CAMPUS-WIDE NETWORKED ADAPTIVE LED LIGHTING

University of California, Davis

Network-controlled adaptive LED fixtures line Old Davis Road on the UC Davis campus.

ENERGY & CO_2E SAVINGS
86%

OCCUPANCY RATE
20–59%

15-YEAR MAINTENANCE COST SAVINGS
$444,480

15-YEAR ENERGY COST SAVINGS
$1,369,155
at UC Davis rate of $0.075/kWh

In order to reduce energy consumption and the state's carbon footprint, the California Public Utilities Commission (CPUC) has called for a 60–80% reduction in lighting energy consumption by 2020. Answering this call, UC Davis established the Smart Lighting Initiative (SLI), an effort to reduce campus-wide lighting electricity consumption at least 60% below 2007 levels. The first phase of this program included a large-scale deployment of over 1,500 network-controlled LED streetlights, area lights, post-tops, and wall packs. The "ultra-smart" lighting installation has reduced annual energy use by an estimated 1,231,758 kWh, saving $120,909 annually in energy and maintenance costs.

"Any large facility could save a lot of energy and money with a system like the one at UC Davis," says Scott Arntzen, Senior Project Manager with UC Davis Design and Construction Management (DCM). "We're exceeding what we anticipated in terms of kilowatt-hour savings."

The project also put UC Davis's exterior lighting in compliance with California's latest energy efficiency codes and standards for outdoor lighting (2013 Title 24, Part 6). Under the code, all fixtures that consume 75 watts or more and are mounted at a height of 24' or less must be controlled with motion sensors in addition to photosensors and automatic scheduling controls.

PROBLEM

Like many university and corporate campuses, UC Davis is illuminated by different types of outdoor lighting fixtures that were installed throughout the development and expansion of the campus. These fixtures use a wide variety of light sources, including high-pressure sodium (HPS), metal halide (MH), induction, and LED technologies. All are controlled by photosensors or scheduling controls to prevent energy waste during daylight hours, but some lack occupancy controls, tuning or scheduling controls that could save energy during nighttime hours of operation.

Through the State Partnership for Energy Efficiency Demonstrations (SPEED) program, UC Davis and its California Lighting Technology Center (CLTC) had successfully demonstrated and documented the potential to incorporate lighting throughout the campus into a single system, and achieve deep energy savings in the process. LED sources and advanced wireless controls are part of this solution, but most campuses have limited bandwidth, which makes it difficult to research new technologies or scope and execute large-scale lighting projects. This is especially true for UC Davis, which is the largest campus in the UC system at 5,300 acres. Undertaking the campus-wide retrofit of over 1,500 fixtures required a coordinated, collaborative scaled deployment strategy.

SOLUTION

UC Davis Design Construction Management (DCM) contracted with Sacramento electrical design house Peters Engineering to audit the campus's exterior lighting, develop a baseline measurement of pre-retrofit energy use, scope the size of the retrofit, and design the one-for-one retrofit.

The university selected wireless network lighting control system manufacturer, Lumewave, to supply the radio frequency (RF) network control system, based on the Lumewave system's capabilities. CLTC obtained pricing for street and area fixtures from three manufacturers and provided economic analysis, which indicated the RoadStar street and area fixture, by Philips Lumec, was the most cost-effective option. UC Davis independently procured the light fixtures and controls, which included Philips Day-Brite wall packs, RoadStar street and area lights, Philips Lumec post-top fixtures, and outdoor motion sensors by WattStopper.

DCM then released a request for proposals (RFP) for the installation. Three contractors responded to the RFP, but only ITS Republic submitted a bid. ITS Republic carried out the fixture and controls installations as well as the initial commissioning of network controls, after which UC Davis Utilities took over ownership and maintenance of the system with the support of UC Davis's DCM and Facilities Management departments, Lumewave, and CLTC.

DEMONSTRATION RESULTS

The campus-wide lighting retrofit at UC Davis succeeded in reducing outdoor lighting energy use 86% on average, surpassing the 60% goal set by the campus. It also now provides extensive maintenance savings and energy monitoring services. Retrofits addressed 86 post-top fixtures, 101 wall packs, and 1,347 roadway and area fixtures.

