

Staff Workshop

Small Diameter Directional Lamp and Light Emitting Diode (LED) Lamps

2014 Appliance Efficiency Rulemaking
California Energy Commission
September 29, 2014

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The California Energy Commission

- ❑ The state's primary energy policy and planning agency, created by the Legislature in 1974
- ❑ Responsibilities include promoting energy efficiency and conservation by setting minimum appliance and building efficiency standards, and other cost-effective measures
- ❑ The Commission's appliance and building energy efficiency standards have saved Californians more than \$74 billion in reduced electricity bills since 1975



Appliance Efficiency –A Statutory Mandate

Warren-Alquist State Energy Resources Conservation and Development Act

Public Resources Code Section 25402(c)

Requires the Commission to adopt minimum levels of operating efficiency, and other cost-effective measures, to promote the use of energy and water efficient appliances whose use requires a significant amount of energy or water on a statewide basis.



Appliance Efficiency –A Statutory Mandate

Assembly Bill 1109, the California Lighting Efficiency and Toxics Reductions Act of 2007 requires the Energy Commission to adopt minimum energy efficiency standards for general purpose lighting.

These standards, in combination with other programs and activities, must be structured to reduce average statewide electrical energy consumption by:

- 50% reduction in residential lighting consumption by 2018
- 25% reduction in commercial and outdoor lighting by 2018.



Other Policy Drivers

Energy efficiency regulations are also identified as key components in reducing electrical energy consumption:

- ❑ In the *2013 Integrated Energy Policy Report (IEPR)*
- ❑ California Public Utilities Commission's 2011 *Energy Efficiency Strategic Plan*.

Energy Efficiency is also identified as key component to meet the Greenhouse gas emissions goals of Assembly Bill 32 and in the California Air Resources Board's *Climate Change Scoping Plan*.



Pre-rulemaking Phase

Order Instituting Rulemaking (3/14/12)

Commission identified a variety of appliances with the potential to save energy and/or water for appliance efficiency measures.

Invitation to Participate (3/25/13)

Opportunity for interested parties to inform the Commission about the product, market, and industry characteristics of the appliances identified in the OIR.

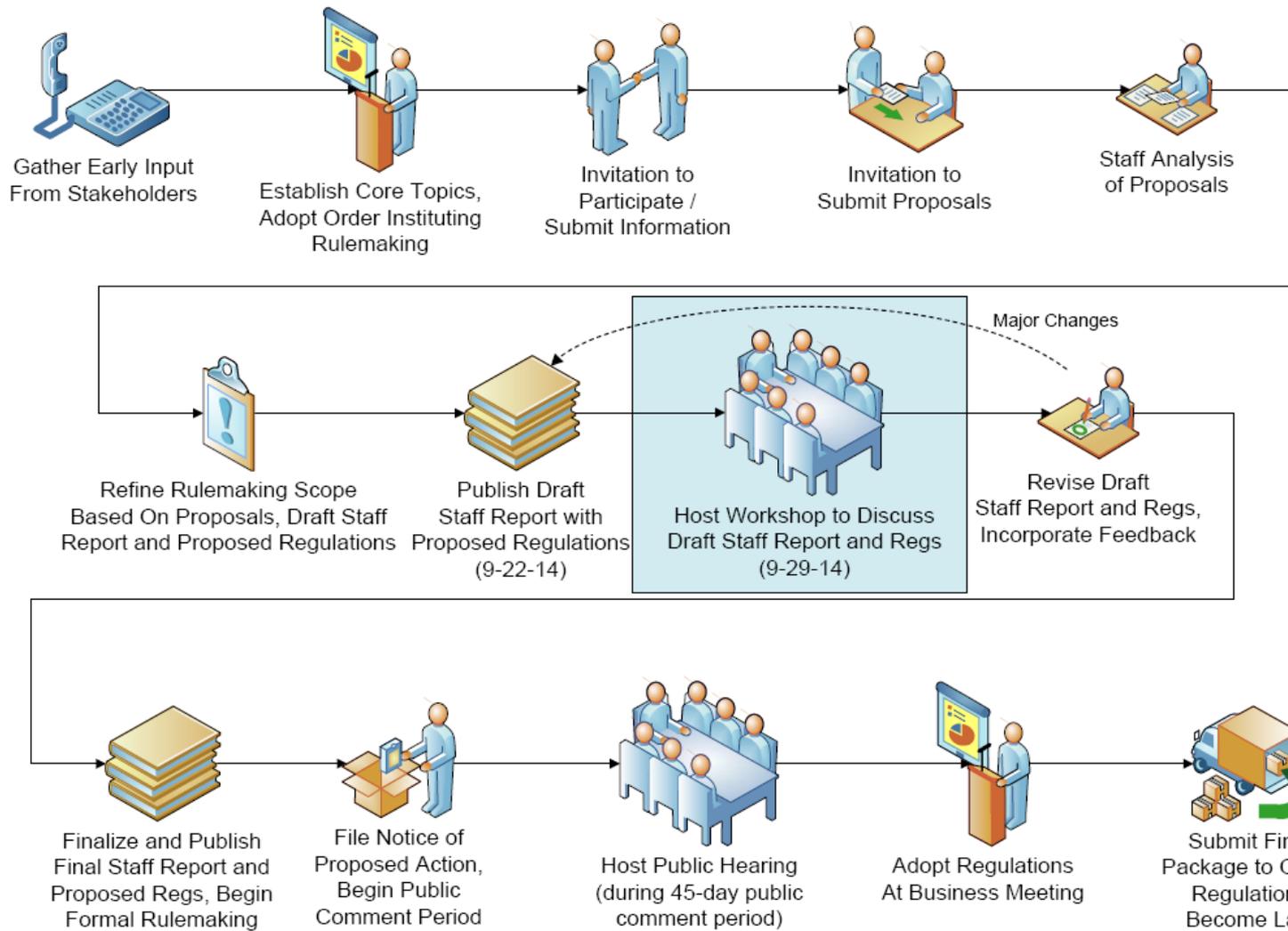
Invitation to Submit Proposals (6/13/13)

Opportunity for interested parties to submit proposals for standards, test procedures, labeling requirements, and other measures to improve efficiency.



