As you find your seats, don’t sit alone and find folks you don’t know!
Discussion Session: Efficacy and Flicker
Objectives, Desired Outcomes, and Agenda

<table>
<thead>
<tr>
<th>Session Objectives:</th>
<th>Agenda:</th>
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</thead>
<tbody>
<tr>
<td>• Review draft Efficacy and Flicker rationale and requirements</td>
<td>• Welcome and Introduction</td>
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<tr>
<td>• Summarize comments received into main themes</td>
<td>• Efficacy</td>
</tr>
<tr>
<td>• Discuss remaining feedback and ways to address main themes</td>
<td>• Overview</td>
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<tr>
<td></td>
<td>• Comments Takeaways</td>
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<tr>
<td>Desired Outcome:</td>
<td>• Flicker</td>
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<tr>
<td>• Actionable feedback to inform Draft 2</td>
<td>• Overview</td>
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<tr>
<td></td>
<td>• Comments Takeaways</td>
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<tr>
<td></td>
<td>• Discussion</td>
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</tbody>
</table>
Session Structure and Ground Rules

• **Structure**
  - DLC will provide overview of each topic, summarize main themes from comments, and ask questions to the group
  - Each table *choose two questions* to discuss and *elect one person to report out* their thoughts to this group
    - Report outs will go in order of the questions
  - DLC will report out results to the larger group at the end of the day

• **Ground Rules**
  - Participate
  - Be respectful
  - Defer to the facilitator
Audience

• Whom do we have in the room?
  • Manufacturers
  • Researchers
  • Specifiers
  • Labs
  • Utilities
  • Distributors
  • Others
Efficacy
Revision History

• V5.0 proposes an **average efficacy increase of 9.6%**

• We have significantly pushed efficacy in the past, but we realize that continuing such increases may impact quality and cost
  • This round of efficacy increase is designed to go **hand-in-hand** with quality improvements

<table>
<thead>
<tr>
<th>Year</th>
<th>SSL Version</th>
<th>Average Efficacy Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>1.6</td>
<td>25%</td>
</tr>
<tr>
<td>2013</td>
<td>2.0</td>
<td>17%</td>
</tr>
<tr>
<td>2015</td>
<td>3.0</td>
<td>n/a (category restructure)</td>
</tr>
<tr>
<td>2016</td>
<td>4.0</td>
<td>27%</td>
</tr>
<tr>
<td>2019</td>
<td>5.0</td>
<td>9.6% (proposed)</td>
</tr>
</tbody>
</table>
Efficacy Increase Bins

• The goal was to strike the balance between efficacy, quality of light, and product cost

• As a result, each General Application was grouped into four bins:
  • ≈ 5% increase
  • ≈ 10% increase
  • ≈ 15% increase
  • ≈ 20% increase

• Draft values represent a DLC Standard classified product-weighted average increase of 9.6%
<table>
<thead>
<tr>
<th>#</th>
<th>Category</th>
<th>General Application</th>
<th>Minimum Light Output (lm)</th>
<th>DLC Standard</th>
<th>DLC Premium**</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Minimum Efficacy (lm/W)</td>
<td>Minimum Warranty (years)</td>
<td>CCT / CRI / L70</td>
<td>Primary Use***</td>
</tr>
<tr>
<td>---</td>
<td>---------</td>
<td>---------------------</td>
<td>--------------------------</td>
<td>--------------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>1</td>
<td>Outdoor</td>
<td>Outdoor – Low Output</td>
<td>250-5,000</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Outdoor</td>
<td>Outdoor – Mid Output</td>
<td>5,000-10,000</td>
<td>95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Outdoor</td>
<td>Outdoor – High Output</td>
<td>10,000-30,000</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Outdoor</td>
<td>Outdoor – Very High Output</td>
<td>≥30,000</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Indoor</td>
<td>Interior Directional</td>
<td>250-4,500</td>
<td>65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Indoor</td>
<td>Case Lighting</td>
<td>≥50 lm/ft</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Indoor</td>
<td>Troffer</td>
<td>≥1,500</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Indoor</td>
<td>Linear Ambient</td>
<td>≥375 lm/ft</td>
<td>105</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Indoor</td>
<td>High Bay</td>
<td>≥5,000</td>
<td>105</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Requirements: **
- Outdoor Pole/Arm-Mounted Area and Roadway Luminaires
- Outdoor Pole/Arm-Mounted Decorative Luminaires
- Outdoor Full-Cutoff Wall-Mounted Area Luminaires
- Outdoor Non-Cutoff and Semi-Cutoff Wall-Mounted Area Luminaires
- Bollards
- Parking Garage Luminaires
- Fuel Pump Canopy Luminaires
- Landscape/Accent Flood and Spot Luminaires
- Architectural Flood and Spot Luminaires
- Stairwell and Passageway Luminaires

