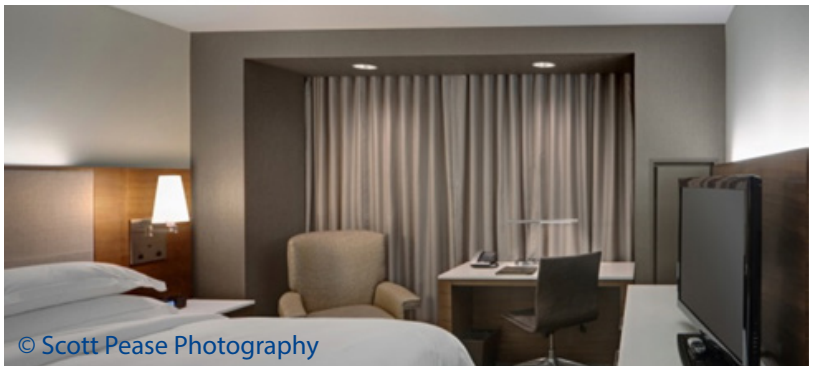
Guest Room Lighting at the Hilton Columbus Downtown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Hilton Columbus Downtown

Introduction

As part of a U.S. Department of Energy (DOE) demonstration project, researchers at Pacific Northwest National Laboratory (PNNL) evaluated the implementation of light-emitting diode (LED) recessed downlight luminaires in the guest rooms at the Hilton Columbus Downtown hotel in Columbus, OH. The facility opened in October of 2012, and the demonstration project included a post-occupancy assessment in January–March of 2014. Each of the 484 guest rooms and 48 suites uses at least seven 15 W LED downlights, for a total of more than 3,700 LED downlights. The LED downlights provided 50% energy savings relative to a comparable CFL downlight, and they enabled the lighting power to be more than 20% below that allowed by code. This case study provides an overview of the lighting design goals and results; the detailed report can be accessed at the link shown in the sidebar.

Guest Room Lighting

As of October 2012, there were approximately 8,500 hotels occupying 1.7 billion square-feet in the U.S.[1] According to the most recent data from the DOE, average electricity consumption in hotels was 61.3 kBtu/ft^2 and total average energy consumption was 110 tBtu/ ft^2.[2] Hotels rank fifth in energy use within the commercial buildings sector.[3] Hotel guest room energy consumption typically represents between 40% and 80% of the total facility energy use.[4]

For lighting in guest rooms, many hotels have transitioned away from incandescent and halogen lamps to compact fluorescent lamps (CFLs); hotel guest rooms now typically use CFL technology for most

[1] EPA, *Energy Use in Hotels*, October 2012 (http://www.energystar.gov/).
[2] DOE, *Buildings Energy Data Book: 3.10 Hotels/Motels*, March 2012 (http://buildingsdatabook.eren.doe.gov).
[3] EIA, *Commercial Buildings Sector Energy Intensities: 1992- 2003*, August 2009 (http://www.eia.gov).
[4] DOE, *Guest Room HVAC Occupancy-Based Control Technology Demonstration*, September 2012 (http://apps1.eere.energy.gov).

Next Generation Luminaires™ (NGL) Downlight Project

To increase the adoption rate of high-quality, energy-efficient LED systems and to stimulate ongoing product development, the DOE conducts demonstration projects that document the real-world performance of LED luminaires relative to conventional technologies. The DOE estimates that there were about 700 million downlight luminaires installed in residential and commercial buildings in the U.S. as of 2012, with LED luminaires representing less than 1% of this installed base. The NGL Downlight Project is a series of demonstrations that focus on documenting the implementation of LED downlight luminaires.

HOTEL PROFILE

LEED Gold certified contemporary facility

- Designed by architects HOK and Moody•Nolan
- $140 million project
- Opened in October 2012

