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To: richard.karney@ee.doe.gov; SSL
Subject: SSL outdoor / roadway comments

To the SSL Energy Star Committee, regarding Draft dated July 1, 2009 for Outdoor Lighting -

There are several points I'd like to bring up. The first two deal with specific requirements of the standard that don't seem to be based on physical properties. The third deals with the basis used to determine the FTE requirements. The fourth covers what should be considered wasted lumens. The final sections cover the role of Energy Star, the role of other standards, and why only SSL products are being rated. There is a final section that summarizes the suggestions for changing the proposed draft.

1: Shielded and Unshielded Distinction

IES Type V and V square will always fall into unshielded. The FTE requirements (Table 1) indicate that for unshielded luminaires the requirement is 70 lm/W while for shielded it is 48 lm/W. The only difference between these two would be the optical control. The difference between 48 and 70 implies that you expect almost a 50% improvement in optical efficiency by going from a tightly controlled Type IV with little house side light to a Type V. This is unreasonable, and not seen in any traditional source products. This change is more typically in the 20-30% range, and many traditional Type II, III, and IV products actually qualify as unshielded, not shielded in the current system. The efficacy requirements should be the same regardless of the specific beam pattern. The method of determining the uniform pool of light already takes into account where the light is falling, so simply doing Lumens per Watt at this point would be sufficient. Having different requirements for Shielded and Unshielded makes the incorrect assumption that unshielded light is always wasted light (hence the higher overall efficacy requirement.... less ability to spill). In many parking lots and area lighting, two Type III or IV's will often be placed back to back. The effect is producing a Type V pattern with the benefit of not having too much light hit the pole as if you placed two V's back to back. The standard currently would have the Type V's be 50% more efficient than the Type III's or IV's, even though they would be lighting the same task with the same lumens. Since the standard has so many distinctions, products are going to tend towards the easiest requirements to achieve, hence shielded low output products will prevail. This standard will make the unshielded high lumen output product much more difficult to design and expensive to produce given the higher efficacy requirement, so manufactures will likely shy away from patterns that are unshielded and just use back to back shielded products of half the wattage to achieve the same goal. This leads to more production costs, material costs and installation costs, increasing the overall impact of the fixtures, which is the opposite of the goal with Energy Star.

2: Low and High Lumen Output

The difference between low and high output fixtures doesn't seem to be rooted in physical properties. Any LED data sheet will show that to get more lumens typically comes at a penalty in overall efficacy. Take a given SSL roadway luminaire that has two dimming levels, one at 7000 lumens, one at 14000 lumens. This product has the exact same optical configuration, same LEDs, same power supply, just two different driving conditions. Say the fixture just meets the FTE requirement at 7000 lumens, so it consumes 189W. Now if you double the light output, the actual power will more than double, say roughly 2.3 times depending on the specific drive conditions and LED. Now you're creating 14000 lumens at only 32 lumens per Watt, however the standard expects you to achieve 48 lm/W. Given the curfew dimming requirement in the upcoming MLO and the ease of dimming LEDs, this will be a feature of many products, and these products may only be capable of being Energy Star certified at one of the two light output levels. How would manufacturers indicate Energy Star compliance in these situations? It seems like most manufacturers will likely test just test at low lumen outputs to get Energy Star and then just put an asterisk and fine print that states "only at curfew dimming level". The Energy Star standard should take into account the physical properties of the sources, including the decrease in lm/W as lumens increase since this is seen across every LED product line. It currently looks like Energy Star thinks that higher output, harder driven LEDs are more efficient, and this just is not the case. If folks want to achieve Energy Star, they'll be driven towards smaller lumen package products since the requirement is easier to meet, which will just lead to lower mounting heights, closer spacing, and significantly more poles (30% more in the case of shielded, and 32% more in the case of unshielded). Shorter poles also lead to increased glare and spill light. This drive towards lower lumen products will increase the quantity of poles and overall project cost, as well as the environmental impacts associated with each pole, which are significant. This standard should not be driving manufacturers to an increase in the pole quantity and decrease in light output, but actually the other way around. It is suggested that the distinction between Low and High output be corrected to show the physical trend in lm/W with LEDs, or be eliminated altogether.

