

ENRG 54 - Introduction to Lighting Systems and Controls

COURSE DESCRIPTION: Fundamentals of lighting systems and controls for energy auditors. Concepts of lighting, terminology, measurement tools, identifying energy efficiency opportunities, codes, standards.

30 Hours (20 lecture, 10 lab)

LEARNING OUTCOMES:

- Summarize terminology, physics and principles of lighting
- Identify and compare various types of lighting systems, including field identification and interpretation of nameplate data
- Measure illuminance and lighting intensity
- Describe the theory and operations of various lighting control systems
- Evaluate energy use by various types of lighting systems and identify opportunities for energy efficiency measures
- Calculate energy savings of energy efficiency measures and estimate their financial impact
- Apply relevant local, state and national codes, standards and regulations relevant to lighting system recommendations

COURSE TOPICS:

- I. Introduction to fundamentals of lighting
 - A. Lighting terminology
 1. Luminous flux
 2. Illuminance
 3. Reflectance
 4. Power
 5. Efficacy
 6. Lighting power density
 7. Lamp life
 8. Lumen depreciation
 9. Correlated color temperature
 10. Color rendering index (CRI)
 11. Ballast factor
 - B. Physics and principles of lighting
 1. Spectral power distribution
 2. Inverse square law
 - C. Units of measurement
 1. Lumen
 2. Foot-candle
 3. Power (wattage)
 4. kWh
 - D. Vision and colors
 - E. Ambient, directional and task lighting
 - F. Over-and under-illuminance
- II. Lighting systems
 - A. Components
 1. Luminaire
 2. Lamp
 3. Ballast
 4. Reflector
 5. Diffuser, lens or louver

- B. Types of lamps
 - 1. Incandescent
 - 2. Halogen
 - 3. Fluorescent
 - 4. High intensity discharge
 - a. Metal halide
 - b. Mercury vapor
 - c. High pressure sodium
 - d. Low pressure sodium
 - 5. Induction lamps
 - 6. Light emitting diodes (LED)
 - 7. Neon
- C. Ballasts
 - 1. Electro-magnetic (magnetic) ballast
 - 2. Electronic ballast
 - 3. Ballast factor
- D. Lamp comparison matrix
- E. Types of lighting luminaires and intensities
- F. Energy efficiency measures (EEMs)
 - 1. Lamp replacement
 - 2. Ballast replacement
- III. Lighting controls
 - A. Basic concepts of effectiveness of lighting control
 - B. Types and appropriate applications of lighting controls
 - 1. Manual switches
 - 2. Schedule controls or sweeps (building automation systems)
 - 3. Timers and time clocks
 - 4. Infrared and ultrasonic occupancy sensors
 - 5. Manual dimmers
 - 6. Daylight controls or photo sensors
 - 7. Bi-level switching
 - C. Lighting control equations
 - D. Energy efficiency measures (EEMs)
- IV. Additional EEMs
 - A. De-lamping
 - B. Scotopic lighting
 - C. Task and ambient light levels
 - D. Circadian rhythms
- V. Lighting measurements
 - A. Tools
 - 1. Flicker checker
 - 2. Illuminance meter
 - 3. Luminance meter
 - 4. Lighting measurement devices
 - 5. Spectrophotometer
 - 6. Goniophotometer
 - 7. Circuit tracer
 - B. Data loggers and applications
 - 1. Occupancy
 - 2. Hours of use
- VI. Lighting calculations
 - A. Equation and method of calculating lumens (zonal cavity formula)
 - B. Equation and method of calculating energy savings

- C. Method of calculating skylight energy savings
- VII. Lighting standards, codes and regulations
 - A. Underwriters' Laboratory (UL)
 - B. Uniform Building Code (UBC)
 - C. Americans with Disabilities Act (ADA)
 - D. Title 24 applications
- VIII. O&M (operations and maintenance) measures to assure optimal performance

TYPES OF ASSIGNMENTS:

- I. In-class
 - A. Class discussions and demonstrations
 - B. Perform energy usage and energy savings calculations from assigned problem sets
 - C. Hands-on tool and meter use and interpretations
 - D. Field trips such as visiting the Pacific Energy Center lighting lab, walk-throughs of various campus facilities to identify lighting types
 - E. Small group projects such as oral presentation of findings from field trip site visits
- II. Out-of-class
 - A. Readings from texts, websites and instructor handouts
 - B. Calculations of energy use and energy savings from assigned problem sets
 - C. Research and prepare brief (1-2 page) report comparing strengths and weaknesses of different lamp types
 - D. Brief written paper (2-3 pages) on topics such as appropriate applications for various lighting types

TEXTBOOKS & RESOURCES:

- Instructor handouts on such topics as comparison of qualities of various lamp types
- Lighting wattage tables