

“New” Lighting Technology Applications and Resources



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Photopic? – Scotopic?



What a Topic!!

The issue:

Human perception of the lighted environment is driven by **both Photopic and Scotopic** vision

.... but

only Photopic vision is typically considered applicable to interior lighting design

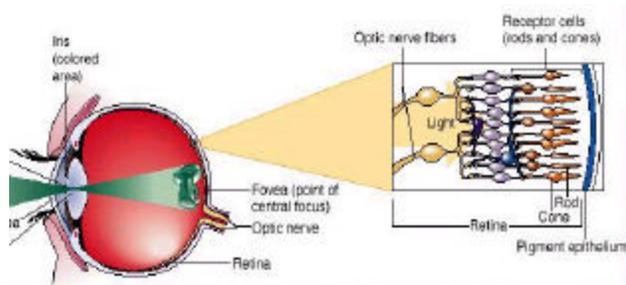
.... however

Studies show **Scotopic vision is also important** and may support lighting energy savings

The Eye

Photopic (Cones)

Scotopic (Rods)



Photopic/Scotopic Properties

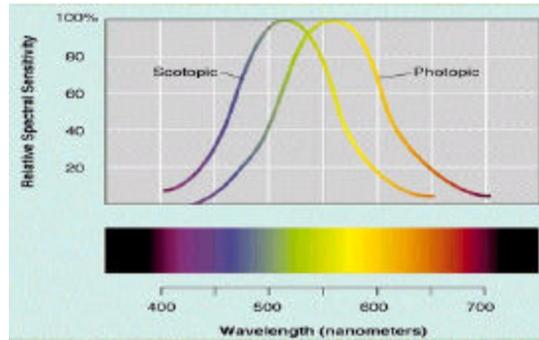
▲ Photopic

- ▲ Known as light or daylight vision ("cones")
- ▲ Higher sensitivity in "brighter" light
- ▲ Peak sensitivity towards "red" (550 nm)
- ▲ Basis for modern photometry (light metering)

▲ Scotopic

- ▲ Known as dark or night vision ("rods")
- ▲ Higher sensitivity and speed in different spectral range
- ▲ Peak sensitivity towards "blue" (500 nm)
- ▲ High color temperature lamps 3500K – 7000K

Photopic/Scotopic Spectral Peaks



Historical Views

- ▲ Only photopic (cones) important for typical working tasks in interiors or daylight
- ▲ Light source efficiency based on photopic measurements - example:
 - (Standard) 32W, **3500K**, 3000 (Photopic lumens)
efficacy = **93.8** lumen/watt
 - (Scotopic) 32W, **6500K**, 2800 (Photopic lumens)
efficacy = **87.5** lumen/watt

Recent Study Results

- ▲ Rods are active in bright light and do contribute to the perception of brightness
- ▲ Scotopic contributes to improved acuity but this is not yet well defined
- ▲ Higher Scotopic sources can provide equivalent brightness with lower energy
- ▲ S/P ratio

Scotopic/Photopic Ratios

Light Source	Scotopic/Photopic Ratio (S/P)
Low Pressure Sodium	0.20
High Pressure Sodium (35W)	0.40
Warm White Fluorescent	1.00
Cool White Fluorescent	1.46
Metal Halide (Sodium/Scandium)	1.49
Quartz Halogen (~3200° K)	1.50
4100°K Fluorescent (RE741)	1.54
4100°K Fluorescent (RE841)	1.62
5000°K Fluorescent (RE850)	1.96
6500°K Fluorescent (RE865)	2.14
Daylight Fluorescent	2.22
7500°K Fluorescent lamp	2.47

Where's the Potential Benefit?

- ▲ Scotopic sources **may** allow for reduced lighting power needs but must consider:
 - ▲ Specific application
 - ▲ existing light levels
 - ▲ Difference in existing and retrofit lamps
- ▲ Scotopic lighting is more like “daylight” - possible benefits
 - ▲ Appearance of daylight – mood enhancement
 - ▲ Potential increase in acuity

The New Math!

