LED and Home Energy Savings:
The Next Chapter

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Residential Recessed Lighting - HALO

Eaton

EATON
Powering Business Worldwide

SOURCE
lighting education center

1121 Highway 74 South
Peachtree City, Georgia 30269
1 hour/ HSW LHES

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Overview

Lighting is often overlooked when building a home, yet it has the greatest opportunity to reduce energy use intensity (EUI).

This presentation will count toward CEU credits and describe how LED technology affects the entire home by changing the characteristics of light from radiant heat to conductive energy.

Participants will learn how the absence of heat affects other investments and aspects of the home including the overall building envelope, insulation and air conditioning. The course will also describe key differences between LED Luminaires and lamps in addition to ideal applications for each.

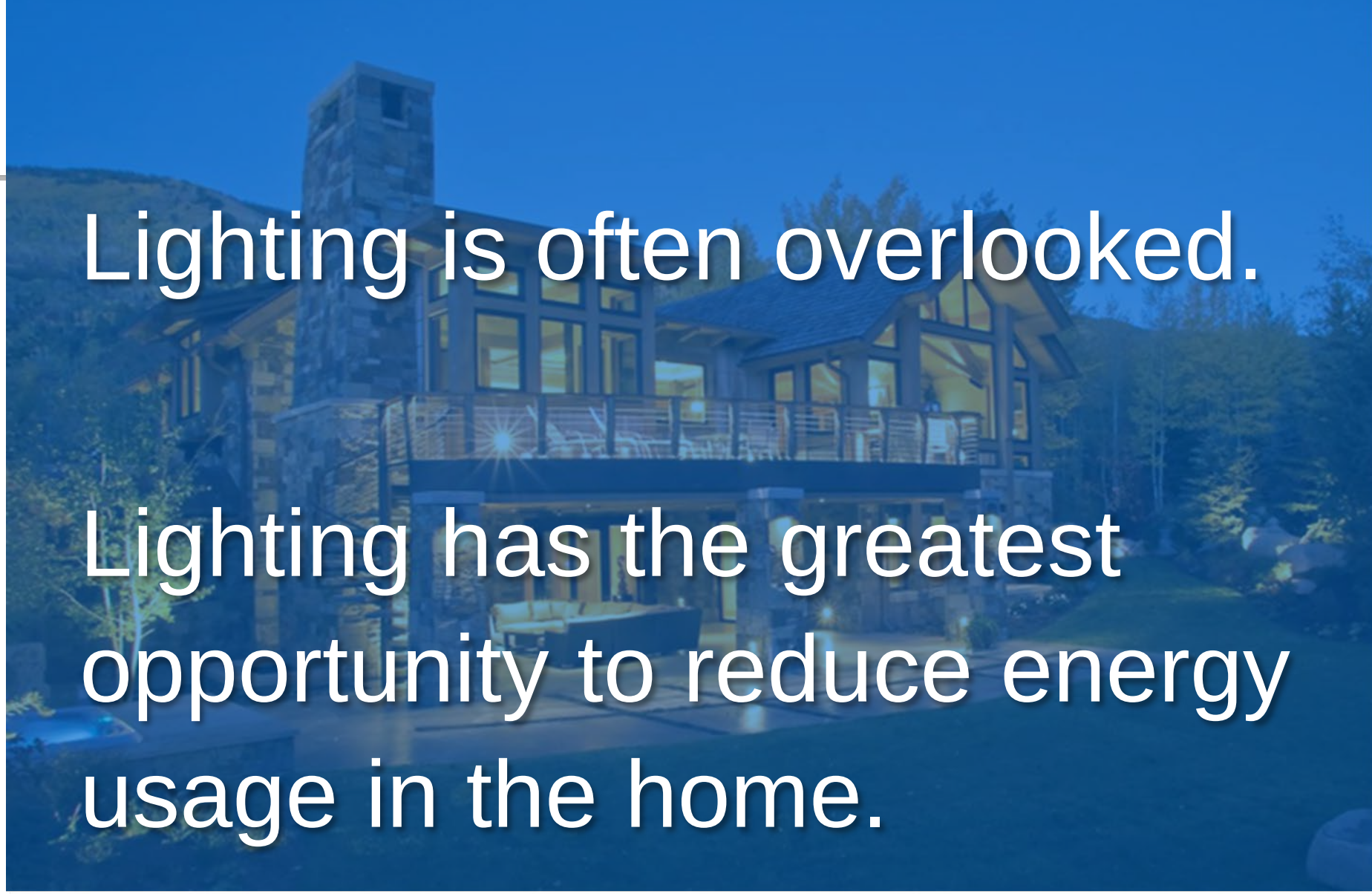
Learning Objectives

- *Participants will gain an understanding of how LED lighting reduces energy usage and can increase the overall investment value of the home.*

- *Participants will learn fundamental differences between LED luminaires and LED lamps through product and application examples to ensure appropriate fixture selection in the home.*

