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Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Lighting Specification Guidance for Schools

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Lighting for School Environments

Introduction

Lighting is a key component to creating a functional and high-quality learning environment for students and staff. LED lighting is a common lighting technology being specified today and many options are available for replacement or integration with existing fluorescent systems.

Upgrading your lighting system can reduce energy consumption and operating costs, improve or refresh the look of the school, and improve occupant comfort due to dim or unsatisfactory existing conditions.

This document intends to help school districts retrofit or replace existing lighting systems in order to improve the classroom and school environment and meet the needs of students, teachers, and the school community.

The following specification guidance is a reference for evaluating product offerings and should be customized or detailed as necessary to meet your specific needs.

The document is organized into the following sections:

1. Terminology & Definitions
2. Scope & System Description
3. Materials for Procurement
4. Interior Lighting Fixtures
5. Lighting Controls
6. System Installation & Maintenance
7. References & Other Resources

LED Replacement Options

There are three primary LED options for upgrading lighting systems that use linear fluorescent lamps:

Tubular LED (TLEDs)

Replace only the fluorescent lamps with tubular LEDs (TLEDs). There are three types of TLED replacement lamps:

- **Underwriters Laboratories (UL) Type A** – The sockets remain wired to a new or existing fluorescent ballast; the TLED has an internal driver designed to operate on the ballast output voltage. No re-wiring is needed.
- **UL Type B** – The wiring to the existing fluorescent ballast is terminated as well as the wiring from the ballast to the sockets. The sockets are rewired for direct connection to the branch circuit, and the TLED has an internal driver that is designed to operate on the line voltage supplied to the fixture.
- **UL Type C** – The TLEDs have an external driver that operates on line voltage; electrical connections to the existing ballast are terminated and the line voltage and sockets are connected to the new external TLED driver. The external driver can drive multiple TLEDs and provides better thermal management than internal drivers, which may contribute to a longer lasting lamp. The TLEDs do not have an internal driver.

Retrofit Kits

Remove the fluorescent lamps and other fixture components and replace with an LED retrofit kit that fits into the existing housing.

New Luminaires

Replace the entire fluorescent luminaire or fixture, including the housing, with a new LED luminaire.

Upgrading Linear Fluorescent Fixtures to LED in Schools

Read "Upgrading Linear Fluorescent Fixtures to LED in Schools" for more information on the following topics:

What are the initial and ongoing costs?

Consider the upfront equipment and labor costs, as well as the ongoing replacement and maintenance costs.

TLEDs

Lowest equipment cost.

Some require an electrician to install.

Ongoing costs may include fluorescent ballasts, LED drivers, and TLED lamps.

Retrofit Kits

Costs vary – compare to other options.

Requires an electrician to install.

Ongoing costs may include LED drivers or entire retrofit kit replacement.

New Luminaires

Highest equipment cost, not always prohibitive.

Requires an electrician to install.

Ongoing costs may include LED drivers or entire luminaire replacement.

Will the upgrades affect the lighting quality in our school?

Yes. It is important to evaluate the amount of light, the light distribution, the color quality and appearance of the light, as well as quality concerns like glare or flicker. Consider dimming to enhance teacher control of the classroom. Products may vary, but typically new luminaires and retrofit kits will have a better quality of light compared to fluorescent lamps or TLEDs.

Will we save energy? What about lighting controls?

Compared to fluorescent lighting systems, upgrading to LED can reduce lighting energy consumption between 20 and 60%. Because the fixtures are designed to optimize LED source performance, retrofit kits and new luminaires have greater energy savings potential than TLEDs, which utilize the existing fluorescent fixture housing.

Lighting controls like occupancy sensing or scheduling can further reduce lighting energy consumption by turning light off or reducing output when the space is unoccupied. Generally, retrofit kits and new luminaires offer greater control capabilities.

How do the existing conditions in our school affect our decision?

If your existing equipment is in poor condition, your upgrade options may be limited to retrofit kits or new luminaires which do not rely on existing sockets or fluorescent ballasts. Depending on the type of TLED, sockets may need to be replaced as part of the upgrade regardless of their condition.

If your existing lenses are cracked or yellow or the housing interior is scratched or worn it may be time to replace these components.

Some upgrades will require access into the ceiling plenum, particularly if you are installing new luminaires. Consider the potential health hazards if asbestos is present. New luminaires may not be a viable solution.

