



## Department of Energy

Washington, DC 20585

May 19, 2009

Dear ENERGY STAR Stakeholders:

Please find attached revised draft criteria for ENERGY STAR Integral LED Lamps. DOE published the first draft of these criteria January 16, 2009 as the basis for initial review and dialogue with stakeholders. DOE received 26 comment letters during the review and comment period ending February 27, 2009. Of these, 20 were from manufacturers; the others came from utilities, energy efficiency program sponsors, and consultants. Comments on this second draft will be accepted through June 26, 2009. DOE anticipates publication of final criteria for integral LED lamps in August 2009.

This letter summarizes the stakeholder feedback received on the key issues identified by DOE in the cover letter to Draft 1, i.e., dimming, non-standard lamp forms, low-voltage MR-16 replacements, and reliability testing, and reports DOE's progress in addressing these issues in the revised draft criteria. This letter also lists specific changes to technical requirements made in response to stakeholder feedback and/or additional technical analysis and data gathering.

### **PROGRESS TOWARD ADDRESSING KEY ISSUES**

With publication of the first draft criteria, DOE invited industry and other stakeholder feedback on several issues presenting challenges to market adoption of integral LED lamps. These are complex issues to be addressed over time, in some cases through industry consensus processes. Useful feedback was provided by stakeholders, contributing to DOE's proposed interim solutions described below.

#### **1. Dimming**

In the Draft 1 cover letter, DOE posed several questions related to dimming performance:

- a) Is it possible to define a common protocol for LED products that would ensure acceptable dimming performance on most currently installed residential dimming controls?
- b) Is it necessary to transition to new "LED-compatible" dimmers as more LED products come to market?
- c) How can DOE and the ENERGY STAR program best facilitate progress and improvement in the area of LED-dimmer compatibility?

Stakeholder feedback acknowledged the complexity of the dimmer compatibility problem and cautioned that additional time, product development, and industry consensus on dimming protocols are needed to solve this problem over the long term. Stakeholder comments are summarized below:

- It is premature to require all lamps be dimmable, due to compatibility limitations of the existing stock of installed dimmers, particularly those used in residential settings.
- Industry needs to develop standards for evaluating dimming performance and common protocols for design compatibility between LED lamps and dimmers. Stakeholder feedback included initial specifications for LED lamps to perform with existing forward or reverse phase control dimmers, at the same time acknowledging the need for common understanding of acceptable dimming performance.
- Stakeholders also encouraged DOE to consider the unique or advanced dimming features that LED lamps may have, not only how well LED lamps may perform with existing dimmers.
- DOE should work with industry standards organizations to support development of standards and protocols.
- DOE should consider step dimming, including interactions with utility demand response programs.

DOE has taken several steps to respond to stakeholder feedback on dimming. First, DOE is engaging with the relevant industry standards committees (i.e., the NEMA Lighting Controls and Solid State Lighting Sections, and the ANSI 82.04 LED Drivers committee) and has hired an industry expert specifically to work with these committees and accelerate the development of industry consensus standards addressing this topic. This process is expected to proceed over the remainder of 2009 and into 2010.

Further, DOE has revised the dimming requirements in the Draft 2 document to allow for both dimmable (including continuous, three-way and other step dimming) and non-dimmable integral LED lamps to earn the ENERGY STAR. Manufacturers will be required to clearly label their lamps as dimmable or non-dimmable. DOE proposes to require all lamps be “dimmer safe,” meaning they will not suffer catastrophic failure if operated on a dimming circuit. DOE seeks additional industry feedback on this requirement. Finally, participating manufacturers must agree to maintain a webpage containing dimmer compatibility information for consumers, and to include a cautionary label on product packaging indicating potential compatibility limitations on existing dimmers and providing the dimmer page URL for up-to-date information.

## **2. Non-Standard Lamps**

With regard to LED lamps in non-standard forms (shapes, sizes, dimensions), DOE sought stakeholder input on how the ENERGY STAR Integral LED Lamps criteria could be structured to encourage innovation while ensuring consumer and specifier expectations are met. For example:

- a) Should luminous intensity distribution requirements be specified for non-standard lamps? Minimum luminous flux levels?
- b) How can non-standard lamp performance be communicated to the buyer without creating false expectations?

- c) How can DOE allow for non-standard lamp forms without creating a loophole through which products sold as replacement lamps can circumvent the requirements for standard lamp forms?

