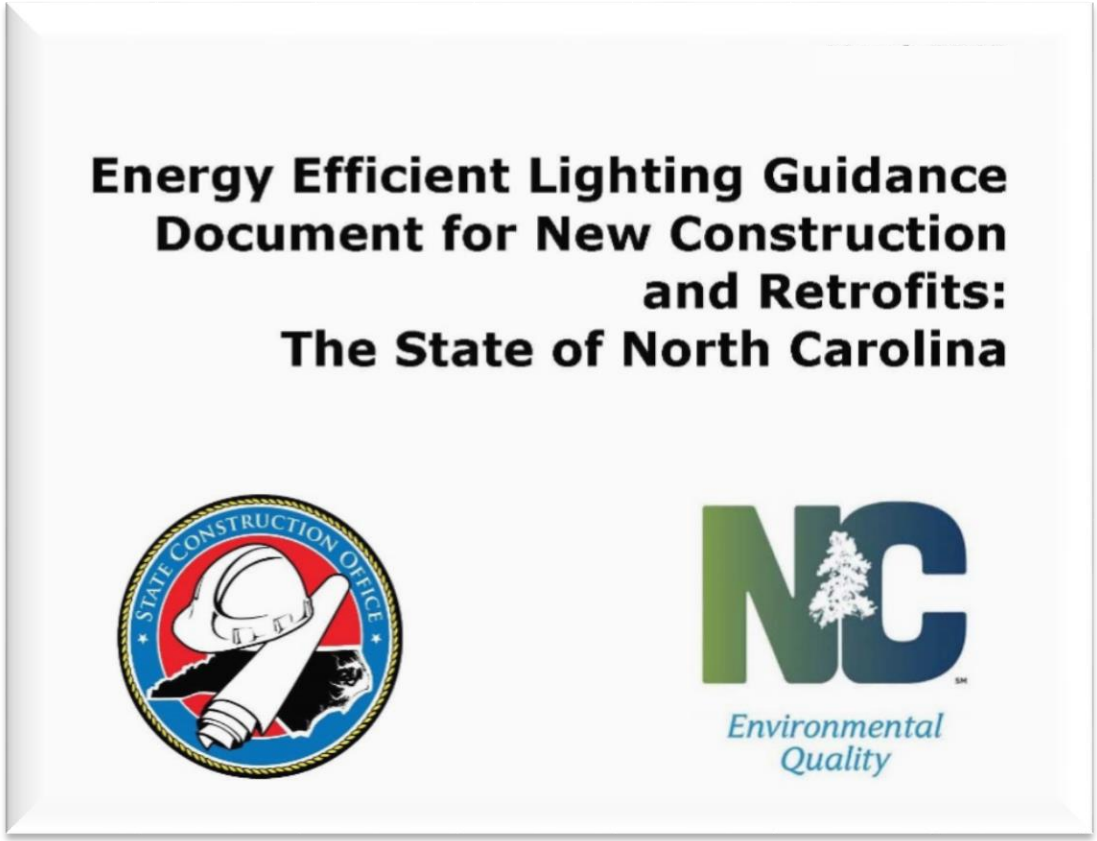
Nothing Compares
NORTH CAROLINA

Solid State Lighting

LED Lighting Panel Discussion



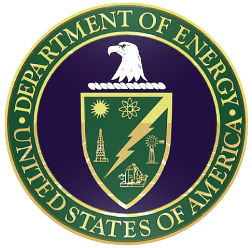
Department of Environmental Quality

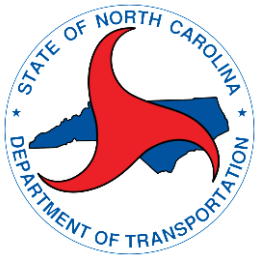
The Panel

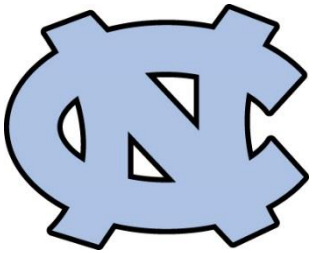
Panelists:

- **Dr. Lynn Davis**, Fellow, RTI International
- **Robert Talley**, PE, NC Dept. of Administration, State Construction Office
- **Renee Hutcheson**, FAIA, NC Department of Environmental Quality
- Questions during the presentation

The Work Group







RTI INTERNATIONAL

NC Environmental Quality

Public Schools of North Carolina
State Board of Education
Department of Public Instruction