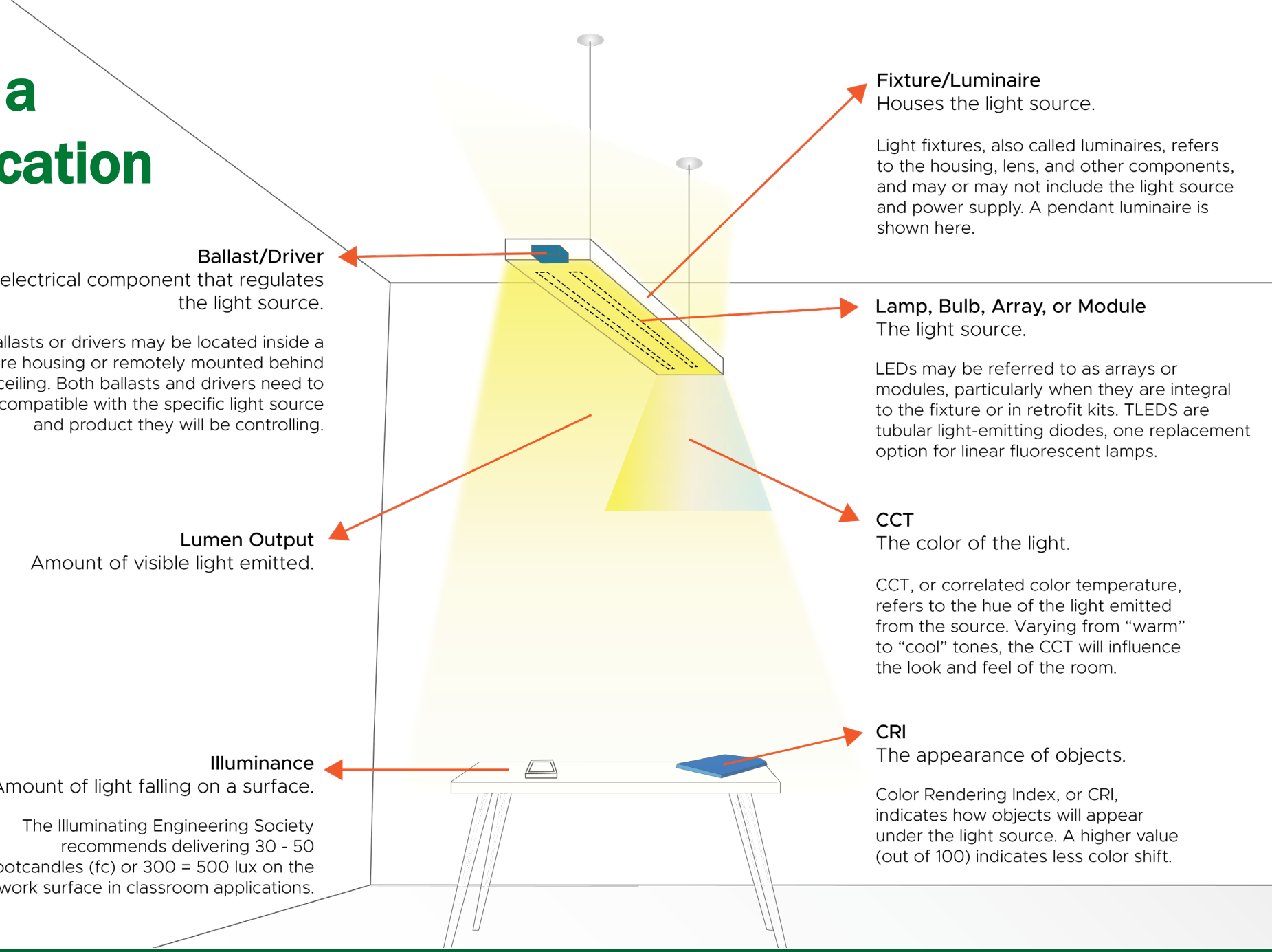
1 Terminology & Definitions

Components of a Lighting Specification

Good quality lighting provides an appropriate amount of light for tasks, enhances the environment, and increases occupant comfort.

Unfortunately, poor quality lighting can produce the opposite effects. School lighting causing glare, flicker, or other visual discomfort can lead to headaches, eye strain, or other negative effects.

The following definitions and specification considerations provide guidance towards achieving high-quality school lighting.



Ballast/Driver
An electrical component that regulates the light source.

Ballasts or drivers may be located inside a fixture housing or remotely mounted behind the ceiling. Both ballasts and drivers need to be compatible with the specific light source and product they will be controlling.

Lumen Output
Amount of visible light emitted.

Illuminance
Amount of light falling on a surface.

The Illuminating Engineering Society recommends delivering 30 - 50 footcandles (fc) or 300 = 500 lux on the work surface in classroom applications.

Fixture/Luminaire
Houses the light source.

Light fixtures, also called luminaires, refers to the housing, lens, and other components, and may or may not include the light source and power supply. A pendant luminaire is shown here.

Lamp, Bulb, Array, or Module
The light source.

LEDs may be referred to as arrays or modules, particularly when they are integral to the fixture or in retrofit kits. TLEDS are tubular light-emitting diodes, one replacement option for linear fluorescent lamps.

CCT
The color of the light.

CCT, or correlated color temperature, refers to the hue of the light emitted from the source. Varying from "warm" to "cool" tones, the CCT will influence the look and feel of the room.

CRI
The appearance of objects.

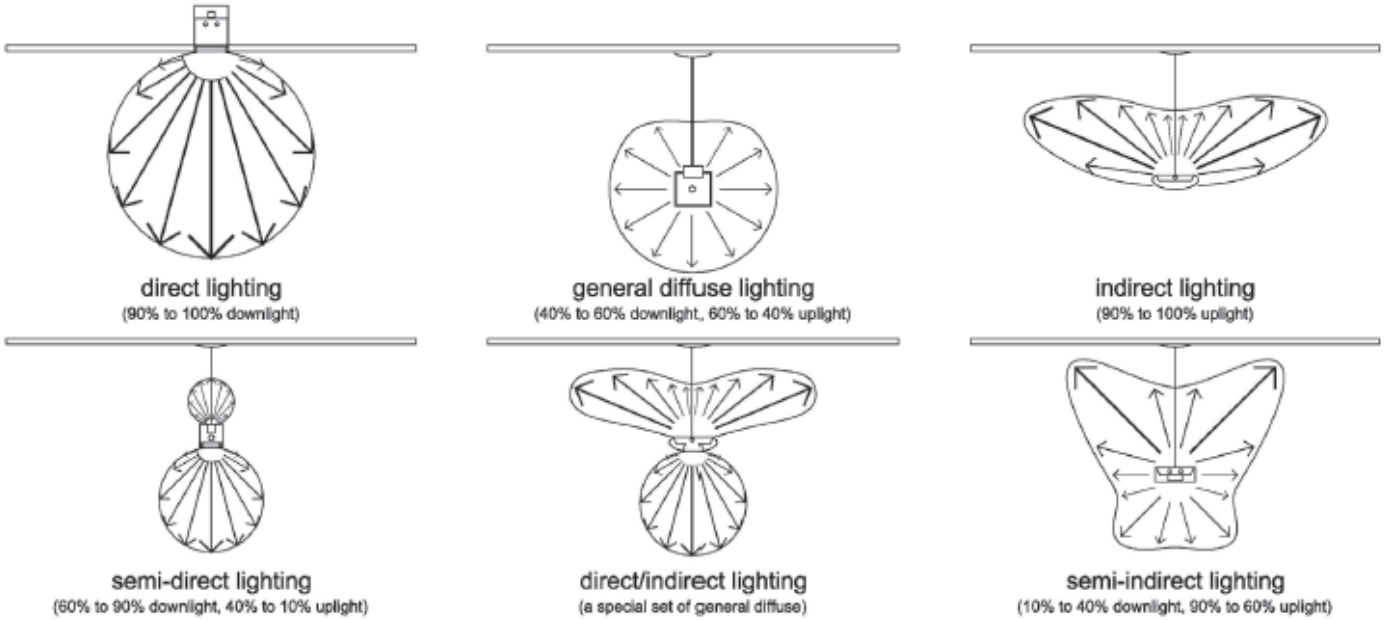
Color Rendering Index, or CRI, indicates how objects will appear under the light source. A higher value (out of 100) indicates less color shift.

Definitions – Light Output

Term	Definition	Specification Considerations
Efficacy	The ratio of light produced to energy consumed. It's measured as the number of lumens produced divided by the rate of electricity consumption (lumens per watt).	
Illuminance	Indicates the light intensity on a surface per unit area. It is measured in footcandles (fc). 1 fc = 1 lumen/square foot.	Target illuminance levels are achieved by selecting an appropriate lumen output, fixture spacing, and distribution.
Lumen / lumen output	A measurement of light emitted by a lamp.	Although some traditional technologies expressed light output in watts (e.g., 60 W incandescent), lumens are the unit of light. This value is a key component to a successful specification and providing an appropriate light level. For reference, a 100-watt incandescent lamp emits about 1,600 lumens and a four-foot 32-watt fluorescent lamp emits around 2,800 lumens.

Definitions – Light Distribution

Term	Definition
Direct lighting	Lighting involving luminaires that distribute 90% to 100% of the emitted light in the general direction of the surface to be illuminated. The term usually refers to light emitted in a downward direction.
General diffuse lighting	Lighting that is projecting in all directions.
Indirect lighting	Lighting involving luminaires that distribute 90% to 100% of the emitted light upward.
Direct/indirect lighting	Lighting involving luminaires that distribute light both downward and upward. The percentage of light emitting upward or downward is flexible.



International Commission on Illumination (CIE) classifications for luminaires.

