

BEYOND

SMART CITIES

SUSTAINABLE SITES - 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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LIGHT POLLUTION REDUCTION - CREDIT

FOR GREEN BUILDING AND SUSTAINABILITY SPECIALIST

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LEARNING OBJECTIVES

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GREEN BUILDING SPECIALIST

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SS- CR(1) - DESIGN

INTENT

To increase night sky access, improve nighttime visibility, and reduce the consequences of development for wildlife and people.

POTENTIAL TECHNOLOGIES & STRATEGIES

Adopt site lighting criteria to maintain safe light levels while avoiding off-site lighting and night sky pollution.

Minimize site lighting where possible and use computer software to model the site lighting.

Technologies to reduce light pollution include full cut-off luminaires, low-reflectance surfaces and low-angle spotlights.

LIGHT POLLUTION REDUCTION

REQUIREMENTS

Meet uplight and light trespass requirements, using either the backlight-uplight-glare (BUG) method (Option 1) or the calculation method (Option 2). Projects may use different options for uplight and light trespass.
Meet these requirements for all exterior luminaires located inside the project boundary (except those listed under "Exemptions"), based on the following:

the photometric characteristics of each luminaire when mounted in the same orientation and tilt as specified in the project design; and

the lighting zone of the project property (at the time construction begins).

Classify the project under one lighting zone using the lighting zones definitions provided in the Illuminating Engineering Society and International Dark Sky

IMPLEMENTATION

REQUIRED DOCUMENTATION

REQUIRED DOCUMENTATION	IF APPLICABLE	TABLE 1	TABLE 2	TABLE 3	TABLE 4
Site plan showing building footprint, setbacks, and other site information	1				
Photometric data for all luminaires, including beam spread, candela, and foot-candle distribution	2				
Lighting calculations showing uplight, glare, and light trespass	3				
Lighting calculations showing uplight, glare, and light trespass	4				

Calculations for uplight, glare, and light trespass must be provided for all luminaires.
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BEHIND THE INTENT

Artificial exterior lighting not only provides human safety and comfort, it enables us to productively use more hours of the day. If done correctly, exterior lighting offers safety, security, building identification, aesthetics, and way finding. However, poor lighting design causes light pollution.

Light pollution is the misdirection or misuse of light, generally resulting from an inappropriate application of exterior lighting. Backlight creates light trespass onto adjacent sites by directing light in the opposite direction of the area intended to be lit. Uplight causes artificial sky glow. Glare is caused by high-angle front light.

Light pollution creates an abundance of environmental problems. Wildlife-species that hunt or forage at night may be unable to feed. Some flora and fauna are unable to adjust to seasonal variations when exposed to light pollution. Migratory birds that rely on stars to guide them during migration may become disoriented. Even human health can be damaged by misuse of light. Studies have shown that overexposure to artificial lighting, particularly at night, may disrupt our circadian rhythms and melatonin production, impair night vision, and lead to sleep disorders.⁴ Finally, light pollution directed into the sky or into areas that do not need illumination is a waste of both energy and money.

Good lighting design involves reducing three forms of light pollution: uplight, glare, and light trespass. This credit addresses all three with requirements for specifying only the necessary lighting, selecting the right luminaires (lamp-ballast combinations), locating them appropriately on the project site, and implementing an appropriate control strategy. So that designers have flexibility, this credit offers two compliance options—a calculation method (as in LEED 2009) and a new backlight, uplight, and glare (BUG) rating method.

Thoughtful selection of lighting results in luminaires that are not only aesthetically pleasing but also generate well-shielded, well-directed light. Minimizing direct views of lamps avoids glare, and gradually changing light levels allows the human eye to adapt. Efficient design specifies both luminaire distribution and lighting controls, including motion sensors, photocells, time clocks, and other devices that reduce the amount of light at times and places it is not needed.