Building specifications

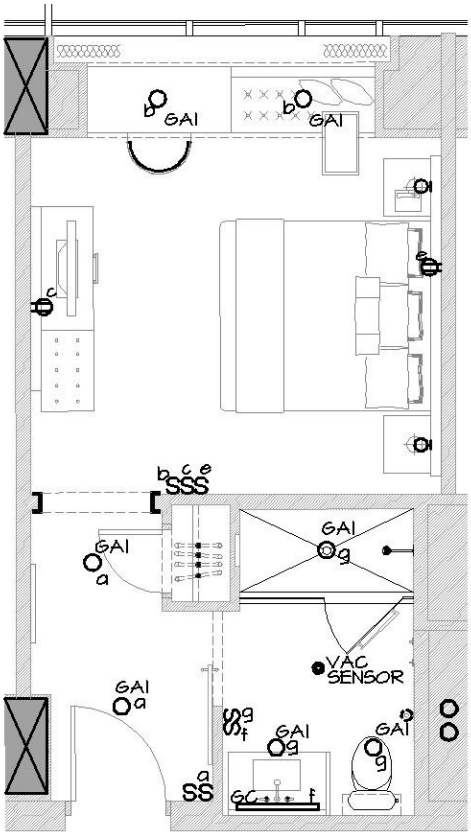
- 450,000 ft^2 total area
- 15,000 ft^2 skylight in atrium
- 484 guest rooms, 48 suites
- 32,000 ft^2 of event space, 160-seat restaurant, coffee bar and lobby lounge, fitness center, indoor pool and whirlpool

Named the Best Urban Development of 2012 by Columbus Underground

The full report may be accessed here: https://www4.eere.energy.gov/alliance/activities/technology-solutions-teams/lighting-electrical/downlight

NGL Solid-State Lighting (SSL) Design Competition

The NGL Design Competition seeks to encourage technical innovation and recognize and promote excellence in the design of energy-efficient LED luminaires for commercial, industrial and institutional applications. This report is the first in a series of demonstrations that will focus on documenting the implementation of LED downlight luminaires, with preference given to manufacturers with winning NGL downlight products. For more information on the NGL Competition, see http://www.ngldc.org/.



Above: Typical guest room lighting plan showing designer Ardra Zinkon's specified layout. The seven LED downlights are designated as GA1.

LIGHTING DESIGN GOALS

- Energy-efficient equipment that would exceed energy codes and help meet LEED goals;
- Products that offered low operational costs with long lifetimes and low maintenance;
- A light source that was at full output immediately and did not require any warm-up time;
- A light source for which the expected lifetime was not affected by possible frequent switching;
- A light source that could be dimmed;
- A downlight luminaire in which the light appeared to come from a single light source;
- A downlight luminaire that could physically fit within the architectural constraint of a 6" depth; and
- A light source in the downlight luminaires with excellent color consistency.

if not all of the lighting. CFLs offer reduced energy use, higher efficacy, and much longer lifetimes than incandescent and halogen lamps, but they also have drawbacks. CFLs usually have a warm-up period before they reach their full light output, they vary in color consistency and have lower color rendering indices compared to incandescent lamps, and they are difficult or impossible to dim.

LEDs improve upon many of the drawbacks to CFLs, and offer an attractive combination of energy savings, longer lifetime, instant "on" at full light output, and in many cases improved dimming and other control capabilities. LED lamps and luminaires can have efficacy ratings that approach (or in some cases exceed) twice the efficacy of CFL lamps and luminaires, providing the potential for reducing lighting power by 50% or more. Many LED products offer warranty periods that exceed the expected lifetime of CFL products, enabling operating savings in replacement and labor costs. Compared to CFLs, LED products can make it much easier for hotels to implement solutions that use both dimming and occupancy control systems, once the dimming performance and compatibility have been verified. The implementation of LED downlights in the Hilton Columbus Downtown hotel demonstrates many of these advantages.

Lighting at the Hilton Columbus Downtown

Meeting the Hilton's sustainability and LEED rating goals required the use of energy-efficient light sources. In addition, lighting designer Ardra Zinkon, President and Director of Lighting Design for Tec Studio Inc. in Columbus, wanted the hotel guests to have the lighting in their guest rooms provide a familiar aesthetic appearance and operational behavior. "Hotel guests do not expect a delay when they turn on a light switch before the light comes on, and they do not expect to have to wait for the light to warm up before it is at full brightness," Zinkon told the PNNL project team during an interview. "LED technology allowed us to provide guests lighting that was instant-on at full brightness, plus we could provide cost-effective dimming capability with LED."

Guided by the design goals shown in the sidebar at left, the design team recommended the use of LED downlights for the general lighting in the guest room entryways, bedrooms, and bathrooms. CFLs were eliminated from consideration early in the design process based on their inability to meet goals related to dimming, color quality, full light output without warm-up time, and long life regardless of switching frequency. The designers reviewed dozens of LED downlight options. Product samples of each option were obtained and evaluated during table-top review sessions.