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** Primary Use***:
- Wall Wash Luminaires
- Track or Mono-Point Luminaires
- Specialty:

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** Distribution:**
- See Primary Use Zonal Lumen Density Requirements in Table 4, below

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** Note:**
- The table includes various categories of lighting applications with specific output requirements and energy efficiency levels.
Please note:

• As this is a conceptual draft, we haven’t proposed specific level for DLC Premium or additional allowances. This will be proposed in the second draft.
Clarifying Questions?

We’ll get to the technical issues shortly...
Takeaway 1: Balance Efficacy & Quality

• The proposed efficacy levels may be reasonable in isolation, but there also may be tradeoffs with quality of light
  • Aspects of quality may suffer, such as glare / optical control, color quality, and flicker
• V5.0 quality requirements must be determined before we decide if the proposed efficacy levels are reasonable
  • To meet rigorous quality thresholds, efficacy could be penalized
Discussion Q1: Balance Efficacy & Quality

• What are some strategies for balancing efficacy and quality in the V5.0 specification?
Takeaway 2: Cost Implications

- Meeting the efficacy requirements may have an impact on product cost
  - Difficult to avoid higher cost with both efficacy and quality requirements
  - May require manufacturers to use more low- or mid-power LEDs, which drives up cost
  - The new requirements would need higher utility rebate support
Discussion Q2: Cost Implications

• What strategies could DLC use to mitigate cost increases associated with V5.0 efficacy?
Takeaway 3: Highbay levels are too high

• 15% increase (105 lm/W $\rightarrow$ 120 lm/W) for high-bay is too steep
  • While most high-bays could achieve this level, incorporating glare control will make it very difficult to meet
  • The increase is acceptable if the quality requirements are relaxed for high-bay
  • V5.0 would be particularly challenging for low-bay fixtures
Discussion Q3: Highbay levels are too high

• What are the appropriate efficacy levels for high bay? How might we select a final level?
Clarifying Questions?

We’ll review Flicker in the same way and then get to discussions...
Flicker
Rationale

• Flicker free operation is a critical component of **visual comfort**
  • Can cause annoyance, loss in productivity

• Flicker has **health impacts**
  • Can lead to eye strain, migraines, anxiety, photo epilepsy, exacerbate undesirable behaviors among persons with autism

• Flicker can cause **dangerous industrial working environments**
  • Rotating machinery can appear still

• Flicker can **interfere** with machine vision and imaging devices
  • E.g. barcode scanners, sensors, video feeds
Definitions

• DLC uses the term “Flicker” to generally describe Temporal Light Artifacts (TLA), which includes 3 categories of light modulation over time:
  • Flicker (<80 Hz)
  • Stroboscopic Effect (80 Hz – 2,000 Hz)
  • Phantom Array Effect (80 Hz – 2,500 Hz)
## Draft Testing and Reporting Requirements

<table>
<thead>
<tr>
<th>Metric</th>
<th>Current V4.4 Requirements</th>
<th>V5.0 Draft Requirements</th>
<th>Method of Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Threshold</td>
<td>Reported</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tier 1</td>
<td>Tier 2</td>
</tr>
<tr>
<td>Short Term Flicker ($P_{st}$)</td>
<td>n/a</td>
<td>≤1.0 at 100% and 20% light output</td>
<td>$P_{st}$ at 100%, 20%, and minimum fraction of light output</td>
</tr>
<tr>
<td>Stroboscopic Visibility Measure (SVM)</td>
<td>n/a</td>
<td>≤0.4 at 100% and 20% light output</td>
<td>≤0.9 at 100% and 20% light output</td>
</tr>
</tbody>
</table>

- $P_{st} \leq 1.0$ is the recommended limit for short term flicker in NEMA 77
- The two tier threshold for SVM reflects recent research that an SVM of 0.9 means 25% of the population will detect the flicker 63% of the time and an SVM of 0.4 means that just 10% of people will detect the stroboscopic flicker
## Draft Testing and Reporting Requirements

<table>
<thead>
<tr>
<th>Metric</th>
<th>Current V4.4 Requirements</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Threshold</strong></td>
<td><strong>Reported</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Tier 1</strong></td>
<td><strong>Tier 2</strong></td>
</tr>
<tr>
<td>Percent Flicker</td>
<td>n/a</td>
<td>No required threshold</td>
<td>Report values at 100%, 20%, and minimum fraction of light output for frequencies under 40, 90, 200, 400, and 1,000 Hertz</td>
</tr>
<tr>
<td>Flicker Index</td>
<td>n/a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Reporting Percent Flicker at these various light outputs and frequency cutoffs allow users to compare a product’s flicker performance according to IEEE PAR 1789 and determine if their product meets California’s Title 24 levels.
- Flicker Index accounts for average peak-to-peak amplitude, wave-form shape, and duty cycle of the flicker.
Clarifying Questions?

