# Field Test DELTA Snapshots

## ALTERNATIVE TECHNOLOGIES FOR CONSTRUCTION LIGHTING

**Demonstration and Evaluation of Lighting Technologies and Applications ▲Lighting Case Studies**

Conventional construction lighting often consists of strings of incandescent lamps in a simple cage. Some construction sites turn these lights on only during working hours; others leave the lights on 24 hours a day. Construction lighting is sometimes subjected to rough service and wide temperature variation. Typically, construction lighting is discarded as waste when permanent lighting is activated. Several alternative lighting technologies are now available that save energy and are acceptable to construction site workers.

## *Application Profile*

From 2012 to 2013, the Lighting Research Center (LRC) evaluated four types of construction lighting at the new campus of New York City's Police Academy. This site was at the eastern portion of a multi-story office building. The LRC evaluated the conventional construction lighting on the 3rd floor, consisting primarily of incandescent lamps in plastic cages mounted at approximately 9 feet above the floor. The LRC also evaluated three alternative technologies: screw-base compact fluorescent lamps ("CFL lamps") located on the 4th floor, screw-base light emitting diode lamps ("LED lamps") located on the 5th floor, and a low voltage LED system ("LED luminaires") located on the 6th floor. The table (right) shows manufacturer-reported features of the four technologies. Each floor is approximately 16,000 square feet.

## *Objectives*

- Compare worker acceptance of the four lighting technologies
- Compare installation and maintenance of the four lighting technologies
- Compare energy performance of the four lighting technologies


Construction lighting in use at a site in New York City

### Light Source Comparison

| | Incandescent Lamps | CFL Lamps | LED Lamps | LED Luminaires |
|---|---|---|---|---|
| **Watts per luminaire** | 100 W | 23 W | 17 W | 33.1 W [1] |
| **Operating quantity** [2] | 42-52 | 57-58 | 52-58 | 58-59 |
| **System voltage** | 120 V | 120 V | 120 V | 24 V |
| **Rated light output** | 1750 lumens | 1600 lumens | 1100 lumens [3] | 2400 lumens |
| **Rated lamp life** | 750 hours | 10,000 hours | 25,000 hours | 50,000 hours |

[1] Per manufacturer, assuming optimal loading and power supply efficiency of 0.86

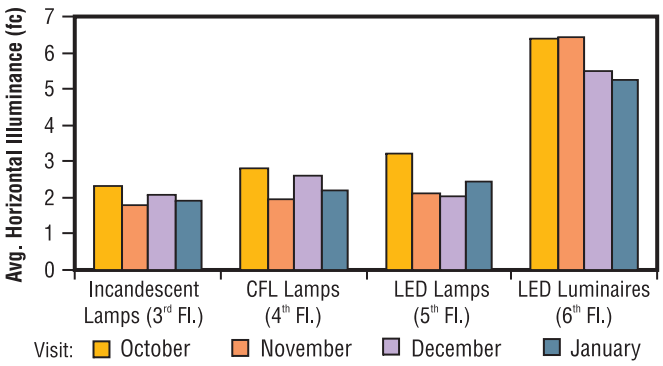
[2] Over the course of four visits, the quantity of operational luminaires varied. The quantity range shown in this table was due to missing or malfunctioning lamps, or added luminaires. Energy calculations below assume the largest quantity.

[3] As of Fall 2012, this was the highest output screw-base LED available on the American market (1100 lumen output).

## Illuminance Comparison

The LRC measured illuminance in the central mechanical core with limited daylight on four winter visits when the spaces were vacant. Because daylight was excluded, three of the four technologies provided an average of less than 5 footcandles (fc). Although the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) requires a minimum illuminance of 5 fc,[4] according to project participants, this requirement can also be met with daylight and other supplemental lighting. Most spaces did have additional daylight.

