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

March 2017 – PNNL-SA-124553
## Compliance Options

### Mandatory Provisions

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

### Compliance Options

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

### Energy Code Compliance

- Compliance
- Power

[Source: www.energycodes.gov]
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
Building System

- Envelope
- HVAC
- SWH
- Power
- Lighting

Compliance Options

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

Mandatory Provisions (required for most compliance options)
Basic Lighting Requirements

**Mandatory Requirements (Interior and Exterior)**
- Controls
- Switching
- Efficiency

**Interior Lighting Power Limits**
- Total Connected Power
- Interior Lighting Power Allowance

**Exterior Lighting Power Limits**
- Tradable
- Exemptions
- Non-Tradable

**Additional Allowances**
- Space-by-Space

**Building Area**

```
Exemptions
```

```
Total Connected Power
```

```
Exterior Lighting Power Allowance
```

OR

```
Additional Allowances
```

```
Total Connected Power
```

```
Exterior Lighting Power Allowance
```
Section 9
Lighting

✓ 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

<table>
<thead>
<tr>
<th>Building Area Type</th>
<th>LPD, W/m²²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive facility</td>
<td>0.71</td>
</tr>
<tr>
<td>Convention center</td>
<td>0.76</td>
</tr>
<tr>
<td>Courthouse</td>
<td>0.90</td>
</tr>
<tr>
<td>Dining: Bar lounge/leisure</td>
<td>0.90</td>
</tr>
<tr>
<td>Dining: Cafeteria/fast food</td>
<td>0.79</td>
</tr>
<tr>
<td>Dining: Family</td>
<td>0.78</td>
</tr>
<tr>
<td>Dormitory</td>
<td>0.61</td>
</tr>
<tr>
<td>Exercise center</td>
<td>0.65</td>
</tr>
<tr>
<td>Fire station</td>
<td>0.53</td>
</tr>
<tr>
<td>Gymnasium</td>
<td>0.68</td>
</tr>
<tr>
<td>Health-care clinic</td>
<td>0.82</td>
</tr>
<tr>
<td>Hospital</td>
<td>1.05</td>
</tr>
<tr>
<td>Office</td>
<td>0.79</td>
</tr>
<tr>
<td>Parking garage</td>
<td>0.15</td>
</tr>
<tr>
<td>Penitentiary</td>
<td>0.75</td>
</tr>
<tr>
<td>Performing arts theater</td>
<td>1.18</td>
</tr>
<tr>
<td>Police station</td>
<td>0.80</td>
</tr>
<tr>
<td>Post office</td>
<td>0.67</td>
</tr>
<tr>
<td>Religious facility</td>
<td>0.94</td>
</tr>
<tr>
<td>Retail</td>
<td>1.06</td>
</tr>
<tr>
<td>School/university</td>
<td>0.81</td>
</tr>
</tbody>
</table>
Building Energy Codes Program

Section 9 – 9.6.1
Space-by-Space Method of Calculating Interior Lighting Power Allowance

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)

