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See attached.

Additional submitted attachment is included below.

GE Lighting

1975 Noble Road
East Cleveland, OH 44112
USA

December 7, 2015

Submitted via email: docket@energy.ca.gov

Commissioner Andrew McAllister
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

GE Lighting Comments on proposed Title 20 regulations for Light Emitting Diode (LED) Lamps and Small Diameter Directional Lamps

Dear Commissioner McAllister,

GE Lighting appreciates the opportunity to comment on the California Energy Commission's (CEC) proposed regulations for Light Emitting Diode (LED) lamps and Small Diameter Directional Lamps. GE Lighting is a leading global lamp manufacturer headquartered in the United States and it manufacturers a wide variety of products including the products covered by this proposed regulation. GE Lighting's long history of selling lighting products provides unique insight into consumer wants, needs and preferences.

GE Lighting supports comments submitted by the National Electrical Manufacturer Association (NEMA) which provide more detail on the many technical issues with the proposed standards.

We note at the outset that GE supports progressive energy efficiency standards and the fundamental purpose of Title 20 to push poor performing, low efficiency products out of the marketplace. Experience has demonstrated that these products can negatively bias consumer perceptions of emerging technologies with predictable consequences. With respect to this regulatory proceeding, GE supports an energy efficiency level for general service LED A-line lamps and certain LED MR16 lamps. We also agree that minimum performance specifications are necessary to satisfy consumer expectations relative to incumbent technologies. The challenge before CEC is to strike the proper balance between performance and cost-effectiveness. Just as negative experiences with low quality lamps will drive consumers away from LED technology, too much emphasis on performance will push the price point of LED lamps sufficiently above incumbent technologies to discourage consumer adoption and reduce consumer options. Neither of these outcomes is in the best interest of consumers or the state's ambitious energy efficiency objectives.

GE Lighting also believes CEC's proposals introduce serious concerns that, if enacted without further modification, will greatly limit the number and types of LED lighting products available to California

consumers and result will slow the adoption of LED lamps in California. While other states benefit from a far greater selection of consumer-preferred LED products, California would be limited to a smaller selection of higher priced premium products designed for specialty applications. This slower adoption will also inhibit the energy savings potential that a more widespread adoption of LED products can deliver.

There is no evidence in the staff report that specifications, such as the extensive color quality metrics in the proposed regulations are necessary or even desired by consumers. Premium specialty products that could potentially meet these proposals may be appropriate for limited niche applications, but they will not enhance the consumer experience in the vast majority of general service lighting applications.

The following comments include specific recommendations for changes to the staff proposals, both for general service LEDs and small diameter directional LEDs, along with supporting technical and policy rationale. These changes would strike the critical balance noted above and achieve our shared objectives of a high, sustained rate of consumer adoption and maximizing actual energy efficiency gains.

LIGHT EMMITTING DIODE LAMPS

While Title 20 has historically enacted minimum energy efficiency standards to weed low efficiency consumer products out of the market, this proposal goes far beyond minimum standards. Instead, it sets a high performance benchmark that will eliminate from the market all but a few extremely efficient specialty LED products operating in a very narrow color range that are designed for use in a narrow range of applications. Presentations from CEC staff and California utilities addressing the feasibility of the proposed regulations only take into consideration a subset of the relevant specifications, and incorrectly suggest that many products on the shelf today will comply with the regulations. If fact, it is not possible to determine what existing products would meet ***all*** of the proposed regulations from publically available data. If one evaluates existing products against ***all*** of the proposed specifications, few, if any products sold today would be able to comply with the proposed regulations.

If enacted as proposed, these regulations would create an unworkable enforcement environment, where no one in the supply chain can be certain that any product ever actually complies. This is especially true for importers, distributors and retailers doing business in California. For instance, a single Duv number listed on an LM-79 report does not provide adequate information to the Commission and Distributors about the manufacturing process tolerance capability that this metric measures.

Indeed, the color space proposed by the staff (- 0.0033 on and slightly below the black body curve) is not a color space that suits consumers in many applications. Lamps producing light in the preferred "white" color space, such as GE's Reveal lamps, would be prohibited in California under this specification, even though the Staff report states on pages 58 and 59 (CCT) that such products would be allowed to be sold using an alternative approach. This is a contradiction that is just one example of the extreme complexity of the proposed regulations, which could lead to misinterpretation and unintended consequences that are not in the best interest of consumers or the Commission's energy efficiency objectives.

