August 25, 2025

Brian A. Bilberry
Deputy Corporation Counsel
Department of the Corporation Counsel, County of Maui
200 S. High Street, 3rd Floor
Wailuku, Maui, Hawai'i 96793

Dear Brian,

Before answering counsel's questions, I would like to first provide some background information regarding the physics of color, human vision and perception and a review of how these factors interact to allow drivers to avoid collisions with objects that they encounter while driving:

1) The fundamental reason for installing lighting along streets and highways is to provide adequate illumination at night to allow the identification of objects in the driver's path and provide the driver enough time to take appropriate actions to avoid contact with those objects:
    a. Driving a vehicle requires constant vigilance to avoid collisions with road hazards such as other vehicles, potholes, changes in road direction, road debris (fallen trees, large boulders, etc.), roadway flooding to name a few.
    b. Likewise, it is critical for the driver of the vehicle to avoid collisions with other occupants of the road such as pedestrians and bikers. In many cases, these occupants can be crossing the road or highway and first appear in the driver's periphery vision.
    c. Finally, wildlife also represents potential hazards. Larger animals such as deer, elk can destroy a vehicle, while smaller animals such as dogs, cats, etc., can represent both potential damage to the vehicle in a collision as well as an accident due to loss of control of the vehicle in swerving to avoid a collision. These hazards usually first appear in the driver's periphery vision.
2) Human vision is made up of two types of sensors, rods and cones.
    a. Cones detect light in one of three spectral ranges: long wavelength (red); medium wavelength (green) and short wavelength (blue). They are concentrated in the fovea section of the eye where vision is sharpest.

b. Rods detect light in one part of the spectrum only, the very short wavelengths (blue-violet). They are distributed mostly in the portion of the retina beyond the central fovea region and are responsible for periphery vision.
c. Which of the two types provides the visual stimulus to the brain is dependent on the overall brightness of the images falling on the retina. In daylight, the cones provide the high resolution, color images that the brain uses to see. This is called photopic vision and is how humans see in sunlight and brightly lit night environments. In dark, moonless night environments, the rods (which have a much higher sensitivity to light) take over. Since there is only one type of rod, there is almost no color information provided to the brain. This is called scotopic vision and is how humans see in darkness. Finally, in the case where the environment is dimly lit, both rods and cones are active at a lower level. This is called mesopic vision.

3) Humans require a finite amount of time to allow the brain to identify images detected by the retina and to respond to those images, if necessary. The human brain can start to process an image (e.g. shape, orientation, color, etc.) in as little as 13 msec. Reaching conscious awareness of the image can take 75 - 150 msec. Total reaction time to a visual image can take 250 msec or more.
4) Critical to the effectiveness of roadway lighting is to provide the proper illumination to allow the driver to avoid collisions with any objects, humans, hazards or wildlife. The time necessary for a driver to avoid a collision with an object is a function of the distance to the object, the speed of the vehicle and the reaction time of the driver to the appearance of the object or "target." The shorter the reaction time, the less likely a collision will occur. Obviously, the higher the vehicle's velocity, the shorter the reaction time required in order to stop the vehicle and avoid a collision.
5) For a human to identify a target, it must present a visual contrast with the background. Contrast is the difference in luminance or color that makes a target visible against a background or environment of different luminance or color. The human visual system is more sensitive to contrast than to absolute luminance. Thus, humans can perceive the world similarly despite significant changes in illumination throughout the day or across different locations.

