ENERGY CODE TRAINING

Commercial Lighting

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INTRODUCTIONS

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INTRODUCTIONS

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EFFECTIVE COMMERCIAL LIGHTING

Lighting Trivia 1

"If you are gone for 20 minutes, it's better to leave the lights on the whole time since turning lights off and then on causes a surge in power consumption."

- True
- False

Lighting Trivia 2

"Lighting retrofit to LED's is typically less than a 7 year payback (ROI)."

- True
- False

LED RETROFITS OPTIONS FOR TUBE FLUORESCENTS

There are different levels of LED retrofits for fluorescent fixtures

A. Entirely new LED fixture
B. Keep the existing fixture housing – replace the electronics, lens and lighting with LED
C. Keep the existing fixture but upgrade to electronic ballast and install LED tubes
D. Swap the fluorescent tubes with LED tubes

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LED Retrofits – Scenarios Trivia 3

Match the LED Retrofit scenario with a letter (below)

- 100 yr-old Small College had recently (5 years ago) upgraded from T-8 fluorescents to T-5 with new electronic ballasts
- 1992 former Storage building with original T-12 fixtures being converted to open retail market
- 2014 Rec Center with well-maintained fixtures wants to upgrade from original T-8 fluorescents
- 1999 Doctor's office with under-lit patient rooms and ugly four-lamp T-8 troffers

A. New LED fixture
B. Keep existing fixture but replace "guts"
C. Keep existing fixture new electronic ballasts and LED tubes
D. Swap fluorescent tubes with LED tubes

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Lighting Trivia 4

"New lighting fixture retrofits should be one-for-one in terms of fixture counts."

- True
- False

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Lighting Trivia 5

"Vacancy Sensor controls save more energy than Occupancy Sensors."

- True
- False

Occupancy: Auto ON…Auto OFF

Vacancy: Manual ON…Auto OFF

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INTERIOR & EXTERIOR LIGHTING CONTROLS

Fostering human habits proves to save energy

- Vacancy sensors preferred
- Occupancy sensors (no daylight)
- Multi-level controls
- Photosensors for daylit areas
- Automatic shut-offs
- Building automation systems or scheduled auto off
- KISS principle and verify/Cx

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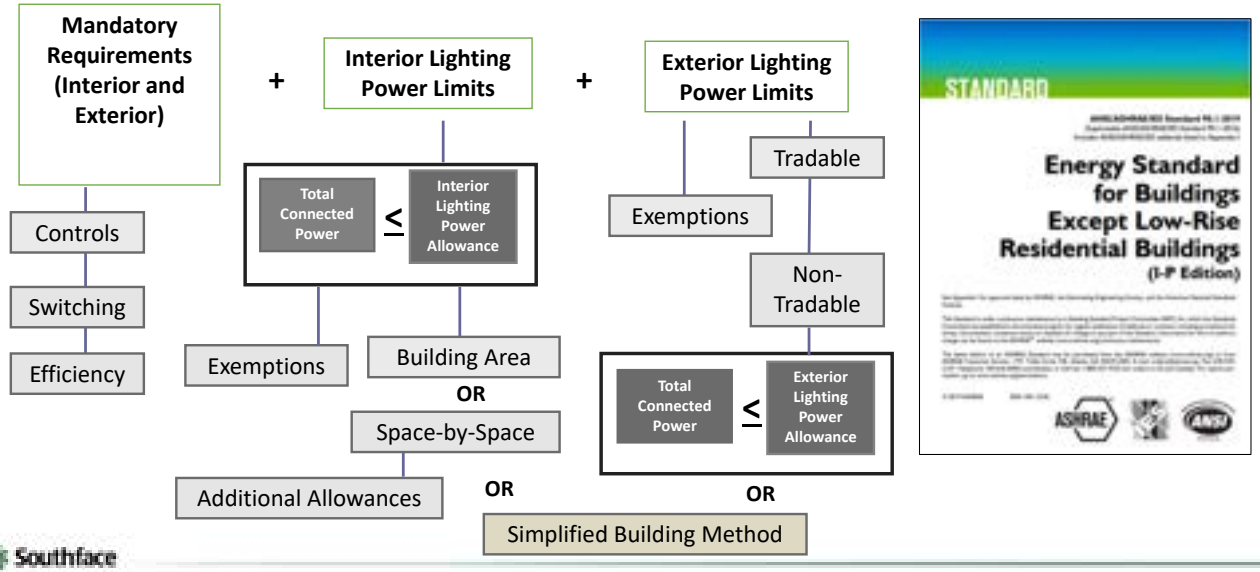
COMPLIANCE OPTIONS



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COMPLIANCE OPTIONS

Prescriptive path must comply with these:

- C402 Envelope
- C403 Mechanical
- C404 SWH
- **C405 Lighting**

Plus one optional path from C406

- C406.3 Reduced Lighting Power
- C406.4 Enhanced Digital Controls

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406.3 REDUCED LIGHTING POWER (OPTIONAL)

- The total connected interior lighting power calculated in accordance with Section C405.3.1 shall be less than **90 percent** of the total lighting power allowance calculated in accordance with Section C405.3.2.

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NEW BUILDINGS AND…

Retrofits:

- Where luminaires are added, replaced, or removed
- That include replacement of lamp plus ballast in luminaires

Requires BOTH interior and exterior alterations to comply with Lighting Power Density (LPD) limits and basic after hours automatic shutoff requirements

Photo Courtesy of Verde Energy Efficiency Experts

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EXCEPTIONS

- Spaces where alterations involve less than 20% of connected lighting load and the LPD for the space is not increased
- Alterations that only involve replacement of lamps plus ballasts/drivers or only involve one-for-one luminaire replacement to only comply with LPD requirement and Section 9.4.1.1(h) and 9.4.1.1(i)
- Routine maintenance or repair

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EXCEPTIONS

- Historic buildings
  - State or National listing
  - Eligible to be listed
- A report demonstrating that compliance with that provision would threaten, degrade or destroy the historic form, fabric or function of the building must be submitted by a code official and one of the following:
  - A registered design professional
  - A representative of the State Historic Preservation Office
  - The historic preservation authority having jurisdiction

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EXCEPTIONS (CONT.)

- Alterations where less than **20%** of the luminaires in a space are replaced and installed interior power lighting is not increased
- Lighting within dwelling units
  - Where ≥ 75% of permanently installed fixtures (except low-voltage) are fitted for and include high-efficacy lamps
- Walk-in coolers, walk-in freezers, refrigerated warehouse coolers, and refrigerated warehouse freezers comply with C403.2.15 or C403.2.16

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HIGH-EFFICACY LAMPS

- Neither ASHRAE nor the IECC require LEDs
- Future codes, your local jurisdiction, and your customers might have more stringent requirements
- Compact fluorescent lamps, T8 or smaller diameter linear fluorescent lamps, or other lamps with an efficacy based on lamp wattage may be made to comply
- Avoid halogen & incandescents

Lighting	Efficacy
bulbs	65 lumens/watt
luminaire	45 lumens/watt

However…

- 90.1-2019 does include partial or complete LED efficacy in many space type models in recognition of:
  - Proven LED efficacy and energy savings capability
  - Continued reduced cost of LEDs
  - Product maturity and reasonable applicability

However…

- IECC does require minimum 90% of all bulbs in dwelling units be efficient

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CALCULATING LPD & LPA'S

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BUILDING AREA METHOD

- Determine gross lighted area for each building type area using:
  - Exterior faces of exterior walls
  - Centerline of interior walls
- Calculate the area power allowance by multiplying the gross lighted area by the applicable building type allowance from Table 9.5.1
- Sum all the allowances (if more than one building type area)

BUILDING AREA METHOD

Advantages
- Fewer calculations
- One and done, so fast

Disadvantages
- Limited building area type selection - use reasonably equivalent type
- Insensitive to specific space functions and room configurations
- Generally more restrictive that space-by-space method

Table 9.5.1 *Lighting Power Density* **Allowances Using the** *Building* **Area Method**

Building Area Type[a]	*LPD*, W/ft²
Automotive facility	0.75
Convention center	0.64
Courthouse	0.79
Dining: Bar lounge/leisure	0.80
Dining: Cafeteria/fast food	0.76
Dining: Family	0.71
Dormitory	0.53
Exercise center	0.72
Fire station	0.56
Gymnasium	0.76
Health-care clinic	0.81
Hospital	0.96
Hotel/motel	0.56
Library	0.83
Manufacturing facility	0.82
Motion picture theater	0.44
Multifamily	0.45
Museum	0.55
Office	0.64
Parking garage	0.18
Penitentiary	0.69
Performing arts theater	0.84
Police station	0.66
Post office	0.65
Religious facility	0.67
Retail	0.84
School/university	0.72
Sports arena	0.76
Town hall	0.69
Transportation	0.50
Warehouse	0.45
Workshop	0.91

SIMPLIFIED BUILDING METHOD

9.3 Simplified Building Method Compliance Path

The Simplified Building Method contains the requirements for interior lighting in Section 9.3.1 and exterior lighting in Section 9.3.2 and shall be allowed to be used where at least 80% of the floor area supports either office buildings, retail buildings, or school buildings. The Simplified Building Method shall be used for new buildings or tenants improvements of less than 25,000 ft². Interior and exterior wattage allowances shall be calculated and complied with separately.

