BUILDING ENERGY CODES UNIVERSITY

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

2012 IECC Commercial Electrical Power and Lighting Systems

July 2011

PNNL-SA-82199

Commercial Compliance Options

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

1

- 90.1-2010

OR

2

2012 IECC

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

AND

- Pick One:
  - **C406.2 – Eff. HVAC Performance**

  or
  - **C406.3 – Eff. Lighting Systems**

  or
  - **C406.4 – On-site Renewable Energy**

OR

3

2012 IECC

- C407 – Total Building Performance
- C402.4 – Air Leakage
- C403.2 – Provisions applicable to all mechanical systems
- C404 - SWH
- Lighting Mandatory Sections
  - C405.2
  - C405.3
  - C405.4
  - C405.6
  - C405.7
- Building energy cost **to be ≤ 85% of** standard reference design building

Additional Efficiency Package Options

C406

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- One additional efficiency feature must be selected to comply with the IECC
  - More efficient lighting system (consistent with 90.1-2010), OR
  - More efficient HVAC system, OR
  - Installation of onsite renewables
    - 3% of the regulated energy

High Efficiency HVAC

More Efficient Lighting System

Onsite Renewables

Additional Efficiency Package Options

C406

- Efficient HVAC performance per C406.2 **OR**
  - Per Tables C406.2(1) thru C406.2(7)
  - Only used when efficiencies in the above tables are greater than those in the efficiency tables in C403
- Efficient lighting system per C406.3 **OR**
  - Whole building LPD complies with C406.3.1
  - Determine total LPD of building using reduced whole building interior lighting power in Table 406.3 x floor area for the building types
- On-site supply of renewable energy per C406.4
  - Total minimum ratings to comply with
    - Provide ≥ 1.75 Btu or ≥ 0.50 watts per ft^2 of conditioned floor area OR
    - Provide ≥ 3% of energy used for mechanical and SWH equipment and lighting

Individual tenant spaces to comply with either C406.2 or C406.3 unless documentation is provided that demonstrates compliance with C406.4 for the entire building

Referenced Codes and Standards

C106.1

Codes and standards listed in Chapter are considered part of the requirements of this code to the "prescribed extent of each such reference and as further regulated in Sections C106.1.1 and C106.1.2"

- Conflicts, C106.1.1 – where differences occur between this code and the referenced codes and standards, provisions of this code apply
- Provisions in reference codes and standards, C106.1.2 – "where the extent of the reference to a referenced code or standard includes subject matter that is within the scope of this code, the provisions of this code, as applicable, shall take precedence over the provisions in the referenced code or standard"

What's Covered Under Electrical Power and Lighting Systems Requirements?

Mandatory Interior Lighting requirements

- ✓ Required Controls
- ✓ Wattage/Efficiency Limits

Interior Lighting Power Allowances (watts/ft^2)

Exterior Lighting Controls

- ✓ Required Controls
- ✓ Lamp Efficiency

Exterior Lighting Power Allowances (watts/ft^2)

Electric Metering

When do the Lighting and Power Requirements Apply?

- ✓ Original Installed Lighting System in a New Building, Addition, or Tenant Build-out
- ✓ Existing Lighting System that is Altered
- ✓ Change in Occupancy that Increases Energy
- ✓ Change in Occupancy that requires less LPD as shown in the LPD tables

Exceptions:

- Historic buildings
  - State or National listing
  - Eligible to be listed
- Alterations where less than 50% 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

High-Efficacy Lamps - Definition

- ✓ Compact fluorescent lamps, T-8 or smaller diameter linear fluorescent lamps, or lamps with a minimum efficacy based on lamp wattage

Lamp Wattage	Efficacy
> 40 watts	60 lumens/watt
15-40 watts	50 lumens/watt
< 15 watts	40 lumens/watt

Interior Lighting Power Allowance
C405.5.2

Two methods to determine allowance:

- ✓ Building Area Method
  - Floor area for each building area type x value for the area
  - "area" defined as all contiguous spaces that accommodate or are associated with a single building area type as per the table
  - When used for an entire building, each building area type to be treated as a separate area
- ✓ Space-by-Space Method
  - Floor area of each space x value for the area
  - Then sum the allowances for all the spaces
  - Tradeoffs among spaces are allowed

Building Area Method
Table C405.5.2(1)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building Area Type	LPD (w/ft^2)
Automotive facility	0.9
Convention center	1.2
Courthouse	1.2
Dining: bar lounge/leisure	1.3
Dining: cafeteria/fast food	1.4
Dining: family	1.6
Dormitory	1.0
Exercise center	1.0
Fire station	0.8
Gymnasium	1.1

(partial table)

Space-By-Space Method
Table C405.5.2(2)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Common Space-by-Space Types	LPD (w/ft^2)
Atrium – First 40 feet in height	0.03 per ft. ht.
Atrium – Above 40 feet in height	0.02 per ft. ht.
Audience/seating area – permanent	
For auditorium	0.9
For performing arts theater	2.6
For motion picture theater	1.2
Classroom/lecture/training	1.30
Conference/meeting/multipurpose	1.2
Corridor/transition	0.7
Dining area	
Bar/lounge/leisure dining	1.40
Family dining area	1.40

(partial table)

Additional Retail Lighting Power Allowance

Table C405.5.2(2) – Footnotes

Additional Interior Lighting Power Allowance =
500 watts +
(Retail Area 1 x 0.6 W/ft2) +
(Retail Area 2 x 0.6 W/ft2) +
(Retail Area 3 x 1.4 W/ft2) +
(Retail Area 4 x 2.5 W/ft2),

Where:

- ✓ **Retail Area 1 = the floor area for all products not listed in Retail Area 2, 3 or 4.**
- ✓ **Retail Area 2 = the floor area used for the sale of vehicles, sporting goods and small electronics.**
- ✓ **Retail Area 3 = the floor area used for the sale of furniture, clothing, cosmetics and artwork.**
- ✓ **Retail Area 4 = the floor area used for the sale of jewelry, crystal, and china.**

Additional Retail Lighting Power Allowance

Table C405.5.2(2) – Footnotes

Photo courtesy of Ken Baker, K energy

Exception:

Other merchandise categories may be included in Retail Areas 2 through 4 above, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is approved by the authority having jurisdiction.

Connected Lighting Calculation

C405.5.1.1-C405.5.1.4

Lighting wattage must be calculated in accordance with Section C405.5.1

- ✓ Screw lamp holders: maximum labeled wattage of the luminaire
- ✓ Low voltage lighting: transformer wattage
- ✓ Line voltage track:
  1. specified wattage with minimum of 30 W/linear ft **OR**
  2. wattage limit of system's circuit breaker **OR**
  3. wattage limit of other permanent current limiting devices
- ✓ Other: manufacturer's rated wattage of lamp and associated ballast

Exemptions to Proposed Lighting Power Calculation
C405.5.1

Connected power for following not included in calculations:

- ✓ Professional sports arena playing field
- ✓ Sleeping unit lighting
- ✓ Emergency lighting automatically off during normal building operation
- ✓ Lighting in spaces specifically designed for use by occupants with special lighting needs including visual impairment and other medical and age related issues
- ✓ Lighting in interior spaces specifically designated as a registered interior historic landmark
- ✓ Casino gaming areas
- ✓ Lighting equipment used for the following exempt if in addition to general lighting and controlled by an independent control device
  - Task lighting for medical and dental procedures
  - Display lighting for exhibits in galleries, museums and monuments

Exemptions to Proposed Lighting Power Calculation (cont'd)

- ✓ Theatrical, stage, film, and video production
- ✓ Used for photographic processes
- ✓ Integral to equipment or instrumentation installed by manufacturer
- ✓ Plant growth or maintenance
- ✓ Advertising or directional signage
- ✓ Food warming and food prep equipment (in restaurant buildings and areas)
- ✓ Lighting equipment that is for sale
- ✓ Lighting demonstration equipment in lighting education facilities
- ✓ Approved because of safety or emergency considerations, exclusive of exit lights
- ✓ Integral to both open and glass-enclosed refrigerator and freezer cases
- ✓ In retail display windows when the display is enclosed by ceiling-height partitions
- ✓ Furniture-mounted supplemental task lighting controlled by automatic shutoff

