DOE ZERO ENERGY READY HOME: LIGHTING EFFICIENCY

Presented by:

Brooke Silber, LC, IES, LEED AP

- Jan & Brooke Luminae

David Brignati, AIA, LEED AP

- Newport Ventures

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

High Efficacy Lighting in DOE Zero Energy Ready Home

Exhibit 1: DOE Zero Energy Ready Home Mandatory Requirements for All Labeled Homes

Area of Improvement	Mandatory Requirements
1. **ENERGY STAR for Homes Baseline**	☐ Certified under ENERGY STAR Qualified Homes Version 3 or 3.1 [9, 10]
2. **Envelope**[11]	☐ Fenestration shall meet or exceed ENERGY STAR requirements [12, 13] ☐ Ceiling, wall, floor, and slab insulation shall meet or exceed 2012 or 2015 IECC levels[14, 15]
3. **Duct System**	☐ Duct distribution systems located within the home's thermal and air barrier boundary or optimized to achieve comparable performance[16]
4. **Water Efficiency**	☐ Hot water delivery systems shall meet efficient design requirements[17]
5. **Lighting & Appliances**[18]	☐ All installed refrigerators, dishwashers, and clothes washers are ENERGY STAR qualified. ☐ 80% of lighting fixtures are ENERGY STAR qualified or ENERGY STAR lamps (bulbs) in minimum 80% of sockets ☐ All installed bathroom ventilation and ceiling fans are ENERGY STAR qualified
6. **Indoor Air Quality**	☐ Certified under EPA Indoor airPLUS [10]
7. **Renewable Ready**	☐ Provisions of the DOE Zero Energy Ready Home PV-Ready Checklist are Completed; (Solar Hot Water Ready provisions are encouraged but not required) [19]

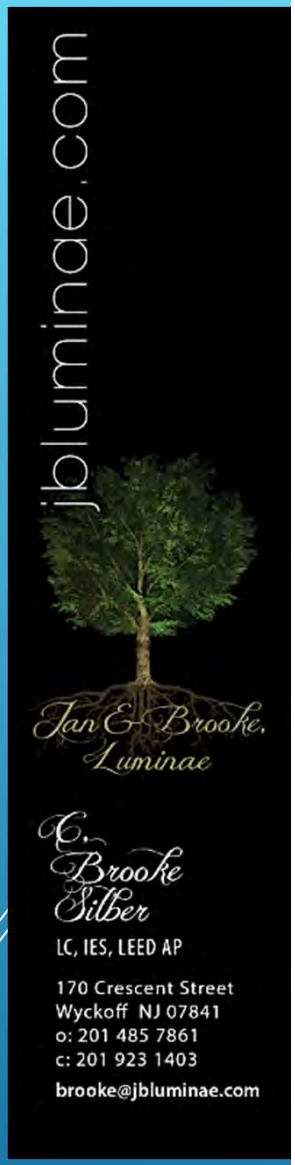
LEDs in High Performance Homes …
- Practical Experience

- LEDs are increasingly used in DOE ZERHs
- Design can be different…
- Building integration can be different…
- User experience ***should*** be different!

C. Brooke Silber, IES, LC, LEEDAP
Principal, Jan & Brooke, Luminae LLC

In 2014, Jan Moyer and Brooke Silber founded lighting design firm Jan & Brooke, Luminae. Brooke's current projects include multiple videoconferencing facilities for the CoStar Group and interior and exterior lighting for high-end residences and hotels. Before partnering with Jan, Brooke was a senior associate at Domingo Gonzalez Associates, where her projects included the award-winning New York State Capitol and Thurgood Marshall Courthouse. She teaches at Parsons The New School for Design and is co-chair of the joint IES/InfoComm Lighting for Videoconferencing and Multi-Media Committee. Brooke received a Bachelor of Fine Arts from Syracuse University in interior design and a Master of Science in lighting from Rensselaer Polytechnic Institute.

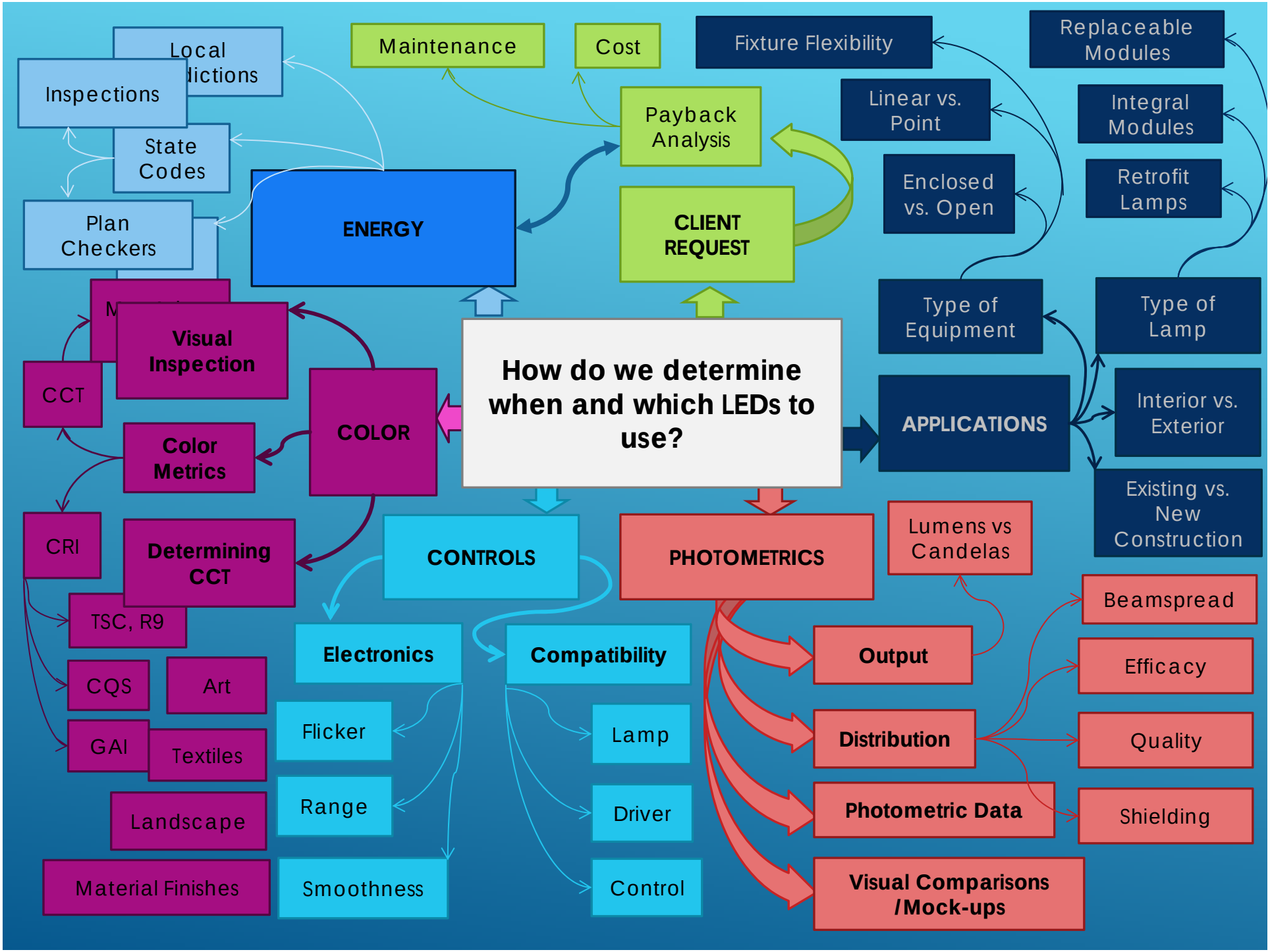
BROOKE SILBER



DESIGNING WITH LED’S

“The Design Process is neither linear nor sequential. It is random like a strange board game. Go three steps forward, select a card from a huge shuffled deck, attempt to answer a question, and either go back and repeat the sequence again or advance. Often you must loop through a sequence several times before you advance. Sometimes movement seems tangential. And even near the end you may draw a card … and have to begin again!

Each time you play you become more skilled in anticipating the questions.” - MSH 2002


How do we determine when and which LEDs to use?
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State Codes
Plan Checkers
Maintenance
Cost
Payback Analysis
CLIENT REQUEST
Fixture Flexibility
Linear vs. Point
Enclosed vs. Open
Replaceable Modules
Integral Modules
Retrofit Lamps
Type of Equipment
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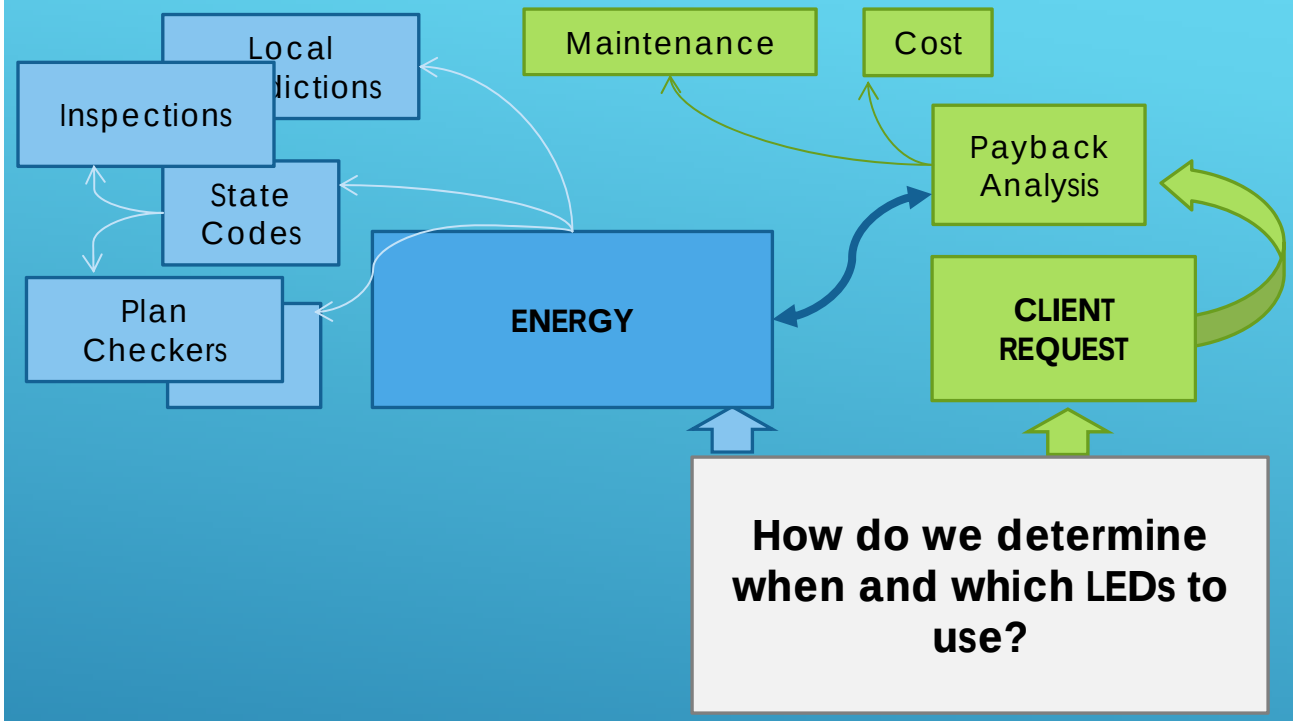
CONTROLS
Electronics
Flicker
Range
Smoothness
Compatibility
Lamp
Driver
Control
PHOTOMETRICS
Lumens vs Candelas
Output
Distribution
Photometric Data
Visual Comparisons /Mock-ups
Beamspread
Efficacy
Quality
Shielding



How do we determine when and which LEDs to use?