Applicable to

- Offices
- Retail
- Schools

Limitations

- Limited to new buildings or tenant spaces < 25,000 s.f.

Table 9.3.1-1 Simplified Building Method for Office Buildings

Interior Space Type	Interior Lighting Power Allowance	Controls[a]
All spaces in office buildings other than parking garages, stairwells, and corridors	0.70 W/ft²	All lighting shall be automatically controlled to turn off when the building is either unoccupied or scheduled to be unoccupied. (**Exception:** Lighting load not exceeding 0.02 W/ft² multiplied by the gross lighted area of the building shall be permitted to operate at all times.) Each space shall have a manual control device that allows the occupant to reduce lighting power by a minimum of 50% and to turn the lighting off.
Office spaces less than or equal to 250 ft², classrooms, conference rooms, meeting rooms, training rooms, storage rooms, and break rooms	0.70 W/ft²	These spaces shall also be controlled by manual-on occupant sensors.
Office spaces greater than 250 ft² and restrooms	0.70 W/ft²	These spaces shall also be controlled by occupant sensors.
Stairwells and corridors in office buildings and parking garages	0.70 W/ft²	These spaces shall also be controlled by occupant sensors that reduce the lighting power by a minimum of 50% when no activity is detected for not longer than 20 minutes and be controlled to turn off when the building is either unoccupied or scheduled to be unoccupied.
Parking garages	0.13 W/ft²	All lighting shall be automatically controlled to turn off during garage nonoperating hours. Lighting shall also be controlled by occupant sensors. Controls shall reduce the power by a minimum of 50% when no activity is detected for not longer than 20 minutes. No device shall control more than 3600 ft².

a. All lights in the space shall be controlled.

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SIMPLIFIED BUILDING METHOD

Advantages

- Streamlined details for offices, retail and schools (under 25,000 s.f.)

Table 9.3.1-2 Simplified Building Method for Retail Buildings

Interior Space Type	Interior Lighting Power Allowance	Controls[a]
All spaces in retail buildings other than parking garages, stairwells, and corridors	1.00 W/ft²	All lighting shall be automatically controlled to turn off when the building is either unoccupied or scheduled to be unoccupied. (**Exception:** Lighting load not exceeding 0.02 W/ft² multiplied by the gross lighted area of the building shall be permitted to operate at all times.) Each space shall have a manual control device that allows the occupant to reduce lighting power by a minimum of 50% and to turn the lighting off.
Sales area	1.00 W/ft²	These spaces shall also be controlled • to reduce the general lighting power by a minimum of 75% during nonbusiness hours, • to turn off all lighting other than general lighting during nonbusiness hours, and • by continuous daylight dimming controls[b] in spaces with toplighting.
Stock rooms, dressing/fitting rooms, locker rooms, and restrooms	1.00 W/ft²	These spaces shall also be controlled by: auto-on or manual-on occupant sensors, and continuous daylight dimming controls[b] in spaces with toplighting.
Office spaces, conference rooms, meeting rooms, training rooms, storage rooms, break rooms, and utility spaces	1.00 W/ft²	These spaces shall also be controlled by: manual-on occupant sensors, and continuous daylight dimming controls[b] in spaces with toplighting.
Stairwells and corridors in retail buildings and parking garages	1.00 W/ft²	These spaces shall also be controlled by occupant sensors that reduce the lighting power by a minimum of 50% when no activity is detected for not longer than 20 minutes and be controlled to turn off when the building is either unoccupied or scheduled to be unoccupied.
Parking garages	0.13 W/ft²	All lighting shall be automatically controlled to turn off during garage nonoperating hours. Lighting shall also be controlled by occupant sensors. Controls shall reduce the power by a minimum of 50% when no activity is detected for not longer than 20 minutes. No device shall control more than 3600 ft².

a. All lights in the space shall be controlled.
b. When the combined input power of the general lights completely or partially within the daylight areas is 150 W or greater.

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SIMPLIFIED BUILDING METHOD

Advantages

- Streamlined details for offices, retail and schools (under 25,000 s.f.)

Table 9.3.1-3 Simplified Building Method for School *Buildings*

Interior Space Type	Interior Lighting Power Allowance	Controls[a]
All spaces in school *buildings* other than parking garages, stairwells, and corridors	0.70 W/ft^2	All lighting shall be automatically controlled to turn off when the *building* is either unoccupied or scheduled to be unoccupied. (**Exception:** Lighting load not exceeding 0.02 W/ft^2 multiplied by the gross lighted area of the *building* shall be permitted to operate at all times.) Each space shall have a manual control device that allows the occupant to reduce lighting power by a minimum of 50% and to turn the lighting off.
Classrooms, offices spaces, conference rooms, meeting rooms, library, storage rooms, and break rooms	0.70 W/ft^2	These spaces shall also be controlled by *manual-on occupant sensors*.
Gymnasiums and cafeterias	0.70 W/ft^2	These spaces shall also be controlled by *occupant sensors*.
Restrooms	0.70 W/ft^2	These spaces shall also be controlled by *occupant sensors*.
Stairwells and corridors in school *buildings* and parking garages	0.70 W/ft^2	These spaces shall also be controlled by *occupant sensors* that reduce the lighting power by a minimum of 50% when no activity is detected for not longer than 20 minutes and be controlled to turn off when the *building* is either unoccupied or scheduled to be unoccupied.
Parking garages	0.13 W/ft^2	All lighting shall be automatically controlled to turn off during garage nonoperating hours. Lighting shall also be controlled by *occupant sensors*. Controls shall reduce the power by a minimum of 50% when no activity is detected for not longer than 20 minutes. No device shall control more than 3600 ft^2.

a. All lights in the space shall be controlled.

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SIMPLIFIED BUILDING METHOD

Building Exteriors

- Streamlined details for offices, retail and schools (under 25,000 s.f.)

Table 9.3.2 Simplified Building Method for *Building* Exteriors

Exterior Area Type	Exterior Lighting Power Allowance[a,b]	Controls[c]
Base allowance	200 W	*Luminaires* shall be turned off or the power reduced by a minimum of 75% during nonoperating hours.
Façade lighting and special feature areas, walkways, plazas	0.10 W/ft^2	*Luminaires* shall be turned off or the power reduced by a minimum of 75% during nonoperating hours.
Landscape	0.04 W/ft^2	*Luminaires* shall be turned off or the power reduced by a minimum of 75% during nonoperating hours.
Entry doors	14 W/linear foot	*Luminaires* shall be turned off or the power reduced by a minimum of 75% during nonoperating hours.
Stairs and ramps	0.7 W/ft^2	No additional controls required.
Parking lots and drives	0.05 W/ft^2	*Luminaires* mounted 25 ft or less above grade shall be controlled to reduce the power by at least 50% when no activity is detected for not longer than 15 minutes.
All other areas not listed	0.20 W/ft^2	*Luminaires* shall be turned off or the power reduced by a minimum of 75% during nonoperating hours.

a. To calculate the exterior allowance, multiply the space or area square footage by the allowed W/ft^2 and sum the exterior allowances and the base allowance. Façade lighting shall be calculated separately by multiplying the façade area by the allowed W/ft^2. Façade allowance shall not be traded with other exterior areas or between separate façade areas.
b. For *buildings* in Lighting Zone 2, as defined in Table 9.4.2-1, decrease exterior allowances by 20%. For *buildings* in Lighting Zone 4, as defined in Table 9.4.2-1, increase exterior allowances by 20%.
c. All exterior lighting shall be automatically controlled by either a photocell or an astronomical time switch to shut off the lighting when daylight is available.

