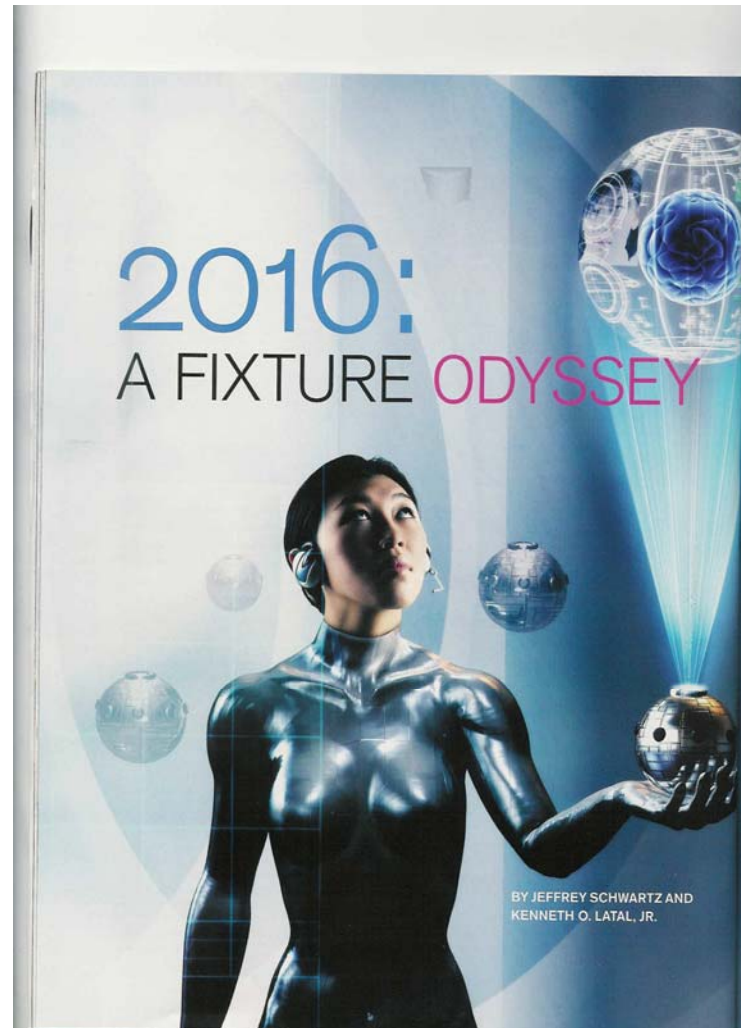


Lighting for Now and for the Future



Lighting Today's Office Environment

Presented by

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ICF International

Today's Topics

- The Why = Code, Standards, and Energy Efficiency Programs
- The What = Establishing General Lighting Quality Metrics
- The Where = Understanding Today's Office Environment
- The How = Potential Solutions

The Why

- Why is this all this energy efficiency lighting push going on
- What is happening
- How to keep up with the changes

An Overview

Places That Influence Our Lives

The World
The US

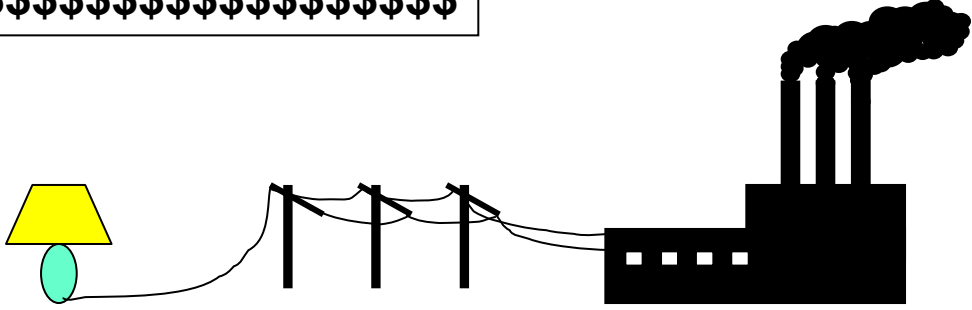
What Can I Do?

Influences
Opportunities
Technologies

The World



\$



Credit for Dark Sky Photo: [C. Mayhew & R. Simmon \(NASA/GSFC\)](#), [NOAA/ NGDC](#), [DMSP Digital Archive](#)