The lumen output and shielded/unshielded differences will drive most products towards the easiest to qualify product categories, which will lead to a lot of shielded, low wattage products. If lighting large areas like parking lots, using shielded low wattage products will lead to increased pole quantities, increased fixture quantities and ultimately more overall product waste. The standard should just define efficacy within the broader product category of roadway / area SSL, and not influence a shift towards certain lumen output and distribution requirements. Output and distribution should only be governed by the application and any lighting code for the location, they should not be part of a product qualification requirement that is supposed to quantify energy savings.

3: Derivation of FTE Requirements

The basis that LED products should be 20% better performing than the best performing current HID technology seems unreasonable. LEDs are a relative infants when it comes to usable light for outdoor applications, and with an infant product, it should be expected that there is much more advancement to come in the future. As such, infant LEDs should not be compared to metal halide sources and optical packages that have been under development for 20+ years. The best CMH sources are currently around 120 lumens per Watt, under normal operating conditions. Even the best performing cool white production LEDs are not yet at 120 lumens per Watt, and that's at a 25C junction temperature, which isn't achieved in a luminaire. If LEDs are supposed to be 20% better that would mean you expect the control gear or optical system to make up this difference. That is a lot to expect of technologies that have been around and under continual improvement for quite a while. There is also the assumption that HID technology is inherently underperforming, which is definitely not the case. The best HID and the best LED products should perform about equally, given similar source efficacy, similar target efficiency, and similar control gear efficiency.

In looking at the current SSL products on the market, products that have proven energy savings, very few will actually satisfy the proposed requirements. As an optical design company that has many ties to the optical and product design engineers in the lighting industry, as well as having designed many LED roadway optics ourselves, we understand the challenges and know that many of the products are doing the best that they can given the current technology and demands of the market. Current generation SSL products from BetaLED, Kim, and Lumec don't appear to meet the FTE requirements. However, the best traditional source products from Gardco, Kim, and Lumec also don't meet the Energy Star requirements. The fact that the best products currently on the market which are providing significant energy savings don't quality for Energy Star indicates that there is a problem with the current requirement being too strict. The DOE indicated that they tested a range of current HID products to serve as a baseline for these requirements, and it would be helpful if they could publish these results so that it is clear where the market currently stands instead of just arbitrarily arriving at the lumen per Watt FTE requirements. From the first draft of this standard which basically didn't allow any light above 60 degrees for roadway distributions, the DOE didn't show itself as an expert at the practice of outdoor lighting, so some backing of how the specific LPW requirements were achieved should be provided, even if this just is a table of FTE values for the current products from each of the major outdoor lighting brands. This would lend credibility and justify the requirements which currently seem arbitrarily determined and unjustly high.

I understand that the DOE desires to set some level of performance requirement, but if anything this should be only equal to the current best technology. LEDs are popular for many reasons beyond energy efficiency, and to put such strict requirements on energy efficiency will limit their use based on other benefits. LEDs are easily dimmed and controlled, so even though the source may have the same Lumens per Watt as a metal halide, if it can be dimmed after a defined curfew, it suddenly saves significant energy with an identical LPW. This current standard provides no way to address these other forms of energy saving. There are also other benefits, including the absence of mercury and halide salts, which give LEDs an advantage. Since there are other benefits, LEDs should be granted some leeway from current products. It would be reasonable to say an Energy Star product needs to be in the top 20% of current HID products, instead of 20% better than all of them.

4: Wasted light?

This standard also regards any light that doesn't go towards the roadway as purely wasted since it can't count towards the lumens per Watt requirement. Any lighting designer will know that in certain situations providing uplight is a very necessary and required part of the lighting scheme. Imagine a pedestrian mall in an urban district. If there is no uplight, all of the buildings will be dark, which will lead to a very gloomy and unsafe feeling area. Some uplight is necessary to set a scene and provide for safety. If an energy code requires Energy Star certified SSL product there will be no uplight. If a manufacturer desires to get a certified product, uplight will be minimal or absent since they can't afford to put any of the valuable lumens up when they'll likely be struggling to get as many lumens on the roadway as possible to meet the FTE requirement. What we'll end up with is a market of entirely full-cutoff, zero uplight SSL products, which means that we won't see SSL products used in urban environments, where uplight and spill are actually beneficial to the overall environment. The MLO is going to cover distribution requirements based on the application location, TM-15-07 Addendum A already has limits on uplight, Energy Star shouldn't try to do this also. Energy Star should just state if the product puts out lumens with acceptable energy. Saying which lumens are useful and which are not is something that always will depend on application so it shouldn't be part of a product rating. Using FTE to try and define the