STEP-BY-STEP GUIDANCE

STEP 1. ESTABLISH EXTERIOR LIGHTING PROJECT GOALS

Determine which team members will be responsible for the lighting design, luminaire selection, and overall lighting concept. Prepare a schematic site lighting design by doing the following:

- Identify the desired lighted areas on site.
- Consult the Illuminating Engineering Society (IES) Lighting Handbook recommendations to establish target light levels and uniformities for the identified areas.
- Identify any areas of the site where it may be difficult to meet the credit requirements because of light level needs, proximity to a boundary, or other factors.

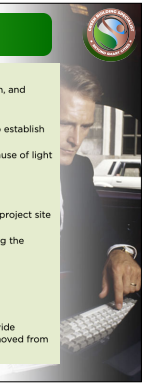
STEP 2. DETERMINE LIGHTING ZONE

Identify the project's lighting zone. The lighting designer (or someone with knowledge of the project site and lighting zone classifications) is responsible for classifying the lighting zone.

- Refer to the IES Model Lighting Ordinance (MLO) User Guide for information on determining the project's lighting zone (see [Further Explanation, Lighting Zones](#)).
- Classify the entire project as one lighting zone.
- Provide justification for the lighting zone chosen for the project.

STEP 3. ESTABLISH LIGHTING BOUNDARY

Determine the lighting boundary for the project and create a lighting boundary site plan. Provide justification for any modification of the lighting boundary (e.g., if the lighting boundary was moved from the project boundary to the center line of an adjacent public street).



STEP-BY-STEP GUIDANCE +

STEP 4. PREPARE SITE LIGHTING DESIGN

Prepare a site lighting plan based on the lighting zone designation and develop a luminaire schedule for the project, selecting luminaires that eliminate or minimize uplight and light trespass off site (see [Further Explanation, Choosing Luminaires](#)).

- Designate all exterior luminaires (both exempt and nonexempt) within the project boundary, and indicate locations, including pole heights.
- Depict the project boundary, the property line (if different from the project boundary), the lighting boundary, any additional properties included in the lighting boundary, and any relevant project site conditions.
- Indicate the total number of each luminaire type in the project.
- Identify the manufacturer, model number, lamp type, orientation, tilt angle (if applicable), and input wattage for each luminaire type.

This is only a preliminary design; the project team may need to revisit the design after completing the subsequent steps and determining the uplight and light trespass values.

STEP 5. DETERMINE EXEMPTIONS

- Identify any luminaires that are exempt from the uplight and light trespass requirements and provide justification for the exemptions.
- Examples of exempt lighting include emergency lighting, government-mandated roadway lighting, theatrical lighting, and lighting of the national flag in certain lighting zones.
- If no lighting is required except what is listed in exemptions (see credit requirements) the project achieves the credit, provided the team justifies the exemptions.



STEP-BY-STEP GUIDANCE +

STEP 6. SELECT COMPLIANCE OPTION FOR NONEXEMPT LIGHTING

Determine which method of compliance documentation the project team will follow for all nonexempt lighting, and for each of the two sets of requirements (uplight and light trespass). The two compliance options are the BUG Rating Method (Option 1) or the Calculation Method (Option 2). Project teams can also combine the two options.

- Option 1 may be the easier compliance path if BUG ratings are available for all or most project luminaires (see [Further Explanation, About the BUG Method](#)).
- Option 2 is for projects with some luminaires that would not comply or would be difficult to include under the BUG rating method. Examples include a particular luminaire that, in itself, would not meet the BUG thresholds but when used in concert with other luminaires can pass based on the calculation method, and adjustable luminaires tilted from their nominal position, such that it is difficult to determine the BUG rating.
- A project can pursue different options for the uplight and trespass requirements. For example, Option 1's BUG rating method can be applied to uplight and Option 2's calculation method can be used for light trespass, and vice versa. However, project teams cannot mix compliance paths within uplight or light trespass; only one option may be used to demonstrate uplight, and only one option may be used to demonstrate light trespass.

STEP 7. GATHER DATA ON LUMINAIRES

Option 1

- List the backlight, uplight, and glare ratings of each unique luminaire for the orientation and tilt specified in the project design.
- Ratings for luminaires without published BUG rating can be determined via software (see [Further Explanation, Calculating BUG Values](#)).

