

Codes and Controls 2.0

How lighting controls help meet commercial building energy code requirements in ASHRAE 90.1-2013, IECC 2015, and Title 24 2016



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Learning Objectives

- By reviewing U.S. Department of Energy data, the participant will be able to describe the importance of energy conservation in buildings and how light control significantly helps.
- Using several light control strategies, the participant will be able to explain how light control saves energy in commercial buildings.
- By reviewing commercial building energy codes requirements, the participant will be able to determine how light control helps meets those requirements.
- Through examination of the provided real world case studies, the participant will be able to describe how they used lighting controls to save energy.

Big picture – efficiency and conservation

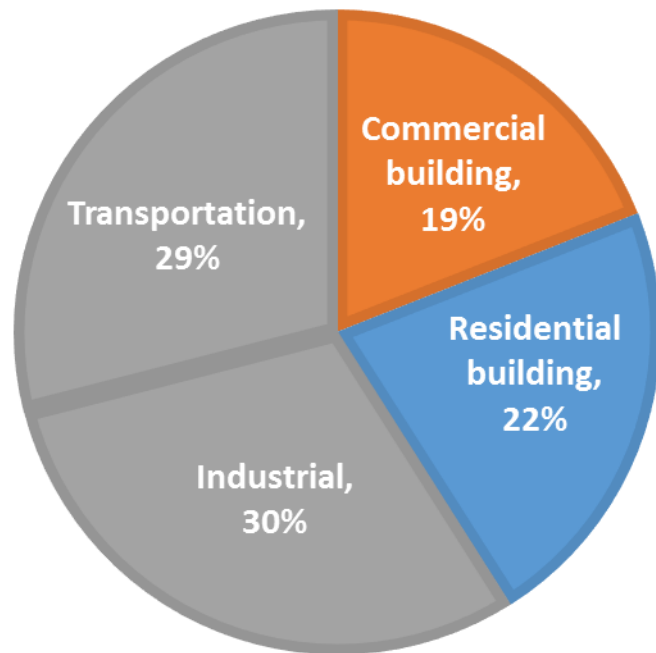
*"**Efficiency** is going to be a big focus going forward. I just don't see the solutions to our biggest energy and environmental challenges without a very big demand-side response. That's why it's important to move this way, way up in our priorities."*



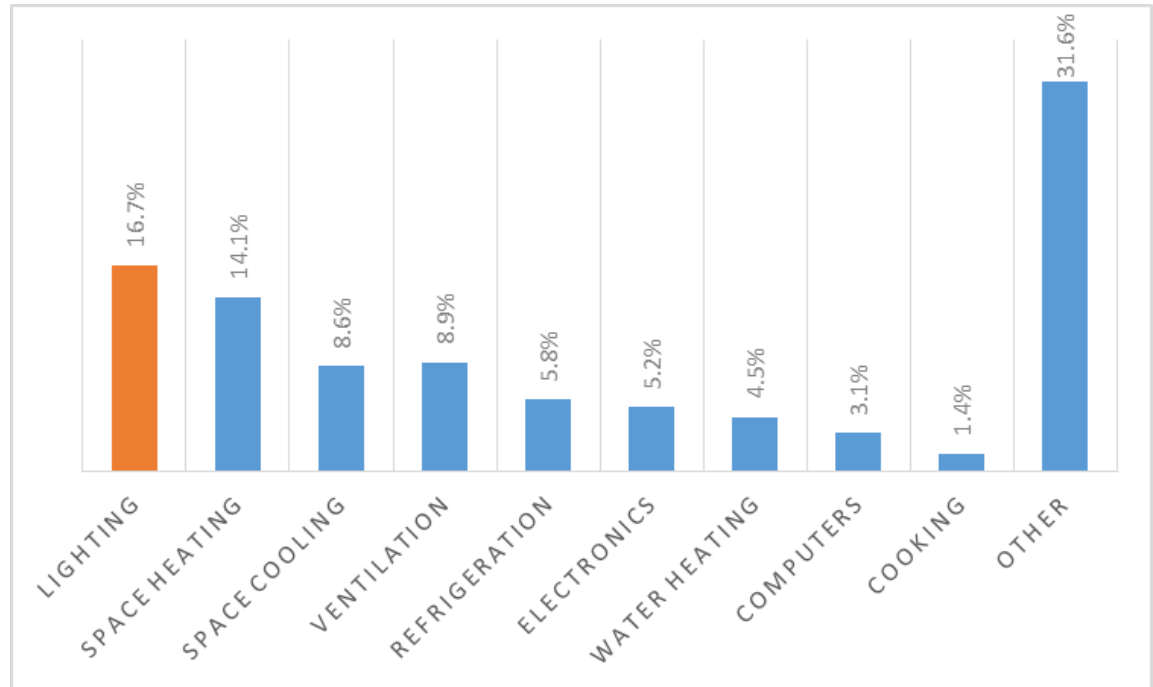
Dr. Ernest Moniz
Past U.S. Secretary of Energy

Lighting is the lowest hanging fruit

All buildings consume 41% of total U.S. primary energy



Commercial building primary energy by end use



Problem: Wasted lighting energy

Buildings:

- Are over-illuminated
- Don't take into account daylight
- Leave lights on in vacant spaces or after operating hours
- 75% were built before 1989



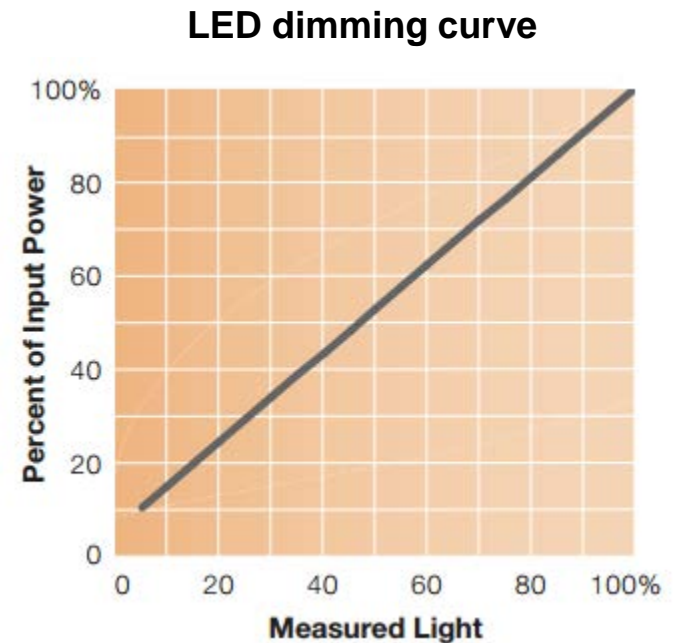
What's wrong with this picture?

“Most buildings don’t deliver the right amount of light where and when it is needed. Lighting is often set at a ‘worst case’ level, which is usually higher than desired.” -- Stephen Selkowitz LBNL

Solution: Light control

Primary ways light control saves energy:

1. Reduces operating hours (switching off)
2. Reduce watts used when lights are on (dimming)
3. Reduces cooling load
4. Maximizes effective use of sunlight



More than energy savings

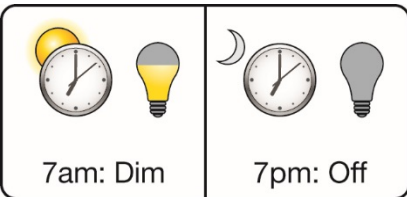
“Zero energy buildings that provide zero comfort or zero productivity increases to the occupants are of zero value”

Kevin Kampschroer
Director, Office of Federal High-
Performance Green Buildings

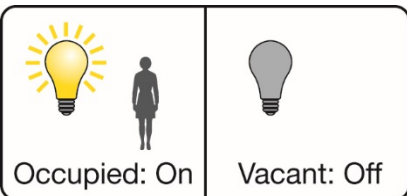


Source: Luncheon on Net Zero Energy Buildings at the House of Representatives in Washington D.C., June 18, 2010.

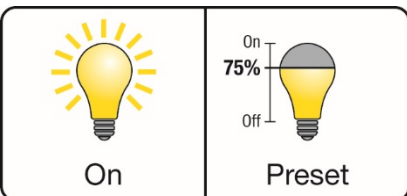
Light control strategies



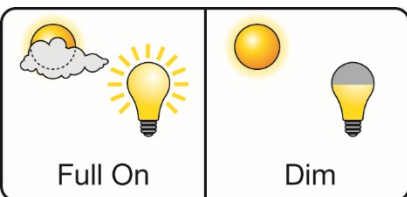
Scheduling: Lights automatically turn off or are dimmed at certain times of the day or based on sunrise or sunset.



Occupancy/Vacancy Sensing: Automatically turning lights off when people vacate the space.

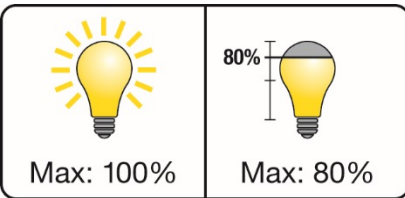


Multi-level Lighting/Dimming: Providing users one or more light levels than full-on and full-off.

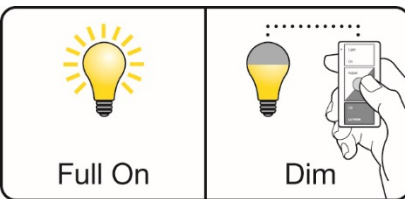


Daylight Harvesting: Automatically adjust light levels based on the amount of daylight in the space.

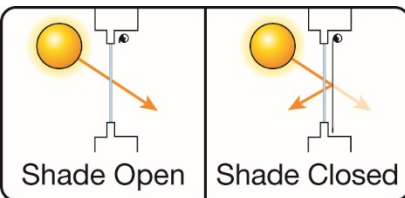
Light control strategies



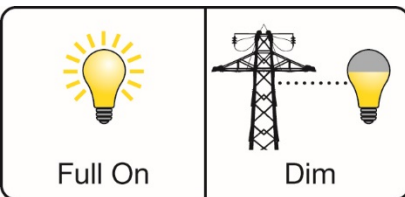
High end trim/Tuning: Set target light level based on occupant requirements in the space.