The Commission can avoid the above noted pitfalls by simplifying the proposed regulations and allowing more flexibility with regard to performance metrics. We respectfully request that you challenge the CEC staff to simplify the proposed standard for Light Emitting Diode (LED) lamps using commonly available market information. In doing so, the agency would allow for a greater variety of energy efficient LED products in the marketplace and drive greater energy savings in the state. Such a simplified regulation would also be easier for the Commission to implement, easier for the market to understand, and easier for the Commission to enforce, making it more effective and yielding greater energy savings.

The unprecedented complexity of the current proposal alone should be a red flag to all stakeholders. The proposal calls out specifications for information that is not publically available and not commonly understood, even by Commission staff, which is troubling. The regulation must be readily understood by all stakeholders in the market, and must be easy for the agency to enforce, or the desired energy savings will not be realized.

To achieve simplification, first, the commission should remove the proposed complex Duv requirement and replace it with a requirement to meet the ANSI C78.377 color standard. In proposing the Duv requirement, the Commission is will be creating a brand new de-facto industry standard without any manufacturer input or external peer review. As a result of this development approach, the staff proposal is fraught with technical and practical problems, such as the requirement to consistently place all lamps in an overly narrow color space.

The Duv specification should also be removed because Duv information is not commonly available or commonly understood in the marketplace. If the Commission wants to ensure that manufacturers maintain color consistency in their manufacturing process, it should use the current consensus-based standard. The ANSI color standard, ANSI C78.377 is well understood by industry as a method to consistently meet standardized color points. This approach would ensure that consumers have a uniform and favorable color experience when buying the same color temperature lamp regardless of the manufacturer. This standard has been in place since white LED consumer lamps appeared on the market. There is no evidence to suggest anything further is needed to ensure color consistency for LED technology.

Second, the Commission should remove the R-1 through R-8 requirements. As with Duv, the R1 through R8 specification should be removed because this information is not commonly available or commonly understood in the marketplace. CRI presents an average of R1 through R8, and the only color fidelity requirement necessary is placing a minimum CRI requirement in the standard. CRI is well understood and CRI data is commonly available in the marketplace. Average CRI is the only color requirement that will be easily understood by the distributors and retailers importing LED products into the California market and therefore the only color fidelity requirement that assures compliance and enforceability.

GE Lighting strongly recommends that the Commission limit its color quality specification to a CRI of 80 or greater. Such action would be the most appropriate approach for a minimum state energy efficiency regulation. Over 1 billion CFL lamps have been sold over the past decade with a CRI 80 or greater. Anything more stringent in the color quality space will significantly limit LED product availability and consumer choice in California, and in turn will limit the energy savings achieved by the Title 20 standard. While a CRI greater than 80 is not necessary for most consumer and commercial applications, manufacturers would still be able to compete with higher CRI products that are desired for certain applications.

The intense focus on color quality seems to be driven by an attempt to make LEDs more attractive than CFLs as replacements for incandescent lamps in certain applications such as bathrooms and kitchens. However, a focus on mimicking incandescent lamp color is misguided. CEC seems to have made an assumption that lack of acceptance in particular applications is due predominantly to lamp color properties. However, such an assumption is unsupported. There is research suggesting that consumers actually prefer white light (compared to the yellow-tinted light of incandescent sources), which is perceived by the human eye as an area below the black body curve at low color temperatures.[1],[2] Furthermore, we assert that the lack of CFL use in certain applications is not color related. Rather, the primary reason CFLs were not as well accepted in bathrooms is due to frequent, short duration use and consumer frustration with slow warm-up time and, the significant reduction in CFL life resulting from the frequent on-off daily duty cycle.

The primary reason CFLs were not accepted in kitchens has do with the fixture type used in these spaces. The primary light source used in many kitchens is a fixture that uses linear fluorescent lamps which often have CRIs in the 70s or low 80s. These fixtures have been used for many decades with no consumer complaints. The second most common light source is a downlight. While CFLs cannot be used in linear fluorescent fixtures, reflector CFL versions can be used in downlights. However, the reflector CFL lamp has never been very effective at focusing light directly below the downlight on a kitchen counter top. Since a CFL is a diffuse source, it is difficult to effectively focus the light into the center beam. Therefore, when replacing incandescent reflector lamps or halogen PAR lamps with CFL reflector lamps, the lighting level on the kitchen counter is not nearly as high. This is not color related, but rather a function light level and brightness. Fortunately, LEDs do not have this same short coming. LED reflector lamps focus light very effectively in downlight applications and should be readily accepted in kitchen downlight applications.

