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ASHRAE/IES 90.1-2013 and IECC 2015: A Review of the Lighting Requirements

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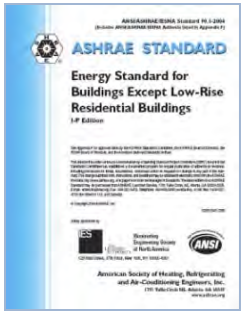
Course Description

Review and comparison of the Lighting requirements in the ASHRAE/IES 90.1-2013 and IECC 2015 national energy codes.

Learning Objectives

- Understand the basic requirements of the 90.1-2013 and IECC 2015 Lighting and Power requirements
- Become familiar with the development basis for some of the major requirements
- Review examples of acceptable paths to compliance for specific code requirements
- Better understand the code application process for use in real projects.

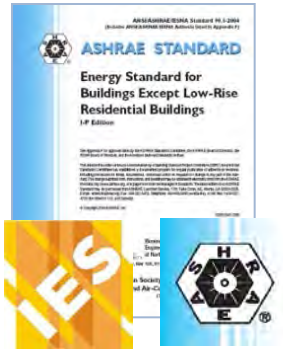
Why 90.1-2013 and IECC 2015?



- ASHRAE/IES 90.1-2013:
  - is adopted in some US States and represents some of the latest developed requirements across the country
  - provides much of the basis for other existing energy codes
- IECC 2015:
  - is most widely adopted energy code in the US
  - has many requirements that are identical or similar to 90.1-2013
  - references 90.1-2013 as an alternative compliance path
- **This presentation is based on ASHRAE/IES 90.1-2013 with notation of differences in IECC 2015**

Some Relevant Code Background

- ASHRAE/IES 90.1
  - jointly sponsored by ASHRAE and IES.
  - developed by engineers, builders, lighting designers manufacturers, building operators, and advocates
  - provisions are often adopted/modified for other codes
  - current published version is 90.1-2013
  - Other versions adopted and used in various states



- IECC
  - developed by the International Code Council through approval of membership (primarily building officials)
  - primarily a unified collection of provisions from others
  - Current version is 2015
  - Other versions adopted and used in various states

The Basis for Energy Code Requirements

- In the 1990s, the Energy Conservation and Production Act (amended by EPAct 1992) required that States adopt energy codes
- The U.S. DOE determines the effective stringency level to meet or exceed (currently 90.1-2013)
- States adopt (or develop) codes or standards to meet these requirements
- Many versions of nationally available codes (90.1, IECC) are enforced….and some states still have no statewide code ☺

Interior Lighting Power Density (LPD) Limits

- Space-by-Space LPDs - The change from the previous 90.1-2010 version is mixed – some went up but others went down
- Building area LPDs - Most stayed about the same with a few being reduced
- 90.1-2013 added new spaces used exclusively by the "visually impaired" (higher LPD allowance) in specific facilities:

> *A "Facility for the Visually Impaired" is a facility that can be documented as being designed to comply with the light levels in ANSI/IES RP-28 and is licensed or will be licensed by local/state authorities for either senior long-term care, adult daycare, senior support and/or people with special visual needs.*

LPD Limits for IECC 2015

- Whole building LPDs identical to 90.1-2013
- Space type LPDs mostly the same as 90.1-2013 with exceptions:
  - IECC 2015 Lower than 90.1-2013:
    - Hospital Corridor
    - Dining area for visually impaired
  - IECC 2015 Higher than 90.1-2013:
    - Electrical/Mechanical room
    - Sales Area

Where Do Space Type LPDs Come From?

- For 90.1 - Developed within the ASHRAE/IESNA 90.1 Lighting subcommittee with IESNA committee support.
- Generated from building space type models using the IES lumen method calculation and applying:
  - Current lighting product performance data
  - Current lamp/ballast efficacy and light loss factors
  - Latest IESNA recommended light levels
  - Professional consensus of quality lighted environments
- These elements are combined in the models to calculate space type lighting power densities
- IES recommended light level basis ensures that quality lighting designs can be maintained with compliance

…and Whole Building LPDs?

- Developed from detailed room data for commercial buildings
  - DODGE Construction plan sets
  - Complete space type area takeoffs for detailed square footage by space type
  - Current set at 387 buildings representing 31 building types
- Applicable space type model LPDs assigned to each space
- Weighted average whole building LPDs calculated

Energy Code LPDs and LED Lighting

- Energy codes do limit the installed lighting power for interior and exterior (LPD), but….
- Currently adopted energy codes typically do not:
  - specify individual technologies
  - Include LED product efficacies in determining LPD limits

However….

