Energy Efficient Lighting

Watt You Need To Know

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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

Source: Energy Information Administration (EIA)
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
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

- 10,000k
- 6500k
- 3500k
- 2800-3000k
- 1800-1900k
- 1700k
- 1000k

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

1. IECC 2009, Section 404.1 Lighting equipment
   - A minimum of 50 percent of the lamps in permanently installed lighting fixtures shall be high-efficiency lamps

2. IECC 2009, Section 202 General Definitions
   - High-Efficiency Lamps - sets the criteria

3. IRC 2009, Section N1104.1 Lighting Equipment
   - A minimum of 50 percent of the lamps in permanently installed lighting fixtures shall be high-efficiency lamps

2009 IECC

1. The 2009 IECC definition - High Efficacy Lamps
   - 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
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 eye strain**

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

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