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Dear Alex,

We would like to offer a few comments to the draft specification proposal for the Energy Star Program for Luminaires. In general the document is well structured and the performance targets seem reasonable. We have a few comments and recommendations, all relating to the specifications for solid state lighting

Luminous Efficacy and Output Requirements: Non-Directional Luminaires (page 10) and Directional Luminaires, Inseparable Luminaires (page 13)

Our first comment relates to the proposed source efficacy of > 70LPW per LED Light Engine and > 70LPW for Inseparable Luminaires in the Directional Luminaire category. We think this performance level is 20-25% beyond the capability of currently available technology at realistic prices and volumes. Our input is based on market feedback for typical luminaire system losses. Our rationale is as follows:

Best commercially available warm white LED	110 LPW
Derating for thermal losses	10-20% (from 25C rating)
Derating for driver	15-20% – high for triac dimming
Derating for optical losses	15-35% - low glare
Resulting in typical light engine efficacy	45–70LPW

This is consistent with our experience over 10 years of working with the major and second tier residential and commercial luminaire manufacturers. Higher volume LED luminaire system losses are typically in the range of 50% as performance, cost, aesthetics and size are balanced.

So current LED technology enables luminaires with efficiencies in the range of 55LPW. To achieve 70LPW we believe that warm white LED efficacies need to be in the range of 120-150LPW. This range is definitely on the roadmaps of LED manufacturers over the next 2-3 years (commercial production), but with the one year lead time for luminaire product development, we believe Energy Star certification of broadly available residential luminaires will be severely limited for the next 3-4 years.

We certainly acknowledge that a key objective of the Energy Star program is to establish challenging performance metrics, with system efficacy > 70LPW being appropriate as a medium to long term goal. However, if these targets are implemented in the near term,

we believe that only a very limited number of higher cost luminaires will be available to the market within the next couple of years.

To enable Energy Star certification and encourage the earliest possible mass market adoption of energy efficient technology, Bridgelux recommends the efficacy requirements for “Solid State LED Engine” (page 10) and “Inseparable Luminaires” (page 13) be reduced to 50LPW through the end of 2012. We believe LED and luminaire manufacturers will reasonably be able to bring product to market in 2013 that can meet the 70LPW system specification.

Luminous Efficacy Requirements: Directional Luminaires Residential (pages 12 and 13)

Our second question/comment is in regard to efficacy targets in the range of 29–45LPW for specific luminaire types on page 12 and the target of 70LPW for Inseparable Luminaires on page 13. Additionally, we note that there is no corresponding efficacy requirement for Inseparable Luminaires in the Commercial Lighting category (pages 14 and 15)

We believe the large gap between the specifications may cause the market to behave in unintended ways, since manufacturers and end-users will often seek the lowest cost solution to comply with a specification. In particular, this may lead to a significant sacrifice in energy savings and the quality of illumination.

We have 2 potential scenarios as examples:

1. Designers may choose to light entire areas with Down Lights (42LPW) and Surface Mount Lights (35 LPW) instead of choosing the better illumination provided by a 55 LPW Inseparable Luminaire. Potentially worse is the scenario where Energy Star certification is simply by-passed.
2. We may be forcing the market to adopt separable solutions with much lower efficiencies. A LED using the luminaire as a heat sink with a driver mounted away from the hot LED often produces a much more efficient and aesthetically pleasing luminaire.

Bridgelux recommends that the 70LPW requirement be removed from the Directional Luminaire Residential specification, which would align well with the Commercial requirements that have no Inseparable requirement. Alternatively, we suggest that the target efficacy be reduced to 50LPW, which would align with our previous recommendation above and would be more consistent with the 29-45 LPW specified for the designated luminaires in the category (page 12).

Lumen Maintenance Requirements: Directional and Non-Directional Luminaires (page 16)

Our next comment relates to the two options being considered for lumen maintenance certification. At a higher level we believe that the proposal of certifying reliability at the luminaire level is well intended - this concern has been voiced over the last 30 years as new light sources, such as CFL and metal halide lamps were introduced.