PROJECT TECHNOLOGIES

LED WALL PACK

WTM-40W wall pack by Philips Day-Brite, available at **daybrite.com**

LED STREET AND AREA LIGHT

RoadStar by Philips Lumec, available at **lumec.com**

LED POST-TOP LIGHT ENGINE AND FIXTURE COLLAR

EcoSwap LED light engine and SFPH4 fixture collar for post-top fixtures by Philips Lumec, available at **lumec.com**

CONTROLS

FS-305-LU and EW-205-12-LU PIR motion sensors by WattStopper, available at **wattstopper.com**

TOP900 RF network control modules and LumeStar Software by Lumewave, Inc., available at **lumewave.com**

New 40W and 90W LED fixtures were installed in place of a variety of previously installed roadway and area lights. Monitoring data provided through the Lumewave control system indicated a high average occupancy rate of 59% for street and area lighting across the campus, yet, with the standardization to LED technology and the advanced programming features available through the control network, the RoadStar retrofits (system power: 40W and 90W) reduced lighting energy use 73%. With maintenance savings factored in, these retrofits resulted in payback periods of 12.9 years at UC Davis's low electricity rate of $0.075/kWh.

The average power consumption of the metal halide and HPS wall packs replaced during this retrofit was 150 watts (system power: 189W). The new LED wall packs operate at 42 watts and automatically dim during vacant periods, so they operate at just 20% of full lighting power when in standby mode. Top-end trimming allows the fixtures to be programmed through the network, so they operate at 80% or 90%, versus 100%, when occupants are detected. The network control system that operated the wall packs measured an occupancy rate of only 20%. This low occupancy rate coupled with the low energy consumption of the LED wall packs yielded energy savings of 89% and a payback of 9.9 years, including maintenance savings.

The new LED post-top light engines consume only 45W (system power: 45W), replacing the 100W HPS lamps (system power: 128W) previously installed. Data collected through the network control system operating the post-tops showed an occupancy rate of 40% in the areas surrounding these fixtures. This occupancy rate, coupled with the low energy consumption of the LEDs, resulted in average energy savings of 87% and a payback of 12.8 years, including maintenance savings.

ECONOMIC EVALUATION

The campus leveraged a number of funding sources to execute this campus-wide project. Facilities with limited funding or lower electricity rates may find installing fixture-level controls, without the network system, provides a more affordable solution.

The UC/CSU/IOU Energy Efficiency Partnership provided an incentive of $0.24 per annual kWh saved by the project. The Energy Technology Assistance Program (ETAP) provided a flat incentive of $200 per fixture head for the area lights included in the retrofit. Remaining costs for materials and installation were covered by a loan provided through the UC Office of the President. Campuses not eligible for a UCOP loan may be eligible for utility on-bill financing.

Since the project's completion in 2012, a number of street and area fixtures have become available at 20–40% below costs paid for the UC Davis project. Figure 1 illustrates the impact of this cost difference on the simple payback calculations associated with the project. Figure 1 also illustrates how electricity rates affect payback results.

COLLABORATORS

This project was a collaborative effort led by UC Davis's Design & Construction Management team (DCM), the campus Utilities unit, Facilities Management, and CLTC, with support from the Office of Environmental Stewardship and Sustainability. CLTC's engineering team partnered with Lumewave on early field tests of the network control system on the UC Davis campus. CLTC worked with Philips, WattStopper and Lumewave to make the fixtures, sensors and control modules fully compatible for the UC Davis installation and future projects.

FIGURE 1: SIMPLE PAYBACK BASED ON ELECTRICITY RATES

Calculations include incentives and reflect payback periods for a campus-wide retrofit like that deployed at UC Davis.