Definitions – Fixture Types

Term	Definition
Downlight	A small direct-lighting unit that directs the light downward and can be recessed, surface mounted, or suspended.
Flush mounted or recessed luminaire	A luminaire that is mounted above the ceiling with the opening of the luminaire level with the surface. The light is directed downward.
Pendant	A luminaire that is hung from a ceiling by supports. Pendants can have a variety of light distributions: direct only, indirect only, or direct/indirect.
Troffer	A recessed lighting unit usually installed with the opening flush with the ceiling and distribute light downward. The term is derived from “trough” and “coffer.”
Strip light	A strip light luminaire typically has 1 or 2 exposed lamps which allow light to be distributed in all directions.
Surface mounted luminaire	A luminaire that is mounted directly on a wall or on the ceiling and distributes light downward.
Wrap around	Wrap around fixtures have a lens that curves around the sides and across part of the top of the fixture. The light distribution is mostly downward but includes some uplight as well.

Definitions – Lighting Quality

Term	Definition	Specification Considerations
Color rendition	Color quality, or how colors appear when illuminated by a light source. Color rendition is generally considered to be a more important lighting quality than color temperature. Most objects are not a single color, but a combination of many colors, and certain light sources may change the apparent color of an object.	The most common metric used to communicate color rendition is Color Rendering Index (CRI). CRI varies between 1 and 100. A higher value means that the color of objects appears natural and without color shift. Specifications typically list a minimum CRI threshold (e.g., 80 for interior applications) that is acceptable for most applications; however, it is always acceptable to exceed the minimum suggested CRI for greater color quality.
Correlated color temperature (CCT)	For light sources, the appearance or hue of the light source is defined as a temperature in Kelvin. The scale is based on the absolute temperature of a blackbody radiator and for commercial lighting applications typically ranges from 2,000 – 7,000 K.	In addition to CRI, CCT will influence the look and feel of a space. Higher values indicate a cooler color and lower values indicate a warmer color. It is best practice to select one CCT to use in all interior spaces. Most interior spaces in the U.S. use 3,000 – 4,000 K sources.
Tunable white	A form of spectral tuning used to vary the CCT of a white light source.	
Flicker	Flicker is the rapid variation in light source intensity, which can cause visual effects ranging from uncomfortable or distracting to harmful or (rarely) dangerous.	At present, there is not a straightforward way to evaluate the risk of flicker during the specification process. It can be helpful to evaluate the product in place prior to a large procurement.
Glare	The excessive brightness from a direct light source that makes it difficult to see what one wishes to see. A bright object in front of a dark background usually will cause glare. Bright lights reflecting off a television or computer screen or even a printed page produce glare. Intense light sources are likely to produce more direct glare than large fluorescent lamps. However, glare is primarily the result of relative placement of light sources and the objects being viewed.	Similar to flicker, evaluating glare during the specification process can be challenging because the sensation of glare is contextual. Avoid exposed or unshielded lamps.

Definitions – Lighting Controls Terminology

Term	Definition	Specification Considerations
Lighting zone	Any number of individual luminaires in a space that, when combined, form a logical control group.	For most projects, the existing wiring will determine the lighting zones, or lighting that can be switched on and off together. If you want to change the lighting zones, you will need to rewire the fixtures or install wireless lighting controls.
Time switch or timeclock	A time switch is a clock-operated switch programmed to turn lighting on and off for selected periods. An astronomical time switch control automatically compensates for local sunrise and sunset times across the year.	
Occupancy sensing	Occupancy sensing turns lights on, off, or reduces output automatically when a space is occupied or unoccupied.	
Daylight-responsive-controls	Daylight-responsive control – prioritizing daylight by dimming electric light – is mandated by energy codes for many interior spaces. Photosensors adjust electric lighting to maintain the contribution of electric light and daylight so that the horizontal illuminance does not drop below a target level.	
Networked lighting controls	Networked lighting controls are systems where individual lighting elements are interconnected through a digital network, enabling centralized management and automation.	
User interface	User interfaces can include wall switches, remote control devices, scene controllers, touchscreens, central computer-based systems, or software-based control.	The operation of user interfaces varies between manufacturers. User interfaces should be clearly labeled and as intuitive as possible.
LED driver	A device composed of a power source and LED control circuitry designed to operate an LED package, an LED array, or an LED lamp.	TLEDs, retrofit kits, and new luminaires all require a driver. With any replacement option, the driver may be integral to the product or mounted externally. The driver is also responsible for dimming LEDs and compatibility with other control equipment or existing equipment is important.

2 Scope & System Description

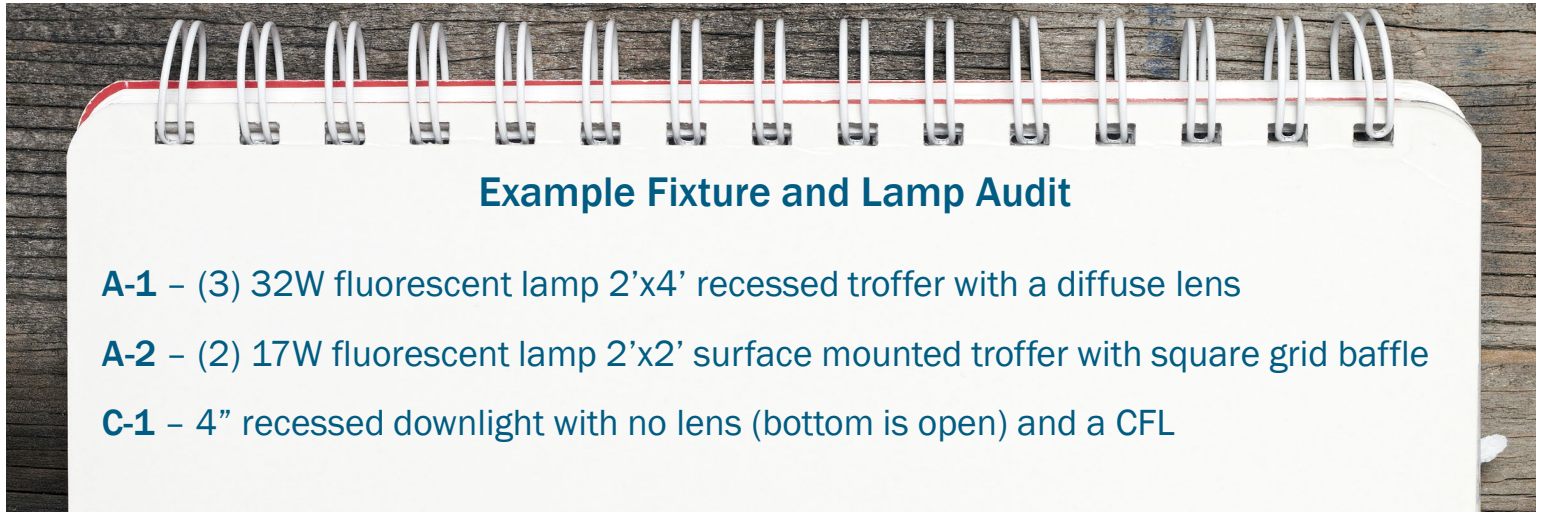
Assess Existing Equipment and Describe System

The first step towards replacement is to understand the current system.

