“Is there an easy way to keep out the bad stuff?

“How do we know what won’t disappoint?”.

Mark Lien LC, HBDP, CLMC, CLEP

LEED Accredited Professional BD&C

Illuminating Engineering Society

mlien@ies.org

The IES Promotes the Art and Science of Quality Lighting Through Technical Standards and Recommendations

Mission Statement:

The IES seeks to **improve the lighted environment** by bringing together those with lighting knowledge and by translating that knowledge into actions that benefit the public.

Vision Statement:

The IES will build upon a century of excellence to create the premier lighting community **dedicated to promoting the art and science of quality lighting** to its members, allied professional organizations, and the public.

Quality Lighting Requires an Understanding of…

- Lighting products
- The application
- Lighting design
- Metrics
- User needs
- User preferences

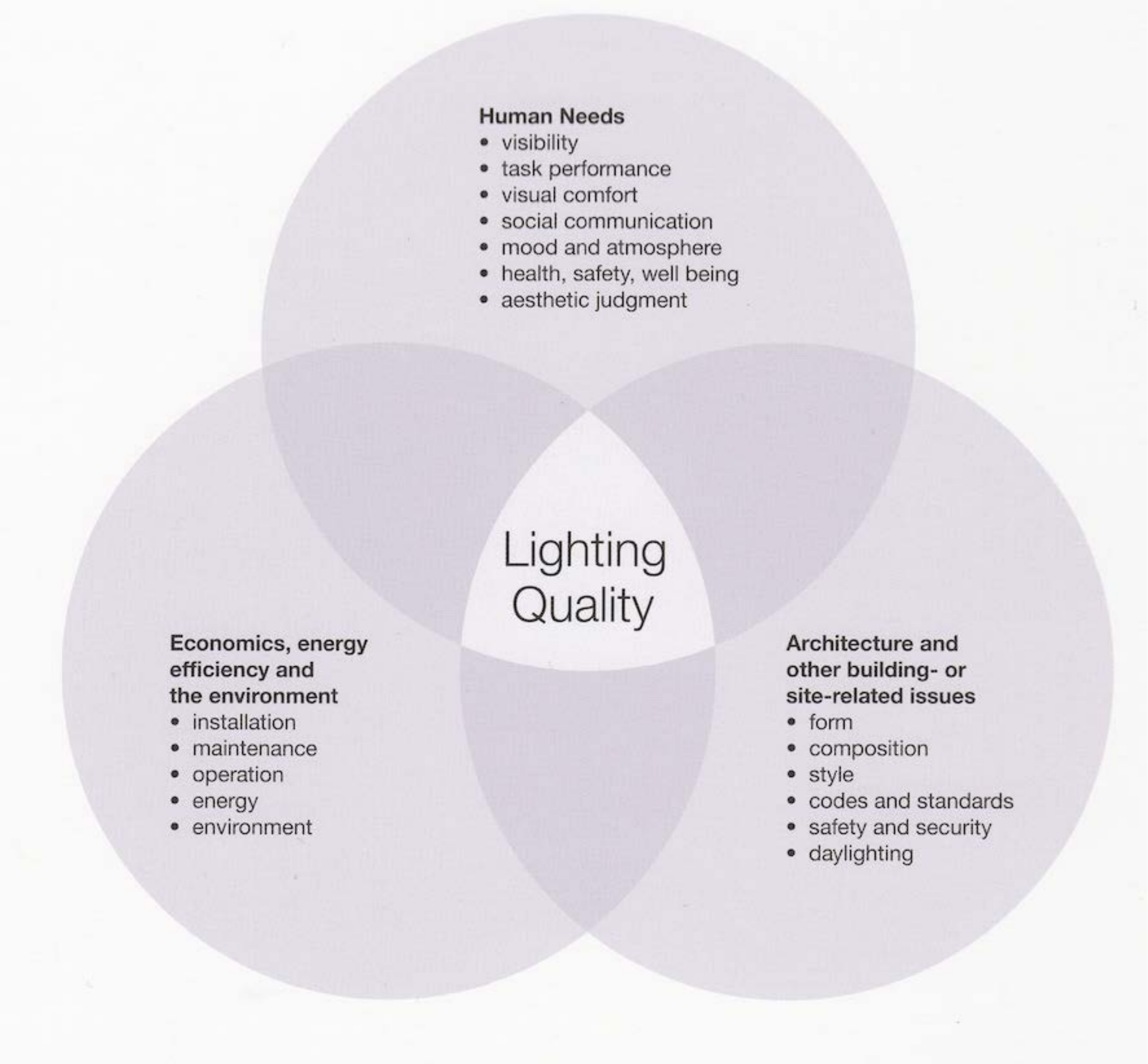
A Well Intended Narrow Focus Impacts Quality Lighting

- **CRI** (not synonymous with quality)

