Tracy Beattie, LC, CLMC has been in the lighting industry since 1988. He was ‘Lighting Certified’ by NCQLP in December 2013. He worked for a lighting distributor in the LA market until 2010 when he partnered with his wife in the launching of Renovise, Inc., a Woman Owned Energy Solutions Company.

Renovise provides design, procurement, installation, financing & rebate facilitation for lighting & lighting controls solutions in the industrial commercial retrofit sector.

Renovise is also a California C10 Electrical Contractor and CALCTP Certified Installer / Contractor & Certified Acceptance Tester for CA Title 24-2013, Part 6-Lighting.

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LED vs Other Technologies

Are LED’s ready for Prime Time?
“Thompson, I need you to redefine key metrics through dynamic optimization alignment. The rest of you, figure out what that means.”
LED vs Other Technologies

• Key Metrics (Basics for Understanding Light)
  • Efficacy – Lumens per Watt
  • CRI – Color Rendering Index
  • Kelvin – CCT- Color Corrected Temperature
  • Life Span
  • Scotopic Photopic Ratio (SP Ratio)
  • Point Source vs General lighting
  • Dimming Capability
  • Pitfalls
LED vs Other Technologies

- Lumens per Watt
LED vs Other Technologies

- **CRI** – Color Rendering Index
  - # between 0 & 100
  - Not a % but higher number is better
  - Reference to how accurately artificial light source replicates natural light at a given Kelvin Temp.

- **Kelvin - CCT** – Corrected Color Temperature
  - Range from ~1700k to ~8000k
  - Sunrise = ~1700k
  - High noon, overcast day, no smog ~8000

- Best of Breed LED = 95 CRI
LED vs Other Technologies

- CRI Comparisons between Technologies

<table>
<thead>
<tr>
<th>CRI</th>
<th>Incandescent</th>
<th>Halogen</th>
<th>Metal Halide</th>
<th>Light-Emitting Diodes (LEDs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CRI Medium E11</td>
<td>CRI Medium A19</td>
<td>CRI Medium A19</td>
<td>CRI Medium A19</td>
</tr>
</tbody>
</table>

- Incandescent (CRI Medium E11): Candidate Base
  - This is the traditional “soft” light bulb, emitting light in a warm, broad spectrum, producing a natural, but not necessarily true, color rendering. CRI is low, as it is not dominated by visible light.

- Halogen (CRI Medium A19): Candidate Base
  - Halogen is a type of incandescent. It has the least color rendering of any light source available in the United States and is therefore often used to enhance the effect of tungsten-halogen lamps in lighting fixtures. Due to high color rendering and excellent performance, it is used for outdoor and commercial applications.

- Metal Halide (CRI Medium A19): Candidate Base
  - Metal halide is a very high-output lamp commonly used in businesses and large outdoor areas. They are designed to operate at a lower temperature than incandescent lamps, making them more efficient and longer lasting.

- Light-Emitting Diodes (LEDs): Candidate Base
  - LEDs are a promising technology currently undergoing rapid development. They are the most efficient and longest-lasting light source available, with a long lifespan and low maintenance costs.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Energy Output (W)</th>
<th>CRI</th>
<th>CCT (K)</th>
<th>Lumen Output (lm)</th>
<th>Cost (USD)</th>
<th>Run Cost (USD)</th>
<th>CRI</th>
<th>CCT (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent</td>
<td>25</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>3000</td>
<td>4000</td>
</tr>
<tr>
<td>Halogen</td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>3000</td>
<td>4000</td>
</tr>
<tr>
<td>Metal Halide</td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>3000</td>
<td>4000</td>
</tr>
<tr>
<td>LEDs</td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>3000</td>
<td>4000</td>
</tr>
</tbody>
</table>

**CRI Comparisons**

- **Incandescent**: Low CRI, favors brightness over color.
- **Halogen**: Low CRI, less efficient than LEDs.
- **Metal Halide**: Medium CRI, efficient, but less than LEDs.
- **LEDs**: High CRI, most efficient and longest lasting.

