



# FLEXLAB<sup>®</sup>

## EVALUATING TUNABLE WHITE LED FOR CIRCADIAN LIGHTING

**This FLEXLAB project demonstrated the use of tunable LEDs for circadian lighting in offices and evaluated lighting energy implications.**

### THE CHALLENGE

#### Evaluating tunable LED systems in real-world applications

Exposure to adequate light during the day is crucial for maintaining circadian health for office occupants, and commercial light-emitting diode (LED) systems with color temperature tuning (“tunable white”) features can address this need, particularly for office lighting systems. However, little research has directly measured tunable white LED energy usage for visual and circadian criteria; existing studies have mostly relied on computer simulations and models. Moreover, there are no standards for implementation of these systems. Measuring the performance of tunable LEDs in an actual setting provides the information necessary to align human health and productivity needs with energy usage and cost data, to support optimal business decisions.

### THE SOLUTION

Southern California Edison’s Emerging Technologies Program and the Electric Power Research Institute turned to the U.S. Department of Energy’s FLEXLAB<sup>®</sup> facility at Lawrence Berkeley National Laboratory (Berkeley Lab) to evaluate select commercial lighting systems, including tunable white LEDs, to determine their ability to meet visual and circadian criteria in an office environment, and to quantify lighting performance and energy usage. FLEXLAB enables researchers to quantify the performance of commercially available technologies through detailed monitoring of performance parameters such as illuminance, spectral output, glare, and energy consumption in an office environment.



## THE BOTTOM LINE

### Circadian lighting goals can be met in an office environment with tunable LEDs and daylighting; energy impacts vary by location and approach

Implementing LED systems for visual and circadian criteria can incur incremental energy costs relative to meeting visual criteria only (“standard” office lighting practice). However, with the low energy intensities of LEDs relative to existing fluorescent systems, prioritizing energy savings over circadian performance may not be necessary. When pursuing circadian performance goals, focus on minimizing the incremental energy cost, using the recommendations outlined in the results.

## THE EXPERIMENT

- The experiment evaluated the performance of tunable white LED troffer and pendant light fixtures through rigorous testing in a mock office environment, which included two zones of 300 square feet (ft<sup>2</sup>) each; an open-plan interior zone (non-daylit) and a perimeter (daylit) zone.
- Key lighting parameters were measured to evaluate visual and circadian performance, including spectral irradiance measurements converted to circadian units.
- The study implemented a baseline system of standard non-tunable dimmable LED fixtures to meet task illuminance criteria (“standard” office lighting practice) with daylight dimming in the perimeter. Then the same system was commissioned to meet visual and circadian criteria through scheduled increases in lighting intensity for a four-hour circadian performance period. Finally, tunable white LED systems were implemented and tested under the same illuminance and circadian criteria with intensity and correlated color temperature (CCT) changes, to explore the impact of different spectral power distributions on circadian performance and lighting energy.

## THE RESULTS

- LED systems addressing circadian design meet building energy code requirements and save energy over fluorescents.
- For interior offices with no daylight, meeting circadian criteria with LEDs (instead of just visual criteria) typically required higher light levels and more lighting energy — an 11% to 42% energy increase was measured.
- For the daylit zone, daylight dimming provides significant energy savings and meeting circadian criteria requires no extra lighting power for the tested conditions.
- Tunable white LED pendants required the least incremental energy to meet circadian criteria. Higher CCT correlated positively with key circadian performance metrics.
- Recommendations include:
  - Specify LED lighting with high photopic efficacy (lumens/Watt) and high melanopic daylight efficacy ratios (m-DERs)
  - Use tunable white or high-CCT non-tunable LEDs to minimize the incremental energy cost
  - Schedule increases in light levels only during specified circadian performance periods
  - Prioritize daylighting to minimize extra energy needed