The designers selected the Portfolio LED downlight from Eaton's Cooper Lighting Business as the basis for design, with the Philips Lightolier Calculite LED downlight listed as an acceptable alternate. Both of these selections provide lenses for obscuring a direct view of the individual LEDs. A full-scale mock-up of two guest rooms demonstrated that the luminaires satisfied the designer's goal of evoking an impression of "familiar" lighting, when the participants did not realize that the luminaires used LED sources.

The lighting in the guest rooms consists of several layers. Upon entering the room, two LED downlights provide the ambient lighting needed for entry. These downlights also illuminate the guest as he or she stands before the wall-mounted mirror. Moving through the entry and into the bedroom, there are two LED downlights in the soffit near the window. The bathroom has three LED downlights: two providing general lighting for the sink and toilet area and one lighting the shower. Other than the LED downlights, two wall-mounted luminaires provide the reading task lighting near the bed, linear fluorescent luminaires are integrated into the millwork behind the television and the bed to provide ambient uplighting, and the bathroom mirror includes an integral linear fluorescent luminaire.

Lighting controls

The ability to dim some of the guest room lighting was an important design criterion. For this project, the two LED downlights in the window soffit area and the three LED downlights in the bathroom were installed with dimming capability. Based on several factors, the designers selected the Lutron Diva dimming system. The interface for the guest is an on-off rocker switch with a slide dimmer control alongside the switch. (Other dimming options that are now common, such as 0-10V control, were not readily available at the time of this installation.)

Due to the number of different switches used in the guest rooms, clear labeling was needed. The labeled switches are shown in the photos below. The two switches just inside the entry door include the switch for the two LED downlights in the entry area and a master switch that allowed the guest to turn off all the room lighting upon leaving. These switches are on-off rocker switches. Three switches control the lighting for the bedroom; one for the LED downlights in the window soffit and two for the millwork-integrated uplights behind the television and bed, respectively. The two uplight switches are on-off rocker switches; the downlight control combines an on-off rocker switch with a slide dimmer beside the switch. The reading light fixtures mounted to the headboard had individual switches built into the fixtures.

The prevailing energy code for the Hilton Columbus Downtown project required a manual master control switch at the main room entry that controls all permanently installed luminaires and switched receptacles. The master switch controls the LED downlights in the entry area and

PERFORMANCE MEASUREMENTS

▶ Photometric performance

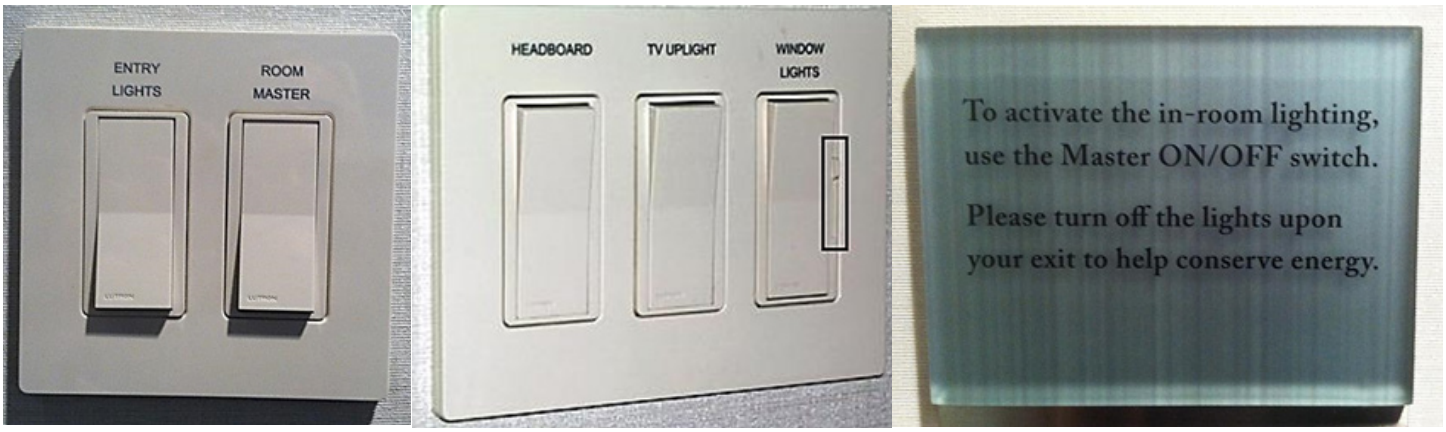
Illuminance levels were measured in the entry area, on the desk, and in the bathroom sink area. The LED downlights provided sufficient lighting to satisfy IES task requirements, in most cases exceeding the IES recommended values for guests of any age. The dimming functionality of the downlights enabled further energy savings for guests who chose to reduce the light levels.

