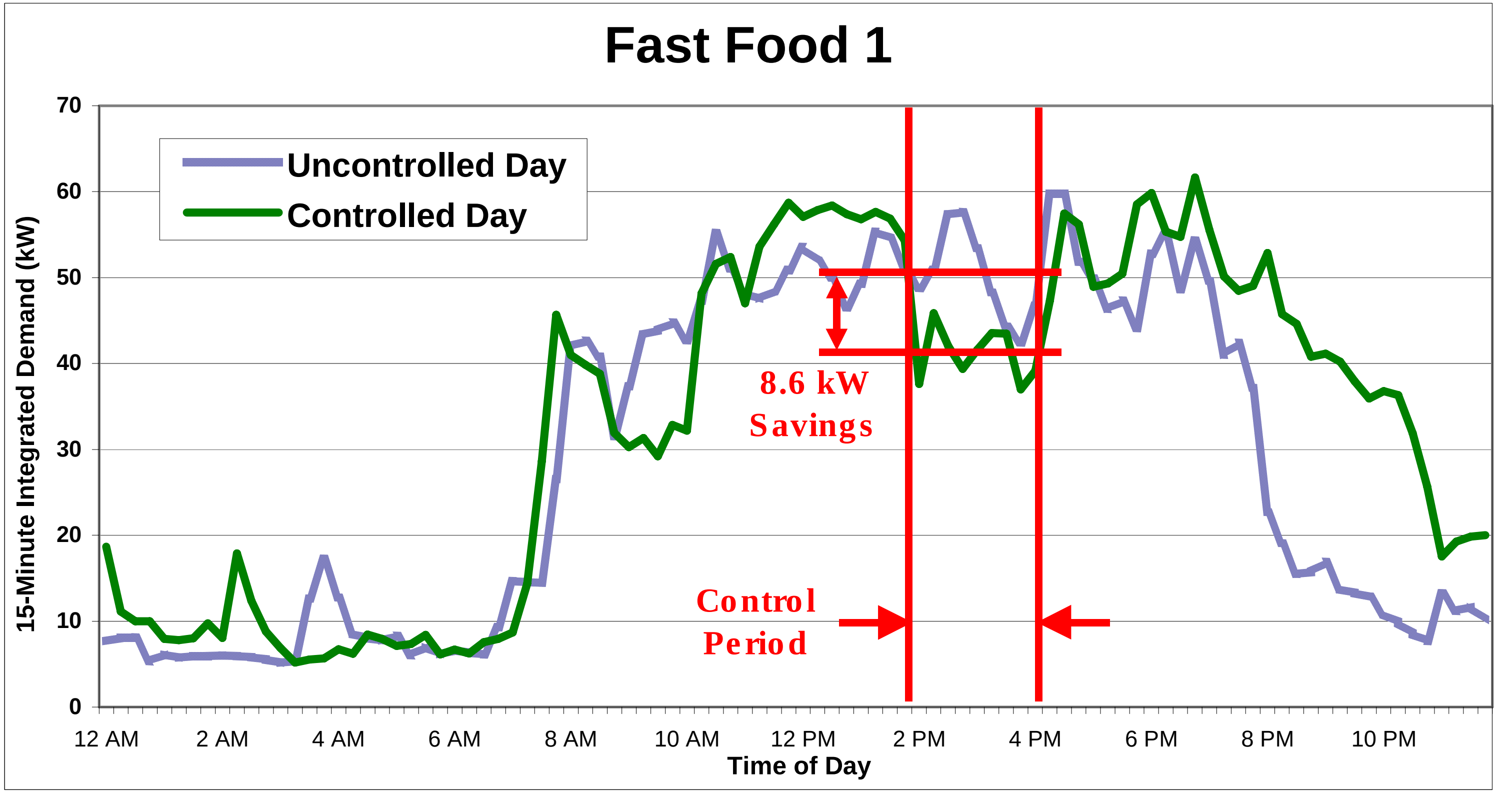


- The next page contains a plot of the composite load data (sum of all facilities) for the CPP event on August 26th. The subsequent pages contain load-shapes for each facility for August 26th (control day) and August 25th (baseline day).

