General Services Administration
Public Buildings Service

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TLED LIGHTING RETROFITS WITH DEDICATED DRIVERS

Testing LED Retrofits in Place is Critical to Ensure Proper Technology Selection

Linear fluorescent lamps (LFLs), specifically those used in recessed "troffers," are the workhorses of commercial interior lighting. According to the Department of Energy (DOE), they consume almost 70% of all commercial lighting energy in the U.S. and account for 80% of the commercial lamp inventory. A recent DOE study estimates that GSA's real estate portfolio contains some 1.53 million fluorescent troffers, consuming 470 gigawatt hours (GWh) of electricity annually.[1] GSA could save 134 GWh of electricity each year (roughly 30%) by replacing the LFLs in its troffers with light-emitting diode (LED) lamps of similar form, fit, and function. Adding advanced lighting controls (ALCs), such as dimming and occupancy sensing, would result in greater savings still. With this in mind, GSA's GPG program recently commissioned DOE's Pacific Northwest National Laboratory (PNNL) to evaluate two LED retrofits that are compatible with ALCs and do not require alterations to the existing ceiling grid for installation. Findings from three federal test sites equipped with prismatic-lensed troffers confirmed appreciable LED energy savings—between 27% and 29%, when compared with the baseline T8 LFL powered by a generic electronic ballast. Researchers also found that lamps with similar illuminance ratings produced different light output, noting that it is critical to test LED retrofits in place before committing to a particular technology.

The GPG program enables GSA to make sound investment decisions in next generation building technologies based on their real world performance.

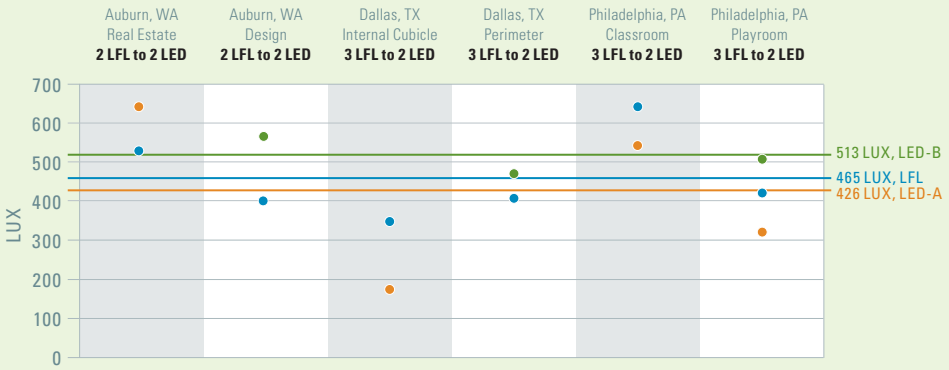
INTRODUCTION

Average Light Levels Across Test-Bed Sites

Key

- LFL
- LFL AVERAGE
- LED-A
- LED-A AVERAGE
- LED-B
- LED-B AVERAGE

Note: A difference of < 100 Lux is not typically noticeable by the human eye.



"Because LEDs are inherently brighter, we could downsize from three lamps to two. We found this to be a particularly effective in our perimeter zones."

— Brett Stubbs
Building Manager, Cabell Federal Building
Dallas, Texas
Greater Southwest Region
U.S. General Services Administration

MINIMUM SPECIFICATIONS
LED Retrofits

CERTIFICATION
Use DesignLights Consortium qualified products

ELECTRICAL
Operating voltage: 120V to 277V
Power factor: 0.90 at full light output
Total Harmonic Distortion: <20% at full light output
Source Efficacy: 100 lm/W at full light output

PHOTOMETRIC PERFORMANCE
Light Output: minimum 1600 lumens or as needed to meet required light levels
Beam Angle: >120°, greater beam angle may be desirable for open (e.g. parabolic) fixtures

CHROMATICITY
CCT: 3000K, 3500K, 4000K or as specified by site
CRI: 80, R9 >0

CONTROLS
Look for "dimmable" products if considering daylight harvesting or task tuning controls methods

LUMEN MAINTENANCE
Minimum 70% light output at 50,000 hours derived from LM-80 and TM-21 reportable rating

WARRANTY
Minimum 5 years

What Is This Technology?