Interior Residence:
Long Island

- Energy Codes
- Client Request
- Payback Analysis
- Color
- Output
- Distribution
- Flexibility
- Shielding
- Control

	MR16/Retrofit	Integral LED
DN Fixture Cost	$ 180.00	$ 365.00
Distributor Mark-up (10%)	$ 18.00 $ 198.00	$ 36.50 $ 401.50
Electrical Contractor Mark-up (15%)	$ 29.70 $ 227.70	$ 60.23 $ 461.73
Cost of Lamp	$ 38.25	$ 0.00
Luminaire Cost	$ 265.95	$ 461.73
Total number of fixtures	220	220
TOTAL COSTS	$ 58,509.00	$ 101,580.60
SAVINGS	-$ 42,999.60	

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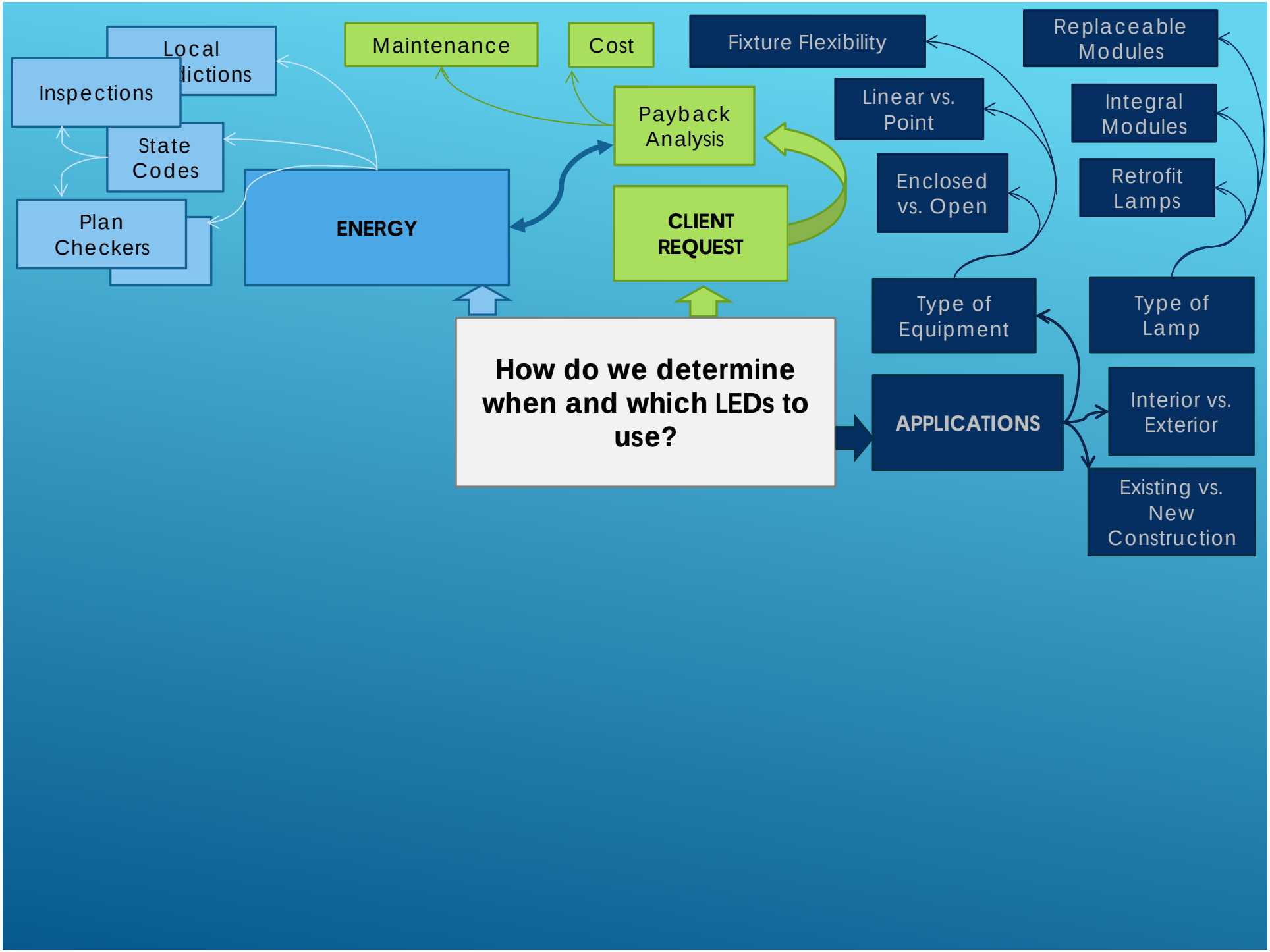
Interior Residence: Long Island

	Halogen	MR16 LED Replacement	Integral LED
Lamp Load	37W max.	10.5W	13W
Total Load	8140W	2310W	2860W
Hours of Operation	8 hours/day	8 hours/day	8 hours/day
Cost of Electricity	$ 0.36 per kWh	$ 0.36 per kWh	$ 0.36 per kWh
Cost per Day	$ 23.44/day	$ 6.65/day	$ 8.24/day
SAVINGS/day		-$ 16.79	-$ 15.20
Cost per Year	$ 8,555.60	$ 2,427.25	$ 3,007.60
SAVINGS/year		-$ 6,128.35	-$ 5,548.00

Difference in Cost of Lamps/Fixture:	$38.25	$ 461.73
Number of Fixtures:	220	220
Anticipated payback cycle:	1.4 years	8.8 years

(Payback cycle is for lamp and/or fixture cost only. Labor cost not included.)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Fixture Flexibility
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How do we determine when and which LEDs to use?
APPLICATIONS
Interior vs.
Exterior
Existing vs.
New
Construction

Establish Project Lighting Objectives

- Energy Codes
- Client Request
- Payback Analysis
- Color
- Output
- Distribution
- Applications
- Shielding
- Control

- Specific elements which result in the accomplishment of the Owner's Project Goals
- Approved by the Owner and Agreed to by the Project Team
- Determine the Owner's expected result(s) from Lighting

Develop together with the Owner and primary Design Team members

Objectives

- Energy Codes
- Client Request
- Payback Analysis
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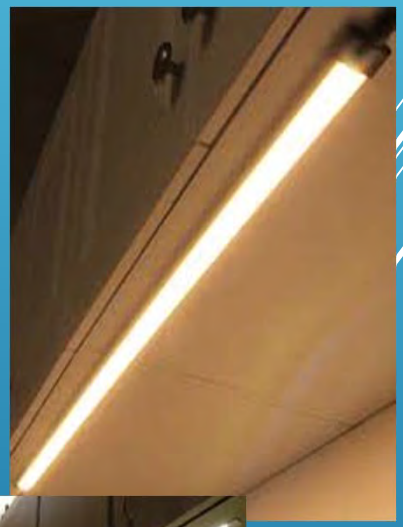
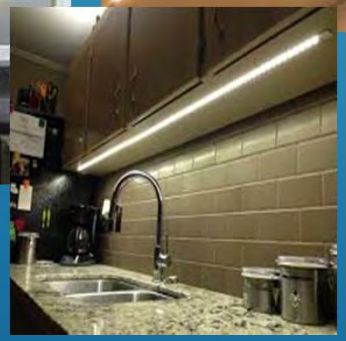
- Control

Visibility	Composite of everything that assists in sight, understanding, and recognition
Composition	Organization of Lighting consisting of brightness relationships between surfaces and objects in space
Image	A visible representation of the style, character, and impression to convey
Mood	An emotional response to the environment
Comfort	Subjective satisfaction and freedom from pain and anxiety (physical, aesthetic, functional, psychological support)
Orientation	Awareness of location, time, enclosure, direction, destination, and presence

APPLICATIONS

- Good applications for LEDs include:
  - Undercabinet lighting
  - In-cabinet lighting





- Energy Codes
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APPLICATIONS

- Good applications for LEDs inclu
  - Cove lighting
  - Uplighting

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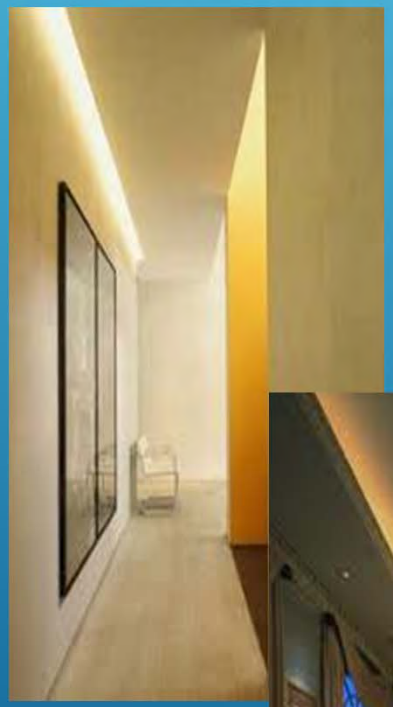

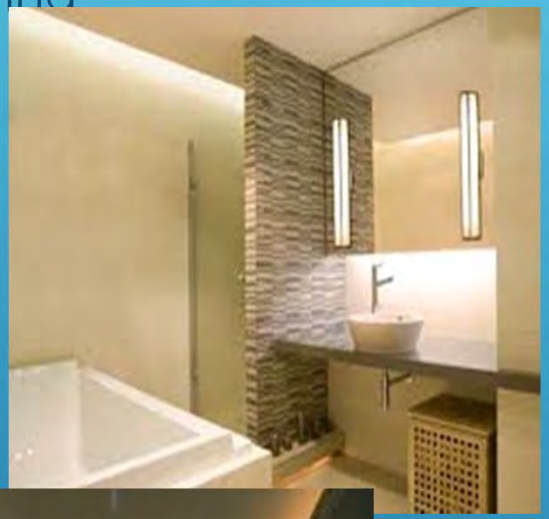

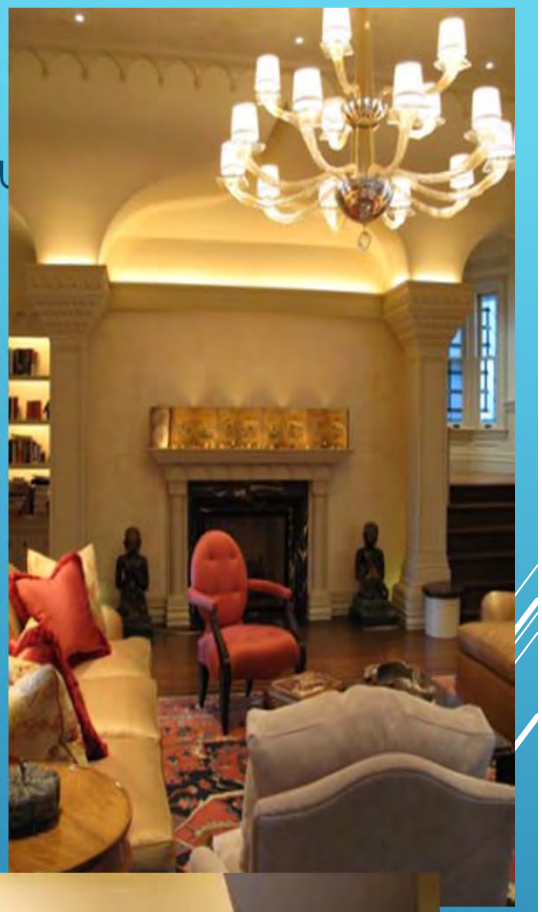

APPLICATIONS

- Good applications for LEDs includ
  - Step Lighting
  - Task Lighting

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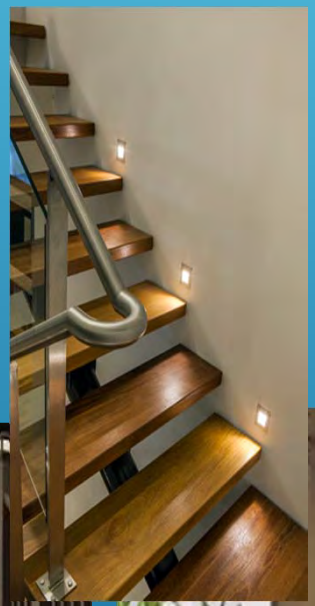
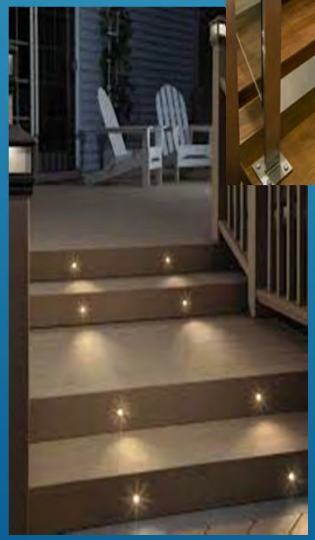
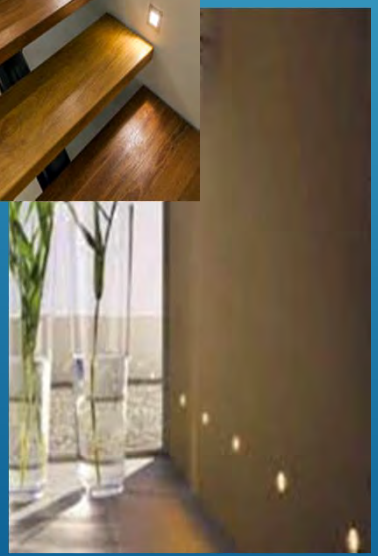
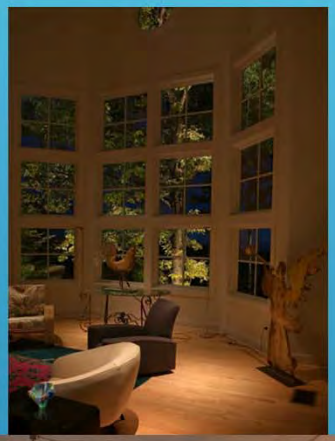






