Subject: Reaction to Energy Star Lamps (“Light Bulbs”) Product Specification Framework March 2011
From: Keith Cook

General comment:

In general, a difficulty we see with the Energy Star specifications for LED products is that they specify too many parameters that have nothing to do with energy savings. The standard tries to apply in a general way to all applications, which is basically impossible. For example:

- The Color temperature and CRI of a portable light is often not important, but energy savings is particularly important for portable lamps, since it strongly affects the total amount of light obtained and the size of storage (battery) required. Highest energy efficiency is obtained with a high CCT. But high CCT lamps are excluded from Energy Star.
- MR-16 lamps are constrained by Energy Star to fit within the ANSI outline for halogen MR-16 lamps. The small volume of the MR16 outline basically excludes MR16 lamps from both qualifying for Energy Star AND replacing higher-powered 35W and 50W halogens. It is simply not possible presently to dissipate the necessary amount of heat in such a small volume.

In these cases, and other similar cases, Energy Star actually slows the adoption of energy-saving light sources. A lamp without Energy Star will not be eligible for rebates at this critical stage of high market growth. The cost of lamps for these applications will thus be artificially inflated with respect to other lamps that are able to qualify for Energy Star. Although it is understandable that Energy Star wants to avoid a repetition of the slow adoption of energy-saving CFL lamps, the attempt to control the lamp specifications has overreached, in our opinion. We do not think that Energy Star is responsible for setting standards for all parameters including life time, reliability and quality of light sources.

Specific comments:

II.b)ii. Considering the limitation of CFLi technology, E26 and E12 was setting as main base in the ENERGYSTAR criteria. However, as LED lamp, it can be made based on more comprehensive bases compliance with ANSI C81.61, such as GU10, GU5.3, GX53, G4…Hence, to keep ANSI C81.61 compliance is viable.

II.c)1. The current Energy Star version 4.2 divides CFLs in Bare, Covered (Globe, Outdoor, etc.) and Reflector lamps. This sub-division is clear enough to establish efficacy limits.

It must be clear that CFL products are not identical to the incandescent types they intend to replace. NEMA actuals FY 2010, show that 71% of CFL sales correspond to Bare products, 17% for Reflectors, with the remaining portion for Covered products and other types. Due to the nature of CFL products, it becomes obvious that this technology requires a larger size for the lamp to accommodate the discharge tube inside the lamp Cover. Doing a further subdivision as the one for all incandescent lamp shapes (A, B, C, F, G, etc.) is not practical due to the size and shape of CFL.

Rather than requiring CFLs to meet additional dimensional limits, we suggest that the dimensional limits for LED lamps be relaxed to require compliance to only ANSI C79.1-2002 and not to all the other specifications presently listed in the Energy Star requirements for integral LED lamps (e.g. LED MR-16 lamps must comply with the more stringent requirements of ANSI C78.24-2001 and PAR and R lamps must comply with the more stringent requirements of ANSI C78.21-2003).

Subjecting CFLs to specific dimensional limits will have a negative impact on lamp life and lamp cost. Being the CFL technology a mature technology which is not having major breakthroughs any more, a change in one lamp parameter, will adversely affect other. So in this case, if we reduce the lamp size, it will make the efficacy to go down. Moreover, and excessively small size will make the ballast component temperatures to go up, thus reducing lamp life.

CFL lamps are produced with a particular technology, which is different form incandescent and does not need to produce identical lamps. But it does provide the energy savings required to reduce carbon emissions and save energy costs.

II.c)2. Current LED lamp criteria, for directional lamp, only Par, R and MR16 were included. Actually, MR11 product has also big potential market with 75%+ energy saving comparison to halogen lamp.

II.c)3. CRI 90 CFL-I products should have an exemption to allow a lower efficacy requirement. This is a market segment that is requested by customers and cannot be made due to the current high efficacy requirements (developed for CRI 80 lamps).

Additionally, the requirement to provide 40% lifetime results before introducing products to the market, seriously delays the introduction of new products. This requirement hampers product innovation seriously.

We expect retrofit lamps to eventually be replaced by new luminaires, but this is likely to take decades, since the installed base changes only slowly. Energy Star needs to be aware of this slow transition and foster both categories of products, in order to save the maximum amount of energy. The form that new luminaires will take is not yet entirely clear, so flexibility will be required.

III.a)i. Propose that the specification should update minimum lm/w periodically in accordance with the DOE LED efficacy curves. The yearly DOE R&D SSL Multi Year Program Plan could serve as the reference document

III.a)ii. Current information available indicate that a high power factor CFL does not deliver any additional value either to the grid-operator or the end-user, under most conditions other than isolated, micro or mini-grids with high peak lighting loads.