Appliance Energy Efficiency Rulemaking Process

9/26/2014



*Office of Administrative Law



Purpose of Staff Workshop

- ❑ The Commission has posted staff reports on September 22:
- ❑ Staff report for Small diameter directional Lamps (SDDL) and Light Emitting Diode (LED) Lamps.
- ❑ The Workshop is an opportunity for stakeholders to comment and seek clarifications on the draft staff analysis.
- ❑ Written comment period has begun on September 22, and stakeholders can submit their comments by October 29.
- ❑ All comments received will be evaluated and staff will update the proposed draft regulations as needed.



How to Submit Data & Information

- ❑ Written comments should be submitted in writing to the Dockets Unit by 4:00 p.m. (Pacific Daylight Savings Time) on October 29, 2014.
- ❑ The Commission encourages interested parties to send information **up to 5 MB** by e-mail at docket@energy.ca.gov
- ❑ Please include docket number 14-AAER-1 in the subject line.



How to Submit Data & Information (Continued)

If the file size is more than 5 MB, if the information includes an application for confidential designation, or if you prefer, paper copies of responses with electronic information provided on a CD or DVD may be sent to:

California Energy Commission
Dockets Office, MS-4
Re: Docket No. 14-AAER-1
1516 Ninth Street
Sacramento, CA 95814-5512



Confidentiality of Data

If interested parties need to maintain the confidentiality of specific data or information, they should contact Jared Babula in the Commission's Chief Counsel's Office *before submitting a* response to this Invitation. Otherwise, all responses received will become publicly available.

Jared Babula,

California Energy Commission,

Office of the Chief

1516 Ninth Street, MS 14, Sacramento, CA 95814-5512

Telephone: (916) 651-1462

Email: jared.babula@energy.ca.gov



Small Diameter Directional Lamps

MR-11, MR-16, PAR-11, and PAR-16 Lamps



Agenda

- ❑ Scope
- ❑ Background
- ❑ Why Standards for Small Diameter Directional Lamps
- ❑ Regulatory Approaches
- ❑ Proposed Requirements
- ❑ Analysis
- ❑ Next Steps



Scope

Includes lamps of 2.25 inches or less in diameter, which include multifaceted reflector lamps (MR 11s and MR 16s) and MRX and parabolic aluminized reflector lamps (PAR11s and PAR16s).

Includes 2-pin GU 5.3 for low voltage applications and GU 10 base and medium screw base for line voltage applications.

Includes low voltage lamps of 6 Volt, 12 Volt, and 24 Volt and line voltage lamps of 120 Volts or 277 Volts.



Background

Small diameter directional lamps are often used in retail, hospitality, residential, and museum applications. However, their popularity in residential applications is also growing. Incandescent based small diameter directional lamps are practical and relatively inexpensive

A large majority of the small diameter directional lamps currently installed in California buildings are inefficient Incandescent and halogen lamps.

LED lamps are now available in the market that are highly efficient and their efficacy, quality, light output, and beam angle continues to improve.



Why Standards for Small Diameter Directional Lamps

Lamp stock and energy consumption by SDDLs are continuously growing. In 2018 SDDLs are estimated to consume about 1900 GWh/year.

LED small-diameter directional lamps provide comparable utility and are highly energy efficient.

In 2028, the proposed SDDL standards will save about 1700 GWh/year.

Regulations will transform the market towards more cost-effective and energy-efficient LED lamps.

LED SDDLs are cost effective and will save California consumers money on their electric bills.



Regulatory Approaches

DOE's Activity and Status

There are no existing DOE standards for small diameter directional lamps.

DOE has started conducting a rulemaking on Incandescent Reflector Lamps, but MR 16s, MR 11s, PAR 16s, and PAR 11s are outside the scope of its rulemaking.

DOE has established HIR performance standards for Incandescent Reflector Lamps (IRLs) of diameter greater than 2.25 inches that use 40 watts or more.



Regulatory Approaches Energy Star Criteria

Energy Star established specifications for LEDs in Version 1.4, including MR and PAR lamps of diameter less than or equal to 2.25 inch.

Energy Star specifications require minimum efficacy of lamps to be at least 40 lumens per watt.

Energy Star provides a tool for PAR and MR lamps to calculate minimum CBCP requirements based on the replacement lamp's beam angle and claims about wattage equivalency.



Regulatory Approaches Seoul Semiconductors' Proposal

California should harmonize with Energy Star specifications.

The Energy Star program provides a framework of standards and testing that California can adopt.

Harmonizing with Energy Star would mean manufacturers would need to test only their equipment once and therefore reduce testing cost.



Regulatory Approaches

Australian Lamp Standard

Staff reviewed the Australian Lamp Standards:

The Australian commission for lighting standards established lighting standards for low voltage MR 16 lamps by establishing a wattage cap at 37W, which became effective on April 14, 2012.

This cap effectively banned 50W halogen lamps from being sold in the market, leaving the 37W HIR lamp (a 50W equivalent) and LED replacements to be sold in the market.



Regulatory Approaches

IOU and Natural Resources Defense Council Proposals

The IOUs and Natural Resources Defense Council initially proposed two-tier performance standards for small diameter directional lamps.

IOUs current proposal is aligned with the CEC staff proposal requiring small diameter directional lamps to produce at least 80 lumens per watt.



Proposed Requirements

Section 1601. Scope

(k) Lamps

Lamps which are federally-regulated general service fluorescent lamps,

federally-regulated incandescent reflector lamps, state-regulated general service incandescent lamps, general service lamps, and includes GU-24 base lamps, small diameter directional lamps of diameter less than or equal to 2.25 inches and operate on low voltage and line voltage.

