

BEYOND

SMART CITIES

INDOOR ENVIRONMENTAL QUALITY - GREEN

BUILDING TECHNOLOGY TRAINING PROGRAM

FOR GREEN BUILDING AND SUSTAINABILITY SPECIALISTS

KRISHNAJI PAWAR, LEED AP BD+C, GSAS CGP, ISO 14001:2015, GCP

GREEN BUILDING SPECIALIST CURRICULUM

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INTERIOR LIGHTING - CREDIT

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LEARNING OBJECTIVES



Intent of Interior Lighting - Credit

Behind the Intent

Step by Step Guidance

Requirements

Required Documentation

Connection to Ongoing Performance

Terms and Definitions

IEQ- CR(2) - DESIGN

INTERIOR LIGHTING

INTENT

To promote occupants' productivity, comfort, and well-being by providing high-quality lighting.

POTENTIAL TECHNOLOGIES & STRATEGIES

Studies of lighting in buildings have shown that workers are more comfortable and productive in an environment that is carefully illuminated and where lighting controls are provided for individual and group needs. 1 Also, high-quality lighting helps eliminate distractions, creates visual interest and a sense of place, supports interaction and communication, contributes to occupants' well-being, and reduces health problems.

REQUIREMENTS

REQUIREMENTS
Meet 1 strategy for 1 point. Meet 3 strategies total for 2 points.

1. Glare Control For all regularly occupied spaces, meet one of the following requirements:
2. Color Rendering For all regularly occupied spaces meet one of the following requirements:
3. Lighting Control Provide dimmable or multilevel lighting for 90% of occupant spaces.
4. Surface Reflectivity For at least 90% regularly occupied spaces, use interior finishes with a surface reflectance greater or equal to 80% for ceilings and 55% for walls. If included in the project scope, use furniture finishes with a surface reflectance greater or equal to 45% for work surfaces and 50% for movable partitions.

IMPLEMENTATION

REQUIRED DOCUMENTATION

[illegible]

BEHIND THE INTENT

Studies of lighting in buildings have shown that workers are more comfortable and productive in an environment that is carefully illuminated and where lighting controls are provided for individual and group needs.¹ Also, high-quality lighting helps eliminate distractions, creates visual interest and a sense of place, supports interaction and communication, contributes to occupants' well-being, and reduces health problems.² This credit rewards lighting quality that dramatically improves occupants' comfort and productivity.³

The credit encourages lighting quality in multiple ways.

- Minimizing light fixture luminance (Strategy A) helps reduce disability and discomfort glare; the threshold, 400 candelas per square meter, was selected because research by the Light Right Consortium found that above this level, the glare becomes noticeable.
- Using light sources with a color rendering index less than 80 (Strategy B) helps approximate natural light.
- Using light sources with long lamp life (Strategy C) can lengthen the period over which the integrity of the lighting design is maintained; it also reduces maintenance costs and lowers material and resource inputs.
- Using light sources with low power factor (Strategy D) reduces energy consumption.
- Designing spaces with less direct-only lighting (Strategy D) helps minimize glare, reduces the perceived brightness of the direct luminaires, and reduces contrast between ceiling and luminaires.
- Designing spaces with less direct-only lighting (Strategy D) helps minimize glare, reduces the perceived brightness of the direct luminaires, and reduces contrast between the specific surface reflectance values for ceilings, walls, and floors are above the standard luminance (L) assumptions of 0.5, 0.3, and 0.2, respectively, as shown in the table below.
- Designing for an illuminance ratio less than 10:1 (Strategy G) minimizes the amount of contrast that occupants experience between their work surface and the ceiling and wall surfaces around them; the ratio 10:1 is the least contrast that presents one less decade in lighting levels (human eyes are logarithmic, but illuminance is linear).

Research on lighting and visual performance is cited in *Further Explanation, Additional Lighting Resources*.

STEP-BY-STEP GUIDANCE

STEP 1. ESTABLISH LIGHTING NEEDS

Work with the owner to understand occupants' lighting needs and desires.

- Document the types of tasks that will occur in each space and the tools and equipment that occupants will use regularly, and determine appropriate light levels for tasks.
- Identify the level of control that occupants should have and the characteristics of the occupant population.

STEP 2. SELECT OPTION(S)

Determine which option(s) are appropriate for the project. All projects except Healthcare and Retail may earn one or both options.

