BUILDING ENERGY CODES PROGRAM

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

ANSI/ASHRAE/IES Standard 90.1-2016: Power and Lighting

March 2017– PNNL-SA-124553

Building System

- Envelope
- HVAC
- SWH
- **Power**
- Lighting
- Other

Mandatory Provisions
(required for most compliance options)

Compliance Options

- Prescriptive Option
- Trade Off Option
- Energy Cost Budget
- Simplified
- Performance Rating Method

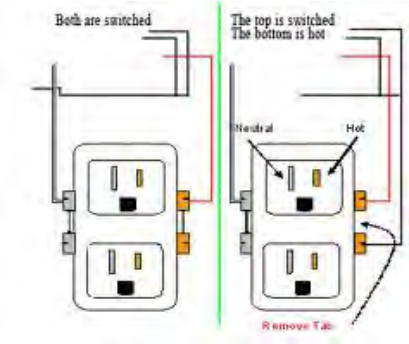
Energy Code Compliance

- ✓ New Buildings
- ✓ Additions
- ✓ Alterations
- ✓ Mandatory Provisions
  - ✓ Voltage drop
  - ✓ Automatic receptacle control
  - ✓ Electrical Energy Monitoring
  - ✓ Low-Voltage Dry Type Distribution Transformers
- ✓ Submittals

Automatically controlled

≥ 50% of all 125 volt 15- and 20-amp receptacles in:

- Private offices
- Conference rooms
- Rooms used primarily for printing and/or copying functions
- Break rooms
- Classrooms
- Individual workstations



Automatic control devices must function on:

- Time-of-day controller provided to control ≤ 5,000 ft^2 and not more than one floor (occupant able to manually override up to 2 hours) OR
- Occupant sensor(s) to turn off receptacles within 20 minutes of occupant leaving the space, OR
- Automated signal from another control or alarm that turns receptacles off within 20 minutes after determining the area is unoccupied

Controlled receptacles must be

- visually marked to differentiate from uncontrolled receptacles
- uniformly distributed throughout the space

Plug-in type devices may not be used to comply with this requirement

Exceptions

- Receptacles designated for equipment requiring 24 hr/day 365 days/yr operation
- Spaces where automatic lighting shutoff would cause security or safety concerns

Measurement devices in new building to monitor electrical energy use for each of these separately:

- Total electrical energy
- HVAC systems
- Interior lighting
- Exterior lighting
- Receptacle circuits

For buildings with multiple tenants, the above must be separately monitored for total building and for each tenant (excluding shared systems)

Exception:

- up to 10% of each separate load (other than total) can be from other electrical loads