6) The color of any object depends on two characteristics: the reflective property of the object and the spectral content of the light source illuminating the object.
    a. For example, a red ball is red because if it is illuminated by white light (which contains wavelengths of all colors of the visible spectrum) it will reflect light in the long wavelength portion of the spectrum (red) and absorb the other wavelengths (medium-green and short-blue wavelengths).
    b. However, if that red ball were illuminated by light that contained only green and blue portions of the spectrum, it would absorb those wavelengths and reflect nothing. Thus, under blue or green or blue & green illumination, a red ball will appear black, and against a dark background would be "invisible."
7) A property known as the Color Rendering Index (CRI) is a measure of the spectral content of a light source. It is determined by measuring the light energy reflected from a pallet of 8 standard color samples when illuminated by a test light source as compared to the same color samples illuminated by a standard light source (e.g. an incandescent lamp or the sun). CRI is the ratio of the test source divided by the standard source and ranges from 0 to 100. The higher the CRI, the broader the color spectrum of the light source. Incandescent light sources have a CRI of 100.

Counsel's Questions

What is the importance of the color rendering index for streetlighting roadway applications?
The higher the color rendering index for a light source used for roadway illumination, the broader the spectral content of the roadway light. As previously mentioned in the discussion on the previous page, broad spectral content of a light source is one way to increase the contrast of an object on a roadway (e.g. a pedestrian, cyclist, elk, disabled vehicle, etc.

What effect does the value of the color rendering index have on a motor vehicle driver?
A higher CRI indicates a broader spectral content in the roadway lighting. This in turn, increases the contrast between an object (or target) on the roadway and the general environment or background. In other words, roadway lighting with a higher CRI provides greater contrast between background and roadway object. This has the effect of reducing the time required for a vehicle driver to recognize an object on the roadway ahead and decide the best course of action to avoid striking the object (e.g. steer around the object; bring the vehicle to a stop).

What is the relationship and/or effect of the color rendering index on the brightness of streetlighting?

Brightness and CRI are not directly related. At night, a driver's ability to discern objects depends heavily on contrast sensitivity – the ability to detect differences in luminance and separate an object from its background. Low CRI lighting can make objects blend more easily into their surroundings, reducing this contrast. To counter the negative effects of low contrast and poor color rendering, higher brightness levels are often needed to make objects more discernible under low CRI lights. So, when considering object recognition, to compensate for the lower contrast when using low CRI lighting, the brightness of the lighting must be increased.

What are the consequences for not having an adequate color rendering index for streetlight roadway applications?

Street or roadway lighting with lower CRI values reduces the contrast between objects on the roadway ahead and the background. This makes it more difficult for a driver to recognize the object and determine what action should be taken to avoid striking the object. This is particularly critical when it comes to roadway lighting where vehicle speeds are generally higher, necessitating shorter target recognition times in order to avoid striking objects. This is less critical for street lighting where vehicle speeds are lower allowing more time for a driver to recognize a target and bring the vehicle to a stop.

What are the standard Correlated Color Temperature (CCT) and Color Rendering Index (CRI) values for roadway lighting applications that you have been able to determine?

In a survey of state specifications for roadway lighting applications (examining coastal states) the typical Correlated Color Temperature (CCT) is generally between 2700K and 4000K. Not all the states examined specify a minimum Color Rendering Index, but those that do typically specify a minimum CRI of 70. Likewise, some research papers also show similar values of 2700K for CCT and CRI >70. In situations where video cameras are in use CRI of 90 are typically recommended. While some standards suggest a reduction in CCT for environmental sensitive areas, I have found no standards that recommend reducing the CRI to 50 or less, nor reducing the percentage of blue light to 2% or less (except for the present lighting ordinances in Maui and Hawaii counties).

Does the 2% blue light content restriction in Maui County's Outdoor Lighting Ordinance have implications for the safety of motorists, pedestrians, cyclists, and visitors on Maui County's roadways?

Most definitely! Limiting the spectral content of roadway lighting to 2% or less greatly reduces the resulting CRI of the light source. As mentioned previously, this increases the reaction time of vehicle drivers, requiring more time to stop their vehicles, putting other occupants of the roadway like other motorists, pedestrians, etc., at greater risk of being struck by the vehicle. Similarly for tourists driving Maui's highways, a lower CRI with result in longer target recognition times, whether that target is a curve in the road, a roadway directional sign or residents out for a walk. Specifying lighting that greatly reduces the spectral content of the roadway lighting, makes it more difficult for a tourist driving a vehicle on an unfamiliar road to react to potential hazards. Add wet roadways and it becomes even worse with stopping times doubling in some cases.