APPLICATIONS

- Applications I still think twice about (at least for now):
  - General Lighting



- Energy Codes
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APPLICATIONS

- Applications I still think twice about (at least for now):
  - Decorative Lighting

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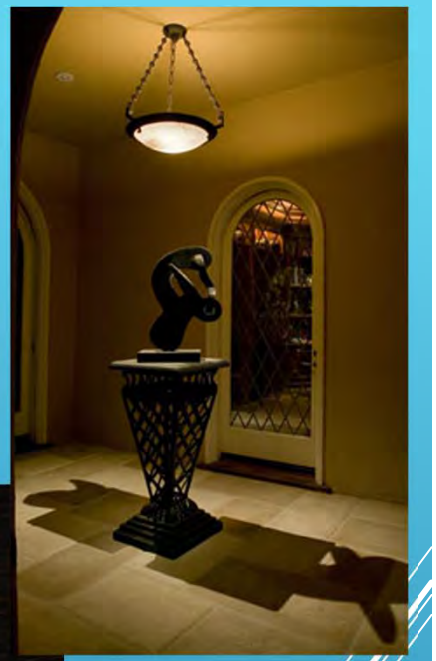

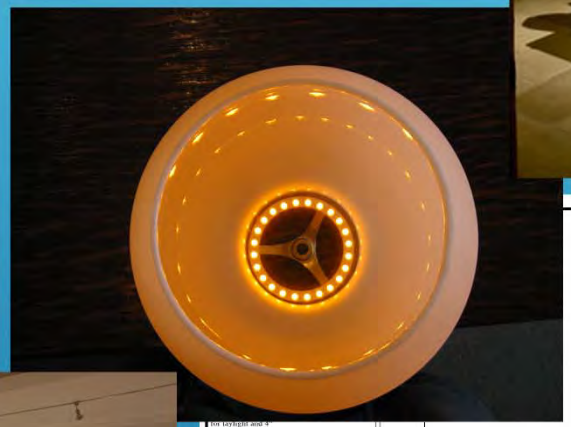

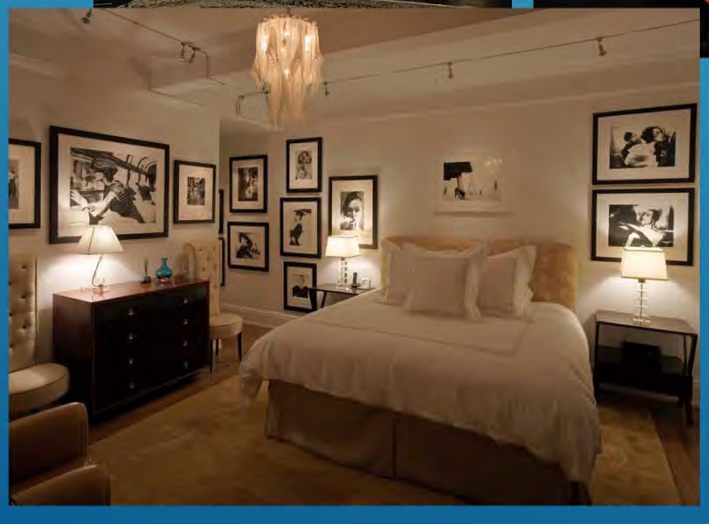

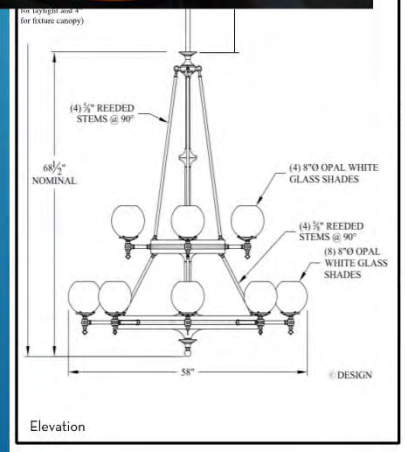

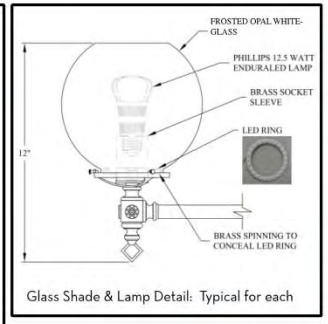

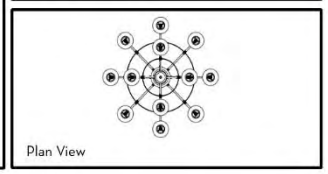

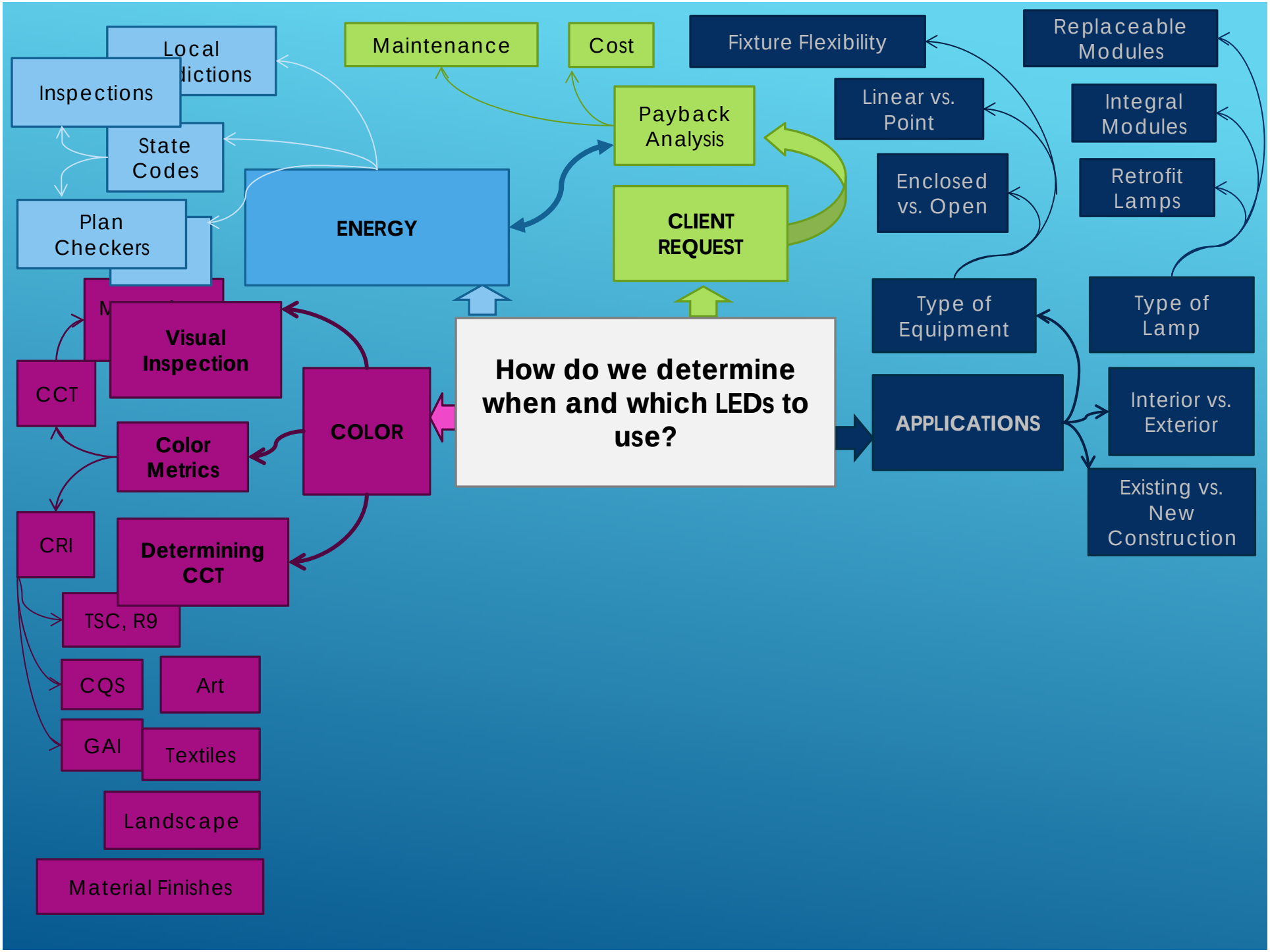
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COLOR

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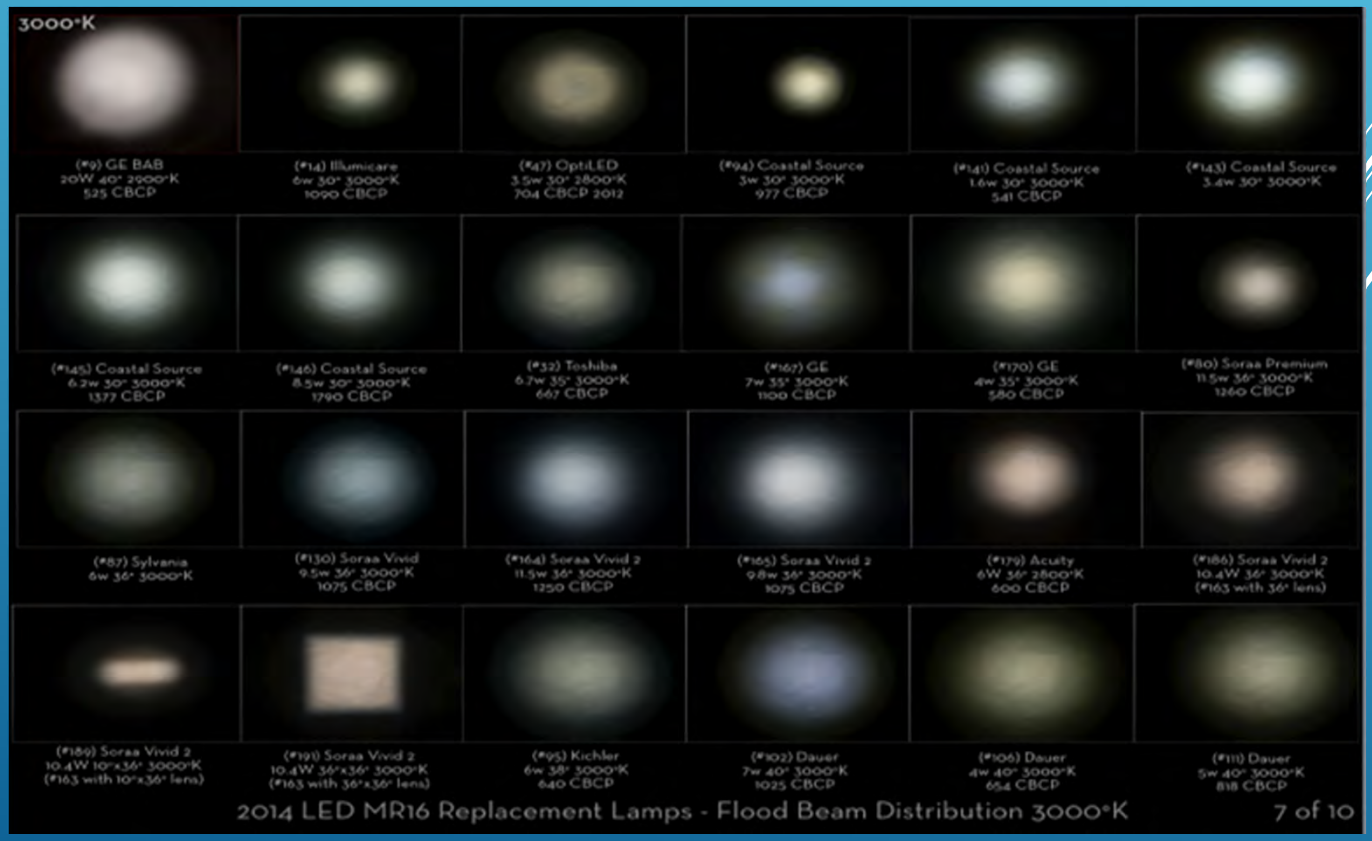
- Color consistency is getting better but..
  - But still be an issue



