We'll be starting in just a few minutes….

Tell us…

What topics are you interested in for future webinars?

Please send your response to the webinar organizers via the question box.

Better Buildings®
U.S. DEPARTMENT OF ENERGY

Bright Idea: Lighting Toolkit for K-12 School Districts

November 6, 2018

3:00 – 4:00 PM EST

U.S. DEPARTMENT OF ENERGY

Better Buildings®

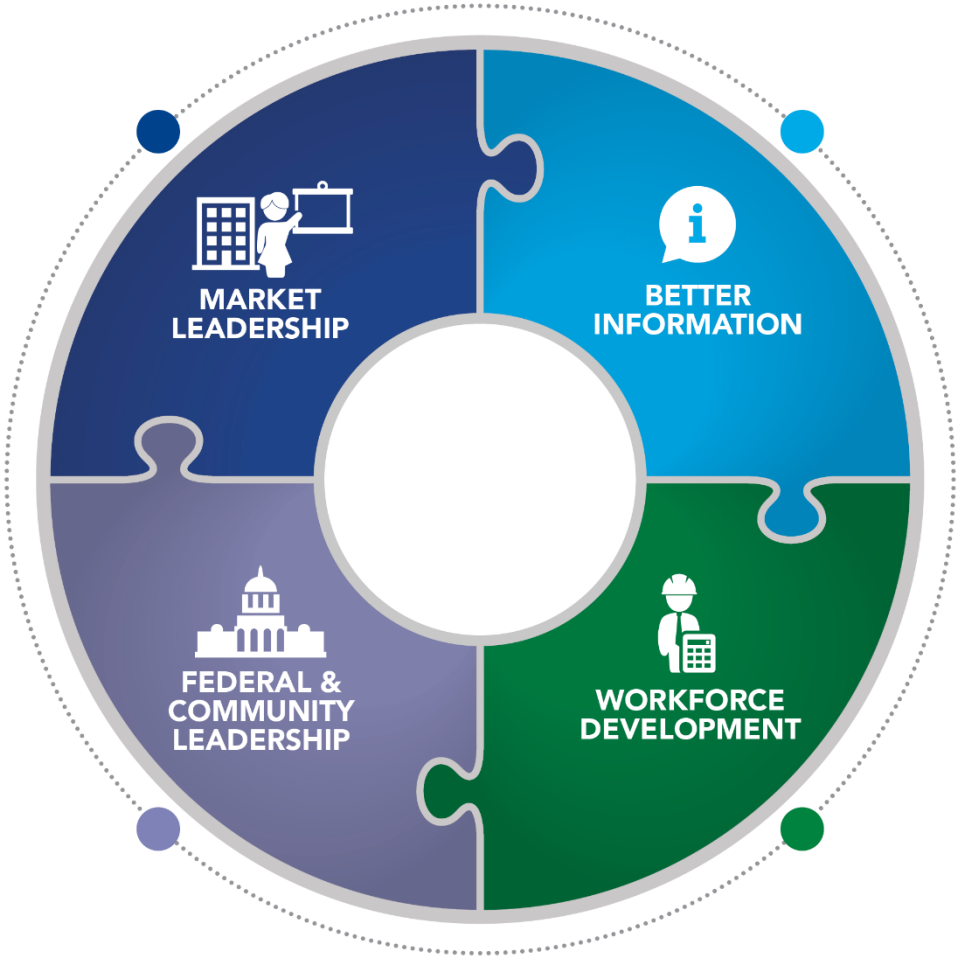
U.S. DEPARTMENT OF ENERGY

Developing Innovative, Replicable Solutions with Market Leaders

- Better Buildings Challenge
- Better Buildings Alliance
- Better Buildings, Better Plants
- Better Buildings Accelerators
- Better Buildings Residential
- Strategic Energy Management

State, Local, and Federal Governments Leading by Example

- State and Local Engagement
- Performance Contracting



Making Energy Efficiency Investment Easier

- Better Buildings Solution Center
- Financing Navigator
- Improved Data Consistency and Access
- Better Buildings Energy Asset Score
- Home Energy Score
- Tools for Industrial Energy Management

Expanding the Workforce

- Better Buildings Workforce Guidelines
- Industrial Energy Management Workforce

K-12 School District Facilities in the U.S.

CHALLENGE

- > 50 million students
- ~ 130,000 school buildings
- 1,000 hours and 200 school days
- Utility expenditures ~ $10 billion

OPPORTUNITY

- Manage energy costs and maintain healthy learning environments
- Leverage STEM academic requirements, learning labs
- Redirect utility expenditures back into the classrooms

Today's Presenters

Name		Organization
Tracy Beeson		Pacific Northwest National Laboratory
Robert Davis		Pacific Northwest National Laboratory

Tracy Beeson
PNNL

U.S. DEPARTMENT OF
ENERGY

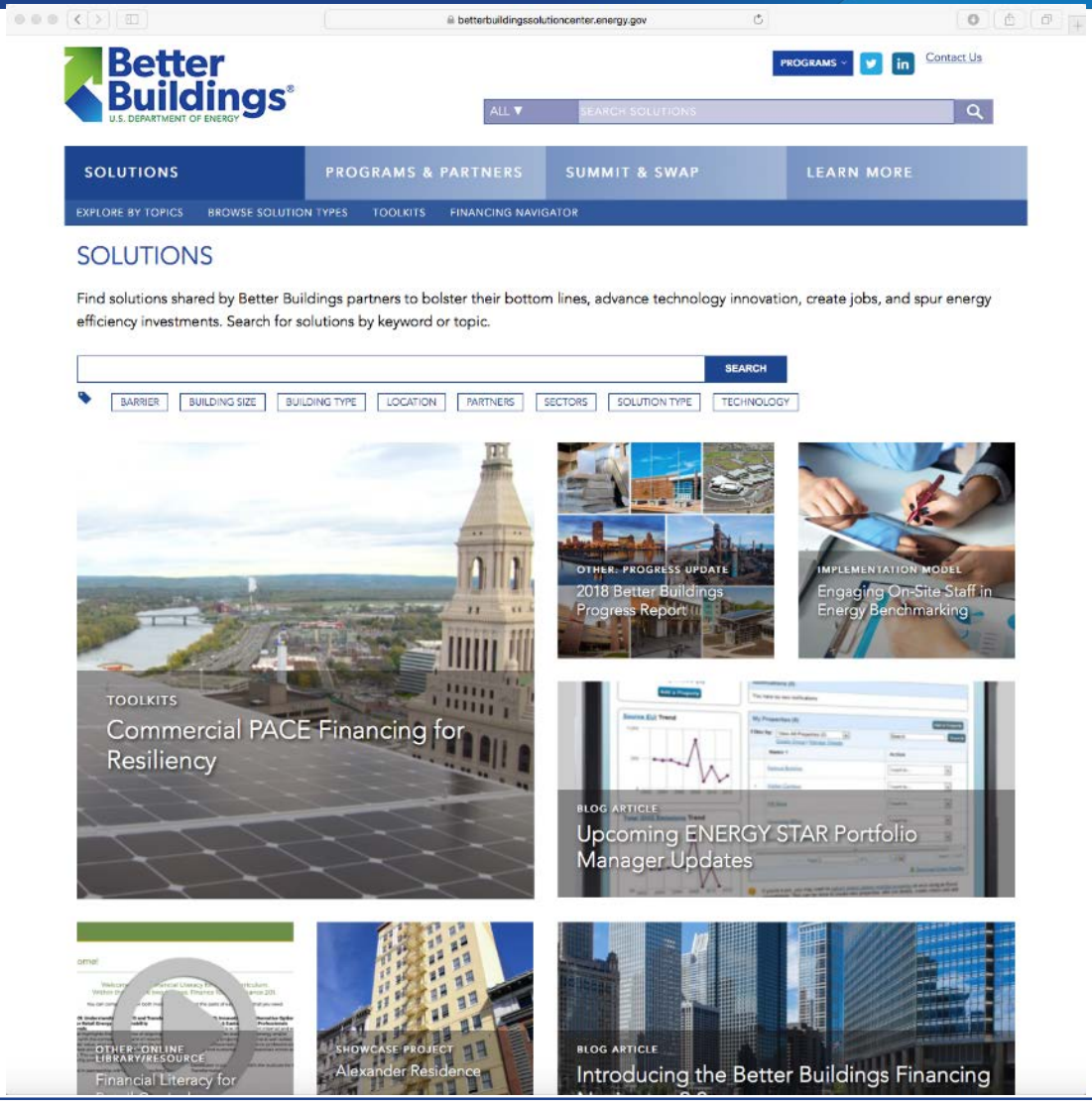
Webinar outline

- Overview of new K-12 Lighting Toolkit
- What is tunable LED lighting (and why should I care)?
- Pilot studies with tunable LED lighting in K-12 Classrooms

Solutions Center

- An abundance of resources
  - Search by technology
  - Help to overcome barriers
  - Find Promising Solutions
    - Buildings by size
    - By location
    - By sector
  - Financial options and planning
  - Successful project showcase
  - Analysis tools
  - Accelerators
  - Toolkits

https://betterbuildingssolutioncenter.energy.gov



Identifying Resources

- Needs specific for schools
  - Dynamic use of spaces
  - Maintenance
  - Scheduling of upgrades
  - Time of use
- Challenges specific to schools
  - Dimming and controls
  - New science on light and healthy environments
  - Financing options

K-12 Lighting Toolkit

- Case Studies
- Design Guides
- Fact Sheets
- Reports
- Specifications
- Videos
- Webinar

Case Studies

- Highlight actual projects
- How other schools approached challenges
- Specific Solutions

INSTITUTIONAL-LEVEL ADAPTIVE CONTROL SYSTEM FOR EXTERIOR LIGHTING

Networking luminaires at the University of California, Davis

The Institutional-level Adaptive Control System incorporates exterior light points — pathways, building perimeters, parking lots, and roadways — into one smart, wireless system.

Originally launched as a pilot study, this system has since been installed for over 1,600 luminaires at the University of California, Davis.

CLTC and Lumewave, Inc. developed the Institutional-Level Adaptive Control System for Exterior Lighting, an easy-to-integrate RF network that offers streamlined control of a facility's various exterior luminaires, regardless of fixture type or application.

