Energy Efficient Lighting

Watt You Need To Know

Tuesday, October 8th, 2013 1:00 PM

Presented By:
Bryan Heitzmann, Training & Edu. Dev. Specialist

Pennsylvania Housing Research Center

www.engr.psu.edu/phrc

Objectives

- Understand the market for residential lighting products & how each product can vary in its construction, light characteristics, and lifespan.
- Realize existing options, characteristics, & best practices for lighting products & understand how they can contribute to reducing the energy consumption of a building
- Recognize current code requirements regarding residential lighting & realize their impact on occupant safety & well-being
- Make educated & informed lighting selections for residential projects that can improve indoor environments & increase visual comfort for occupants

Agenda

- Background
- Lighting Characteristics
- Types of Lighting
- Lighting and Residential Code Requirements
- Lighting & How It Relates To Energy Efficiency
- Summary

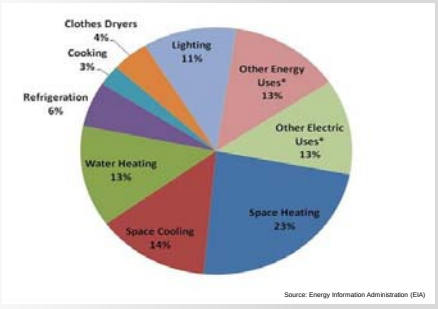
Background - History

- **The invention of the incandescent light bulb dates back to the early 1800s**
- **Scientists & inventors desired a cost effective, practical, long-life bulb**
- **Edison developed bamboo filaments in 1880**
  - lasted up to 1200 hours
- **Modern tungsten filament incandescent light bulb developed from 1906-1910**
  - By the General Electric Company and William Coolidge

Background - Today

- **Many homes still use incandescent bulbs**
  - Low cost
  - Shape and size availability
  - Not very efficient
    - 10% of the electricity consumed converted into light
    - 90% is converted to heat
- **Residential lighting consumption in 2011 totaled 186 billion kWh**
  - 10%-13% of residential energy use
- **New bulbs, new code requirements & energy saving strategies exist**
  - Use less electricity than incandescent light bulbs
  - Result in lower electricity bills

Average Annual Energy Usage



Reduction of Energy Loads in Pennsylvania

Why is it important?

- **American Recovery and Reinvestment Act**
  - Passed by US Congress in February of 2009
- **Funding contingent upon 90 percent energy code compliance within 8 years**
  - Rendell sent letter of assurance to DOE Secretary of Energy

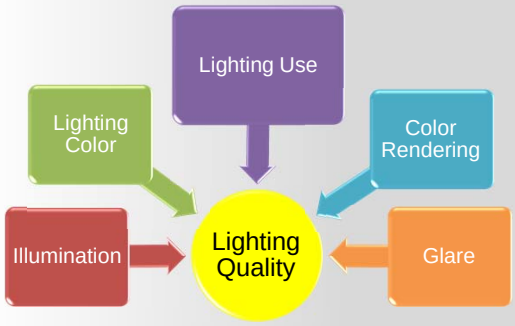
Three Basic Uses For Lighting

- **Ambient**
  - Main source of illumination for an area
  - Provides safety and security
- **Task**
  - Provides lighting for a work area
  - Elevated lighting levels for task execution
- **Accent**
  - Illuminates areas creating a brightness contrast
  - Makes an area more visually comfortable

Lighting Characteristics

- **Efficacy**
- **Illumination**
- **Lighting Color**
- **Glare**
- **Lighting Quality**

Lighting Characteristics



Efficacy

- **Lighting efficiency = Efficacy**
- **Efficacy is measured in lumens per watt**
  - Listed as **lm/W** or **LPW**
  - Higher efficacy #'s indicate greater energy efficiency
- **Watts x hours = Watt hours**
  - 1000 watt hours = 1 KWH

Illumination

- **"Illumination"**
  - The distribution of light on a surface
- **Illumination is measured in footcandles**
  - A lumen of light distributed over 1 sq. ft. of area
- **Lumen (lm)- measure of the total amount of visible light emitted by a source**
  - More lumens = more light output from lamp/fixture
    - Candle produces on the close order of 13 lumens
    - 100 watt incandescent lamp = 1750 lumens