One other consequence of reducing the percentage of blue light will be a reduction in the sensitivity to objects in the driver's periphery vision. As was mentioned in the beginning of this report, human vision is made up of two types of sensors, rods and cones. The rods are responsible for periphery vision and are most sensitive to the shorter wavelength portion of the spectrum (scotopic vision). By reducing the light that the rods are most sensitive to, recognizing objects (like pedestrians) in the driver's periphery vision will be more difficult and can take longer.

What are the comparative distinctions that can be drawn as between the Cree manufactured Guideaway LED light at 1900K at 50 CRI and the G.E. manufactured ERL1 LED fixture at 2700K at 70 CRI related to motorist, pedestrian, cyclist, and visitor safety on Maui County's roadways?

The GE ERL1 fixture has a CRI of 70 which is the minimum value specified by most of the coastal state motor vehicle departments surveyed. For drivers, there is no downside to higher CRIs. The broader the spectral content of roadway lighting (e.g. the higher the CRI value), the easier it is for drivers to distinguish objects in their path, due to the increased contrast.

Conversely, the Cree Guideway fixture has a CRI of 50, well below what states typically specify. Also to make up for the reduced contrast for targets, the brightness of the Cree unit will need to be increased. Besides compensating for the reduced contrast, the lower CCT of 1900K will probably require a higher brightness, simply because human observers tend to feel that lower CCT values are less bright than higher values. So installing the Cree Guideway 2% blue fixture results in a longer reaction time for drivers due to the lower CRI and will require increased brightness due to the lower CCT.

Finally, by reducing the amount of blue light in the case of the Cree Guideway, periphery vision will be affected due to the response characteristics of the rods which are most sensitive to short wavelength light, as discussed earlier.

Sincerely,

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LED Transformations LLC
Your Guide to Solid State Lighting

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Executive Summary Dr. Curran is an applied physicist with experience in the lighting, electronics, fire, consulting, security and oil industries. His executive experience includes senior positions managing the R&D efforts of a number of industrial high technology businesses. Presently, he is president of a technology consulting company specializing in providing guidance to manufacturers, architects, contractors and facility managers on the proper use of LED technology. Previously he headed the technology division of one of the leading manufacturers of solid-state lighting and signaling products and prior to that, a similar position with the leading signaling manufacture in the fire and life safety industry. His over 30 years of technical and business experience allow him to provide creative solutions grounded in practical approaches for his clients.

EMPLOYMENT HISTORY AND ACHIEVEMENTS

LED Transformations, LLC, Bluffton, South Carolina — 2008 thru Present

President and founding member of this technical consulting firm specializing in providing guidance to companies involved in the lighting industry on the proper use of solid-state lighting technology. Founded in 2007, the firm is in high demand for conducting training classes on LED technology and has given numerous invited talks on the subject. In addition, from 2010 thru 2018 the company provided educational workshops and seminars on behalf of the US Department of Energy. It has established itself as a source of both technical information and unbiased advice for clients wishing to provide quality LED lighting products.

Dialight Corporation, Farmingdale, New Jersey — 2005 thru 2008

CTO and VP Engineering for this leading worldwide manufacturer of high brightness LED (Light Emitting Diode) products. Responsibilities includes management of optical, mechanical and electronics functions; technology transfer among the various corporate development and manufacturing sites; manufacturing cost reductions; representing the corporation at scientific, engineering and government symposia and conferences.

- Eliminated duplication of efforts among the different facilities resulting in a 50% increase in the rate of new product introductions with no increase in staff.
- Introduced 2 new product lines within the first year which were expected to provide over $10 MM in sales within 18 months including the world's first LED-based obstruction light strobe.
- Designed a new documentation system, which resulted in a 40% reduction (thus far) in manufacturing documentation while improving accuracy and availability throughout the corporation.

