

# ADAPTIVE EXTERIOR LIGHTING

University of California,  
Santa Barbara



Post-retrofit network controlled LED streetlights (left) and post-top fixtures (right) at UC Santa Barbara



**ENERGY &  
CO<sub>2</sub>E SAVINGS**  
78% – 88%



**OCCUPANCY RATE**  
20% for paths with  
post-top lighting



**15-YEAR (LIFETIME)  
MAINTENANCE  
SAVINGS**  
\$270 per fixture

*In 2013, UC Santa Barbara partnered with the SPEED team to demonstrate network controlled LED lighting for streetlights and post-top fixtures. These exterior fixtures were purchased with dimming power supplies and equipped with radio frequency (RF) control modules. The post-top fixtures were also equipped with occupancy sensors. These lighting controls allowed all the units to be incorporated into an adaptive mesh network control system that optimized the fixtures' energy efficiency and gave the campus unprecedented control of its lighting.*

"The Lumewave system monitors energy use and occupancy rates where occupancy sensors are installed," says UCSB LEED Program Manager Jordan Sager. "We've been able to use this data to inform project decision-making in other areas of campus, and it is helping the campus qualify for utility incentives."

This retrofit also put the area and street lighting in compliance with California's 2013 Title 24, Part 6 standards for outdoor lighting. These standards require that all area lighting mounted at a height of 24 feet or less must use motion-sensitive lighting controls or a lighting control system, in addition to daylight harvesting controls. Although streetlights are not required to utilize any controls, the use of a central control system eases maintenance and allows for energy savings through tuning.

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## PROBLEM

Street and area lighting typically uses high-intensity discharge (HID) light sources such as high-pressure sodium (HPS) and metal halide (MH) lamps. These sources are only moderately efficacious, contribute significantly to light pollution, and generally provide lower quality light. Because street and area lighting primarily operates during off-peak hours, a great deal of energy is also wasted when fixtures operate at full lighting power during unoccupied hours of the night.

## SOLUTION

The street and area lights selected for the UCSB retrofit each have a dimmable LED driver and wireless control module. A collar was added to each post-top fixture, between the lamp post and the light fixture, to house occupancy sensors and the RF module. All fixtures on the network are fully dimmable and fully programmable, allowing for tuning and curfew dimming. The post-top fixtures are also controlled by motion sensors, making them capable of adaptive (bi-level) lighting. Both high and low modes (for occupied and vacant periods, respectively) are adjustable via the network lighting control system.

The RF network control modules were added to the streetlights through a NEMA twist-lock receptacle and to the post-top fixtures via internal wiring through the collar. The RF modules serve as a point of communication between each fixture and the network. A network gateway serves as a central communication point for the control modules and allows authorized system administrators to make dynamic adjustments to individual fixtures or groups of fixtures.

System administrators can program lights to automatically turn on and off at preset times or defer to integrated daylight sensors. Administrators can also monitor energy use patterns, create event schedules, control profiles, change dimming schedules, modify bi-level settings, and receive automated alerts from the fixtures when a maintenance issue is detected.

## DEMONSTRATION RESULTS

The SPEED program and CLTC partnered with UC Santa Barbara to install 27 streetlights and 10 post-top fixtures at the west entrance of the UCSB campus. These lights are on for an average of 12 hours each night. Lumewave, Inc. produces and maintains the TOP900 and EMB900 wireless control modules, RF network and LumeStar system software used to incorporate the fixtures into the mesh network control system.

The 101 W XSP LED streetlight fixtures, manufactured by Cree, replaced 250W HPS cobrahead streetlights (system power: 289 watts). Bi-level (44 W/9W) LED retrofit kits by Philips Lumec replaced 100W HPS lamps (system power: 128W) in the post-top fixtures. WattStopper motion sensors were mounted to the post-top fixtures via fixture collars. These retrofits reduced the streetlights' energy use by 78% and reduced the post-top fixtures' energy use by 88% (see Table 2 for project costs and savings). Using a standard fixture with network controls, the campus can further deepen its savings by tuning the fixtures down to 50% of full lighting power and still maintain IES recommended street and area lighting levels.

