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August 23, 2012

Environmental Protection Agency
Energy Star Program
Ms. Taylor Jantz-Sell
Lighting Program Manager, Energy Star
1200 Pennsylvania Avenue NW 6202J
Washington, D.C. 20160

Subject: ENERGY STAR Program Requirements Product Specification for Lamps (Light Bulbs) Eligibility Criteria Version 1.0 Draft 2

Dear Ms. Jantz-Sell,

We are in full support of the stated purpose of Energy Star: to reduce greenhouse gas emissions and to make it easy for consumers to identify and purchase energy-efficient products without sacrificing performance, features, and comfort. In this context, we would like to submit comments on the current Draft 2 and suggest alternatives, which we believe are more closely aligned with Energy Star core tenants, while attempting to be more technology-neutral and innovation-friendly.

- **Commercial category –** We suggest eliminating the commercial grade classification from this specification. MR-16 is the only lamp held to this higher standard; it seems unfair to require this lamp type to meet these standards, while it is optional for all other lamp types. LEDs are currently the only viable energy-efficient alternatives to halogen bulbs in the MR16 form factor. The goal should be to encourage the largest number of competitors with a product that compares favorably to halogens, rather than having a particularly strict standard, which would lead to slower halogen replacement.
    - **Proposal**: Remove the commercial grade category from the specification or make it optional for all bulb types.

- **Lifetime requirements** – We believe these should be reconsidered. In the current draft, fluorescents require 10,000 hours, indoor residential LEDs require 25,000 hours, outdoor residential LEDs require 35,000 hours, and commercial LEDs require 35,000 hours. The primary rationale for these long lifetimes appears to be the high cost of LEDs and the long time to pay back the upfront investment. Requiring such long lifetimes leads to compromises in lamp design, much higher costs (thus slowing adoption), and lower performance. As LED costs continue to decrease, likely even faster than expected, the long lifetime requirement doesn't really make sense. Further, it is extremely likely that, even within a few years, efficiency in lumens per watt will double and keep increasing thereafter. Hence, long lifetime requirements would force consumers to pay more initially and live with lower efficiency bulbs for much longer. Imagine if personal computers had lifetime requirements of ten, twenty, or more years! Most people would have paid more for this extra lifetime and be living with it longer. Long lifetimes make little sense in rapidly improving technology areas, especially when factors of four or more in efficiency, network connectivity, and other features like auto-dimming, light sensing, etc. are likely coming over the next few years. **The goal is to maximize the adoption of high-efficiency lighting.** Holding LEDs to very long lifetime requirements will require manufacturers to compromise on other performance parameters or

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increase costs – the longest lifetime is achieved by keeping the light chip temperature low by using a large lamp assembly for heat dissipation and/or reducing driver power. Large lamp assemblies create compatibility and aesthetic concerns (hence slowing or preventing adoption) for many consumers, especially for MR16 light bulbs used in "aesthetics sensitive" applications. Reducing the driver power decreases light output per area, either requiring multiple LEDs to get adequate brightness (which decreases the crispness of the light) or yielding products that don't provide adequate light output (thus slowing adoption). In many applications, consumers want point sources and many would readily trade lifetime for that while focusing on energy efficiency and lower cost (initial and lifetime). LED material efficiency gains of 500% per square mm of active LED area is possible with this approach.

  - **Proposal**: The lifetime required to qualify an LED could be eliminated or reduced to 10,000 hours (estimated hours required to more than pay back the initial cost with energy savings) and thus allow the next generation of much more efficient LEDs to replace these early LEDs within five years. Each product's Energy Star application should include an estimate of the payback period based on standard operating conditions.
  - **Alternate Proposal**: Each Energy Star application would submit a 'total energetic cost of production' calculation, accounting for the materials used in production and their estimated energy and carbon footprint. This would be netted against the energy saved over the bulb lifetime and a multiple of that would be used to calculate the required lifetime to produce overall energy (*i.e.* carbon) savings, equivalent to an energy return on investment (EROI) calculation.
  - **Explanation:** The general assumption is that LEDs should last much longer than conventional or fluorescent lights in order to be economical. This assumption is primarily the result of a lifetime cost analysis which assumes that LEDs are very expensive. For instance, a $50 MR16 LED bulb will need to last at least 10,000 hours to pay back (assuming $0.15/kWh and a 2,000 hour halogen lifetime). In contrast, a $10 MR16 LED (which we expect soon) would require less material and energy to produce and would pay back in under 1,500 hours, representing less than a year of normal operation. Given how quickly LED technology is advancing, it would be a mistake to plan for the past by setting unnecessarily long lifetimes, which would stick consumers with old technologies for a long time instead of encouraging the development of very low-cost, ultra-efficient LEDs.

