SSL DEMONSTRATION:

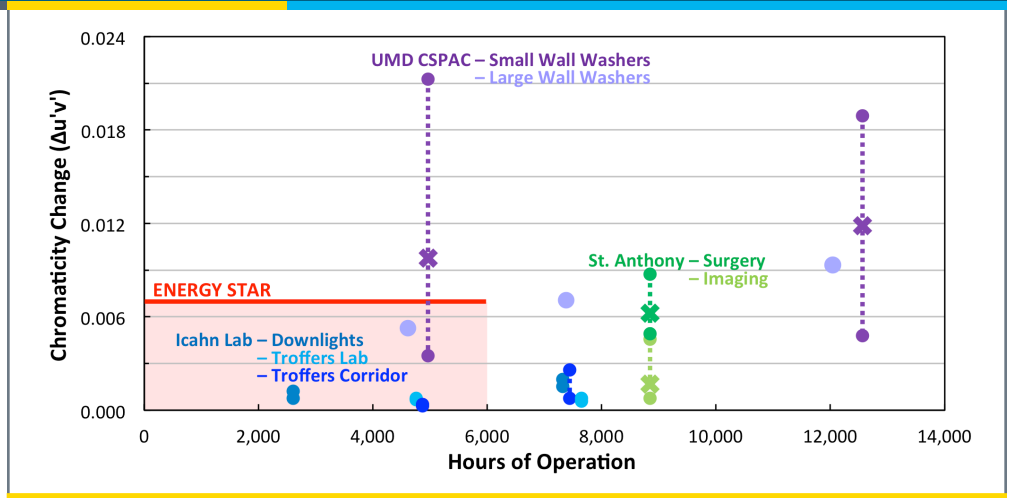
Long-Term Evaluation of Indoor Field Performance

Four projects illustrate that switching to solid-state lighting is often motivated not only by significant energy savings, but also by other advantages—including operations and maintenance savings, easier integration with control systems, and improved lighting quality.

To realize their full potential, solid-state lighting (SSL) products must prove their ability to perform over long operating times. Data available so far indicate that good lumen and chromaticity maintenance are possible and that significant energy and operating savings can be achieved, but installed performance has not been well documented. Beyond the energy savings made possible by SSL's higher efficacies, improving long-term performance can provide additional savings by reducing the need to overlight initially to account for later light loss, and by increasing SSL's market penetration.

A new report from the U.S. Department of Energy's (DOE) GATEWAY program evaluates the long-term performance characteristics (chromaticity change, maintained illuminance, and operations and maintenance) of SSL systems in four field installations, to better understand the obstacles to manufacturing, specifying, procuring, and installing LED lighting products. These four installations, each of which was previously documented in its own DOE report, include:

- Hilton Columbus Downtown Hotel—Columbus, OH (dedicated LED downlights)
- University of Maryland's Clarice Smith Performing Arts Center (CSPAC)—College Park, MD (LED retrofit kits in halogen wall washers)
- Princeton University's Carl Icahn Laboratory—Princeton, NJ (LED retrofit kits in 2x2 troffers and CFL downlights)
- St. Anthony Hospital—Gig Harbor, WA (LED replacement lamps in CFL downlights)



Overall chromaticity change for UMD CSPAC wall washer retrofit kits, Icahn Lab troffer and downlight retrofit kits, and St. Anthony replacement lamps. The average chromaticity change is marked by an X, while the minimum and maximum values are marked with circles connected by a dotted line. If the range in performance is small, the average may not be marked, and the circles may overlap.

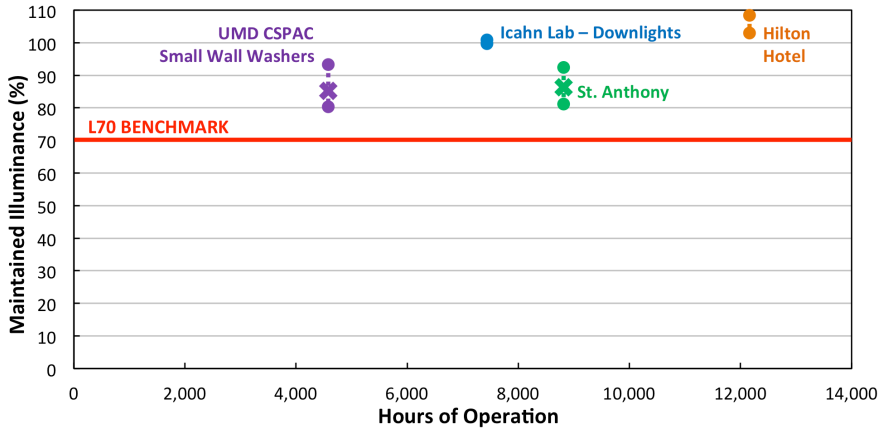
Colorimetric Performance

Pacific Northwest National Laboratory collected two or three sets of illuminance and/or color data at each site. Although the chromaticity data collected for the downlights at the Hilton did not allow the calculation of Δu'v', these products showed very little change in their CCT, CRI, and R_9 values after more than 12,000 hours of use. The retrofit kits installed in the downlights and troffers at the Icahn Lab similarly showed stable color performance after 7,400 hours, with the downlight and troffer retrofit kits in the corridor having an average Δu'v' of 0.0018 and the troffer retrofit kits in the small lab having an average Δu'v' of 0.0007. After 8,800 hours of use, the integral LED lamps used at St. Anthony had average Δu'v' values of 0.0062 (surgery waiting area) and 0.0017 (imaging changing rooms).