FREEDM systems center

N★C DPS
DEPARTMENT OF PUBLIC SAFETY
PREVENT · PROTECT · PREPARE

IES Illuminating ENGINEERING SOCIETY

UL Underwriters Laboratories Inc.®

WAKE TECH COMMUNITY COLLEGE

NC

Department of Environmental Quality

The Work Group

Dr. Lynn Davis

Renee Hutcheson, FAIA

Randy Allison, PE

Howard Beasley, PE

David Bell, PE

Eric Frazier

Thomas Hunter, PE, RA

Jonathan Jones, PE

Lalitha Krishnasami, PE

John Majernik, EI, PEM

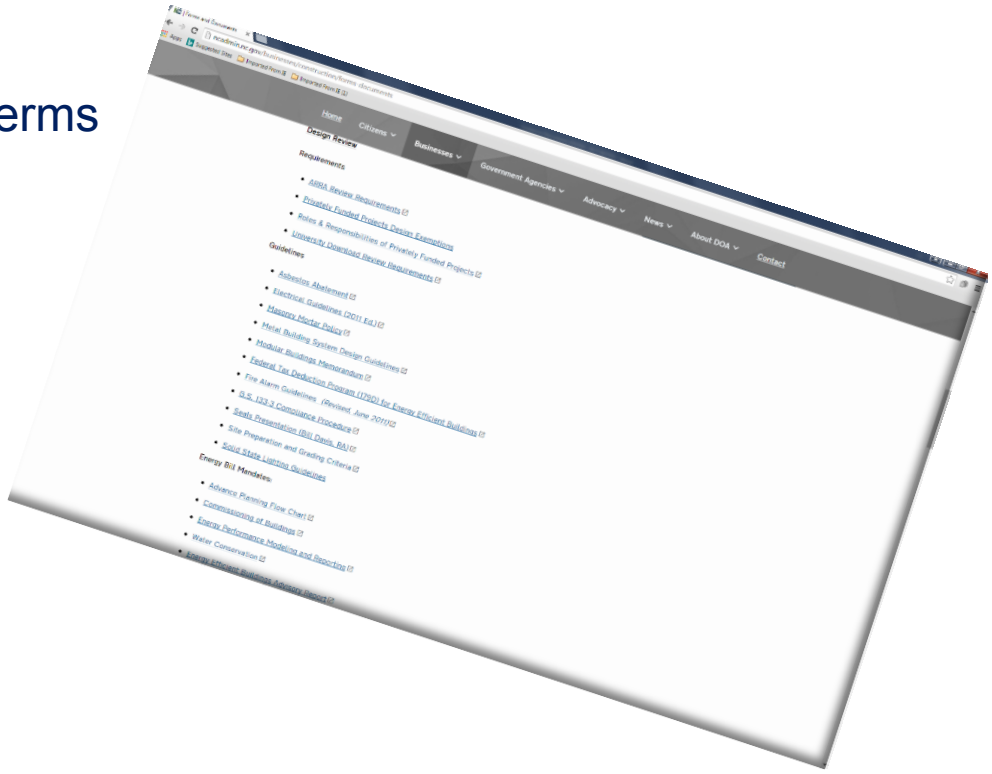
Jeannie Smith, PE

Robert Talley, PE

Dr. Leonard White, PE

AGENDA

1. Background
2. Basic Principles of Good Lighting Design
3. Basic Principles of Building Designs
4. LED Retrofits
5. Additional Resources
    - A. Nomenclature and Common Terms
    - B. List of Reference Standards
    - C. Examples of Performance Specifications



GUIDELINES not RULES for using SSL

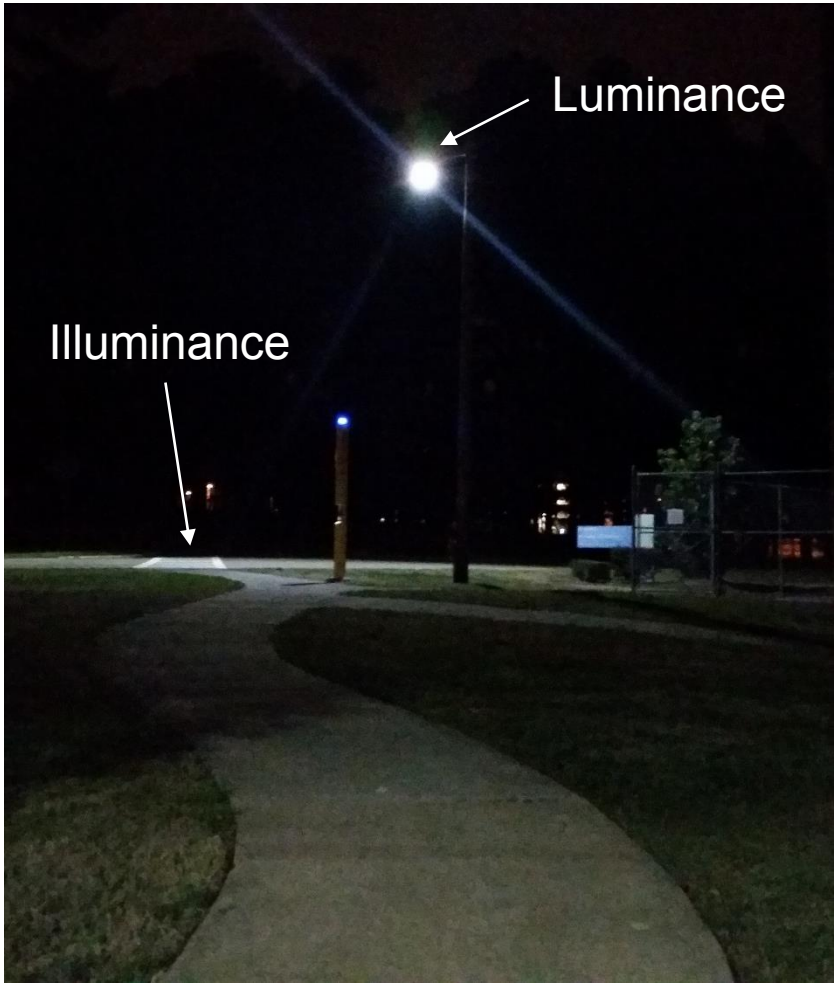
~~Building Code~~

~~Standard~~

~~Specification~~

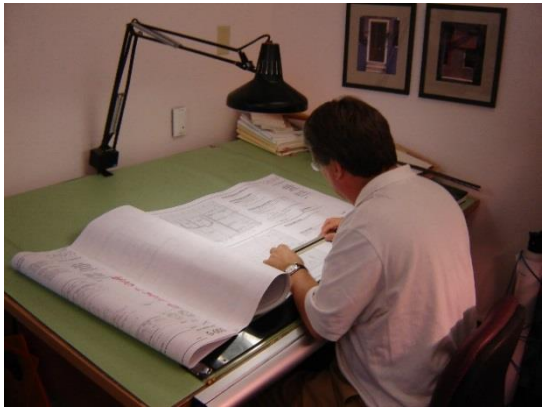
BASIC PRINCIPLES OF GOOD LIGHTING DESIGN