- Option 1 requires lighting controls for 90% of the individual occupant spaces and 100% of shared, multioccupant spaces. Standard on-off switches are not acceptable; at least three lighting levels or scenes must be provided. Project teams that are familiar with previous versions of LEED may prefer this option, and it is easier to implement in later phases of design than Option 2.

STEP-BY-STEP GUIDANCE +

- Option 2 offers eight strategies (Table 5), of which four must be implemented to meet the requirements. Strategies A-D are based on characteristics of the lighting fixtures, light sources, and luminaires. Strategies E-H are based on characteristics of the surface in the project and the luminance level that fall on these surfaces. This option requires attention during early design phases because achievement depends on luminaire selection and configuration and architectural surface specifications.

For the different requirements for Healthcare and Retail projects, see [Further Exploration, Rating System Variations](#).

TABLE 5. Strategies for Option 2, Lighting Quality		
Strategy	Scope	Exceptions, exclusions
A. Light fixture luminance	All light fixtures located in regularly occupied spaces	<ul style="list-style-type: none">Wallwash fixtures properly aimed at walls, as specifically mentionedIndirect lighting fixtures, provided there is no view down into these lights from regularly occupied space above (e.g., adjustable fixtures)Any other specific applications (e.g., adjustable fixtures)
B. Color rendering index (CRI)	All light fixtures	<ul style="list-style-type: none">Lamps or fixtures specifically designed to provide correct lighting effectSite lightingAny other special use
C. Lamp life	70% connected lighting load	—
D. Direct overhead lighting	25% connected lighting load for regularly occupied areas	—
E. Surface reflectance: offices, sales floor	80% of regularly occupied floor area	—
F. Surface reflectance: workspaces	All function used for work surfaces	—
G. Surface luminance ratio: walls and ceiling	75% regularly occupied floor area	—
H. Surface luminance ratio: ceiling in work surface	70% regularly occupied floor area	—

STEP 3. COMPLY WITH OPTION REQUIREMENTS

For the option(s) selected, follow the appropriate set of steps to confirm compliance.

STEP-BY-STEP GUIDANCE +

Option 1. Lighting Control

Identify all individual occupant and shared, multioccupant spaces in the project (see [EQ Overview](#)).

- Design lighting controls for individual and multioccupant spaces to meet the credit requirements. Task lighting may be used to meet the credit requirements for individual occupant spaces. Task lights are not required to be hardwired.
- All lighting controls must provide at least three lighting levels or scenes: including on, off, and a midlevel, defined as 30% to 70% of the maximum illumination level (not including daylight contributions). Daylight does not qualify as a separate lighting level.
- For multioccupant spaces that can be subdivided by movable walls or partitions, provide the required lighting controls for each subdivision of the space.
- Tabulate all individual and multioccupant spaces and their respective lighting controls. Confirm that at least 90% of individual occupant spaces and 100% of multioccupant spaces meet the credit requirements. The percentage of compliant individual occupant spaces is based on the number of spaces, not floor area.

STEP-BY-STEP GUIDANCE +

Option 2. Lighting Quality

Option 2. Lighting Quality, Strategy A

- Identify all regularly occupied spaces in the project and all light fixtures in these spaces (see [EQ Overview](#)). The following fixtures may be excluded:
 - Wallwash fixtures properly aimed at walls, as specified by manufacturer's data
 - Indirect lighting fixtures, provided there is no view down into these lights from regularly occupied space above
 - Any other specific applications (e.g., adjustable fixtures)

For the light fixtures, review luminaire cutsheets, Illuminating Engineering Society photometric files, or other documentation to identify luminance between 45 degrees and 90 degrees from nadir and select products that meet the credit requirements. The luminance must be below 2,500 candelas per square meter.

Complete documentation that confirms compliance with the credit requirements for luminance.

Option 2. Lighting Quality, Strategy B

- Specify all light sources to meet the credit requirements for color rendering index (CRI).
 - The following light sources may be included: lamps or fixtures specifically designed to provide colored lighting for effect, site lighting, and lamps or fixtures designed for some other special use.
 - For the light sources, determine the CRI, not to be confused with correlated color temperature (CCT), which refers to the spectrum of warm to cool. A light source can have a high or low CRI regardless of its CCT.
 - Complete documentation that confirms compliance with the credit requirements for the lighting's CRI.

