Today’s LED products offer facility owners and managers an opportunity to dramatically reduce their lighting system’s energy consumption. However, until recently, the options for updating four-pin (G24) CFL lamps with LED solutions were limited to retrofit kits or new dedicated fixtures. Over the last few years, manufacturers have improved and developed a cross-section of LED retrofit options including GU24 LED replacement lamps (Figure 1) that should be considered when conducting a lighting upgrade.

The California Lighting Technology Center (CLTC), in collaboration with Pacific Gas and Electric Company, evaluated emerging G24 LED replacement lamps to determine if these products are a viable retrofit option for G24 CFL applications. Compatibility and performance raise real concerns because CFL and LED technologies produce and emit light in different, distinct ways. These differences affect the interchangeability of LED and CFL lamp products and restrict compatibility based on the existing electrical architecture and lamp-base infrastructure. When non-compatible products are paired together there is typically a noticeable decline in performance, such as visible flicker or audible noise, which results in end-user dissatisfaction. Such issues limit broad market acceptance of emerging LED products.

To evaluate the GU24 product category, CLTC researchers conducted a market and technology assessment for G24 LED lamp replacements (Figure 2). Results indicate these GU24 LED products are appropriate for niche applications and can deliver load reduction and energy savings under certain scenarios. Based on the average lamp wattage of G24-base CFL and LED lamps commercially available at the time of this study (manufacturer’s literature), G24 LED replacement lamps show potential to deliver 60 percent or more savings as compared to a CFL baseline.

Laboratory testing of a small product sample, however, produced a lower average savings result of 53.3 percent. Test results did verify that product category performance trends include an average increase in efficacy over CFLs, and LED products are generally compatible with fluorescent ballasts, as claimed. In addition, it was found that pairing lamps with programmed-start ballasts results in a lower system load than rapid-start ballasts (Table 1).

In addition, evaluations confirmed commercial lamps marketed for this product category are, overall, complying with industry-standard safety markings and compatibility labeling. No safety concerns were encountered over the course of the evaluation and no issues regarding safety markings were identified for the evaluated lamps.

FOUR FACTORS

Based on results from the evalu-
tion, CLTC recommends consumers follow a basic plan when conducting a retrofit of G24 CFL lamps with G24 LED lamps. Consumers should consider the following four focus areas when upgrading a lighting system:

1. **Application and building code appropriate design.** The most critical application for lamp and ballast interoperability occurs with downlights. Downlight housings are marketed for target commercial or residential applications. Building efficiency code requirements for residential applications require housings rated for insulation contact (IC). IC-rated downlight housings traditionally present more thermal management issues than non-IC rated as the housing is required to fully isolate the light source from the insulation in the plenum.

   Another variation in downlight housings pertains to lenses. Open housings do not have a lens, and the light source is in an “open-air” environment. Open-air environments offer more airflow, which makes it easier to manage the thermal properties of a light source. Lensed housings are typically installed where a diffuse light is desired, preventing the end user from seeing the light source directly. Closed housings, or lensed housings, are also typically required for sub-applications that may be exposed to water. They may also be labeled as wet- or damp-rated products. In these applications, air flow can be restricted, which can create higher operating temperatures that can impact LED performance over the long-term.

   Downlight housings also vary with respect to socket orientation and number of sockets. Vertically oriented sockets are typically only sold in one-socket configurations. For applications requiring two lamps, two-socket housings can be found with horizontal orientation. Horizontal orientation housings also come in one-socket configurations.

   When conducting lighting retrofits, it’s important to verify the base type of the lamps identified for replacement as multiple G24 configurations are commercially available (Figure 3). Identify the equivalent light output required to achieve desired light levels on the task plane via specification comparison or photometric modeling.

2. **Product interoperability.** CFL multi-pin lamps require an external ballast to provide the initial voltage required for start-up and to regulate the current during lamp operation. This is in contrast to screw-base (Edison) CFL lamps which are self-ballasted and can be powered directly by line voltage. There are a variety of ballasts marketed for use with CFL multi-pin lamps.