Option 2

- Show the total lumens per luminaire and lumens emitted above horizontal by each luminaire (lamp-ballast combination) for the orientation and tilt specified in the project design.
- Show the performance for each angular position (tilt) if there are multiple angular positions for a luminaire type.
- Identify all auxiliary shielding specified.



STEP-BY-STEP GUIDANCE +

STEP 8. EVALUATE UPLIGHT COMPLIANCE

Determine compliance with the uplight requirements and make any necessary adjustments to the preliminary lighting design.

Option 1

Consult Table 1 of the credit requirements for the maximum luminaire BUG uplight rating for the project's lighting zone. Ensure that all luminaires, when installed in the specified design position, do not exceed this maximum uplight rating (see [Further Explanation, Example 1](#)).

Option 2

Calculate the percentage of total lumens emitted above horizontal (see [Further Explanation, Example 2](#)). Ensure that the selected luminaires, cumulatively, do not exceed the maximum allowable uplight percentage listed in Table 2 of the credit requirements, based on the project's lighting zone.

- The requirements apply not to each individual luminaire but to the total uplight generated by all luminaires.
- Use manufacturer's data sheets or IES files for each luminaire to identify the total luminaire lumens emitted plus the total luminaire lumens emitted above 90 degrees (horizontal). This information is typically shown in catalogue cutsheets or in IES files.

STEP 9. EVALUATE LIGHT TRESPASS COMPLIANCE

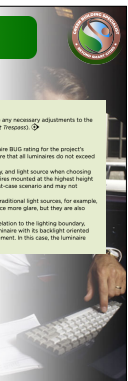
Determine compliance with the light trespass requirements and make any necessary adjustments to the preliminary lighting design (see [Further Explanation, Calculating Light Trespass](#)).

Option 1

Consult Table 3 of the credit requirements for the maximum luminaire BUG rating for the project's lighting zone and the luminaire location and angular position. Ensure that all luminaires do not exceed the maximum backlight and glare ratings.

- Consider mounting location, distance from the lighting boundary, and light source when choosing the luminaires that meet the backlight and glare ratings. Luminaires mounted at the highest height and located closest to the lighting boundary constitute the worst-case scenario and may not comply (see [Further Explanation, Mounting Angles](#)).
- Consider trade-offs when choosing luminaires. Compared with traditional light sources, for example, LEDs are more directional and brighter and can therefore produce more glare, but they are also more controllable.

Ensure that the luminaires chosen are located appropriately in relation to the lighting boundary, as stipulated in the credit requirements. A building-mounted luminaire with its backlight oriented toward the building can be exempted from the backlight requirement. In this case, the luminaire must meet only the light trespass requirements for glare.



STEP-BY-STEP GUIDANCE +

Option 2

Calculate the vertical illuminance at the lighting boundary to ensure that the illuminance does not exceed the maximum allowance shown in Table 4 of the credit requirements (see *Further Explanation, Vertical Illuminance*).
• Calculate the vertical illuminances on all vertical planes as they extend upward from the lighting boundary at grade level to a height at least 33 feet (10 meters) above the tallest luminaire on the project. Calculation points on each plane must be no more than 5 feet (1.5 meters) apart. For each plane, ensure that the greatest vertical illuminance does not exceed the threshold indicated in the credit requirements.
• Retain point-by-point calculation output for the vertical plane containing the greatest vertical illuminance (the worst-case scenario).

STEP 10. SELECT COMPLIANT, INTERNALLY ILLUMINATED EXTERIOR SIGNAGE

Choose luminaires that meet the threshold requirements for light pollution and light trespass given in the credit requirements. If the signage company does not have any data for the manufactured sign, assess compliance in other ways. For example,
• Take a measurement of the sign's maximum luminance.
• Have the lighting consultant construct the sign in calculation software by putting an automatic placement grid on the luminous surface(s) of the object with a transmission assigned to the surface(s) and setting the measurement type to diffuse luminance to get the results.