- *Participants will recognize hidden benefits of how LEDs affect the home by changing the characteristics of light from radiant heat to conductive energy in order to take advantage of additional energy saving opportunities.*

- *Participants will be able to determine which home lighting applications are suitable for LED luminaires or LED lamps by understanding appropriate lighting performance expectations.*



Lighting is often overlooked.

Lighting has the greatest opportunity to reduce energy usage in the home.

Evolution of Lighting

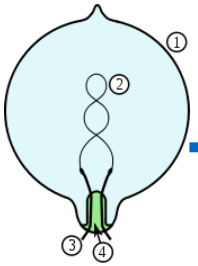
Oil lamp

1780

Gas lamp

1795

Vacuum tube



1820

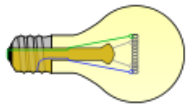
Arc lamp

1842

Fluorescent Technology

1869

Electric light bulb



1875

Gas discharge lamp

1895

Mercury vapor lamp

1900

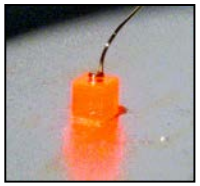
Neon

1910

Fluorescent lamp

1925

Red LED



1962

CFL

1975

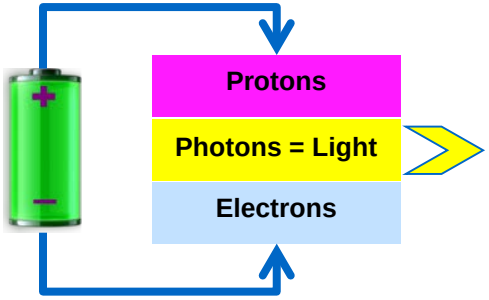
Blue LED

1998

What is an LED?

Lighting Emitting Diode (LED)

LED is a semi-conductor that emits light when voltage is applied.



- No Filament Failures
- Convert AC to DC
- Thermal Management
- Optical Efficiency