- The 2016 version of 90.1 will include LED technology as a driver for LPD limits because of:
  - Proven efficacy and energy savings capability
  - Continued reduced cost
  - Product maturity and reasonable applicability
- Until 90.1-2016 (and IECC 2018) are adopted…… the use of LED technology (when well applied!) can help with code compliance

LPD Exemptions

- 90.1-2013 lists 18 exemptions - interior lighting wattage you DO NOT have to count for compliance:

a. Display or accent lighting that is an essential element for the function performed in galleries, museums, and monuments.
b. Lighting that is integral to *equipment* or instrumentation and is installed by its *manufacturer*.
c. Lighting specifically designed for use only during medical or dental procedures and lighting integral to medical *equipment*.
d. Lighting integral to both open and glass-enclosed refrigerator and freezer cases.
e. Lighting integral to food warming and food preparation *equipment*.
f. Lighting for plant growth or maintenance.
g. Lighting in spaces specifically designed for use by occupants with special lighting needs including visual impairment and other medical and age-related issues.
h. Lighting in *retail* display windows, provided the display area is enclosed by ceiling-height partitions.
i. Lighting in interior spaces that have been specifically designated as a registered interior *historic* landmark.
j. Lighting that is an integral part of advertising or directional signage.
k. Exit signs.
l. Lighting that is for sale or lighting educational demonstration systems.
m. Lighting for theatrical purposes, including performance, stage, and film and video production.
n. Lighting for television broadcasting in sporting activity areas.
o. Casino gaming areas.
p. Furniture-mounted supplemental task lighting that is controlled by *automatic* shutoff and complies with Section 9.4.1.6(d).
q. Mirror lighting in dressing rooms and accent lighting in religious pulpit and choir areas.
r. Parking garage transition lighting: Lighting for covered vehicle entrances and exits from buildings and parking structures, that comply with section 9.4.1.3 a

- IECC has a similar set of exemptions – review the actual code
- Compliance tools may not always completely and clearly represent exemptions – review the actual code

Don’t leave watts on the table

Interior LPD Adjustment

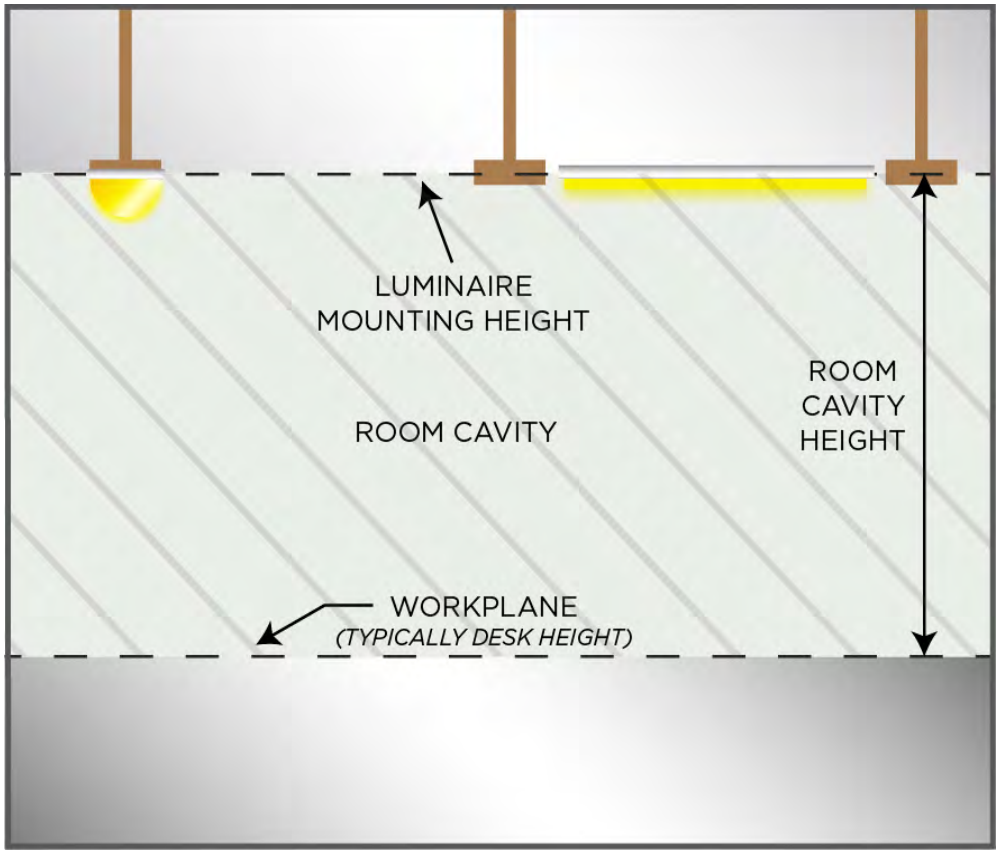
Room Cavity Ratio Adjustment for unusual spaces