Illumination

- **The amount of illumination required will vary depending on the visual task being performed**
  - Cooking vs. eating
- **Ideal illumination**
  - Minimum footcandles required to perform a task
  - Allows for task performance at maximum speed
  - No eyestrain

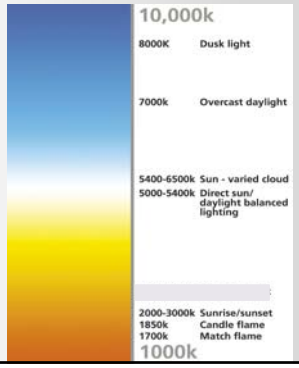
Lighting Color

- **Color temperature**
  - Stated in unit of absolute temperature – kelvin(K)
  - Color temperatures over 5,000K – "**cool**" colors
  - Color temperatures 2,700–3,000K – "**warm**" colors
- **Color rendering**
  - Effect on the color appearance of an object
  - Light's ability to render correct color
    - Color Rendering Index (CRI)
  - Compared with a reference illuminant (sun)
    - Sunlight = CRI of 100
    - Our eyes are designed to read colors illuminated by sun

Color Temperature

- **"Cool" light**
  - Preferred for visual tasks
    - Produces better contrast
      - Reading, writing, sewing, cooking
      - Used in offices to enhance concentration
- **"Warm" light**
  - Preferred for living spaces
    - More pleasing to occupants skin tones and clothing
  - Used in public areas to promote relaxation

Color Temperature



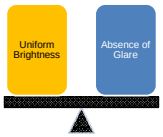
Glare

- **Difficulty seeing due to bright light**
- **Eliminating glare is essential to good lighting quality**
- **Three types of glare**
  1) Direct Glare – light shining directly into the eyes
  2) Reflected Glare – light reflected off a surface into the eyes
  3) Veiling Reflections – light emitting from a work surface

Example - Computer Screen

Lighting Quality

- **How well occupants can:**
  - Perform visual tasks
  - Feel visually comfortable



- **Light Quality = Energy Efficiency**
  - Higher lighting quality requires less illumination

Types of Lighting

Incandescent

- **Oldest, most inexpensive, most common**
- **Shortest service life of common lighting types**
  - 1000 – 1500 hours
- **Extremely inefficient light source**
  - convert less than 10% of their energy into visible light
  - Remaining 90% energy is converted to heat
- **The efficacy of a typical incandescent bulb is 16 lumens per watt**

Incandescent

- **Produces light with a filament wire**
  - Heated to high temperature by an electric current passing through it until it glows
  - The glass enclosure surrounding the filament determines the light beam's characteristics
    - Type A bulb

Incandescent - Types

- **Type R lamps (Reflector lamps)**
  - Designed to spread light over a specific area
  - Mainly used indoors
    - Spot lighting, down lighting

- **Type PAR lamps (Parabolic Reflectors)**
  - Designed to spread light
  - Used outdoors
    - Flood lighting

Fluorescent

- **Very low pressure mercury-vapor gas-discharge lamp that uses fluorescence to produce visible light**
- **Electric current (in the gas) excites mercury vapor producing short-wave ultraviolet light which causes a phosphor coating on the inside of the bulb to fluoresce**
- **Much more efficient than incandescent lamps**
  - Convert about 22% of their energy into visible light
  - 60 lumens per watt
  - Approx. 10,000 -20,000 hours of service life

Fluorescent

- **Most common tubular fluorescent lamps:**
  - 4-foot – 40 watt
  - 8-foot – 75 watt

- **Preferred for ambient lighting in large indoor areas**
  - Less glare
  - Shape of lamp more effectively distributes light

Compact Fluorescents (CFL)

- **Combine the efficacy of fluorescent lighting and the convenience of incandescent bulbs**
- **Designed as a fluorescent lamp to replace an incandescent lamp**
  - Service life of 10,000 hours
  - 50–70 lumens per watt
  - Slightly higher initial cost
- **Recent designs provide more natural color rendition**

Compact Fluorescents (CFL)