Option 2. Lighting Quality, Strategy C

- Specify all light sources to meet the credit requirements for lamp life.
 - Calculate the total connected lighting load for all lighting in the project, in watts or kilowatts. Refer to the lighting power calculations prepared for EA Prerequisite Minimum Energy Performance and tabulate luminaire quantities and wattages to determine the total connected load. For guidance on determining connected lighting load, see ASHRAE 90-200, Sections 9.3 and 9.4. Plug-in lighting is included in the calculation for connected load.
 - For lamp life, review luminaire cutsheets or other documentation. Lamp life depends on the type of source. For traditional light sources, the lamp life is based on the time at which 50% of the test samples have burned out. For LED light sources, the lamp life criterion (L70) is based on the time at which the light source has a 30% reduction in light output. Review the [IES Lighting Handbook](#) for more information on lamp life.
 - Calculate the amount of connected lighting load with compliant light source. It must be 75% or greater.

Complete documentation that confirms compliance with the credit requirements for lamp life.

Option 2. Lighting Quality, Strategy D

- Specify a combination of direct-only overhead lighting and other lighting. Minimize the use of direct-only overhead lighting to meet the credit requirements for lighting D.
 - Identify all regularly occupied spaces in the project and the total connected lighting load associated with these spaces (see [EQ Overview](#)). Refer to the lighting power calculations prepared for EA Prerequisite Minimum Energy Performance and tabulate luminaire quantities and wattages to determine the total connected load. For guidance on determining connected lighting load, see ASHRAE 90-200, Sections 9.3 and 9.4. Plug-in lighting is included in the calculation for connected load.
 - Determine the connected lighting load that is associated with direct-only overhead lighting. It must be 25% or less.
 - Complete documentation that confirms compliance with the credit requirements for overhead lighting.

STEP-BY-STEP GUIDANCE +

Option 2: Surface Reflectance, Strategies E and F

Select or specify high-reflectance finish materials as applicable to the strategy pursued: ceilings, walls, and floors for strategy E, and work surfaces and movable partitions for strategy F.

- Before construction begins, review manufacturers' cutbooks to identify reflectance, typically expressed as a fraction or percentage (L8 light reflectance) or L8 light reflectance value (R_l manufacturers' data do not include reflectance; measure the reflectance of product samples (colorimetric measurement) or the installed product (spectrophotometry) using the methodology described in IES Lighting Handbook, Section 9.2.2, Measuring Reflectance and Transmittance. Or use reflectance charts, such as Lighting Guide 5, Surface Reflectance and Contrast.
- For strategy E, 5% of the regularly occupied floor area may be excluded.
- For strategy F, work surfaces include desks and table surfaces where individuals perform tasks. The surface area for movable partitions is limited to visible surfaces of the partition: transparent or partially transparent surfaces are not included in the calculation.
- Use Equation 1 to calculate the average surface reflectance for walls, ceilings, and floors (strategy E) and work surfaces and movable partitions (strategy F).

EQUATION 1 Average surface reflectance

Weighted average of surface reflectance

$$\left(\frac{\text{reflectance} \times \text{surface area of ceiling}}{\text{total surface area}} \right) + \left(\frac{\text{reflectance} \times \text{surface area of wall}}{\text{total surface area}} \right) + \left(\frac{\text{reflectance} \times \text{surface area of work surface and movable partitions}}{\text{total surface area}} \right)$$

total surface area

- Confirm that the average surface reflectance of the specified surfaces meets or exceeds the values in the credit requirements.

Option 3: Illuminance, Strategies G and H

Develop a lighting design strategy to minimize the ratio of wall surface luminance (strategy G) or ceiling surface luminance (strategy H) to work surface luminance. Consider the following design strategies:

- Specify ceiling and wall finishes that are light colored or have high surface reflectance.
- Design the lighting system to intentionally light the walls or ceiling.
- Consider luminaires that throw 20% to 30% of light on ceiling or wall, such as direct indirect lighting. Average luminaires to provide wall wash.

Use lighting calculation software or measurements to determine the average illuminance levels on work, wall, and ceiling surfaces for each regularly occupied space. (Illuminance refers only to light incident on the space, either substrate or on the predominant luminance level. Work surfaces include desks or other table surfaces where individuals perform tasks. Where work surfaces are not specified, calculate the illuminance at a height of 30 inches (762 millimeters) above the finished floor. Alternatively, calculate illuminance at the height where most visual tasks are expected to be performed. For existing building projects or after construction is complete, the illuminance may be measured. The luminance of a given surface is measured with a light meter, with the sensor facing away from the surface for which the measurement is being taken.)