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SPACE-BY-SPACE METHOD

- Determine the gross lighted area of each space type, include balconies and mezzanines
- Use centerline of walls between spaces
- Calculate the space power allowance by multiplying the space type area by the applicable allowance from Table 9.6.1
- **Sum all the allowances**

SPACE-BY-SPACE METHOD

Advantages

- More flexible than building area method
- More accurately accounts for actual room lighting power needs
- Provides additional allowances for:
  - Difficult room configurations
  - Decorative and retail needs
  - Use of advanced controls not already required in the standard

Disadvantages

- More calculations needed (individual spaces)

Common Space Types	LPD (w/ft²)
Locker room	0.52
Lounge/breakroom	
In a healthcare facility	0.42
Otherwise	0.59
Office	
Enclosed (≤ 250 s.f.)	0.74
Open plan	0.61

SPACE-BY-SPACE METHOD

- If a physical space has multiple functions such that more than one space type from Table 9.6.1 applies
- Break the space into smaller subspaces
- Use the centerline of interior walls and dividing line between subspaces to determine subspace areas
- Calculate the allowance separately for each subspace
- Exception - Subspaces with areas less than 20% of the original space and less than 1,000 ft^2 do not need to be broken out separately

SECTION 9.6: INTERIOR LIGHTING BUDGET

9.6.2 - Space-by-Space Method

Additional Interior Lighting Power

Decorative / highlighting luminaires

- 0.75 W/ft^2 in space where used

Retail Sales Area

Additional Allowance = 1000 watts
+ (Retail Area 1 x .45 W/ft2)
+ (Retail Area 2 x .45 W/ft^2)
+ (Retail Area 3 x 1.05 W/ft^2)
+ (Retail Area 4 x 1.88 W/ft^2)

Retail 1 – All goods not covered in 2, 3, 4
Retail 2 – vehicles, sporting goods, small electronics
Retail 3 – furniture, clothing, cosmetics, artwork
Retail 4 – jewelry, crystal, china

SECTION 9: INTERIOR LIGHTING BUDGET

9.6.3 – Space-by-Space Method

Additional Interior Lighting Power Using Better **Controls** (5% to 30% bonus)*

*Additional interior lighting control = lighting power under control **X** control factor (per table 9.6.3)

Additional *Control* Method (in Addition to Mandatory Requirements)	Space Type				
	Open Office	Private Office	Conference Room, Meeting Room, Classroom (Lecture/ Training)	Retail Sales Area	Lobby, Atrium, Dining Area, Corridors/ Stairways, Gym/ *Pool*, Mall Concourse, Parking Garage
Manual, continuous dimming control or programmable multilevel *dimming control*	0.05	0.05	0.10	0.10	0
Programmable multilevel *dimming control* using programmable time scheduling	0.05	0.05	0.10	0.10	0.10
Occupancy sensors controlling the downlight component of workstation specific *luminaires* with continuous dimming to off capabilities	0.25[A]	0	0	0	0
Occupancy sensors controlling the downlight component of workstation specific *luminaires* with continuous dimming to off operation, in combination with personal continuous dimming *control* of downlight illumination by workstation occupant	0.30[A,B]	0	0	0	0
Automatic continuous daylight dimming in secondary sidelighted areas	0.10[F]	0.10[F]	0.10[F]	0.10[F]	0.10[F]

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SECTION 9: INTERIOR LIGHTING BUDGET

9.6.4 – Space-by-Space

Room Geometry Adjustment

(20% LPD bonus if calculated RCR is greater than RCR threshold)

RCR = 2.5 **X** room cavity height* **X** room perimeter length **/** room area

*Room cavity height **=** luminaire mounting height **-** workplane

Common Space Types[1]	RCR Threshold
Electrical/Mechanical Room[7]	6
Emergency Vehicle Garage	4
Food Preparation Area	6
Guest Room	6
Laboratory	
In or as a classroom	6
All other laboratories	6
Laundry/Washing Area	4
Loading Dock, Interior	6
Lobby	
Facility for the visually impaired (and not used primarily by the staff)[3]	4
Elevator	6
Hotel	4
Motion picture theater	4
Performing arts theater	6
All other lobbies	4
Locker Room	6

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ROOM CAVITY RATIO ADJUSTMENT

RCR = 2.5 **X** room cavity height* **X** room perimeter length **/** room area

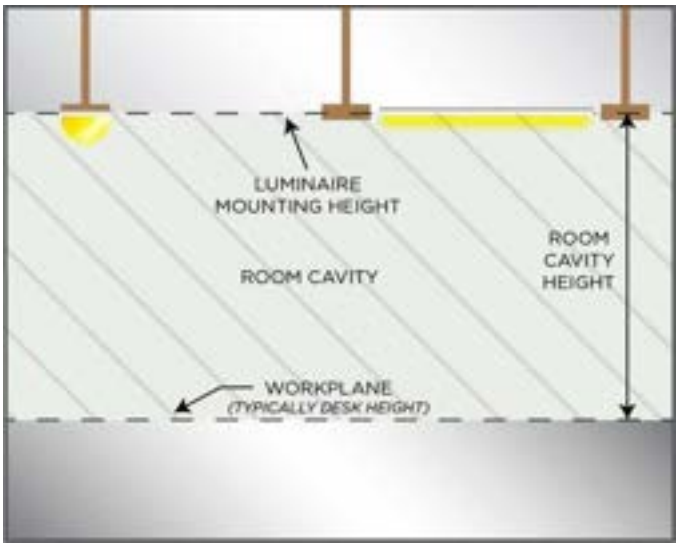
*Room cavity height **=** luminaire mounting height **-** workplane

Example: 30'x40' open office with 16.5' fixture height:

RCR = 2.5 x 14 x (140/1200) = **4.1**

Common Space Types[1]	LPD, W/ft²[2]	RCR[1]
Office		
Enclosed and <250 ft²	0.74	8
Enclosed and >250 ft²	0.66	8
Open plan	0.61	4
Parking Area, Interior	0.15	4
Pharmacy Area	1.66	6

This space is allowed 20% more wattage!



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SPACE-BY-SPACE METHOD

School Example	LPD (w/ft²)
Audience Seating Area - Gym	0.23
Classroom	0.71
Computer Room	0.94
Lab - Classroom	1.11
Cafeteria	0.40
Restroom	0.63
Locker Room	0.52

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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

Informative Note: This table is divided into two sections; this first section covers space types that can be commonly found in multiple building types. The second part of this table covers space types that are typically found in a single building type.			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 REQs shall be implemented; (2) At least one ADD1 (when present) shall be implemented; (3) At least one ADD2 (when present) shall be implemented.								
			Local Control (See Section [X])	Restricted to Manual/ON (See Section [X])	Restricted to Partial Automatic ON (See Section [X])	Stairwell Lighting Control (See Section [X])	Automatic Daylight Responsive Controls for Toplighting (See Section [e]*)	Automatic Daylight Responsive Controls for Toplighting (See Section [g]*)	Automatic Partial OFF (See Section [X] [f-ut Off compliant])	Automatic Full OFF (See Section [X])	Scheduled Shutoff (See Section [X])
Common Space Types[1]	LPD Allowances, W/ft²	ADD Threshold	a	b	c	d	e	f	g	h	i
Atrium											
<20 ft in height	0.39	NA	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
≥20 ft and ≤40 ft in height	0.48	NA	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
>40 ft in height	0.60	11	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Audience Seating Area											
Auditorium	0.61	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Gymnasium	0.23	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Motion picture theater	0.27	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Penitentiary	0.67	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Performing arts theater	1.16	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Religious facility	0.72	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Sports arena	0.33	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
All other audience seating areas	0.23	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Banking Activity Area	0.61	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Breakroom (See Lounge/breakroom)											
Classroom/Lecture Hall/Training Room											
Penitentiary	0.89	4	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
All other classroom/lecture hall/training	0.71	4	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	

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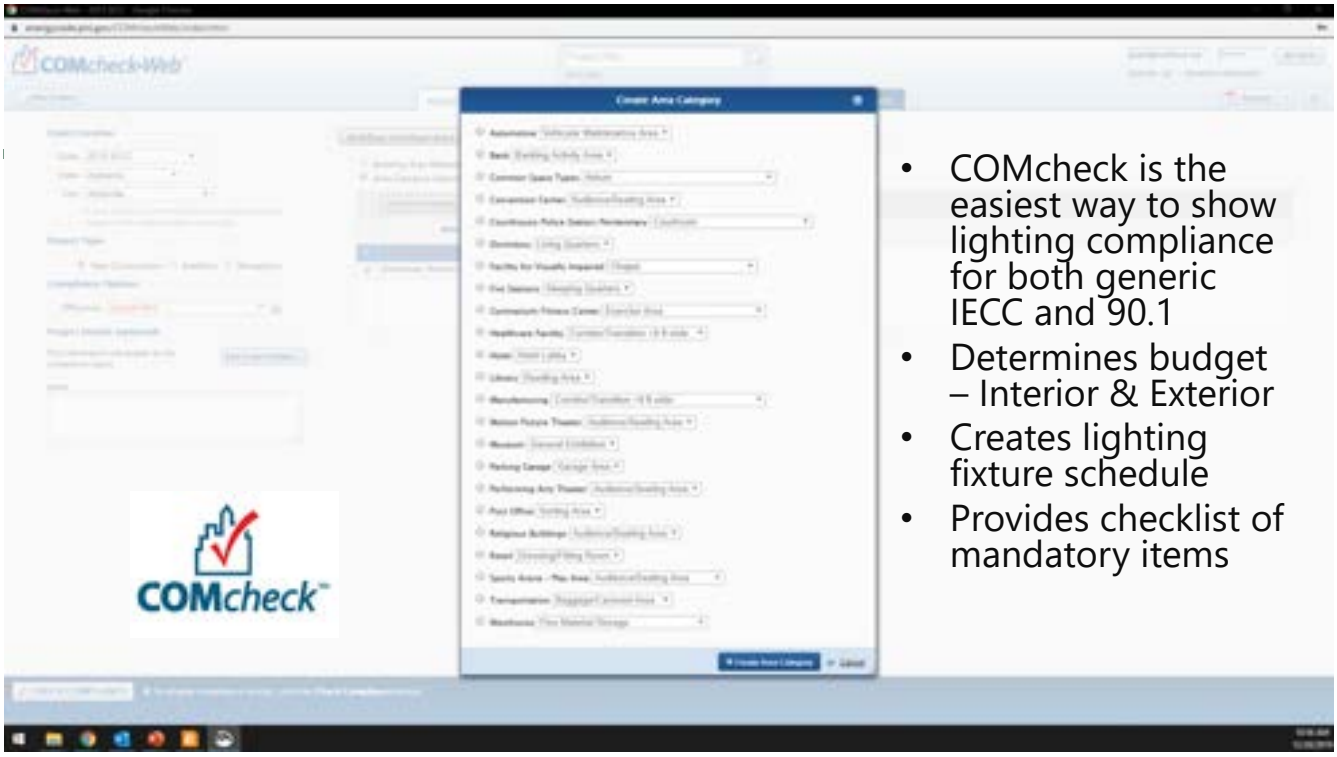