- **There are two types of CFLs:**
  - Integrated
  - Non-integrated lamps (modular)
- **Only specific CFL lamps are labeled for dimming control**
  - Dimmer with a standard CFL can be ineffective
- **Take time to achieve full brightness**
  - "Instant On"

High-Intensity Discharge (HID)

- **Extremely efficient lighting type**
  - Save 75% or more over incandescent
  - Long life
    - Up to 24,000 hours
- **Primarily used for outdoor lighting**
- **Use intense light emitting arc to produce light**
  - Require ballasts
  - Slow start up time

High-Intensity Discharge (HID)

- **Common types of HID's Include:**
  - **Mercury vapor lamps**
    - Oldest type of HID lighting
    - 50 lumens per watt
  - **Metal halide lamps**
    - Used as replacement upgrade to mercury vapor lamps
    - Higher light output, more lumens per watt, better color
  - **High pressure sodium**
    - 90 – 150 lumens per watt
    - Faster start up time

Light Emitting Diodes (LED)

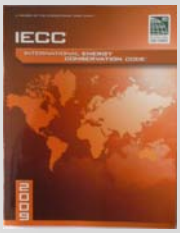
- **Most efficient**
  - Emit most light per watt
    - Only 2 watts produce 100 lumens
  - Longest lamp life
    - 50,000 hours
  - Low heat production
  - Dimmable
  - Fast start-up times
- **Come in variety of sizes, shapes, colors, and styles**
- **Can emit light of an intended color without using any color filters**

Light Emitting Diodes (LED)

- **Lighting manufacturers have tried to make LEDs familiar-looking**
  - Have a screw-in connector
  - Give off light in 1 direction

- **Made of clusters of smaller bulbs**
- **Seen as the future of residential lighting**
- **Relatively expensive**
  - Becoming more affordable

Lighting & Current Code Requirements



Code Citations

- **IECC 2009, Section 404.1 Lighting equipment**
  - A minimum of 50 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps
- **IECC 2009, Section 202 General Definitions**
  - High-Efficacy Lamps - sets the criteria
- **IRC 2009, Section N1104.1 Lighting Equipment**
  - A minimum of 50 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps

2009 IECC

- **The 2009 IECC definition - <u>High Efficacy Lamps</u>**
  - Compact fluorescent lamps, T-8 or smaller diameter linear fluorescent lamps, or lamps with a minimum efficacy of:

1. 60 lumens per watt for lamps > 40 watts,
2. 50 lumens per watt for lamps > 15 watts and ≤ 40 watts
3. 40 lumens per watt for lamps < 15 watts

Plan Review

- Verify 50% of all lamps will be high-efficacy
  - Count of lamps as shown on the plans
- Confirm each lamp type's efficacy by requiring manufacturer #'s or independent test data

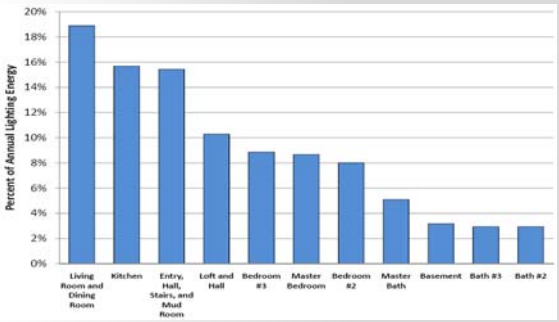
If the manufacturer/product packaging has separate ratings for lumen output & wattage - divide the lumen rating by the wattage to get lumens per watt

Field Inspection

- Inspect representative CFL lamps, linear fluorescents, and other lamps
  - At least 50% of all lamps are high-efficacy
  - Compare installed lamp make/model number to the ones on the approved plans
- Non-specified lamps should have efficacy rating information supplied at inspection

Energy Efficient Lighting Strategies

Interior Lighting Uses



Energy Reduction Strategies

- **50% of energy used for residential lighting is wasted**

- **Why?**
  - Illumination levels are higher than necessary
  - Incorrect lamp optimization
    - Size and type
  - Lights remain on too long
    - Inadequate controls and user negligence
  - Outdated, inefficient, and unclean lamps

Energy Reduction Strategies

- **Approaches to energy reduction include:**
  - Decreasing light source consumption
  - Reducing illumination time

