Proposal for Standards – LED lamps

Appliance Efficiency Standards and Measures

for California Energy Commission's Invitation to Submit Proposals

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Submission to California Energy Commission 2013 Rule Making (by email)

Re: Docket No. 12-AAER-2B – Lighting – LED Lamps

Soraa expresses its gratitude for the opportunity to submit supporting material for considered energy measures related to lighting appliances.

The proposal for LED lamps follows the format provided.

We look forward to provide clarification and further information if desired, to support the 2013 rule making.

Best regards,

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1 Executive summary

Soraa thanks the California Energy Commission for the provided opportunity to submit proposals for the 2013 Appliance Rulemaking.

Soraa Inc. is a California based manufacturer and developer of lighting products, using a GaN substrate based lighting-emitting diode (LED) technology, called GaN on GaN™. Being a young company with limited resources, we provide a short proposal focusing on a few key elements.

Soraa recommends keeping regulations open to innovative products with respect to form and size, output, controllability and connectivity. The regulations should not be limited to or constrained by today's lamp shapes, sizes, form and functionality.

Our proposal focuses on two key factors to maximize end user expectation. When end user expectations are met, LED lamps can be adopted broadly with accompanying benefits of energy savings and economic advantages.

Soraa proposes to differentiate LED lamp efficacy requirements (lm/W) in relation to quality of light. The required lm/W for greater than 90CRI products with an R9 greater than 50, should be less than the required efficacy of products with a CRI lower than 90. This is a valuable trade-off, because higher CRI products address a primary concern of a substantial segment of end users who state that quality of light is of primary concern when considering adopting energy saving lighting technology. The positive effect that increased light quality has on adoption of energy saving lamps, outweighs the lower efficiency that is inherently associated with higher color rendering products.

Soraa further proposes a lifetime requirement of 10,000 hours for LED lamps, based on operating conditions that correspond to enclosed or poorly ventilated fixtures. LED lamps operate at higher temperatures in these types of fixtures and as a result life time expectations are shorter. The current practice to specify lamp life on open fixture conditions is not in line with many real life applications and has the potential to disappoint end users.

In line with a life requirement of 10,000 hours, Soraa proposes lamp qualification test requirements to be limited to 3,000 hours. On the one hand, long test durations increase the confidence that products are durable and reliable. On the other hand, long testing hours delay the market availability of more efficient products. Also, with energy efficiency of LED lighting products increasing at a significant rate, locking in today's products with very long lifetimes actually serves to reduce the potential energy savings compared to the case wherein lamps are replaced at a reasonable cycle.

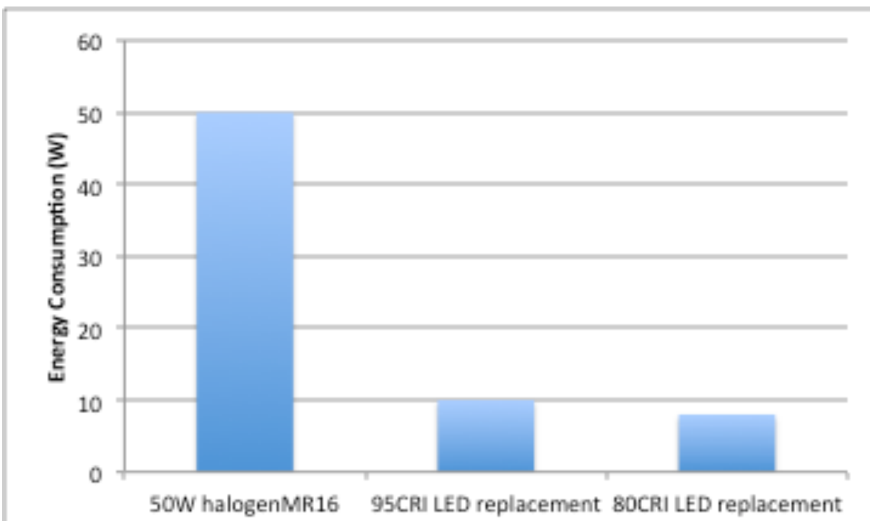
2 Product Description and Proposal Scope

2.1 Technical Description

- LED lamps of various shapes and sizes
- Not limited to ANSI / CIE defined sizes and bases
- With or without an internal driver, that can be driven of mains voltage or require a transformer (example 12V or 24V DC or AC, can be a fixed or variable voltage) or LED driver module supplying constant or varying current
- Directional and emitting light in all directions
- Indoor and outdoor use
- With optional variable light output (dimmable and not dimmable)

2.2 Technologies and Best Practices for Energy Efficiency

LED lamps with high color rendering, tend to have lower efficiency than parts with worse color rendering properties, under comparable conditions. For halogen MR16 replacement, the difference between a 95CRI lamp and 80CRI lamp is 10W vs. 8W. This is a 20% difference. The percent difference in energy saved between these two lamps is much smaller, only 4% (80% savings vs. 84% savings).