- **CCT** (can be manipulated and is not a good metric for reducing “blue” light)

- **Energy** (90.1 is a joint document with IES referencing RP’s with LPD’s verified-other regulations and associations do not have lighting quality as a primary consideration

Considerations of Lighting Quality



Achieving good quality lighting depends upon context

Recommended Practices / ANSI Standards*

RP-1-12	Office Lighting*
RP-3-13	American National Standard Practice on Lighting for Educational Facilities*
RP-4-13	Library Lighting
RP-5-13	Recommended Practice for Daylighting Buildings
RP-6-15	Sports and Recreational Lighting
RP-8-14	Roadway Lighting*
RP-16-10	Nomenclature and Definitions for Illuminating Engineering*
RP-20-14	Lighting for Parking Facilities
RP-22-11	Tunnel Lighting*
RP-27.1-15	**Photobiological Safety for Lamp & Lamp Systems-General Requirements***
RP-27.2-00	Photobiological Safety for Lamp & Lamp Systems-Measurement Techniques* (Reaffirmed 2011)
RP-27.3-07	Photobiological Safety for Lamp & Lamp Systems-Risk Group Classifications & Labeling*
RP-28-07	Lighting and the Visual Environment for Senior Living*
RP-29-06	Lighting for Hospital and Health Care Facilities*
RP-30-96	Museum and Art Gallery Lighting* (Reaffirmed 2008)
RP-31-14	Recommended Practice for the Economic Analysis of Lighting
RP-33-14	Lighting for Exterior Environments
RP-36-15	IES/NALMCO Recommended Practice for Lighting Maintenance
RP-37-15	**Outdoor Lighting for Airport Environments**

*Indicates ANSI Approved Standard: **

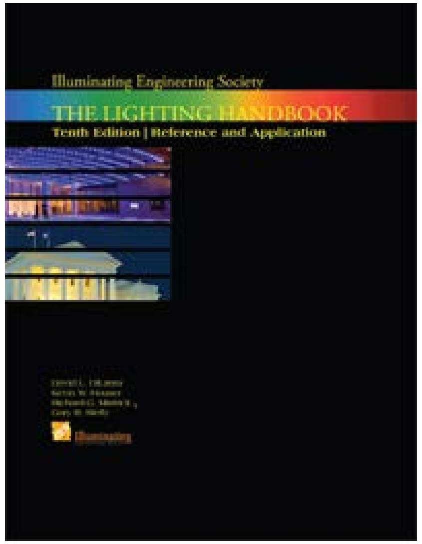
Design Guides, Guidelines, Energy Management, Technical Memoranda

DG-3-00	Application of Luminaire Symbols on Lighting Design Drawings* (Reaffirmed 2015)
DG-4-14	Design Guide for Roadway Lighting Maintenance
DG-10-12	Choosing Light Sources for General Lighting
DG-16-05	Guidelines for Professional Filming or Photographing Works of Art in Museums
DG-17-05	Fundamentals of Lighting for Videoconferencing
DG-18-08	Light + Design: A Guide to Designing Quality Lighting for People and Buildings
DG-19-08	Design Guide for Roundabout Lighting
DG-20-09	Stage Lighting: A Guide to the Planning of Theatres and Auditoriums
DG-21-15	Design Guide for Residential Street Lighting
DG-22-12	Sustainable Lighting: An Introduction to the Environmental Impacts of Lighting
DG-23-14	Design Guide for Toll Plazas
DG-25-12	Design Guide for Hotel Lighting
DG-28-15	Guide for Selection, Installation, Operations and Maintenance of Roadway Lighting Control Systems*
DG-29-11	The Commissioning Process Applied to Lighting and Control Systems
G-1-03	Guideline on Security Lighting for People, Property, and Public Spaces
G-2-10	Guideline for the Application of General Illumination ("White") Light - Emitting Diode (LED) Technologies
LEM-3-13	IES Guidelines For Upgrading Lighting Systems In Commercial and Institutional Spaces
LEM-7-13	Lighting Controls for Energy Management
TM-1-12	The Five Lighting Metrics
TM-10-00	Addressing Obtrusive Light (Urban Sky Glow and Light Trespass) in Conjunction with Roadway Lighting (Reaffirmed 2011)
TM-11-00	Light Trespass: Research, Results and Recommendations (Reaffirmed 2011)
TM-12-12	Spectral Effects of Lighting on Visual Performance at Mesopic Light Levels
TM-15-11	Luminaire Classification System for Outdoor Luminaires
TM-18-08	Light and Human Health: An Overview of the Impact of Optical Radiation on Visual, Circadian, Neuroendocrine, and Neurobehavioral Responses
TM-21-11	Projecting Long Term Lumen Maintenance of LED Light Sources
TM-23-11	Lighting Control Protocols
TM-24-13	An Optional Method for Adjusting the Recommended Illuminance for Visually Demanding Tasks within IES Illuminance Categories P through Y Based on Light Source Spectrum
TM-25-13	Ray File Format for the Description of the Emission Property of Light Sources
TM-26-15	Methods for Projecting Catastrophic Failure Rate of LED Packages
TM-27-14	IES Standard Format for the Electronic Transfer of Spectral Data
TM-28-14	Projecting Long-Term Luminous Flux Maintenance of LED Lamps and Luminaires
TM-30-15	IES Method for Evaluating Light Source Color Rendition

