

## Electric Lighting Sources: Lamp Issues First

### How To Become A Lighting Designer



Understand lamps and fixtures...

Find your way through a MAZE OF LIGHTING OPTIONS. Join us.



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## Lamp Issues

	<b>Efficacy</b> Efficiency in Lumens/Watt
	<b>Lumens</b> Total output
	<b>Life</b> Hours of use
	<b>Color</b> How objects look
	<b>Design</b> Integration and beauty

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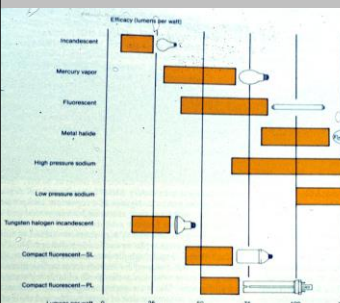
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## Efficacy varies with lamp type...



Source	Efficacy (Lumens per Watt)
Candle	0.1
Oil lamp	0.3
Original Edison lamp	1.4
1910 Edison lamp	4.5
Modern incandescent lamp	14-20
Tungsten halogen lamp	18-20
Fluorescent lamp <sup>a</sup>	50-80
Mercury lamp <sup>a</sup>	30-60
Metal-halide lamp <sup>a</sup>	60-80
High-pressure sodium <sup>a</sup>	90-100
Low-pressure sodium	120-140

<sup>a</sup>Including ballast losses.

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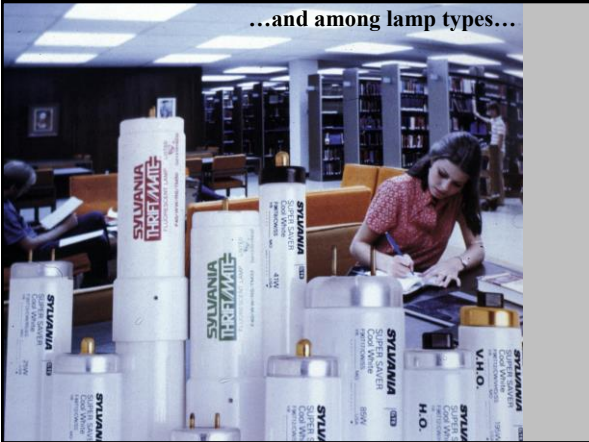
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...and among lamp types...



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**DOE CALIPER RESULTS TO DATE**

	POWER (W)	OUTPUT (LM)	EFFICACY (LM/W)	CRCP (CRI)	CCT	CRI*
<b>ROUND 2</b>						
R30 Rep. (Warm)	8.8	239	27	--	2945	72
R30 Rep. (Cool)	9.1	310	34	--	5973	82
R30 Rep. (Warm-RCB)	15.6	406	26	--	2689	15 <sup>1</sup>
R30 Rep. (Cool-RCB)	13.8	352	25	--	4006	13 <sup>1</sup>
A19 Rep. Lamp	0.7	10	16	--	3161	70
A-lamp (A17) Rep.	1.5	20	13	--	25263 <sup>2</sup>	79
<b>ROUND 3</b>						
SSL MR16 Rep.	3.9	77	20	--	6381	80
SSL E27 Rep.	8.6	180	21	--	7878	77
SSL PAR30 Rep.	17.1	650	38	--	2854	52
SSL A-lamp Rep. (retrofit)	0.7	33	48	--	3059	70
Downlight Retrofit (6 in.)	11.8	719	61	--	2754	95
Downlight Retrofit (6 in.)	10.8	663	61	--	3402	91
<b>ROUND 4</b>						
SSL T8	25	1058	42	--	3494	75
SSL MR16	3	82	27	283	300	74
SSL MR16	9	193	16	220	3338	89
SSL MR16	3	75	26	59	3458	74
SSL Candelabra	2.2	28	13	--	2855	71

**LED efficacy varies from 13 to 61 l/w for lamps up to 25 watts**

ABOVE: Results of CALIPER testing of solid-state lighting directional and non-directional replacement and retrofit lamps. CRCP = center beam candlepower. CCT = correlated color temperature, CRI = color rendering index.

\* All numbers except input watts are rounded to nearest whole integer. For RFL sources, CRP does not reflect color quality of white light. <sup>1</sup> For A19 lamps, CRP is the light produced by the lamp in an energy-efficient mode only. <sup>2</sup> This product is a direct ancestor of the A19 replacement lamp tested in Round 1.

