

DOCKETED

Docket Number:	15-AAER-06
Project Title:	Small Diameter Directional LED Lamps and General Purpose LED Lamps
TN #:	207130
Document Title:	Supplemental Staff Analysis for General Service Light-Emitting Diodes (LEDs)
Description:	N/A
Filer:	Harinder Singh
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	12/28/2015 8:59:00 AM
Docketed Date:	12/28/2015

Memorandum

To: Docket #15-AAER-6

Date: December 23, 2015

Telephone: (916) 654-4147

From: **California Energy Commission** Kristen Driskell, Supervisor, Appliance Efficiency Program,
Efficiency Division
1516 Ninth Street
Sacramento CA 95814-5512

Subject: **Supplemental Staff Analysis for General Service Light-Emitting Diodes (LEDs)**

INTRODUCTION

The purpose of this supplemental staff analysis is twofold:

- Provide information about the cost-effectiveness and technical feasibility of the Energy Commission's proposed changes in 15-day language to the Tier 1 compliance equation for general service LEDs, and
- Provide additional information about the cost-effectiveness of the individual color metrics (R1-R8) for general service LEDs.

Under the Warren-Alquist Act, the Energy Commission's appliance efficiency standards must be both cost-effective to the consumer and based on feasible and attainable levels of efficiency (technically feasible). The Energy Commission Staff's *2015 Analysis of Small-Diameter Directional Lamp and General Service Light-Emitting Diode Lamp Efficiency Opportunities* presents evidence on both of these criteria for each product type. Specifically, the cost and savings analysis for general service LEDs, including the color rendering requirements, is on pages 69-78, and the technical feasibility is on pages 62-68.

PROPOSED CHANGES TO TIER 1 COMPLIANCE EQUATION

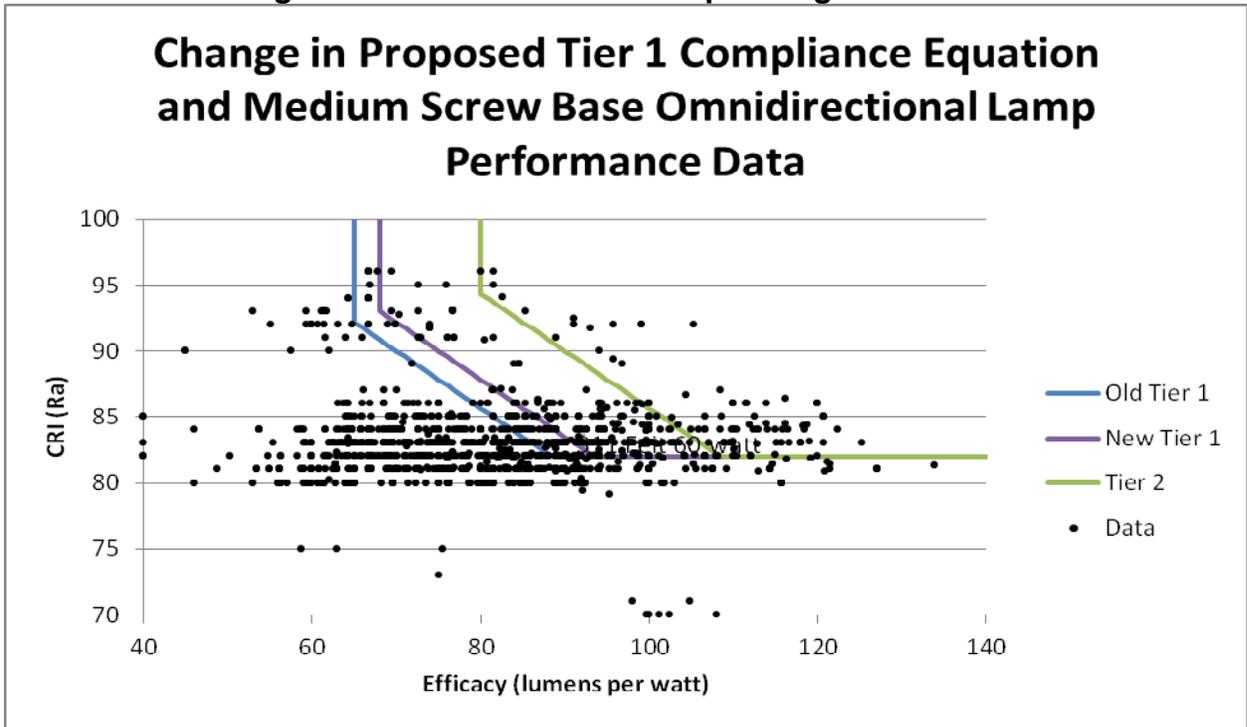
Proposed Changes

Staff proposes in 15-day language to modify the Tier 1 compliance equation as follows:

$$2.3 \times CRI + Efficiency \geq 282 \text{ and } CRI \geq 82, \text{ Efficiency} \geq 68 \text{ lpw}$$