TWO RETROFITS WITH TWO DISTINCTLY DIFFERENT DESIGNS

LEDs differ from other kinds of lamps in that their light comes from semiconductors rather than filaments or gases. PNNL investigators assessed two LED retrofit technologies with two distinctly different designs. The "LED-A" retrofit takes a fairly conventional approach to linear form factor, consisting of two or three individual tubular lamps and a dedicated LED driver. The system bypasses existing fluorescent connection sockets and installs, via self-tapping screws and clips, directly onto the underside of the fluorescent fixture housing. "LED-B," on the other hand, has a unique "optical-wing" design that directs light upward within the lamp, where it bounces, diffuses, and angles downward again toward the work surface below. LED-B installs directly into the existing fluorescent medium bi-pin connection base (using it as its electrical and mechanical interface) and, like LED-A, is powered by a dedicated driver. Unlike LED-A, however, it is compatible with shunted *and* non-shunted sockets. LED-A and LED-B both claim a lifetime of 50,000 hours, considerably longer than most linear florescent lamps. Their efficacy, expressed as the amount of light generated per watt of energy, is also greater.

What We Did

INTERVIEWS AND OCCUPANT SURVEYS SUPPLEMENT COST AND ENERGY DATA

In 2014, GSA replaced linear fluorescent lamps with LEDs in offices within three federal buildings: GSA 's regional headquarters in Auburn, Washington; the Cabell Federal Building in Dallas, Texas; and the Veterans Administration Center in Philadelphia, Pennsylvania. All test-bed locations had prismatic-lensed 2ft-by-4ft recessed troffers, spaced either 8ft-by-8ft or 8ft-by-10ft on center. Each troffer contained either two or three T8 lamps powered by electronic ballasts. To assess the performance of replacement lamps, PNNL researchers conducted interviews and surveyed occupants, electrical contractors, and facility managers about their experience with the new lighting, in addition to measuring LED light levels and comparing them with light-level measurements taken previously of the incumbent technology. Researchers also gauged energy savings and cost-effectiveness. Energy assessment was based on instantaneous voltage and current readings of several fixtures at each site before and after installations.

FINDINGS

ENERGY SAVINGS AS HIGH AS 29% At a post-retrofit operating power of 44 watts (W) for LED-A and 42.9W for LED-B, the retrofits achieved a 27% and a 29% energy savings respectively. Savings would increase with the new, lower-wattage systems currently available. Also, additional savings can be achieved through the use of ALCs.

RATED LIGHT OUTPUT DIFFERED FROM MEASURED LIGHT LEVELS LED-A and LED-B had similarly rated illuminance levels—4500 lumens for LED-A and 4400 for LED-B. But in the assessment's only head-to-head comparison, in prismatic troffers, LED-B delivered between 25% and 30% more light, despite its narrower beam angle. When averaged across all test beds, output from LED-B exceeded output from LED-A by 20%.

COST-EFFECTIVE AT NATIONAL ENERGY RATE Simple payback was between 6.3 years and 8.9 years at the national average electricity rate of $0.11/kilowatt hour (kWh). Because of their higher light output, LED systems can be downsized from 3 LFLs to 2 LEDs, which will augment savings. Such downsizing, however, can cause issues in parabolic troffers where the middle, or "inboard," lamp space is vacated. The parabolic lens, coupled with directional LED lamps, heightens contrast and increases shadowing.

OCCUPANTS GENERALLY SATISFIED WITH LED LIGHT QUALITY FROM BOTH RETROFITS Overall, occupants were satisfied with LED light quality. An exception to this rule was found in the Cabell Federal Building in Dallas, where 43% of occupants surveyed reported that LED-A was too dim for paper tasks.

STRAIGHT-FORWARD INSTALLATION No special tools or electrical modifications were necessary during installation. Because it uses the existing fluorescent bi-pin connection base, installers found LED-B more familiar and voiced few concerns about installation. Installing LED-A proved moderately difficult for some installers because of the bracket placement that precedes lamp installation. On the other hand, because of those brackets, LED-A lamps can be repositioned within the fixture, which can be advantageous during 3-to-2 conversions.