- COMcheck is the easiest way to show lighting compliance for both generic IECC and 90.1
- Determines budget – Interior & Exterior
- Creates lighting fixture schedule
- Provides checklist of mandatory items

INTERIOR LIGHTING POWER CALCULATION EXEMPTIONS

- Theatrical, stage, film, and video production
- Medical and dental procedures
- Exhibit displays for museums, monuments, and galleries
- Integral to equipment or instrumentation installed by manufacturer
- Integral to both open and glass-enclosed refrigerator and freezer cases
- Retail display windows, provided the display is enclosed by ceiling-height partitions
- Food warming and food preparation equipment
- Interior spaces specifically designated as registered interior historic landmarks
- Integral part of advertising or directional signage
- Exit signs
- Sale or lighting educational demonstration systems
- Lighting for television broadcasting in sporting activity areas
- Casino gaming areas
- Furniture-mounted supplemental task lighting controlled by automatic shutoff and complying with 9.4.1.4(d)
- For use in areas specifically designed for life support of nonhuman life forms
- Mirror lighting in dressing rooms and accent lighting in religious pulpit and choir areas
- Parking garage transition lighting
- Antimicrobial lighting for disinfecting a space

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NEW ENERGY CODE LIGHTING QUIZ - OFFICE

What is the Lighting Power Density Allowance for a 2500 ft^2 enclosed office under the Building Area Method of 90.1-2019?

Building Area Method

Building Area Type[a]	LPD, W/ft^2
Automotive facility	0.75
Convention center	0.64
Courthouse	0.79
Dining: Bar lounge/leisure	0.80
Dining: Cafeteria/fast food	0.78
Dining: Family	0.71
Dormitory	0.53
Exercise center	0.72
Fire station	0.58
Gymnasium	0.76
Health-care clinic	0.81
Hospital	0.96
Hotel/motel	0.56
Library	0.83
Manufacturing facility	0.82
Motion picture theater	0.44
Multifamily	0.45
Museum	0.55
Office	0.64

What is the LPD Allowance using the Space by Space Method of 90.1-2019?

Common Space Types[1]	LPD, W/ft^2
Office	
Enclosed and ≤250 ft^2	0.74
Enclosed and >250 ft^2	0.66
Open plan	0.61
Parking Area, Interior	0.15
Pharmacy Area	1.66
Restroom	
Facility for the visually impaired (and not used primarily by the staff)[3]	1.26
All other restrooms	0.63
Sales Area[4]	1.05

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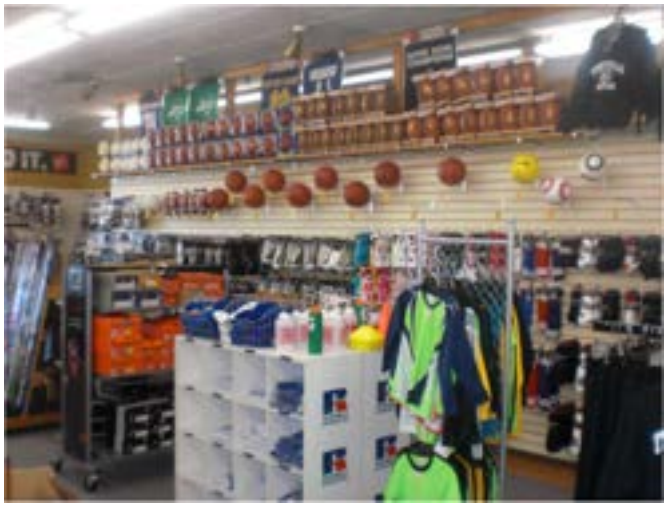
ENERGY CODE LIGHTING QUIZ - RETAIL

What is the Additional Interior Lighting Power Allowance provided for a retail sporting goods store using the Space-by-Space Method in 90.1-2019?



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TOTAL CONNECTED LIGHTING POWER

TCLP = [LVL + BLL + LED + TRK + OTHER]

LVL = labeled wattage of luminaires connected directly to building power

BLL = wattage of the ballast or transformer

LED = wattage of LEDs with either integral or remote drivers

TRK = wattage of lighting tracks, cable conductors, rail conductors, and plug-in busways specified wattage of the luminaires

- not less than **8 W per linear foot** *or*
- the wattage limit of other permanent current-limiting devices on the system *or*
- wattage limit of the transformer

OTHER = the wattage of all other luminaires and lighting sources not covered previously

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SECTION 9.1.4: CONNECTED LIGHTING POWER LIGHTING DESIGN WATTAGE

Luminaire Wattage – *"the rules"*

Luminaires not containing permanently installed ballasts, transformers, etc. = **max. labeled wattage of the luminaire**

Luminaires with permanently installed or remote ballasts, transformers, etc. = **operating input wattage of the lamp/auxiliary combination***

Line-voltage track =

- **Minimum 30 W per foot**
- **Or limit of system's circuit breaker**
- **Or wattage of other current-limiting device**

Low-voltage track = **transformer wattage**

All others as specified

*based on manufacturer's data, lab results, or max labeled wattage of luminaire (exception for adjustable ballast factors)

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SECTION 9.1.4: LIGHTING DESIGN WATTAGE

Example: Installed Interior Lighting Design

Calculate the total lighting wattage of a room containing the following fixtures:

Eight 4' Fluorescent Fixtures

- Three 4' fluorescent T8 lamps per fixture, 32 Watts
- One three-lamp electronic ballast
- Ballast Input Wattage – 90 Watts

Six Incandescent Downlights

- Specified Lamps – 60 Watt, A-line, Medium Screw Base
- Maximum labeled wattage of fixture – 75 Watts

16 Feet of Line Voltage Track

- Specified – 5 Track Heads
- 90 Watts Halogen PAR38 Lamps

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SECTION 9.1.4: LIGHTING DESIGN WATTAGE

Example: Installed Interior Lighting Design

Eight 4' Fluorescent Fixtures

- Three 4' fluorescent T8 lamps per fixture, 32 Watts
- One three-lamp electronic ballast
- Ballast Input Wattage – 90 Watts

Wrong Way!

8 Fixtures x 3 Lamps x 32 Watts per Lamp = 768 Watts

Right Way!

8 Fixtures x 90 Ballast Input Watts = 720 Watts

"the rules"

Ballasted Luminaires = wattage of the lamp/ballast combination

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SECTION 9.1.4: LIGHTING DESIGN WATTAGE

Example: Installed Interior Lighting Design

Six Incandescent Downlights

- Specified Lamps – 60 Watt, A-line, Medium Screw Base
- Maximum labeled wattage of fixture – 75 Watts

Wrong Way!

6 Downlights x 60 Watts/A-line lamp = 360 Watts

Right Way!

6 Downlights x **75** Watt Labeled fixture = 450 Watts

"the rules"

Standard incandescent = max. labeled wattage of the luminaire

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SECTION 9.1.4: LIGHTING DESIGN WATTAGE

Example: Installed Interior Lighting Design

16 Feet of Line Voltage Track

- Specified – 5 Track Heads
- 90 Watts Halogen PAR38 Lamps

Wrong Way!

5 Track Heads x 90 Watts/Halogen Par Lamp = 450 Watts

Right Way!

16' Track x 30 Watts/Foot = 480 Watts

"the rules"

Line voltage track = min. 30 W per foot

SECTION 9.1.4: LIGHTING DESIGN WATTAGE

Interior Lighting Wattage Calculation

Wrong Way!

8 Fixtures x 3 Lamps x 32 Watts per Lamp	=	768 Watts
6 Downlights x 60 Watts/A-line lamp	=	360 Watts
5 Track Heads x 90 Watts/Halogen Par Lamp	=	450 Watts
Total Wattage		**= 1,578 Watts**

Right Way!