To do so, make a list of all the unique light fixtures and lamps. You may decide to organize this by school, or at the district level. In lighting, it is common practice to give each fixture and lamp type a unique identifier. Begin the audit by creating a list of all the light fixtures and lamps along with a brief plain language description. If it is helpful, you may decide to follow the naming scheme shown to the right.

- **A-series (A-1, A-2, A-3…):** Troffers
  - Fixtures that are different sizes or with unique lens/louver/baffle should each have a unique identifier within the appropriate series.
- **B-series:** Pendants
- **C-series:** Downlights
- **D-series:** Recessed Linear
- **E-series:** Track Lighting
- **F-series:** Accent Lighting and Task Lights

For any other fixture types, continue alphabetically (G, H, I…) as needed.



Assess Existing Equipment and Describe System

After generating a master fixture list, collect the following information on a room-by-room basis.

The table below can be used as a template for assessing the existing condition of the lighting system.

Room	Fixture Quantity & Type	Condition of Equipment																	
		Lighting Functionality			Evidence of Power Failure		Ballast	Socket/Wiring			Interior Fixture Surfaces			Lens or Louver			Ceiling Access		
		Appears adequate; no perceived flicker	Lamps out; light level reduced	Hum or noise present; flicker present	Yes	No	Age; Condition; Type	Like new	Some wear; no major cracks	Looks old or blackened; cracks apparent; exposed or degraded wiring	Clean and white	Slightly worn; no major scratches or peeling paint	Very worn; scratches in paint or peeling paint	Like new; very little or no wear apparent	Some minor color variations or scratches	Looks old; obvious cracks or yellowing	No concerns working above the ceiling; easy access	Some concerns working above the ceiling; limited access	Working above the ceiling should be avoided
Room 101 - Classroom	12 A-1			X		X	< 5 years; like new; ELV	X											X
	3 F-1		X			X	7 years; replace	X							X				X
Room 102 - Restroom	9 C-1	X				X		X									X		
First Floor Hallway	35 A-2	X				X		X										X	

Scope of Work

Based on the condition of the existing equipment and considering other factors, the next step is to decide what you want to replace and the timeline for completing the work.

Other factors, such as initial and ongoing costs, are discussed in "Upgrading Linear Fluorescent Fixtures to LED in Schools."

Upgrade Path

Your upgrade options may be straight forward or limited based on your assessment of the existing conditions. However, if you are unsure whether a lamp replacement, retrofit kit, or new fixture is most appropriate, consider taking the next step by reviewing actual products and comparing price information and product availability.

Project Timeline and Scheduling

Due to the nature of the building use, scheduling renovation work for schools can be challenging. Lighting renovations may be just one part of a larger scope of work, may be completed as a standalone renovation, or can even be phased over a longer period of time. While the timeline is extended, phasing the renovation either by classroom or wing of a building helps to isolate the area under construction and spread out the cost of installation. Within a school district, you may decide to focus on classrooms first, complete one school or building at a time, or complete the entire renovation at once over the summer or during evenings and weekends.

Regardless of your approach, it can be advantageous to complete one or several pilot installations to compare products in place. With LED light sources, variation product to product can result in a variety of compatibility issues as well as color quality or simply preference at the same price point. Visually reviewing the products in place ahead of time allows you to refine the general approach, installation process, or product selection prior to completing the entire renovation.

3 Materials for Procurement

Materials for Procurement

Assembling digital or printed materials for procurement will not only help you stay organized during the renovation process but will also be useful during maintenance and operation. These materials typically include a fixture or lamp list as well as technical manufacturer product literature.

After you have summarized the existing equipment and determined the project scope, you can begin reviewing the quality and performance of different products. Leveraging the master fixture or lamp list you created during the inventory process, create a spreadsheet detailing the replacement lamp, retrofit kit, or new luminaire upgrade solution for each unique fixture type. Table 2 provides an example of the type of information to include in the fixture list and where you might find the information. The baseline performance criteria in Part 4 will address the relevant criteria in this table.

Collect the following items to stay organized during a lighting upgrade or renovation:

- Floor plans and lighting layouts, as available
- Fixture and lamp inventory list
- Manufacturer product specification sheet and installation instructions
- Replacement solution spreadsheet and summary

Materials for Procurement – New Product Information

Collect the information shown in the table on the right for each of the products you want to purchase. Much of the information comes from reviewing manufacturer product specification sheets online. Be sure to save the product specification sheets that are ultimately procured and installed in your school district. Keeping a record of the specific product, including the product number can assist during troubleshooting, repair, or future replacement.

Decision-makers from the school may need to provide input on some items, such as CCT, which will influence the visual appearance of the space. CCT and other options (e.g., lens, accessories, etc.) for each product will be listed on the specification sheet.

Criteria	Information Source	Fixture Type 1…	Fixture Type 2…
Description	Manufacturer Product Information (MPI)		
Quantity	Scope of Work		
Dimensions	MPI		
Product Number	MPI		
Price	MPI /Distributor		
Manufacturer	MPI		
Mounting	MPI		
Lumen Output	Options listed on MPI, value depends on existing installation		
Voltage	Options listed on MPI, value depends on existing installation		
Light Source/Lamp	Will reflect upgrade path (lamp, retrofit kit, new luminaire). Options listed on MPI		
Wattage	MPI		
Rated Life (Hours)	MPI		
Dimming Performance	MPI		
Optics	MPI		
CCT	School Input, options listed on MPI		
Color Rendering Index	School Input, options listed on MPI		
Finish	School Input, options listed on MPI		
Accessories/Options	School Input or MPI, use as needed		
Special Coordination	School Input or MPI, use as needed		
Notes	School Input, use as needed		

Information to include in a lighting fixture or lamp specification. Most of the information is summarized from Manufacturer Product Information (MPI), but other details will depend on the existing conditions (e.g., voltage) or will require input from school decision makers (e.g., finish/aesthetics, CCT).

Consider a Mock-up Installation or Pilot Classroom

In the event you find multiple suitable replacement options or want to decide between retrofit kits or new luminaires, purchase a few and have them installed in a pilot classroom.

If possible, observe the installation process as well to understand how easy or difficult the upgrade will be and what future maintenance might entail.

It is also important to visually evaluate the products in place, as lighting quality considerations such as flicker or glare can be hard to navigate without seeing at the installed product. Invite others to visit the pilot classroom and share their opinions on the amount of light, the color of the light (CCT), and how comfortable the lighting is.

A pilot classroom in an elementary school in Texas. The school wanted to try new tunable luminaires and installed them in one classroom for evaluation prior to completing the rest of the lighting upgrade. Photos courtesy of Acuity Brands Lighting.

Executing the Upgrade

After the final product selections have been made, create a simple table outlining the replacement strategy. This may include the existing products, the replacement solution, typical room or school locations, and any project phasing information if appropriate.