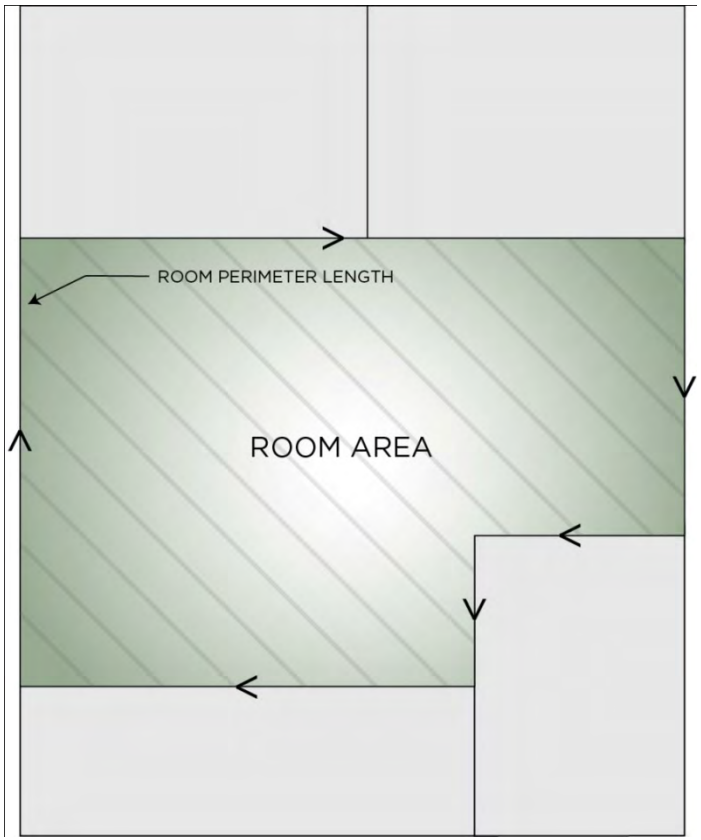
- Used only with the space by space method
  - Calculate *Room Cavity Ratio* (RCR) for a room
  - If greater than listed RCR threshold, a 20% increase is allowed
- For corridor/transition spaces, the increase is allowed for spaces with widths less than 8 feet

This adjustment is not included in IECC 2015

Interior LPD Adjustment

RCR = 2.5 X Room Cavity Height X Room Perimeter Length / Room Area





Retail Display Allowances

Additional allowance for lighting specifically designed/installed to highlight merchandise

- Additional Lighting Power Allowance:

  1000 watts

  + (Retail Area 1 × 0.6 W/ft2)
  + (Retail Area 2 × 0.6 W/ft2)
  + (Retail Area 3 × 1.4 W/ft2)
  + (Retail Area 4 × 2.5 W/ft2)

Retail Area 1 = floor area for all products not listed in Retail Areas 2, 3, or 4
Retail Area 2 = floor area for vehicles, sporting goods, and small electronics
Retail Area 3 = floor area for furniture, clothing, cosmetics, and artwork
Retail Area 4 = floor area for jewelry, crystal, and china.

These are use-it-or-loose-it allowances – only for display lighting

IECC 2015 provides only 500W base allowance instead of 1000W

Exterior Lighting Power Limits

Tradable surfaces

Common exterior applications where wattage can be traded for other needs.

For example, wattage allowed for parking lot lighting can be “traded” and used for canopy lighting.

Nontradable surfaces

Less common exterior lighted needs that **cannot** be traded for other needs.

These applications have more specific security or task illuminance needs.

Exterior Power Allowance by Zones (partial list)

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		Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance		**500 W**	**600 W**	**750 W**	**1300 W**
Tradable Surfaces	**Uncovered Parking Areas**				
	Parking areas and drives	**0.04 W/ft^2**	**0.06 W/ft^2**	**0.10 W/ft^2**	**0.13 W/ft^2**
	Building Grounds				
	Walkways less than 10 feet wide	**0.7 W/linear foot**	**0.7 W/linear foot**	**0.8 W/linear foot**	**1.0 W/linear foot**
	Walkways 10 feet wide or greater **Plaza areas** **Special Feature Areas**	**0.14 W/ft^2**	**0.14 W/ft^2**	**0.16 W/ft^2**	**0.2 W/ft^2**
	Stairways	**0.75 W/ft^2**	**1.0 W/ft^2**	**1.0 W/ft^2**	**1.0 W/ft^2**
	Pedestrian Tunnels	**0.15 W/ft^2**	**0.15 W/ft^2**	**0.2 W/ft^2**	**0.3 W/ft^2**
	Landscaping	**0.04 W/ft^2**	**0.05 W/ft^2**	**0.05 W/ft^2**	**0.05 W/ft^2**

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Exterior Lighting Power Allowance Zones

The zone designations follow the current IESNA development work on Model Lighting Ordinances (MLO)

ZONE 1
Developed areas of parks, forest, and rural areas.

ZONE 2
Residential and mixed use, neighborhood business, light industrial with limited night use.

ZONE 3
All other.

ZONE 4
High activity commercial in major metro as designated by AHJ.

In 2010, Zone 0 was introduced to represent undeveloped areas within national parks, forest land, and rural areas as defined by AHJ.

Exterior LPD Limits for IECC 2015

IECC 2015 exterior LPD values are the same as 90.1-2013 with limited exceptions:

- IECC 2015 has slightly lower LPD allowances for Building Façade category
- IECC 2015 does not include a few new categories in 90.1-2013:
  - Landscaping
  - Loading Docks

Interior Lighting Control Requirements

Interior control requirements in 90.1-2013 and IECC 2015 are applied by space type (with exemptions)

- 90.1-2013 has adopted a tabular format that shows control requirements by space along with applicable LPD limits and separately defines each control type.
- IECC 2015 specifies and defines control requirements in sections and paragraphs with defined or listed application.
- Both have similar approaches to control but with some differences in application.

90.1 Tabular Format for Controls (and LPDs)

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TABLE 9.6.1 - Lighting Power Density Allowances Using the Space-by-Space Method and Minimum Control Requirements Using Either Method

The control functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1. For each Space Type:
(1) All REQ's shall be implemented.
(2) At least one ADD1 (when present) shall be implemented.
(3) At least one ADD2 (when present) shall be implemented.

