Northwest Open Automated Demand Response Technology Demonstration Project

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DISCLAIMER

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Executive Summary

Introduction

Lawrence Berkeley National Laboratory (LBNL) and the Demand Response Research Center (DRRC) performed a technology demonstration and evaluation for Bonneville Power Administration (BPA) in Seattle City Light's (SCL) service territory. This report summarizes the process and results of deploying open automated demand response (OpenADR) in Seattle area with winter morning peaking commercial buildings. The field tests were designed to evaluate the feasibility of deploying fully automated demand response (DR) in four to six sites in the winter and the savings from various building systems. The project started in November of 2008 and lasted 6 months.

Methodology

The methodology for the study included site recruitment, control strategy development, automation system deployment and enhancements, and evaluation of sites' participation in DR test events. LBNL subcontracted McKinstry and Akuacom for this project. McKinstry assisted with recruitment, site survey collection, strategy development and overall participant and control vendor management. Akuacom established a new server and enhanced its operations to allow for scheduling winter morning day-of and day-ahead events. Each site signed a Memorandum of Agreement with SCL. SCL offered each site $3,000 for agreeing to participate in the study and an additional $1,000 for each event they participated. Each facility and their control vendor worked with LBNL and McKinstry to select and implement control strategies for DR and developed their automation based on the existing Internet connectivity and building control system.

Once the DR strategies were programmed, McKinstry commissioned them before actual test events. McKinstry worked with LBNL to identify control points that can be archived at each facility. For each site LBNL collected meter data and trend logs from the energy management and control system. The communication system allowed the sites to receive day-ahead as well as day-of DR test event signals.

Measurement of DR was conducted using three different baseline models for estimation peak load reductions. One was three-in-ten baseline, which is based on the site electricity consumption from 7 am to 10 am for the three days with the highest consumption of the previous ten business days. The second model, the LBNL outside air temperature (OAT) regression baseline model, is based on OAT data and site electricity consumption from the previous ten days, adjusted using weather regressions from the fifteen-minute electric load data during each DR test event for each site. A third baseline that simply averages the available load data was used for sites less with less than 10 days of historical meter data. The evaluation also included surveying sites regarding any problems or issues that arose during the DR test events. Question covered occupant comfort, control issues and other potential problems.

Results

- **Recruitment is a lengthy and on-going effort.** The teams experience in the Northwest is much similar to the early field test recruitment efforts in California. Recruitment is part education and part keeping on-going relationship with the participants to get them comfortable with the ideas that:
    - the service levels in their facilities will be diminished for a period of time;
    - on going assistance and monitoring will help them select detectable but at the same time acceptable DR strategies; and

- o they can opt-out anytime from any where.

- o **Healthy pipeline of customers enabled us to achieve the targeted number of customers.** Seven sites had indicated interest in participating in the study after the completion of initial sites surveys at ten facilities. Three of the sites could not participate in the test events due to:
    - o Limitations within control systems and the increased cost of overcoming these limitations.
    - o Communication problems within the control systems that prevented the research team to monitor and collect data from each test DR event.
    - o Decision to back out of the field tests due to concerns from tenants.
- **Lighting provides year-round DR**. While detectable, lighting sheds have short response time and can provide excellent year-round DR. However, there are less centralized lighting control systems and most lighting control systems in commercial buildings have local closed-loop controls that optimize for daylight availability.
- **HVAC systems with gas heating have limited savings opportunities.** Two buildings with gas powered roof-top units selected duty cycling as a DR strategy. The DR opportunities in these types of systems comes from fan and exhaust power savings.
- **All electric heating systems are the low hanging fruit.** Global temperature adjustment strategy, which is successfully tried in California to reduce peak demand during summer afternoons, worked well in one of the only all electric heating building. The zone temperatures were temporarily reduced to save on electric loads.
- **Adjustment periods for baselines must be considered.** Studies on baseline with data collected from buildings that participated in automated DR programs in California show that adjustments to the baseline increase accuracy and reduce bias. While morning adjustment periods are used for buildings with summer afternoon peaks, a good representative period must be used for adjusting baselines for winter morning peaking buildings.
- **Auto-DR concepts work for winter DR in commercial buildings.** This study showed that HVAC and lighting remain to be the major opportunities for Auto-DR in commercial buildings and with or without electric heating, there are opportunities in HVAC systems to reduce demand for a period of time to relieve the stress on the electric grid.

Recommendations and Future Directions

The project was a first step in demonstrating technology performance. There is a need to study and develop cold morning strategies for consumers who would like to participate in DR programs but may not know how. A guide that categorizes buildings and building systems and recommends DR strategies would be a suggested final deliverable. In addition, simulation tools that are developed for estimating DR capabilities for buildings in hot summer climates can be enhanced to support estimating cold winter morning DR capabilities in commercial buildings. We recommend a next phase for the project to evaluate the same technology and same test sites but consider DR strategies for demand savings summer days. The objectives of the next phase of the pilots are:

- To evaluate the commercial buildings capability to respond to DR events in dual peaking climates
- To develop methods for evaluating DR for buildings in dual peaking climates
- To consider the feasibility of geographically targeted DR.

OpenADR is currently in use by four electric utilities to automate their DR programs and has been adopted by a wide range of building and industrial controls companies. It is also identified as one of the 16 standards for the Smart Grid applications. A detailed specification for OpenADR was developed over a two year period and released as an official CEC/LBNL report (http://openadr.lbl.gov/). The OpenADR specification will be the basis of ongoing DR communications standards development efforts within both the Organization for the Advancement of Structured Information Standards (OASIS - http://www.oasis-open.org/home/) and the UCA International Users Group (UCAIug - http://www.ucaiug.org/). Both are highly regarded organizations that are active within the emerging "Smart Grid" domain. With the ongoing efforts within OASIS and UCAIug, OpenADR is on a path towards becoming a formal standard within organizations such as the International Electrotechnical Commission (IEC. - http://www.iec.ch/)

1. Project Background

California utilities have been exploring the use of critical peak pricing, demand bidding, and other form of demand response (DR) to help reduce needle peaks in customer end-use loads. These activities are forms of price-responsive demand response. Experience in California has shown that customers have limited knowledge of how to operate their facilities to reduce their electricity costs under these programs. At the same time LBNL through the Demand Response Research Center has been conducting research to demonstrate how price-response can be automated using standard XML-based communications with customer owned control systems. Fully automated demand response accounts for over 50 MW in California provided by over 200 customer facilities (Wikler et al. 2009). Many end-use customers have suggested that automation will help them institutionalize their electric demand reduction.

The overall goal of this research is to develop, demonstrate, and evaluate demand response technologies and strategies for commercial buildings in the Northwest. This initial effort is based on cold winter morning peaks to be addressed with DR that is automated based upon receipt of an emergency signal or rise in the price of electricity. In this system, a price signal,[1] was published on a single Web services server, available on the Internet using the meta-language, XML (Extensible Markup Language). Each of the participating facilities monitored the common price signal using Web services client applications and automatically shed site-specific electric loads when the price increased. This project demonstrated use of the Open Automated Demand Response Communication Specification (version 1) which is designed to facilitate DR automation without human intervention.

The structure of this report is as follows. The paper begins with a summary of previous work and additional background followed by a discussion of the project objectives (**Section 2**). **Section 3** outlines the project methodology covering the technology used for the automation, plus the DR test event design and steps for participation. **Section 3,** methodology also discusses the technical coordination role and introduces the DR controls strategies. The methodology section also covers the evaluation methods used in the study that include the baseline models, data collection methods used, evaluation of

[1] Price signal used for this project was either "Normal", indicating no change in the participants' actual rates, or "High", indicating a peak demand problem with the electricity grid.

the effectiveness of the automation, and surveys used in the study. **Section 4,** Results discusses the characteristics of the participants, automation systems used, DR controls strategies automated, and the use and results of automated DR test events for each site. The results section also provides an overview of the aggregated and individual facility demand reduction. **Section 5** is a discussion of key findings relative to the project objectives. **Section 6** presented recommendations and a discussion of next steps. **Section 7** lists key references. Extensive **appendices** provide details on the program design, technology, facility characteristics, and peak demand reduction data.

1.1. Prior Work

The Demand Response Research Center (DRRC) has been working with California utilities to develop a low cost automation infrastructure to improve DR capability; evaluate the readiness of buildings to receive price and reliability signals and evaluate control capabilities of current and future buildings. DR experience in California has shown that customers have limited knowledge of how to operate their facilities in order to reduce their electricity costs under CPP (Quantum 2004). While the lack of knowledge about how to develop and implement DR control strategies is a barrier to participation in DR programs, another barrier is the lack of automation of DR systems. Most DR activities are manual and require building operations staff to first receive emails, phone calls, and pager signals; and second, to act on these signals to execute DR strategies.

The various levels of DR automation can be defined as follows (Piette et al. 2005). **Manual Demand Response** involves a labor-intensive approach such as manually turning off or changing comfort set points at each equipment switch or controller. **Semi-Automated Demand Response** involves a pre-programmed demand response strategy initiated by a person via centralized control system. **Fully-Automated Demand Response** does not involve human intervention, but is initiated at a home, building, or facility through receipt of an external communications signal. The receipt of the external signal initiates pre-programmed demand response strategies. We refer to this as **Auto-DR**[2]. One important concept in Auto-DR is that a homeowner or facility manager should be able to "opt out" or "override" a DR event if the event comes at time when the reduction in end-use services is not desirable.

The experience in California with DR automation infrastructure led LBNL to develop open and interoperable specifications and to work with standards organizations to facilitate its adoption as a standard. From the customer side, modifications to the site's electric load shape can be achieved by modifying end-use loads. Examples of demand response strategies include reducing electric loads such as dimming or turning off non-critical lights, changing comfort thermostat set points, or turning off non-critical equipment. These demand response activities are triggered by specific actions set by the electricity service provider, such as dynamic pricing or demand bidding. Many electricity customers have suggested that automation will help them institutionalize their demand response. The alternative is manual demand response -- where building staff receive a signal and set in motion a set of activities to reduce demand. The LBNL research has found that many building Energy Management and Control Systems (EMCS) and related lighting and other controls can be pre-programmed to initial and manage electric demand response.

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[2] Previous terms such as Auto-DR and Open Auto-DR have also been used. OpenADR is an open, secure, two-way information exchange model that is used to publish Price and reliability signals for DR applications.

2. Project Objectives

The overall objective of this research is to understand commercial buildings' demand response technologies and strategies to address winter morning peaks in the Northwest upon receipt of an emergency signal or rise in the price of electricity.

Specific project objectives are:

- to demonstrate open automated DR communication systems in the Northwest, and
- to conduct an initial evaluation of opportunities for winter DR commercial building control strategies.

Additional points of consideration include:

- to evaluate DR baseline measurements and baseline methods for the winter commercial building shifts and sheds,
- to develop initial analysis methods of cold weather DR control strategies for commercial buildings, and
- to evaluate Northwest DR program design issues.

To achieve these objectives, LBNL assembled the following team for the project:

- Akuacom – Developed and maintained the DR automation server (DRAS) through out the demonstrations.
- McKinstry – Local engineering firm assisted in recruitment, DR audits, installations, configurations and commissioning of OpenADR compliant automation of DR.

3. Methodology

3.1. Technology

3.1.1. Control and Communication System Configuration

OpenADR systems use the public Internet and private corporate and government intranets to communicate DR test event signals that initiate reductions in electric load in commercial buildings. The DR test event signals are received by energy management and control systems, which perform pre-determined demand response strategies at the appropriate times. This section describes this system's technical details.

LBNL provided the participants either:

- Web Services DRAS Software Client development template [3]
- Or CLIR Box (see Appendix C)

The Web Services (WS) client is a software client that is typically embedded into an existing gateway device or building automation system. DR automation server currently supports Rest WS with plans to support SOAP and BACnet WS. CLIR box is a hardware device that maps price and event signals into dry contact relay closures.

The commercial building participants recruited for the demonstration agreed to work with their controls vendor or in-house staff to modify their system to be able to retrieve the XML signal or receive a control signal, and initiate an automated demand response. McKinstry coordinated installations, configurations, commissioning and iterations.

Once the OpenADR system setup was completed, LBNL published an XML DR test event signals via the Internet that contained information to represent electricity prices for the DR test event days. The project simulated and used a two-level price schedule: normal and high. The prices were "high" during the three hour DR test events. The Participant was able to override the test and "opt out" if needed. Since these were tests, participants' actual price of electricity was not affected. Seattle City Light offered $3,000 to each participant for their initial efforts and $1,000 per event for their participation.

The Demand Response Automation Server (DRAS) is the server for Internet-based system used to enable OpenADR. The DRAS was conceptualized and funded by California Energy Commission, Public Interest Energy Research (PIER), and the Lawrence Berkeley National Laboratory. (CITE) The DRAS provides a common signaling infrastructure for economic and contingency-based demand response. The DRAS allows each utility to communicate with energy service companies (ESCOs) and DR aggregators as well as customers in their territory. Since published open standards are used, ESCOs, aggregators and "trans-utility" statewide customers minimize development effort through use of the common interface. Industry standards such as XML, SOAP and Web services are used.

[3] http://www.openadr.org/pdf/openadr-client-develop.pdf

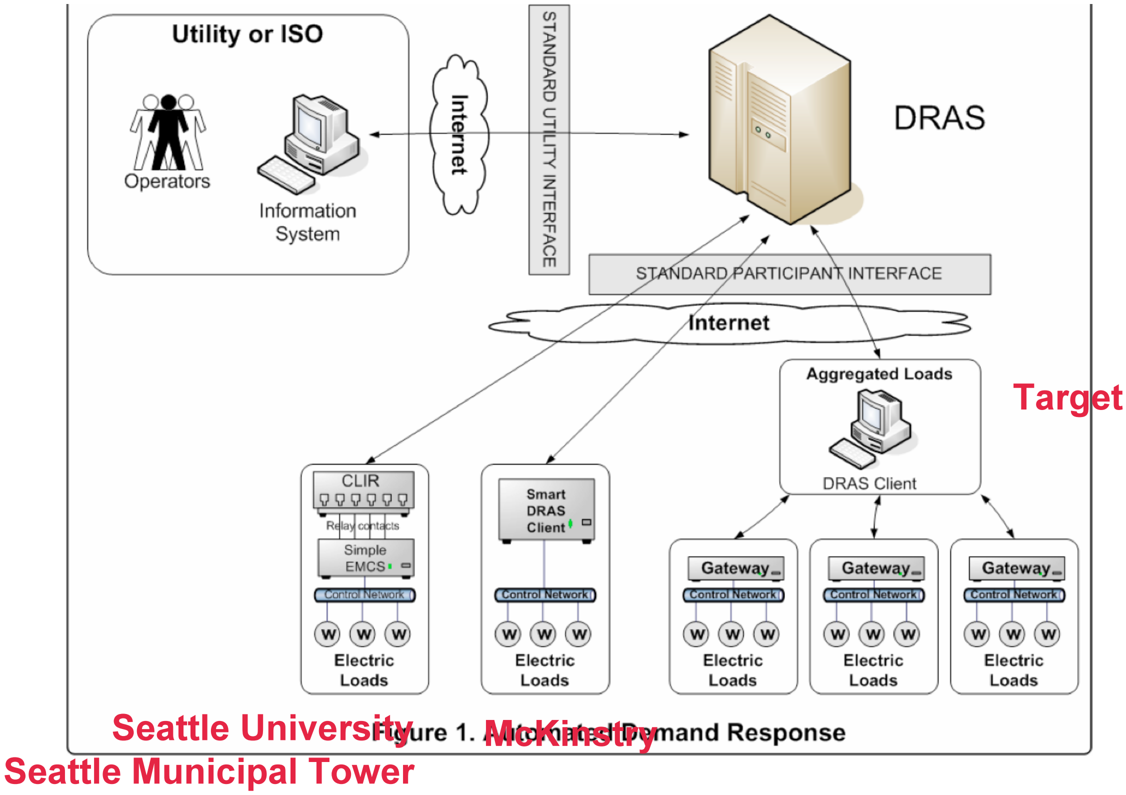

Figure 1: OpenADR system architecture

3.1.2. Automated Demand Response System Description

The DRAS is used to initiate DR control strategies through virtually any control system as well as via devices that control loads directly. Publishing OpenADR specification (OpenADR 2009) and making DRAS Web services client template available to the software client developers minimize the effort required by developers who wish to interface their systems to the DRAS. Sample files and descriptions are in the public domain. The client software continuously polls the DRAS to determine the timing and magnitude of demand response events. Logic to shift or shed electric loads based on DR signals and connectivity to each system is created using the existing control systems based on the requirements of the site.

3.1.3. The DR Automation Server

Several enhancements were made to the DR Automation Server. OpenADR specification was initially drafted and offered for review in May 2008. The specification that this DRAS was built to was published in April of 2009. The enhanced OpenADR (version1.0) compliant DR Automation Server 2009 supported the DR test requirements for Bonneville Power Administration (BPA) and Seattle City Light (SCL) DR test events. Figure 2 displays the front page of the DRAS Web interface.

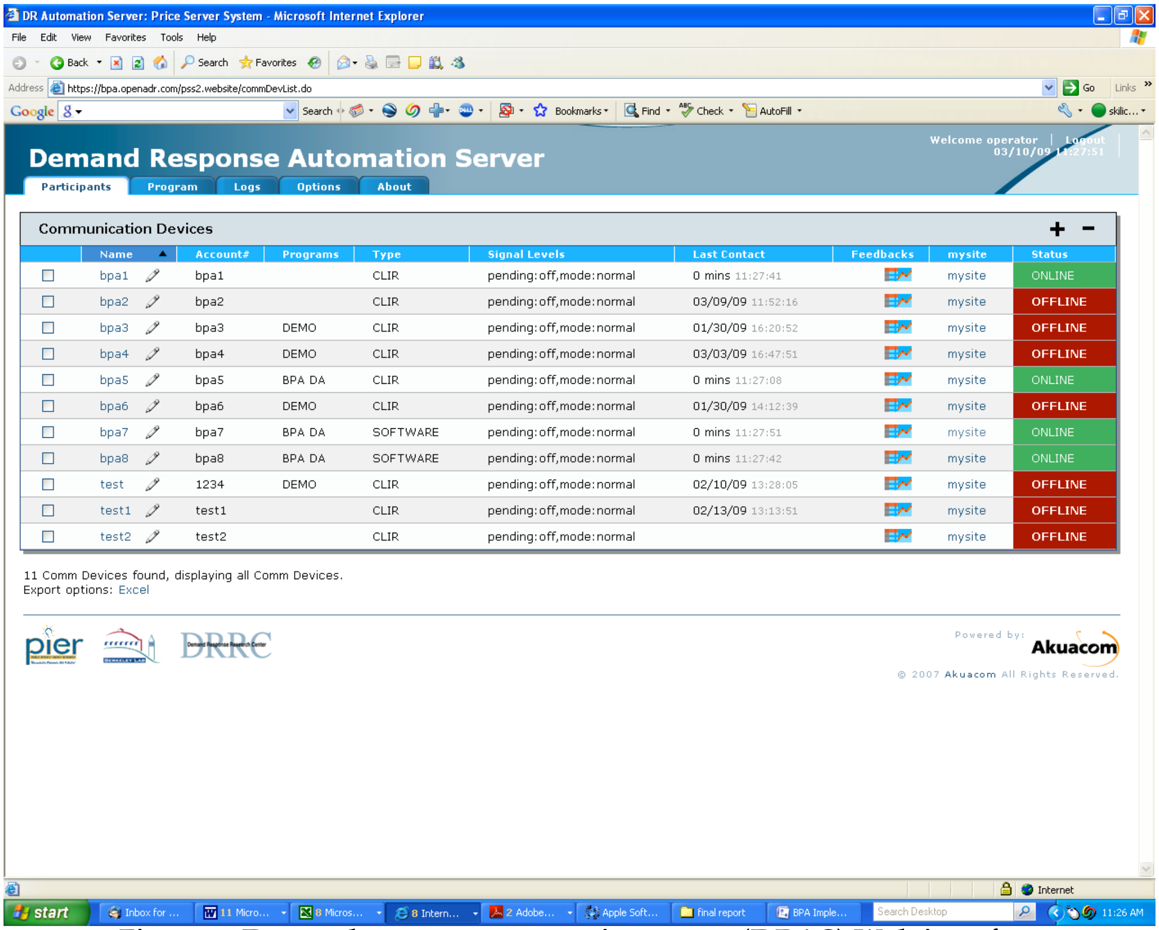

Figure 2: Demand response automation server (DRAS) Web interface

The front page of the DRAS displays each DRAS client, the DR program the DRAS client is participating in, the type of DRAS client (CLIR vs. WS software), current DR event signals, last contact with the client, a link to the meter data and online portal to the client, which is called "mysite". The link to each site's meter data, called "feedback", was not used in this project. The far right hand column shows whether the client is on-line or off-line. For these tests, each client was named "bpa" followed by a number. The clients remained in the "DEMO" program until tests were completed and they were assigned to day-ahead (DA) or day-of (DO) events. For day-ahead DR test events, a pending signal was sent at 3 pm the day before. For day-of events, the pending signal was scheduled to be sent at 6 am. This process was hard-coded into the system so whenever a day-of event was scheduled, the event notification was sent at 6 am on the day of the test DR event. During events, the pending is set to "on" and mode is set to "high". Akuacom configured and managed a dedicated server for this project.

3.2. DR Test Event Design

3.2.1. Requirements for Participation

The basic requirements to participate in the DR test events are as follows;

- Since SCL indicated that their system peak demand period was between 7 am and 10 am, the team looked for facilities with loads during this period.
- The sites are screened for an energy management control system (EMCS) or energy information system (EIS), or similar end-use devices.

- Since the DR automation infrastructure uses the internet to send DR event signals, access to the Internet (be able to access the Web at the site) is required. Having a Web-enabled EMCS was preferred but not required.
- Each site is encouraged to select DR control strategies that fit with their daily operations. Global zone temperature set point setup/setback, lighting reductions, or shutting off other non-critical loads are examples of such strategies. Each site's facilities staff was to develop these and other strategies that were best suited to their facility.
- Program or hardwire energy management control systems to curtail loads based on CLIR relay contact or XML signal. Simple program changes were conducted by staff or contractor.

In preparation for winter morning DR test events days, the participating sites and subcontractor worked with LBNL on the following tasks (see Appendix A):

1) **Sign Memorandum of Understanding (MOU) -** The MOU was designed for mutual communication purposes. It outlined responsibilities and described the payment of the participation incentive (Appendix B).
2) **Provide General Site Data -** LBNL requested general information about each site including: facility size, use, HVAC equipment type, etc. (Site surveys for each site are located in Appendix D)
3) **Define Electric Data Collection Methods** - Some commercial sites have local databases that archive data from electric meters, Energy Management Control Systems (EMCS) or Energy Information Systems (EIS). The MOU describes allowing access by LBNL project staff and the project subcontractors.
4) **Define Shed Strategies -** Successful strategies that were used in summer peaking climate were global zone temperature adjustment, duct static pressure reset, variable frequency drive (VFD) position limiting, chilled water valve position limiting, and reductions in lighting level (Motegi et al. 2007).

   We encouraged facilities management staff to come up with innovative shed strategies that are appropriate for winter morning periods.
5) **Establish Connectivity -** Each site was outfitted to receive the DRAS generated DR test event signals with one of the two following methods:
   - **Client Logic Integrated Relay Box (CLIR Box)** (see Appendix C)
   - **Web services client** – for sites that already have a gateway that connects the EMCS/EIS to the Internet
6) **Program DR Strategies into EMCS –** Once a method of receiving the price signals was established, the EMCS was programmed by the site's control vendor to facilitate the desired sheds upon a rise in price.
7) **Price Signal -** During the DR test event period each participating site and LBNL received e-mail notifications from the DRAS. SCL and LBNL worked together to select the coldest days to schedule DR test events. Akuacom scheduled DR test Events directly from the DRAS. During each DR test event, each participating site automatically reduced predetermined electric loads.

   In order to receive notification, customers need to have access to an e-mail address.
8) **Documenting the Shed** – LBNL and McKinstry collected whole-building/facility demand data for each site in the pilot. When available, we also collected detailed

data from an EMCS or other end-use meters to help us understand the dynamics of the DR control strategies.

3.2.2. Recruitment Process

The goal was to recruit 4 to 6 different types of facilities with varying system types. SCL and McKinstry identified and approached facility managers. Each site was offered a DR to determine if the site would be a "good candidate" for the study. A "good candidate" is identified as one that had loads in the morning periods and could be ready for testing by the beginning of February. Sites with interval meters and connection to SCL's MeterWatch utility information system were preferred.

3.2.3. Technical Coordination

The project team identified a need to work with a local engineering firm to assist in the coordination of fieldwork. McKinstry was retained to assist with recruitment, DR audits, DR strategy development, as well as overseeing controls vendors' activities at each facility to program and commission DR strategies. McKinstry was also instrumental in collecting meter data and trend logs.

3.2.4. Pre-evaluation of Sites

A pre-evaluation of sites to assess weather sensitivity and load variability was conducted to develop the DR baselines. Most of the sites that were approached for recruitment did not have meters that record and archive demand data in 15 minute intervals. There were two sites with archived demand date that LBNL evaluated their weather sensitivity and load variability, and developed plots that display minimum, maximum and average demand. One of these sites did not participate in the study because the building was not fully operational during the DR test event period. The other site was Seattle Municipal Tower. A plot that only includes weekday average, minimum and maximum 15-minute demand created for this site for the winter of 2008 is displayed in figure below.

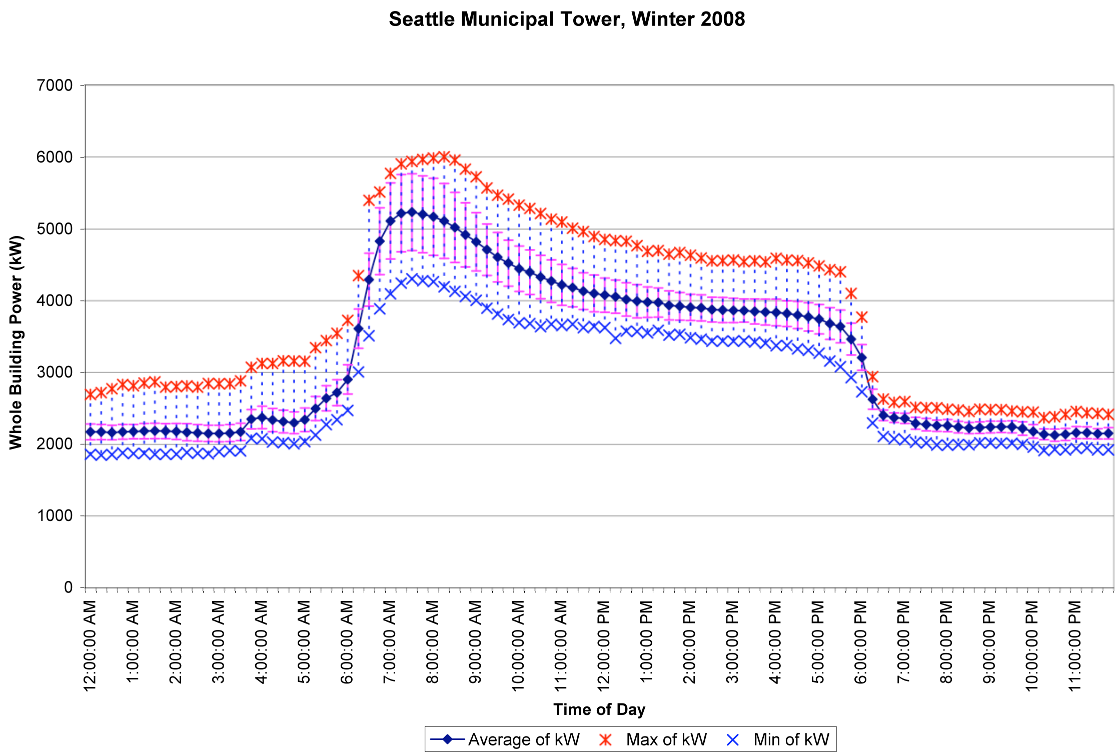

Figure 3. Seattle Municipal Tower 15-minute demand characterization for winter 2008

The plot in Figure 3 shows the average demand profile for all business days in January, February and March of 2008, standard error bars for the average demand as well as 15-minute minimum and maximum demand values within the selected period. This site is considered weather sensitive because the demand is highly correlated with outside air temperature. The demand has low variability during winter months. Variability is defined as the deviation of the load in each hour from an average calculated over all the business days.