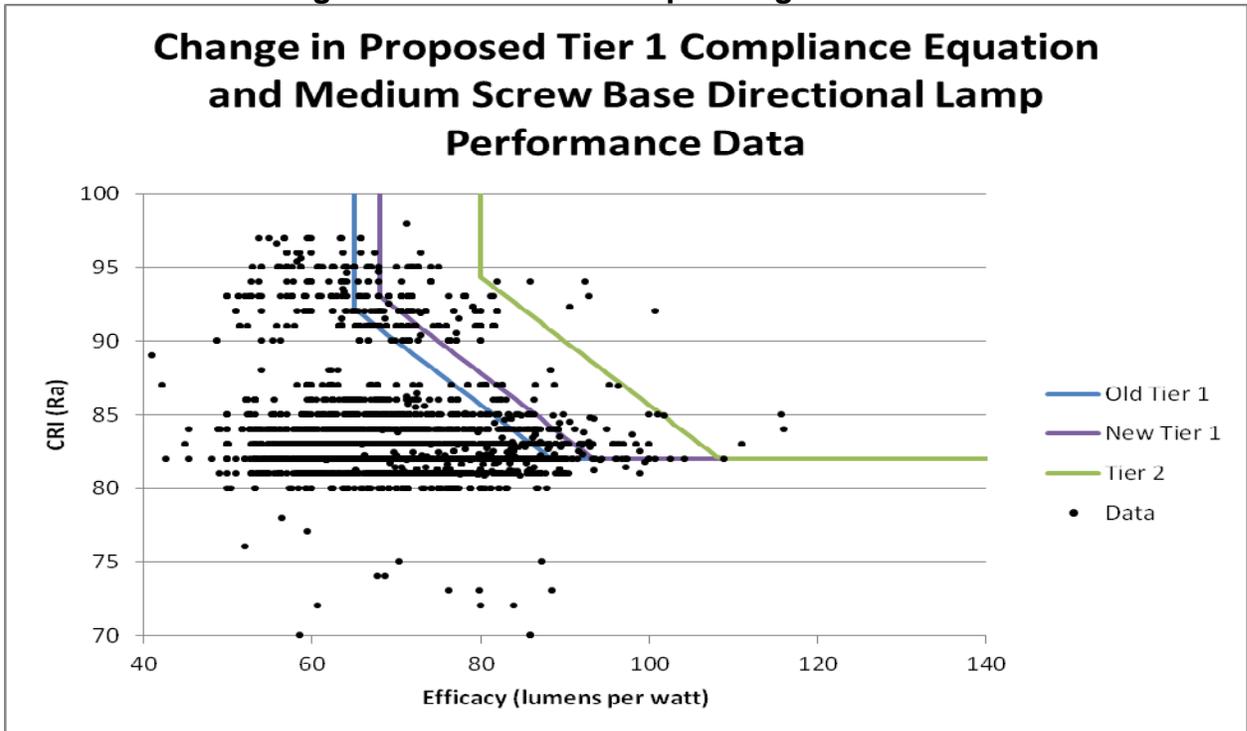
The Tier 2 compliance equation is unchanged. The proposed effective dates are January 1, 2018 for Tier 1 and July 1, 2019 for Tier 2. The proposed changes to Tier 1 are shown in purple in the Figures 1, 2, and 3 below for omnidirectional, directional, and decorative lamps, respectively.

