National Electrical Contractors Association
NECA 2011 Convention & Trade Show
San Diego Convention Center

ELECTRI International
Energy Roadmap For Electrical Contractors

Lighting Retrofits: Benefits Beyond Energy Efficiency

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The University of Kansas
October 23, 2011

What Is Today's Growth Market For ECs?

Energy Services

Energy Services Build On The EC's Design-Build And Service Capabilities

Energy Services

Lighting & Lighting Controls

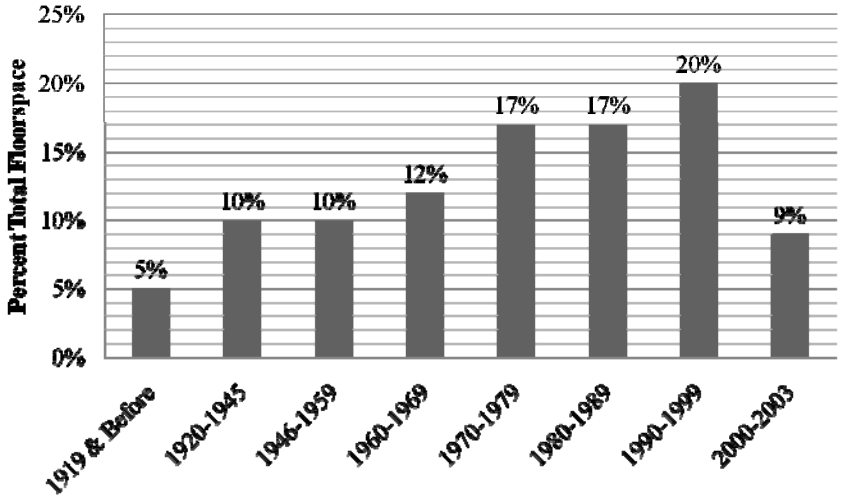
- Conservation (Lighting Controls)
- Efficiency (Light Source)
- Supply (Artificial Or Daylighting)
- Reliability (Emergency Lighting)

U.S. Building Statistics

- Buildings number about:
  - 76 million residential
  - 5 million commercial
- Buildings consume about:
  - One third of energy
  - Two thirds of electricity
- Buildings account for about:
  - 35% carbon dioxide emissions
  - 49% sulfur dioxide emissions
  - 25% nitrous oxide emissions
  - 10% particulate emissions

