Advanced DR Control Technologies for Small/Medium Customers

Presented to:

MADRI Business Case Sub-Group Meeting

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April 6, 2006

Topics Covered

Study to Identify Enabling Technologies

- Three Groupings of Enabling Technologies
  - Migrated-up from residential
  - Targeted to the small/medium segment
  - Migrated-down from large customer segment
- Future ET trends

Dencor Pilot Program

- Description of technology
- Description of host facilities
- Installation activities and costs
- Procedure for Calculating DR Results
- Demand Reduction Results

Study to Identify Enabling Technologies

Three Groupings of Enabling Technologies that can be used for Small/Medium Customer DR programs:

1. Those that “migrated-up” from the residential sector
2. Those that basically target this sector (~20kW to 200 kW) exclusively
3. Those that “migrated-down” from the Large Customer segment

Study to Identify Enabling Technologies

Enabling Technologies that Migrated Up from the Residential Sector:

- Remotely controlled relays ("switches")
  (Most frequently controlled by radio or pager signals to cycle
  AC unit (<u>most often</u>) or shut-off DHW heater or pool pump.
  Can also be controlled via a "gateway" that is in turn controlled by
  a Web message or PLC signal.)
  Usually "one-way," but "two-way" is possible.
  Vendors include Comverge, Carrier, Cannon.

- "Smart" Thermostats (PCTs)
  Same control linkages as with "switches"
  Control action can be either to cycle or to shift set-point
  Customer can override control action
  Vendors include Comverge, Carrier, Cannon, LightStat, Invensys(?)

Study to Identify Enabling Technologies

Enabling Technologies that Migrated Up from the Residential Sector (continued)

- M&V can be a problem if interval meters with remote readout are not installed at premises.
- The historic approach has been to periodically (every 2 to 5 years) perform an Impact Evaluation to determine average savings for each type of controlled unit, and simply multiply these numbers by the corresponding populations of each type of equipment being controlled.
- The Impact Evaluation used end-use or whole-facility metering at a statistically valid sample of sites.

Study to Identify Enabling Technologies

Enabling Technologies that Migrated Up from the Residential Sector (continued)

- Today, more sophisticated M&V approaches are desired, with a requirement for "instant" or "next-day" feedback" concerning amount of reduction achieved.

  "Two-way" communications linkages can provide run-time data for 100% of controlled units. For AC units, nameplate kW is known for 100% of controlled units. Outdoor temperature at time of event is approximately known. End-use metering is done once (in advance) to establish a statistical relationship between average running load as a function of outdoor temperature. These data are then used to produce an estimate of reduction achieved.

  Technologies with "one-way" communications rely on a submetered sample of units from which load data can be remotely downloaded.

Study to Identify Enabling Technologies

Enabling Technologies that basically target the (~20kW to 200 kW) sector exclusively

- These technologies use EMSs or DDCs (digital demand controllers). Basically, a DDC is a collection of relays (8 or more) connected to individual end-use loads. An on-board computerized control logic operates to shut-off or cycle equipment in a way that prevents all loads from operating at the same time. The actual facility “real-time” load is an input to the controller, which operates to reduce facility load to a “target” level that is pre-set.
  Load data is stored in an internal memory and can be remotely download via phone, Internet, pager, PLC, etc.
  (Loads can also be controlled by time of day.)

- To use an EMS or DDC as a DR enabling technology, all that is needed is to be able to remotely change the target load level for the duration of the event.

Study to Identify Enabling Technologies

Enabling Technologies that basically target the (~20kW to 200 kW) sector exclusively (continued)

- Two vendors: Dencor and Site Controls.
- Dencor will be described later.
- Site Controls markets its system primarily as an EMS/DDC that saves the customer money every month. Added features include:
  (1) monitoring CO_2 level and using this to control operation of the exhaust fans
  (2) monitoring security (“is the back door open or unlocked?”) and health and safely (fire, smoke, power outage), and sending a message (or the police or firemen) when problem is detected.
  (3) Participation in utility or ISO DR programs.

Study to Identify Enabling Technologies

Enabling Technologies that "migrated down" from the Large Customer Segment

- Most use sophisticated EMS units and ability for remotely changing setpoints and downloading kW and temperature data.
- Lighting and HVAC most often controlled.
- Large number of vendors, some of whom have not as yet added DR capability.
- Electric City specializes in Lighting Control
- EnerNOC specializes in controlling back-up generators and selected loads for DR.

Study to Identify Enabling Technologies

Future DR Enabling Technology Trends

- Many new and sophisticated communications linkages ("smart meters" as gateway) are being marketed.
- Wireless control of dimmable fluorescent fixtures are being commercialized. (Lighting has been the neglected end-use in the small/medium sector).
- Mesh networks for sensors and controls are being developed and applied.

Dencor Pilot Program

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.

Dencor Pilot Program

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.