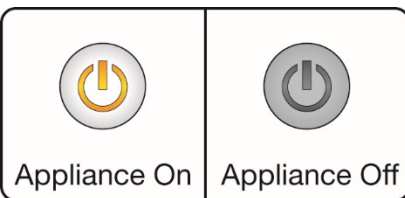
Personal Light Control: Allow users in the space to select the correct light levels for the desired task.



Controllable Window Shades: Allows users to control daylight for reduced solar heat gain and glare.

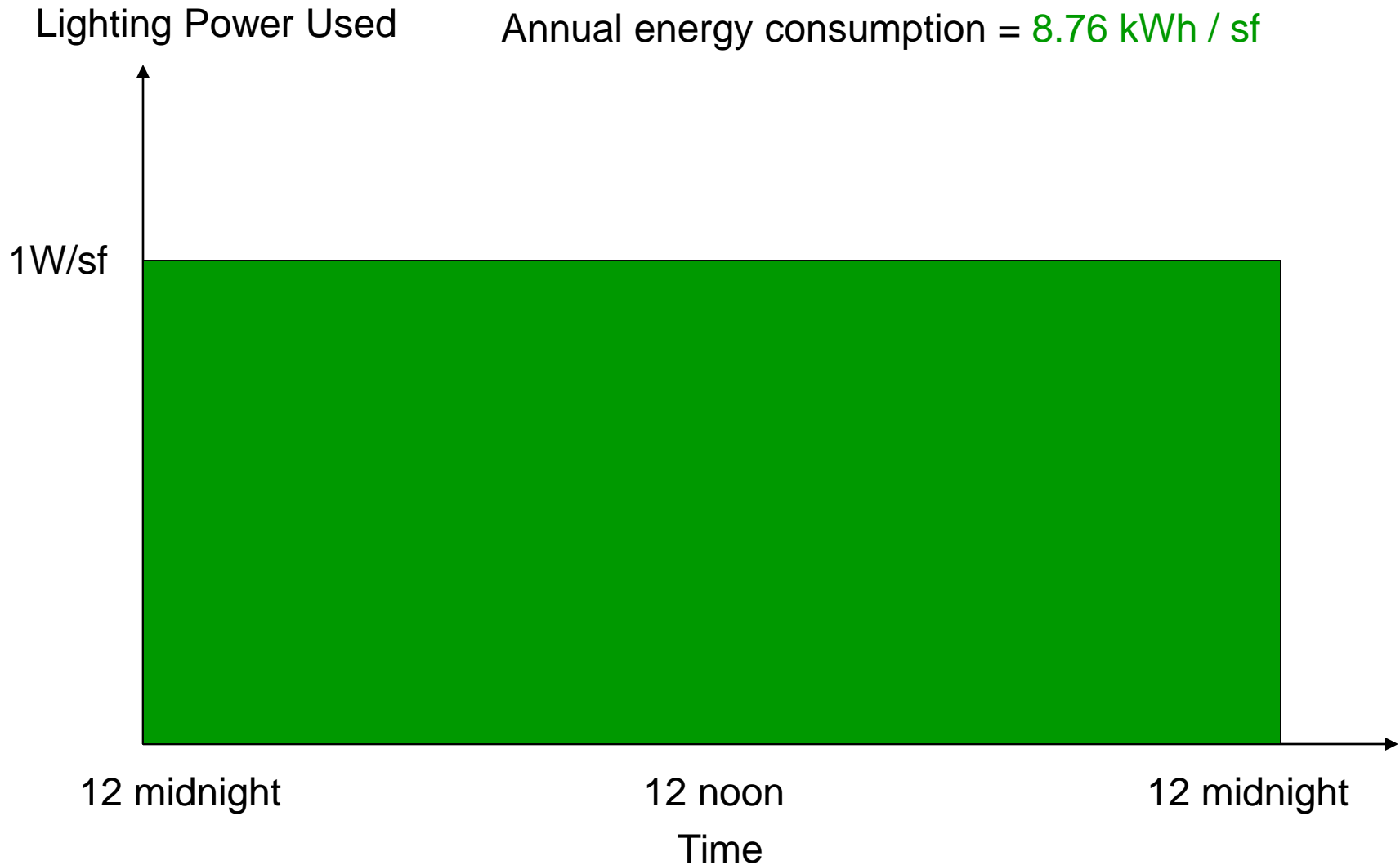


Demand Response: Reducing lighting load at times of peak electricity pricing.

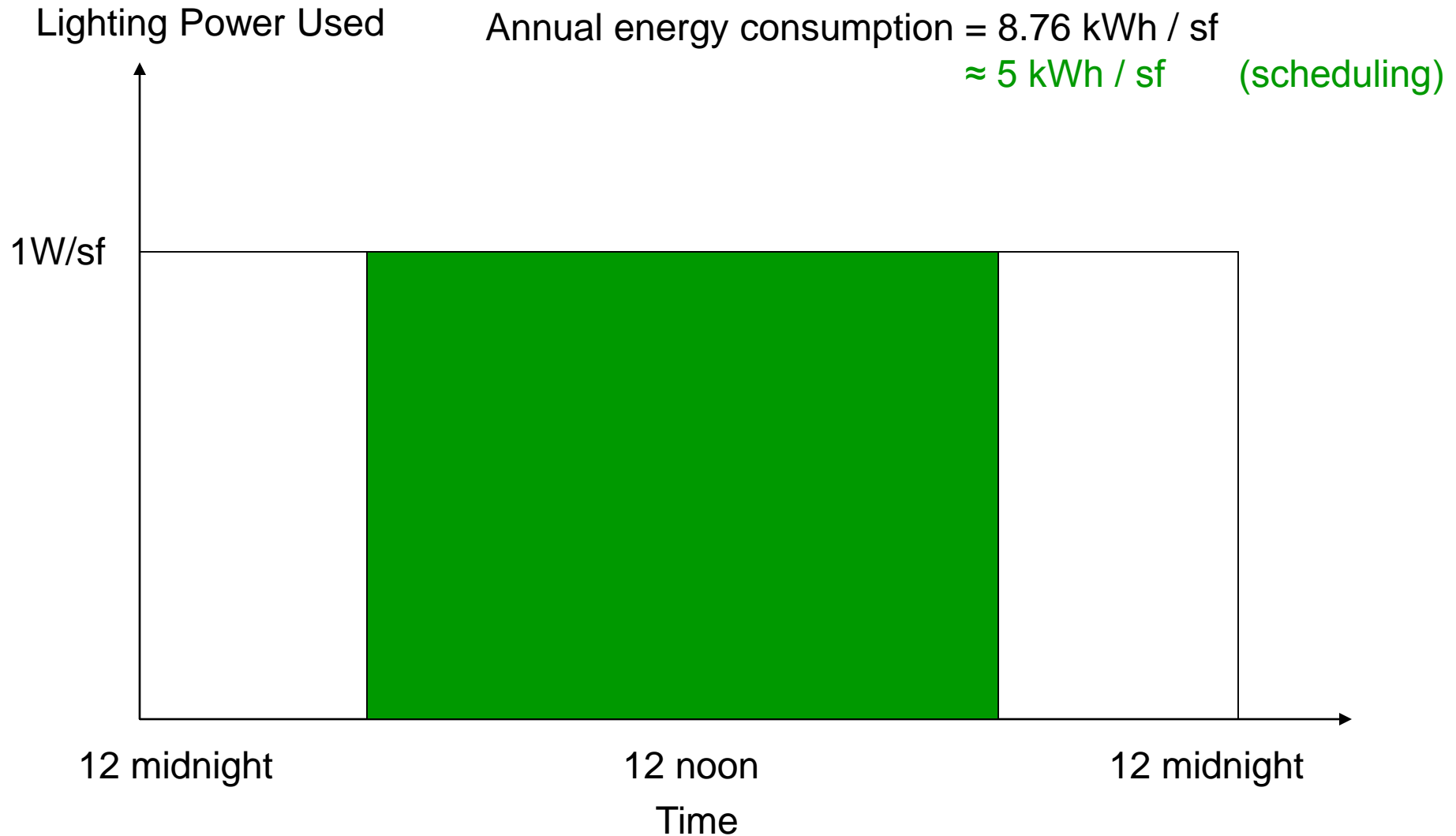


Plug-load Control: Automatically turning task lighting and other plug loads off when they are not needed.