8 Fixtures x 90 Ballast Input Watts	=	720 Watts
6 Downlights x 75 Watt Labeled A-line	=	450 Watts
16' Track x 30 Watts/Foot	=	480 Watts
Total Wattage		**= 1,650 Watts**

USING COMCHECK FOR LIGHTING

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EAZEE BUILDING –INTERIOR LIGHTING

COMCHECK HW PROBLEM

Small 10′ Strip Retail Building

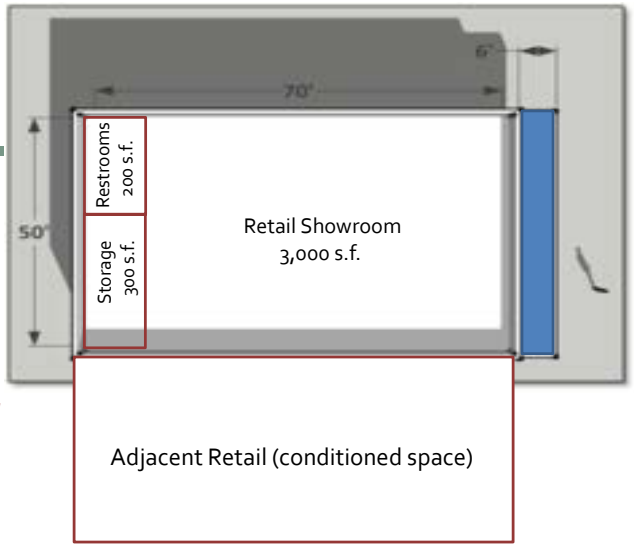
East Wall: R-19 2x6, 16″ o.c. all metal curtain-wall glazing is on the Front

Enter the following fixtures into COMcheck to check for lighting compliance [Quantity]:

A – 48″ T-8 Fluorescent-(3)32W bulbs, elec ballast) – 90W [12]

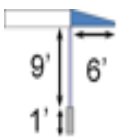
B – 96″ Linear LED – 8000 Lumens – 80W [30]

C – Wall sconces – 11 W LED [32]



Using COMCheck, enter lighting fixtures and create a budget using both the Building Area and also the Space-by-Space methods. Does the building pass 90.1-2019?

.84x3500 = 2940 W (BAM)



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LIGHTING CONTROLS
EXTERIOR LIGHTING

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INTERIOR LIGHTING CONTROLS

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Minimum Control Requirements (a-i) from Table 9.6.1

Table 9.6.1 *Lighting Power Density* Allowances Using the Space-by-Space Method and Minimum Control Requirements Using Either Method (Continued)

Common Space Types[1]	LPD, W/ft²	IECR Threshold	a	b	c	d	e	f	g	h	i
Conference/Meeting/Multipurpose Room	0.97	4	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Confinement Cells	0.70	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD1	ADD1
Copy/Print Room	0.91	4	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Corridor[2]											
Facility for the visually impaired (and not used primarily by the staff)[3]	1.71	width ≤8 ft	REQ				REQ	REQ	REQ	ADD1	ADD1
Hospital	1.11	width ≤8 ft	REQ				REQ	REQ	ADD1	ADD1	ADD1
All other corridors	0.41	width ≤8 ft	REQ				REQ	REQ	REQ	ADD1	ADD1
Courtroom	1.20	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD1	ADD1
Computer Room	0.84	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD1	ADD1
Dining Area											
Penitentiary	0.82	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD1	ADD1
Facility for the visually impaired (and not used primarily by staff)[3]	1.27	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD1	ADD1
Barlounge or lounge/leisure dining	0.86	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD1	ADD1
Cafeteria or fast-food dining	0.40	4	REQ	ADD1	OR ADD1	REQ	REQ	REQ		ADD1	OR ADD1
Family dining	0.69	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD1	ADD1
All other dining areas	0.43	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD1	ADD1

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A. LOCAL CONTROL

Requires one or more manual control in the space that controls all the lighting in that space.

- Each control device will control a maximum of:
  - 2,500 ft^2 in spaces < 10,000 ft^2
  - 10,000 ft^2 in spaces > 10,000 ft^2
- Readily accessible to occupants
- Located where the controlled lights are visible
- Must identify the area served by the lights and indicate their use

Exceptions:

Remote location for safety & security (requires pilot indicator and lighting clearly labeled)

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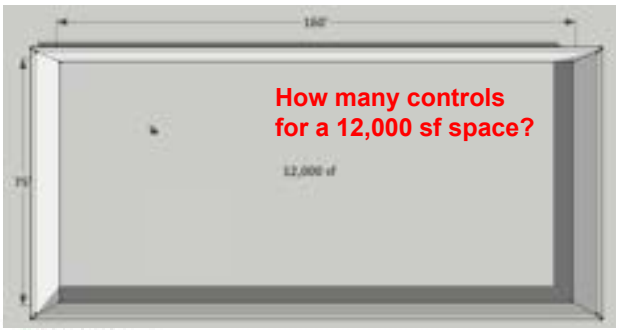
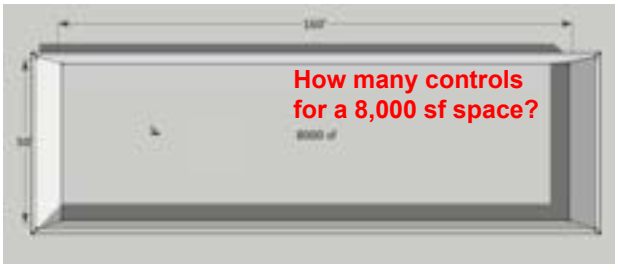
ASHRAE 90.1 SECTION 9.4.1.2 SPACE CONTROL

"Small" Spaces (<10,000 s.f.):

1 control / 2,500 s.f.





"Large" Spaces (>10,000 s.f.):

1 control / 10,000 s.f.

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B. RESTRICTED TO MANUAL ON

Occupancy

- Turn lights ON automatically upon detecting the presence of people
- Occupancy sensors are better for areas with no daylight like bathrooms or where safety is a concern

Vacancy

- Must be turned on manually
- Vacancy sensors save more energy
- No "false positives"

EXEMPTIONS

Full auto-on controls allowed in

- Public corridors
- Stairways
- Restrooms
- Primary building entrance areas and lobbies
- Areas where manual-on operation would endanger safety or security of room or occupants

C. RESTRICTED TO PARTIAL AUTOMATIC ON

Maximum of 50% of the lighting power for general lighting is allowed to be automatically turned on and none of the remaining shall be auto ON

Exception

- Lighting in open-plan offices allowed to turn on automatically to > 50% if control zone is ≤ 600 ft^2

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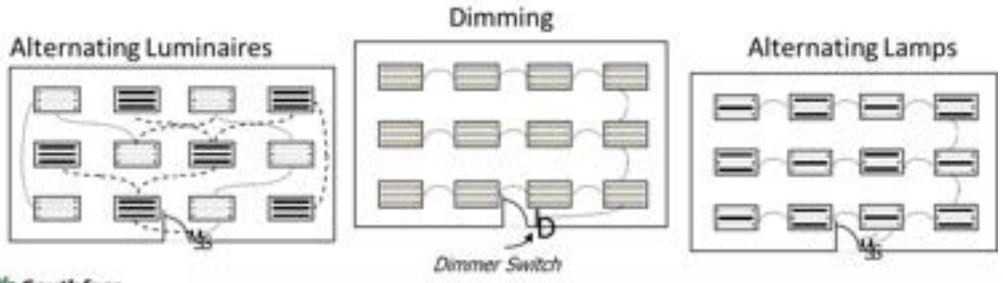
D. BILEVEL LIGHTING CONTROLS

- Light Reduction Controls must allow the occupant to reduce connected lighting load
  - To have at least one control step between 30% and 70% (inclusive) of full lighting power in addition to all off
  - In a reasonably uniform illumination pattern
- Light-reduction control are not required in daylight zones with daylight responsive controls complying with C405.2.3



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D. BILEVEL LIGHTING CONTROLS (CONT.)

