Performance Insights on Solid State Lighting
DOE’s CALiPER, NGL, and LED Lighting Facts Programs

ACEEE Market Transformation Conference
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Outline

• The programs
• The trends
• Digging deeper
• Next steps
• CALiPER – think consumer reports
• LED Lighting Facts – think food labels
• NGL – think J.D. Powers
Understanding the Trends

- CALiPER – significantly dependent on products tested in a given year
- LED Lighting Facts – best trend set (over 7000 products listed)
- NGL – only products meeting strict competition requirements
CALiPER – CRI, Lamps

Color Rendering

- CRI Values:
  - 2006: 66
  - 2007: 73
  - 2008: 76
  - 2009: 79
  - 2010: 82
  - 2011: 83

Mean values for each year are represented by the horizontal line within the box plot.
CALiPER – Efficacy, All Products

Number of Products

Luminous Efficacy (lm/W)

Purchase Year

- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012

Number of Products:

- 9
- 43
- 62
- 73
- 77
- 84
- 87
CALiPER – CRI, All Products

Number of Products

Color Rendering Index (CRI)

Purchase Year

- 2006
- 2007
- 2008
- 2009
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- 9
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- 68
- 71
- 74
- 77
- 79
- 80
- 82
CALiPER 2012 Conclusions

- Overall improvements in light output, efficacy, light distribution, power factor, color quality, etc.
- Manufacturer claims and equivalency claims are improving… but can still be a problem
- Suitability often depends on application
- Careful comparisons based on accurate performance data is an absolute necessity
- Be cognizant of “secondary” quality issues: glare, flicker, color tolerances, physical formats, reliability…
LED Lighting Facts

Light Output (Lumens) 840
Watts 9
Lumens per Watt (Efficacy) 93

Color Accuracy 87

Color Rendering Index (CRI) 2900 (Warm White)

Light Color Complete Color Temperature (DCT)
- Warm White
- Bright White
- 2700K
- 3000K
- 4600K
- 6500K


LED Lighting Facts - Efficacy

Quarter of Initial Listing

Luminous Efficacy (lm/W)


40  43  46  49  52  50  57  55  54  60  62  63  68  71  73
LED Lighting Facts - CRI

![Box plot showing CRI values over different quarters of initial listing.][1]

- CRI values range from 78 to 80 across different quarters.
- The box plot indicates variability in CRI values within each quarter.

[1]: www.ssl.energy.gov
LED Lighting Facts – Mean Efficacy

Mean Luminous Efficacy (lm/W)

Quarter of Initial Listing

Lamp
Luminaire
LED Lighting Facts – Max Efficacy

Max Luminous Efficacy (lm/W)

Quarter of Initial Listing

- Lamp
- Luminaire
LED Lighting Facts – Max Efficacy

Max Luminous Efficacy (lm/W) vs. Quarter of Initial Listing

- Indoor
- Outdoor
- Other
Next Generation Luminaires
Design Competition

www.ngldc.org
NGL Efficacy Advancements

All recognized (avg. efficacy)

• 2008 - 37 lm/W
• 2009 - 52 lm/W
• 2010 - 45 lm/W
• 2012 - 65 lm/W
• 2013 – 75 lm/W (indoor)
Shift in Focus

Shift to Lighting Facts QA

Product Selection & Purchasing
Independent LM-79-08 Testing
Data Analysis
Report Publication

New CALiPER Focus
CALiPER Digging Deeper

- **Snapshot Reports** using data from LED Lighting Facts
- **Application Reports** focusing on specific product types and design scenarios, going beyond LM-79 testing
- **Exploratory Studies** that incorporate product installations and evaluations
- **Standards Support** for emerging areas such as flicker, dimming, power quality, long-term performance, etc.
Recessed Troffer Exploratory Study

- Install 24 pairs of similar performing recessed luminaires (2 × 2 and 2 × 4) and 0–10 V dimming controls in mock office space

- Show examples of fluorescent benchmarks, LED tubes, LED retrofit kits, and dedicated LED troffers

- Invite 18 designers/engineers to observe, brainstorm, and comment

- Get feedback from non-lighting experts as well
Energy efficiency – Luminaire efficacy

- All LED products did as well or better than the Fluorescent

<table>
<thead>
<tr>
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<th>Min LPW</th>
<th>Max LPW</th>
<th>Average LPW</th>
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<tbody>
<tr>
<td>FL benchmark troffers (28W lamps)</td>
<td>54</td>
<td>72</td>
<td>65.3</td>
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<tr>
<td>Dedicated LED troffers</td>
<td>75</td>
<td>104</td>
<td>90.6</td>
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<tr>
<td>LED tube retrofits</td>
<td>55</td>
<td>76</td>
<td>68.8</td>
</tr>
<tr>
<td>LED retrofit kits</td>
<td>60</td>
<td>76</td>
<td>66.5</td>
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Energy use – Luminaire watts

- If you’re not careful, LED retrofit tubes may not alter watts

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<td>49 (2x2)</td>
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<tr>
<td>Dedicated LED troffers (2x2 and 2x4)</td>
<td>34 (2x2)</td>
<td>58 (2x2)</td>
<td>43.6</td>
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<tr>
<td>LED tube retrofits</td>
<td>48 (2x4)</td>
<td>79 (2x4)</td>
<td>16 to 26W per tube</td>
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<tr>
<td>LED retrofit kits</td>
<td>35 (2x2)</td>
<td>51 (2x2)</td>
<td>41.2</td>
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What did we learn?

• Wide range of quality in LED troffers
• LED tubes produce some funky luminaire appearance
• Be careful in choosing the beam angle on these tubes, LED tubes can change the distribution of light from the luminaire
• LED tubes may have unexpected installation problems, especially concerning sockets
• Luminaire efficacy is very high. Holds great promised. Look for LPW of 90+
• Dedicated LED troffers are a good option for new installations

See it, mock it up before you buy a bunch of them!
CALiPER – 2013 Preview

- Additional Office Study testing (T8 replacements first)
- PAR38 long term & stress testing
- Start Retail Display Exploratory Study
- Continued standards support and testing (Roundtable next month)
What’s Next?

- CALiPER – focus on deeper dives
- LED Lighting Facts – verification testing for QA
- NGL – discussions on separate competition for cutting edge, emerging products

Any thoughts?