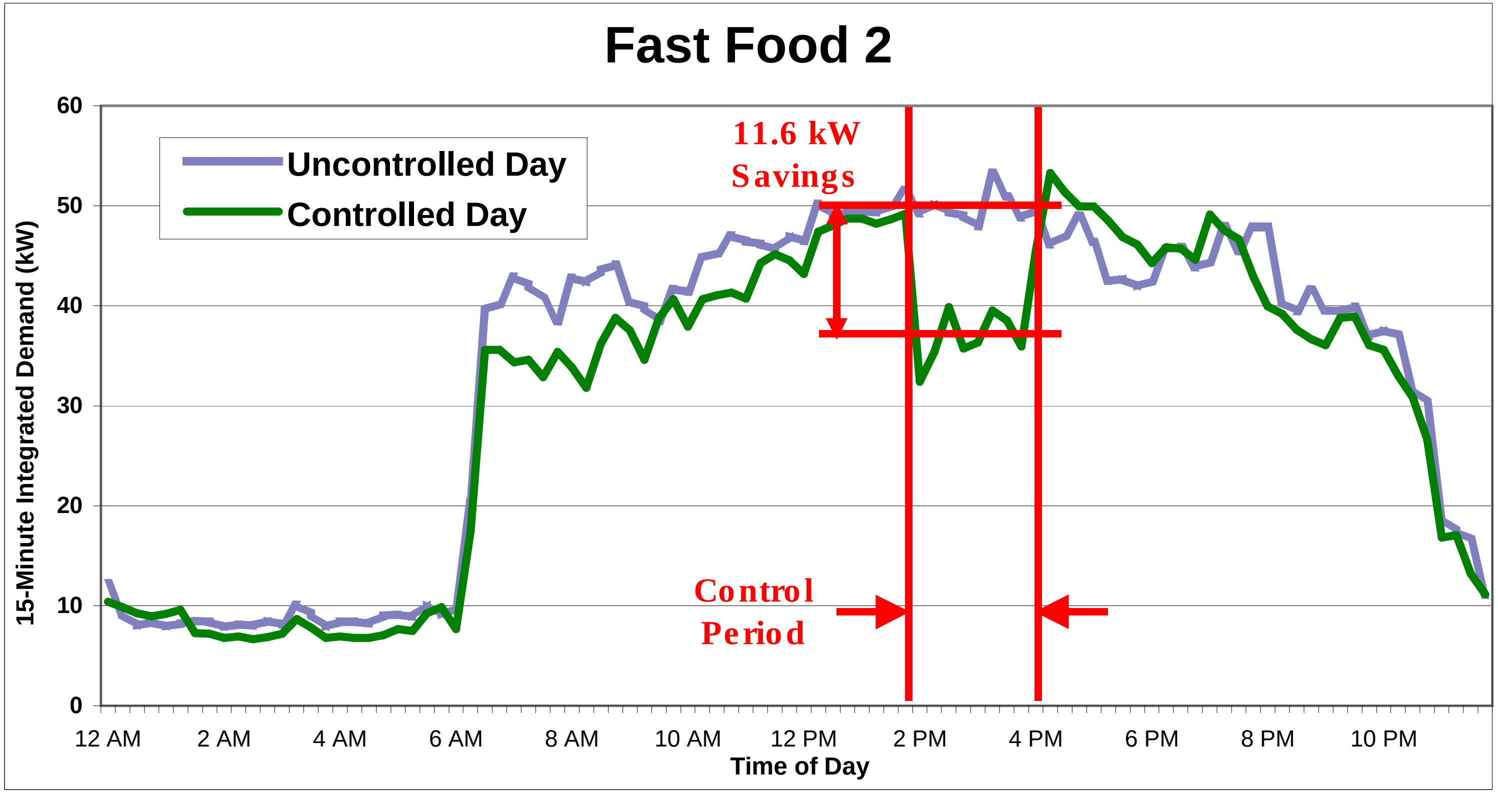
Composite Facility Curtailment Profile