With a separate energy efficiency requirement for 90CRI LED lamps, they can be offered at a comparable price to the end user (refer to section 8.1) as 80CRI lamp. With both options available side-by-side, it is expected that overall adoption will increase. As a result, more energy inefficient incandescent and halogen lamps will be replaced and energy savings increase.

Shorter qualification cycles for LED lamps can have a net positive effect on overall energy consumption. If for example a product improvement that results in 20% less energy consumption can be released after 3,000h (proposal) instead of 6,000h (Energy Star), an overall reduction of energy consumption of 8% of the lamps sold in a particular year can be achieved.

2.3 Design Life

The following key elements form the basis of LED lamp life

- Maintenance of light output
- Maintenance of light color
- Likelihood of occurrence of failures

Typically for LED lamps, life expectation according these three elements is shortened at elevated temperatures.

References of LED lamp life tend to emphasize light output maintenance with little attention for lamp failures. Soraa proposes that LED lamp qualification requirements include testing to validate failure levels.

Operating hrs / day	Life time in years based on 10,000 hours
1	27.4
2	13.7
3	9.1
4	6.8
5	5.5
10	2.7
24	1.1

Most LED lamps on the market today meet long life claims in terms of lm and color maintenance, but are recommended not to be used in enclosed or poorly ventilated fixtures. It is expected that they do not reach their life claims when operated at the substantially higher temperatures that can occur in a fully enclosed or poorly ventilated fixture.

Examples of poorly ventilated or fully enclosed fixtures

2.4 Manufacturing Cycle

Soraa's perspective is that innovations in LED performance (lm/W) can be delivered to the market in an annual cycle. These improvements can be delivered within existing lamp model configurations. These improvements can be reductions in power consumption while maintaining the same light output, or increases in light output while maintaining the same power consumption.

2.5 Product Classes

Soraa recommends that regulation is open to innovative lamp product configurations. While today's scope might be largely determined by incumbent lamp types like MR16, PAR lamps, candelabra, etc. with for example Edison style bases, future lamp types can have different configurations and dimensions for example to enhance control or communication options and because the LED technology platforms allows for reconfiguration of the larger lighting system.

Product classes include:

- LED lamps of various shapes and sizes
- Not limited to ANSI / CIE defined sizes and bases
- With or without an internal driver, that can be driven of mains voltage or require a transformer (example 12V or 24V DC or AC, can be a fixed or variable voltage) or LED driver module supplying constant or varying current
- Directional and emitting light in all directions
- Indoor and outdoor use

- With optional variable light output (dimmable and non-dimmable)

Refer to Energy Star Draft 4 for additional definitions of lamp product classes

3 Unit Energy/Water Usage

A good summary of Energy use for LED lamps is giving in the IOU report on LED lamps that was prepared in response to CEC invitation to participate in 2013 appliance rulemaking.
Additional up to date sources are Energy Star qualified lamps listing and Lighting Facts full product list.

3.1 Duty Cycle

Different states that LED lamps can be in:

- Off
- Standby
- On in dimmed mode (0-100%)
- On at nominal output (100%)

Estimates on duration in each state are largely dependent on lamp use and are not available to us.

3.2 Efficiency Levels

Soraa proposes multiple tiers for LED lamp efficiency, depending on quality of light (CRI) and lamp type:

	Lamp Rated Wattage	80 ≤ CRI < 90 0 ≤ R9 < 50	CRI ≥ 90 R9 ≥ 50
Omni directional	< 15	60	55
	≥ 15	70	65
Directional	< 20	45	40
	≥ 20	55	50
Decorative	< 15	50	45
	15 ≤ W < 25	55	50
	> 25	65	60

Lamp Efficacy (initial lm/W)