Common Space Types[1]	LPD (watts/sq.ft.)	RCR Threshold	Local Control see 9.4.1.1 (a)	Restricted to Manual ON see 9.4.1.1 (b)	Restricted to Partial Automatic ON see 9.4.1.1 (c)	Bi-level Lighting Control see 9.4.1.1 (d)	Automatic Daylight Responsive Controls for Sidelighting see 9.4.1.1 (e)6	Automatic Daylight Responsive Controls for Toplighting see 9.4.1.1 (f)6	Automatic Partial OFF see 9.4.1.1 (g) (Full Off complies)	Automatic Full OFF see 9.4.1.1 (h)	Scheduled Shutoff see 9.4.1.1 (i)
			a	b	c	d	e	f	g	h	i
Audience Seating Area											
... in a motion picture theater	1.14	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
... in a penitentiary	0.28	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
... in a performing arts theater	2.43	8	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
... in a religious building	1.53	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
... in a sports arena	0.43	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
... otherwise	0.43	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Banking Activity Area	1.01	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Breakroom (See Lounge/Breakroom)											
Classroom/Lecture Hall/Training Room											
... in a penitentiary	1.34	4	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
... otherwise	1.24	4	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Conference/Meeting/Multipurpose Room	1.23	6	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Confinement Cells	0.81	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Copy/Print Room	0.72	6	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	

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Interior Lighting Control Requirements

Each space is <u>required to have</u> or is <u>limited by</u> one or more control functions:

- Local on/off control
- Manual on restriction
- Partial automatic on (occupancy/timer based)
- Partial automatic off (occupancy/timer based) **- <u>not used in IECC 2015</u>**
- Automatic full off (occupancy/timer based)
- Bi-level control available to occupant
- Scheduled automatic shutoff
- Daylight control (Continuous dimming or multi-step) – sidelighting or toplighting as appropriate

Occupancy Based or Timer/shutoff Control

- 90.1-2013 requires occupancy sensor **or** automatic timer/scheduled shutoff control in most spaces (some exceptions apply)
- IECC 2015 applies the specific occupancy sensor requirement to a specific limited list:
  - Classroom, conference
  - Private office, copy/print
  - Storage, janitorial closets
  - Restrooms, locker rooms
  - Warehouses
  - Other rooms 300 ft^2 and smaller

- IECC 2015 requires automatic timer/shutoff control in all other spaces (some exceptions apply)

Occupancy Manual-on Control Restriction

Both 90.1 and IECC require that Automatic control devices shall not be set to Automatically turn the lighting to full on.

- This effectively requires manual-on OR 50% auto-on function for automatic controls
- Exceptions (where full automatic-on is allowed):
  - public corridors, and stairwells, restrooms,
  - primary building entrance areas and lobbies ,
  - areas where manual-on operation would endanger the safety or security of the room or building occupant(s).

“Bi-Level” Space Lighting Control

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Manual controls for lighting are required to provide at least one control step between 30% and 70% plus full on and off. Applies to:

- Many spaces in 90.1-2013
- Only spaces with timer control in IECC 2015

Exemptions:

- Lights in corridors, electrical/mechanical rooms, public lobbies, restrooms, stairways, and storage rooms. **IECC 2015 does not exempt restrooms, stairways, and storage rooms**
- Spaces with only one luminaire with rated input power < 100W.
- Space types with a lighting power allowance < 0.6 W/ft^2

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Partial Auto-Off Control

- 90.1-2013 requires automatic partial off for spaces previously exempted from any shutoff including some corridors and lobbies, stairwell, warehouse.
- IECC 2015 either exempts from control or requires full off.
- State or local egress requirements may exempt or modify this requirements in application

Daylighting Control

Electric lighting must be controlled when daylight is available…and made available when possible