Each bi-level pathway fixture has a wireless controller and occupancy sensor that accurately determines an occupant's direction of travel, delivering full light output where and when it's needed, for only as long as it's needed. The result is a smart, dynamic lighting system that improves safety, energy savings and maintenance features.

UC Davis received a best-practice award for lighting at the 2013 California Higher Education Sustainability Conference (CHESC), recognizing UC Davis' innovative adaptive control system for exterior lighting.

FEATURES:

- Easy-to-integrate RF network
- Compatible with nearly all exterior light fixtures and applications
- Fixture-integrated occupancy sensors enable accurate network response to an occupant's path of travel
- Fixture-level diagnostics allow for enhanced maintenance strategies

UCDAVIS UNIVERSITY OF CALIFORNIA · CLTC · Lumewave, Inc · CLTC.UCDAVIS.EDU · LUMEWAVE.COM

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

SOLID-STATE LIGHTING

SSL DEMONSTRATION:

Wall Washers at the University of Maryland

Exterior view of the University of Maryland Clarice Smith Performing Arts Center. The varying shapes and sizes hint at the diversity of the interior spaces.

Nothing to Mock At

In the spring of 2014, UMD facilities management considered all known LED alternatives, but there were limited LED wall washer options available. One significant consideration was whether the fixtures would fit into the existing openings in the drywall ceiling, because any additional work done to the ceiling would add to the project's complexity and overall cost. A solution that could work for both the small and large wall washers was also a priority. The options were narrowed down to two that were considered financially feasible and were then mocked up: a complete LED wall washer and a retrofit of the internal components of the existing wall washer with an LED module. The mockup provided an opportunity to visually evaluate light distribution (on the wall and floor), glare, color, dimming behavior, and flicker. Many of these factors were unfavorable for the LED wall washer, while the LED module cost less, delivered the desired quality of light, was easier to install, and was selected by UMD as the best solution—with the approximately 80% energy savings over the halogen wall washers viewed as an added bonus.

Wall washing is one of the more difficult lighting applications, for two reasons: first, because any change in color is easily noticeable when illuminating a plain, smooth wall, thus making color consistency an important consideration; and second, because a frequent goal of modules dissipated much less heat than the halogen lamps.

LED modules in existing wall washer housings. The left image is a side view of a large wall washer housing with two LED modules, and the right image is a front view of a small wall washer housing with one LED module.

BUILDING TECHNOLOGIES OFFICE

Design Guides

- Design considerations
- Guidance for specific applications
- Tailored solutions/approaches

LIGHTING LAYOUT GUIDE SERIES

GYMNASIUM GUIDE 1

GYMNASIUM (K-12 INSTITUTIONS)

LED HIGH BAY

ROOM CHARACTERISTICS

Length: 140'
Width: 120'
Height: 30' Open Ceiling
Reflectivity:
Ceiling = 50%
Walls = 50%
Floor = 20%

PRODUCT SPECIFICATIONS

Dimensions: Various
Optics: Narrow Distribution
Light Source: High Output LEDs
CCT: 4000K
CRI: 80
Lumens: 40,000-46,000 Delivered
Depreciation: 0.85 @ 50,000 hrs.
Rated Life: 100,000 hrs.
Watts: 394

THE OPPORTUNITY

Provide high-quality lighting that illuminates the gymnasium floor area to recognized light level standards, and meets or beats the local energy codes. LED sources offer instant full brightness and significant longevity. When used in conjunction with an appropriate control system, the fixtures can be dimmed to allow the gymnasium to be used for other assembly functions.

THE SOLUTION

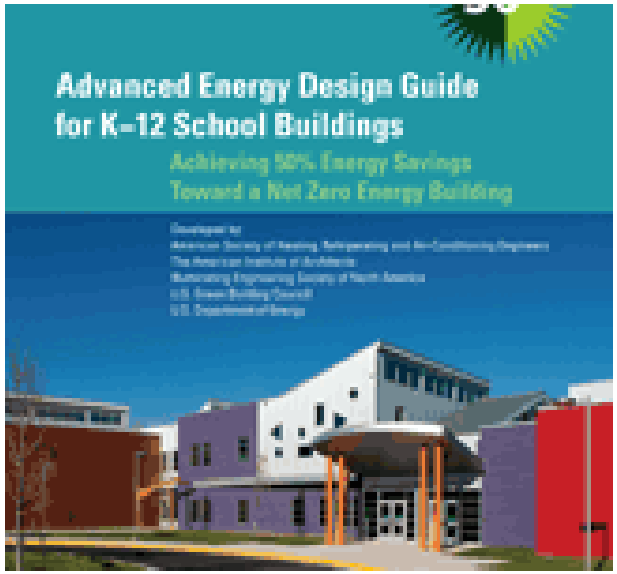
Install industrial LED high bay luminaires on 25' x 25' centers. Fixture options allow for integrally mounted occupancy sensors, photo cells, emergency lighting and dimming. It should be noted that the highest light levels are required at the playing area, while the spectator area requires less light.

DESIGN CONSIDERATIONS

In this application the emphasis is not only on appropriate horizontal and vertical illumination, but also on uniformity. This layout achieves a desirable contrast ratio of less than 3 to 1. Note: Recommended light levels for collegiate facilities and televised events are significantly higher than for K-12 institutions.

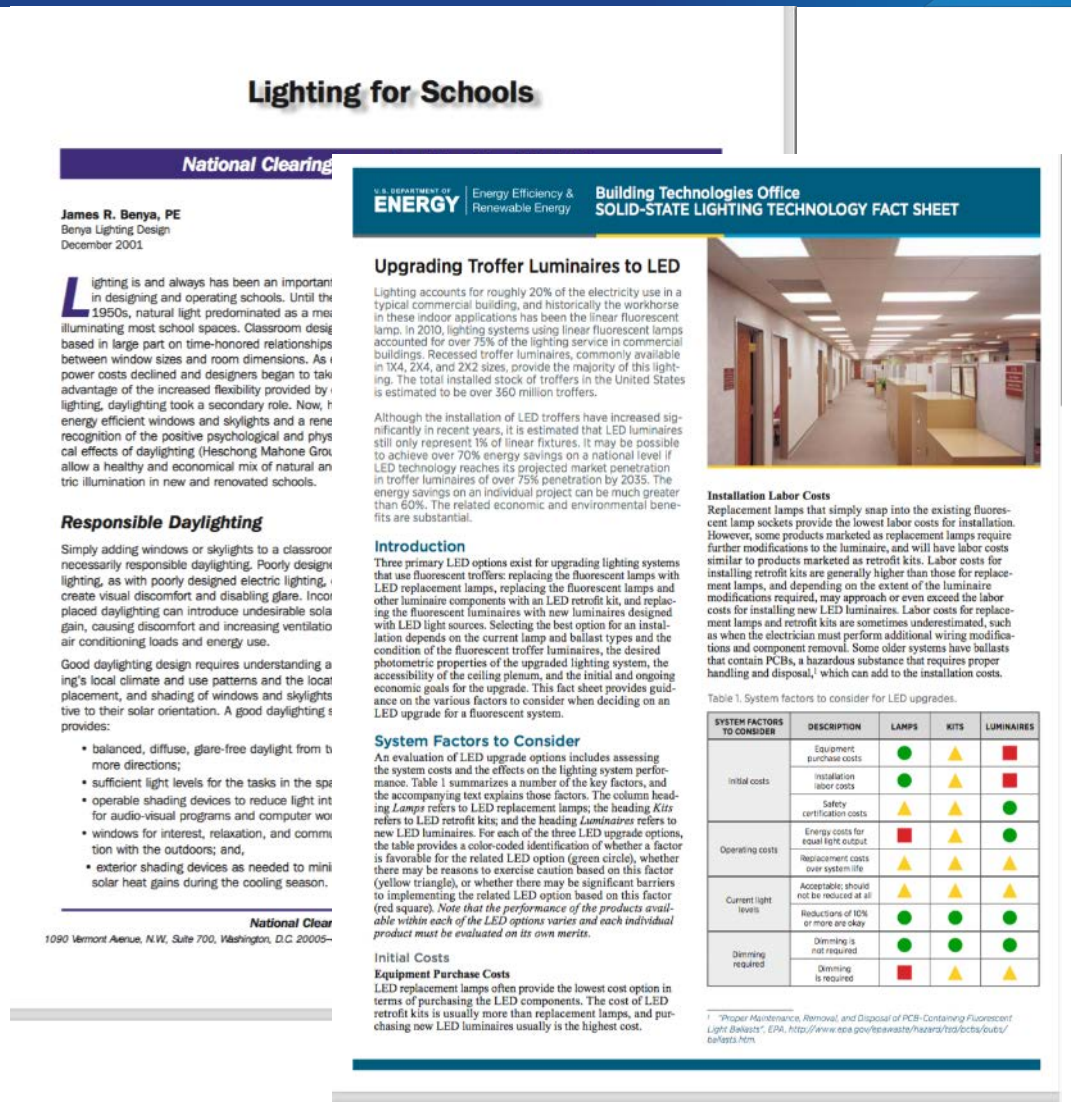
lighting design lab
www.lightingdesignlab.com

NORTHWEST LIGHTING NETWORK
www.nwlightingnetwork.com



Fact Sheets

- Compilation of potential issues
- Provides multiple paths to solutions
- Application-specific guidance



Lighting for Schools

National Clearing

James R. Benya, PE
Benya Lighting Design
December 2001

Lighting is and always has been an important in designing and operating schools. Until the 1950s, natural light predominated as a mea illuminating most school spaces. Classroom desig based in large part on time-honored relationships between window sizes and room dimensions. As power costs declined and designers began to tak advantage of the increased flexibility provided by lighting, daylighting took a secondary role. Now, h energy efficient windows and skylights and a rene recognition of the positive psychological and phys cal effects of daylighting (Heschong Mahone Grou allow a healthy and economical mix of natural an tric illumination in new and renovated schools.

