HISTORIC STREETSCAPE LIGHTING: INTEGRATION OF AESTHETIC CONCERNS WITH MODERN TECHNOLOGY
(TRB Paper 13-4142)

Sloane D. Bullough (corresponding author)
New York State Office of Parks, Recreation and Historic Preservation
P.O. Box 189
Waterford, NY 12188 USA
Tel. +1.518.237.8643
Fax: +1.518.233.9049
Email sloane.bullough@parks.ny.gov

John D. Bullough
Lighting Research Center, Rensselaer Polytechnic Institute
21 Union Street
Troy, NY 12180 USA
Tel. +1.518.687.7100
Fax +1.518.687.7120
Email bulloj@rpi.edu

Word count: 3400 words + 7 figures + 1 tables = 5400 words.

ABSTRACT
Street lighting can contribute significantly to the visual environment of a historic downtown. Lighting technologies used in modern street lighting systems are very different from those used in street lighting a century ago. The present paper compares the lamps, luminaires and design approaches used for street lighting when it was first introduced to those of the present day. Also provided are some preliminary considerations for the selection of lighting equipment to optimize the benefits of historic streetscape lighting in terms of safety, context sensitivity and historic compatibility, against the costs of historic streetscape lighting in terms of equipment, energy, maintenance and light pollution concerns. Carefully designed street lighting can be an important component of maintaining historic character as well as contributing to safety in historic downtowns.
INTRODUCTION
Street lighting can contribute significantly to a context-sensitive and appropriate visual environment of a historic downtown containing shopping, dining and entertainment (Leslie and Rodgers, 1996). At the same time, technologies used in present and future lighting systems differ substantially from those used near the introduction of electric illumination systems for public lighting. Understanding the technical and visual issues related to historic street lighting can help design professionals and transportation engineers ensure that lighting enhances the rich history many downtowns have while at the same time providing optimal visibility, safety, and energy efficiency.

BENEFITS AND COSTS OF STREET LIGHTING
It is important to understand why streets are illuminated in the first place. Vehicle and pedestrian safety and personal security as well as that of property are among the issues likely to be most important to government entities. Many governments include lighting as part of their strategy to bring people into downtowns for shopping, dining and entertainment. And because many downtowns have some historic character, lighting is often deployed as a way to reinforce that character during the daytime as well as the nighttime. These are the supposed benefits of street lighting, but they have to be balanced by the costs, including the cost of luminaries and poles, lamps, energy costs, lamp replacement costs, and even environmental costs such as light trespass that may disturb neighbors, glare, and light pollution – the loss of the dark nighttime sky.

Several investigators have studied whether, and how much, street lighting actually achieves the benefits that it is intended to achieve. It seems only logical that light helps vehicle drivers see at night, and that this should improve safety. The evidence suggests that this is indeed the case. A review of studies of traffic safety conducted by the Commission Internationale de l’Eclairage (CIE, 1992) found that the presence of roadway lighting was often associated with statistically significant reductions in nighttime crashes. Bullough and Rea (2011) compared visibility improvements from roadway intersection lighting (Rea et al., 2010) and nighttime crash reductions (Donnell et al., 2009, 2010) in the state of Minnesota. Figure 1 indicates, for a few different types of intersections, that when visibility is improved by installing street lighting, the night-to-day crash rate was reduced approximately proportionally to the visibility improvement.

![Figure 1](image-url)  
**FIGURE 1** Relationship between visibility improvements from street lighting (ΔRVP) and reductions in the night-to-day crash ratio (ΔN/D) for several intersection types (Bullough and Rea, 2011).

For other issues, like crime prevention (Tien et al., 1979) and economic development, the evidence is not as strong. Some well-lighted locations have very high crime rates, and lighting alone will not automatically generate foot traffic and associated increases in business. Many other factors are critical, of which lighting is only one, and probably not the most important. Without frequent police patrols, lighting may only help the burglar or vandal. And people need more reason than attractive luminaires to visit a downtown. Still, lighting can be a part of an intelligent security and economic development strategy, and reinforcing historic character is certainly a worthwhile objective.