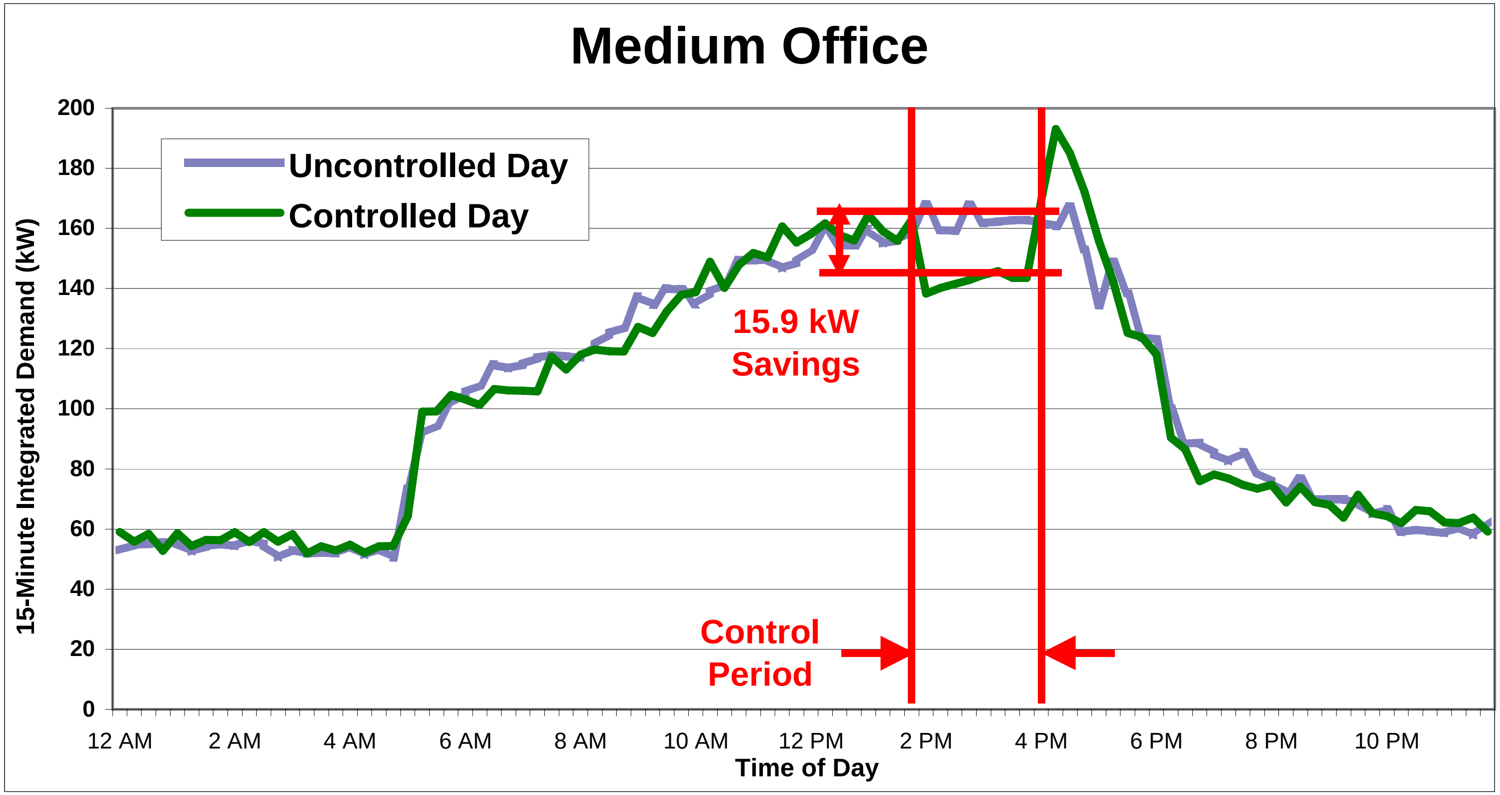
Individual Facility Curtailment Profile