The proposed complex specifications for LED color are entirely unrelated to actual consumer complaints and therefore are not necessary to ensure consumer satisfaction. Previous studies[3] on CFL use have indicated:

1. Users report the most important characteristics of light bulbs include brightness, equivalent light output, and warm color. They expect color consistency and predictability from CFLs (Rensselaer, 2003).
2. Eighty percent of CFL purchasers reported they were at least as satisfied with the CFLs they purchased as with purchases of incandescents (NEEA 2004 [14]). More than one-third said they were **more** satisfied.
3. The main reasons for dissatisfaction were:
    - **the lamps were not as bright as they were led to expect**, or
    - they didn't like the lighting
4. CFL purchasers are becoming more satisfied over time. One study (KEMA 2005 [8]) noted that 28% of purchasers are more satisfied with newer CFLs than earlier purchases, and only 5% were less satisfied. Reasons for higher satisfaction were related to the shape and size of the CFL; reasons for remaining dissatisfaction included **early burnout**, **cost**, and **product style**.

The research found that over 80% of consumers are satisfied with CFL lamps (which have a CRI of 80). The main reason they would not be satisfied with color is that they purchased a "cool" daylight lamp

[1] White Light for Residential Applications, MS Rea PhD, JP Freyssinier MS, Lighting Research Technology, 2013, 45, 331-344

[2] White Lighting, MS Rea PhD, JP Freyssinier MS, Color Research and Application, Volume 38, Number 2, April 2013

[3] Findings and Gaps in CFL Research: Update and Review of Existing Literature, SERA, September, 2009, pg. 5.

when they were expecting a "warm color". Four of the primary reasons that users were dissatisfied with CFLs are 1) they were not as bright as needed (for example, when using CFL downlights), 2) they burned out earlier than expected (in certain applications with frequent starts such as bathrooms), 3) they cost too much, or 4) they didn't like the look and product style of a spiral CFL. Of these four concerns, the only one still remaining for LED lamps is product cost. As noted above, overly aggressive color specifications will drive-up LED lamp cost, which will undermine, not promote, consumer adoption.

As a third step toward simplification, the Commission should take into account the lower efficiency of high CRI lamps – a premise we support - by setting one efficiency level for LED lamps with a CRI of 80 or greater and a second efficiency level for lamps with a CRI of 90 or greater. We would strongly suggest 75 LPW for 80+ CRI lamps and 65 LPW for 90+ CRI lamps as a very simple approach that will be more effective than the compliance equations currently proposed.

The equation approach has too many degrees of movement and will create compliance and enforcement problems. A random sample of several of the same lamp with varying CRI values and varying LPW values selected for initial testing against the complex compliance score equation will never match a random set of the same lamps selected for enforcement. For products that barely pass, this can create a very confusing enforcement situation as there are too many variables feeding the equation and affecting the outcome. Changing the specification to a minimum LPW and CRI requirement would eliminate a multitude of future problems. This simple approach will lead to much more effective compliance and enforcement, greatly simplify reporting, and ultimately lead to greater energy savings in the state.

In addition, most LED chips being manufactured today are binned at or slightly above the 80 CRI level or at or slightly above the 90 CRI level. It makes no sense to create a linear equation when two discrete chip sets are being regulated. A two-step regulation would be the most effective approach.

Conflicting Standards

Regardless of how the Commission sets these specifications (e.g., whether by the compliance score method, or the simplified method suggested above), it cannot maintain ***both*** a minimum CRI of 82 and an R8 color point minimum of 72. While it is possible to produce a lamp with an R8 over 72, all such products (especially 2700K & 3000K) have an average CRI of approximately 90 or higher due to the naturally high R values occurring at many of the other color points. Therefore, this complex standard as proposed, conflicts with itself as manufacturers cannot meet both a CRI of 82 at 2700K or 3000K (the most popular color temperatures) and an R8 of 72 at the same time. The R8 value would need to be lowered to 50 or higher to allow 2700K LED products with a CRI between 80 and 85. This change is an absolute necessity if the Commission insists on pursuing this complex, multi-faceted approach and to avoid a standard that conflicts with itself. The alternative simplified approach suggested above would avoid these conflicts while achieving the same energy savings.

Omnidirectional Requirement

The omnidirectional requirement stipulates that lamps with an ANSI Standard shape of A, B, BA, C, CA, F or G lamps must meet the ENERGY STAR® product specification for LAMPS Version 1.1. Based on

updated information, ENERGY STAR® is currently in the process of modifying this specification for LAMPS version 2.0. In order to avoid locking an outdated version of Omnidirectional specifications into Title 20, the CEC should modify this proposal to state that lamps must meet the omnidirectional light distribution requirements specified in ENERGY STAR Lamps version 2.0.