Connected Interior Lighting Power Calculation

Sum the wattage of all proposed connected lighting power

This must include all lighting that is part of the design for the space including:

- ✓ Overhead lighting
- ✓ Task lighting
- ✓ Decorative lighting

Independent Lighting Control required for each space surrounded by floor-to-ceiling partitions

- ✓ Must be located in the space served, **- OR -**
- ✓ Switched from a remote location
  - Must have indicator that identifies the lights served and their status (off or on)
- ✓ **<u>Exemptions</u>**
  - Security or emergency areas that must be continuously lighted
  - Lighting in stairways or corridors that are elements of the means of egress

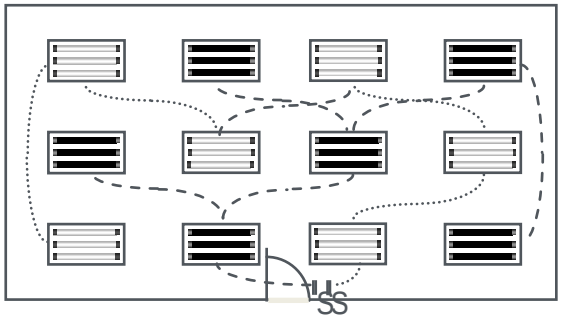
Light Reduction Controls must allow the occupant to reduce connected lighting

- ✓ By at least 50%
- ✓ In a reasonably uniform illumination pattern

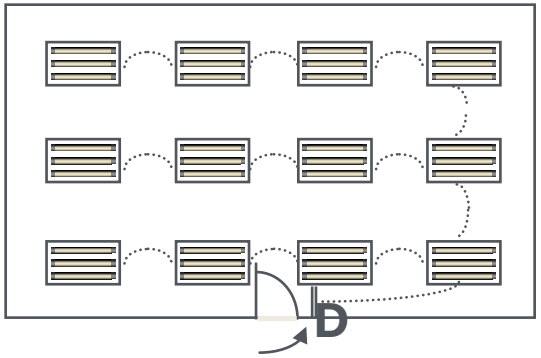
Light Reduction Control Options

- ✓ 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
- ✓ Each luminaire or each lamp

Alternating Luminaires

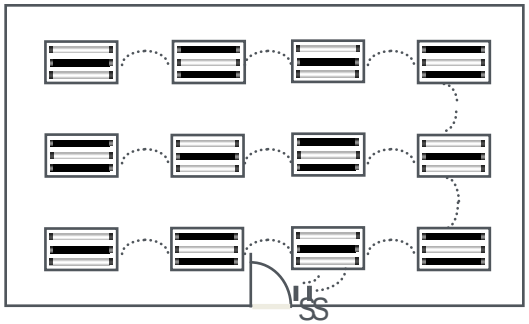


Dimming



Dimmer Switch

Alternating Lamps



Light Reduction Control **Not** required for the following:

- ✓ Areas with only one luminaire with rated power < 100 W
- ✓ Areas controlled by occupancy sensor
- ✓ Corridors, equipment rooms, storerooms, restrooms, public lobbies, electrical or mechanical rooms
- ✓ Sleeping units
- ✓ Spaces with <0.6 w/ft^2
- ✓ Daylight spaces complying with Section C405.2.2.3.2

Each area required to have a manual control to also have controls meeting:

- C405.2.2.1 – Automatic time switch control devices
- C405.2.2.2 – Occupancy sensors
- C405.2.2.3 – Daylight zone control

Exempted spaces

- ✓ Sleeping units
- ✓ Lighting for patient care
- ✓ When an automatic shutoff would endanger occupant safety or security
- ✓ Lighting intended for continuous operation

Automatic Time Switch Control Devices

C405.2.2.1 Additional Lighting Controls

Override switching devices:

- ✓ Readily accessible
- ✓ Within view of the lights or area controlled
- ✓ Manually operated
- ✓ ≤ 2 hour override
  - The override allows lighting to remain on no more than 2 hours when override is initiated
- ✓ Controls an area ≤ 5,000 ft^2

Exemptions

- Emergency egress lighting
- In spaces with occupancy sensors
- Can be over 2 hour override in malls and arcades, auditoriums, single-tenant retail space, industrial facilities and arenas when using captive key override
- Override in malls and arcades, auditoriums, single-tenant retail space, industrial facilities and arenas can cover up to 20,000 ft^2

Additional Lighting Controls
C405.2.2.1 Occupancy Sensors

Occupancy sensors are required in:

- ✓ Classrooms
- ✓ Conference/meeting rooms
- ✓ Employee lunch and break rooms
- ✓ Private offices
- ✓ Storage rooms and janitorial closets
- ✓ Other spaces < 300 ft2 enclosed by floor-to-ceiling height partitions

Features:

- ✓ Automatically turn lights off within 30 minutes of occupants leaving space
- ✓ Either manual or controlled to automatically turn lighting on to not more than 50% power

Exemptions

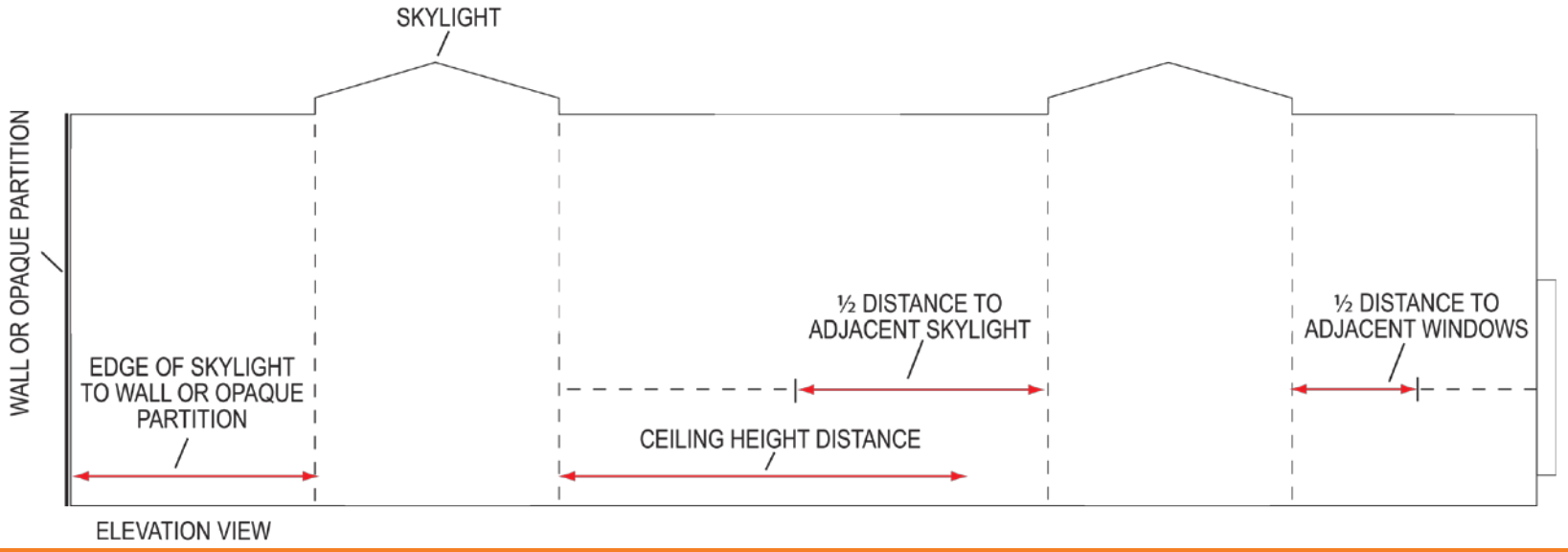
Full auto-on controls allowed in

- ✓ Public corridors
- ✓ Stairways
- ✓ Restrooms
- ✓ Primary building entrance areas and lobbies
- ✓ Areas with safety or security concern