WHEELOCK, INCORPORATED, Long Branch, New Jersey — 1992 thru 2005

Vice President, Engineering for this leading supplier of fire signaling, security and emergency voice alerting equipment in the US ($47MM in sales in 2004). Directed a group of 24 engineers and technicians responsible for design, documentation, agency approvals and manufacturing engineering of all product lines. Additional responsibilities included concept development, market research for possible new business lines, coordinating involvement with various industry regulatory councils as well as special order manufacturing.

- Co-invented the industry's first LED-based visual notification appliance (fire signal).
- Introduced innovative approaches to optic, electronic and mechanical product designs resulting in 25 patents issued (others pending).

PA CONSULTING GROUP, Princeton, New Jersey 1988 thru 1992

Manager, Sensors and Communications Technologies Group for the US Division of this international technical consulting firm (sales in excess of $300MM in 1991). Responsible for developing sales in the sensors and communications areas as well as formulating and managing development programs for clients

- Managed a $2MM project to develop a consumer product for the financial industry involving Optical Character Recognition and scanning system for a low power microprocessor based unit.
- Developed optics subsystem for a portable data acquisition two-dimensional bar coding system.

IDENTITECH CORPORATION, Livingston, New Jersey 1987 thru 1988

Vice President, Development for this joint venture of Allied-Signal and Sensormatic Electronics. As head of Engineering Division, directed 18 engineers and technicians in the development of new products as well as providing support for manufacturing, QC and customer service.

ALLIED-SIGNAL CORPORATION, Morristown, New Jersey 1985 thru 1986

Manager, Product Development, New Ventures Group directed 12 engineers and technicians in the development of a new technology Electronic Article Surveillance System. Responsibilities included: product development; technical liaison for negotiations between joint venture partners.

EXXON PRODUCTION RESEARCH, Houston, Texas 1979 thru 1985

Research Physicist, Long Range Research Group developed new seismic exploration techniques.

DREXEL UNIVERSITY EVENING COLLEGE, Philadelphia, Pennsylvania 1976 thru 1979

Adjunct Assistant Professor, Physics Department taught undergraduate physics classes and labs.

EDUCATION

Doctor of Philosophy (Physics), Drexel University
Title of Thesis: An Experimental Evaluation of the Biot Porous Elastic Theory for a Kaolinite Clay

MS Civil Engineering / MS Physics, Drexel University

BS Physics, Villanova University

PATENTS, PUBLICATIONS AND ASSOCIATIONS

33 US Patents Issued
150+ Lectures (Solid-State Lighting Technology)
9 Publications
Member Acoustic Society of America
Member SPIE International Society for Optical Engineering
Member Illumination Engineering Society
Member Optical Society of America

List of Public Talks & Seminars Given on LED Technology
Dr. John W. Curran

SPIE Fourth Annual Solid State Lighting Conference, *An Examination of a prototype LED fire alarm signaling appliance*, 2004.

SPIE Sixth Annual Solid State Lighting Conference, *Replacement of fluorescent lamps with high-brightness LEDs in a bridge lighting application*, 2006.

Lightfair, *Comparison of White LEDs*, 2006.

CLEO/PhAST, *Limitations to be Aware of When Using LEDs in Lighting Systems*, 2007.

Indiana Electrical Expo, *The Darker Side of LEDs*, 2008.

Lightfair, *One Hundred Thousand Hour Lifetimes and Other LED Fairytales*, 2008

IESNA-Philadelphia Lighting for a Green World Conference, *How to Avoid Feeling Blue when Using Green LEDs,* 2008.

Solid State Lighting Design Summit, *Questions to Ask About Luminaire Lifetimes*, 2008.