Power Factor

The proposal requires a minimum power factor of 0.7 which is the current Power Factor requirement in ENERGY STAR Version 1.1. EPA is also considering changes to this factor based on new information about updated LED designs to 0.5. In order to be consistent with this national LED quality standard, the CEC should base their Power Factor requirement on the LAMPS 2.0 ENERGY STAR requirement. As such, the CEC should change this requirement to read that lamps must meet the power factor of 0.5 or the Power Factor requirements in ENERGY STAR Lamps version 2.0. Lower power factor designs can lower costs by approximately 10%, and since LED lamps have leading power factors, they tend to offset the lagging power factors associated with motors in the building.

Standby Power

As smart lamps with integrated management technology is a developing area containing very few product sales and consuming very little energy, the CEC should not set an overly stringent requirement which will stifle innovation in the area. GE strongly recommends that CEC set the standby power specification for connected lamps at a maximum of 1 watt until such time as more is known about this developing product area. The current 0.2 watt maximum is overly restrictive and could retard development and deployment of smart energy management systems, diminishing opportunities for much greater energy savings than would be achieved through an incremental standby power specification. As an alternative, the CEC could also tie its standby power requirement to the ENERGY STAR LAMPS 2.0 standard.

Test Methods

GE supports the NEMA comments on testing concerns. In particular it is extremely important for the CEC to continue to allow the use of LM-80 and TM-21 to show compliance. The LM-84 and TM-28 standards are inappropriate to mandate at this time given the rapid pace of change in these methods. Alternatively, allowing a manufacturer to use either set of standards to show compliance would also be acceptable.

Marking of Lamps

To assist consumers in LED lamp selection, manufacturers often make incandescent equivalency claims. LED lamps should not be prohibited from making incandescent “wattage” equivalency claims simply because they have a high color temperature or they are not dimmable. The “wattage” equivalency claims are used to indicate similar light output or brightness. Wattage equivalency claims are not an indication of dimmability or color temperature. Today, LED lamps clearly state whether or not they are dimmable and they provide a clear indication of their color temperature. No further regulation is required. When making wattage equivalency claims, we agree with using the DOE lumen minimums in Table K-15.

Additionally, the proposed requirements are not consistent with today's customary national packaging approaches. It would force manufacturers to create unique packaging specifically for the California market for several product categories. A requirement to provide unique California packaging would further drive-up LED product costs and create national distribution challenges. It would further limit the number of compliant LED products available in the State.

Scope

GE is concerned about the number of products included in the Light Emitting Diode (LED) lamp scope. Although the analysis concentrates heavily on medium-base A-line replacement lamps, and sets efficiency standards based on this analysis, it sets a scope that includes more than just medium base A-line lamps. It is not appropriate to set standards for Reflector LED lamps, Decorative LED lamps and downlight LED reflector kits, in a regulation that has been developed primarily for A-line lamps. Separate analysis and discussion is necessary to ensure that Title 20 standards address attributes, applications and market circumstances unique to each technology. Once properly analyzed, it is likely that the standards for these products would be set at different efficiency levels (higher or lower) than currently proposed. In this case, the Commission has not performed an adequate analysis for all lamps types subject to the proposed regulations and cannot assume the efficiency levels for A-line lamps would be appropriate for all four categories. Accordingly we recommend the Commission explicitly limit the scope only to medium-based A-line LED lamps at this time.

In addition, the scope of the medium base A-line standard should start at a floor of 310 lumens to be consistent with federal standards for medium base lamps. Lamps less than 310 lumens use very little power, so mandatory specifications will have negligible energy savings in the state. Forcing high quality standards that increase cost on these niche lamps types would increase the likelihood that consumers continue to use incandescent options, since they are not regulated by DOE below 310 lumens and remain widely available in the marketplace. This outcome would undercut opportunities for energy savings and thus would be at odds with the Commission's statutory mandate.

Recommended Scope Change

GE recommends the following changes to the scope:

State-regulated Light Emitting Diode (LED) lamp" means a lamp capable of producing light with Duv between -0.012 and 0.012, and that has an ~~E12, E17,~~ E26, or GU-24 base, ~~including~~ excluding LED ~~lamps~~ kits that are designed for retrofit within existing recessed can housings that contain one of the preceding bases~~.~~, and excluding LED Reflector or LED PAR lamps. State-regulated LED lamp does not include a lamp with a brightness of more than 2600 lumens or a lamp that cannot produce light with a correlated color temperature between 2200K and 7000K.