(1) This also includes halogen, halogen-infrared, and LED technologies, as well as any other lighting technology that falls within the definitions outlined for this standard. This standard establishes minimum performance levels for efficacy and lamp lifetime.



State Standards for Non-Federally Regulated Appliances

Section 1604. Test Method for Specific Appliances

(k) Lamps

- ❑ IES LM-79-08 “IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting.”
- ❑ IES LM-80-08 “Approved Method: Electrical and Photometric Measurement of Lumen Maintenance of LED Light Sources”



Proposed Requirements

1605.3 State Standards for Non-Federally Regulated Appliances

(k) Lamps

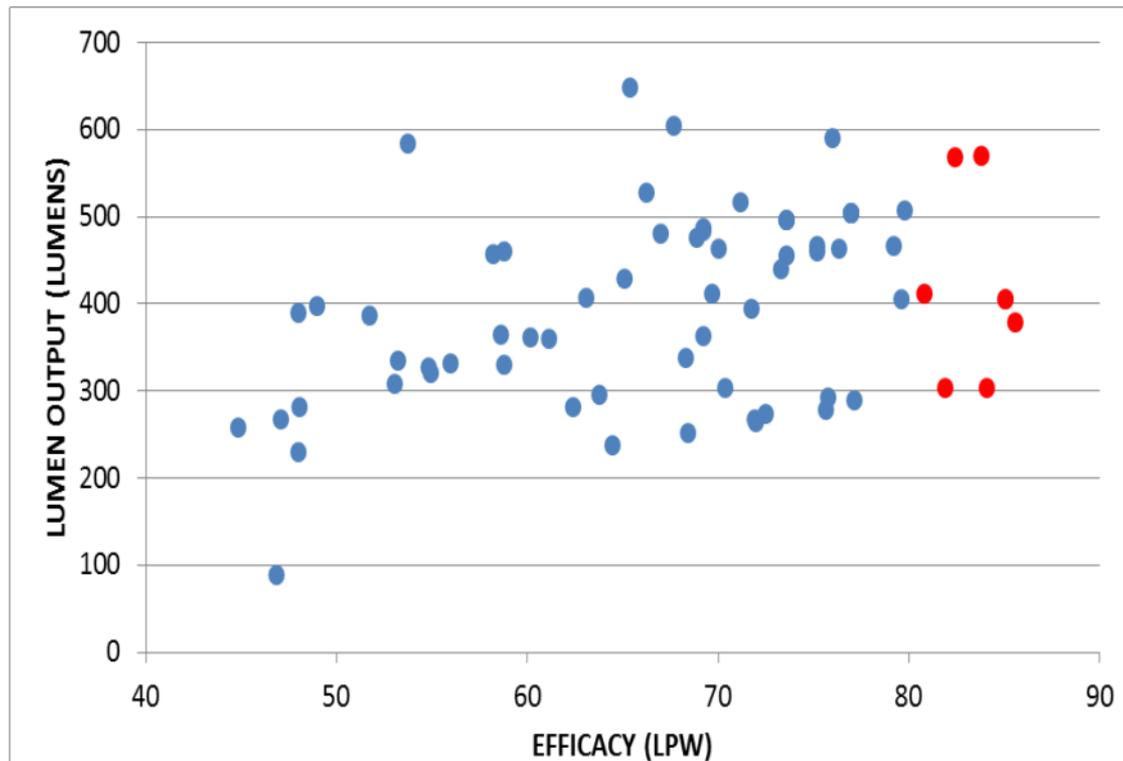
(6) Effective January 1, 2018, all small diameter directional lamps must have

- a luminous efficacy of 80 lumens per watt or greater,
- a power factor of 0.9 or greater, and
- a minimum rated life of 25,000 hours.



Proposed Regulations

Lumen Output vs. Luminous Efficacy



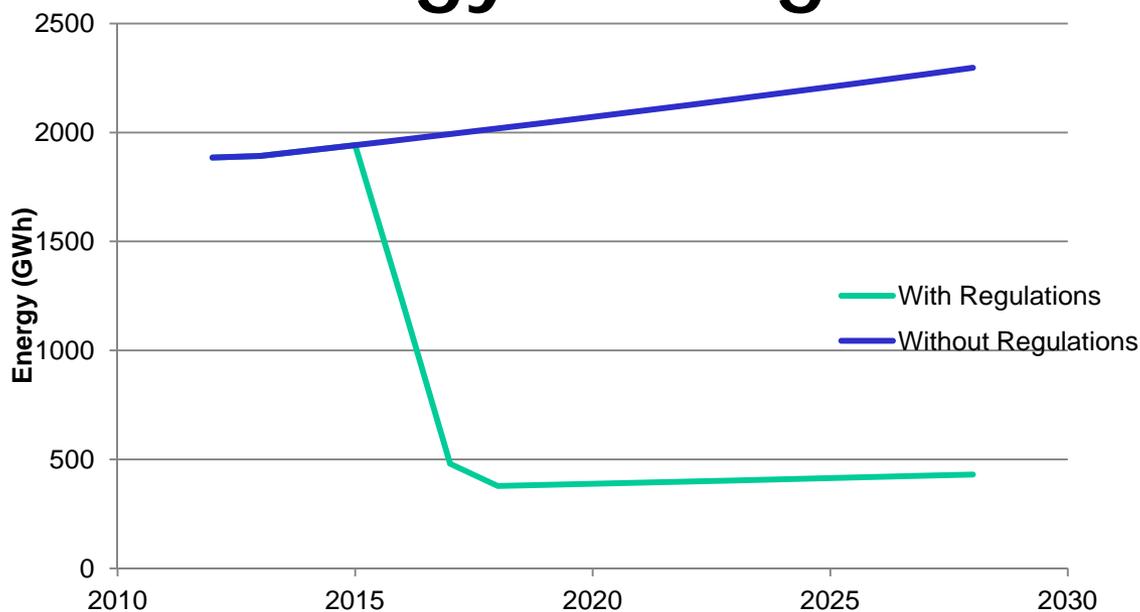
Stock

Existing Stock											
Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
50 Watt stock is 70percent	11.04	11.19	11.33	11.48	11.63	11.78	11.93	12.09	12.25	12.40	12.57
35 Watt Stock is 20percent	3.16	3.20	3.24	3.28	3.32	3.37	3.41	3.45	3.50	3.54	3.59
20 Watt Stock is 10percent	1.58	1.60	1.62	1.64	1.66	1.68	1.70	1.73	1.75	1.77	1.80
Total Estimated Stock in Millions	15.8	16.0	16.2	16.4	16.6	16.8	17.0	17.3	17.5	17.7	18.0

