

County DGS Building LED Lighting Study Report

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Sacramento Municipal Utility District



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About the Customer Advanced Technologies Program...

SMUD's Customer Advanced Technologies (C.A.T.) program works with customers to encourage the use and evaluation of new or underutilized technologies. The program provides funding for customers in exchange for monitoring rights. Completed demonstration projects include lighting technologies, light emitting diodes (LEDs), indirect/direct evaporative cooling, non-chemical water treatment systems, daylighting and a variety of other technologies.

For more program information, please visit:

<https://www.smud.org/en/business/save-energy/rebates-incentives-financing/customer-advanced-technologies.htm>

1. Executive Summary

In California, interior lighting accounts for nearly 29% of the annual electricity use for commercial buildings¹. Many of these are office spaces with suspended ceilings and are lit by recessed lighting troffers, so it is no surprise that manufacturers offer a wide variety of new LED fixtures for these applications. Some of these new products offer impressive performance; they're fully dimmable, have efficacies of over 105 lumens per Watt and ten year warranties. However, replacing light fixtures in occupied office spaces may be a daunting, messy challenge—especially if the insulation is sitting on top of the ceiling tiles! (Figure 1)

Fortunately several manufacturers now offer LED troffer retrofit kits (Figure 2) which are designed to fit into existing fixture housings. These kits include the LEDs, drivers and optical assemblies and offer many of the same benefits as installing new LED fixtures. On the downside, some of these kits can be rather labor intensive to install so it is a good idea to perform a test installation before making any major commitments.

Another promising technology is advanced lighting controls. These controls are available in both wired and wireless systems and offer end users tremendous flexibility and several potential benefits including:

- Energy savings of 50-90%.
- Flexibility in scheduling lighting operation.
- Improved lighting quality and increased employee satisfaction.
- Ability to track lighting energy consumption, costs and savings in real-time.
- Ability to control lighting on-site or remotely from Internet-based interfaces, such as smart phones or wireless computers.
- Automated demand response capability.

During the last twenty years, the County of Sacramento has been very active in the area of energy efficiency and has worked with SMUD on a wide variety of projects. In late 2013 the County installed LED troffer retrofit kits, tubular LED lamps (aka TLEDs), recessed LED downlights, and advanced wireless controls throughout the second floor of their Department of General Services building. The new control strategies include task tuning, daylight harvesting, occupancy sensors, and sophisticated scheduling.

¹ California Commercial End-Use Study <http://capabilities.itron.com/CeusWeb/ChartsSF/Default2.aspx>



Figure 1: Replacing light fixtures in an occupied office space may be a daunting, messy challenge



Figure 2: LED troffer retrofit kit

SMUD hired ADM Associates Inc. to monitor the energy consumption before and after the lighting retrofit and to evaluate the overall performance of the new lighting system. Overall, the results of this project were favorable; lighting energy consumption was reduced by 67.9% and peak electrical demand by 71.4% (Figure 3). Feedback obtained from County employees regarding the new system was also very favorable; they especially like the ability to dim the lights to a comfortable level. This was evident by the illumination measurements taken after the retrofit; employees actually preferred lower light levels.

The project wasn't all roses however; County electricians encountered some unexpected technical challenges during the retrofit. For example:

- Although the tubular LEDs had external drivers and were designed to be dimmable using 0-10V controls, they did not work properly. After multiple unsuccessful attempts by both the electricians and manufacturer representatives to resolve the problem, the County decided to replace the TLEDs with LED troffer retrofit kits (Figure 4).
- The occupancy sensors have delayed response times. Sometimes people had to walk five feet down the hallway before the lights turned on. The Facility Manager believes the problem is related to "latency" in the wireless control system, rather than the sensors' detection capabilities. This problem was somewhat mitigated by changing the system setpoints to operate in the 'bi-level' mode (dim the lights when no one is around) rather than in the on/off mode during regular working hours.
- At first, the electricians experienced trouble getting some of the LED troffer retrofit kits to lay in flush with the ceiling grid. However, after installing a few kits, they experienced no more difficulties.