Rationale for scope changes:

1. Eliminating the E12 and E17 base types eliminates some decorative LED lamps from the scope. Due to size and thermal constraints, small base Decorative LED lamps cannot

achieve the same efficiency performance as medium base A-line LED lamps. LED decorative lamps are competing against incandescent, halogen and CFL decorative lamps in the marketplace. They can compete much more effectively and deliver greater efficiency in decorative applications without significant regulatory constraints. However, if CEC continues to pursue regulations for small base LED decorative lamps, a new more simple set of specifications must be developed and based on analyses specific to these lamp types. The extensive proposed regulations for A-line LED Lamps are a poor fit for decorative LED lamps. In particular, the proposed efficiency equations are infeasible for this technology. Minimum efficiency levels must be set lower than proposed for decorative lamp types and we would support the NEMA proposal if CEC does not remove this product class from the scope. The CEC staff analysis focuses on the A-line LED lamps, not small-based decorative LED lamps. The particular issues associated with decorative LED lamps have not been sufficiently analyzed to set proper efficiency levels for this technology.

2. We also recommend clearly excluding LED downlight retrofit kits from the proposed scope because these products have not been sufficiently analyzed such that the proposed standards are shown to be technologically feasible in these applications. In addition, these products are already covered within Title 24 regulations. However, if CEC continues to pursue regulations for LED downlight retrofit kits, a new more simple set of specifications must be developed and based on an analysis specific to these retrofit kits. It is not clear that the proposed efficiency equations and additional specifications are set properly for this technology. Further analysis is necessary before feasibility and cost-effectiveness can be reasonably assessed and final regulations can be developed for these products.

3. We also recommend excluding LED Reflector lamps and LED PAR lamps from the scope for the reasons stated above.

Given the lack of analysis demonstrating technical feasibility and cost effectiveness, we recommend that all of these technologies be removed from the scope of this rulemaking. A future rulemaking covering one or more of these product areas may be appropriate if a future analysis supports such actions.

Recommended Standards Change for E26 or GU-24 A-line LED lamps

Per the discussion above, GE recommends the following changes in the proposed LED Lamp standard to greatly simplify the requirements while achieving greater consumer adoption and energy savings:

State –regulated LED lamps with lumen output of ~~150~~ 310 lumens or greater and manufactured on or after January 1, 2017 shall have:

~~(i)~~ A color point that meets the ANSI C78.377 Standard for Color Targets and Color Consistency ~~A color point with a Duv that is:~~

~~1. No less than -.0033~~ (Alternatively change to a Duv that is no less than -.006 and no greater than .006 from $57700 \times (1/T)^2 - 44.6 \times (1/T) + 0.00854$ where T means the measured correlated color temperature)

~~2. No greater than $57700 \times (1/T)^2 - 44.6 \times (1/T) + 0.00854$ where T means the measured correlated color temperature.~~

~~i.~~ *Lamps that are rated with a color temperature of 3000K or less and have a color point that is more than 4 McAdam steps below the black body curve do not have to meet this requirement (This is to allow lamps to be designed in a color space around the "ANSI White Curve" such as GE Reveal lamps.)*

(ii) A CRI (Ra) of ~~82~~ 80 or greater

~~(iii) Individual color scores of R1, R2, R3, R4, R5, R6, R7, and R8 of 72 or greater.~~ (Alternatively change R8 minimum to 50.)

(iv) A power factor of ~~0.7~~ 0.5 or greater (Alternatively, require Power Factor requirements in ENERGY STAR Lamps 2.0.)

(v) A rated life of 10,000 hours or greater as determined by the lumen maintenance and time to failure test procedure

(vi) State-regulated LED lamps that have an ANSI standard lamp shape of A shall meet the omnidirectional lamp requirements of ENERGY STAR's Product Specification for Lamps Version ~~1.1~~ 2.0. State-regulated LED lamps that have an ANSI standard lamp shape of B, BA, C, CA, F, or G shall meet the decorative light distribution requirements of ENERGY STAR's Product Specification for Lamps Version ~~1.1~~ 2.0.

(D) In addition to the requirements in 1605.3(k)(2)(C), state-regulated LED lamps manufactured on or after January 1, 2019 shall have a standby mode power of ~~0.2~~ 1.0 watts or less. (As an alternative, require standby mode power specifications in ENERGY STAR Lamps 2.0. To greatly simplify this standard, and allow for much easier manufacturer compliance, CEC can simply require manufacturers to meet the Color, Power Factor, Omnidirectional Lamp requirements, and Standby requirements of ENERGY STAR Lamps 2.0. Although this standard is voluntary, many LED products will be designed to meet this standard in 2017.)