## PROJECT TECHNOLOGIES

### LED STREETLIGHT

XSP Series streetlight by Cree, Inc. available at [cree.com](http://cree.com)



### LED POST-TOP LIGHT ENGINE AND FIXTURE COLLAR

EcoSwap LED light engine and SFPH4 fixture collar for post-top luminaires by Philips Lumec, available at [lumec.com](http://lumec.com)



### LIGHTING CONTROL NETWORK

TOP900 lighting control module by Lumewave, available at [lumewave.com](http://lumewave.com)



### OUTDOOR MOTION SENSOR

EW low-voltage outdoor motion sensor by WattStopper, available at [wattstopper.com](http://wattstopper.com)



## ECONOMIC EVALUATION

Project incentives available through the UC/CSU/IOU Energy Efficiency Partnership make energy-saving lighting installations more cost-effective. At an incentive of \$0.24 per annual kWh saved, these incentives would reduce project costs by an estimated \$237 per streetlight and \$118 per post-top fixture (see Table 1), shortening payback periods for the streetlights and post-top fixtures by 40% and 10% respectively. Information on the UC/CSU/IOU Energy Efficiency Partnership and its incentive programs is available at [uccsuioeee.org](http://uccsuioeee.org).

After factoring in energy savings, maintenance savings, and Partnership incentives, an installation like that at UCSB, consisting of 27 networked streetlights and 10 networked adaptive post-top luminaires, would result in a payback period of just 4.7 years at UCSB's rate of \$0.11/kWh. The streetlight retrofit would pay for itself in 1.6 to 3.9 years, and the payback period for the post-top retrofit would range from 8.9 to 20.2 years, depending on a campus's electricity rate (see Figure 1).

The networked exterior lighting control system demonstrated at UCSB is a leading-edge, best-practice solution. The costs of these systems are expected to come down as the technologies they utilize gain wider

use and manufacturers recoup the costs of research and development. Even now, large-scale implementation can make investing in a networked lighting control system cost-effective. In June of 2012 UC Davis successfully completed an exterior lighting project that involved retrofitting over 1,500 luminaires with LED technology and installing the Lumewave network lighting control system throughout the campus (information on this project is at [cltc.ucdavis.edu](http://cltc.ucdavis.edu)).

Facilities with limited funding or lower electricity rates may find it more affordable to install local controls, as opposed to a network control system. Local controls do not provide all the features or long-term savings of a network system, but they can still provide deep energy savings.

## COLLABORATORS

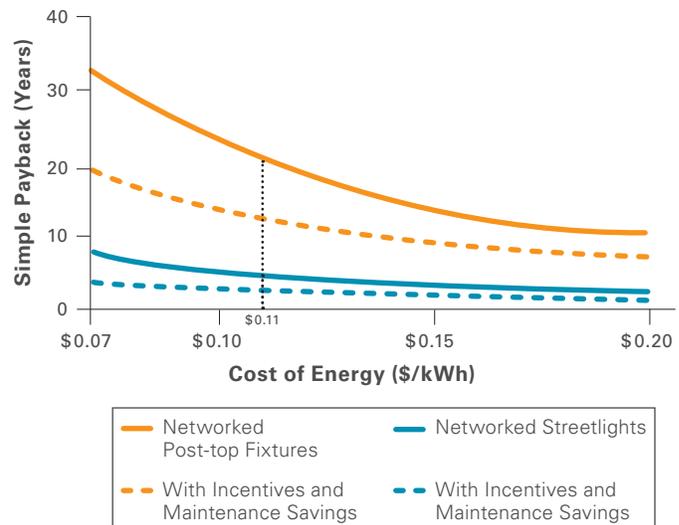
This project was completed through collaborative efforts by UC Santa Barbara, UC Davis's California Lighting Technology Center, and the State Partnership for Energy Efficient Demonstrations (SPEED) program. SPEED demonstrations are coordinated by the California Institute for Energy and Environment (CIEE).