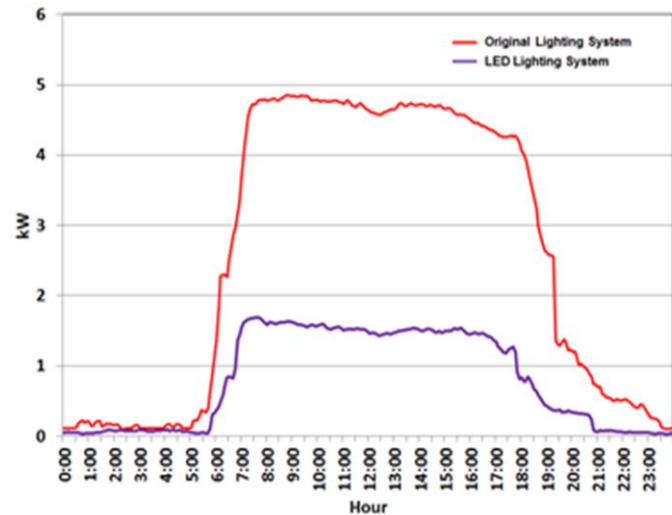


Figure 3: The new LED lighting system reduced energy consumption by 67.9% and peak electrical demand by 71.4%



Figure 4: Philips troffer retrofit kits

Although the savings potential is impressive for using these technologies, the costs are still too high for this approach to be viable for most commercial customers. The simple financial payback for this project was 9.3 years—not including labor costs since the County used in-house electricians to install the system.

The good news is that prices for LED troffer retrofit kits have dropped significantly since this project began and are expected to go lower. Furthermore, Philips and other manufacturers are now offering LED troffer retrofit kits and fixtures with integrated controls, so the cost effectiveness should improve.

In the meantime, SMUD will continue to work with the County of Sacramento and other customers to evaluate different approaches to office lighting retrofits.

Project Summary

Energy savings: 13,440 kWh / yr. (67.9%)

Demand savings: 2.79 kW (71.4%)

Project cost: \$37,960

SMUD research grant: \$23,000

Net project cost: \$14,960

Estimated utility bill reduction: \$1,613 / yr.

Simple payback: 9.3 yrs.

Acknowledgments

While many people contributed to the success of this project, we particularly appreciate the cooperation and help from the following individuals:

- Daniel Mendonsa (County of Sacramento)
- Connie Samla (SMUD)
- Paul Cohen (Philips)
- John Caffrey (ADM Associates)
- Daniel Mort (ADM Associates)
- Doug Thomas (ADM Associates)

2. Project Description

2.1 Background

The Sacramento County Department of General Services (DGS) provides facility and fleet management, and support services to more than 11,000 County employees in 54 departments. DGS's charter includes architectural services, space planning, energy management, lease development and environmental stewardship of County owned facilities.

Over the years, the County of Sacramento has been very active in the area of energy efficiency and has worked with SMUD on a wide variety of projects. In 2013, the County agreed to help SMUD test some new LED retrofit options for office lighting. SMUD provided a research grant to cover the material and equipment costs and the County provided the labor. The site chosen for the test was the second floor of the County's DGS building in Rancho Cordova.

The original lighting system consisted of 187 three lamp fluorescent troffers mounted in continuous rows (Figure 5). As part of a previous energy efficiency project, these fixtures had been de-lamped to one 32-Watt T8 fluorescent lamp. The lighting system operated approximately 3,364 hours per year.

After surveying the site, the project team decided to create a new lighting design which included the following:

- Break up the continuous rows of fluorescent fixtures in the main office areas by removing every other fixture. Install dimmable LED retrofit kits (0-10V control) and wireless controls in the remaining fixtures.
- Replace the fluorescent fixtures in the aisle ways with recessed LED downlights. Install wireless controls to manage the downlights as a separate control zone.
- Retrofit nine fixtures in the Construction Management section of the office with dimmable tubular LED lamps with external drivers that are controlled via 0-10V input signals. This provided an opportunity to compare TLEDs against LED troffer retrofit kits.



Figure 5: The original lighting system had been de-lamped as part of a previous energy efficiency project



- Install ceiling-mounted motion and daylight harvesting sensors and incorporate them into the wireless controls network. Use the new system to implement task tuning, daylight harvesting, occupancy sensors, and detailed scheduling.

After reviewing several products, the County chose to use the products listed below.

- Main office areas: ninety-seven Philips EvoKits (Figure 6)

- 44 Watts, 4000 lumens (initial)
- 85 CRI, 4000K
- ~90 LPW
- 72,000 hours rated life (L⁷⁰)
- External LED driver with 0-10V input



Figure 6: Philips EvoKit

- Office corridors: forty-five Gotham 41/06-4ARWD (Figure 7)

- 16 Watts, 600 lumens (initial)
- 83 CRI, 4100K CCT
- 49 LPW
- 60,000 hours rated life (L⁷⁰)
- External LED driver with 0-10V input



Figure 7: Gotham Evo 41/64 ARWD

- Construction Management section: eighteen ledgreenlight® tubular LED lamps (Figure 8)

