# ASSIST Application Design Guide: Roadway Lighting

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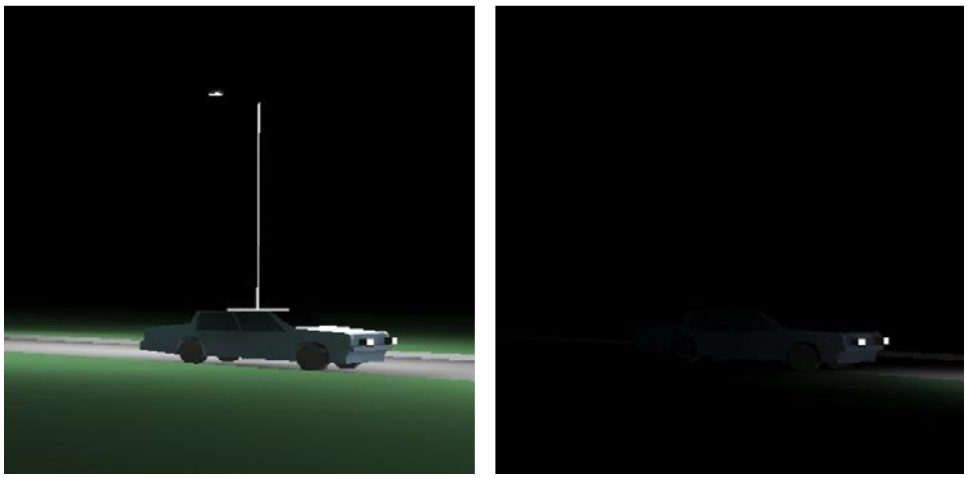
## Introduction

Lighting along public roads and streets serves multiple purposes and multiple end users. On complex roadways with substantial traffic and large potential for conflicts (e.g., busy roadway intersections), lighting may primarily support traffic safety. Along residential streets, where vehicles travel at low speeds and pedestrians' use for recreation and transportation is important, lighting may instead support residents' perceptions of safety and security. Understanding these purposes is key to the successful implementation of lighting in these public areas.

This *ASSIST Application Design Guide* is meant to assist lighting specifiers in identifying appropriate metrics for quantifying the benefits of lighting relative to their costs, and in doing so, maximize the value of the specified lighting system.

## Application Issues

### *Roadway Lighting for Vehicle Safety*



***Roadway lighting provides figure-ground information (left) useful to judge vehicle speeds, even though vehicle headlights alone (right) are highly visible.***

The safe and efficient passage of vehicle traffic is often of primary concern in many roadway locations. The majority of crashes along roadway intersections, for example, involve vehicle collisions, and roadway illumination reinforces important visual cues drivers need to judge the relative speed and distance of other vehicles on the road.

***Roadway light source color can influence pedestrians' perceptions of brightness, personal safety and security.***

Pedestrians are often the primary users of roadways in residential areas and in many urban downtowns. Here, vehicle speeds are low and because of headlights, pedestrians are often visible at distances from which drivers can safely respond to them. Reinforcing a sense of safety and personal security and thereby encouraging pedestrian use might be an important design objective.

### *Glare and Light Pollution*

In all roadway applications, minimizing glare and light pollution is essential. Controlling the distribution of roadway luminaires to minimize upward light and to reduce illuminances on adjacent properties and at the eyes of drivers or pedestrians will help in maintaining visual performance and comfort in roadway lighting. Avoiding direct views of high-luminance optical elements also reduces discomfort.

## Benefit Metrics

### *Roadway Lighting for Vehicle Safety*

The **photopic illuminance** on (or **photopic luminance** of) the roadway is the primary basis for current recommendations for roadway lighting, and illuminance is a useful metric for illumination that provides drivers with the figure-ground information needed to judge the speed and direction of travel of vehicles and other potential hazards along roadway conflict areas. Recommended **uniformity** ratios of illumination ensure that areas between luminaires are not so dark that hazards become difficult to see.

| Light Source | Brightness Factor |
|---|---|
| High pressure sodium (2100 K) | 100% |
| Ceramic metal halide (4200 K) | 140% |
| Light-emitting diode (6500 K) | 185% |

### *Street Lighting for Pedestrians*

In residential and many urban areas, visibility requirements are not as critical because headlights provide visibility at low vehicle speeds in these locations. In urban areas where pedestrian use can be heavy at times, ambient illumination from commercial properties often assists in visibility as well. Using **scene brightness** as a metric for street lighting in these situations can allow the specifier to create a sensation of increased brightness with "white"

light sources compared to the "yellowish" illumination from commonly used high pressure sodium lamps. Increased brightness will in turn reinforce perceptions of increased personal safety and security. Refer to the table above for the relative brightness factors of a few common light sources used for street lighting. Specifying light based on brightness will usually also increase the **visual efficacy** of the lighting system, which can assist in the detection of unexpected hazards. It is suggested for street lighting applications that the **scene brightness** and **visual efficacy** from a light source be at least equal to that provided by high pressure sodium meeting existing consensus light level recommendations.