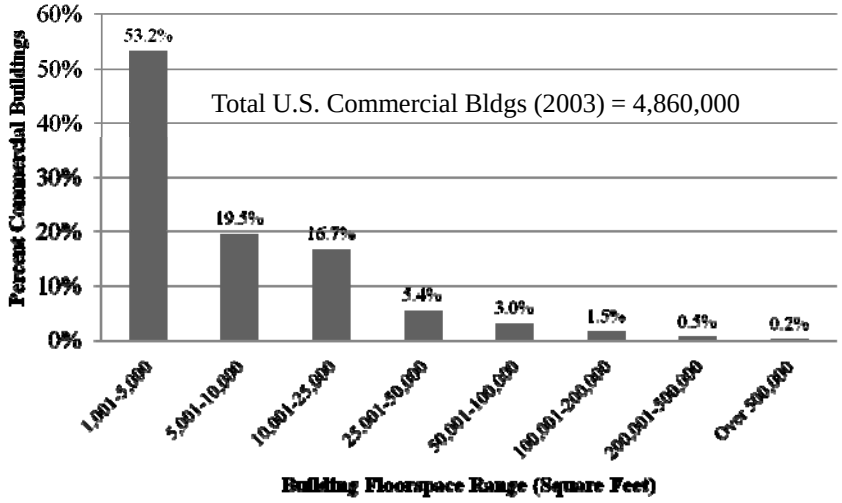
Data Source: U.S. Department of Energy

U.S. Commercial Building Vintage



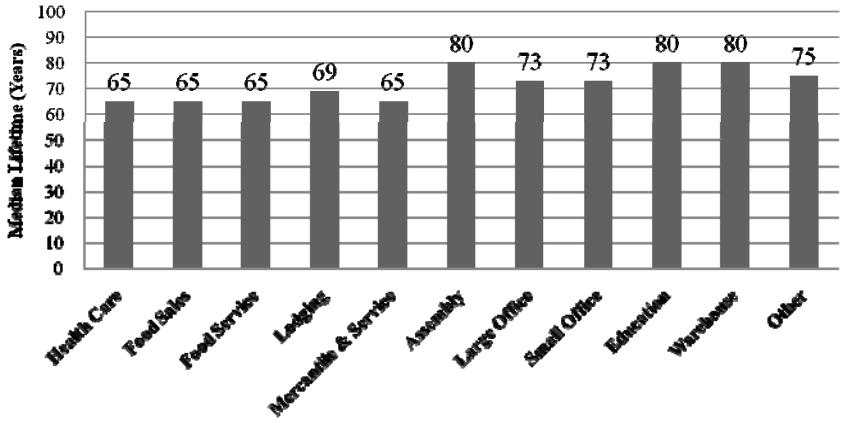
Source: EIA, 2003 Commercial Buildings Energy Consumption Survey: Building Characteristics Tables, October 2006, Table A1, p 1-2.

U.S. Commercial Buildings By Size



Source: EIA 2003 Commercial Buildings Energy Consumption Survey: Building Characteristics Tables, October 2006, Table A1, p. 1-2.

U.S. Commercial Building Median Lifetime



Median Lifetime Of Commercial Buildings = 70-75 Years

Source: Department of Energy, *Buildings Energy Data Book*, Table 3.2.7, October 2009.

EC Lighting Retrofit Market

Lighting Retrofit Market Is Existing Buildings

Lighting Retrofit Market Is "So Over" ... Or Is It?

- New & Different Building Use
- New Understanding Of Lighting & IEQ
- New Lighting Performance Criteria
- New Lighting Design Methods
- New Light Sources
- New Luminaires
- New Lighting Controls
- New Installation Methods

New "Low-Hanging Fruit" But Must Be Marketed

Re-Light Inefficient Buildings

According to the U.S. Department of Energy (DOE) there are over five million non-residential buildings in the country and more than 75 percent of them were built before the energy-efficient lighting technologies we have today were available. By utilizing new lamp/ballast efficiencies, we could eliminate a large portion of $50 billion wasted each year on outmoded lighting systems.

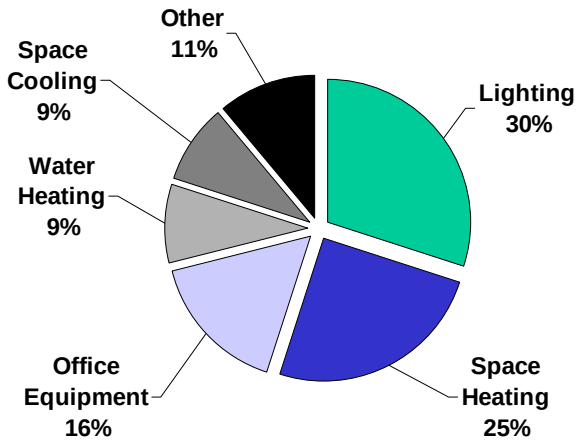
Willard L. Warren, "Energy Advisor," *Lighting Design + Application* (*LD+A*), Illuminating Engineering Society of North America, April 2009, pp. 18-22.

Commercial Building Non-Energy Lighting Retrofit Goals & Outcomes

- Increased Employee Productivity
- Reduced Employee Absenteeism
- Reduced Employee Turnover
- Improved Employee/Customer Satisfaction
- Increased Revenue
- Reduced Errors & Rework
- Increased Safety & Accident Prevention
- Enhanced Business Public Image

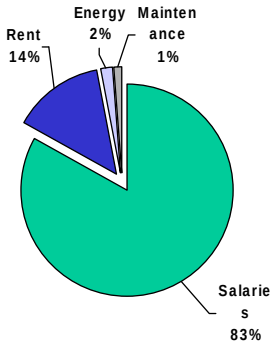
Non-Energy Benefits Difficult To Quantify

Commercial Building Energy Use



Data Source: U.S. Department of Energy, Energy Energy Efficiency & Renewable Energy (EERE) Building Technologies Program

Comparing People, Energy, & Other Costs Of Operating An Office Building



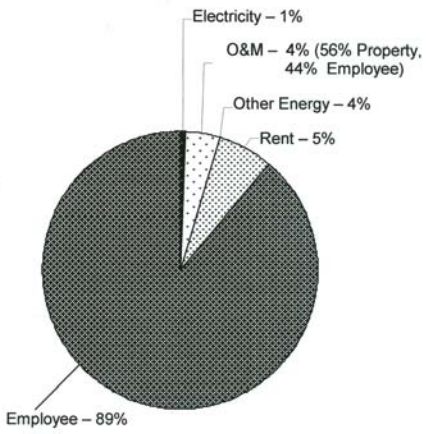
Salaries	83%
Rent	14%
Energy	2%
Maintenance	1%

Data Source: Paul Hawken, Amory Lovins, & L. Hunter Lovins, *Natural Capitalism: Creating The Next Industrial Revolution, Little*, Brown and Company, 1999, p.90.