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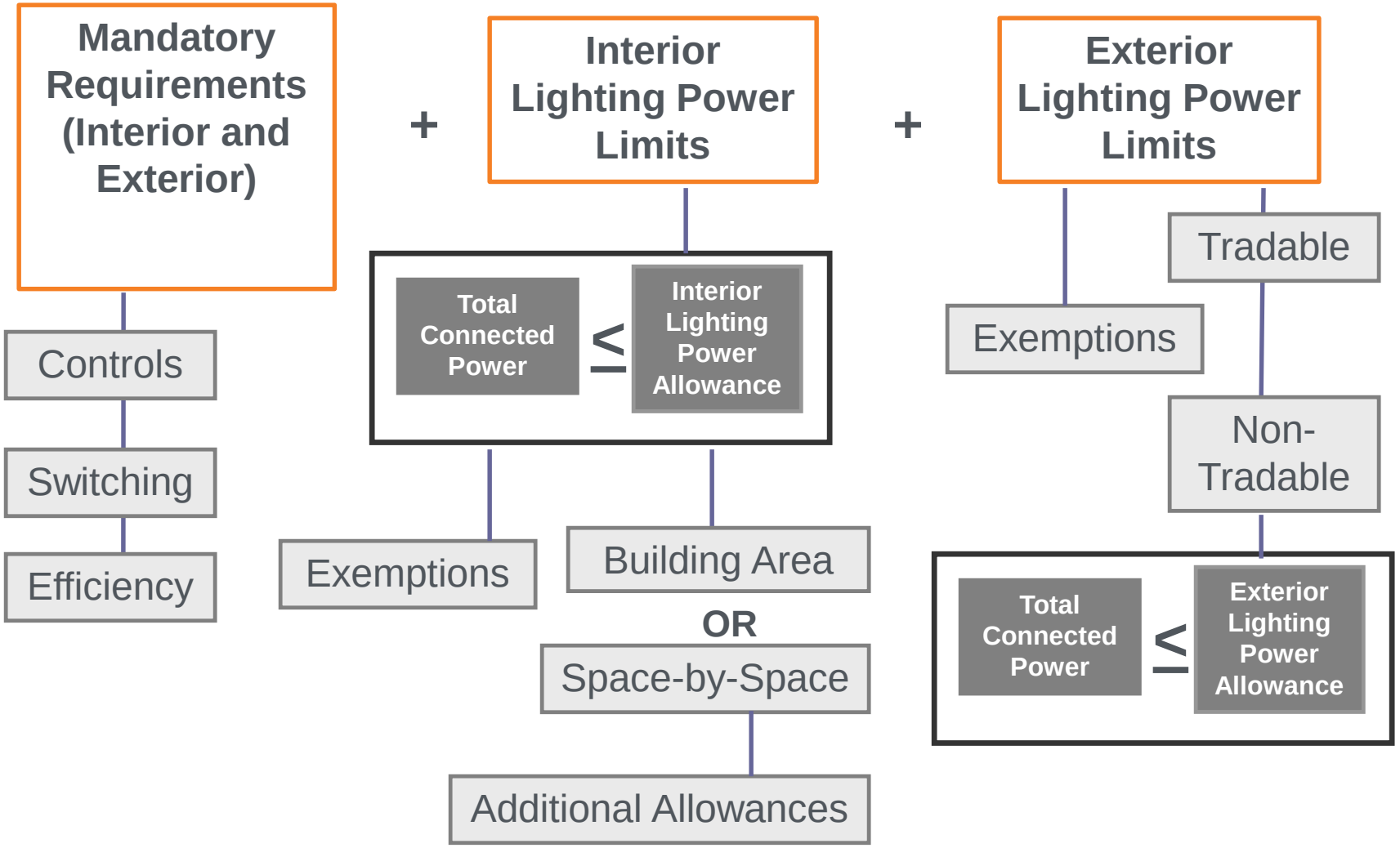
Energy Code Compliance

Basic Lighting Requirements



- ✓ General Application *(Section 9.1)*
  - Scope
  - Lighting Alterations
  - Installed Lighting Power
  - Interior and Exterior Luminaire Wattage
- ✓ Compliance *(Section 9.2)*
- ✓ Mandatory Provisions *(Section 9.4)*
  - Lighting control
  - Exterior lighting power
  - Functional testing
  - Dwelling units
  - Climate zone exception for daylighting control
- ✓ Building Area Method Compliance Path *(Section 9.5)*
- ✓ Alternative Compliance Path: Space-by-Space Method *(Section 9.6)*

Section 9 – Table 9.5.1
Building Types - Examples

Building Area Type[a]	*LPD*, W/ft^2
Automotive facility	0.71
Convention center	0.76
Courthouse	0.90
Dining: Bar lounge/leisure	0.90
Dining: Cafeteria/fast food	0.79
Dining: Family	0.78
Dormitory	0.61
Exercise center	0.65
Fire station	0.53
Gymnasium	0.68
Health-care clinic	0.82
Hospital	1.05
Office	0.79
Parking garage	0.15
Penitentiary	0.75
Performing arts theater	1.18
Police station	0.80
Post office	0.67
Religious facility	0.94
Retail	1.06
School/university	0.81

Applies to any building configuration by calculating allowances for individual spaces

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

Limitations

- ✓ More calculations needed (individual spaces)