Responsible Daylighting

Simply adding windows or skylights to a classroor necessarily responsible daylighting. Poorly designe lighting, as with poorly designed electric lighting, create visual discomfort and disabling glare. Incor placed daylighting can introduce undesirable sola gain, causing discomfort and increasing ventilatio air conditioning loads and energy use.

Good daylighting design requires understanding a ing's local climate and use patterns and the locat placement, and shading of windows and skylights tive to their solar orientation. A good daylighting s provides:

- balanced, diffuse, glare-free daylight from b more directions;
- sufficient light levels for the tasks in the spa
- operable shading devices to reduce light int for audio-visual programs and computer wo
- windows for interest, relaxation, and commu tion with the outdoors; and,
- exterior shading devices as needed to mini solar heat gains during the cooling season.

National Clear

1090 Vermont Avenue, N.W, Suite 700, Washington, D.C 20005–

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building Technologies Office
SOLID-STATE LIGHTING TECHNOLOGY FACT SHEET

Upgrading Troffer Luminaires to LED

Lighting accounts for roughly 20% of the electricity use in a typical commercial building, and historically the workhorse in these indoor applications has been the linear fluorescent lamp. In 2010, lighting systems using linear fluorescent lamps accounted for over 75% of the lighting service in commercial buildings. Recessed troffer luminaires, commonly available in 1X4, 2X4, and 2X2 sizes, provide the majority of this lighting. The total installed stock of troffers in the United States is estimated to be over 360 million troffers.

Although the installation of LED troffers have increased significantly in recent years, it is estimated that LED luminaires still only represent 1% of linear fixtures. It may be possible to achieve over 70% energy savings on a national level if LED technology reaches its projected market penetration in troffer luminaires of over 75% penetration by 2035. The energy savings on an individual project can be much greater than 60%. The related economic and environmental benefits are substantial.

Introduction

Three primary LED options exist for upgrading lighting systems that use fluorescent troffers: replacing the fluorescent lamps with LED replacement lamps, replacing the fluorescent lamps and other luminaire components with an LED retrofit kit, and replacing the fluorescent luminaires with new luminaires designed with LED light sources. Selecting the best option for an installation depends on the current lamp and ballast types and the condition of the fluorescent troffer luminaires, the desired photometric properties of the upgraded lighting system, the accessibility of the ceiling plenum, and the initial and ongoing economic goals for the upgrade. This fact sheet provides guidance on the various factors to consider when deciding on an LED upgrade for a fluorescent system.

System Factors to Consider

An evaluation of LED upgrade options includes assessing the system costs and the effects on the lighting system performance. Table 1 summarizes a number of the key factors, and the accompanying text explains those factors. The column heading *Lamps* refers to LED replacement lamps; the heading *Kits* refers to LED retrofit kits; and the heading *Luminaires* refers to new LED luminaires. For each of the three LED upgrade options, the table provides a color-coded identification of whether a factor is favorable for the related LED option (green circle), whether there may be reasons to exercise caution based on this factor (yellow triangle), or whether there may be significant barriers to implementing the related LED option based on this factor (red square). *Note that the performance of the products available within each of the LED options varies and each individual product must be evaluated on its own merits.*

Initial Costs

Equipment Purchase Costs

LED replacement lamps often provide the lowest cost option in terms of purchasing the LED components. The cost of LED retrofit kits is usually more than replacement lamps, and purchasing new LED luminaires usually is the highest cost.

Installation Labor Costs

Replacement lamps that simply snap into the existing fluorescent lamp sockets provide the lowest labor costs for installation. However, some products marketed as replacement lamps require further modifications to the luminaire, and will have labor costs similar to products marketed as retrofit kits. Labor costs for installing retrofit kits are generally higher than those for replacement lamps, and depending on the extent of the luminaire modifications required, may approach or even exceed the labor costs for installing new LED luminaires. Labor costs for replacement lamps and retrofit kits are sometimes underestimated, such as when the electrician must perform additional wiring modifications and component removal. Some older systems have ballasts that contain PCBs, a hazardous substance that requires proper handling and disposal,[1] which can add to the installation costs.

Table 1. System factors to consider for LED upgrades.

SYSTEM FACTORS TO CONSIDER	DESCRIPTION	LAMPS	KITS	LUMINAIRES
Initial costs	Equipment purchase costs	●	▲	■
	Installation labor costs	●	▲	■
	Safety certification costs	▲	▲	●
Operating costs	Energy costs for equal light output	■	▲	●
	Replacement costs over system life	▲	▲	▲
Current light levels	Acceptable; should not be reduced at all	▲	▲	▲
	Reductions of 10% or more are okay	●	●	●
Dimming required	Dimming is not required	●	●	●
	Dimming is required	■	▲	▲

1 "Proper Maintenance, Removal, and Disposal of PCB-Containing Fluorescent Light Ballasts", EPA, http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/ballasts.htm.

FACT SHEET: Upgrading troffer luminaires to LED

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building Technologies Office
SOLID-STATE LIGHTING TECHNOLOGY FACT SHEET

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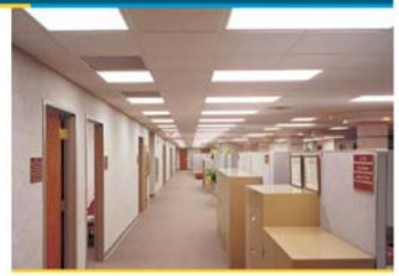

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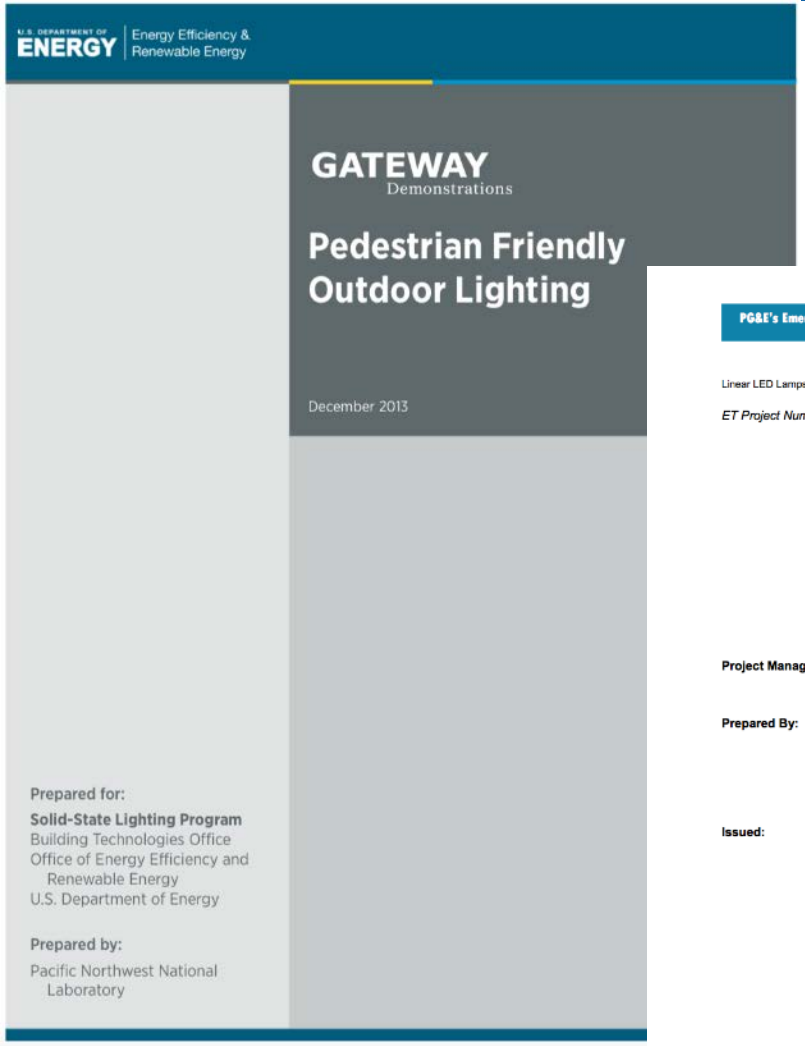
	Yes, dimming is required	■	▲	▲

Reports

- Technical
- Vast level of detail
- Research-oriented
- Facts to support why we consider investing in the upgrades and work that is done



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

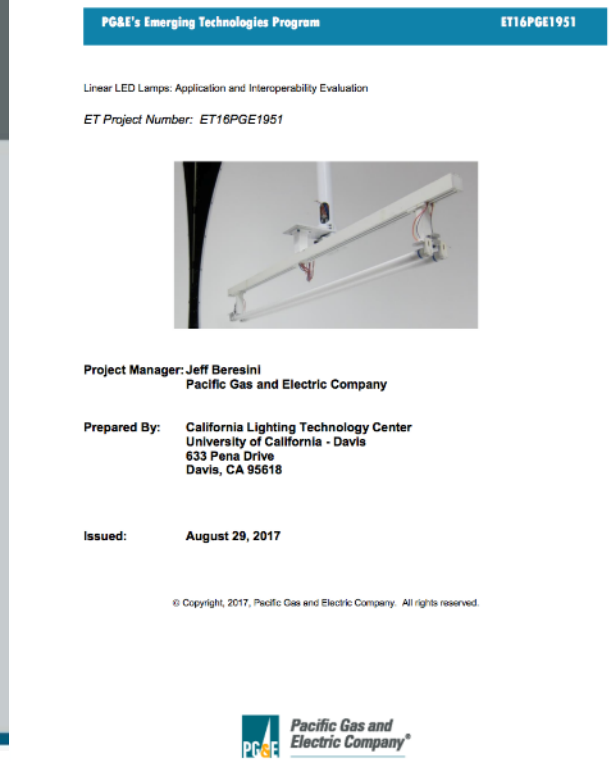
GATEWAY Demonstrations

Pedestrian Friendly Outdoor Lighting

December 2013

Prepared for:
Solid-State Lighting Program
Building Technologies Office
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

Prepared by:
Pacific Northwest National Laboratory



PG&E's Emerging Technologies Program ET16PGE1951

Linear LED Lamps: Application and Interoperability Evaluation

ET Project Number: ET16PGE1951

Project Manager: Jeff Beresini
Pacific Gas and Electric Company

Prepared By: California Lighting Technology Center
University of California - Davis
633 Pena Drive
Davis, CA 95618

