SCE DRET Findings
December 2011

DR11SCE1.05.02: Demand Response Tests of Lighting in a Typical College Corridor

DR LIGHTING TESTS IN A TYPICAL COLLEGE CORRIDOR

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. This project focuses on demand response potential of lighting in a typical college corridor. A typical college corridor is a good representation of a typical office, and according to the California Commercial Energy Use Survey (CEUS), offices are the single largest draw of commercial energy use in California. In the SCE service territory, offices represent 18% of commercial square footage (385,110,000 sf), and have an interior lighting connected load of 1.16 Watts per square foot (W/sf).

This study evaluates the Demand Response (DR) capability of an advanced lighting control system (ALCS) developed by Redwood Systems. This ALCS was installed on the ground floor of the Natural Sciences 1 building at the University of California, Irvine (UCI). This study examined the energy savings potential in corridors and stairwell where the lighting was controlled by occupancy sensors.

The primary goals of this project are to:

1. Determine whether the advanced lighting controls system allows for reliable control of corridor lighting loads from SCE or business management as part of a Demand Response Program,
2. Examine demand reductions that can be achieved with a well-designed lighting system, and
3. Provide measured and technical data in support of the Smart Corridor and Stairwell concept.

The project site consists of several small areas in the Natural Sciences building. The total area of these spaces represents 2,000 square feet (sf) of a college classroom and laboratory building.

INTRODUCTION

What Is This Technology?

ADVANCE LIGHTING CONTROL SYSTEM

The technology being tested in this study is an ALCS which allows for DR response in an office corridor. There were three types of fixtures installed. The existing straight corridor fixtures were replaced with recessed can lights, Lightolier Calculite LED downlights with DR control, and an occupancy sensor. The programmed timeout is 6 seconds so that the lights do not stay on any longer than is needed.

LED fixtures with DR control were installed in the lobby. Each DR-capable fixture has an occupancy sensor mounted flush in the ceiling tile near each fixture. The fixtures are 2' x 2' Lunera 2230 series. They consist of grid lay-in ultra-thin LED plates that easily replace ceiling tiles.

LED fixtures with DR controls were also installed in the curved corridor. Each DR-capable fixture has an occupancy sensor mounted in a gray can on the end of the fixture. The programmed timeout is 6 seconds so that the lights do not stay on any longer than is needed. The fixtures are Lunera 6430 series ultra-thin LED light bars, which are suspended from the ceiling and measure 1' x 4'. The teaching lab has the same configuration of lighting layout and fixture types as the curved corridor.

This project installed a new lighting control system. A Redwood Systems RE64 (Redwood Engine) conducts reliable operation of the LED fixtures. It provides full dimming for LED fixtures that use 60W or fewer and uses Redwood occupancy sensors. Full dimming allows for optimization of light levels to accommodate the user's comfort while maintaining maximum energy savings.

What We Did?

TECHNOLOGY AND TESTING

This project consists of the corridor and teaching lab lighting on the ground floor of the Natural Sciences 1 building at UCI. The project area consists of four different adjoining spaces. Lights are in typical straight corridors, a small mid-building lobby, a curved corridor, and a small teaching laboratory. The corridors and lobby occupy 1,440 square feet and the teaching lab occupies 560 square feet, for a total of 2,000 square feet. Some of the fixtures in the test areas are security lights that remain on continuously. The layout of the test areas displays in Figure 1.

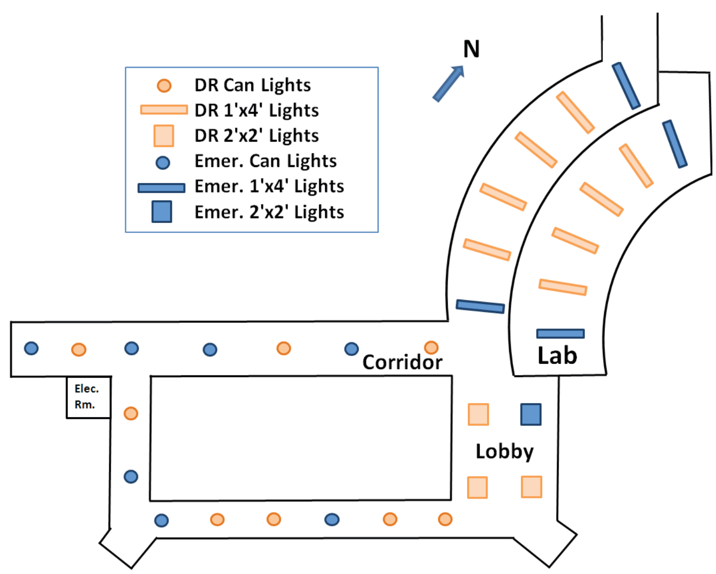
Data loggers were installed in each individual light fixture to collect electric load profile data during DR testing, and to measure demand reductions attributable to the ALCS.

The system provides the following functions and strategies:

o Tuning to reduce lighting use by 15%. Commissioning reduced the light output settings to 85% of the lighting's rated output. This new commissioned level is also designated as the baseline for the DR testing.

o DR was measured for 19 lighting fixtures. Emergency lighting fixtures were not affected by DR signals. A signal from SCE or building management can reduce the power setting of the fixtures by 10%, 15%, 20%, 25%, and 30% below the commissioned level. Each setting lasted for one hour, after which it returned to the baseline DR level of 0%.