Daylight Zone Definition
Under Skylights

The area under skylights whose horizontal dimension, in each direction, is equal to the skylight dimension plus the smaller of:

- ✓ The floor-to-ceiling height, **or**
- ✓ The distance to a ceiling height opaque partition, **or**
- ✓ One-half the distance to adjacent skylights or vertical fenestration *(whichever is least)*

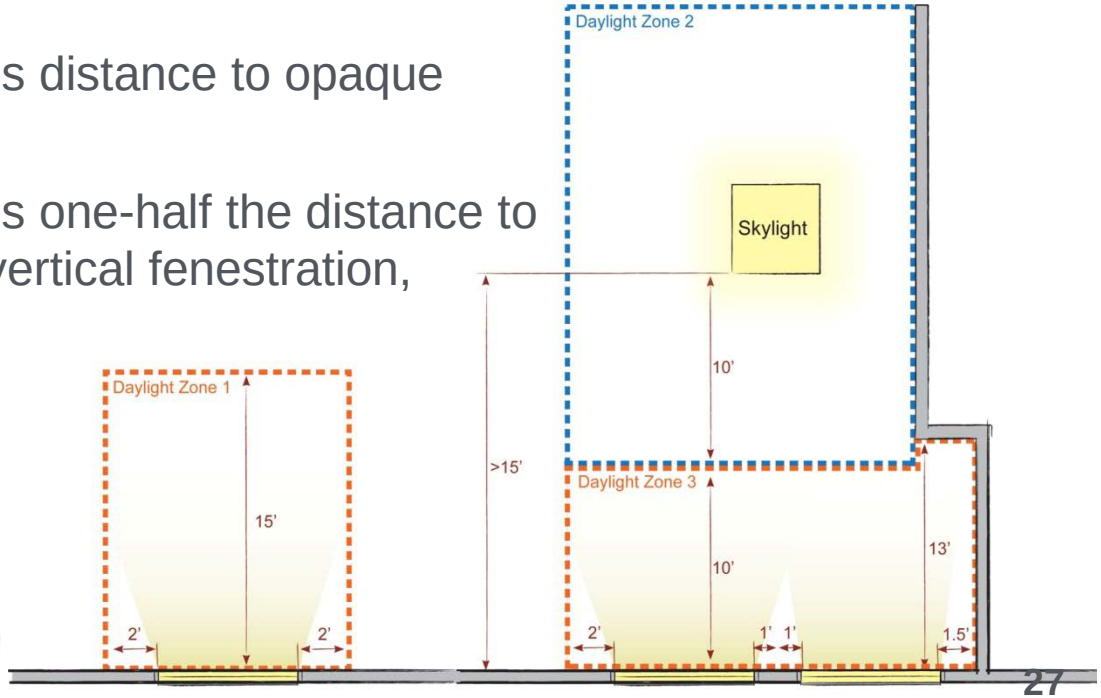


Daylight Zone Definition
Adjacent to Vertical Fenestration

The daylight zone depth is assumed to be 15 feet into the space or to the nearest ceiling height opaque partition, whichever is less

The daylight zone width is assumed to be:

- ✓ the width of the window plus 2 feet on each side, **or**
- ✓ the window width plus distance to opaque partitions, **or**
- ✓ the window width plus one-half the distance to adjacent skylight or vertical fenestration, whichever is least.



