SEDAC ENERGY SMART TIPS

Outdoor Lighting

Outdoor lighting makes our streets safe for travel and supports commerce, socializing, night activities, and work tasks.

Recent improvements in outdoor lighting systems use considerably less energy, while meeting energy requirements and providing better light quality. Energy costs can be dramatically reduced by strategically addressing lighting needs, selecting energy-efficient equipment, and controlling lighting appropriately.

Address Lighting Needs
The first step is to identify and prioritize the main objectives for a particular lighting project (e.g., way-finding, safety, shopping, or highlighting activities). Different outdoor lighting applications can have very different performance requirements. Next, review guidelines from the Illuminating Engineering Society of North America (IESNA) for recommended light levels (*illuminance,* measured in footcandles) and acceptable variations in brightness (*uniformity,* measured as a ratio).

Select Energy Efficient Equipment
Meet lighting needs with a low *lighting power density* (Watts per square foot) well below the maximum allowed by code. Select, space, align, and place fixtures to direct light only where it is needed. The *complete lighting assembly*, combined with the *support assembly* (pole or mounting bracket), mounting position, and spacing, will impact energy performance as much or more than the specific lamp technology.

Control Lighting Appropriately
Strategic use of lighting controls can result in significant energy savings for outdoor lighting. For instance, you can reduce run hours and lower light levels after curfew. Options include astronomical time clocks, photocells, motion sensors, dimmers, bi-level switching, partial-night lighting, or a combination of strategies. Be sure lamp types are compatible with planned controls strategy (or vice versa). For example, if dimming is planned be sure lamp type can be dimmed.

Minimize Glare and Light Trespass
Be a good neighbor and improve safety by minimizing glare and light trespass.

Finding Answers
SEDAC can assess your outdoor lighting system and help you make appropriate changes. We also recommend working with qualified lighting designers and vendors for optimal equipment selection, layout, and control.

The Smart Energy Design Assistance Center performs energy assessments on various building types. Each building type has different energy requirements. SEDAC's Energy Smart Tips help building operators identify energy cost reduction measures.

ADDRESS LIGHTING NEEDS

Clarify Functional Objectives

Begin by establishing functional objectives for your outdoor lighting application. List the specific activities to be supported by the lighting (way-finding, sports, merchandise sales, etc.). Required outdoor lighting levels (illuminance, measured in footcandles) differ depending on the visual properties of the site and the activities housed in the site, as well as whether a site is residential or commercial, urban or rural.

Understand Security and Safety Issues

Identify any special safety requirements. Many people mistakenly assume that higher light levels alone mean better safety and security. However, increased light does not guarantee a safe and secure environment. [1] In fact, excessive light, high contrast lighting, shadows and glare may actually decrease safety and waste energy.

Meet Recommended Light Levels

IESNA-recommended light levels, widely used by design and industry professionals over the years, provide useful guidelines for assessing existing lighting and establishing initial target levels for lighting upgrades or new lighting projects. For most non-retail outdoor lighting applications, an average of 2 fc (or less) is adequate. Examples taken from recent IESNA publications are summarized in the following tables to the right.

Recommended Illuminance Values for Parking Lots				
	Min. Horizontal Illuminance		Min. Vertical Illuminance	
	Pre-Curfew	Post-curfew	Pre-Curfew	Post-curfew
Asphalt Surfaces	0.5 fc	0.2 fc	0.25 fc	0.1 fc
Concrete Surfaces	1.0 fc	0.2 fc	0.5 fc	0.1 fc
Maximum Uniformity Ratio (Max: Min)				
All Surfaces	15.1			
Source: IES RP-20-14, Recommended Practice for Lighting for Parking Facilities				

Recommended Maintained Illuminance Targets for Building Entries (Canopied Entries and Exits) for Medium Activity		
Lighting Zone	Target Horizontal Illuminance	Target Vertical Illuminance
LZ4	2.0 fc	1.0 fc
LZ3 (& LZ4 Curfew*)	1.5 fc	0.8 fc
LZ2 (& LZ3 Curfew*)	1.0 fc	0.6 fc
LZ1 (& LZ 2 Curfew*)	0.8 fc	0.4 fc
LZ0 (& LZ1 Curfew*)	0.6 fc	0.2 fc
Source: IES RP-33-14, Recommended Practice for Lighting for Exterior Environments		

Nighttime Outdoor Lighting Zone Key:

LZ4: High Ambient Lighting (High-activity commercial districts in major metropolitan areas)

LZ3: Moderately High Ambient Lighting (All other areas)

LZ2: Moderately Ambient Lighting (Residential Areas)

LZ1: Low Ambient Lighting (Developed Areas of National Parks)

LZ0: No Ambient Lighting (National Parks, State Parks, Rural Areas)

* Curfew is the time defined by clients or jurisdiction when outdoor lighting is reduced or extinguished

1. 2009 DOE report, *Exterior Lighting for Energy Savings, Security, and Safety*.