COLOR

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- Metrics are getting tighter but…
  - Numerous various metrics
    - CCT with MacAdam Ellipses
    - CRI with TCS, R9
    - CQS (NIST TC 1-69)
    - GAI (gamut-area index)
  - Manufacturers can chose metric
  - Standards are lagging

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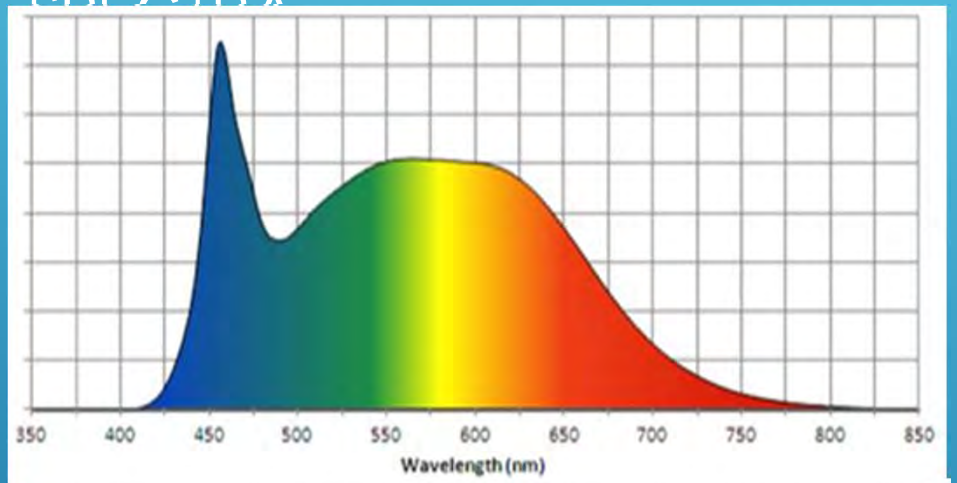
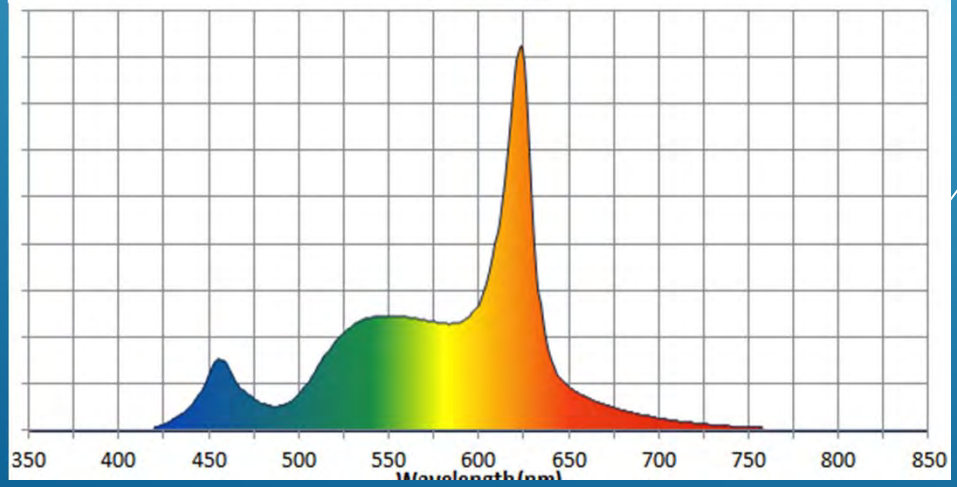
SOURCES WITH EXACTLY THE SAME CCT CAN HAVE VERY DIFFERENT SPECTRA





COLOR

- Visual Inspection is the only true metric

Tungsten

- Energy Codes
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COLOR

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LED 2700K

COLOR

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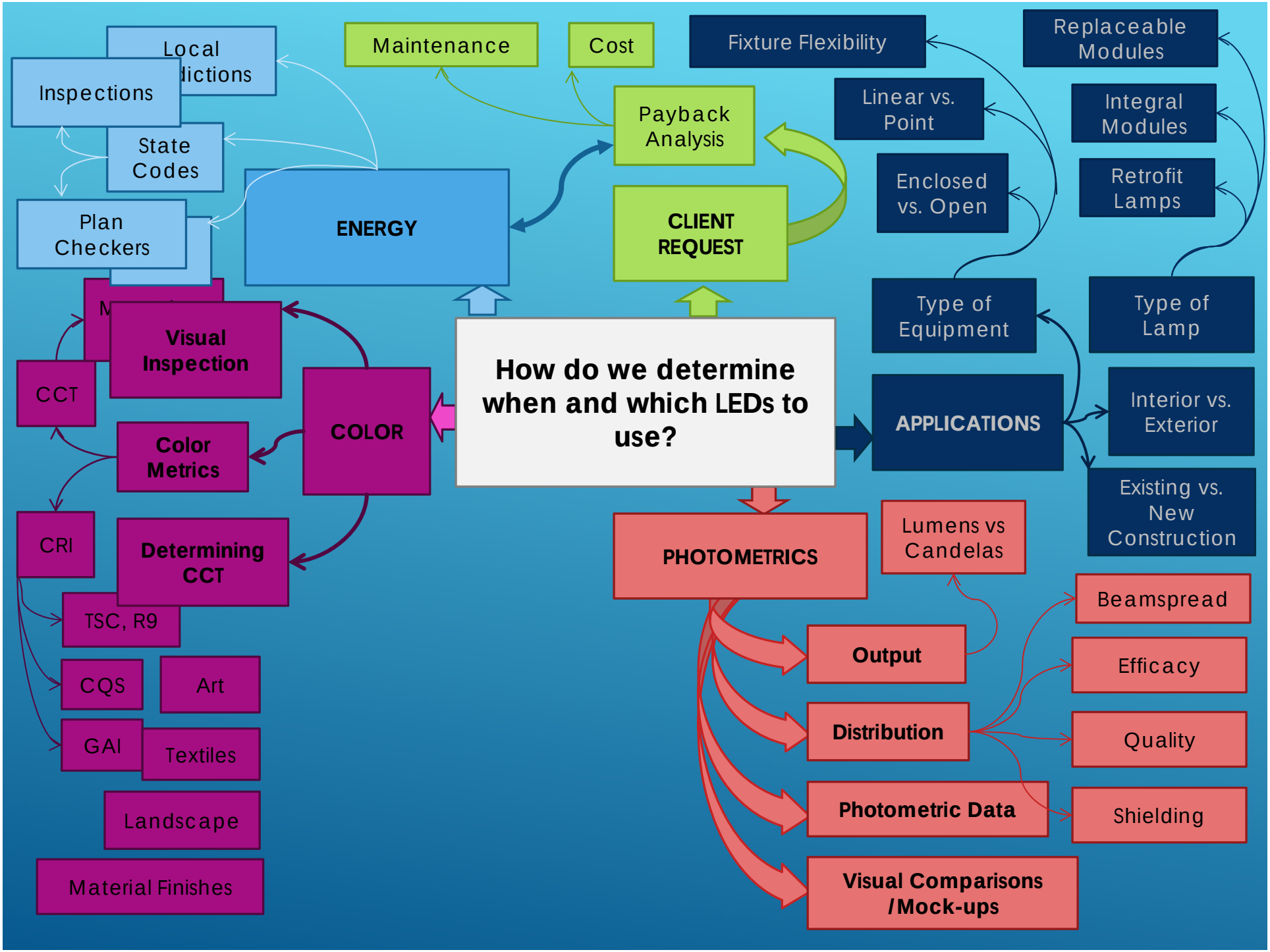
LED 3000K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OUTPUT

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Lumen refers to a quantity of light dispersed in ALL directions

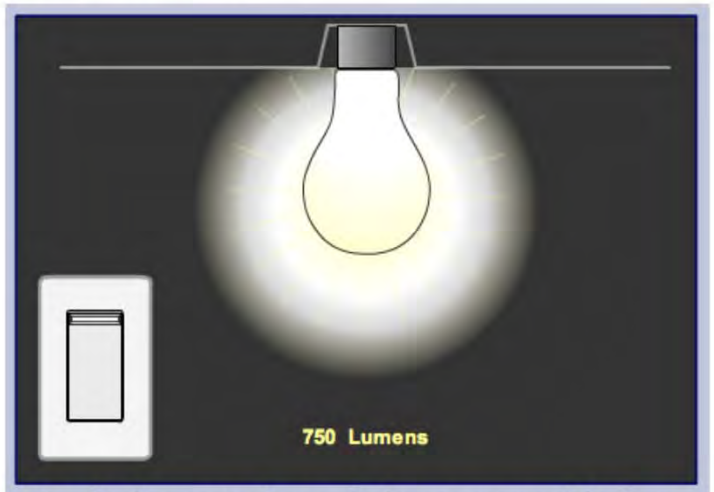
Currently, LED chip manufacturers are touting their LED efficacy in lumens

It falls to the fixture manufacturer to translate the light output & distribution of the LED package they use by testing each and every fixture combination of wattage, beamspread, and color for photometric quantity and distribution

Lumen

Courtesy of NYSERDA

The lumen is the time rate flow of light. Whereas a lamp will have many candela values, depending upon the direction of interest, it will have only one lumen output rating. The lumen rating can be considered as the measure of the summation of light output of a lamp. Ratings are determined and published by the lamp manufacturer.



Use the dimmer to change the lumen output of the lamp.

During the design process, lighting specifiers use the lumen ratings of lamps to predict the final illuminance in a space. Since energy-efficient design has become increasingly important to the end user, designers also evaluate the lumen output per watt consumed, or efficacy, of the various lamp choices. Here are a few examples of lumen ratings for some commonly used lamps:

Lamp	Lumens
60-W A19 incandescent	750
135-W A21 energy-efficient incandescent	2580
34-W T12 cool white fluorescent	2650
34-W T12 4100 K, CRI 82	2850
32-W T8 4100 K, CRI 85	3050
70-W medium base metal halide, clear	5200

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CBCP or MBCP

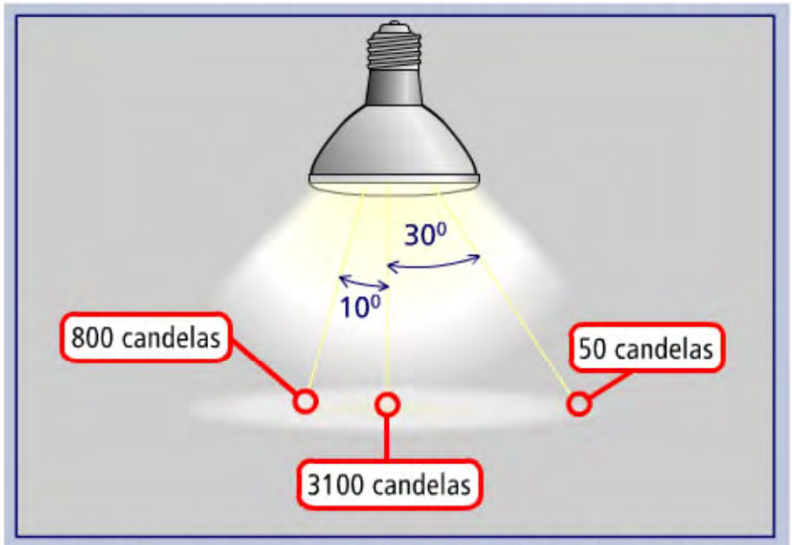
The main intensity is measured slightly differently for varying lamp types, but, it refers to the main intensity in a specific beam diameter or 'beam spread'

FIELD

The "field" refers to all the remaining light that the lamp puts out – beyond the listed beam spread width

Candela

The intensity of a light source in a specific direction is expressed in candelas (cd). Any given light source will have many different intensities, depending upon the direction considered. Since intensity is a property of the source itself, the candlepower (luminous intensity expressed in candelas) for a specified direction remains the same, regardless of distance from the source.