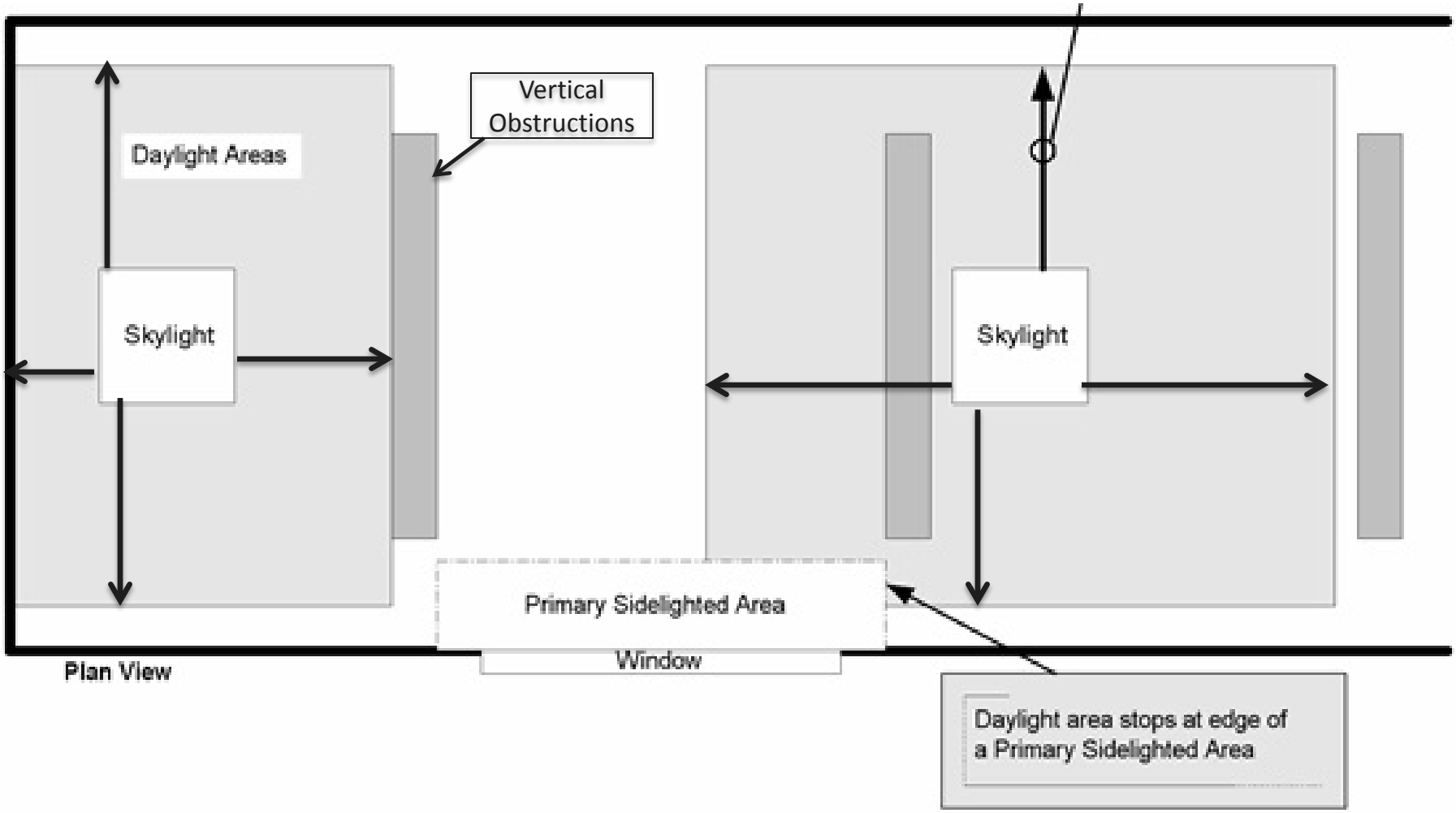
- Require the control of electric lighting when top and side daylight is present ….AND….
- Require the installation of skylights when applicable (exceptions apply)

Lighting Control for Toplighting

Electric lighting must be automatically controlled if toplighting daylight is available

- Applied based on “daylight area under skylights” + “daylight area under rooftop monitors” with lighting wattage exceeding 150W
- Control is required for the general lighting over these areas – some exceptions apply
- Control must be multi-level photocontrol - at least two output levels at 0% - 35% and 50% - 70% or Continuous dimming