3.3 Energy and/or Water Consumption

Average operating hours per year is not available to us

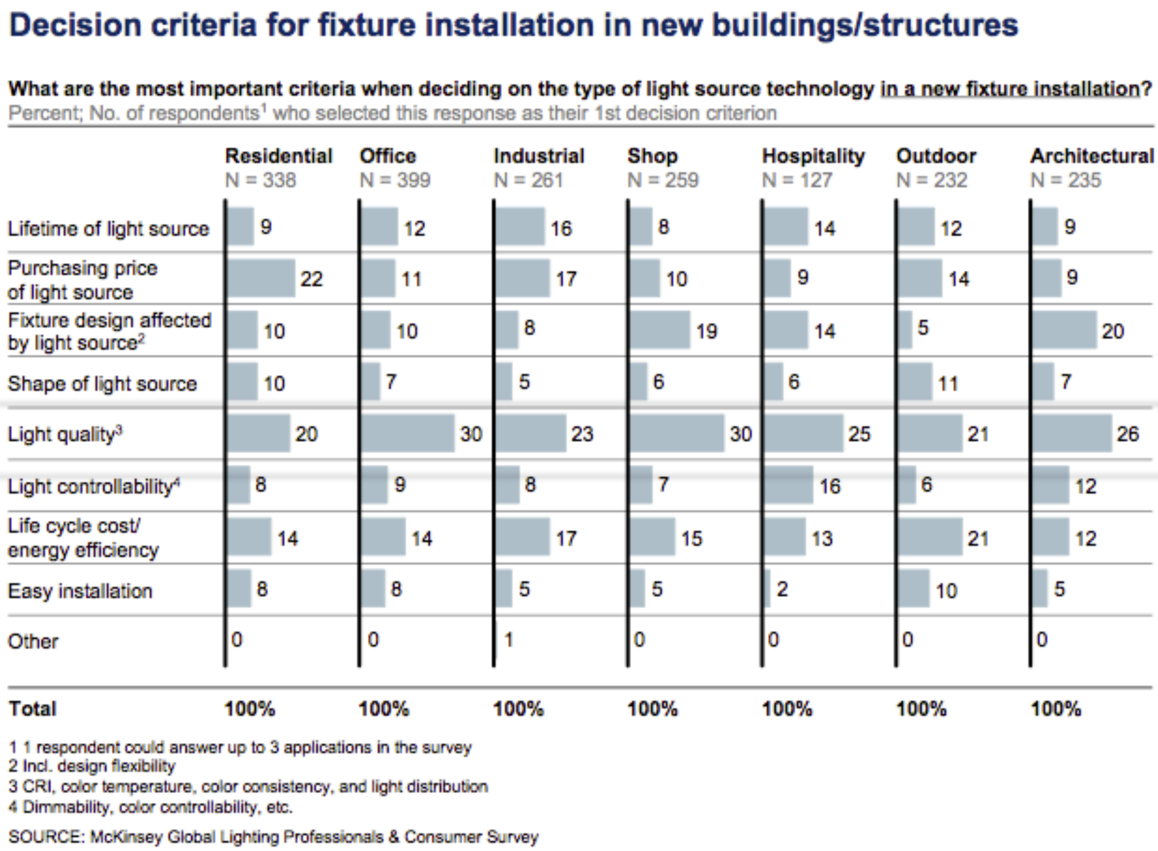
4 Market Saturation and Sales

4.1 California Stock and Sales

Refer to Navigant reports for DOE on LED market adoption in common lighting applications and US 2010 lighting market characterization, update 2012. No specific California data is available to us.

4.2 Efficiency Options: Current Market and Future Market Adoption

High efficiency compact fluorescent with a CRI around 80, has been available for sale for many years and has seen limited adoption of around 20% (Relighting American Homes with LEDs, Siminovitch). It is documented that the modest adoption of CFLs is in part due to their poor light quality. For adoption of LED lighting, quality of light is a top concern for both commercial and residential lighting (McKinsey, Lighting the Way)



In addition to poor quality of light, many CFL's exhibit shortened life spans, particularly when they are used in a warm environment like a fully enclosed or poorly ventilated fixture.

California's own LED lamp quality specification is in place to address the concern of poor quality of light as a barrier to broader adoption of energy efficient lighting.

5 Statewide Energy Usage

The information of number of lamps used in CA is not available to Soraa.

6 Proposal

6.1 Summary of proposal

Soraa has the following proposals to be included in the requirements for LED lamps:

- Differentiated luminous efficacy requirement based on CRI / R9.

	Lamp Rated Wattage	$80 \le CRI < 90$ $0 \le R9 < 50$	$CRI \ge 90$ $R9 \ge 50$
Omni directional	< 15	60	55
	≥ 15	70	65
Directional	< 20	45	40
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With a separate energy efficiency requirement for 90CRI LED lamps, they can be offered at a comparable price to the end user (refer to section 8.1) as 80CRI lamp. With both options available side-by-side, it is expected that overall adoption will increase. As a result, more energy inefficient incandescent and halogen lamps will be replaced and energy savings increase.

