California Quality LED Lamp Specification

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Energy Solutions, on behalf of PG&E
November 14, 2013
California Quality LED LampSpecification

1. **Where did it come from?** (history and context)

2. **What is it?** (details of the specification)

3. **How is it being used?** (update on program roll out)
1. A look back at the CFL: market growth and price trends

Sources: PNNL (for DOE), June 2006, “Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market”; D&R International (for DOE), Sept 2010, Energy Star CFL Market Profile; & Presenter’s market research
1. Lessons learned from CFL programs

Energy Efficiency / Lighting Industry Interest in Quality

- DOE: Lessons Learned on the Way to Market – 2006
- CLTC: Relighting American Homes with LEDs – 2011

Primary take-home messages:
- *Price is not the only factor in market share*
- *Poor performance of CFL lamps was a major impediment to increased market penetration of those products*
- *If consumers don’t like the products, the market will not be transformed*
- *First impressions are lasting!*

There is an opportunity ahead for LED lamps to address these items
1. LED Lamp Projections: market share and pricing forecasts

1. CPUC and CEC tag-team effort leads to CA LED quality spec

California Public Utilities Division (CPUC)
- Guidance Decision – Issued May 2012
- “Our goal is to avoid offering incentives for lighting products that do not meet consumer expectations and result in a poor lighting experience, discouraging customers from investing in energy efficient lighting in the future.”

California Energy Commission (CEC)
- Voluntary California Quality LED Lamp Specification
- Approved Dec 2012
- “ENERGY STAR PLUS” Approach
- Additional Focus On:
  - Light Color
  - Light Quality
  - Directionality
  - Dimmability
  - Lamp Life
  - Power Factor
## 2. CA Quality Spec compared to ENERGY STAR Lamps Spec

<table>
<thead>
<tr>
<th>Lamp Property</th>
<th>ENERGY STAR® Lamps Spec</th>
<th>CA Quality LED Lamp Spec</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Published 8/2013; Phasing in, fully effective 9/2014</td>
<td>Approved 12/2012; Effective 12/2013</td>
</tr>
<tr>
<td>Rated Life / Warranty</td>
<td>Decorative ≥15,000 hrs, All Other ≥ 25,000 hrs</td>
<td>Same except Commercial ≥ 35,000 hrs</td>
</tr>
<tr>
<td></td>
<td>Warranty 3 yrs</td>
<td>Warranty 5 yrs</td>
</tr>
<tr>
<td>Lamp Dimmability</td>
<td>Dimmability not required</td>
<td>Dimmability required down to 10%</td>
</tr>
<tr>
<td></td>
<td>Compatibility and performance specs exist for lamps marketed as dimmable</td>
<td>&quot;Flicker &amp; noise-free&quot;</td>
</tr>
<tr>
<td>Color Rendering (CRI)</td>
<td>CRI ≥ 80, R9 &gt; 0</td>
<td>CRI ≥ 90, R9 &gt; 50</td>
</tr>
<tr>
<td>Color Appearance</td>
<td>Within a 7 step quadrangle of: 2700K, 3000K, 3500K, 4000K, 5000K, 6000K</td>
<td>Within a 4 step quadrangle of: 2700K or 3000K</td>
</tr>
</tbody>
</table>
| Light Directionality / Scope   | • Omni (not decorative) distribution: 90% of the measured candela values shall vary by no more than 25% from the average of all measured values. All measured values shall vary by no more than 50% from the average of all measured values. No less than 5% of flux in the 135° to 180° zone.  
• Decorative: 5% of flux in 110° to 180° zone  
• Directional distribution: None (intensity only) | • Omni (including decorative) distribution (same as ENERGY STAR Lamps v1 Draft 2): Each measured candela value shall vary by no more than 20% from the average of all measured values. No less than 5% of flux in the 135° to 180° zone.  
• Directional: Specific requirements for spots and floods |
| Power Factor                   | PF ≥ 0.70 (Lamps under 5W exempt)                                                     | PF ≥ 0.90                                                                               |
2. Light Color (Color Temperature)

5000K vs. 2700K

(Incandescent Reference: 2700K)
2. Directionality (omni-directional vs semi-directional)

“Snow-Cone” A-lamp vs. Omni-Directional

Source: GE Lighting

(Incandescent Reference: True Omni)
2. Light Quality (Color Rendering)

80 CRI vs. 92 CRI

(Incandescent Reference: 100)
2. PG&E research to understand the impacts of the specification

Since 2011, PG&E has been funding a number of research efforts on the topic of LED Quality, including:

- **Product Availability / Performance Trends**
  - Lighting Facts Database and Energy Star lists

- **Product Testing at the CLTC**
  - Over 50 directional and omni-directional LED lamp models
  - 10 samples per model for many of the models
  - Full array of test metrics

- **Consumer Preference Research**
  - Developing methodology for a study

- **Cost Implications**
  - Energy Solutions regression analysis
2. Color: Market Snapshot

Color Temperature

![Color Temperature Chart]

- Color Rendering Index (Ra)