<table>
<thead>
<tr>
<th>Common Space Types¹</th>
<th>LPD, W/m²</th>
<th>RCR Threshold</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
<th>i</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>0.93</td>
<td>8</td>
<td>REQ</td>
<td>ADD1</td>
<td>ADD1</td>
<td>REQ</td>
<td>REQ</td>
<td>REQ</td>
<td>REQ</td>
<td>ADD2</td>
<td>ADD2</td>
</tr>
<tr>
<td>Enclosed and ≤250 ft²</td>
<td>0.93</td>
<td>8</td>
<td>REQ</td>
<td>ADD1</td>
<td>ADD1</td>
<td>REQ</td>
<td>REQ</td>
<td>REQ</td>
<td>REQ</td>
<td>ADD2</td>
<td>ADD2</td>
</tr>
<tr>
<td>Open plan</td>
<td>0.81</td>
<td>4</td>
<td>REQ</td>
<td>ADD1</td>
<td>ADD1</td>
<td>REQ</td>
<td>REQ</td>
<td>REQ</td>
<td>REQ</td>
<td>ADD2</td>
<td>ADD2</td>
</tr>
<tr>
<td>Parking Area, Interior</td>
<td>0.14</td>
<td>4</td>
<td>See Section 9.4.1.12.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pharmacy Area</td>
<td>1.34</td>
<td>6</td>
<td>REQ</td>
<td>ADD1</td>
<td>ADD1</td>
<td>REQ</td>
<td>REQ</td>
<td>REQ</td>
<td>REQ</td>
<td>ADD2</td>
<td>ADD2</td>
</tr>
<tr>
<td>Restroom</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Facility for the visually impaired (and not used primarily by the staff)²</td>
<td>0.96</td>
<td>6</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All other restrooms</td>
<td>0.85</td>
<td>8</td>
<td>REQ</td>
<td>REQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Sales Area³</td>
<td>1.22</td>
<td>6</td>
<td>REQ</td>
<td>ADD1</td>
<td>ADD1</td>
<td>REQ</td>
<td>REQ</td>
<td>ADD2</td>
<td>ADD2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seating Area, General</td>
<td>0.42</td>
<td>4</td>
<td>REQ</td>
<td>ADD1</td>
<td>ADD1</td>
<td>REQ</td>
<td>REQ</td>
<td>ADD2</td>
<td>ADD2</td>
<td></td>
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<tr>
<td>Stairway</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>The space containing the stairway shall determine the LPD and control requirements for the stairway.</td>
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</tr>
<tr>
<td>Stairwell</td>
<td>0.58</td>
<td>10</td>
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<td></td>
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</tr>
<tr>
<td>Storage Room</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50 ft²</td>
<td>0.97</td>
<td>6</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥50 ft² and ≤1000 ft²</td>
<td>0.46</td>
<td>6</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>All other storage rooms</td>
<td>0.46</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

**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.
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:
  \[ RCR = 2.5 \times \frac{\text{Room Cavity Height} \times \text{room perimeter length}}{\text{room area}} \]
  (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/ft²
- 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/ft²) +
(Retail Area 2 x 0.45 W/ft²) +
(Retail Area 3 x 1.05 W/ft²) +
(Retail Area 4 x 1.88 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.

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
Section 9.4.1.1
Control Functions

- 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 ft², each control serves 2,500 ft² maximum and in spaces > 10,000 ft², serves 10,000 ft² 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 ft²

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/ft²
• 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/ft² multiplied by gross lighted area of the building
Section 9 – 9.4.1.1 (h)  
Automatic Full OFF

- 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$^2$

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

Typically, users are allowed to choose to implement this control or Automatic Full Off
Section 9 – 9.4.1.2
Parking Garage Lighting Control

• 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 ft²
• 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
Section 9 – 9.4.1.3
Control of Special Applications

• 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
Section 9
 Tradable Exterior LPDs

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>
<thead>
<tr>
<th>Table 9.4.2-2 Individual Lighting Power Allowances for Building Exteriors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Zone 0</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td><strong>Base Site Allowance (Base allowance may be used in tradable or nontradable surfaces.)</strong></td>
</tr>
<tr>
<td>No allowance</td>
</tr>
<tr>
<td>** 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.)</td>
</tr>
<tr>
<td><strong>Uncovered Parking Areas</strong></td>
</tr>
<tr>
<td>Parking areas and drives</td>
</tr>
<tr>
<td><strong>Building Grounds</strong></td>
</tr>
<tr>
<td>Walkways/ramps less than 10 ft wide</td>
</tr>
<tr>
<td>Walkways/ramps 10 ft wide or greater</td>
</tr>
<tr>
<td>Plaza areas</td>
</tr>
<tr>
<td>Special feature areas</td>
</tr>
<tr>
<td>Dining areas</td>
</tr>
<tr>
<td>Stairways</td>
</tr>
<tr>
<td>Pedestrian tunnels</td>
</tr>
<tr>
<td>Landscaping</td>
</tr>
<tr>
<td><strong>Building Entrances, Exits, and Loading Docks</strong></td>
</tr>
</tbody>
</table>
Section 9 – 9.4.4

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.