“Daylight Area Under Skylights” – Top View

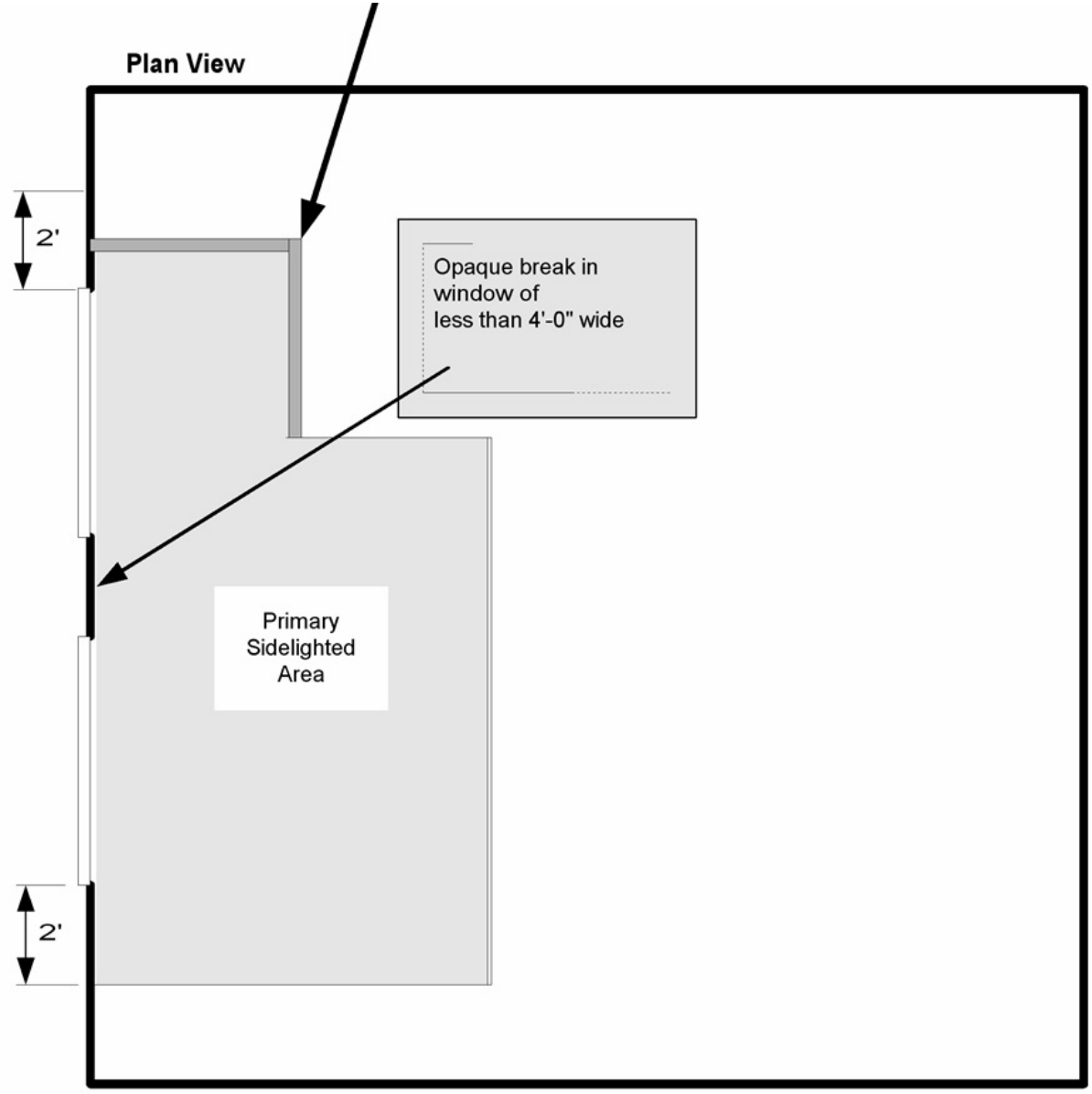


Lighting Control for Sidelighting

Electric lighting must be automatically controlled if sidelighting daylight is available

- Applied based on “primary sidelighted area” with lighting wattage exceeding 150W.
- Control is required for the general lighting over these areas – some exceptions apply
- Control must be multi-level photocontrol - at least two output levels at 0% - 35% and 50% - 70% or Continuous dimming