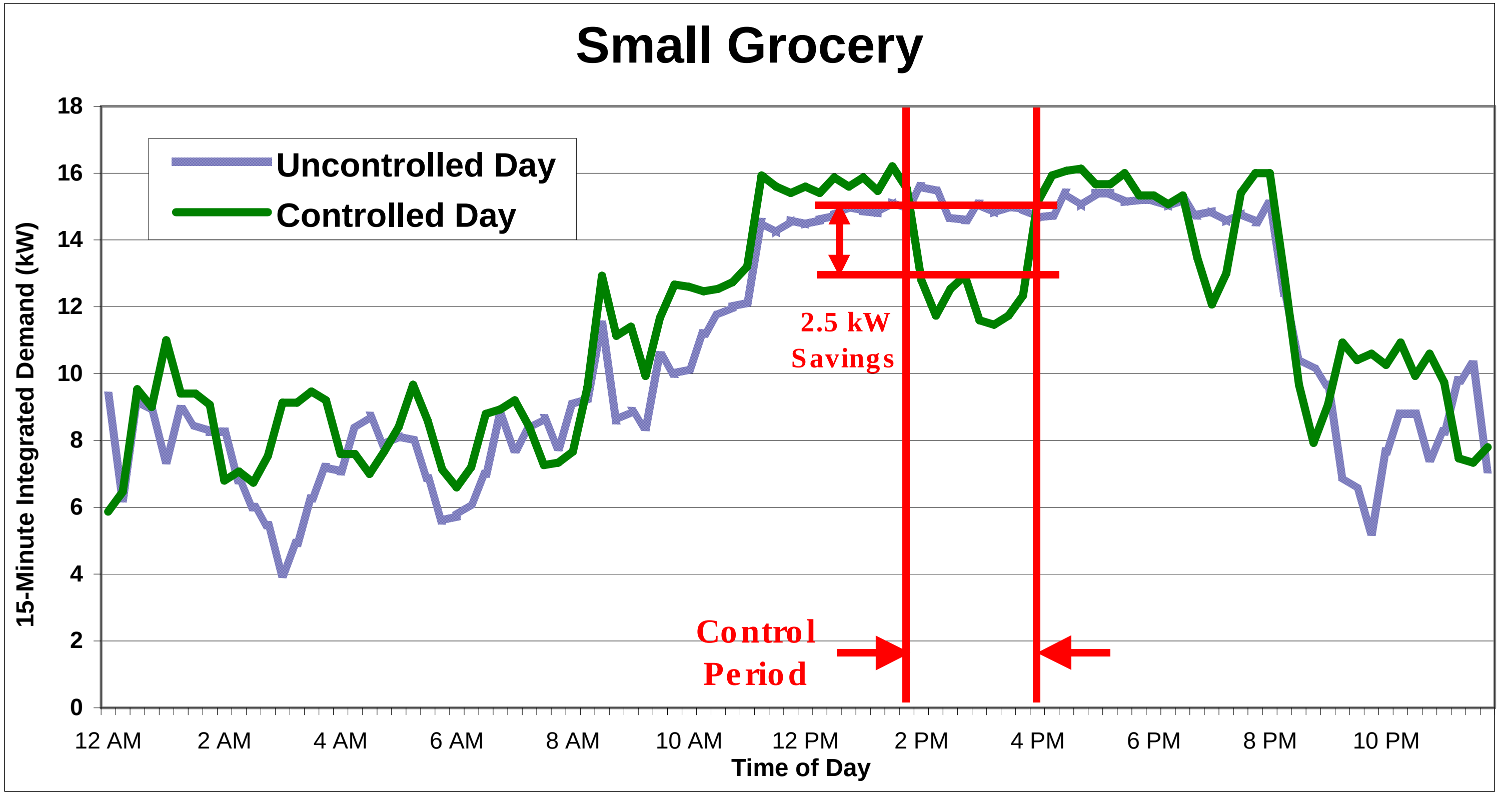
Individual Facility Curtailment Profile (continued)