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**Replace or Reinvent MR-16 Lamps?**

All Super High Power LED MR-16s and PARs have 3 approved lumens (3000A, 3000B, 3000C) standards and have 14 Adconex® Lighting Facts Labels.

Full line of LED retrofit lamps now available.

Learn more about LEDs at our monthly webinars. For more information visit us at [www.bulbrite.com](http://www.bulbrite.com).

**SR6 LED Downlight**  
The SR6 LED architectural downlight from Cree Lighting Products delivers up to 1,800 lumens of 90+ CRI light, with efficacy of up to 75 lumens per watt, for applications including airports, hospitality, and museums. Combined with Cree TrueWhite technology, the SR6 delivers high-quality light with greater optical control than before, according to the manufacturer. The SR6 is available in a variety of color temperatures and with anodized-aluminum reflector finishes and out-of-the-box controls compatibility. [cree.com](http://cree.com)

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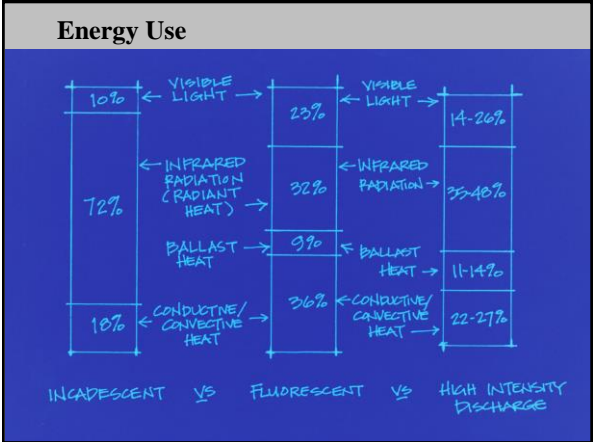
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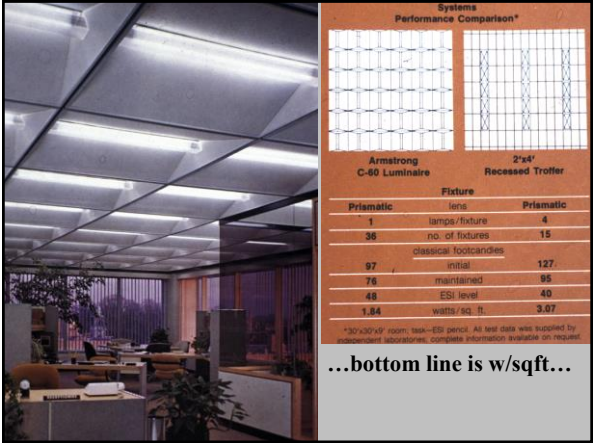
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### ...and remember, dimming and occupancy sensors reduce watts/square foot

"I went out to see the NY Times building and was very impressed with how well it is working. Below is a picture I took of the commissioned 8th floor, and you can see how much energy is being saved right in the picture..."

**Francis Bahnsen**  
 Neil Rosen  
 Building Technology Department  
 Lawrence Berkeley National Laboratory

As a consultant we were used by permission.

**the principle:**  
Dimming lights saves energy.

**the strategy:**  
Automatically dim lights near windows when daylight is available.

**the details:**  
[www.lutron.com/hyd](http://www.lutron.com/hyd)

**the numbers:**  
Fluorescent fixtures with Lutron EcoMaster™ dimming ballasts - 15,000  
 Included annual lighting energy savings - 40%  
 Annual CO2 reduction - 470 metric tons

Creating a smart, sustainable building requires a collaboration of design, engineering, and innovative technology. The New York Times, their design team, and Lutron created a lighting control system that achieves a seamless blend of comfort, productivity, and energy savings.

As the global leader in dimming and occupancy light control, Lutron has been delivering stable, innovative, and energy savings to buildings for over 60 years. Call us to find out how Lutron lighting controls enhance your projects. 1-800-251-2517.

**LUTRON**

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### Lumens output varies with lamp type...

For a 400 watt lamp...