Existing Low Voltage and Line Voltage Stock											
Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Low voltage stock= 80percent	12.6	12.8	13.0	13.1	13.3	13.5	13.6	13.8	14.0	14.2	14.4
Line Voltage Stock 20percent	3.2	3.2	3.2	3.3	3.3	3.4	3.43	3.5	3.5	3.5	3.6
Total Stock in Millions	15.8	16.0	16.2	16.4	16.6	16.8	17.0	17.3	17.5	17.7	18.0



Energy Savings



Annual \$ cost Savings over the life time of the lamp at a discount rate of 3% per year											
Annual \$ savings in millions											
Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
\$ savings (in Millions)	223	220	216	212	208	205	201	198	194	191	187



Cost Analysis

Statewide Energy and Cost Impact								
Proposed Standard	Design Life Hours	Annual Energy Savings/Unit KWh/year	Incremental Cost of Improvement/ Unit	First year Unit Energy Savings	Reduced Total savings over the design life(\$)	Simple payback period	Annual sales in millions	1 st year statewide energy savings
80 lumens/Watt	10 years	97KWh/year	\$13.52	\$12.65	156.87	<1.5 years	15.8	1535 GWH

Annual Energy Consumption Per Lamp:		
Without Standard 119 KWh/year	80 lumens/watt 22 KWh/year	Savings 97 KWh/year
Annual Operating Cost		\$ Savings/year
Without Standards \$15.51	80 lumens/watt \$2.86	\$12.65

Duty Cycle		
Annual Energy Consumption	Hrs/year	Market share
Commercial	3720	65 percent
Residential	840	35 percent
Average Operating Hours	2712	100 percent



Next Steps

- Consider input from today's workshop and written comments. Written comments are due by October 29, 2014
- Revise staff report analysis and proposed requirements, as necessary
- Commission staff are available to discuss questions and concerns at any time during the proceeding.



To submit comments or information related to Rulemaking

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Harinder Singh
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Efficiency Division

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LED Lamp Proposal

LED Lamp Efficiency Opportunities
Hearing Room A

September 29, 2014

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Efficiency Division

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Scope

Color: Only lamps that produce white light are covered. This is determined through a lamp's distance from the black-body curve which is a standardized measurement.

Base types: medium, intermediate, candelabra screw base, GU-24, and lamps designed to retrofit recessed can housings that contain one of these bases.



California Market

Over 600 million sockets with covered based types in California existing buildings.

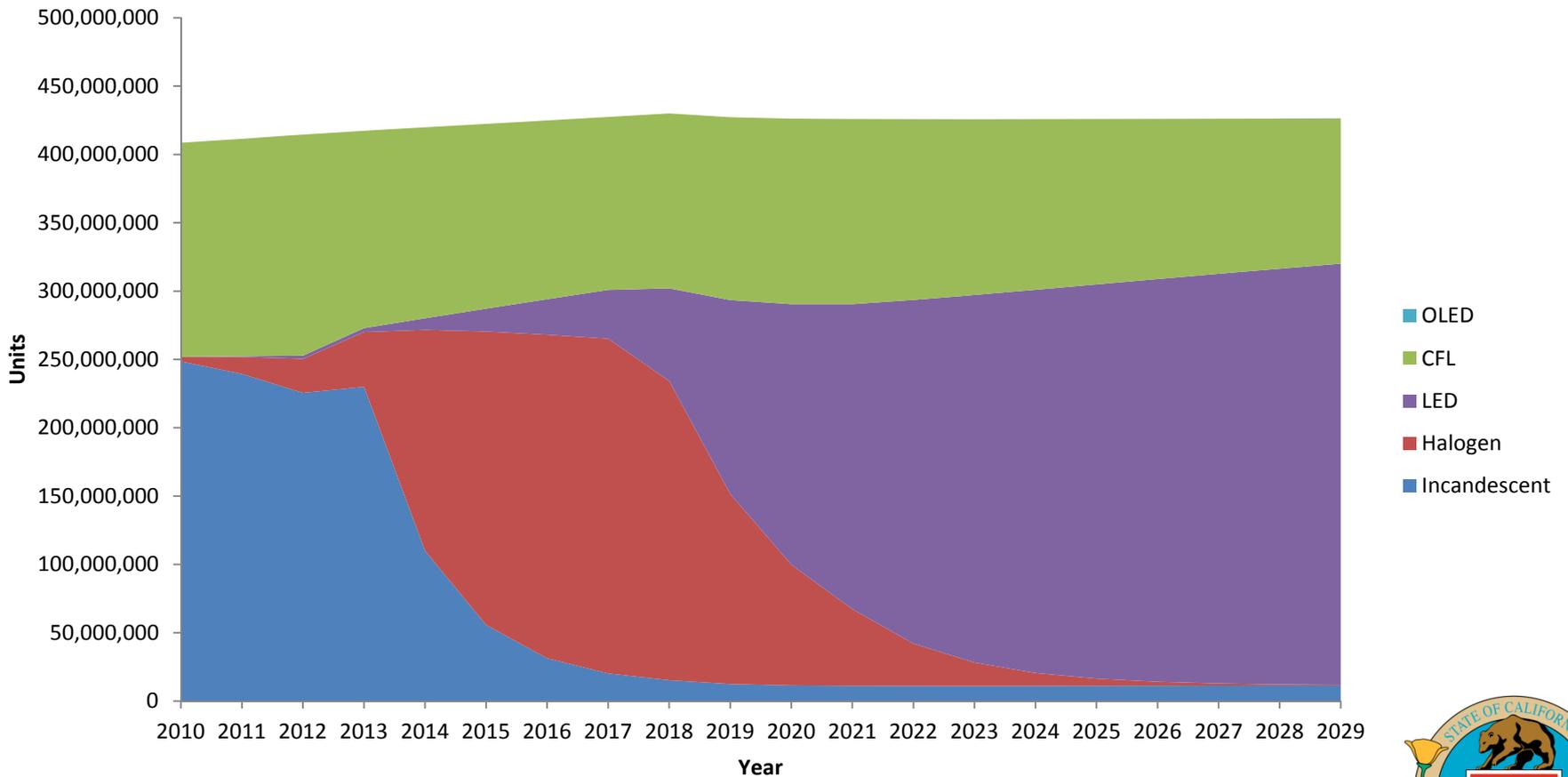
Current stock and future projection of lamps in these sockets are a mixture of incandescent, halogen-incandescent, CFL, and LED lamps.