SELECT ENERGY-EFFICIENT LIGHTING EQUIPMENT

Target Low Lighting Power Density

Lighting power density (LPD) is a good metric for comparing how much energy will be used by different lighting designs to meet lighting requirements. The Illinois Energy Conservation Code (IL ECC) governs the maximum allowable LPD for exterior lighting to ensure energy efficient lighting design. These limits vary based on lighting zones (LZ0, LZ1, LZ2, LZ3, and LZ4) and fuction (e.g., parking, walkways). The maximum allowable LPDs are found in the ANSI/ASHRAE/IESNA Standard 90.1-2013, *Energy Standard for Buildings Except Low-Rise Residential Buildings* (ASHRAE 90.1 2013). Example recommended maximum allowances for LZ3 are summarized in the following table. Much lower LPDs are also readily achievable.

Allowed Maximum Lighting Power Density	
Uncovered Parking Areas and Drives	0.095 W/ft^2
Walkways <10 ft wide	0.76 W/linear ft
Walkways ≥10 ft wide	0.15 W/ft^2
Landscaping	0.048 W/ft^2
Stairways	0.95 W/ft^2
Entry Canopies	0.38 W/ft^2
Source: ANSI/ASHRAE/USGBC/IES Standard 189.1-2014, *Standard for the Design of High Performance Green Buildings Except Low-Rise Residential Buildings*	

Deliver Light Where You Need It

Light that shines where it is not needed represents wasted energy. Fixture housings, reflectors, ballasts, lenses and shields affect lighting fixture efficiency (ratio of light output emmitted by the fixture to the light output emmitted by its lamps). Feature efficiency, combined with the mounting height and position, as well as the reflectance properties of the pavement (e.g., dark asphalt vs. light concrete), determine the distribution of light—both within and outside of the intended target area. Select light fixtures and support assemblies designed to deliver the appropriate amount of light to the target areas while minimizing light spill (light falling outside the area to be illuminated).

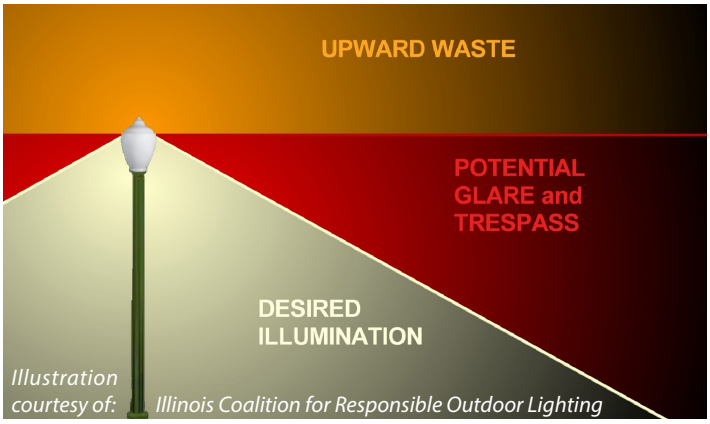


Illustration courtesy of: Illinois Coalition for Responsible Outdoor Lighting

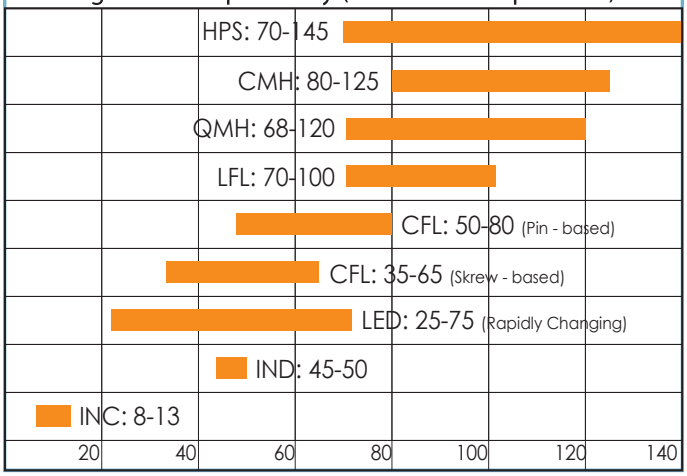
Use High Efficacy, Long Lasting Lamps with Good CRI

There are many outdoor lighting lamp types to choose from. Choose wisely because once fixtures are installed, it can be difficult to replace lamps with more efficient or longer life lamps. When selecting fixtures, consider the following properties: *required lamp lumens* (look at both initial lumens and lumen depreciation), *lamp efficacy* (lumens per Watt), *lamp life*, and *color rendering* [high color rendering index (CRI) where 100 is maximum]. Lamp efficacy represents the ratio of light produced to energy consumption and is measured in lumens per Watt. While lamp life may not directly affect energy consumption, shorter lamp life results in higher maintenance costs costs from lamp replacement.