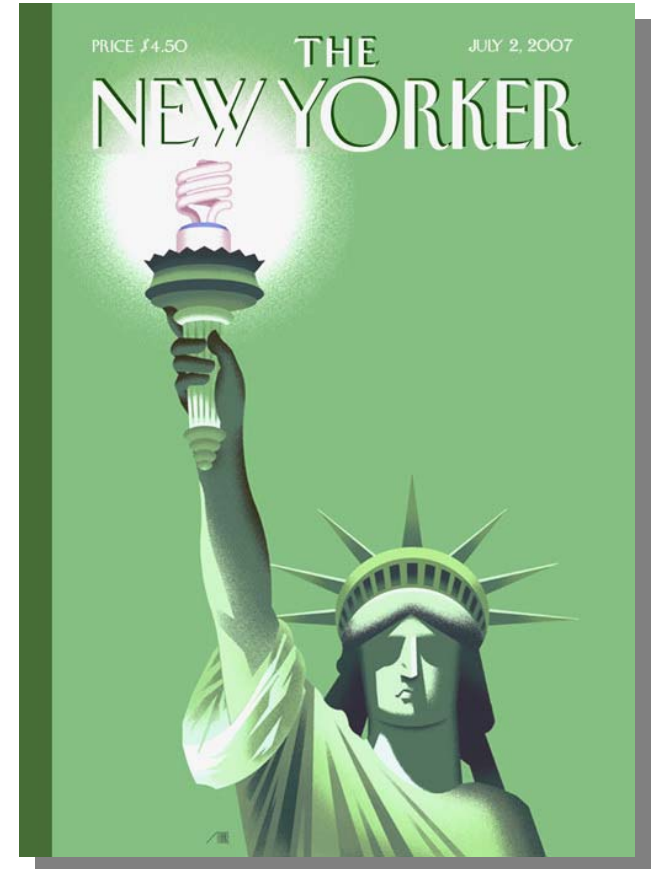
The World

- Climate Change and Global Warming
- Greenhouse Gas Emissions
- Light Pollution/Light Trespass/Dark Skies
- World Economy – Need to Cut Costs
- World Bank: *to advance the vision of an inclusive and sustainable globalization; provide low-interest loans, interest-free credits and grants to developing countries for a wide array of purposes that includes investments in **environmental and natural resource management.***
- USAID: *Growing populations are placing increasing pressure on the natural resources in many countries and many of these resources, once used, are not renewable. **USAID takes an integrated approach to natural resources management.***



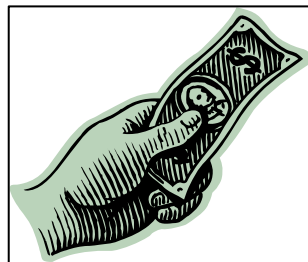
The United States

- Americans' concerns about the environment have increased **more than 10 percentage points** between 2004-2006 (Gallup Poll)
- **88%** of Americans stated that “energy efficiency” is very important in their lighting purchases*



The United States

- Climate Change and Global Warming
- Greenhouse Gas Emissions
- Our Economy – Problems or Opportunities?
- “Going Green”



Utilities and energy efficiency program sponsors offer incentives for energy efficiency

The United States

- Federal Tax Deductions
- Federal Legislation: Incandescent, General Service Fluorescent Lamps, Ballasts, HID lighting
- State Energy Codes – ASHRAE Standards
- Local Codes

