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LED Street Lighting Academy

Understanding Impacts on the Public

December 10, 2019

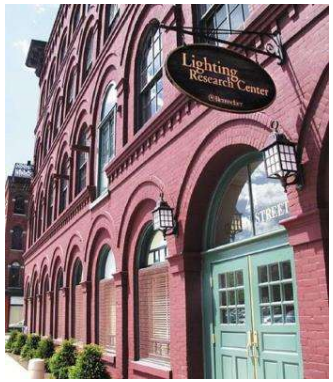
Introduction

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

Focus Areas: Energy, Technology Development, Human Health, Lighting Benefits, Transportation and Safety, Product Testing, Plant Health, Design

~30 full-time faculty and staff

15 graduate students

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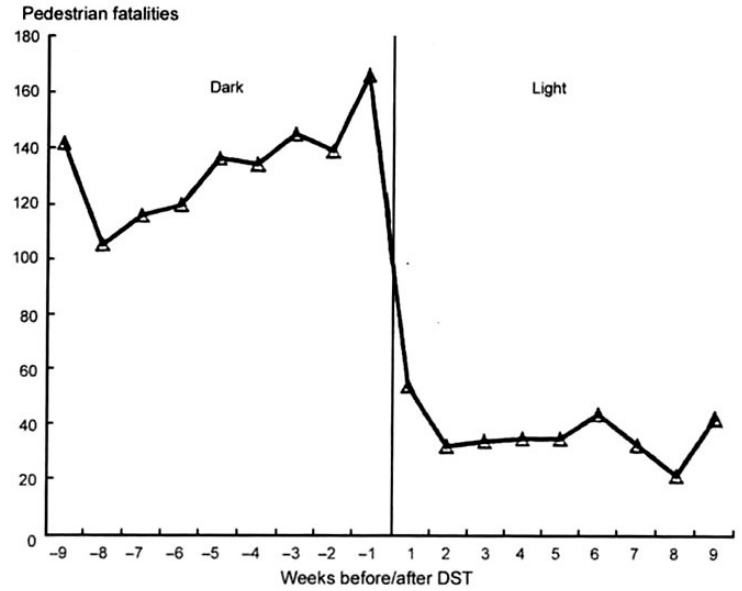
Outline for Today's Webinar

- 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



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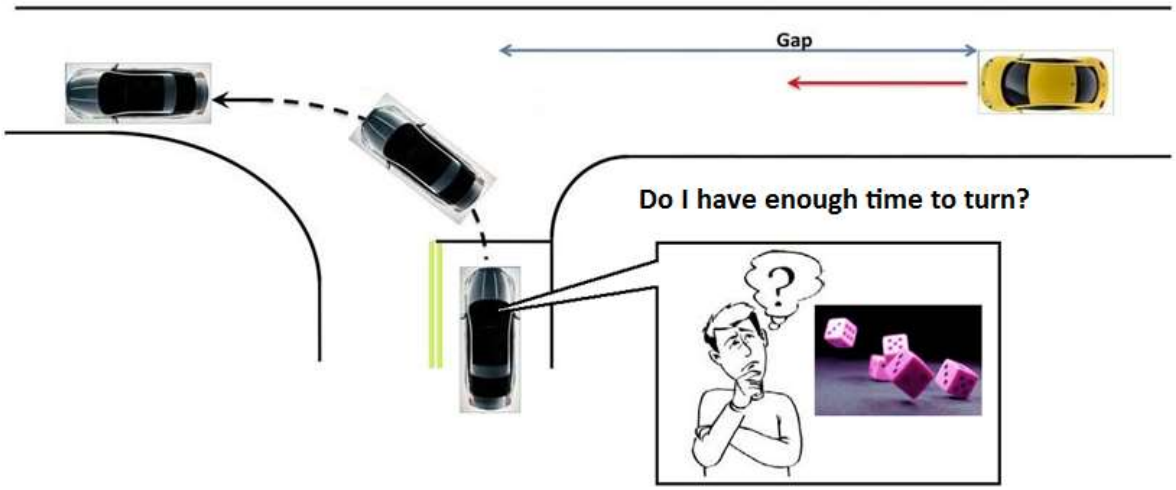
What Causes Accidents at Night?