	<b>Incandescent</b> 7,000 lumens
	<b>Mercury Vapor</b> 20,000 lumens
	<b>Fluorescent</b> 31,000 lumens
	<b>High Pressure Sodium</b> 42,000 lumens
	<b>Light-Emitting Diodes</b> unknown (24w gives 1800 lumens)

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### Life expectancy varies with lamp type...

	<b>Incandescent 100w</b> 750 hours (long life = 2500 hrs)
	<b>Mercury Vapor 75w</b> 16,000 hours
	<b>Fluorescent 40w</b> 20,000 hours
	<b>High Pressure Sodium 100w</b> 20,000 hours
	<b>Light-Emitting Diode 24w</b> 35,000 hours

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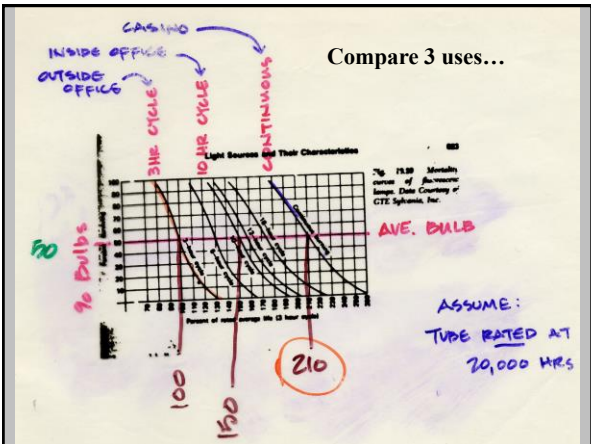
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	EXPECTED BULB LIFE	THE NUMBER OF YEARS IT'LL LAST w/ GIVEN USE
EXTERIOR OFFICE	20000 x 1.00 20,000 hrs	$\frac{20000}{3 \text{ hrs/day} \times 365} = 37.04$
INTERIOR OFFICE	20000 x 1.50 30,000 hrs	$\frac{30000 \text{ hrs}}{10 \text{ hrs/day} \times 365} = 8.22$
CASINO	20000 x 2.10 42,000 hrs	$\frac{42000 \text{ hrs}}{24 \text{ hrs/day} \times 365 \text{ days/yr}} = 4.79$

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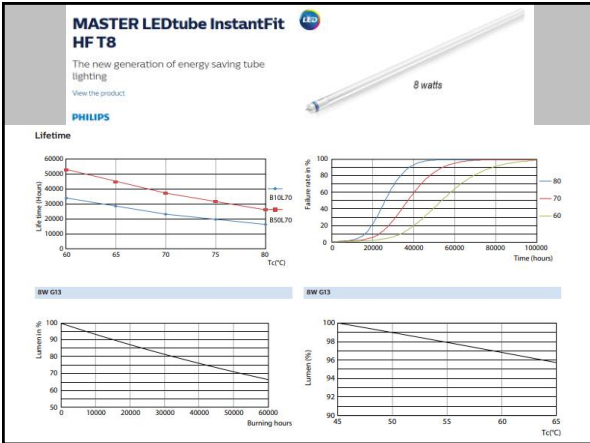
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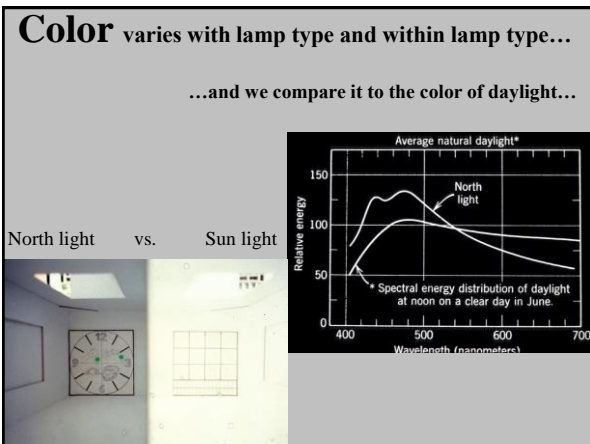
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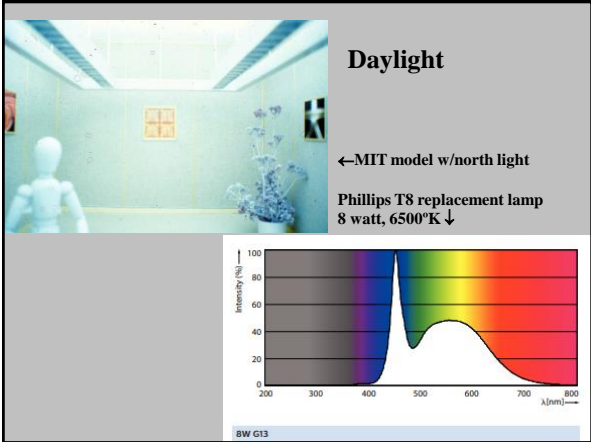
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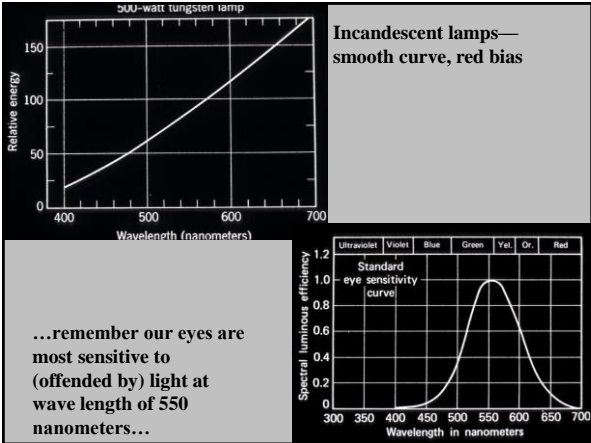
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Fast Company