- R9

Color Consistency

![Color Consistency Chart]
2. Warranty and Power Factor: Market Snapshot

**Warranty**

- **A Lamps - Warranty**
  - ENERGY STAR QPL
  - Warranty in Years vs. Months (2009-2013)
  - CEC Proposed Level

- **Directional Lamps - Warranty**
  - ENERGY STAR QPL
  - Warranty in Years vs. Months (2009-2013)
  - CEC Proposed Level

**Power Factor**

- **Omni-directional Lamps - Power Factor**
  - ENERGY STAR QPL
  - Power Factor vs. Months (2009-2013)
  - CEC Proposed Level

- **Directional Lamps - Power Factor**
  - ENERGY STAR QPL
  - Power Factor vs. Months (2009-2013)
  - CEC Proposed Level
2. Directionality and Dimmability: Market Snapshot

Light Distribution

Dimmability

### Dimmability of ENERGY STAR
**Omnidirectional Lamps**
- Not dimmable: 35%
- Dimmable: 65%

### Dimmability of ENERGY STAR
**Directional Lamps**
- Not dimmable: 17%
- Dimmable: 83%
### 2. Summary of availability and trends by performance attribute

<table>
<thead>
<tr>
<th>Performance Attribute</th>
<th>Portion of Market Meeting CEC Spec</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Light Color Appearance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Color</td>
<td>CCT (2700 or 3000 K)</td>
<td>▲</td>
</tr>
<tr>
<td>Appearance</td>
<td>4 Step ANSI Quadrangle</td>
<td></td>
</tr>
<tr>
<td><strong>Light Quality</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Quality</td>
<td>CRI (≥90)</td>
<td>▲</td>
</tr>
<tr>
<td></td>
<td>R9 (≥50)</td>
<td>▲</td>
</tr>
<tr>
<td><strong>Dimmability</strong></td>
<td>Dimmable</td>
<td>▼</td>
</tr>
<tr>
<td><strong>Directionality</strong></td>
<td>True Omni</td>
<td>▲</td>
</tr>
<tr>
<td><strong>Warranty</strong></td>
<td>Warranty (5 years)</td>
<td>▼</td>
</tr>
<tr>
<td><strong>Power Factor</strong></td>
<td>Power Factor (.9)</td>
<td>▼</td>
</tr>
</tbody>
</table>
2. 2012 Pricing Analysis

703 Price Points: Average Price by Shape

- **A**
- **MR**
- **PAR**
2. The Cost of Quality in 2012: surprising results

<table>
<thead>
<tr>
<th>Metric</th>
<th>Availability of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watts</td>
<td>100%</td>
</tr>
<tr>
<td>Distribution Type</td>
<td>100%</td>
</tr>
<tr>
<td>ENERGY STAR certified</td>
<td>100%</td>
</tr>
<tr>
<td>Dimmable</td>
<td>100%</td>
</tr>
<tr>
<td>Lumens</td>
<td>95%</td>
</tr>
<tr>
<td>Lumen Maint (L70)</td>
<td>95%</td>
</tr>
<tr>
<td>CCT</td>
<td>94%</td>
</tr>
<tr>
<td>Warranty</td>
<td>84%</td>
</tr>
<tr>
<td>CRI</td>
<td>82%</td>
</tr>
<tr>
<td>Power Factor</td>
<td>61%</td>
</tr>
<tr>
<td>Beam Angle</td>
<td>41%</td>
</tr>
<tr>
<td>Voltage</td>
<td>25%</td>
</tr>
<tr>
<td>R9</td>
<td>5%</td>
</tr>
<tr>
<td>Chromaticity Bins</td>
<td>5%</td>
</tr>
<tr>
<td>Zonal Lumens</td>
<td>0%</td>
</tr>
<tr>
<td>Harmonic Distortion</td>
<td>0%</td>
</tr>
</tbody>
</table>

Predicted Impact on Price
- ENERGY STAR: 21%
- 5 CRI Units: 6%
- 1 watt: 5%
3. CA currently launching programs around “CEC Quality” lamps

- California IOUs rolling out rebates for “CEC Quality” products in November (now)
- Phasing out residential rebates for non-CEC Quality products by December
- Manufacturers currently submitting product test reports to IOU lighting program managers for review
- Several A-lamp products ready, others expected before end of the year
3. Efforts outside of CA IOUs

- Promotion has been set up between Home Depot, CREE, Western Regional Utility Network (includes SMUD and various utilities throughout the Pacific Northwestern US and Canada)
- Rebates being offered for CREE’s TW product line
- More to follow (and the more the merrier!)
3. Future Program Implementation

- As more products begin to meet specification, there will be a need for a more formal method to track Qualifying Products
  - Opportunity to leverage existing lists: ENERGY STAR, Lighting Facts
  - Challenges

- CA database work
  - On behalf of PG&E, CLTC working on gathering results of product testing into searchable database that could be used by utility Program Managers
  - Brainstorming now for additional database functionality

- California Title 20 (mandatory standards) activity
  - CEC opening rulemaking to propose mandatory quality requirements for LED lamps
  - May include many of the elements in the Voluntary Quality Spec, but it is 2-3 years away from being effective
Thank you

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