“Primary Sidelighted Area” – Top View



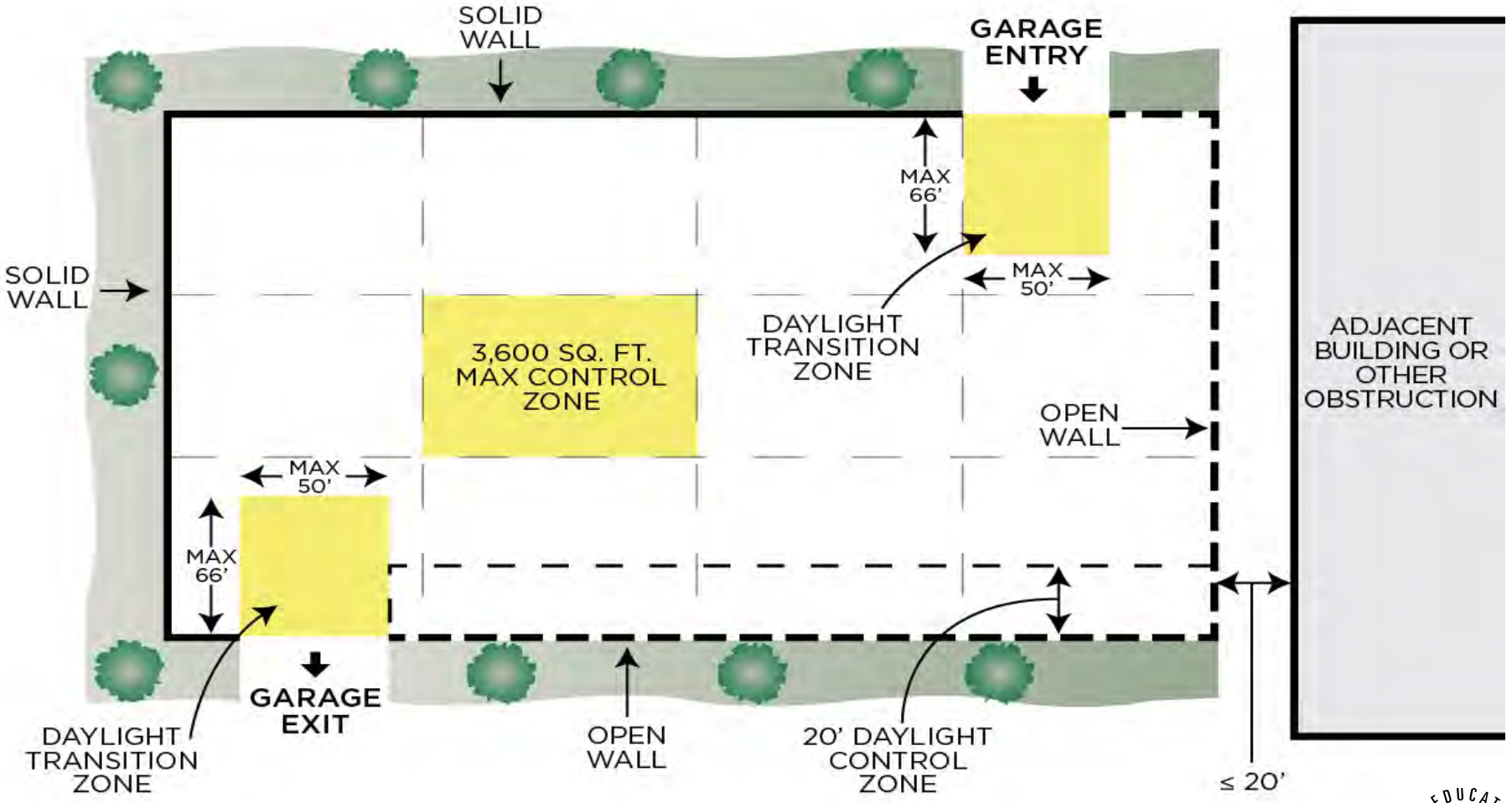
Interior Parking Garage Control

Parking garage lighting must be automatically controlled including daylighting

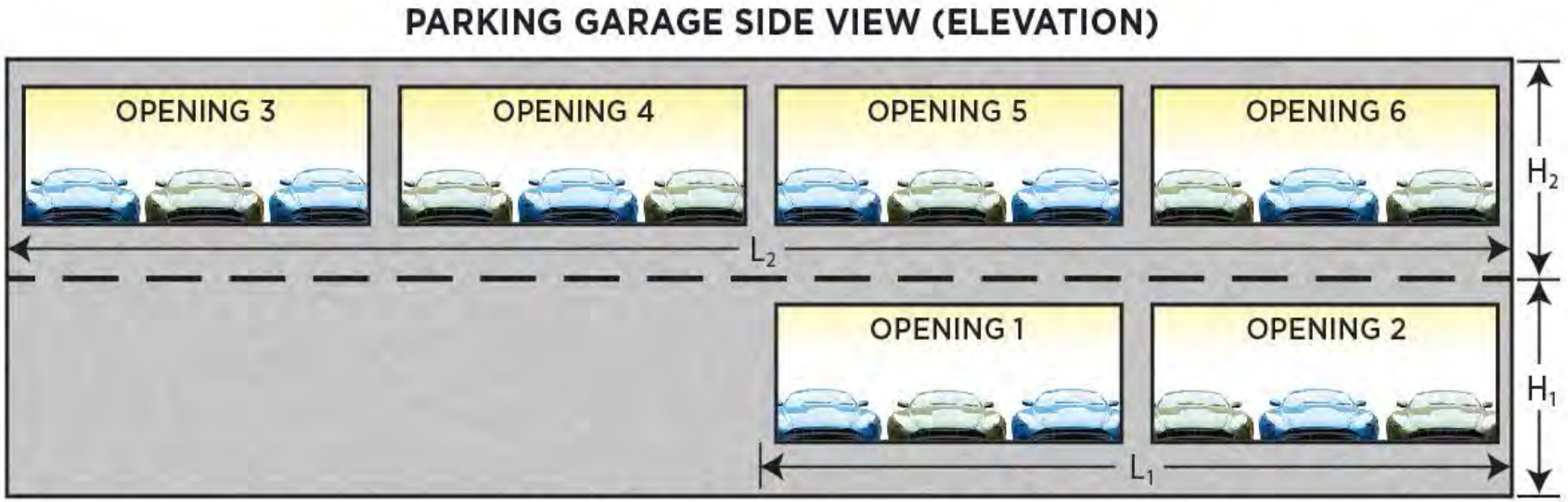
- Reduce lighting power by 30% or more when no occupancy detected in a lighting zone (< 3,600 sf)
- Daylight transition zone lighting (66 ft. wide by 50 ft.) must be separately controlled for eye adaptation.
- Daylight control required for lights within 20 feet of perimeter wall with net opening to wall ratio of 40%.
- Exceptions apply

These controls are not required in IECC 2015

Parking Garage Control



Parking Garage Control: Opening to Wall Ratio



Daylighting control required if the total area of all openings in a wall section (i.e. openings 1-2) are greater than or equal to 40% of the total wall area (HxL).

Example: $\frac{\text{Opening 1 + Opening 2}}{H_1 \times L_1}$

Example: $\frac{\text{Opening 3 + Opening 4 + Opening 5 + Opening 6}}{H_2 \times L_2}$

Exterior Lighting Control

Requires specific daylight and building operation lighting controls for exterior

- Automatic dusk-to-dawn shutoff required
- Building façade/landscape lighting must be off from latest of midnight or closing to earliest of 6am or opening
- Other lighting including ad signage, shall be automatically reduced by at least 30% either after-hours or when area is unoccupied
- Exceptions apply

Advanced Control Incentives

If all mandatory control requirements are met AND advanced controls are installed, THEN additional limited lighting power is allowed

- Based on control of specific spaces only
- Additional power can be used anywhere in the building
- Additional Interior Lighting Power is calculated as:

Lighting Power Under Control x Control Factor

- Available options are limited and reflect very advanced systems, programmable control, or additional control in secondary spaces

Incentives are not provided in IECC 2015

Control Factors for Advanced Optional Controls (partial list)

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Control Factors Varying by space type				
	Space Type			
Additional Control Method	Open AND Private offices	Conference meeting Classroom (lect./train.)	Retail Sales area	Lobby, Atrium, Dining, Corridor/stairs, Gym/pool Mall concourse, Parking garage
Manual, continuous dimming control OR Programmable multi-level dimming control	0.05	0.10*	0.1	0
Programmable multi-level dimming control using programmable time scheduling	0.05	0.10*	0.1	0.1
Multi-level occupancy sensors	0.05	0.05	0	0
Automatic bi-level or multi level switching in *primary sidelighted areas* when *EA* > 0.15	0	0	0.1	0
…….	…	…	…	….