Figure 1: Ground Floor Corridor Lighting Layout



DEMAND RESPONSE TEST DAYS DR testing was conducted for the same business hours over three separate days in November of 2011: Wednesday, November 2; Thursday, November 3; and Tuesday, November 8. During the test periods recording intervals were 1-minute. After the first two test days it was determined the tests should include periods with all the lights on. The occupancy timeout was increased from 6 seconds to 10 minutes. This control could only be made manually and the system was left in this mode for several days. The third day of the test (Nov. 8) was not representative of typical operation because monitoring staff continually walked through the hall to turn on the lights. A fourth day (Nov. 16) was added to the test where the lights were programmed to stay on and run through an identical set of DR levels at a faster pace.

DEMAND RESPONSE REDUCTION The average demand reductions from this study across all fixtures were as follows: 23 Watts (0.011 W/sf) at 10% DR level; 30 Watts (0.015 W/sf) at 15% DR level; 36 Watts (0.018 W/sf) at 20% DR level; 55 Watts (0.028 W/sf) at 25% DR level; and 62 Watts (0.031 W/sf) at 30% DR level. The maximum DR reduction of 62 Watts represents an approximately 43% reduction of average wattage. In an alternative analysis, the impact of dimming from the occupancy sensors was ignored. This resulted in a maximum DR reduction of 236 Watts (0.118 W/sf) or 54% of the commissioned wattage from the fixtures at the 30% DR level setting.

SPACE TYPE IMPORTANT IN DEMAND SAVINGS The occupancy sensor controls have a timeout of 6 seconds for individual corridor lights. The result is they are off most of the time, and no DR reduction is available if the lights are off. The teaching lab lights have a 10-minute timeout that controls all four of the fixtures in the lab. Almost all the DR reduction is attributable to the lights in the teaching lab because these lights are on for most of the day. The teaching lab uses approximately 88% of the energy use of the DR-controlled lights. As this site demonstrated, the savings is very dependent on space type and the resulting control type.

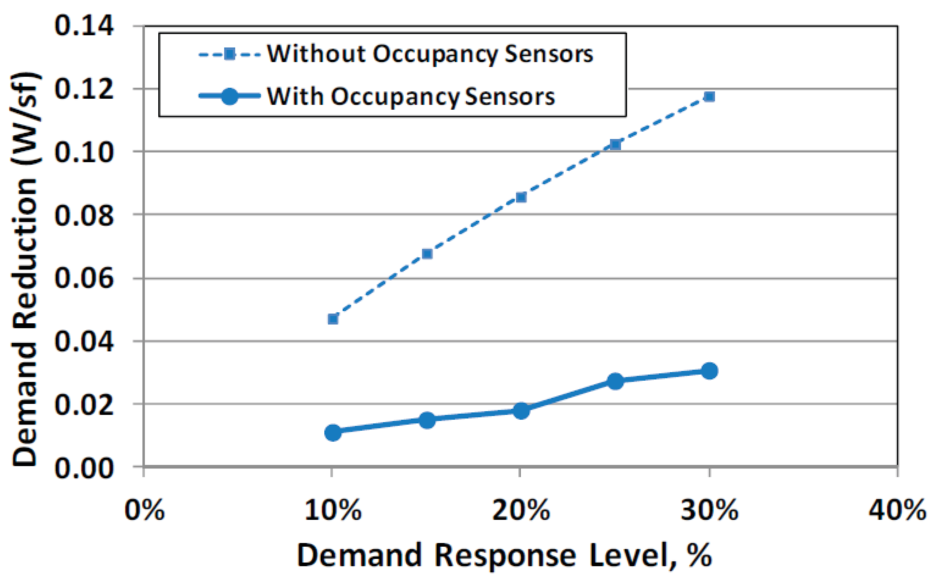


Figure 2: Demand Reduction with and without Occupancy Sensors

CONCLUSIONS

What We Concluded?

ALCS A VIABLE OPTION

The main objectives of the project were to determine the following:

1. *Examine the ALCS that allows for reliable control of corridor lighting loads from business management as part of a DR Program:* DR testing for the ALCS confirmed that lighting loads can be reliably managed by business management as part of a DR Program, but requires local connection to the controller.

2. *Examine demand reductions that can be achieved with a well-designed, smart lighting control system:* There was a reduction in overhead lighting load demand after the installation of ALCS and new lighting fixtures. The DR reduction for lighting averaged 62W, or 0.031 W/sf at the 30% DR level. The percentage reduction is approximately 43%.

The project originally was intended for corridor lighting but was expanded to include a teaching lab. Almost all the DR reduction is attributable to the lights in the teaching lab because these lights are on for most of the day.

The results of this pilot and other DR projects show evidence of demand reduction. The highly controlled lighting solutions demonstrated in the pilot qualify for SCE's incentive program. In addition, the broader Smart Corridor concept that addresses demand feedback to occupants and overall building demand would experience further demand reduction under these methods.

These Findings are based on the report "Demand Response Tests of Lighting in a Typical College Corridor," which is available from the ETCC program website, https://www.etcc-ca.com/reports.

Recommendations

This pilot study was successful in demonstrating that the ALCS is a viable demand response option. However, there are still further steps to take.

FURTHER STUDIES

Further study of highly controlled lighting solutions may further clarify the results, which include the following:

o Measurement of power usage throughout the course of the year to understand seasonal variations in various locations.

o Measurement of hourly profiles to study demand reduction impact potential for various time windows that are most likely to have a call for DR.

ADDITIONAL RECOMMENDED STEPS

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

o This pilot only explored incremental DR settings up to 30%. Future studies that examine greater power reductions (for example, incremental DR settings up to 50%) could further the understanding of the power saving potential of this ALCS.

o Further study of the market impact of mass implementation of this ALCS would improve our understanding of factors related to easing the stress to the electric grid.