- Lamp life requirement of 10,000h based on fully enclosed fixture conditions. Lamp life is based on a requirement on color shift, reduction in light output and a drift in color point. Related qualification requirements 3,000h. If lamp life of 10,000h is ensured in fully enclosed fixtures, a substantially longer life in open or well ventilated fixtures can be expected

Shorter qualification cycles for LED lamps can have a net positive effect on overall energy consumption. If for example a product improvement that results in 20% less energy consumption can be released after 3,000h (proposal) instead of 6,000h (Energy Star), an overall reduction of energy consumption of 8% of the lamps sold in a particular year can be achieved.

6.2 Implementation Plan

- Lamp manufacturers – submitting data for products
- Validation by independent qualified test laboratories
- Submission and keeping of records – appointed by CEC.

6.3 Proposed Test Procedure(s)

Soraa proposes a substantially shortened test procedure. Details of the test procedure and required results have to worked out. The requirements should be related to meeting low lamp failure levels and maintaining sufficient light output and color stability of the lamp over its life. The test conditions must correspond to the operating conditions of the lamp in fully enclosed or poorly ventilated fixture.

6.4 Proposed Regulatory Language

To be proposed at a later point in time

7 Technological Feasibility

As can be seen from the Energy Star qualified products lists and the Lighting facts products list, many products meet the minimum 80CRI requirements (see also Report on LED Replacement lamps, McGaraghan May 2013). The proposed difference between 80CRI and 90CRI required minimum efficacy is in line with corresponding LED efficacy difference for 80 and 90CRI. Hence, it is feasible that the proposed minimum efficacy requirements can be met with today's 90CRI LED components.

LED lamps capable of running in fully enclosed fixtures, without compromising life are currently available on the market. The offering of LED lamps that combine this with sufficiently high output to replace mainstream incandescent and halogen lamps is limited, but their existence is a proof of feasibility. In addition, LED products and the electronics that are required to drive them are becoming widely used in high temperature applications like automotive headlamps and have proven to be durable and reliable in those conditions.

8 Economic Analysis

8.1 Incremental First Costs

Considering incremental first cost, it is important to take the longer life of LED lamps into account. Comparing halogen products with LED lamps, a 10x longer life for the latter can be assumed.
Soraa is not able to provide a good data set for cost comparisons between different lamp technologies, across multiple lamp types.

Incremental cost of high CRI: Soraa MR16 lamps of 80CRI and 95CRI are offered on Amazon and 1000bulbs.com for the same price.

8.2 Incremental Operating Costs and Savings

Soraa is not able to present a generic cost savings projection for a broad range of lamp types.

8.3 Infrastructure Costs and Savings

Replacement lamps are intended to be fully compatible with the infrastructure. No additional costs are expected.

Because of their lower energy consumption and because they generate less heat, LED lamps are expected to have a positive impact on overall heat and energy load of buildings. Consequently, cooling systems and energy delivery systems can be sized smaller and / or operate at a lower load level.

Soraa is not able to quantify these benefits on a more generic basis.

8.4 State or Local Government Costs and Savings

Soraa does not have sufficient information to provide estimates

8.5 Business Impacts

Since in many scenario's the payback time for LED lamps in comparison to halogen and incandescent is less than a year, substantial savings for business can be achieved. In addition, the long life of LED lamps requires substantially less frequent lamp replacements.