Table K-14
Standards for State-regulated LED Lamps

Effective Date	*~~Minimum Compliance Score~~ Minimum CRI*	*Minimum Efficacy Lumens per Watt*
January 1, 2017	*~~277~~ 90*	*65*
January 1, 2017	*80*	*75*
January 1, 2019	*~~297~~ 90*	*~~80~~ 75*
January 1, 2019	*80*	*85*
~~The compliance score shall be calculated as the sum of the efficacy and 2.3 times the CRI of the lamp.~~		

The rationale for GE Lighting's recommended changes to the CEC's proposed A-line LED lamp specifications are detailed in the preceding arguments.

Small Diameter Directional Lamps

Without further narrowing the scope of the proposed Title 20 regulation, some lighting systems and specialty equipment would become obsolete. As written, the staff proposal covers many MR 16 lamp types that currently have no LED equivalent at any efficiency level, and will not have an LED equivalent by 2018, and the proposed specifications cannot be achieved by existing products. Further, it is our understanding that the Commission does not intend to adopt a regulation that would eliminate lighting options for any consumer or commercial application. Accordingly, the Scope of the proposed Title 20 regulation covering small diameter lamps must be narrowed.

SPECIALTY LAMPS

The definition is too broadly worded and includes many specialty MR16 lamp types for which there is no LED replacement lamp. The MR16 lamp was originally developed for specialized equipment. The main advantage of the halogen MR16 lamp when used in specialized equipment is its ability to use an ellipsoidal reflector to focus the majority of the light into a narrow point at a precise location in front of the lamp. These lamps normally specify a working distance in order to perform properly in specialty equipment. These lamps often have unusual operating voltages, relatively short lamp lives and very precise optical focal points. In contrast, General lighting MR16 lamps operate at 12 volts, with less expensive versions being designed at 120 volts.

While there are many specialty lamp types, the majority of power is consumed in general lighting applications due to their long operating hours. LED MR16 lamps used for general accent lighting do not refocus the beam at a second focal point and would not work properly in specialized equipment requiring halogen MR16 lamps. Therefore, the specialty equipment already in service will continue to require specialty halogen MR16 replacement lamps.

If specialty MR16 lamps are taken off the market upon the effective date of the proposed regulation, the equipment they are used in, which can cost up to tens of thousands of dollars, will become immediately obsolete. Such forced obsolescence cannot be justified as cost effective pursuant to Public Resources Code section 25402(c)(1) because CEC would not be able to demonstrate that the proposed standard "does not result in any added total costs for consumers over the designed life of the appliances concerned", which in this case would necessarily include the cost of replacing the specialty equipment. For these reasons, halogen MR16 products used in specialty applications must be excluded from the regulations by redefining the scope. This can be accomplished by limiting the **lamp voltage**, **lamp life** and **lumen output** (some equipment uses very high lumen output specialty lamps) currently covered by the proposed scope.

DIMMING

A recent DOE Caliper Report, Report 22.1, dated August 2015 documented many performance problems with LED MR16 lamps used on dimming systems. In most cases, the transformer and dimming system had to be replaced for the user to get full dimming performance with these lamps. While this outcome may be cost-effective in some simple dimming applications, it would not be cost-effective for advanced dimming systems used in restaurants and other commercial and custom residential applications. Some of these advanced dimming systems can cost many thousands of dollars to purchase and install. Even when replacing the components, the system will be unable achieve the deep dimming performance of Halogen MR16 lamps required in certain applications such as home theatre applications. The following issues documented in the Caliper report illustrate these problems:

1. LED MR16 lamp performance on actual transformers demonstrated substantial performance variation and clearly indicated the difficulty in retrofitting LED lamps into existing systems intended for use on Halogen MR16 lamps.

2. The MR16 form factor and system requirements pose substantial challenges for LED technology compared to line voltage products. The small size poses unique driver design challenges and trade-offs including greatly increased thermal challenges. Lamps that have thermal issues will have significantly shortened lamp lives.

3. The system requirements often require an electronic driver, an electronic transformer and an electronic dimmer, all designed by different manufacturers, to work together. This can lead to unwieldy compatibility issues and result in complications before, during and after installation as well as unacceptable performance. Caliper determined that most LED MR16 lamps are only compatible with certain combinations of equipment. In many cases, MR16 LED lamps exhibited undesirable dimming behavior, such as dead travel or erratic dimming performance due to incompatible electronic circuits in the driver, transformer and/or dimmer.

4. When testing an electronic transformer on an incandescent dimmer most LED MR16 lamps did not dim in a reasonable manner even though they were marketed as dimmable. Some products dimmed in a non-monotonic manner, meaning light levels could go higher when they were dimmed lower, and many did not dim below 60% light output.