Issued: August 29, 2017

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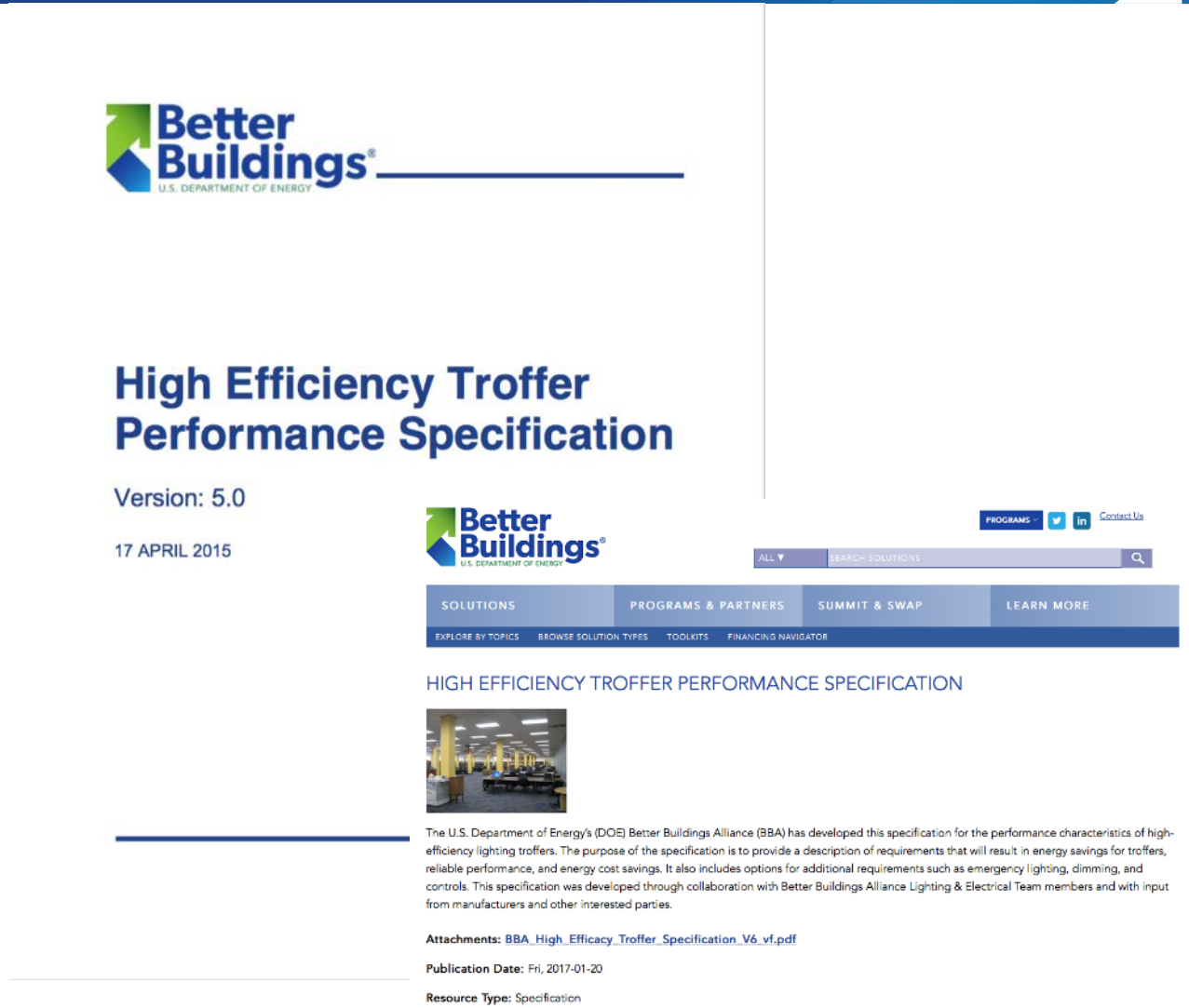
Pacific Gas and Electric Company®

Specifications

- Technical documents
- Sets high standards
- Provides guidance on performance characteristics



Better Buildings
U.S. DEPARTMENT OF ENERGY

High Efficiency Troffer Performance Specification

Version: 5.0

17 APRIL 2015

Better Buildings
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PROGRAMS Contact Us

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EXPLORE BY TOPICS | BROWSE SOLUTION TYPES | TOOLKITS | FINANCING NAVIGATOR

HIGH EFFICIENCY TROFFER PERFORMANCE SPECIFICATION

The U.S. Department of Energy's (DOE) Better Buildings Alliance (BBA) has developed this specification for the performance characteristics of high-efficiency lighting troffers. The purpose of the specification is to provide a description of requirements that will result in energy savings for troffers, reliable performance, and energy cost savings. It also includes options for additional requirements such as emergency lighting, dimming, and controls. This specification was developed through collaboration with Better Buildings Alliance Lighting & Electrical Team members and with input from manufacturers and other interested parties.

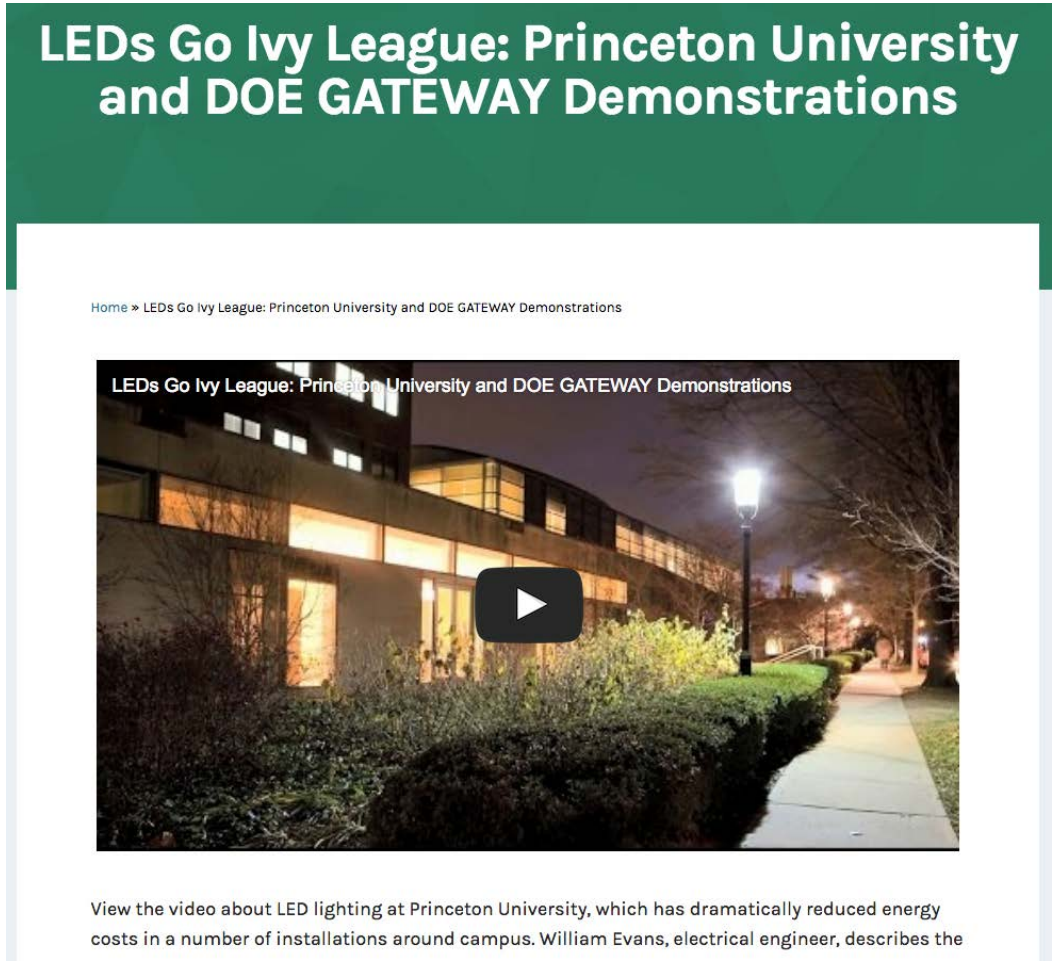
Attachments: BBA_High_Efficacy_Troffer_Specification_V6_vf.pdf