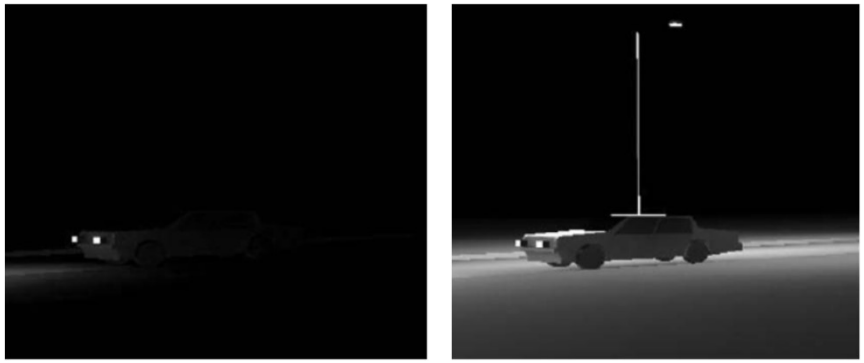
- Accidents at intersections are very common at night
- Misjudging the speed and direction of other vehicles is a leading cause of accidents



Adapted from connectedvehicle.challenge.gov

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

Roadway Lighting Design Manual

May 2006

Intersection type	Increase in RVP
Urban signalized	+0.073
Urban unsignalized	+0.186
Rural signalized	+0.027
Rural unsignalized	+0.021

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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

Intersection type	Reduction in nighttime crashes
Urban signalized	-7%
Urban unsignalized	-13%
Rural signalized	0%
Rural unsignalized	-2%

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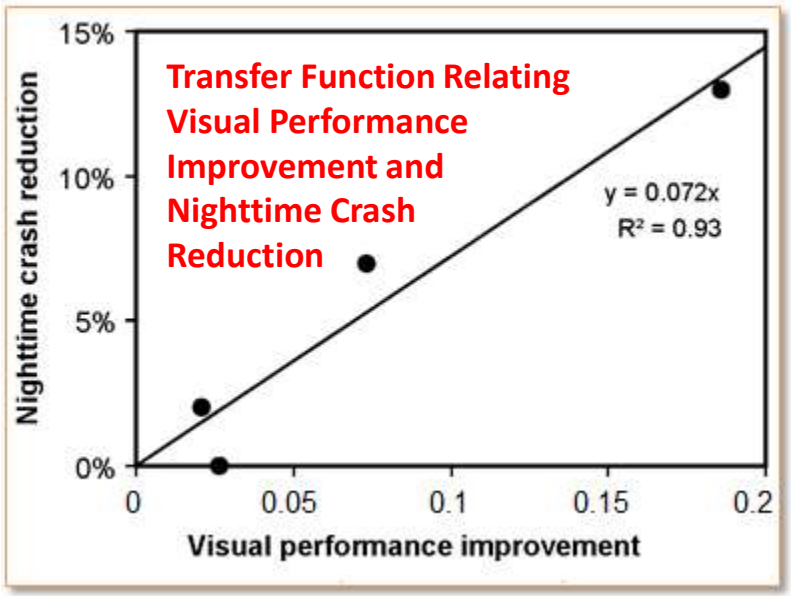
Linking Visibility and Safety

Intersection type	Change in nighttime crashes	Increase in RVP
Urban signalized	-7%	+0.073
Urban unsignalized	-13%	+0.186
Rural signalized	0%	+0.027
Rural unsignalized	-2%	+0.021



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Street Lighting, Crime and Economic Development

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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

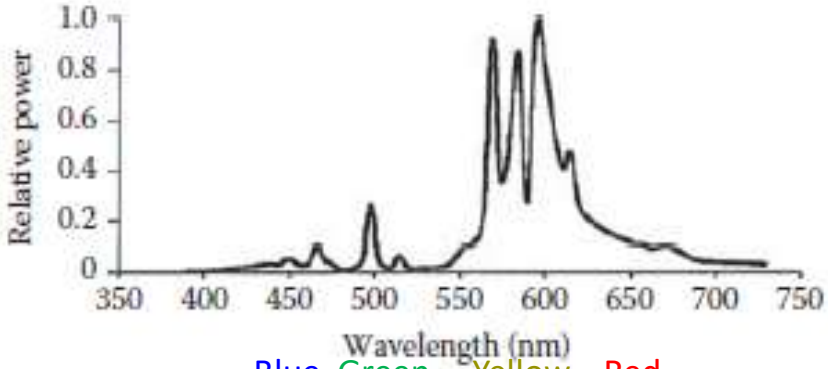
What about Economic Development?