The addition of circuitry to bring the power factor from 0.5 (normal power factor) to 0.9 (high power factor) for CFLs consumes a small amount of additional power and generates a small amount of heat. Both of these factors will affect adversely the life and efficacy of CFLs. The addition of this extra circuitry to increase the PF will also increase the size of the CFL (which is one of the dissatisfiers for these lamps) and will increase the cost of a CFL by 15 – 25% (which is another of the dissatisfiers for CFLs; lamp price).

From technical point of view, it should be emphasized that the metric Power Factor (PF), which is used to quantify the effect of lighting equipment on the power quality of the grid is not the most effective metric. The reason is that the PF metric is a composite metric consisting of the primary metrics displacement factor (κ displacement) and distortion factor (κdistortion). PF (λ) = κdisplacement*κ distortion. Use of primary metrics instead of the composite metric, as this helps regulators to monitor and regulate the real causes of power quality issues.

Metric	Limit			
	P < 2W)	2W ≤ P ≤ 5W)	5W < P ≤ 25W	P > 25W
κdisplacement (cos φ1)	No Limit	≥ 0.4	≥ 0.7	≥ 0.9
κdistortion	IEC 61000-3-2 Clause 7.3b			IEC 61000-3-2 Clause 7.3a

III.a)iii. We suggest that EPA consult with DOE to obtain the extensive measurement data from the L Prize competition. Data includes luminous efficacy and many other lamp parameters. DOE has well-established projections for where the technology is headed, in terms of efficacy, and is a good source of information on this topic.

III.b)i. Similar to the comments on II.c)1., we do not think it is proper for Energy Star to specify what light intensity distribution a lamp should have, since the ideal distribution is application dependent. For instance, an LED (or CFL) A lamp that emits light in only one hemisphere is a better retrofit replacement for an incandescent or CFL in a recessed can than a true omni-directional lamp. But, it is not a better replacement in a table lamp. How does one specify an intensity distribution without penalizing one of these (or other) applications? Consider a split between non directional light sources (omni directional) and directional light sources.

III.b)ii. What is the rationale for making the start and run-up times tighter? How much tighter? Again, for some applications these times are not critical. A tight Energy Star specification will penalize those applications where these times are not critical.

III.b)iii.5. As stated above, we do not favor forcing LED and CFL products to conform to incandescent light distributions. Such requirements artificially penalize certain applications. Especially with narrow beams, LED's are relatively more efficient. Below table illustrates the required lumen equivalency of a LED lamps compared to traditional light sources:

Group NSP	Group SP	Group NFL	Group FL	Group WFL	Group VWFL	Group XWFL	Group XXWFL
3 – 9˚	**9 – 15˚**	**15 – 20˚**	**20 – 30˚**	**30 – 40˚**	**40 – 60˚**	**60˚ - 90˚**	**≥ 90˚**
Min Flux (lm)	Min Flux (lm)	Min Flux (lm)	Min Flux (lm)	Min Flux (lm)	Min Flux (lm)	Min Flux (lm)	Min Flux (lm)
% of reference	% of reference	% of reference	% of reference	% of reference	% of reference	% of reference	% of reference
80%	85%	90%	100%	100%	100%	100%	100%

III.b)iii.6. Energy Star LED products have a lifetime of at least 25000 hours. Most lamps will probably be upgraded or replaced during remodeling before the lifetime is ended. The additional cost of requiring end-of-life features is not worthwhile. Such features should be left to high-end products for special applications (e.g. applications where the lights burn 24 hours/day) and not made a requirement. At present, the lifetime of LED lamps is designed for a worst-case condition. Therefore, a method that relies on timing will result in end-of-life indications that are too soon for many lamps. A method that truly detects when the light output has dropped to 70% of initial light output level will require an integral photodiode (and accompanying electronics and software) or another complicated characterization of lamp performance. This will add cost.

Propose that lamps, as a maximum, have indicator(s) for information only as an option, but have no requirements for cutoff/shutdown feature

III.c)i. Tightening color specifications will increase cost, again penalizing applications that are less sensitive to color accuracy. See III.c)v.7. below.

III.c)ii. DOE has been working on this topic for several years. EPA should consult carefully with DOE before introducing any new specifications here.

III.c)iii. Propose to set up labeled separate classes of lamps (A, B, C etc.) based on longevity (khours) to encourage price/performance market forces. Reliability and longevity of lamps needs to be de-coupled from LM -80 lumen depreciation data because LED lumen depreciation is only one of many factors which determine the functional longevity of a lamp. A "full system" analysis which includes the LED light engine, driver components, optical components and mechanical components needs to be developed.