RESEARCH RECOMMENDS REPLACING LFLS WITH LEDS THROUGHOUT PORTFOLIO If an existing fixture's lens and/or connection sockets are not in good condition, consider a new fixture. Before committing to any particular option, install a small number of lights in order to assess such things as fit, light levels, color temperature, and glare. For additional guidance on choosing the best retrofit option, see the full report.

LED Retrofit Options Assessed During M&V

Consider compatibility and controls when selecting an LED replacement

	PROS	CONS	COST*
LED-A Replacement lamp uses alternative mounting, LED driver	• Lamps can be repositioned in the fixture • Dimming & ALC possible	• Performance depends on optics & lens of existing fixture • Self-tapping screws could cause electrical problems • Wire harnesses won't always fit legacy situations • Not compatible with master/remote configurations or shunted lamp holders	**Equipment:** $40–$70 **Installation:** $34–$68
LED-B Replacement lamp uses existing socket, LED driver	• Familiar installation process • Compatible with shunted and unshunted lamp holders • Dimming & ALC possible	• Performance depends on optics & lens of existing fixture	**Equipment:** $40–$70 **Installation:** $34–$68

* 50% and 100% RS Means derived labor estimates; similar cost to lamp + ballast replacement

CONCLUSIONS

These Findings are based on the report, "Linear LED Lighting Retrofit Assessment," which is available from the GPG program website, www.gsa.gov/gpg

For more information, contact GSA's GPG program gpg@gsa.gov

What We Concluded

LEDS SHOULD BE CONSIDERED WHEN REPLACING INCUMBENT FLUORESCENT TROFFERS

The linear LED retrofits evaluated in this study should be considered when retrofitting or relamping existing fluorescent troffers. Both technologies demonstrated significant energy savings (between 27% and 29%, when compared with the T8 LFL baseline) and were cost-effective at low energy rates. Photometric assessments revealed that both retrofits delivered high initial light levels and that some test sites even saw improved uniformity, when compared with the incumbent lighting. That said, results of this evaluation will not apply equally to all linear LED retrofits, nor will they apply equally to all applications. There is wide variation in design and performance of LED retrofit options, and of course in incumbent lighting systems, which can lead to an equally wide range of test results. Nor will rated output guarantee adequate light levels; the present assessment demonstrated that two linear LED products with similar illuminance ratings could deliver notably different light output. A due-diligence approach to technology selection and placement is strongly advised. See the full report for guidance on selecting an LED retrofit option.

BEST PRACTICES FOR RETROFITTING FLUORESCENT TROFFERS WITH LEDS

- **Target facilities where conversion will be most cost-effective** Facilities with higher energy costs (national average commercial rate is $0.11/kWh) and comparatively inefficient existing fixtures, such as T12s or T8s with standard efficiency lamps (32W), will be more cost-effective. Locations that have light levels that are above what is needed, or required by the P-100 or other standards, are also good candidates.
- **Select LED replacement option** When making a selection, consider the condition of the existing system, the replacement system's installed cost, the system's ability to provide adequate light levels, current need for advanced lighting controls (ALC), and whether the new system will provide a transition to future lighting control strategies.
- **Define site-specific specifications** Determine the necessary system performance (e.g., lumen output and distribution) and desired appearance (e.g., color temperature). Any chosen system should also meet minimum specifications and GSA-specific criteria.
- **Test retrofits in place** Require the manufacturer to demonstrate that their solution meets the established specifications. Install the solution in at least four fixtures that have the predominant spacing (e.g., 8'x10'); get feedback from the installer on the amount of time and effort required. Also, get feedback from occupants on the appearance of the light from the modified luminaires. Note: inspect parabolic louvered fixtures carefully. They can alter the intended distribution of light, and sometimes create unappealing contrast when viewed from below. This is especially true when the retrofit involves delamping from three LFL lamps to two LEDs.

Footnotes

[1]DOE FEMP, "Interior Commercial Lighting Market Characterization for the Federal Sector," September 2013.

Technology for test-bed measurement and verification provided by NEXT Lighting and Cree.