December 07, 2023

LED LIGHTING AND CONTROLS GUIDANCE FOR FEDERAL BUILDINGS

Green Proving Ground | U.S. General Services Administration

Agenda

Introduction (1 minute)
Andrea Silvestri, GSA Green Proving Ground

LED and Controls Guidance (20 minutes)
Michael Myer, Principal Investigator, Pacific Northwest National Laboratory

Q&A (10 minutes)

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LED LIGHTING AND CONTROLS GUIDANCE

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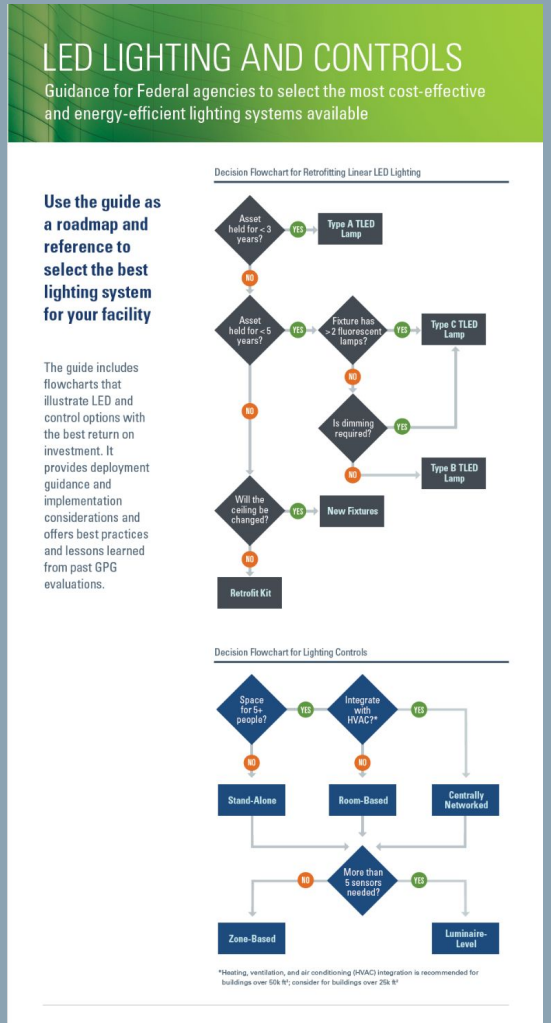
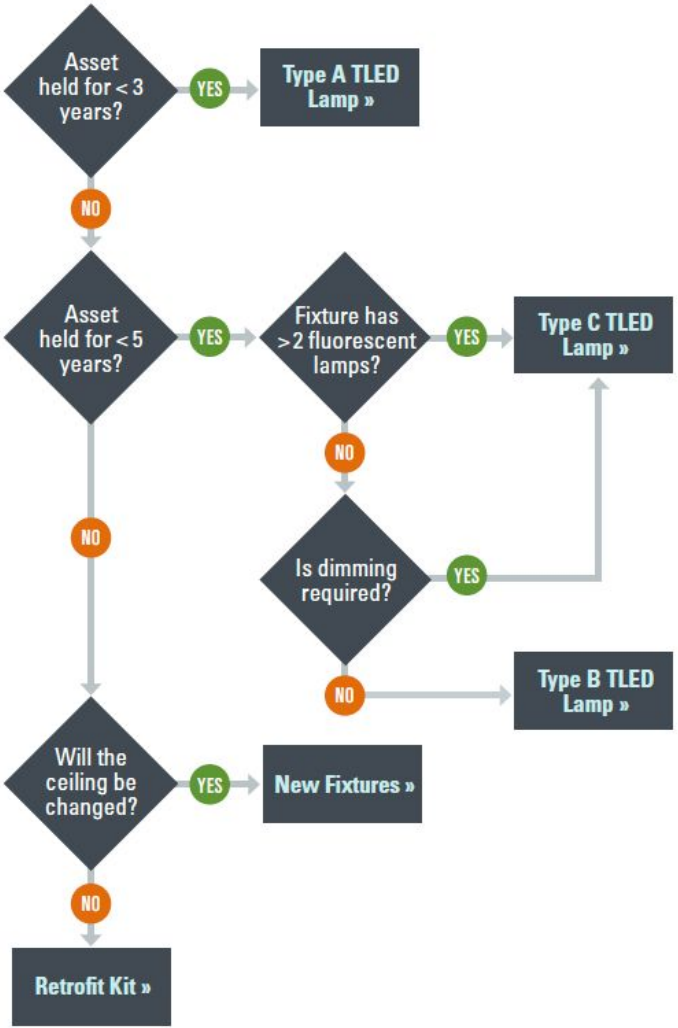
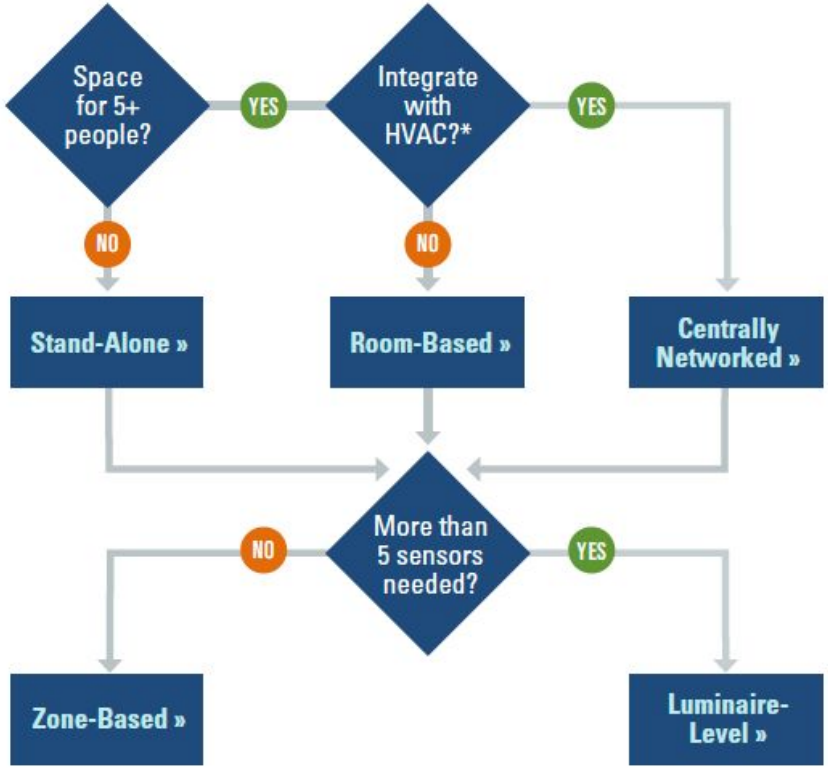


