DR10SCE01: Office of the Future: Integrating DR and EE in Commercial Office Space Lighting

DR LIGHTING TESTS IN COMMERCIAL OFFICE SPACE

Demand reduction is needed when there is a stress to the electric grid. This stress occurs when demand for electricity nears the capacity of the available power generation, an event that is typically most prevalent during hot summer afternoons. SCE is investigating the potential for DR technologies on several projects to reduce the peak electric system load. Supported by the Office of the Future (OTF) Consortium, a collaboration of some of the nation's largest and most progressive utilities, including Southern California Edison (SCE), the OTF initiative is working to assemble technical guidelines for office renovation projects that specify performance requirements for different attributes of office spaces (e.g., lighting, plug loads, air conditioning, etc.) and whole building that result in at least a 25% and 50% savings over the building energy efficiency code. This project focuses on demand response potential of lighting in a commercial office space.

The lighting design goal was not only to provide energy efficient and demand responsive solutions but also to improve significantly the lighting quality and the overall look and feel of the space. To accomplish this goal a combination of modern fixtures with reflector technology, that maximized light output, and daylight sensors, occupancy/vacancy sensors, energy efficient lamps, and dimming ballasts were used creating a fully integrated and highly controllable lighting system.

This project has three primary goals:

- Evaluate the demand response opportunities associated with advanced lighting design combined with innovative lighting controls and strategies to allow for easy and reliable control of the building lighting loads to foster greater customer participation in SCE's Demand Response (DR) programs.
- Quantify the demand reduction that can be achieved with advanced lighting design and innovative lighting controls.
- Provide measure and technical data that can be leverage for future utility program offerings.

The project site consists of a small office area occupied by the owner, Brookfield Properties, in the Landmark Square Building in Long Beach, California. The total area of the project is 1,577 square feet (sf) and consists of offices and common areas.

INTRODUCTION

What Is This Technology?

ADVANCE LIGHTING SOLUTION (ALS)

As a leasing office space for Brookfield Properties, the project is used to show new and prospective tenants various lighting approaches that can be used given the building's physical characteristics. Therefore, each of the five private offices was equipped with a different lighting solution to present the many available alternatives to the standard 2 x 4 parabolic fixtures and to showcase the extensive improvements.

High-performance, low-glare 2 x 2 recessed, wall washers, direct/indirect pendants, lensed light slots, and wall mount indirect fixtures were all represented. Separately controlled fixtures were dimmed based on available daylight from each office window in order to provide even illumination at the work surface while taking advantage of available daylight. When the office was not occupied, the lights were automatically dimmed and then shut off. Additionally, light emitting diode (LED) task lights were provided at each desk.

'Task areas' were established within the project which allowed for lower ambient lighting for the other spaces. Separately controlled task lighting with automatic shutoff allowed the designers to put higher light levels specifically where they were required for the task, and through the use of controls, only when they were required by the users.

Proposed lighting solutions incorporate energy efficient and demand responsive technologies offering advanced control features to adjust to personal preferences, daylight availability, vacancy in workspace, and demand control. Advanced designs enhance lighting quality and provide options for personal control that are linked to increased visual comfort, satisfaction, health, and productivity.

What We Did?

TECHNOLOGY AND TESTING

This project consists of a 1,577 sf office suite in the 24-story Landmark Square building in Long Beach, California. The office suite includes five private offices, a conference room, a kitchen, lobby, and a corridor.

Lighting and plug load end-use monitoring equipment was installed in the office space to evaluate the potential energy savings and demand reduction associated with advanced lighting design and highly controllable lighting. The electrical service serving the space was metered in a way that both the lighting and plug load could be monitored separately.

Metering was installed at the whole building and office space level to establish the 'As-Is' baseline which represents the existing energy use before any energy efficient and demand response measures were installed. After the new lighting was burned in and fully commissioned, the 'post-lighting' baseline was established.

Commissioning reduced the light output settings to 70% or lower of the lighting's rated output. This new commissioned level is also designated as the baseline for the DR testing.

There were three separate testing days in March of 2011. The test procedure included reducing the lighting power up to five different levels per day with each level lasting from 30 to 120 minutes. A signal from SCE or building management can reduce the power setting of the fixtures by 10%, 15%, 20%, 25%, 30%, 35%, 45% and 50% below the commissioned level.