Publication Date: Fri, 2017-01-20

Resource Type: Specification

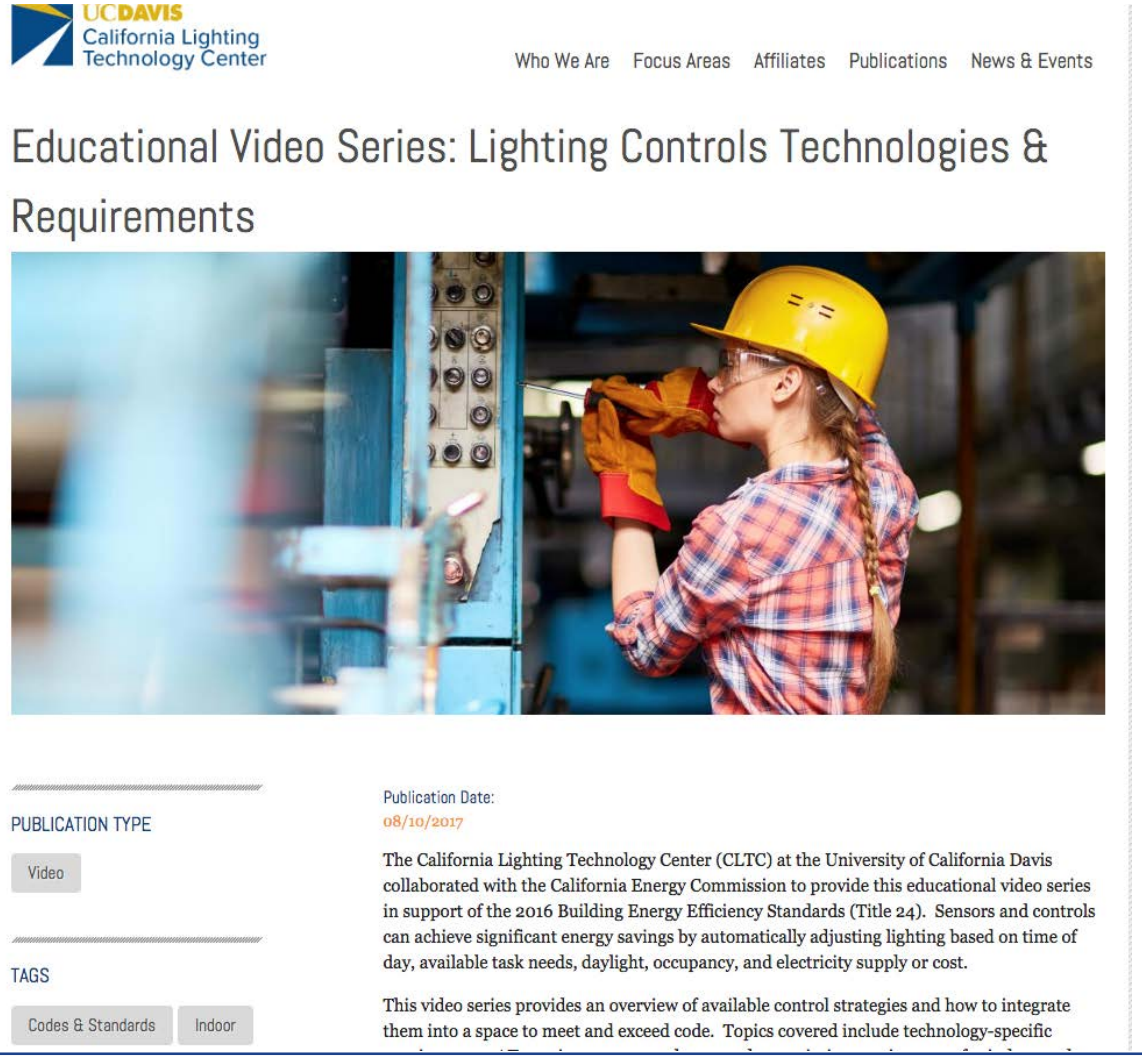
Videos

- Summarizes projects in a more visual way
- Easily shared
- Generally less technical



Webinars

- Summaries from experts
- Dynamic discussions
- Provides additional resources, considerations, and avenues for additional exploration



UCDAVIS California Lighting Technology Center

Who We Are | Focus Areas | Affiliates | Publications | News & Events

Educational Video Series: Lighting Controls Technologies & Requirements

PUBLICATION TYPE

Video

TAGS

Codes & Standards | Indoor

Publication Date:
08/10/2017

The California Lighting Technology Center (CLTC) at the University of California Davis collaborated with the California Energy Commission to provide this educational video series in support of the 2016 Building Energy Efficiency Standards (Title 24). Sensors and controls can achieve significant energy savings by automatically adjusting lighting based on time of day, available task needs, daylight, occupancy, and electricity supply or cost.

This video series provides an overview of available control strategies and how to integrate them into a space to meet and exceed code. Topics covered include technology-specific

Robert Davis
PNNL

U.S. DEPARTMENT OF
ENERGY

Energy efficient lighting

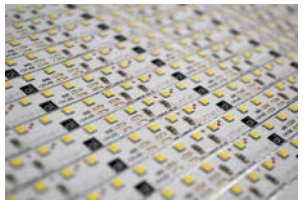
Fluorescent lighting saved energy and money . . .

BUT

- Mediocre color quality
- Difficult to dim
- Flicker, buzz
- Warm up time
- Static color
- Mercury

Energy efficient lighting

LED lighting saves energy and money . . .

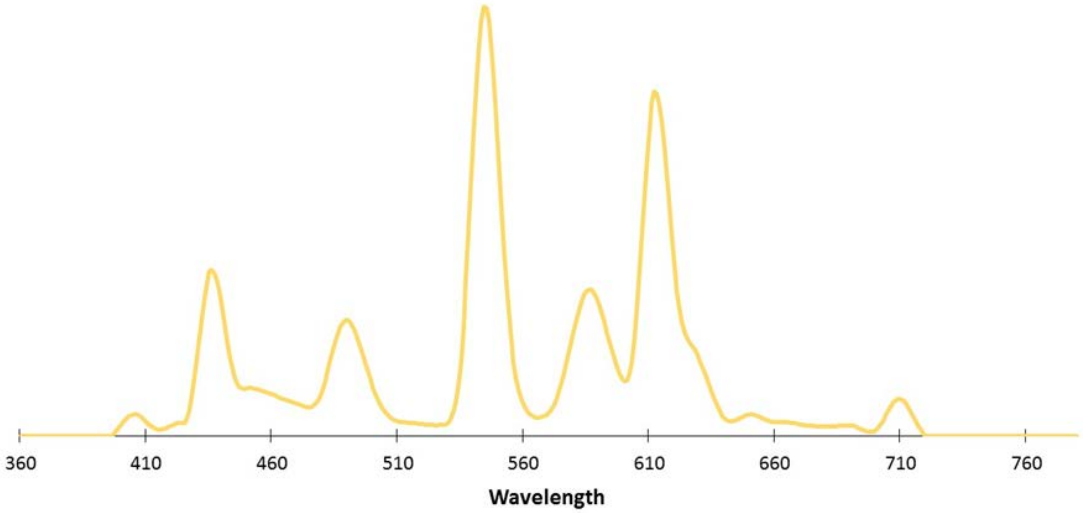


AND

- Good color quality
- Easy to dim
- Instant on
- Tunable color
- No mercury
- Better for learning??

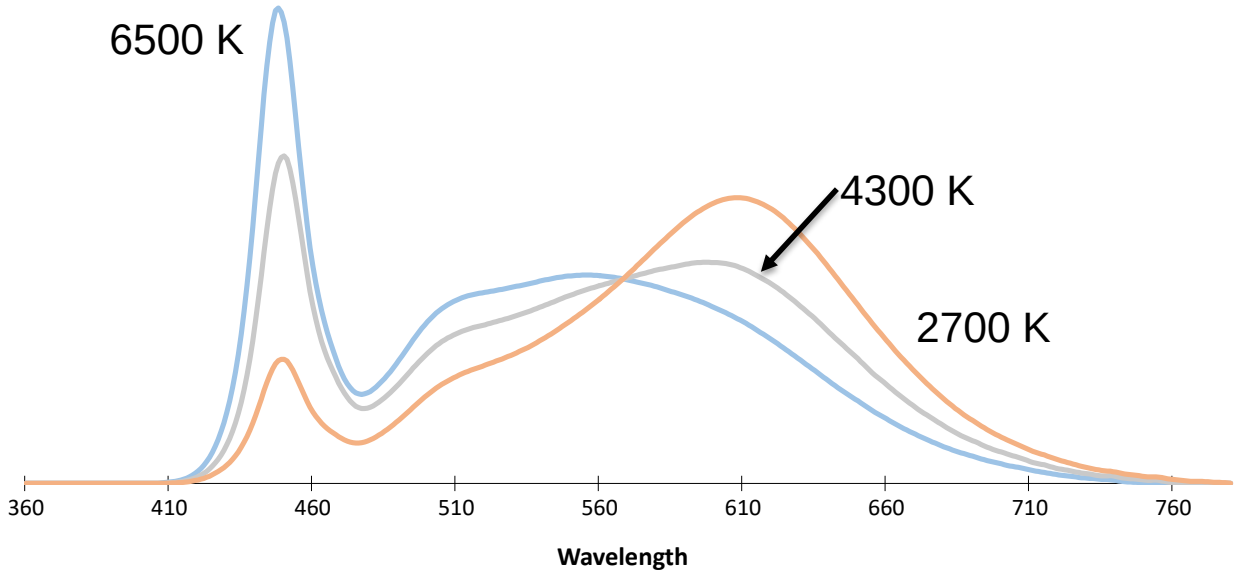
What is tunable LED lighting?

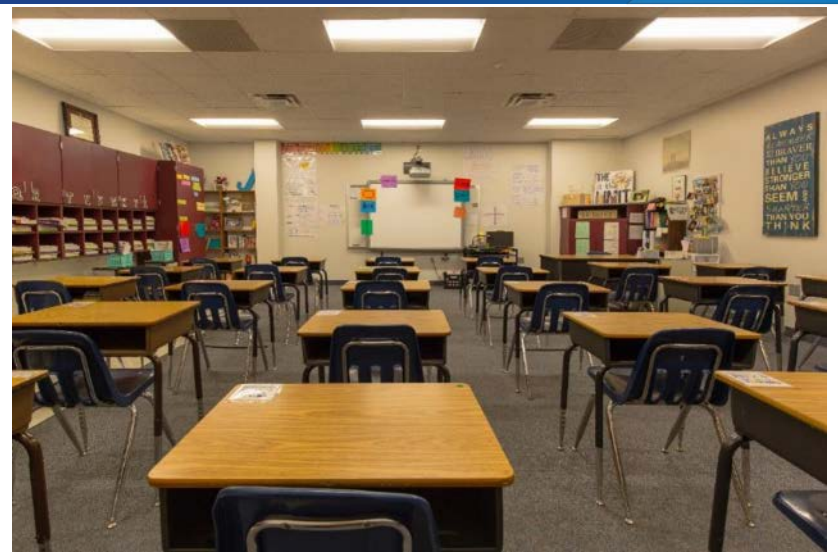
Fluorescent – 3800 K

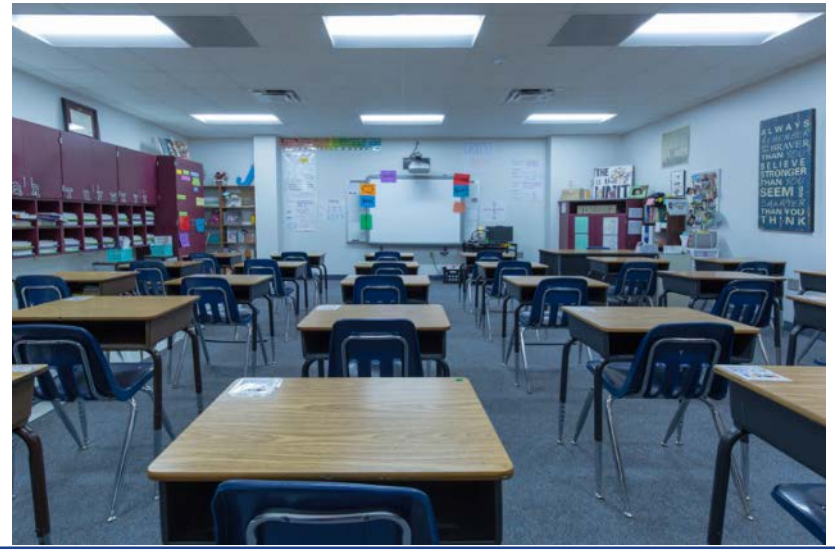


What is tunable LED lighting?