LED and halogen-incandescent lamps are taking over the market from incandescent lamps and CFL's.

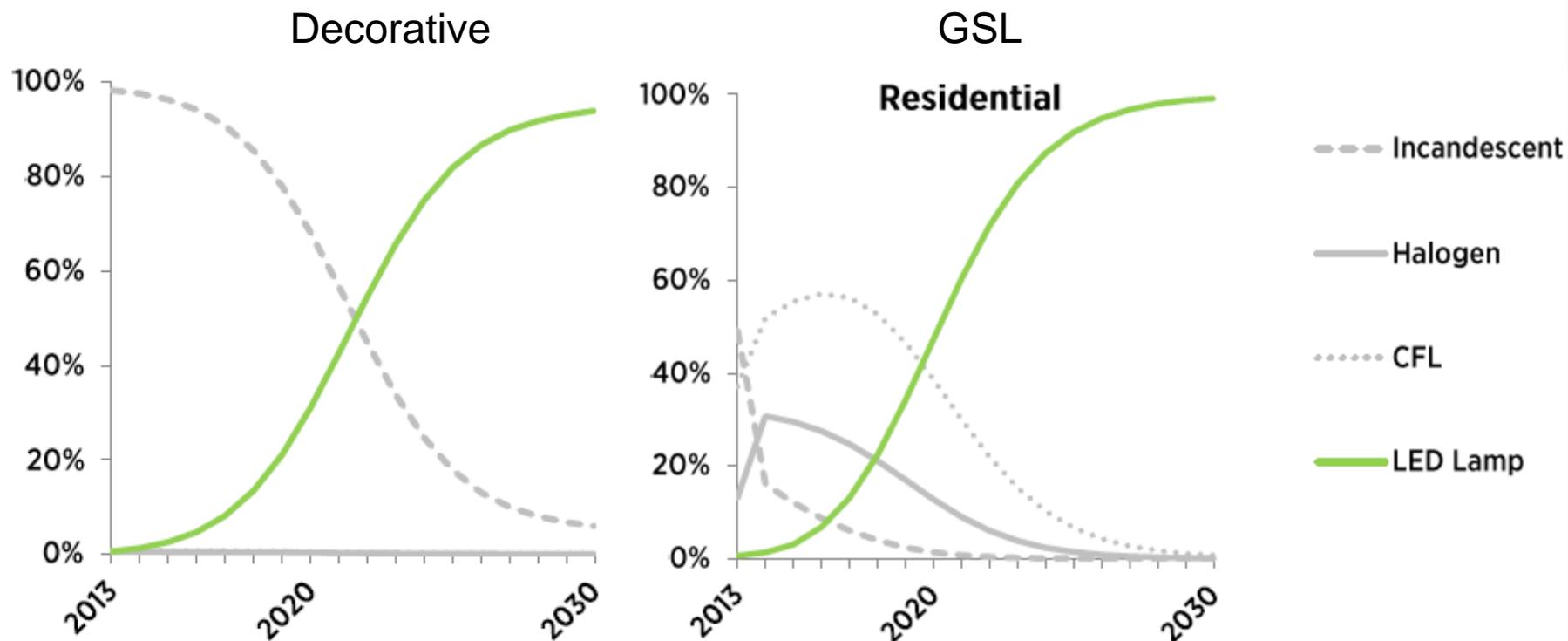
The trend towards halogen-incandescent expected to end in 2018 for general service lamps due an existing Energy Commission regulation that requires 45 lumens per watt.