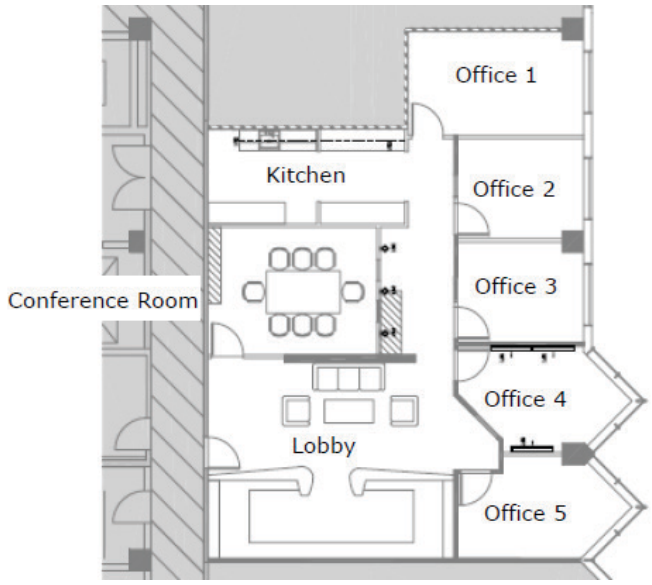

Figure 1: Office Suite Lighting Layout

DIFFICULTY IN TESTING While the DR test calls for an actual percentage reduction in power, the Lutron lighting controls used in this project could not directly measure power, only infer it. As a result, the control system would rely on preset dimming scenes to deliver the requested demand reduction. Combine this with occupancy sensing, daylighting controls, a dynamic office environment, and some missteps during the testing periods; it became difficult at times to properly isolate the impact of the lighting control system on demand reduction. As well, the power reduction did not always properly align with the DR event period throughout the day. At times, it seems the DR test was started earlier than scheduled and at times it seems the DR event was terminated later than schedule.

DEMAND RESPONSE REDUCTION There were significant reductions in the lighting load when a DR strategy was invoked by the lighting controls. For a request of 50% power reduction, the control system delivered 0.254 W/sf (or 25% drop in power), while for a request of 30%, the reduction was 0.174 W/sf (or 30% drop in power). It is interesting to note that for requests for power reduction of 10%, 15%, 20%, and even 25%, the lighting control system under performed significantly. This is most likely the result of the lighting control relying on preset dimming scenes to accomplish the demand reduction. See Figure 2 for detailed results.

TASK LIGHTING INCREASES WATTAGE BUT DECREASES USAGE The most energy saving light fixture is the one that is turned off. At first glance, it appears that the design team added wattage to the design by providing dedicated lighting at major task areas and separately controlling decorative features. By designating 'task areas' within the project, lower ambient light levels were established for all other spaces. Separately controlled task lighting with automatic shutoff allowed the designers to put higher light levels specifically where they were required for the task, and through the use of controls, only when they were required by the users. By providing and separately controlling task and decorative fixtures that are usually turned off, the design helps to create a drastic reduction in energy consumed over the typical office layout without sacrificing design or the occupants' comfort for focused tasks.

DR Test Level (%)	Starting Test Demand (kW)	Avg. Demand Reduction during the Test Period (kW)	Avg. Demand Reduction (kW/SF)	Avg. Demand Reduction (%)
Friday, March 4				
10	1.30	1.06	0.152	18.5
15	1.25	1.29	N/A	N/A
25	1.45	1.44	0.006	0.7
50	1.60	1.20	0.254	25.0
Tuesday, March 8				
15[1]	0.65[1]	0.63	0.013	3.1
20[2]	0.95[2]	0.89	0.038	6.3
30	0.93	0.65	0.174	29.7
Thursday, March 10				
10	1.00	0.95	0.032	5.0
15	0.90	0.90	0.00	0.0
25	1.25	0.66	0.374	47.2
35	1.00	1.18	N/A	N/A
45	1.20	0.95	0.159	20.8

Notes: 1. It appears that the 15% DR test started 45 minutes earlier than schedule.

2. It appears that the 20% DR test started 45 minutes later than schedule.

Figure 2: Demand Reduction at Different DR levels

CONCLUSIONS

What We Concluded?

ALS A VIABLE OPTION

The three main goals of this project were to:

1. Evaluate the demand response opportunities associated with advanced lighting design combined with innovative lighting controls and strategies to allow for easy and reliable control of the building lighting loads: *The testing performed indicated significant opportunities to implement DR strategies leveraging the advanced lighting design and innovative controls. However, the demand reduction was not proportional to the reduction being requested particularly for demand reduction requests of 20% or less.*

2. Quantify the demand reduction that can be achieved with advanced lighting design and innovative lighting controls. *There were significant reductions in the lighting load when a DR strategy was invoked by the lighting controls. For a request of 50% power reduction, the control system delivered 0.254 W/sf (or 25% drop in power), while for a request of 30%, the reduction was 0.174 W/sf (or 30% drop in power).*

3. Provide measure and technical data that can be leverage for future utility program offerings: *The project provided valuable data, insights, and lessons learned which should benefit not only future utility program offerings, but also the lighting controls industry as a whole.*

These Findings are based on the report "Office of the Future: Integrating DR And EE in Commercial Office Space Lighting," which is available from the ETCC program website, https://www.etcc-ca.com/reports.

Recommendations

The results of this project show the potential for leveraging advanced lighting design and innovative controls to promote effective DR strategies in office buildings. However, there are still several things that requires continued, if not greater, involvement with the lighting controls industry.

ADDITIONAL RECOMMENDED STEPS

Additional recommended steps may support and expand upon the results of this pilot:

- Continue engagement of key lighting controls companies to demonstrate the need and value of having lighting control products measure directly power.

- Continue engagement of lighting controls companies to help them develop DR strategies that leverage power measurement instead of dimming levels to further the incorporation of DR strategies into their product offerings.

- Continue engagement of lighting controls companies to help them develop DR strategies for leveraging their lighting control products to manage plug loads in commercial office spaces.

- Development of Codes and Standards Enhancement (CASE) studies to support requiring under Title 24 that lighting controls must measure power.

- Evaluation of other market segments that could benefit from incorporating aggressive lighting DR strategies.

- Renovation (or new construction) of an entire building.