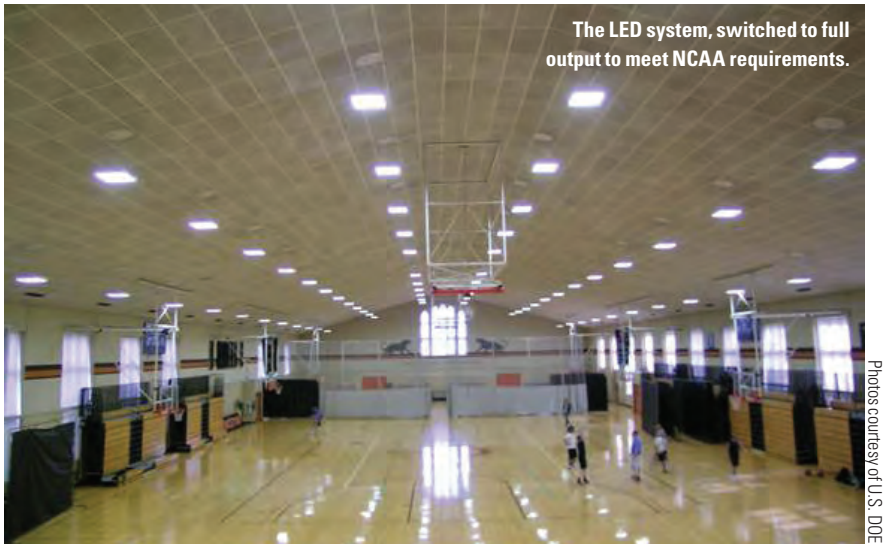
LEDs Go Ivy League

Princeton University is home to two DOE Gateway demonstrations

BY JAMES BRODRICK

In addition to educating our best and brightest, institutions of higher learning can teach us a thing or two about lighting. A complex facility that resembles a mini-city in many ways, the typical college campus offers a range of lighting applications under one administrative roof—from classrooms and offices to theaters, labs, libraries, dining halls, dormitories, museums, chapels, walkways, parking lots, garages, lecture halls, arenas and outdoor stadiums. This makes the campus an ideal testing ground for lighting.

Princeton University, located in Princeton, NJ, began working with LED lighting when the technology first became available for general lighting. After several parking lot and garage lighting installations, the university expanded its focus to include interior lighting and currently is engaged in a number of projects in collaboration with the U.S. Department of Energy's (DOE) Gateway Demonstration Program. Two of those projects are described here.



The LED system, switched to full output to meet NCAA requirements.

Photos courtesy of U.S. DOE

ZONE COVERAGE IN THE DILLON GYMNASIUM

Completed in 2012, relighting of the Dillon Gymnasium was Princeton University's first extensive interior LED project. In addition to the main gymnasium, the facility includes a swimming pool, squash courts, a dance studio, a spinning room, several multipurpose spaces, coaches' offices and the bi-level Stephens Fitness Center.

The main gym floor has four multi-use courts for basketball, volleyball and badminton. Since the gym also gets heavy day-to-day recreational use, with people dropping by to play half-court pickup basketball or some other sport, the new lighting solution had to satisfy more-demanding NCAA criteria as well as less stringent criteria for recreational use.

The incumbent lighting system consisted of 111 round high-bay luminaires at a mounting height of between 25 and 32 ft, each luminaire using eight 32-W CFLs. The original intent was to have four lamps within a luminaire switched on for recreational use and all eight lamps for varsity events. However, switching was manual, and the Princeton facilities staff observed that all of the switches were often turned on whenever the gym had any occupancy, and that the lighting frequently remained on during unoccupied hours. The new system would need a means for easy control, so that the whole gym wasn't lighted just for the benefit of eight people playing a half-court basketball game.

After sampling a number of different prospects, the facilities staff settled on a 2 ft x 2 ft square fixture from the Lusio Lighting Pro-Optics Series. The architects approved the decision, since the fixture form was a simple, primary shape. The fixture options included an integrated passive infrared (PIR) motion sensor and standard 0-10V dimming control. But staff didn't want individual fixtures turning on and off based on occupancy, opting instead to control them by zones, so that groupings of fixtures over unoccupied spaces would automatically turn off and remain dark until needed.