- Controlling all lamps or luminaires
- Dual switching of alternate rows of luminaires, alternate luminaires or lamps
- Switching middle lamp luminaires independently from the outer lamps
- Switching each luminaire or each lamp

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E./F. AUTO DAYLIGHT CONTROLS

- Photocontrols required for general lighting in any space top-lit by >150 W
- Photocontrols shall have:
  - Continuous dimming or
  - At least one control point between 50% and 70% of design light power
  - Second control point between 20% and 40% of design light power or
  - Lowest dimming level technology allows
  - Third control point that turns off all controlled lighting
  - Calibration doesn't require physical presence of a person at sensor while calibration is processing
- Calibration adjustment located ≤ 11ft above finished floor
- Exceptions for toplighting with tall adjacent shading, skylight VT <0.4, spaces in CZ 8 <200 W

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DAYLIGHTING

- Daylighting maximizes sunlight through proper window placement, window types and room dimensions
- Keeps lights off
  - Save lighting energy
  - Save energy on cooling
- Couple with daylight sensor

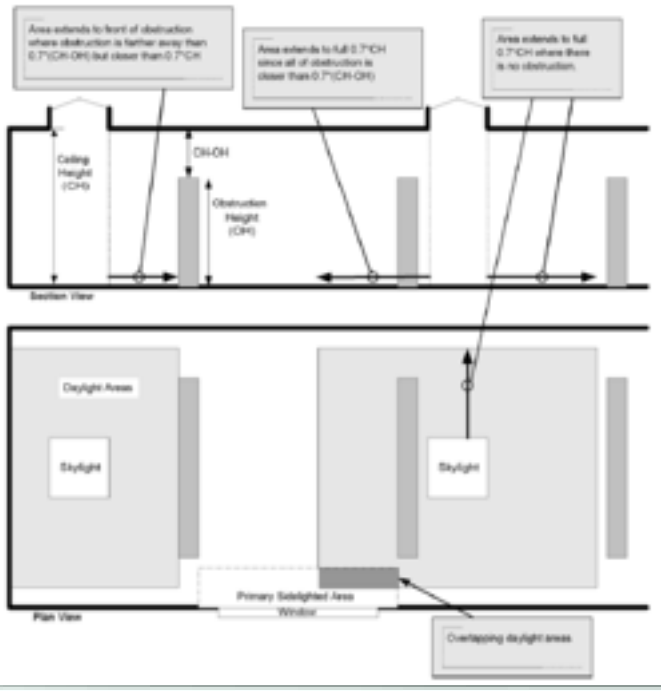
DAYLIGHTED AREA - SKYLIGHTS

Daylight area: the floor area substantially illuminated by daylight

daylight area under skylights: the *daylight area under skylights* is the combined *daylight area* under each *skylight* within a *space*. The *daylight area* under each *skylight* is bounded by the opening beneath the *skylight* and horizontally in each direction (see Figure 3.2-2), the smaller of

a. 70% of the ceiling height (0.7 × CH) or

b. the distance to the nearest face of any *opaque* vertical obstruction, where any part of the obstruction is farther away than 70% of the distance between the top of the obstruction and the ceiling (0.7 × [CH − OH], where CH = the height of the ceiling at the lowest edge of the *skylight* and OH = the height to the top of the obstruction).

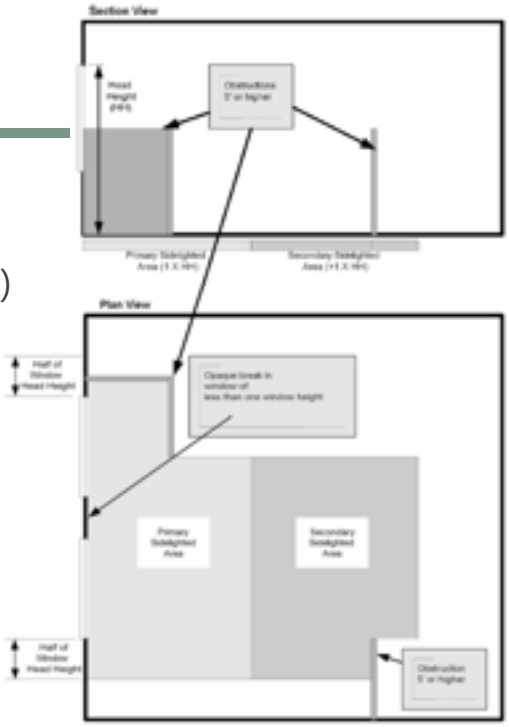


DAYLIGHT ZONES - WINDOWS

- Primary and Secondary
  - Based on Head Height (HH) (distance from floor to top of glazing)

a. The *primary sidelighted area* width is the width of the *vertical fenestration* plus, on each side, the smaller of
   1. one half of the *vertical fenestration* head height (where head height is the distance from the *floor* to the top of the glazing) or
   2. the distance to any 5 ft or higher *opaque* vertical obstruction.

b. The *primary sidelighted area* depth is the horizontal distance perpendicular to the *vertical fenestration*, which is the smaller of
   1. one *vertical fenestration* head height or
   2. the distance to any 5 ft or higher *opaque* vertical obstruction.



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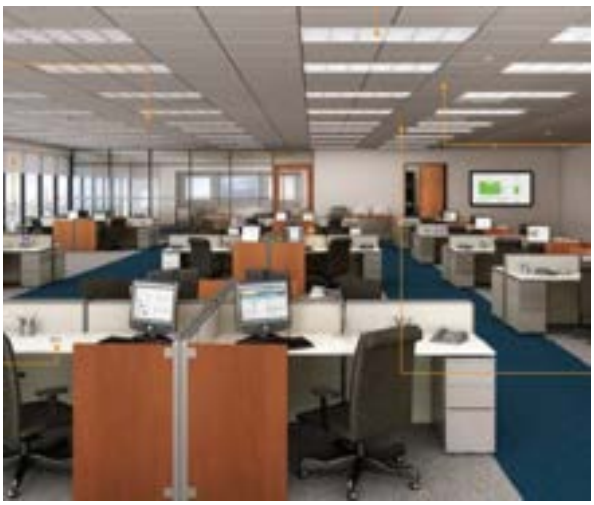
DAYLIGHT ZONE CONTROL

- Lights in daylight zones shall be controlled independently from general area lighting
- Exceptions
  - Daylight spaces enclosed by walls with only 1 or 2 fixtures.



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MAXIMUM SKYLIGHT AREA

IECC

Can increase skylight area from 3 percent to **5 percent** with the use of daylight responsive lighting controls

ASHRAE

Can increase skylight area from 3 percent to **6 percent** with the use of daylight responsive lighting controls

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G. AUTO PARTIAL OFF

- Automatically turn lights off within 20 minutes after occupants have left space
- Either manual-on or controlled to automatically turn on lighting to not more than 50% power
- Incorporate a manual control to allow occupants to turn off lights

Exceptions

- Space has LPD < 0.80 W/ft^2
- Space is lighted by High Intensity Discharge technology
- General lighting power in space is automatically reduced by ≥ 30% within 20 minutes of all occupants leaving the space
- Lighting load ≤ 0.02 W/ft^2 multiplied by gross lighted area of the building

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H. AUTO FULL OFF

- All lighting shall be auto shut off within 20 minutes of being unoccupied
  - Maximum control device area served is 5000 s.f.

Exceptions:

- General and task lighting in shop and lab classrooms
- General and task lighting where it would endanger safety or security of the room or building occupants
- Lighting for 24/7 operation

I. SCHEDULED SHUTOFF

Must include an override switching device with the following:

- Minimum 7-day clock
- Capable of being set for 7 different day types/week
- Incorporate holiday "shutoff" feature to turn all controlled lighting loads for ≥ 24 hours and resume to normally scheduled operations
- Program backup capabilities to prevent loss of program and time setting for ≤ 10 hours if power is interrupted

OVERRIDE CONTROLS

Override switch should include:

- Manual control
- Control lighting to remain on for <2 hours
- Control lighting for an area <5,000 ft^2

CONTROL OF SPECIAL APPLICATIONS

Special applications separately controlled from general lighting

- Display or accent lighting
- Case lighting
- Nonvisual lighting
- Demonstration lighting

Photo Courtesy of Sweet Grass Pastures

SPECIAL APPLICATIONS

9.4.1.3 Special Applications

Lighting controls noted in this section are the only required controls for this equipment and these applications. Lighting exempt from interior lighting power shall be controlled in accordance with Table 9.2.3.1. Lighting using additional interior lighting power applications shall be controlled in accordance with Section 9.4.2.

a. Lighting used for the following applications shall be equipped with a local control independent of the control of the *general lighting* in accordance with Section 9.4.1.1(a). In addition, such lighting shall be controlled in accordance with Section 9.4.1.1(b) or Section 9.4.1.1(c).
   1. Display or accent lighting
   2. Lighting in display cases

b. Guestrooms
   1. All lighting and all switched receptacles in guestrooms and suites in hotels, motels, boarding houses, or similar *buildings* shall be *automatically* controlled such that the power to the lighting and switched receptacles in each *enclosed space* will be turned off within 20 minutes after all occupants leave that *space*.

Exception to 9.4.1.3(b)(1)

Enclosed spaces where the lighting and switched receptacles are controlled by card key *controls* and bathrooms are exempt.

   2. Bathrooms shall have a separate *control device* installed to *automatically* turn off the bathroom lighting within 30 minutes after all occupants have left the bathroom.

Exception to 9.4.1.3(b)(2)

Night lighting of up to 5 W per bathroom is exempt.

c. Supplemental *task lighting*, including *permanently installed* undershelf or undercabinet lighting, shall be controlled from either
   1. a *control device* integral to the *luminaire*; or
   2. a local control independent of the control of the *general lighting* in accordance with Section 9.4.1.1(a).

   In addition, such lighting shall be controlled in accordance with Section 9.4.1.1(b) or Section 9.4.1.1(c).

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DWELLING UNITS

- Dwelling units (apartment, condo, living space, etc.) must be built so that at least 75 percent of the permanently installed lighting fixtures utilize lamps with an efficacy of at least 55 lm/W, or have a total luminaire (fixture) efficacy of at least 45 lm/W.