"Select a CRI rating >80 in spaces where people communicate with each other regularly, or if food is involved; this includes offices, conference rooms, schools, restaurants and cafeterias." DG-18 page 45

Lighting Measurement Testing and Calculation Guides & Handbook

LM-9-09	Electrical and Photometric Measurement of Fluorescent Lamps
LM-15-03	Reporting General Lighting Equipment Engineering Data for Indoor Luminaires (Reaffirmed 2011)
LM-20-13	Photometry of Reflector Type Lamps
LM-28-12	IES Guide for the Selection, Care and Use of Electrical Instruments in the Photometric Laboratory
LM-40-10	Life Testing of Fluorescent Lamps
LM-41-14	Approved Method for Photometric Testing of Indoor Fluorescent Luminaires
LM-45-15	Electrical and Photometric Measurements of General Service Incandescent Filament Lamps
LM-46-04	Photometric Testing of Indoor Luminaires Using HID or Incandescent Filament Lamps (Reaffirmed 2012)
LM-47-12	Life Testing of High Intensity Discharge (HID) Lamps
LM-49-12	Life Testing of Incandescent Filament Lamps
LM-50-13	Photometric Measurement of Roadway and Street Lighting Installations
LM-51-13	Electrical and Photometric Measurement of High Intensity Discharge Lamps
LM-52-03	Photometric Measurements of Roadway Sign Installations (Reaffirmed 2014)
LM-54-12	IES Guide to Lamp Seasoning
LM-58-13	IES Approved Method for Spectroradiometric Measurement Methods for Light Sources
LM-61-06	Identifying Operating Factors for Installed High Intensity Discharge Luminaires (Reaffirmed 2014)
LM-62-06	Laboratory or Field Thermal Measurements of Fluorescent Lamps and Ballasts in Luminaires (Reaffirmed 2015)
LM-63-02	Standard File Format for Electronic Transfer of Photometric Data* (Reaffirmed 2008)
LM-65-14	Life Testing of Single-Based Fluorescent Lamps
LM-66-14	Electrical and Photometric Measurements of Single-Based Fluorescent Lamp
LM-71-14	Photometric Measurement of Tunnel Lighting Installations
LM-72-03	Directional Positioning of Photometric Data (Reaffirmed 2010)
LM-73-04	Photometric Testing of Entertainment Luminaires Using Incandescent Filament Lamps or High Intensity Discharge Lamps (Reaffirmed 2009)
LM-74-05	Standard File Format for the Electronic Transfer of Luminaire Component Data
LM-75-01	Goniophotometer Types and Photometric Coordinates (Reaffirmed 2012)
LM-77-09	Intensity Distribution Measurement of Luminaires and Lamps Using Digital Screen Imaging Photometry
LM-78-07	Approved Method for Total Luminous Flux Measurement of Lamps using an Integrating Sphere Photometer
LM-79-08	Electrical and Photometric Measurements of Solid State Lighting Products
LM-80-15	IES Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules*
LM-81-10	Photometric Testing of Skylights and Tubular Daylighting Devices Under Hemispheric Sky Conditions
LM-82-12	Characterization of LED Light Engines and LED Lamps for Electrical and Photometric Properties as a Function of Temperature
LM-83-12	IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE)
LM-84-14	Measuring Luminous Flux and Color Maintenance of LED Lamps, Light Engines, and Luminaires
LM-85-14	Electrical and Photometric Measurements of High-Power LEDs
LM-86-15	IES Approved Method: Measuring Luminous Flux and Color Maintenance of Remote Phosphor Components