The final control solution included a PIR motion sensor mounted on one luminaire in each of the eight zone groupings, which were aligned with the basketball half-courts. The sensor was connected to a digital Lutron Ecosystem controller that adjusted the output of the entire group based on the detected occupancy. Each group is off when there's no occupancy detected on that half-court, and operates at 20 percent input power when there's occupancy. Because of the efficiency of the LEDs at the lower power ranges, Princeton staff determined that 20 percent power would provide adequate lighting for recreational use, while full power was only needed for NCAA varsity sports. Thus, the 180-W LED fixtures only consume about 36 watts the majority of the time they're on.

Although Princeton wanted the individual addressability that the Lutron system provided, at the time the system was being designed, Lutron did not offer an interface to allow for dimming an LED fixture that was wired for 0-10V control. But by coordinating directly with the manufacturers, Princeton was able to get a solution from Lutron that interconnected the digital controls with the 0-10V dimming. No wireless motion sensors would work at that height, so eight wired Hubbell high-bay occupancy sensors were positioned above the center of each half-court.

The LED fixture had an option for 4 percent uplight to add some ceiling brightness, which initially seemed important because the existing system provided some uplight. This option required additional power for the LED uplight. Princeton staff questioned the need for the additional wattage for the uplight, and found that the reflected light within the gym cast sufficient light onto the ceiling behind the fixtures.

One issue encountered with the new LED system was that the volleyball coaches were concerned that players who looked straight

up could see the raw LEDs in the luminaire, which were very bright—a necessity in order to illuminate the floor 30 ft below. The Princeton staff did some experimenting and found that adding even just a very light diffusion layer—which the manufacturer was able to do in the factory—cut the glare enough to satisfy the volleyball coaches.

The installed LED system reduced the overall power for the lighting in the gym and two related spaces by more than 35 percent, resulting in annual energy savings of about 66,900 kWh at the same operating hours. The task-tuned recreational use dimming and the occupancy-based controls in the main gym are estimated to reduce annual energy use by an additional 42,200 kWh.

ROOM	MAIN GYM	MULTI-PURPOSE ROOM 203	GROUP FITNESS ROOM 204	TOTALS
NUMBER OF FIXTURES	84	15	12	**111**
INCUMBENT TECHNOLOGY	CFL8-lamp	CFL8-lamp	CFL8-lamp	
POWER (W)	282	282	282	
ANNUAL ENERGY (kWh)	146,866	21,150	16,920	**184,936**
LED PRODUCT	Lusio Pro-Optics High Bay 2x2 (High output)	Lusio Pro-Optics High Bay 2x2 (High output)	Lusio Pro-Optics High Bay 2x2 (High output)	
LED POWER (W)	180	180	180	
HOURS OF OPERATION	6,200	5,000	5,000	
LED ANNUAL ENERGY w/o CONTROLS (kWh)	93,744	13,500	10,800	**118,044**
ANNUAL ENERGY SAVINGS w/o CONTROLS (kWh)	53,122	7,650	6,120	**66,892**
ANNUAL ENERGY SAVINGS w/CONTROLS (kWh)	95,306	7,650	6,120	**109,076**

Dillon Gymnasium.

Fluorescent luminaires in the Icahn lab prior to retrofit.

RETROFIT KITS AT THE CARL ICAHN LABORATORY

A pioneer in biological research—as well as in the application of LEDs—Princeton's 98,000-sq ft Carl Icahn Laboratory of the Lewis-Sigler Institute for Integrative Genomics represents the school's first building-wide interior LED project.

Designed to hold 125 to 150 people, the L-shaped Icahn facility includes 35,000 sq ft of labs on two stories, with a central atrium and curving glass curtain wall joining them. The atrium is a social place where researchers and students can meet in formal and informal common areas, and features a metal-clad wood sculpture by Frank Gehry that houses a conference room. The two-story curtain wall is shielded by 31 external 40-ft vertical aluminum louvers that rotate with the sun to maximize shade, minimize thermal loading and reduce cooling load. The computer-controlled louvers are patterned to project a double-helix DNA-style shadow onto the atrium floor as a dynamic interplay of light and shadow. The south-facing glass wall introduces natural light deep into the center of the building.