There are significant variations in these properties for the different lamp types. For example, incandescent lamps have low lamp efficacy and short lamp life but excellent color properties (CRI 98 to100); metal halide lamps provide good lamp efficacy, fair lamp life, and can have good color properties (CRI 65 to 94).

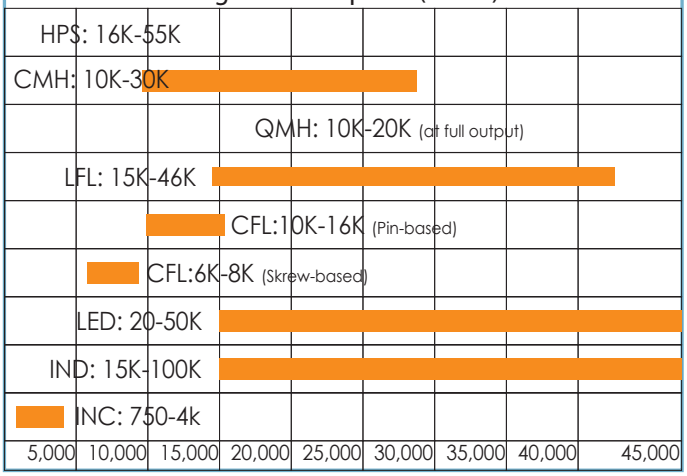
Figures 1 and 2 show the range of lamp efficacies and lamp life for the different lamp types.

Figure 1. Lamp Efficacy (mean lumens per watt)



Source: Data from www.eere.energy.gov.

Figure 2. Lamp Life (hours)



Source: Data from www.eere.energy.gov.

HPS: High Pressure Sodium
CMH Ceramic Metal Halide
QMH: Quartz Metal Halide
LFL: Linear Fluorescent Lamp
CFL: Compact Fluorescent Lamp
LED: Linear Fluorescent Lamp
IND: Induction
INC: Incandescent

CONTROL LIGHTING APPROPRIATELY

Select Effective Light Controls

Employing the right controls for outdoor lighting can result in substantial energy savings.

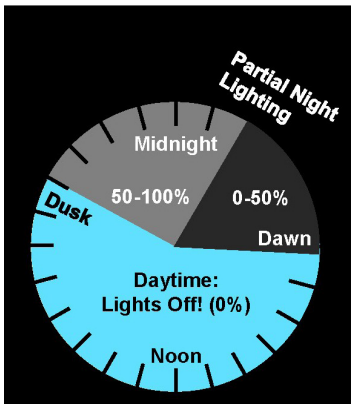
Astronomical time clocks permit scheduling of lighting operation based on sunrise and sunset. Standard time clocks for controlling exterior lights may use more energy and provide too much or too little lighting because they do not account for daily changes in sunset and sunrise.

Photocells send signals to turn on and off lighting in response to light levels. Some photocells are not adequately sensitive to low light levels during dark cloud conditions (or early dusk and dawn) and may switch lights on before they are needed. Be sure to keep photocells clean as dirty photocells can also lose sensitivity.

Motion sensors automatically turn outdoor lights on when they detect motion and turn them off after a specified delay (when motion is no longer detected). They can be very useful for outdoor security lighting and utility lighting. Strategic placement is important to avoid false triggers from movement on adjacent property and to assure lights will turn on when vehicles or pedestrians are present in the target area.

Dimming or bi-level switching reduces lighting levels when higher levels are not needed (such as after closing time, or late in the evening to reduce light spill onto residential properties).

Curfew lighting controls can be used to turn off certain fixtures based on time (rather than dusk to dawn). For example, you may wish to turn off parking lot fixtures after hours in areas far from a building's entrances. As an alternative, fixtures could be wired so that some percentage shut off by timer during the night while scattered security lights remain on. How curfew lighting is implemented depends on the area being lit and the type of lamps in use.



Combine Controls to Maximize Savings

Combining controls is a great way to meet exterior lighting needs. For example, astronomical time clocks, which turn on lights at sunset, can be combined with photocells, which are more sensitive to light levels during dark cloud conditions. Motion sensors can be added to these controls to turn lights back on when movement is detected. Dimming, bi-level switching, or curfew lighting controls can also be added to reduce or increase lighting as needed. This combination of controls can work very well for parking lots.