3.2.5. DR Control Strategies

After the final site selection, potential DR control strategies were developed for each site. McKinstry visited each site to review the DR strategies with the customer and select the final plans. For a site to have a successful automated DR plan, they need to achieve a demand reduction consistently more than the standard error of the baseline over three hours during the DR test event period (Section 3.3.1). Later, the criteria also included load shape and required that a "successful" site would have a smooth load shape, free of oscillations during the DR period, with no after event rebound.

One challenge was to identify DR strategies for facilities with gas heating. When HVAC system is not the largest contributor to the peak electric demand within a building, demand reduction due to HVAC DR strategies may not be large enough compared to the whole building loads. While a combination of lighting and HVAC strategies were selected for one site, another site chose to reduce temperature set points and duty cycle roof-top units. Another challenge was to get the sites ready for test events by the beginning of February. Completing all the steps outlined in the previous section takes on average six months depending on the effort required for coordinating the process among facility managers, controls contractors, and upper management decision-makers

(Wikler 2009). In addition, there are often sites that go through the entire process and drop out due to unforeseen issues.

3.3. Evaluation

3.3.1. Peak demand baseline models

Three baseline models are used to calculate demand reductions. These are outside air temperature regression model, three-in-ten (3/10) baseline model and average of similar day baseline model. An afternoon adjustment factor calculation is proposed to improve the accuracy of the baseline model. This section describes the three baseline models and the afternoon adjustment calculations.

Outside air temperature regression model baseline

LBNL has developed a number of baseline models to estimate the demand savings from the DR strategies (Coughlin et al. 2008). The electric consumption data for each site were collected either through meter data monitoring and logging equipment installed at each facility or through Seattle MeterWatch which is available through SCL. The actual metered electric consumption was subtracted from the baseline-modeled demand to derive an estimate of demand savings for each 15-minute period. Previous research recommends a weather sensitive baseline model with adjustments for morning load variations for accuracy (KEMA-XENERGY, 2003). The LBNL model, which is used to calculate the summer afternoon demand reductions, uses outside air temperature (OAT) regression with a scalar adjustment for the morning load. Since the morning periods are when the DR test events took place in Seattle, morning adjustment component was replaced and tested with afternoon adjustment multiplier component.

First, the whole building power baseline is estimated using a regression model that assumes that whole building power is linearly correlated with OAT. The source of the OAT data is Boeing Field. Input data are 15-minute interval whole building electric demand and 15-minute interval or hourly OAT. The model is computed as shown in equition 1;

$$Li = ai + bi\ Ti \qquad (1)$$

where Li is the predicted 15-minute interval electric demand for time i from the previous non-DR work days. Depending on the frequency of the available weather data, Ti is the hourly or 15-minute interval OAT of time i. ai and bi are estimated parameters generated from a linear regression of the input data for time i. Individual regression equations are developed for each 15-minute interval, resulting in 96 regressions for the entire day (24 hours/day, with four 15-minute periods per hour. i is from 0:00 to 23:45). To develop the baseline electric loads for the demand savings we selected 10 "non-demand response" days. These 20 baseline days were non-weekend, non-holiday Monday through Friday workdays.

The demand savings estimates for most of the buildings and DR test event days are based on the baseline OAT regression model. The exception to this rule is that Target facilities did not have any historical data so for the first site and for the first events, we used as many non-DR days as available. If the model predicts a lower baseline than the actual demand at any given 15-minute of hourly period, it indicates negative demand savings. Negative demand savings are often found after a DR period as part of a "rebound" or recovery peak in which the HVAC or cooling systems tries to bring the thermal zones back to normal conditions.

The evaluation we perform includes quantifying the demand savings (kW) at each site, along with the savings in whole-building power reduction by percentage, and the demand intensity (W/ft^2). The demand savings is calculated by subtracting the actual whole building power from its baseline demand. The demand saving percentage is defined as the percentage of savings in whole building power. The demand-saving intensity (W/ft^2) is the saved demand (W) normalized by the building's conditioned floor area (square footage).

Three-in-ten (3/10) baseline

Utilities in California use the 3/10 baseline. Baseline electric load shape is the average hourly load shape of the three highest energy consuming days in the last ten work days (excluding holidays). The baseline algorithm for this project considers the site electric consumption from 7 am to 10 am when selecting the highest three days. DR test event days are excluded from the reference days. The 3/10 baseline may be lower than the actual demand if the site's demand is weather-sensitive, since a DR test event day typically occurs on a day with lower outside temperatures. If the previous ten working days are warmer than the DR test event day, the baseline tends to be lower.

For commercial buildings, OAT regression baseline calculates a more accurate and less biased baseline than 3/10 baseline (Coughlin et al. 2008).

As an example, Seattle Municipal Tower's participation in March 3rd DR test event is displayed in Figure 4. The chart shows the actual whole building power, the LBNL OAT regression baseline and the 3/10 baseline. These baselines estimate what the whole-building power would be if the demand response had not occurred. The vertical line at each baseline power data point is the standard error of the regression estimate. The vertical lines at 7 am and 10 am indicate DR test event period. On this day, 3/10 baseline is higher than the OAT regression baseline because there have been cooler days within the last 10 days that are used to develop the baseline. A more accurate baseline may be to use an OAT regression baseline with afternoon adjusted loads (OAT_AA). In OAT_AA baseline, an afternoon adjustment factor (ra) is multiplied by the each 15-minute-load. The factor ra is defined as the ratio of the actual to the predicted load in the four hours in the afternoon of the event day, as shown in Equation 2.

$$r_a = \sum_{i=1}^{n} L_{a,i} \Big/ \sum_{i=1}^{n} L_{p,i} \qquad (2)$$

Where, r_a is the afternoon adjustment factor,

$L_{a,i}$ is the actual hourly average loads on DR day at the hour's start at *i pm* ;

$L_{p,i}$ is the predicted load by baseline at the hour's start at *i pm*.; and

n is the number of hours which are used for adjustment (here *n*=4.).

Average of similar day baseline

For two of the sites whose interval meters were installed two days before the test events, the average of similar day baseline is used due to the limitation of accessible data range. For these sites, available data is averaged to develop the baseline for test event dates. As the events progressed, the average included non-test days to develop the baseline.

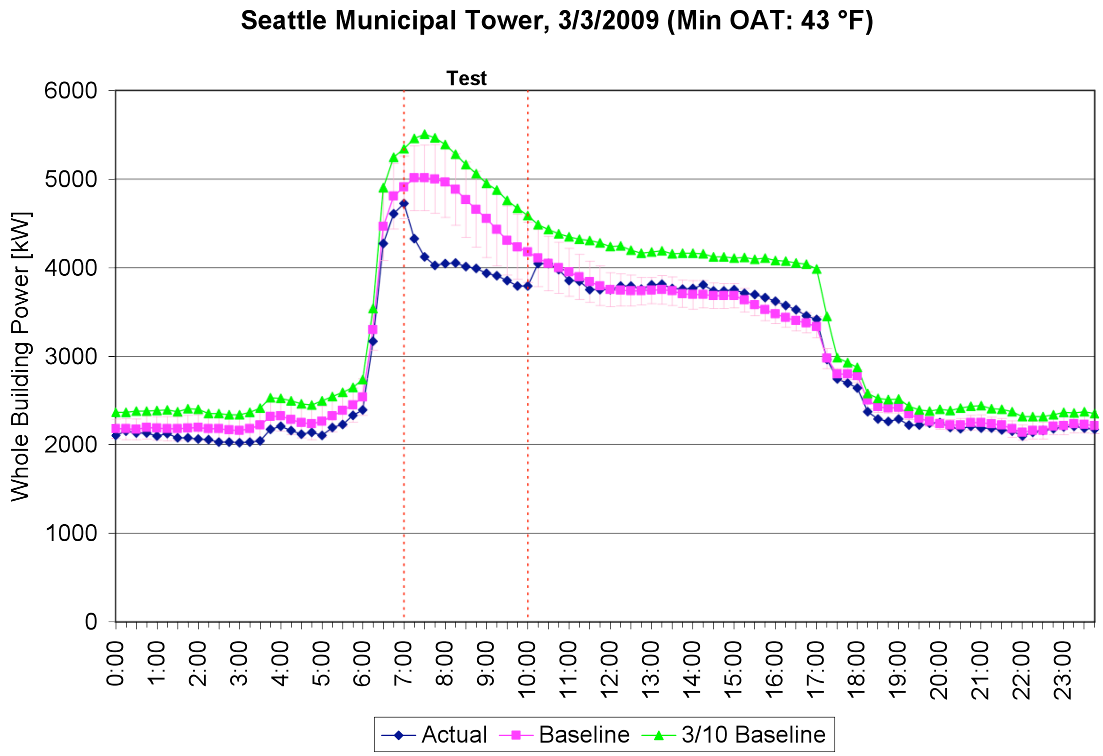

Figure 4: Whole building demand profile

3.3.2. Data collection

LBNL requested the collection of various types of data to evaluate the demand savings and changes in building systems and conditions. For all the participating sites, 15-minute whole building interval data was collected. A minimum of ten days of data prior to each DR test event was required to develop a baseline model. Some sites did not have interval meters so 15-minute demand data logging devices were installed. We also collected HVAC, control, communications, energy, and other building-related time-series data relevant to their demand response strategies. The data collection methods are described in Appendix E. Additional information about the effectiveness of the demand response strategies and issues that arose as a result of the tests was obtained by interviewing the responsible building engineer after each DR test event. Section 4.7 documents the results obtained from the post-test surveys.

Outside air temperature data

Outside air temperature (OAT) from Boeing Field were gathered for each site to develop the OAT-regression baseline model. The proximity of the OAT data to the site is summarized in Table 4.

3.3.3. Successfulness of participation

Each DR test event was reviewed after each event with special attention give to the first event. After the first event, depending on the load amount and load profile, each site received a "pass" or "fail" indication. While we continued to test technologies on the passed sites, failed sites had to re-visit their DR control strategies. LBNL worked with them to develop new strategies and the project provided funds to reiterate the strategies. There are five milestones that the "system", from the DR Automation Server to the end-use control strategy, has to meet in order for the system to work properly. These milestones are:

1. **Readiness**: The system was configured and ready to for commissioning.
2. **Commissioning of DR strategies**: At each site, DR strategies were commissioned by the control vendor or McKinstry and trend logs were set up before the site participated in the DR test events.
3. **Client to DR automation server communication**: When clients are brought on-line or when they go off-line, DRAS operator and site personnel receives an e-mail message. Failures to pass this milestone were generally caused by a defective client or network.
4. **Control of equipment**: End-use systems and equipment were controlled as planned. These included HVAC equipment, lighting and other equipment that generates electric loads.
5. **Effectiveness**: To pass this milestone, the planned demand response strategy must have been proven to effectively reduce electric demand. Effectiveness was tested by comparing the average power (kW) saving during the test to the average standard error of the regression model. The demand response strategy was considered effective if in the high price period, the average power savings over the 3-hour period was larger than the average of the standard error in the baseline model.

3.3.4. Surveys

Site Survey

This is a detailed survey to collect the following information from each site that participates in the pilot study. Key data collection fields include:

- Site contact information
- Building information
- Electric Demand
- HVAC system
- Domestic Hot Water
- Lighting system information
- Process and other equipment loads

Appendix D contains all the sites surveys collected from all the sites that participated in DR test events.

Post-Event Survey

After each CPP event, each site is reminded to answer the post-event surveys. This survey proposes questions in order to collect the perception of the facility operator about the automated CPP day. Examples of questions are as follows:

- Was the operator on site and watching the event?
- Did he notice a change?
- Were there any operational issues?
- Did the occupants notice any difference?
- Were there any complaints?

3.3.5. Project Timeline

Table 1 summarizes the project timeline and progression. The project started in early November 2008. The first training session for the team took place on November 18. BPA, SCL, McKinstry, Akuacom and LBNL participated in the all-day training. The training session consisted of a presentation by LBNL on project methodology and a presentation and hands-on training by Akuacom on the DR automation server and client technologies. Recruitment started right after the training and lasted three months. Ten sites filled the site survey and only six were selected to participate in DR test events. LBNL scheduled a half-day training session for the installation contractors to explain DR and DR strategies. While Akuacom configured the DR automation server (DRAS), site installations and commissioning of DR strategies continued. Winter DR test events started on February 28th and ended with the last event on March 20th. LBNL analyzed collected data after each event and provided feedback to the participants on their performance. The project report was finalized in the first week in June.

Table 1. Actual project timeline

Tasks	Timeline
Team Training	11/18/2009
Recruit Sites	12/1/ 2008 - 3/1/2009
Site Audits	12/18/ 2008 - 3/1/2009
Train Installati on Contractor	1/13/2009
Confi gure DRAS	12/1/2008 - 2/1/2009
Site Installati ons	2/1/2009 - 3/5/2009
Winter DR Test Events	2/18/2009 - 3/20/2009
Evaluate Results	2/18/209 - 4/20/2009
Report Findings	6/1/2008

4. Results

This section outlines the key results from the 2009 Northwest OpenADR technology demonstration tests. This section begins with a review of the participant characteristics followed by DR strategies and results from their participation in four DR test events.

4.1. Site Profiles

This section describes the five sites that participated in the 2009 Northwest OpenADR technology demonstration tests. Table 2 lists the site name, location, building use, floor space, and peak electric demand winter 2009. The participant buildings include two office buildings, one higher education facility and two retail stores. Each site participated in three day-ahead events and one day-of event as described in Section 3.1.3.

Table 2: Summary of site information

Site	Site Address	Building Type	Gross Floor Area ft^2	Year Constructed	Peak Load kW	Peak W/ft
McKinstry	5005 3rd Avenue S	Office	100,000		347	**3.5**
Target - T1284*	302 NE Northgate Way	Retail	165,667	2000	685	**4.1**
Target - T0637*	2800 SW Barton St.	Retail	99,471	1990	225	**2.3**
Seattle Municipal Tower	700 Fifth Avenue	Office	1,200,000	1989	6168	**5.1**
Seattle University	901 12th Avenue	Education	99,840	2001	841 kVA	**8.4**

The following sections will describe the test results from all sites except Target - T0637. Although this store participated in the study, metering data were unavailable due to several trend historian issues. Therefore, this site is eliminated from the results section. In addition to the sites that participated in the project, four sites were studied in detail. The site surveys, completed for each of these facilities, are included in Appendix E. All four sites had shown interest in participating in the demonstration project. Two out of four sites were unsuitable for the study because they are mix-use buildings where DR strategies could be carried out only in one part of the building.

4.2. Northwest OpenADR System Profiles

4.2.1. OpenADR Communications

Table 3 summarizes the connectivity options used by the sites. Of the five sites the two Target stores and McKinstry utilized the software clients. Target built on their experience with Auto-DR in California for their software client development effort. The new software client they built adheres to the OpenADR Specification Version 1.0. McKinstry worked with Richards Zeta which developed the software client and embedded into their Mediator™ device. The remaining two sites installed CLIR boxes onsite. No information technology problems occurred during or after the installation of the CLIR boxes. In one facility, the CLIR box had to be replaced because it required repeated reboots. This box was tested before it was shipped out, and it is believed that it was damaged during shipping , which caused the hardware failures.

Table 3: Communication profiles by site

Site	Client UN	Client Type
McKinstry Seattle	bpa7	WS Client
Target - T1284	bpa8	WS client
Target - T0637		
Seattle Municipa Tower	bpa5	Hardware Client (CLIR)
Seattle Univ.	bpa1 (formerly bpa2)	Hardware Client (CLIR)

4.2.2. Site Data Collection

Table 4 lists the distance from each site to the outside air temperature (OAT) data source used for each participating site. The data were used to develop the OAT regression baseline. EMCS data were collected and analyzed at each facility. The data allowed to confirm the operation of the strategies and evaluate the indoor conditions during DR events. The detail analysis of the EMCS data is described in Appendix D.

Table 4: Outside air temperature source by site

Site	Distance to Boeing Field
McKinstry	2.3 miles
Target - T1284	12.4 miles
Target - T0637	3.2 miles
Seatt le Municipal Tower	5.4 miles
Seatt le Univ.	5.6 miles

4.2.3. DR Strategies at Each Site

Throughout the previous studies in California, which addressed the summer afternoon peak demand, the global temperature adjustment (GTA) strategy was found to be effective and one of the least disruptive DR strategy (Motegi et al. 2007). To develop heating strategies, the heating system had to be studied in detail. If the building system used gas for heating, the only potential saving from GTA is the savings from fan power in variable air volume (VAV) systems. When the heating setpoint is reduced, the fans that supply heat to a zone will temporarily slow down or stop thus reducing the electric demand. Of the five buildings that participated in the OpenADR test events, two Target stores participated with both lighting and HVAC system reductions. SMT has all electric heating and employed the GTA as a strategy. Seattle University selected preheating as a strategy and turned off electrical heating units as well as adjusting temperature setpoints. McKinstry duty cycled roof-top units. Detailed description of the strategies and comments on these sites are as follows:

- **Target (both stores):**
  - **DR Strategy:** Turn off 50% of sales area lights, turn off two out of 12 roof-top units and decrease setpoints by 2 ºF.
  - **Recovery:** No known recovery strategy
  - **Issues:** stores did not have interval meters therefore additional meters had to be installed.
- **Seattle Municipal Tower**
  - **DR Strategy:** Decrease setpoints from 72 ºF to 68 ºF on selected 24 floors out of 62 floors. Cycle VAV boxes (690) and corresponding AHUs (48).
  - **Recovery:** Set setpoints back 1º every 15 minutes and bring back quarter of the equipment on line every five minutes.
  - **Issues:** The site completed the DR strategies programming only on selected floors due to time limitations.
- **McKinstry**
  - **DR Strategy:** Uniformly turn off half of the 23 roof-top units for 15 minutes and alternate with the remaining units every 15 minutes.
  - **Recovery:** Stage turning on equipment every 2 minutes.
  - **Issues:** This site was also not connected to SCL's MeterWatch utility information system.

- **Seattle University**
  - **DR Strategy:** Pre-heat at 5 am at 74 ºF (only on the day-ahead days because pending signal for day-of events are received at 6 am) Decrease set point to 68 ºF. Cycle cabinet heaters (7) and unit heaters (2) 20 minutes every 30 minute. Cycle through half of VAV/Air terminal boxes (75) and AHU fans (4) every half hour. Set CO_2 setpoint up by 200 ppm. Turn off hot water panel radiator.
  - **Recovery:** Return setpoints to original levels (maximum rate of setpoint change is 1º per 15 minutes) and turn half of units on, then turn remainder of units on five minutes later.
  - **Issues:** This site also did not have an interval meter. A logger was installed for the duration of the project.

Table 5 displays a range of DR strategies that were discussed with the sites and summarizes the DR control strategies chosen by each site.

Table 5. Summary of DR control strategies

	HVAC												Lighting					Other		
Site	Global temp. adjustment	Duct static pres. decrease	SAT decrease	Fan VFD limit	RTU Shut off	Duty Cycling RTUs	Pre-heating	Fan-coil unit off	Cycle electric heaters	Cycle AHU Fans	Cycle VAVs	Set up CO2 Setpoints	Common area light dim	Office area light dim	Turn off light	Dimmable ballast	Bi-level switching	Non-critical process shed	Elevator cycling	Slow Recovery
McKinstry						X														X
Target - T1284	X				X												X			
Seattle Municiple Tower	X									X	X									X
Seattle University	X					X	X		X	X	X	X								X

4.3. Automation of Events

This project successfully demonstrated that using OpenADR specification to deliver automated DR is technically feasible with existing technology and buildings can provide significant levels of automated demand response on winter mornings. This section discusses the key results from the buildings that participated in the OpenADR test events. Starting with a summary overview of each site's participation in the DR test process and events, summary results for DR test events are discussed. See Appendix E for further information and detailed event results for each site.

4.3.1. Participation Summary

OpenADR test events started on February 18th. Total of 12 events were scheduled to make sure that all sites participate in four events, one of which is a day-of event. As the sites were enabled, events were called to capture cold winter mornings. There is no one event that all the sites participated. However, on March 11th, four out of five sites participated in DR test events.

Table 6: Summary of Event Participation

	18-Feb	25-Feb	3-Mar	5-Mar	9-Mar	10-Mar	11-Mar	12-Mar	16-Mar	18-Mar	20-Mar
Site	Test 1	Test 2	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	Test 11	Test 12
McKinstry Seattle	Day Ahead	Day Ahead		Day-Of			Day Ahead				
Target - T1284			Day Ahead	Day-Of	Day Ahead		Day Ahead				
Target - T0637							Day Ahead		Day-Of	Day Ahead	Day Ahead
Seattle Municipal Tower			Day Ahead	Day-Of	Day Ahead		Day Ahead				
Seattle Univ.						Day Ahead		Day Ahead	Day-Of	Day Ahead	

4.4. Demand Savings

This section describes the results of the demand reduction savings analysis of the OpenADR technology demonstration project. Throughout this report, the demand savings are based on LBNL's OAT regression model baseline unless otherwise noted. Savings estimates based on the 3/10 baseline are also shown. First, summary of each site's performance is presented, followed by aggregated savings on March 11 where four out of five sites participated in the test event.

4.4.1. Individual Sites

In this section, for each site, the demand profiles for best performing and worst performing days are discussed. The performance criterion was based on percent demand reduction.

McKinstry

McKinstry's initial strategy was to uniformly turn off half of the 23 roof-top units for 15 minutes and alternate with the remaining units every 15 minutes. The impact of this initial strategy on the first test DR event on February 18 on the load profile and the demand reduction amount is displayed in Figure x below.

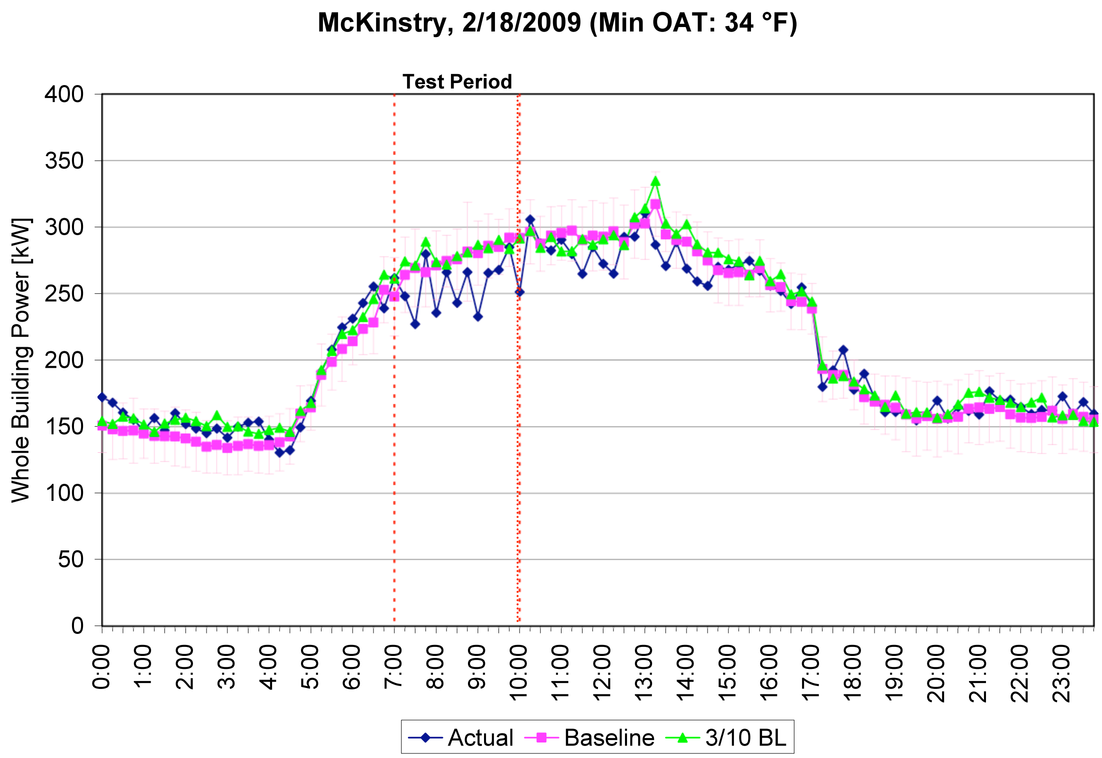

Figure 5. Demand profile of McKinstry from DR test on February 18, 2009

There are two problems with this demand profile: 1) the shape itself is not smooth and displays unsteadiness; and 2) "successful" criteria is not met, i.e. for a site to be "successful", they needed to achieve demand reduction consistently more than the standard error of the baseline over three hours during the DR test event period. After this feedback, the site extended the duty cycling period, balanced the load of the turned-off rooftop units, and worked on slow DR recovery strategies such that instead of bringing equipment on every minute, the roof-top units were staged.