III.c).iv Durability and testing belong in the domain of the manufacturers. Energy Stars should not be telling manufacturers how to test and design their products. The market will penalize manufacturers who do not live up to their specifications. Testing requirements and conditions have been standardized by appropriate bodies like IEC, ANSI etc

III.c)v.7. Tightening color requirements will have a negative impact on lamp cost for CFL-Is. This will imply more process checks and phosphor corrections during lamp production.

For a low cost product as CFL-Is are, we would be going in the wrong direction as people will need to pay more for the products for something that cannot be perceived without measuring instruments.

More stringent color requirements will definitely impact cost. LED manufacturers will have to bin LEDs more tightly resulting in more SKUs, more complicated algorithms for mixing and matching LEDs will have to be developed and applied, lamp SKU's will also multiply and presumably the allowed variation of color with time (poorly understood) will also be tightened.

III.c)v.8. Yes. This could change in the future if multi-color RGB+ light sources become popular. However, the exact composition of such sources and its impact on color quality is not clear. For instance, will all three colors be directly generated? Will green be a phosphor-converted blue? Will red be a phosphor-converted blue? Etc. The answers to these questions will impact which color quality metric is used, since phosphor generally produce a broader spectrum that directly-generated LED colors.

III.c)v.9. The consumer does not understand CRI now. Adding additional parameters will make this situation worse. Manufacturers should be allowed to determine this on their own, and differentiate themselves with better products accordingly, if they are able to do so.

III.c)v.10. We have nothing better than CRI, at present. Propose to keep a 100 point metric which corresponds to academic grading which everyone understands.

III.c)v.11. In order to extend the switching and life performance of CFLs, the lamp filaments require pre-heat prior to lamp ignition. Reducing the ignition time from the already restrictive 1.0 second requirement, will seriously affect CFLs designed for intensive switching (e.g. designed for occupancy sensor applications) or lamp designs intended for long life (e.g. longer than 10 or 12 K hours).

Reducing the starting time from the current requirement will only allow the release of instant start CFLs with the negative consequences implied for these type of lamps. No real benefit will be perceived by the end-user.

As mentioned above, CFLs are essentially products made with a mature technology, which is not having big breakthroughs any more. Restricting some parameters will adversely affect others or will increase the product price or both.

We are not aware of benefits to shortening the start time for LEDs below one second, except for applications like brake lights. We are aware that cost will increase to shorten start time. We do not think it is necessary to shorten this time.

III.c)v.12. There are two main methods to control the mercury vapor pressure inside the discharge tube and thus, an adequate level of light output for the lamps: Cold spot and amalgam.

Cold spot, also called non-amalgam is mainly used for low wattage bare lamps, where the cold spot method is good enough to maintain a proper mercury pressure inside the discharge tube.

Amalgam is typically used for lamps that run hot, e.g. Covered products or higher wattage bare lamps or lamps intended for warmer applications, e.g. recessed cans. The amalgam method to control the mercury pressure inside the discharge tube, can provide a good level of light output and thus a good efficacy over a wider range of ambient temperatures, but it has the disadvantage of a slower run-up.

The cold spot method has the advantage of a quicker run-up, but has the disadvantage that it can only be used in bare lamps, especially low power types.

Reducing the currently specified run-up time (1 minute for non-amalgam types and 3 minutes for amalgam), will severely affect the range and types of CFL products that can be offered to the market.

Long run-up time is a dis-satisfier with CFL lamps. However, manufacturers are solving this problem on their own.

III.c).13. We think that life time, expressed in hours, is a good definition for product performance regarding life for CFLs. Current incandescent products use that definition.

Life time defined in years of operation can be difficult to get a common baseline, as consumers use the products in different manners and for different applications.

Regarding tradeoffs for cost versus life, it is evident that the lifetime of CFLs is based on a) life of the lamp filaments and b) life of the electronic ballast.

Regarding a), in order to extend the life of the lamp filaments, it is necessary to have a good filament design, appropriate to the current that they are handling and a good pre-heat current before the lamp starts. Reducing the starting time of the lamps will severely affect the switching performance and the lamp life of the products, particularly for products intended for long life times.

Regarding b), in order to increase lamp life, it is evident that we need to use higher temperature rated electronic components to increase lamp life and thus increase the cost of the products and / or increase the size of the products to be able to manage the electronic component temperatures.

Both of these alternatives would be contrary to consumer expectations to have lower cost and smaller products.