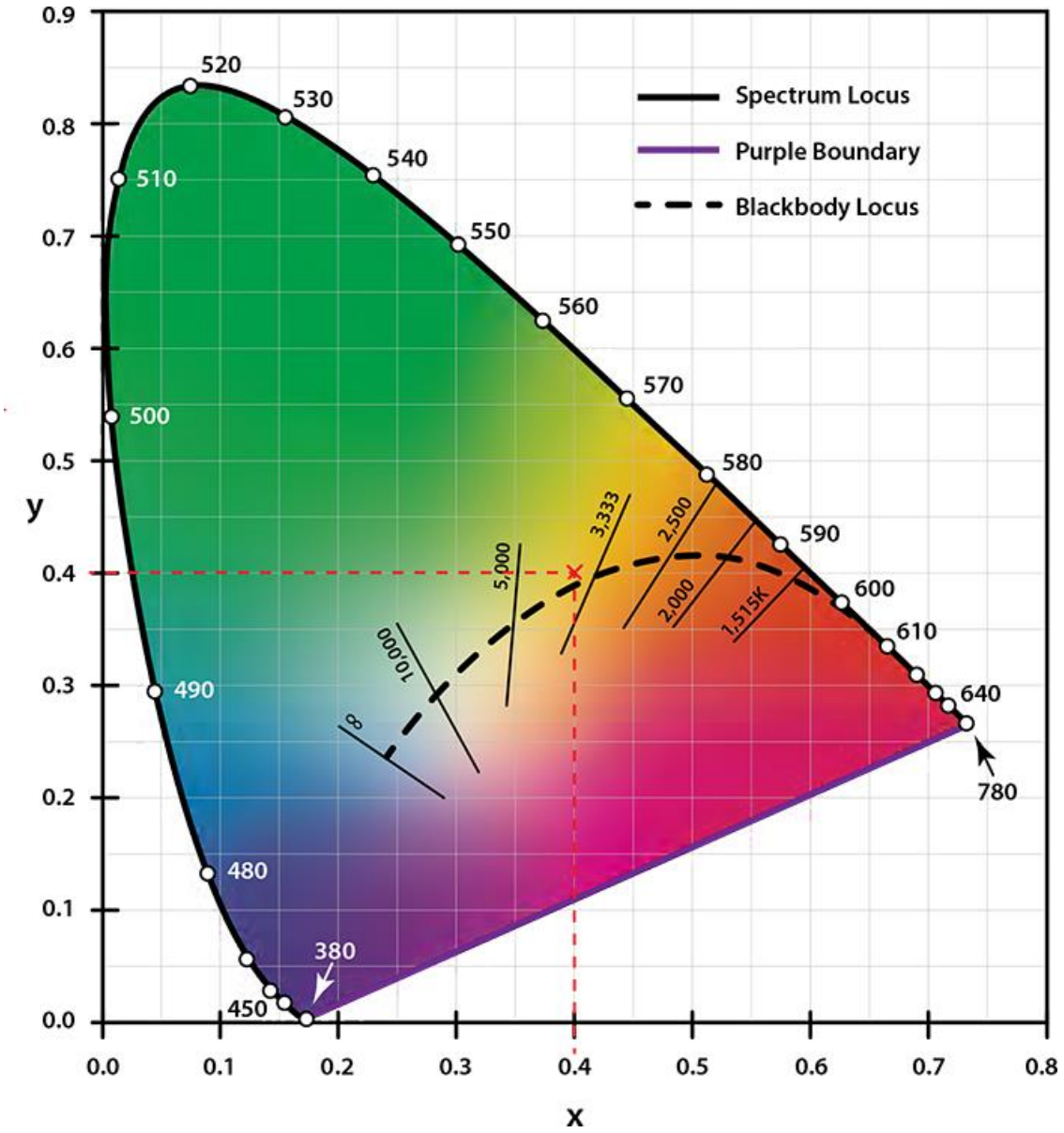
- Illuminance
  - Amount of light falling onto and illuminating an object such as table or sidewalk (horizontal illuminance) or wall or open space (vertical illuminance)
  - Two common units of measure
    - Lux – lumens/m^2
    - Footcandles (fc) – lumens/ft^2
- Luminance
  - Amount of emitted or reflected light contained within a solid angle.
  - Common units
    - Candela/m^2 (nit, Σ)



BASIC PRINCIPLES OF GOOD LIGHTING DESIGN

- **Light Level and Illuminance (measured in lux or foot-candles)**
  - Energy consumption (costs) is proportional to light level
    - Less energy can be consumed if a lower lighting level or illuminance is feasible,
    - IES recommended illuminance levels have changed as more technology is used in the office and classroom
  - Provide illuminance levels sufficient for the task
  - Light levels must still meet code requirements.
  - Follow appropriate recommended IES illuminance levels for the space type/application,
  - Understand light distribution in the space
  - Lighting calculations are recommended for all spaces




Spectrum Locus
Purple Boundary
Blackbody Locus
520
530
540
550
560
570
580
590
600
610
640
780
510
500
490
480
380
450
3,333
2,500
2,000
1,515K
5,000
10,000
∞
y
x
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

BASIC PRINCIPLES OF GOOD LIGHTING DESIGN

- **Correlated Color Temperature (CCT) and Color Rendering Index (CRI)**
  - lower CCT value - warmer the perceived color of the light
  - higher CCT value - cooler the perceived color of the light
  - CRI - metric that measures how accurately the lighting source reproduces colors
  - **R9 – what is it?**

BASIC PRINCIPLES OF GOOD LIGHTING DESIGN

- **Luminance and Luminous Intensity (measured in candela)**
  - LED light sources tend to produce intense white light
  - Glare can be an issue in both indoor and outdoor lighting
  - Luminance values can be too high
  - Luminance ratios can be too high
  - 4 Factors to Evaluate for glare
    - Luminance of light source
    - Size of the light source
    - Position of the glare source in the field of view
    - Luminance of the background