*These control factors may only be used if the requirements of section 9.4.1.2 are met using an occupancy sensor.

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Alterations Requirements

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Lighting alterations (retrofits) must comply with interior and exterior power limits

- Includes retrofits where luminaires are added, replaced, or removed.
- Altered interior space or exterior area or application must also have basic auto shutoff control **IECC 2015 requires full lighting section compliance including controls as applicable**
- Alterations of less than 10% of a spaces connected lighting load are exempted **(IECC 2015 exception notes both 10% or 50% of luminaires)**
- Includes lamp plus ballast retrofits **Not included as part of IECC 2015**

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Functional testing required for lighting controls (calibrated, adjusted, programmed)

- Must be performed by individuals NOT involved in design, manufacture, or installation **IECC 2015 only specifies that design professional verify that controls perform as designed**
- Primarily for *occupant sensors*, *time switches,* or daylight control *photosensors*
  - Verify all performance criteria is met
  - Confirm occupant sensor time-out and sensitivity settings
  - Confirm timers and programs set to turn lights off
  - Confirm photosensor controls effectively control electric lighting
- Must follow specific (step-by-step) directions

Power Requirements

- Low Voltage Dry Transformer efficiency
  - Must effectively meet EPAct 2005
- Voltage Drop for efficiency **Not part of IECC 2015**
  - Feeder circuits – 2% of design load
  - Branch circuits – 3% of design load
- Automatic receptacle control – 50% **Not part of IECC 2015**
- Electrical Metering
- Document submittals
  - Drawings
  - Manuals

Receptacle (wall plug) Control

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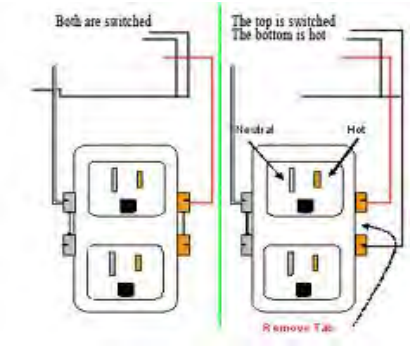
A portion of receptacles (wall plugs) in a space must have automatic shutoff control

- Applies to 50% of 125 volt, 15 and 20 Amp receptacles in:
  - Private offices and Conference rooms
  - Print/copy rooms and Break rooms
  - Open office workstations and Computer classrooms
- Also applies to 25% of modular furniture circuits
- Requires automatic control using: time-of-day schedule, occupancy sensor, or other automatic occupancy control
- Exceptions for safety/security or required 24 hour use
- Controlled receptacles must be marked and uniformly distributed
- **Plug-in type devices do not comply**



These requirements are not included in IECC 2015

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Electrical Energy Use Monitoring

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- For new construction only. Separate measurement for:
  - Total electrical energy
  - HVAC systems
  - Interior and exterior lighting separately
  - Receptacle circuits
- Separate tenants monitored separately
- Recording and data availability required
- Exceptions:
  - Building < 25,000 sq.ft. or tenant < 10,000 sq.ft. or **dwelling unit**
  - Residential buildings w/< 10,000 sq.ft. common area
  - Critical branches (NEC 517)

IECC 2015 only requires separate electrical meter for each dwelling unit

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Additional IECC 2015 Requirement

Additional Efficiency Package Requirement

- One additional efficiency feature must be selected to comply with IECC 2015
  - More efficient HVAC performance, OR
  - **Reduced lighting power density system**, OR
  - **Enhanced lighting controls**, OR
  - On-site supply of renewable energy, OR
  - Dedicated outdoor air system, OR
  - More efficient SWH

IECC 2015 Additional Efficiency Package Options

- Reduced lighting power
  - Use only 90% of whole building LPD for compliance OR
  - Use only 90% of the space-by-space LPD for compliance

.....OR.....

- Enhanced digital lighting controls:
  - Luminaires capable of continuous dimming
  - Luminaires capable of being addressed individually OR as a controlled group of ≤ 4 luminaires/≤ 8 luminaires together in a daylight zone
  - Fixtures controlled through digital control system that includes:
    - Control reconfiguration based on digital addressability
    - Load shedding
    - Individual user control of overhead general illumination in open offices
    - Occupancy sensors capable of reconfiguration through the digital system

A Few Words About Compliance Enforcement

- DOE requires adoption of codes….but….

State and local jurisdictions monitor compliance.

- Codes are not perfect!....your project may not fit the requirements….interpretation may be needed
- Most building officials are just as interested in a reasonable application of the code as the builder
  - working to the intent of the requirement is the goal
  - offering an energy-effective solution with reasoning may prove successful!

THANK YOU!

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Building Energy Codes Program
www.energycodes.gov

BECP help desk
http://www.energycodes.gov/resource-center/help-desk

Eric Richman
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QUESTIONS

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