8.6 Lifecycle Cost and Net Benefit

9 Savings Potential

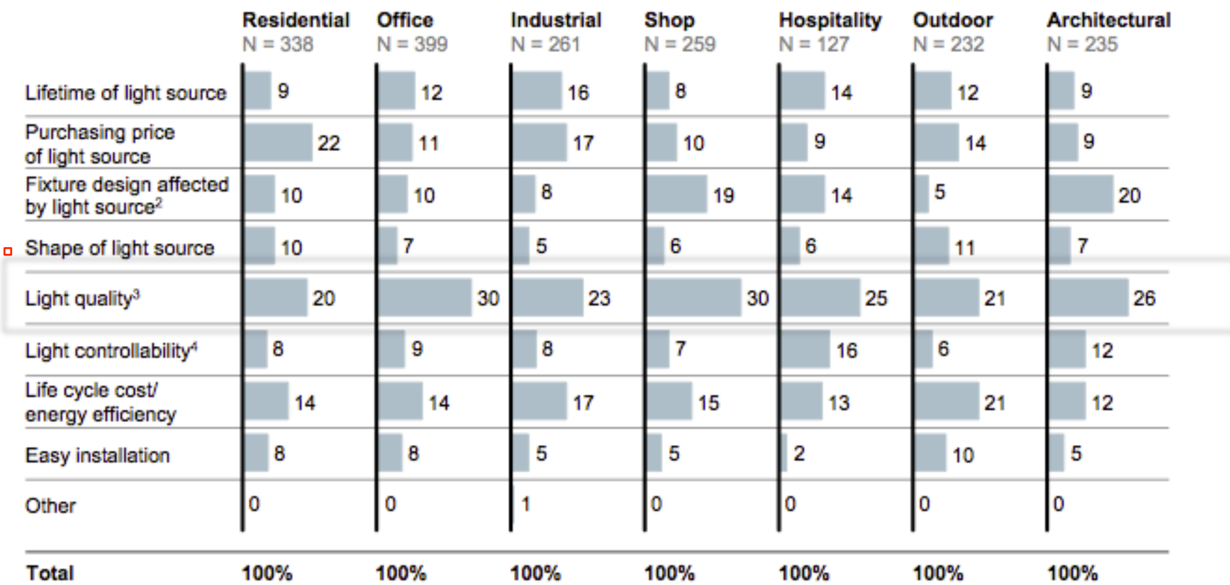
Over the life of 25,000h, the saving potential of an LED MR16 lamp in comparison to a halogen 50W halogen MR16, amounts to $275, for a single lamp. Refer to appendix Savings Potential.

10 Acceptance Issues

Quality of light has been documented by the McKinsey Lighting the Way survey as a key element to customer adoption.

Decision criteria for fixture installation in new buildings/structures

What are the most important criteria when deciding on the type of light source technology in a new fixture installation?
Percent; No. of respondents[1] who selected this response as their 1st decision criterion



1 1 respondent could answer up to 3 applications in the survey
2 Incl. design flexibility
3 CRI, color temperature, color consistency, and light distribution
4 Dimmability, color controllability, etc.

SOURCE: McKinsey Global Lighting Professionals & Consumer Survey

11 Environmental and Societal Impacts

Soraa cannot provide information on this.

12 Federal Preemption or Other Regulatory or Legislative Considerations

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13 Methodology for Calculating Cost and Savings

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14 Bibliography and Other Research

Lighting the Way – Perspectives on the global lighting market – McKinsey Company

LED replacement lamps, Michael McGaraghan, May 9 2013, prepared in Response to CEC 2013 Pre-Rulemaking Appliance Efficiency Invitation to Participate

Adoption of Light-Emitting Diodes in Common Lighting Applications, April 2013, Prepared by Navigant for DOE

2010 U.S. Lighting Market Characterization, January 2012, Prepared by Navigant for DOE

Relighting American Homes with LEDs, Siminovitch

Energy Star specification draft 4

Energy Star qualified Lamps: downloads.energystar.gov/bi/qplist/Lamps_Qualified_Product_List.xls

Lighting Facts listed products: http://www.lightingfacts.com/content/products

APPENDIX: Cost Analysis Assumptions

[The Energy Commission used the following rates to evaluate initial proposals received in response to the August 31, 2011 scoping workshop.

The cost of electricity: $0.15 per kWh

The cost of natural gas: $1 per therm

The cost of water: $0.0052 per gallon

Discount rate: 3%

The Energy Commission is investigating whether to update these figures over the course of the rulemaking. Stakeholders are welcome to suggest appliance-specific rates, or alternates to these flat rates to support cost-effectiveness of their proposals. If stakeholders choose a different rate, they should describe the analysis and rationale for the different rate.]

APPENDIX: Savings potential

PAYBACK ANALYSIS:	
LED LAMP COST	**$25.00**
Sales Tax*	$0.00
Freight Estimate & Duty*	$0.00
Labor Cost**	$0.00
Utility Rebate Incentive***	$0.00
NET INITIAL COST PER LAMP	**$25.00**
Lamp Wattage + Transformer	10
Annual Operating Hours	25000
$/kWh	$0.15
Watts Saved	42.0
Annual Energy Cost	$37.50
ANNUAL ENERGY SAVINGS PER LAMP	**$157.50**

Replacement Lamp Cost****	$0.00
Replacement Labor Cost	$5.00
Lamp Life	25,000
Annual Operating Hours	25000
Annual Relamping Cost	$5.00
ANNUAL MAINTENANCE SAVINGS PER LAMP	**$105.00**
Cooling Multiplier	0.34
Annual % Cooling is Run	100%
Adjusted Cooling Multiplier	0.34
Adjusted HVAC Cost	$3.40
ANNUAL HVAC COOLING SAVINGS PER LAMP	**$14.28**
ANNUAL SAVINGS PER LAMP (Energy + Maint + Cool)	**$276.78**