Daylight Zone Control Requirements

C405.2.2.3

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Daylight Zones

- ✓ Must have individual control of the lights independent of general area lighting and
- ✓ Controlled per C405.2.2.3.1 manual daylighting controls or C405.2.2.3.2 automatic daylighting controls
- ✓ Each daylight control zone to be ≤ 2500 ft^2

Contiguous daylight zones adjacent to vertical fenestration

- ✓ Can be controlled by a single controlling device if the zone doesn't include areas facing more than two adjacent orientations *(i.e., north, east, south, west)*

Daylight zones under skylights > 15 ft from the perimeter

- ✓ Must be controlled separately from daylight zones adjacent to vertical fenestration

Exception

- ✓ Daylight spaces 1) enclosed by walls or ceiling height partitions and 2) containing two or fewer light fixtures
  - not required to have a separate switch for general area lighting

Note: required controls may be manual or automatic

Manual controls in daylight zones

Exemption:

Unless automatic controls are installed per C405.2.2.3.2 Automatic Daylighting Controls

Automatic Daylighting Controls

C405.2.2.3.2

Set-point and other controls for calibrating the lighting control device to be readily accessible

Daylighting controls device to be capable of automatically reducing the lighting power in response to available daylight either by

- Continuous dimming using dimming ballasts and daylight-sensing automatic controls
  - capable of reducing general lighting power in daylit zone continuously to < 35% of rated power at maximum light output

OR

- Stepped dimming using multi-level switching and daylight-sensing controls capable of reducing lighting power automatically. System to:
  - provide at least two control channels per zone
  - be installed so that at least one control step is between 50-70% of design lighting power and another control step is no greater than 35 % of design power

Multi-Level Lighting Controls

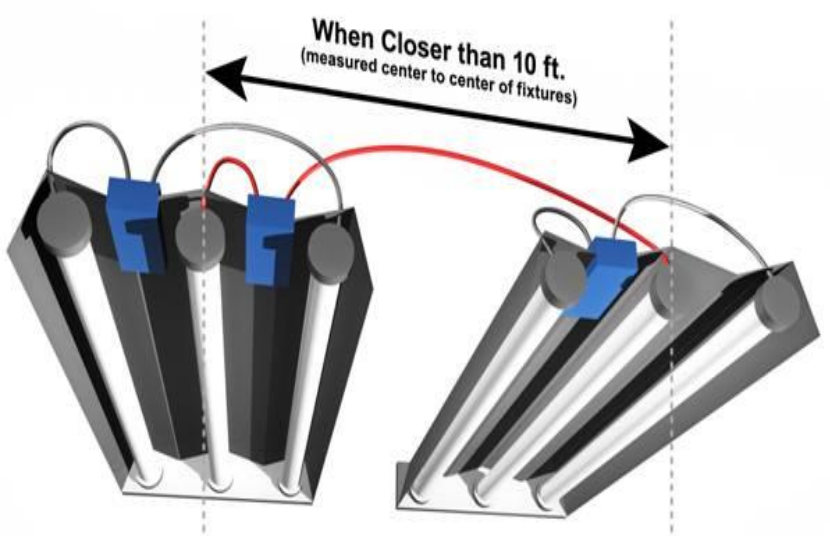
C405.2.2.3.3

- ✓ Where multi-level lighting controls are required:
  - general lighting in daylight zone to be separately controlled by at least one multi-level lighting control
    - that reduces lighting power in response to daylight available in the space
- ✓ Where daylight illuminance in the space is > rated illuminance of the general lighting
  - general lighting to be automatically controlled so its power draw is no greater than 35 % of its rated power
- ✓ Multi-level lighting control to be located so that calibration and set point adjustment controls are readily accessible and separate from light sensor

Tandem Wiring for all Odd Numbered Lamp Configurations

Exceptions

- ✓ Where electronic high frequency ballasts are used
- ✓ Luminaires on emergency circuits
- ✓ Luminaires with no available pair in the same area



Exit Signs

- ✓ Internally illuminated exit signs shall not exceed 5 watts per side

Specific Application Controls

C405.2.3

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- ✓ These types be controlled by dedicated, independent control
  - Display and accent lighting
  - Display case lighting
  - Nonvisual applications (i.e., plant growth and food warming)
  - Lighting equipment for sale or demonstration in lighting education
- ✓ Hotel and motel sleeping units and guest suites
  - Master control device at main room entry
    - Controls all permanently installed luminaires and switched receptacles
- ✓ Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting
  - Have control device integral to luminaires **OR**
  - Be controlled by readily accessibly, wall-mounted control device