- 20 Watts
- 2400 initial lumens
- >80 CRI, 4100K
- 120 LPW
- 100,000 hours rated life (L⁷⁰)
- External LED driver with 0-10V input



Figure 8: ledgreenlight® tubular LED lamps

- Entire Building: Daintree Networks Wireless Controls (Figure 9)

- Wireless adapters (WA100)
- Occupancy sensors
- Daylight harvesting sensors (photo sensors)
- Wireless Area Controllers (WAC)
- Wireless wall dimmers
- BACnet server

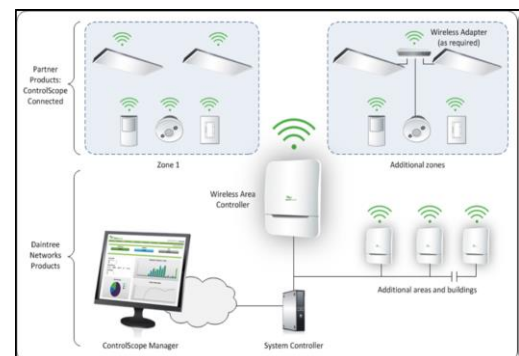


Figure 9: Daintree Networks wireless controls

2.2 Assessment Objectives

The goal of this study was to understand the performance characteristics of Philips EvoKits Gotham LED downlights, ledgreenlights TLED lamps, and Daintree wireless controls in the County DGS building. This assessment included monitoring the energy consumption, measuring the illumination levels before and after the retrofit, and obtaining feedback from project participants.

2.3 Methodology

Since only a portion of the County DGS building was retrofitted, ADM used a two part monitoring approach to determine the energy savings:

1. Lighting power consumption was measured at the breaker panel using a WattNode wathour meter (model WNB-3D-240-P) and high accuracy split-core current transducers (CTs) placed inside the panel. The system was connected to a battery operated Hobo pulse logger (model UX90-001M) and set to record energy use in 5-minute intervals.
2. Lighting loggers were used to monitor hours of use for the remaining 26 stairway and hallway fixtures not included in the monitored electrical panel (Figure 10). The lighting loggers installed were Hobo U12-012 Temp/RH/Light External data loggers. The units were set up to take measurements at five minute intervals.

Lighting level measurements were made to quantify the available light. The measurements were made with a NIST calibrated Extech Light meter.

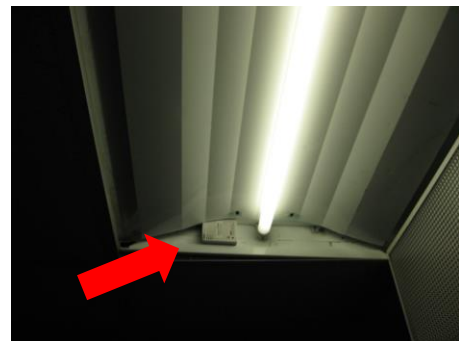


Figure 10: a Hobo lighting logger installed in an original fluorescent fixture

3. Results

The baseline monitoring period took place between 9/11/13 and 10/25/13 and the as-built (post retrofit) monitoring period took place between 2/1/14 and 2/28/14. Based upon the monitoring data, typical day load profiles were created for weekdays, weekends, and holidays. The weekday profile is the average of the non-holiday weekdays (Figure 11), and the weekend profile is the average of all weekend days (Figure 12). The holiday profile was determined using data for Columbus Day, Abraham Lincoln's and George Washington's birthdays (Figure 13). These monitored average load profiles were used to determine normalized savings for a typical year consisting of 249 weekdays, 104 weekend days, and 12 holidays.