Tunable LED System







Ability to vary the spectrum and intensity of light

Why use tunable LED systems?

Circadian

Why use tunable LED systems?

Behavioral cues

Circadian

Alertness

Why use tunable LED systems?

Biophilic

Behavioral cues

Control

Preferences

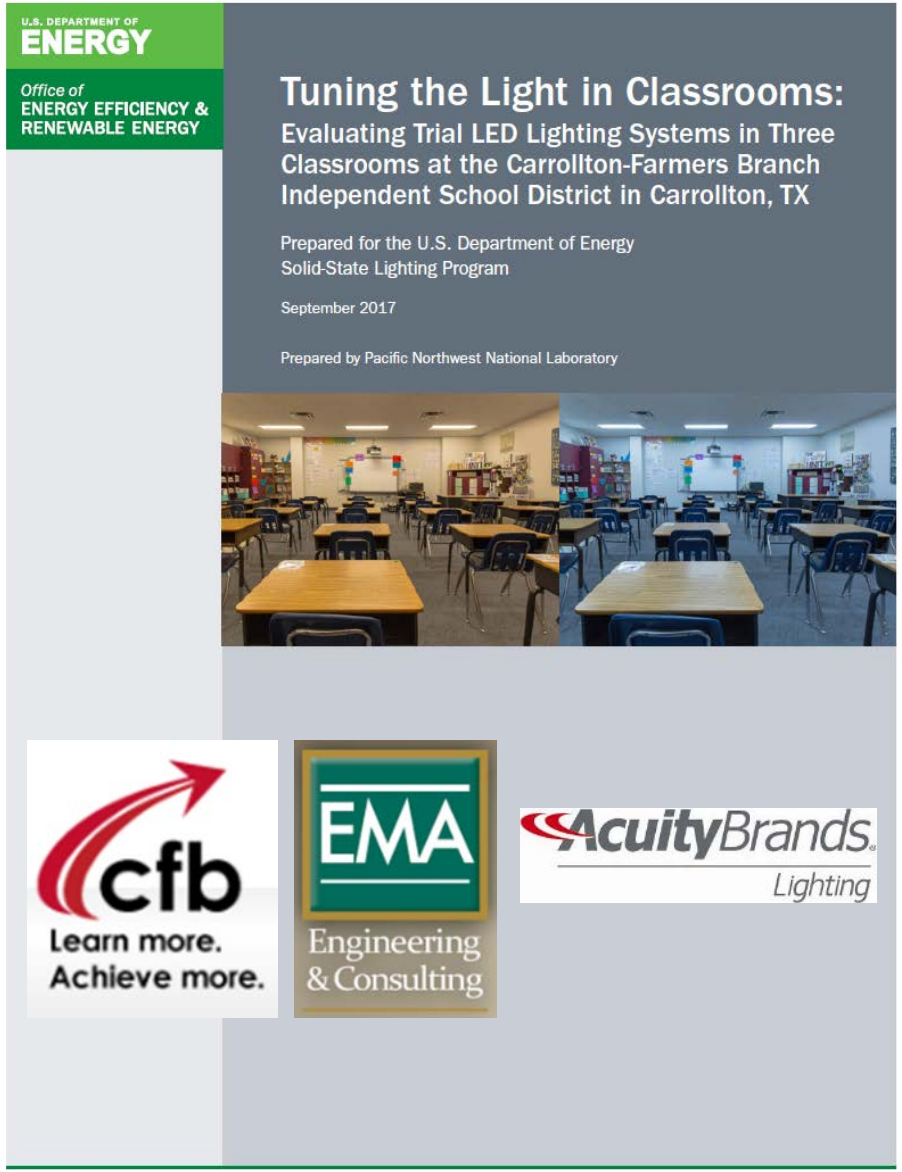
Circadian

Atmosphere

Matching

Alertness

DOE GATEWAY Pilot Studies:
Carrolton TX & Folsom CA



Carrollton-Farmers Branch Schools

4200K

3000K

3500K

5000K

1: FULL – All 100%

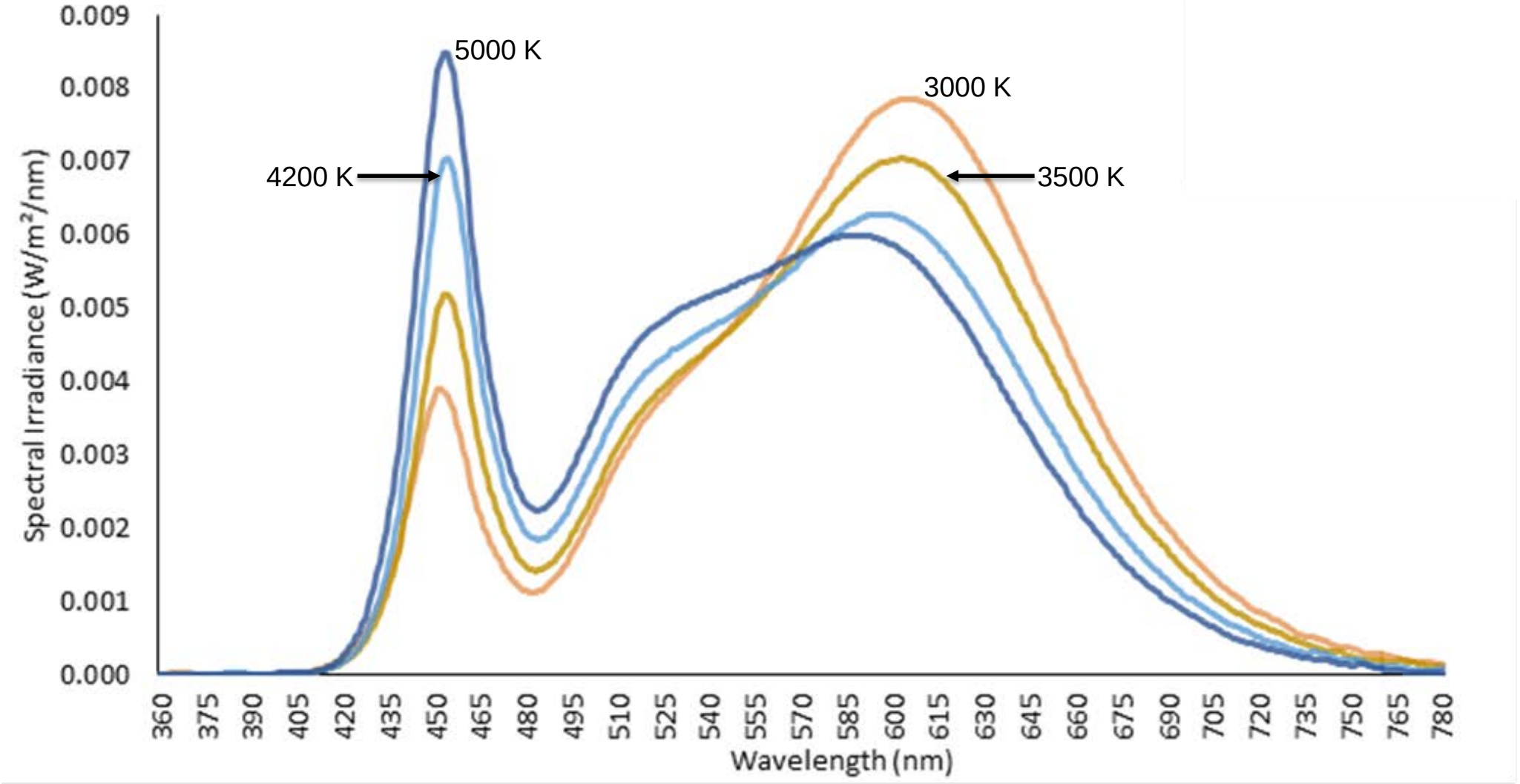
2: AV – Front Off, Room 40%

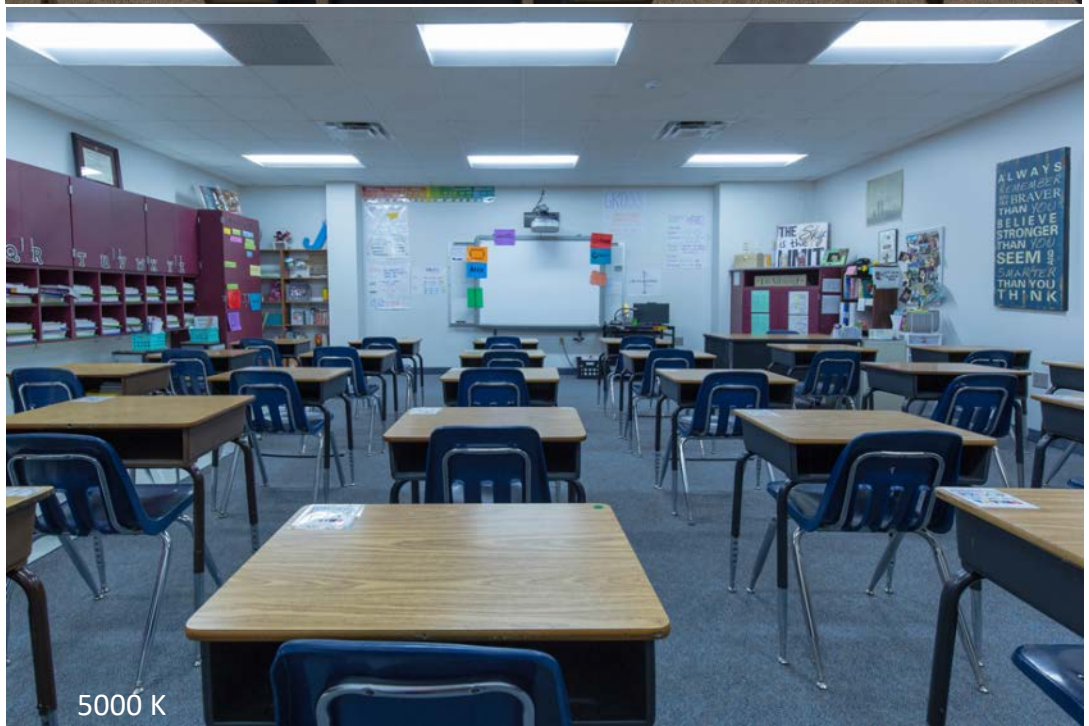
3: PRESENT – Front 100%, Room 60%

4: ALL Dim 10%

UP / DOWN – Change all by 5% each click

Tunable spectrum LED lighting

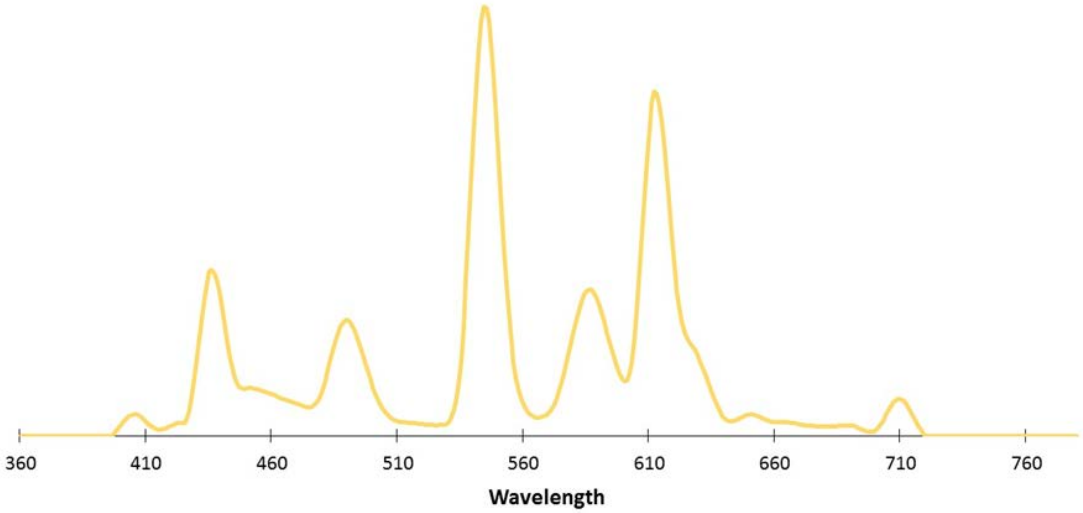




Photos: Acuity Brands Lighting

Folsom-Cordova Unified School District

Fluorescent – 3800 K



Folsom-Cordova Unified School District

SCENE CONTROLS

General

AV Mode

Screens

Energize

Calm

Sensor Override