Decision FlowChart for Linear LED



Decision FlowChart for Lighting Controls



* Heating, ventilation, and air conditioning (HVAC) integration is recommended for buildings over 50k ft^2; consider for buildings over 25k ft^2

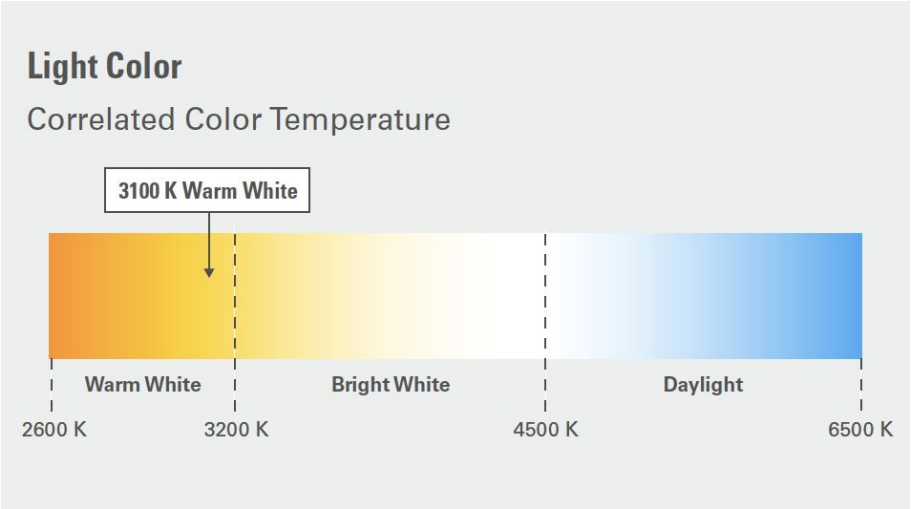
Life-Cycle Cost Effectiveness

- Make sure your life-cycle cost effectiveness captures all cost inputs
- Integrating with HVAC can be the most cost-effective for larger spaces
- ESPC may use the low 1st cost of LED (e.g. Type A TLED) to offset other non-lighting ECMs
  - Will be hard to make LED upgrade pay off in subsequent ESPC
  - Most ballasts will fail shortly and this will be left to O&M to replace

Retrofit Kits	SYSTEM LIFE (yrs)	ENERGY SAVINGS (%)	ENERGY SAVINGS (/ft²)	ENERGY SAVINGS ($ / ft²)	FIRST COST ($ / ft²)	PAYBACK (yrs)	LCC 15-YEAR
Retrofit kit with zone-based control	15	65%	1.87 kWh 6.38 kBtu	$0.21	$1.67	8.1	$170,182
• As building size increases, a retrofit may involve both a combination of mostly retrofit kits and some TLEDs. • As size increases, retrofit installation becomes more efficient. • Requires either low voltage wires or wireless communication between the sensor and the luminaires. • Ideal for low occupancy transitory spaces (e.g., restrooms, corridors, stairs, etc.). • Spaces with many different fixture types and many custom or outlier fixture types may make finding retrofit kits more difficult.							
Retrofit kit with luminaire-level lighting control (LLLC), room-based	15	65%	1.87 kWh 6.38 kBtu	$0.21	$2.27	11.0	$200,882
• Room-based controllers will be sized on both electrical capacity and number of zones—this will affect control design. • Requires communication—either wired or wireless—between the controller, sensors, and luminaires. • Spaces with many different fixture types and many custom or outlier fixture types may make finding retrofit kits more difficult.							
Retrofit kit with LLLC, centrally networked	15	70%	2.03 kWh 6.92 kBtu	$0.22	$2.45	11.0	$196,785
• Economies of scale play a role; technology is more cost effective as the building size increases. • Allows for more lighting control strategies than other options. • If a digital system is selected, diagnostics or other information can queried from the system.							
Retrofit kit with LLLC, centrally networked with HVAC integration	15	70% lighting 20% HVAC	4.03 kWh 13.74 kBtu	$0.44	$2.82	6.4	$123,889

Consider the Following when Selecting an LED System

- Circadian Lighting
- Color Rendering
- Color Temperature
- Communication Protocols
- Controls Interfaces
- Controls-Ready Fixtures
- Dimming
- Drivers
- Distribution
- Efficacy
- Flicker



Interior LED Retrofit Options

TLED-A (uses existing fluorescent ballast)

- Pros: least expensive 1st cost
- Cons: most ballasts will fail shortly; 7 states have banned fluorescent tubes

TLED-B (bypasses ballast with direct wiring)

- Pros: can be delivered “sight unseen”
- Cons: relies on optics of existing troffer; glare and distribution

TLED-C (new LED driver)

- Pros: 1 driver can operate multiple lamps; controls can be added
- Cons: relies on existing wiring; glare and distribution

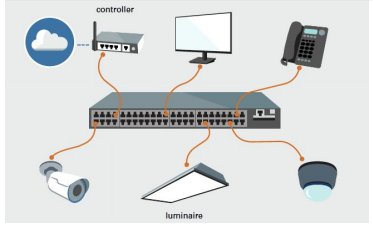
Interior LED Retrofit Options

Troffer Retrofit Kit

- Pros: can include integrated controls
- Cons: challenging to match different sizes; requires communication

New Fixture

- Pros: aesthetics, longer-lived than retrofit kits
- Cons: more expensive than retrofit kit, requires ceiling modification