Click on the circles to see the intensity at those points

It is interesting to compare lamps of the same wattage with regard to luminous intensity. In the following examples, imagine the lamps aimed straight down, with 0° representing a point directly beneath each one, and 20° representing a point 20° up from 0°. Although not true for all sources, the highest candela values occur at 0° in these examples:

Lamp	Candelas at 0°
75-W MR16 Flood	2,500
75-W MR16 Spot	14,000
75-W PAR38 Flood	3,150
75-W PAR38 Spot	19,200

Data taken from OSRAM/SYLVANIA and Philips Lamp Catalog

Courtesy of NYSERDA

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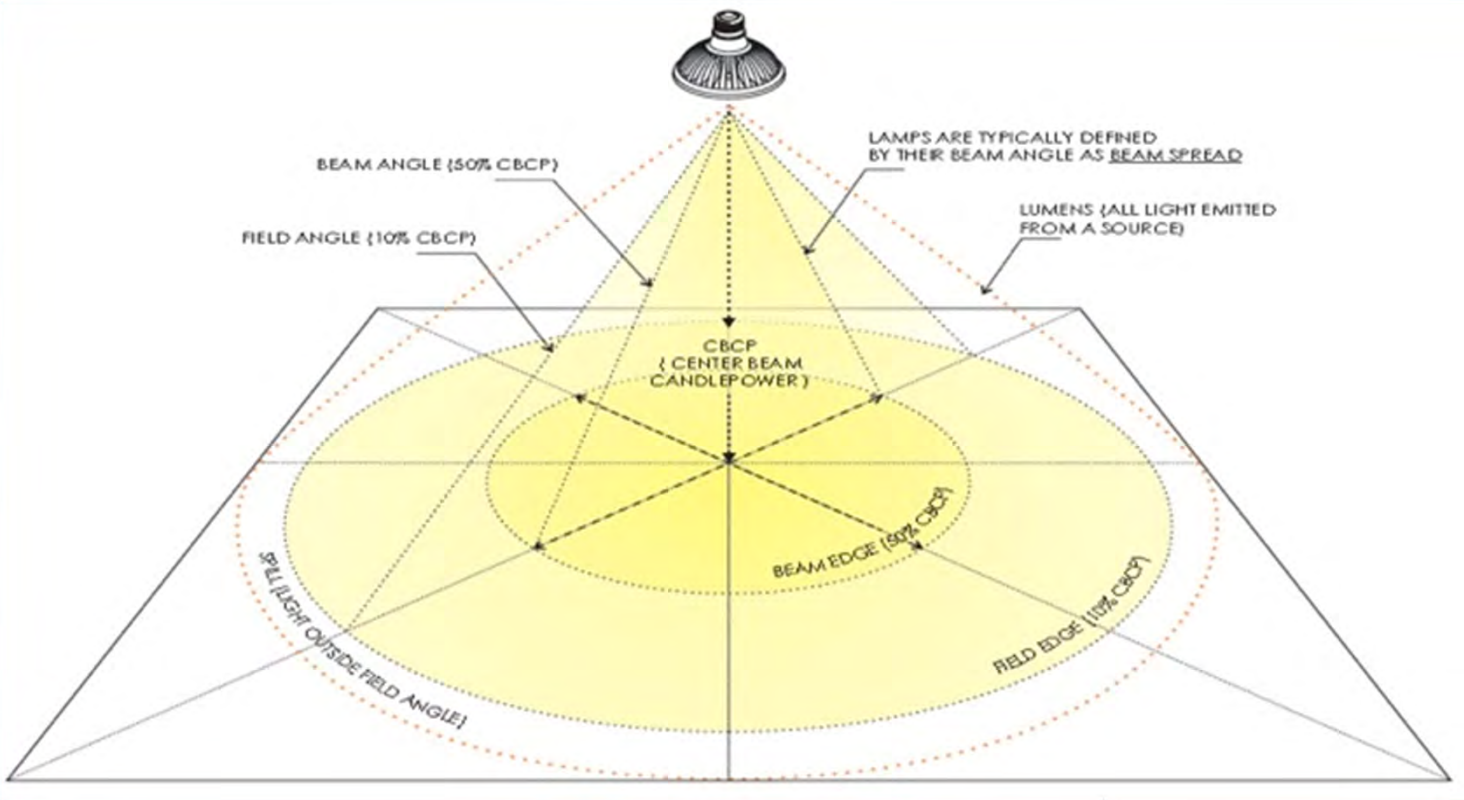

DISTRIBUTION

- LEDs produce light differently

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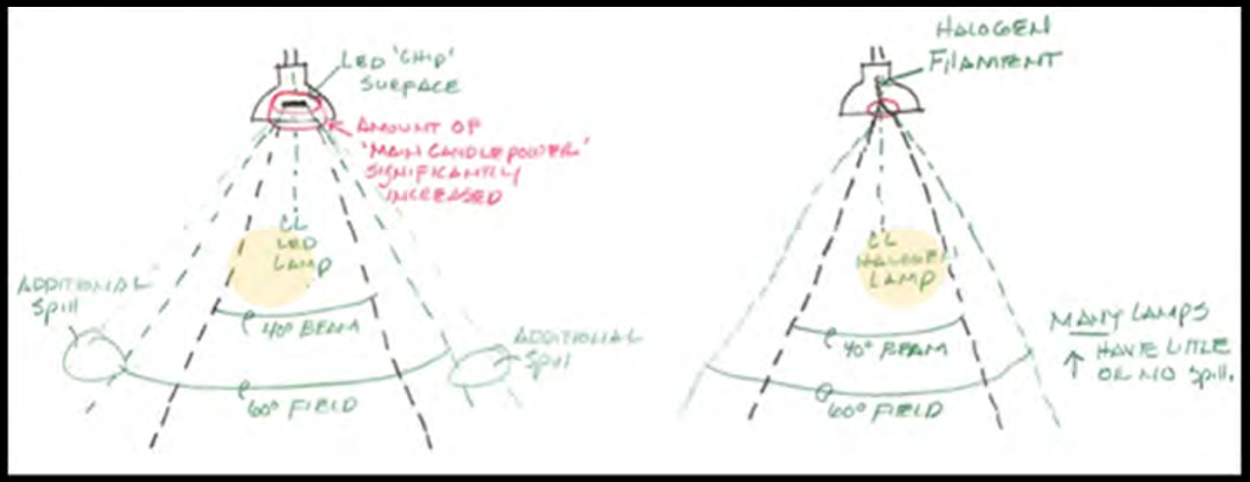


LED Lamps produce light differently from other sources.
"Beamspreads" are not the same.

•The CBCP - listed for halogen lamps occurs at 0° only, but in LED it occurs across the chip surface, making the beam typically appear more regular and often larger than the same beam in halogen.

•LED have a higher percentage of lumens in the the beam and more in the additional spread - many MR16 halogen lamps have very little or no spill

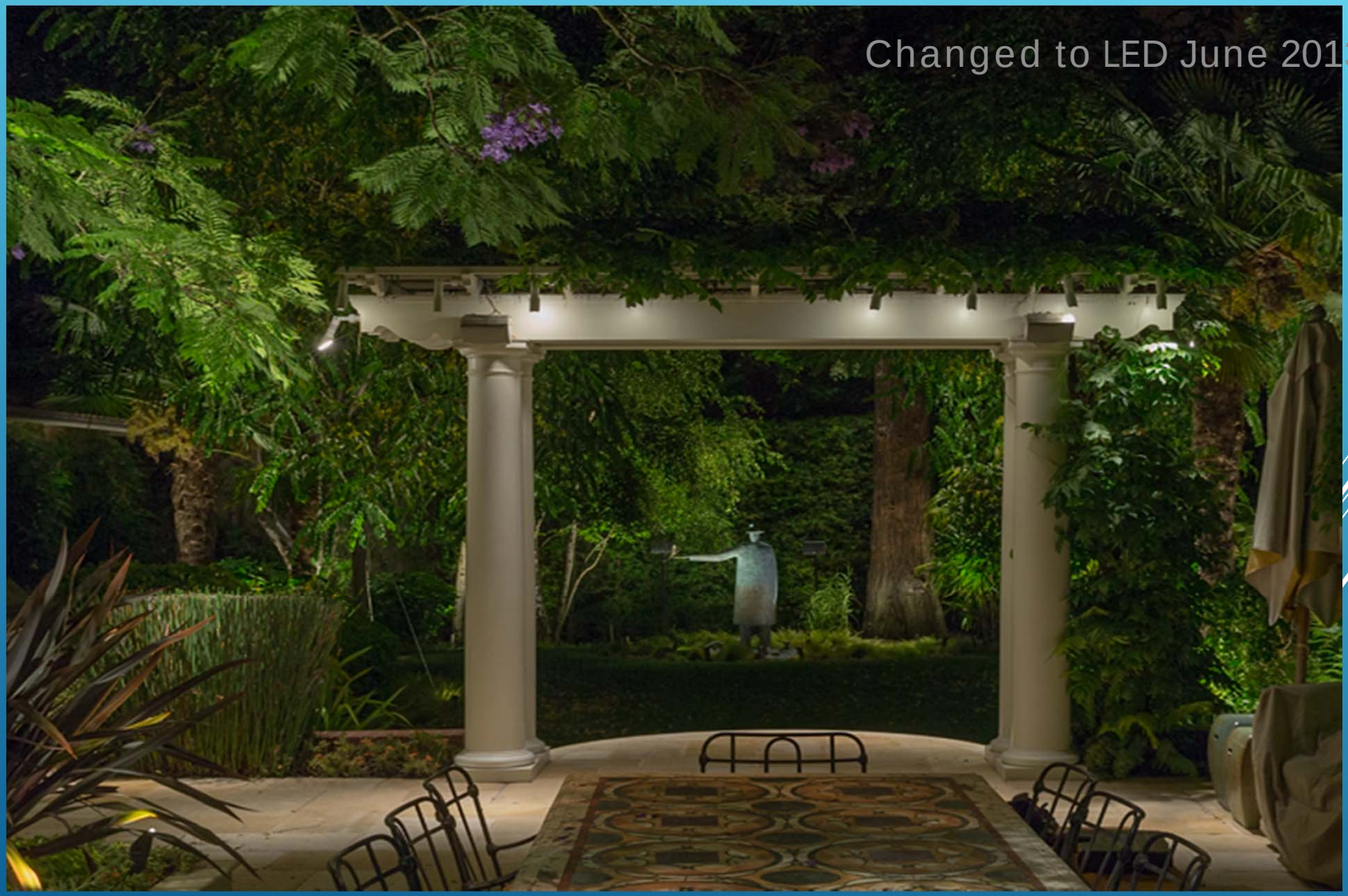
Illustration Courtesy of Jan Moyer (Jan & Brooke, Luminae LLC)