We’ll get to the technical aspects shortly...
Takeaway 1: Testing Cost and Burden

• Flicker testing on every fixture variation and at dimmed states may add significant testing cost burden
• Test labs may not have proper equipment and will be required to purchase new equipment, passing that cost onto manufacturers
Discussion Q4: Testing Cost and Burden

• What strategies might DLC use to balance the tradeoff between flicker performance and testing burden?
Takeaway 2: Thresholds

- Various arguments for threshold limits, such as:
  - SVM < 0.4 seems roughly equivalent to PAR1789, good.
  - Do not deviate from NEMA 77 metrics limits
  - SVM < 0.9 is not an enormous improvement for many sources that are causing visible problems today
  - IEEE PAR 1789 limits should be used for Tier 1
  - SVM and Pst are not widely used in the lighting industry yet; DLC should apply the flicker requirement of California Title-24
  - Short term flicker (Pst) and stroboscopic visibility measure (SVM) should be enough; no need for other metrics
Discussion Q5: Thresholds

• What are the appropriate thresholds for flicker? How would DLC decide?
Takeaway 3: Application Specific Requirements

• Flicker is not as critical for most outdoor locations as indoor locations
  • Not a concern for spaces where people do not spend long periods of time
• Flicker requirements related to dimming should not be imposed on spaces that dim in result to vacancy
  • For example, outdoor and highbay areas
  • Flicker requirements for architectural or office settings are reasonable
Discussion Q6: Application Specific Requirements

• What might be the application-specific requirements for flicker?
Clarifying Questions?

If not, on to discussions...
Discussion Questions: Pick 2 and Discuss!

Please provide actionable, solution-based ideas and input

<table>
<thead>
<tr>
<th>Efficacy</th>
<th>Flicker</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are some strategies for balancing efficacy and quality?</td>
<td>4. What strategies might we use to balance the tradeoff between flicker performance, testing burden, and cost?</td>
</tr>
<tr>
<td>2. What strategies could DLC use to balance the tradeoff between efficacy and cost?</td>
<td>5. What are the appropriate thresholds for flicker? How would we decide?</td>
</tr>
<tr>
<td>3. What are the appropriate efficacy levels for high bay? How might we select a final level?</td>
<td>6. What might be the application-specific requirements for flicker?</td>
</tr>
</tbody>
</table>
Other Issues Not Discussed

Is there another issue related to flicker and efficacy that you think should be addressed by this group?
Next Steps
Next Steps

• We’ll summarize take-aways from this session
  • DLC will report out at the end of the day

• How to get involved
  • Send additional comments and questions to comments@designlights.org
  • Sign up for DLC newsletter and keep an eye out for Draft 2
  • Submit comments and participate in policy development process

• Enjoy the rest of the Meeting!
  • If something comes to mind later on, track us down
Thank You!

Axel Pearson, DLC
Bernadette Boudreaux, DLC
Matt Rusteika, DLC
Dan Mellinger, Energy Futures Group
Naomi Miller, PNNL

Please send questions and comments to:
Comments@designlights.org

DesignLights Consortium®
www.designlights.org
Appendix
Other Efficacy Issues Heard in Comments

• Efficacy levels...
  • The draft efficacy levels are just right
  • The draft efficacy levels are too low
  • Efficacy levels for outdoor should be flat instead of tiered
  • The draft efficacy levels will result in too many delisted products

• Reference fixture testing for lamps needs to be removed and replaced with lamp distribution requirements

• The efficacy allowances permitted under V4.4 need to be maintained
  • Existing family grouping will make the delist impact more severe
Other Flicker Issues Heard in Comments

• Flicker thresholds in dimmed states
  • As flicker is exacerbated with dimming, it should be required, but perhaps at more lax thresholds
  • Designing around full light output should be sufficient
  • Should be a requirement to list the dimmer used to pass the qualification and any other recommended dimmers
  • Require testing with a standard dimmer.

• Phantom array frequency limit
  • Upper frequency limit for the phantom array should be higher