Table 7. Hourly average and maximum demand savings of McKinstry on February 18, 2009

Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Feb-18	OAT BL	7:00-8:00	42	20	0.42	0.20	16%	7%
		8:00-9:00	48	26	0.48	0.26	17%	9%
		9:00-10:00	41	21	0.41	0.21	14%	7%
		7:00-10:00	48	22	0.48	0.22	17%	8%
	3/10 BL	7:00-8:00	44	29	0.44	0.29	16%	11%
		8:00-9:00	54	27	0.54	0.27	19%	10%
		9:00-10:00	40	20	0.40	0.20	14%	7%
		7:00-10:00	54	26	0.54	0.26	19%	9%

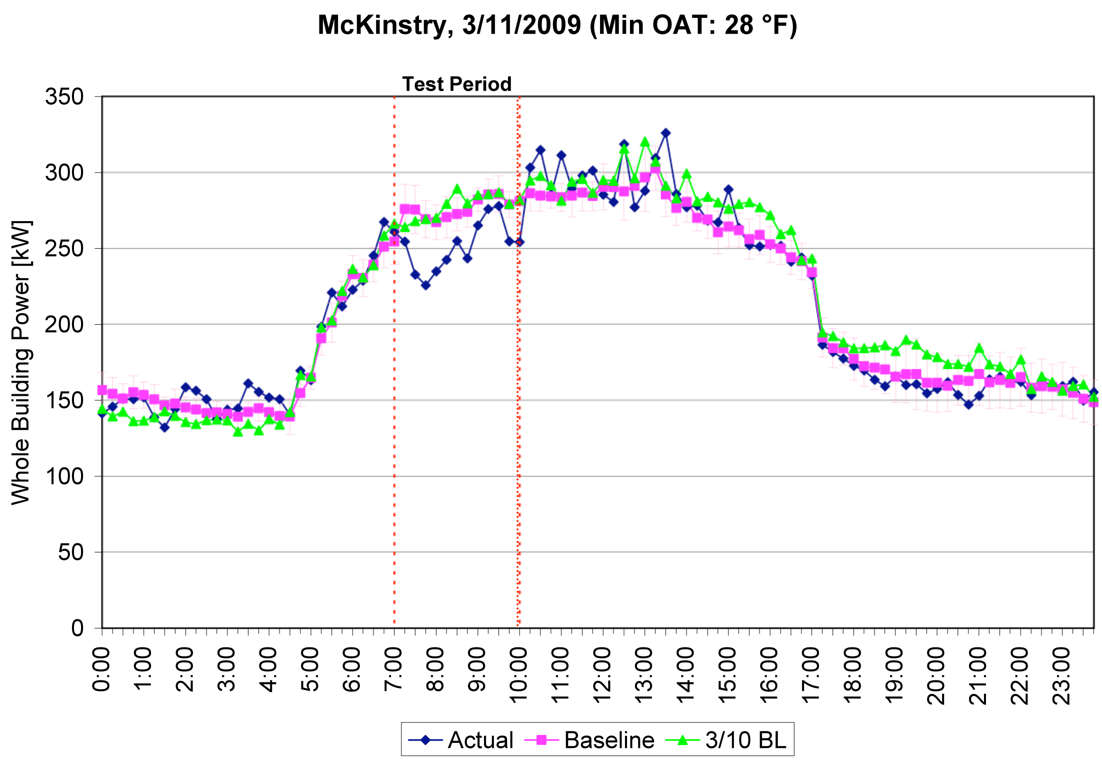

Figure 6. Demand profile of McKinstry from DR test on March 11, 2009

The effects of the DR strategy iteration are displayed in Figure 6. This site achieved a deeper shed which remained outside of the standard error during the DR period. The summary of the three hour DR test period is displayed in

Table 8.

Table 8. Hourly average and maximum demand savings of McKinstry on March 11, 2009

Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-11	OAT BL	7:00-8:00	44	35	0.44	0.35	16%	13%
		8:00-9:00	31	23	0.31	0.23	11%	9%
		9:00-10:00	27	17	0.27	0.17	10%	6%
		7:00-10:00	44	25	0.44	0.25	16%	9%
	3/10 BL	7:00-8:00	44	31	0.44	0.31	16%	11%
		8:00-9:00	37	32	0.37	0.32	13%	11%
		9:00-10:00	28	18	0.28	0.18	10%	6%
		7:00-10:00	44	27	0.44	0.27	16%	10%

Target Stores

None of the Target stores were on SCL's MeterWatch system and both required the installation of meter data collection and monitoring devices. Both monitoring devices were then connected with Target's enterprise EMCS system. Due to a problem that occurred in this system, the meter data and trend logs were not available for the second store. Therefore, in this section, only data for Target T1284 store is presented. The baseline used is an averaging baseline explained in detail in Section 3.3.1 and does not have the standard error bars. There were only two days of data collected before the first event.

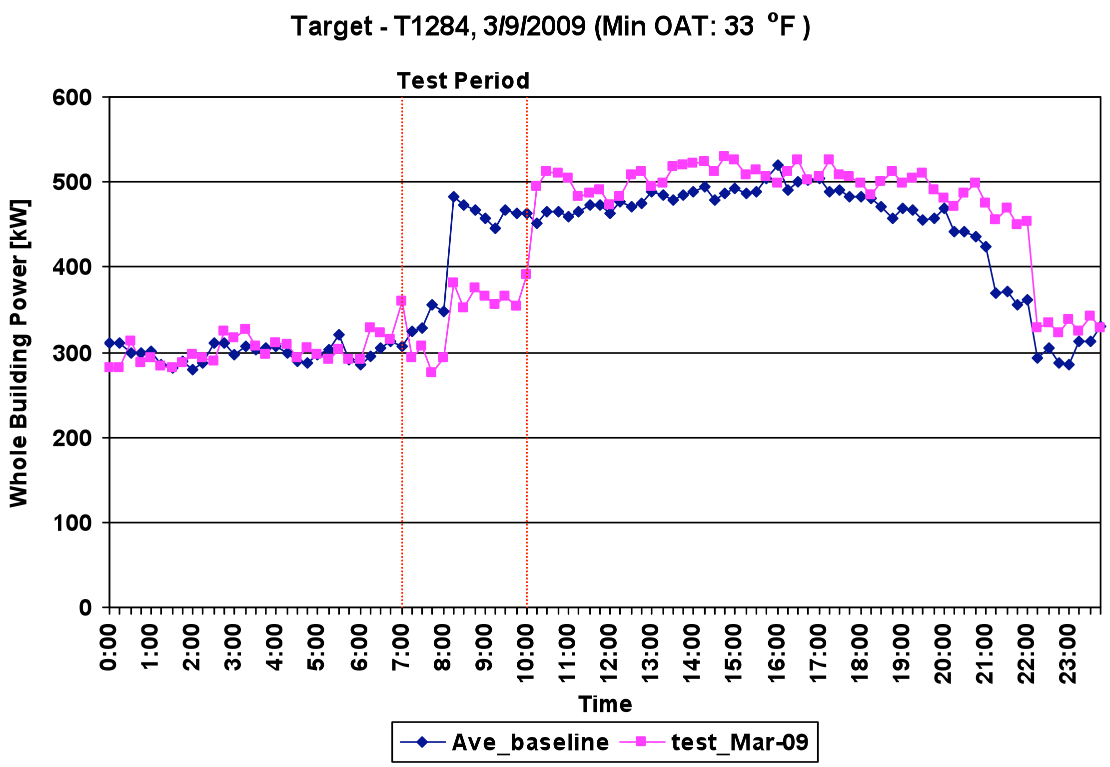

Figure 7. Demand profile of T1284 from DR test on March 9, 2009

In the first hour, the store turned off two out of 12 of their sales area roof-top units and adjusted their temperatures down by 2°F. The effect was observed from the demand profile presented in the figure above. The larger effect of the DR strategy happened when the sales are lights are turned on to prepare for store opening at 8 am and only half of the lighting fixtures were turned on. The store maintained on average 19% load reduction for the duration of the DR test. After the test, there is a slight rebound peak that can be attributed to the lack of recovery strategies. Hourly demand savings is presented in the table below. The existing data collected from this site showed that there is no variation in demand reduction among the events and the same level of demand reduction was maintained from all the events they participated in.

Table 9. Hourly average and maximum demand savings of T1284 on March 9, 2009

Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-09	Ave BL	7:00-8:00	80	47	0.48	0.29	22%	14%
		8:00-9:00	122	101	0.74	0.61	26%	22%
		9:00-10:00	109	93	0.66	0.56	24%	20%
		7:00-10:00	122	81	0.74	0.49	26%	19%

Seattle University Student Center

The first event day for this facility was March 10, 2009. On that day, and every event following that day, this site has successfully participated in DR test events. March 10th is selected as their most successful day. Least average reduction for this site was on March 12, 2009 (Figure 8).

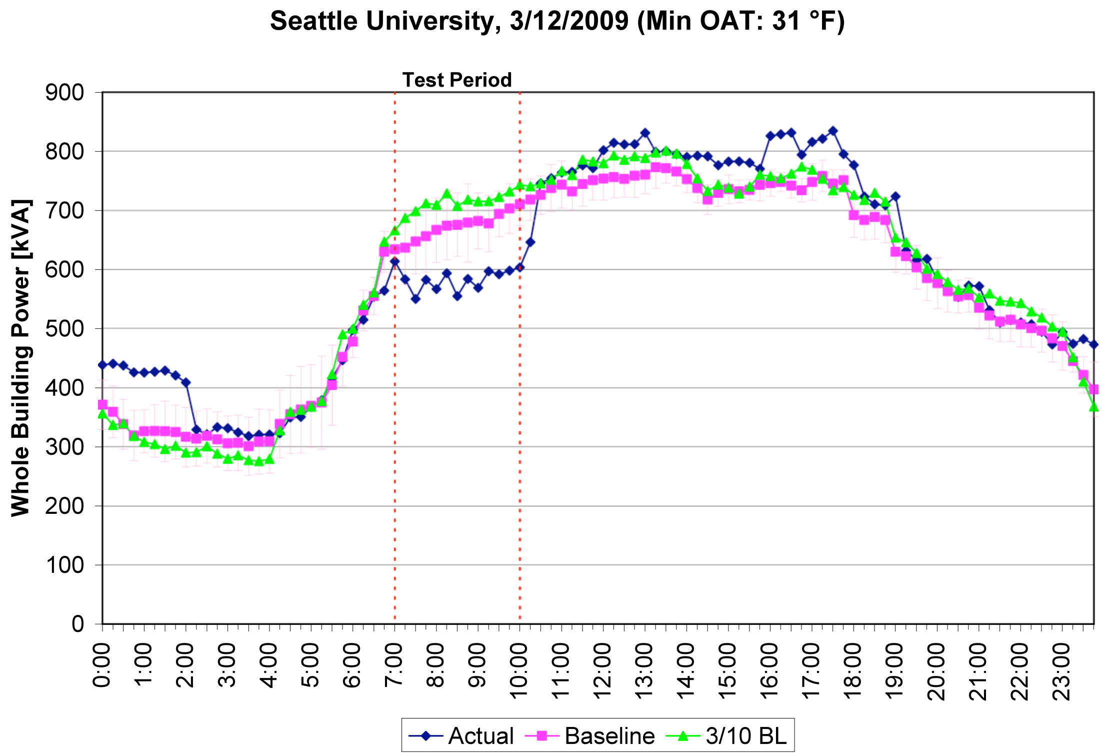

Figure 8. Demand profile of Seattle University Student Center from DR test on March 12, 2009

On March 12, the average shed was 14%. While the trend logs show that all of the DR strategies took place as designed, the site did not achieve the same level of reduction calculated on other DR test days. A closer observation of the demand profile and the baselines show that the baseline was actually lower that the actual demand recorded on in the afternoon on the same DR test day. Therefore the variation in the reduction amount may be due to the variation in the baseline used to calculate the sheds.

Table 10. Hourly average and maximum demand savings of Seattle University Student Center on March 12, 2009

Date	Baseline	Period	kVA		VA/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-12	OAT BL	7:00-8:00	100	81	1.00	0.81	15%	12%
		8:00-9:00	121	102	1.21	1.03	18%	15%
		9:00-10:00	107	99	1.07	0.99	15%	14%
		7:00-10:00	121	94	1.21	0.94	18%	14%
	3/10 BL	7:00-8:00	149	131	1.49	1.31	21%	19%
		8:00-9:00	153	142	1.53	1.42	22%	20%
		9:00-10:00	140	131	1.40	1.31	19%	18%
		7:00-10:00	153	135	1.53	1.35	22%	19%

March 10th was the first day Seattle University participated in a DR test event. On one of the coldest test days, the site's average reduction was 21% and well outside of the standard error f the baseline. There is a high morning load that may be because it was a cold morning.

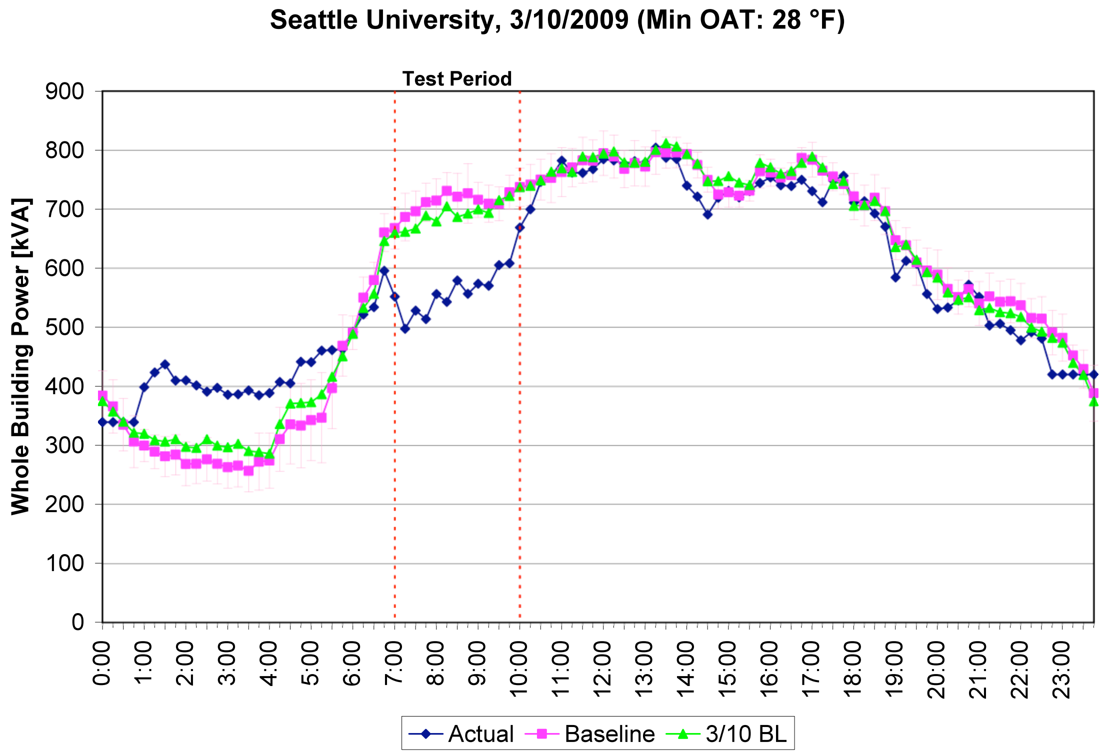

Figure 9. Demand profile of Seattle University Student Center from DR test on March 10, 2009

The trend log collection started at 5 am on the test day so there is not enough information to conclude why the loads were higher than usual on the DR test event day.

Table 11. Hourly average and maximum demand savings of Seattle University Student Center on March 10, 2009

Date	Baseline	Period	kVA		VA/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-10	OAT BL	7:00-8:00	198	178	1.98	1.79	28%	25%
		8:00-9:00	188	160	1.88	1.61	26%	22%
		9:00-10:00	139	108	1.39	1.08	20%	15%
		7:00-10:00	198	149	1.98	1.49	28%	21%
	3/10 BL	7:00-8:00	175	150	1.75	1.51	25%	22%
		8:00-9:00	162	133	1.62	1.33	23%	19%
		9:00-10:00	123	104	1.24	1.04	18%	15%
		7:00-10:00	175	129	1.75	1.29	25%	19%

Seattle Municipal Tower

Seattle Municipal Tower's demand profile is representative of the winter morning peaks. This all electric heating buildings has over 6 MW of peak that coincides between 7 am and 10 am on cold winter mornings. Although this site implemented DR strategies in 24 of their 62 floors, the sheds were visible from their loads. The worst performing day for this facility was on March 9th. While the shed is clearly identifiable from the demand profile, the baseline generated seemed not representative of this day and remained below the actual.

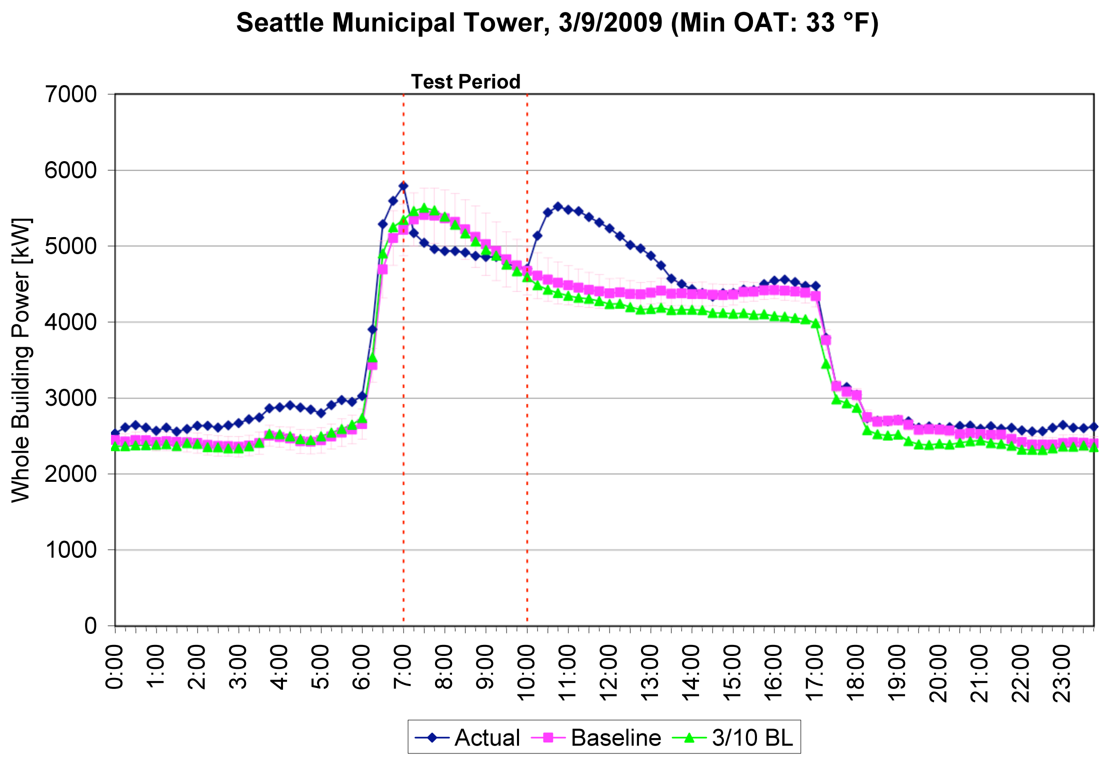

Figure 10. Demand profile of Seattle Municipal Tower on March 9, 2009

Table 12. Hourly average and maximum demand savings of Seattle Municipal Tower on March 9, 2009

Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-09	OAT BL	7:00-8:00	440	353	0.37	0.29	8%	7%
		8:00-9:00	384	277	0.32	0.23	7%	5%
		9:00-10:00	78	31	0.07	0.03	2%	1%
		7:00-10:00	440	220	0.37	0.18	8%	4%
	3/10 BL	7:00-8:00	509	428	0.42	0.36	9%	8%
		8:00-9:00	348	220	0.29	0.18	7%	4%
		9:00-10:00	18	-41	0.02	-0.03	0%	-1%
		7:00-10:00	509	202	0.42	0.17	9%	4%

Demand profile for this facility on March 11th, show better results for their participation. On this coldest day of the tests, the shed was outside of the standard error and averaging 8%. The baseline remains below the actual demand immediately before and several hours after the event, indicating that this baseline may not be the best but may be typical representation of the loads on the DR test event day.

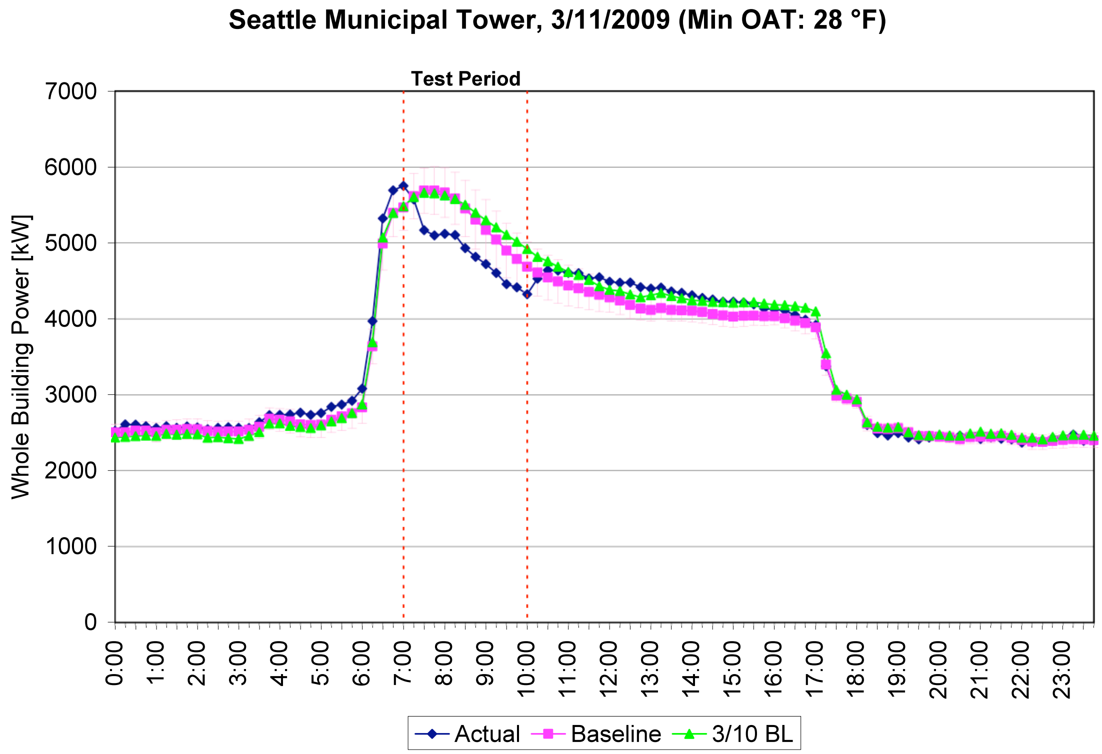

Figure 11. Demand profile of Seattle Municipal Tower on March 11, 2009

Table 13. Hourly average and maximum demand savings of Seattle Municipal Tower on March 11, 2009

Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-11	OAT BL	7:00-8:00	590	424	0.49	0.35	10%	7%
		8:00-9:00	523	487	0.44	0.41	10%	9%
		9:00-10:00	441	403	0.37	0.34	9%	8%
		7:00-10:00	590	438	0.49	0.37	10%	8%
	3/10 BL	7:00-8:00	554	396	0.46	0.33	10%	7%
		8:00-9:00	581	551	0.48	0.46	11%	10%
		9:00-10:00	650	613	0.54	0.51	13%	12%
		7:00-10:00	650	520	0.54	0.43	13%	10%

4.4.2. Aggregated Results from March 5, 2009

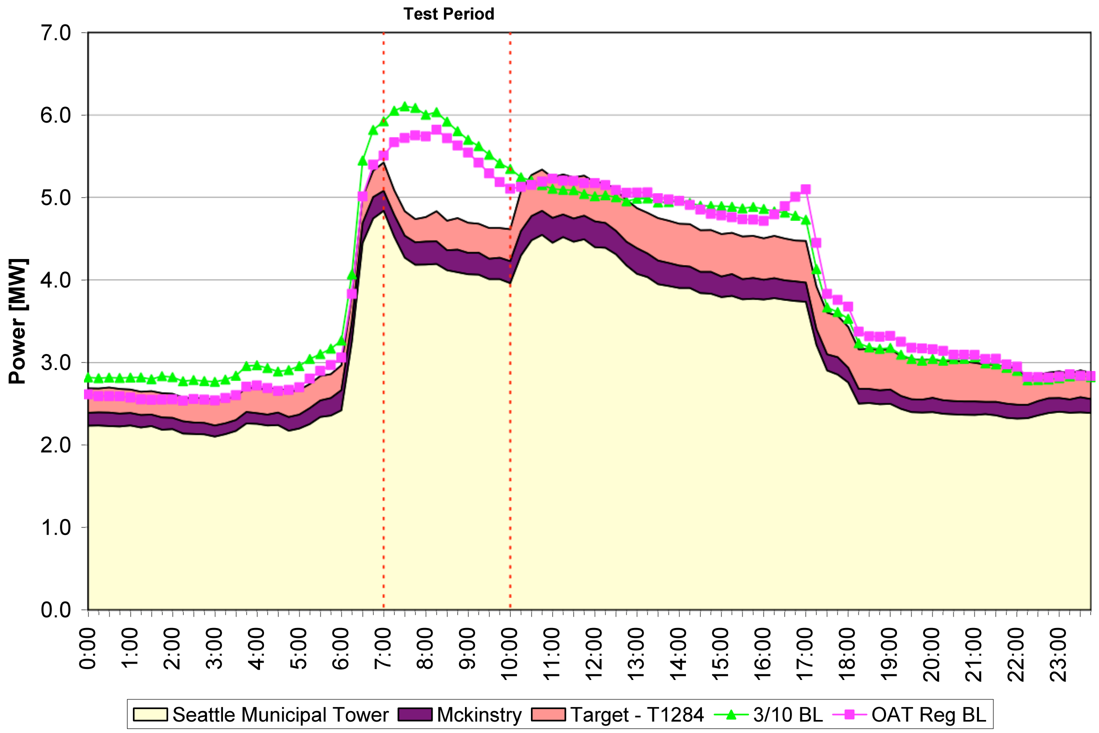

Figure 12. Aggregate demand reduction

All three sites participated in the test DR event on March 5th. However, meter data from Target store was lost due to communications problems. The aggregate data above is the non-coincident aggregate that was put together with March 5th data from Seattle University and Seattle Municipal Tower and with average of March 3rd and March 9th data from Target test DR events. The expected demand reduction from three of the sites is summarized below.

Table 14: Summary of Demand Savings, March 5, 2009

Baseline	Period	kW		W/ft²		WBP%	
		Max	Ave	Max	Ave	Max	Ave
OAT BL	7:00-8:00	1014	865	0.69	0.59	18%	15%
	8:00-9:00	1002	929	0.68	0.63	17%	16%
	9:00-10:00	742	613	0.51	0.42	13%	11%
	7:00-10:00	1014	802	0.69	0.55	18%	14%
3/10 BL	7:00-8:00	1348	1206	0.92	0.82	22%	20%
	8:00-9:00	1202	1115	0.82	0.76	20%	19%
	9:00-10:00	941	836	0.64	0.57	17%	15%
	7:00-10:00	1348	1052	0.92	0.72	22%	18%

4.5. Summary of Demand Savings

Table 15: Summary of average demand saving by each site

Site	Test Date	Feb-18	Feb-25	Mar-03	Mar-05	Mar-09	Mar-10	Mar-11	Mar-12	Mar-16	Mar-18	Average
	OAT (DegF)	41	41	43	38	33	28	28	31	37	39	36
McKinstry	W/sqft	0.25	0.16		0.15			0.27				**0.21**
	kW	25	16		15			27				**21**
	WBP%	9%	6%		5%			10%				**8%**
Target - T1284*	W/sqft			0.50		0.51						**0.51**
	kW			102		104						**103**
	WBP%			19%		19%						**19%**
Seattle Municipal Tower	W/sqft			0.57	0.60	0.18		0.40				**0.44**
	kW			678	717	220		477				**523**
	WBP%			15%	15%	4%		9%				**11%**
Seattle University	W/sqft						1.41		1.02	1.27	1.12	**1.21**
	kW						141		102	127	112	**121**
	WBP%						20%		15%	19%	17%	**18%**

Sheds are calculated using OAT regression model with no adjustments

*Baseline calculations for Target sites lack historical data.