Dencor Pilot Program

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.

Dencor Pilot Program

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. .

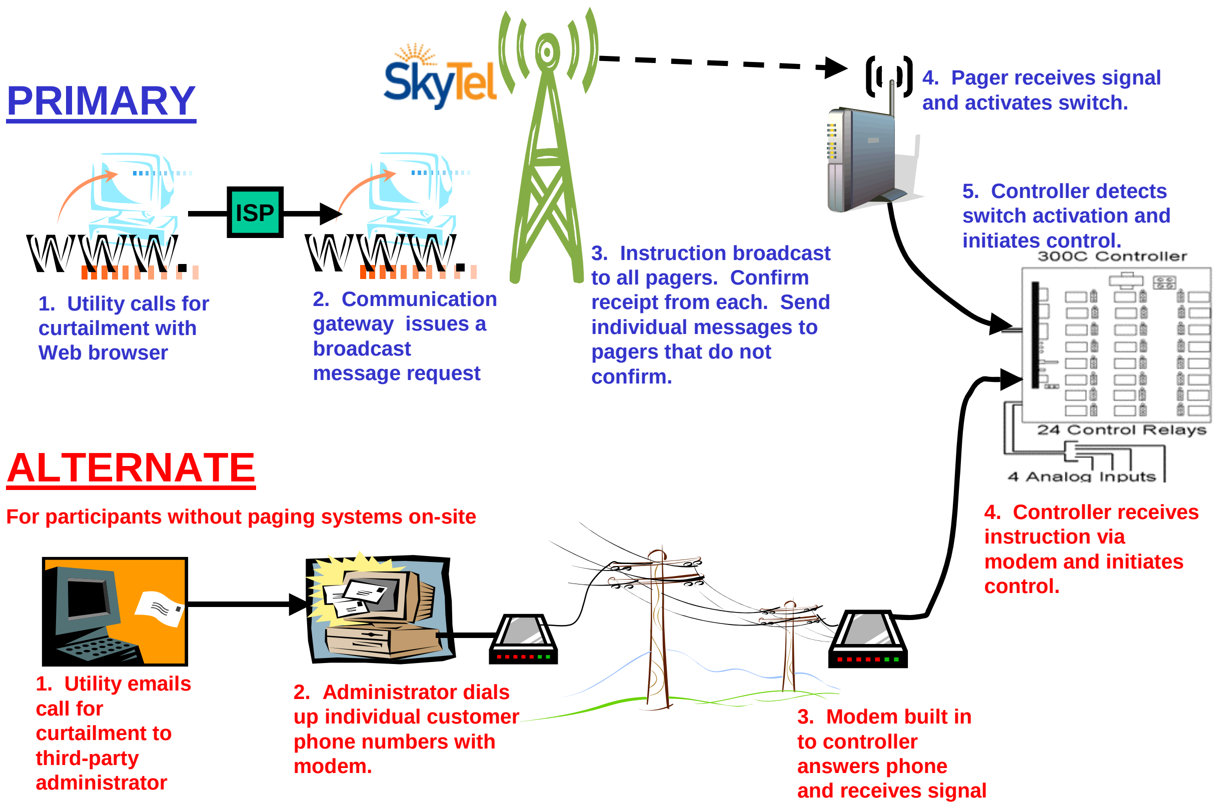
The DDC unit continuously monitors the electric power being used by the facility, and also monitors up to three temperatures associated with controlled equipment. These data are stored in an internal memory.

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.

The diagram on the next two pages show how the various components interact to initiate load reductions by the DDC installed at a participating facility. The following page shows some of the other communications linkages that can be used to activate Dencor DDC units.

Dencor Pilot Program

Pilot Communication Methods Used



Dencor Pilot Program

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

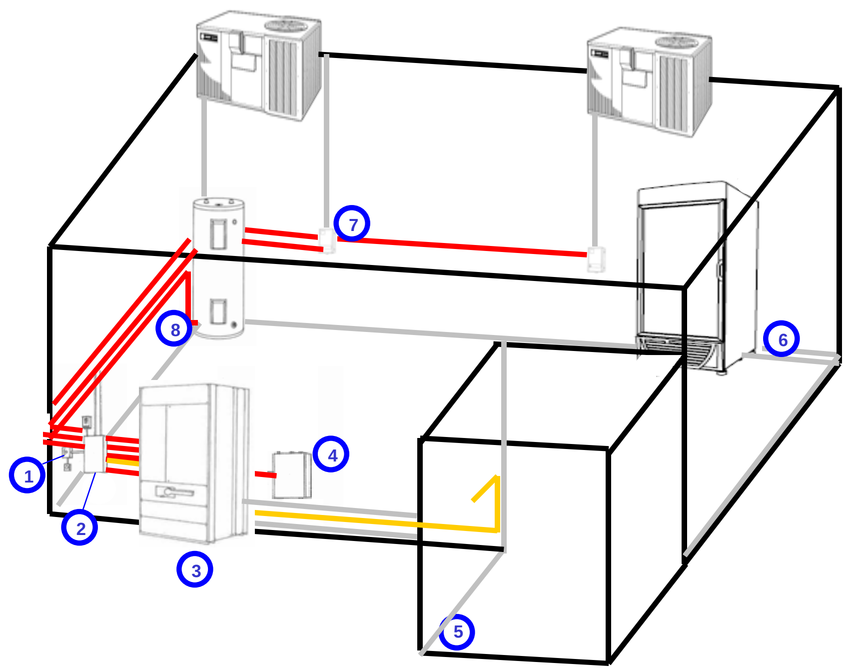
6 Novelty cooler or other controllable plug load on dedicated circuit