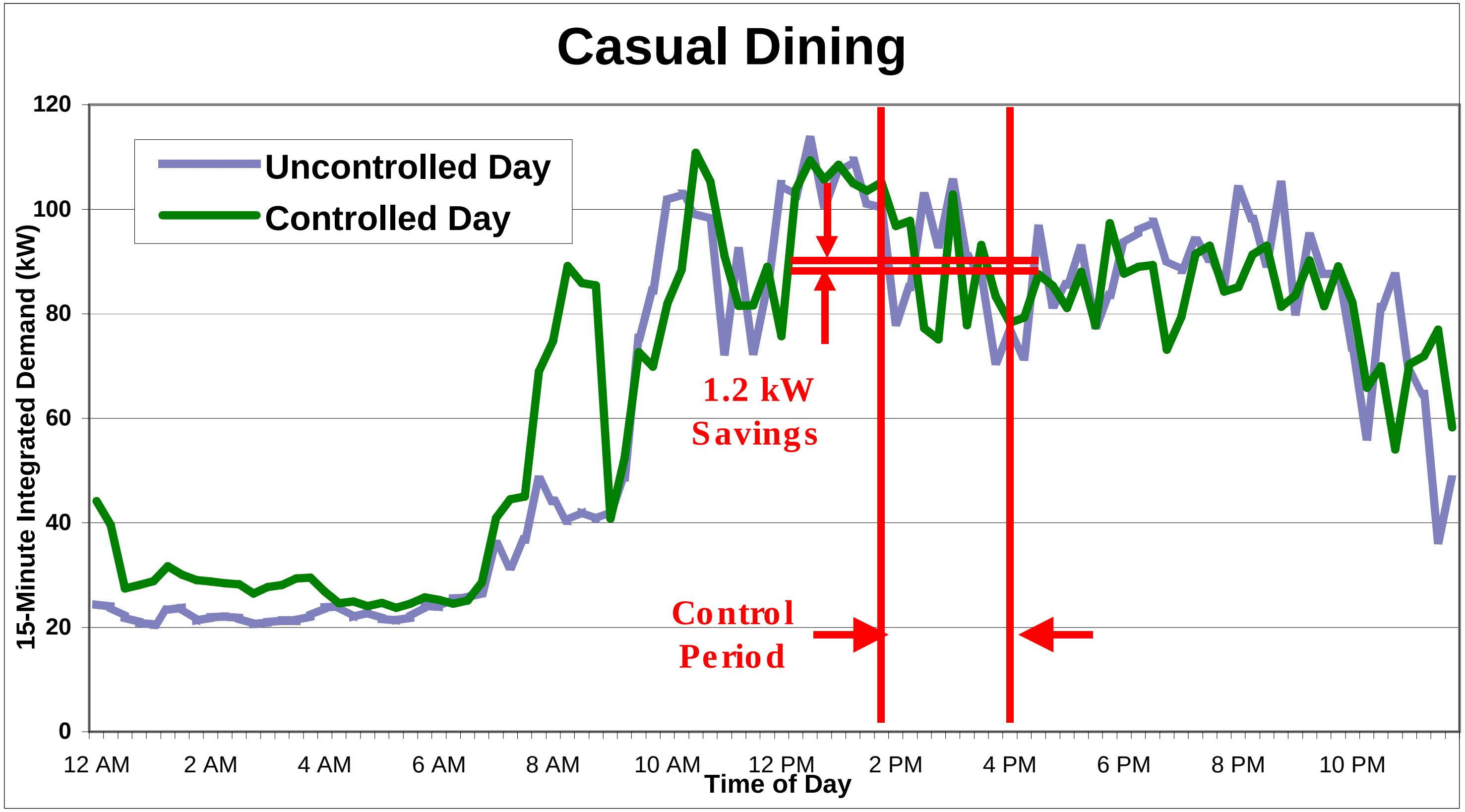
Individual Facility Curtailment Profile (continued)



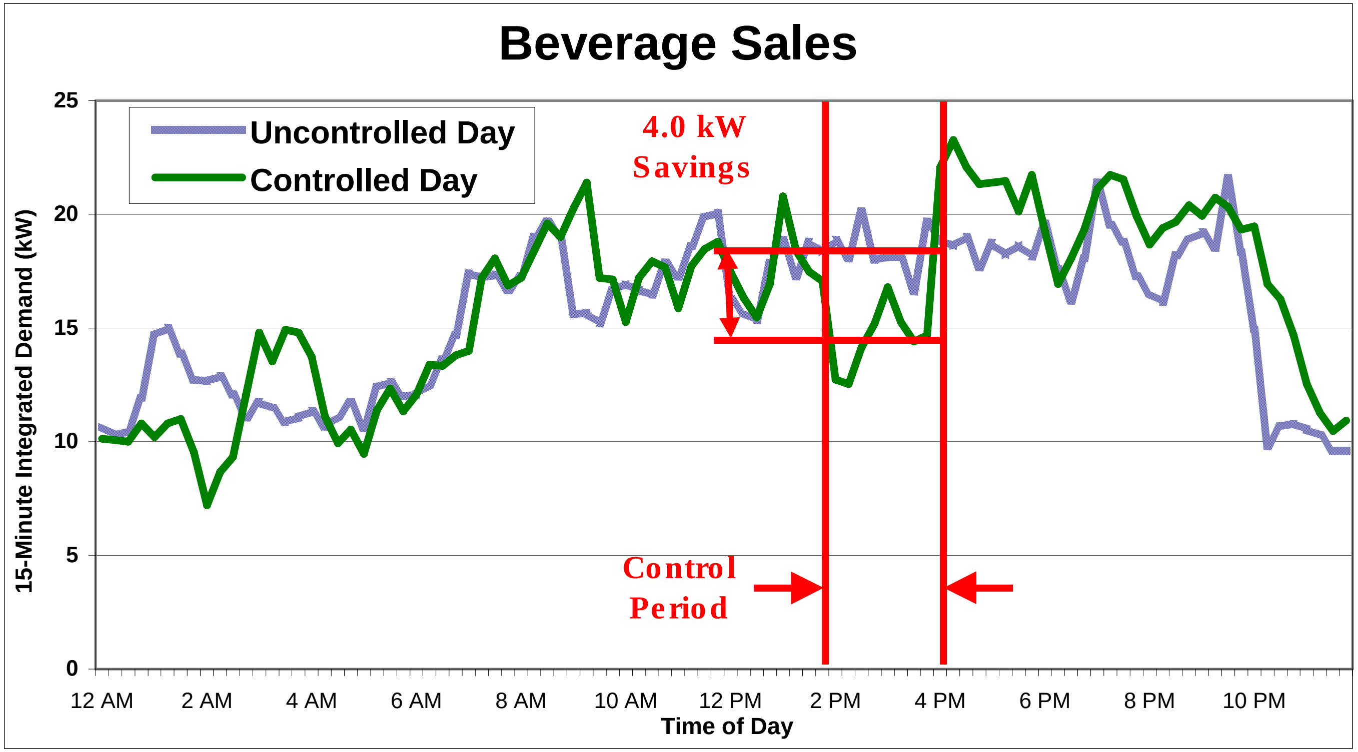
Individual Facility Curtailment Profile (continued)