Exterior Lighting Power Limits

C405.6.2

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Connected Exterior Lighting Power must not exceed Exterior Lighting Power Allowance

1. Calculate exterior lighting power allowance
   - Lighting power densities by exterior function and by applicable lighting zone
2. Calculate proposed connected lighting power
   - Wattage calculation “rules”
   - Exempted lighting
3. Compare values: proposed wattage must be less than or equal to allowed wattage

Exterior Lighting Power Limits

C405.6.2

What areas are covered under exterior lighting allowances?

- ✓ **Tradable surfaces**

  Common exterior lighted needs that 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.

Tradable Surfaces

- ✓ Uncovered parking lots and areas
- ✓ Walkways (under and over 10 feet wide)
- ✓ Stairways
- ✓ Pedestrian tunnels
- ✓ Main building entrances and exits
- ✓ Other doors
- ✓ Entry canopies
- ✓ Free-standing and attached sales canopies
- ✓ Open sales areas
- ✓ Street frontage sales areas

Nontradable Surfaces

- ✓ Building facades
- ✓ Automated teller machines and night depositories
- ✓ Entrances and gatehouse inspection stations at guarded facilities
- ✓ Loading areas for law enforcement, fire, ambulance and other emergency vehicles
- ✓ Drive-up windows/doors
- ✓ Parking near 24-hour retail entrances

Exterior Lighting Zones

Table C405.6.2(1)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Lighting Zone	Description
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
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

Exterior Lighting Zones

Table C405.6.2(1)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Exterior Lighting Zones

Table C405.6.2(2)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

		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

Exterior Lighting Zones cont'd

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

		Zone 1	Zone 2	Zone 3	Zone 4
Tradable Surfaces	**Building Entrances and Exits**				
	Main entries	20 W/linear foot of door width	20 W/linear foot of door width	30 W/linear foot of door width	30 W/linear foot of door width
	Other doors	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width
	Entry Canopies	0.25 W/ft^2	0.25 W/ft^2	0.4 W/ft^2	0.4 W/ft^2
	Sales Canopies				
	Free-standing and attached	0.6 W/ft^2	0.6 W/ft^2	0.8 W/ft^2	1.0 W/ft^2
	Outdoor Sales				
	Open areas (including vehicle sales lots)	0.25 W/ft^2	0.25 W/ft^2	0.5 W/ft^2	0.7 W/ft^2
	Street frontage for vehicle sales lots in addition to "open area" allowance	No allowance	10 W/linear foot	10 W/linear foot	30 W/linear foot

Exterior Lighting Control Requirements
C405.2.4

- ✓ For dusk-to-dawn lighting: astronomical time switch or photosensor
- ✓ For all other: astronomical time switch **OR** photosensor + time switch
- ✓ All time switches must have at least 10 hour battery backup