  Exception: Lighting that is controlled with dimmers or automatic control devices.
- Applies to 4 story above grade multi-family (3 story and below not in scope of 90.1)
- Other common spaces in the building must follow standard 90.1 Requirements.

IECC 2021
- 100% efficient bulbs

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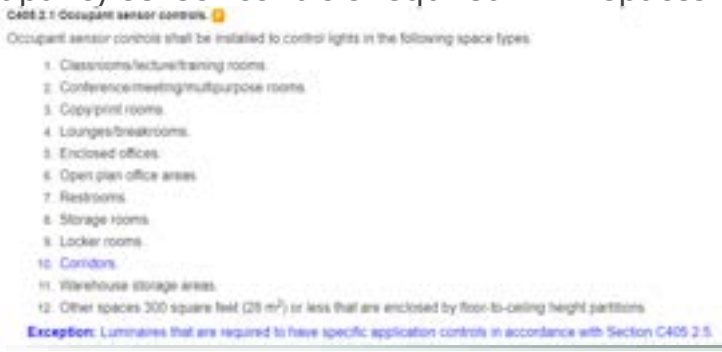
C405: LIGHTING SYSTEMS
Major Items of Note

- Dwelling units *may* comply by having 90% of permanently installed fixtures be high efficacy — C405.1.1
- Lighting control requirements are similar to 90.1 but worded very differently — C405.2
- Occupancy sensor controls required in 12 spaces — C405.2.1



C405.2.1 Occupant sensor controls.

Occupant sensor controls shall be installed to control lights in the following space types:

1. Classrooms/lecture/training rooms
2. Conference/meeting/multipurpose rooms
3. Copy/print rooms
4. Lounges/breakrooms
5. Enclosed offices
6. Open plan office areas
7. Restrooms
8. Storage rooms
9. Locker rooms
10. Corridors
11. Warehouse storage areas
12. Other spaces 300 square feet (28 m²) or less that are enclosed by floor-to-ceiling height partitions

Exception: Luminaires that are required to have specific application controls in accordance with Section C405.2.5.

C405.2

Auto shut-off within **20 minutes**
Limits to all on %
Manual override
Warehouse aisles
Open plan offices

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C405: LIGHTING SYSTEMS

Major Items of Note (cont.)

Time-switch controls required: — C405.2.2
- 7-day clock with seven different daily programs
- automatic holiday "shutoff"
- 10-hour power backup for settings
- 2-hour manual override for up to 5,000 s.f. area

Exceptions for: — C405.2.2
- daylit zones,
- patient care,
- safety or security,
- continuous operation lighting,
- shop and laboratory classrooms

Light-reduction controls required — C405.2.3

Exception for daylit zones (with compliant daylight responsive controls):
- 50% power reduction
- dimming or alternate lamp switching

Manual Controls: — C405.2.6
- Readily accessible,
- Located in space with fixture or status indicator required,

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C405: LIGHTING SYSTEMS

Major Items of Note (cont.)

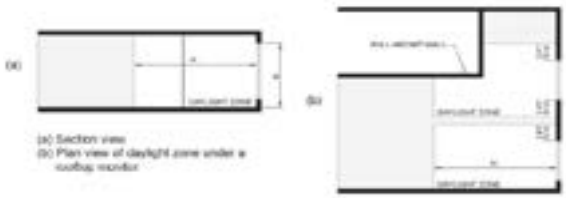
C405.2.3

Daylight responsive controls required:

- Electric general lighting > 150 Watts in daylit zones
- Sidelight daylit zones separate from Toplight zones

Exceptions for:

- Sleeping units,
- Patient care,
- Exempted lighting
- First floor in Group A2 and M occupancies



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C405: LIGHTING SYSTEMS

Major Items of Note (cont.)

C405.2.5

Specific application controls required:

- Display & Accent Lighting
- Case lighting
- Supplemental task lighting
- Lighting sales demonstration
- Hotel/motel sleeping unit master control for luminaires and switched receptacles
  - Exceptions for captive key system
  - Exceptions for direct patient care
- Non-visual lighting (food warming and plant growth) – time switch control (separate from room controls)

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C405: LIGHTING SYSTEMS

Major Items of Note (cont.)

Exterior Lighting controls — C405.2.7
- Auto-off when available daylight
- Façade or landscape light controls dawn/dusk and opening/closing time
- Curfew lighting for other exterior fixtures (minimum 30% reduction)
- Exterior time-switch control

Connected lighting may not exceed budget — C405.3
- List of exempt lighting

Lighting power budget (Building Area vs. Space-by-Space) — C405.3.2.1&2

Additional lighting power for retail & decorative lighting — C405.3.2.2.1
- No RCR or Additional Control wattage allowance

LIGHTING CONTROL DESIGN

- Keep sensors simple and verify that they are set up properly
- Foster good human behavior to save energy
- An *educated* occupant is the best sensor

LIGHTING CONTROL DESIGN

- Occupants must have ready access
- Recommission equipment if necessary, even (especially) on new buildings

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FUNCTIONAL TESTING

ASHRAE 90.1

- Functional testing (calibrated/adjusted/programmed) of lighting control devices and systems required within 90 days of occupancy
- Must be performed by individuals **not** involved in design, manufacture, or installation

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Prior to passing final inspection, a *registered design professional* shall provide evidence that lighting control systems have been tested to ensure that control **hardware** and **software** are calibrated, adjusted, programmed and in proper working order per construction documents and manufacturer's installation instructions

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EXTERIOR LIGHTING

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EXTERIOR LIGHTING POWER ALLOWANCES

Table 9.4.2-2 Individual Lighting Power Allowances for Building Exteriors

	Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance (Base allowance may be used in tradable or nontradable surfaces.)					
	No allowance	350 W	400 W	500 W	900 W
Tradable Surfaces (LPD allowances for uncovered parking areas, building grounds, building entrances, exits and loading docks, canopies and overhangs, and outdoor sales areas may be traded.)					
Uncovered Parking Areas					
Parking areas and drives	No allowance	0.03 W/ft^2	0.04 W/ft^2	0.06 W/ft^2	0.08 W/ft^2
Building Grounds					
Walkways/ramps less than 10 ft wide	No allowance	0.5 W/linear foot	0.5 W/linear foot	0.6 W/linear foot	0.7 W/linear foot
Walkways/ramps 10 ft wide or greater Plaza areas Special feature areas	No allowance	0.10 W/ft^2	0.10 W/ft^2	0.11 W/ft^2	0.14 W/ft^2
Dining areas	No allowance	0.65 W/ft^2	0.65 W/ft^2	0.75 W/ft^2	0.85 W/ft^2
Stairways	No allowance	0.6 W/ft^2	0.7 W/ft^2	0.7 W/ft^2	0.7 W/ft^2
Pedestrian tunnels	No allowance	0.12 W/ft^2	0.12 W/ft^2	0.14 W/ft^2	0.21 W/ft^2
Landscaping	No allowance	0.03 W/ft^2	0.04 W/ft^2	0.04 W/ft^2	0.04 W/ft^2
Building Entrances, Exits, and Loading Docks					
Pedestrian and vehicular entrances and exits	No allowance	14 W/in ft of opening	14 W/in ft of opening	21 W/in ft of opening	21 W/in ft of opening
Entry canopies	No allowance	0.20 W/ft^2	0.20 W/ft^2	0.20 W/ft^2	0.20 W/ft^2
Loading docks	No allowance	0.35 W/ft^2	0.35 W/ft^2	0.35 W/ft^2	0.35 W/ft^2
Sales Canopies					
Free standing and attached	No allowance	0.4 W/ft^2	0.4 W/ft^2	0.6 W/ft^2	0.7 W/ft^2
Outdoor Sales					
Open areas (including vehicle sales lots)	No allowance	0.2 W/ft^2	0.2 W/ft^2	0.20 W/ft^2	0.20 W/ft^2
Street frontage for vehicle sales lots in addition to "open area" allowance	No allowance	No allowance	7 W/linear foot	7 W/linear foot	21 W/linear foot

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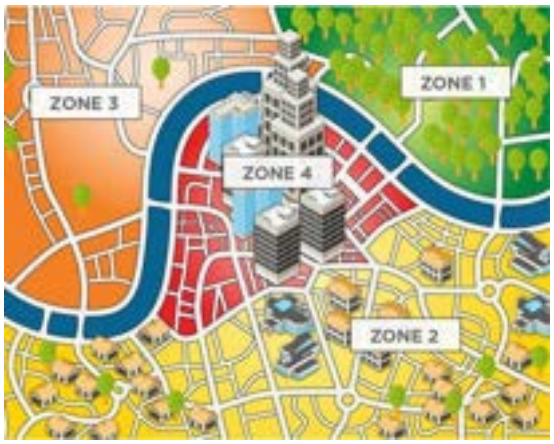
EXTERIOR LIGHTING ZONES