application area for a given product makes too much of an assumption about the only task being roadway lighting. It is suggested that the Energy Star requirement simply use the overall product lumens divided by the input wattage, as it does for all other products. There are other standards in place that will govern and indicate good and bad distributions of light, there is no reason to add one more location for this data since it will likely get out of sync and be conflicting.

The process of removing data points that don't fall within the specified max/min ratios to find the uniform pool of light also has some issues. When this is done on a single luminaire, you'll achieve a certain sized uniform pool. However if you did a grid or linear arrangement of luminaires, such as in a parking lot or along a roadway, and did the same procedure, you'd end up with a larger area for each luminaire since the neighboring luminaires help to bring the minimums up on adjacent luminaires. The standard assumes that this light which falls outside the uniform pool is useless or wasted, when in fact it helps even out the distribution between two adjacent luminaires.

Based on the current proposed requirements, luminaires will likely tend in certain directions since it will be easier to get certified. I've already mentioned the preference given towards shielded low output luminaires. In order to achieve the highest target lumens, a beam would be perfectly rectangular of uniform illuminance with a sharp cutoff to zero at the edge. This isn't desired at all since it will lead to bright and dark areas if the products aren't laid out to the exact rectangular dimensions. It will also mean that a single point only gets light from a single source. This will lead to very harsh shadows and objects being hidden in darkness instead of being lit up from multiple angles. Sharp cutoffs at the edge of a roadway will leave opposing sidewalks in complete darkness, which is unsafe for both motorists and pedestrians.

5: What should be the role of Energy Star? How should this drive the requirements?

When the residential SSL standards initially came out, the DOE indicated that they felt rating and validating SSL products was important in order to avoid bad products coming to market and setting back adoption due to people being burned by bad early products, as was the case with CFL products and their much delayed adoption in the residential market. If this is really the purpose for Energy Star for SSL products (preventing junk from getting to market), the requirements should only prevent bad products from getting the rating, but as it stands it basically only allows the very best products to be rated (if any, see section 3). This isn't only preventing bad products from getting to market, but also decent and good products. Again, being in the top 20% of current products would be adequate, there isn't a reason to be 20% better than every product. Additionally, outdoor roadway and area lighting is already one of the most technologically advanced segments of architectural lighting since the performance requirements are so strict, fixtures are so expensive, and energy consumption is so significant. The market has demanded high performance products and manufacturers have always responded. Unlike residential LED downlights, PAR, and MR replacement lamps, outdoor LED products already have significantly high performance, typically the best that is possible given current LED technology. Poor outdoor products simply won't be specified or used, having Energy Star interfere in what has been a market segment that has very successfully weeded out the poor performers seems unnecessary. The commercial segment has been the

first to implement many energy saving technologies, from early metal halide technology, fluorescents, CFLs, induction, and now LEDs. By not letting the market decide what level of efficiency versus cost is acceptable, these Energy Star restrictions on outdoor SSL LED products will likely slow adoption of these products by making them prohibitively expensive. An Energy Star sticker will basically indicate the most expensive products on the market. Also, the rating system seems to cover much more than just energy use, including life, lumen maintenance, color temperature, color rendering.... things that have very little if anything (especially CCT and CRI) to do with Energy Stars goal of indicating energy saving products.

6: Why only SSL and not traditional sources?