DISTRIBUTION

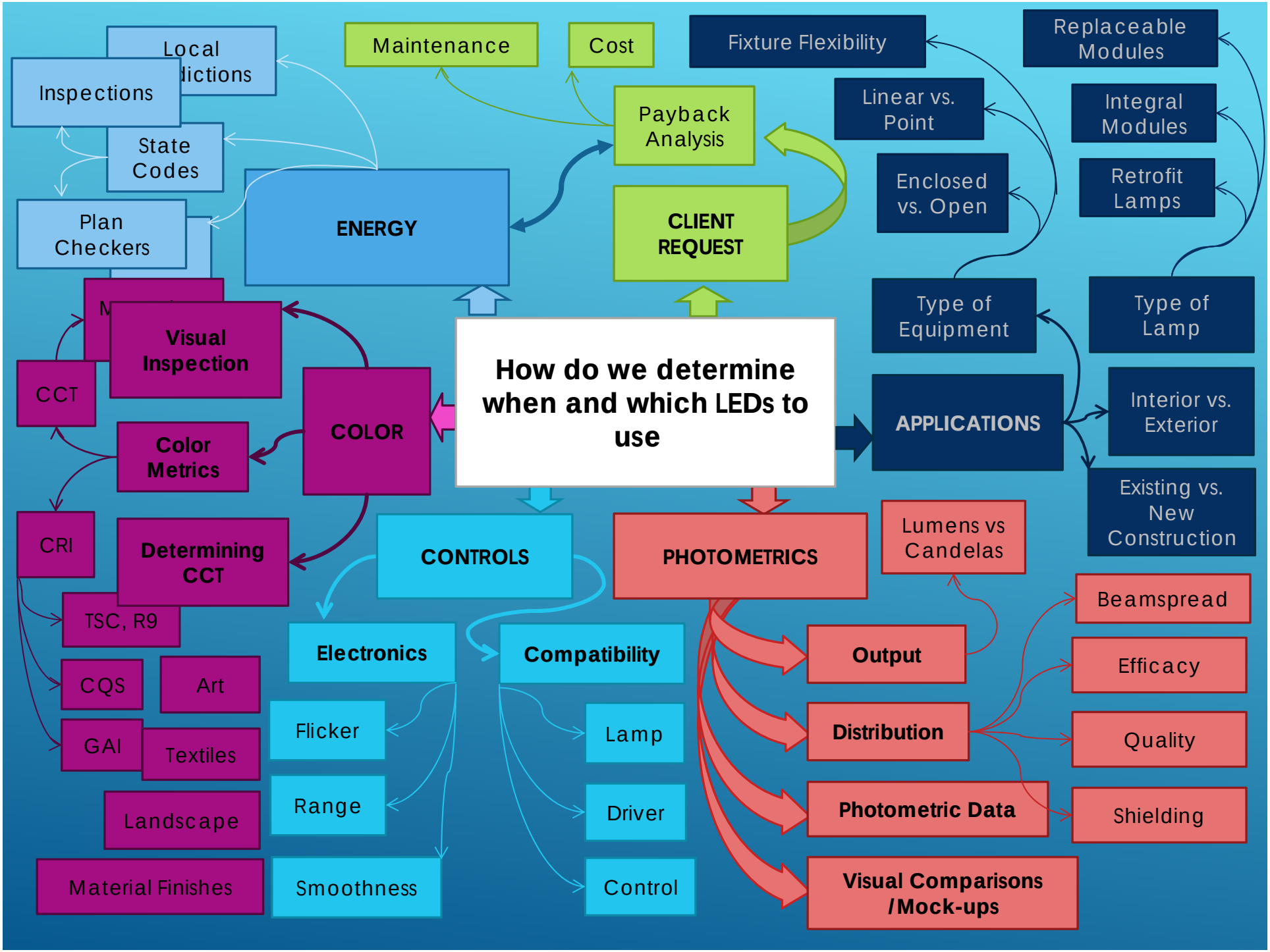
- Energy Codes
- Client Request
- Payback Analysis
- Color
- Output
- Distribution
- Flexibility
- Shielding
- Control

- Not all beams look the same
- Incumbent sources have predictability to their beam profiles
- LED beam profiles are highly varied. This makes specification difficult without seeing samples of each product in person.

Photos Courtesy of Jan Moyer



Photos Courtesy of Jan Moyer


How do we determine when and which LEDs to use
ENERGY
Local
dictions
Inspections
State Codes
Plan Checkers
Maintenance
Cost
Payback Analysis
CLIENT REQUEST
Fixture Flexibility
Linear vs. Point
Enclosed vs. Open
Replaceable Modules
Integral Modules
Retrofit Lamps
Type of Equipment
Type of Lamp
APPLICATIONS
Interior vs. Exterior
Existing vs. New Construction
COLOR
Visual Inspection
Color Metrics
CCT
CRI
Determining CCT
TSC, R9
CQS
Art
GAI
Textiles
Landscape
Material Finishes
CONTROLS
Electronics
Flicker
Range
Smoothness
Compatibility
Lamp
Driver
Control
PHOTOMETRICS
Lumens vs Candelas
Output
Distribution
Photometric Data
Visual Comparisons /Mock-ups
Beamspread
Efficacy
Quality
Shielding

CONTROLS

- Energy Codes
- Client Request
- Payback Analysis
- Fixture Flexibility
- Color
- Output
- Distribution
- Shielding
- Control

Halogen

LED

CONTROLS

- Energy Codes
- Client Request
- Payback Analysis
- Fixture Flexibility
- Color
- Output
- Distribution
- Shielding
- Control

CONTROLS

- Energy Codes
- Client Request
- Payback Analysis
- Fixture Flexibility
- Color
- Output
- Distribution
- Shielding
- Control

- Compatibility of systems
  - Lamps/Module
    - Reverse Phase
    - Forward Phase
  - Driver VS. Control Options
    - ELV Forward Phase
    - ELV Reverse Phase
    - O-10V
    - 2-Wire
    - 3-Wire
    - DALI
    - DMX

CONTROL

- Range and consistency of dimming
  - Limited range
  - Non-smooth dimming

- Energy Codes
- Client Request
- Payback Analysis
- Fixture Flexibility
- Color
- Output
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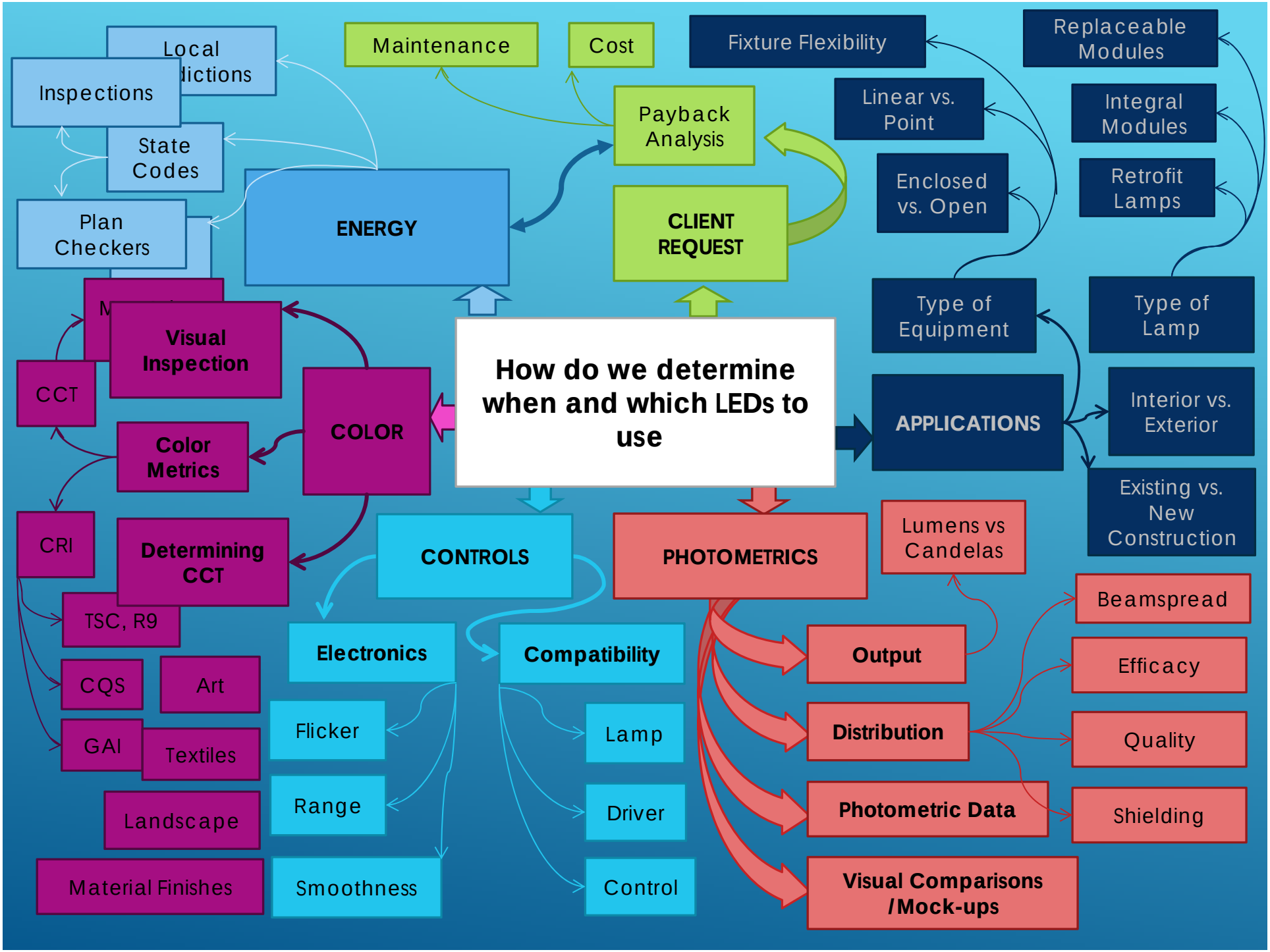
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NEWPORT VENTURES

David Brignati, AIA, LEED AP has over 20 years of experience in the field of architecture and project management. With familiarity in both commercial and residential design, he brings a unique perspective to our energy efficiency and high performance design group as well as an understanding of the various codes required for the design a construction of a building.

Mr. Brignati has been part of the team training Code Officials, Architects and Builders in issues related to the current energy code and building science. He also provides design and technical support for several Newport publications such as *Durability By Design* and *Incremental Reconstruction of Disaster Damaged Homes*. Prior to joining Newport Ventures, Mr. Brignati has been involved with many building types ranging from industrial, medical, retail and educational to production and custom homes. With a background and deep interest in building science in addition to environmental design and sustainability, he was the Team Leader for the first home in New York's Capital Region to achieve LEED® Gold certification.

David is a registered Architect in the states of New York and New Hampshire, a LEED® Accredited Professional with specialties in Building Design and Construction as well as Homes, a member of the American Institute of Architects and a member of the Committee On The Environment through the American Institute of Architects of Eastern New York as well as an ICC certified Commercial Energy Inspector and Residential Energy Inspector/Plans Examiner.

He holds a bachelor's degree in Environmental Design from the University of Colorado in Boulder.