Table 15 shows the demand savings of each site for the test period (7 am to 10 am) for all the test events. The sheds in table 11 are calculated by OAT regression model with no adjustments. Similar day average baseline is used for Target site duo to the lack of historical data. The average saving was 192 kW (14%) for average 1.4 participant sites per event. The average of site average savings is defined as;

- $\text{Average of site average saving kW} = \sum_{i=1}^{i=N}\left(\sum_{i=1}^{i=n} Average.kW \big/ n\right)$

  (N: number of participant sites, n: number of event days)

$$\text{Average of site average saving \%} = \frac{Average.of.site.average.saving.kW}{\sum_{i=1}^{i=N}\left[\sum_{i=1}^{i=n}\left(Average.baseline.kW\right)\big/ n\right]} \frac{Average.of.site.average.saving.kW}{\sum_{i=1}^{i=N}\left[\sum_{i=1}^{i=n}\left(Average.baseline.kW\right)\big/ n\right]}$$

Figure 13 displays the three ways average demand reduction data is summarized for each of the buildings: absolute demand savings, demand savings as a percentage of the peak demand and demand savings per square foot of conditioned space. For each average value, maximum and minimum savings are also included to indicate the variation in savings. The variations are due to variations in the whole building demand and baseline. Seattle Municipal Tower achieved the largest absolute demand savings because it is the largest building in the sample. A better comparison is the demand savings as a percentage of the peak demand. Both Target and Seattle University have average savings around 20%. However, the demand savings intensity graph shows that Seattle University achieved deeper savings intensity to achieve the same level of whole building percentage demand savings. Two days of data for Target is not enough to assess demand reduction variations.

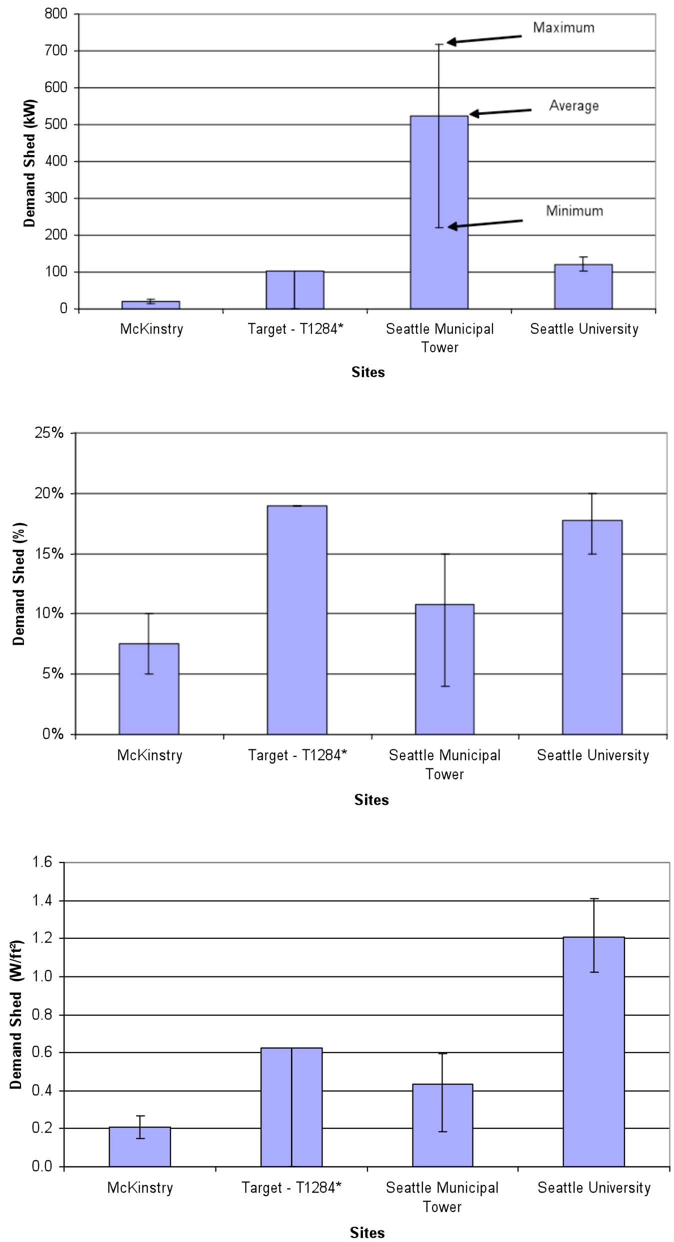

Figure 13. Average, minimum and maximum demand savings at each site by demand (kW), percentage (%) and demand intensity (W/sqft)

4.6. Cost of Automating DR at Participant Facilities

In this section, we summarize the cost of enablement of Auto-DR for each site including electrical costs, cost of labor, programming and commissioning the systems. The cost data is collected after the payments are finalized for each facility. Table 16 shows the breakdown of costs for each site.

Table 16. Cost of automated DR implementations

Site	Controls Vendor	Controls Cost	Material	Commissioning DR Strategies	Total
McKinstry (McK)	ATS	$ 3,780	$ 1,064	$ 1,071	$ 5,915
Seatt le Municipal Tower (SMT)	Siemens	$ 4,007	$ 1,500	$ 1,071	$ 6,578
Target (both stores)	ALC	$ 6,500	$ 1,582	$ -	$ 8,082
Seatt le University (SU)	ESC	$ 2,783	$ 1,000	$ 1,071	$ 4,854
Average costs		**$ 3,414**	**$ 1,029**	**$ 1,071**	**$ 5,086**

Controls costs summarize DR strategy development, programming, hardware client installation and/or software client development costs at each facility. Material costs include metering or logging devices that were installed to collect the required data. Although the controls companies did test the DR strategies they programmed, the local subcontractor also commissioned each DR strategy prior to testing. Target facilities were thoroughly commissioned by their controls vendor. In addition, not reported in the table above, there is on average $1,000 electrical cost per site that includes the installation of CLIR boxes and pulling wires to the controllers.

Table 17. Summary of costs per average demand reduced (kW)

Site	Controls Vendor	Controls Cost ($/kW)	Material ($/kW)	Commissioning DR Strategies ($/kW)	Total ($/kW)
McKinstry (McK)	ATS	180	51	51	282
Seatt le Municipal Tower (SMT)	Siemens	8	3	2	13
Target (both stores)	ALC	33	8	0	40
Seatt le University (SU)	ESC	23	8	9	40
Average costs		**61**	**17**	**21**	**94**

Table 17 has the same columns as the previous table but presents cost per demand (kW) reduced. One-time costs of automation of DR presented as cost per kW can be directly compared with on-going generation costs. Experience in California agrees with the findings in the Northwest: Automation is least costly for larger commercial buildings and industrial facilities (Kiliccote at al. 2008).

4.7. Participant Survey Results

While the project team intended to collect feedback from building mangers after each event, due to the short span of the test period and repeated events within weeks, the sites provided overall feedback on the comfort conditions and overall automation issues at the end of the test event period. The summary of the feedback form each site is as follows:

- McKinstry: No comfort or automation issues.
- Target: There were issues with the reduced sales floor lighting due to zoning. When lighting was reduced to 50% the fitting rooms were too dark for guests. However, this is directly related to the switching zoning selected by Target. Lighting zones for switching half of the lighting fixtures is suspected to be set up incorrectly. The store had no complaints regarding temperature comfort. Problems with notifications were observed. The DRAS accommodates notifications to three e-mail addresses for each client while eight people had to

be notified for Target. A distribution list was created but was neglected to be included in one of the e-mail slots available. No automation issues.

- Seattle University: No comfort issues. The CLIR box is suspected to be damaged during shipment. A new CLIR was installed and worked fine throughout the tests DR events.
- Seattle Municipal Tower: Of the four test DR events, one day, on Monday, March 9th four tenants complained that it was too cold. Facility management speculated that because the building was shut down over the weekend, the temperature adjustment may have been more noticeable. No automation issues.

5. Discussion

Automated DR technology demonstration field tests in the Northwest demonstrated open automated DR communication systems and identified opportunities for winter DR control strategies. Results from four sites that participated in the study were presented in this report. Key issues are discussed in detail below:

- **Recruitment is a lengthy and on-going effort.** The teams experience in the Northwest is much similar to the early field test recruitment efforts in California. Recruitment is part education and part keeping on-going relationship with the participants to get them comfortable with the ideas that:
    - the service levels in their facilities will be diminished for a period of time;
    - on going assistance and monitoring will help them select detectable but at the same time acceptable DR strategies; and
    - they can opt-out anytime from any where.
- **Healthy pipeline of customers enabled us to achieve the targeted number of customers.** Seven sites had indicated interest in participating in the study after the completion of initial sites surveys at ten facilities. Three of the sites could not participate in the test events due to:
    - Limitations within control systems and the increased cost of overcoming these limitations.
    - Communication problems within the control systems that prevented the research team to monitor and collect data from each test DR event.
    - Decision to back out of the field tests due to concerns from tenants.
- **Lighting provides year-round DR**. While detectable, lighting sheds have short response time and can provide excellent year-round DR. However, there are less centralized lighting control systems and most lighting control systems in commercial buildings have local closed-loop controls that optimize for daylight availability.
- **HVAC systems with gas heating have limited savings opportunities.** Two buildings with gas powered roof-top units selected duty cycling as a DR strategy. The DR opportunities in these types of systems comes from fan and exhaust power savings.
- **All electric heating systems are the low hanging fruit.** Global temperature adjustment strategy, which is successfully tried in California to reduce peak demand during summer afternoons, worked well in one of the only all electric heating building. The zone temperatures were temporarily reduced to save on electric loads.
- **Adjustment periods for baselines must be considered.** Studies on baseline with data collected from buildings that participated in automated DR programs in

California show that adjustments to the baseline increase accuracy and reduce bias. While morning adjustment periods are used for buildings with summer afternoon peaks, a good representative period must be used for adjusting baselines for winter morning peaking buildings.

- **Auto-DR concepts work for winter DR in commercial buildings.** This study showed that HVAC and lighting remain to be the major opportunities for Auto-DR in commercial buildings and with or without electric heating, there are opportunities in HVAC systems to reduce demand for a period of time to relieve the stress on the electric grid.

6. Summary and Future Directions

This section summarizes the recommendations for the next phase of the project and plans for the future directions for OpenADR.

The project was a first step in demonstrating technology performance. There is a need to study and develop cold morning strategies for consumers who would like to participate in DR programs but may not know how. A guide that categorizes buildings and building systems and recommends DR strategies would be a suggested final deliverable. In addition, simulation tools that are developed for estimating DR capabilities for buildings in hot summer climates can be enhanced to support estimating cold winter morning DR capabilities in commercial buildings. We recommend a next phase for the project to evaluate the same technology and same test sites but consider DR strategies for demand savings summer days. The objectives of the next phase of the pilots are:

- To evaluate the commercial buildings capability to respond to DR events in dual peaking climates
- To develop methods for evaluating DR for buildings in dual peaking climates
- To consider the feasibility of geographically targeted DR.

The next phase of the project should increase understanding of the customer's seasonal issues and technologies that can address these needs.

Automation of Demand Response (DR) programs has proven to be an effective means of obtaining more reliable and consistently higher performing electric load shifts and sheds than using manual techniques. Furthermore, OpenADR is potentially an important component in automating the response of the facilities participating in DR programs by specifying a standardized communications data model between the Utilities and Independent System Operators (ISO's) and the energy management systems within the facilities.

OpenADR is currently in use by four electric utilities to automate their DR programs and has been adopted by a wide range of building and industrial controls companies. A detailed specification for OpenADR was developed over a two year period and soon to be released as an official CEC/LBNL report (http://openadr.lbl.gov/). The OpenADR specification will be the basis of ongoing DR communications standards development efforts within both the Organization for the Advancement of Structured Information Standards (OASIS - http://www.oasis-open.org/home/) and the UCA International Users Group (UCAIug - http://www.ucaiug.org/). Both are highly regarded organizations that are active within the emerging "Smart Grid" domain. With the ongoing efforts within OASIS and UCAIug, OpenADR is on a path towards becoming a formal standard within organizations such as the International Electrotechnical Commission (IEC. - http://www.iec.ch/)

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Glossary

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CEC – California Energy Commission

CLIR Box – Client Logic Internet Rely – an internet gateway device designed, built, and provided to PG&E clients (where needed) to accept DR event signals and transmit them to the customer's EMCS for this project

CPUC – California Public Utility Commission

DHCP – Dynamic Host Configuration Protocol

DR – Demand Response – strategies and programs to facilitate load shedding during peak system demand periods.

DRAS - DR Automation Server – an internet-based communications server and database system that produces a computer-readable, electricity price signal on a Web services server, using the meta-language XML (Extensible Markup Language).

DRRC – Demand Response Research Center – A program at LBNL funded primarily by the California Energy Commission's PIER Program.

EMCS – Energy Management and Control System

IT – Information Technology

LBNL – Lawrence Berkeley National Laboratory performs Work for University on this Research Project Contract

LAN – Local Area Network

MOU – Memorandum of Understanding

OpenADR – Open Automated Demand Response – an information exchange model to communicate price and reliability signals for demand response.

PIER – California's Public Interest Energy Research Program

URL - an internet Uniform Resource Locator

VAV – Variable Air Volume

VFD – Variable Frequency Drive

XML – Extensible Markup Language

APPENDICES

Northwest Open Automated Demand Response Technology Demonstration Project

Sila Kiliccote
Mary Ann Piette
Junqiao Han Dudley
Lawrence Berkeley National Laboratory

Table of Contents

Appendix A – Project Plan

Open Auto-DR Technology Demonstration Project

Project Plan

December 1, 2008

Introduction

The purpose of this Project Plan is to document the plans and procedures that Lawrence Berkeley National Laboratory (LBNL) intends to implement over the course of this demonstration project. The overall goal of the project is to demonstrate how the Open Automated Demand Response (Open Auto-DR) Communication Signaling infrastructure can work with commercial facilities with winter morning peaking loads and evaluate DR building control strategies and baseline models for winter peaking commercial facilities.

Background: California utilities have been exploring the use of critical peak prices (CPP) And Demand Bidding Program (DBP) to help reduce needle peaks in customer end-use loads. Both CPP and DBP are forms of price-responsive demand response. Experience in California has shown that customers have limited knowledge of how to operate their facilities to reduce their electricity costs under CPP. At the same time LBNL has been conducting research to demonstrate how price-response could be automated using standard XML-based communications with Energy Information Systems and Energy Management and Control Systems. Fully automated electric load shedding accounts for over 50 MW in California. Many end-use customers have suggested that automation will help them institutionalize their electric shedding.

System Overview: The overall goal of this research is to understand commercial buildings' demand response technologies and strategies to address winter morning peaks in the Northwest upon receipt of an emergency signal or rise in the price of electricity. In this system, a price signal, mimicking CPP, will be published on a single Web services server, available on the Internet using the meta-language, XML (Extensible Markup Language). Each of the participating facilities will monitor the common price signal using Web services client applications and automatically shed site-specific electric loads when the price increases. The system shall be designed to operate without human intervention during the test period.

Objectives

The objectives of this project are:

1. Demonstrate how an automated notification system can be used in large commercial facilities for demand response (DR). Evaluate effectiveness of such a system. Determine how customers will respond to this form of automation.
2. Evaluate what type of DR shifting and shedding strategies can be automated.

3. Demonstrate integrated energy management using advanced controls for both energy efficiency and DR. (Sample candidate for such a demonstration is dimmable ballast.)
4. Explore how automation of control strategies can increase participation rates and DR from automation.
5. Understand the costs and benefits of participation from the owners' perspective.
6. Identify optimal control and shedding strategies.
7. Determine occupant and tenant response.

Roles and Responsibilities

The members of the project team and their roles and responsibilities are identified below:

Bonneville Power Administration (BPA)

- Participate in finalizing project plan and test plan, providing on-going support, including but not limited to advice, technical assistance, and design assistance, to key milestones in project design and execution, evaluate relevance to regional DR plans.
- Review and approve project deliverables.

Seattle City Light (SCL)

- Assist in project planning and management
- Provide funding to the project by a) providing financial incentives to the DR sites and b) leading site recruitment; and c) cost-sharing project implementation costs.
- Assist in project execution, especially on-the-groud activities.
-

LBNL/DRRC

- Develop and execute overall final project plan, develop evaluation methods, collect data, perform analysis, develop final report.

Akuacom (sub-contractor to LBNL)

- Modify DR Automation Server to accommodate SCL tests
- Monitor DRAS during tests
- Provide ongoing technical support for automation

McKinstry (sub-contractor to LBNL)

- Assist LBNL in recruitment, conducting DR audits, working with control vendors to determine DR strategies and establish DR communication, conduct tests and evaluate test results.

I. Pre-Test

In preparation for test days, the participating sites must work with SCL and LBNL on the following tasks:

Training – LBNL and Akuacom will schedule a one-day training session with BPA, SCL and a local subcontractor, McKinstry, who will conduct the DR audits and work with each site to prepare facilities for test events.

Recruitment - SCL will work with LBNL to recruit facilities into the program. A DR audit will be completed for a sufficient number of participants so that four to six sites are selected as demonstration facilities.

Sign Memorandum of Agreement (MOA) - The MOA is for mutual communication purposes. It allows us to ensure that participants understand the SCL/LBNL agreement for collaboration ensures the payment of the participation incentive and outlines roles and expectations and milestones for payments.

Provide General Site Data - LBNL will request general information about participant site including: facility size, use, HVAC equipment type, etc. to get a better understanding of end use loads that contribute to the winter morning peaks.

Define Electric Data Collection Methods - Most commercial sites have local databases that archive data from electric meters, Energy Management Control Systems (EMCS) or Energy Information Systems (EIS). LBNL project staff should have full access to data.

Define Shed Strategies - Successful strategies that were used in the previous years in California for summer afternoon peaking facilities included: global zone temperature adjustment, duct static pressure reset, VFD position limiting, chilled water valve position limiting, and reductions in lighting level. We encourage participating facilities to come up with innovative shed strategies that are appropriate for each facility.

Demand Response Automation Server Updates - Akuacom/LBNL will update the DRAS functionality and user interface to accommodate BPA's and SCL's requirements for the test events.

Establish Connectivity - Each site must be outfitted to receive the LBNL/Akuacom generated price signals (or the associated operational mode signals) with one of the two following methods:

1. Client Logic Integrated Relay Box (CLIR Box):

2. Internet to EMCS or EIS Gateway - If a participating site already has a gateway that connects the EMCS/EIS to the Internet then this method may be used. If you can currently view your EMCS data using an Internet browser then such a gateway is likely installed.

Program Shed Strategies into EMCS – Once a method of receiving the price signal has been established, the EMCS is programmed to facilitate the desired sheds upon a rise in price. The strategies are well understood for summer peaking hot climates but are still widely unknown for buildings in winter peaking cold climates. McKinstry and LBNL will oversee this activity and coordinate it with the controls vendor.

Set up Trend Logs – LBNL will work with the controls vendor to set up trend logs in the facilities to record key control points for DR strategy implementation. After the events, the trend logs will be matched with the implemented DR strategy so as to confirm that the test events took place and the EMCS responded as programmed.

II. During the Test

Price Signal - During the winter test period (January 1st- March 31st), each participating site will receive DR test notifications, determined by SCL operators and issued by Akuacom. For the day-ahead tests, participants will receive notifications at 3pm previous day and for the day-of events, participants will receive notifications 30 minutes prior to the event start time. The table below summarizes the automated signals, e-mail notification list and timing for day ahead and day-of events between when the event is scheduled to be called and the end of the event. Each event will last three hours, which ill be determined and specified by the SCL operators. There will be a total of four test events. During each shed event, each participating site will automatically shed electric load, visible (5 to 10%) from the whole building load profile. The shed actions at each facility will be based on the strategy created ahead of time by LBNL and the facility staff.

Phase	Description	EventStatus*	Pending*	OperationMode*	E-mails	DA Timing	DO Timing
Decided	BPA decides to call an event	NONE	OFF	NORMAL	BPA to DRAS Operator (Date, Start, End)	before 12:00 DA	before 12:00 DA
Received	DRAS operator enters event	NONE	OFF	NORMAL	DRAS to BPA and DRAS Operator	before 15:00 DA	before 15:00 DA
Issue	Far Notification	FAR	OFF	NORMAL	DRAS to Facility Manager	15:00 DA	30 minutes prior to start
Near	Near Notification	NEAR	ON	NORMAL		21:00 DA	30 minutes prior to start
Start	Start of Event	ACTIVE	ON	HIGH	DRAS to DRAS Operator, Facility Manager	6:00 - 11:00	6:00 - 11:00
End	End of Event	NONE	OFF	NORMAL	DRAS to DRAS Operator, Facility Manager	7:00 - 12:00	7:00 - 12:00

* indicates Automated Signals

III. After the Test

Documenting Shed – LBNL and McKinstry will collect whole-building electricity consumption data for each site in the pilot. When available, we will also collect detailed data from an EMCS or other end-use meters to help us understand the dynamics of the shed strategies. In addition to the electric load data, when available, LBNL will collect gas consumption data. LBNL will study load profiles, weather and load data and use several baseline methods to evaluate sheds at each site and make recommendations for baseline development.

Participant Interviews – LBNL and McKinstry will contact each site to record the facilities' reaction to the DR strategies and record any comfort complaints.

IV. Project Report

After the test, LBNL will provide a detailed project report that evaluates the automated sheds at each participating facility. The report will compare the DR technologies and shed strategies; and develop metrics such as total kW shed, W/sqft shed, and percent of whole-building shed. The report will include the electric consumption data from each facility, a statistical analysis of the shed data (using a weather-corrected baseline), and other EMCS or related data. The report will also describe the controls and communications systems at each test site, the ease or difficulty of installing the automation and how DRAS communications perform. These results will be presented publicly in academic and trade publications and conferences.

V. Project Timeline

Activity	Date	Who
Training	November	LBNL, Akuacom
Plan Shed Strategies, Connectivity, Sign MOU	November-December	SCL, LBNL, McKinstry & Participants
Establish Connectivity, Preprogram EMCS Shed Strategies	December - January	LBNL, Akuacom, Subcontractor
Confirmation of System Readiness	December-January	LBNL, Akuacom, McKinstry & Participants
Tests	January - March	LBNL, Akuacom, McKinstry
Data Analysis and Write-up	March - May	LBNL, Akuacom and McKinstry

VI. LBNL Staff:

Project Lead: Mary Ann Piette, mapiette@lbl.gov, (510) 486-6286
LBNL Staff: Sila Kiliccote, skiliccote@lbl.gov, (510) 495-2615, (510) 384-1635 - cell
Rish Ghatikar, gghatikar@lbl.gov, (510) 486-6768
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Nance Matson, namatson@lbl.gov, (510) 486-7328
Nobuyuki Yamaguchi, NYamaguchi@lbl.gov

Appendix B

MEMORANDUM OF AGREEMENT
AUTOMATED DEMAND RESPONSE TECHNOLOGY DEMONSTRATION

This Memorandum of Agreement for work related to the Automated Demand Response Technology Demonstration Project ("Auto-DR Project") is made and entered into this _____ day of April, 2009, between Participant in the Auto-DR Project "Participant," and Seattle City Light "City Light," collectively the "Parties".

WHEREAS, the intent of the Auto-DR Project is to install communicating technologies to allow building management systems an opportunity to respond to peak demand ("Technology");

WHEREAS, the Participant is a business entity managing or owning a specific building in which the Technology is to be installed and tested:
____;
(business entity)

WHEREAS, City Light, working collaboratively with the Bonneville Power Administration, will work with other business entities and contractors (collectively to be known as the "Project Partners") to execute the Auto-DR Project and install the Technology;

WHEREAS, the Project will begin no earlier than September 1st, 2008 and conclude no later than July 1st, 2009; and

WHEREAS, City Light wishes to pay the incentives as specified below to Participants for their active engagement and cooperation with City Light and its Project Partners;

NOW, THEREFORE, in consideration of the terms, conditions and performances contained herein,

IT IS MUTUALLY AGREED AS FOLLOWS:

1. The Parties agree to work cooperatively with each other and shall make reasonable, good faith efforts to timely and expeditiously complete the work requested.

2. The Participant shall:

- Select appropriate shed strategies and implement them in a manner appropriate for their site.

- Provide information to City Light and its Project Partners, about the facilities, control systems, shed strategies, energy consumption patterns, and performance measurement systems. The Participant also allows this information to be published by City Light and its Project Partners without identifying the Participant directly. Upon Participant's advance request and City Light's permission, the Project Partners may provide a copy of the report to Participant prior to making such report public.
- Participate in the test as described in the test plan (Appendix A).
- Collaborate with City Light and its Project Partners as necessary to implement and perform the tests.
- If changes in circumstances cause the participant to drop out of the test, inform City Light and its Project Partners of these changes.
- Develop over-ride and fall-back strategies to switch to manual operation and activate facility shedding if the Auto-DR Project system fails.
- Participate in up to four additional mock events if necessary.

3. City Light agrees to:

- Serve as point of contact for scheduling of initial demand response audit and test events with its Project Partners;
- Answer questions about project purpose, intent, and status.
- Present a direct incentive of $3,000 to the Participant for participation in the project.
- Award additional amounts of $1,000 to the Participant reponding to each of the test events (up to four total).
- Pay the total incentives and awards no later than July 31st, 2009, upon the receipt of appropriate invoices from the Participants; and
- Share results and analysis of test events with Participant.

4. City Light understands that the work requested should be completed in a timely manner no later than July 1st, 2009.

5. If the first phase of the Auto-DR Project is successful, the Participant and City Light may choose to continue in additional phases of the Auto-DR Project. Terms for continuation of the Auto-DR project will be described in a new or updated Memorandum of Agreement.

6. To the extent authorized by law, the Participant agrees to protect, defend, indemnify and hold harmless City Light from any and all costs, claims, demands, attorney fees, lawsuits/judgments, recoveries/awards of damage to persons or property, arising out of, or in any way resulting from the actions or inactions of City Light, the

Project Partners, its employees, contractors, or agents. The Participant shall not be required to indemnify, defend or hold harmless City Light if the claims or litigation arises out of the sole negligence of City Light. Upon prompt notice by City Light, the Participant shall assume responsibility for the claims or action and shall undertake the defense of the claim or action on behalf of City Light. City Light shall cooperate fully with the Participant in the defense of the claim or action.

EXECUTED, this _____ day of April, 2009.

Participant	Seattle City Light
________________________________	________________________________
(Print Name, Title)	Robert Balzar, Director
________________________________	Conservation Resources Division
(Business Entity Name)	Seattle City Light
________________________________	
________________________________	
________________________________	
(Address)	
________________________________	
(Tax Identification Number)	

APPENDIX A

AUTOMATED DEMAND RESPONSE
PROJECT

FACTSHEET

OVERVIEW

Select commercial building owners who are customers of Seattle City Light have an opportunity to reduce their energy demand, receive technology assistance, and receive cash payments of $3,000 or more, for participating in a demand response pilot project.

Seattle City Light, in partnership with the Bonneville Power Administration, is conducting a regional demonstration of Automated Demand Response (Auto DR) technology developed at Lawrence Berkeley National Laboratory. This technology communicates with existing building information systems to enable our commercial customers to reduce their electricity usage demand for electricity during peak or emergency periods. These technologies have already been tested in California, but there is broad interest in testing these technologies in a heating climate such as the Pacific Northwest. Starting in the winter of 2008-2009, Seattle City Light will begin working pro-actively with selected customers to develop strategies in order to allow them to respond flexibly to unexpected events, such as peak periods or emergency events, and to improve overall system reliability.

HOW AUTOMATED DEMAND RESPONSE (DR) WORKS

At present, this is a limited technology demonstration for the Pacific Northwest. If widely deployed in the future, in the event of a peak period or emergency event, Seattle City Light will send an internet-based signal through the Internet to a secure device or software program on the customer site, which then triggers the customer's Building Energy Management System to reduce load. Load is reduced through pre-programmed strategies developed in consultation with the building manager, contractors and Seattle City Light. Building managers can override the load reduction event at their discretion.