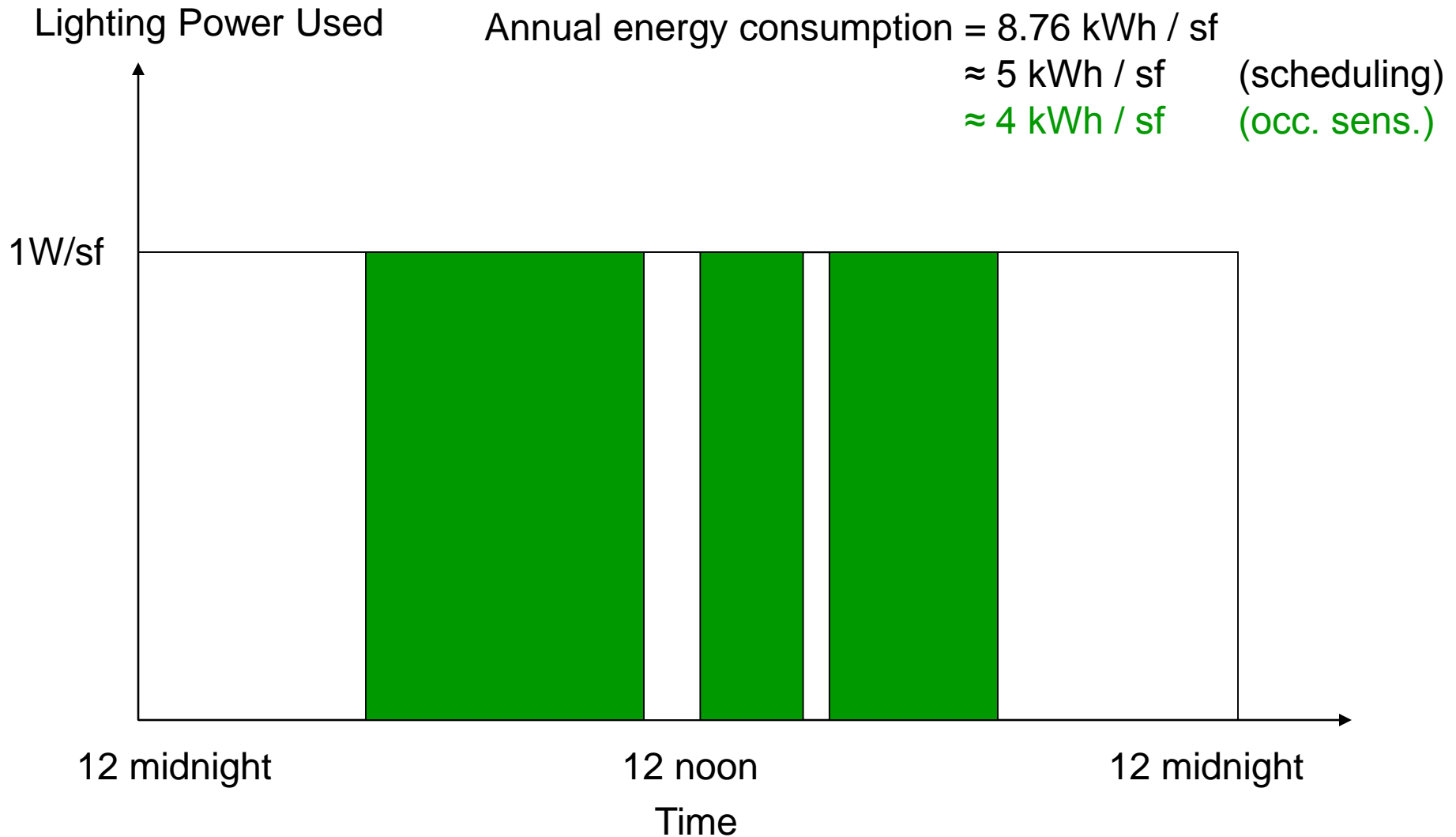
Office building example – lighting energy



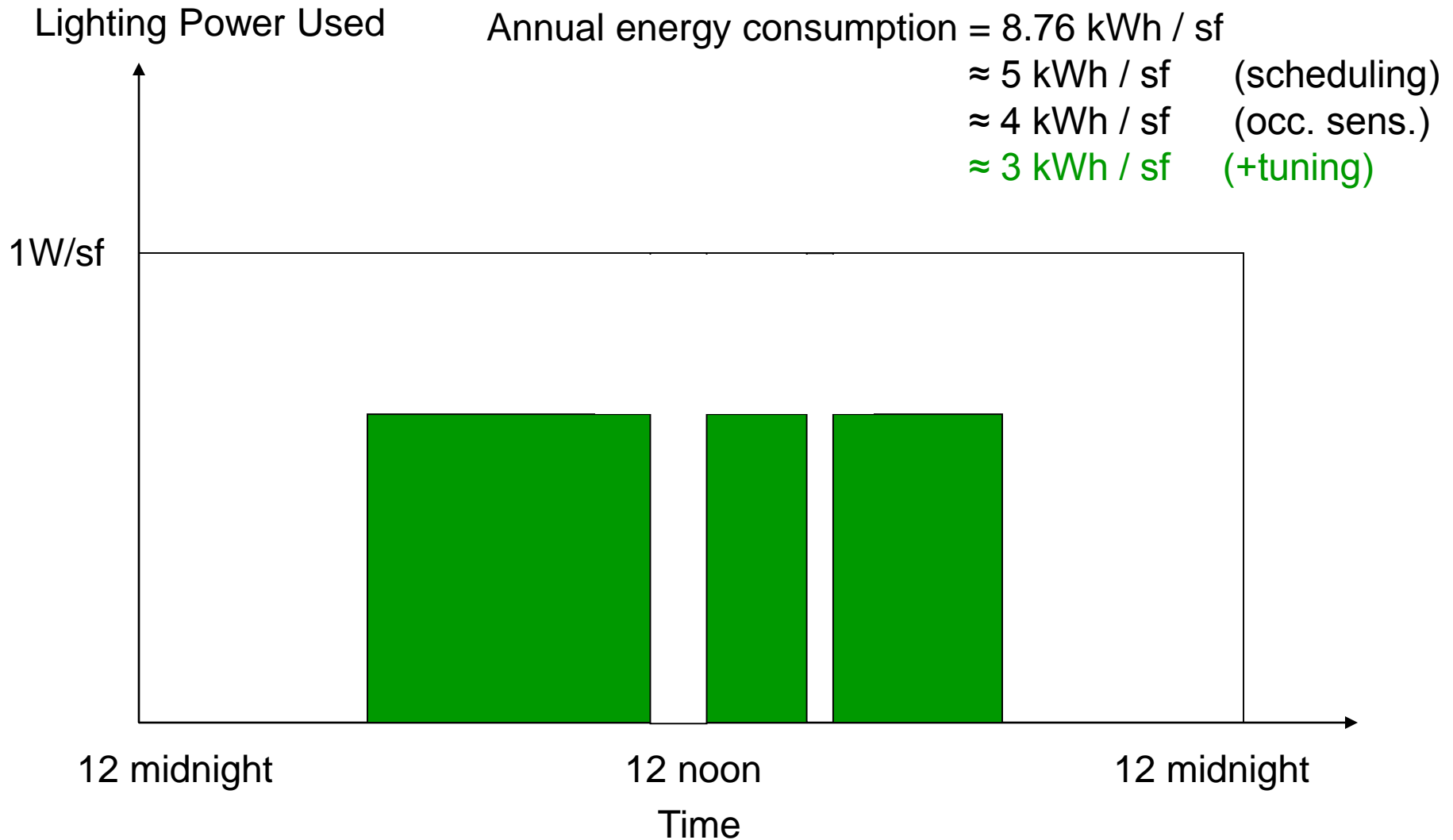
Office building example – lighting energy



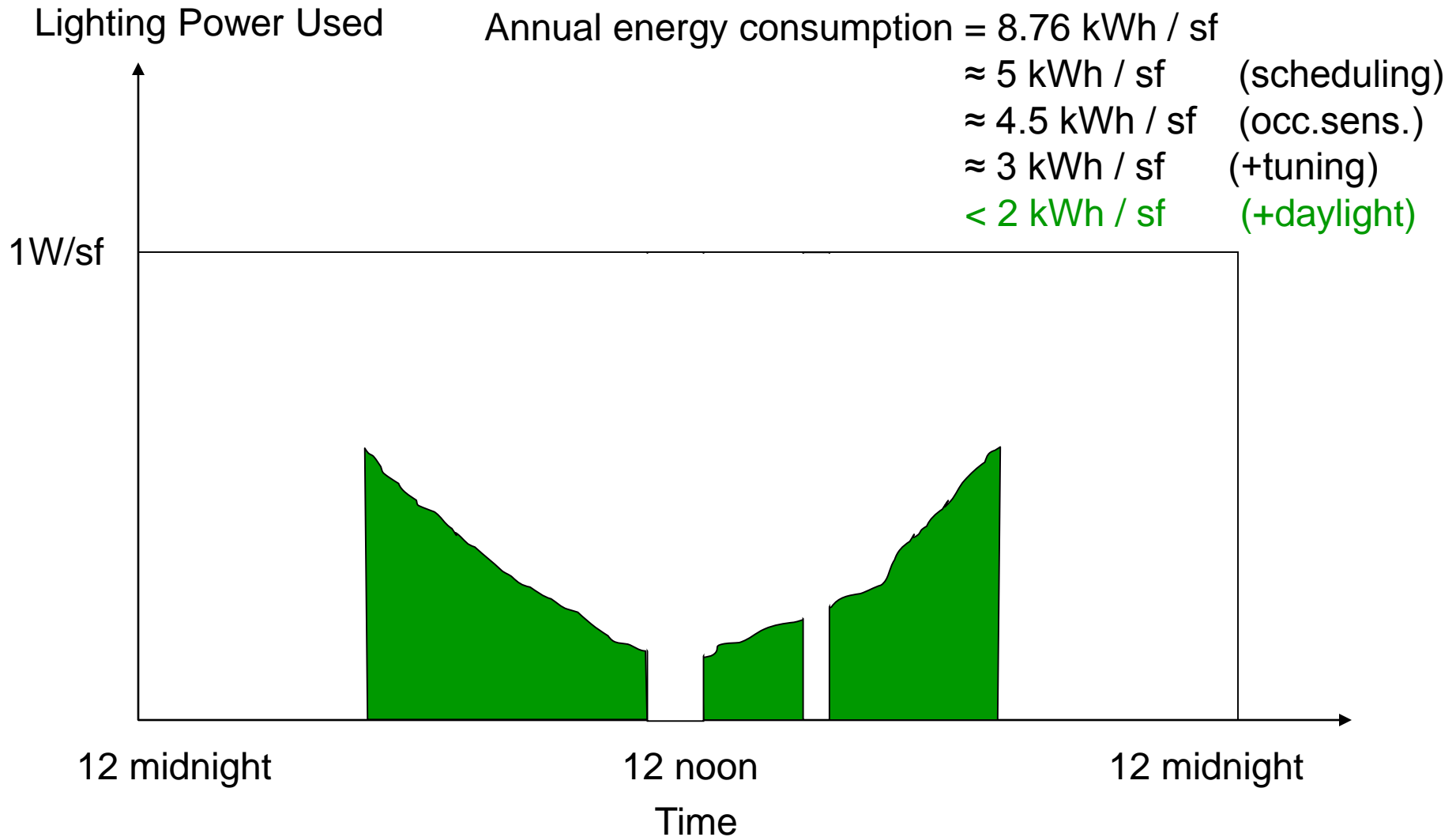
Office building example – lighting energy