People Spend 90 Percent Of Time In Buildings

State Employee-Occupied Office Building Costs

California Department of General Services Real Estate Division

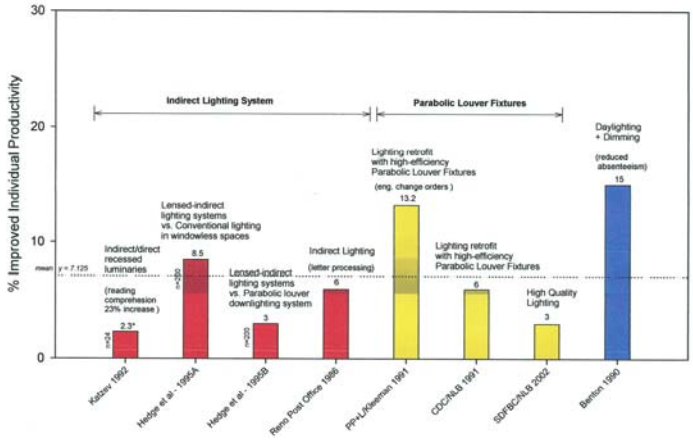


... if green design measures can increase productivity by 1%, this would over time, have a fiscal impact roughly equal to reducing property costs by 10%.

Greg Kats

Greg Kats, *The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force*, October 2003, pp. 54-55.

Relating Lighting To Improved Performance



Eight studies measured the relationship between increased lighting control and productivity, finding productivity gains from 3% to 34% with a mean of 7.1%.

Greg Kats, *The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force*, October 2003, p. 64. (Data from Vivian Loftness, BIDS™, Carnegie Mellon University, Department of Architecture, February 20003.)

Potential Impact Of NYC Increased Employee Productivity

A growing body of case study evidence supports the theory that high performance buildings – those with better lighting, improved ventilation, and fewer air contaminants – are beneficial to employee productivity. Although precise methods of measuring these costs and benefits are still in development, the potential savings in development, the potential savings is significant. In New York City, annual benefits are still in development, annual agency personnel costs vary from $200-300 per square foot for administrative agencies, to over $500 per square foot for uniform agencies. A 1% increase in productivity could be worth $2.00 to $5.00 per square foot, or up to $500,000 a year for a 100,000 square foot building.

City of New York Department of Design and Construction, *High Performance Building Guidelines*, April 1999, p. 21.

Possible Reduced Absenteeism Due To Improved Lighting Quality

- Reduced Eye Strain
- Reduced Headaches
- Improved Ergonomics
- Reduced Fatigue
- Increased Job Satisfaction

Separate Ambient & Task Lighting

Potential Impact Of NYC Reduced Employee Absenteeism

Investing in high performance buildings can also help insure against predictable losses in productivity. The New York City personnel services budget is about $18.4 billion per year. Total equivalent sick leave taken is about 9 days a year. If a healthier work environment reduced the average number of employee sick days taken each year to 8 or 7, the City could realize benefits of $55 million to $110 million each year.

City of New York Department of Design and Construction, *High Performance Building Guidelines*, April 1999, p. 21.

Potential Impact Of NYC Reduced Employee Turnover

Loss of productivity and additional personnel costs occasioned by employee turnover can also be significant, though environmental conditions are only some of the many factors that can contribute to the turnover problem. If investing in a better work environment helped the City increase retention by only 1%, the avoided cost of personnel turnover could exceed $120 million per year.

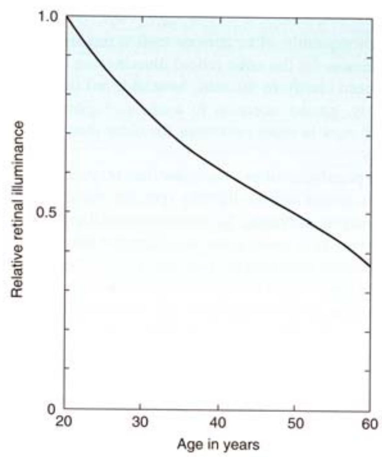
City of New York Department of Design and Construction, *High Performance Building Guidelines*, April 1999, p. 21.