## AN ENERGY-EFFICIENT BULB THAT MAKES THOSE IT ILLUMINATES MORE ATTRACTIVE



Do you think you look better in a certain kind of lighting? Plumen, the award-winning LED lighting company, has released a product they claim will make those bathed in its light more beautiful while still saving energy.

*"It's hard to let go of incandescents because there's something burning inside. There's something really beautiful about that. Not just in the way you see it, but it's romantic," says Nicholas Roope, Plumen's creative director. "It makes people look beautiful. The way the light dances, it masks something but brings out qualities that a brighter light takes away."*

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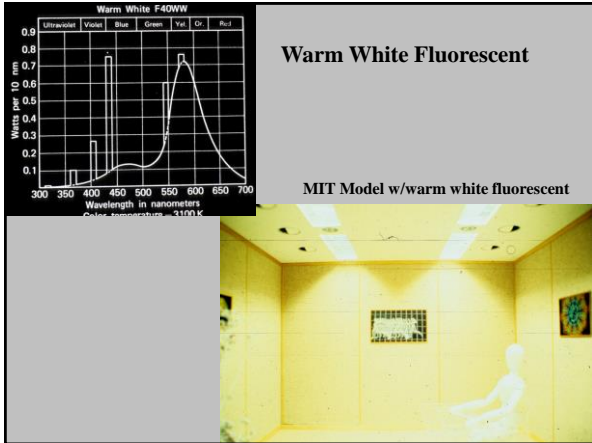
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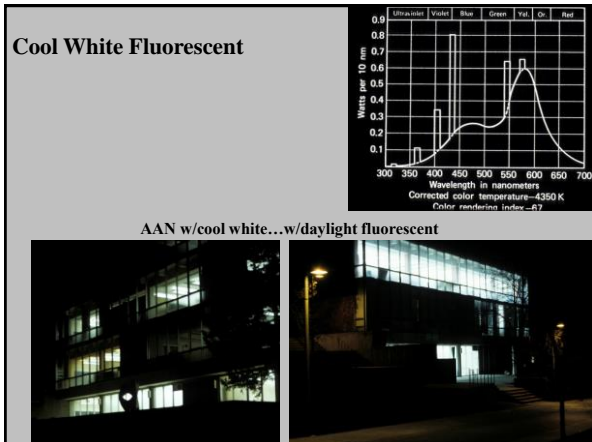
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### Heather Carson—Fluorescent lamp artist

WWDX	WW	WWDX	CoolW
CoolW	NatW	WW	Sunlight
		WW	Daylight
		NatW	Daylight DX

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### High Intensity Discharge Lamps