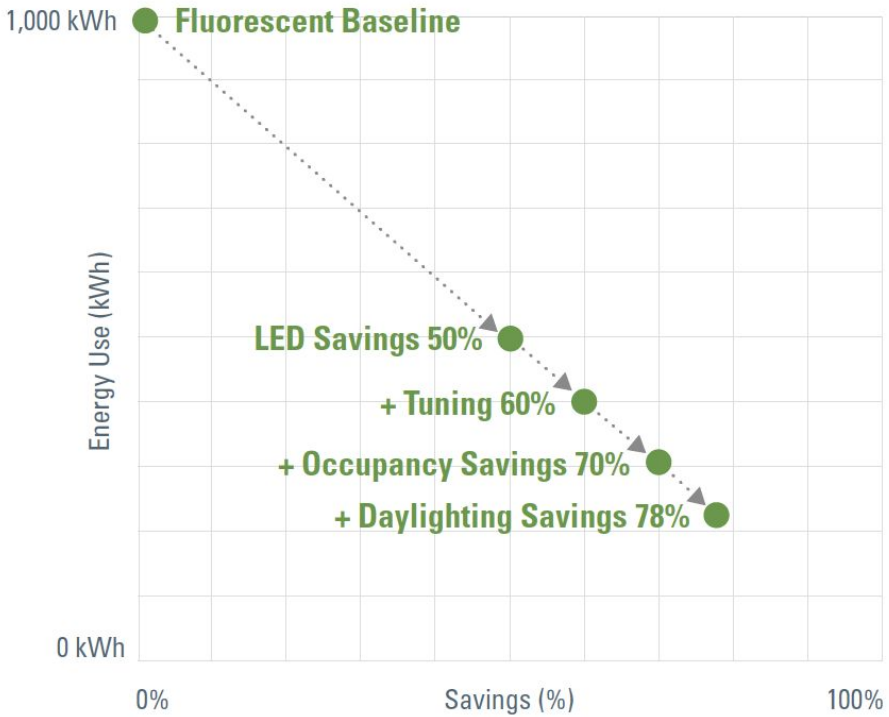
Power-over-Ethernet (POE) Lighting

- Pros: 10%-20% more efficient, material and labor savings
- Cons: more planning and design, cybersecurity

Energy Savings Controls

Control Strategy	Lighting Savings					Integrated System Savings	
	Scheduling	Occupancy Sensing	Dimming	Daylight-Responsive Control	Task Tuning	Demand Response	HVAC Integration
							
Typical Energy Savings[1]	40% lighting if lights are on 24/7	24% lighting[2]	20% (will depend on your preference)	28% lighting[3]	20%+ lighting[4]	20% kW reduction (not energy)[5]	30% HVAC[6]
Code Compliance	GSA PBS-P100 ASHRAE/IES 90.1	GSA PBS-P100 ASHRAE/IES 90.1	GSA PBS-P100 ASHRAE/IES 90.1	GSA PBS-P100 ASHRAE/IES 90.1	—	Supports GSA's GEB initiative	Unoccupied setpoints will be required in ASHRAE/IES 90.1 2022
Minimum System Requirements	Scheduler with astronomic and time- and day-based functions	Occupancy sensors	LED naturally dims	Daylight sensors	Digital communication protocol Centrally networked system	Digital communication protocol Centrally networked system	Digital communication protocol Centrally networked system

Controls Offer Diminishing Returns



Controls offer significant savings but it can be challenging to realize a positive ROI because LED lighting is so efficient.

Steps for Designing a Lighting Control System

1. **Review Energy Code Requirements**
   Control requirements will vary by space type.

2. **Assess Need for Enhanced Capabilities**
   Determine if additional energy savings or lighting performance capabilities are needed.

3. **Design Lighting Zones**
   Determine the final size of zones, number of luminaires, and layout of each zone.

4. **Select a System Architecture**
   System architecture can be stand-alone, room-based with a controller, or centrally networked.

5. **Determine Sensor and Controller Locations**
   Sensors can be located in each luminaire for luminaire-level lighting control or in the space for zone-based control.

6. **Configure Control Wiring**
   Control systems can be wired, wireless, or a combination of both.

7. **Identify Communication Protocols**
   The lighting communication protocol refers to how the LED array communicates with the LED driver within the luminaire.

8. **Plan for Retro- and Re-Commissioning**
   Lighting systems need to be updated regularly to accommodate system updates and building changes.

System Architecture

Stand-Alone controls have no interactions or communication with each other.