It is good to keep the current requirements for lifetime. Otherwise the Energy Star requirements will severely restrict the type of products offered in the market. If the lifetime requirement is increased, then only expensive and / or larger products will be able to be marketed under the Energy Star mark.

Propose to adopt a new definition of "life" that does not rely only on lumen depreciation and LM-80 data for LEDs. The new definition of life needs to incorporate the longevity of the non-LED components as stated in Life Requirements above.

IV.i. DOE's Lighting Facts label, adopted by FTC, seems to be working well.

IV.ii. This may be the most useful thing that Energy Star can do. Harmonization with other parts of the world will reduce costs by increasing product volume and reducing the number of product SKUs.

IV.iii. Other bodies like ROHS already regulate hazardous substances. Refer to ROHS and avoid double requirements.

IV.iv.14. This is a very complex problem, considering the availability of dimming systems available and installed.

Moreover, it is the combination of (specific) dimmer design and (specific) lamp design that determines the performance, so not only the lamp itself. Better compatibility between self ballasted lamps and wall dimmers will be developed by lamp and dimmer manufacturers together within NEMA.

Probably the best way to address this problem is that the manufacturer of the lamp posts in internet the dimmer brands and models compatible with their dimmable CFL-I.

NEMA's SSL-6 is a complete document describing lamps, dimmers and their interactions for LEDs. Please refer to this document. Refer to the latest version, since it will soon be updated.

IV.iv.15. Not to our knowledge, as CFLs (and fluorescent lamps in general) need a specific current through the lamp filaments to keep a proper operation of the lamp. If the RMS voltage received by the lamp is lowered, we would need an intelligent circuit (e.g. an IC) to provide the proper current compensation to the lamp filaments.

So, in essence to make a "dimming tolerant" CFL, which "would meet consumer expectations" when operated on a dimming circuit, we would need to make the lamp dimmable. This will make the lamp more expensive as additional circuitry will be needed in the lamp ballast to perform this function. People should only buy this additional circuitry when it is needed.

This is a matter of education for the customers. A CFL lamp is not an incandescent lamp and customers should learn how to use them. This will come with time as CFL use increases.

For LEDs, the only way it could meet consumer expectations is if it Is a dimming lamp.

IV.iv.16. As stated above, this is a very complex issue given the availability of dimmers installed and available in the market.
The lamp manufacturer should post the list of dimmers compatible with their dimming CFLs.

Again, please refer to NEMA SSL-6 and the manufacturers.

IV.iv.17. Minor product variations are needed for a variety of reasons, e.g. component suppliers who stop supplying lamp sub-components, process manufacturing changes, etc. It is evident, that re-testing the product for every engineering change is not viable and will increase the product cost significantly, since the testing is rather expensive, not to mention the time involved for re-testing, which most of the times is not available.

It is also obvious that re-testing the product is not necessary for every minor product variation, e.g. if the lamp base is changed, this will have absolutely no impact on lamp life or performance.
The lamp should only be re-tested when the product model or wattage change. Otherwise the cost to the manufacturer and eventually to the end-user who pays for this will become extremely heavy. Moreover, the supply of products will be seriously jeopardized.

The burden of testing and certification is quite high for LED lamps and multiplication of requirements is increasing cost. For instance, incandescent and fluorescent lamps have no cost for UL, LM79, or LM80 testing, but LED lamps do. There are costs for LM79, LM80, DOE, FTC, UL, and FCC as examples. Many of these tests require long testing periods. (6 months for Energy Star, for instance). This testing burden increases costs and delays the introduction of energy saving products. Anything that can be done to combine tests and reduce costs will help increase market acceptance of these products.

Propose that the primary factors that define the lumen maintenance behavior of a LED Package or Array, lamps and luminaires are:

1. Thermal resistance of packaged device.
2. Material system - photonic path of the photons after exiting the EPI.
3. Power density (Power per die area [mW/mm2])
4. Ts (EPA definition)

Based on this, LED design changes that do not impact lumen maintenance and; therefore, do not require new LM-80 testing are:

1. Phosphor variations resulting in higher CCT
2. Package changes which do not affect the the 4 parameters above (shape, size, wire bonds, etc.)
3. Same or lower thermal resistance of the packaged device
4. Radiation pattern changes
5. Same or lower die power density [mW/mm^2] than the previously tested version

Whereas LED design changes that do impact lumen maintenance and; therefore, do require new LM-80 testing are:

1. Phosphor variations resulting in lower CCT
2. Increased thermal resistance of the packaged device
3. Increased power density compared to the previously tested version
4. New material system in optical path after exiting the EPI
5. Higher qualification temperature than previously tested version (claim of higher Ts ENERGY STAR compliance than reported in the current LM-80 test report).