- **How is this achieved?**
  - Reducing on-time through the use of "controls"
    - Dimmers & Sensors
  - Reduce unnecessary high illumination levels
    - Relamping
  - Using natural light to illuminate spaces
    - Daylighting
  - Preserve illumination and quality of light
    - Maintenance

Relamping

- **The practice of substituting one lamp for a more energy efficient lamp**
- **Allows for adjustment of illumination level**
  - Lumen output = task being performed in the space
- **Reduces unnecessary/excessive wattages**
  - Replace energy wasting incandescents
- **Replace fixtures to improve reliability & longevity**

Lighting Controls

- **Devices used to control illumination**
  - On/Off or dimming
- **Snap Switches**
  - Manually operated on/off switch
  - Usually wall-mounted
- **Also can be in the form of**
  - Dimmer controls
  - Timers
  - Sensors

Dimmers

- **Reduce the illumination output of lamps**
  - Decrease wattage
- **Dimmable switch is required**
- **Dimming incandescent lamps reduces lumens more that wattage**
  - Less efficient when dimmed
- **Fluorescents – require special ballasts to dim**
  - Labeled as “dimmable”
  - Non-dimmable CFLs do not reduce efficacy of fluorescent lamps

Timers

- **Operates an electric switch controlled by a timing mechanism**
- **The mechanism may be:**
  - Mechanical – clock or motor that mechanically operates switches
  - Electronical - timing circuitry and switching devices and no moving parts
- **Examples:**
  - Crank Timers – Spring driven dials
    - Limit illumination to short durations
  - Programmable
- **Save energy by consuming only when required**

Occupancy Sensors

- **Detects occupancy of a space and turns lights on or off automatically**
  - Use infrared or ultrasonic technology
- **Illumination extinguishes after detecting no human presence for a precise time**
  - 30 minutes, 15 minutes, etc.
  - Reducing off-delay intervals can save significant $$
- **Common for outdoor lighting**
  - Offers security for occupants

Daylighting

- **Using natural light to provide effective internal lighting**
- **Creates a visually stimulating and productive environment for building occupants**
- **Energy savings can be achieved from the reduced use of artificial lighting**
  - Also provides passive solar heating
  - Reduce up to 60% of total building energy costs

Daylighting

- **Fenestration must be designed to avoid the admittance of direct sun, avoiding "glare"**
  - Use of blinds, reflective louvers, light shelves
- **Not just about windows. Involves additional decisions about:**
  - Building form
  - Siting
  - Climate
  - Building components (windows and skylights)
  - Lighting controls
  - Lighting design criteria

Maintenance

- **Light output levels reduce over time because:**
  - Fixture dust
  - Room surface dirt
  - Lamp aging

  Can reduce illumination levels by 50% while lamps draw full power
- **What can be done?**
  - Clean fixtures/lamps every 6 – 12 months
  - Consider "group relamping"
    - Keeps illumination levels high
    - Saves labor

Summary

- **Proper lamp utilization will improve:**
  - Lighting quality of the space
  - Energy efficiency
- **Reduce illumination levels without sacrificing illumination quality**
  - Spaces with no visual tasks
    - Provide minimum levels necessary
  - Reduce output levels for task areas that currently have excessive levels

Summary

- **Limit energy consumption and enhance lighting quality**
  - Task lighting should be provided at an optimal level depending on the task being performed
    - Cooking vs. eating
  - Increase the efficiency of lamps
    - Relamping
    - Maintenance
  - Ambient lighting = minimum acceptable level

Remember - Ideal illumination is minimum level allows task performance at maximum speed without eyestrain

Summary

Code Citations

- **IECC 2009, Section 404.1**
  - IECC 2009, Section 202 General Definitions
- **IRC 2009, Section N1104.1**

- **At least 50% of all lamps are high-efficacy**
  - Plan Review
  - Field inspection

Energy Efficient Lighting

Questions & Evaluations

http://www.cvent.com/d/p4qmbq/4W

Next Month's Webinar: ***OSHA Residential Regulations***
Tuesday, November 12, 2013 1:00 PM

Presented By: Chris Hine, Housing and Land Development Specialist

PHRC

Pennsylvania Housing Research Center

www.engr.psu.edu/phrc