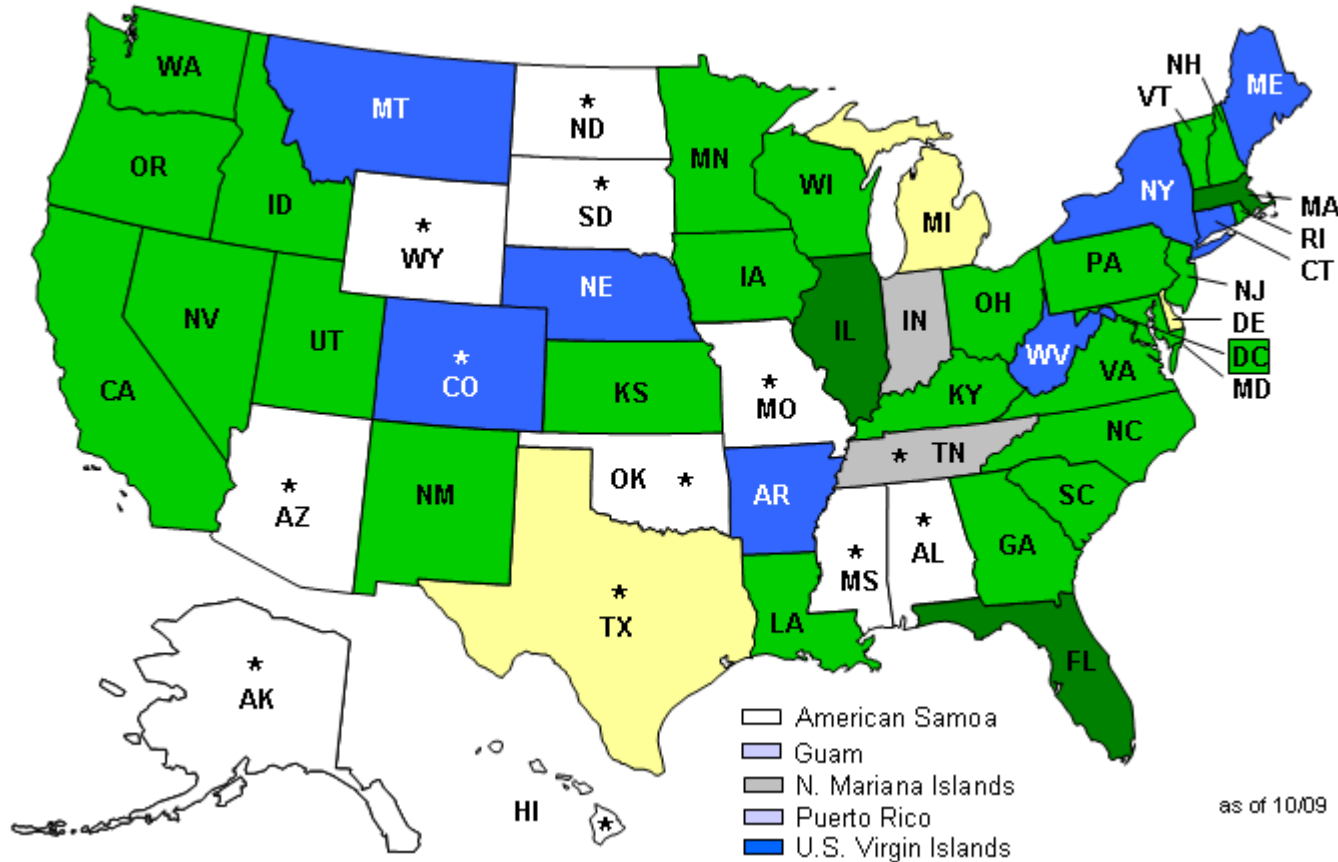
Legislation and Programs

- Mandatory Energy Codes, funds to help states
- Mercury Vapor & Metal Halide
- Incandescent
- General Service Fluorescent Lamps
- Light Emitting Diodes
- Light Trespass & Light Pollution**

** Sorry, Not Today

Energy Codes - Commercial

USDOE



■	ASHRAE 90.1-2007/2009 IECC, equivalent or better
■	ASHRAE 90.1-2004/2006 IECC, equivalent or better
■	ASHRAE 90.1-2001/2003 IECC or equivalent
■	ASHRAE 90.1-1999/2001 IECC or equivalent
■	ASHRAE 90.1-1989/2000 IECC or equivalent
■	Older or less stringent than ASHRAE 90.1-1989/2000 IECC
□	No statewide code
*	Adoption by county/jurisdiction above state mandated minimum

Stimulus Funds and Energy Codes

- State Energy Assistance Grants:
- \$787 billion economic stimulus package that included over **\$20 billion in appropriations for energy efficiency.**
- The American Recovery and Reinvestment Act (ARRA) includes **\$3.1 billion for energy assistance grants for states that adopt and administer the national model building energy codes.** The act requires governors who want a share of the energy assistance grants to certify that their state, or the applicable units of local government that have authority to adopt building codes, will implement the following:

The What

Establishing Quantitative Metrics for Energy Efficiency and Quality

- Product – efficacy and efficiency
- Energy - W/sf
- Uniformity – spacing criteria
- Color Rendering - CRI
- Glare – luminous intensity and volumetric lighting

Energy Efficiency

System Efficacy:

- Some sources have higher efficacy (lumens per Watt) than others.
- You must look at the system wattage (source plus ballast or driver) not just the source.
- Many sources have both initial lumens and maintained lumens, to evaluate the efficacy over the useful rated life, you need to look at the maintained (also called design) lumens per Watt.

Energy Efficiency

More efficient luminaires:

- Some luminaires do a better job of getting the available light out of the fixture. Based on percentage of available light (lumens) vs. the light (lumens) that leave the fixture.
- Must be careful to look at the fixture “class.”
- Many utilities have set minimum efficiency criteria for luminaire classes.
- Using more efficient luminaires can mean fewer fixtures or fewer lamps per fixture while providing the appropriate light level.

Energy Efficiency

Limiting Lighting Power Allowances:

- For office lighting the ASHRAE 90.1 allowances have been decreasing. Only a few years ago we were given 1.5W/sf for office lighting. The new proposed version out for review has gone to 0.96W/sf.
- It takes good technology plus good design to meet Code requirements and still provide the appropriate light levels.

Uniformity – spacing criteria

Uniformity is a measurable metric and is an important consideration in office lighting, especially in large open office areas.

- Consider the effects of non-uniform lighting creating dark and bright areas within the same work area.
- Uniformity can be evaluated by adhering to the luminaire's spacing criteria derived from the fixture IES file, and the photometric report.

Uniformity – spacing criteria

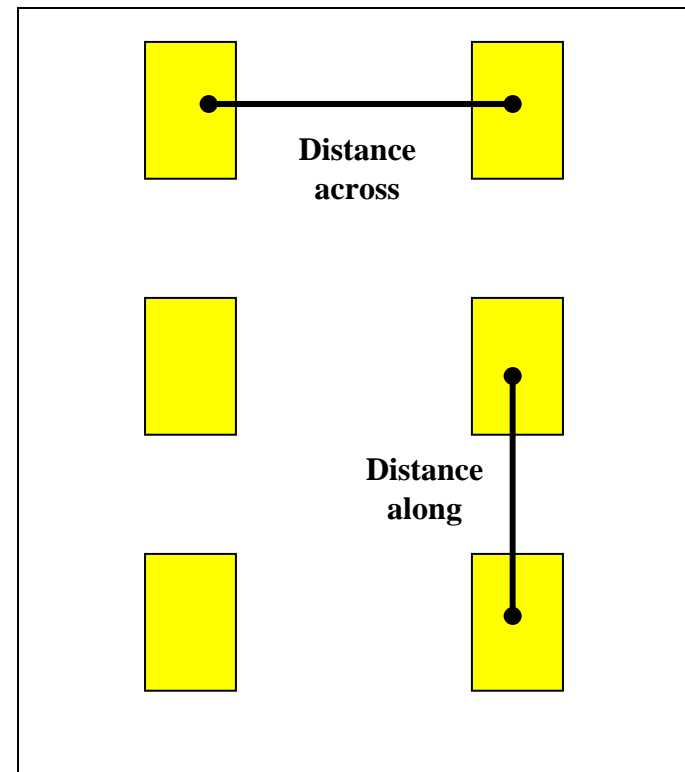
- Photometric reports also provide spacing criteria (SC) or mounting height ratios (S/MH). SC for this 2x4 troffer is 1.2 for both the 0° (along the length of luminaire) and the 90° (across the length of luminaire) planes.
- In an 8 ft. ceiling, the recommended maximum spacing for this fixture will be 1.2 x 8.0 ft.= 9.6 ft. (9 ft. 7 in.)