- 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

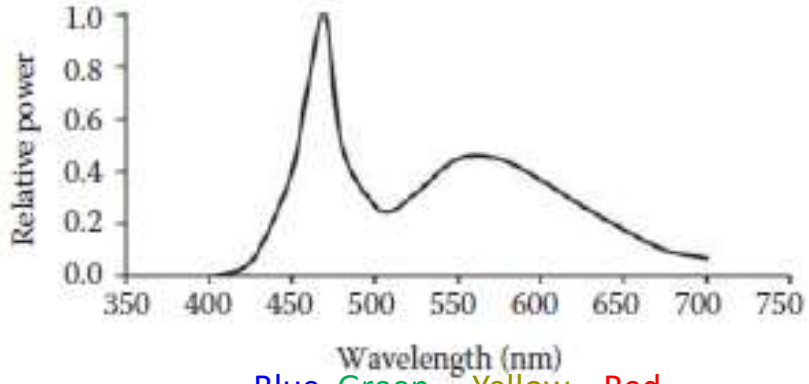
Differences between Sodium and LED Spectral (Color) Output

High pressure sodium (HPS)



Blue Green Yellow Red

Light emitting diode (LED)



Blue Green Yellow Red

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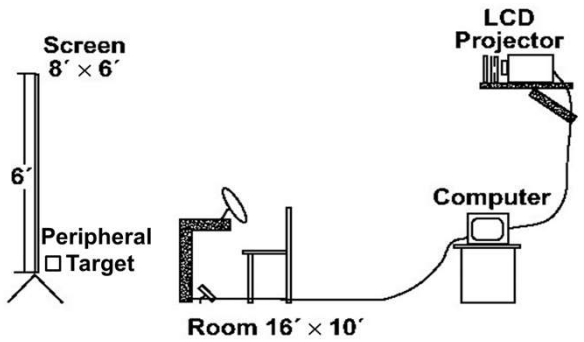
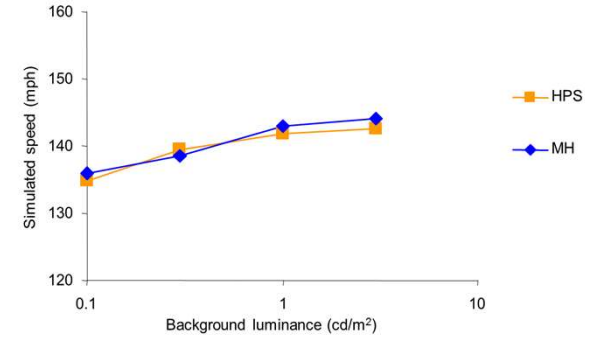
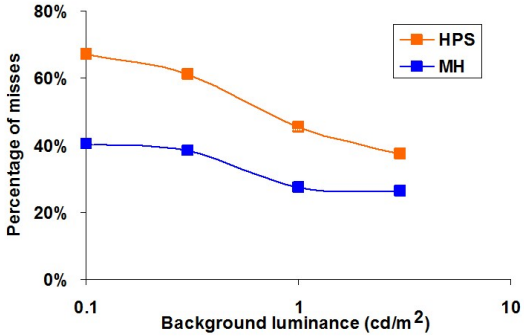
Mesopic Vision: Peripheral Detection

- Drivers' ability to see peripheral targets is improved under white (MH or LED) light compared to sodium (HPS) illumination







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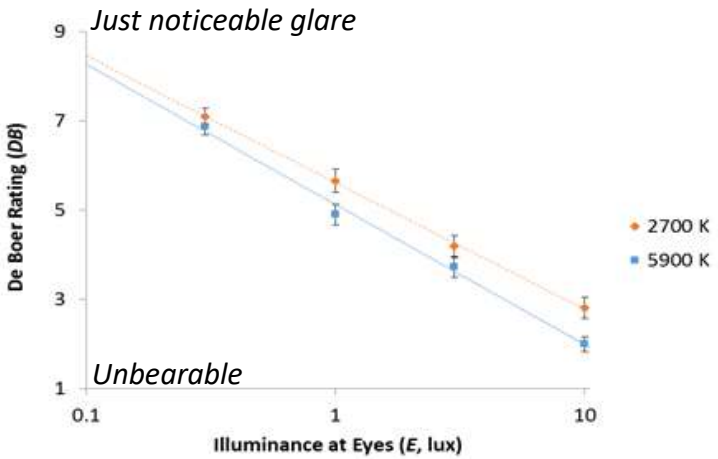
Light Source Spectrum and Color Identification