7 One- or two-stage thermostats for rooftop air conditioners

8 Water heater with two elements

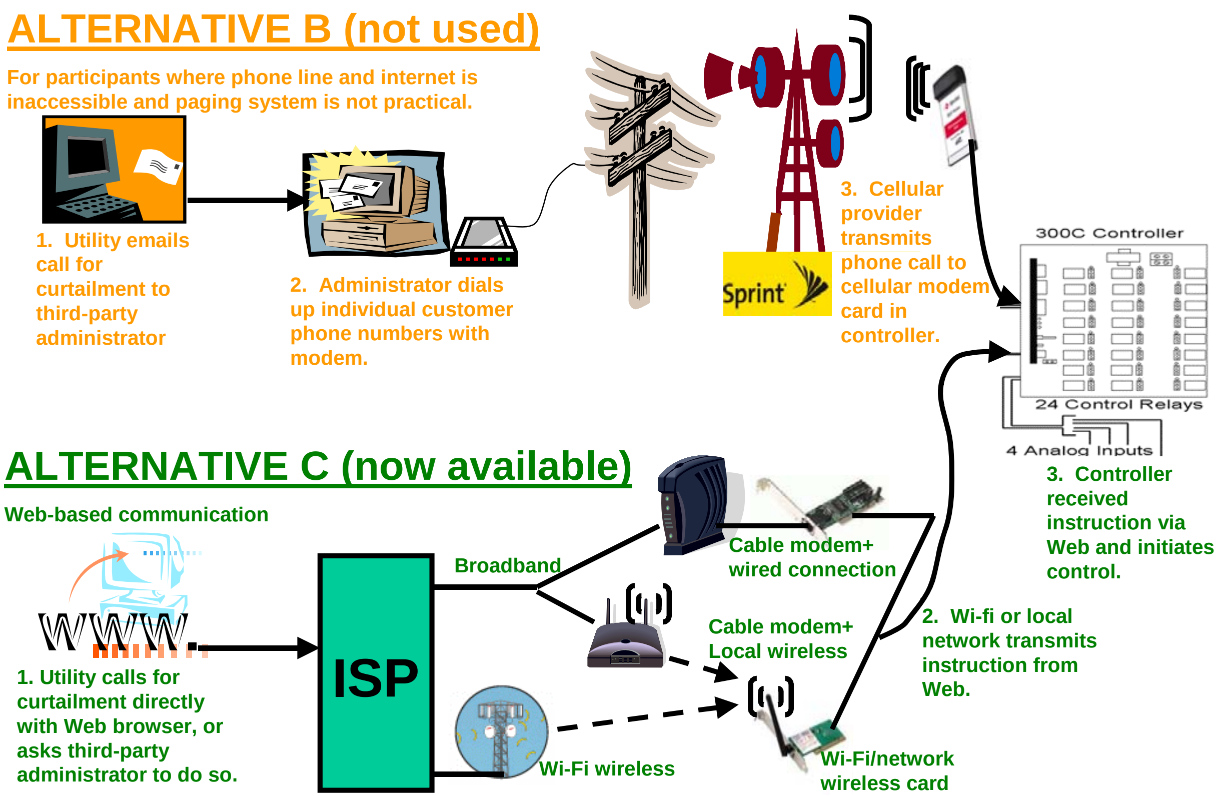
New control wiring

New monitor wiring



Dencor Pilot Program

Additional Communication Options



Dencor Pilot Program

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.

Dencor Pilot Program

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.