Popular LED Types

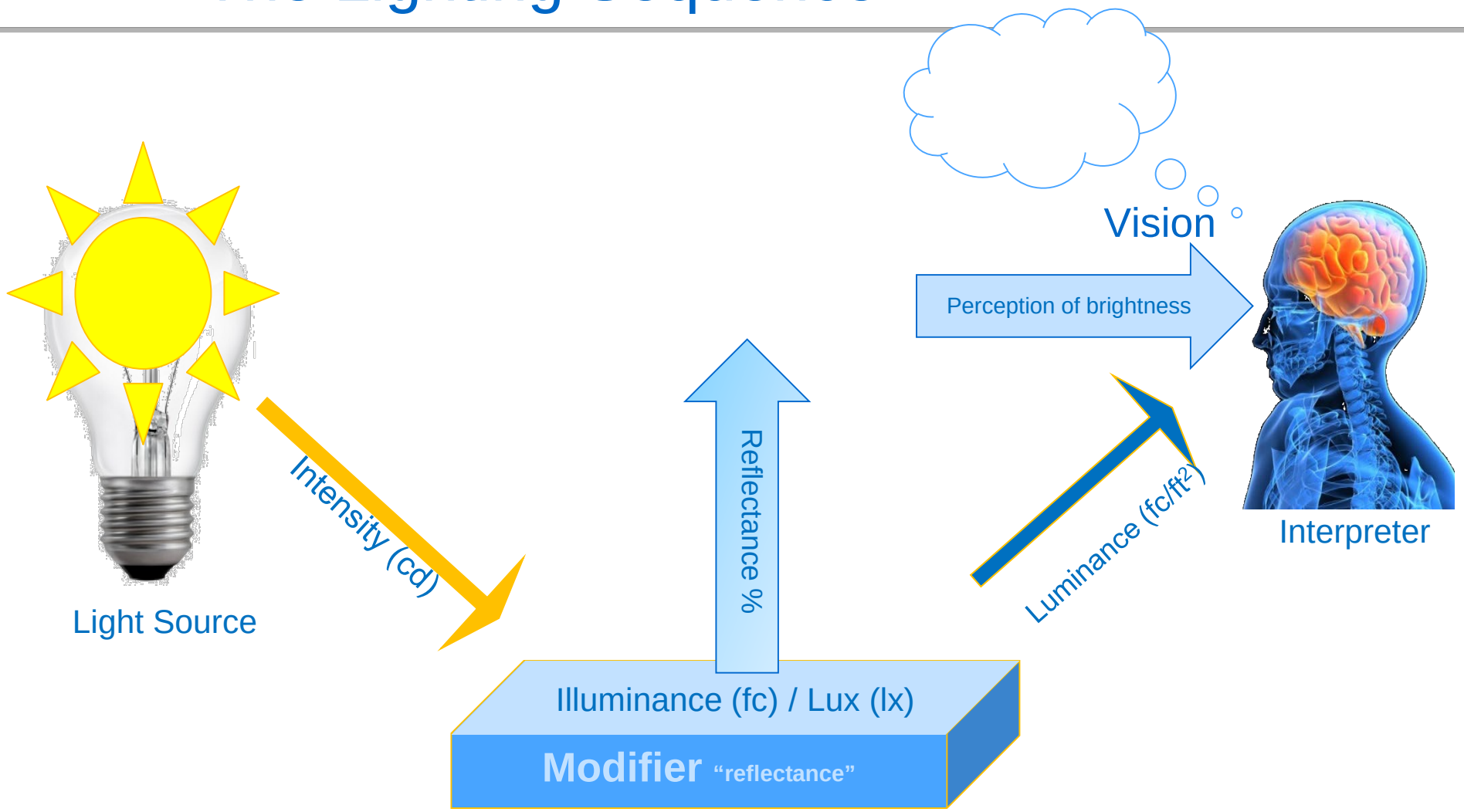
Discrete

- Higher optical control
- Higher thermal losses
- Requires special optics
- Can be multi-colored
- Low cost LED

Chip on Board

- Lower optical control but great light mixing
- Lowest thermal losses
- Very high efficacies
- Lowest cost

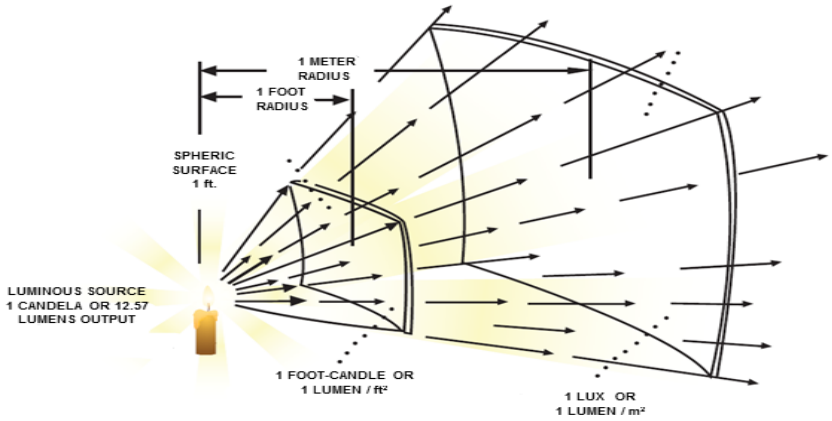
The Lighting Sequence



Terminology

Luminous Flux (Φ lm)

The **total** amount of light producing power of a light source and is measured in lumens (lm) and the symbol used is **Φ (PHI)** per international System of units not considered).