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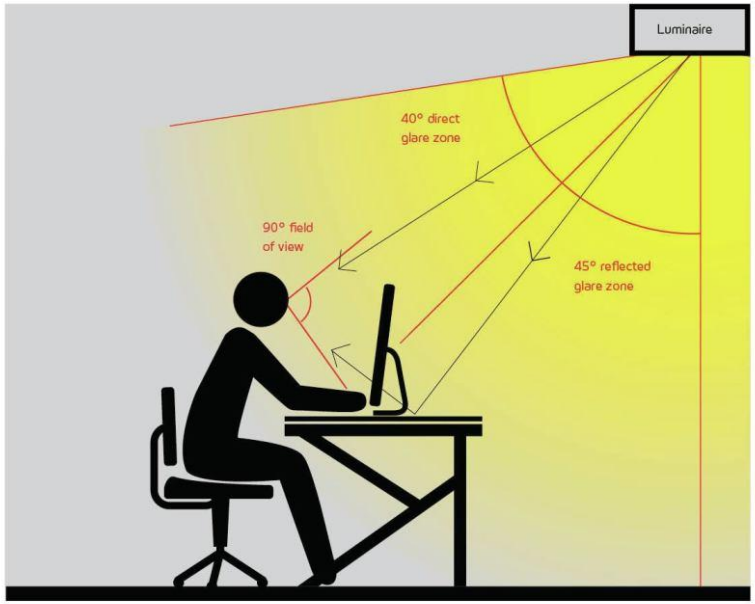
Direct and Reflected Glare



BASIC PRINCIPLES OF GOOD LIGHTING DESIGN

- **Control**
  - Dimming range
  - Dimmer loads
  - Control architectures and compatibility
  - Improper use of controls can lead to premature failure

Reverse Phase Dimming

DMX

4 Wire (0-10V)

DALI

DALI

PWM

BASIC PRINCIPLES OF GOOD LIGHTING DESIGN

- **Exit and Emergency Lighting**
  - LED Exit signs typically are in use 24/7
  - This section of the document is based on over 20 years of use

- **Third Party Listings and Certifications**
  - NC General Statutes for Electrical Safety
  - NEC requirements
  - Life Safety

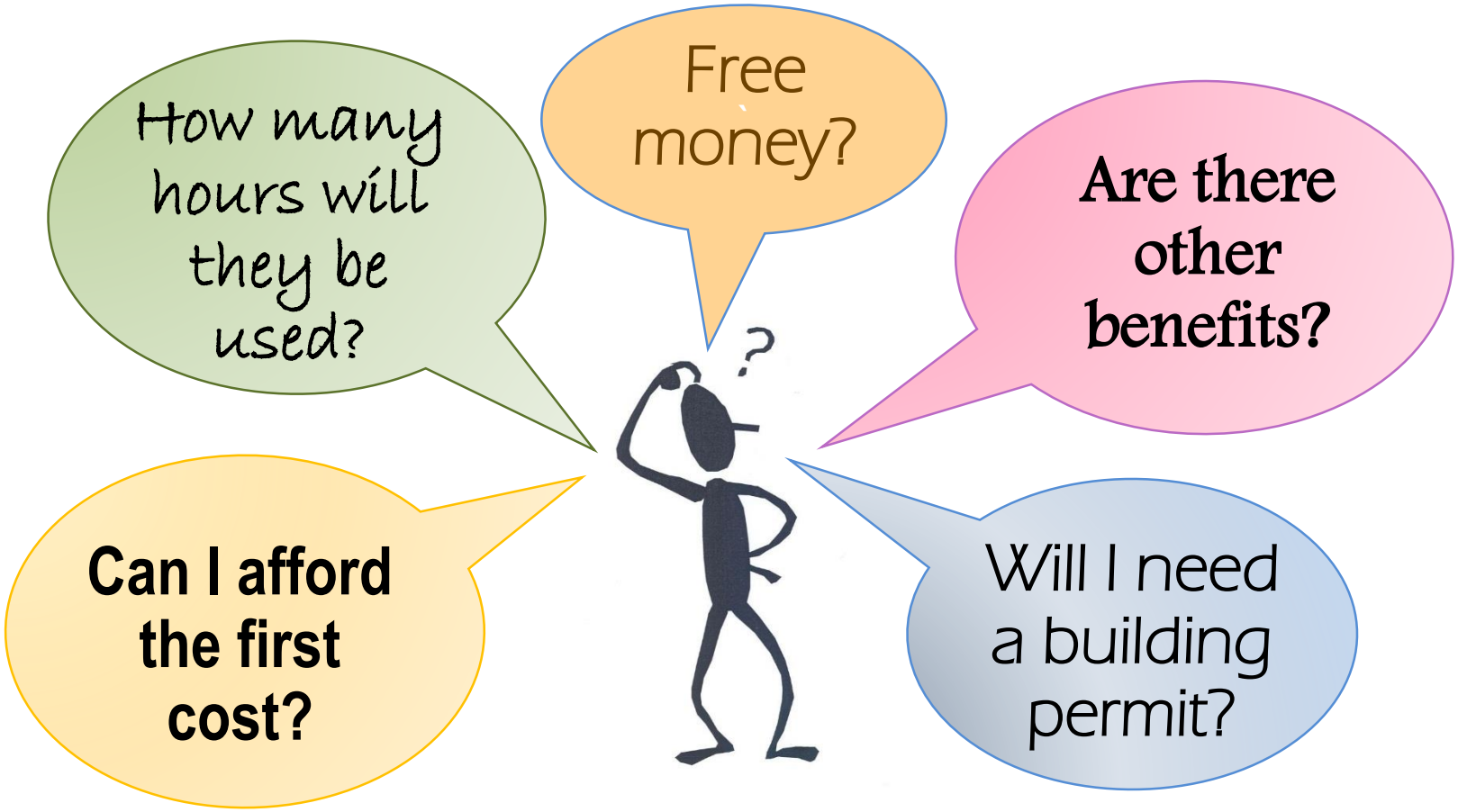
- **Outdoor Lighting**
  - Surge protection - rated for surges of at least 10 KV.
  - Grounding
  - Filters