Folsom-Cordova Unified School District

SCENE CONTROLS

General

AV Mode

Screens

Energize

Calm

Sensor Override

SLIDE CONTROLS

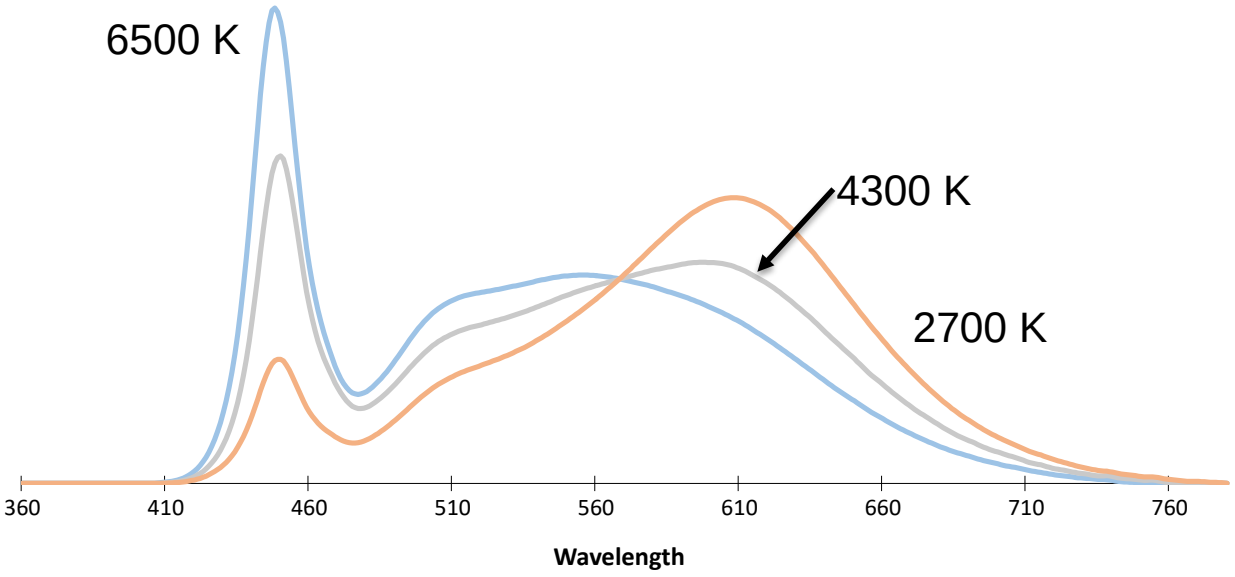
General room intensity

Whiteboard intensity

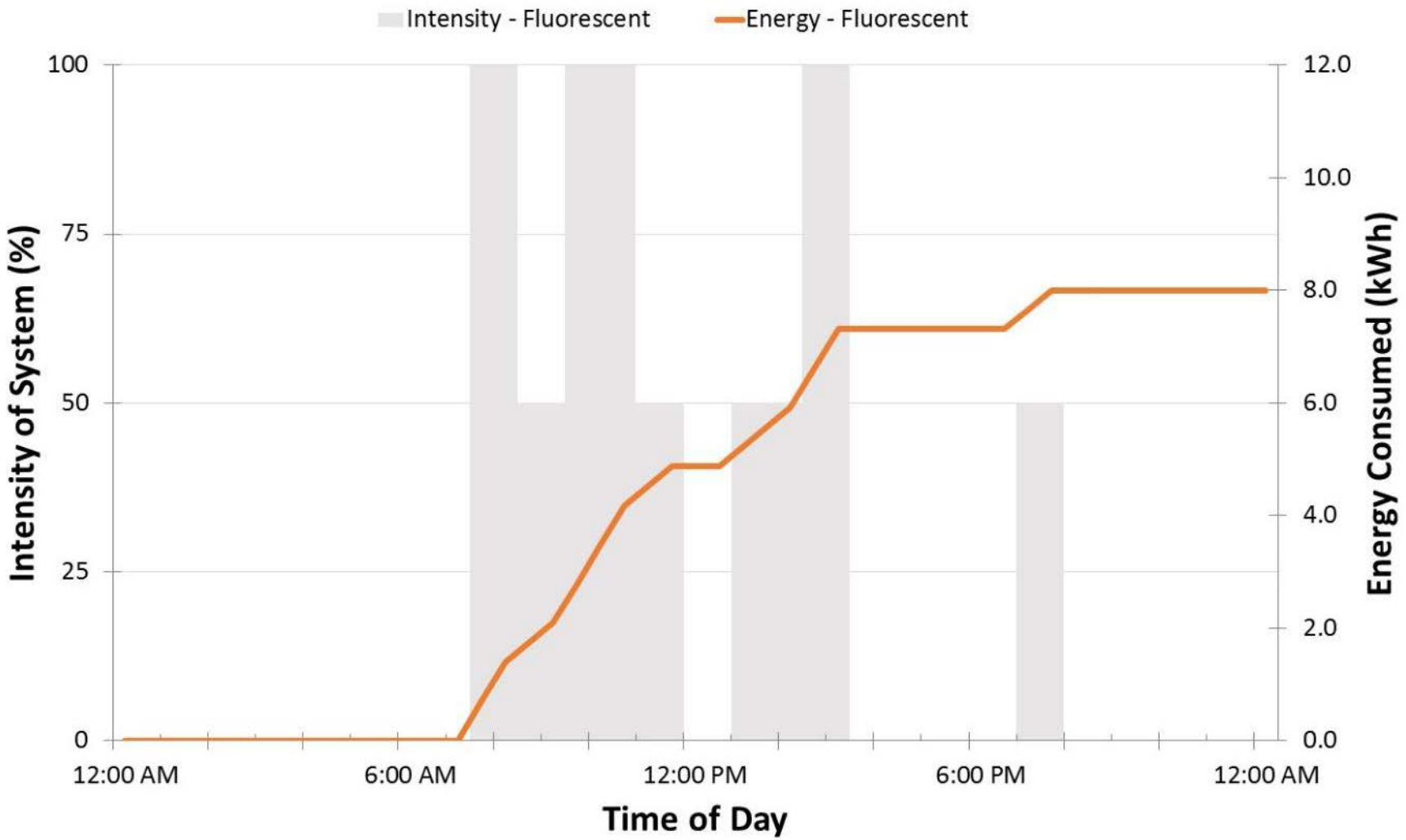
Color tuning of all fixtures

Folsom-Cordova Unified School District

Tunable LED System



Energy use for lighting during a typical day



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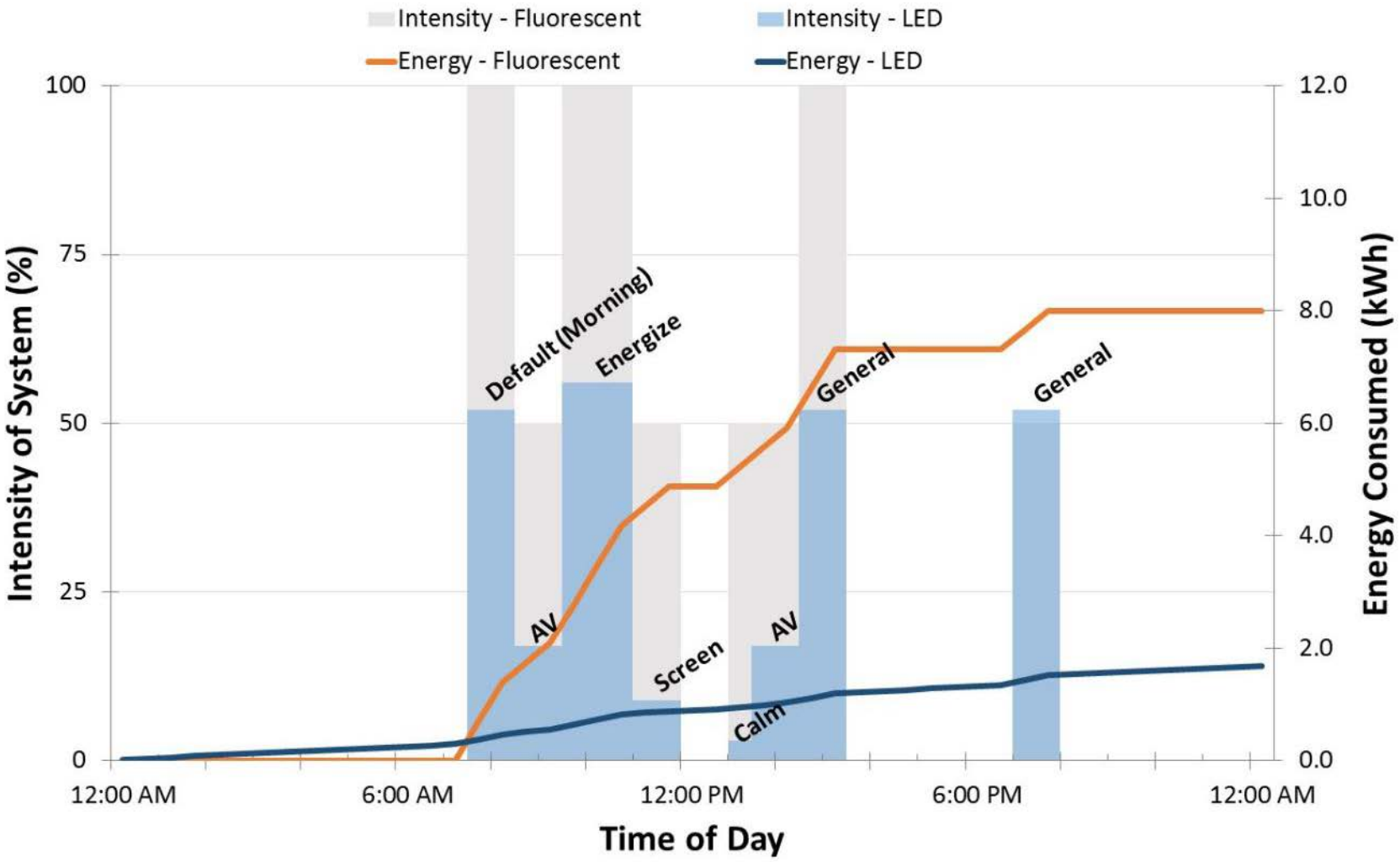
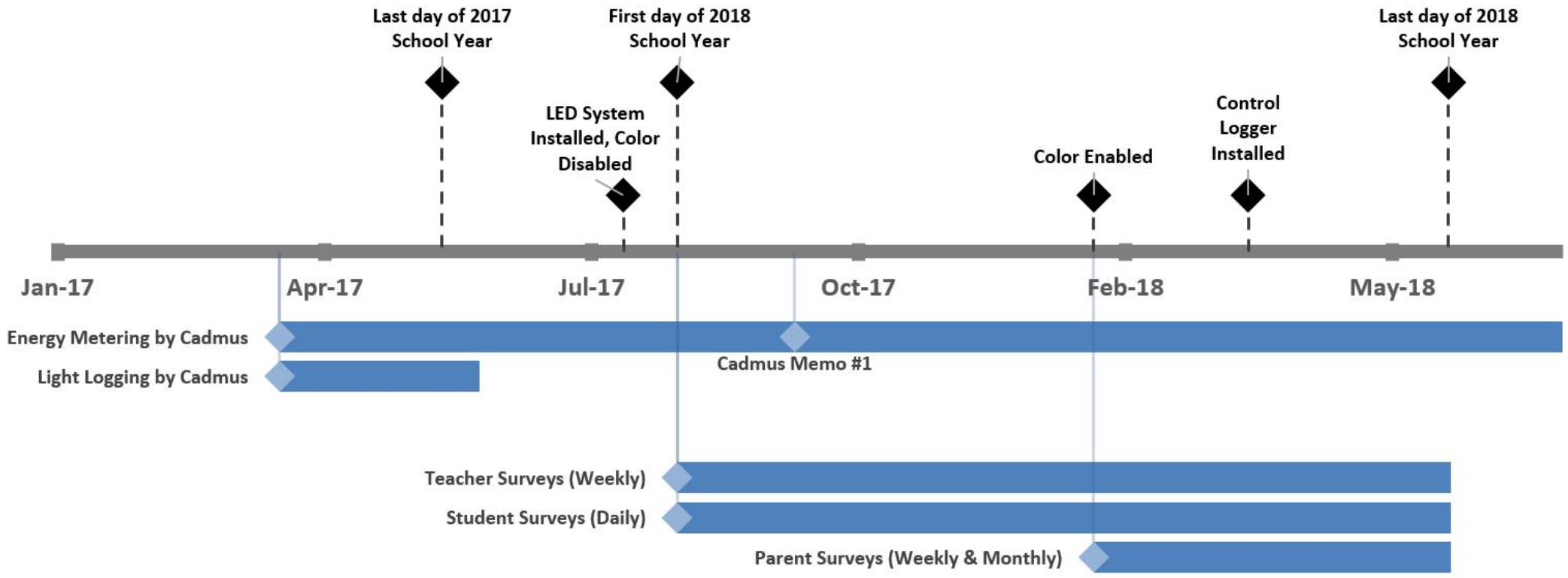


Folsom-Cordova Unified School District



Classroom Outcomes in GATEWAY Pilot Studies

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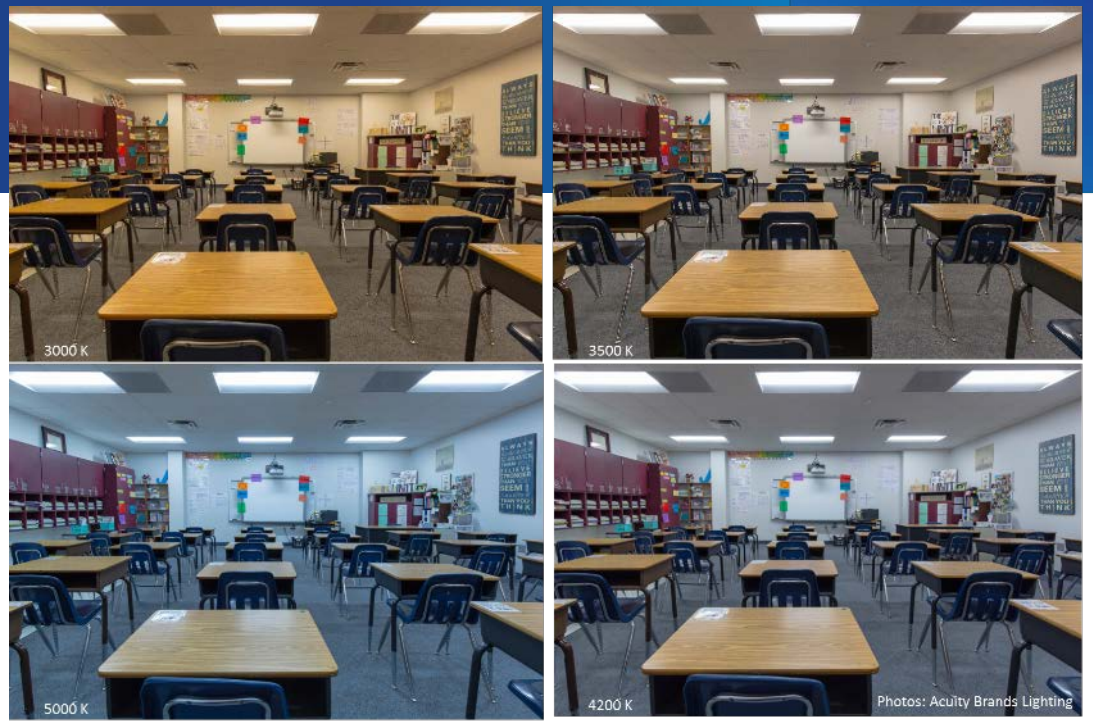
- One teacher credited the lighting with “keeping me from retiring”

Summary



- LED lighting systems can offer significant energy and economic benefits to schools
- Dimming & scene control of LED lighting can produce even deeper savings
- Tuning the spectrum of LED lighting may offer further benefits
  - *Not* more energy savings (non-energy benefits or NEB)
  - Gives teachers more control of classroom environment
  - Provides visual cues for desired student behaviors
  - Allows for “future proofing” to adapt to emerging science on alertness and focus

robert.davis@pnnl.gov

Additional Resources

To access the new K-12 Lighting Toolkit (coming soon!):

- https://betterbuildingssolutioncenter.energy.gov

FACT SHEET: Upgrading troffer luminaires to LED:

- https://www.energy.gov/eere/ssl/technology-fact-sheets

GATEWAY Evaluation Reports

- https://www.energy.gov/eere/ssl/gateway-evaluations

LED Color-Tunable Products

- https://www.energy.gov/eere/ssl/led-color-tunable-products

Q&A

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- Multi-faceted and applicable across sectors

Other Resources, Case Studies, Guidance

BETTER INFORMATION

Additional Questions? Please Contact Us

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