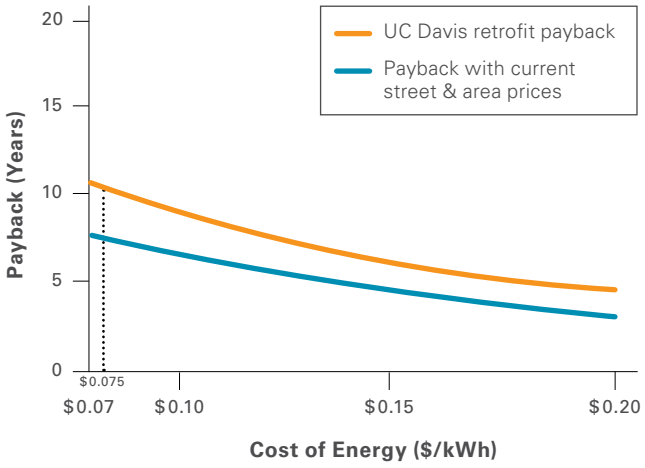

TABLE 1: ANALYSIS WITH INCENTIVES & MAINTENANCE

	STREET & AREA FIXTURES	WALL PACKS	POST-TOP FIXTURES
Initial Cost per Fixture	$1,214	$890	$1,240
Incentive per Fixture	$316	$178	$180
Project Cost per Fixture	$898	$712	$1,060
Payback	12.9 years	9.9 years	12.8 years

Initial cost includes fixture, controls and installation. Savings reflect Lumewave system operation at UC Davis's rate of $0.075/kWh.

TABLE 2: OPERATIONAL COSTS & SAVINGS SUMMARY

	STREET & AREA LUMEC ROADSTAR 59% Occupancy			WALL PACKS DAY-BRITE WTM 20% Occupancy			POST-TOP FIXTURES LUMEC ECOSWAP WITH COLLAR 40% Occupancy			TOTAL SYSTEM SAVINGS FOR ALL FIXTURES
	BEFORE	AFTER	SAVINGS	BEFORE	AFTER	SAVINGS	BEFORE	AFTER	SAVINGS	
Energy Savings			**73%**			**89%**			**87%**	**86%**
Annual Energy Consumption (kWh)	1,111	300	**811**	828	87	**741**	861	111	**750**	**1,231,758**
Annual Energy Cost	$83	$23	**$60**	$62	$7	**$55**	$65	$8	**$57**	**$91,277**
Annual Maintenance Cost	$19	$0	**$19**	$17	$0	**$17**	$27	$0	**$27**	**$29,632**
15-Year Energy Cost	$1245	$345	**$900**	$930	$105	**$825**	$975	$120	**$855**	**$1,369,155**
15-Year Maintenance Cost	$285	$0	**$285**	$255	$0	**$255**	$405	$0	**$405**	**$444,480**
Total 15-Year (Lifetime) Cost for All Fixtures	$2,060,910	$464,715	**$1,596,195**	$119,685	$10,605	**$109,080**	$118,680	$10,320	**$108,360**	**$1,813,635**

Values listed are per-fixture quantities unless otherwise noted and reflect average performance. All post-retrofit solutions include photocells, motion sensors and network system controls. Savings are based on data reported through the Lumewave network lighting control system.

Number of Fixtures *1,534 fixtures total*
Street/area: 1,347
Wall packs: 101
Post-tops: 86

Cost of Labor *$65/hour*

Replacement Time *1 hour*

Energy Cost *$0.075/kWh*

Pre-retrofit lifetime (hours)
Street/area: 21,816
Wall packs: 18,900
Post-tops: 12,500

Pre-retrofit lifetime (hours)
Street/area: 70,000
Wall packs: 60,000
Post-tops: 70,000

Annual Hours of Use *4,100*

HID lamp cost
Street/area: $28
Wall packs: $28
Post-tops: $30

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 this project, including technology costs, can be directed to:

PEDRAM ARANI
California Lighting Technology Center, UC Davis
pmarani@ucdavis.edu
cltc.ucdavis.edu

KARL JOHNSON
California Institute for Energy and Environment
karl.johnson@uc-ciee.org
uc-ciee.org

For more resources and information, including technology catalogs, business case studies and demonstration maps, visit PARTNERSHIPDEMONSTRATIONS.ORG.