LIGHTING TECHNOLOGIES

Luminaire Types
Lantern, acorn and teardrop fixtures are common in historic downtowns, but usually these are not themselves historic fixtures. Rather, they are modern ones with a historic-looking appearance to match ones like the gas street
lights in Figure 2. Street lighting technologies have evolved substantially since it first emerged more than 100 years ago. Light levels were much lower 100 years ago than recommended at present (IES, 2000), being provided by less efficient gas or incandescent lamps, rather than the high pressure sodium (HPS) lamps common today (NYSDOT, 1995) and the light emitting diodes (LEDs) of tomorrow, and fixtures were typically spaced less than 100 ft apart. Most functional street lights today have the well known “cobrahead” shape shown in Figure 3, mounted 25 to 30 ft above the road and often spaced 150 ft or more apart, whereas older street lights were only 10-15 ft above the ground. In addition, as part of efforts to help reduce light pollution, cobrahead luminaires now use flat glass lenses instead of dropped lenses so that they emit all their light downward instead of both up and down. Almost all new cobrahead luminaires used to light highways will have flat lenses like the one shown in Figure 3.

FIGURE 2 Appearance of historic gas street light luminaires (from American City magazine, 1920).

FIGURE 3 Appearance of a modern cobrahead luminaire.

Timing Control
Another difference between street lighting of a century ago and that of the present has to do with timing. Most street lights burn from dusk to dawn (Bullough, 2010). A century ago, when street lights could barely compete with the full moon in terms of brightness, many cities and towns used them on a “moonlight” schedule in order not to waste gas or electricity, which was not the commodity often taken for granted in the present day. It was often considered not only redundant but even wasteful to illuminate streets when the moon was full. A scanning tour of roadway lighting practices in Europe (Wilken et al., 2001) found that dynamic roadway lighting, using lower light levels during periods of reduce traffic, was increasing in use.

Interestingly, in these days of fiscal challenges, many local governments are looking to reduce costs, and street lighting is often one of the top municipal expenses along with water and wastewater treatment. Present recommendations for light levels along roadways are well above those provided by moonlight, but the idea of adaptive lighting makes some sense when considering that there are usually fewer pedestrians and cars on the road at 4 a.m. than at 10 p.m. (Ivan et al., 2002), and perhaps less need for higher light levels for safety throughout the entire night. It has been estimated by the National Lighting Product Information Program (NLPIP) that adaptive or dynamic street lighting might save 30% to 50% of the energy costs compared to conventional dusk-to-dawn lighting (Bullough, 2010).
Light Sources
As mentioned previously, first gas and then incandescent lamps were the main light sources available for street lighting when it was first used. Relatively speaking, these sources are much less efficient and produce substantially less light than the primary street lighting lamps of today (Rea, 2000), and mantles and incandescent bulbs have much shorter lives, as well. Both gas light and incandescent illumination is often a “warm” yellowish-white color. The most common lamps used for street lighting today are HPS lamps (NYSDOT, 1995). These sodium vapor lamps are even yellower in color appearance than gas and incandescent. HPS lamps are also very efficient, and have long rated lives, a feature that makes them popular among highway engineers. The efficiency and high light output of lamps such as HPS means that street lights can be located hundreds of feet apart, and their long life means the lamps can last 6 to 9 years between replacements, instead of 6 to 9 months for gas and incandescent sources.

However, the yellow color of HPS illumination is usually perceived as less bright and judged as less safe than “white” illumination from metal halide (MH) lamps (Rea et al., 2009), which have begun to be used more frequently for outdoor lighting. It is also easier to see different colors under the whiter light (Rea et al., 2009). However, highway engineers do not prefer MH lamps because they are less efficient and have shorter lives than HPS lamps. LEDs are already starting to be used in some street lighting installations (Radetsky, 2010, 2011). These newer sources have promise for very long lives, up to 20 years, and also can produce a range of white illumination colors from warm to cool white. Table 1 lists the properties of several light sources used for street lighting in the past, present and future.

### Table 1 Properties of Light Sources Used for Street Lighting

<table>
<thead>
<tr>
<th>Light Source Property</th>
<th>Yesterday</th>
<th>Today</th>
<th>Tomorrow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gas</td>
<td>Incandescent</td>
<td>High Pressure Sodium (HPS)</td>
</tr>
<tr>
<td>Efficacy (lumens per watt)</td>
<td>1-2*</td>
<td>10-20</td>
<td>80-120</td>
</tr>
<tr>
<td>Power (watts)</td>
<td>250-500*</td>
<td>25-200</td>
<td>35-400</td>
</tr>
<tr>
<td>Operating Life (hours)</td>
<td>100-1000</td>
<td>750-2000</td>
<td>24,000-30,000</td>
</tr>
<tr>
<td>Correlated Color Temp. (kelvins)</td>
<td>1500-2000 (yellowish)</td>
<td>2500-3000 (warm white)</td>
<td>2100 (yellowish)</td>
</tr>
</tbody>
</table>

*Values for gas are given in equivalent electrical units for comparison.

