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Outdoor Lighting: A Short Guide to Applications, Objectives and Considerations

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Lighting Research Center Technical Staff

Jennifer Taylor

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Introduction

A successful outdoor lighting design, as with any interior lighting design, incorporates the needs for visibility, aesthetic appeal, economy, and energy efficiency. But outdoor lighting must also fulfill some additional needs unique to lighting the night. Depending on the application, it may need to provide a sense of safety and security, deter criminals, and attract shoppers or patrons—all while limiting light pollution. A successful outdoor lighting design also considers the different mechanisms in the human eye used to see at night.

Outdoor lighting is a quickly growing market for light-emitting diodes (LEDs). This volume of *ASSIST recommends* provides a general overview of outdoor lighting. Issue 1 discusses the objectives and applications of outdoor lighting and factors to consider when planning an outdoor lighting installation. Issue 2 discusses in more detail "mesopic" vision; that is, how the human eye sees at night and under nighttime lighting applications commonly found outdoors. It also provides a simple method of choosing an optimal, energy-efficient light source for a given outdoor lighting application that considers the eye's mechanisms at work under nighttime illumination. Subsequent volumes of *ASSIST recommends* discuss specific outdoor lighting applications.

This document was developed by the Lighting Research Center (LRC) at Rensselaer Polytechnic Institute in collaboration with members of the Alliance for Solid-State Illumination Systems and Technologies (ASSIST).

Common Applications

Outdoor lighting encompasses a wide range of applications. In many cases, more than one application can be found in a given area. Applications include:

- Parking lot and area lighting
- Roadway and street lighting
- Sports fields
- Shopping centers and pedestrian malls
- Business districts, office parks, and industrial areas
- Parks, plazas, green areas, and landscaping
- Vertical surfaces (facades, signs, flags, civic monuments)
- Schools and university campuses
- Multi-family residential outdoor areas (e.g., row houses, group housing and apartments)

Figure 1. Samples of outdoor lighting applications.

Objectives and Considerations for Outdoor Lighting

Knowing the objectives for lighting an area is the first step to a successful lighting design. In general, outdoor lighting designs are meant to fulfill the following overall objectives (Leslie and Rodgers 1996):

- enhance safety to people and security to property,
- provide or maintain aesthetics suitable to the space, and
- deliver lighting economically for equipment, installation, operation and maintenance with minimal environmental impact

Within these overarching objectives, outdoor lighting designers and specifiers must meet the needs of pedestrians, drivers, municipalities, and systems operators, including visibility, visual comfort, energy, and environmental concerns.

Visibility and Visual Comfort

Light level, uniformity, distribution, contrast, visual size, and glare all affect visibility. In terms of light level, uniformity, and distribution, the visual effects of moving from a bright area to a dark area can temporarily reduce visual function. Therefore, outdoor lighting should provide luminance and uniformity levels that are appropriate for the application and provide sufficient visual adaptation when moving between brighter and darker areas. In terms of contrast, the relative luminance between adjacent objects and the background should be appropriate for the application. Additionally, glare from light sources or reflected off surfaces can be particularly uncomfortable and reduces visibility. Uniform surface illuminances help cut glare reflected off objects, while shielded luminaires placed carefully can help minimize direct glare from light sources, as well as glare reflected from windows and wet pavement.

Visual efficacy

Luminous efficacy, a calculation of photopic lumens per watt, is perhaps the most common measure of the benefit-cost ratio for any lighting system. Yet, a better measure for outdoor lighting applications is a photometry system that considers how the human eye sees under typical nighttime, or mesopic, lighting applications.

The human visual system uses two classes of photoreceptors, rods and cones. Cones are used under daytime ("photopic") light levels found outdoors during the day and in nearly all indoor applications illuminated by electric lighting systems. Under starlight ("scotopic" light levels), only rods provide visual information. However, many nighttime applications, such as outdoor lighting of parking lots, provide light levels in the "mesopic" range, where both rods and cones work together to provide vision. Rods and cones are tuned to different parts of the electromagnetic spectrum. Thus, depending upon the light level, rods and cones provide a different overall spectral sensitivity to light (Rea 2000).

Conventional photometry is based solely on the photopic luminous efficiency function, which may result in misestimation of the visual effectiveness and energy efficiency of some light sources used outdoors at night. It generally has been unclear which luminous efficiency function—photopic, scotopic, or a combination—should be used to characterize mesopic lighting applications. The Lighting Research Center has proposed a "unified system of photometry," which can more accurately characterize different light sources at any light level, facilitating the specification of effective lighting systems for different applications, including those used outdoors at night (Rea et al. 2004). For more information, read *ASSIST recommends…Outdoor Lighting: Visual Efficacy*, Volume 6, Issue 2 (ASSIST 2009).

Security

Security lighting facilitates the detection and identification of people, animals, and objects. People tend to feel safer when they can see far ahead and identify escape paths, if necessary. The visibility provided by lighting makes people more likely to enter an area and stay awhile, encouraging others to do the same, which can be a deterrent to crime (Leslie and Rodgers 1996).