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### High Pressure Sodium

HP Sodium vs. Daylight Fluorescent

UI Memorial Gym

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## Improved Mercury Vapor

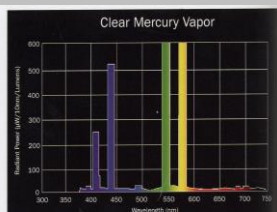


Plate 27

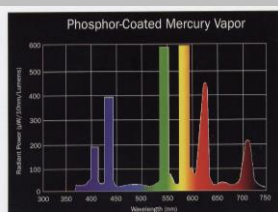


Plate 28

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## Improved Metal Halides

- Phosphors
- Ceramic Arc Tube

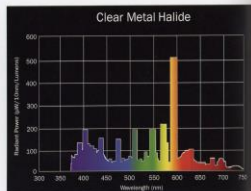


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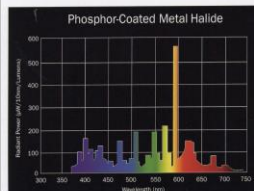


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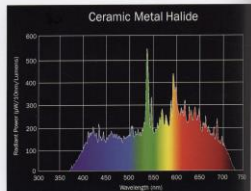


Plate 31

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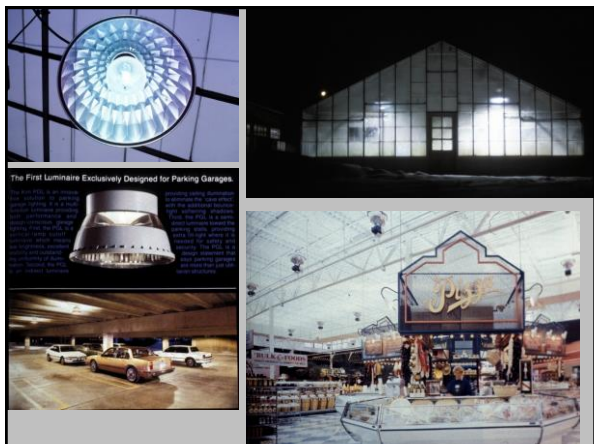
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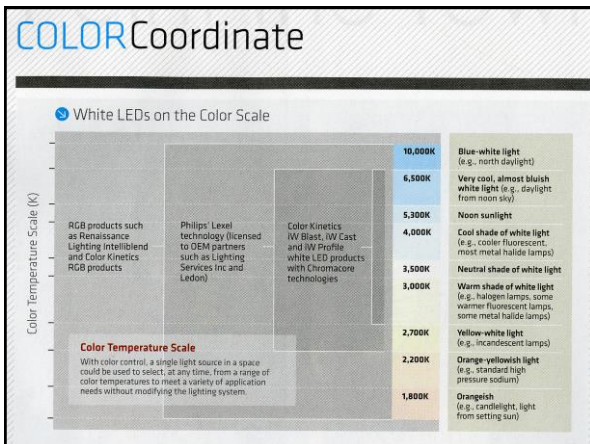
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**LUMINAIR 3.1 SYSTEM FX**  
 System FX has updated the Luminaire software that offers wireless control of DACC because most commercial buildings are built on third floors. The software allows a user to adjust color temperature remotely. It also allows the contractor to control custom settings. The DACC network must be AIA-Net compatible. [» visit the site » contact us](#)

## RGB LEDs allow color tuning from your smart phone.

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## How to rate color rendering...

**World Class Color Rendering**  
 The color rendering index (CRI) is a measure of how accurately an artificial light source can render color. **EYE Color Arc®** lamps, with a CRI of 96, are worldwide leaders in color rendition. Accurate color enhances the value of any setting.

CRI 96 — EYE Color Arc®      CRI 65 — Retail Halide

Lamp	CRI (approximate)	CCT (°K)	Whiteness
FLUORESCENT	52	3050	Yellowish
	62	4200	White
	77	4050	White
Triphosphor	75	2800	Yellowish
	80	3000	Pale yellowish
MERCURY	20	7000	Blue-Green
	45	3700	Pale-purplish
METAL-HALIDE	65	4000	White
	80	4200	White
HPS	21	2100	Yellowish
	60	2200	Yellowish-White
Incandescent	89+	2800	Yellowish

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**3000K** The 3000 K EYE Color Arc® lamp produces warm white illumination that is rich with red and orange tones. Color rendering is excellent and appears natural. It is ideal for residential applications, bars, and restaurants. It provides a warm, relaxing atmosphere and is the color rendering that most closely matches incandescent lighting.