Integration of Lamps and Luminaires
Using a MH or HPS lamp inside an acorn- or lantern-style luminaire mounted on a pole that is 10 or 15 ft high is a common way to provide a semblance of historically-accurate appearance during the daytime, but it is also important to consider that at night, such street lights can produce 20 or more times as much light than the gas street light of a century ago (Figure 4). The combination of higher light output (in lumens, lm) and relatively low (compared to typical overhead street lights) mounting heights can result in substantial discomfort glare.

In addition, many historic-appearing acorn and other post-top luminaires that enclose the lamp with a decoratively shaped glass or acrylic refractor lens, might not only contribute to glare, but these luminaires can also emit substantial amounts of light upward, where it usually does not serve any purpose except to produce unwanted light pollution (Brons et al., 2008). However, not all luminaires with historic appearance are the same (Leslie and Rodgers, 1996). Some luminaires, known as decorative cutoff types, are similar in their optical design to cobrahead systems where the lamp is mounted below a metal reflector, which spreads the light mainly downward through a clear glass lens, reducing light pollution.
Sometimes there is a glass or acrylic chimney inside the lower part of the housing where a mantle might have been located in a gas street light of the early 20th century, to better simulate the historic daytime appearance of gas lighting. These types of luminaires may be better at reducing glare as well as light pollution because more of the light is directed downward. However, when viewed from a fairly close distance of approximately 20 to 30 ft, it can sometimes be possible to have a direct view of the lamp, which could create substantial discomfort glare, especially since the luminaire height is lower than a conventional cobrahead street light. In general, for both post-top and decorative cutoff luminaire types mounted at 10-15 ft, meeting the light levels usually recommended for roadways (IES, 2000) will require shorter luminaire spacing than needed with cobrahead luminaires mounted 25 to 30 ft high.

OPERATION OF STREET LIGHTING
For many municipalities, street lighting systems are leased from the local electrical utility, which installs, maintains and energizes the lights for a flat, monthly fee per street light. This allows the costs to be spread over a long time, which is attractive because a municipality often does not have to access large amounts of funding to install street lighting systems. However, in order to keep costs low, utilities generally have a relatively limited assortment of available luminaires. Mainly, streets are lighted with cobrahead luminaires but there is usually a small number of period luminaires that may evoke a generically old fashioned appearance. Among the types of period-style luminaires that may be available from an electric utility are several of the following types:

- Carriage lantern
- Gothic
- Teardrop
- Acorn
- Nautical
- Contemporary

Municipalities can decide to purchase, own and maintain their street lights on their own, and some have. In such cases the utility simply provides the electric power, and the city or town is responsible for all other aspects of keeping the lights operating, including the costs of system installation, labor and equipment costs for replacing lamps, and costs for fixing or replacing poles and luminaries when necessary. There is a good deal more flexibility in choosing a luminaire that matches or is compatible with the architectural styles in a given location, as well as in selecting an optical design that can minimize glare and light pollution. Over the long term, there is evidence that owning street lighting may actually be less costly to the city or town than leasing, as long as there is access to funds to purchase and install them up front, according to the New York State Comptroller (2007). Despite the lower long-term costs, the high initial expenses and commitment to maintain the system still makes utility leasing an attractive option that will be common among municipalities.

PLANNING AND DESIGN OF HISTORIC STREET LIGHTING
An early step in the proper planning of street lighting in an Historic district is to determine whether street lights existed at all during the district’s period of historic significance. This period, usually a range of dates, can be found on the National Register nomination form, if the location is a National Register listed historic district. If historic street lights are extant (Figure 5), then ascertaining the appearance of the historic lighting is relatively easy. Otherwise,
historic photographs may be located at a local historical society or library. Options for the selection of luminaires include repairing existing luminaires, replicating luminaires documented in historic photographs, or finding luminaires that match as closely as possible in catalogues.