Dencor Pilot Program

Facility Type	Number
Restaurants	6
Retail Stores (No Refriger'n)	4
Office/Manufacturing	3
Office/Warehouse	3
Grocery Store	1
Retail Store (with Refriger'n)	1
Equipment Rental	1
Auto Dealer	1
Food Catering	1
Total	21

Dencor Pilot Program

Facility Type	Floorspace (sq. ft.)	Floors	Baseline (kW)
Restaurant “A”	5,000	1	96
Restaurant “B”	7,600	1	139
Beverage/Convenience Store	2,800	1	17
Retail store “A”	10,000	1	13
Restaurant “C”	2,800	1	59
Restaurant “D”	2,800	1	17
Office/Warehouse “A”	27,000	2	162
Grocery “A”	4,000	1	15
Restaurant “E”	3,800	2	50
Office /Warehouse “B”	10,000	2	26
Equipment Rental	13,000	2	23
Auto Dealer	6,000	2	87
Retail store “B”	40,000	2	37
Retail store “C”	6,000	2	30
Office/Manufacturing “A”	22,000	1	43
Office/Manufacturing “B”	10,000	2	18
Coffee Shop	2,000	1	21
Office/Warehouse “C”	97,500	2	67
Retail store “D”	23,000	2	42
Office/Manufacturing “C”	39,000	2	25
Food Catering	10,000	1	214

Description of Host Facilities

Dencor Pilot Program

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.

Dencor Pilot Program

Typical Installation Cost: $6,000

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.

Dencor Pilot Program

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).

Dencor Pilot Program

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.

Dencor Pilot Program

- 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).

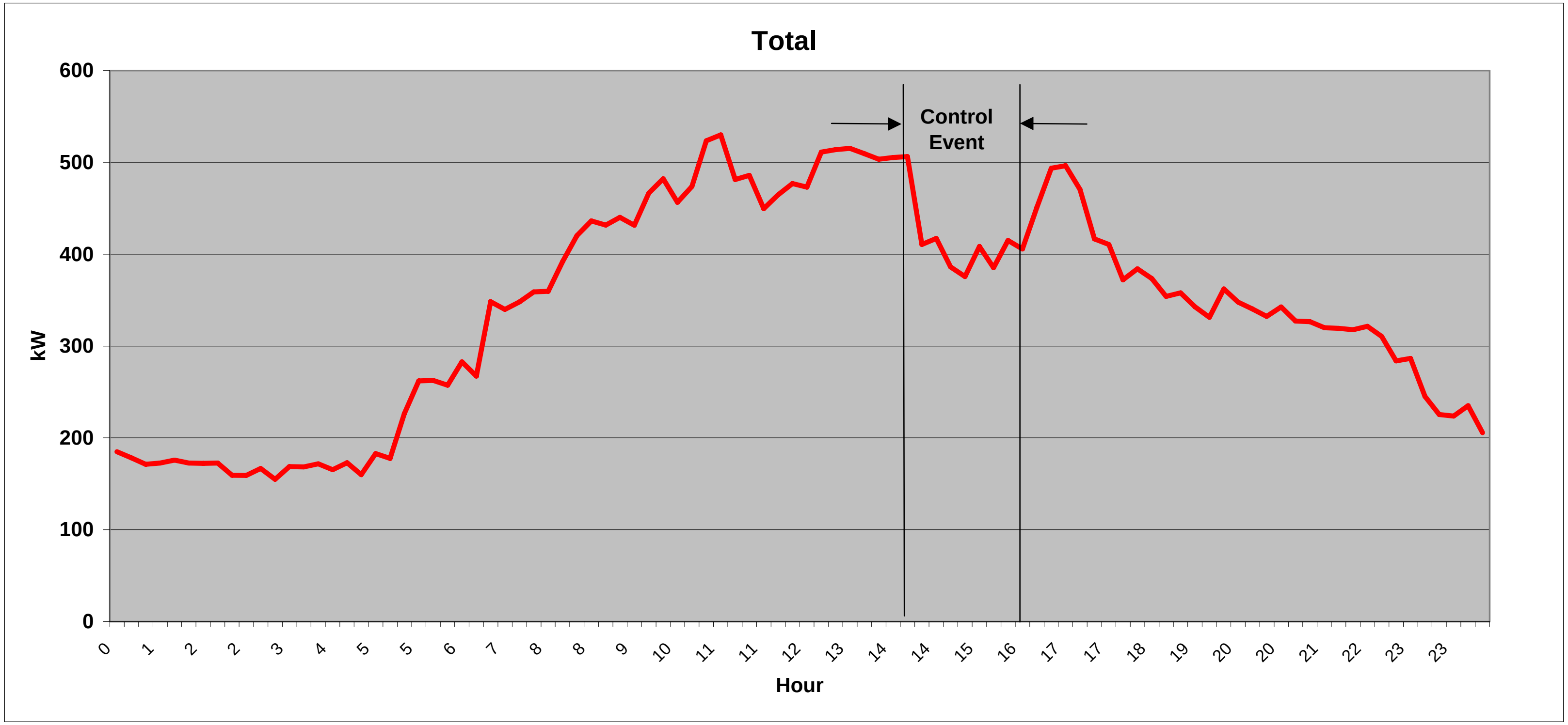
Dencor Pilot Program

- 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.