For all measurement times, each site has measurement points indicating that the chromaticity change was less than the ENERGY STAR® standard of 0.007. The retrofit products in UMD's CSPAC exhibited substantially greater color shift than the other products, with most of the measurement points above 0.007. After the third round of measurements (at least 12,000 hours of operation), the small wall-washer products had an average Δu'v' of 0.0118 compared to the initial set of measurements. Although the chromaticity shift measured for the LED retrofit kits at the UMD's CSPAC was greater than expected, the fact that the products have operated for more than 17,000 hours without any required maintenance satisfied the university's goals for the project. The incumbent halogen lamp system would have required numerous lamp replacements during the same period, with much greater energy use.

Photometric Performance

As for maintained illuminance, the LED downlights at the Hilton provided sufficient lighting to satisfy IES task



Overall maintained illuminance for the Hilton new downlights, UMD CSPAC wall washer retrofit kits, Icahn Lab downlight retrofit kits, and St. Anthony replacement lamps. The average maintained illuminance percentage is marked by an X, while the minimum and maximum values are marked with circles connected by a dotted line. If the range in performance is small, the average may not be marked, and the circles may overlap.

requirements after both sets of measurements, and all maintained illuminance values were significantly greater than the benchmark 70%; in fact, all the values increased. CFL downlights typically have rated lifetimes of 10,000 hours, so at least half the incumbent lamps would have been expected to be replaced within the first 12,100 hours of data. At the Icahn Lab, illuminance levels after 7,400 hours of operation were also the same, if not slightly greater than, the initial levels, with a maintained uniformity ratio. The average illuminance for the integral LED lamps at St. Anthony Hospital decreased but still met the relevant IES requirements after 8,800 hours. While the illuminance produced by the retrofit kits installed in UMD's CSPAC decreased, it remained above 70% of initial levels after an estimated 5,000 operating hours. Although additional illuminance data were not collected, after 17,000 hours of operation only one of the 135 modules may need to be replaced, whereas the incumbent halogen lamps with rated lifetimes of 1,500 hours would have been replaced 11 times within the first 17,000 hours. Thus, from an energy and maintenance savings standpoint, the conversion was worthwhile.

Beyond Energy Savings

Beyond the energy savings made possible by SSL's higher efficacy, the four evaluations illustrate that SSL use is often motivated by such things as maintenance savings, easier integration with control systems, and improved lighting quality. They demonstrate that the success of any lighting implementation cannot be determined only by a simple review of technical performance data, but instead depends on full consideration of the individual project goals and priorities.

The installation of dedicated LED downlight luminaires at the Hilton was primarily motivated by architectural and lighting-design goals, and the light distribution and quality improved upon the incumbent technologies. In addition, the LED lighting provided both greater control for the hotel guests and substantial energy and operational savings for the Hilton. The LED luminaires have maintained their performance quite well over the time of this study.

The replacement of existing CFLs with integral LED lamps at St. Anthony Hospital was the lowest-cost option to convert the five-year-old luminaires to LED and reduce the system's maintenance burden. The retrofit continues to make sense because of the attractive economics and the maintenance savings, despite a few performance and operational issues.

The conversion to LED retrofit kits at Princeton's Icahn Lab was initiated based on the university's energy and sustainability goals. The LED retrofit kits installed in 2x2 fluorescent troffers and in CFL downlights have maintained their performance over the time of this study. The use of controls demonstrates the additional savings that can be gained from controls strategies, but also illustrates the difficulties that can be encountered in commissioning controls systems.

The incumbent halogen wall-wash luminaires at the University of Maryland's CSPAC had high energy and operational costs due to the incumbent high-wattage lamps and long operating hours, but converting to LED was made problematic by architectural constraints and the unusual luminaire shape. Despite some performance concerns in color shift and maintained illuminance, the LED retrofit kits have provided a cost-saving solution due to the low initial cost, ease of installation, and energy and maintenance savings.

Final reports on GATEWAY indoor demonstration projects are available for download at http://energy.gov/eere/ssl/gateway-demonstration-indoor-projects.

GATEWAY Demonstrations

GATEWAY demonstrations showcase high-performance LED products for general illumination in commercial, municipal, and residential applications. Demonstrations yield real-world experience and data on the performance and cost effectiveness of lighting solutions. For more information, see http://energy.gov/eere/ssl/gateway-demonstrations.

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