If there is no indication that historic street lights existed during the period of significance, the designer is faced with challenging decisions. Street lighting projects often receive state or federal government funding, which triggers a review by the State Historic Preservation Office (SHPO). The SHPO uses the Secretary of the Interior Standards for Rehabilitation when reviewing projects in historic districts that are listed in or eligible for listing in the National Register of Historic Places. There are ten Standards, published by the National Park Service (NPS), to encourage the appropriate treatment of historic buildings, structures and districts. The NPS recommends that when installing missing features, replacements should be clearly differentiated so that a false historical appearance is not created. Where there is insufficient historical, pictorial, and physical documentation, a new design should be compatible with the size, scale, material, and color of the historic feature (U.S. Department of the Interior, 1990). Despite these general principles, there appear to be few concrete recommendations for SHPOs to follow regarding street lighting in historic districts.

![Figure 5](image.png)

**FIGURE 5** Photograph of a historic gaslight in Newport, Rhode Island.

It is important to initiate discussions early with the SHPO when designing street lighting because the meaning of “clearly differentiated” can be interpreted in many ways. As a recent example, the Arizona SHPO reviewed a street lighting proposal in Phoenix under Section 106 of the National Historic Preservation Act, and determined that decorative post-top luminaires needed to be contemporary in appearance and compatible with the district’s architectural scale when they were installed in a historic district where there was no evidence that historic street lighting had previously existed. Other planning review bodies in the United States might interpret the Standards differently and prefer that historic looking streetlights, such as an acorn post-top luminaire, be installed in a turn of the 20th century historic district (Tell, 2003).

Where utility leasing is the only practical option, designers could attempt to choose an option that most closely matches the area’s historic character, could choose not to introduce decorative post-top luminaires that might represent an historic period not associated with a historic location, or could choose to install contemporary post-top decorative luminaires.

“Main Street” lighting designs in urban locations could consider a two-tiered lighting system that is not commonly used at present: conventional cobrahead luminaires at intersections and other important conflict points for vehicle and pedestrian safety, while using decorative post-top luminaires with as low a wattage as possible and with the optical design least likely to create glare for drivers and pedestrians, for areas between intersections.

This latter, two-tiered approach actually has some historic precedent. Figure 6 is a woodcut from *Harper's Weekly* magazine in 1882, showing high-mounted arc lighting near New York City’s Madison Square, which is supplemented by post-top lighting at a lower mounting height in areas with greater pedestrian traffic. More recently, a similar approach was utilized along a main street in the village of Lewiston, New York (ICF Consulting and LRC, 2002). Center Street was originally lighted by 44, 400-W HPS cobrahead street lights. Only those cobrahead luminaires at intersections and pedestrian crossings were kept, and sidewalk areas were illuminated by 70-W, post-top lantern-style, luminaires containing MH lamps (Figure 7). The total energy use was slightly lower; illumination levels on sidewalks were increased.
FIGURE 6 Two-tiered approach to historic street lighting. High-mounted luminaires provide ambient general illumination, while lower-mounted ones illuminate potential pedestrian conflict areas.

FIGURE 7 Historic-appearing lantern luminaires used to illuminate pedestrian areas in Lewiston, New York (ICF Consulting and LRC, 2002).

DISCUSSION AND CONCLUSIONS
The issues that design professionals and transportation engineers face today are very different than the ones municipalities faced over a hundred years ago when street lighting became common in the United States. Light pollution is a modern issue that can be addressed by modifying luminaire designs slightly and using the lowest lamp wattages practical. Heavy vehicle traffic and a need for energy efficiency are modern issues that can be taken into account with the two-tiered approach previously mentioned and by dynamic or adaptive lighting approaches. The two-tiered approach to historic street lighting described above could provide one solution to preserving an inviting historic atmosphere while meeting the modern needs of providing for safety and energy efficiency.

At present there is little centralized collection of information from states and municipalities about their review processes and planning issues regarding street lighting in historic districts. Additional case studies such as the Lewiston example presented here could assist planners and reviewers to identify appropriate design characteristics and technologies suitable for implementing them. Additional synthesis of practices and policies should be undertaken by review bodies and by transportation agencies. Understanding these issues and working toward mindful solutions to integrating modern needs with the preservation of historic character will help design professionals and transportation engineers create more effective lighting in historic downtowns.

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