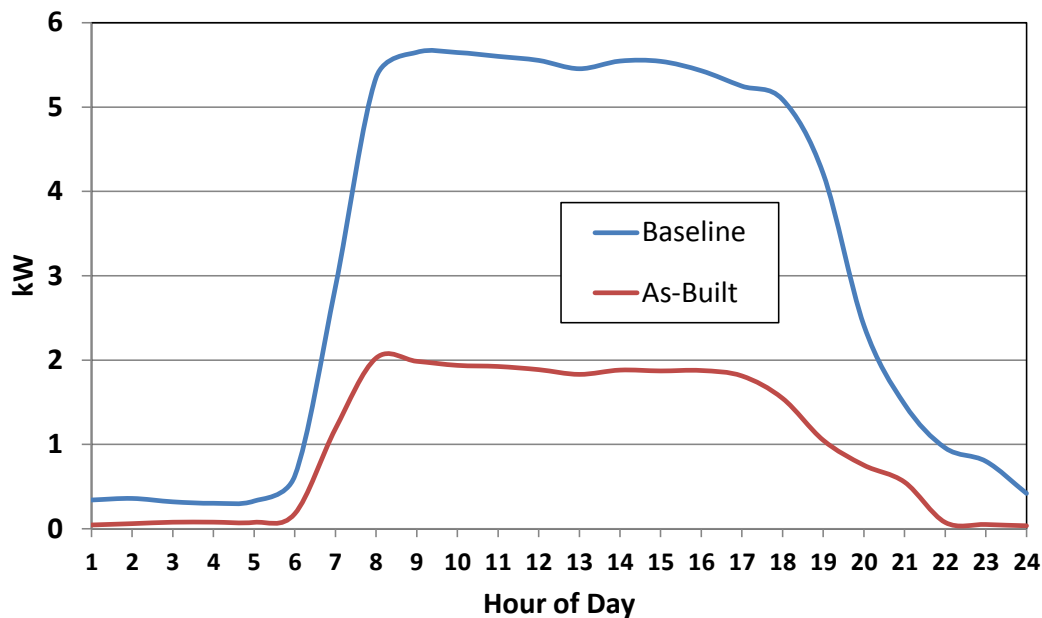


Figure 11: Typical Weekday Lighting Load Profile

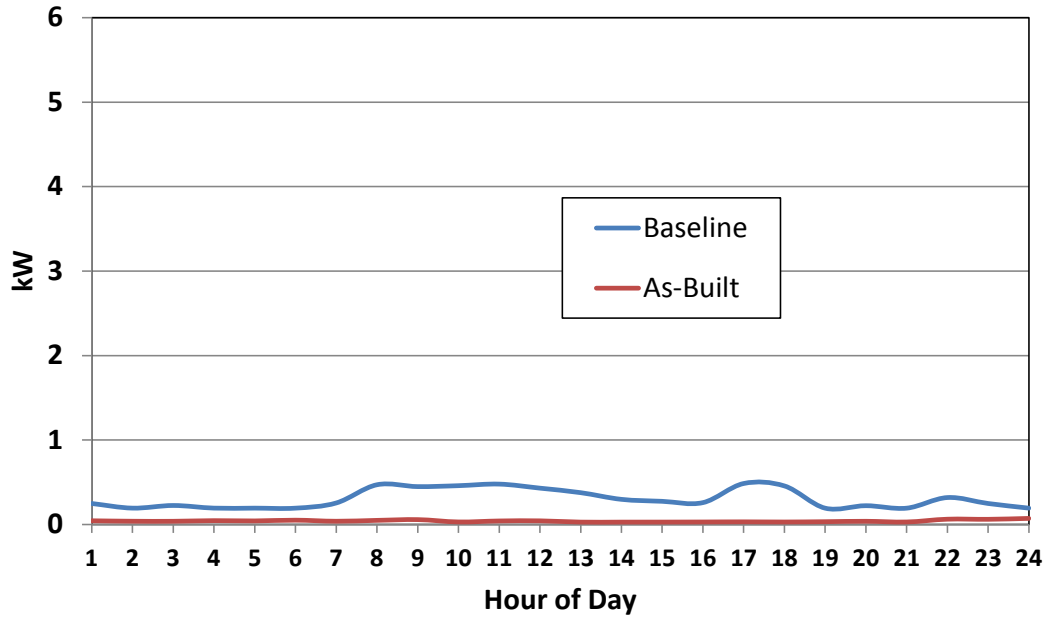


Figure 12: Typical Weekend Day Lighting Load Profile

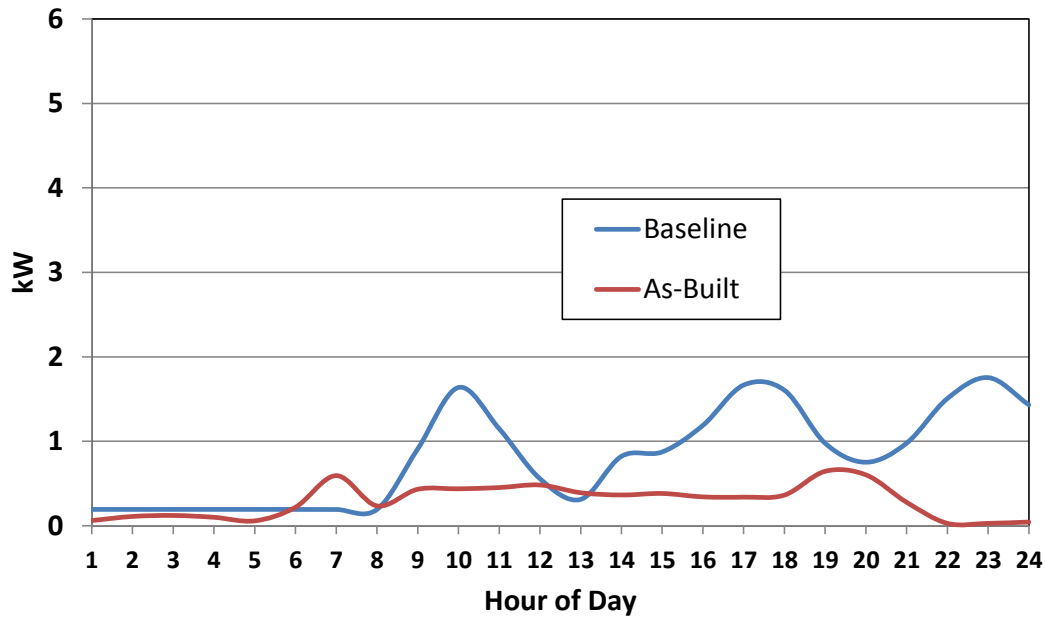


Figure 13: Typical Holiday Lighting Load Profile

The results of the study show a 67.9% reduction in annual lighting energy consumption, as well as a 71.4% reduction in peak demand use (see Table 1 on next page).

Table 1: Results

	Baseline	As-Built	Savings	% Reduction
Annual Energy Use, kWh	19,800	6,360	13,440	67.9%
Peak Demand, kW	3.903	1.116	2.787	71.4%

Peak savings are defined as the average savings during June through the end of September between 4:00PM and 7:00PM. The peak savings were assumed to be the average difference between pre and post monitoring points recorded on non-holiday weekdays between 4:00PM and 7:00PM.

Light intensity measurements were taken at 59 points throughout the second floor of the facility. Measuring was conducted in the early morning prior to sunrise in order to limit interference from daylight. Measurement points were taken at various office locations; both underneath and in-between fixtures, and all at equal height (30 inches above the floor). The results of the measurements (**Table 1**) show a 32 percent reduction in average light intensity throughout the facility. The average baseline light level was 21.8 fc and the as-built light level was 14.9 fc. It should be noted, however, that the lower illumination levels were *chosen* by the occupants—the system was set to 20 to 30% of maximum output based upon feedback from people working within the space. Additionally, during the as-built period there are varying measurements because of multiple settings throughout the floor from occupancy and dimming controls.

Table 2: Light Intensity Measurement Results

	Baseline (foot-candles)	As-Built (foot-candles)	Reduction (%)
Average	21.8	14.9	32%
Minimum	2.5	6.3	---
Maximum	35.1	41.0	---

4. Discussion