Quantity Of Light

- Recommended light levels published by the IESNA are consensus values based on typical tasks performed by typical people.
- IESNA system of establishing illumination levels recognizes the following:
  - Requirement for light increases with age.
  - Speed and accuracy that a visual task is performed impacts the amount of light needed.
  - Tasks with low contrast require more light than tasks with high contrast.

Light Quantity ≠ Light Quality

Age & Required Illuminance



Source: The IESNA Lighting Handbook
Figure 10-13

- Visual requirements of older people are significantly different from younger people.
- As people age:
  - Thickening of the yellow crystalline lens which reduces the amount of light reaching the retina, increases scatter within the eye, and the range of distances that can be properly focused.
  - Reduction of pupil size decreasing the amount of light reaching the retina.
- Retinal illuminance of a 60-year-old person is about a third of that of a 20-ear-old person.

IESNA Lighting Handbook
Recommended Task Illuminances

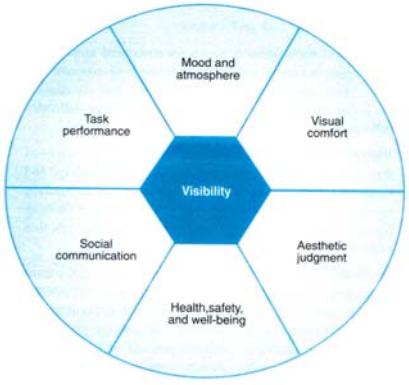
I. INTERIOR — Very Important | Important | Somewhat important | Blank = Not important or not applicable

LOCATIONS AND TASKS	Design Issues	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)[a]	Illuminance (Vertical)	Category or Value (lux)[a]	Notes on Illuminance - see end of section	Reference Chapter(s)
Offices (13)																									Ch. 11
Filing (see Reading)																					E		C		
General and private offices (see Reading)																									
Open plan office																									
Intensive VDT use																			(14, 15)		D		B		
Open plan office																									
Intermittent VDT use																			(14, 15)		E		B		
Private office																					E		B		
Libraries (see Libraries)																									
Lobbies, lounges, and reception areas																					C		A		
Mail sorting																					E		A		
Copy rooms																					C		A		

IESNA Lighting Handbook
Illuminance Categories

CAT	LOCATION/TASK REQUIREMENTS	ILLUMINANCE	
		FC	LX
A	Public spaces.	3	30
B	Simple orientation for short visits.	5	50
C	Working spaces where simple visual tasks are performed.	10	100
D	Performance of visual tasks of high contrast and large size.	30	300
E	Performance of visual tasks of medium contrast and small size, or visual tasks of low contrast and large size.	50	500
F	Performance of visual tasks of low contrast and small size.	100	1000
G	Performance of visual tasks near threshold.	300-1000	3000-10000

Lighting Quality: Human Needs



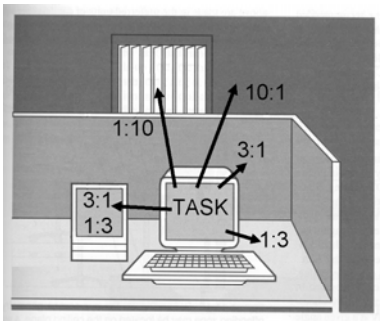
- Task Performance
- Mood & Atmosphere
- Visual Comfort
- Aesthetic Judgment
- Health, Safety, & Well-Being
- Social Communication

Source: *The IESNA Lighting Handbook*
Figure 10-2

Criteria Important For A High-Quality Visual Environment

- Appearance of Space and Luminaires
- Color Appearance & Color Contrast
- Daylighting Integration & Control
- Direct Glare
- Flicker & Strobe
- Light Distribution On Surfaces
- Luminances Of Room Surfaces
- Modeling Of Faces & Objects
- Point(s) Of Interest
- Reflected Glare
- Shadows
- Source/Task/Eye Geometry
- Sparkle/Desirable Reflected Highlights
- Surface Characteristics
- System Control & Flexibility
- Illuminance
  - Horizontal
  - Vertical
- Special Considerations:
  - Intrinsic Materials Characteristics
  - Uniformity Of Light Distribution On Task Plane
  - Light Pollution/Trespass
  - Luminaire Noise
  - Peripheral Detection
  - Other Special Considerations