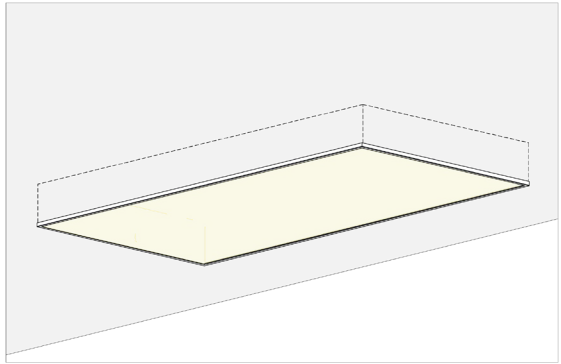
Existing Equipment	Replacement Equipment	Quantity	Typical Locations	Project Phase
A-1 (3 lamp 2x4 recessed troffer) →	New Luminaire (remove existing housing, lamps, ballast, and lens)	250 School A 145 School B	Classrooms	Phase 1 – Summer 2024 (All schools)
C-1 (2 lamp 2x2 recessed troffer) →	Type B TLED Lamp Replacement (electrician to rewire fl. ballast directly to sockets)	40 School A 68 School B	Offices, support spaces	Phase 2 – Winter Break 2024 (All schools)
C-1 (4” recessed downlights) →	Retrofit Kit (remove existing housing and other fixture components)	75 School A 104 School B	Hallways, lobbies, cafeteria	Phase 2 – Winter Break 2024 (All schools)

4 Interior Lighting Fixtures

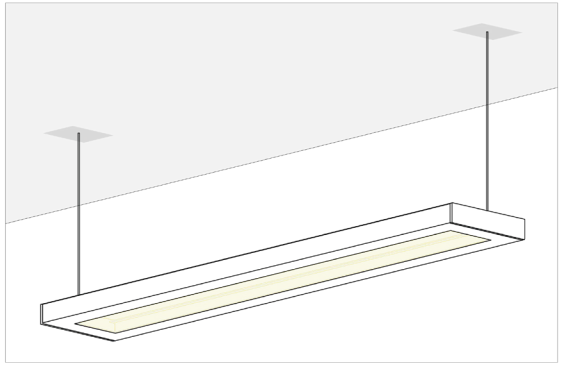
Linear Fluorescent Replacement

Fixtures with linear fluorescent lamps can be found in nearly every commercial building in the country, and schools are no exception. Linear fluorescent lamps are commonly installed in troffer fixtures, pendants, strip lights, and wrap around fixtures. Each of these fixtures generally houses 1 to 4 fluorescent T5, T8, or T12 lamps. T8 fluorescent lamps are the most common, followed by T5 and T12 lamps.

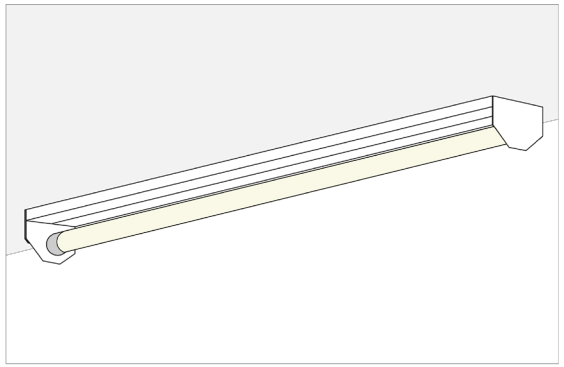
There are several replacement options for these types of fixtures, which include lamp replacement, retrofit kits, and installing entirely new fixtures. Retrofit kits and new fixtures will be the most efficient because the housing and other components are optimized for an LED light source.



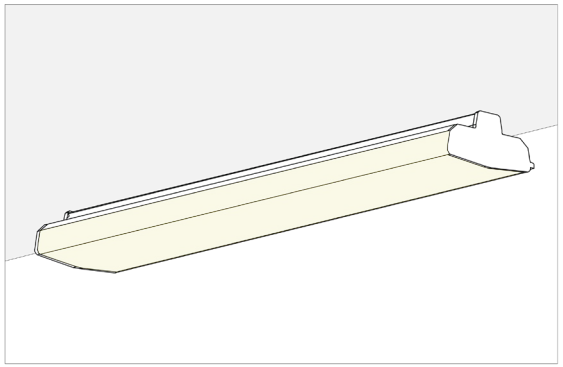
Troffer



Pendant



Strip Light



Wrap Around

Linear Fluorescent Replacement

General Notes for Replacing Linear Fluorescent Fixtures or Lamps

- For retrofit kits and new luminaires, select products with field replaceable components, such as the LED driver, whenever possible.
- Select as many fixtures that use the same light source type as possible. Fewer source types simplify maintenance and replacement and reduce storage costs.
- Some TLEDs have a variable lumen or CCT output that is modifiable via a switch on the lamp. This can be a simple approach to finding a suitable solution for a variety of spaces and minimizing the number of different lamps you need to keep on hand.
- Select “generic” looking fixtures and lenses in case you need to replace in the future and cannot replace with the same product. Avoid highly specific shaped housings or odd lens patterns that may be difficult to match or upgrade when fixtures fail in the future.
- Some existing linear pendants with indirect and direct lighting components may not be suitable for TLED replacement due to the more complicated optical design. These fixtures are intended to direct light toward the ceiling as well as toward the room. A new luminaire may be the best upgrade option.

Linear Fluorescent Replacement

Criteria	Type A TLED	Type B TLED	Type C TLED
Description	Replacement lamp with integral LED driver – must be compatible with fluorescent ballast.	Replacement lamp with integral LED driver.	Replacement lamp with external LED driver.
Mounting	Existing fixture housing to remain. The existing housing may be recessed, surface-mounted, or pendant/suspended.		
Lumen Output	Assume a 4-foot fluorescent lamp has an ouput between 2,500 and 2,800 lumens. Minimum efficacy of a bare lamp (typically reported) should be ~95 - 100 lm/W.		
Light Source/Lamp	Tubular LED Replacement Lamp		
Rated Life (Hours	Minimum 35,000 (fluorescent varies between 24,000 and 40,000)		
Dimming Performance	N/A Products are not dimmable.	Some products are dimmable. Dimming communication may be wired or wireless.	Most products are dimmable. Dimming communication may be wired or wireless.
Optics	Look for lamps with a beam angle greater than 270°. If not available, look for lamps with at least a 180° beam angle. This is particularly important when the fixture has an uplight component that illuminates the ceiling and/or walls. If the existing fixtures have an open baffle instead of a diffuse lens, look for frosted lamps to reduce glare.		
CCT	3000 – 4000 K – Pick one value and be consistent.		
CRI	Minimum of 80 (comparable to 800 series fluorescent lamps)		
Special Coordination	Lamp MUST be compatible with existing ballast. Review manufacturer literature and test in place to confirm. Incompatible lamps will strobe or flicker.		
Notes	Include relevant emergency lighting information here. TLEDs may require external emergency solution. Require a 3-year warranty.		