Pacific Gas & Electric Seminar, *Solid State Lighting—Both Sides of the Revolution,* 2008.

Energy Efficiency & Sustainability Symposium*, Energy Savings and Solid State Lighting Technology: How GREEN are LEDs?,* 2008.

Lightfair, *One Hundred Thousand Hour Lifetimes and Other LED Fairytales (Encore)*, 2009.

Lightfair, *A Lighting Specifier's Survival Guide to LED Technology*, 2009.

Pacific Gas & Electric Seminar, *Solid State Lighting—The truth, the whole truth and nothing but the truth*, 2009

Solid State Lighting Design Summit, *Common Sense Luminaire Design*, 2009

Solid State Lighting Design Summit, *Common Sense Luminaire Design in LA*, January 2010.

Better Buildings by Design Conference (VT), *Integrating LEDs into your Designs*, February 2010.

Pacific Gas & Electric Seminar, *LED Lighting—Technology and Applications*, May 2010

Lightfair, *LED Performance Guidelines: Good, Bad and How to Tell the Difference*, May 2010.

Lightfair, *Smoke, Mirrors and LEDs*, May 2010.

Neocon, *Unraveling the Mysteries of Solid-State Lighting*, June 2010.

Green Buildings NY, *Solid-State Lighting*, June 2010

SEBC, *Understanding Solid-State Lighting: Separating Fact from Hype*, July 2010

SPIE Tenth Annual Solid State Lighting Conference, *Physical constraints on the performance of LED lamp replacements for A-19, PAR-38 and MR-16 configurations*, August 2010.

GovEnergy, *Introduction to Solid-State Lighting: A Market in Motion,* August 2010

Hawaiian Energy Expo, *Avoiding uwe with LED lighting,* September 2010

IMARK, *Solid-State Lighting: Fad, Phenomenon, Future*, November 2010

Michigan SSL Association, *DOE Solid-State Lighting Initiatives, Resources and Observations*, November 2010

World Energy Engineering Congress, *Introduction to Solid-State Lighting*, December 2010

Electric West, *LED Lighting: Ready or Not?,* February 2011

MiaGreen, *LED Lighting Marketplace*, March 2011

OECM, *LED Lighting: A Practical Overview*, March 2011

Pacific Gas & Electric Seminar, *LED Lighting—Technology and Applications (Encore)*, April 2011

NAILD, *LED Lighting: Changing the Rules*, April 2011

AIA – New York, *LED Lighting – Worth the Risk?* May 2011

Lightfair, *LED Performance: Myths and Facts,* May 2011

Lightfair, *LED Lighting: The Real World*, May 2011

MEEA, *Reducing the Risk with LED Lighting*, July 2011

AIA-Westchester, *LED Lighting: Worth the Risk?* August 2011

GovEnergy, *Cutting Edge Lighting Technologies: OLEDs*, August 2011

GovEnergy, *LED Lighting Basics*, August 2011

IES Street and Area Lighting, *Standards: Creator's Responsibilities – Roadmap*, September 2011

National Building Museum, *LED Lighting: A Clash of Cultures*, September 2011

Facilities Decisions Conference, *Risk and Rewards of LED Lighting*, October 2011

National Electrical Contractors Association, *What You Don't Know About LED Lighting Can Hurt Your Business*, October 2011

Alaska Center for Appropriate Technologies, *A Guide to LED Lighting Basics*, November 2011

Pacific Gas & Electric Seminar, *LED Lighting—Technology and Applications (2012 Edition)*, March 2011

National Facilities Management & Technologies (NFMT), *Risk and Rewards of LED Lighting*, March 2012

NAILD, *LEDs and the Implications of a Semi-Conductor Lighting World*, April 2012

AIA (San Diego/San Francisco Chapters), *LED Lighting: Worth the Risk?* April 2012