- 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

REPORT OF THE COUNCIL ON SCIENCE AND PUBLIC HEALTH

CSAPH Report 2-A-16

Subject: Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting

Presented by: Louis J. Kraus, MD, Chair

Referred to: Reference Committee E (Theodore Zanker, MD, Chair)

INTRODUCTION

With the advent of highly efficient and bright light emitting diode (LED) lighting, strong economic arguments exist to overhaul the street lighting of U.S. roadways.[1-5] Valid and compelling reasons driving the conversion from conventional lighting include the inherent energy efficiency and longer lamp life of LED lighting, leading to savings in energy use and reduced operating costs, including taxes and maintenance, as well as lower air pollution burden from reduced reliance on fossil-based carbon fuels.

Not all LED light is optimal, however, when used as street lighting. Improper design of the lighting fixture can result in glare, creating a road hazard condition.[4,5] LED lighting also is available in various color correlated temperatures. Many early designs of white LED lighting generated a color spectrum with excessive blue wavelength. This feature further contributes to disability glare, i.e., visual impairment due to stray light, as blue wavelengths are associated with more scattering in the human eye, and sufficiently intense blue spectrum damages retinas.[6,7] The excessive blue spectrum also is environmentally disruptive for many nocturnal species. Accordingly, significant human and environmental concerns are associated with short wavelength (blue) LED emission. Currently, approximately 10% of existing U.S. street lighting has been converted to solid state LED technology, with efforts underway to accelerate this conversion. The Council is undertaking this report to assist in advising communities on selecting among LED lighting options in order to minimize potentially harmful human health and environmental effects.

METHODS

English language reports published between 2005 and 2016 were selected from a search of the PubMed and Google Scholar databases using the MeSH terms: “light,” “lighting methods,” “color,” “photic stimulation,” and “adverse effects,” in combination with “circadian rhythm/physiology/radiation effects,” “radiation dosage/effects,” “sleep/physiology,” “ecosystem,” “environment,” and “environmental monitoring.” Additional searches using the text terms “LED” and “community,” “street,” and “roadway lighting” were conducted. Additional information and perspective were supplied by recognized experts in the field.

ADVANTAGES AND DISADVANTAGES OF LED STREET LIGHTS

The main reason for converting to LED street lighting is energy efficiency; LED lighting can reduce energy consumption by up to 50% compared with conventional high pressure sodium (HPS)

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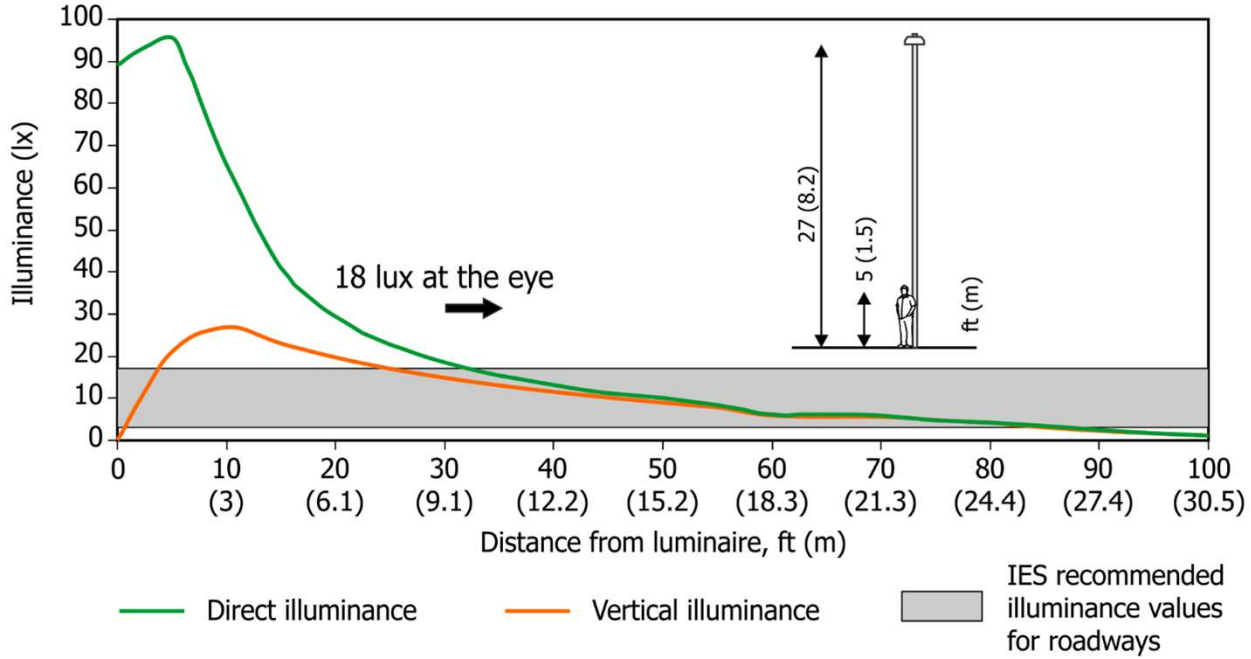
Light Exposure from Street Lighting