REQUIREMENTS

NC, CS, SCHOOL, RETAIL, DATA CENTERS, WAREHOUSES & DISTRIBUTION CENTERS, HOSPITALITY, HEALTHCARE

Meet uplight and light trespass requirements, using either the backlight-uplight-glare (BUG) method (Option 1) or the calculation method (Option 2). Projects may use different options for uplight and light trespass.
Meet these requirements for all interior luminaires located inside the project boundary (except those listed under "Exemptions"), based on the following:
• the photometric characteristics of each luminaire when mounted in the same orientation and tilt as specified in the project design; and
• the lighting zone of the project property (at the time construction begins). Classify the project under one lighting zone using the lighting zone definitions provided in the Illuminating Engineering Society and International Dark Sky Association (IES/IDA) Model Lighting Ordinance (MLO) User Guide.
Additionally, meet the internally illuminated signage requirement.

Uplight
Option 1. BUG Rating Method
Do not exceed the following luminaire uplight ratings, based on the specific light source installed in the luminaire, as defined in IES TM-18-11, Addendum A.
Table 1. Maximum uplight ratings for luminaires
MLO lighting zone Luminaire uplight rating
L20 L0
L1 L1
L2 L2
L3 L3
L4 L4
OR
Option 2. Calculation Method
Do not exceed the following percentages of total lumens emitted above horizontal, by lighting zone
Table 2. Maximum percentage of total lumens emitted above horizontal, by lighting zone
MLO lighting zone Maximum allowed percentage of total luminaire lumens emitted above horizontal
L20 0%
L1 0%
L2 1%
L3 3%
L4 6%
AND
Light Trespass
Option 1. BUG Rating Method
Do not exceed the following luminaire backlight and glare ratings (based on the specific light source installed in the luminaire), as defined in IES TM-18-11, Addendum A, based on the mounting location and distance
Table 3. Maximum backlight and glare ratings
Luminaire mounting MLO lighting zone
L20 L1 L2 L3 L4
Allowed backlight ratings
2-2 mounting heights from lighting boundary
B1 B3 B4 B5 B6
1 to 2 mounting heights from lighting boundary and properly oriented
B1 B2 B3 B4 B4
0.5 to 1 mounting height to lighting boundary and properly oriented
B0 B1 B2 B3 B3
0.5 to 1 mounting height to lighting boundary and properly oriented
B0 B0 B0 B1 B2
Allowed glare ratings
Building-mounted > 3 mounting heights from any lighting boundary
G0 G1 G2 G3 G4
Building-mounted > 2 mounting heights from any lighting boundary
G0 G0 G1 G1 G2
Building-mounted 0.5 to 1 mounting heights from any lighting boundary
G0 G0 G0 G1 G1

REQUIREMENTS +

Option 1. BUG Rating Method

Do not exceed the following luminaire backlight and glare ratings (based on the specific light source installed in the luminaire), as defined in IES TM-18-11, Addendum A, based on the mounting location and distance
Table 3. Maximum backlight and glare ratings
Luminaire mounting MLO lighting zone
L20 L1 L2 L3 L4
Allowed backlight ratings
2-2 mounting heights from lighting boundary
B1 B3 B4 B5 B6
1 to 2 mounting heights from lighting boundary and properly oriented
B1 B2 B3 B4 B4
0.5 to 1 mounting height to lighting boundary and properly oriented
B0 B1 B2 B3 B3
0.5 to 1 mounting height to lighting boundary and properly oriented
B0 B0 B0 B1 B2
Allowed glare ratings
Building-mounted > 3 mounting heights from any lighting boundary
G0 G1 G2 G3 G4
Building-mounted > 2 mounting heights from any lighting boundary
G0 G0 G1 G1 G2
Building-mounted 0.5 to 1 mounting heights from any lighting boundary
G0 G0 G0 G1 G1

REQUIREMENTS +



Building-mounted < 0.5 mounting heights from any lighting boundary	00	00	00	00	01
All other luminaires	00	01	02	03	04

The lighting boundary is located at the property lines of the property, or properties, that the LEED project occupies. The lighting boundary can be modified under the following conditions:

- when the property line abuts a public area that includes, but is not limited to, a walkway, driveway, plaza, or parking lot, the lighting boundary may be moved to 5 feet (1.5 meters) beyond the property line;
- when the property line abuts a public street, alley, or transit corridor, the lighting boundary may be moved to the center line of that street, alley, or corridor;
- when there are additional properties owned by the same entity that are contiguous to the property, or properties, that the LEED project is within and have the same or higher MLD lighting zone designation as the LEED project, the lighting boundary may be expanded to include those properties.