Estimates and Projections of General Service Lamp (GSL) Stock



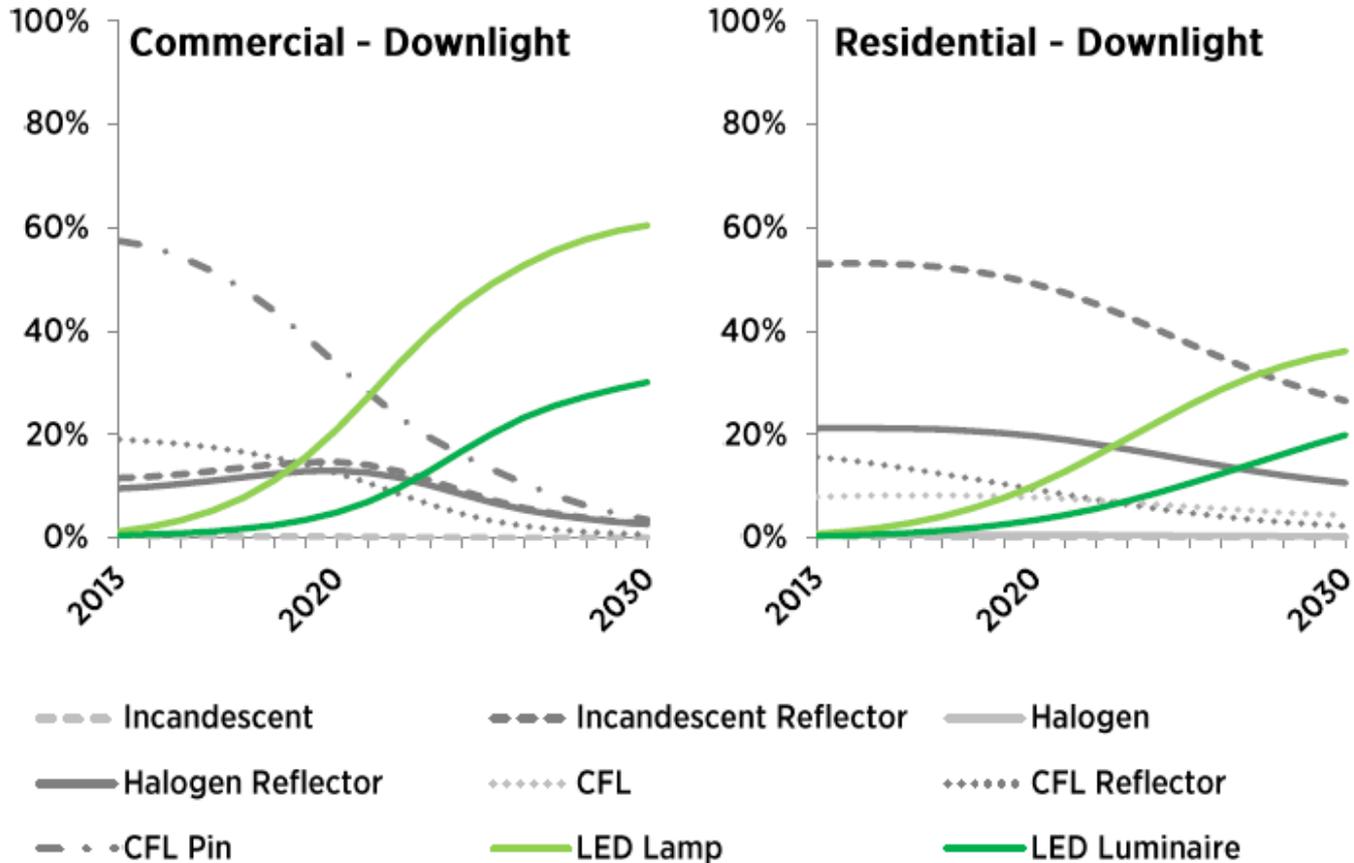
Transition to LED



Source: US DOE, *Energy Savings Forecast of Solid-State Lighting in General Illumination Applications*, August 2014



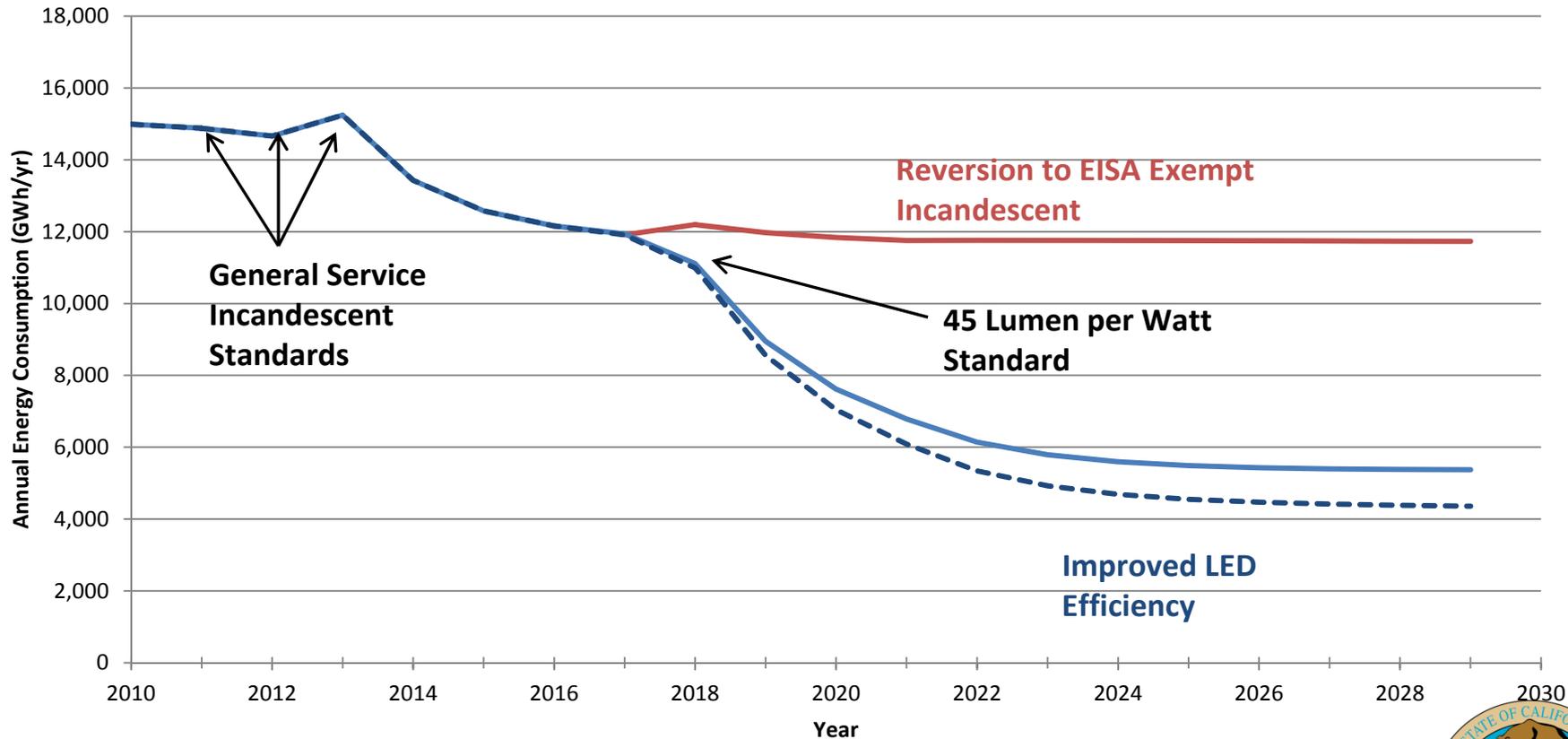
Transition to LED Cont'd



Source: US DOE, *Energy Savings Forecast of Solid-State Lighting in General Illumination Applications*, August 2014