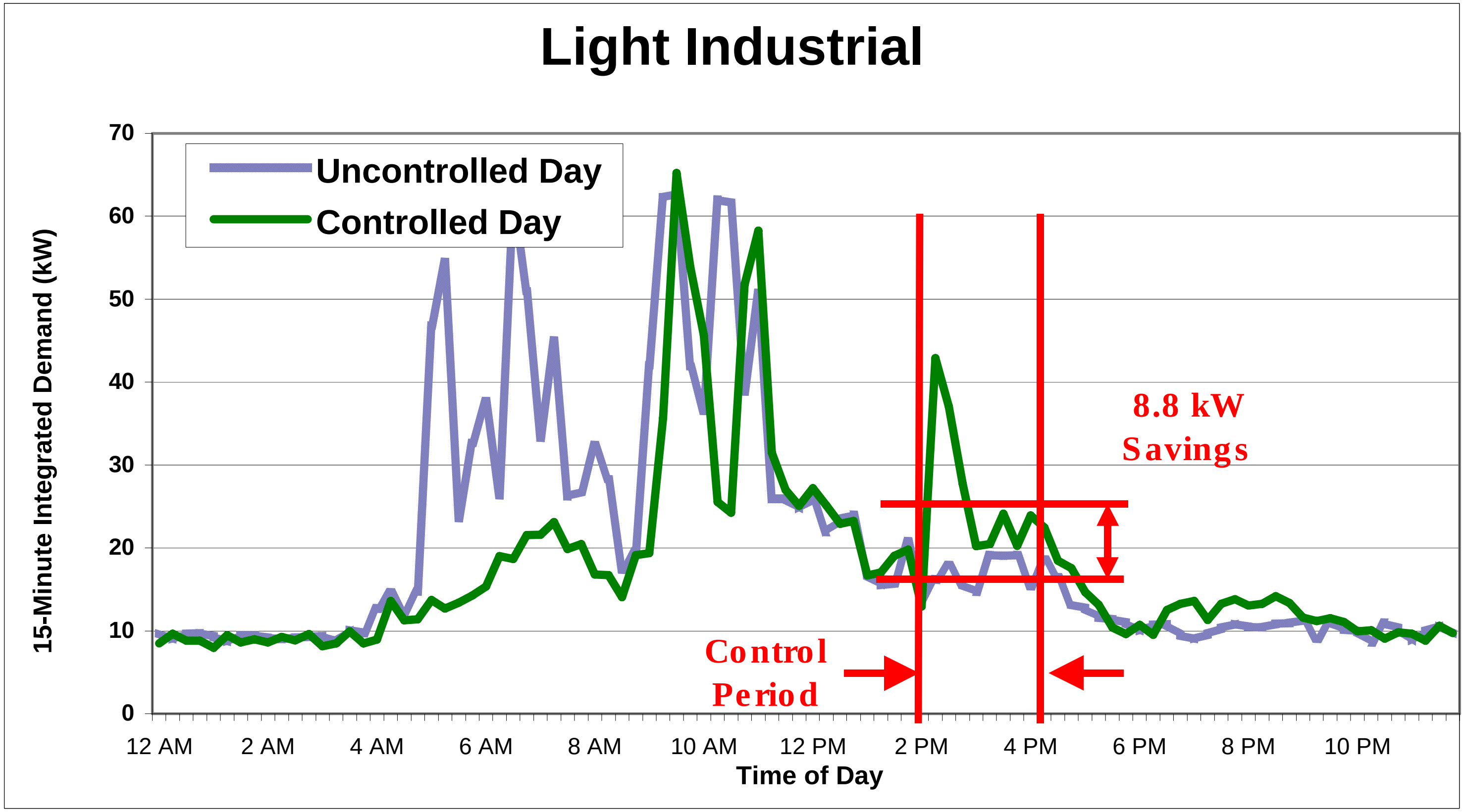
Individual Facility Curtailment Profile (continued)