TOTAL LUMINAIRE EFFICIENCY = 67.0 %
 TOTAL REFLECTANCE OF PAINT = 86.9 %
 LUMINAIRE EFFICACY RATING = FP55
 COST OF LIGHTING = 4.36
 CIE TYPE - DIRECT

PLANE	: 0-DEG	90-DEG
SPACING CRITERIA	: 1.2	1.2
PLANE	: 0-DEG	90-DEG
LUMINOUS LENGTH	: 44.938	20.813

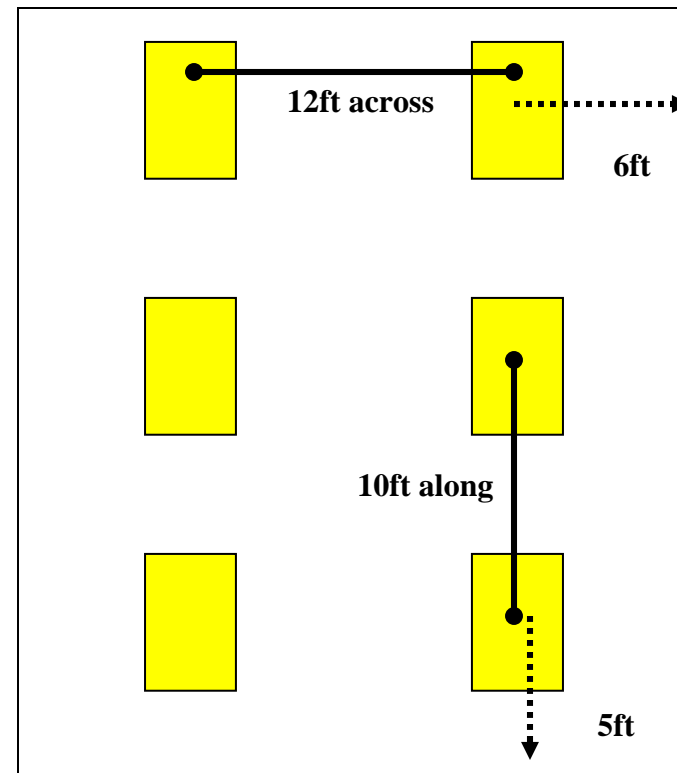
Uniformity – spacing criteria

- Illuminance Uniformity
 - The maximum to minimum light levels on the work plane and throughout the space. Based on the fixture's spacing criteria.
 - Fixtures must be spaced within the fixture manufacturer's spacing criteria listed on the fixture photometric/specification sheets. This does not apply to accent fixtures.



Uniformity – spacing criteria

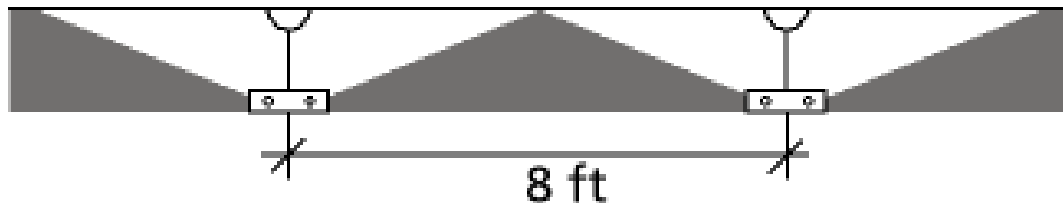
- Vertical Illuminance
 - Average light level on walls.
 - Distance between walls and adjacent fixtures should not exceed one-half of the fixture spacing criteria.
 - Wall-wash fixture must be mounted no more than 3ft from walls.



- Example: if spacing criteria across is 12ft, then distance from the center of the fixture to wall should not exceed 6ft.

Spacing Criteria for Indirect Lighting Fixtures

- Usually no spacing criterion for pendant light fixtures
- Manufacturers provide spacing recommendations to ensure uniform lighting at the work plane and uniform ceiling brightness.
- The ceiling ratio is measurable and can be used to evaluate uniformity.



Color Rendering Index (CRI)

- *IESNA Definition:* measure of the degree of color shift objects undergo when illuminated by the light source as compared with the color of those same objects when illuminated by a reference source, of comparable color temperature.
- Light sources differ in their ability to render the color of objects “correctly.”