Stakeholders indicated these concerns could be addressed through appropriate package labeling and product information, and agreed equivalency to existing standard lamps should not be claimed. One stakeholder suggested lamps be identified on packaging as “non-standard,” and simply state light output, wattage, and color characteristics. Others suggested a checklist of common fixture types/lighting applications, indicating which are appropriate for the lamp.

Draft 1 established luminous efficacy (55 lm/W) and minimum light output (400 lumens) requirements for non-standard lamps; manufacturers were also required to provide a luminous intensity distribution (LM-79 goniophotometer report) for the lamp and to identify intended applications. In Draft 2, DOE has added a requirement for lamp packaging to include a simple graphic indicating beam shape. DOE invites stakeholder feedback on the proposal to develop or adapt a common set of beam graphics to be used by all ENERGY STAR Integral LED Lamp Partners. The luminous efficacy and minimum light output requirements remain unchanged in Draft 2.

### **3. Low-Voltage MR16s**

DOE sought industry and stakeholder input on how to address compatibility and minimum load problems for LED MR16 replacement lamps intended for use in existing low-voltage lighting systems/fixtures.

Stakeholder feedback acknowledged this problem, which is similar in many respects to the challenges with dimmer compatibility. In spite of the challenges, no stakeholders suggested excluding this lamp category and interest in this category of products remains high. Comments indicated:

- Clear labeling and instructions for use of LED MR16 lamps with existing low-voltage fixtures is needed.
- Over time, there will be a transition to new electronic low-voltage transformers with lower load requirements, thus phasing out the minimum load problem.
- DOE should require testing of MR16 lamps with low-voltage transformers, in multiple lamp combinations.

In response, DOE proposes the following additional requirements for LED MR16 lamps intended for use on low-voltage fixtures in Draft 2:

- Manufacturers must provide results of in-house testing of their LED MR16 lamps on commercially-available low-voltage transformers.
- Product packaging must identify known incompatibilities.
- Manufacturer must maintain a web page containing low-voltage transformer compatibility and appropriate use information, including description of possible problems and how to address them (“troubleshooting” advice).

- Product packaging must carry a cautionary label indicating the product may not be compatible with all low-voltage lighting fixtures and providing the web page URL for up-to-date information.

DOE invites additional stakeholder feedback on this approach and further information and suggestions for addressing low-voltage MR16 replacement lamp compatibility issues.

#### **4. Reliability Testing**

In the Draft 1 cover letter, DOE identified the current lack of industry standard test procedures for evaluating reliability of integral LED lamps. Draft 1 communicated DOE's intent to require reliability testing such as elevated temperature testing of at least 10 lamps for at least 6,000 hours, with a threshold lumen maintenance level to be used on a pass/fail basis. DOE sought stakeholder feedback on this approach and posed the following questions:

- a) What kinds of requirements should be considered to minimize the likelihood of premature failure of ENERGY STAR qualified integral LED lamps?
- b) What duration of testing is adequate to verify long-term performance?

Stakeholders made several suggestions ranging from short-term "burn in" tests to identify electronics failures, to longer term lumen maintenance testing similar to or exceeding the duration identified by DOE. Industry stakeholders emphasized the need for accelerated test procedures to avoid long lead times for product introduction.

Expected integral LED lamp life is related to lumen maintenance of the LEDs, as well as overall system reliability. DOE proposes a series of steps to evaluate lumen maintenance and reliability, and seeks additional stakeholder feedback and consensus on the items listed below.

With regard to lumen maintenance, DOE proposes a similar approach to that used in the ENERGY STAR SSL Luminaires program:

- Lumen maintenance (LM-80) test results for the LED packages, arrays, or modules used in lamp.
- Verification of the LED device or module temperature (at manufacturer-designated temperature measurement point or TMP) in the lamp through pre-drilled holes with thermocouples attached.