**3500K** The moderate high color of the warm white illumination. The hue is a very rich, warm white. The 3500 K EYE Color Arc® lamp has the best of both worlds. Warm, rich color with the best of both worlds. Warm, rich color with the best of both worlds. Warm, rich color with the best of both worlds.

**4500K** The best choice for general illumination. The 4500 K EYE Color Arc® lamp produces a rich, warm white illumination with a subtle yellowish tint. It is ideal for commercial applications, offices, and retail environments. It provides a clean, bright atmosphere and is the color rendering that most closely matches incandescent lighting.

**6500K** The white illumination with the highest color rendering index. The 6500 K EYE Color Arc® lamp produces a bright, clean white illumination with a subtle yellowish tint. It is ideal for commercial applications, offices, and retail environments. It provides a clean, bright atmosphere and is the color rendering that most closely matches incandescent lighting.

**Very Similar Spectrum to Natural Sunlight**  
 Spectral distribution of EYE Color Arc® lamps are very similar to natural sunlight. This superb characteristic fits any applications where natural color is necessary.

**Actual Daylight (D65)**      **6500K EYE Color Arc®**      **Standard Metal Halide**

Relative Energy (%) vs Wavelength (nm)

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## Gamit Area Index – see [lrd.rpi.edu/assist](http://lrd.rpi.edu/assist)



The Color-Rending Index (CRI) for a given lamp is based on the average of how well the source renders the correct pastel color samples (left) compared to an ideal reference source. To address the limitations of CRI, the Lighting Research Center has proposed a supplemental scale—Gamit Area Index—for color-critical applications such as retail installations. To learn more about GAI, go to [lrd.rpi.edu/assist](http://lrd.rpi.edu/assist).



To address the shortcomings of the Color-Rending Index (CRI), which has become amplified by the use of some solid-state lighting products, The National Institute of Standards and Technology has developed a metric called the Color Quality Scale (CQS), intended to replace CRI. CQS is based on 15 high chroma (highly saturated) color samples (left). To learn more about CQS go to [nist.gov/pml/div685/grp05/vision\\_colorcfm](http://nist.gov/pml/div685/grp05/vision_colorcfm).

## Color Quality Scale – see [nist.gov/pml/div685/grp05/vision\\_colorcfm](http://nist.gov/pml/div685/grp05/vision_colorcfm)

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## The re-emergence of flicker

Flicker Metrics for Common Sources

Technology	Percent Flicker	Flicker Index
Incandescent lamp	6.3	0.02
T12 linear with magnetic ballast	28.4	0.07
Spiral compact fluorescent lamp (CFL)	7.7	0.02
Quad-tube CFL with magnetic ballast	37.0	0.11
Quad-tube CFL with electronic ballast	1.8	0.00
Metal halide lamp	52.0	0.16
High-pressure sodium lamp	95.0	0.30
Direct current LED	2.8	0.0037
LED with significant flicker	99.0	0.45

Source: Michael Poplawski, Naomi Miller, PNNL (2011); Michael Grather, Luminaire Testing Laboratory (2009)