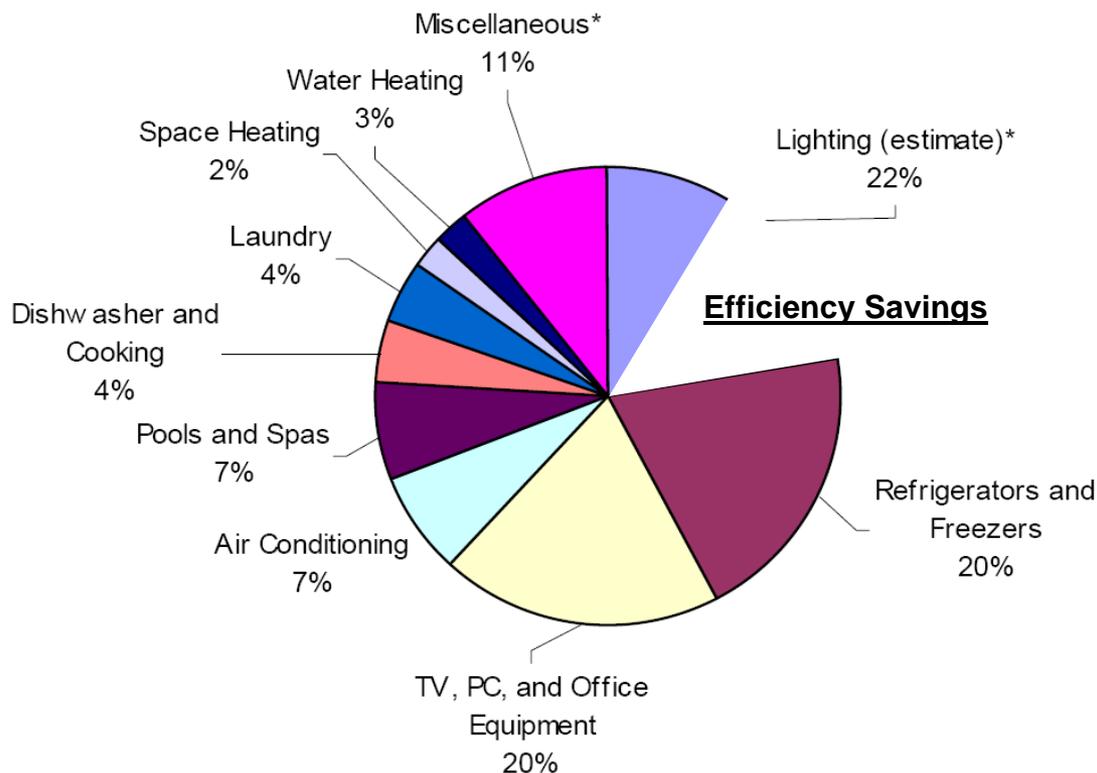


Effects of LED Transition and Proposed Improved Efficacy (GSL)



Effect on Residential Electricity Consumption

6,296 kWh per Household



Modification of figure ES-1: California Energy Commission, 2009 Residential Appliance Saturation Survey, October 2010



Energy Commission Staff Proposal

Staff is a trade-off standard that allows manufacturers to either have improved quality, improved efficacy, or a mixture of both.

Compliance score = $3 \times \text{CRI} + \text{Efficiency (lumens per watt)}$.

Tier 1 – effective January 1, 2017 all lamps shall have a minimum compliance score of 335.

Tier 2 – effective January 1, 2019 all lamps shall have a minimum compliance score of 350.



Energy Commission Staff Proposal (cont'd)

The proposal also includes absolute minimums of 82 CRI and 55 lumens per watt in 2017 and 84 CRI and 65 lumens per watt in 2019.