In addition, DOE is investigating the following reliability tests to be applied to the integral LED lamps as complete systems:

- Burn-in test (4 hours at 60°C) for all products before sale
  - NEMA proposed to define a procedure
  - Would eliminate from the sales stream those products likely to fail early
- Wet high temperature operating life test (WHTOL)
  - Ref std: EIA/JESD22-A101-B (Electronic Industries Alliance and JEDEC)
  - Temperature, humidity, power cycling, and total test time to be determined

- Elevated temperature testing + rapid cycling stress testing
  - Similar to testing to qualify reflector type CFLs in the ENERGY STAR CFL program

## ADDITIONAL CHANGES BETWEEN FIRST AND SECOND DRAFTS

- 1) Luminous efficacy – Many stakeholder comments indicated the minimum efficacy levels in Draft 1 were too high. DOE set the efficacy requirements knowing they are high relative to current commercially-available integral LED lamp performance. In setting requirements for efficacy, DOE considered several factors. First, ENERGY STAR qualified integral LED lamps should be at least as efficacious as qualified CFLs for similar power and light output. Second, LED technology, both at the device level and in terms of product integration and development, continues to improve. DOE anticipates the efficacy requirements set currently will be achievable by well-designed products in the near term (6 to 12 months).

In Draft 2, DOE has made several modifications to luminous efficacy levels as summarized in the table below:

<b>Comparison of Draft 1 and Draft 2 Efficacy Requirements</b>			
<b>Category</b>	<b>Draft 1</b>	<b>Draft 2</b>	<b>Applies to:</b>
Omnidirectional	55 lm/W	50 lm/W	LED lamp power <10W
		55 lm/W	LED lamp power ≥10W
Decorative	45 lm/W	40 lm/W	All decorative lamps
Directional	45 lm/W	40 lm/W	Lamp diameter ≤ 20/8"
		45 lm/W	Lamp diameter > 20/8"

These revised efficacy levels remain at least as efficacious as CFLs for comparable power and light output. Differentiation of smaller form factor and/or lower-power lamps allows for earlier participation by ENERGY STAR qualified integral LED lamps in categories not currently well-served by CFL technology. Efficacy levels for LED directional lamps exceed CFL requirements. This is because the relatively high reflector losses inherent in CFL reflector lamps can be largely eliminated using LED technology. The comparable CFL requirements are listed below for reference:

<b>Comparison of Draft 2 LED and ENERGY STAR CFL Efficacy Requirements</b>				
<b>Category</b>	<b>Draft 2</b>	<b>Applies to:</b>	<b>CFL v 4.0</b>	<b>Applies to:</b>
Omnidirectional	50 lm/W	<10W	50 lm/W	Bare lamps <10W
	55 lm/W	≥10W	55 lm/W	Bare lamps ≥10W and <15W
Decorative	40 lm/W	All	40 lm/W	Covered lamp (no reflector) ≤ 7W
Directional	40 lm/W	Diameter ≤ 20/8"	33 lm/W	Reflector CFL Lamp power < 20
	45 lm/W	Diameter > 20/8"	40 lm/W	Reflector CFL Lamp power > 20

- 2) CCT – Some industry stakeholders indicated a preference for all nominal CCTs defined by ANSI C78.377 (2700, 3000, 3500, 4000, 4500, 5000, 5700, and 6500 K) to be allowed in the ENERGY STAR for Integral LED Lamps criteria. Draft 1 limited CCTs to 2700, 3000, and 3500 K, because integral LED lamps to be qualified under these criteria are intended to replace incandescent and halogen lamps, which have warmer white color appearance.

In Draft 2, DOE has added 4000 K to the allowable CCTs. This allows an additional option for applications in which a more neutral white color appearance is desired, such as in commercial settings. Draft 2 continues to exclude nominal CCTs above 4000 K, to help ensure end-user satisfaction with LED lamp color appearance.

- 3) Decorative lamps, minimum light output – Draft 1 required minimum light output for decorative lamps to be calculated as:

Target incandescent lamp wattage x 10

Stakeholder feedback and additional benchmark information from DOE's CALiPER program indicated this factor was too high.

In Draft 2, the minimum light output requirement for decorative lamps has been changed to:

Target lamp wattage x 7

## **EXPECTED TIMELINE**

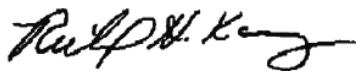
DOE anticipates active stakeholder review and commentary related to this second draft integral LED lamp criteria. Our planned schedule is:

June 26, 2009 – Due date for 2<sup>nd</sup> round stakeholder comments

August 2009 – Final criteria published

DOE appreciates the on-going level of stakeholder interest in the ENERGY STAR program, and looks forward to your substantive input in helping us establish the integral LED lamp criteria.

Sincerely,



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