Lighting Zone	Description
0	Undeveloped areas within parks or undeveloped areas
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas
3	All other areas not classified as lighting zone 1, 2 or 4
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority



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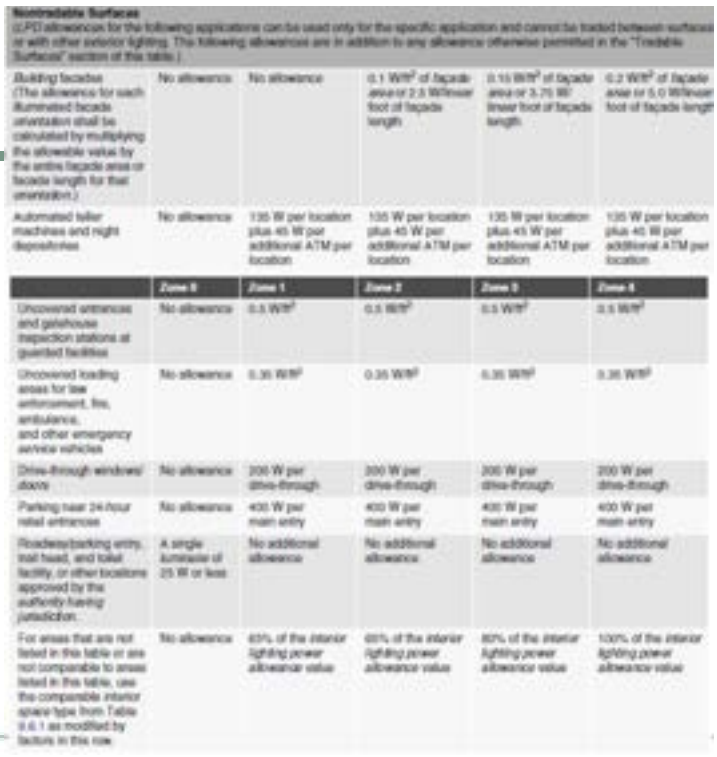
NONTRADABLE SURFACES

- Building grounds, building entrances, exits/loading docks, canopies/overhangs, and outdoor sales areas may be traded
- Building facades, parking entrances, roadways, etc. are not tradeable



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90.1-2019 ENERGY CODE LIGHTING QUIZ

What is the exterior lighting Base Site Allowance for a building being developed in a mixed-use residential area?

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EXTERIOR LIGHTING CONTROLS

- Automatic off control when daylight is available
- Curfew hours for façade and landscape lighting
  (midnight – 6am or close to open)
- Other exterior lighting (**including advertising**) must automatically reduce power by a minimum of 30% either:
  - Midnight – 6am (or 1 hour after business close until open)
  - Motion sensor control (any period of inactivity greater than 15 min)

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EXTERIOR CONTROLS EXCEPTIONS

- Lighting for covered vehicle entrances or exits where required for safety, security or eye adaptation
- Lighting integral to signage

PARKING GARAGE CONTROLS

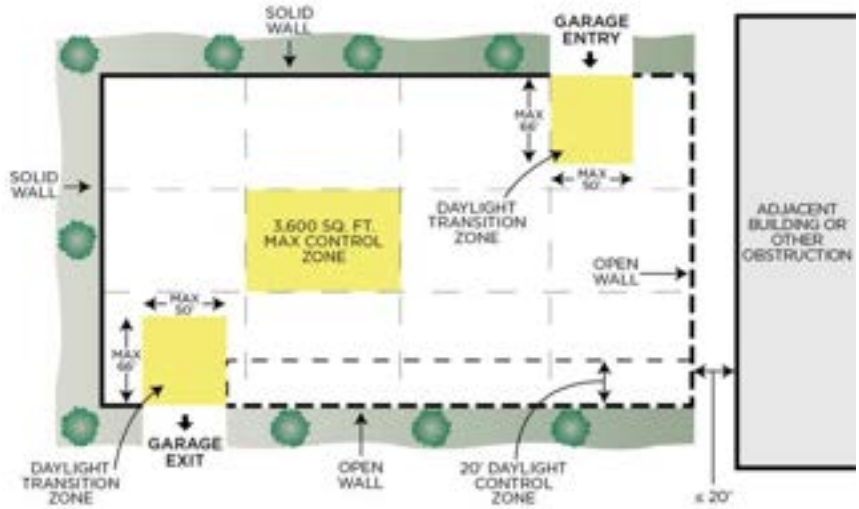
Automatic lighting shutoff

- Must reduce lighting power at least 30% when no activity is detected for 20 minutes within a lighting zone ≤ 3,600 ft^2
- Automatically reduce power at least 50% in response to daylight for luminaires within 20 ft of any perimeter wall that has
  - a net opening to wall ratio of greater than 40% and
  - no exterior obstructions within 20 ft

Exception

Daylight transition zones and ramps without parking are exempt from 30% reduction and daylight control

PARKING GARAGE CONTROLS



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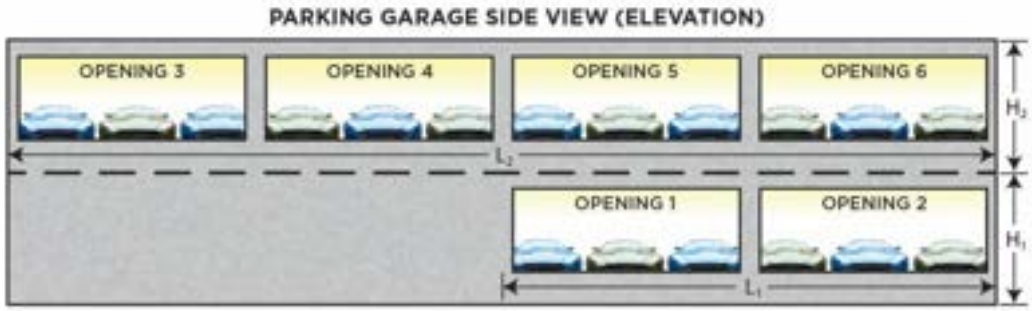
PARKING GARAGE CONTROLS



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

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POWER

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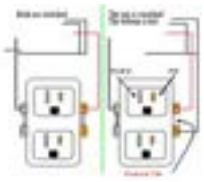
ASHRAE

AUTOMATIC RECEPTACLE CONTROL



- At least 50% of all 125V 15 and 20 amp receptacles and at least 25% of branch circuit feeders for modular furniture
  - Private offices, conference rooms, printing/copy rooms, break rooms, classrooms, and individual workstations
- Controlled by:
  - Scheduled control (zones of 1 floor or 5,000 SF, whichever is less)
  - Occupancy sensor
  - Automated control system
- Must be permanently marked to differentiate controlled and non-controlled and distributed uniformly

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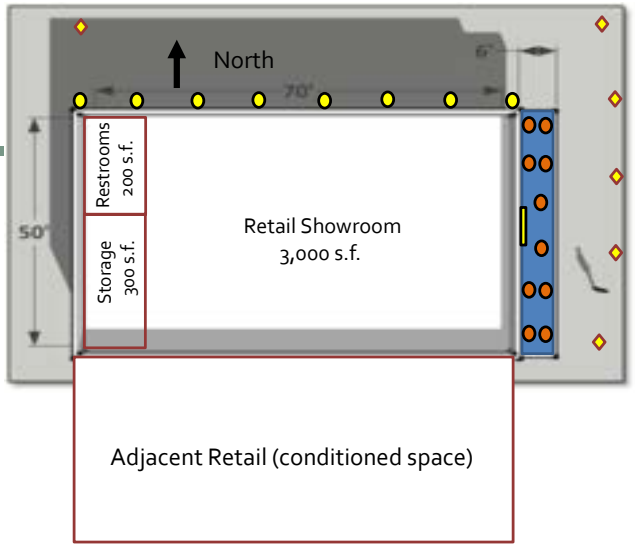
ELECTRICAL ENERGY MONITORING

- Each of the following must be monitored separately:
  - Total electrical energy
  - HVAC systems
  - Interior lighting
  - Exterior lighting
  - Receptacle circuits
- Individual tenant spaces separately monitored and made available to each tenant
- Recorded every 15 minutes for at least 36 months

EAZEE BUILDING –EXTERIOR LIGHTING
COMCHECK HW PROBLEM

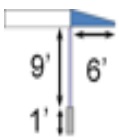
Small 10' Strip Retail Building

North Wall: A - 8 exterior sconces – 28W LED downlights
East Wall: B - 1 LED strip doorway light – 8' 20W LED
C -10 Canopy Can lights – 13 W CFL's
D- 6 Parking overhead fixtures – 88W LED's



Enter the above exterior fixtures into COMcheck as well as the following to check for lighting compliance:
– North side driveway, 70'x15'
– East Entry Canopy, 50'x6'
– Main Entry Doorway, 6'
– Front Parking Area, 65'x100'

Using COMCheck, enter exterior lighting fixtures and create an exterior lighting budget assuming typical neighborhood business district. Does the design pass or fail 90.1-2019 for exterior lighting and by what percentage?



CONCLUSION