CRI = 90



CRI = 70








CRI = 50

Color Rendering

People judge color rendering by their skin tones

- Poor color rendering creates an uncomfortable environment
- People and objects appear “unnatural.”
- Think of the investment in flooring, paint, art, and furniture.

Color Effect:	Cool (blue tones)
Temperature (Kelvin):	4100K
Mood:	Efficient
Visual Effects On Flesh Tones	
Visual Effects On Maple Finish	
Visual Effects On Oak Finish	
Visual Effects On Cherry Finish	
Visual Effects On Walnut Finish	

Glare is an enemy

Glare causes discomfort which in turn can result in errors, fatigue, and an unproductive work force.

- Today's computer screens cause less problems with reflective glare, but are still a concern in many offices

Direct Glare

- Occurs when light travels directly from the source to the eye
 - Disability glare
 - Discomfort glare
 - Overhead glare

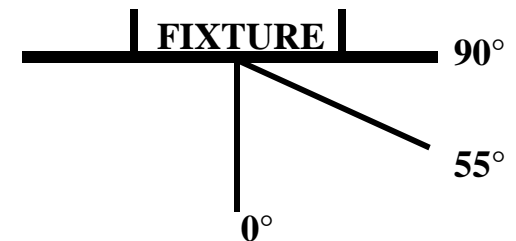


Photo courtesy of LRC

Candela Distribution for CLP

Luminous Intensity (Glare)

- Luminous intensity is one metric for evaluating glare. The current IES Recommended Practice for Office Lighting (RP1-04 uses this metric) providing limits for office lighting
- Approximately 300 candela max @ 55 degrees VDT Intensive spaces
- Approximately 300 candela max @ 65 degrees for VDT Normal spaces



	CANDLE POWER				
DEG	0	22.5	45	67.5	90
0	1764.	1764.	1764.	1764.	1764.
5	1750.	1753.	1731.	1711.	1699.
10	1732.	1703.	1685.	1660.	1632.
15	1668.	1635.	1641.	1667.	1668.
20	1585.	1556.	1640.	1764.	1765.
25	1480.	1472.	1683.	1827.	1875.
30	1368.	1375.	1689.	1949.	2009.
35	1258.	1321.	1684.	1979.	1988.
40	1159.	1175.	1539.	1369.	1291.
45	819.	745.	1076.	830.	649.
50	467.	631.	561.	489.	437.
55	121.	202.	216.	114.	68.
60	34.	41.	42.	39.	35.
65	19.	29.	39.	25.	29.
70	11.	13.	13.	13.	13.
75	6.	7.	7.	6.	7.
80	3.	4.	4.	4.	4.
85	1.	2.	1.	1.	2.
90	0.	0.	0.	0.	0.

High Efficiency Low Glare Fixtures

- This refers to a fairly new group of fixtures known as “volumetric lighting.” They use T8 or T5 technology.
- In addition to energy savings per fixture based on the system efficacy and fixture efficiency, most can be **spaced at greater distances** than other fixture categories (such as many parabolic fixtures), reducing the number of fixtures needed while providing uniform light at the appropriate light level.

Volumetric Lighting

- Overall fixture efficiency should exceed 80%. Design at about 0.8Wsf
- Fixture should distribute lighting at high angles to reduce contrast (typically at least 15% of the zonal lumens between 60 and 9 degrees)
- Incorporate advanced lighting distribution AND glare control