***Glare and Light Pollution***

Roadway luminaires are classified by the amount of light they produce in terms of backlight (B) such as onto adjacent properties, uplight (U) into the sky, and high-angle light that can contribute to glare (G). Selecting luminaires with low so-called **BUG ratings** can help reduce these characteristics. The **outdoor site-lighting performance (OSP) system** can be used with specific roadway installations to evaluate the potential to create sky glow, light trespass and discomfort glare. The ASSIST discomfort glare metric extends the OSP glare metric by incorporating the impact of the maximum source luminance.

## Reducing Costs to Optimize Lighting Value

Because roadway lighting is among the top expenses of local governments, minimizing the initial, operating and maintenance costs of roadway lighting is critical to a successful installation. An effective way to reduce these costs is to maximize the spacing between luminaires in a roadway lighting installation. This minimizes the number of luminaires and poles needed, reducing initial costs, and by doing so minimizes the energy use by the luminaires. Putting light only in the application area can also help reduce costs while minimizing negative effects such as light trespass. Determining an installation's **luminaire system application efficacy** (LSAE) will allow comparisons among different roadway lighting options and assist in selecting optimal pole spacing and height to maximize the value for the application.

## Summary

In order of priority, the following criteria and metrics should be considered for roadway lighting:

- **Photopic illuminance** (or **photopic luminance**) and uniformity to meet consensus recommendations
- **Visual efficacy** for street lighting applications to match that from high pressure sodium lighting
- **Scene brightness** for street lighting applications to match that from high pressure sodium lighting
- **BUG ratings** and **OSP system** characteristics to minimize light pollution and glare

## Resources

*This short design guide is meant to assist specifiers with a few preliminary considerations for roadway lighting and is not meant to provide comprehensive guidance. Many states and localities have specific requirements for roadway lighting that must be followed. The following resources describe the application metrics discussed here and point the reader to additional information.*

ASSIST. 2009. *ASSIST recommends…Outdoor lighting: A short guide to applications, objectives and considerations.* Vol. 6, Iss. 1. Troy, NY: Lighting Research Center. Internet: http://www.lrc.rpi.edu/programs/solidstate/assist/recommends/outdoorlighting.asp.

ASSIST. 2009. *ASSIST recommends…Outdoor lighting: Visual efficacy.* Vol. 6, Iss. 2. Troy, NY: Lighting Research Center. Internet: http://www.lrc.rpi.edu/programs/solidstate/assist/recommends/outdoorlighting.asp.

ASSIST. 2011. *ASSIST recommends…A method for estimating discomfort glare from exterior lighting systems.* Vol. 9, Iss. 1. Troy, NY: Lighting Research Center. Internet: http://www.lrc.rpi.edu/programs/solidstate/assist/recommends/discomfortglare.asp.

ASSIST. 2011. *ASSIST recommends…Recommendations for evaluating street and roadway luminaires.* Vol. 10, Iss. 1. Troy, NY: Lighting Research Center. Internet: http://www.lrc.rpi.edu/programs/solidstate/assist/recommends/roadway.asp.

Illuminating Engineering Society. 2000. *American National Standard Practice for Roadway Lighting, RP-8.* New York: Illuminating Engineering Society.

Illuminating Engineering Society. 2011. *Luminaire Classification System for Outdoor Luminaires, TM-15.* New York: Illuminating Engineering Society.

Rea MS. 2013. *Value Metrics for Better Lighting.* Bellingham, WA: SPIE Press.

***About ASSIST:*** The Alliance for Solid-State Illumination Systems and Technologies (ASSIST) was established in 2002 by the Lighting Research Center as a collaboration among researchers, manufacturers, and government organizations. ASSIST's mission is to enable the broad adoption of solid-state lighting by providing factual information based on applied research and by visualizing future applications. ASSIST members include: 3M; Acuity Brands Lighting; Amerlux; BAE Systems; Bridgelux; Cree; Crouse-Hinds by Eaton; Dow Corning; Federal Aviation Administration; GE Lighting Solutions; Hubbell Lighting; Legrand; Lumileds; New York State Energy Research and Development Authority (NYSERDA); OSRAM SYLVANIA/OSRAM Opto Semiconductors; Philips Lighting; Samsung Electronics Co.; Seoul Semiconductor; United States Environmental Protection Agency.