Lightfair, *LED Performance: Myths and Facts – An Industry Update,* May 2012

DOE Market Introduction Workshop, *Solid-State Lighting 101*, July 2012

NECA, *The Hype vs. Reality of LED Luminaire Lifetimes*, October 2012

NFMT-West, *Risk and Rewards of LED Lighting*, October 2012

LightShow East, *Managing the Risks of LED Lighting*, October 2012

NALMCO, *LED Lighting: Some Things You Might Not Know*, October 2012

Design Lights Consortium, *Solid-State Lighting 101/SSL Advanced*, October 2012

NECA (Ohio Chapter), What You Don't Know About LED Lighting, October 2012

Portland General Electric, *LED Lighting: Changing All the Rules*, October 2012

IES (Portland Chapter), *Some Lesser Discussed Solid-State Lighting Topics*, October 2012

NRECA, *Solid-State Lighting – An Industry Update* (Webinar), October 2012

ArchEx, *LED Lighting – Worth the Risk?*, November 2012

Pacific Gas & Electric Workshop, *LED Lighting: Technology & Applications*, November 2012

Pacific Gas & Electric Workshop, *Hands-On LED Applications*, November 2012

NAILD, *LED Update – A Light Lunch with NAILD* (Webinar), December 2012

MSSLA, *LED Lighting: An Industry Update*, December 2012

NET (Touchstone Energy), *Cutting Edge Lighting Technologies*, January 2013

IES (New Jersey Chapter), *Some Lesser Discussed Solid-State Lighting Topics*, February 2013

NFMT, *Revealing some of LEDs Deep, Dark Secrets,* March 2013

AIA (Eastern Kentucky Chapter), *LED Lighting: Worth the Risk?,* March 2013

IMARK *LED Lighting: Saving Energy Can Be Complicated*, April 2013

Lightfair, *How LEDs Work*, April 2013

AIA (Denver Chapter), *LED Lighting: Managing the Risk*, May 2013

Portland General Electric, *LED Lighting: Changing All the Rules*, June 2013

Portland General Electric, *How LEDs are Changing The Lighting World, June 2013*

AIA (National Conference), *LED Lighting: Worth the Risk?*, June 2013

AIA (National Conference), *Lighting at a Crossroads*, June 2013

Design Lights Consortium, *Solid-State Lighting*, July 2013

US Green Buildings Council (Kentucky Chapter), *LED Lighting – Managing the Risk,*
September 2013

World Energy Engineering Congress, *Trends, Improvements and Issues as the Digital Lighting Revolution Evolves*, September 2013

NALMCO, *Where Does LED Lighting Belong in My Facility?* October 2013

LightShow West, *LED Lighting – How it has Changed, What to Expect Going Forward*, October 2013

ArchEx, *Why Things Go Wrong with LED Lighting,* November 2013

DOE Marketing Workshop, *Solid-State Lighting - The New Basics*, November 2013

Architecture Boston Expo, *LED Lighting – Worth the Risk?,* November 2013

LED Specifier Summit, *LED Reality Check: Today and Tomorrow*, November 2013

Michigan Advanced Lighting Conference, Research*, Design & Development: What's Next?*, December 2013

NAILD (Webinar), *The Eye, Color and LEDs*, **February 2014**

IESNJ, *LED Luminaires: Choosing Wisely*, February 2014

NFMT-East, *LED Lighting – Less Secrets; More Surprises,* March 2014

Pacific Gas & Electric Workshop, *LED Lighting: Technology & Applications*, March 2014

NAILD, *LED Lighting Has Arrived - Now What?*, April 2014

GrayBar, *LED Lighting Basics*, April 2014

Virginia Energy Purchasing Governmental Association, *LED Lighting: Choosing Wisely Amidst the Confusion*, May 2014

Lightfair, *LED 101*, June 2014

NeoCon, *New Features, New Cautions When Lighting Facilities With LEDs*, June 2014