- ▲ Scotopic/Photopic adjustment - $P(S/P)^{0.78}$
[for VDT – computer tasks use $P(S/P)$]
- ▲ The example revised:
 - 32W, 3500K, 3000 lumen with S/P ratio of 1.45 = 4009 lumen (P+S), efficacy = **125** vs 93.8
 - 32W, 6500K, 2800 lumen with S/P ratio of 2.10 = 4994 lumen (P+S), efficacy = **156** vs 87.5

Application Considerations

- ▲ New applications should be considered pilot studies- this is still a new technology
- ▲ Scotopic sources have a “bluish-cooler” tone
- ▲ Color rendering of faces
- ▲ System cost vs. energy reduction
- ▲ Other psychological benefits
- ▲ The S/P ratio – where is it?

Here! - Not Here!

- ▲ Task lighting for critical visual tasks like electronics assembly or pharmacies – **Good** application for increased visual acuity
- ▲ School and office lighting – **Possible** but should consider skin color (“cool-blue”)
- ▲ Hospitality and home spaces – **Least Likely** because of “cool-blue” appearance

Research/Resources

- ▲ <http://www.lightresource.com/article9.html>
- ▲ Veitch, J.A., and McColl, S.I., (1995) Modulation of fluorescent light: Flicker rate and light source effects on visual performance and visual comfort, *Lighting Research and Technology*, 27, 243-256.
- ▲ <http://www.ergolight.com/articles/berman.html>
- ▲ Boyce, P.R., Akashi, Y., Hunter, C.M., and Bullough, J.D., (2002) The impact of spectral power distribution on visual performance, LRC report to the US Department of Energy (to be published in *Lighting Research and Technology*)
- ▲ *Visual Performance and Light Spectrum: The Inadequacy of Conventional Photometry*, S. Berman, G. Fein, D. Jewett, B. Benson, T. Law and A. Myers, December 1994, LBL-37861, Proceedings of the CIE Symposium on Advances in Photometry, Vienna, Austria, December 1994.

Long Life Electrodeless

The big deal: NO electrode to wear out!

Current market offerings:

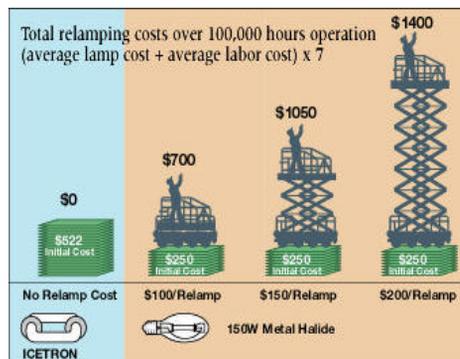
Philips QL induction & Osram Sylvania Iccetron



Advantages

- ▲ No electrode to wear out!
- ▲ Extremely long life – 100,000 hours or more
- ▲ Good color temperature and color rendering
- ▲ Efficiencies in Compact Fluorescent range
- ▲ High lumen packages

Relamping Savings



Osram Sylvania

GSA Case Study

- ▲ GSA Peachtree Summit Bldg, Atlanta
- ▲ 35 ft ceiling – lift and scaffolding to reach
- ▲ Existing Mercury Vapor
- ▲ Needs:
 - ▲ Low cost maintenance!
 - ▲ Efficiency
 - ▲ Quality light
 - ▲ Cost effective



Option Comparison

Criteria	Metal	QL		
	Halide	HPS	Induction	ICETRON
System life	15,000	24,000	100,000	100,000
Initial lumens	15,000	16,000	12,000	11,000
Mean lumens	11,300	14,400	9,600	8,635
Luminaires	✓	✓	✗*	✓
Input watts	168	170	165	157
Color temp (CCT)	4,000	2,000	4,000	4,100
Color rendering	65 CRI	22	80	80
Efficacy (lumens/watt)	67	85	57	55

* subsequent to this project, additional fixtures have become available

Energy Comparison

▲ Existing Mercury Vapor/Incandescent:

3rd floor ceiling MV downlights, 18 @ 285 watts = 5,130

3rd floor ceiling INC wall washers, 14 @ 350 watts =
4,900

Total for existing connected load = 10,030 watts

▲ Icetron/CFL Retrofit:

3rd floor ceiling Icetron down lights, 22 @ 157 watts =
3,454

1st, 2nd, 3rd floor CFL wall washers, 30 @ 80 watts =
2,400

Total for proposed connected load = 5,854 watts

Partial Cost Comparison

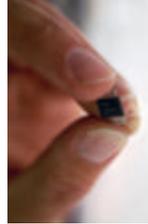
Costs over projected life of retrofit:

	<u>Metal Halide</u>	<u>Icetron</u>
Initial Cost	\$13,819	\$20,185
Maint. Cost	\$12,828	\$0