BASIC PRINCIPLES OF BUILDING DESIGNS

- **Wiring Methods**
  - Dedicated full-sized (i.e., 100%) neutrals
  - Wiring per NEC
- **Special Considerations for the Distribution System**
  - A dedicated lighting panel is recommended
  - Separate from large non-linear loads
  - Consider harmonic filters and harmonic mitigating
- **Voltage Drop**
  - consideration should be given to wire length and size
- **Inrush Current and Circuit Loading**
  - NEMA 410 allows for short duration (i.e., less than several milliseconds) inrush currents
  - many of our successful project have used branch circuit loading of 50% or less.
- **Emergency Power for LED Systems**

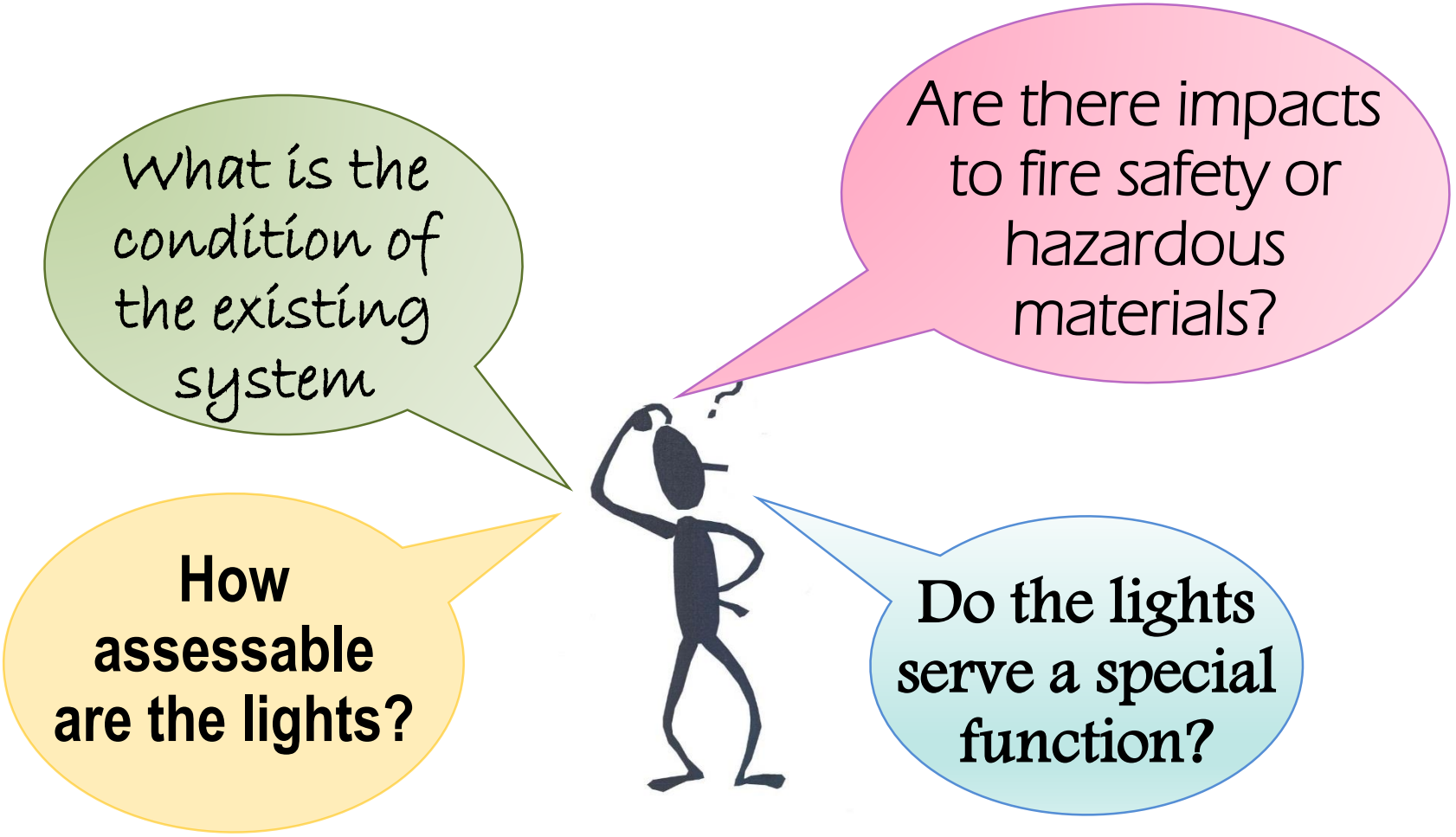
LED RETROFIT PROJECTS

- **Costs/Budget**
  - consistent with the scope of the work
  - consistent with the Life Cycle Costs Analysis (LCCA)



LED RETROFIT PROJECTS

- **Costs/Budget**
  - The cost-benefit analysis of LED lighting could be impacted by site considerations



UNC System-wide Lighting PC

15 Universities and Affiliates

East Carolina
UNC Charlotte
Western Carolina
UNC Asheville
Appalachian State
NC A&T
NCCU
The NC Arboretum
UNC Pembroke
School of the Arts
School of Science of Math
Fayetteville State
UNC General Administration
Winston-Salem State
UNC-TV

Department of Environmental Quality

UNC System-wide Lighting PC

$ 25.5m	Lighting Contract Costs
96,000	New Fixtures
174,000	New Lamps
2,850	Occupancy Sensors
1,300	Exit Signs

Department of Environmental Quality

UNC System-wide Lighting PC

$ 4m Annual Projected Energy Savings

$ 29.2m Energy Savings over 7 Years

7 yr. Payback

Yr	Guaranteed Electric Dollar Savings*	Guaranteed Natural Gas Dollar Savings*	Guaranteed Operational Dollar Savings	Guaranteed Dollar Savings
1	$ 3,503,129.03	$ (74,657.48)	$ 496,100.28	$ 3,924,571.82
2	$ 3,573,191.61	$ (74,657.48)	$ 506,022.28	$ 4,004,556.41
3	$ 3,644,655.44	$ (74,657.48)	$ 516,142.73	$ 4,086,140.69
4	$ 3,717,548.55	$ (74,657.48)	$ 526,465.58	$ 4,169,356.65
5	$ 3,791,899.52	$ (74,657.48)	$ 536,994.90	$ 4,254,236.93
6	$ 3,867,737.51	$ (74,657.48)	$ 547,734.79	$ 4,340,814.82
7	$ 3,945,092.26	$ (74,657.48)	$ 558,689.49	$ 4,429,124.27
Total	**$ 26,043,253.90**	**$ (522,602.36)**	**$ 3,688,150.06**	**$ 29,208,801.59**