PROJECT STRUCTURE & TIMELINE

The project is designed to evaluate the suitability of buildings in the Pacific Northwest for this technology in three phases:

Late 2008:	First, demand response audits will be conducted in ten to fifteen buildings in late 2008.

Late 2008 – Early 2009:	Second, the Auto- DR technology will be installed in four to six buildings at no cost to the building owner in late 2008 and early 2009.
Early 2009:	Finally, Seattle City Light will test the technology two to four times in early 2009.

ELIGIBILITY

The Auto-DR program is open to commercial customers that have an existing Energy Management and Control System (EMCS) and an interval meter.

Seattle City Light, working with contractors, will pay for initial DR audits for ten to fifteen potential sites. Seattle City Light will then select four to six buildings for further study, installation of the technology, and testing.

INCENTIVES

All participants will receive a free demand response audit, including an assessment of energy efficiency and conservation opportunities in each building. Selected facilities will receive initial energy audits to assess energy efficiency and conservation opportunities in each building. For the four to six buildings selected for the technology demonstration phase, they will receive both technical and financial incentives. In addition, the selected local contractors will install and test additional technology needed to connect the building's Energy Management and Control Systems to the Internet. Financial incentives for participating in the testing phase are an initial payment of $3,000 for participation, contingent on completion of the demand response audit and technology installation; and a $1000 payment for active participation in each of the subsequent four test events. Participating buildings will also be able to monitor their energy consumption on the project's website through a secure Internet connection to the building's EMCS.

PARTICIPATION REQUIREMENTS

In the evaluation phase, the buildings selected and their energy managers must participate in an initial energy demand response audit. In the technology demonstration phase, project contractors will require access to install and test the necessary technology. In the testing phase, specific buildings will be called upon to reduce or shift their loads for a limited one or three hour morning period, with notice given either the day before or day of the test itself.

FURTHER INFORMATION

More information about the technology can be found on the web at www.drrc.lbl.gov. If you are interested in participating in, or learning more about the project, please contact any of the following participating organizations or staff:

Seattle City Light

- David Hsu, david.hsu@seattle.gov, 206-684-4288
- Jerry Raitzer, jerry.raitzer@seattle.gov, 206-684-4289

Bonneville Power Administration

- Pam Sporborg, pjsporborg@bpa.gov, 503-230-3170

Lawrence Berkeley National Laboratory

- Mary Ann Piette, mapiette@lbl.gov, 510-486-6286
- Sila Kiliccote, skiliccote@lbl.gov, 510-384-1635495-2615

McKinstry

- Contact: Patty Anderson, pattya@mckinstry.com, 206-832-8074

Appendix C

Demand Response Research Center

Client and Logic with Integrated Relay User Guide: Installation and Troubleshooting for Auto-DR

Author(s): Girish Ghatikar (DRRC) and Dan Hennage (Akuacom Inc.)
Reviewer(s): DRRC, Akuacom Inc, Global Energy Partners LLC, and C&C Building Automation Company Inc.

Table of Contents

Purpose:

This user guide is intended to introduce and guide installers and coordinators of Automated Demand Response (AutoDR) systems through pre (before visiting a facility) and post (at the facility) install procedures for the Client and Logic with Integrated Relay (CLIR) and to receive remote signals from Utility's Demand Response Automation Server (DRAS). These signals facilitate a response to Utility's Automated Demand Response (AutoDR) program services such as Critical Peak Pricing (CPP), Demand Bidding Program (DBP), and other related program services. These install procedures will enable CLIR as an interface device for these programs.

In addition to notifications such as pager alerts and e-mails, the CLIR enables sites equipped with this AutoDR technology to receive signals over the Internet to trigger pre-programmed demand response strategies and reduce peak electric loads. This user guide does not cover the Energy Management Control Systems (EMCS) programming for DR strategies or signals to facility's HVAC or lighting systems or other environmental controls. The other form of receiving signals from DRAS using the "DRAS Software-Client" (or Web Service Client) is also not covered in this document.

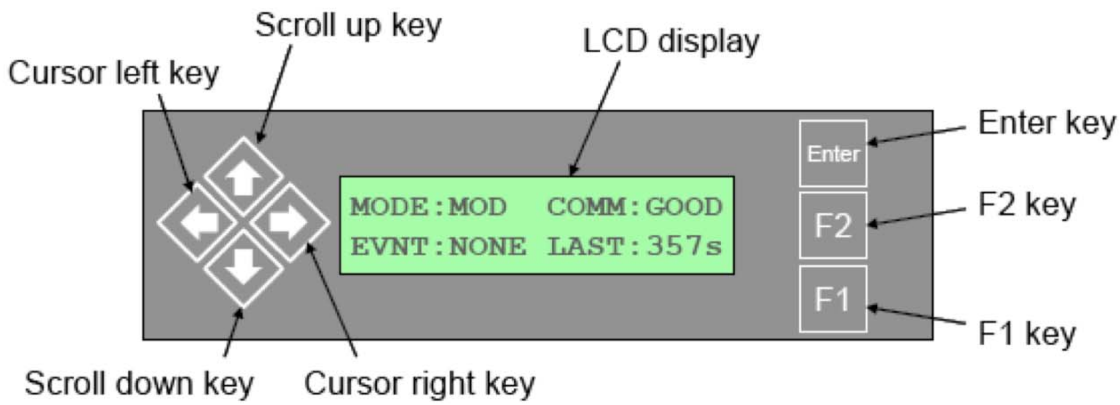
Introduction to CLIR:

The CLIR is a secure, self-configuring Internet relay. The CLIR enables the EMCS to receive AutoDR signals over the Internet. These signals are translated into relay contacts that are sensed by the EMCS. The EMCS causes the facility to automatically enter preconfigured low energy modes through modifications to the HVAC, lighting systems, etc. during the AutoDR event.

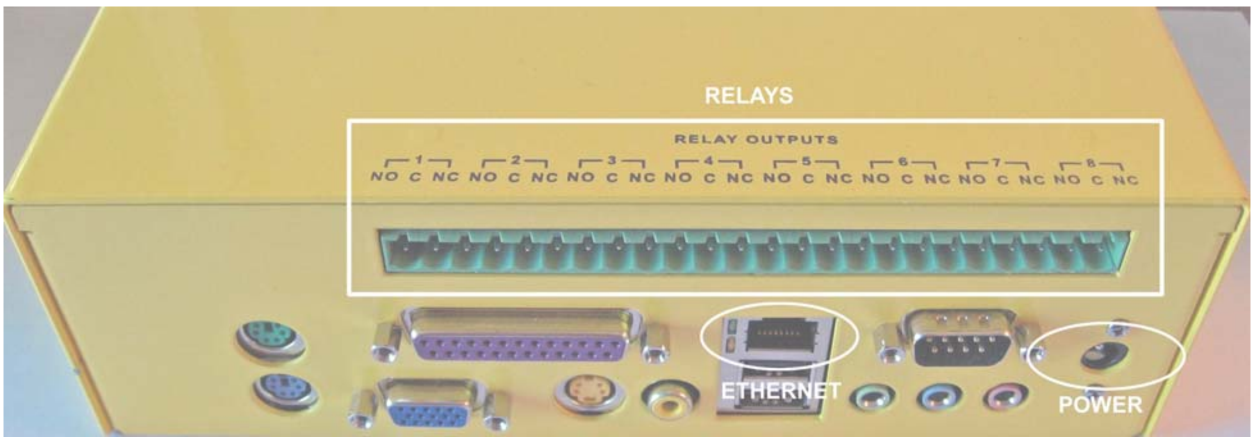
Once powered on, the status of the CLIR Box is visible via a LCD display. Internet connectivity, time since last successful communication with the server, event modes and other relevant data is shown. An integrated keypad allows installers of the CLIR box to set all relevant configurations without the use of a laptop or remote terminal. Parameters such as static IP address, DHCP, and proxy server address can be configured using the keypad. The complete minimum list of all CLIR parameters is shown in "Appendix A.1 or Table 1" and "Appendix A.2 or Table 2." The CLIR specifications are detailed in Appendix A.3.

Buttons, Display, and Connectors:

The front of the CLIR has 7 buttons and an LCD display which can be used to enter configuration information and inspect the status as shown in the figure. More details are shown in Appendix B.



The back of the CLIR has the connectors for power, Ethernet, and relays to control the EMCS:



- The power connector accepts an input of 12 VDC from the supplied power adapter.
- The Ethernet connector accepts a RJ-45 10/100BaseT cable.
- The 8 relays are connected using the supplied removable screw terminals. The relays supports both normally open (NO) and normally closed (NC) connections. The center pin of each terminal is common (C). The labeling on the top of CLIR indicates the function of each terminal.

None of the other are connectors are used presently.

Event Pending Signal:

The DRAS communicates to the CLIR whether a DR event is pending (upcoming) for the facility. This signal is either day-ahead or day-of and can be used by the EMCS in addition to the event mode signals for functions such as pre-cooling, preparing the loads for reduction, etc. This signal is reflected on relay 3 on CLIR as shown in the table below assuming a normally open connection is used (Note: If normally closed connections are used, the logic should be reversed):

Relay	Event Not Pending	Event Pending
3	open	closed

Note that the event pending signal can be sent any time on the day-ahead or the day-of the event (check with the DRAS operator and/or technical coordinator for further details on this time frame for specific AutoDR program). The signal will go off (normal-level) after the event is over.

Event Mode Signal:

The DRAS communicates three different DR event modes to the CLIR – normal, moderate, and high. The EMCS in the facility is programmed to respond to either or all of these three event modes based upon the state of the relays 1 and 2 on the CLIR and AutoDR program(s). The table below shows the states of the relays for each event mode assuming normally open connections are used (Note: If normally closed connections are used, the logic should be reversed):

Relay	Normal Shed	Moderate Shed	High Shed
1	open	closed	closed
2	open	open	closed

CLIR End-Point DRAS Server Name:

The *servername* for CLIR end-point host depends on the electrical utility territory servicing the participant's facility and is to be configured as follows:

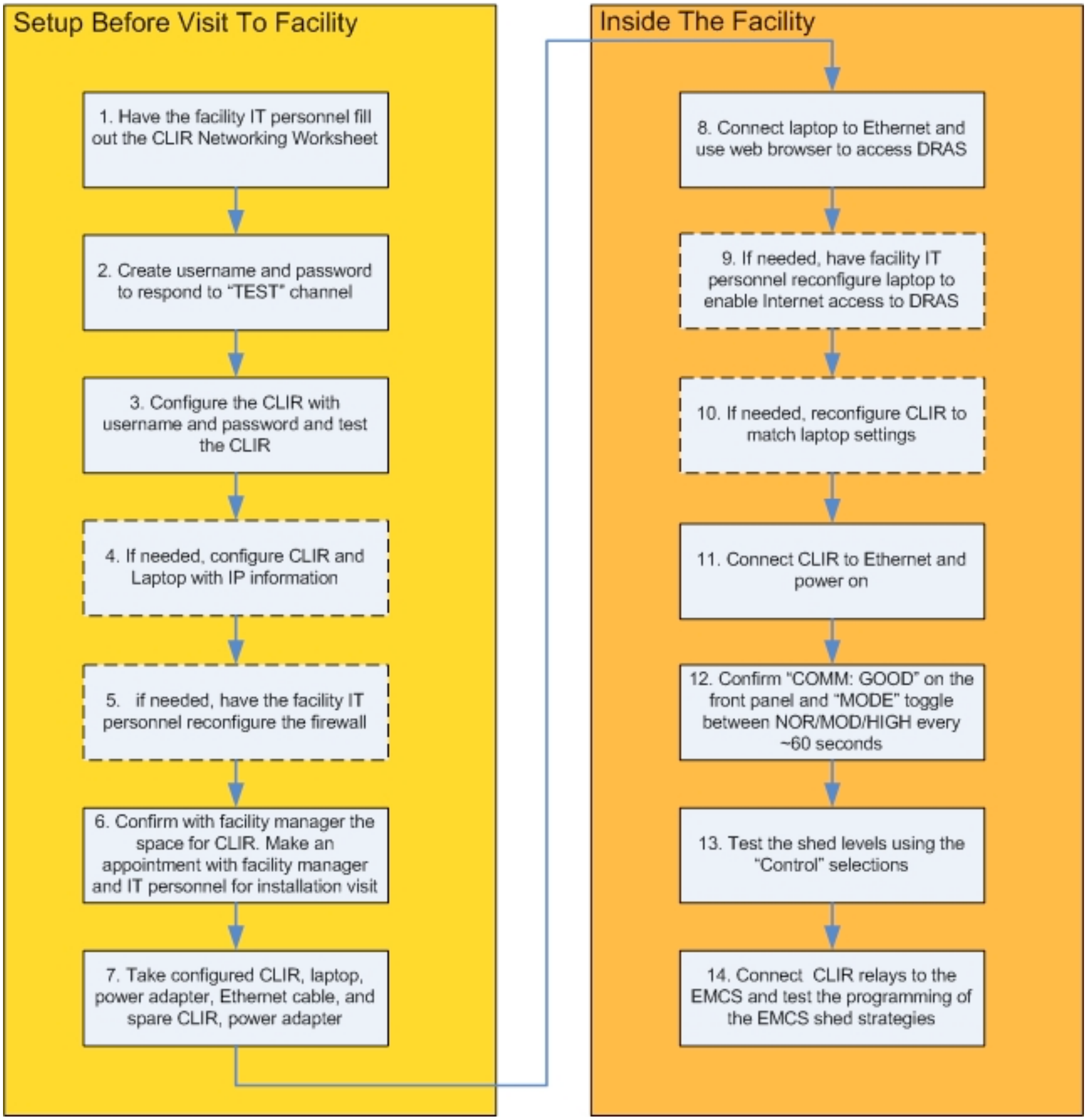
- Pacific Gas & Electric (PG&E) - *pge.openadr.com*
- Southern California Edison (SCE) - *sce.openadr.com*
- San Diego Gas & Electric (SDG&E) - *sdge.openadr.com*

CLIR Security:

CLIR Box is "IT Friendly". It is typically installed inside of the secure enterprise network and "polls" for CPP event information using 128 bit Secure Socket Layer (SSL) encryption using Secure Hyper Text Transfer Protocol (HTTPS). HTTPS is generally accepted Internet standard, also used for most financial transactions. No modification to corporate enterprise firewalls is required. Since the CLIR Box only polls outside network, it is not accessible from the public Internet and adds no security risk from outside the private network. The CLIR Box is also secure from internal threats (employees, contractors etc.) due to its internal firewall which filters out all messages except those from the LBNL DRAS. The CLIR firewall also protects it if the box is installed outside of the private network on the “De-Militarized Zone (DMZ)”. The CLIR Box is password protected and uses (SSL) encryption for all network communications.

Optionally, for those who need additional security and use a firewall to regulate Internet traffic. The firewall can be configured to deny all outgoing communications from the CLIR except for HTTPS access to the utility’s DRAS <*servername*> and DNS access to 206.13.28.12, 206.13.31.12, and 206.13.29.12. All incoming communications to the CLIR can be blocked.

CLIR setup and installation flowchart:



CLIR setup before visiting the facility:

1) Have the facility IT personnel fill out the "CLIR Networking Worksheet" (see appendix F).

2) Create a `username` and secure `password` (8 or more characters long including at least

one number or symbol) for the CLIR and communicate it to the DRAS operator. Note that this same username and password is used to access the My Site page.

3) If you have access to a DHCP network with no proxy server and outgoing firewall restrictions, test that the CLIR can connect to the DRAS using the username and password as follows:

   a) Connect CLIR to the Ethernet port and plug in the power connector.
   b) Wait until the CLIR boots up, enter the username and password. Refer to Appendix B for description on using the CLIR keypad and display.
   c) You should see "**`COMM: GOOD`**" on the CLIR display. If not, contact the DRAS operator.

4) If the subnet where the CLIR is to be connected does not have DHCP or requires a Proxy Server, configure the CLIR and dedicated laptop with prior to arriving at the facility.

   a) Does the subnet where CLIR is connected require static IP address configuration (no DHCP)? If yes, CLIR attributes have to be configured. Enter the information obtained from the "Worksheet – Reference 1" to CLIR. CLIR attributes to be configured are – Static IP address (`netIPAddress` and `DHCP=n`), Default Gateway (`netGatewayAddress`), Subnet Mask (`netSubnetMask`), Preferred and Alternate DNS are needed only for laptop to connection inside facility's network.
   b) Does the subnet require a "Proxy Server" to access HTTPS sites? If yes, more CLIR attributes have to be configured from information in the "Worksheet – Reference 2." CLIR attributes to be configured are – Proxy Server IP (`netProxyIPAddress` and `netProxyServer=y`), Proxy port (`netProxyPort`).
   c) Details on configuring the dedicated laptop are explained in Appendix D.x.

5) If the subnet where the CLIR is to be connected does not have HTTPS or DNS access, the firewall must be reconfigured by the facility IT personnel to provide this access.

6) Confirm with the facility manager that there is physical space to mount the CLIR and connect its power supply, network cables, and relay connections and schedule an appointment w/ facility manager and IT personnel at same time for a visit.

7) Take the pre-configured dedicated laptop, Ethernet (RJ 45) cable, and an extra CLIR box and power adapter to the facility.

At The Facility:

8) Connect the configured laptop to the Ethernet port to be used by CLIR and use a web browser to access the DRAS (https://<utility>.openadr.com/pss2.website) where <utility> is ether "pge" (PG&E), "sce" (SCE), or "sdg" (SDG&E).

9) If the laptop can't access the DRAS log in page, hand in the laptop to IT personnel and ask it to be reconfigured so that Internet access to DRAS is possible.

10) If the laptop was reconfigured by the IT personnel in step 10 above, reconfigure the CLIR to match the new laptop settings.

11) Connect CLIR to the Ethernet port and plug in the power connector and wait until the CLIR boots up (this takes about 2 minutes).

12) Confirm that "**`COMM: GOOD`**" appears on the front panel of the CLIR. If not, confirm the laptop settings to CLIR attributes and try again. Note that the "Mode:" on the front panel may toggle between NOR/MOD/HIGH every 60 seconds or so if the CLIR has been assigned to a test program by the DRAS operator

13) Use another live Internet connection to connect to the DRAS My Site page using the username and password and test the event modes from the following available controls and confirm if CLIR responds to following event mode of operations and test if the relays on the back of CLIR are correct (see Appendix E for details):

    a) Opt Out - For facilities to override Utility's load reduction signals - **`MODE: NORM`**
    b) Forced Moderate – Moderate CPP rate – **`MODE: MOD`**
    c) Forced High – Highest CPP rate – **`MODE: HIGH`**

    Note: Make sure to set the control back to Auto-CPP when this test is completed.

14) Connect the CLIR relays to the EMCS and program the EMCS DR load reduction strategies. Please be aware that in "test" channel the levels toggle between normal/moderate/high when on "AutoDR" mode. See Appendix C for an example.

Note: Please coordinate with Facility Mangers and programmers and clearly communicate the different relay signals, its functions, and relevant actions to be taken for enabling automation and DR strategies.

Contact:

- GEP | gepop@gepllc.com | 925.284.3780
- Akuacom | info@akuacom.com
- LBNL | Demand Response Research Center (DRRC) | AutoDR@lbl.gov

The most recent version of this user-guide is available on – http://www.auto-dr.com

Appendices:

Appendix A.1: Table 1 – LCD Display – Terms and Definitions

CLIR Front Panel Display	Attribute	Description

Display Page 1
`MODE:NORM COMM:GOOD`
`EVNT:NONE LAST:43s`
	MODE	Current shed mode of operation.
		NORM = No shed (Normal)
		MOD = Moderate shed mode (moderate CPP rate)
		HIGH = High shed mode (highest CPP rate)

	COMM	Communication status between CLIR and DRAS. GOOD or BAD.
	EVNT	AutoCPP/AutoDBP event indication. NONE = No upcoming event pending PEND = Event is pending or there is an event in progress.
	LAST	Time duration since the last successful communication between the CLIR and DRAS.

Display Page 2
`IP:128.2.32.154`
`UP:0d 12h 08m 01s`
	IP	IP address of CLIR. The IP address may be automatically assigned by a DHCP server or manually assigned. If the CLIR Box does not have a valid IP address, "IP: Cable?" will be shown. This indicates that either 1) Ethernet cable not connected 2) DHCP server not available on network or 3) Static IP address has not been assigned.

	UP	Time duration since CLIR was last booted.

Display Page 3
`CLIR      R:12345678`
`VER:2.4     10010000`
	CLIR VER	Version of CLIR box.

	R	Status of relays (R1-R8). 0 = Relay de-energized 1 = Relay energized (i.e. normally open contact is closed)

Display Page 4
`SUCC: 27     FAIL: 0`
`AVE:247    MAX:675`
	SUCC	Number of successful communications since start.

	FAIL	Number of communication failures since start.
	AVE	Average communication latency in milliseconds.
	MAX	Maximum communication latency in milliseconds.

Appendix A.2: Table 2 – F2 Setting Menu

Attribute	CLIR Default Settings	Description
consoleLogLevel	INFO	Do not change.
endPointHost	[utility DRAS host]	Do not change.
endPointPath	PSS2WS/PSS2WS	Do not change.
endPointPort	443	Do not change.
fileLogLevel	INFO	Do not change.
ipAddressFile	/usr/clir/eth0-ipaddress	Do not change.
logFile	/usr/clir/clir.log	Do not change.
netDHCP	**y**	If "y", CLIR automatically obtains IP address from DHCP server. Change to "n" if a static IP address is used.
netGatewayAddress	**192.168.1.1**	Default Gateway. If "netDHCP" is "n", the manually entered static IP address is used as default gateway.
netIPAddress	**192.168.1.99**	CLIR Box IP address. If "netDHCP" is "n", the manually entered static IP address is used as IP address for the CLIR Box.
netProxyIPAddress	**192.168.1.2**	If "netProxyServer" is "y", the manually entered static IP address is used as IP address for the proxy server on your network.
netProxyPort	**8080**	Port of proxy server access. If "netProxyServer" is "y", enter IP port of proxy server on your network. Note that the CLIR uses SSL, so this should be the https port.
netProxyServer	**n**	If "y", CLIR accesses to proxy server.
netSubnetMask	**255.255.255.0**	If "netDHCP" is "n", use this IP address for subnet mask.
noLCD	n	Do not change.
noRelay	n	Do not change.
password	**test**	Change to the password you received.
pollPeriodMS	**60000**	Do not change. Frequency of polling activity. Default 60,000 milliseconds indicate 1 poll per minute.
ssl	y	Do not change.
statsLoggingPeriodMS	60000	Do not change.
trustStore	/usr/clir/cacerts.jks	Do not change.
trustStorePassword	epriceLBL	Do not change.
username	**test**	Change to the username you received.

Appendix A.3: CLIR specifications

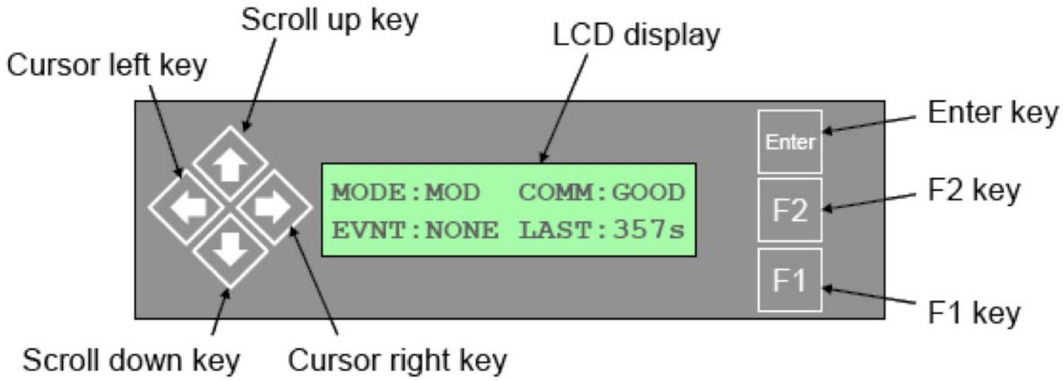
Electrical Specifications:

- 8 Relay Outputs, relay ratings: 24VDC@15A
- 10/100 Base T RJ45 Ethernet connector
- External 100-240VAC power supply: AC INPUT: 100 -240 VAC, DC OUTPUT: 12V, 6.6A, high power (80watt)

Physical Specifications:

- Dimensions: 8.116” x 8.868” x 2.558”
- 8 x 3 position screw terminals for relay connections
- 5mm/2.5mm barrel power jack
- Wall or shelf mount

Appendix B: CLIR Connection and using front-panel



1. Connect CLIR Box

a) Connect Ethernet to CLIR.
b) Plug in power adopter to CLIR.
c) Wait ~ 2 min. for CLIR boot-up. Check the LCD display. At first, you'll see "**`COMM: BAD`**"

2) Configure **`Username`** and **`Password`**

a) Enter username & password using keypad.
b) Press "F2". Scroll up/down until you see "username". The factory default is "test".
c) Press "Enter". Type your username assigned by scrolling up/down. You can move your cursor by pressing left/right arrow button. By pressing "F1", you can delete all characters to the right of the cursor. Once you complete entering your username, press "Enter" again.
d) Scroll up/down until you see "password". The factory default is usually "test".
e) Press "Enter". Type your password assigned by LBNL by scroll up/down. Once you complete, press "Enter" again.
f) Press "F2" to accept the setting and return to the main display Page.
g) Wait a few sec. to 1 min. for CLIR to establish communications with the Demand Response Automation Server (DRAS). The CLIR should respond with "**`COMM: GOOD`**" if the Ethernet connection is configured for DHCP or dynamic IP allocation. If it remains "**`COMM: BAD`**", check the network connection configuration explained previously in this document.

Appendix C: Example Shed Strategy

The CLIR receives signals from the utility indicating when a DR load reduction strategy should be activated. As described above in the section “Event Modes”, these signals are reflected on the relays of the CLIR.

If the facility is signed up for the “AutoCPP” program, the event mode signals have the following meaning:

Event Mode Signal	Price Level
Normal	Normal
Moderate	3 X
High	5 X

- Upon receiving a ”Moderate” event mode signal from Utility, the EMS will increase cooling space set-point by 2 deg F. Heating set-point remain unchanged; hot water valve shall not open as a result of the CPP event. Exhaust Fan 1 LED shall turn off

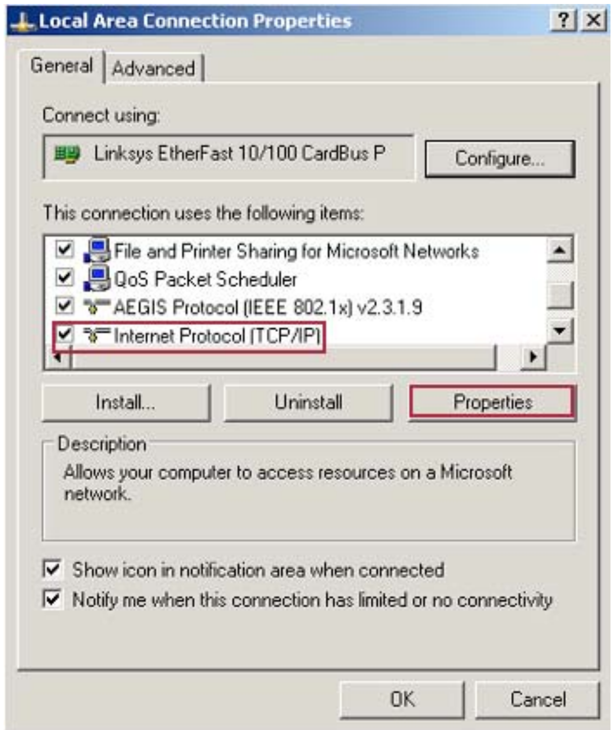
- Upon receiving a ”High” event mode signal from Utility, the EMS will increase cooling space set-point an additional 2 deg F. Heating set-point remains unchanged; hot water valves shall not open as a result of the CPP event. Exhaust Fan 2 LED shall turn off, Exhaust Fan 1 shall remain off.