Room-Based controller communicates with luminaires in a room. Does not integrate with the grid or HVAC.

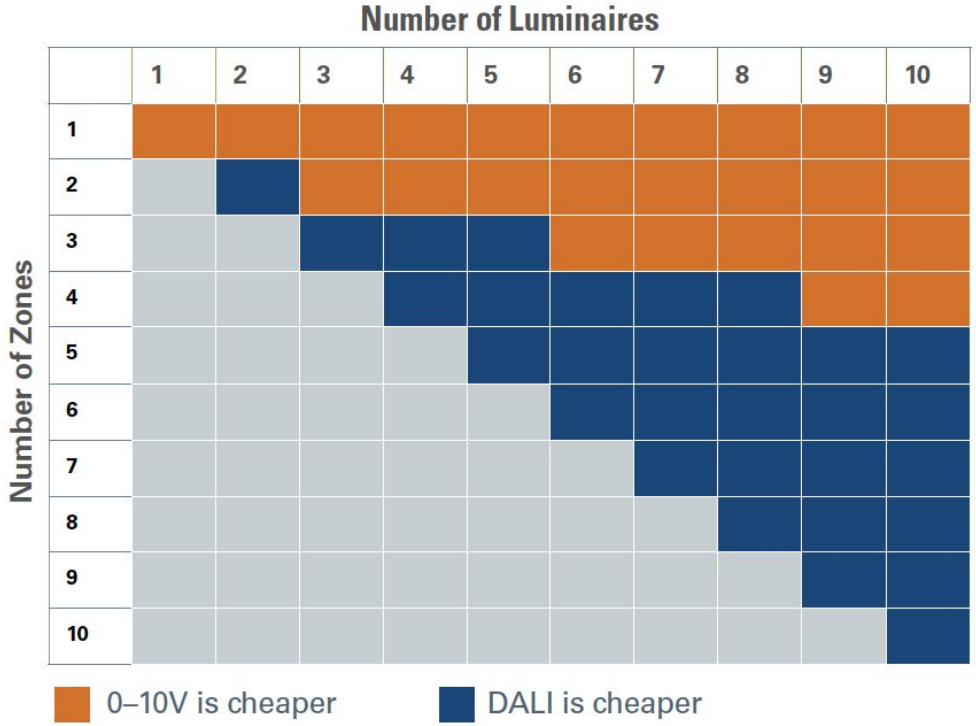
Centrally Networked includes a centralized control point where users can modify the system and integrate with other systems.

Feature	Stand-Alone	Room-Based	Centrally Networked
# of Luminaires	1 luminaire to a single room	3 or 4 zones in a room; limited by the size of the circuit powering it	Multiple luminaires, multiple rooms, even multiple buildings
# of Control Strategies	1 or 2	1–3	1–5 or more
Installed Cost	< $1/ft²	< $1/ft²	$3/ft²
Demand Reduction	No	No	Yes
BAS and/or HVAC Integration	No	No	Yes
Allows for Expansion	In limited applications	Yes	Yes
Cybersecurity Risk	None to low	None to low	Medium to high

Analog vs. Digital Communication Protocols

Feature	Analog (0–10V)	Digital (DALI)
Data Exchange	• One-way	• Two-way
Luminaire Addressability	• No	• Yes • Enables advanced features such as reporting run time, energy use, and failures
Zoning Flexibility	• Determined by wiring	• Can be reconfigured in software
Dimming Precision	• Inconsistent dimming output between products. Some 0–10V drivers have a maximum output of 90%. • No standardized luminaire response signal. One luminaire may dim to 60% at 7V and another may dim to 80% at 7V.	• Consistent logarithmic dimming, matching the eye's sensitivity • Standardized response signal. Different fixture types respond the same.
Cybersecurity Risk	• None to low	• None to low • If a 0–10V lighting system has already passed cyber security clearance, it should be a small add-on to have a digital driver remediated.
Availability	• Widely available with greater familiarity	• Most manufacturers have at least two DALI options

Digital Control Can be Less Expensive



0–10V can be more expensive than DALI because of the need for additional wire, conduit, output devices, and adjustments in the field.


Q&A

Thank you!

For more information: gsa.gov/GPG

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