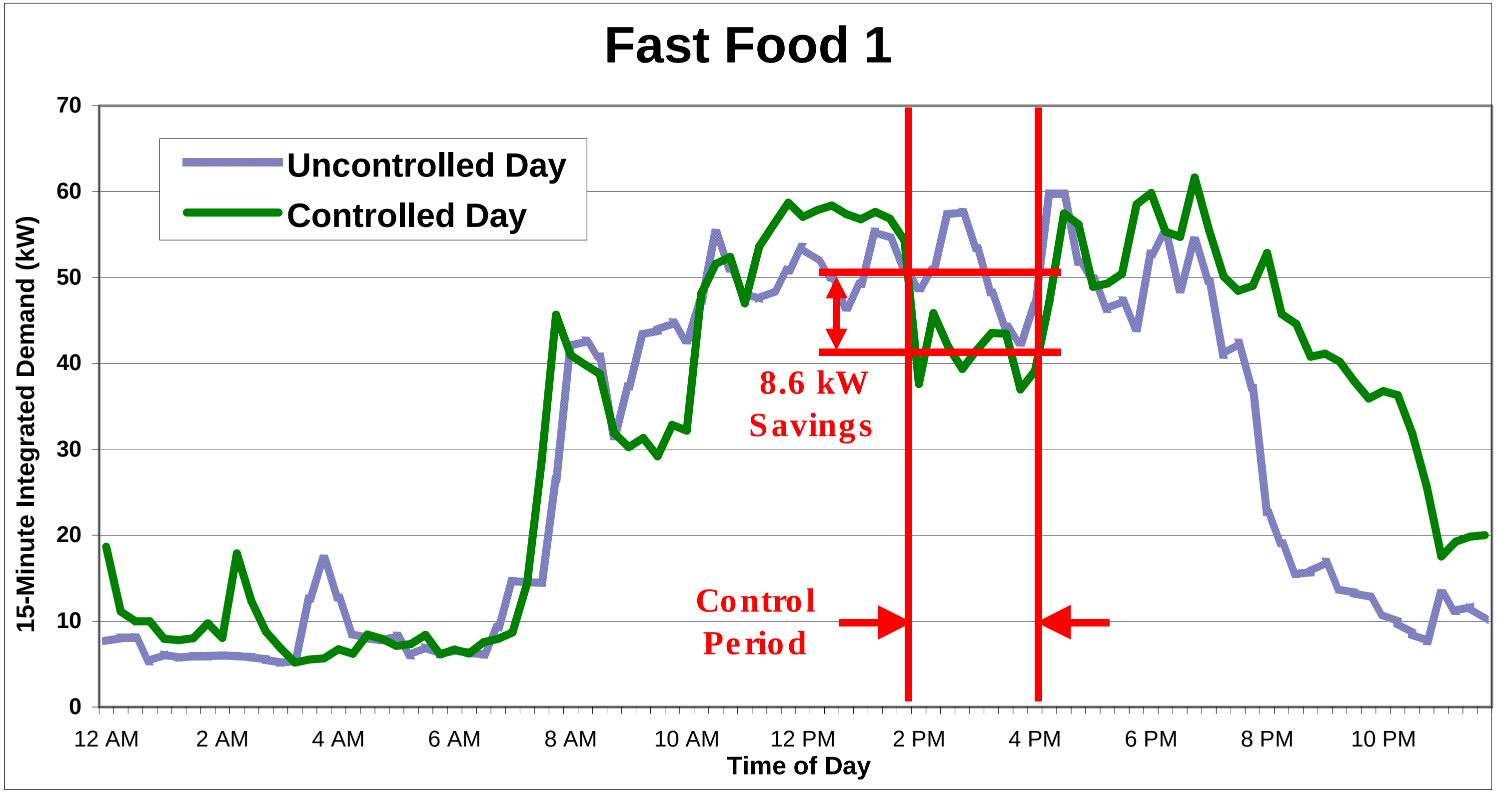
Customer Name	Baseline Day		Control Day		Adjusted Baseline Demand (kW Avg)	Demand Reduction (kW - %)	
	Noon-2 pm Demand (kW Avg)	2- 4 p.m. Demand (kW Avg)	Noon-2 pm Demand (kW Avg)	2-4 p.m. Demand (kW Avg)			
Retail Store “A”	32.5	33.4	31.8	24.0	32.7	8.7	27%
Limited Serv. Rest. “A”	49.4	49.9	52.3	38.2	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 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).