Linear Fluorescent Replacement

Criteria	Retrofit Kit	New Luminaire
Description	Remove existing fluorescent ballast and lamps. Replace with a retrofit kit that includes an integral LED light source, driver, optics, and lens.	Remove entire existing fixture. Replace with a new luminaire that includes an integral LED light source, driver, optics, and lens.
Mounting	Existing housing to remain	Recessed in ceiling, surface mount, or pendant/suspended
Lumen Output	Minimum fixture efficacy should be ~115 lm/W. For equivalent light levels: Existing 2-lamp 2x2 troffer – replace with 2,000 – 3,000 lumen LED retrofit kit or luminaire Existing 1-lamp 4 ft. linear fixture – replace with 1,000 – 1,500 lumens Existing 2-lamp 4 ft. linear fixture – replace with 2,500 – 4,000 lumens Existing 3-lamp 4 ft. linear fixture – replace with 3,000 – 5,000 lumens Existing 4-lamp 4 ft. linear fixture – replace with 5,000 – 7,000 lumens	
Light Source/Lamp	Integral LED module or array	
Rated Life (Hours)	Minimum of 50,000	
Dimming Performance	Where dimming is required, the LED driver, LED light source, and dimmer switch must be compatible. Review manufacturer documentation and/or test in place.	
Optics	Diffuse lens	
CCT	3000 – 4000 K – Pick one value and be consistent!	
CRI	Minimum of 80	
Special Coordination		Verify that there is enough room above the ceiling to accommodate the depth of the fixture housing.
Notes	Require a 10-year warranty	

Downlight Replacement

General Notes for Replacing Downlights

Downlights may be present in schools as accent fixtures, in lobbies, restrooms, or corridors. Existing downlights will most likely have a replaceable lamp installed in a recessed housing; however, keep in mind that LED lamps may produce a different distribution or output and may operate less efficiently because the housing was designed for a different lighting technology. Retrofit kits or new luminaires will be the most efficient, have the lowest maintenance, and longest lifetime.

- Retrofit kits for downlights may or may not utilize the existing fixture housing. Some products have an adapter to screw directly into the existing socket and can be easily installed without an electrician if the existing equipment is in good condition.
- Retrofit kits for downlights may also be called “inserts,” as the new, lightweight fixture is simply inserted into the existing aperture and rests on the ceiling.
- A new luminaire may require modification to the ceiling because it may have a larger housing and will most likely require an electrician to wire the new fixture.
- Many retrofit LED lamps are not rated for enclosed luminaires. Check lamp specifications prior to installation if the downlights have a lens.

Downlight Replacement

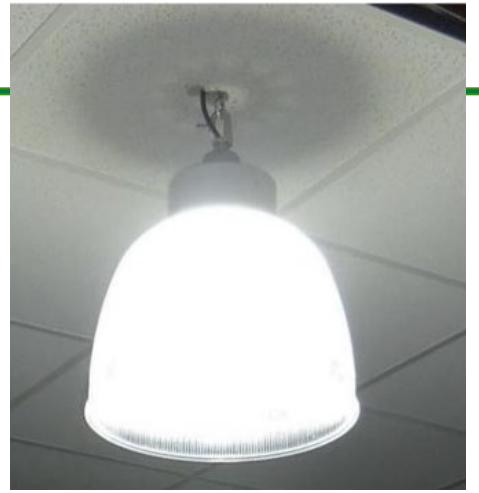
Criteria	Replacement Lamp	Retrofit Kit	New Luminaire
Description	Replacement lamp that is installed in the existing housing.	New light source and driver that may or may not leverage the existing fixture housing/socket.	A new fixture, including housing, driver, and light source.
Mounting	Recessed, Semi-recessed, or surface mount (wall or ceiling)		
Lumen Output	Guidelines for replacing existing lamps: 25 W incandescent – replace with 250–450 lumen LED lamp or fixture 40 W – replace with 450 – 800 lumens 60 W – replace with 800 – 1,100 lumens 75 W – replace with 1,100 – 1,600 lumens 100 W – replace with 1,600 – 2,000 lumens	Guidelines for retrofit kits or new luminaires: Specify a lumen output of half to two-thirds of the existing incandescent lamp lumen output shown to the left. For example, if your existing downlights use a 60W incandescent lamp, specify a fixture or kit with a lumen output between 400 and 550 lumens.	
Light Source/Lamp	Lamps will most likely require a screw base or pin base – confirm existing equipment.	Integral LED light source and driver. Most are not field replaceable and the entire fixture will need to be replaced at the end of life.	
Rated Life (Hours)	Minimum 15,000	Minimum 25,000	
Dimming Performance	Where dimming is required, the LED driver, LED light source, and dimmer switch must be compatible. Review manufacturer documentation and/or test in place.		
Optics	Optics inherent to existing equipment. Specific lamp selection may yield a different outcome compared to the existing technology.	Downlights are available in a variety of light distribution angles such as narrow, flood, or wide flood. Narrow distributions will produce a small, concentrated beam of light on the floor compared to wider distributions which will produce a softer beam of light and may light walls or other nearby vertical surfaces.	
CCT	3000 – 4000 K – Pick one value and be consistent!		
CRI	Minimum of 80		
Notes	Require a 3-year warranty	Require a 10-year warranty	

Gymnasium Lighting Replacement

General Notes for Gymnasium Lighting

Depending on the size of the gymnasium space, the light fixtures most likely fall into a high-bay or low-bay category. Ceilings under 25 feet are typically considered low bay. In either case, retrofit kits that reuse the existing housing or new fixtures are available to replace these fixtures.

- For either retrofit kits or new luminaires, carefully review the light distribution in comparison to the existing system. Some gymnasium fixtures direct light towards the ceiling in addition to the floor. You will want to replicate that distribution with your fixture replacement. Because LEDs are not omni-directional, some products have a solid backing and will not distribute light upward. **(See photos to the right)**
- Some existing gymnasiums may have multi-lamp linear fluorescent low-bay fixtures. TLED replacement may be appropriate for these linear fixtures. Consider Type C TLED replacement for fixture with more than two lamps. See Section 4.1 for TLED performance criteria.
- New fixture options allow for integrally mounted occupancy sensors, photocells, emergency lighting, and dimming.
- Consider wire guards in addition to an impact resistant lens to protect light fixtures.



Existing fixture distributes light towards the ceiling.

Retrofit kit has a solid backing and no longer illuminates the ceiling.