5. The presence of audible noise greatly increased when dimming. In addition, the overall flicker index was quite poor with lamps exhibiting objectionable flicker when dimmed.

6. The MR16 LED lamps demonstrated irregular or unpredictable dimming, essentially showing a high level of incompatibility with the transformer-dimmer system. None of the LED products matched the dimming curve of the halogen benchmarks, and the flicker performance of most of the lamps was very poor.

7. In retrofit situations, where other system components are unknown, a significant investment in time and new equipment may be required to achieve acceptable system compatibility and performance. The likelihood that a combination of a new LED MR16 lamp, an unknown transformer, and an unknown dimmer will operate smoothly and meet halogen performance expectations is extremely low and highly unlikely.

To address these issues, the CEC must allow some types of Halogen MR16 lamps to remain on the market to be used on advanced dimming systems. Replacing systems that can cost over $10,000, which would be necessary to preserve product efficacy[4], would not be cost-effective pursuant to Public Resources Code section 25402(c)(1). This is especially true because the lamps used in these applications draw very little power when dimmed. Halogen MR16 lamp life is also greatly increased when lamps are regularly dimmed, meaning fewer replacements and lower total cost to the consumer.

Commercial MR16 lamps used at full power, up to 16 hours a day, 7 days a week, require a long lamp life of 3000 to 6000 hours to make their use practical. These applications also use the most power and are well suited to LED conversion in terms of maintenance and product cost. Allowing continued use of some halogen MR16 lamps on dimming systems would enhance the cost-effectiveness of the proposed standard and preserve product and system efficacy for the consumer with minimal impact on statewide energy savings. This can be done by limiting the scope to MR16 lamps with a relatively long lamp life.

LUMENS

As stated in the Caliper report: *"The MR16 form factor and system requirements pose substantial challenges for LED technology. The small size poses unique driver design challenges and trade-offs including greatly increased thermal challenges."* The lumen output of a small LED MR16 lamp is limited by the need to dissipate heat generation during lamp operation. It is easier to match Center Beam

[4] Public Resources Code section 25402(c)(1) also requires CEC to consider the "impact on product efficacy for the consumer" when determining cost-effectiveness.

Candlepower than to match lumens, which is acceptable in applications which have a secondary general lighting system. However, in applications that also rely on the lumen output to provide general illumination to the surrounding area, as well as accent light, matching lumens is necessary. Whether the LED replacement MR16 lamp is acceptable ultimately depends on the application. As no LED MR16 lamp has been demonstrated to achieve more than approximately 800 lumens due to the above noted technology limitations, the scope of the standard must be limited by total lumen output. We note that there is a high lumen scope limitation on the Light Emitting Diode (LED) lamp proposal. There is simply no LED MR16 lamp available today or anticipated by 2018 that can achieve the 1200+ lumens produced by some halogen MR16 lamps. Sales of these high lumen lamps are very small compared to sales of 50 watt, 35 watt and 20 watt Halogen MR16 lamps. Narrowing the scope in this way will have little impact on energy savings. Moreover, the scope of the proposed standard must exclude these higher lumen products because replacement LED lamps simply do not exist for such applications.

To address these serious concerns, and to ensure products are available that work in all applications after the regulation takes effect, the proposed definition must be changed. GE supports the industry suggestion to address these issues as follows:

a) "State-regulated small diameter directional lamp" means a directional lamp with a diameter less than or equal to 2.25 inches and a GU-10, GU5.3, GUX5.3, GU8, GU4, or E26 base that is capable of meeting performance specifications when operated within a voltage range of 11 to 13 volts, or, 110 to 130 volts, has a rated life of more than 2000 hours, and has a lumen output greater than 150 lumens and less than 825 lumens. Small diameter directional lamp includes incandescent filament, LED, and any other lighting technology that falls within this definition. State-regulated small diameter directional lamp does not include products that use LEDs and have an E-26 base, which are state regulated light emitting diode lamps.

Rationale for proposed changes:

1. Limiting the voltage range to 12 volt and 120 volt products, or products close to these voltages, will appropriately focus the standard on lamps designed for general lighting applications. Specialty lamps made at other voltages (e.g., 8, 10.8, 13.8, 14.5, 17, 19, 20, 21, 24, 30, 36, 68, and 82 volts) will not be affected as there is no possible LED replacement lamp that provides the proper optical performance for specialized equipment.