It is also unclear why there are going to be Energy Star SSL products, but not Energy Star traditional sources. If the goal is overall energy savings, Energy Star should apply to all sources so that they can compete equally in the market. If Energy Star only certified LCD TVs and not Plasmas since the source is different it would seem odd since energy is energy, regardless of what is consuming it. Only rating SSL will lead to a disparity, where if a code requires only EnergyStar certified products, a traditional source couldn't be used, or if a code requires an SSL product to be certified, but places no restriction on traditional sources, fewer SSL products will be used since they'll be subject to more stringent performance requirements and thus be more expensive. Only giving the Energy Star rating to SSL products will convey a false impression that SSL products are superior to HID products, when this is not always the case. It seems like the DOE has jumped on the LED bandwagon along with everyone else, without considering the similarities to other sources and that LEDs are not a completely unique and new phenomenon. The industry has successfully adopted other technologies, and it isn't expected that LEDs need to be ushered in by the DOE instead of pure market demand and economics. Treating LEDs as an unusual source is just going to lead to confusion. They should be rated, judged and compared to traditional sources, not separated and isolated like they are in the Energy Star requirements. Expecting 20% higher efficiency just leads into the belief that LEDs are a miracle source that are going to be instantly better than anything on the market, which is unreasonable. So it is suggested to include traditional sources in this program. They can be rating using the same FTE calculator, the program just needs to be adjusted to not work with only absolute photometry.

6: Isn’t this stuff covered in other places? Commercial versus Residential Product Qualification

Energy Star is generally trying to cover too much in these standards. For commercial lighting, new buildings are typically governed by a whole series of codes, including energy codes, UL/CSE, and IES RPs. Commercial buildings typically must satisfy ASHRAE / IESNA 90.1, which defines minimum performance level of various building products, including lighting fixtures. For lighting, 90.1 specifies a maximum # of Watts / Sq Ft based on the space. This serves to limit overall energy use. IESNA has many standards which define the required light levels for a given space. Between these two standards, you can actually determine the required lumens/Watt that would be required. These are already defined and in use. LEED is increasingly in use and also has lighting energy and efficacy requirements, which are based on energy savings of the entire building as a complete system. Now Energy Star is adding a whole additional qualification that quantifies the same basic parameters. The possibility for multiple standards to conflict becomes much too easy when they cover the same topics. It is likely now that a product may qualify for Energy Star, but if improperly applied, will not achieve any energy savings. It is also possible (and highly likely) that products that do not qualify for Energy Star could be properly applied and actually yield significant energy savings.

Energy Star has its place as Product Qualification, but qualifying a product is only useful when the application won't be qualified for energy savings, or in the case of residential appliances, its merely a choice between single products. This is typical in residential homes, which don't have strict and specific energy requirements and where a consumer will have 1 washer/dryer and choosing an energy efficient one will ensure energy savings. However, with commercial buildings, the energy codes already assure energy savings, regardless of product or layout. And these savings are based on application which means that even if poor products are properly applied the savings will still be present. With an Energy Star certified roadway SSL product, someone could install them at a 20'MH with a pole spacing of only 10'.
Just because the product is Energy Star certified provides no proof that it will actually save energy since that is application based and not covered by the requirements. If Energy Star certification of commercial products becomes widespread, standards like 90.1 and LEED may change to simply require certified products, in which case we will have lost the ability to save energy by application and not just by product. Product certification makes sense for residential products that are bought out of the scope of a building design and engineering and by relatively unqualified homeowners and when the choice is like a clothes washer, where you're only buying one and you want to compare energy use. However for commercial buildings, there are already so many other programs that insure installed energy efficiency, and products are typically always chosen by professional engineers or designers, that product level certification just doesn't make sense. The certification implies that when installed these products will be more energy efficient than non-certified products, however this will not always be the case since the applications may be different.

7: Summarized Suggestions

- Set standards based on the top 20% of the HID products, not 20% better than the best
- Allow HID products to be certified as well so that different technologies can be directly compared (this will drive the market towards the most efficient products, whether they be SSL or HID)
- Provide concrete data that shows the current range of product performance that was used to derive the FTE requirements
- Eliminate any requirements that are based on a specific distribution of light since these are covered in other standards and also judged by the specifying engineer or lighting designer based on their given application and will drive all products in a certain direction. The standard should only drive towards products with higher lumens per watt, not certain distributions, lumen output, or other items which are application specific and application defined.
    - The 50% preferential FTE rating for shielded luminaires
    - the preference for lower lumen products
    - the preference for no broad, fading beams based on the method of calculating FTE by eliminating any light outside the main uniform pattern.
- Instead use overall output lumens per Watt. Lighting designers and electrical engineers will decide what distributions provide the best combination of uniformity, pole spacing, overall cost, and overall energy savings.

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