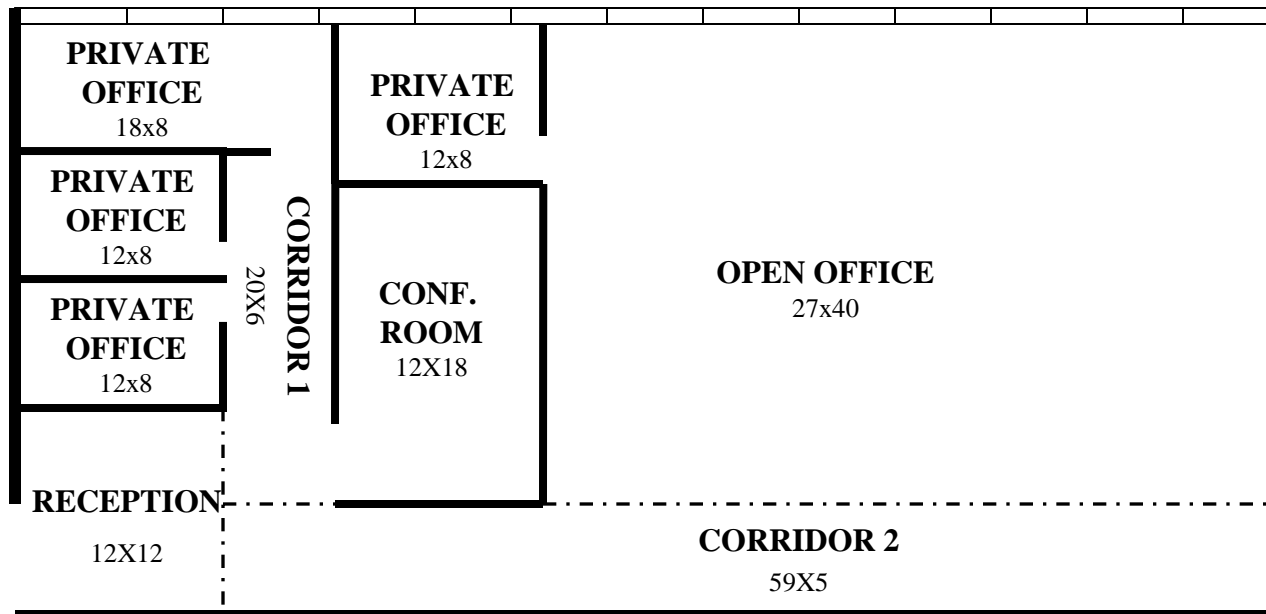


These are not common “basket” fixtures. Highly efficient, glare control, and good distribution are part of the specification.



Understanding Today's Office

- What other spaces are there?
- What light levels are needed in each space for the tasks normally associated with the use?
- What fixture categories or combination of categories are appropriate



Office Lighting Solutions

- Know your customer and their needs
- Know your lighting power allowance and design to beat it!
- Design Concepts
- Technology
- Controls

Light Level and W/sf

Space	W/sf goal	Light Level (FC)
Private Office	0.9	30 - 50
Open Office	0.9	30 - 50
Conference/Meeting Room	1.0	30 layered
Break Room	0.7	30 max
Corridor	0.5 – 0.7	5 - 15
Reception/Lobby Area	0.9	10 to 30
File Room/ Copy Room	?	?

Effective, Energy-Efficient Office Lighting

Consider

- The needs of people using the space
- Visibility, visual comfort, and safety
- Architectural characteristics
- Economic and environmental concerns



Photo courtesy NY Times

Lighting for Offices

Lighting should reinforce all aspects of the office environment:

- image
- worker comfort
- worker performance



Photos courtesy of Kenn Latal, project designer

Lighting for Offices

Luminance Issues – Surfaces



Photos courtesy LRC

The use of Task Lighting creates a better image, reduces energy, and provides flexibility for the worker.

Lighting for Offices

Glare Issues

- If using direct luminaires evaluate the luminous intensity;
- If using indirect or indirect/direct evaluate the ceiling ratios. Be sure you have appropriate ceiling reflectance;
- If using volumetric type lighting, be sure to evaluate the fixture efficiency and the percentage of light at the higher angles.

Lighting for Offices

Glare Issues – Indirect Luminaires

- Area Glare: non-uniform indirect lighting – distracting but it doesn't cause eye focus problem.
- Uniform Glare: Indirect lighting producing high luminance levels on the ceiling that reduce task contrast.



Lighting for Offices

Lighting Controls

- Lighting control technologies:
 - Occupancy Sensors, Photosensors, Dimming Controls
- Can save 30% - 60% of lighting energy depending on application

Controls

Wireless and Self Commissioning

Dimming

Occupancy Sensors

Vacancy Sensors



Fixture Mounted
Wall Mounted
Ceiling Mounted

Load Shedding
Ballasts

©2009 Lighting Controls Association –
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Occupancy Sensors

Always consider occupancy sensors in the following space types:

- Private Offices
- Restrooms
- Conference Rooms
- Storage and Stock Rooms
- Spaces with Intermittent Use



Occupancy Sensors

Types of Occupancy Sensors Include:

- Wall Mounted



- Ceiling Mounted



- Fixture Mounted (also known as integral)

Occupancy Sensors

Passive Infrared:

- Detects movements in a direct line of sight from the sensor— PIRs cannot look around corners
- Detects movements across the field of view (across the segments) rather than movements toward or away from the sensor

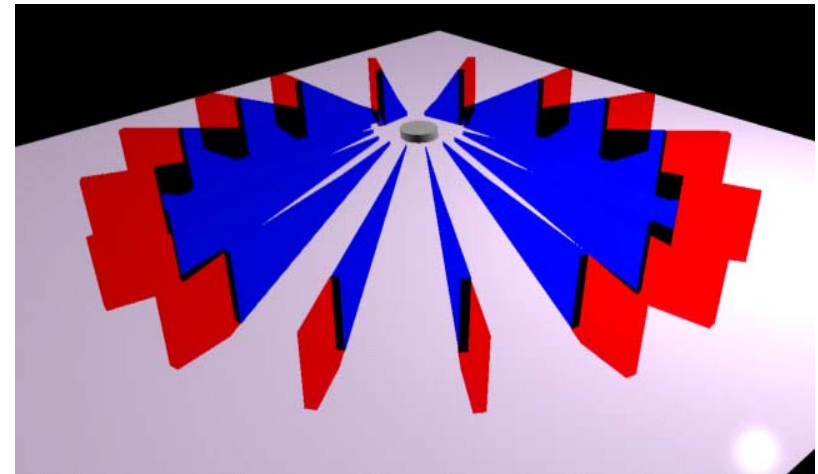


Photo courtesy of LRC

Occupancy Sensors

Ultrasonic:

- Detects movement **in any part of the space**, even around corners or behind obstructions such as washroom partitions
- Detects movement toward the sensor, rather than movement across the space

Occupancy Sensors

Dual Technology

- Combines both technologies in one product
- Most expensive option, but appropriate for certain areas
- Very sensitive to motion while preventing “false triggering”



Nature's Gift



Daylighting does not save energy unless the electric lighting is controlled

Lighting for Offices

Daylighting

- Can be used as a mechanism to save energy.
- Windows important for view
- Roll-down solar shades reduce window glare while maintaining the view to the outdoors
- Low transmission do not block direct sunlight

Dimming

Dimming controls require dimming ballasts for fluorescent and HID applications.