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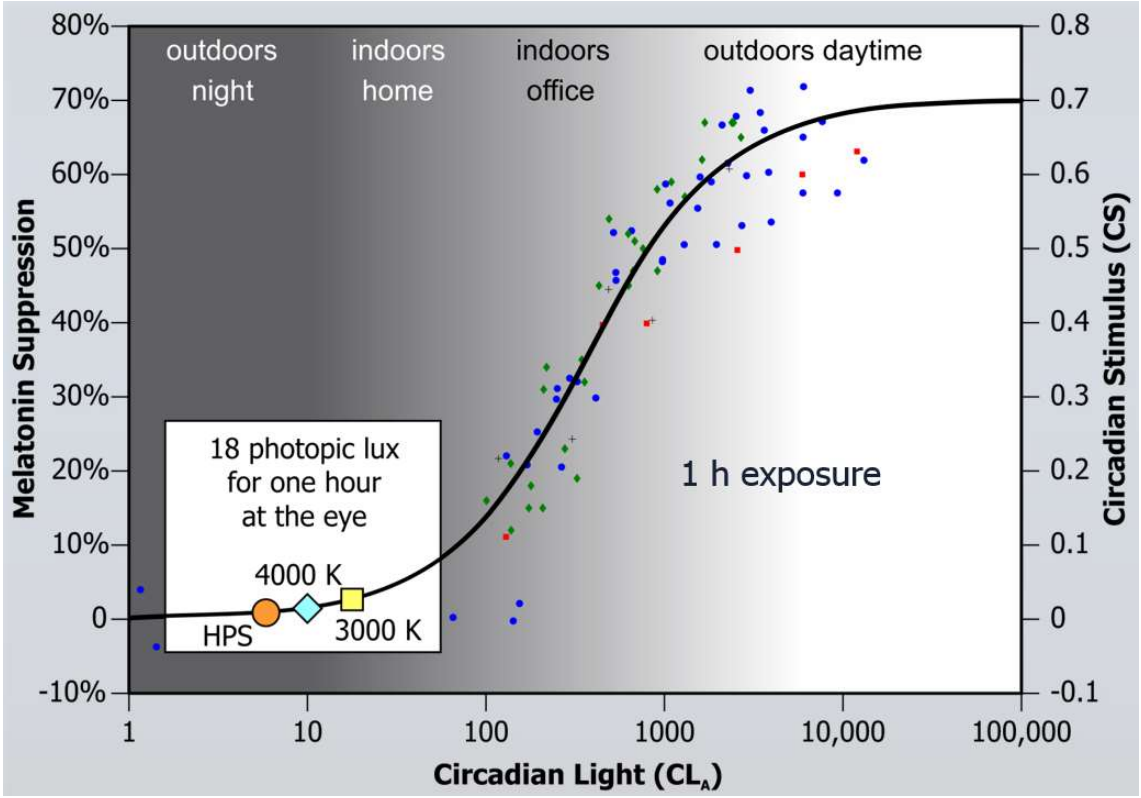
Impact of Light on Circadian Function