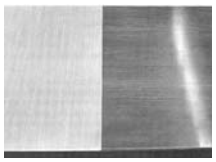
Lighting Quality Issues &Vision



Luminance Ratios

Veiling Reflections

Direct Glare



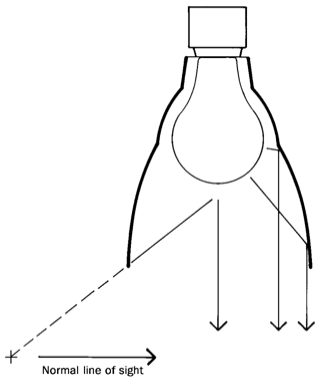
Reflected Glare

Glare

Glare: What Is It?

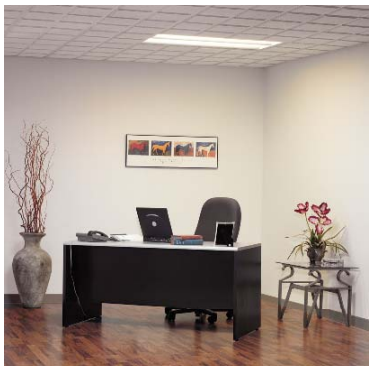
Glare is excessive contrast in the visual environment that is distracting or annoying.

Reduce Glare By Luminaire Optics



Change Direction Of Beam To Control Direct Glare

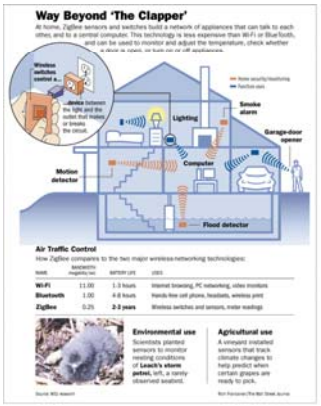
Visual Comfort Probability



- **Visual comfort probability (VCP)** rating is defined as *the percentage of people who, if seated in the least desirable location in an office work space, will find a lighting installation comfortable*.
- A VCP of 70 or more is recommended for general office use and 80 or more is recommended for office areas using computers. VCP is typically found in manufacturer's literature.

Visual Comfort Results From Reducing Glare And Distracting Luminance In The Field Of View

ZigBee (IEEE Std 802.15.4) Wireless Bldg Controls



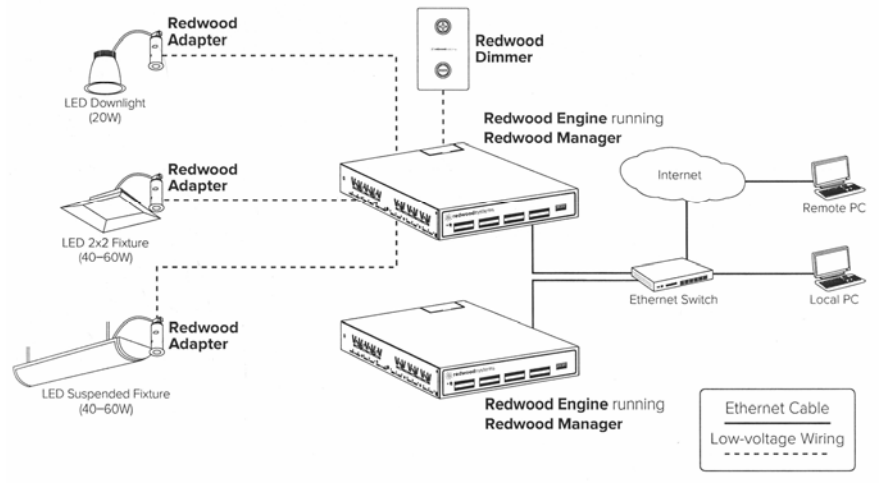
Self-Organizing, Self-Healing Mesh Network