Dencor Pilot Program



Dencor Pilot Program



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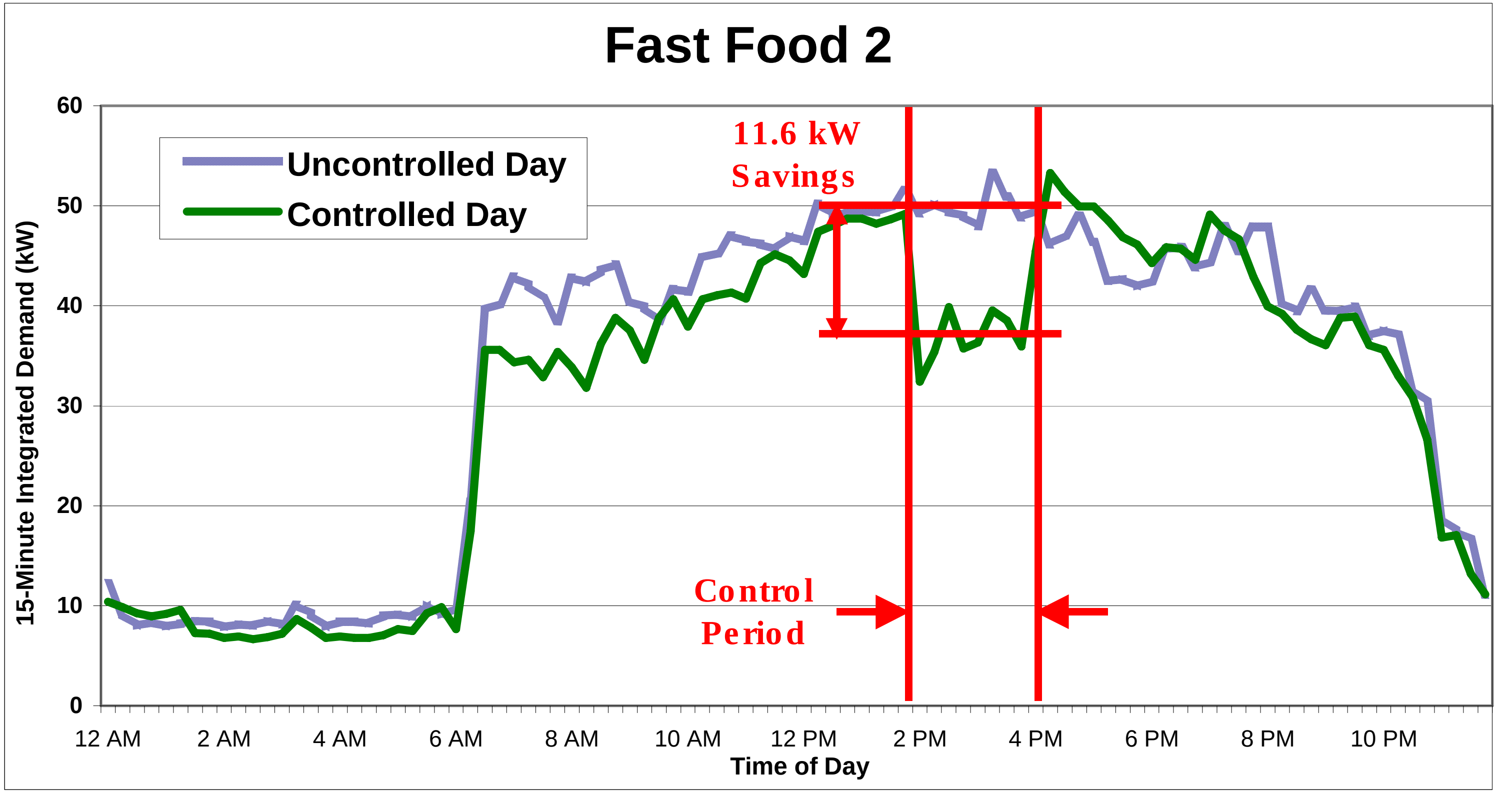