Figure 1: Omnidirectional Lamp Change in Tier 1



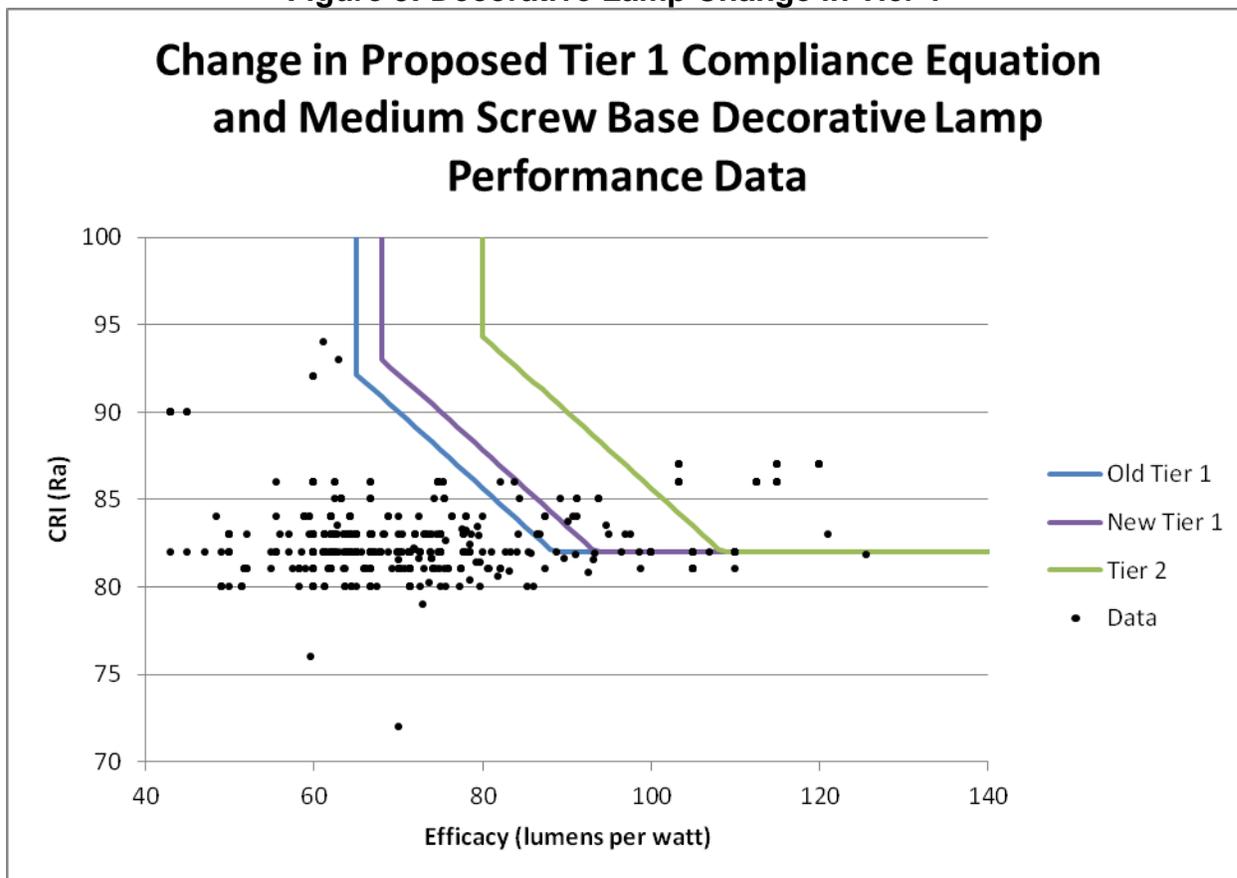
Source: California Energy Commission. The source of the data points is ENERGY STAR and Lighting Facts, June 2015.

Figure 2: Directional Lamp Change in Tier 1



Source: California Energy Commission. The source of the data points is ENERGY STAR and Lighting Facts, June 2015.

Figure 3: Decorative Lamp Change in Tier 1



Source: California Energy Commission. The source of the data points is ENERGY STAR and Lighting Facts, June 2015.

The effective date for the chromaticity, color rendering, light distribution, product life, and power factor requirements remain in line with the new Tier 1, and so are proposed to take effect on January 1, 2018, while the connected standby requirements remain in line with Tier 2, taking effecting July 1, 2019.

These changes are proposed to address stakeholder concerns raised during the public comment period on the 45-day language. Stakeholders expressed two primary concerns with the original Tier 1 standard: (a) that the least cost pathway for meeting the standard was inconsistent with current manufacturer processes with respect to “binning” LED packages and chips,¹ and (b) that the lifetime test would take approximately 4 months to complete, reducing the actual time that manufacturers had to redesign their products.² Extending the effective date for Tier 1 addresses both of

¹ See, e.g., Comment from Alex Baker, Lumileds (Dec.4, 2015), in reference to binning and supplying LED devices. Available at: http://docketpublic.energy.ca.gov/PublicDocuments/15-AAER-06/TN206865_20151207T153658_Alex_Baker_Comments_Lumileds_Comments_on_Title_20_45_Day_Langua.pdf.

² See, e.g., Comment from Kyle Pitsor, National Electrical Manufacturers Association (NEMA) (Dec. 4, 2015), at page 17-18, noting 3000-6000 hour test period for rated life under IES LM-84/TM-28. Available at http://docketpublic.energy.ca.gov/PublicDocuments/15-AAER-06/TN206828_20151204T051310_Alex_Boesenberg_Comments_NEMA_Comments_to_Title_20_45day_Langua.pdf.

these concerns by giving manufacturers additional time – more than a year from the originally proposed effective date – to optimize their processes to meet the standards at the least cost. As the cycle time for lamp design is 6-8 months,³ this gives manufacturers approximately two design cycles as well as time for testing to meet the proposed standard.