▶ Colorimetric performance

PNNL measured the CCT, CRI, and R_9 values for each fixture. All of the light sources in the room had CRI values in the range of 80 to 85. The LED downlights had R_9 values which were greater than the other sources, particularly relative to the CFLs. The total range of measured CCT values for the seven LED downlights was less than 40 K, less than the range for any of the fluorescent sources.

Fixture Type (quantity)	CCT	CRI	R_9
Downlights - LED (7)	3069	83	40
Bed fixtures - CFL (2)	2798	81	-3
Millwork fixtures - FL (2)	3802	85	29
Mirror fixtures - FL (2)	3001	85	8

Colorimetric performance of the different light sources in the representative guest rooms.



Examples of the guest room switches: the entry area (left) and bedroom (middle) switches with slide dimmer (outlined) for the window lights. The entry area sign (right) encourages guests to use the master switch to turn off room lighting when leaving.

Grayscale renderings of the entry area, based on simulations of LED (bottom) vs. halogen PAR lamp (top) downlights. The PAR lamp downlight provided higher illuminances on the floor but produced dark walls. The LED downlight provided more light onto the walls, and also produced better lighting for visual tasks such as selecting clothing from the closet and evaluating appearance in the mirror.

Estimated Annual Energy Use for Downlights in the Hilton Columbus Downtown

	Portfolio 6" Downlight			
	LED	CFL: vertical	CFL: horizontal	HAL
Fixture power (W)	15	29	31	75
Luminaire efficacy (lm/W)	62	40	32	13
Energy use (kWh)	203,330	377,986	406,661	977,550
LED energy savings (%)	N/A	46%	50%	79%

the bedroom, the wall-mounted luminaires mounted at the bed headboard, and the millwork-integrated fluorescent luminaires. To further encourage guests to use the master switch, a special placard was designed and mounted just above the switch (see photo below).

The energy code for the project did not require automatic control in the bathroom, but to enhance energy savings a passive infrared ceiling-mounted vacancy sensor was implemented. Occupancy sensors are estimated to provide 16% savings in lighting energy in guest rooms.[5] PNNL verified that the vacancy sensor was operating properly during the site visit, as it consistently extinguished the bathroom lights after 15 minutes of vacancy.

Energy savings

The decision by the design team to use LED downlights was driven primarily by the lighting needs of guests in the rooms and by the desired functional and aesthetic qualities. The high efficacy of the LED downlights enabled the designers to provide the lighting needed for various guest activities at very low power density, freeing more of the lighting power budget for other task and ambient needs. Based on the design goals and some of the architectural constraints within the rooms, alternatives to LED technology were not seriously considered.

A lighting power allowance of 330 W was established for the guest rooms, based on the applicable energy code. The installed power for the lighting system in the guest rooms was 252 W, more than 20% below the allowance. Based on the Hilton's assumptions of 3,500 annual operating hours for guest room lighting, the lighting in the 532 guest rooms and suites saves 145,236 kWh and $10,167 in energy costs per year relative to the code power allowance, using the Hilton's energy rate of $0.07 per kWh.

The PNNL project team also evaluated the energy implications of implementing the desired lighting design using alternate technologies. For these comparisons, three alternate 6" downlight luminaires were selected based on their roughly matching the light output from the 6" LED downlight used: a downlight with a 32 W vertical CFL, a downlight with a 32 W horizontal CFL, and a downlight with a 75 W halogen PAR lamp. The LED downlight enabled estimated energy savings of at least 46% compared to the alternates.

The LED downlights at the Hilton Columbus Downtown were selected not only to meet Hilton's sustainability goals and LEED rating energy criteria, but also based on the desire to provide hotel guests with familiar lighting quality and operation. Based on general cost information, PNNL estimates that the dimmable LED downlight used ranges in price from roughly 10% less to 20% more than dimmable versions of comparable CFL downlights, depending on the type of dimming and dimming ballast used. The LED downlights saved 46% to 50% energy compared to the CFL downlights, and provided the aesthetic appearance and dimming functionality desired.

[5] California Utilities Statewide Codes and Standards Team, *2013 California Building Energy Efficiency Standards: Guest Room Occupancy Controls*, October 2011 (http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Nonresidential/Lighting_Controls_Bldg_Power/2013_CASE_NR_Guest_Room_Occupancy_Controls_Oct_2011.pdf).