Improved Light Quality

Lower Maintenance Costs

Department of Environmental Quality

LED RETROFIT PROJECTS

LED RETROFIT PROJECTS

- **4 Types of Retrofit Projects**
  1. Lamp replacement
     - a direct replacement of an existing conventional lamp

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     - replace key components of a luminaire such as lamps, drivers, connectors, lenses, reflectors

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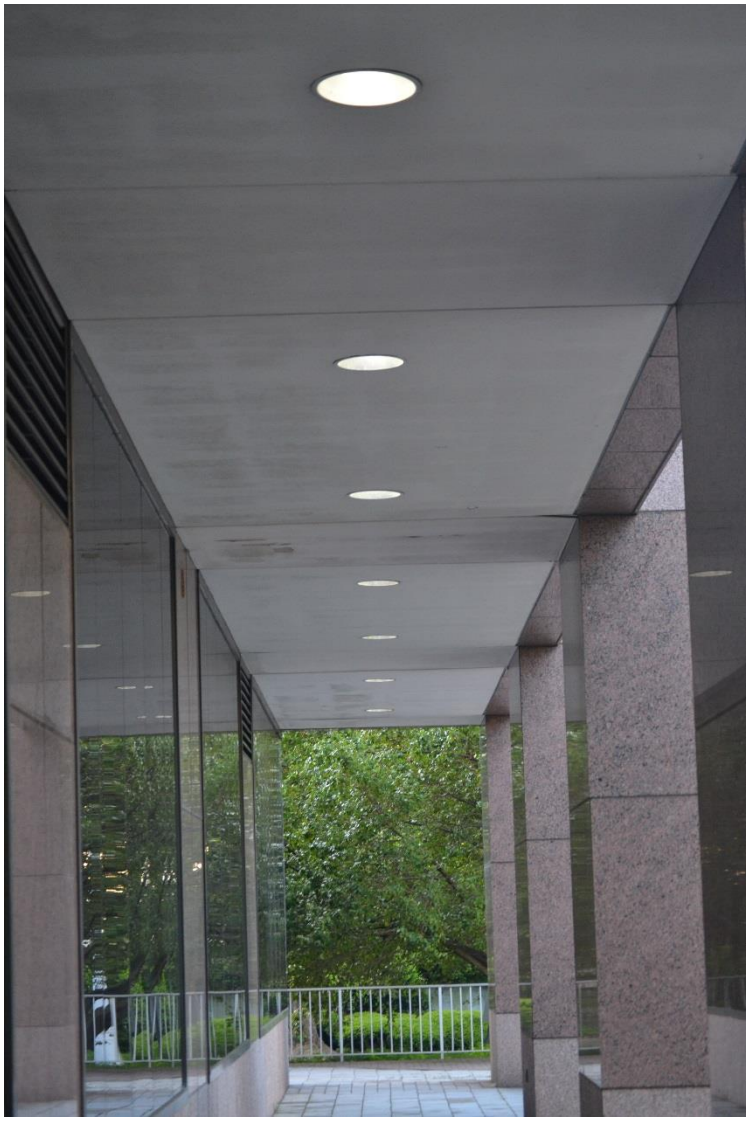

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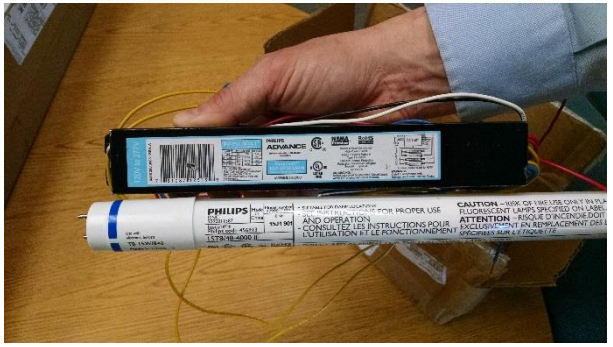
(2) 14 Watt LED with existing ballast



(2) 32 Watt T8 with ballast

LED RETROFIT PROJECTS

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  3. Complete luminaire replacement
     - 1:1 replacement

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Before: (7) 175 w metal halides After: (7) 99 w LED's

View of Dayrooms from Officer's Control Room

LED RETROFIT PROJECTS

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New and Old Fixtures Side-by-Side

66% reduction in energy

50% increase in fc

LED RETROFIT PROJECTS

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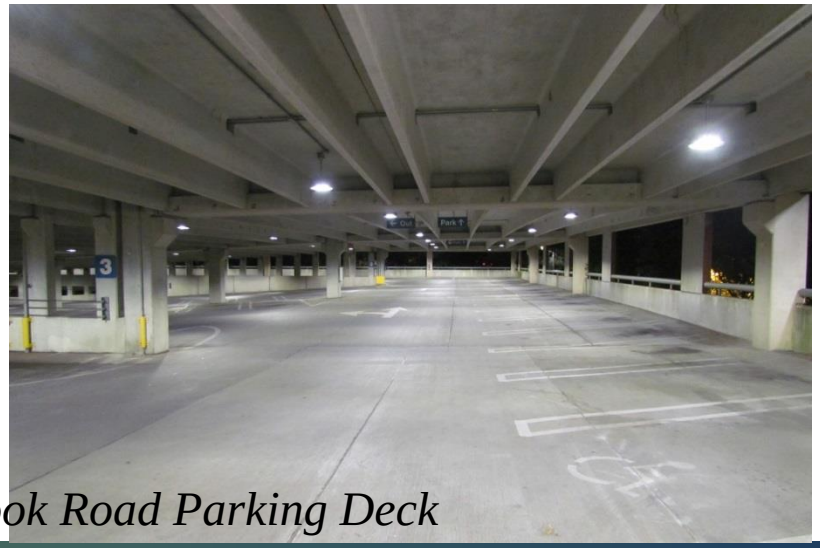
     - 1:1 replacement
  4. Lighting system redesign
     - Re-design of the illuminance in a space - lighting simulation software