**Average illuminance on the ground (excluding daylight to the degree possible).**

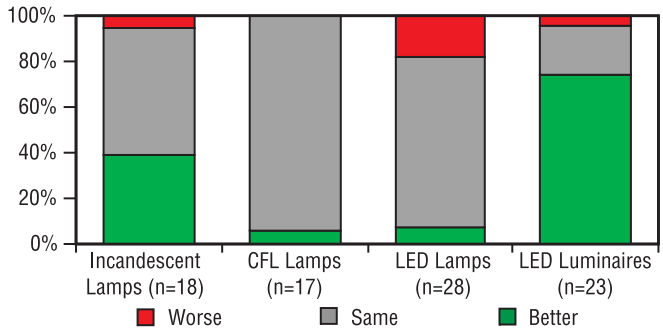



## Worker Response

The LRC administered a questionnaire to construction workers on all four floors. The majority of the workers indicated that they had enough light to do their work, without much difference between lighting technologies. A few workers on floors 3 to 5 commented that they would prefer more light, or that the core mechanical spaces (without daylight) looked too dark. Glare was not a widespread concern on any of the floors. Use of flashlights or other portable lighting was common on all floors. Workers preferred the LED luminaires with 74% of the workers rating these lights as "better" compared to other lights. Many comments from the workers reinforced their preference for the LED luminaires.

*LED luminaires provide "plenty (of light). These are the best in the building."*

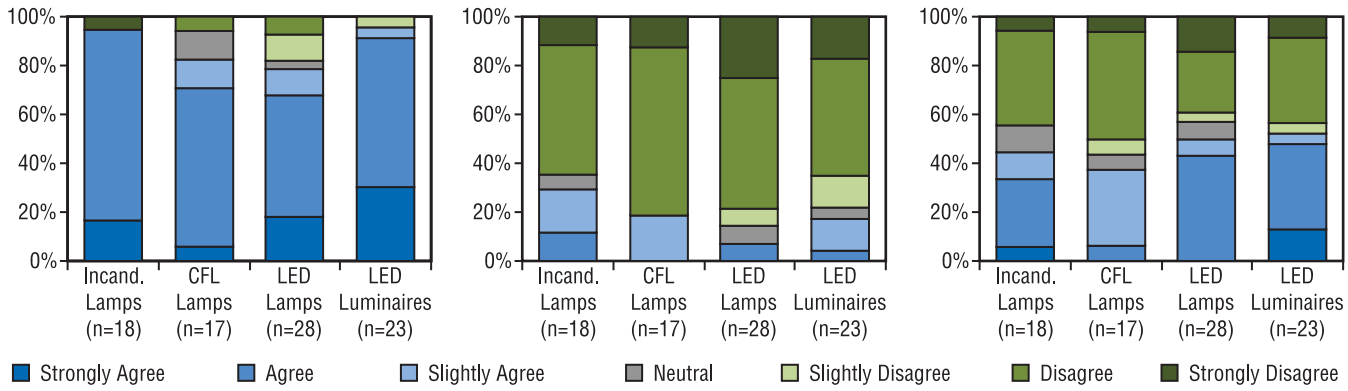
**(Overall) "Compared to other temp lights, I think these lights are:"**

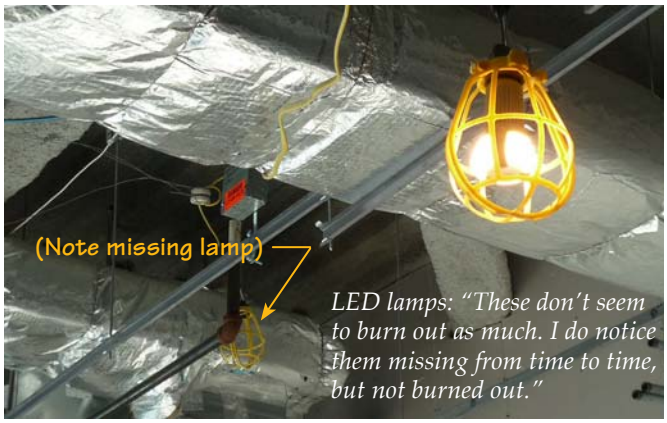



**"These lights give me enough light to do my work."**

**"Glare from these lights interferes with my work."**

**"In order to see my work, I need to bring my own flashlight, headlamp, or other extra light."**




## Installation and Maintenance

Workers frequently cited relamping as an issue with the incandescent lighting. CFL lamp durability was not cited as a major problem at this site despite its breakable glass tube. Theft of the LED lamps was a major concern; theft might be deterred if these lamps were available with reverse (left-handed) thread.