AIA (National Conference), *Lighting at a Crossroads*, June 2014

IES (Regional), *LED Luminaires: Choosing Wisely*, July 2014

Design Lights Consortium, *Solid-State Lighting*, July 2014

USGBC (Kentucky Chapter), *What You Need to Know About LED Lighting,* August 2014

Ameren (Webinar), *LED Luminaires: Choosing Wisely,* September 2014

Boston Lights, *LED Lighting: Managing the Risk,* September 2014

LightShow South, *The Second Tsunami Coming to the Lighting Industry*, September 2014

NECA, *LEDs and Lighting Controls: The Second Tsunami,* September 2014

WEEC, *LEDs and Lighting Controls: Amazing Features and Complex Issues*, October 2014

NFMT-West, *LED Lighting – Less Secrets; More Surprises,* October 2014

NALMCO, *Troubleshooting Before You Get Into Trouble,* October 2014

LED Specifier Summit, *The LED Revolution Is Over – Now What?* October 2014

Architecture Boston Expo, *What Goes Wrong* With *LED Lighting and Why,* October 2014

ArchEx, *LED Lighting: Color, Control, Consequences,* November 2014

Michigan Advanced Lighting Conference*, Manufacturing Round Two: LEDs and Lighting Controls Merge*, November 2014

NFMT, *How to Select the Right LED Products for Your Facility* (Webinar), January 2015

NAILD, *LED Lighting for People* (Webinar), February 2015

NFMT-East, *An Introduction to OLEDs: The Other Solid-State Lighting Technology*, March 2015

ElectroExpo, *What You Must Know About LED Lighting*, March 2015

AEE (Washington DC Chapter), *LED Lighting: Choosing Wisely Amidst the Confusion*, April 2015

IES (NJ Chapter), *An Introduction to OLEDs: The Other Solid-State Lighting Technology*, April 2015

NAILD, *LEDs and Lighting Controls: What it can Mean for Your Business*, April 2015

CxEnergy, *Why Things Go Wrong with LED Lighting*, April 2015

Lightfair, *LED 101 and a Little More*, May 2015

AEE EMC, *LED Lighting: Color, Control and Consequences*, June 2015

NeoCon-15, *LED Lighting and the Second Tsunami*, June 2015

BOMA, *LEDs and Lighting Controls: A Combination of Promise and Risk*, June 2015

DLC-15, *SSL-101: New Rules for Lighting*. August 2015

AEE WEEC, *People–The Least Discussed Element of LED Economics*, October 2015

NECA-15, *OLEDs: An Introduction to the Other SolidState Lighting Technology*, October 2015

AIA-Ohio Regional Conference, *The Other Solid-State Lighting Technology: Comparing LEDs and OLEDs*, October 2015

LightShow West-15, *OLEDs: The "Other" Solid-State Lighting Technology*, October 2015

NFMT Orlando, *An Introduction to OLEDs – The Other Solid-State Lighting Technology*, October 2015

Michigan Advanced Lighting Conference, *The Revolution of SSL Manufacturing*, October 2015

ArchEx-15, *OLEDs - The Other Solid-State Lighting Technology,* November 2015

Pacific Gas & Electric Workshop, *LED Lighting: Technology, Applications and Specifications*, November 2015

LED Specifier Summit-15, *LED Economics: The Cost of Lighting for People*, November 2015

USGBC-Nevada Chapter, *What You Need to Know About LED Lighting*, January 2016

Better Buildings by Design, *An Introduction to OLEDs: The Other Solid-State Lighting Technology*, February 2016

IES (NJ Chapter), *LED Lighting and the Second Tsunami*, February 2016

NFMT-East, *LEDs and Lighting Controls: Exciting Future and Some Cautions*, March 2016

NALMCO, *An Introduction to OLEDs: The Other Solid-State Lighting Technology*, April 2016

NAILD, *Predicting Performance of LED Products*, April 2016

CxEnergy, *OLEDs – The Other Solid-State Lighting Technology*, April 2016

Lightfair, *LED/SSL 101 and a Lot More, April 2016*

High Performance Buildings, *LEDs, Lighting Controls and the Economics of People*, May 2016