Technical Feasibility

In addition to extending the effective dates, which would not change the technical feasibility analysis for the standard, staff increased the stringency of the Tier 1 standard to ensure that the standard is not made irrelevant by the rapid improvements being made in terms of efficacy, quality, and cost of general service LED lamps. Staff has found that a significant number of lamp models already meet the CRI-efficacy tradeoff equation proposed in 15-day language for Tier 1: 349 medium screw-base omnidirectional lamps; 280 medium screw-base directional lamps; and 73 decorative lamps. This demonstrates that the revised compliance equation, all other standards being held constant, remains technically feasible.

Savings and Cost Analysis

The initial staff analysis of the cost-effectiveness of the standard was based on compliance with the Tier 2 levels. As the Tier 2 levels remain unchanged, this cost-effectiveness analysis also remains true with the adjustments to the Tier 1 levels. Thus, the proposed changes to the compliance equation are still cost-effective to the consumer.

The energy savings from the proposed changes to the Tier 1 compliance equation will decrease slightly due to the extension in the effective date, as this will eliminate a year of estimated savings from the standards. However, some of these lost savings are gained back through the adjustments in the compliance equation, which will require lamps to be more efficacious in 2018 than originally proposed. Staff believes that the difference in energy savings from the 45-day language to the 15-day language is very small, while the proposed change will be less burdensome to manufacturers, potentially less costly to manufacturers and consumers, and still achieve the goals of this rulemaking – to enact cost-effective standards that will reduce the wasteful consumption of energy in the state.

COST EFFECTIVENESS OF R1-R8 REQUIREMENTS

Staff's 2015 *Analysis of Small-Diameter Directional Lamp and General Service Light-Emitting Diode Lamp Efficiency Opportunities* highlights several different pathways to compliance with the color rendering requirements, and specifically R8, including adding red phosphor, adding a narrow band red phosphor, adding a red LED, or increasing overall CRI. (Pages 71-74). In conducting its cost-effectiveness analysis, the Energy Commission analyzed the lowest cost compliance pathway – adding red

³ *Id.* at page 18.

phosphor – to determine the cost-effectiveness of the regulation. This yielded an incremental cost of approximately \$0.15 to meet the CRI and R1-R8 requirements. Added to the costs of compliance with remaining requirements, the total estimated cost of compliance for medium screw-base LEDs is \$0.50, compared with over \$7.00 in estimated energy savings. These costs and savings compare only LED lamps to other LED lamps, and do not include savings from LED lamps that replace incumbent incandescent technologies.

Since the publication of the 45-day language and staff analysis, the Energy Commission received comments from stakeholders suggesting that while the R1-R8 requirements proposed are technically feasible (meaning that they can be achieved), the lowest-cost compliance pathway is not available to every manufacturer due to existing manufacturer binning and limited supply of LED components used to achieve that pathway.

Staff believes that extending the deadline to comply with the R1-R8 requirements will alleviate some of the barriers to the identified lowest-cost compliance pathway. Nonetheless, other compliance pathways remain cost-effective to the consumer. Staff's 2015 analysis includes costs for compliance pathways other than adding red phosphors. These costs range from the \$0.15 per unit estimated for adding red phosphor, to \$1.04 to add a red LED, to \$1.84 to improve the CRI to 90.⁴ The Energy Commission's initial incremental cost determination was \$0.50 for medium screw base omnidirectional lamps, \$1.50 for directional lamps, and \$1.00 for decorative lamps, based on a \$0.15 cost per unit to add red phosphors. Assuming this cost were now \$1.84, the highest cost assumed to improve the lamp to 90 CRI, the total incremental cost per unit for omnidirectional, directional, and decorative lamps would be \$2.19, \$3.19, and \$2.69, respectively. At estimated energy-saving benefits of \$7.80, \$11.57, and \$4.47, respectively, per unit, the benefits still clearly exceed the costs of improvement, making the color rendering and efficacy requirements, together, clearly cost-effective even in the most conservative case. Again, as the incremental cost and unit energy savings analysis was based on Tier 2, changes to the compliance equation for Tier 1 have no impact on the estimated costs and benefits of the proposed standards.

⁴ Singh, Harinder, Ken Rider, 2015. *Analysis of Small-Diameter Directional Lamp and General Service Light-Emitting Diode Lamp Efficiency Opportunities*, California Energy Commission. Publication Number: CEC-400-2015-034, at pages 71, 74-75. Available at http://docketpublic.energy.ca.gov/PublicDocuments/15-AAER-06/TN206387_20151016T152059_2015_Staff_Report_Analysis_of_SDDL_and_General_Service_LED_Lamp.pdf.