WAKE COUNTY
NORTH CAROLINA

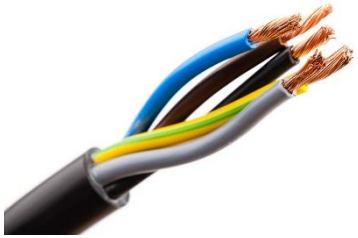


Wake County - Sunnybrook Road Parking Deck

LED RETROFIT PROJECTS

LED RETROFIT PROJECTS

- **Existing Infrastructure and Building Conditions**
  - Electrical – non linear loads
  - Hazardous materials
  - Ceiling types
  - Painting and patching
  - Insulation above ceilings
  - Emergency systems and exit lighting
  - HVAC and heat load effects
  - All fixtures are not equal…



LED RETROFIT PROJECTS

- **Condition of Existing Fixtures**
  - Physical Size
  - Housing
  - Sockets
  - Lenses
  - Ballast/drivers
  - Input voltages
  - Whip length and location of knock out boxes
  - Manufacturer
  - Third Part Listing

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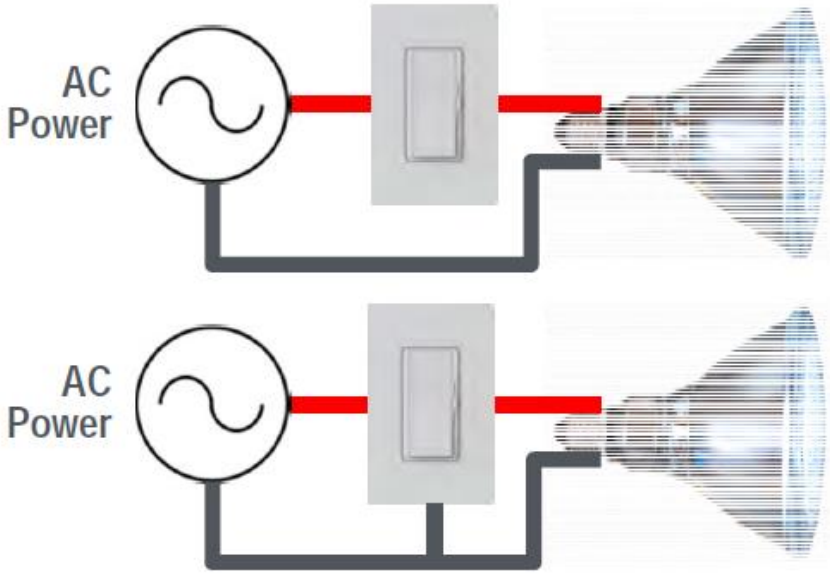
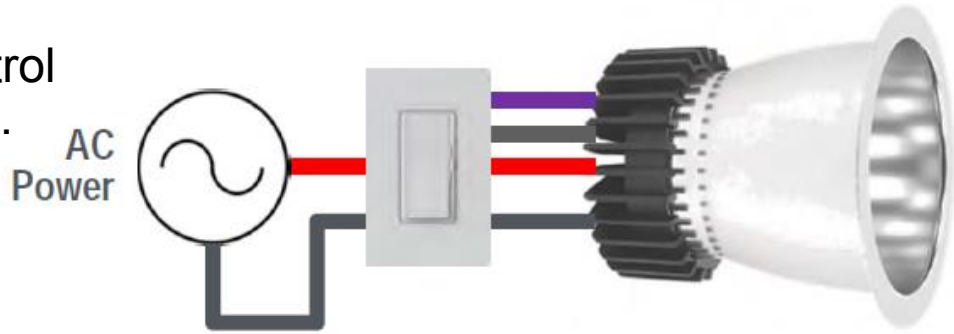
LED RETROFIT PROJECTS

- **Two main methods of lighting controls for dimming**
  - Analog/change in AC power supplied to luminaire
    - Phase-cut
    - Amplitude reduction
    - Most existing dimming circuits
  - Independent supply signal between control & driver (Pulse width modulation)
    - DALI
    - DMX
    - Others