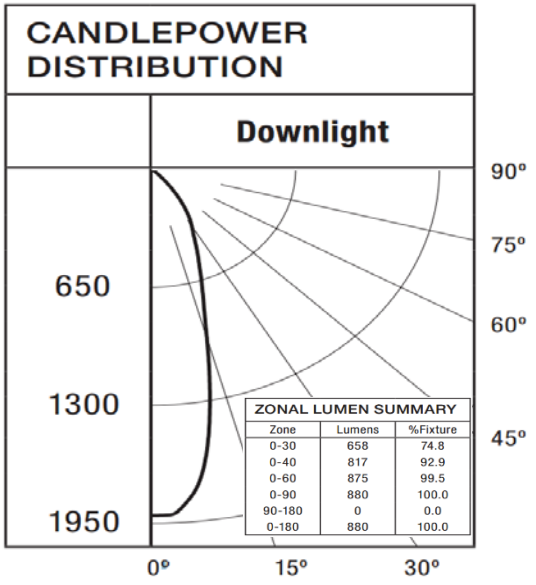


Note: 1 fc ≈ 10 lux

[Exact conversion: 1 fc = 10.76 lx]

INTENSITY Luminous Intensity ("*I*" cd)

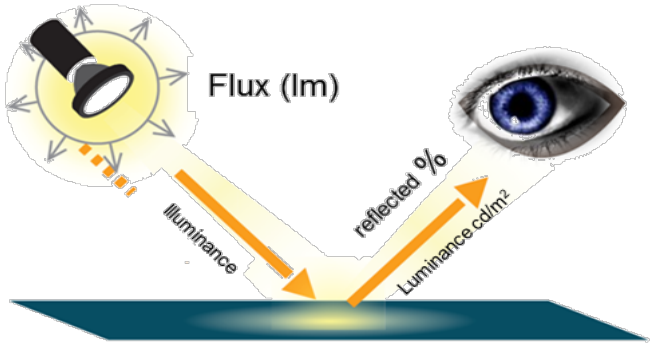
Candela is the Luminous intensity refers to the intensity or "strength of light" in a specific direction



Terminology

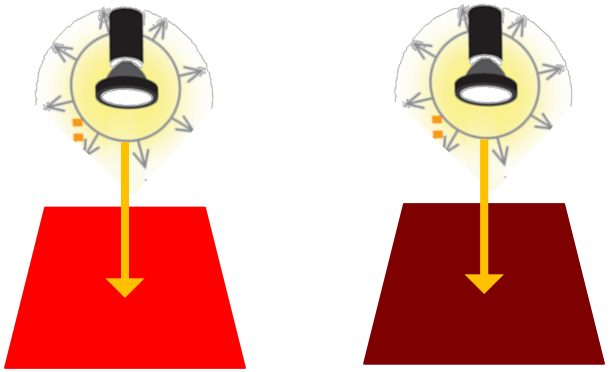
REFLECTANCE P (RHO %)

The percentage of reflected light from a surface as compared to the light arriving on that surface.



LUMINOUS EXITANCE (lm/ft²) (lm/m²)

This metric expresses the amount of light per unit area emitted by a lighted surface. This metric is used primarily in conjunction with “matte” or “diffuse” surfaces.



LUMINANCE cd/m² or lux/m²

The strength of visual sensation is usually referred to as brightness (technically photometric brightness).

BRIGHTNESS

The perception of a surface’s luminance, sensed by the eye and interpreted as sensation by the brain.