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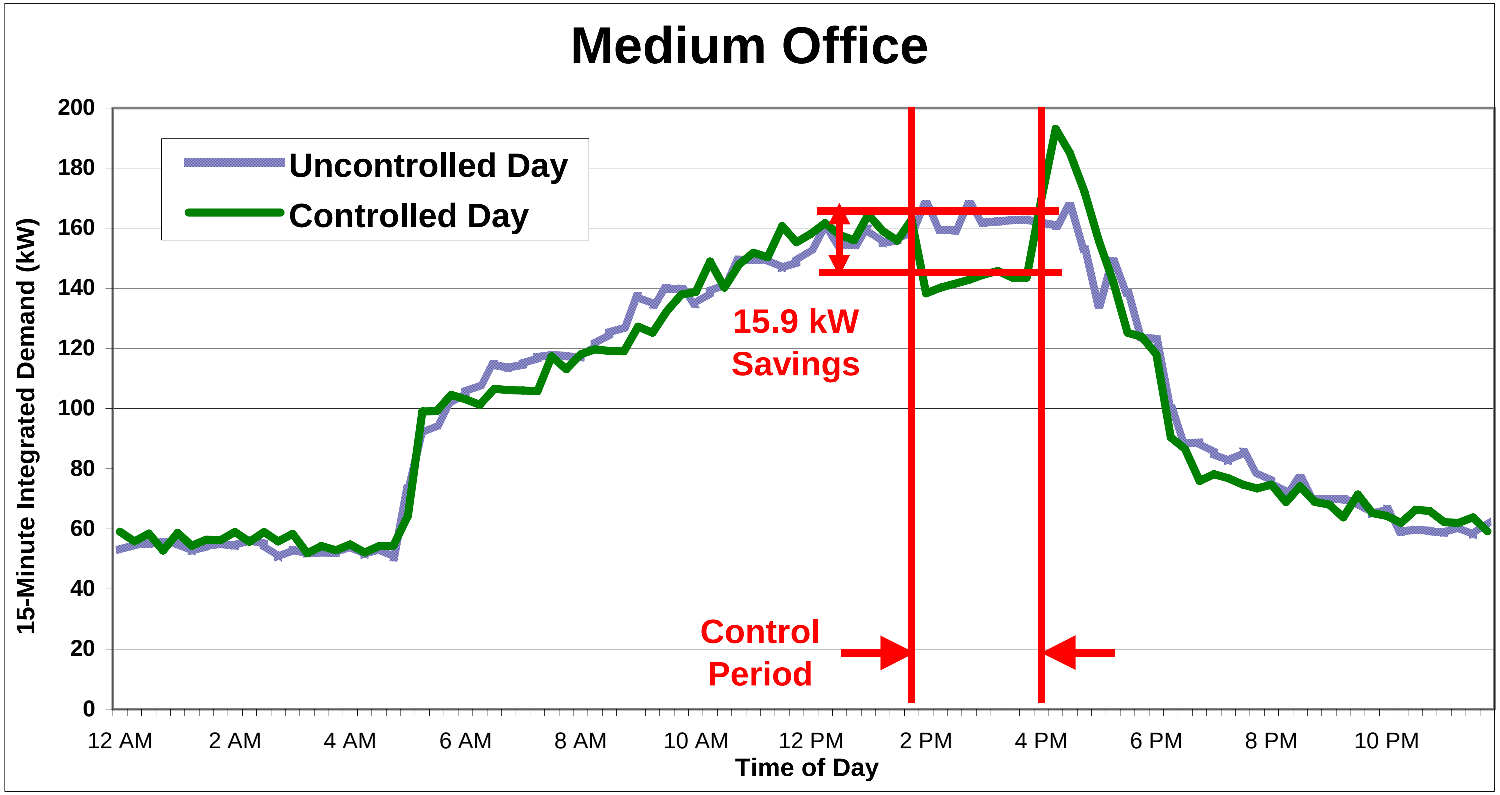