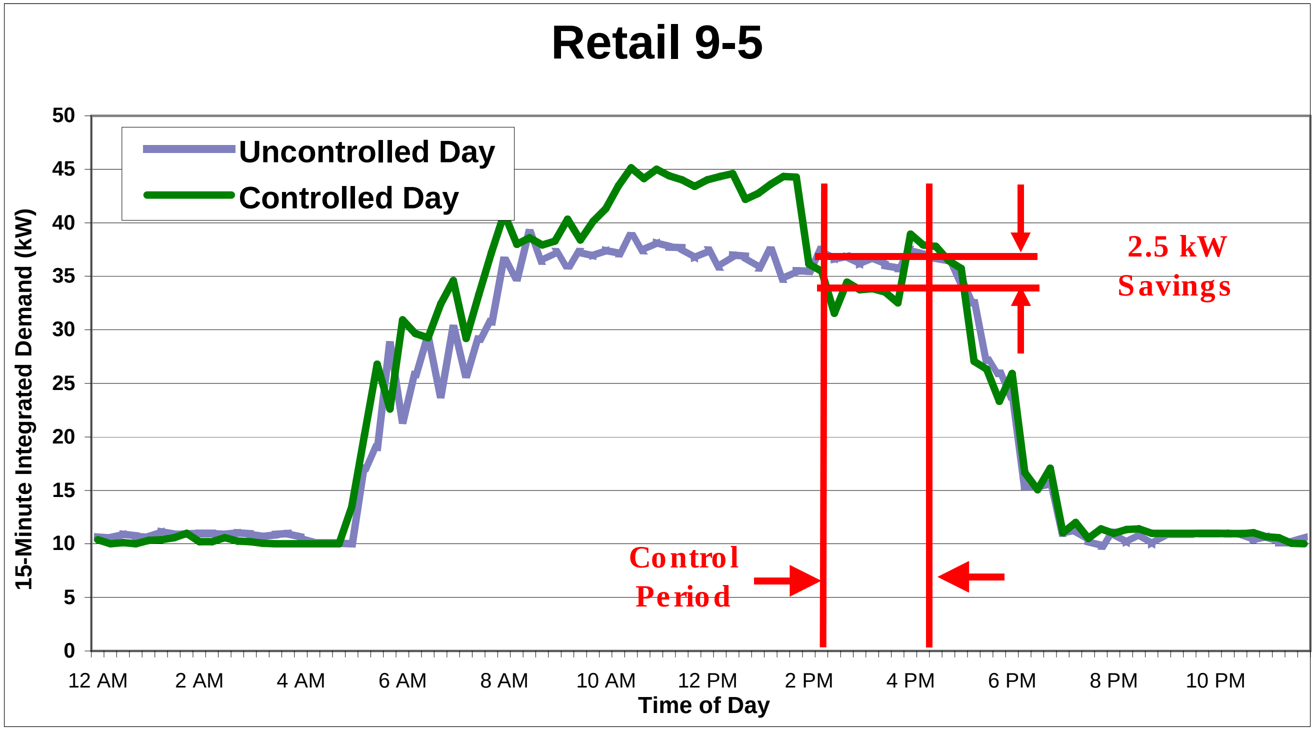
Individual Facility Curtailment Profile (continued)