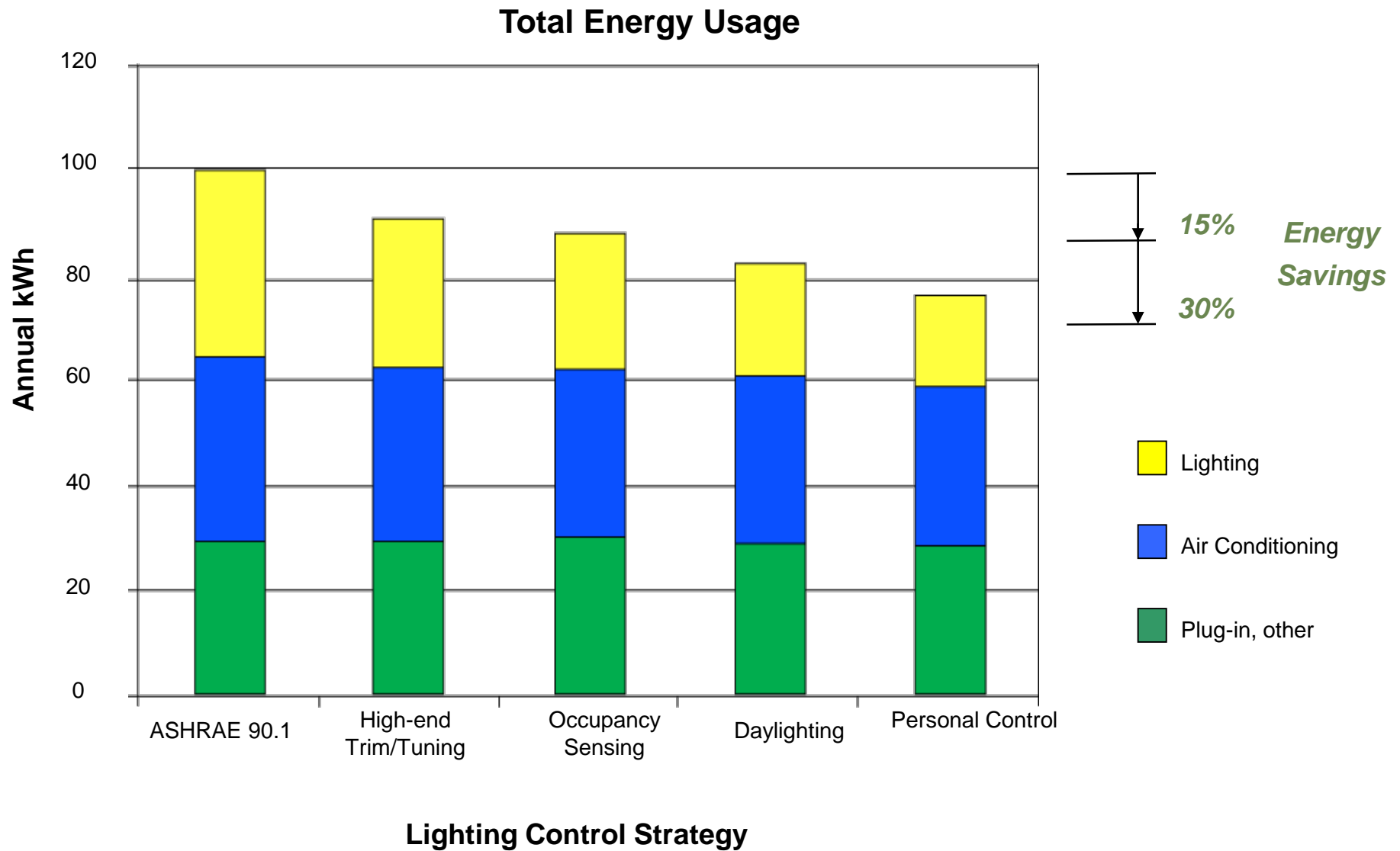
Office building example – lighting energy



Office building example – lighting energy



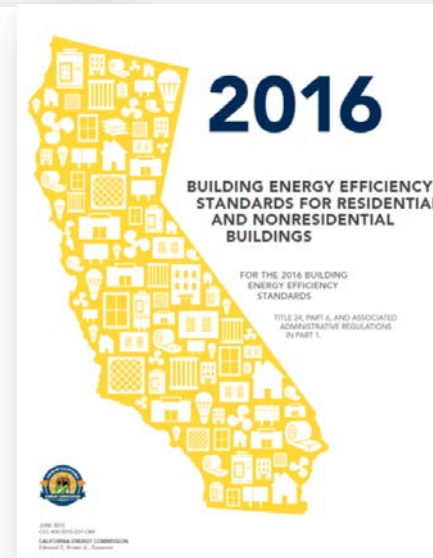
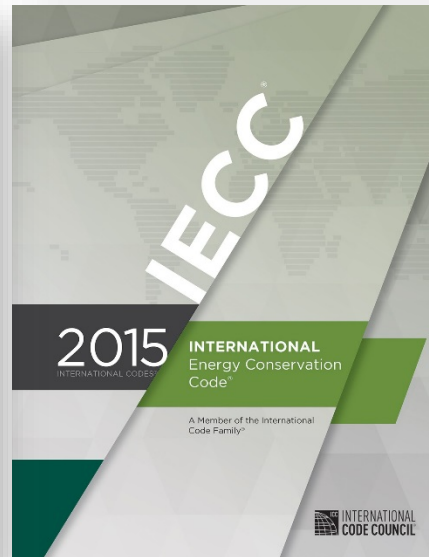
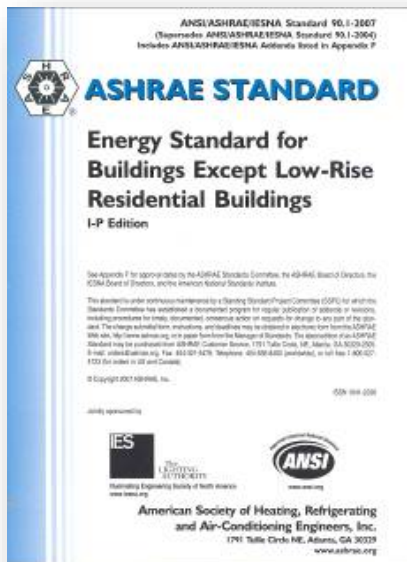
Total building energy savings



Energy codes -- the big 3

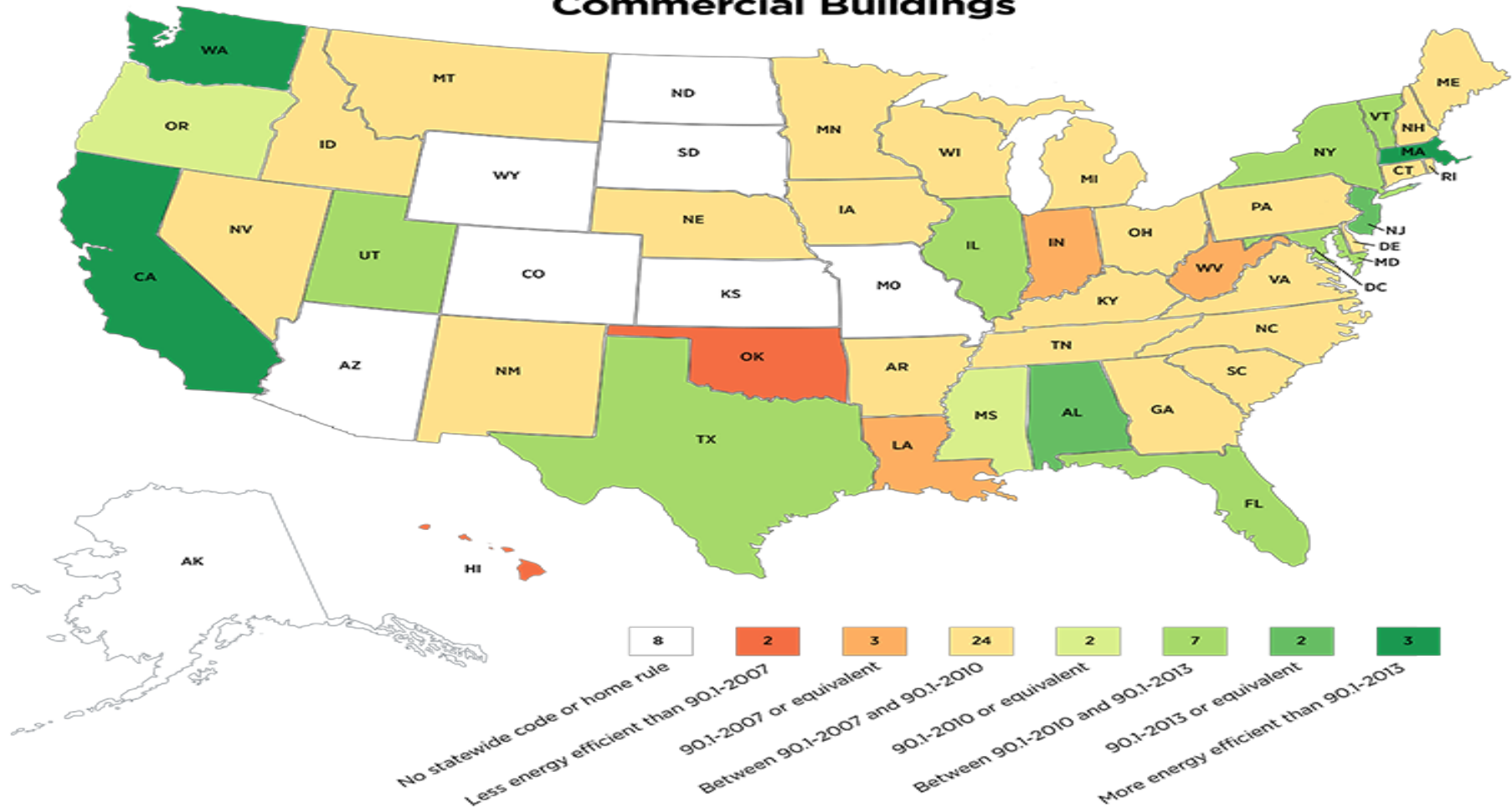
This presentation focuses on the following codes/standards with a look at what's coming in future drafts:

- ASHRAE 90.1-2013
- IECC 2015
- CA Title 24 Part 6 2016



State energy code adoption

Commercial Buildings

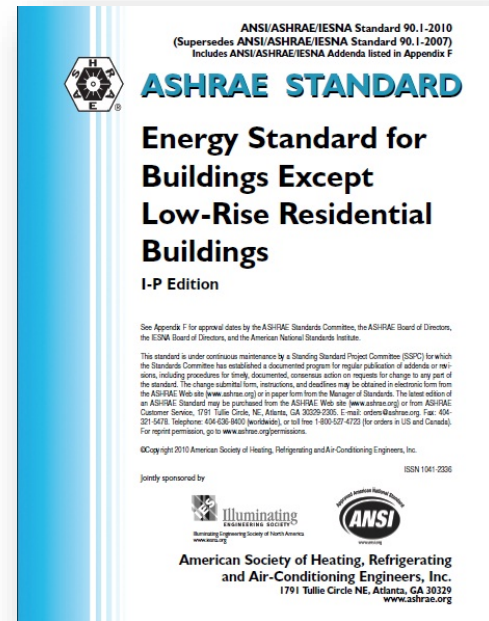


DOE Ruling Sept 26, 2014: All states must adopt an energy code as stringent as 90.1-2013 by Sept. 26, 2016.