Intelligent Lighting

Smart lighting has arrived, several systems are on the market

- ▲ Complete energy management packages: occupant sensing, daylight control, load shedding
- ▲ Personal control systems: effects both physical and psychological aspects of lighting at work station
- ▲ Tremendous potential energy savings in addition to the other positive features
- ▲ Plug & play reduces design installation costs



Advantages

- ▲ Cumulative Energy Savings:
 - ▲ Layout results in less connected load
 - ▲ Software allows for peak load shaving
 - ▲ Software allows for lumen depreciation
 - ▲ Photocells in perimeter daylighted areas
 - ▲ Occupancy sensors in direct component
 - ▲ Personal control for direct component

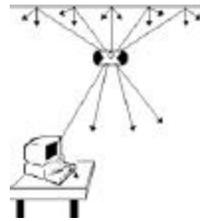
More Advantages

▲ High Quality Lighting

- ▲ Indirect component creates a perception of brightness in the space
- ▲ Electronic ballasts reduce flicker

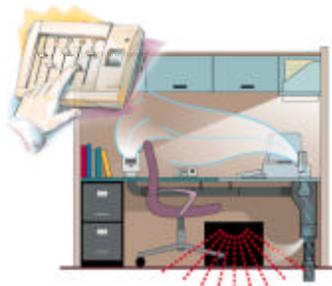
▲ Personal control is a significant psychological advantage

▲ Personal control also allows users to optimize light levels for their visual needs



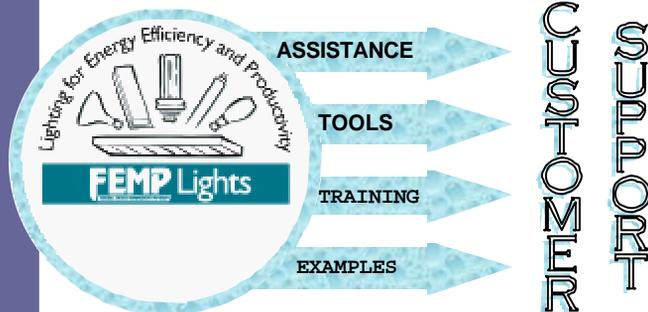
Personal Control

- ▲ Positive psychological impact on workers; creates a greater sense of control throughout the day



Personal Environments, graphic courtesy of Johnson Controls, Inc.

Federal Lighting Project Support



FEMP Lights supports agencies and providers, helping them to be technically correct and achieve greater benefits in their relighting projects.

Design Assistance

▲ Hands-on support from FEMP for technically challenging lighting projects



▲ Must meet FEMP criteria, decisions made on a case-by-case basis

Tools & Information

▲ Standardized Occupant Evaluation Tool

- ▲ Web based, email distributed, automatic data compilation
- ▲ For use by your staff and project teams
- ▲ Will help you to take credit for occupant satisfaction

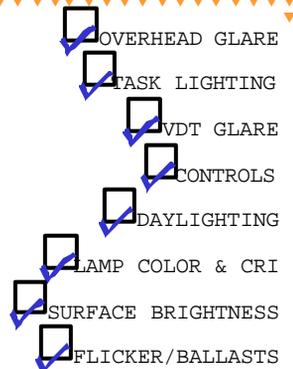
▲ Energy Effective Lighting Contract Language

Go to the web site: www.eren.doe.gov/femp/

Tools & Info continued...

▲ Energy Effective Lighting Information

- ▲ Energy Effective Lighting **Checklist**
- ▲ **Benefits** of Energy Effective Lighting
- ▲ **Economics** of Energy Effective Lighting
- ▲ Energy Effective Ltg Recommendations (Office, Warehouse)



FEMP Lighting Training

Web-based course

- At your desktop
- 9 weeks
- Basic level instruction
- Email interaction w/instructors



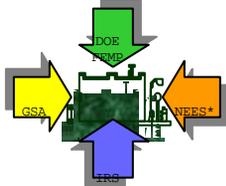
Advanced Workshop

- In-person instruction
- Your project questions answered
- Basic knowledge is a prerequisite
- Workshops tailored to attendees

Examples

Energy Effective Lighting Video

- 8 Steps to Energy Effective Lighting
- Excerpted from TeleFEMP VI
- Two projects featured
- Order a copy off the FEMP web site



FUNDING PROVIDED BY



Go to the web site: www.eren.doe.gov/femp/