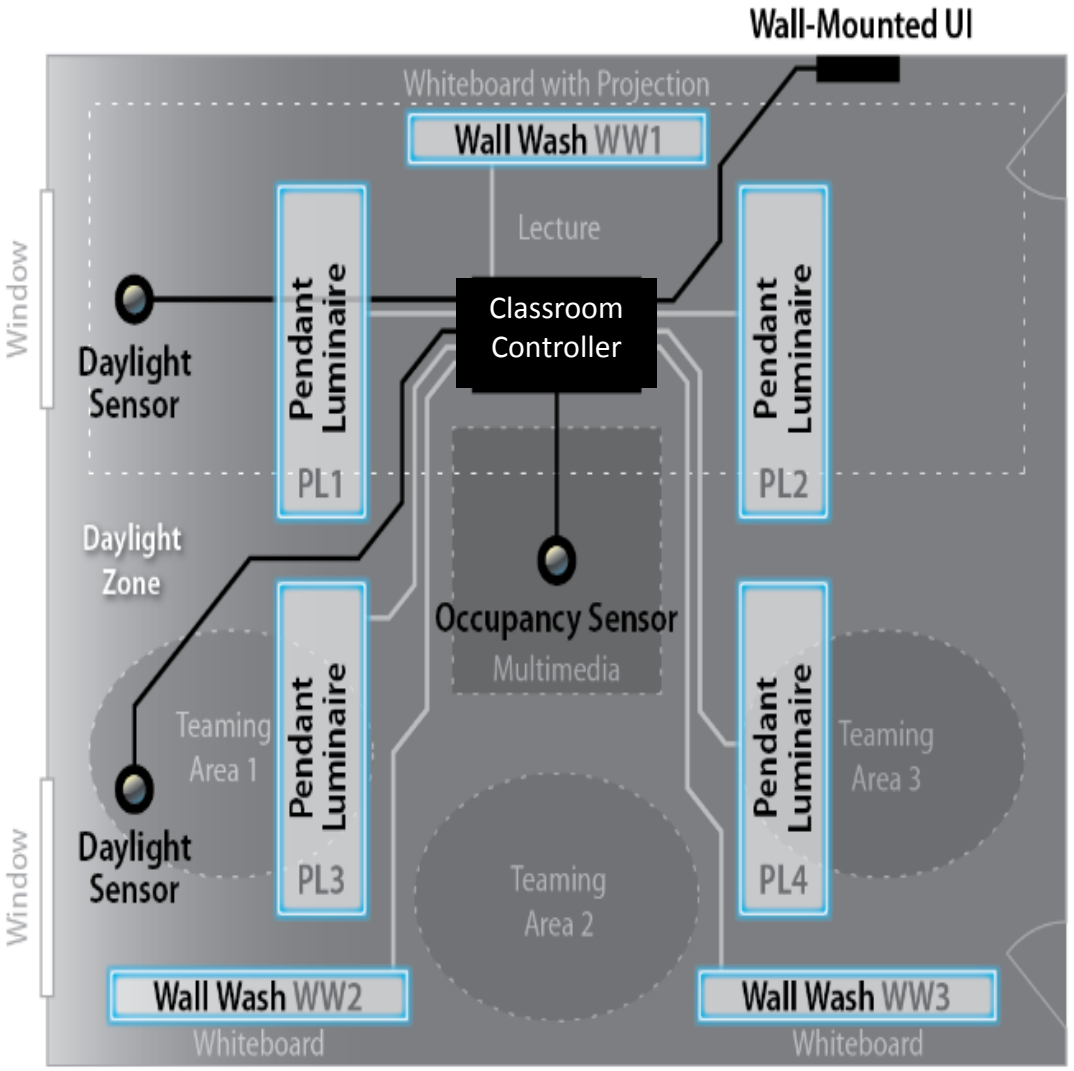
- Compatibility between the existing control system and the retrofit must be verified.
  - Check with manufacturers
  - Mock-ups and hardware verification



LED RETROFIT PROJECTS

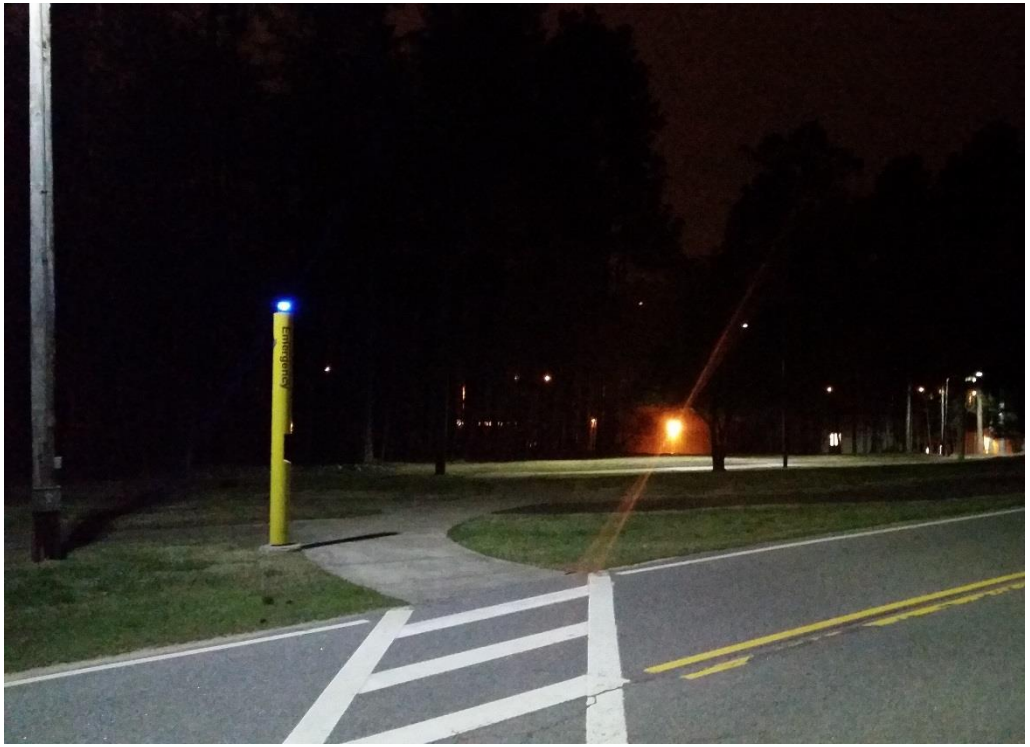
- **Common Controls**
  - Photocells
  - Daylight harvesting controls
  - Dimming
  - Occupancy/Vacancy
  - Building or room control systems

- Controls can have an impact on both energy consumption and flicker.



LED RETROFIT PROJECTS

- **Outdoor and Exterior Lighting LED Retrofits**
  - Spacing and light distribution
  - Glare
  - Light trespass
  - Sky glow
  - Backlight, Uplight, and Glare (BUG) rating
  - Durability
  - Surge protection
  - Vibration rating
  - Grounding
  - Photocell and controls
  - Warranty
  - Wiring / rewiring
  - Availability
  - Cost payback



Where Can I Find The Guidance Document?

SCO Website

http://ncadmin.nc.gov/document/ssl-guidance

DEQ Website

http://deq.nc.gov/conservation/utility-savings/tools-technology

Where Can I Find The Presentation?

http://deq.nc.gov/conservation/utility-savings/outreach-training

For Questions and Comments:

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Renee Hutcheson, FAIA

NC Department of Environmental Quality

renee.hutcheson@ncdenr.gov