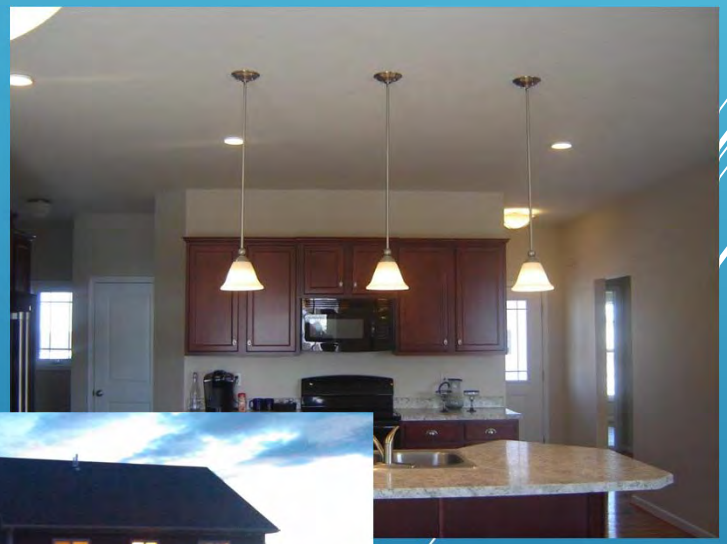
DAVID BRIGNATI

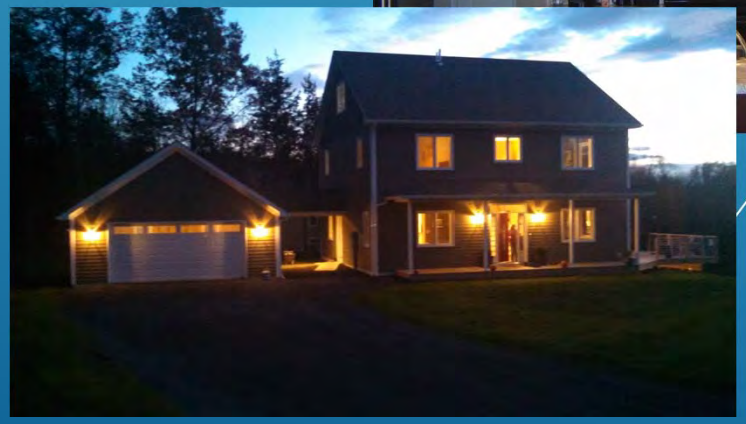
BUILDER INTEGRATION

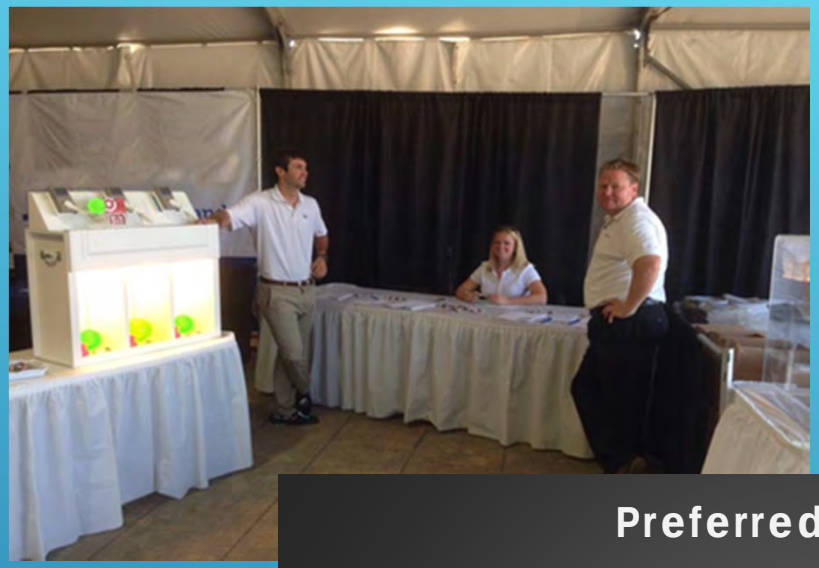
LED PROJECT

100% LED Lighting

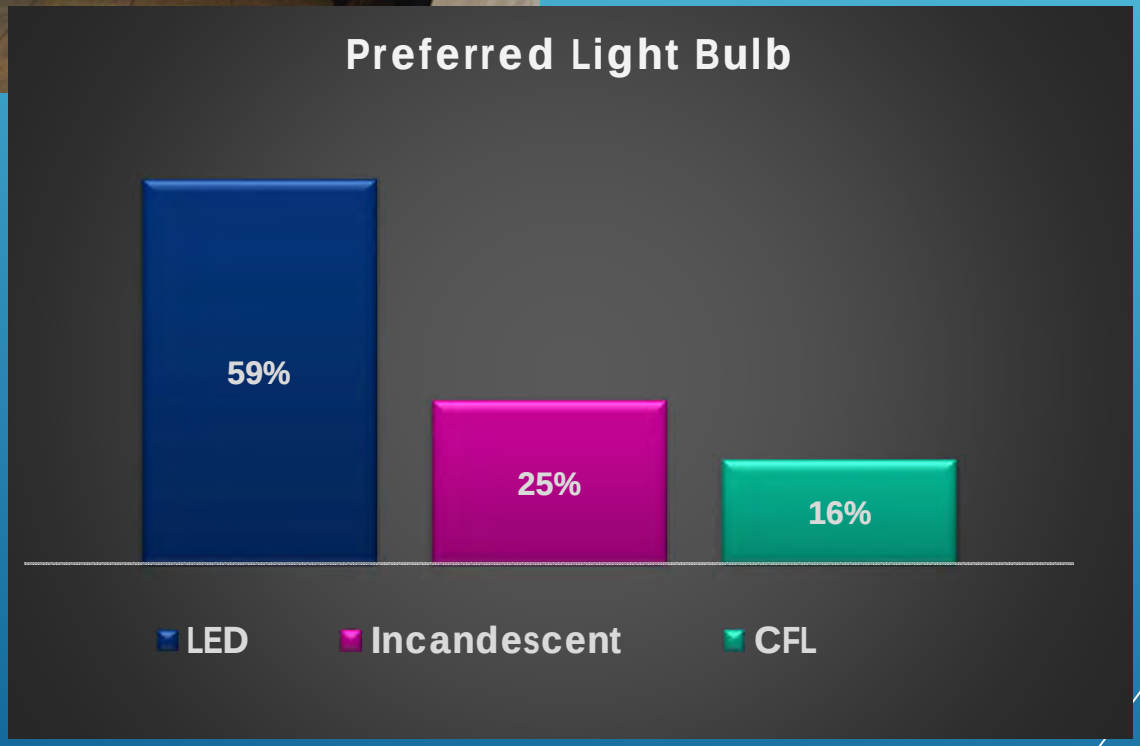
- Sponsored by NYSERDA
- 5 pilot homes across NY State
- Integrate 100% LED lighting
- Design
- Incremental costs for lighting upgrade
- Energy monitoring
- Consumer reaction







PREFERRED LIGHT SOURCE



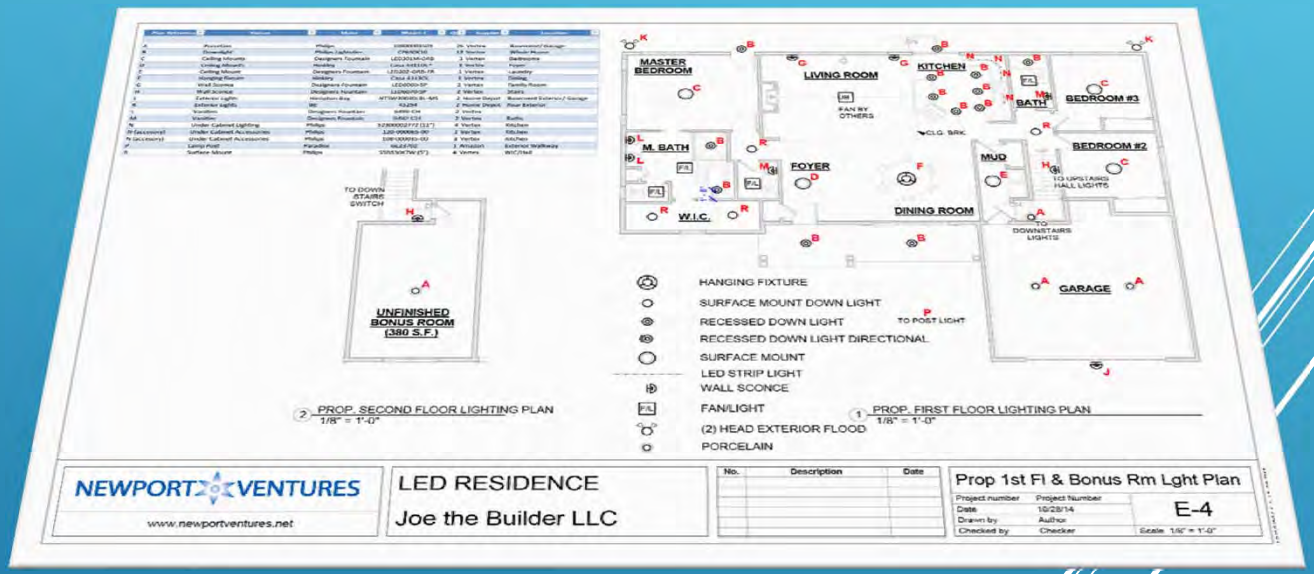
CONSUMER REACTIONS

What's being said…

- "I hate CFL's"
- "The light seems brighter"
- "The light seems clearer"
- "I like the colors in this box most"
- " L-E- what's?"

LIGHTING DESIGN

- USE OF SPACE
  - TRAFFIC PATTERNS
  - FURNITURE
- TYPE OF LIGHT
  - GENERAL
  - TASK
  - ACCENT
- AMOUNT OF LIGHT
  - LUMEN OUTPUT
- COLOR (TEMPERATURE)
  - WARM (2700K)
  - COOL (3500K)
  - DAYLIGHT (5000K)
- CO$T

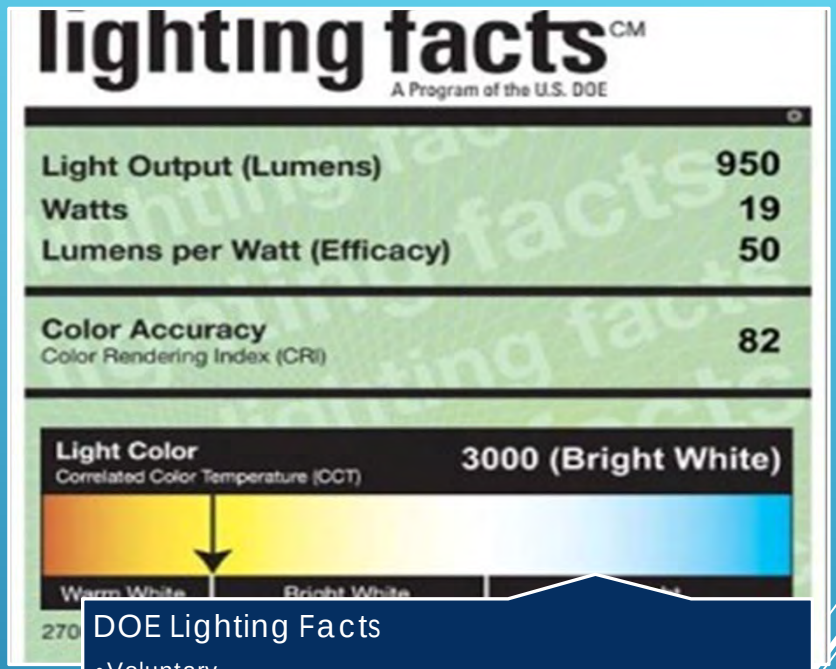


BENEFITS OF LED'S

60W
Wasted Energy
870 Lumens
Traditional Incandescent
Life Span: 1,000 hrs
$0.50
43W
785 Lumens
Halogen Incandescent
4,000 hrs
$2.12
13W
800 Lumens
CFL
10,000 hrs
$2.29
9W
800 Lumens
LED
25,000 hrs
$6.28

FTC Lighting Facts

- Mandatory
- Directed to consumers
- Applies to all medium screw based bulbs
- Does not require testing to back performance claims



DOE Lighting Facts

- Voluntary
- Directed to retail buyers, utilities, and lighting professionals
- Requires appropriate product testing for all products listed

WHAT'S IN THE LABEL?