Use Equation 2 (for Strategy G) and Equation 3 (for Strategy H) to calculate an illuminance ratio for each regularly occupied space. Determine the percentage of regularly occupied area that achieves an illuminance ratio of 100 or less; it must be at least 75%.

EQUATION 2 Ratio to work plane illuminance ratio

Illuminance ratio

$$= \frac{\text{average work surface luminance}}{\text{average wall surface luminance}}$$

EQUATION 3 Ceiling to work plane illuminance ratio

Illuminance ratio

$$= \frac{\text{average work surface luminance}}{\text{average ceiling illuminance}}$$

REQUIREMENTS

1. Glare Control

For all regularly occupied spaces, meet one of the following requirements:

- Use light fixtures with a luminance of less than 7,000 candelas per square meter (cd/m²) between 45 and 90 degrees from nadir.

OR

- Achieve a Unified Glare Rating (UGR) rating of <19 using software modelling calculations of the designed lighting.

Exceptions include wallwash fixtures properly aimed at walls, as specified by manufacturer's data, indirect uplighting fixtures, provided there is no view down into these uplights from a regularly occupied space above, and any other specific applications (i.e. adjustable fixtures).

2. Color Rendering

For all regularly occupied spaces meet one of the following requirements:

- Use light sources that have a Color Rendering Index (CRI) of at least 90.
- Use light sources that have a Color Fidelity Index greater than or equal to 78 and a gamut index between 87 and 110, determined in accordance with Illuminating Engineering Society (IES) TM-30.

3. Lighting Control

Provide dimmable or multilevel lighting for 90% of occupant spaces.

4. Surface Reflectivity

For at least 50% regularly occupied spaces, use interior finishes with a surface reflectance greater or equal to 80% for ceilings and 55% for walls. If included in the project scope, use furniture finishes with a surface reflectance greater or equal to 40% for work surfaces and 50% for movable partitions.

CONNECTION TO ONGOING PERFORMANCE

LEED Q+M EQ prerequisite Indoor Environmental Quality Performance Strategies to promote occupant comfort and wellbeing by providing high quality lighting in form of designing for lighting controls as well as by providing enhanced lighting quality measures in newly constructed buildings can contribute to better indoor environmental quality and overall occupant satisfaction during operations phase.



REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2							
		A	B	C	D	E	F	G	H
Table of individual occupant and multioccupant spaces and lighting controls in each space	x								
Table of regularly occupied spaces and associated lighting details		x			x				
Calculations of total connected lighting load				x	x				
Lighting details, including manufacturer and model, results of estimations, or in situ or laboratory photometric tests		x	x	x	x				
List of ceiling, wall, and floor surfaces and their associated surface reflectance values						x			
List of work surfaces and movable partitions and their associated surface reflectance values							x		
Average surface reflectance calculations						x	x		
List of work surfaces and illuminance values (lux)								x	
List of wall or ceiling surfaces with illuminance values (lux)									x
Illuminance ratio calculations							x	x	



REFERENCED STANDARDS

The Lighting Handbook, 10th edition, Illuminating Engineering Society of North America: ies.org



TERMS AND DEFINITIONS

Color rendering index a measurement from 0 to 100 that indicates how accurately an artificial light source, as compared with an incandescent light, displays hues. The higher the index number, the more accurately the light is rendering colors. Incandescent lighting has a color rendering index above 95; standard high-pressure sodium lighting (such as orange-hued roadway lights) measures approximately 25; many fluorescent sources using rare earth phosphors have a color rendering index of 80 and above. (Adapted from U.S. ENERGY STAR)

Illuminance the incident luminous lux density on a differential element of surface located at a point and oriented in a particular direction, expressed in lumens per unit area. Since the area involved is differential, it is customary to refer to this as illuminance at a point. The unit name depends on the unit of measurement for area: foot-candles if square feet are used for area, and lux if square meters are used. (Adapted from Illuminating Engineering Society) In lay terms, illuminance is a measurement of light striking a surface. It is expressed in footcandles in the U.S. (based on square feet) and in lux in most other countries (based on square meters).