- Continuous dimming will allow for a full range of dimming from 100% to levels as low as 2% depending on the ballast.
- Step dimming provides preset levels of dimming such as 50% or 70% or a combination of several steps.
- As a last alternative, at least consider bi-level switching that can reduce the light at least 50% in a uniform pattern.

Dimming Controls

Manual Dimming Controls:

- Typically wall mounted (or controlled from desktop computer), they allow the individual user or users to control the light level based on wants, needs, or task being performed.
- Allows more flexibility for presentations, computer work, etc.



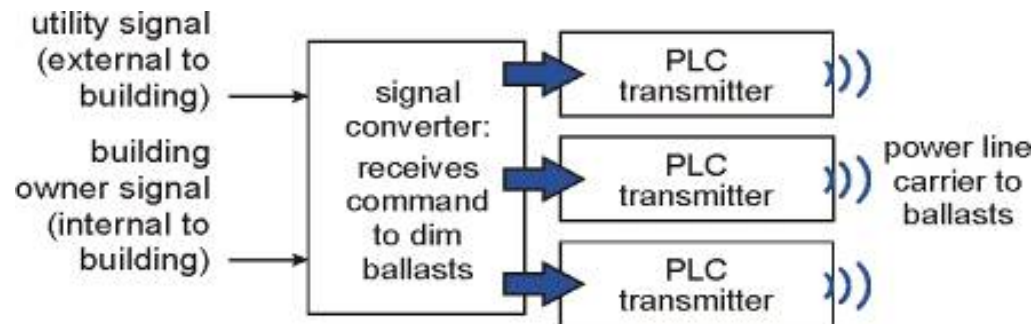
Dimming

Daylight Dimming Controls:

- Daylight dimming controls require the use of photosensors. The photosensor detects the amount of available daylight and adjusts the light level accordingly.
- Daylight dimming saves energy by reducing the use of electric lighting during time periods when natural light is available

Dimming Controls

Load Shed Ballasts offer another form of dimming. Power usage (and light levels) can be reduced during peak demand times either manually, by a signal from a computer, or even directly through the lines by a signal from



Controls

- There are also complete energy management systems (or sub systems for lighting) that can integrate time of day settings with the occupancy sensors and dimming. An example would be to have pre-set settings for cleaning crews or after hour operation.
- Wireless technology for controls is also available. While initial cost may be higher, installation costs may be lower.
- Self-commissioning units are now also available which helps reduce commissioning time.

Controls Summary

- Select the proper control for the application
- Be sure the ballast selected is appropriate for the type of control
- Controls save energy costs by reducing the load when electric lights are off or dimmed
- Controls are required for certain spaces under the Energy Codes.

Putting It All Together

Direct/Indirect
Louvered for glare control
About 0.9Wsf
Occupancy Sensor
Photo Sensor
Manual Dimming
Centrally Controlled
Individually Controlled



Sources

- High Performance T8 Systems
- Reduced Wattage T8 Systems
- T5 and T5 HO Systems
- Low Wattage Metal Halide
- CFLs
- Halogen
- LED
- Which delivers the appropriate light most efficiently?

Luminaires

- Indirect
- Indirect/Direct
- Parabolic / Volumetric
- Wall Washers
- Downlights
- Task Lights