Source: www.energycodes.gov

ASHRAE 90.1

- Jointly sponsored by ASHRAE and IES
- 90.1-2016 is the current version (published Oct. 2016)
- New construction, additions, and alterations
- For commercial buildings and residential structures 4 or more stories
- National reference standard for commercial buildings and energy baseline for all LEED projects
- Interior and exterior lighting and lighting control requirements



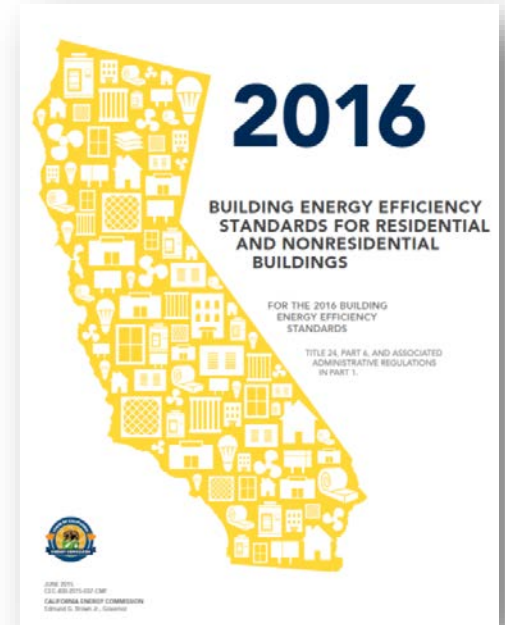
IECC

- Created by the International Code Council
- IECC 2015 is the current version (published 5/2014)
- New construction, additions, and alterations
- Covers commercial and residential buildings.
- Allows use of 90.1-2013 as an alternate compliance path
- Part of a set of codes, known as the I-Codes.
- Interior and exterior lighting and lighting control requirements



Title 24

- Title 24, Part 6 is California's energy efficiency code
- Title 24 2016 is the upcoming version, effective Jan. 1, 2017
- Effects all newly constructed or altered commercial and residential buildings
- Considered to be the strictest energy code
- Interior and exterior lighting and lighting control requirements



Automatic lighting shut-off (90.1 / IECC / T24)

Standard/Code:

90.1-2013; IECC 2015; T24 2016

Intent:

Eliminate after-hours lighting waste

Requirements:

- Automatic lighting shutoff control required in all interior spaces
- Override of automatic shutoff allowed for not more than 2 hours



Automatic lighting shut-off (90.1 / IECC / T24)

Light control solutions:

1. Control lights on a scheduled basis (automatic time switch)
2. Occupant sensor
3. Signal from another control or alarm that indicates the area is unoccupied

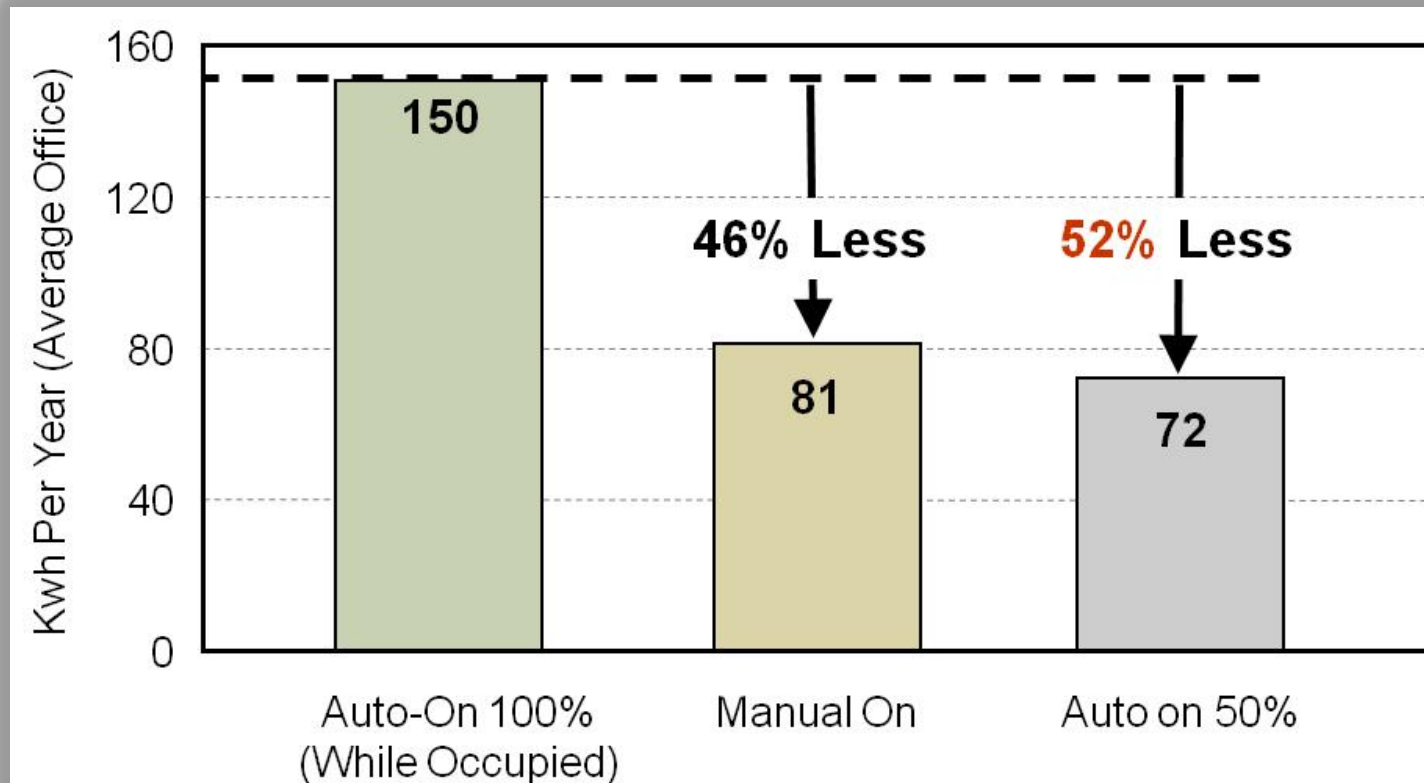
Notes:

- *90.1-2013 and IECC 2015, occupancy sensors must be manual-on or auto-on to not more than 50% lighting power except in some spaces.*
- *90.1-2013 and T24 2016 requires occupancy sensors to be set to 20 minute timeout or less.*



Manual vs. Auto-ON

52% energy saving with Auto-On 50% control strategy over Auto-On 100%



http://www.aboutlightingcontrols.org/education/papers/2009/2009_bilevel_study.shtml

Space control (90.1 / IECC / T24)

Standard/Code: 90.1-2013; IECC 2015, T24 2016

Intent: Allow occupants to control unneeded lighting

Requirements:

- At least one lighting control for each room or space enclosed by ceiling-height partitions
- Readily accessible to occupants
- Remote location is allowed but must have indicator that identifies the lights served and their status (off or on)



Space control (90.1 / IECC / T24)

Light control solutions:

- Dimmers, switches, multi-scene controls, keypads
- Note that if using a timeclock for automatic lighting shut-off, the space controls must be connected to timeclock to allow for override of no more than 2 hours



Hotel guestroom control (90.1 / IECC / T24)

All lighting and switched receptacles in hotel/motel guest rooms must automatically turned off when room is vacant

- Shutoff within 20 minutes (IECC 2015/90.1-2013)
- Shutoff within 30 minutes (CA T24 2016)
- Captive key card is acceptable



Occupant sensor control (90.1 / IECC / T24)

Occupancy sensors are required in:

- Classrooms
- Conference/meeting rooms
- Employee lunch/break rooms/lounges
- Storage and supply rooms between 50 ft² and 1000 ft²
- Rooms used for document copying and printing
- Private office spaces
- Restrooms
- Dressing, locker, and fitting rooms
- Spaces less than 300 ft² (IECC 2015)

Note: For 90.1 and IECC, occupancy sensors must be manual-on or auto-on to not more than 50% lighting power except in some spaces.



Automatic partial-off lighting (90.1 / IECC / T24)

Standard/code:

90.1-2013, IECC 2015, and T24 2016

Intent:

Eliminate wasted lighting in stairwells, corridors, and warehouse spaces.

Requirements:

Lighting shall be automatically reduced by at least 50% when vacant.