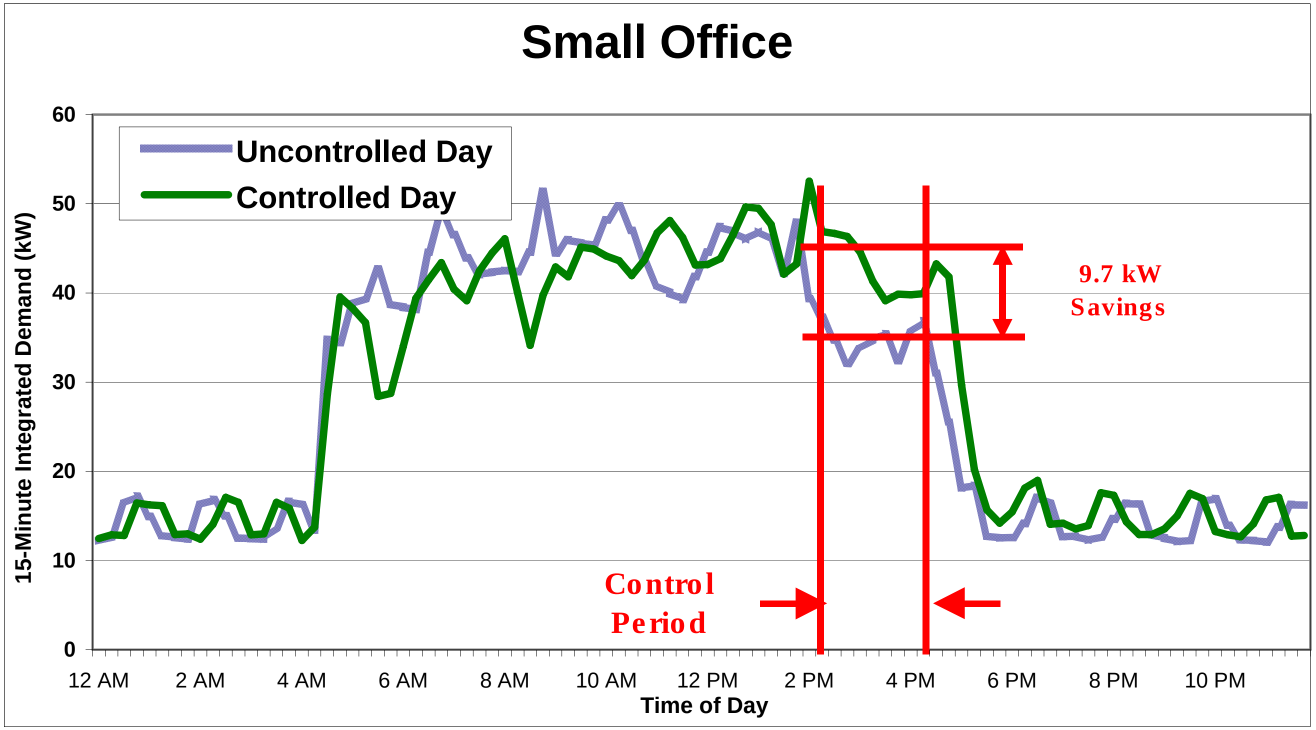
Individual Facility Curtailment Profile (continued)



Individual Facility Curtailment Profile (continued)



Individual Facility Curtailment Profile (continued)



Section 9: Market Potential

Contents

- Description of Procedure
- Estimated Market Potential

Description of Procedure

Aspen analyzed data from a sources such as the U.S. Census Bureau's County Business Patterns and market studies conducted by various contractors for California's utilities. From these sources, we developed the following breakdown:

Facility Type	Percentage
Retail	26
Office	18
Education	9
Restaurant	7
Manufacturing	15
Warehouse	6
Health Care	3
Lodging	1
Miscellaneous	15
Total	**100**

We further estimated that, of a total of around 900,000 small/medium facilities in California, approximately 122,000 had a baseline demand of 45 kW or more.

Estimated Market Potential

Our analysis indicates that if 50 percent of the small/medium commercial facilities in California with a baseline demand of 45 kW or more installed a DDC enabling technology (Dencor or equivalent), the aggregate reduction during a DR event would be about 1,000 MW. The distribution by facility size range and market penetration is:

Facility Size Range	Number of Host Facilities	Average Per Facility Demand Reduction (kW)	Demand Reduction (MW) at Indicated Market Penetration		
			50%	25%	10%
151 kW to 200 kW	7,000	37	130	65	26
101 kW to 150 kW	18,000	26	234	117	47
66 kW to 100 kW	35,000	18	315	158	63
45 kW to 65 kW	60,000	12	360	180	72
Total:	**120,000**		**1,039**	**519**	**208**