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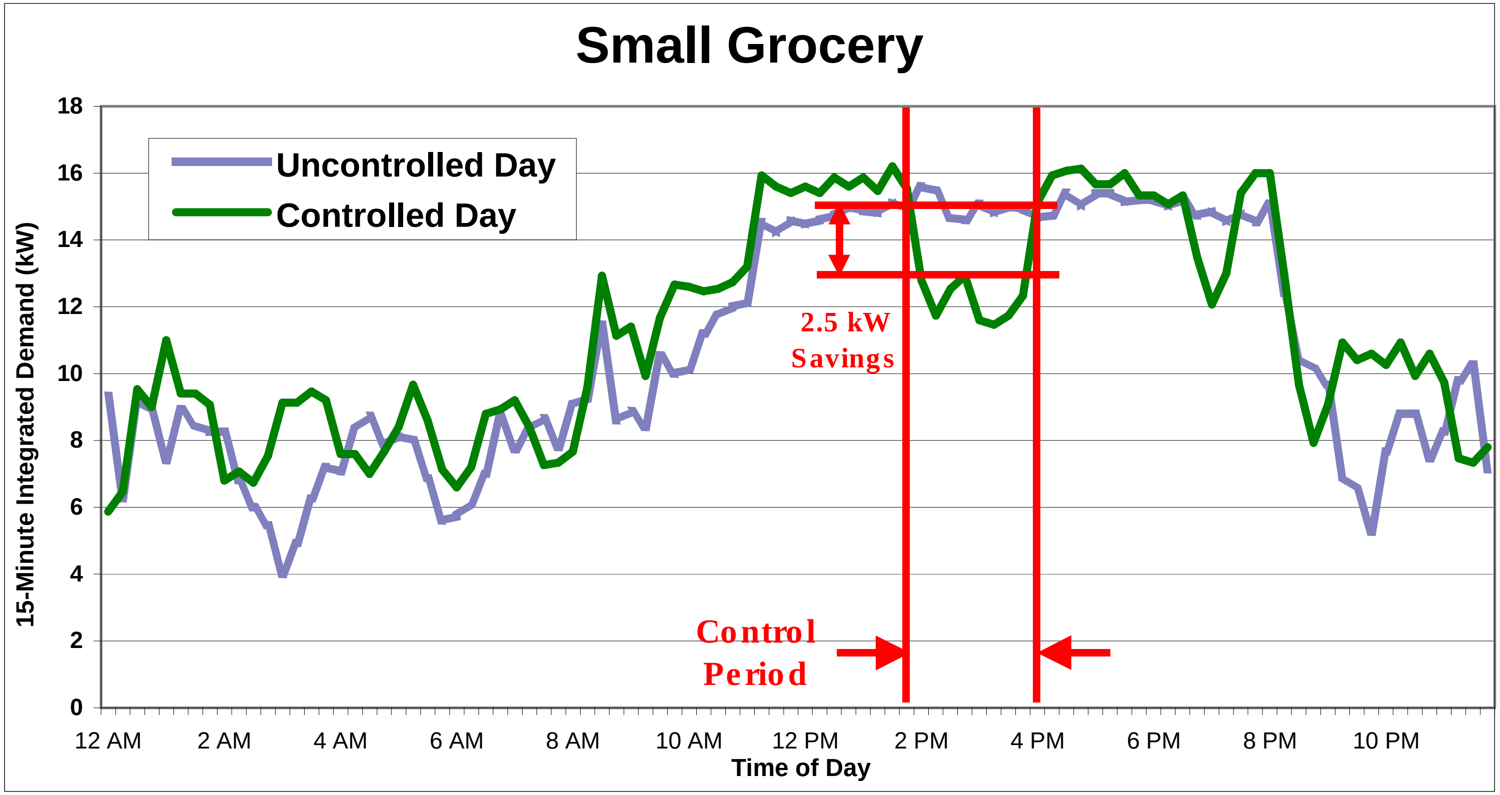
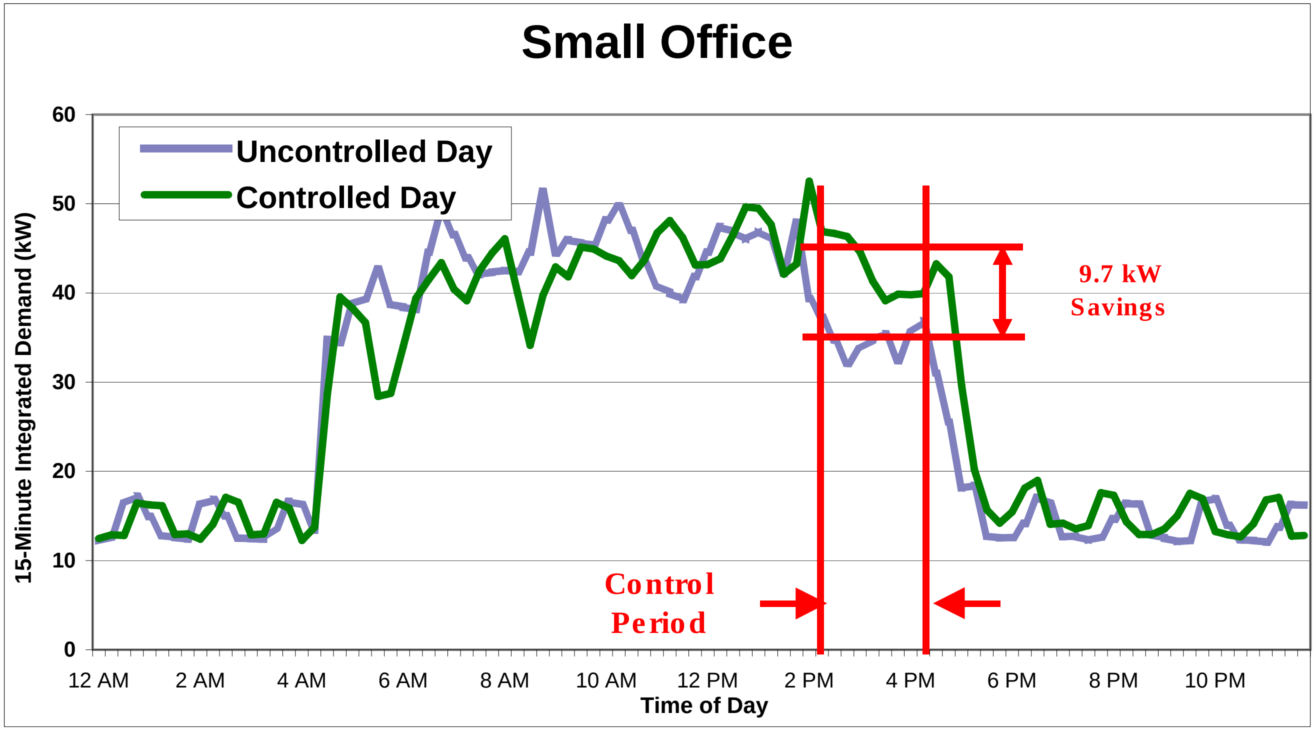


Dencor Pilot Program



Demand Reduction Results