

AUTOMATED DEMAND RESPONSE IN NEW CONSTRUCTION - A FORWARD THINKING APPROACH TO MANAGE PEAK DEMAND EVENTS

Lionel Metchop, P.E., Lincus Inc.
Karen Klepack, C.E.M., LEED AP BD+C, Southern California Edison

ABSTRACT:

The Santa Monica Community College (SMC) new construction case study for Automated Demand Response (Auto-DR) is an example of how to enable customers with automated load control systems, such as an Energy Management System (EMS), to participate in demand response events without manual intervention. Although it is most cost effective to design a project with energy management in mind, new construction has traditionally been a missed opportunity for utility program participation. In an effort to incorporate Auto-Demand Response measures in new construction projects, a pilot "Technical Audit" (plan review) was done on Santa Monica College Campus new construction projects. This presentation draws from the lessons learned about this pilot audit both from an engineering analysis and project management standpoints to propose solutions on how to manage future peak demand events.

INTRODUCTION

Like newborn babies hungry for food, new constructions (NC) enter the world of facilities as new consumers of energy. Santa Monica College's campus extension is one of these babies. And as responsible parents work to feed their offspring, all conscious stakeholders: utilities, business owners and builders continuously have to make room to accommodate the newcomer's need for energy. Accommodation is made by applying a method called demand side management (DSM). It is modification of consumer demand for energy through various methods, aided by financial incentives and education from the local utility. There are several mechanisms used to manage the demand for energy, two major of which are demand response (DR) and energy efficiency (EE). On one hand, DR is a resource that allows end-use electric customers to reduce their electricity usage in a given time period, or shift

that usage to another time period, in response to a price signal, a financial incentive, an environmental condition or a reliability signal. Demand response saves ratepayers money by lowering peak time energy usage, which is high-priced. This lowers the price of wholesale energy, and in turn, retail rates. Demand response may also prevent rolling blackouts by offsetting the need for more electricity generation and can mitigate generator market power¹. On the other hand, EE programs are designed to reduce energy consumption with efficient technologies every day, without sacrificing the benefits afforded by electricity and without direct personal intervention of the end user². The key to IDSM for new construction is to first design as energy efficiently as possible for everyday savings, and then to look for noncritical loads that can be shed during a DR event. While several programs are available across west coast utility territories to promote energy efficiency in new construction, the large majority of DR programs are designed and marketed with a focus on existing facilities. Because it is more cost effective to design a building with energy management in mind from the beginning rather than retrofitting after fact, Southern California Edison (SCE)'s DSM team decided to address the shortage of DR program targeting NC by developing a New Construction Auto-Demand Response Pilot program. The philosophy of the program is that if a building system is automated during design/construction, the customer will be set up to participate in DR programs from the first day of occupancy by automatically and temporarily reducing the requested load on weekdays during summer between 2:00 PM and 5:00 PM, depending on the program. The next sections of this paper will further present the goals of the program, describe the strategy, and showcase the Santa Monica College Auto DR as a project which illustrates challenges and success of this program.

GOALS

SCE would like to have an Integrated Demand Side Management (IDSM) approach to designing new buildings with energy efficiency and load management in mind during design. With that vision in mind, the goal of the Auto DR pilot program intends to integrate delivery of Auto DR programs (and incentive reservation) with the already established delivery of the EE programs so that the NC group is a “one stop shop” for new construction customers. It is SCE’s expectation that through this effort, the barriers separating the design budget from the operations budget will be broken down, and the customer could leverage incentives to offset capital costs associated with EE and Auto DR.

For Santa Monica College (customer), which plans to expand two campuses, the goal has been to integrate measures in the construction process that make all six buildings ready to:

- 1- Operate efficiently at all times by implementing EE measures incentivized by SCE
- 2- Benefit from electric price and reliability signals at any time by installing demand response measures promoted by SCE

STRATEGY

To meet this goal, the strategy has been at the program management level to leverage the existing resources to extend the DR offering to new customers. These resources are in two folds:

- 1- On one side, there is the Savings by Design program’s task force currently in the field meeting with customers and designers to promote EE efforts in NC processes.
- 2- On the other side, there is the Technical Assessment & Technology Incentive (TA&TI) program, which has developed processes and forms to offer demand response incentives and associated services to the traditional market of existing customers.