Gymnasium Lighting Replacement

Criteria	TLED	Retrofit Kit	New Luminaire
Description	Type A, B, or C TLED. Replace the existing fluorescent lamps with TLED lamps.	Existing housing to remain. Remove other electrical components from existing fixture. Replace with retrofit kit that includes an integral LED light source, driver, optics, and lens.	Remove entire existing fixture. Replace with a new luminaire that includes an integral LED light source, driver, optics, and lens.
Mounting	Existing fixture housing to remain. The exiting housing may be recessed, surface-mounted, or pendant/suspended.		
Lumen Output	Assume a 4-foot fluorescent lamp has an output of 2,800 lumens. Minimum efficacy of a bare lamp (typically reported) should be ~95 - 100 lm/W.		
Light Source/Lamp	Tubular LED Replacement Lamp	Integral LED light source and driver. Most are not field replaceable and the entire fixture will need to be replaced at the end of life.	
Rated Life (Hours)	Minimum of 50,000		
Dimming Performance	If dimming is required, consider a retrofit kit or new luminaire.	Where dimming is required, the LED driver must be compatible with the LED light source. Review manufacturer documentation and/or test in place. Dimming communication may be wired or wireless.	
Optics	Consider a diffuse lens to minimize glare.		
CCT	4000 K		
CRI	Minimum of 80		
Notes	Consider an impact resistant lens.	Consider an impact resistant lens. Require a 10-year warranty.	

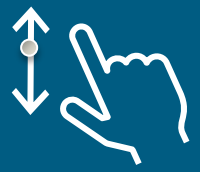
5 Lighting Controls

Lighting Controls

Virtually all energy codes in use today require some form of lighting control beyond a local switch in each room.

Always review energy codes from your local jurisdiction. Many jurisdictions reference a specific code year of ANSI/ASHRAE/IES Standard 90.1 titled, "Energy Standard for Buildings Except Low-Rise Residential Buildings" or the International Energy Conservation Code (IECC), but there may be local modifications to consider. In addition, code requirements may depend on the scope of the upgrade; see *Upgrading Linear Fluorescent Fixtures to LED in Schools* for more information. Most building energy codes require some or all of the following lighting control capabilities:

Local or Manual Control



Dimming

Occupancy Sensing

Scheduling

Daylight-responsive Control

Common Lighting Control Strategies

- **Local or Manual Control**

Each space may be required to have a local switch that can override other control strategies such as time-based schedules. Manual controls can also be the primary source of user input and lighting control in a space.

- **Dimming**

Dimming allows the occupants or other lighting control strategies to reduce the light output. Compared to other lighting technologies, LEDs are very easy to dim.

- **Time Scheduling**

Scheduling lighting to turn on, off, or dim is a commonly used control strategy in spaces with predictable occupancy patterns. Simple or highly programmable timeclocks can signal lighting to change according to the hour or day of the week. Astronomical timeclocks can automatically adjust sunrise and sunset times based on location throughout the year.

Table 3 provides some details about how to implement each of these basic control capabilities for different space types in schools.

Common Lighting Control Strategies

- **Occupancy Sensing**

Occupancy sensors turn lighting on or off in the presence or absence of people. Occupancy sensors primarily use one or both of two primary sensing technologies: Passive Infrared (PIR) or Ultrasonic. PIR sensors sense heat and temperature changes in a space to detect occupants and will not work if the line-of-sight is obstructed. Ultrasonic sensors emit sound waves (above the range of human hearing, “ultrasonic”) and look for disruption or interference with the waves to detect movement. Ultrasonic sensors do not require a clear line-of-sight to operate. Many new sensors include both sensor technologies to reduce poor operation. These sensors are referred to as “dual technology.”

Further, in interior applications occupancy sensors can operate in one of two modes: Occupancy Mode or Vacancy Mode. Using occupancy mode, the sensor automatically turns the lighting on or off when a change in occupancy is detected. Using vacancy mode, an occupant must decide to turn the lights on upon entering the space; however, the lighting will automatically be turned off after they leave. Some products provide a method to switch between operating modes in the field while others will be factory-set.

- **Daylight-responsive Control**

In interior spaces, daylight-responsive dimming uses a photocell and allows the lighting to dim or even turn off in response to available daylight. In exterior spaces, photocell sensors can be used to turn lighting off around dawn and turn lighting on around dusk.

The following table provides common strategies for implementing lighting controls for the variety of space types in schools.

Common Lighting Control Strategies

Space Type	Control Strategies
Administration/Office	Consider using occupancy sensors in vacancy mode with a 5-to-15-minute time out period.
Classroom	Consider dimming. Use occupancy sensors in vacancy mode with a 5-to-15-minute timeout. Consider separate switching for lights near the main teaching area or video displays.
Computer Lab/Media Center	Consider dimming or multiple lighting zones for audio visual displays.
Corridor	Corridors may have keyed or other local controls. Consider using occupancy sensors in occupancy mode that reduce light output to ~50% when the space is not occupied to reduce energy consumption. Consider a slightly longer timeout period of 10-20 minutes.
Gymnasium	Gymnasiums may have keyed or more secure local controls. Other control strategies such as occupancy sensing may be used as an automated way to reduce light output or turn lights off when the area is unoccupied. Use PIR sensors in occupancy mode and be sure all entrances to the gym have adequate coverage so that the lighting automatically turns on when someone enters.
Lobby	If there are any workstations in the lobby or entry area, rely on a time schedule that will reduce or turn off lighting after normal operating hours. Provide local controls to override for after-hours events.
Nurse/Support Spaces	Consider dimming.
Restroom	Use dual technology occupancy sensors that pick-up activity near the entrance and within the restroom stalls in occupancy mode with a 10-to-15-minute time out period.
Storage/Custodial	Most common to rely on local control or a timer switch that will turn lighting off after a predetermined amount of time.
Exterior	Use an astronomical timeclock or combine a photocell with a standard timeclock to ensure lights are not on during the day. Carefully consider photocell sensor location and orientation so it will not be shaded during the day. If lighting must remain on all night, it may be required by code to dim or reduce light output based on occupancy sensors or a schedule. PIR occupancy sensors are most commonly used in exterior applications.

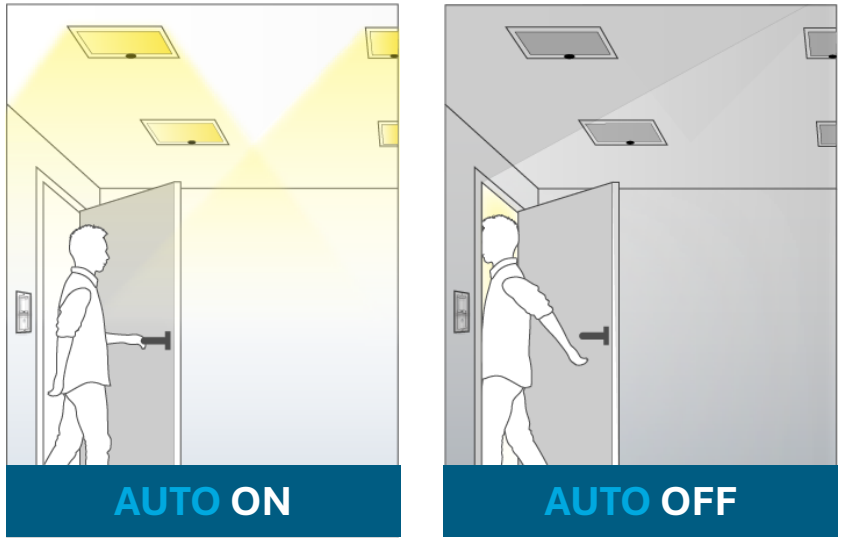
Common control strategies for space types in schools.