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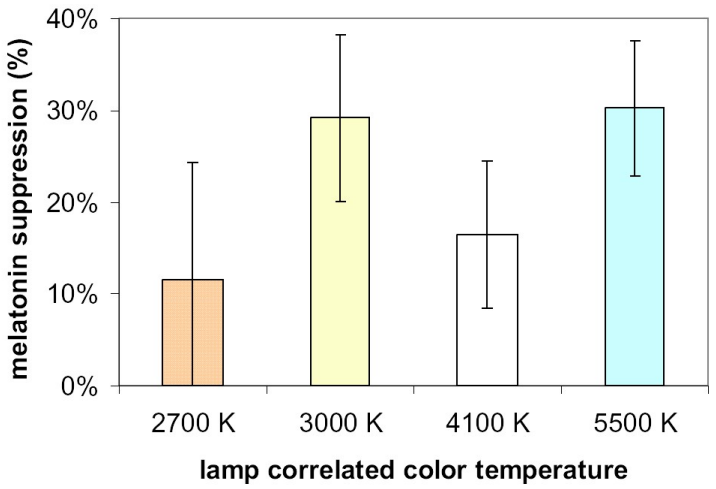
CCT is Not a Useful Circadian Metric

- 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



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http://www.lrc.rpi.edu/cscalculator

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Adaptive Street Lighting Control

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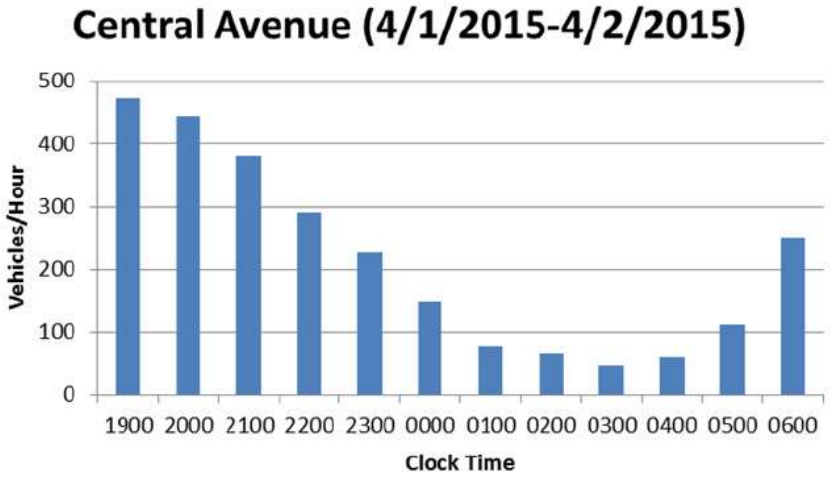
Nighttime Activity Fluctuates with Time

- Vehicle traffic and pedestrian use is not constant throughout the night
- Should street lighting be constant throughout the night?



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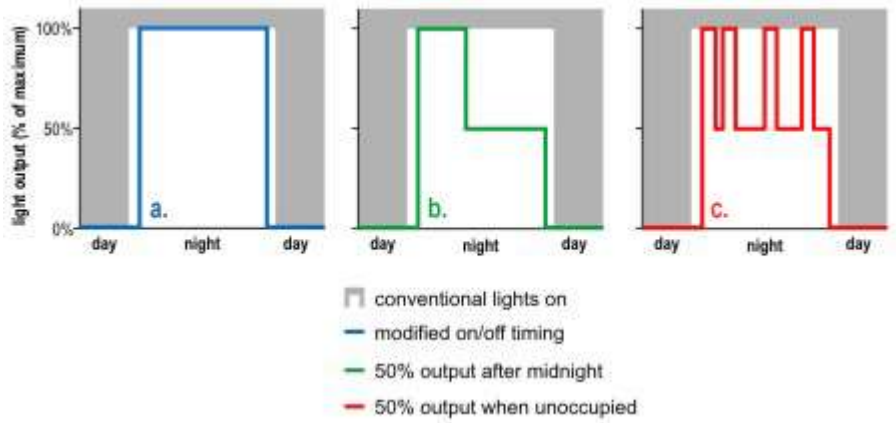
Justification for Reducing Light Levels

- 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

Street classification	Pedestrian area class.	Avg. luminance (cd/m²)
Major	High	x
	Medium	0.9
	Low	x
Collector	High	x
	Medium	x
	Low	0.4
Local	High	x
	Medium	x
	Low	x

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



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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

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Thank You!

Questions & Answers

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