At the customer’s level, the strategy is to authorize a full review of the NC plans during which the utility-appointed engineering firm will:

- 1- Be given access to the NC plan documents: mechanical & electrical schedules, architectural drawings, specifications of various end use equipment to be installed, and energy code compliance simulation models.

- 2- Have a preliminary meeting with the NC owner and his/her design team, as well future building operators, to gather missing information regarding both the NC building specifics (control system to be installed) and the expected operational patterns of the facility. During the meeting, the engineering firm will also listen to the perspective of the customer’s representatives about willingness to incorporate DR opportunities at the facility.
- 3- Review the design documents:
 - a. Analyze the code-compliance energy simulation models
 - b. Simulate monthly and hourly peak consumption patterns, quantify peak load end-uses
 - c. Describe the building automation control system including the designed end-uses control strategy
 - d. Identify opportunities for demand response
 - e. Quantify the load shedding potential
 - f. Describe the control upgrades that need to be done to implement Auto DR measures
 - g. Estimate the associated costs, and prepare an audit report
- 4- Meet with the customer’s design team to discuss design review efforts for incorporation of the DR recommendations.
- 5- Coordination with the utility representatives to process paperwork

At the customer level, through the Auto DR mechanism the utility intends to remotely activate (via internet) load shedding on a specified equipment upon receiving an event or a price signal³. Therefore, an Energy Management System or an automated load control system is needed at the customer’s site.

The next section describes how the strategy described above was applied to Santa Monica College’s new construction projects.

SANTA MONICA COLLEGE (SMC) – NC BACKGROUND

Santa Monica College is a two-year, public junior college, located in Santa Monica, California with approximately 30,000 enrolled students. The technical audit addresses two new construction locations, which are scheduled to be

completed between 2014 and 2015. The first includes buildings B, C, and D, which are primarily dedicated to office use, and a parking garage. Sites 2 through 4 include new Student Services, IT, Health, Fitness, and Dance buildings.

SMC – NC DESIGN DESCRIPTION

Site 1: AET Campus

AET campus has three new buildings B,C,D. AET's 34,076ft² Building B is a structure that will house a Radio Station expected to operate 24/7. Its capacity is 494 people. AET's 31,370 sq ft Building C and 46,050 sq ft Building D have classrooms and office spaces. Building C has a 617 people capacity and building D has a 1,105 people capacity. Regular business hours for these buildings are 7 AM to 10 PM Monday to Friday.

The three occupied buildings B, C & D are served by central air cooled chiller. Two air cooled rotary screw chillers (TRANE-RTAC-155) are used. Each has a cooling capacity of 154 tons and an EER of 11.1. Air distribution is a variable air volume system. There are separate units (Emerson's Liebert) for computer room air conditioning (CRAC) with capacities varying from 2.4 tons to 34 tons. Thermal storage is provided. Four ice storage tanks (CALMAC-1500 CSF), each with a capacity of 420 ton-hours, are used to meet the buildings' cooling load during peak load hours (2 PM to 5 PM). Fluorescent T8 lamps of 28 W are used in majority of spaces. Certain spaces have T8 lamps of 32W. LPD in Buildings in this campus is approximately 0.89 W/ft².

Site2: Student Services

Student Services (SS) building is part of main campus where other buildings like IT relocation, PE, Library, Science building, etc. are located. It is an 84,000ft² facility with office space of 350 people capacity, and an auditorium with 200 people capacity. The building has three floors above grade. This building also has three levels of parking. Regular business hours for these buildings are 7 AM to 5 PM Monday to Friday.

The SS building will be served by central air cooled chillers. Presently two air cooled scroll water chillers (TRANE CGAM080) of 82 tons each having an EER of 11.1 are used.

Air distribution is a variable air volume system. Fan coil units are used for cooling mechanical and electrical rooms.