Installation of the LED luminaires reportedly took 50% longer than the other technologies; there were no problems with LED luminaire maintenance. After construction, removal and storage of the LED luminaires presents a new set of salvage responsibilities, not consistent with conventional practice for construction lighting. There is a substantial opportunity for reuse of this equipment. After construction, the electrical contractor expects to discard the low voltage power wiring and quick disconnects, and may not reuse the luminaires and low voltage power supplies.

[4] United States Department of Labor, Occupational Safety and Health Administration (OSHA). Standard 1926.56 "Safety and Health Regulations for Construction." Accessed online October 2012 at: http://www.osha.gov/

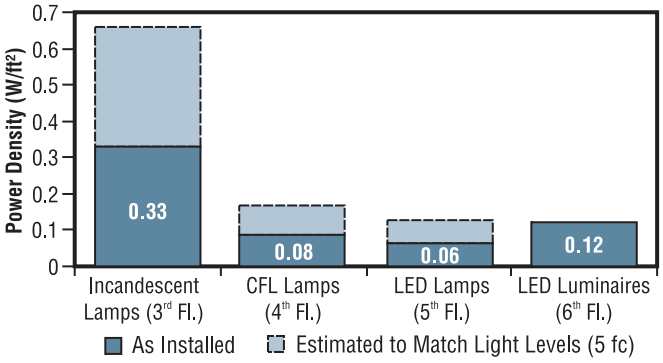
## Power Density and Energy

All three alternative technologies had considerably lower power density than the conventional construction lighting. As shown at right, power density would have been increased in three of the four technologies, if lamps had been spaced more closely together in order to match illuminances.

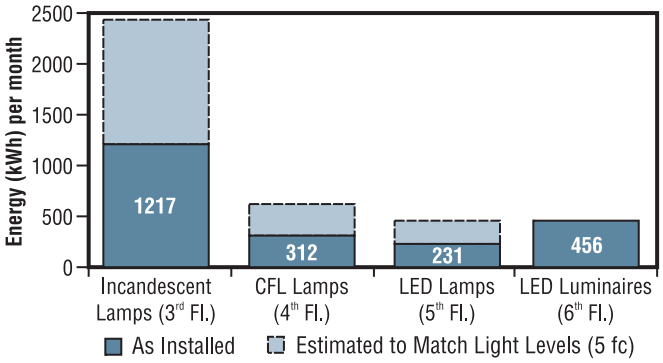
LRC compared the energy use of the four technologies assuming operation for 9 hours a day and 6 days per week. All three of the alternative technologies offered energy savings. These energy savings would have been approximately three times higher under continuous operation, as is common at other construction sites. For matched light levels, the LED luminaires would have provided similar energy savings to the CFL and LED lamps.

The manufacturer of the CFLs used at this site reports low power factor (0.5); the manufacturer of the LED luminaires also reports low power factor (0.6). While these did not result in additional utility charges at this site, other sites might have an issue with low power factor, especially if using generators.

**Lighting power density**




**Estimated Monthly Energy per Floor (assuming 54 hrs per week)**




## Pollution Avoided

The three alternative technologies reduce emissions according to the U.S. Environmental Protection Agency calculator that calculates pollution avoided due to energy saved.[5]

**Monthly pollution avoided due to energy savings**

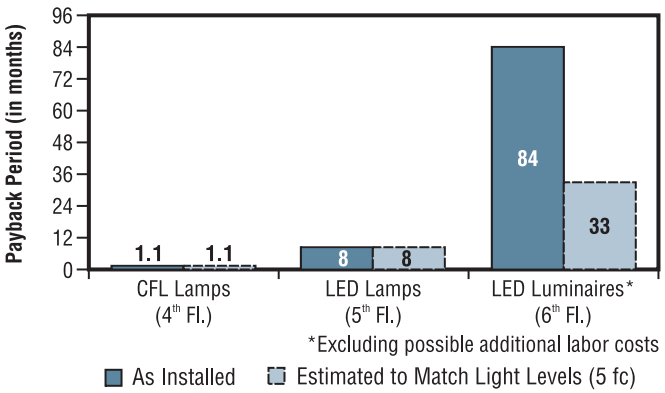
| As Installed | $SO_2$ | | $NO_x$ | | $CO_2$ | |
|---|---|---|---|---|---|---|
| | lbs | kg | lbs | kg | lbs | kg |
| CFL Lamps | 0.09 | 0.04 | 0.25 | 0.12 | 553 | 251 |
| LED Lamps | 0.10 | 0.04 | 0.28 | 0.13 | 602 | 274 |
| LED Luminaires | 0.08 | 0.03 | 0.21 | 0.10 | 465 | 211 |