Orient all luminaires less than two mounting heights from the lighting boundary such that the backlight points toward the nearest lighting boundary line. Building-mounted luminaires with the backlight oriented toward the building are exempt from the backlight rating requirement.

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Option 2: Calculation Method

Do not exceed the following vertical illuminances at the lighting boundary (use the definition of lighting boundary in Option 1). Calculation points may be no more than 5 feet (1.5 meters) apart. Vertical illuminance shall be calculated on vertical planes extending parallel to the lighting boundary, with the normal to them being oriented toward the property and perpendicular to the lighting boundary, extending from grade level to 33 feet (10 meters) above the height of the highest luminaires.

Table 4. Maximum vertical illuminance at lighting boundary, by lighting zone

MLD lighting zone	Vertical illuminance
1-20	2.00 fc (22 lux)
21	2.00 fc (22 lux)
22	2.00 fc (22 lux)
23	2.00 fc (22 lux)
24	2.00 fc (22 lux)
25	2.00 fc (22 lux)

AND:

Internally Illuminated Exterior Signage

Do not exceed a luminance of 200 cd/m² (2000 cd/m²) during nighttime hours and 2000 cd/m² (20000 cd/m²) during daytime hours.

Exemptions from Uplight and Light Trespass Requirements

The following exterior lighting is exempt from the requirements, provided it is controlled separately from the nonexempt lighting:

- landscape lighting, directional, and marker lighting for transportation;
- lighting that is used solely for facade and signage lighting in MLD lighting zones 3 and 4, and is automatically turned off from midnight until 6 a.m.;
- lighting for theatrical purposes for stage, film, and video performances;
- government-mandated roadway lighting.

CONNECTION TO ONGOING PERFORMANCE



LEED O+M EA credit Energy Performance: A proper lighting design both minimizes light pollution and maximizes energy efficiency, which could improve a project's overall energy performance.

REQUIRED DOCUMENTATION



Documentation	All Projects	Option 1, Uplight	Option 1, Light Trespass	Option 2, Uplight	Option 2, Light Trespass
Site lighting plan with boundaries, elements, location of fixtures, and applicable measurements	X				
Projects with internally illuminated exterior signage only: provide maximum luminance data	X				
Luminaire schedule showing uplight ratings		X			
Luminaire schedule showing backlight and glare ratings and mounting heights			X		
Calculations for lumens per luminaire and lumens emitted above horizontal				X	
Greatest vertical illuminance value for each vertical calculation plane at lighting boundary; calculation grid for one vertical plane with greatest vertical illuminance (worst-case scenario), highlighting point of greatest illuminance					X

EXEMPLARY PERFORMANCE

✓NA



REFERENCED STANDARDS

✓Illuminating Engineering Society and International Dark Sky Association (IES/IDA) Model Lighting Ordinance User Guide and IES TM-15-11, Addendum A: ies.org



TERMS AND DEFINITIONS

BUG rating a luminaire classification system that classifies luminaires in terms of backlight (B), uplight (U), and glare (G) (taken from IES/IDA Model Lighting Ordinance). BUG ratings supersede the former cutoff ratings.

Emergency lighting a luminaire that operates only during emergency conditions and is always of during normal building operation.

Light pollution waste light from building sites that produces glare, is directed upward to the sky, or is directed of the site. Waste light does not increase nighttime safety, utility, or security and needlessly consumes energy.

Light trespass obtrusive illumination that is unwanted because of quantitative, directional, or spectral attributes. Light trespass can cause annoyance, discomfort, distraction, or loss of visibility.