Note: *For T24 2016, this requirement is also for aisles in open warehouse and library book stacks. For IECC 2015, this requirement is for warehouse aisles and open areas.*



Automatic partial-off lighting (90.1 / IECC / T24)

Lighting control solutions:

- Occupancy sensor with multi-level or dimmable light fixtures

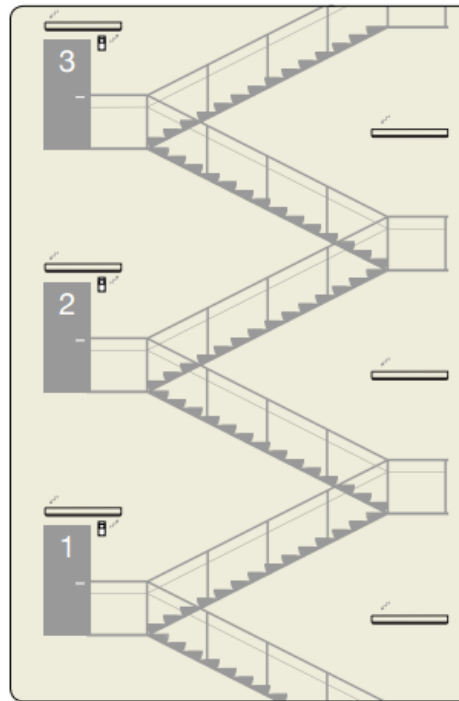


Stairwell fixture

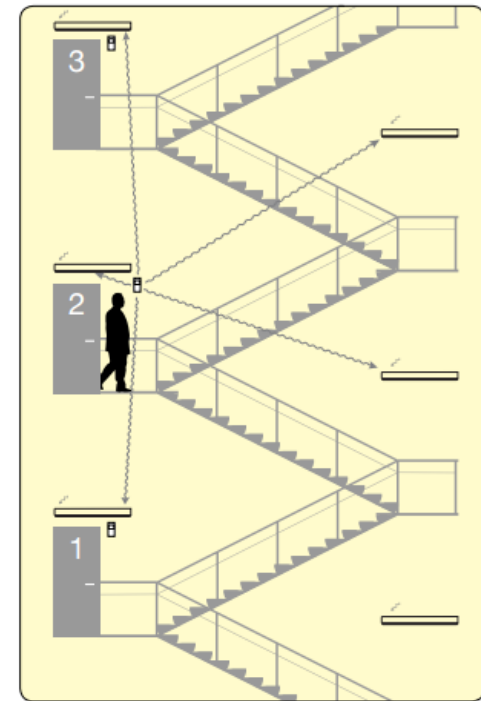


Occupancy sensor

Unoccupied: 20% light level



Occupied: 80% light level



Daylight zone control (90.1, IECC, T24)

Standard / Code: 90.1-2013; IECC 2015; T24 2016

Intent: Save lighting energy in daylighted spaces

Requirements:

- Daylight zones must be independently controlled
- Automatic multi-level daylight controls

Light control solution: Daylight sensors, dimming ballasts



Daylight responsive controls IECC 2015

- Automatic daylight control (continuous dimming) required in classrooms, labs, libraries and offices
- Automatic daylight control is required in all other spaces
- Automatic full OFF required
- Daylight zones with less than 150 Watts are exempt



Daylight zones

IECC 2015

Window Daylight Zones

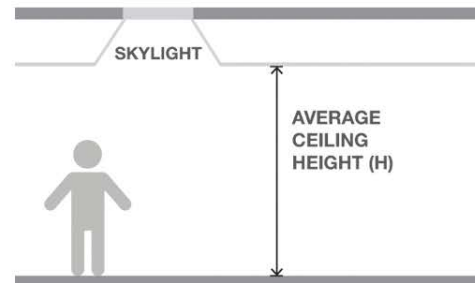


Section View
NOT TO SCALE

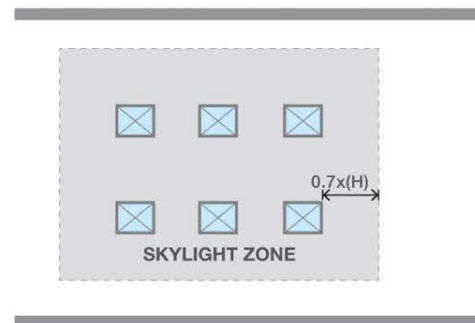


Plan View
NOT TO SCALE

Skylight Daylight Zone



Section View
NOT TO SCALE



Plan View
NOT TO SCALE

Light reduction control (90.1 / IECC / T24)

Standard/code: 90.1-2013, IECC 2015;
T24 2015

Intent: Allow occupants to moderate light levels to save energy.

Requirements:

- Light Reduction Controls must allow the occupant to reduce connected lighting
 - By at least 50% (IECC)
 - Between 30% to 70% lighting power in addition to OFF (90.1)
 - Minimum of 5 steps for most light sources including OFF and ON (T24)

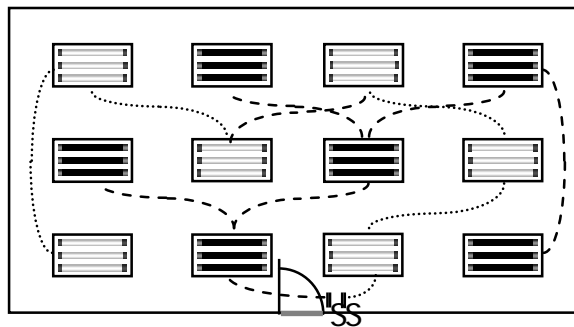


Light reduction control (90.1, IECC, T24)

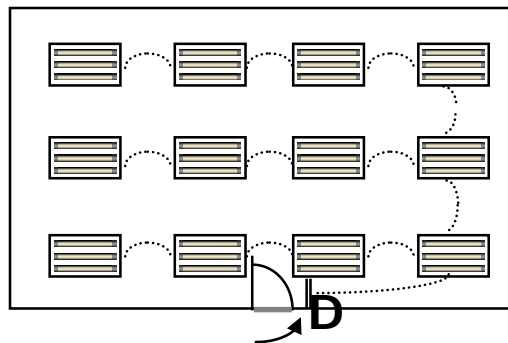
Light control solutions:

- Controlling all lamps or luminaires (i.e. dimming)
- Dual switching of alternate rows of luminaires, alternate luminaires or lamps
- Switching middle lamp luminaires independently from the outer lamps
- Switching or dimming each luminaire or each lamp (i.e. personal control)

Alternating Luminaires

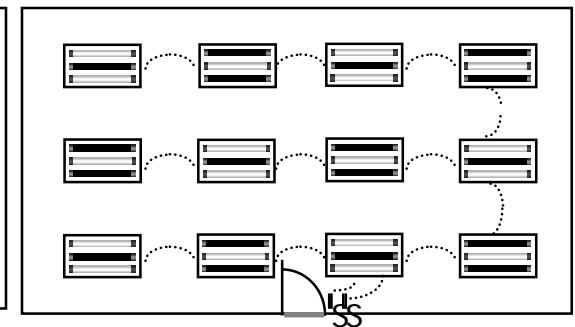


Dimming



Dimmer Switch

Alternating lamps



Exterior lighting control (IECC / T24 / 90.1)

Standard/code: IECC 2015; T24 2016; 90.1-2013

Intent: Eliminate wasted exterior lighting

Requirements:

- Automatically turn outdoor lighting off when daylight is available.
- All façade and landscape lighting shall be automatically shut off from midnight to 6 am (90.1/IECC 2015)
- All other lighting shall be controlled by a device that automatically reduces the connected lighting power by at least 30% from midnight to 6 am or when no activity detected (90.1/IECC 2015)
- Parking lot poles 24 ft. or less automatically controlled so that lighting is reduced by 40% to 90% when no activity is detected (T24)

Light control solution:

- Astronomical timeclocks, time switches, daylight and motion sensors



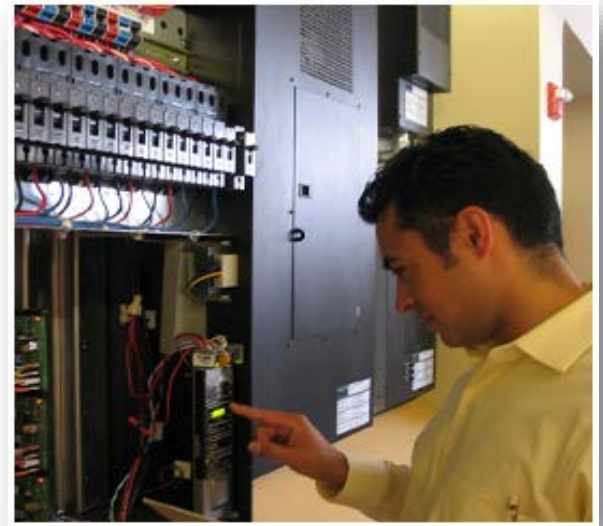
Functional testing (90.1, IECC , T24)

Standard/code: 90.1-2013; IECC 2015; T24 2016

Intent: To ensure that controls are calibrated, adjusted, programmed, and in proper working condition

Requirements:

- Confirm that the following devices have been functionally tested:
 - Occupancy Sensors
 - Photosensors
 - Time Switches (Timeclock)
 - Demand Responsive Lighting (T24 only)



Notes:

- *90.1 and IECC, the party responsible for functional testing cannot be part of the design or construction team. The light control manufacturer can do the functional testing.*
- *T24 2013 requires certified lighting control acceptance test technicians perform the functional testing.*

Automatic receptacle control

Standard/code: 90.1-2013; T24 2016

Intent: Eliminate unnecessary plug loads from task lighting and other devices.

Requirements:

- At least 50% receptacles installed in private offices, conference rooms, printing rooms, break rooms, open offices, and classrooms shall be controlled by an *automatic control device*

Light Control Solution:

- Receptacles controlled by timeclocks or occupancy sensors.

Notes:

- *The automatic control devices cannot be plugged into the receptacle (i.e. a power strip that incorporate an occ sensor doesn't comply).*
- *The controlled receptacles must be marked.*



Energy monitoring (90.1 / T24)

Standard/code: 90.1-2013; T24 2016

Intent: Monitoring of energy usage so that corrective action can be taken when excessive or unnecessary use is found.

Requirements:

- Whole-building electrical monitoring of total electricity usage plus breakout of HVAC, lighting, and plug loads separately. For T24, need to disaggregate by load type to allow for future metering of lighting and other loads.

Exceptions:

- Buildings less than 25,000 ft² (90.1)
- Buildings rated for 50kVA or less (T24)

Light Control Solution:

- Lighting control systems that report and monitor their energy use.