Wireless Lighting Controls For Retrofit Applications

Lutron

Leviton

Redwood Systems Platform Application Diagram

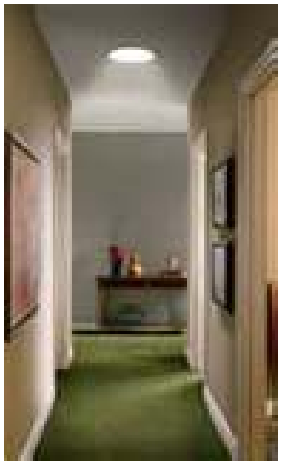


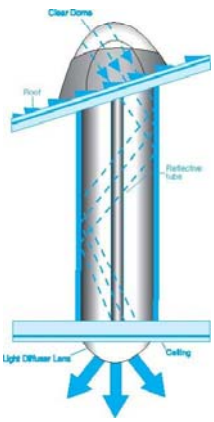
Source: *www.redwoodsystems.com*

Interior Daylighting Systems
Daylighting System Retrofit

Hybrid Solar Lighting Systems Using Solar Energy To Illuminate The Inside Of A Building Using Fiber Optics To Distribute The Sunlight May Be Eligible For Solar Energy Tax Credit

Interior Daylighting Systems
Tubular Skylights Retrofit





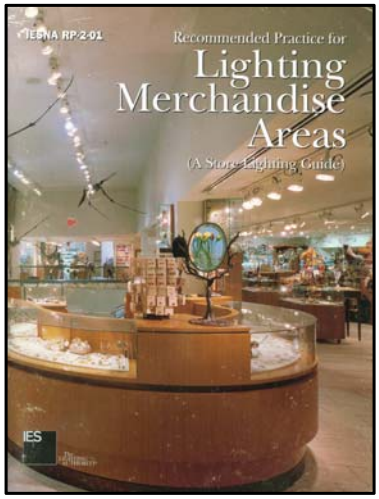
Health Care Lighting Non-Energy Lighting Retrofit Goals & Outcomes

The Sky Factory (*www.theskyfactory.com*)

Retail Store Non-Energy Lighting Retrofit Goals & Outcomes

- Improve Employee Productivity
- Increase Customer Satisfaction
- Increase Length Of Customer Visit
- Increase Revenue Per Square Foot
- Create An Interesting Space That Draws Customers In & Directs Through Store
- Assist Customers In Merchandise Appraisal
- Increase Customer Transaction Accuracy
- Reduce Returns & Exchanges

Illuminating Engineering Society of North America
Recommended Practice for Lighting Merchandise Areas: A Store Lighting Guide (IESNA RP-2-01)

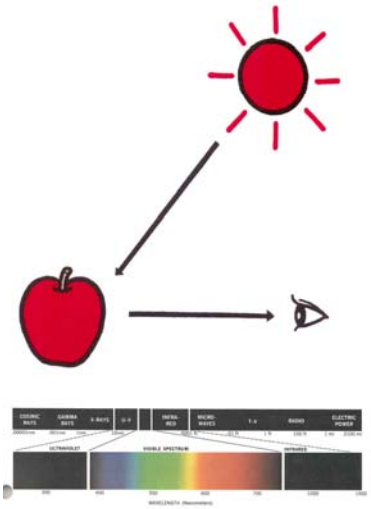


1.0 Introduction
2.0 Types Of Stores And Goals Of Merchandise Lighting
3.0 Characteristics Of Light & Lighting
4.0 Lighting Design Considerations
5.0 Lighting Requirements Of Specific Merchandise Spaces
6.0 Techniques For Lighting Merchandising Spaces
7.0 Lighting Systems Considerations
References
Appendices

Retail Store Lighting
Lighting Strategies & Illumination Ratios

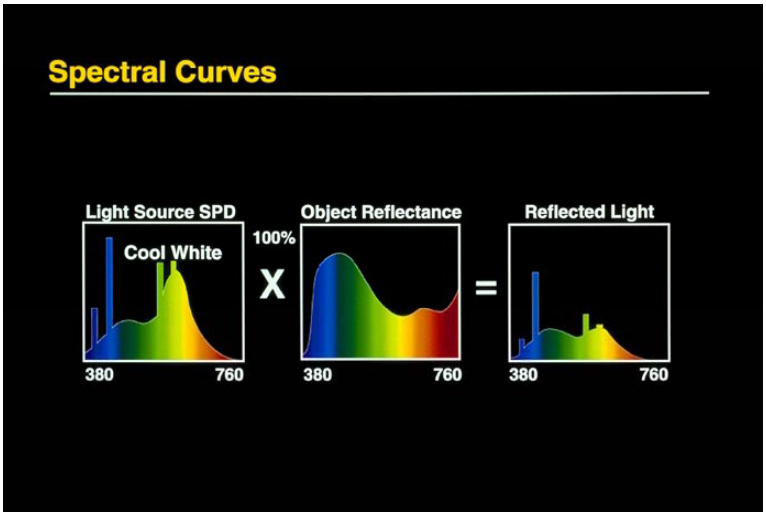
- Cove lighting can provide ambient lighting while also creating an impression of spaciousness as well as directing the flow of consumer traffic
- Halogen accent lighting provides sparkle and focal glow to create excitement
- A minimum 3:1 contrast ratio is required to highlight merchandise displays.
- 10:1 ratios are preferred for maximum impact.
- Maximum impact be difficult to achieve given energy restrictions. High CRI, low wattage metal halide may provide a good solution.