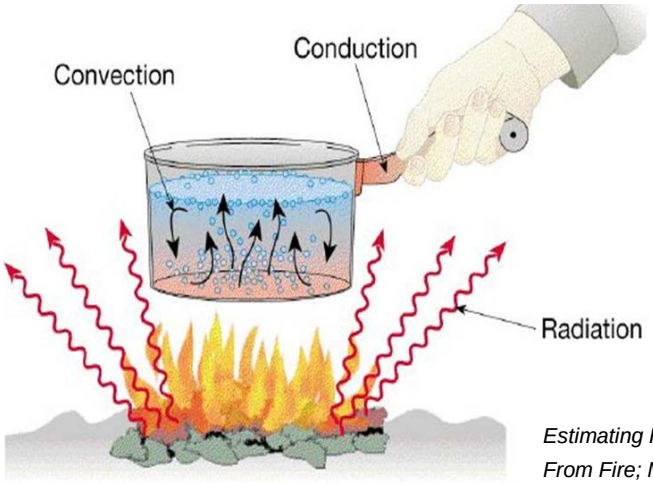
Light and heat… a fiery tale

1% Light

99% Heat

70% convective

The first light (1,472° – 2,192°)



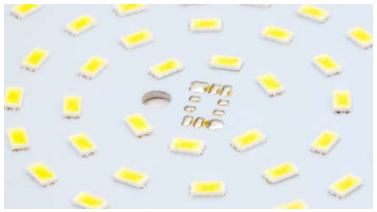
- Burned gases rises carrying heat (convective)
- Radiant heat emanated
- Nearby materials absorb heat and conduct

Estimating Fire Flame Height and Radiant Heat Flux From Fire; Marchetti; 2012

Light vs. Heat – today

- Incandescent – 8% light / 92% heat
  - Heat is predominately infrared
  - Commonly used for to keep food warm

- Fluorescent – 21% light / 79% heat
  - Losses from electronics are conductive
  - Produces nearly 40% infrared heat with the remaining convective



- LED – 35% light / 65% heat
  - Negligible infrared heat, mostly conductive

Energy considerations:
bulbs vs. luminaires

LED bulb and luminaire

- 800 lumens
- 9 watts
- 88.9 lpw

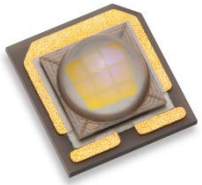
- 2 bulbs

+

- 40% efficient bowl

640 lumens / 18 watts / 35.6 lpw

LED integrated luminaire



- LEDs

- Driver electronics

+

- Complete luminaire

1010 lumens / 14 watts / 72.1 lpw

Nearly 60% more light with lower energy usage.
Better lighting or opportunity for control savings.

Translating into demand savings for the home

LED Bulb-based

LED Luminaires

Luminaire type	Quantity LED bulbs	Optical eff.	Total delivered lumens	Total wattage consumed
Table Lamps	9	30%	2,160	81
Shower Lights	3	30%	720	27
Recessed Downlights	48	50%	19,200	432
Surface	12	40%	3,840	108
Accent	3	30%	720	27
Vanity Lights	16	60%	7,680	144
Totals			**35,120**	**819**
Lumens per watt			**42.9**	

Luminaire type	Optical eff.	Total delivered lumens	Total wattage consumed
Table Lamps	100%	3,375	71
Shower Lights	100%	2,058	22
Recessed Downlights	100%	31,200	365
Surface	100%	12,120	168
Accent	100%	1,970	29
Vanity Lights	100%	10,160	115
Totals		**60,883**	**770**
Lumens per watt		**79.1**	

Over 70% more light with 6% lower energy.
Better lighting to leverage control savings.

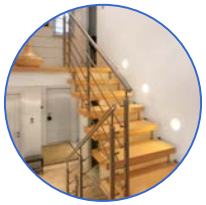
Significance of higher light levels

Improved lighting with lower energy demand creates:

1. Resale / higher valuations

2. Reduced plug-load additions for table/floor lamps

3. Improved visual acuity (aging population)



4. Improved safety

Evolution of Controls

ON/OFF switch

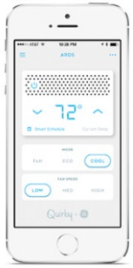
Timers

Dimmer

Plug in Smart Devices (WEMO)

IOT & Voice (Amazon Echo, IFTTT, Nest, HomeKit, etc)

Connectivity APPs (Wink, SmartThings, etc.)