IES Strategic Research Plan 2016

Goal 1: Refine Knowledge about Lighting and Visual Processes

Goal 2: Understand the Impact of Light Exposure on Human Health

Goal 3: Foster the Integration of Lighting into the Holistic Built Environment

Goal 4: Demonstrate the Value of Quality Lighting

Strategic Research Plan 2016 Guiding Assumptions

- Based primarily upon extensive experience in their respective fields, the 2016 SRAP developed the following consensus list of assumptions about lighting (and related topics that will impact lighting) for the period of time from 2016 through 2020. These assumptions, together with surveys and other resources described in the next section of this report, helped shape final development of the strategic goals in the 2016 Plan:
- LEDs will be the dominant light source.
- Controls linked to LEDs that can adjust their spectrum and intensity will be seen more in some markets than others. For example, roadway lighting, hospitality and domestic lighting will be major applications. In other markets, controls will still be concerned primarily with energy efficiency via response to occupancy and daylight.
- Over the next five years there will become a greater awareness of the limitations of V(λ) as a primary predictor of physiological and behavioral responses.
- **Pressure for more energy savings and reducing light pollution will continue to grow. For interior lighting, this means further conflict between lighting/daylighting and other building systems, requiring clear evidence to support lighting requirements in support of integrated lighting quality in the face of pressure to reduce installed lighting power. Similarly, exterior lighting will increasingly require evidence to support requirements.**
- The primary way to get new lighting design procedures into practice will be to see them implemented in software that is widely used by designers and specifiers.
- The mechanisms involved in the effects of light exposure on health will be revealed to be more complicated than previously thought, and the practical applications will be limited in this time frame.
- There will be more night work, and therefore a push to do more with simulated daylighting for tasks that are typically done at night.
- Control algorithms and applications will become more fine-grained and ubiquitous.
- Funding for purely lighting research will be limited, but the best route to improving such funding will be to partner with other disciplines.
- Post-occupancy evaluations/research/surveys of the built environment (field studies) are increasing, which will likely be important in the arenas of lighting quality and improved design over time.
- Feedback from luminaires and connected systems will enable a revolution for engagement with users.

Goal 1: Refine Knowledge about Lighting and Visual Processes

We light the built environment primarily to ensure that **human goals** are met, and most of the time this means enabling people to see and do, without being distracted or suffering discomfort. Although we know much about how to ensure that small, achromatic details are visible by using knowledge about luminance, contrast, target size, viewing time, and viewer age, **there remain outstanding questions**.

1.1 Decreasing Interference

Important Research Questions:

Glare: As new light sources and systems are developed, what are the effects of these on discomfort and how can we improve predictive models of glare to account for these effects?

Flicker: What are the physiological and psychological effects of light instability, particularly for people with enhanced sensitivity?

Pattern: What are the types of luminance patterns that cause discomfort or disrupt visual processing?

1.2 Enhancing Visibility

Background:

Existing models of visual performance have been built on achromatic tasks and have assumed that there is no effect of light source spectrum on visual performance at varying adaptation luminances. The omission of color information made sense when, for example, much office work was performed with black print on a white background. Today, color printers and self-luminous colored displays are ubiquitous, so these **incomplete models merit re-examination**.

Another limitation of existing models of visual performance is that they are all devoted to on-axis work, i.e. foveal performance. However, there are tasks, such as driving, where off-axis detection is required. The spectral response of the visual system is very different from V(λ) off axis and in the mesopic state. **There is already evidence that different light spectra influence off axis detection by drivers but there is no comprehensive model of the performance of such task**s.

LED technology allows for the construction of almost any desired light spectrum but **what the optimum spectrum is for different purposes remains to be determined.**

Enhancing Visibility

Important Research Questions:

On-axis performance: What is the role of light spectrum in visual performance for on-axis tasks, both photopic and mesopic? Can existing models of on-axis visual performance be expanded to include the effects of light spectrum?

Off-axis performance: Can a model of off-axis detection be constructed that allows for the effects of light level, light spectrum and eccentricity?

Color fidelity: How good does color fidelity need to be in order to provide the desired appearance of objects and people under both photopic and mesopic adaptation?

Goal 3: Foster the Integration of Lighting into the Holistic Built Environment

Important Research Questions:

Daylighting

- Quality: How can quality daylighting be characterized for different types of user groups and spaces?

- Balance: How can the balance among the percent of fenestration, daylight management, thermal impact, and visual objectives (view, glare reduction) be optimized for various applications?

Controls

- **Spectral Tuning: What are the benefits of tuning the color of light (including white light) for various applications?**

- Task Tuning: What are the parameters under which task tuning and personalization provide benefit?

Progress Report 2016 – Color Tuning is Trending

- Warm dimming
- Tunable color arrays
- Day and night color temperature lamps
- CCT luminaire ranges with various sensors
- “Intelligent” control systems for color adaptation

Impediments to Quality Lighting to be Addressed

- **Complexity** - the ability for specifiers and consumers to differentiate performance characteristics is increasingly difficult

- **Lack of Federal minimum standards** (2000 hour LED lamps, etc)

- **Enforcement** – so all play by the same rules/deceitful marketing

- **Ignorance** of the need to meet regulatory requirements

- Internet & Telecom Companies that think “**Lighting is Easy**”

“Is there an easy way to keep out the bad stuff?

“How do we know what won’t disappoint?”.

Mark Lien LC, HBDP, CLMC, CLEP

LEED Accredited Professional BD&C

Illuminating Engineering Society

mlien@ies.org