| Estimated to Match Light Levels (5 fc) | $SO_2$ | | $NO_x$ | | $CO_2$ | |
|---|---|---|---|---|---|---|
| | lbs | kg | lbs | kg | lbs | kg |
| CFL Lamps | 0.18 | 0.08 | 0.51 | 0.23 | 1,105 | 502 |
| LED Lamps | 0.20 | 0.09 | 0.55 | 0.25 | 1,205 | 548 |
| LED Luminaires | 0.20 | 0.09 | 0.55 | 0.25 | 1,208 | 549 |

## Economics

Energy savings also translate to utility cost savings,[6] which can be compared to initial equipment costs. Even without considering labor saving benefits, the initial cost of the CFL lamps would be paid back in a short time frame (one month), and would have been even shorter (two weeks) if operated continuously. At 2012 prices, screw-base LED lamps would pay back in eight months (or four months if operated continuously). The initial cost of the LED luminaires would be paid back in several years.

**Estimated Payback Period (in months)**
**(54 hrs/wk; does not include maintenance labor benefits)**




[5] Accessed online February 2013 at www.epa.gov

$NO_x$ = "In the atmosphere, nitrogen oxides can contribute to formation of photochemical ozone (smog), can impair visibility, and have health consequences; they are thus considered pollutants."

$SO_2$ = "High concentrations of sulfur dioxide affect breathing and may aggravate existing respiratory and cardiovascular disease. Sulfur dioxide is also a primary contributor to acid rain. In addition, sulfur compounds in the air contribute to visibility impairment in large parts of the country."

$CO_2$ = "It is the principal anthropogenic greenhouse gas that affects the earth's radiative balance. It is the reference gas against which other greenhouse gases are measured."

[6] Assuming energy supply and delivery charges of $0.129/kWh and demand supply and delivery of $23/monthly kW.



## Lessons Learned

- All three of the alternative lighting technologies saved energy compared to the conventional lighting.
- The LED luminaires met OSHA requirements without daylight or other supplemental lighting, and were most preferred by workers.
- Three of the four technologies depended on daylight and supplemental lighting to meet OSHA illuminance requirements.
- All three alternative lighting technologies have a higher initial equipment price than the conventional technology. The CFL and LED lamp alternatives cost the same to install as the conventional technology but are expected to have a lower maintenance cost. The LED luminaires require more labor to install and salvage, but are expected to have lower maintenance costs than the conventional technology.
- Even without considering labor saving benefits, the payback period for CFL lamps was extremely short (1 month). Screw-base LED lamps would pay back in 8 months. The LED luminaires would pay back in several years.
- Low power factor was reported by the manufacturers of the CFLs (0.5) and LED luminaire system (0.6). While this did not result in additional utility charges at this site, other sites might have an issue with low power factor, especially if using generators.
- Theft was a problem with the screw-base LED lamps; development of a reverse-thread product could be helpful.
- Alternative lighting technologies are expected to have a longer lamp life than the duration of the construction project. Some electricians stated that they were not interested in salvaging this equipment due to disassembly and storage requirements. However, according to project participants, construction waste standards may require salvaging in the future.

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The LRC also thanks all the workers at the Police Academy jobsite who shared their opinions about the lighting.

**Field Test DELTA** evaluates new energy-efficient lighting products to independently verify field performance claims and to suggest improvements. A primary goal of the Field Test DELTA program is to facilitate rapid market acceptance of innovative energy-efficient technologies.

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