Calculation Process

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

Small part of Table 9.6.1 shown below

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

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 9.4.1.1[a])	Restricted to *Manual* ON (See Section 9.4.1.1[b])	Restricted to Partial *Automatic* ON (See Section 9.4.1.1[c])	Bilevel Lighting *Control* (See Section 9.4.1.1[d])	*Automatic* Daylight Responsive *Controls* for Sidelighting (See Section 9.4.1.1[e][6])	*Automatic* Daylight Responsive *Controls* for *Toplighting* (See Section 9.4.1.1[f][6])	*Automatic* Partial OFF (See Section 9.4.1.1[g] [Full Off complies])	*Automatic* Full OFF (See Section 9.4.1.1[h])	Scheduled Shutoff (See Section 9.4.1.1[i])
Common *Space* Types[1]	*LPD*, W/ft^2	*RCR* Threshold	a	b	c	d	e	f	g	h	i
Office											
Enclosed and ≤250 ft^2	0.93	8	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Enclosed and >250 ft^2	0.93	8	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Open plan	0.81	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Parking Area, Interior	0.14	4	See Section 9.4.1.2.								
Pharmacy Area	1.34	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Restroom											
Facility for the visually impaired (and not used primarily by the staff)[3]	0.96	8					REQ	REQ		REQ	
All other restrooms	0.85	8					REQ	REQ		REQ	
Sales Area[4]	1.22	6	REQ	ADD1	ADD1	REQ		REQ		ADD2	ADD2
Seating Area, General	0.42	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Stairway	The *space* containing the stairway shall determine the *LPD* and *control* requirements for the stairway.										
Stairwell	0.58	10				REQ	REQ	REQ	REQ	ADD2	ADD2
Storage Room											
<50 ft^2	0.97	6	REQ							ADD2	ADD2
≥50 ft^2 and ≤1000 ft^2	0.46	6	REQ	ADD1	ADD1		REQ	REQ		REQ	
All other storage rooms	0.46	6	REQ	ADD1	ADD1		REQ	REQ	REQ	ADD2	ADD2

Room Geometry Adjustment – 9.6.4

Room Cavity Ratio Adjustment for relief in unusual space configurations

- Used only when applying the space by space method
- Calculate the *Room Cavity Ratio* (RCR) for the empty room:

  $$RCR = \frac{2.5 \times \text{Room Cavity Height} \times \text{room perimeter length}}{\text{room area}}$$

  (Room Cavity Height = Luminaire mounting height – Workplane height)

- If RCR is greater than the RCR threshold for that space type from Table 9.6.1, a 20% increase is allowed
- For corridor/transition spaces, a 20% adjustment is allowed when less than 8 feet wide, regardless of the RCR

Decorative and Retail display highlighting

An increase in the lighting power allowance is allowed for specific decorative and retail applications when using the space-by-space method.

Applications must be automatically controlled, separately from the general lighting, to be turned off during non-business hours. The additional allowances can only be used for the additional lighting equipment – and not general lighting

- ✓ Decorative luminaires in addition to the general lighting = 0.75 W/ft^2
- ✓ Retail display lighting = varies by retail type

Advanced Controls

An increase in the allowance is also allowed for the use of specified advanced controls that are installed in addition to those already required

Additional Interior Lighting Power Allowance = 1000 watts +
(Retail Area 1 x 0.45 W/ft^2) +
(Retail Area 2 x 0.45 W/ft^2) +
(Retail Area 3 x 1.05 W/ft^2) +
(Retail Area 4 x 1.88 W/ft^2),

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.

Other merchandise categories not listed may be included in Retail Areas 2 through 4, 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.

If all mandatory control requirements are met for a space AND advanced controls are installed in that space, THEN additional limited lighting power is allowed:

- Additional power can be used anywhere in the building
- Additional Interior Lighting Power Allowance is calculated as

  Lighting Power Under Control x Control Factor

- Local control
- Restricted to manual ON
- Restricted to partial automatic ON
- Bilevel lighting control
- Automatic daylight responsive controls for sidelighting
- Automatic daylight responsive controls for toplighting
- Automatic partial OFF (full OFF complies)
- Automatic full OFF
- Scheduled shutoff

At least one control that controls all the lighting in the space

- In spaces ≤ 10,000 ft^2, each control serves 2,500 ft^2 maximum and in spaces > 10,000 ft^2, serves 10,000 ft^2 maximum

No lighting automatically turned on

Exception

- Where manual ON would endanger safety or security

Typically, users are allowed to choose to implement this control or Partial On

< 50% of general lighting power allowed to be automatically turned on, and none of remaining lighting automatically turned on

Exception

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

Typically, users are allowed to choose to implement this control or Manual On

- General lighting to provide at least one intermediate step in lighting power or continuous dimming in addition to full ON and full OFF
- To have at least one control step between 30% and 70% (inclusive) of full lighting power in addition to all off