**CCT Comparison**

- **Incandescent**: Warm white, 2700K-3000K.
- **Halogen**: Warm white, 2700K-3000K.
- **Metal Halide**: Warm white, 2700K-3000K.
- **LEDs**: Cool white, 4000K-6500K.

**Energy Efficiency**

- LEDs are the most energy-efficient lighting solution, reducing energy consumption by up to 90% compared to incandescent lamps.

**Cost Considerations**

- Initial cost: LEDs are more expensive than incandescent lamps, but they are more energy-efficient.
- Longevity: LEDs have a longer lifespan, reducing maintenance costs over time.

**Conclusion**

LEDs offer the best combination of energy efficiency, longevity, and color rendering, making them the ideal choice for modern lighting applications.
LED vs Other Technologies
LED vs Other Technologies

- **Life Span**
  - IESNA – Illuminating Engineering Society of NA
  - Fluorescents & MH = 50% failure = lifespan
  - HPS & MV = 35% failure = lifespan
  - LED – L70= light level is 70% of initial lumens
    - Estimate based on LM80 test protocol which tests LED at 55°C & 85°C for 6000 hours.
    - TM21 protocol runs test > 6000 hours
  - Best of Breed LED > 100,000 hours
LED vs Other Technologies

- Scotopic / Photopic (SP) Ratios
  - How my eye actually sees light
    - E.g.- LED street lights= less wattage but more light
  - Light meters
    - North America = Photopic
    - Europe = Scotopic
  - Based on rods & cones in eye
  - SP ratio X’s delivered lumen package from fixture
LED vs Other Technologies

- Scotopic / Photopic (SP) Ratios
LED vs Other Technologies
LED vs Other Technologies

- Point Source vs Multi-Directional Light
  - Light fixtures are inefficient (60% to 95%)
  - Light fixtures reflectivity degrade in time

| Table 1: Photometric Data Comparison Between HPS, MH and Pozeen's Outdoor LED Luminaires |
|---------------------------------|-----------------|-----------------|-----------------|
| Luminaire watts                 | 150W HPS        | 175W MH         | Pozeen 140W LED |
| CCT                             | 183W            | 208W            | 153W            |
| CRI                             | 2000K           | 4000K           | 5000K           |
| Rated initial lumens            | 16000 lm        | 11700 lm        | 12600 lm        |
| Rated initial lumens            | 16000 lm        | 11700 lm        | 12600 lm        |
| Downward luminaire efficiency   | 70%             | 81%             | 95%             |
| Downward luminaire lumens       | 11200 lm        | 9477 lm         | 11970 lm        |
| Downward luminaire efficacy     | 61 lm/W         | 46 lm/W         | 78 lm/W         |

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LED vs Other Technologies

- Dimming
  - Linear vs Non-Linear
LED vs Other Technologies

- Pricing
  - Initial vs Life Cycle
    - Cost of Energy
    - Accurate financial metrics
      - MIRR vs ROI
      - NPV vs Payback
      - SIR vs 1st Cost
LED vs Other Technologies

- Pitfalls
  - Heat
    - External vs Internal Drivers
  - Poor Electronics
  - Relamp or Refixture
  - Environmental conditions
    - Fixture type (airflow)
    - Irregular Power

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LED vs Other Technologies

“It’s either terrible or fantastic, but we should know for sure by Monday.”
Title 24-Part 6 – 2013
Lighting & Lighting Controls

What has changed?
EVERYTHING!!!
Is this what Title 24-2013 looks like to you?
What triggers compliance with Title 24-2013?

- **2010** Was 50% change of fixtures, ballasts or retrofit kits
- **2013** Now is:
  - Change of fixture, ballast or retrofit kit
  - 40 fixtures
  - 10% of fixtures in facility
  - Whichever is less
Areas of Emphasis

- Lighting Controls
- Daylight Harvesting
- ADR (Automatic Demand Response)
- Outdoors
Lighting Controls

- Manual ON/OFF for all luminaires

- Multi-Level Controls
  - Continuous or Step Dimming
  - Uniformity must be maintained (all fixtures lit equally)
  - Each Luminaire must have at least one capability
    - Manual Dimming
    - Lumen Maintenance
    - Tuning
    - Automatic Daylight control
    - Demand Response
I dunno, maybe deep down I want to bark up the wrong tree.
Shut Off Controls – MUST HAVE one of these!