Wired in Smart Devices (HUE)

Trade names referenced are not Eaton products

Controls offer deeper **demand** reductions for greater energy savings

Amount dimmed during usage
(home behavior when dimmer installed)

Room	Inc/Hal	LED
Basement/Bath/Hall/ Office	34%	39%
Bedroom	34%	39%
Living/Family	73%	79%
Dining	66%	73%
Kitchen	34%	39%

Eaton research comment:

Occupancy/vacancy sensors damage fluorescent, incandescent, and halogen bulbs. Dimmers even damage fluorescent bulbs. ***Not true for LED light sources.***

Avg reduction in hours when unoccupied
(home behavior when sensor installed)

Room	Occupancy/Vacancy Sensor Controls
Basement	60%
Bathroom	50%
Bedroom	44%
Dining Room	16%
Exterior	90%
Garage	33%
Hall	53%
Kitchen	39%
Laundry/Utility	60%
Living/Family	25%

Source: Navigant Consulting and Consortium for Energy Efficiency

Why some LED bulbs don't last as long as they claim in recessed applications

LED bulb ENERGY STAR® testing environment

- Bulbs tested in large housings
- No trim
- Large volume
- Double wall from insulation
- Airflow
- 25C ambient
- "enclosed" bulb rating

LED bulb actual environment

- Bulbs screwed into smaller ICAT and non-ICAT housings and remodels housings
- Trims are used
- Much lower volume
- Direct insulation contact
- Limited airflow: smaller apertures and trims

Higher temperatures in housings cause premature failures and lower light output than expected

Better understanding of technologies
Implementation considerations

LED bulbs

- Dimmable enclosed rated bulbs not readily available
- Controls compatibility issues/ concerns
- Conditions of suitability often not clear
- Enclosed rated bulbs not readily available
- **Lifetime a function of 50% bulb fail**

HALO RA5606930WH

LED integrated luminaries

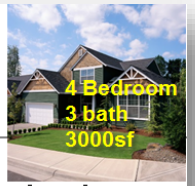
- Use of line voltage and 0-10Vdc commonly available
- ENERGY STAR® requires validation if claimed
- **Lifetime a function of % light loss, not failure**

Energy savings opportunities
Combining fixtures and dimming

Reminder:

Most LED bulbs aren't dimmed

Translating into demand savings for the home



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Higher light levels with integrated luminaires supports use of dimming controls saving an additional 51% over the use of LED bulbs.

Energy savings opportunities
Combining fixtures and dimming

Home Location	Wattage							% Dimmed	Effective Wattage Load	Estimated Hours of use	Hours influenced by Sensors	W-h/day
	Table Lamps	Shower Lights	Recessed Downlights	Surface	Accent	Vanity Lights	Sum					
Basement	-	-	30	28	-	-	58	39%	36	5	2	71.25
Bathroom	-	22	-	-	-	115	137	39%	84	5	2.5	209
Bedroom	55	-	61	56				9%	105	5	2.8	294
Dining Room	-			-				3%	12	5	4.2	52
Garage	-			14				0%	14			
Hall	-			28	19	-	4	39%	29			
Kitchen	-			2	10	-	53	9%	32			
Lunndry/Utility	-	-	-	14	-	-	14	0%	14	5	2	28
Living/Family Room	16	-	213	-	-	-	229	79%	48	5	3.75	180
Totals	**71**	**22**	**365**	**168**	**29**	**115**	**770**		**374**			**1,047**
								Dimming Demand Savings:	**51%**			

LED bulbs and luminaires

LED luminaires only

Rationale:
Most LED bulbs aren't dimmed.
Luminaires are.

Higher light levels with integrated luminaires supports use of dimming controls saving an additional 51% over the use of LED bulbs.

HVAC loads
Interactive influences of lighting

- **Commonly understood**
  - Wattage reduction results in lower HVAC loads
- **Not commonly considered**
  - Time of use reduces HVAC operation – Controls offer savings big role
  - Type of loading impacts HVAC load directly – Radiant vs. conductive

HEAT

Radiant

50W MR16
59W total
70% optical efficiency
8% light / 92% heat
(mostly IR)

VS.