2. Limiting Halogen lamp life to 2000 hours or less will ensure that these products are only used in dimming applications. It will also ensure that specialty products designed at 12 volts or 120 volts, but which have very short lamp lives, are not affected.

3. Limiting the scope only to lamps rated for less than 825 lumens ensures that there will be LED MR16 lamps available for all applications. It will also ensure that specialty products designed at 12 volts or 120 volts, but which have very high lumen output, are not affected. There are no known LED MR16 products that have a lumen output in the high lumen ranges. Placing a floor of 150 lumens recognizes that such products are already very low wattage products that use very little energy and should not be subject to energy efficiency regulations.

SMALL DIAMETER LAMP PRODUCT EFFICACY REGULATION

For the LED MR16 lamps that will be expected to replace the majority of MR16 halogen 20w, 35w, and 50w lamps which represent the largest amount of energy use, the efficiency levels and equations are much too aggressive.

Higher CRI lamps will have inherently lower efficiency and GE agrees that high CRI lamps should have a lower efficiency limit. However, instead of proposing a "minimum" efficiency level that will ensure MR16 products are available in 2018 for all general service applications[5] – a hallmark of Title 20 appliance efficiency standards – the CEC has instead proposed an efficiency level that will only be achievable by a small number of specialty LED MR16 lamps in a narrow range of applications.

While we recognize that large efficiency gains have been achieved in LED technology in the past 5 years, the rate of progress is slowing as the technology and products mature. Moreover, as previously noted, opportunities for future efficiency gains in MR16 lamps are limited relative to general service lamps due to their small size and particular performance requirements. The average efficiency of LED MR16 lamps sold in California today is approximately 56 LPW based on a recent Navigant report[6]. Even if one assumes an ambitious 10% increase in efficiency in each of the next two years, the average will only reach a little over 65 lumens per watt by 2018. The vast majority of the LED MR16 lamps being sold in the USA in 2018 would still be well below the proposed 80 LPW standard.

An Australia E3 study was released in August 2015[7] which evaluated performance characteristics of LED MR16 lamps on a global basis. Figure 46 illustrates that the average worldwide efficiency today of LED MR16 lamps is less than 45 LPW. Only one lamp in this study reached an 800 lumen output, and its efficiency was less than 50 LPW. Only two lamps out of over 100 evaluated for this study were over 80 LPW. Only 6 lamps (or less than 5%) were over 70 LPW, and these lamps represented a very narrow lumen range of between 340 and 620 lumens. Thus, even if one assumes aggressive efficiency gains moving forward, available market data indicates that CEC's proposed efficacy levels are at least 10 LPW too high to ensure that products will be available for all lumen ranges and for all applications.

If CEC's current proposal is adopted without further modification, very few products would qualify at any lumen range. The proposal would set an optimal performance goal rather than a floor designed to ensure a minimum level of performance that meets consumer expectations, achieves additional energy efficiency gains and preserves product availability at a reasonable price. Only a few best-in-class specialty LED products would be available from a limited number of suppliers.

If the state wishes to have many manufacturers competing with quality products widely available for consumers, CEC should lower the proposed levels by at least 15 LPW, which would still eliminate over 75% of today's products from the market.

1) >=65 LPW minimum (current ENERGY STAR Standard), or
2) >= 55 LPW if the CRI is 90 greater

[5] Covering 2 voltages, at least 5 wattages and over 10 beam spreads.
[6] California LED Workpaper Update Study – August 28, 2015, Table A-12
[7] Product Profile: Light Emitting Diodes (LEDs), LED Lighting in Australia and New Zealand, August 17, 2015

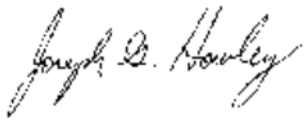
Recommended specification changes:

(3) State-regulated Small Diameter Directional Lamps. State-regulated small diameter directional lamps manufactured on or after January 1, 2018 must have a rated life of 25,000 hours or greater as determined by the lumen maintenance and time to failure test procedure and meet one of the following requirements:

(A) have a luminous efficacy of >= ~~80~~ 65 lumens per watt~~.~~ and a minimum CRI of 80.
(B) Have a minimum luminous efficacy of ~~70~~ 55 lumens per watt or greater and a minimum CRI of 90. ~~compliance score of 165 or greater, where compliance is calculated as the sum of the luminous efficacy and CRI.~~

LED lamps are of crucial importance to the future of the Lighting Business.
Thank you for addressing our concerns.

Sincerely,



Joseph G. Howley
Mgr. – Industry Relations

GE Lighting
1975 Noble Road
Cleveland, OH 44112

216-266-9729
joseph.howley@ge.com