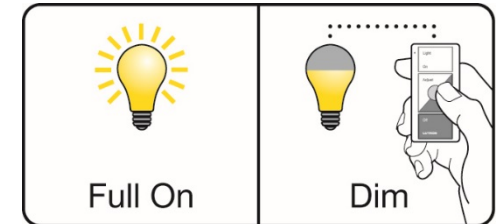
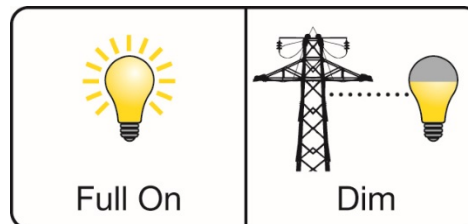
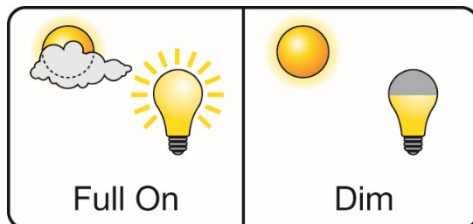
Additional efficiency options (IECC 2015)

You must do 1 of the 6:

- More efficient HVAC
- Reduced LPD
- **Enhanced digital lighting controls**
- On-site supply of renewable energy
- Dedicated outdoor air systems
- High-efficiency service hot water heating

Enhanced digital lighting controls:

- Continuous dimming
- Individually addressable fixtures
- Smaller daylight zones
- Reconfigurable
- Load shedding
- Individual user control of lighting



Lighting control incentives (90.1 / T24)

Watts per square foot incentives for using additional lighting controls above mandated requirements. (Table below is from Title 24 2016, ASHRAE 90.1-2010, and 90.1-2013 have a similar table).

TABLE 140.6-A LIGHTING POWER ADJUSTMENT FACTORS (PAF)

TYPE OF CONTROL	TYPE OF AREA		FACTOR
a. To qualify for any of the Power Adjustment Factors in this table, the installation shall comply with the applicable requirements in Section 140.6(a)2			
b. Only one PAF may be used for each qualifying luminaire unless combined below.			
c. Lighting controls that are required for compliance with Part 6 shall not be eligible for a PAF			
1. Daylight Dimming plus OFF Control	Luminaires in skylit daylit zone or primary sidelit daylit zone		0.10
2. Occupant Sensing Controls in Large Open Plan Offices	In open plan offices > 250 square feet: One sensor controlling an area that is:	No larger than 125 square feet	0.40
		From 126 to 250 square feet	0.30
		From 251 to 500 square feet	0.20
3. Institutional Tuning	Luminaires in non-daylit areas: Luminaires that qualify for other PAFs in this table may also qualify for this tuning PAF.		0.10
	Luminaires in daylit areas: Luminaires that qualify for other PAFs in this table may also qualify for this tuning PAF.		0.05
4. Demand Responsive Control	All building types less than 10,000 square feet. Luminaires that qualify for other PAFs in this table may also qualify for this demand responsive control PAF		0.05

Lighting alteration control requirements

ASHRAE 90.1-2013

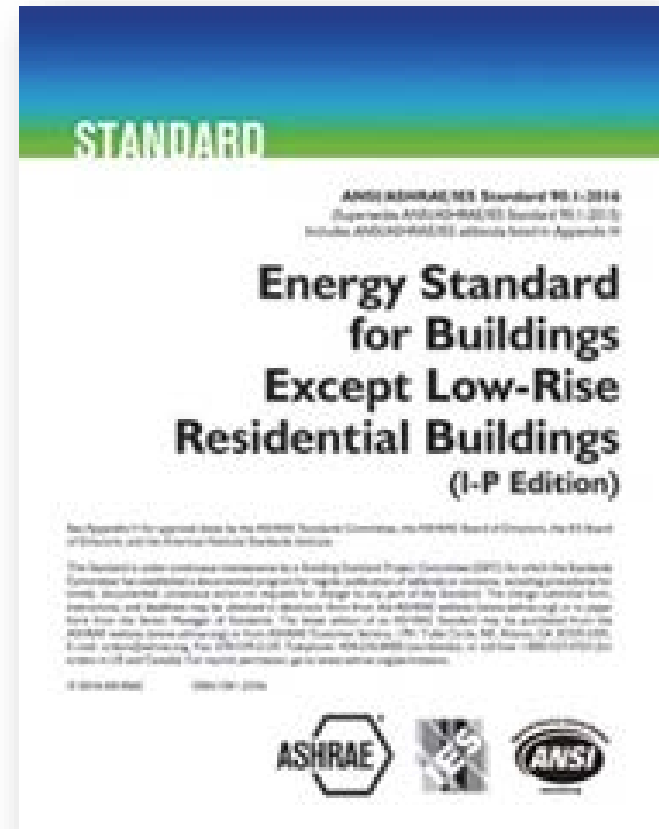
- At least 10% of the total lighting load must be replaced before code requirement needs to be met.
- Includes replacement of just lamp and ballast as well
- Only LPD and Automatic Lighting Shut-off must be met

IECC 2015

- At least 50% of the total luminaires must be replaced before code requirements need to be met.

What's new in ASHRAE 90.1-2016

- Dwelling units must use high-efficacy lighting or controls like dimmers or sensors.
- Alterations of more than 20% of the lighting load must meet nearly all the mandatory lighting control requirements as done for new construction.
- Partial-off occupancy sensor control is required for parking lot lighting polls 24 ft. or less above the ground.



What's coming in IECC 2018

- Alternative compliance path approved when using “luminaire level lighting controls” (fixtures with embedded sensors)
- Occ sensing requirement (at least partial-off ones) for open offices
- 20 minute time-out setting for occ sensors to match 90.1. passed.
- Alternations of more than 10% of the lighting load must comply with new construction requirements



Summary

- Automatic shut-off
- Space Control
- Hotel guestroom control
- Occupant sensor control
- Automatic partial-off lighting
- Automatic daylight zone control
- Light reduction controls
- Exterior lighting control
- Functional testing of controls
- Automatic receptacle control
- Energy monitoring
- Energy efficiency options
- Watts per ft² incentives for additional controls
- Lighting alteration control requirements



Real world example – The NYT Building

“We designed our building to use 1.28 watts per square foot of lighting power...with light management it’s using only 0.396 — that’s about 70% less.”

Strategy:

- Light level tuning
- Daylight harvesting
- Occupancy sensing

Results:

- Over 70% lighting energy saved
- Over \$1 per square foot per year saved
- Over 1,250 metric tons of CO2 emissions prevented each year



Glenn Hughes
Director of Construction
The New York Times Co.

Real world example – The NYT Building

Light control solutions

- Total light management system
 - Digital dimming ballasts
 - Daylight sensors
 - Occupancy sensors
 - Light management software

Lights off

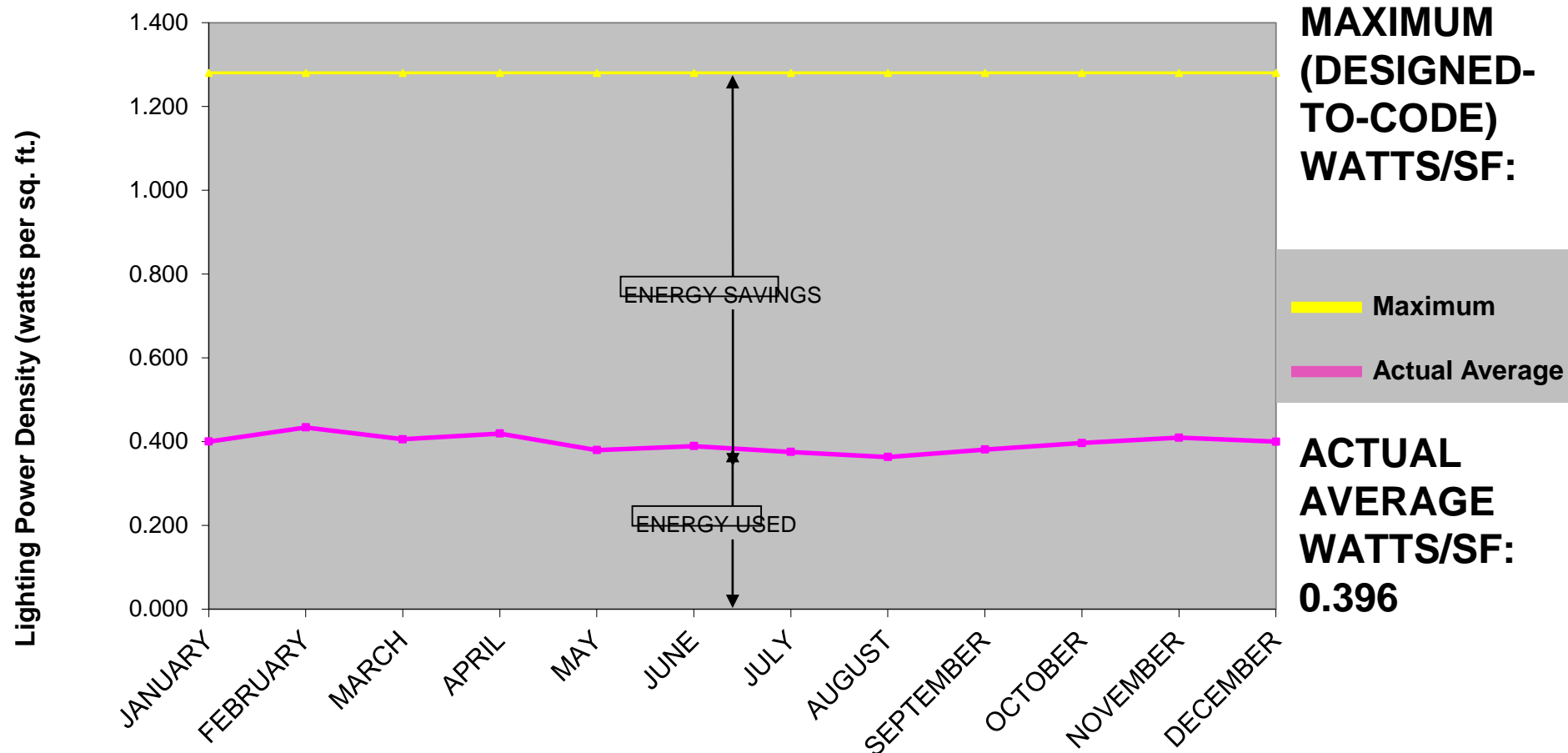
Lights dimmed
by 80%

Lights dimmed
by 50%



Real world example – The NYT Building

Lighting Power Usage 2009
The New York Times Building





Goal:

Standard for energy efficiency in building renovations

Challenges & Opportunities:

- Reduce energy use compared to Oregon code.
- Verify savings and further optimize lighting systems.
- Maximize occupant comfort.

