LED Street Lighting Academy
Understanding Impacts on the Public

December 10, 2019
Introduction
About the Lighting Research Center

Advancing the effective use of light for society and the environment

30,000 sq. ft. research center and laboratory

Established in 1988 by the New York State Energy Research and Development Authority (NYSERDA)

40-60 concurrent projects in field and lab

~30 full-time faculty and staff


15 graduate students
Outline for Today’s Webinar

• Street lighting and safety
• Street lighting, crime and economic development
• Spectral effects
  • Perceptions of brightness and personal security
  • Health and circadian rhythms
• Adaptive lighting control
Street Lighting and Safety
Evidence for the Role of Street Lighting

- During the transition to/from daylight savings time, certain hours of the day undergo a transition between light and dark (University of Michigan)
- Certain types of crashes, especially involving pedestrians, are more common in darkness
- Reduced visibility, not just fatigue or alcohol, contribute to accidents and lighting can improve visibility
What Causes Accidents at Night?

- Accidents at intersections are very common at night
- Misjudging the speed and direction of other vehicles is a leading cause of accidents
Street Lighting and Improved Visibility

- Extracting figure/ground information from a street scene is important for visibility.
- At night, vehicle headlights are visible but without street lighting it can be difficult to judge a moving car’s speed and direction.
Quantifying Improved Visibility

- Speed and accuracy of visual processing depends upon:
  - Light level
  - Contrast
  - Size

- Relative visual performance (RVP) model was used to quantify visibility improvement with lighting for intersections in Minnesota

<table>
<thead>
<tr>
<th>Intersection type</th>
<th>Increase in RVP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban signalized</td>
<td>+0.073</td>
</tr>
<tr>
<td>Urban unsignalized</td>
<td>+0.186</td>
</tr>
<tr>
<td>Rural signalized</td>
<td>+0.027</td>
</tr>
<tr>
<td>Rural unsignalized</td>
<td>+0.021</td>
</tr>
</tbody>
</table>
Quantifying Improved Safety

- Statistical analyses of crash data from Minnesota for intersections at night with and without lighting were carried out.
- Lighting was found to have a beneficial impact on urban intersections, and relatively small impacts on rural intersections.

<table>
<thead>
<tr>
<th>Intersection type</th>
<th>Reduction in nighttime crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban signaled</td>
<td>-7%</td>
</tr>
<tr>
<td>Urban unsignalized</td>
<td>-13%</td>
</tr>
<tr>
<td>Rural signalized</td>
<td>0%</td>
</tr>
<tr>
<td>Rural unsignalized</td>
<td>-2%</td>
</tr>
</tbody>
</table>
Linking Visibility and Safety

<table>
<thead>
<tr>
<th>Intersection type</th>
<th>Change in nighttime crashes</th>
<th>Increase in RVP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban signalized</td>
<td>-7%</td>
<td>+0.073</td>
</tr>
<tr>
<td>Urban unsignalized</td>
<td>-13%</td>
<td>+0.186</td>
</tr>
<tr>
<td>Rural signalized</td>
<td>0%</td>
<td>+0.027</td>
</tr>
<tr>
<td>Rural unsignalized</td>
<td>-2%</td>
<td>+0.021</td>
</tr>
</tbody>
</table>

Transfer Function Relating Visual Performance Improvement and Nighttime Crash Reduction

\[ y = 0.072x \]

\[ R^2 = 0.93 \]
Street Lighting, Crime and Economic Development
Objectives of Lighting for Security

• Provide a clear view of an area from a distance and enable anyone in it to be seen
• Deny potential hiding spaces
• Permit facial identification
• Deter crime against persons or property
Lighting and Facial Recognition

• From about 15 feet away, 1 lux (0.1 footcandles) of vertical illumination provides confident recognition of faces

• From 50 feet away, 30 lux (3 footcandles) are needed for confident recognition

• No difference between sodium and white light sources such as LED
Does Street Lighting Reduce Crime?

- In the U.S., researchers evaluated 15 different street lighting projects in municipalities with at least 25,000 people.
- No statistically significant effect of lighting on crime was found, although lighting reduced the fear of crime.
Why Doesn’t Street Lighting Seem to Reduce Crime?

• Other changes occurred when lighting was installed
• Crime may have simply moved to a new location nearby
• Studies involved large areas, leading to averaging and canceling possible effects
What about Economic Development?

• There is little direct evidence showing that street lighting elicits economic benefits in the communities where it is installed

• Pedestrians are more likely/willing to use sidewalks/walkways when lighting is present; this could possibly lead to economic activity
Spectral Effects of Lighting
Differences between Sodium and LED Spectral (Color) Output

High pressure sodium (HPS)

Light emitting diode (LED)
Mesopic Vision: Peripheral Detection

- Drivers’ ability to see peripheral targets is improved under white (MH or LED) light compared to sodium (HPS) illumination.
Light Source Spectrum and Color Identification

- Crime witness reports often include descriptions of clothing or object color
- Under a “white” light source, color naming of clothing is more accurate than under sodium lighting
Light Source Color and Discomfort Glare

- LED street lights commonly have correlated color temperatures (CCT) of 3000 K or 4000 K
- Sodium street lights have a CCT of 2100 K
- Higher CCT can be judged as more uncomfortable to look toward
Street Lighting and Human Health

- The American Medical Association (AMA) issued guidance expressing concerns about LED outdoor lighting and calling for a limit on LED correlated color temperature (CCT) of 3000 K (“warm white”)
- Impacts on disrupting circadian function in people is cited to justify limiting CCT
- For the full story, visit https://youtu.be/2BcfcONrm58
Light Exposure from Street Lighting
Impact of Light on Circadian Function

![Graph showing impact of light on circadian function](image)

- **Melatonin Suppression**:
  - Outdoors night
  - Indoors home
  - Indoors office
  - Outdoors daytime

- **Circadian Light (CL) vs. Circadian Stimulus (CS)**
  - 1 h exposure

- **18 photopic lux for one hour at the eye**
  - 4000 K
  - 3000 K

- **Lighting Research Center, Rensselaer**

- **NYSERDA**
CCT is Not a Useful Circadian Metric

- The human circadian system requires higher illuminances than street lighting provides to suppress melatonin at night.
- Correlated color temperature (CCT) is not the appropriate metric for characterizing circadian impacts of lighting.

Suppression from 300-600 lux

http://www.lrc.rpi.edu/cscalculator
Adaptive Street Lighting Control
Vehicle traffic and pedestrian use is not constant throughout the night.

Should street lighting be constant throughout the night?
Justification for Reducing Light Levels

- If, based on reduced traffic volume and/or pedestrian use, a road classification changes during part of the night, the recommended level for the new classification could be used during those hours.
Safety and Energy Impacts of Adaptive Lighting

- Using the highest light levels during the hours of activity and lower light levels when there is less activity can reduce light pollution and energy use while minimizing safety impacts.
- Can be accomplished with time clocks or motion sensors.
- 30%+ energy savings are possible.
Technical Assistance is Available

NYSERDA offers limited technical assistance to municipalities looking to convert street lighting to LED technology

- Assistance with product selection
- Technical analysis of light levels/distributions
- Evaluation of existing/replacement lighting

Contact your Clean Energy Communities coordinator to get started
Thank You!

Questions & Answers