Overall, the site facilities manager was satisfied with the new lighting and controls system. In his opinion, the Philips Evokits are a much better option for them than the TLED lamps originally tested in the Construction Management area. Interestingly enough, the site electrician commented that installation of the Evokits was easier than installing the TLEDs. This was somewhat counterintuitive since the Evokits require completely gutting the existing fixture.

The electrician also commented that the wireless controls were convenient to install yet had two concerns. First, the electricians felt that some of the wire connections within the fixtures felt weak, but none failed during installation. Secondly, the electricians experienced trouble getting

some of the LED troffer retrofit kits to lay in flush with the ceiling grid. However, after installing a few kits, they experienced no more difficulties. No other installation issues were mentioned.

The dimming controls have improved the quality of light in the space. The system is capable of responding to light level requests of individual users for their workspace. Pre and post measurements of corridor lighting saw a 26% decrease in illumination levels with no complaints. One possible explanation is that since this office space has relatively low ceilings (8 feet), the EvoKits may appear to be too bright unless dimmed.

The occupancy sensors, however, received less praise. Although the sensors reduced overall energy consumption, delayed response times caused some complaints. Sometimes people had to walk five feet down an unlit hallway before the lights turned on. Previously, lights in front of the elevator operated continuously. The Facility Manager was able to manage the problem by setting the controls to dim rather than completely turn off the lights during occupied hours.

5. Conclusion

LED troffer retrofit kits and wireless controls may provide an attractive option for many commercial office spaces. Since the time this project began, several manufacturers have introduced LED retrofit kits and fixtures with integrated motion sensors, daylight harvesting capabilities and wireless controls. SMUD will continue to work with the County of Sacramento and other customers to evaluate these new options. In the meantime, LED retrofits and controls are currently eligible for commercial energy efficiency incentives. For more information, please visit www.SMUD.org.