- Apply photocontrols if the combined input power of all general lighting completely or partially within:
  - primary sidelighted areas is ≥ 150 W
  - primary and secondary sidelighted areas is ≥ 300 W
  - general lighting in secondary sidelighted area controlled independently of general lighting in primary sidelighted area
- Control system must have following characteristics
  - Calibration adjustment located ≤ 11ft above finished floor
  - Photocontrol to reduce electric lighting in response to available daylight using
    - 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

- Apply photocontrols if the combined input power of all general lighting completely or partially under daylight areas under skylights and daylight areas under roof monitors is ≥ 150 W. Photocontrols must:
  - Reduce electric lighting in response to available daylight using
    - 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
  - Control overlapping toplighted and sidelighted daylight areas together with general lighting in the daylight area under skylights or daylight areas under roof monitors

- Automatically reduce general lighting power by at least 50% within 20 minutes of all occupants leaving the space

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

- All lighting automatically shut off within 20 minutes of all occupants leaving the space
- Control device to control < 5,000 ft^2

Exceptions

- Shop and lab classrooms
- Areas where auto shutoff causes safety or security concerns
- Lighting for 24/7 operation

Typically, users are allowed to choose to implement this control or Scheduled Shutoff

Control lights on a scheduled basis (automatic time switch)

- Time-of-day controller or
- Signal from another control or alarm

Controller or system provide independent control sequences that

- Controls ≤ 25,000 ft^2
- Not more than one floor
- Accounts for weekend and holidays

Manual override control

- < 2 hours during scheduled off
- Control ≤ 5,000 ft^2

Typically, users are allowed to choose to implement this control or Automatic Full Off

Exceptions

- Lighting for 24/7 operation
- Patient care spaces
- Areas where auto shutoff causes safety or security concerns
- Lighting load ≤ 0.02 W/ft^2 multiplied by gross lighted area of the building

- Automatic lighting shutoff per 9.4.1.1(i)
- Must reduce lighting power by minimum of 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 ≥ 40% and
  - no exterior obstructions within 20 ft

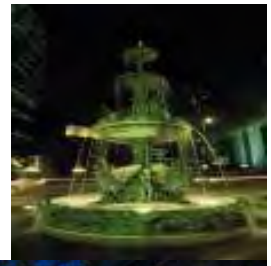
Exception

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

- Guestroom lighting and switched receptacles to be turned off within 20 minutes of occupants leaving the space
  - **Exception**: where captive key systems used
- Bathrooms controlled to automatically turn off lighting within 30 minutes of occupants leaving space
  - **Exception**: night lighting not > 5W
- Supplemental task lighting controlled by
  - Controller integral to the luminaires OR
  - Wall-mounted controller-readily accessible and located so occupant can see controlled lighting

Section 9 – 9.4.1.4
Mandatory Exterior Lighting Control

- Lighting must turn off when there is sufficient daylight
- Building façade and landscape lighting must be shut off between
  - midnight or business closing (whichever is later) and
  - 6am or business opening (whichever comes first) OR
  - times established by AHJ
- Power for other lighting and lighting for signage to be automatically reduced by at least 50%
  - From midnight or within 1 hour of end of business operations (whichever is later) and until 6am or business opening (whichever is earlier) OR
  - During any period when no activity has been detected for a time no longer than 15 minutes
- Luminaires serving outdoor parking areas with rated input wattage > 78 W and mounting height of ≤ 24 ft above ground
  - Lights must automatically reduce power of each luminaire by > 50% when no activity is detected in the area for 15 minutes or less
  - Limited to 1500 W of lighting controlled together



Exceptions

- Covered vehicle entrances
- Exits from buildings or parking structures
  (where required for safety, security, or eye adaptation)
- Lighting integral to signage and installed by manufacturer

Exterior Building Lighting Power must meet prescribed power limits.

- The total exterior lighting power allowance is the sum of the base site allowance plus individual lighting power densities (LPD) for the applicable “lighting power zone”
- Trade-offs are allowed only among “Tradable Surfaces” applications
- Some exemptions apply

Exterior applications are divided into 2 categories:

Tradable: allowed wattage may be traded among these applications

Non-Tradable: allowed wattage cannot be traded between surfaces or with other exterior lighting

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	0.95 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/lin ft of opening	14 W/lin ft of opening	21 W/lin ft of opening	21 W/lin ft of opening

- 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.