Thermal storage is provided by six ice storage tanks (CALMAC-1190 CSF), with a capacity of 180 ton-hours, are used to meet the building's cooling load during peak load hours (2 PM to 5 PM).

CRAC units are exempted from this.

Linear fluorescent 28-watt T8 lamps are used in majority of spaces. Certain spaces have 32-watt T8 lamps. Lighting power density in the building is approximately 0.75 W/ft².

Site 3: IT Relocation Building

The IT Relocation building is part of the main campus where other buildings like Student Services, PE, Library, Science building, etc. are located. The majority of spaces in the IT building are office space and server rooms. The 25,1346 ft² building is made up of three floors above grade, with capacity of 40 people. Regular business hours for the building are Monday to Thursday 7 AM to 10 PM; Friday 7 AM to 5 PM. HVAC will be running 24/7 in server room.

The Media Center will be served by a central chiller plant. Critical areas, like server rooms and computer rooms, are served by unitary systems independent of central chiller plant. Currently the IT building is served by one central air cooled chiller of 52 Ton capacity (TRANE-052 CGAM-052F2A2BA1A1A). AHUs with VAV serve the Media Center. Fan Coil Units with chilled water from this chiller are used for cooling in reception, printer room, training room, police dispatch. The server room is served by one 22 Ton water cooled AC unit (Emerson's LIEBERT VS077WU-AOEI). Two smaller unitary AC units are used for MDF and IDF room.

Details of thermal storage are not provided, but it was told by the customer that this building will be supported by central plant having enough thermal (ice) storage to meet the cooling requirements of all the buildings in this campus during peak hours .

Linear fluorescent 25-watt T5 lamps and 32-watt T8 lamps are used in majority of spaces. Lighting power density in this building is assumed to be 0.80 W/ft².

Site 4: Health, P.E., Fitness, Dance & Central Plant Facility

The Health, P.E., Fitness, Dance & Central Plant Facility is part of main campus where other buildings like Student Services, Library, Science building, etc. are located. The majority of spaces are gym areas, locker rooms, and classrooms. The Central Plant Facility has a central chiller plant, ice storage, cooling tower, hot water boiler, pumps for chilled water and condensing water, etc. It is a 36,610sq.ft. 300 people capacity, 4-story building, three above grade and one below grade. Regular business hours for these buildings are 7 AM to 10 PM Monday to Friday.

The Central Plant has the following mechanical equipment. This plant is designed to meet cooling load for most of the buildings on Campus. The AET Buildings are not part of this campus.

- (2) Water cooled glycol chillers, each with 650 ton capacity in ice making mode, and 870 ton capacity in cooling mode
- (4) Cooling towers, each with 25 hp Fan equipped with VFD
- (1) Ice storage tank of 9000 Ton-Hours
- (2) Frame & plate heat exchanger of 815 tons each
- (2) Hot water boilers, 750 MBH each
- (2) Chilled water supply pumps, each with 100 HP motors
- (2) Chiller water pumps, each with 125 HP motors
- (2) Condenser water pumps of 100 HP each
- (2) Hot water pumps of 2 HP each

The Health, P.E., Fitness, Dance & Central Plant facilities have two AHUs with VFD on supply and return fan, make up air units in locker room with 15 HP fan with a VFD, two exhaust fans with 7.5 HP each and has VFD.

The lighting schedule in these facilities was not provided. A lighting power density of 1.0 W/ ft² is assumed because of specialized activities.

SMC - NC BUILDING CONTROLS & IT INFRASTRUCTURES

Santa Monica College's NC project accounts for the implementation of an Energy Management System (EMS) that is expected to control all of the campus buildings from one central location. All HVAC, lighting and other electricity, gas and water consuming equipment will be integrated to the EMS, which is capable of communicating over internet or intranet without special software or plugins and has ME, SE, ZN line controllers. It can also support third party integration. This feature is essential for the EMS to interact with SCE's Demand Response Automated System (DRAS). The campus has an internally managed robust and reliable internet system for which changes to firewalls and proxys in order for the EMS to interact with the DRAS is not an issue. DRAS/EMS interconnection details should be available when the project enters the final construction phase.