**TABLE 1: 15-YEAR COST ANALYSIS WITH INCENTIVES**

	Networked Streetlights	Networked Post-Top Fixtures
Partnership Incentives per Fixture	\$237	\$118
Net Cost per Fixture*	\$346	\$1,006
Payback	2.7 years	14.5 years
Internal Rate of Return (IRR)	49%	0%

\*Fixture costs and payback periods reflect savings from Partnership incentives (\$0.24/annual kWh saved), energy savings (at a rate of \$0.11/kWh), and maintenance savings.

**FIGURE 1: SIMPLE PAYBACK BASED ON ELECTRICITY RATES**



Electricity rates vary for UC and CSU campuses, from \$0.07 and up. These rates, along with Partnership incentives and maintenance savings, affect project payback periods. Utility rebates and incentives may further lower project costs and shorten payback periods.

**TABLE 2: OPERATIONAL COSTS & SAVINGS SUMMARY**

	STREETLIGHT RETROFIT			POST-TOP RETROFIT		
	BEFORE	AFTER		BEFORE	AFTER	
<b>Technology</b>	HPS without controls	LED with network controls		HPS without controls	LED with motion sensors and network controls	
<b>System Power</b>	289W	101W	<b>78% SAVINGS</b>	128W	44W (High) 9W (Low)	<b>88% SAVINGS</b>
<b>Annual Energy Consumption</b>	1,266kWh	278kWh	<b>988 kWh</b>	561 kWh	70kWh	<b>491 kWh</b>
<b>Annual Energy Cost</b>	\$139	\$31	<b>\$108</b>	\$62	\$8	<b>\$54</b>
<b>Annual Maintenance Cost</b>	\$18	\$0	<b>\$18</b>	\$18	\$0	<b>\$18</b>
<b>Total Annual Cost</b>	\$157	\$31	<b>\$126</b>	\$80	\$8	<b>\$72</b>
<b>Energy Cost Over 15 Years</b>	\$2,085	\$465	<b>\$1,620</b>	\$930	\$120	<b>\$810</b>
<b>Maintenance Cost Over 15 Years</b>	\$270	\$0	<b>\$270</b>	\$270	\$0	<b>\$270</b>
<b>Total 15-Year Operating Cost</b>	\$2,355	\$465	<b>\$1,890</b>	\$1,200	\$120	<b>\$1,080</b>
<b>Total 15-Year Cost for All Fixtures</b>	\$63,585	\$12,555	<b>\$51,030</b>	\$12,000	\$1,200	<b>\$10,800</b>

Metrics listed are per-fixture quantities unless otherwise noted.

<b>Number of Streetlight Fixtures</b>	27	<b>Pre-retrofit Lifetime</b>	24,000 hours
<b>Number of Post-top Fixtures</b>	10	<b>Post-retrofit Lifetime</b>	100,000 hours
<b>Cost of Labor (Including Bucket Truck Cost)</b>	\$135/hr	<b>Lamp Cost</b>	\$20
<b>Replacement Time</b>	1 hour	<b>Capacitor Cost</b>	\$70
<b>Energy Cost</b>	\$0.11/kWh	<b>Annual Hours of Use</b>	4,380 hours
<b>Occupancy Rate (Post-Top Areas)</b>	20%	<b>Lifetime</b>	15 years

**ABOUT THE STATE PARTNERSHIP FOR ENERGY EFFICIENT DEMONSTRATIONS (SPEED) PROGRAM:**

The SPEED program is supported by the California Energy Commission and managed through the California Institute for Energy and Environment (CIEE). SPEED demonstrations are coordinated by the CIEE in partnership with the California Lighting Technology Center and the Western Cooling Efficiency Center, both at the University of California, Davis.

Any questions about lighting technologies, including costs, can be directed to:

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