- Occupancy Sensor (30 minute Maximum delay)
- Auto time switch control (Lighting Control Panel)
  - Count down timer not allowed
  - Allows lights to stay on NO more than 2 hours
- Signal from building system
- Other control capable of shutting lights OFF
Title 24-Part 6 – 2013
Lighting & Lighting Controls

Lighting Controls

• **What needs to be Turned OFF (within 30 minutes)**
  - Offices 250 sf & less
  - Multi-purpose rooms 1000 sf & less
  - All classrooms & conf. rooms
  - Hotel rooms

• **Partial ON/OFF (reduced by min. of 50%)**
  - Aisle ways & Open Areas in warehouses
  - Library aisles
  - Stairwells & Corridors
  - Parking Garages (reduced by 50% to 80%)
Title 24-Part 6 – 2013
Lighting & Lighting Controls

“Are you part of the problem, part of the solution, part of the problem with the solution, or part of the solution to the problem with the solution?”
Automatic Daylighting Controls

• What Triggers Compliance
  - Offices/Warehouses Within Skylit or Sidelit Zone
    • 24 + square feet of Window or Sky Light
    • 120 watts + of luminaires
  - Garages
    • 36 + square feet of opening or glazing
    • 60 watts or < in Primary Sidelit Zone

• Types of Zones
  - Skylit
  - Primary SideLit
  - Secondary SideLit
Title 24-Part 6 – 2013
Lighting & Lighting Controls

Skylit Zone
Title 24-Part 6 – 2013
Lighting & Lighting Controls
Sidelit Zone
Title 24-Part 6 – 2013
Lighting & Lighting Controls

Sidelit Zone
Automatic Daylighting Controls

- All Daylit Zones must be shown on Plans

- Light Levels
  
  - Combined light output from Daylight & electric light must not be less than from electric lighting only.

  - When Daylight is 150% of max. electric light, fixture must shed at least 65% of load.
Title 24-Part 6 – 2013
Lighting & Lighting Controls

what
when
why
how
which
where
how much
what
how many

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Title 24-Part 6 – 2013
Lighting & Lighting Controls

ADR - Automatic Demand Response

• What Triggers Compliance
  • 10,000 SF +
  • Lighting Power Density of < 0.5 watts/SF exempts area

• Controls must have capability to interface with Local utility and receive & act on ADR signal

• Lighting power uniformly lowered by at least 15%

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Title 24-Part 6 – 2013
Lighting & Lighting Controls
Outdoor Lighting

- **Fixtures > 150 watts must be BUG compliant**
  - (Backlight, Uplight, Glare)
- **Controls**
  - Luminaires must have either Photo Control or Astronomical time clock to switch them OFF during daylight
  - Luminaires < 24 feet must have Motion Sensor to step or continuous dim fixture to between 20% to 60% ON (reduce 40% to 80%) when unoccupied
    - Must auto ON to 100% when occupied
- **Exceptions**
  - Pole Lights < 75 watts
  - Wall Packs < 30 watts
  - Linear Lighting of 4 watts/foot
Title 24-Part 6 – 2013
Lighting & Lighting Controls

Misc Issues

• **Circuit Controls for 120v Receptacles**
  - Both controlled and uncontrolled receptacles must be provided
    - Offices, lobby’s, conf rooms, copy rooms, hotel rooms
  - ~50% of receptacles must be controllable
  - Plug in strips using Occ. Sensors do not comply
Title 24-Part 6 – 2013
Lighting & Lighting Controls
Title 24-Part 6 – 2013
Lighting & Lighting Controls

“And we all lived profitably after.”