Which combination is most appropriate for the application

LED: Applications and Products

Under Cabinet and Over Cabinet Lighting



Exit Signs

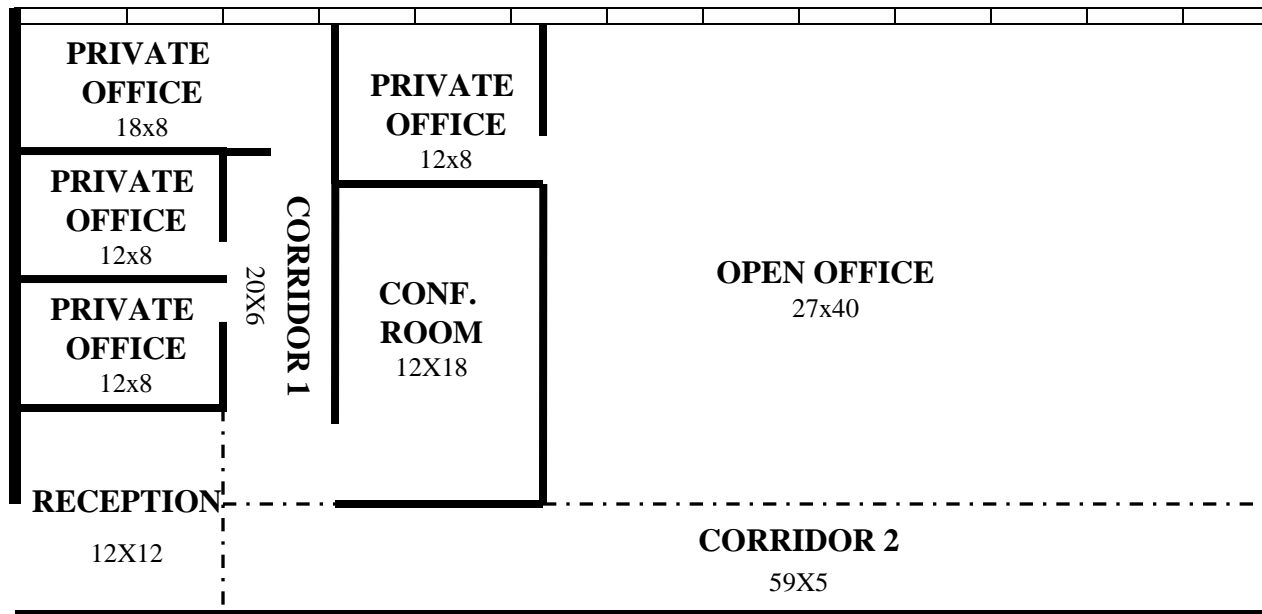


Down Lights (directional)



Application Exercise

- Use low-glare fixtures in the open office space
- Consider occupancy sensors in the private offices
- Provide proper light levels in offices and use less light in the corridors
- Consider multiple light levels in the conference room and consider a dimming system.



Conference Rooms

Layered Lighting

- General System controlled by switching or dimming
- Supplementary system (downlights?) with dimming for low-level illumination requirements
- A perimeter or wall wash lighting system controlled with dimmers for better visual appeal, particularly where presentation materials may be wall mounted.

Video Conferencing

Considerations

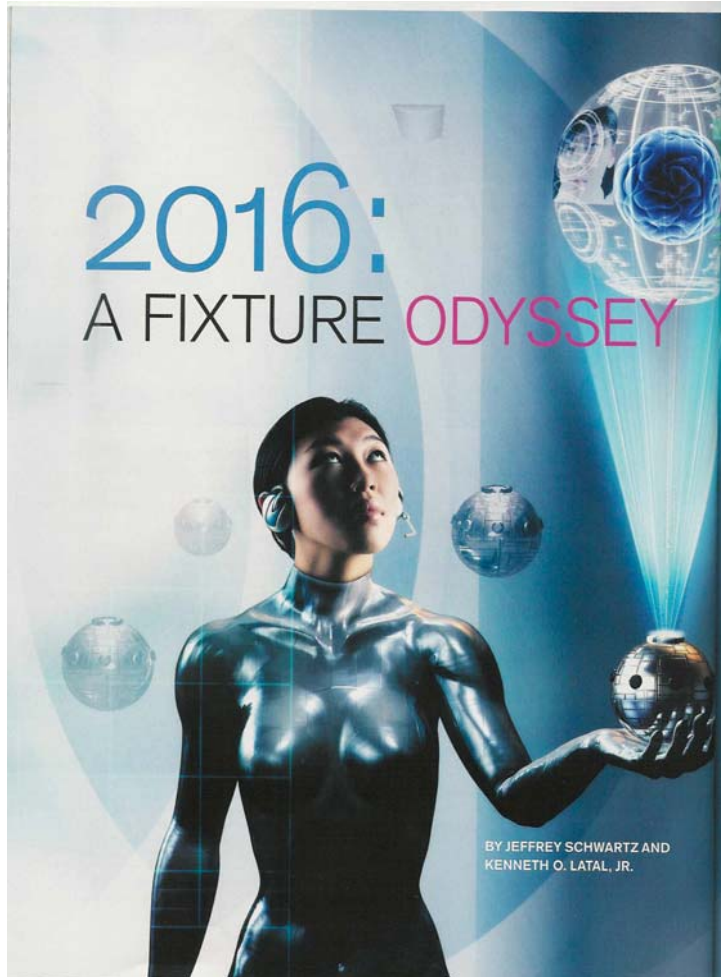
- Light Levels
- Color Temperature
- Color Rendering
- Finishes
- Furniture
- Seating Area in Relationship to Displays

See IES Design Guide (DG-17-05)
Fundamentals of Lighting for Videoconferencing

Problems or Opportunities

- Concerns for the planet, codes, regulations and legislation all lead to opportunities for lighting upgrades and/or reducing kWh in new construction.
- Add to that funding under the stimulus funds and incentive programs and the time has never been better for energy-efficient lighting.

What Will The Future Bring?



Sometimes In Life
You Have to Take A Chance =
Dare to be a Dreamer

Much of What We Discuss Today
Will be Tomorrow's History

What We Have Today
Are the Gifts of the Past
What Will YOU Leave for the Future?

Photo Courtesy of LD&A, Article by Jeffrey Schwartz (ICF) and Kenn Lattal (ICF)

Questions? And Contact Info

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- www.neep.org (regional initiatives – SSL)
- www.energy.gov/recovery/ (stimulus funds)
- www.lrc.rpi.edu

And, of course, Efficiency Vermont