The loft-like labs have 12-ft ceilings capped with 8 ft of plenum space to allow for easy reconfiguration of utilities. The open floor plans, modular partitions and demountable casework allow for flexibility and movability. Faculty offices are clustered rather than located next to each lab, to encourage

FLOOR	SPACE	FIXTURE	QTY.	LAMP	FIXTURE WATTS	HOURS	CONTROL FACTOR	kWh
Basement	Office	2x2	62	Maxlite LED	45	5000	0.6	8,370
Basement	Lab	2x2	40	Maxlite LED	45	5000	0.6	5,400
1st	Office	2x2	78	Maxlite LED	45	5000	0.6	10,530
1st	Lab	2x2	296	Maxlite LED	45	5000	0.6	39,960
2nd	Office	2x2	53	Maxlite LED	45	5000	0.6	7,155
2nd	Lab	2x2	286	Maxlite LED	45	5000	0.6	38,610
		TOTAL	**815**		**45**	**5000**	**0.6**	**110,025**

Carl Icahn Laboratory.

collaboration and "chance" discussions.

The annual energy use for lighting in the Institute is about 564,000 kWh, for an annual cost of nearly $50,000. Most of the lighting in the lab and office spaces is provided by 815 recessed 2 ft by 2 ft luminaires that each use two 31-W T8 fluorescent U-lamps, have an acrylic prismatic lens, draw 59 watts of power and operate for an estimated 5,000 hours per year. These luminaires use 240,425 kWh annually, about 43 percent of the facility's annual energy use. They're being retrofitted with a MaxLite LED retrofit kit that provides 3,315 lumens at 45-W power input, with a CCT of 4,100K and minimum CRI of 82. The kit carries a safety certification from ETL and is on the DesignLights Consortium's Qualified Products List (QPL). The kit is projected to yield an annual energy savings of over 57,000 kWh. Additional savings are expected from the use of lighting controls, as discussed below.

The Princeton engineering staff evaluated products from five different manufacturers for the 2 by 2 luminaire retrofit, with quoted prices ranging from about $75 to over $200 per unit. Three products were selected for further assessment. Multiple samples were installed in the building and evaluated for appearance, perceived impacts on light levels and distribution, and potential glare. The MaxLite kit was selected based on positive assessments during the mockup, substantial reduction in connected power relative to the existing system, favorable pricing and warranty terms, the ability to integrate well with the planned lighting control system and provision of 0-10V dimming with the capability to turn the power completely off at the 0V setting (unlike the other products, which require separate wiring and the associated labor to enable complete power off at 0 volts).

The Icahn Lab also has linear fluorescent cove lighting and some 2 ft by 4 ft recessed troffers—mostly using 4-ft 32-W T8 lamps (with a few T5 and T5HO lamps). These luminaires account for about 31 percent of the facility's annual lighting energy and range from perimeter cove lighting (5,000 hours of annual use), to office lighting (3,500 hours), to corridor and elevator lighting (8,760 hours), to closet and mailroom lighting (1,500-3,000 hours). For the Gateway project, more than 550 of these luminaires are being retrofitted with the Cree UR Series retrofit kit that replaces the lamps and ballasts, providing 4,500 lumens at 44-W power input, with a CCT of 4,000K and a CRI of 80. The UR Series kits are UL-classified as retrofit kits and are on the QPL. Princeton selected the UR Series product based on prior experience in several small-scale retrofit projects. For the 4-ft linear lamp fixtures, annual energy savings including controls are estimated to be about 117,000 kWh.

The luminaires in the open lab spaces, both the recessed 2 by 2 and the cove luminaires, are controlled by relatively few wall switches that control large zones of luminaires. As a result, large areas are illuminated whenever the lab space is occupied, even if the occupancy consists of just a single individual in a small area. Individual enclosed lab and office spaces typically each have a single wall switch controlling all of the luminaires in each space. As part of the lighting upgrade, Princeton plans to implement a Lutron EcoSystem control system, including occupancy and daylight-harvesting strategies. Based on previous project experiences, the university estimates that the control strategies will yield an additional reduction in energy of about 40 percent.

Although Princeton is not trying to improve lighting quality with this project, the current fluorescent systems show the typical assortment of correlated color temperatures (CCT) due to ongoing maintenance, so the LED solutions should provide more consistent color properties throughout operation, while also reducing the necessary maintenance of the system. ■

THE AUTHOR

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