What Is “Color”?



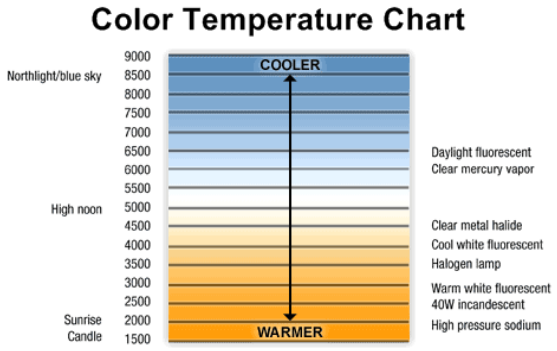
- Color is not a property of an object.
- Color is the psychological response to the different wavelengths of radiant energy incident on the retina.
- Color can only exist when three components are present:
  - Viewer
  - Object
  - Light
- White light is perceived as colorless but actually contains all colors in the visible spectrum.
- When white light strikes an object the object selectively absorbs some colors and reflects other colors.
- Only the reflected colors contribute to the viewer’s perception of color.

Color Perception Is The Result Of The Light Source Interacting With The Object



Correlated Color Temperature

Correlated Color Temperature (CCT) is a measure of warmth or coolness of a light source's appearance. It is measured in degrees Kelvin, expressed in Kelvin (K) and is the closest possible match to Color Temperature



Demonstrating Correlated Color Temperature

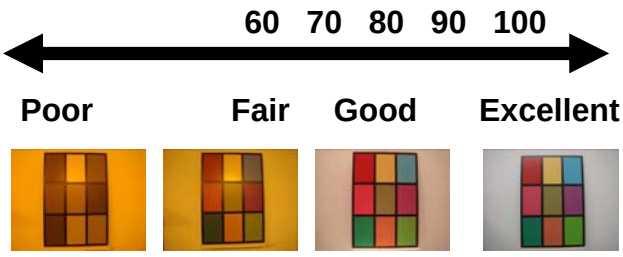
Color Rendering Index (CRI)

- Color Rendering Index (CRI) compares a light source to a reference lamp.
- CRI range is from 0 (no match) to 100 (perfect match) with reference light source.
- Color temperature is concerned with the color of light produced.
- CRI is concerned with:
  - Color of objects illuminated by the light source.
  - How an object's color appearance compares with the color appearance illuminated with a reference source.

Color Rendering Index

Color Rendering Index (CRI) is a unit of measure that defines how well colors are rendered by different illumination conditions in comparison to a standard.

The higher the number, the more likely the light source will render objects "naturally."



CRI is only a guide…

Two Light Sources – Same CRI

Manufacturing Facility Non-Energy Lighting Retrofit Goals & Outcomes

- Improve Productivity
- Increase Safety
- Improve Product Quality
- Reduce Errors, Waste, & Rework
- Increase Morale & Job Satisfaction
- Promote Health & Well Being

Manufacturing: Speed & Accuracy

- When visibility of a visual task is reduced, the person's speed and accuracy will be subconsciously sacrificed.
- Person cannot look at a visual task in a luminous environment and decide to sacrifice speed to maintain a certain level of accuracy or the opposite.
- Adjustment will be subconscious based on other pressures and factors.

Time &Visual Acuity

- Seeing is not an instantaneous process.
- Time lag in the photochemical process in the retina and the transmission and interpretation of nerve impulses to the brain.
- With sufficient time, even small details can be seen under low light levels.
- When speed is important or fast moving objects are involved, light level should be increased.