Lumens (Brightness)

- Lumens measure how much light you are getting from a bulb.
  - More lumens = brighter light
- Think lumens, not watts
  - 60W Incandescent- 800 lumens

Efficacy (Lumens/Watt)

- Measures efficiency
  - Higher number = more efficient

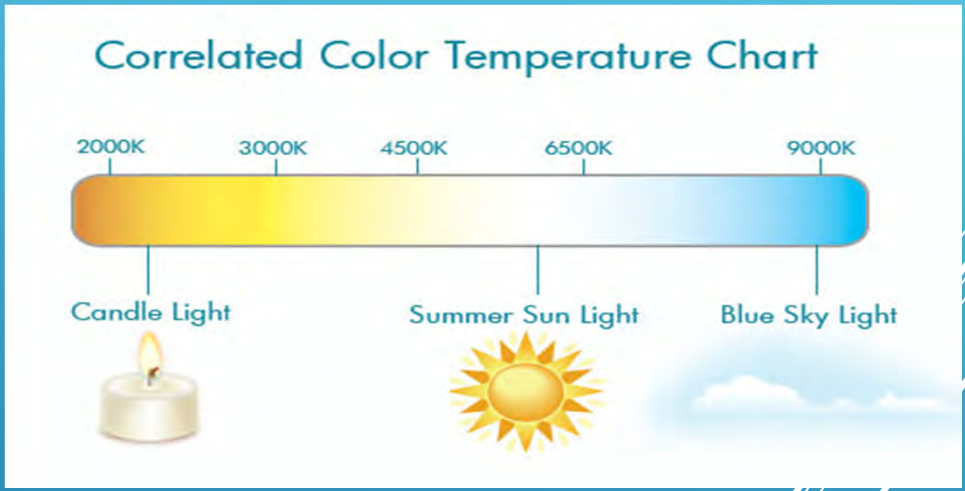
Bulb Type	Efficacy (LPW)
60 W Incandescent	13
15W CFL	53
10W LED	80

IMPORTANT LIGHTING DEFINITIONS

Kelvin (Color Temperature)

- Measures light color
- "Cool" colors have higher Kelvin temperatures (3600–5500 K)
- "Warm" colors have lower color temperatures (2700–3500 K).

Typical range for lighting



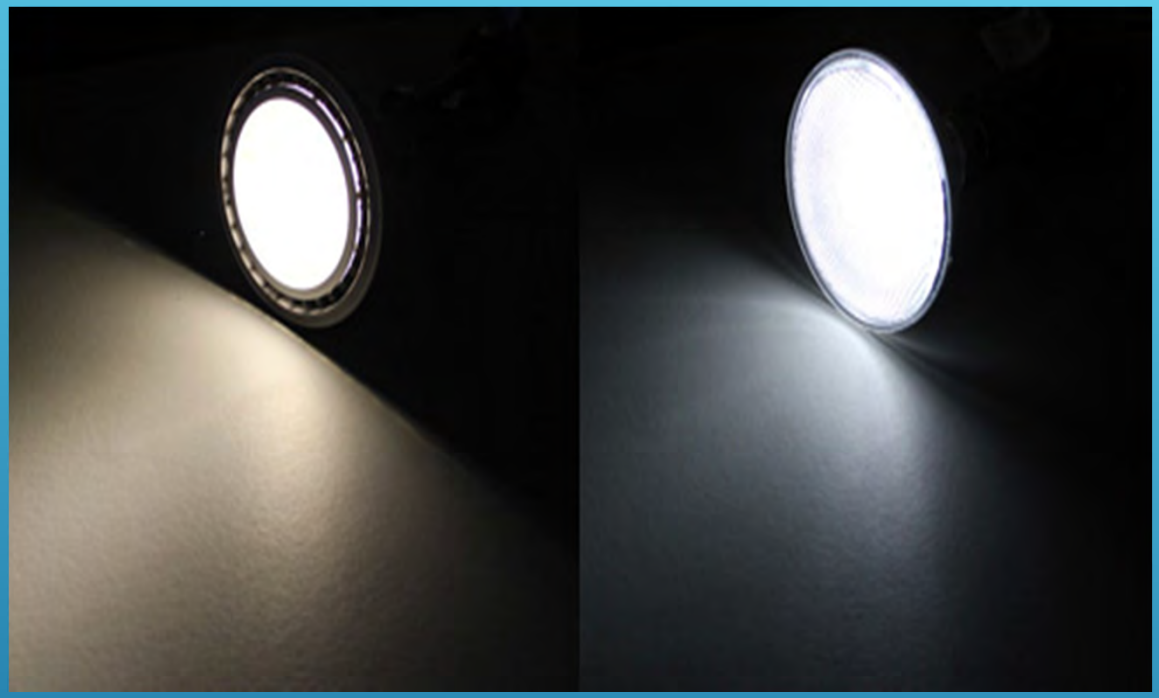
IMPORTANT LIGHTING DEFINITIONS

Color Rendering Index (CRI): Measures color accuracy compared to natural light (100 CRI)

Light Source	CRI Range
Incandescent	95+
CFL	60-85
LED	70-95

IMPORTANT LIGHTING DEFINITIONS

AVAILABILITY



- These two products are both designed to replace a PAR38 Halogen lamp in the 90W range. Can you see a difference?

YOU GET WHAT YOU PAY FOR

LOW QUALITY LEDS:
COMMON PROBLEMS

Watch for lower quality LED's in the market that do not follow minimum standards.

- Look for bulbs labeled with EnergyStar or that contain DOE Lighting Facts

Lacks color quality or brightness

- Eg: Cheaper products use low quality phosphors to lower the cost. Look for products with a higher CRI, which can achieved by using high-quality phosphors.

Failing to meet life expectancy

- LED lights require good heat dissipation which can't be accomplished without a good heat sink design, eg. aluminum. Bulbs that weigh more generally have better heat dissipation.
- Pay attention to warranties over life expectancy.

Unreliable LED drivers

- Low quality components and low-life capacitors found in many non-branded LED products

Variation in LED Chips

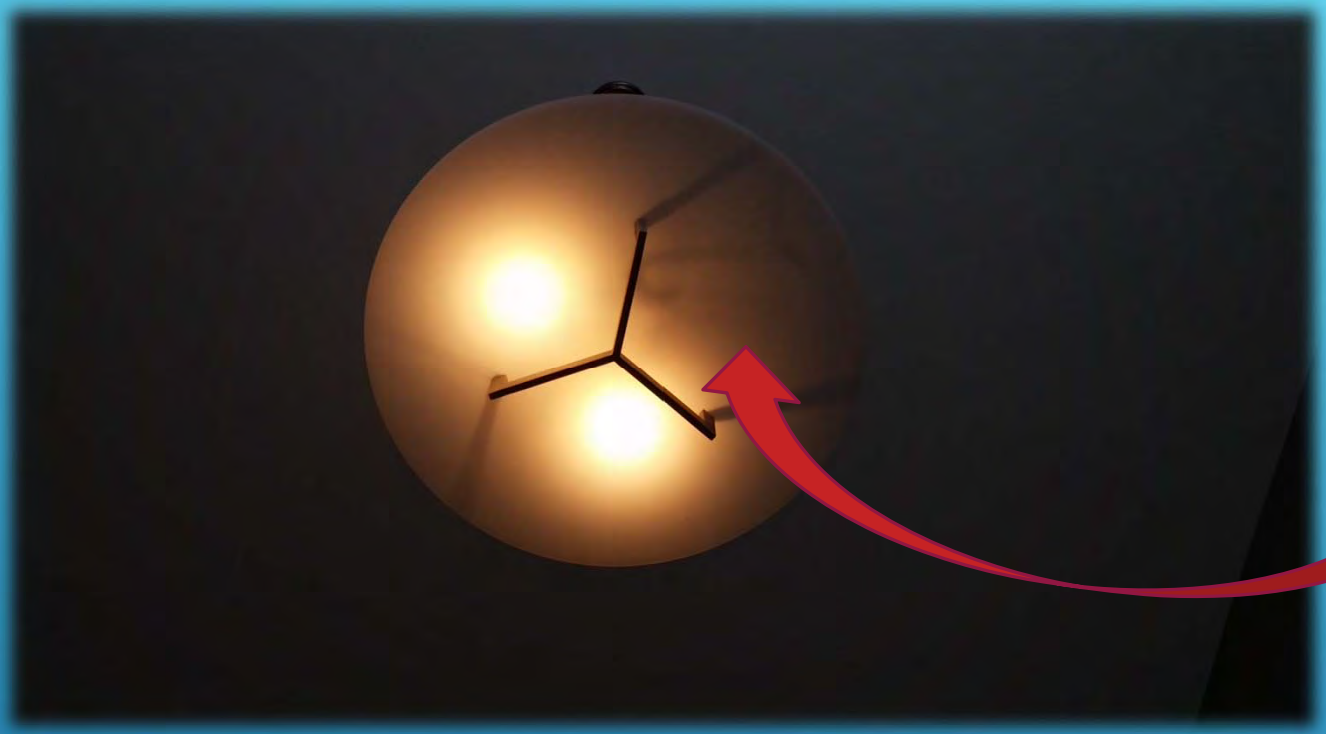
- Larger chips provide more light and stability against current variation but cost more

Inconsistent or incompatible dimming

LOW QUALITY LEDS:
COMMON PROBLEMS

LIFE EXPECTANCY VS. WARRANTY

- Life expectancies greatly outdistance product warranties.
- Currently no standardized way of testing life expectancy
- EnergyStar certified LED's are required to have a minimum 3 year warranty



- 3rd LIGHT SOURCE?

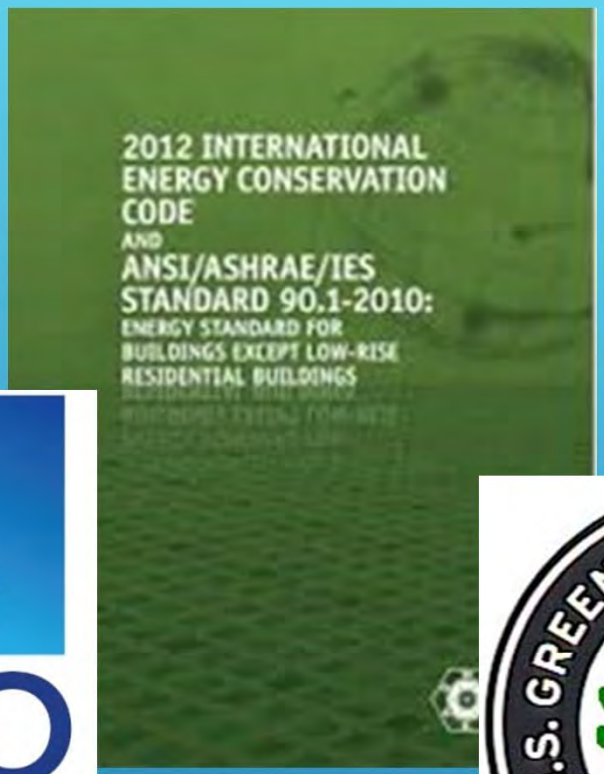
INFANT MORTALITY

LIGHTING CONTROLS

- Use lighting controls to automatically turn lights on and off as needed, and save energy
- Common Lighting Controls include; Dimmers, Motion & Occupancy Sensors, Timers
- Use timers and sensors to save energy and improve security
- Use dimmers to save energy and add ambience to a room

CONTROLS COMPATIBILITY

- No known issues with toggle switches
- Verify compatibility with all other control devices



ENERGY CODES / ABOVE CODE

TRADES COORDINATION

NEW PALTZ HOME

Expected electrical lighting **savings** is estimated to be between **66%-75%**.

Light Source	Avg. Monthly Cost ($0.13 kWh)	Yearly Cost (estimated)	Year One Savings (estimated)
100% LED	$7.03	$84.30	----------
13W+40W	$20.69	$248.28	$163.98
13W+60W	$28.50	$341.94	$257.64

AIR BARRIER COMPLIANCE

Slim line LED's can help maintain integrity of air barrier

Takeaways…

- LED'S ARE INCREDIBLY ENERGY EFFICIENT
- PURCHASE HIGH QUALITY LED'S
- ENSURE CONTROLS COMPATIBILITY
- UNDERSTAND THE USE/TASK BEING LIT AND SPECIFY ACCORDINGLY

Closing Reminders & Resources

To Become a Rater or Builder Partner:

www.buildings.energy.gov/zero

Contacts:
DOE Zero Energy Ready Home:
zero@newportpartnersllc.com

Brooke Silber: brooke@jbluminae.com

David Brignati: dbrignati@newportventures.net

Important Dates for DOE ZERH Partners:

Virtual Office Hours

- **5/26 Noon EDT**
- **6/2 Noon EDT**
- **6/9 Noon EDT**
- **6/16 Noon EDT**

Housing Innovation Awards – Apps Due

- **5/29 COB**