Exterior Building Grounds Lighting

C405.6.1

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

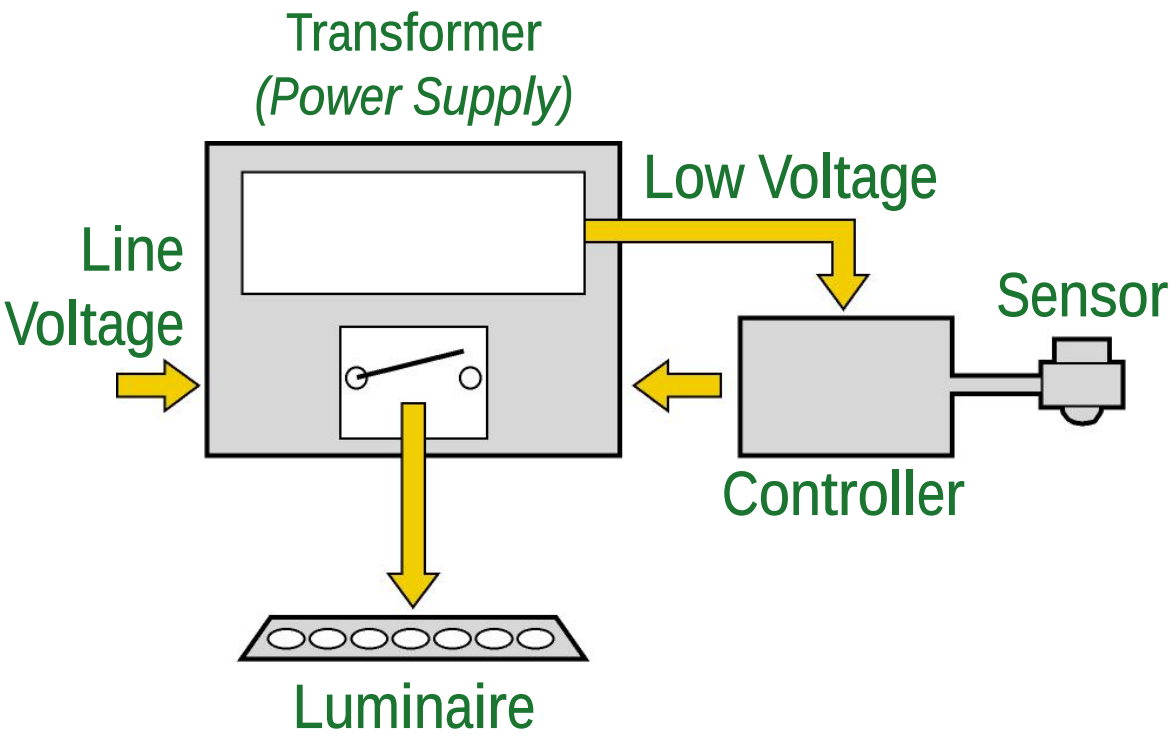
Building grounds lighting luminaires over 100 watts must have source efficacy of at least 60 lumens per watt

Light Source	Typical System Efficacy Range in LPW *(varies depending on wattage and lamp type)*
Incandescent	10-18
Halogen incandescent	15-20
Compact fluorescent (CFL)	35-60
Linear fluorescent	50-100
Metal halide	50-90

Exceptions

- ✓ Controlled by motion sensor
- ✓ Any of the exterior lighting power allowance exceptions

Exterior Grounds Lighting Controls
C405.6.1



Exterior grounds lighting over 100 W provides >60 lm/W unless on motion sensor or fixture is exempt from scope of code or from external LPD

Exemptions from Exterior Calculation
C405.6.2

The following lighting does not need to be included in the proposed lighting calculation:

- Specialized signal, directional, and marker lighting associated with transportation
- Advertising signage or directional signage
- Lighting integral to *equipment* or instrumentation and installed by its *manufacturer*
- Lighting for theatrical purposes, including performance, stage, film production, and video production
- Lighting for athletic playing areas
- Temporary lighting
- Lighting for industrial production, material handling, transportation sites, and associated storage areas
- Theme elements in theme/amusement parks
- Lighting used to highlight features of public monuments and registered *historic* landmark structures or *buildings*

Separate metering required for each dwelling unit

Lighting System Functional Testing
C408.3.1

- ✓ Testing to ensure that control hardware and software are calibrated, adjusted, programmed and in proper working order per construction documents and manufacturer's installation instructions
- ✓ Construction documents to state who will conduct the testing
- ✓ Where required by the code official
  - ✓ an approved independent party shall be responsible for the testing and documentation certifying the installed controls meet the provisions

Lighting System Functional Testing
C408.3.1 Cont'd

Where the following are installed:

- Occupant sensors
- Time switches
- Programmable schedule controls
- Photosensors
- Daylighting controls

It is required that the following be confirmed:

- ✓ Placement, sensitivity and time-out adjustments for occupant sensors yield acceptable performance
- ✓ Time switches and programmable schedule controls are programmed to turn the lights off
- ✓ Placement and sensitivity adjustments for photosensor controls reduce electric light based on the amount of usable daylight in the space as specified