- **CRI requirements –** These should be reconsidered. There is currently a single tier: Ra (CRI) > 80 for LEDs. Again, the primary goal is to maximize adoption of high-efficiency lighting. Achieving higher CRI is important for certain residential and commercial applications – many shops and homeowners opt not to deploy high-efficiency lighting due to poor light quality (for which CRI is an adequate indicator). Higher CRI currently comes at a price – it requires additional or different phosphors and generally lowers the efficiency of a bulb. By setting a low floor of CRI > 80 and a high fixed efficiency rating, it is challenging for high-quality lighting sources to qualify, thus slowing adoption and forcing consumers to stay with their historical incandescent lamps. A CRI > 95 bulb will be direct competition for incumbent incandescent lighting, such as the MR16 and PAR lamps, where light quality and brightness are principal drivers of bulb choices and low-CRI bulbs are not an option. In these cases, a substantial-efficiency LED (*e.g.* > 60-75% more efficient than their incandescent cousins) would still deliver large energy savings.

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- **Proposal:** Create multiple tiers of lighting quality/efficiency. Tie the lower CRI > 80 standard with the highest efficiency rating. Create a second tier with CRI > 95 with an efficiency rating that is lower. Ideally, tiers should be created at CRIs of 80, 85, 90, and 95.

- **Efficiency requirements –** The current proposal uses lumens per Watt (lm/W) for both omni-directional and directional lighting. Lm/W is not the best metric for directional lighting, since with a constant lm output, the brightness will increase as the directed angle is reduced. Therefore, for directional lighting, candela per watt (Cd/W) or equivalent is a more meaningful metric for the consumer. In addition, there is a very simple relationship between illumination level (expressed in foot-candles, fc) and intensity of the light source (expressed in candela, Cd): $fc = Cd/(\text{distance in feet})^2$. Expressing illumination level as a function of lumen or lm/W is far more complicated and less informative. For this reason, the use of a metric that is directly related to intensity (candela) and beam angle is more appropriate for directional lamps of any technology. Encouraging intelligent industrial design and tradeoffs in the design of the lamp, rather than simply rewarding light output per watt regardless of efficacy, will help achieve acceptable illumination levels. As a closely-related example, LED fixtures that replace HID fixtures for outdoor illumination deliver similar or increased illumination levels while producing substantially lower lumen levels. When fewer lumens are required to produce comparable illumination levels, additional energy is saved. From a measurement standpoint, this is a relatively simple adjustment and current testing requirements can still be used.
  - **Proposal**:
    - *Non-Directional:* Maintain the current standard (though include the tiers suggested above related to CRI)
    - *Directional*: Create a simple formula that takes into account the beam angle as defined by IESNA or IEC standards.

- **Principle of Equivalence** – One never knows what technology and new approaches are coming in a space with so much innovation. As a lesson learned from past experiences in regulatory discussions, we recommend that Energy Star include "or equivalent" language to acknowledge that, even while standards are fixed, innovation continues. Since there are companies that are inventing LEDs with a variety of substrates, a variety of form factors, and a variety of parameters under optimization, it would be appropriate for them to be able to submit equivalency claims for third-party testing. In biofuels, this works by including a baseline, such as a gallon of ethanol equivalent (biodiesel, bio-butanol, and other hydrocarbons have different energy content than ethanol but can deliver equivalent energy value when scaled). In lighting, rather than maintaining an only periodically updated Energy Star rating system, we propose creating a "principle of equivalence," under which companies with new products can apply to have new approaches considered if they can show the approaches' equivalence to current standards. This way, new, beneficial, cost-effective, and efficient technologies would not have to wait until the next revision before earning the coveted Energy Star label. ***Here are a few examples of how this could work, though I can imagine there would be other approaches that could also create equivalence.***
  - **Lifetime energetic analysis:** Allow new entrants to demonstrate equivalence by adjusting required lifetime or efficiency targets if their consumption of production resources in making the light bulb is less than the defined standard bulb. This represents an equivalent EROI calculation, which would allow for more technology neutrality and drive innovation.

Provided the net total energy saved is the same or better than the reference, the bulb would receive Energy Star certification.

- **Total cost analysis:** Similar to what I outlined above for lifetime calculations, rather than having a fixed lifetime or efficiency requirement, allow new entrants to show equivalence by adjusting required lifetime and efficiency if they're entering at a lower price point. Provided the aggregate savings are the same or better, the bulb would receive certification.
- **Lifetime carbon analysis:** Another equivalence approach involves looking at the lifecycle carbon equivalence. The Energy Star standard could define a "Standard" LED bulb as emitting a certain amount of carbon due to the manufacturing process to make the lamp (including LED, driver and housing) based on a reference design. Then, equivalence can be shown for a bulb that uses less material in construction, thereby saving upfront carbon impact, trading off with lower efficiency or shorter lifetime. Provided the sum total of carbon impact is the same or better than the reference, then the bulb would receive Energy Star certification.

Thanks very much for your time and consideration

Sincerely,

Vinod Khosla
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