- Upon receiving a “Normal” event mode signal from Utility, the EMS will release space set-points back to its original setting. Exhaust Fans 1 and 2 shall incrementally turn on with a 30 second delay between fans.

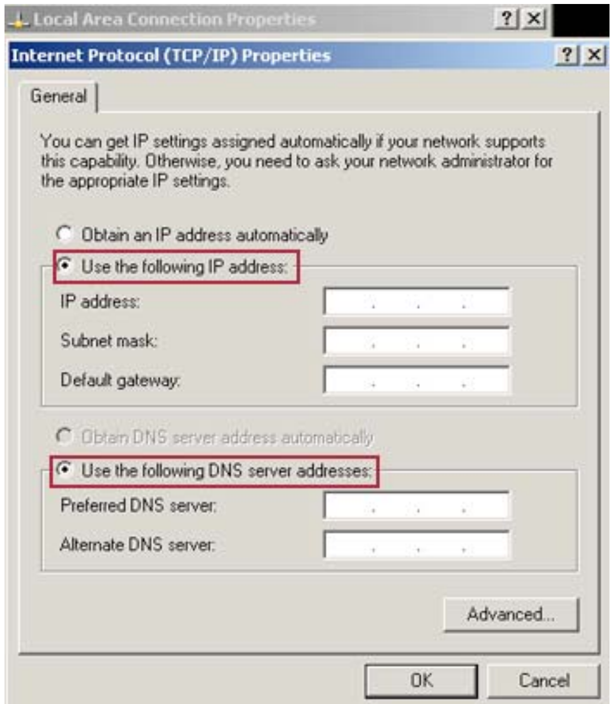
Appendix D.1: Windows IP Configuration

To configure laptop for “Static IP” and/or “Proxy Server” follow these instructions:

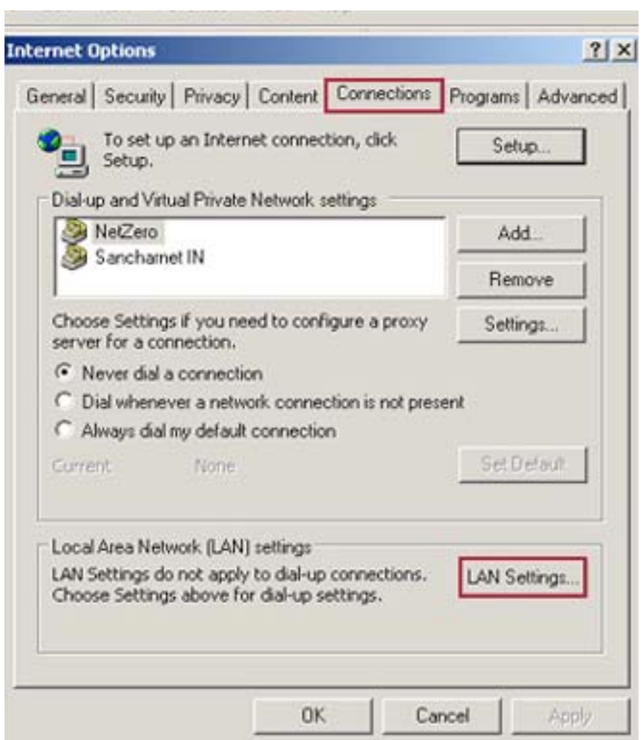
a) For static IP only – Start > Control Panel and select ”Network Connections”
b) Right Click on “ Local Area Connection” and select “Properties”
c) In the resulting window (below) select “TCP/IP” properties



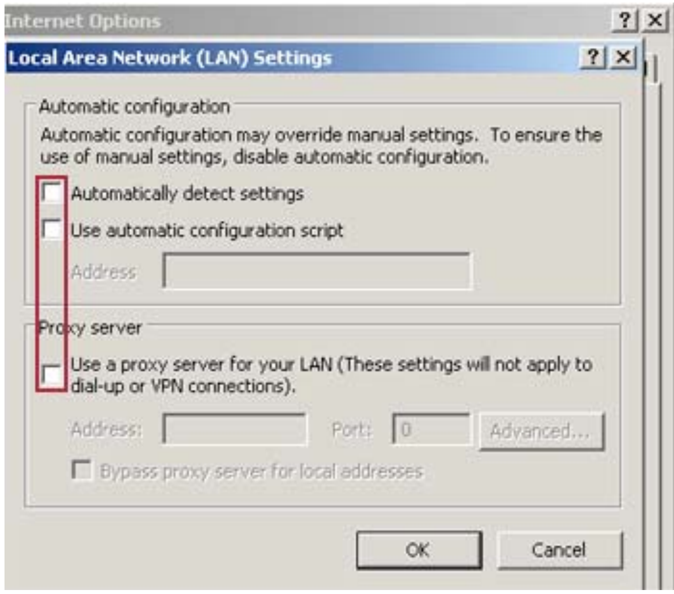
d) In the resulting TCP/IP properties window (below) enter the information obtained from IT personnel in “Use the following IP address” and enter these “Preferred and Alternate DNS Server” IP addresses – 206.13.28.12 and 206.13.31.12.



e) Open your Internet Explorer browser and select Tools > Internet Options. Under "Connections" (below) tab select "LAN settings."

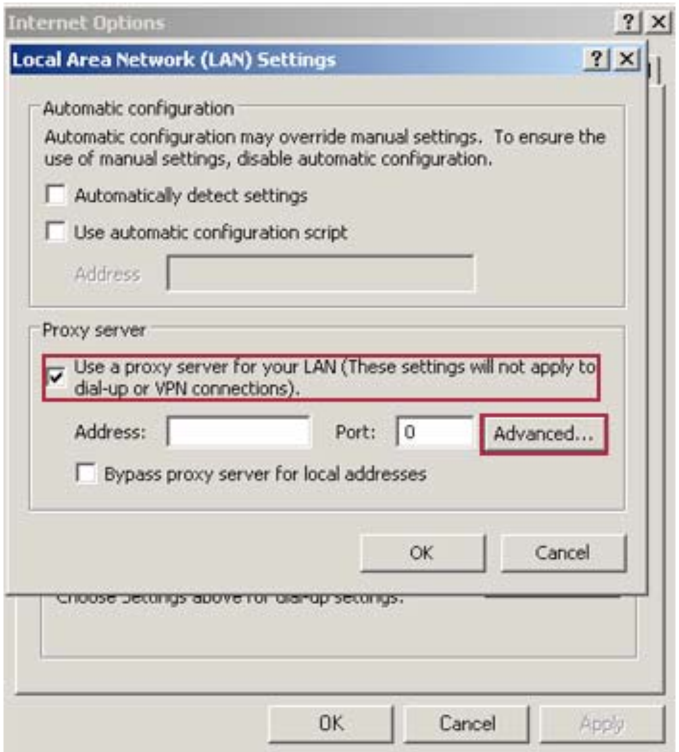


f) Under LAN settings window (below) make sure everything is unchecked.

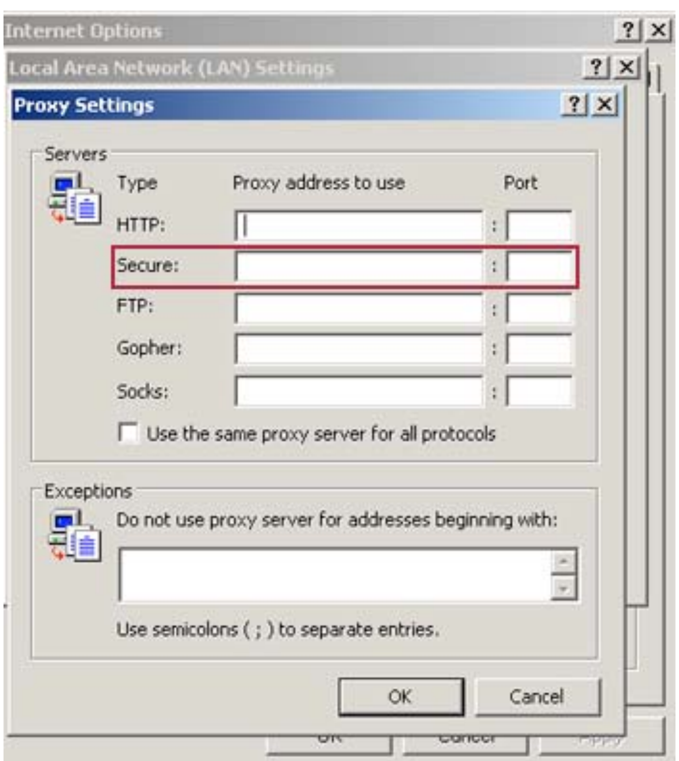


g) Apply the settings and check for the Internet connection. Proceed to synchronize laptop configuration with CLIR attributes, connect CLIR to Internet portal, confirm COMM: GOOD. If not, confirm the laptop settings to CLIR attributes and try again.

h) When facility uses "Proxy Server" for both Dynamic or Static IP address configurations, again in Internet Explorer browser, select Tools > Internet Options. Under "Connections" tab, select "LAN settings" and check "Use Proxy server" (below), enter the proxy IP address, Port (default 8080), and select "Advanced." More details are available at http://support.microsoft.com/kb/135982 as described in Appendix D.2.



i) In the resulting window (below) make sure that for HTTP the address is the same as previous and port is 8080. Optionally "Proxy Server" IP address for "Secure" server (SSL) can also be obtained.



Apply the settings and check for the Internet connection using the laptop.

Appendix D.2: Internet Explorer Proxy Configuration[1]

Internet Explorer 6.0

1. On the Tools menu in Internet Explorer, click Internet Options, click the Connections tab, and then click LAN Settings.
2. Under Proxy server, click to select the Use a proxy server for your LAN check box.
3. In the Address box, type the IP address of the proxy server.
4. In the Port box, type the port number that is used by the proxy server for client connections (by default, 8080).
5. You can click to select the Bypass proxy server for local addresses check box if you do not want the proxy server computer to be used when you connect to a computer on the local network (this may speed up performance).
6. Click OK to close the LAN Settings dialog box.
7. Click OK again to close the Internet Options dialog box.

Internet Explorer 5

1. Click Start, point to Settings, click Control Panel, and then double-click Internet.
2. Click the Connections tab, click LAN Settings, and then click to select the Use Proxy Server check box.
3. In the Address box, type the appropriate proxy server information, and use the following format: http://<address>
4. Click Advanced, and then type the appropriate proxy settings in the Servers area. Use the following syntax for the proxy settings: http://<address>:<port> [where <address> is the Web address of the proxy server, and <port> is the port number that is assigned to the proxy server.] For example, if the proxy server's address is "proxy.example.microsoft.com" and the port number is 80, the setting in the Proxy Server box should appear like this:
http://proxy.example.microsoft.com:80

Important: If you use a backslash (\) instead of a slash (/) in the proxy server's address, the settings disappear from the Proxy Server box and Internet Explorer does not find the proxy server.

If you are using the Internet Protocol (IP) address of your proxy server, make sure not to type leading zeros. For example, use 130.25.0.1 instead of 130.025.000.001.

If you do not know the Web address or port number of the proxy server, contact your network administrator. Also, if there are any Web servers on the local network for which you want to bypass the proxy, type the appropriate host names in the Don't Use Proxy for These Addresses box. For example, if you do not want to use the proxy server to obtain access to the "example.com" Web server on your LAN, type example.com in the Don't Use Proxy for these addresses box.

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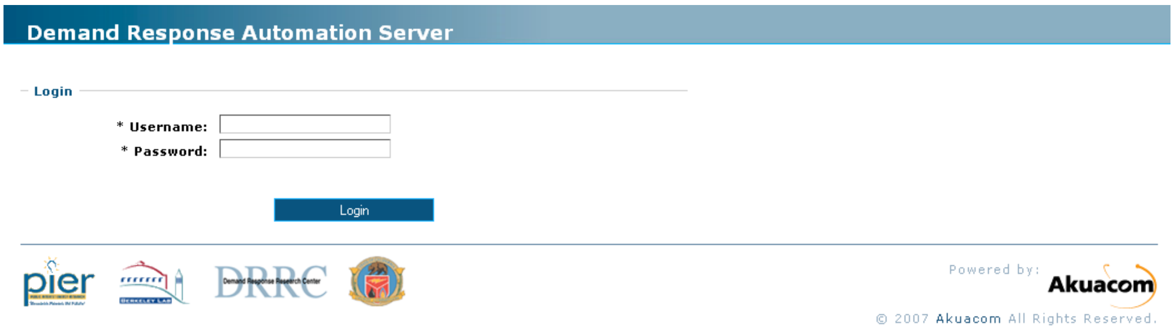
[1] http://support.microsoft.com/kb/135982

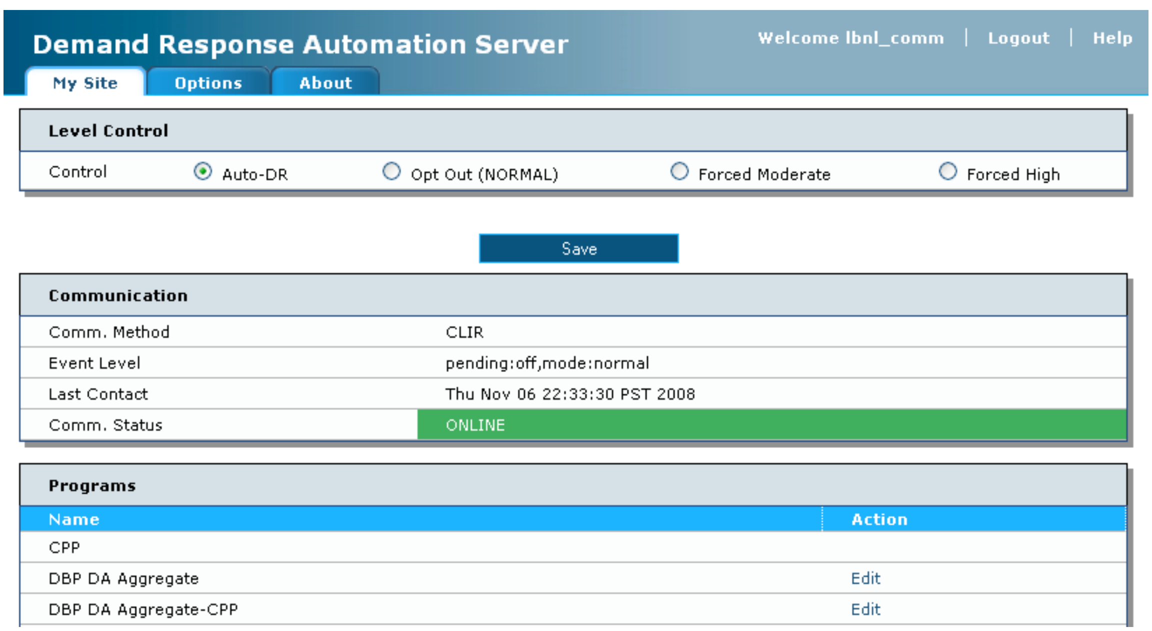
Appendix E: DRAS Relay Test Procedure

Once installation is completed, it is useful to change the event mode signal to confirm the EMCS has programmed and wired to the CLIR correctly. To do this:

1. Login to the DRAS facility manager UI using the provided username and password:



2. On the facility manager "My Site" tab shown below, select the "Forced Moderate" and "Forced High" control settings and confirm the CLIR and EMCS reacts appropriately and the "Last Contact column shows current timestamp. Note that you must click the "Save" button after selecting the control setting for it take affect.



3. Make sure switch the control setting back to "Auto-CPP" when the test is completed.

Note: Under “Options” tab it’s recommended the initial password be changed and known only to the Facility Manager. Any change in password on “My Site” page has to be replicated on CLIR; otherwise CLIR will not communicate to DRAS.

Please contact the program operator to test event pending relay in CLIR.

Appendix F: CLIR Troubleshooting Guide

Once installation is completed, it is useful to change the event mode signal to confirm the EMCS has programmed and wired to the CLIR correctly. To do this:

Problem Type	Possible Reason	Resolution Used	Future Mitigation
Endpointhost "*.openadr.com" does not work at facility	Wrong configuration of local network's access restrictions or network policy	TC had to use the IP format of the endpointhost instead of DNS "*.openadr.com".	Better coordination between Facility IT and TC to obtain accurate information for "CLIR Networking Worksheet."
Cannot change the Endpointhost field on CLIR	Older CLIR software did NOT have built-in functionality to change this setting using front-panel	Required logging to CLIR via SSH to change the settings manually in the configuration file.	UPDATE CLIR software version (2.4.2 or higher) that could be edited by CLIR front-panel
CLIR hangs after reboot	CLIR fails to restart due to Ethernet/LAN cable attached	TC resolved by disconnecting Ethernet/LAN cable before reboot.	Reboot CLIR after disconnecting Ethernet/LAN cable or place CLIR on Uninterruptible Power Supply (UPS).
Monthly generator maintenance causes power outage and subsequent hang to CLIR.	CLIR fails to restart due to Ethernet/LAN cable attached.	TC resolved by placing the CLIR on an UPS.	Refer Above
CLIR does not complete the boot sequence	Pre-boot eXecution Environment (PXE) image loads during DNS resolution	1. Add CLIR MAC/IP to PXE blacklist 2. Use static IP setup (no DNS)	RESOLVED within future embedded HW DRAS clients OR as per resolution
CLIR's relay closures did not work properly	Third-party controls contractor used wrong relays on the CLIR (event pending signal is on Relay #1)	Right relay positions were used.	Refer to the CLIR/Application Guide for relay references and event pending and operation modes.
The CLIR’s relays failed to work at a facility	Faulty CLIR (relays broken or damaged during transport) relays.	Replace CLIR	Refer to the CLIR User Guide and carry extra CLIR and adapter to facility during installation/testing.
Test Event Pending relay closure	Works only when DR event is issued	No feature on DRAS to force event pending signal during testing.	RESOLVED by including forced event pending notification in new release of DRAS
CLIR not communicating to DRAS	Alternate DNS addresses then those hard-coded in the CLIR (blocked by a firewall)	Required logging to CLIR via SSH to change the settings manually in the configuration file.	Allow this field to be editable by CLIR front panel OR order a custom CLIR which points to different DNA servers specified by the facility.

CLIR not communicating to DRAS	Network set-up required static IP configuration and CLIR was not given a dedicated IP address on the local network.	Work with the IT manager to find a dedicated IP address and switch the CLIR to static IP mode.	Better coordination between Facility IT and TC to obtain accurate information for "CLIR Networking Worksheet."
CLIR doesn't communicate to DRAS after a network disruption	Older CLIR software had a bug that stopped a graceful reboot	Required manual reboot	UPDATE CLIR software version (2.4.2 or higher) that has reboot switch. Manual reboot will work too.

Appendix G: CLIR IT managers networking worksheet before visiting a facility.

CLIR NETWORKING WORKSHEET

Customer: ________________________________
IT Contact: ________________________________
[Name]
E-Mail: ________________________________
Phone 1: ________________________________
Phone 2: ________________________________

REFERENCE 1
□ DHCP
□ No DHCP (Static IP Address):
IP Address: ____.____.____.____
Subnet Mask: ____.____.____.____
Default Gateway: ____.____.____.____
Preferred DNS [*]: ____.____.____.____
Alternate DNS [*]: ____.____.____.____

* Required for testing laptop at the facility, NOT CLIR.

REFERENCE 2
□ No Proxy Server
□ Proxy Server:
Proxy IP Address: ____.____.____.____
Proxy Port: ________

REFERENCE 3
□ Hosts on subnet have HTTPS access to the DRAS and to DNS servers 206.13.28.12, 206.13.31.12, and 206.13.29.12

DRAS hostname (TC should highlight the hostname, otherwise please confirm):

- PGE - pge.openadr.com
- SCE - sce.openadr.com
- SDG&E - sdge.openadr.com

Appendix D – Sample Site Survey

Site Questionnaire

Interviewer	
Date Interviewed	

1. Contact Information

Name	
Company	
E-mail	
Phone	
Fax	
Contact's address	

2. Site Information

Primary services or products of the site		
Does the site consist of multiple buildings or single building?	☐ Multiple buildings → # of buildings [ ] ☐ Single building	
Location (address)		
Year constructed		
General description of building(s); e.g. # of floors, construction material, wood frame or masonry, type of windows (single or double pane)		
Floor space	Total	
	Conditioned	

Occupancy schedule	Weekday	

	Non-Weekday	
Utility company		
Facility management type	☐ Company-owned ☐ Outsourced	

3. Energy

Meter numbers		
Peak load [kW]		
Connected load [kW]		
Approximate breakdown of winter morning peak period [in %]	Lighting	
	HVAC	
	Appliances, misc.	
	Process line	

4. HVAC system

<table>
<tr><td>HVAC System Schedule</td><td></td></tr>
<tr><td>Air Distribution Type</td><td>Choose one from below:
<table>
<tr><td rowspan="8">Single Duct</td><td rowspan="3">Constant Volume</td><td>Single zone</td><td>☐</td></tr>
<tr><td>Multiple-zone reheat</td><td>☐</td></tr>
<tr><td>Bypass VAV</td><td>☐</td></tr>
<tr><td rowspan="5">Variable air volume (VAV)</td><td>Throttling</td><td>☐</td></tr>
<tr><td>Fan-powered</td><td>☐</td></tr>
<tr><td>Reheat</td><td>☐</td></tr>
<tr><td>Induction</td><td>☐</td></tr>
<tr><td>Variable diffusers</td><td>☐</td></tr>
<tr><td rowspan="3">Dual Duct</td><td colspan="2">Constant volume</td><td>☐</td></tr>
<tr><td colspan="2">VAV</td><td>☐</td></tr>
<tr><td colspan="2">Dual conduit</td><td>☐</td></tr>
</table>
</td></tr>
</table>

	Direct digital control (DDC) at zone level control ☐ Yes ☐ No
	*Global setpoint control capability **(Not currently setup)*** ☐ Yes ☐ No
	Zone temperature setpoint Cooling: **°F** Heating: **°F**
Heating Plant	Describe heating plant: (central vs. de-centralized (Packaged)) Is the system able to keep setpoints?
	Number and size (tons, kW) of equipments:
	Direct digital control (DDC)? ☐ Yes ☐ No
Air Handling Unit	Choose one from below: Constant volume ☐ Variable speed drive (VSD) ☒

	Number and size (horse power, kW, CFM) of equipments:
	Direct digital control (DDC)? ☐ Yes ☐ No

5. Lighting System

Lighting System Schedule	
Zone control	Choose one from below: Single zone control ☐ Multi-zone control ☐
Control type	Check all applicable: Single circuit control for a zone ☐ Multiple circuit control for a zone ☐ Bi-level switching ☐ *Dimmable ballast* ☐
General description of types of lamps and fixtures; e.g., CFLs, T-12s, T-8s, High Intensity Discharge (HID)	
Centralized control	*Centralized lighting control?* ☐ Yes ☐ No
	Is the lighting control integrated into EMCS? ☐ Yes ☐ No

6. Energy Management and Control System

EMCS vendor	
What protocol is used?	

Remote monitoring/ control capability	Control systems are viewable/controllable via (Check all applicable): | | Viewable | Controllable | | *Web-browser* | ☐ | ☐ | | *Off-site* | ☐ | ☐ | | On-site | ☐ | ☐ | | Never | ☐ | ☐ |
Data collection at EMCS	Does the EMCS have capability to trend logs? ☐ Yes ☐ No
	If yes, data point collected:
	Trend interval (minute) |

7. Other Energy Sources and Use

What other energy sources are being used? (gas, steam, on-site generation, etc.)	
For which end-uses are they being used? (List energy source and end use it serves such as hot water, space heating, re-heat, etc.)	
Can we get access to the meter data for the other energy sources? Explain access,	

8. Energy Information System (data monitoring and collection)

Utility provided EIS	Do you have access to a web-based electricity data archive and visualization system? ☐ Yes ☐ No
Other EIS installed	Do you have web-based Energy Information System other than the Meterwatch? ☐ Yes ☐ No

	If yes, vendor:	
	Data points collected:	
	Trend interval (minute)	
	Is the data accessible from third party (LBNL)? ☐ Yes ☐ No	

9. Connectivity – Connecting the EMCS to the Internet

(a) Does the site have Internet connectivity for tenants? (i.e. can they surf the Web?)	☐ Yes ☐ No
(b) Is EMCS data viewable through a Web browser on site?	☐ Yes ☐ No
(c) Is EMCS data viewable through a Web browser off site?	☐ Yes ☐ No
(d) If ***(c) above is Yes***, is a Web programmer available to install a Web services/XML client (template provided)?	☐ Yes ☐ No
(e) If ***(a) = Yes*** and ***(c) or (d) = No***, can you provide a dynamic IP address? A pre-configured Internet relay will be shipped to your site.	☐ Yes ☐ No

10. Shed Plan

Have you done any type of demand shed before?	
Do you have any shed control ideas?	
How much kW do you think you can shed? [kW]	

Site Questionnaire

Interviewer	
Date Interviewed	

11. Contact Information

Name	
Company	
E-mail	
Phone	
Fax	
Contact's address	

12. Site Information

Primary services or products of the site		
Does the site consist of multiple buildings or single building?	☐ Multiple buildings → # of buildings [ ] ☐ Single building	
Location (address)	2800 SW Barton St., West Seattle, WA 98126	
Year constructed		
General description of building(s); e.g. # of floors, construction material, wood frame or masonry, type of windows (single or double pane)		
Floor space	Total	
	Conditioned	

Occupancy schedule	Weekday	
	Non-Weekday	

Utility company	
Facility management type	☐ Company-owned ☐ Outsourced

13. Energy

Meter numbers		
Peak load [kW]		
Connected load [kW]		
Approximate breakdown of winter morning peak period [in %]	Lighting	
	HVAC	
	Appliances, misc.	
	Process line	

14. HVAC system

HVAC System Schedule	Can be found in the mechanical drawings previously provided.
Air Distribution Type	Choose one from below:

Single duct	Constant volume	Single zone	☐
		Multiple-zone reheat	☐
		Bypass VAV	☐
	Variable air volume (VAV)	Throttling	☐
		Fan-powered	☐
		Reheat	☐
		Induction	☐
		Variable diffusers	☐
Dual duct	Constant volume		☐
	VAV		☐
	Dual conduit		☐

	Direct digital control (DDC) at zone level control ☐ Yes ☐ No
	Global setpoint control capability ☐ Yes ☐ No
	Zone temperature setpoint Cooling °F Heating °F
Heating Plant	Describe heating plant: (central vs. de-centralized (Packaged)) Is the system able to keep setpoints? Can be found in the mechanical drawings previously provided.
	Number and size (tons, kW) of equipments: Can be found in the mechanical drawings previously provided.
	Direct digital control (DDC)? ☐ Yes ☐ No

Air Handling Unit	Choose one from below: Constant volume ☐ Variable speed drive (VSD) ☐	
	Number and size (horse power, kW, CFM) of equipments: Can be found in the mechanical drawings previously provided.	
	Direct digital control (DDC)? ☐ Yes ☐ No	

15. Lighting System

Lighting System Schedule	Can be found in the mechanical drawings previously provided.
Zone control	Choose one from below: Single zone control ☐ Multi-zone control ☐
Control type	Check all applicable: Single circuit control for a zone ☐ Multiple circuit control for a zone ☐ Bi-level switching ☐ *Dimmable ballast* ☐
General description of types of lamps and fixtures; e.g., CFLs, T-12s, T-8s, High Intensity Discharge (HID)	
Centralized control	*Centralized lighting control?* ☐ Yes ☐ No
	Is the lighting control integrated into EMCS? ☐ Yes ☐ No

16. Energy Management and Control System

EMCS vendor	
What protocol is used?	WebCTRL version 4.1

Remote monitoring/ control capability	Control systems are viewable/controllable via (Check all applicable):	

	Viewable	Controllable
Web-browser	☐	☐
Off-site	☐	☐
On-site	☐	☐
Never	☐	☐

Data collection at EMCS	Does the EMCS have capability to trend logs? ☐ Yes ☐ No	
	If yes, data point collected:	
	Trend interval (minute)	mixture of 5 minute and change of value

17. Other Energy Sources and Use

What other energy sources are being used? (gas, steam, on-site generation, etc.)	
For which end-uses are they being used? (List energy source and end use it serves such as hot water, space heating, re-heat, etc.)	
Can we get access to the meter data for the other energy sources? Explain access,	

18. Energy Information System (data monitoring and collection)

Utility provided EIS	Do you have access to a web-based electricity data archive and visualization system? ☐ Yes ☐ No

Other EIS installed	Do you have web-based Energy Information System other than the InterAct II? ☐ Yes ☐ No	
	If yes, vendor:	
	Data points collected:	
	Trend interval (minute)	
	Is the data accessible from third party (LBNL)? ☐ Yes ☐ No	

19. Connectivity – Connecting the EMCS to the Internet

(a) Does the site have Internet connectivity for tenants? (i.e. can they surf the Web?)	☐ Yes ☐ No
(b) Is EMCS data viewable through a Web browser on site?	☐ Yes ☐ No
(c) Is EMCS data viewable through a Web browser off site?	☐ Yes ☐ No
(d) If ***(c) above is Yes***, is a Web programmer available to install a Web services/XML client (template provided)?	☐ Yes ☐ No
(e) If ***(a) = Yes*** and ***(c) or (d) = No***, can you provide a public IP address? A pre-configured Internet relay will be shipped to your site.	☐ Yes ☐ No

20. Shed Plan

Have you done any type of demand shed before?	☐ Yes ☐ No If yes, describe the shed control strategy. Yes, but not at this location. Please see the document previously sent labeled “Specific Sequence of events.”