US Green Buildings Council (AZ Chapter), *What You Need to Know About LED Lighting*, June 2016

NAESCO, *LEDs and the Economics of People*, June 2016

NeoCon, *OLEDs: The Other Solid-State Lighting Technology*, June 2016

US Department of Agriculture (webinar), *LEDs and Lighting Controls: Things to Watch Out For*, July 2016

AIA-Kentucky, *Time to Relearn Everything About Lighting*, September 2016

World Energy Engineering Congress, *Simplicity – The Key to Successful Solid-State Lighting and Control Systems*, October 2016

International Facilities Management Association, *OLEDs – What You Should Know About the Other Solid-State Lighting Technology*, October 2016

National Electrical Contractors Association, *How the Second Lighting Tsunami Will Change Your Business*, October 2016

International Association of Lighting Management Companies (Fall), *LEDs and Lighting Controls: The Second Tsunami Coming to the Industry*, October 2016

National Facilities Management Technologies (Webinar), *How Combining LEDs and Lighting Controls Will Change Lighting Forever*, October 2016

Boston Lights, *Beyond LEDs – Prepare for the Second Tsunami in Lighting*, September 2016

National Facilities Management Technologies (Fall), November 2016

ArchEx, *LEDs and Lighting Controls: The Second Tsunami in Lighting*, November 2016

LED Specifier Summit, *LEDs and Lighting Controls: Prepare for the Second Tsunami in Lighting*, November 2016

NFMT (East) 17, *A Simple Guide to Solid-State Lighting Standards*, March 2017

Lightfair-NYC Special Seminar, LEDs and the Economics of People, *A Simple Guide to Solid-State Lighting Standards*, March 2017

NECA (MN Chapter), *What You Don't Know About LED Lighting*, March 2017

Emerging Technologies Summit, *Solid-State Lighting: Where We Are and Where We're Going,* April 2017

Lightfair-17, *LED / SSL 101 – And a Whole Lot More (Workshop), May 2017*

Lightfair-17, *The Future of Lighting (Seminar)*, May 2017

High Performance Buildings*, What Goes Wrong with LED Lighting and Why*, May 2017

NFPA, *Visual Notification Appliances Using LED Technology,* June 2017

PGE-17, *The Future of Lighting and Controls*, June 2017

NeoCon-17, *The Future of Lighting*, June 2017

WEEC-17, *Education and Complexity: Avoiding a Failing Grade for your Smart Buildings,* September 2017

LightShow West-17, *Solid-State Lighting Standards – How Well Do They Predict Product Performance, October* 2017

ArchEx-17, *How Lighting Will Be Used in the Future*, November 2017

NFMT Orlando-17, *The Future of Lighting,* November 2017

LED Specifier Summit-17, *How Lighting Will be Used in the Future*, November 2017

Better Buildings by Design-18, *The Future of Lighting*, February 2018

NAILD-18, The Lighting Industry: *Today's Landscape and Tomorrow's War for the Ceiling*, February 2018

ElectroExpo-18, *The Future of Lighting*, March 2018

NFMT-18, *The Role of Lighting in Tomorrow's Facilities*, March 2018

Hawaii Energy-18, *Solid-State Lighting and Lighting Controls Workshop for Architects and Design Professionals*, (2 days) March 2018

NeoCon-18, *Can LED Standards Predict Product Performance in the Field*, June 2018

Lightfair-18, *Solid-State Lighting 101*, May 2018

Boston Lights-18, *The Future of the Lighting Industry*, November 2018

NECA (Chicago Chapter)-19, Tomorrow's Lighting Industry: What You Need to Know to Thrive, January 2019

Lightfair-19, LEDs and Lighting Controls 101, May 2019

Note: Presentations in blue given on behalf of the US Department of Energy