SMC – AUTO-DR PLANS REVIEW

Design Considerations:

Recommending any DR measure on a new construction project necessitates that the plan review engineer has up-to-date details about the design specifications of the end use equipment or mechanical system on which load shedding will be applied. Such details, which include equipment sizes, mechanical system configuration, standard control strategy and normal operation settings are used to determine the baseline peak load. The review engineer then evaluates the feasibility of the measures to implement with the customer. As plans are updated throughout the construction process, such information could well be a moving target.

For the SMC NC project, the customer expressed interest to implement Auto DR on lighting and cooling equipment. At the time the plans were reviewed, the following information was still missing:

- 1- Percentage of lighting fixtures controlled by daylight sensors
- 2- Percentage of lights that were designed to stay "ON" in daytime
- 3- Expected design illumination level in the buildings

- 4- Expected building occupancy rates during summer peak time

To mitigate the impact of the information missing at this stage of the NC process, reasonable assumptions ought to be made by the reviewer.

Assumption #1:

The construction of the facilities will not be finished until 2015. DR kW has to be calculated with no billing history & lack of usage baseline. The program verification engineer will not be able to test and identify the actual DR kW until the project is completed and approximately four months of interval data is gathered. Calculations therefore are based on mechanical schedule (pump sizes, designed water flow rate, head) and lighting schedule (lighting power density, fixtures description per area, etc.). That information is found in the submitted plans.

Assumption #2:

It is assumed that in normal conditions during peak time, 15% of the lighting fixtures are connected to daylighting sensors, and that 5% of the lighting fixtures are off. Therefore a diversity factor of 0.8 is considered in the lighting DR savings calculations. The engineer confirmed with the existing building operations manager (who proposed this measure for consideration) that proper lighting levels are maintained according to learning environmental conditions when implementing this measure. It is expected that the customer will do some comfort level testing before fully integrating this measure into the Auto DR portfolio.

Assumption 3:

As shown in the Table 1 below, the typical mild summer weather in the Santa Monica area⁴ makes it possible to cool the building using outside air ventilation without simultaneously any adding any thermal load. The plan review calculations assume a “DR Factor” of 50% reduced DR savings to account for the fact that even though it is possible to cool the building with 100% outside air, the mechanical system will still pump a minimum of cooling water

through the coils to offset the possible addition of heat from outside ventilation. The DR Factor also accounts for the fact that the supply fan motors in the Air Handling Units can increase their electric power usage when introducing 100% OSA into the air conditioned buildings. Indeed, allowing these VFDs to run unconstrained may cancel out some of the identified DR kW.

TABLE 1: TYPICAL SUMMER CLIMATE IN SANTA MONICA⁴

	June	July	August
Avg. Max Temp	71.3	73.3	73.5
Avg. Dew Point Temp	51.4	53.9	54.8
Avg. Wet Bulb Temp	54.9	57	57.6
# Cooling Degree Days	10	20	18

DR Recommendation #1: Set water cooling pumps to minimum speed

This measure is applicable to all sites. During Auto DR events, the building mechanical systems will bypass the chiller/thermal storage loop. Critical spaces like the radio station and server rooms are exempted from this measure. This measure will reduce the pump loads in the chilled water loop. As of now, the customer plans to set up the building intelligence system such that the measure would only be implemented during peak events when the cooling of the facility could be met by 100% outside air without an increase in cooling load that could not be offset by setting the VFD controlled cooling water pumps at minimum speed. To achieve a successful implementation of the measure, it is recommended to program the EMS so that:

- 1- The chiller will pre-cool each building
- 2- The room temperature settings will be put into set back mode at the beginning of the DR event
- 3- Chilled water pumps will be reduced to minimum speed and outside air will be brought in for complementary cooling as needed.

Savings for this measure will come from reduced pumping load.