Do you have any shed control ideas?	Yes...please see the document previously sent labeled "Specific Sequence of events."
How much kW do you think you can shed? [kW]	Probably just kW associated with sales floor lighting reductions.

APPENDIX E

Summary of Site Information and DR Test Events

McKinstry

Site Summary

Building Use	Office; Deli; Rec Room	
Industry Classification	Office/Mix use	
City	Seattle, CA	
Gross Floor Area	100,000 ft²	
Conditioned Area	100,000 ft²	
# of Buildings, floor	1 bldgs, 1 floors	
Peak Load kW	347 kW	
Peak W/ft²	3.47 W/ft²	
Tenant Type	Tenant	
Facility Management	Company-owned	
Weekday Schedule	Mon-Fri, 7:00am – 5:00pm	
Non-weekday Schedule	Closed	
Building Details	Single Story buildings with mixed systems and newer additions.	

HVAC System Summary

Air Distribution Type	Single duct constant volume single zone, 2 exhaust fan w/ VFD, 12 exhaust fans
Air Handler Unit	Two 38 tons self-contained water cooled AC package units with VFD, one 30 ton package water cooler AC unit with VFDs, four rooftop cooling only Package units, 20 RTU, 3 AHUs, 2 condensing units
Cooling Plant	2 chillers? (2) cooling tower with VFD, 5 condenser water pumps, 2 condenser water pumps w/ VFD, 1 hot water pump, heat pump
Heating Plant	2 boilers, one of them is not used, 3 electric water heaters, 2 gas fired radiant heaters,
HVAC Control System	Alerton
DDC Zone Control	Yes
Other Details	Distance from the weather station is 2.3 miles. 10 refrigerators, one freezer, one ice maker, one walk-in frzr condensing unit and one walk-in frzr evaporator section

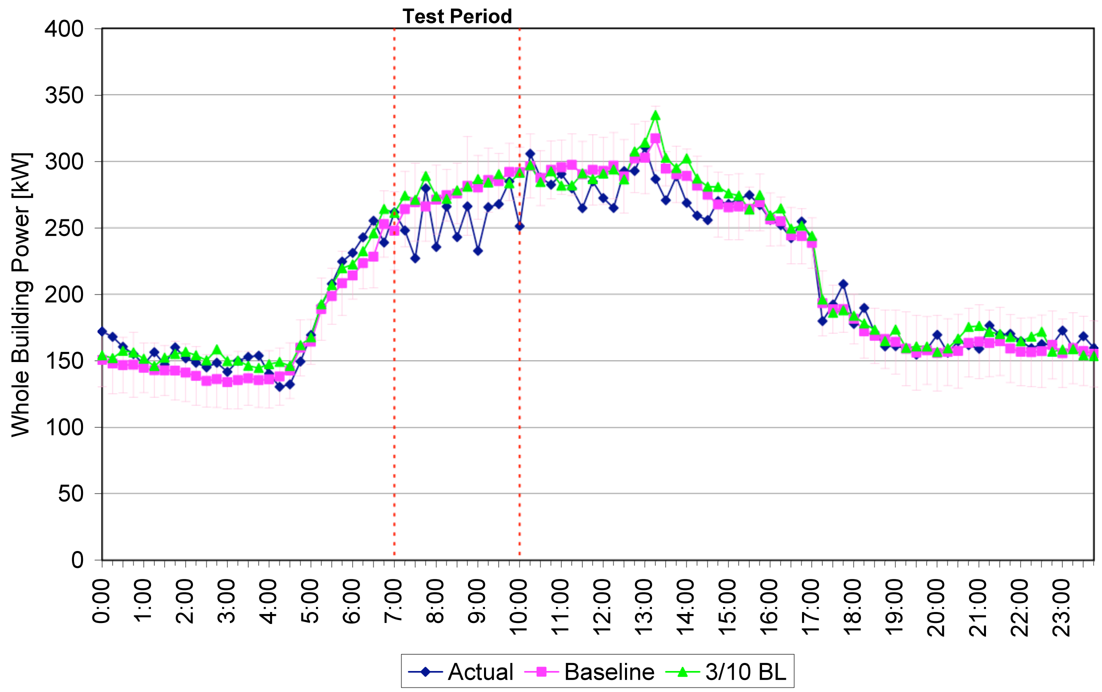
Data Trending

DDC Zone Control	Yes
Data Trending Detail	Zone setpoints and roof-top unit start/stop times

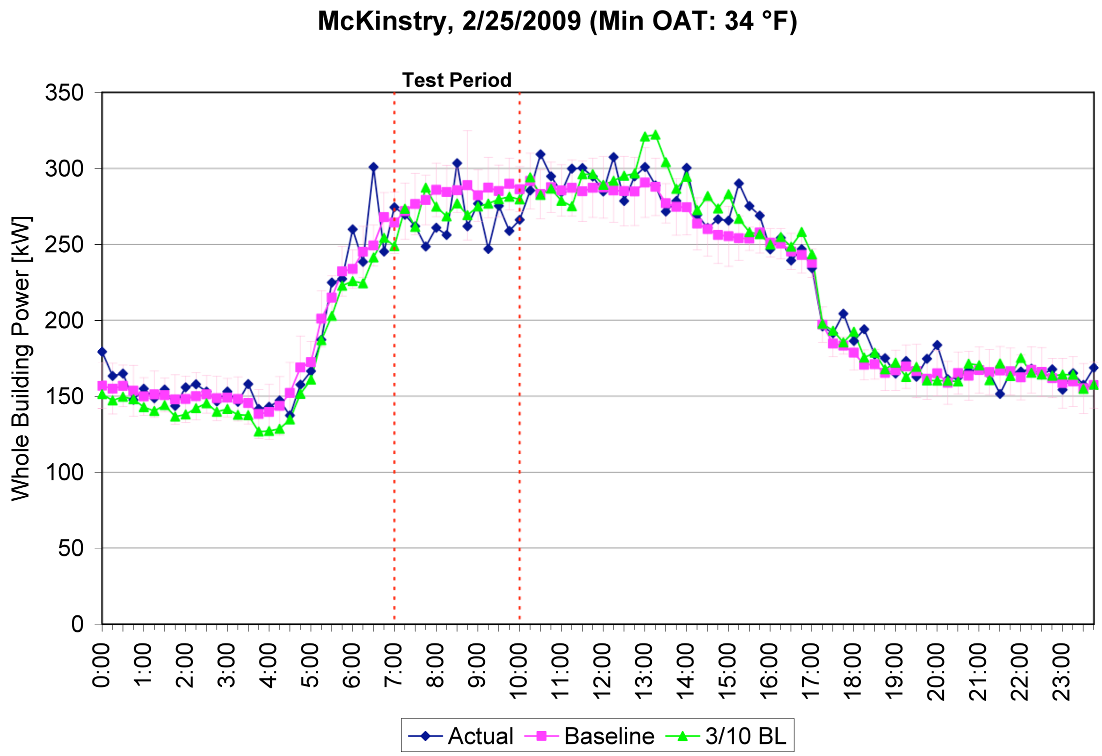
OpenADR System Summary

Communication Method		Software client at site
Gateway/Relay Device	Richards-Zeta	
Shed Strategies	**Pre-Event DR Strategy**	None
	Test Period	Uniformly turn off half of the 23 roof-top units for 15 minutes and alternate with the remaining units every 15 minutes.
	Slow Recovery	Stage turning on equipment every 2 minutes.

McKinstry, 2/18/2009 (Min OAT: 34 °F)

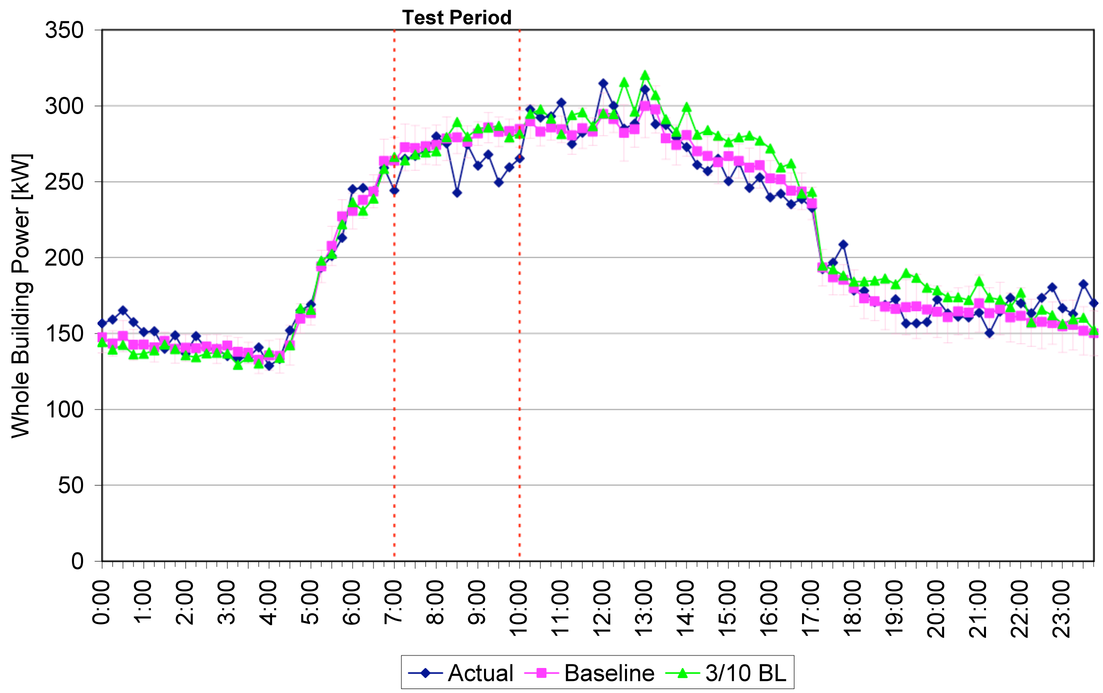


Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Feb-18	OAT BL	7:00-8:00	42	20	0.42	0.20	16%	7%
		8:00-9:00	48	26	0.48	0.26	17%	9%
		9:00-10:00	41	21	0.41	0.21	14%	7%
		7:00-10:00	48	22	0.48	0.22	17%	8%
	3/10 BL	7:00-8:00	44	29	0.44	0.29	16%	11%
		8:00-9:00	54	27	0.54	0.27	19%	10%
		9:00-10:00	40	20	0.40	0.20	14%	7%
		7:00-10:00	54	26	0.54	0.26	19%	9%

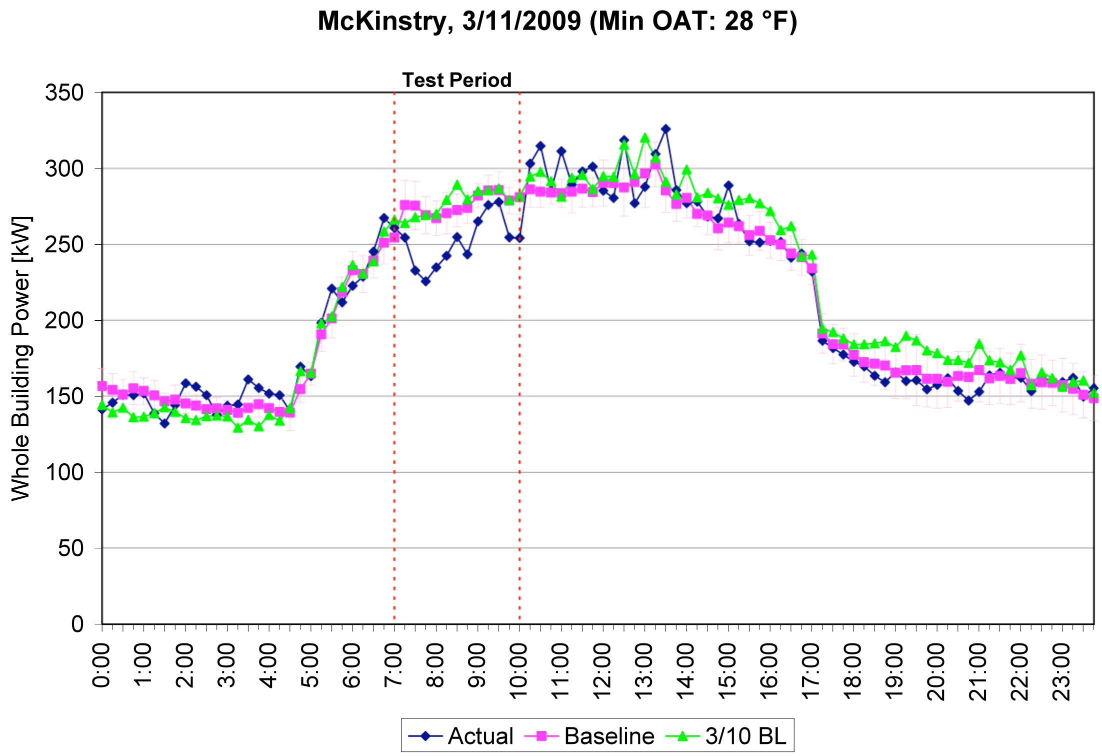


Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Feb-25	OAT BL	7:00-8:00	31	18	0.31	0.18	11%	6%
		8:00-9:00	28	11	0.28	0.11	10%	4%
		9:00-10:00	40	25	0.40	0.25	14%	9%
		7:00-10:00	40	18	0.40	0.18	14%	6%
	3/10 BL	7:00-8:00	39	14	0.39	0.14	13%	5%
		8:00-9:00	12	-2	0.12	-0.02	5%	-1%
		9:00-10:00	30	18	0.30	0.18	11%	6%
		7:00-10:00	39	10	0.39	0.10	13%	3%

McKinstry, 3/5/2009 (Min OAT: 38 °F)



Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-05	OAT BL	**7:00-8:00**	8	2	0.08	0.02	3%	1%
		8:00-9:00	37	16	0.37	0.16	13%	6%
		9:00-10:00	33	24	0.33	0.24	12%	8%
		7:00-10:00	37	14	0.37	0.14	13%	5%
	3/10 BL	**7:00-8:00**	1	-3	0.01	-0.03	0%	-1%
		8:00-9:00	47	20	0.47	0.20	16%	7%
		9:00-10:00	37	23	0.37	0.23	13%	8%
		7:00-10:00	47	13	0.47	0.13	16%	5%



Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-11	OAT BL	**7:00-8:00**	44	35	0.44	0.35	16%	13%
		8:00-9:00	31	23	0.31	0.23	11%	9%
		9:00-10:00	27	17	0.27	0.17	10%	6%
		7:00-10:00	44	25	0.44	0.25	16%	9%
	3/10 BL	**7:00-8:00**	44	31	0.44	0.31	16%	11%
		8:00-9:00	37	32	0.37	0.32	13%	11%
		9:00-10:00	28	18	0.28	0.18	10%	6%
		7:00-10:00	44	27	0.44	0.27	16%	10%

Seattle Municipal Tower

Site Summary

Building Use	office, gym	
Industry Classification	Office	
City	Seattle, CA	
Gross Floor Area	1,200,000 ft²	
Conditioned Area	1,200,000 ft²	
# of Buildings, floor	1 bldgs, 62 floors	
Peak Load kW	6168 kW	
Peak W/ft²	5.14 W/ft²	
Tenant Type	Tenant	
Facility Management	Leased	
Weekday Schedule	Mon-Fri, 6:30am – 11:00pm	
Non-weekday Schedule	Closed	
Building Details	62 story high-rise office building - houses Seattle City Light offices	

HVAC System Summary

Air Distribution Type	Variable Air Volume
Air Handler Unit	4 supply fans: 14,500 CFM (average) each 4 return fans: 2,700 CFM (average) each Supply Air Temperature: 56 F, 20% Outside Air
Cooling Plant	2 chillers: 975 tons/each Chilled Water Supply Temp: 45 F, Cooling lock out at 55 F Outside Air Temperature 1 chilled water pump: 20 hp, variable volume
Heating Plant	1 hot water boiler (2,000 Mbtu/h) + a backup boiler Hot water temp: 160 - 180 F 2 hot water pumps: 15 hp each, CV
HVAC Control System	Invensys
DDC Zone Control	Yes
Other Details	Distance from the weather station is 5.4 miles.

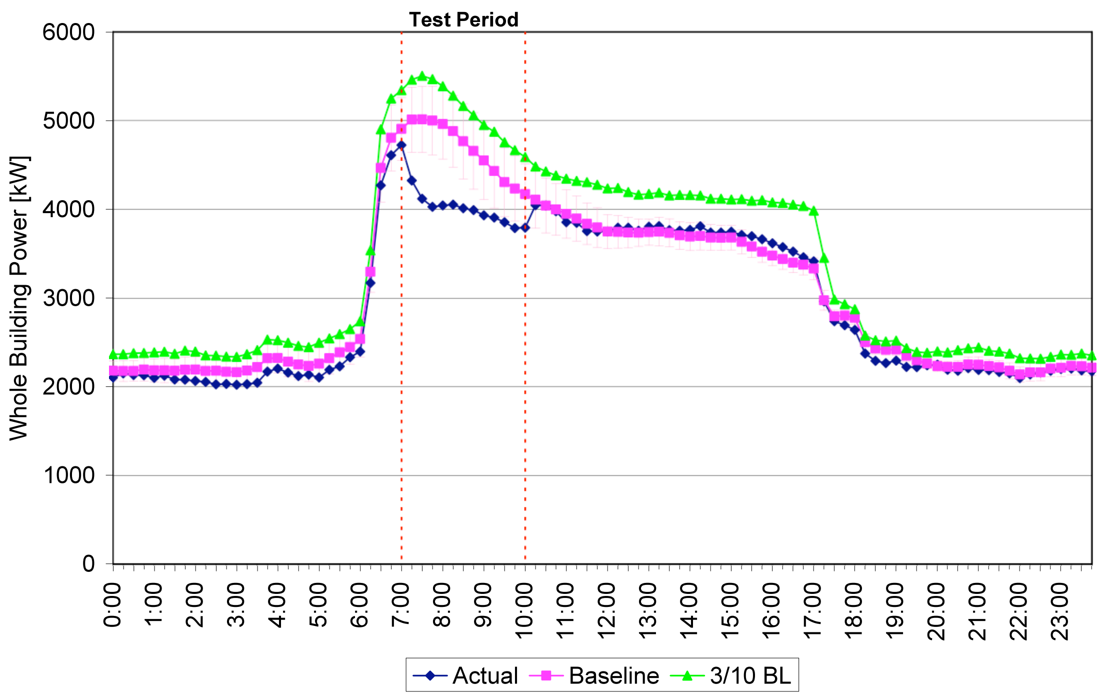
Data Trending

DDC Zone Control	Yes
Data Trending Detail	For each roof-top unit: Fan status, heating stage status, control temperature setpoints

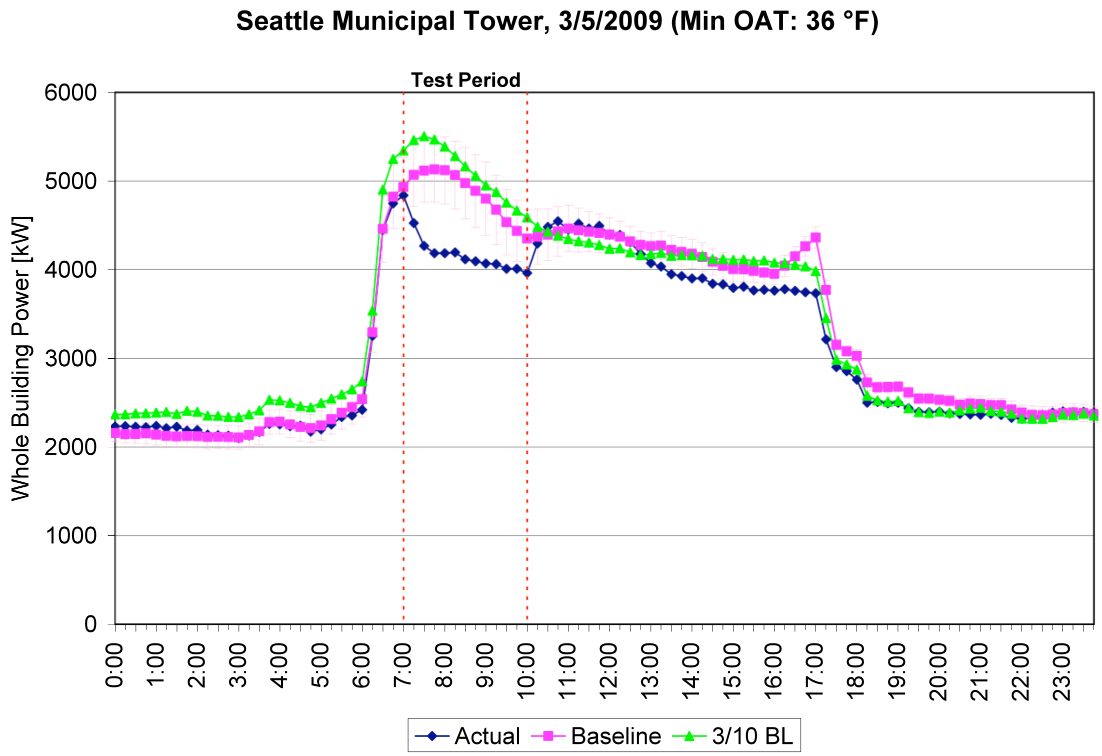
OpenADR System Summary

Communication Method		CLIR at site
Gateway/Relay Device	CLIR	
Shed Strategies	**Pre-Event DR Strategy**	None.
	Test Period	Decrease setpoints from 72 ºF to 68 ºF on selected 24 floors out of 62 floors. Cycle VAV boxes (690) and corresponding AHUs (48).
	Slow Recovery	Set setpoints back 1º every 15 minutes and bring back quarter of the equipment on line every five minutes.