We believe that regardless of which option is chosen, the precedent has already been set for testing the reliability of LEDs in compliance with the LM-80 test procedures and specifying lumen maintenance in accordance with the existing Energy Star criteria. Luminaire manufacturers will continue to demand this testing of LED manufacturers before any product designs move forward strongly. So if we include the additional time required for UL certification and the proposed Energy Star requirements for lumen maintenance testing at the luminaire level, then the time to market for a specified LED technology could be quite long, while acknowledging that some of these activities will follow parallel paths. As we see it:

LM-80 test for new LED package	9 months
Product development	6-9 months
UL Certification	3-9 months
Energy Star Luminaire Certification	9 months
First manufacturing, fill distribution channel	3-6 months

We believe that Energy Star certification of products with established technologies, eg refrigerators, dish washers etc, works well. However, for emerging technologies such as solid state lighting in which technology and performance improvements move at a rapid pace, there is a risk that fully certified Energy Star luminaires may be 25-50% less energy efficient than non-Energy Star certified counterparts because of the 2-3 year lag between release of newer LED technology and production release of the luminaires. We believe that this will delay energy savings or that end-users may side step Energy Star certified luminaires and opt for latest release products featuring significantly better energy savings. The estimated long time frame also puts luminaire manufacturers in an untenable situation in which they spend significant time and resources in bringing a fully compliant luminaire to market only to see limited market adoption because of the rapidly advancing technology.

Bridgelux recommends the following:

1. Create an LM-80 test procedure and accompanying Energy Star specification for the reliability testing of drivers, a potentially weak component in the system from a reliability standpoint.
2. Require a 3 year warranty on LED luminaires, and allow the component suppliers and the luminaire manufacturers to work through the issues of meeting the warranty.
3. Create the specifications for Option 2, publish them as guidelines and then implement option 2 as a requirement in 2015. This will allow time for maturation

of the technology and for manufacturers to adapt their design and manufacturing procedures to align with forthcoming requirements in 2015.

Color Maintenance: Solid State Indoor Luminaires Only (page 20)

Our fourth set of comments and questions are in regard to color temperature shift over lifetime, and the underlying assumptions used to create the targets. The creation of targets that minimize color shift over time is certainly a market demand, and the effort thus far by EPA to do this are well intentioned and on the right track.

Our question is about the assumptions that were made for color degradation over lifetime. We believe that underlying LED technologies exhibit different rates of degradation, for example some are linear while others appear to degrade exponentially for a short period and then stabilize. This is another case where technology is under rapid development and there are no clear and universally accepted models explaining color shift across all technologies and manufacturing processes.

We believe that a clear and consistent model, or group of models, that apply across all technologies and manufacturing processes needs to be established before specifications for $u'v'$ shifts over a designated time can be applied. Additionally, the color shift criteria established in LM-80 and the existing Energy Star document address, at a higher level, acceptable levels of color shift, assuming the luminaire is designed correctly.

Bridgelux recommends the following:

- Expand the scope of the TM-21 working committee to fully understand color shift phenomena. Using the current LM-80 test procedures for the LED, create the guidelines for acceptable color shift, and come back in 2012 with an industry-wide agreement on metrics for measurable, allowable color shift at 6000 hours.
- In the meantime leave the specification for color shift as < 0.007 change in $u'v'$ over the life of the luminaire and require the LED manufacturer to report the LM-80 data at 6000 hours with proposed model for the extrapolation of this data over the lifetime of the luminaire.

Another point to note is that the proposed specification for color maintenance is substantially different from the specification for color shift in the current Energy Star document for Integral LED Lamps which states: “The change in chromaticity over the minimum lumen maintenance period (6000 hours) shall be within 0.007 on the $u'v'$ diagram”.

Power Factor: Directional and Non-Directional Luminaires (page 25)

Our fifth question concerns the power ratings suggested for the family of light sources. Our understanding is that drivers for LEDs and ballasts for compact fluorescent lamps are essentially current limiting devices. The CFL ballasts add starter circuits and possibly circuitry for keeping coils heated. We believe that the power factor of the CFL lamps should be targeted at 0.7 or greater. This levels the field for the two competing technologies and does not arbitrarily favor by regulation one over the other.

Ballast/Driver Replaceability: Directional and Non-Directional Luminaires (page 29)

Our final comment relates to the wording of the Energy Star Requirements. We believe that there may be some confusion in the reading of this requirement if the fixture is lamped with a self ballasted light source. Specifically, will the driver in the self ballasted light source be required to be inter-changeable?

The current wording is, “Ballasts or drivers in all luminaires must be accessible and removable” We recommend that this requirement be modified with the following suggested wording: “Ballasts or drivers in all luminaires without self ballasted LED and CFL light sources must be accessible and removable”

We appreciate the process by which EPA is soliciting feedback from the industry. Thanks for your consideration of our comments and questions. Please contact me if you have any questions.

Tony Marshall
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Bridgelux