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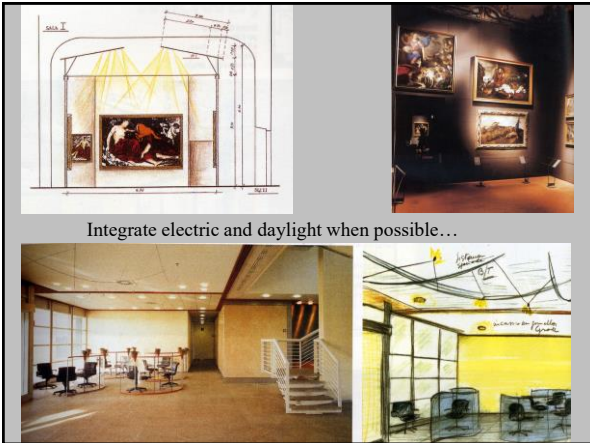
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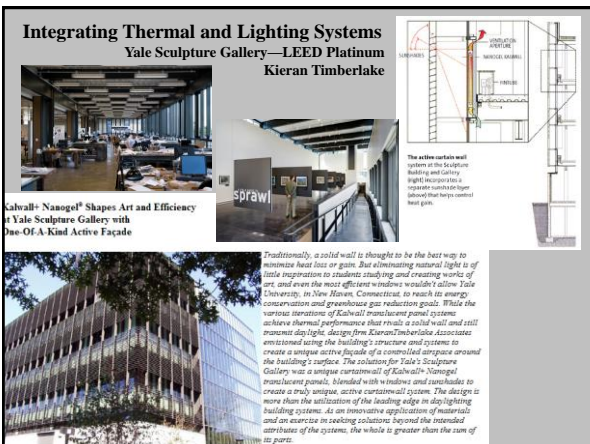
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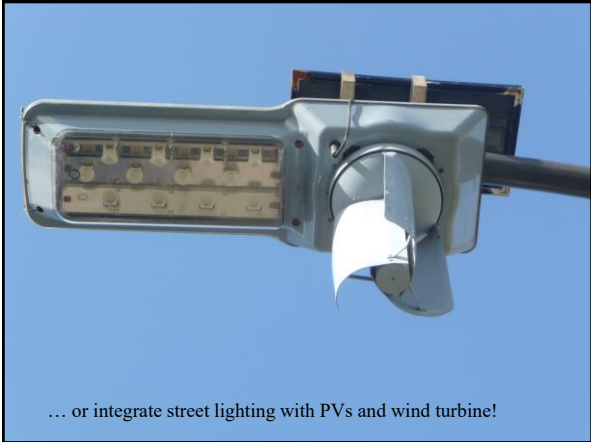
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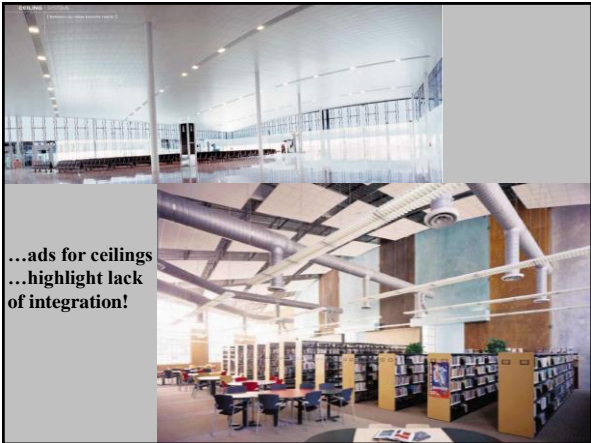
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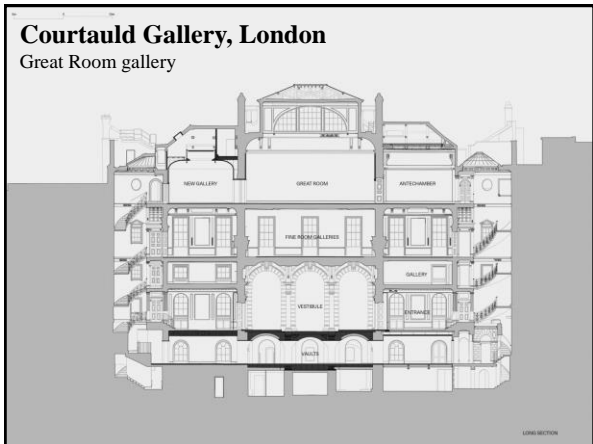
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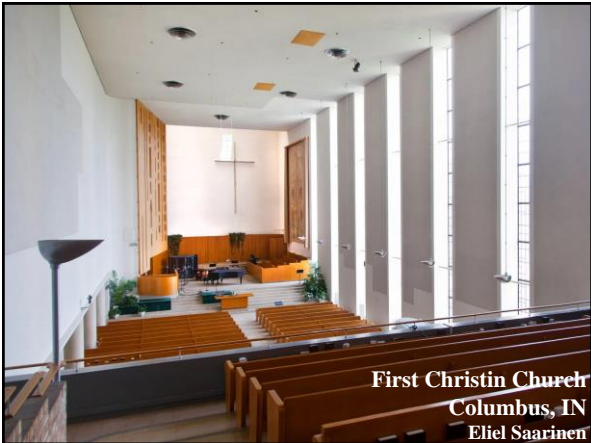
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First Christian Church  
Columbus, IN  
Eliel Saarinen

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...to be continued...

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