HEAT

Conductive

LED
7W total
100% optical efficiency
35% light / 65% heat

Recessed LED = 90% reduction in heat load

- *Per NIST, the plenum area is the best place to store the heat from the lighting system[1] favoring recessed LED products that conduct into the plenum.*

[1] http://fire.nist.gov/bfrlpubs/build92/PDF/b92007.pdf

The Color of Light

Color temperature **(Kelvin)**

The ability for a light to render a color or show the color hue is CRI (color rendering index)

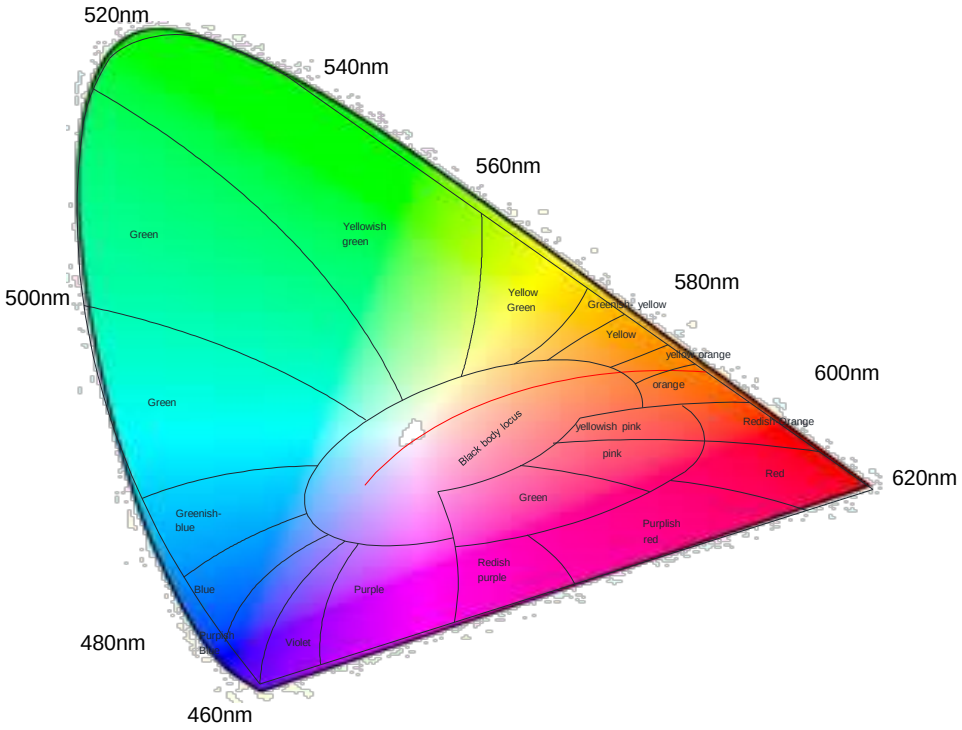
- Scale of 0-100
- IES recommends a CRI of 80 or better for environments which we spend time and 90's or better for tasks

Light and Color

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

In the study of color vision, a MacAdam ellipse is a region on a chromaticity diagram which contains all colors which are indistinguishable, to the average human eye, from the color at the center of the ellipse. The contour of the ellipse therefore represents the just noticeable differences of chromaticity.



Choose Wisely…

Increase home values with color

Health and Well-being / Safety / Energy Savings

Lighting for Humans

Humans have feelings…

and needs.

The visual environment in today's residence is complex.

How Much Light Do We Need?

Three main factors determine the required amount of light for good vision in a space.