   To ensure quality performance and reduce visible flicker and/or audible noise, G24 LED lamps should be paired with ballasts identified as “compatible” per the LED manufacturer’s specification sheet, or as identified by third-party testing.

   When conducting a lighting retrofit, identify the existing ballast type.
installed and determine if the ballast should be replaced based on rated life and warranty. Additional testing of samples installed at the retrofit space is recommended prior to a full retrofit. Critical end users should be present during demonstration of the sample system to evaluate performance while performing typical tasks in the space.

3. Safety listings & installation precautions. One U.S. manufacturer interviewed as part of the market assessment called attention to the pervasive safety and quality issue for all appliances:

“As competition begins to show up from China in this category, we are concerned that the quality of the lamps may result in some denigration of the category. We have already evaluated several competitors’ lamps and issued complaints to UL that they do not meet the technical requirements of the UL standards and pose a safety risk. As there is no simple API to design to the way there is with an Edison socket lamp this category poses a much more substantial technical challenge.”

For these reasons, it is critical that products are verified to comply with applicable safety listings and installation precautions are followed. The most common safety markings are described below and shown in Figure 4 and Figure 5.

UL Listed. The “UL Listed” product category indicates that a testing laboratory found a representative group of product samples met UL’s safety requirements, usually based on published standards. The typical listed product is a complete system meant to be “plug and play” or “drop in,” meaning nothing else needs to be done to the product other than connecting power, either with a cord and plug or by hard-wiring.

ETL Listed. The Electrical Testing Labs (ETL) Listed mark indicates that a product has been tested to the same standards as UL and met the same minimum safety requirements. Testing is performed by an independent Nationally Recognized Testing Laboratory, recognized by OSHA. The ETL Listed mark with the “US” identifier meets U.S. product safety standards only. An ETL Listed mark with the “C” identifier complies with Canadian product safety standards only. Marks bearing both identifiers comply with both U.S. and Canadian product safety standards.

UL Classified. A mark of “Classified” indicates that the product has been evaluated by a qualified laboratory, but only with respect to specific properties, a limited range of hazards, or suitability for use under limited or special conditions.

UL Recognized. The “Recognized” mark is used with components that are intended to be installed as part of a larger specific system, such as an LED driver, where the luminaire housing may provide protection from heat. The components are intended to be installed at a factory, not in the field. A luminaire can be rated for use with a variety of “Recognized” components without requiring retesting.

4. Lifecycle cost analysis. At the time of this evaluation, the average G24 LED replacement lamps cost $24.94
each as compared to $6.42 for the G24 CFL lamps. This is an initial cost difference of $18.52 per lamp. However, the average life expectancy of the LED replacement lamps is approximately 3.3 times longer than the G24 CFL lamps, resulting in a longer maintenance cycle. Similarly, the average warranty for the LED replacement lamp is approximately 3.2 times longer than the average CFL warranty (Figure 6).

Assuming CFL and LED products produce application appropriate light levels, a 15-year lifecycle cost analysis (LCA) conducted for new construction and retrofit scenarios using the average technology characteristics for G24 CFL vs. G24 LED shows a positive return on investment. Using California energy rates, lifecycle cost analyses results show that the average LED replacement lamps paired with the existing ballasts in retrofit applications have a simple payback of 3.3 years (Table 2).

**CONCLUSION**

There are adequate products that perform as stated in the G24 LED replacement lamp product category; however, taking the appropriate steps during specification will ensure that all lighting system components have been analyzed with respect to useful life and compatibility.

As with all lighting retrofit products, awareness and diligence in following recommended steps during the design phase will result in fewer performance issues and lower project costs. Being mindful of the differences in retrofit components as compared to the legacy system will save you headache and heartache if interoperability issues arise.

Detailed results from this evaluation are available for download from the Emerging Technologies Coordinating Council website.

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Table 2. Lifecycle cost analysis for average LED and G24 CFL products.