“My goal is to deliver comfort first, and make sure that the system saves energy too.”

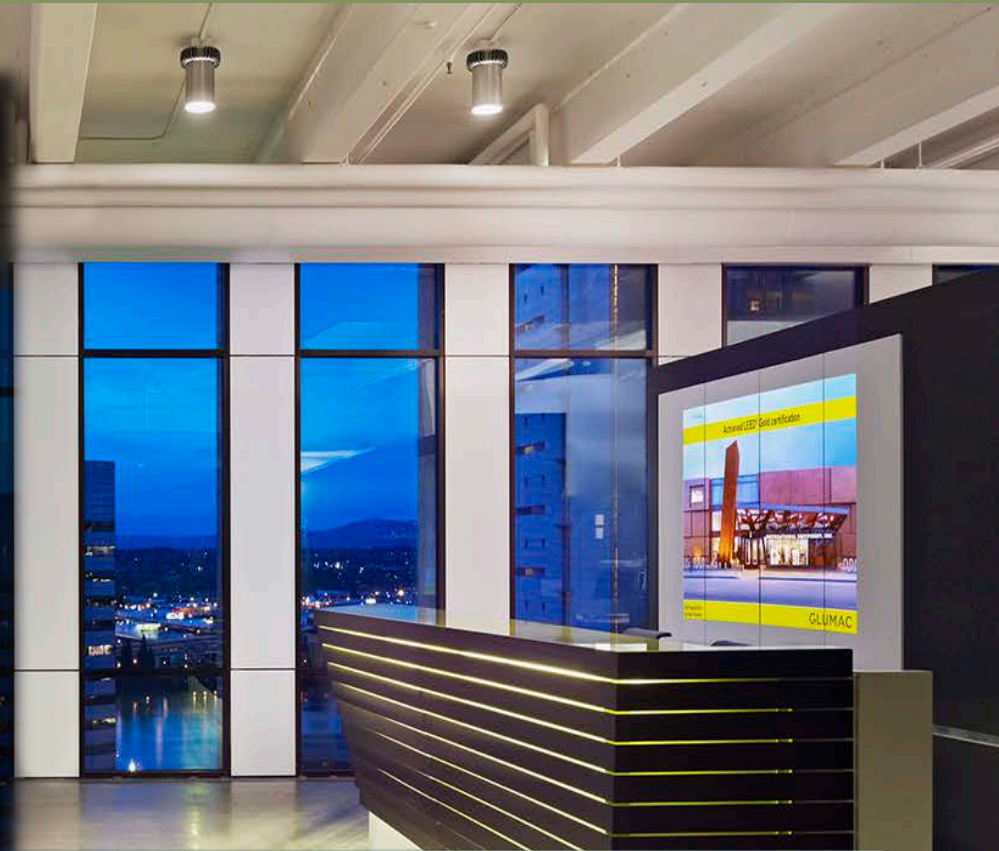
—Carlos Inclan, Lighting Designer, Glumac

Lighting Controls

- Digitally Addressable Luminaires
- Wireless Occupancy Sensing
- Wireless Daylight Harvesting
- Wireless Personal Dimming
- High-End Trim/Tuning
- Fully Automated Shading

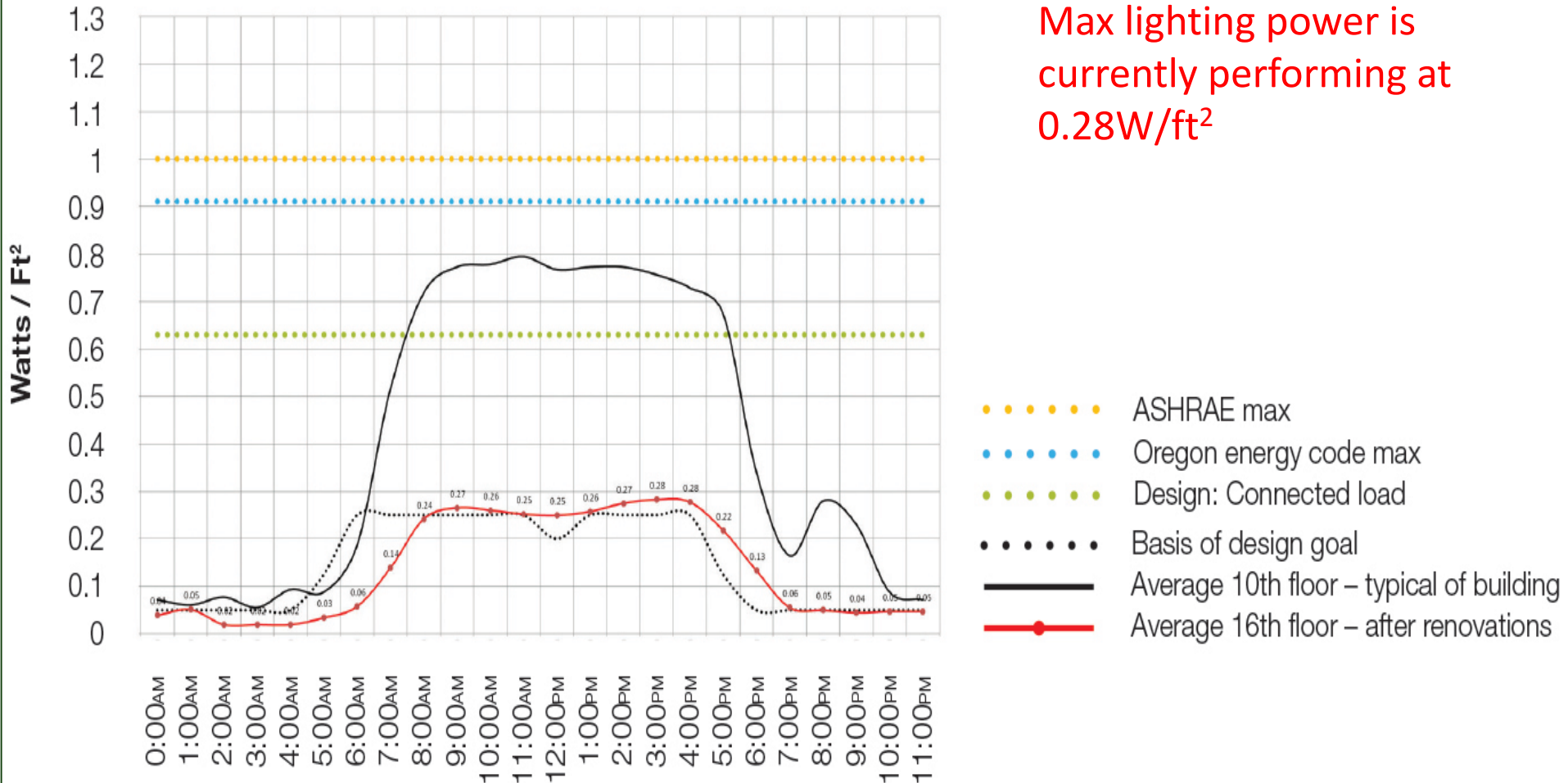
“By seamlessly integrating the lighting control system with the building management system, we can track, monitor, and adjust lighting energy usage to achieve maximum efficiencies.”

—Kirk Davis, Managing Principal, Glumac Portland



Glumac

Glumac Portland - Weekday Lighting Watts / Ft²
(April 02 - 06, 2012)



Max lighting power is currently performing at 0.28W/ft²

More information on energy codes

Energy codes by state

- www.lutron.com/energycodes
- www.lutron.com/appguides
- www.energycodes.gov
- www.energycodesocean.org
- www.ashrae.org
- www.iccsafe.org

Questions?



Follow-up Questions - Answers

The following link is for any of the attendees to use if they want AIA or USGBC credit for the presentation.

www.lutron.com/signmeup

Code: JOLLY3482

- **How is the daylight zone calculated for clerestory windows?**

Clerestories are treated like regular windows. So the daylight zone for spaces that have clerestory windows (basically high section of wall that contains typically small windows to admit daylight in), the daylight zone is the same as a standard side lighted daylight zone. It is the area that is one window head height (distance from the top of the window to the floor) into the space and 2 ft. on each side of the window. Note that for automatic daylight responsive controls to be required by code, the window area must be at least 24 ft² and the electric lighting in the daylight zones must be more than 150W in total per space.

- **For energy monitoring (which is required for large buildings in ASHRAE 90.1-2013 and 90.1-2016), how precise do the end-use breakouts have to be (breakouts are required for HVAC, Interior Lighting, Exterior Lighting, Receptacle Circuits)?**

Up to 10% of the load for each of the breakout categories shall be allowed to be from other electrical loads.

- **For IECC 2015, what is considered a lighting alteration? Does replacing more than 50% of the lamps in the luminaires count as an alteration?**

I got clarification on this from ICC staff on some this. Their technical opinion is that lighting alterations that replace 50% or more of the luminaires without alterations of controls or circuits must comply with the same requirements as if the project was new construction. Alterations of whole lighting systems (luminaires, circuits, and controls) that replace more than 10% of the luminaires in spaces must comply with the same lighting requirements as if the project was new construction. Here's an excerpt from their email:

Exception 7 of Section 503.1 excepts alterations where less than 50% of the luminaires are replaced with no alterations to the controls or the circuits and the exception of Section 503.6 excepts lighting system alterations, which include the luminaires, circuits and controls, which replace less than 10% of the luminaires. For instance, if the number of luminaires that are replaced is 40% and no alterations is being done to the controls or circuiting of the lighting system, Exception 7 of Section 503.1 would apply. On the other hand, if the same luminaires are replaced and the controls and/or the circuits are altered, the altered system must comply with the provisions of Section C405 per Section C503.6, because the 10% threshold was exceeded.

On the second question, replacing just lamps even self-ballasted lamps or LEDi lamps with integral drivers, does not count as an alteration as the lamps/light source are only part of the luminaire but not the whole luminaire.

I hope this addresses all the questions. Below is my contact info. in case there are more questions or if anyone wants more information on this subject.

Thanks for allowing me the opportunity to present to such a great group!

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