Manufacturing Lighting Retrofits – Fabrication & Assembly Facilities

- Visual tasks include assembly and inspection from within larger objects or equipment.
- Ambient lighting may be reduced in areas of shadow caused by these large products and subassemblies.
- Large assembly plants may have ceiling heights in excess of 100 feet, and very unique task lighting requirements.

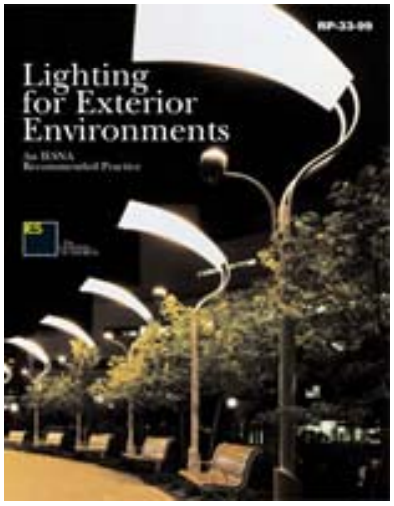
Manufacturing Lighting Retrofits – Warehousing & Storage Facilities

- Warehouse aisle tend to have ceiling heights above 25 feet (high bay) and therefore require luminaires with a higher light output.
- Identifying zone and bin location and positioning stock in the correct location requires high levels of aisle lighting – both in horizontal and vertical illuminance.

Exterior Non-Energy Lighting Retrofit Goals & Outcomes

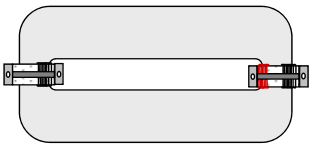
- Increase Personal Interaction & Encourage Pedestrian Foot Traffic
- Improve Safety & Accident Prevention
- Increase Personal & Property Security
- Minimize Light Trespass From Building & Site
- Increase Night Sky Access By Reducing Sky-Glow
- Reduce Glare & Improve Visual Comfort & Nighttime Visibility
- Reduce Nocturnal Environment Impact

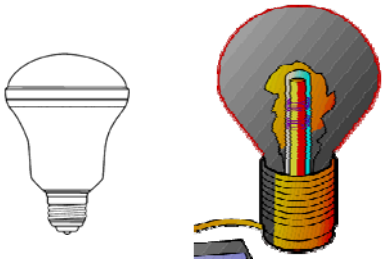
Illuminating Engineering Society of North America *Recommended Practice for Lighting for Exterior Environments* (IESNA RP-33-99)



Electrodeless Fluorescent Lamps

- Developed in the 1990's
- Design eliminates one failure mode of standard fluorescent lamps: the cathode
- Operates on the principle of induction
- Life from 15,000 hours (self-ballasted) to 60,000 hours.
- Life based on lumen maintenance and/or ballast life
- Cost higher than for standard fluorescent
- Used in areas where lighting maintenance cost is high – low-bay industrial, street lighting, signage, tunnel/bridge, etc.

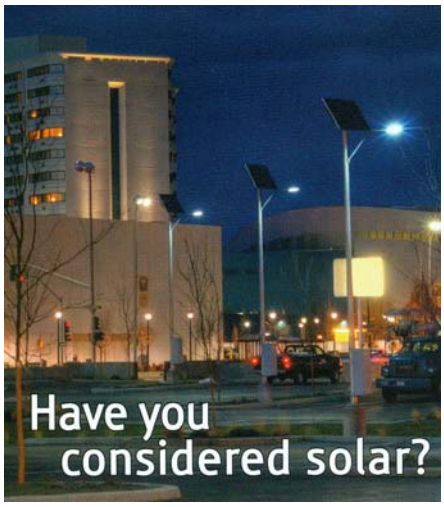




Induction Lighting

Building Exterior LED Lighting

Cooper Lighting



Carmanah EverGEN

Building LED Exterior Lighting

Phillips ColorReach PowerCore LED Floodlighting For Facades
http://www.colorkinetics.com/ls/rgb/colorreach/

Enhanced Public Image Non-Energy Lighting Retrofit Goals & Outcomes

- Reduced Energy Use = Reduced Pollution
- Reduced Energy Demand = Reduced Infrastructure Requirements & Investment
- Increased Employee, Customer, & Public Customer Goodwill
- Increased Environmental & Social Awareness
- Possible Reduced Regulatory Oversight

Beware Of Snake Oil

If it looks or sounds too good, it probably is.

Questions?

Mouse In A Panelboard