Property protection, such as cars in a parking lot, is an important objective of security lighting. The most common technique is to brightly illuminate the whole area to be secured, providing at least twice the illuminance of adjoining areas. This allows people in the area to be easily seen. Another strategy may be to keep the secure area dark, such as a guarded storage unit, but brightly illuminate the entrances, aiming luminaires outward. This technique creates glare and gives the sense that trespassers are being watched (Leslie and Rodgers 1996). These measures, however, need to be evaluated on a case-by-case basis and weighted against potential light trespass or light pollution. Additionally, evidence that lighting increases security is conflicting, but lighting does seem to unambiguously increase one's sense of security (Leslie and Rodgers 1996).

Aesthetics and Economic Development

A well-designed outdoor lighting installation can attract shoppers and patrons to places such as outdoor shopping centers, event and concert halls, museums, plazas and parks, promoting the economic vitality of a community. The lighting in the outdoor areas of these spaces should be attractive, and the appearance of people and architectural features is important. Higher illuminances should be saved to highlight paths, signs, building facades, and landscape features. Designers should consider the color of the light source and its ability to render colors, including skin tones; the appearance of luminaires and matching luminaires to the site; and issues of glare (Leslie and Rodgers 1996).

Energy and Environmental Concerns

Energy usage

The energy used by a lighting system depends on the lamp type, the ballast, the luminaire type, the number of luminaires required, and the control strategy. Because average illuminance and illuminance uniformity are important performance criteria for many outdoor lighting applications, energy usage is affected by the luminaire's efficiency and light distribution (NLPIP 2004). Because not all outdoor lighting needs to be on full light output all night, reducing the number of hours of outdoor lighting can reduce energy usage. Methods include timers, motion sensors, photosensors, curfew dimming, and step switching. Energy usage also can be maximized by considering the unified luminance of a given light source (ASSIST 2008).

Light pollution

Light pollution is a consequence of light at night, and can be evaluated in terms of sky glow, light trespass, and glare. With appropriate lighting design, luminaire selection, and controls, light pollution can be minimized.

Sky glow is a brightening of the sky, which impedes a view of the stars. Luminaires aimed upward or light reflected off the ground contribute to sky glow. The amount of sky glow depends on immediate weather conditions, the amount of dust, pollution, water vapor, and gas in the atmosphere, the amount of light directed skyward, and the direction from which it is viewed. Sky glow is a very visible effect of light at night and gives an indication of wasted energy (NLPIP 2004, 2007).

Light trespass occurs when light spills into an area where it is not wanted or needed. What accounts for light trespass is somewhat subjective, but generally light should not be directed on the facades of adjoining buildings or properties, causing light to enter interior areas. Proper aiming and shielding of light sources can significantly reduce light trespass, as can repositioning lights away from property boundaries (Brons et al. 2008; NLPIP 2004, 2007).

Glare is a visual sensation caused by excessive and uncontrolled brightness, and it can range from uncomfortable to visually disabling. IESNA's Luminaire Classification System for Outdoor Luminaires provides one means of evaluating glare (IESNA 2007). The luminous flux exiting a luminaire at a certain angle (the *glare zone*), the luminaire mounting height, and visually adjacent luminances are other means of evaluating glare (NLPIP 2004, 2007).

Figure 2. Light trespass and glare.

The Lighting Research Center has published two methods of predicting light pollution and glare from outdoor lighting installations. The first is a comprehensive method for predicting and measuring the three aspects of light pollution, called the Outdoor Site-Lighting Performance method (Brons et al. 2008). The second is a simple, quantitative model to predict discomfort glare from outdoor lighting installations (Bullough et al. 2008).

Economic Feasibility

The economics of an outdoor lighting installation include the first cost to purchase and install, annual maintenance costs (e.g., lamp, ballast, or driver replacements, regular cleaning), and annual energy costs, all which amount to the total cost of ownership. Also to be considered in the economics of outdoor lighting are less predictable costs and benefits. For example, good security lighting may reduce vandalism and help control liability and accident expenses (Leslie and Rodgers 1996). Good lighting may attract people to a shopping area or outdoor venue, enhancing the community's vitality and economic development. It may improve the attractiveness of multi-family housing, leading more people to rent or buy into that community. While the costs and benefits of improved security and appearance are less tangible, they can be estimated (Leslie and Rodgers 1996; Leslie 1998).

For More Information

Many municipalities have outdoor lighting installation codes and ordinances to be followed. More information about the challenges inherent to the design of outdoor lighting can be found in *The Outdoor Lighting Pattern Book* (Leslie and Rodgers 1996). The Illuminating Engineering Society of North America publishes recommended practices, design guides, and guidelines for different outdoor lighting applications, such as the *American National Standard Practice for Roadway Lighting* (RP-8-00), *Lighting for Parking Facilities* (RP-20-98), *Guideline on Security Lighting for People, Property, and Public Spaces* (G-1-03), *Recommended Lighting for Walkways and Class I Bikeways* (DG-5-94), and *Lighting for Exterior Environments* (RP-33-99). Additionally, the American Association of State and Highway Transportation Officials publishes a roadway lighting design guide, *AASHTO Roadway Lighting Design Guide* (GL-6-01). A discussion of luminaire types and classifications can be found in *Specifier Reports: Parking Lot and Area Luminaires* (NLPIP 2004).

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About ASSIST

ASSIST was established in 2002 by the Lighting Research Center at Rensselaer Polytechnic Institute to advance the effective use of energy-efficient solid-state lighting and speed its market acceptance. ASSIST's goal is to identify and reduce major technical hurdles and help LED technology gain widespread use in lighting applications that can benefit from this rapidly advancing light source.