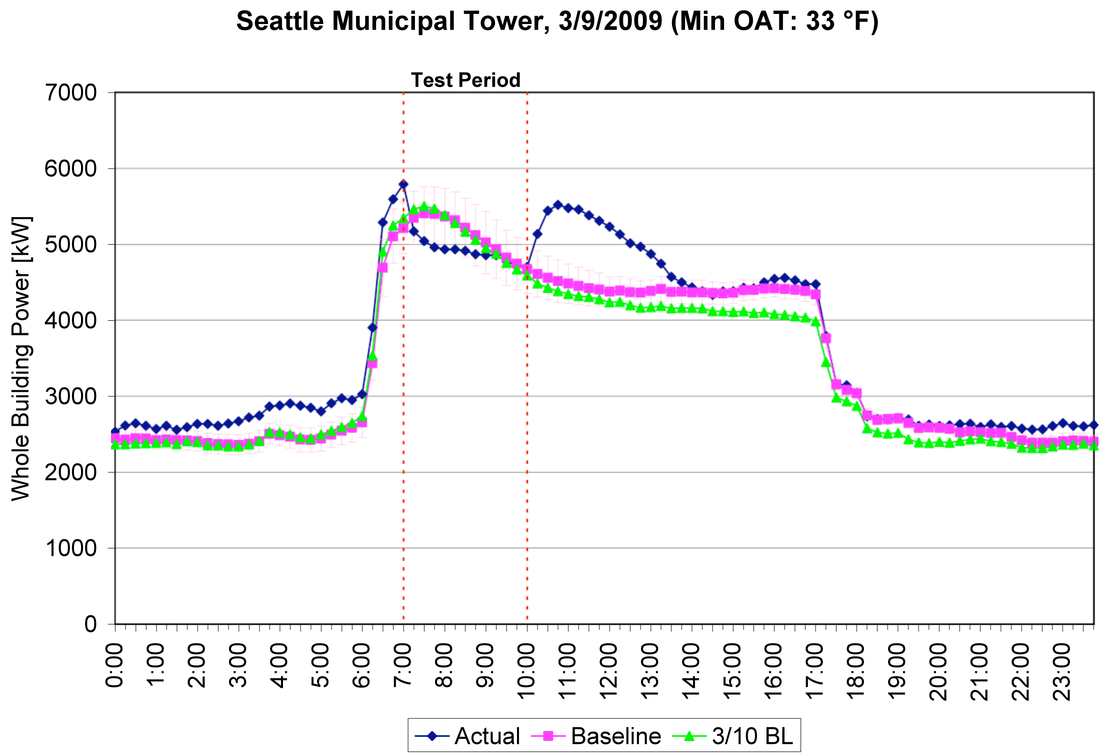
Seattle Municipal Tower, 3/3/2009 (Min OAT: 43 °F)



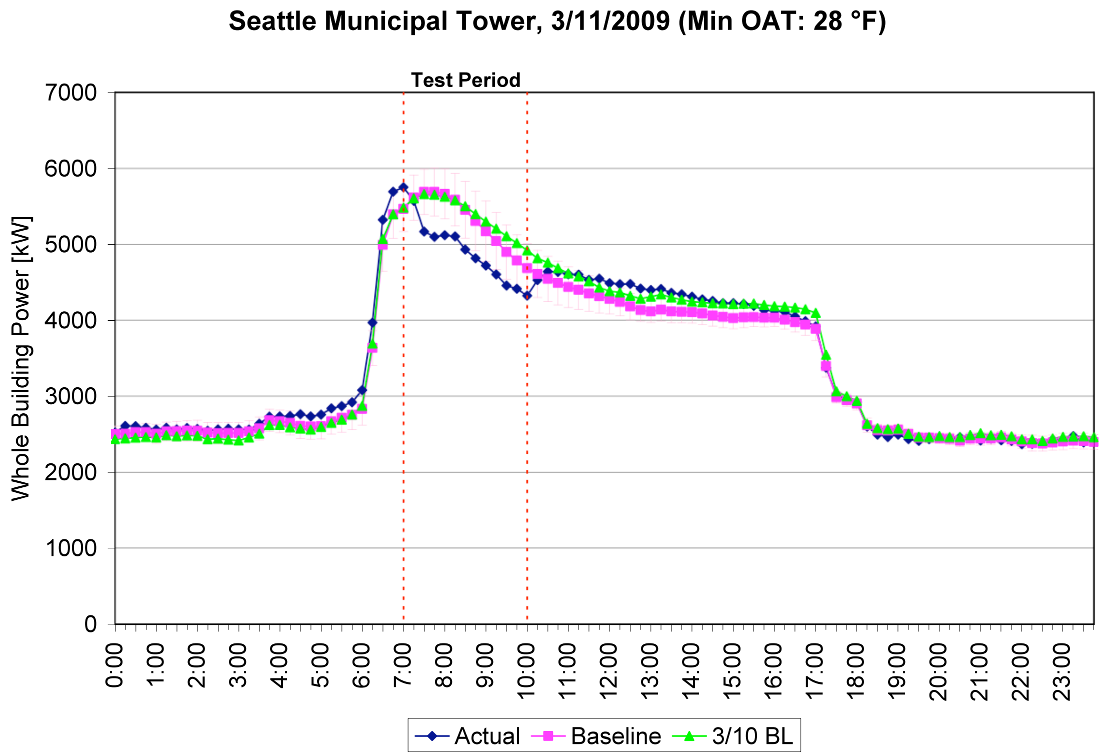
Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-03	OAT BL	7:00-8:00	973	867	0.81	0.72	19%	17%
		8:00-9:00	827	716	0.69	0.60	17%	15%
		9:00-10:00	525	450	0.44	0.37	12%	10%
		7:00-10:00	973	678	0.81	0.56	19%	14%
	3/10 BL	7:00-8:00	1440	1326	1.20	1.10	26%	24%
		8:00-9:00	1227	1116	1.02	0.93	23%	22%
		9:00-10:00	967	886	0.81	0.74	20%	19%
		7:00-10:00	1440	1109	1.20	0.92	26%	22%



Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-05	OAT BL	7:00-8:00	945	818	0.79	0.68	18%	16%
		8:00-9:00	873	814	0.73	0.68	17%	16%
		9:00-10:00	612	488	0.51	0.41	13%	11%
		7:00-10:00	945	706	0.79	0.59	18%	14%
	3/10 BL	7:00-8:00	1283	1164	1.07	0.97	23%	21%
		8:00-9:00	1087	996	0.91	0.83	21%	19%
		9:00-10:00	811	711	0.68	0.59	17%	15%
		7:00-10:00	1283	957	1.07	0.80	23%	19%



Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-09	OAT BL	**7:00-8:00**	440	353	0.37	0.29	8%	7%
		8:00-9:00	384	277	0.32	0.23	7%	5%
		9:00-10:00	78	31	0.07	0.03	2%	1%
		7:00-10:00	440	220	0.37	0.18	8%	4%
	3/10 BL	**7:00-8:00**	509	428	0.42	0.36	9%	8%
		8:00-9:00	348	220	0.29	0.18	7%	4%
		9:00-10:00	18	-41	0.02	-0.03	0%	-1%
		7:00-10:00	509	202	0.42	0.17	9%	4%



Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-11	OAT BL	**7:00-8:00**	590	424	0.49	0.35	10%	7%
		8:00-9:00	523	487	0.44	0.41	10%	9%
		9:00-10:00	441	403	0.37	0.34	9%	8%
		7:00-10:00	590	438	0.49	0.37	10%	8%
	3/10 BL	**7:00-8:00**	554	396	0.46	0.33	10%	7%
		8:00-9:00	581	551	0.48	0.46	11%	10%
		9:00-10:00	650	613	0.54	0.51	13%	12%
		7:00-10:00	650	520	0.54	0.43	13%	10%

Seattle University - Student Center

Site Summary

Building Use	Education	
Industry Classification	Education	
City	Seattle, CA	
Gross Floor Area	99,840 ft²	
Conditioned Area	99,840 ft²	
# of Buildings, floor	1 bldgs, 3 floors	
Peak Load kW	840.9 kVA kW	
Peak W/ft²	8.42 W/ft²	
Tenant Type	Owner Occupied	
Facility Management	Company-owned	
Weekday Schedule	Mon-Fri, 6:30am – 11:00pm	
Non-weekday Schedule	Sat&Sun	
Building Details	This is a mix-use student center.	

HVAC System Summary

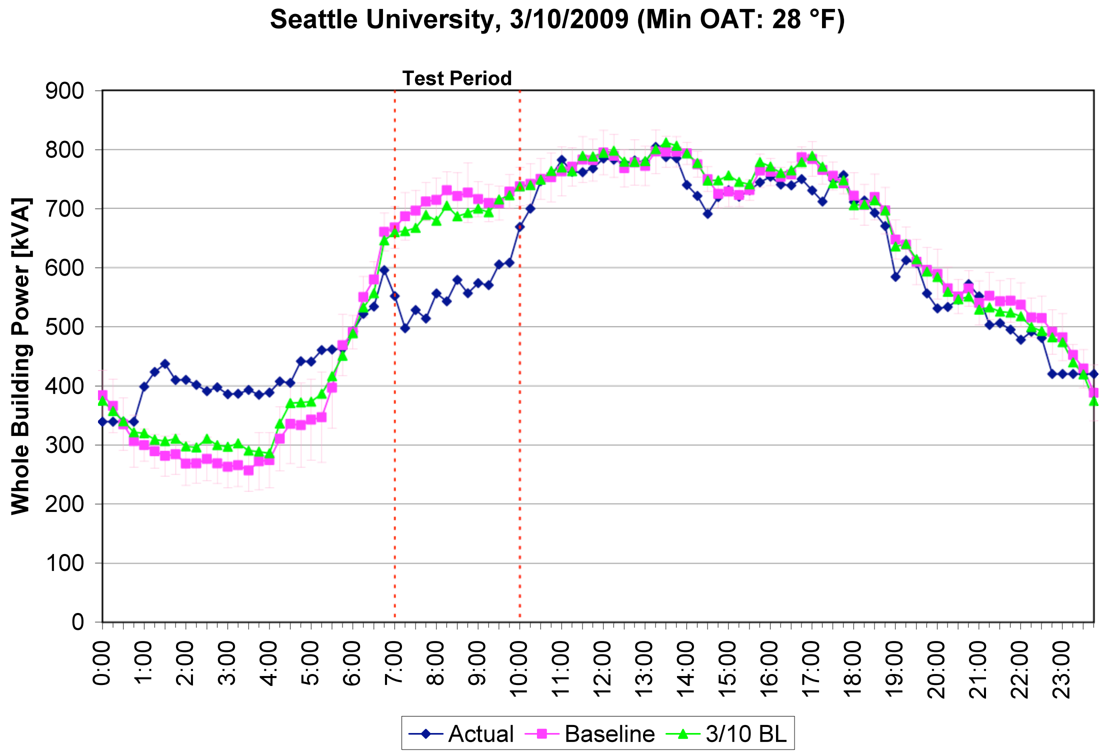
Air Distribution Type	Variable Air Volume with reheat, fan-powered air terminal boxes
Air Handler Unit	6 AHUs w/ VFD for cooling, 102 air terminal boxes, 8 supply fans, 13 exhaust fans, SA 53 F; 7 AHUs w/ VFD for heating, 5 water heating coils, 7 cabinet heaters,1 panel radiator unit, 1 makeup air unit.
Cooling Plant	Chilled water from campus
Heating Plant	Campus steam, 2 electric unit heaters, 2 hot water pumps.
HVAC Control System	BACNet ESC. GRAFIK EYE Lighting Control Panel (LUTRON) installed by Netversant.
DDC Zone Control	Yes
Other Details	Distance from the weather station is 5.6 miles.

Data Trending

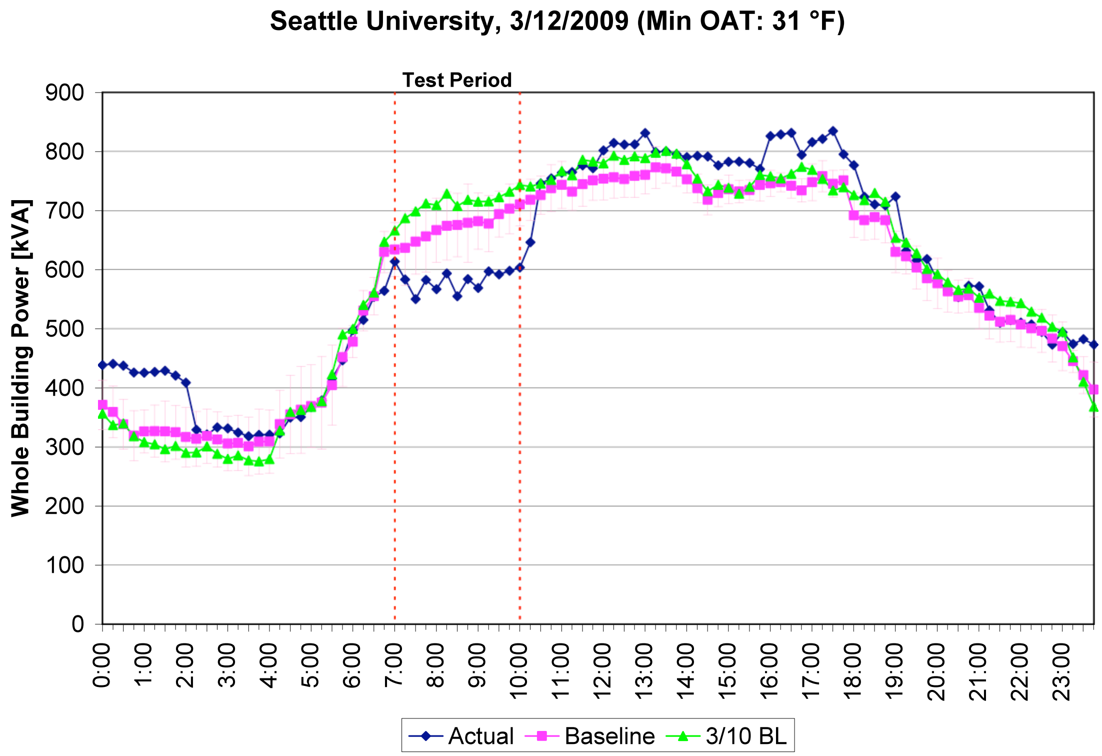
DDC Zone Control	Yes
Data Trending Detail	For each of the AHUs: CO_2 setpoints, supply fans, VAV fans, heating temperature setpoints, cooling temperature setpoints, fans

OpenADR System Summary

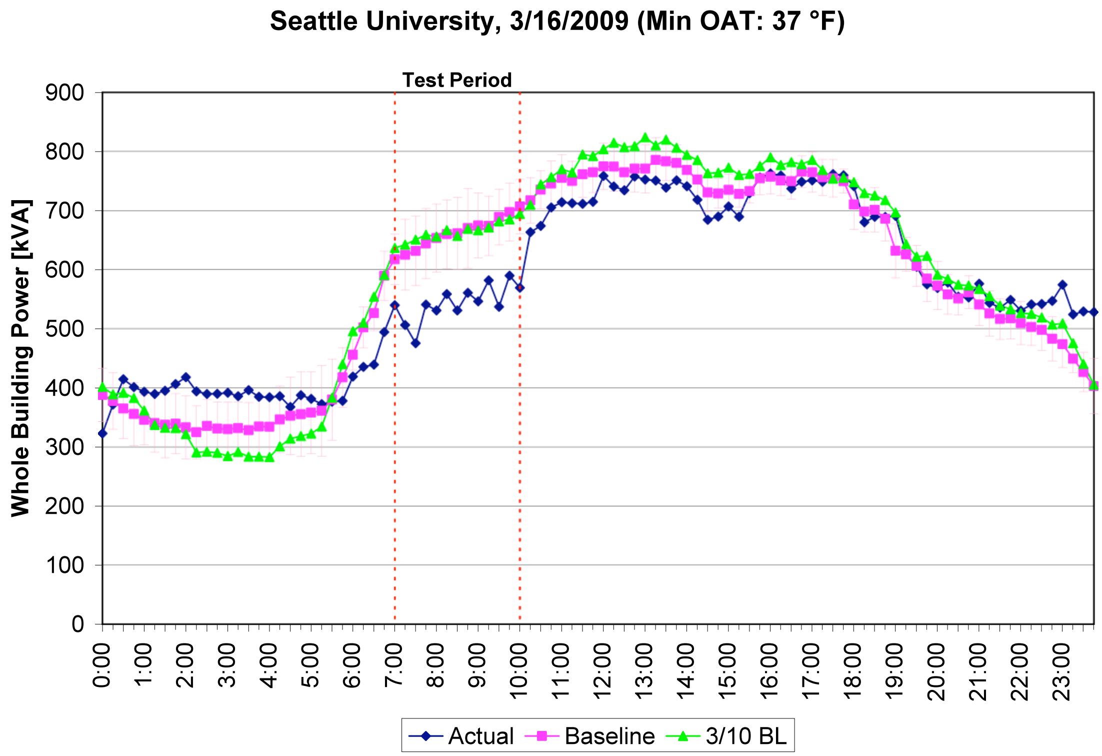
Communication Method		CLIR at site
Gateway/Relay Device	CLIR	
Shed Strategies	**Pre-Event DR Strategy**	Pre-heat at 5 am at 74 ºF (only on the day-ahead days because pending signal for day-of events are received at 6 am)
	Test Period	Decrease set point to 68 ºF. Cycle cabinet heaters (7) and unit heaters (2) 20 minutes every 30 minute. Cycle through half of VAV/Air terminal boxes (75) and AHU fans (4) every half hour. Set CO_2 setpoint up by 200 ppm. Turn off hot water panel radiator.
	Slow Recovery	Return setpoints to original levels (maximum rate of setpoint change is 1º per 15 minutes) and turn half of units on, then turn remainder of units on five minutes later.



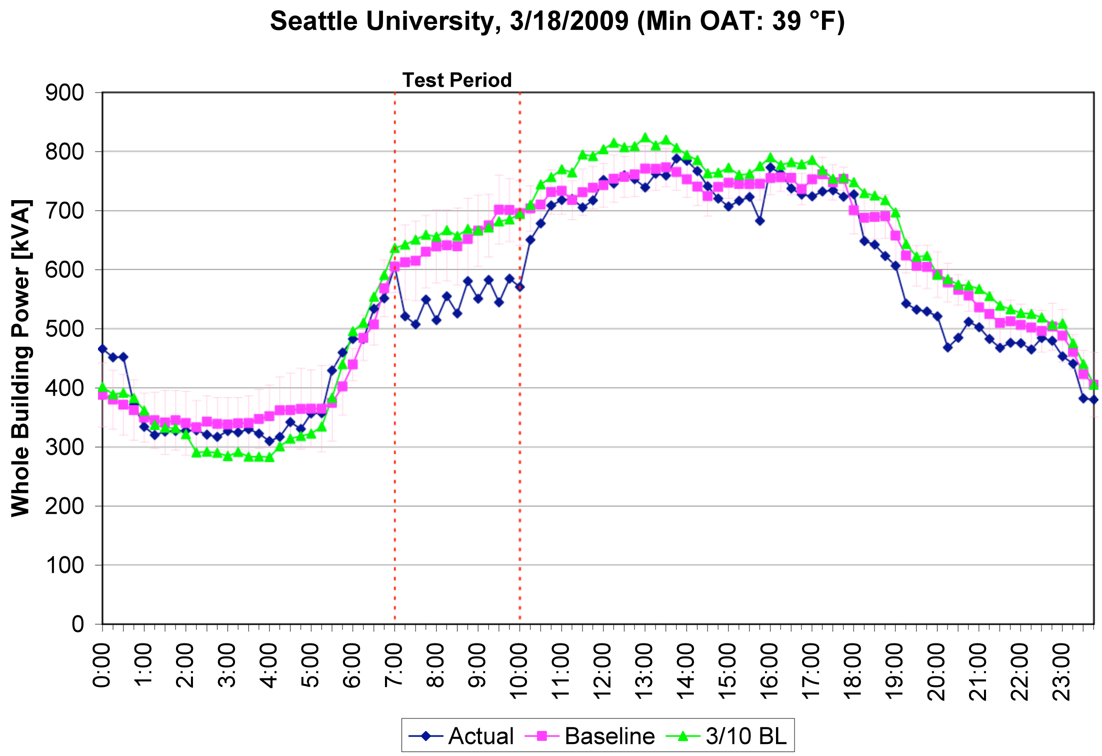
Date	Baseline	Period	kVA		VA/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-10	OAT BL	7:00-8:00	198	178	1.98	1.79	28%	25%
		8:00-9:00	188	160	1.88	1.61	26%	22%
		9:00-10:00	139	108	1.39	1.08	20%	15%
		7:00-10:00	198	149	1.98	1.49	28%	21%
	3/10 BL	7:00-8:00	175	150	1.75	1.51	25%	22%
		8:00-9:00	162	133	1.62	1.33	23%	19%
		9:00-10:00	123	104	1.24	1.04	18%	15%
		7:00-10:00	175	129	1.75	1.29	25%	19%



Date	Baseline	Period	kVA		VA/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-12	OAT BL	7:00-8:00	100	81	1.00	0.81	15%	12%
		8:00-9:00	121	102	1.21	1.03	18%	15%
		9:00-10:00	107	99	1.07	0.99	15%	14%
		7:00-10:00	121	94	1.21	0.94	18%	14%
	3/10 BL	7:00-8:00	149	131	1.49	1.31	21%	19%
		8:00-9:00	153	142	1.53	1.42	22%	20%
		9:00-10:00	140	131	1.40	1.31	19%	18%
		7:00-10:00	153	135	1.53	1.35	22%	19%



Date	Baseline	Period	kVA		VA/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-16	OAT BL	7:00-8:00	156	125	1.56	1.25	25%	20%
		8:00-9:00	130	117	1.31	1.18	20%	18%
		9:00-10:00	152	122	1.52	1.23	22%	18%
		7:00-10:00	156	122	1.56	1.22	25%	18%
	3/10 BL	7:00-8:00	175	139	1.75	1.39	27%	21%
		8:00-9:00	126	116	1.26	1.16	19%	17%
		9:00-10:00	144	114	1.45	1.14	21%	17%
		7:00-10:00	175	123	1.75	1.23	27%	18%



Date	Baseline	Period	kVA		VA/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-18	OAT BL	7:00-8:00	125	101	1.25	1.01	19%	16%
		8:00-9:00	115	97	1.15	0.97	18%	15%
		9:00-10:00	157	123	1.57	1.23	22%	18%
		7:00-10:00	157	107	1.57	1.07	22%	16%
	3/10 BL	7:00-8:00	143	129	1.43	1.29	22%	20%
		8:00-9:00	131	112	1.31	1.12	20%	17%
		9:00-10:00	137	113	1.37	1.13	20%	16%
		7:00-10:00	143	118	1.43	1.18	22%	18%

Target (T1284)

Site Summary

Building Use	Retail
Industry Classification	Retail
City	Seattle, CA
Gross Floor Area	165,667 ft²
Conditioned Area	165,667 ft²
# of Buildings, floor	1 bldgs, 3 floors
Peak Load kW	685 kW
Peak W/ft²	4.13 W/ft²
Tenant Type	Owner occupied
Facility Management	Company-owned
Weekday Schedule	Mon-Fri, 8:00am – 10:00pm
Non-weekday Schedule	Sat 8:00am-10:00pm; Sun 8:00am-9:00pm
Building Details	Newer store

HVAC System Summary

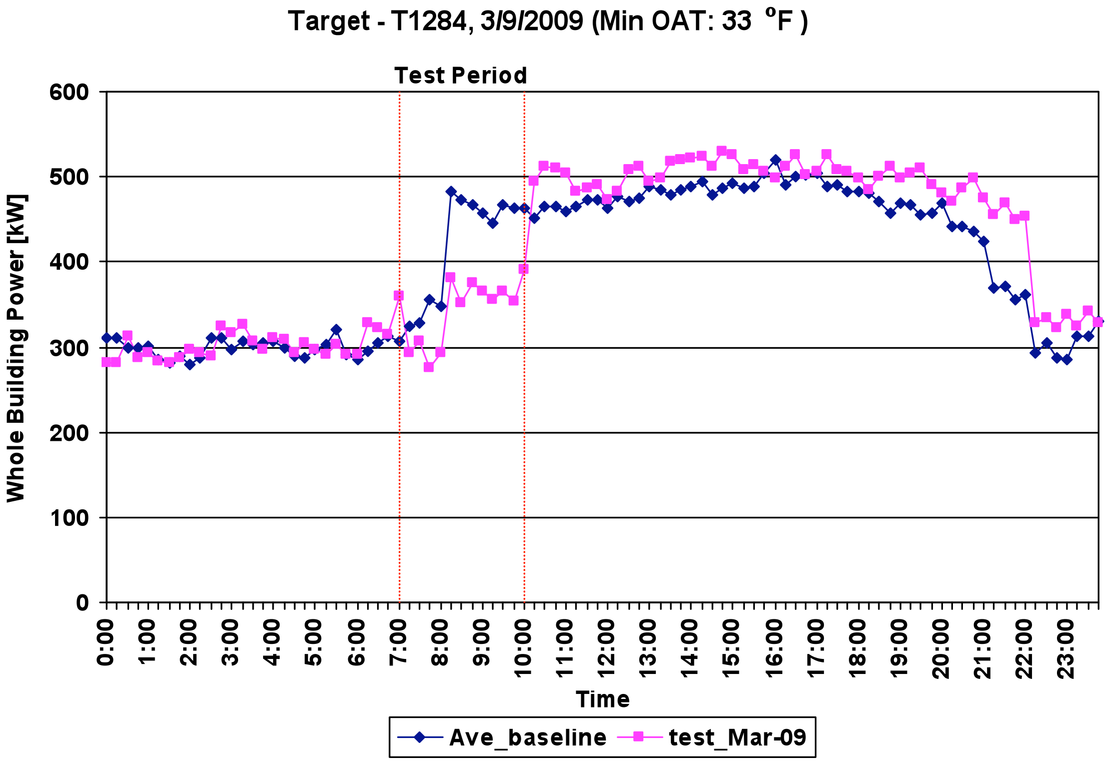
Air Distribution Type	Single duct mix of constant and variable volume.
Air Handler Unit	2 Air conditioning units, 14 roof top units
Cooling Plant	No built-up system
Heating Plant	2 forced air furnaces, 9 water heaters
HVAC Control System	WebCTRL, Automated Logic Corp
DDC Zone Control	Yes
Other Details	Distance from the weather station is 12.4 miles.

Data Trending

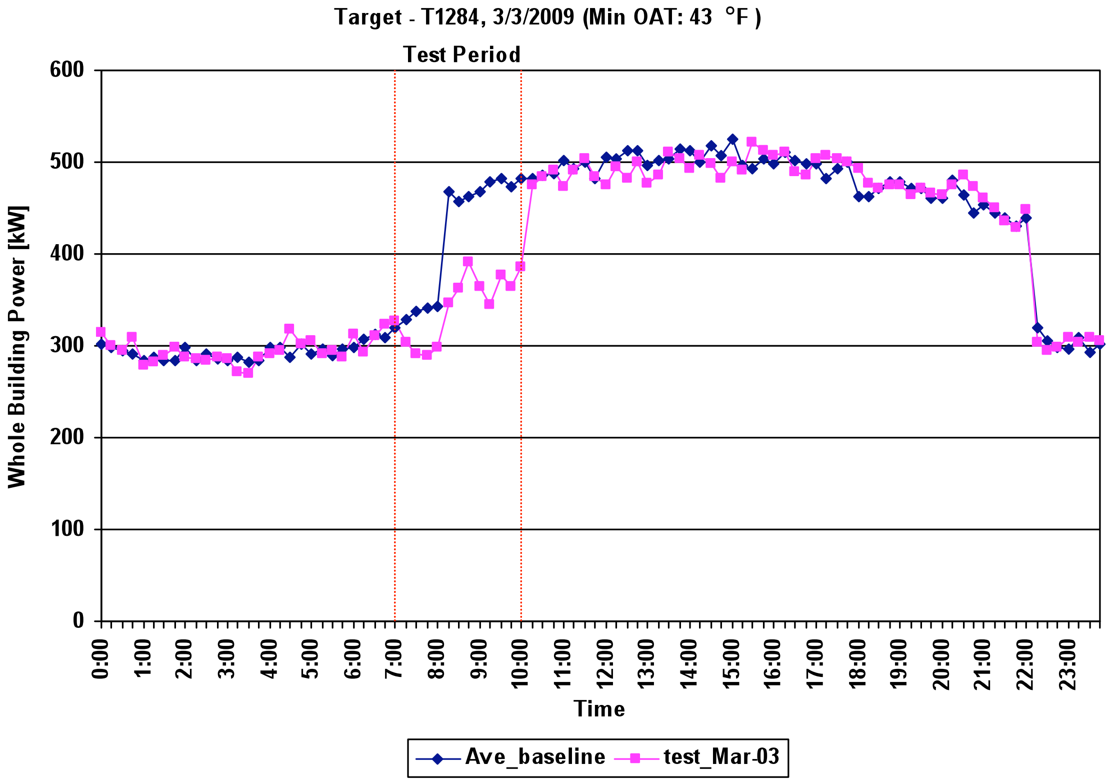
DDC Zone Control	Yes
Data Trending Detail	No data trending available due to problems with obtaining data

OpenADR System Summary

Communication Method		Software client at remote location
Gateway/Relay Device	WebCtrl	
Shed Strategies	**Pre-Event DR Strategy**	None
	Test Period	Turn off 50% of sales area lights, turn off two out of 12 roof-top units and decrease setpoints by 2 ºF.
	Slow Recovery	No known recovery strategy



Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-09	**Ave BL**	**7:00-8:00**	80	47	0.48	0.29	22%	14%
		8:00-9:00	122	101	0.74	0.61	26%	22%
		9:00-10:00	109	93	0.66	0.56	24%	20%
		7:00-10:00	122	81	0.74	0.49	26%	19%



Date	Baseline	Period	kW		W/ft²		WBP%	
			Max	Ave	Max	Ave	Max	Ave
Mar-03	Ave BL	7:00-8:00	52	42	0.32	0.25	15%	12%
		8:00-9:00	122	98	0.73	0.59	26%	21%
		9:00-10:00	133	111	0.80	0.67	28%	23%
		7:00-10:00	133	83	0.80	0.50	28%	19%