The following equation is used to estimate the sheddable load on each pump:

Equation 1:

$$\text{Average DR kW} = (\text{DR Factor}) \times (0.746 \text{ Kw/hp}) \times (1/\text{Motor Efficiency}) \times (1/\text{Pump Efficiency}) \times (\text{Pump Flow rate in GPM} \times \text{Total Head in feet of water} / 3960)$$

For each pump, the pump flow rate and total head information was given in the mechanical schedule of the design drawings. Pump efficiency was assumed to be 73.5% for AET campus pumps and 70% for main campus central plant loop. Motors were assumed to be premium efficiency. The motor sizes were given on the design drawings as follows:

- AET campus primary loop: three 40HP pumps
- AET secondary loop: three 20HP pumps
- Main campus central plant loop: one 100HP chilled water supply pump and one 100HP building cooling loop

Table 2 gives the estimated DR kW that would result from implementing this measure at each location. Using Equation 1 above, the average DR kW numerical calculations indicate that implementing this measure represents removing 29% of the full load on each pump motor at the AET campus (Site 1) and 43% of the motor load of the pumps on the main campus central plant loop (Site #4)

DR Recommendation #2: Reduce lighting levels by 50%

The project intends to reduce the lighting load by shutting down 50% of the lighting fixtures in areas not controlled by daylight sensors. The Equation 2 below was used to estimate the curtailable load:

Equation 2:

$$\text{Average DR kW} = (\text{Lighting power density in W/ft}^2) \times (\text{Illuminated Area}) \times (50\% \text{ reduction}) \times (0.8)$$

Table 2 gives the estimated DR kW that would result from implementing this measure.

DR Recommendation #3: Shut down the courtyard water fountains

There are also two water fountains in the project, whose pumps can be automatically shut down for DR events through a signal sent through the EMS. For each water fountain pump, the equation below was used to estimate the sheddable load.

Equation 3:

$$\text{Average DR kW} = (\text{Electrical Load in VA}) \times (\text{Load Factor}) \times (1 \text{ kW}/1000\text{W}) \times \sqrt{3}$$

Where:

- The electrical load was given in the drawings as 800 VA
- The load factor was estimated at 0.75

Table 2 gives the estimated DR kW that would result from implementing this measure.

TABLE 2: AUTO DR MEASURES - AVERAGE SAVINGS

Auto DR Measure	Building (s)	Estimated Load Shed Potential
1. Reduce speed on campus cooling water pumps	AET's buildings B, C & D	42.0 kW
2. Reduce speed on campus cooling water pumps	Health/ PE/ Fitness & Central Plant	67.1 kW
3. Shut off 50% of lighting fixtures in classrooms and offices	AET's buildings B, C & D	36.0 kW
4. Shut off 50% of lighting in classrooms and offices	Student Services (Main Campus)	12.0 kW
5. Shut off 50% of lighting in classrooms and offices	IT Relocation (Main Campus)	8.6 kW
6. Shut off 50% of lighting in classrooms and offices	Health/ PE/ Fitness & Central Plant (Main Campus)	14.6 kW
7. Shut off fountains	Main Campus	2.0 kW
TOTAL		183 kW

CONCLUSION:

New construction contributes to the capacity need that public utilities have an obligation to meet. While implementing EE measures in NC is one way to manage the oncoming demand for energy, Auto DR has slowly become a practice supported through the partnership of utilities,

business owners, and designers to further alleviate peak load on the grid. The additional integration of demand response in NC is a cost effective mechanism that is adding value to the portfolio of DSM programs. Not only does it prepare the utility to meet its future obligations, but it also reduces the payback period of some DSM measures, such as advanced control systems, where capital investment might not be justifiable if EE incentives were the sole alleviators of the costs.

REFERENCES:

- 1- California Public Utilities Commission:
<http://www.cpuc.ca.gov/PUC/energy/Demand+Response/>
- 2- Tacoma Power, Conservation Market Plan 2011-2012
- 3- SCE Demand Response Programs:
<http://www.sce.com/b-rs/demand->

- [response-programs/demand-response-programs.htm](http://www.wrcc.dri.edu/summary/smx.ca.html)
- 4- Western Regional Climate Center - Desert Research Institute - Reno, Nevada:
<http://www.wrcc.dri.edu/summary/smx.ca.html>