1. The age of the people using the lighting

2. The speed and accuracy of the task

3. The reflectance of the surfaces being lit

Illuminating Engineering Society

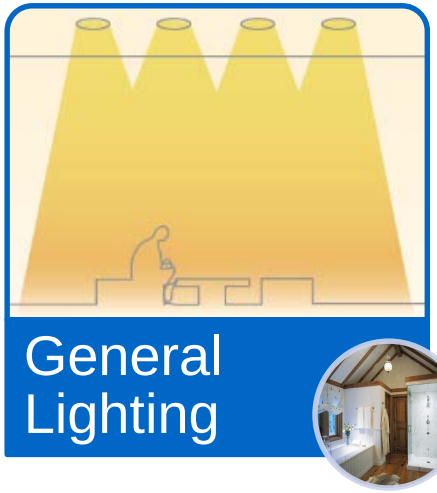
Three Question (3Q) Lighting Plan

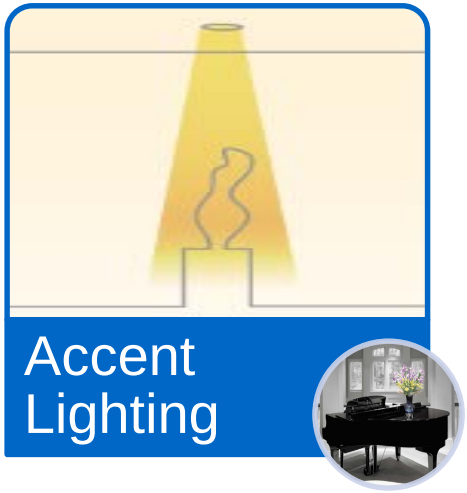
1. What's going on the room
   - Cooking, sleeping, playing, reading, walking

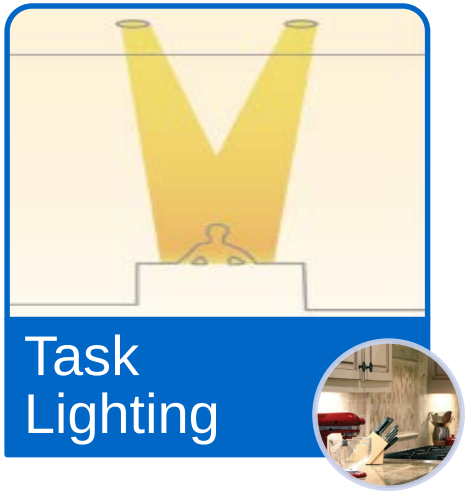
2. What's the ideal lighting solution
   - Task lighting, general down lighting, ambience, wall washing, shower, security

3. How to save energy
   - Air-tight fixtures, LED luminaires, controls such as dimmers and timers

Determining the ideal lighting solution: Choosing a lighting type (beam angle)







Determining the ideal lighting solution: Color, CRI and Footcandles

	Kitchen	Bathroom	Hallway	Living room	Dining	Bedroom	Utility / Laundry	Game / Task	Outdoor
Color Temp (k)	2700 3000 3500	2700 3000 3500	2700 3000	2700 3000	2700 3000	2700 3000	3000 3500	3000 3500	3500+
CRI	90	90	>80	>80	>80	>80	90	>80	n/a
Fixture type	Recessed Track Surface Under Cab Suspended	Recessed Surface Sconce	Recessed Chandelier Suspended	Recessed Table lamp Track Surface	Recessed Sconces	Recessed Sconces Table lamp	Recessed Surface	Recessed Track Suspended	Recessed Surface
Avg Illum. (fc)	Gen: 10-20 Sink: 50 Task: 30-50	Gen: 20-50 Task: 30	Gen: 10-20 Trans: 3-5 Stairs: 10-20	Gen: 10-20 Fire plc: 5-20	Gen: 5-10 Table: 25-50 Art: 10-20	Gen: 5-10 Read: 30-50	Gen: 30-50	Task: 20-50	Entry: 10-20 Security: 30+

- Task Lighting typically increases for older eyes – up to 100 footcandles
- Watch for ceiling fan strobing when installing recessed lights (bedrooms)
- For reading place lights slightly behind or to the side
- For tv/computer screens keep lights to the side rather than in front

Finding the ideal LED lighting solution

Recessed	Surface / Ceiling fan	Track	Under Cabinet	Outdoor	Table and Sconce lamps

The future of lighting in the home

- Shallow housings / Smaller apertures

- Direct surface mounting to ceiling

- Layers of light uses (night light mode)

- Wi-Fi extenders

- Speakers

- Embedded sensor technology

- Personal Lighting

- Low voltage distribution systems


Q?&A!

LED and Home Energy Savings:

The Next Chapter
(LHES)

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