ADDITIONAL CONSIDERATIONS

Match Controls to Lamp Technology

Certain lamps work better with certain controls. For example, LEDs can be dimmed while other types of lamps, including induction, metal halide and high pressure sodium typically cannot. Metal halide and high pressure sodium lamps are not good candidates for motion sensors, since these lamps can take up to 10 minutes to warm up. Be sure to select fixtures/ lamps that are appropriate to the planned controls.

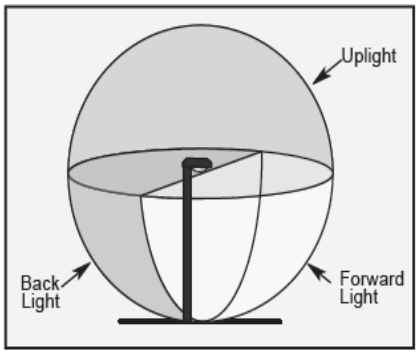
Backlight, Uplight, and Glare

BUG stands for Backlight, Uplight, and Glare. This acronym describes the types of stray light escaping from an outdoor lighting fixture (see the image to the right). Backlight is the light directed in back of the mounting pole. Uplight is the light directed above the light. Glare is forward or backlight that is harsh, bright, or dazzling for viewers. Glare can cause annoyance, discomfort, and even a temporary reduction in ability to see. Glare can often be attributed to poorly shielded fixtures, fixtures aimed in the wrong direction, or highly reflective surfaces.

The Illuminating Engineering Society's BUG system is a set of guidelines for the amount of light that fixtures should emit in all directions[1]. BUG ratings can be used to evaluate outdoor lighting fixtures' performance related to light tresspass, skyglow, and brightness control. Although the values assigned by new BUG ratings are important, the site, application, and fixture installation can still influence backlight, uplight, and glare.

1See http://www.aal.net/content/resources/files/BUG_rating.pdf

3 primary solid angles of BUG rating by IES



KEY LIGHTING TERMINOLOGY

Ballast factor. A measure of actual lumen output for a specific lamp-ballast system.
Color rendering index (CRI). An index commonly used to represent how well a lamp renders the colors of objects.
Distribution curve. A measure of how light is distributed and falls upon a surface.
Illuminance level. Measured in footcandles (fc) at a given location (1 fc equals 1 lumen distributed over a 1 ft^2 area).
Lamp efficacy. Lumens per watt.
Light output. Measured in lumens.
Lighting power density. Lighting power per unit area, commonly Watts per square foot (W/ft2), also Watts per linear foot (W/lf).
Lumen. A measure of the total amount of visible light emitted by a source.
Lumen depreciation. Lamp rated mean lumens over initial lumens as a percentage.
Uniformity ratio. A ratio of maximum-to-minimum (or average-to-minimum) illuminance across an area. It is critical since our eyes experience a delay when adjusting to different light levels.

INCENTIVE FUNDING

Multiple incentives are available for outdoor lighting upgrades from ComEd's Smart Ideas program, Ameren Illinois' ActOnEnergy program and the Illinois Department of Commerce and Economic Opportunity's (DCEO) Illinois Energy Now program (for public sector projects). For all of these programs, you will need to apply and get approval before beginning work or purchasing equipment. Program guidelines and specifications should be consulted during design and selection of equipment.

ENERGY SMART OUTDOOR LIGHTING RESOURCES

ENERGY STAR for Lighting
Learn more about energy efficient lighting products including ENERGY STAR qualified lighting products
http://www.energystar.gov/index.cfm?c=lighting.pr_lighting_landing

Energy Efficiency & Renewable Energy / Department of Energy (EERE / DOE)
Reports, white papers, and fact sheets on Solid-State outdoor lighting
http://www1.eere.energy.gov/buildings/ssl/resources.html

Lighting Research Center
Research publication and project resources on effective outdoor lighting techniques and equipment
http://www.lrc.rpi.edu/searchpublications.asp

Illuminating Engineering Society in North America (IESNA)
Guidelines and educational resources about lighting
http://www.iesna.org/

Who We Are

SEDAC, The Smart Energy Design Assistance Center, provides program implementation, technical assistance, and educational services for buildings and communities seeking to become more energy efficient and sustainable. SEDAC also conducts energy and sustainability research.

SEDAC is a public-private partnership between the University of Illinois at Urbana Champaign and 360 Energy Group. The Energy Resources Center at the University of Illinois at Chicago also provides support.

HOW TO REACH US

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SEDAC PROGRAMS

- Energy Assessments
- Retro Commissioning
- Monitoring based Commissioning
- Technical education
- Program Outreach
- Direct Install
- Building Energy Research
- Program Implementation

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