Common Guidelines for Occupancy Sensors

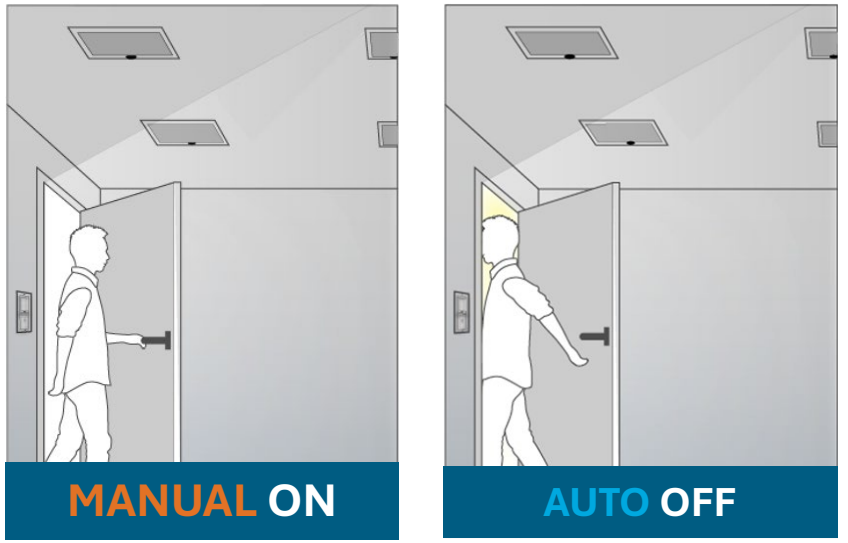
Dos and Don'ts for Lighting Occupancy Sensors

Do	Don't
Position the sensor to trigger the lighting as soon as a person enters the space.	Install sensors within 4 feet of an HVAC supply register or fan.
Always maintain an unobstructed line of sight between the sensor and task areas. No equipment should be blocking the sensor.	Use vacancy sensors in spaces like corridors or stairwells where there are many entrances and not many light switches.
Locate sensors where they can't be tampered with.	Locate wall-mounted sensors behind doors.
Use ultrasonic sensors in large open areas like a lunchroom, media center, or larger classrooms.	Install sensors to point into hallways or other spaces that may send a false trigger.
Use passive infrared (PIR) sensors in enclosed spaces.	

Occupancy sensing:



Vacancy sensing:



6 System Installation & Maintenance

System Installation

Fluorescent Disposal

For disposal information regarding mercury, refer to the U.S. Environmental Protection Agency (EPA) Mercury website: http://www.epa.gov/mercury

A fluorescent ballast may contain polychlorinated biphenyl (PCB), a hazardous substance that needs to be handled properly. Fluorescent ballasts manufactured pre-1985 probably contain PCBs. Ballasts with PCBs are magnetic, large, and heavy. In contrast, electronic ballasts typically manufactured by 1990 do not contain PCBs. Electronic ballasts are small and light weight.

Fluorescent ballasts that do not contain PCBs will have a label stating that fact. Otherwise, assume it has PCBs and dispose of equipment properly. For disposal information regarding fluorescent ballasts, refer to these EPA resources:

- https://www.epa.gov/sites/default/files/documents/PCBsInBallasts.pdf
- https://www.epa.gov/pcbs/polychlorinated-biphenyl-pcb-containing-fluorescent-light-ballasts-flbs-school-buildings

Labeling

If a unique naming convention was established, label each luminaire for easy relamping. Each lamp or fixture type should be visible once the lens is removed.

Cleanliness:

If existing equipment like lenses and or housings are being reused, thoroughly clean all interior and exterior surfaces after existing equipment has been removed.

Do not remove plastic coverings until the renovation, including a final cleaning, is finished.

System Maintenance

- After the renovation, remove or clearly separate all fluorescent lamps and other components to avoid confusion during repair or relamping. Placing a fluorescent lamp into a fixture that has been modified for Type B or C TLEDs can create a hazard. In addition, if multiple types of TLEDs are part of the lighting solution, clearly separate and label each type of lamp to avoid incorrect relamping or a hazardous situation.
- When replacing Type B TLEDs with single-sided socket connections, be sure to insert the lamp in the correct orientation. The labeled end of the lamp should be inserted into the powered sockets.
- Maintain approximately 10% stock of each lamp and/or fixture types, lenses, or diffusers.
- Add warranty information to the packet of product information and fixture list created in Part 3. Write down any schedules or control inputs that were decided during installation for future reference.
- Have a training meeting with relevant staff who will be responsible for maintaining or repairing the lighting system.

7 References & Other Resources

References & Other Resources

Design Guidance

- IES LP-4-20: Lighting Practice: Electric Light Sources – Properties, Selection, and Specification
- IES RP-3-20: Recommended Practice for Lighting Educational Facilities
- IES LP-2-20: Lighting Practice: Designing Quality Lighting for People in Outdoor Environments
- IES LP-9-20: Lighting Practice: Upgrading Lighting Systems In Commercial and Institutional Spaces
- Better Buildings Alliance (BBA) K-12 Lighting Toolkit: https://betterbuildingssolutioncenter.energy.gov/k-12-lighting-toolkit
- Collaborative for High-Performance Schools (CHPS) Criteria, available online: https://chps.net/chps-criteria
- Advanced Energy Retrofit Guide: K-12 Schools. NREL. December 2013. https://www.nrel.gov/docs/fy14osti/60913.pdf
- Pedestrian Friendly Outdoor Lighting. PNNL. December 2013. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/2013_gateway_pedestrian.pdf

Energy Codes

To find your state or territory's energy code, visit: https://www.energycodes.gov/

Lighting Performance Guidance

- The Design Lights Consortium Solid-State Lighting Technical Requirements: https://www.designlights.org/our-work/solid-state-lighting/technical-requirements/ssl-v5-1/
- BBA LED Site Lighting Performance Specification V1.3. 2012. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/led-site-lighting-performance-specification.pdf

Financing

- Affordable Zero Energy K-12 Schools: The Cost Barrier Illusion. NREL. December 2021. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/80766.pdf
- Financing Energy Upgrades for K-12 School Districts. LBNL. April 2013. https://www1.eere.energy.gov/wip/solutioncenter/pdfs/financing_energy_upgrades_k-12.pdf

Definitions

Definitions of common lighting and specification terminology are provided above with practical guidance for using the terms when selecting fixtures or lamps.

For more information or for a term that may not be listed, review the following resources:

- EnergySaver Lighting Principles and Terms
  - https://www.energy.gov/energysaver/lighting-principles-and-terms
- Midwest Energy Efficiency Alliance (MEEA) Lighting Glossary
  - https://www.mwalliance.org/lighting-terminology-glossary
- ANSI/IES LS-1-22 Lighting Science: Nomenclature and Definitions for Illuminating Engineering
  - https://www.ies.org/standards/definitions

Lighting Specification Guidance for Schools

For more information, visit:

energy.gov/eere/ssl

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