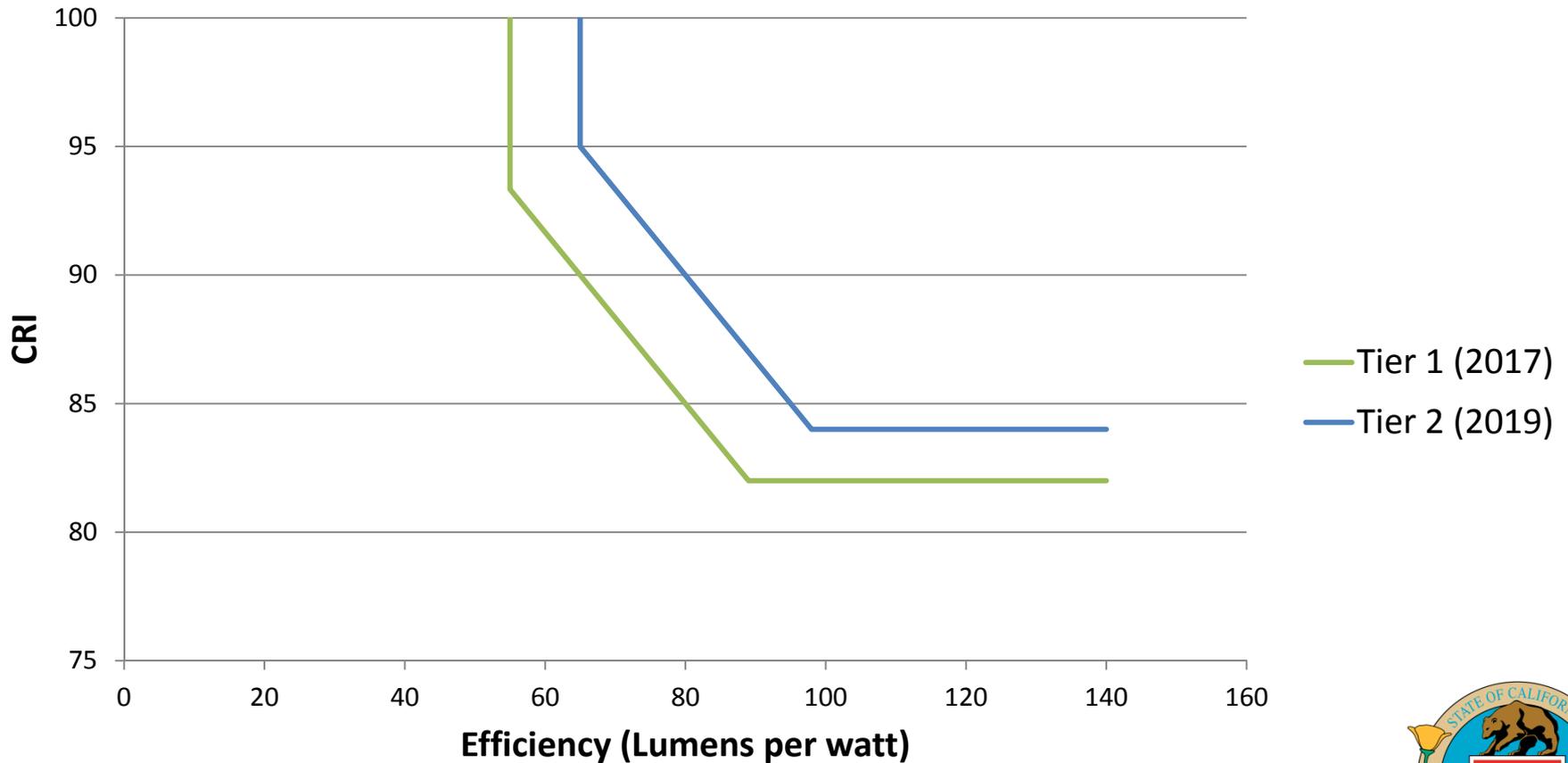
Each color component of the CRI test must have a score of at least 75.

The color correlated temperature must be within 4 MacAdam steps of the black-body curve.

Omni-directional lamps must have a light distribution that meets ENERGY STAR version 1.1.



Tradeoff Standard



Staff Proposal Relative to California Quality LED Specification

Staff Proposed Regulation	California Quality LED Specification
Sets the “baseline” for LEDs sold in California	Encourages higher quality LED lamps
Mandatory	Voluntary
Focuses on efficacy and minimal quality	Focuses on high light quality
Necessary for sale in CA	Tied to rebates in CA

Staff proposal includes certification to support and verify performance with the California Quality LED Specification.



LED Durability

The staff proposal does not include any requirements for lamp durability.

Staff received proposals from stakeholders to test and regulate: premature failure rate, elevated temperature performance, lumen maintenance, and rapid cycling. In addition staff received proposals to require a minimum warranty.

Staff seeks further feedback regarding which measures best address the efficacy of the product to the consumer, test burden, and incremental costs and savings.



Labeling and Claims: Dimmable

To claim “dimmable” an LED model it must be:

1. Dimmable down to 10% of its full light output.
2. Must pass a flicker test.
3. If the LED is not compatible with a standard phase-cut dimmer claims of “dimmable” must be qualified with “dimmable with LED dimmer” and include instructions regarding which dimmers are compatible.

Staff has not specified a flicker test but is considering one under development by the IOUs or the current ENERGY STAR method.



Labeling and Claims: Incandescent Comparisons

To make comparisons to incandescent lamps an LED model it must:

1. Have a color correlated temperature of 3000K or less.
2. Be “dimmable” per the dimmable requirements.
3. Must have a lumen output of at least 450 lumens. For intermediate and candelabra bases the minimum lumens is 200.
4. Claims of incandescent wattage equivalences must match the lumen outputs contained in the current general service incandescent lamp regulations.



Labeling and Claims: Other

To claim that a lamp meets the California Quality LED Specification, it must certify with the California Energy Commission.

A lamp that is certified with a light output of less than 150 lumens for candelabra bases, or less than 200 lumens for other bases, must be marked as “for decorative purposes only.”



energy smart.

LED technology

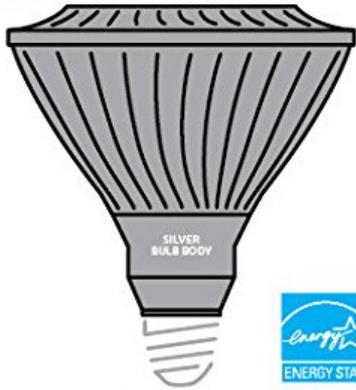
dimmable

Dimming performance may vary. Go to www.ge Lighting.com/dimming for more information

26 watts
PAR 38
3000K

40° FLOOD LIGHT

long life / low energy



Brightness	Estimated Energy Cost
1500 lumens	\$3.13 per year



light output:	energy used:	life:	contains:
1500 lumens	26 watts	25,000 hours	1 bulb (PAR 38)

Conserv-Energy ENERGY EFFICIENT LIGHT BULBS

LED DIMMABLE

SAVE \$264

IN ENERGY COSTS PER PACK

40 WATT REPLACEMENT USES ONLY 8 WATTS

LASTS 22.8 YEARS

INSTANT ON
MERCURY FREE

DECORATIVE

G25 3-PACK

Lighting Facts Per Bulb

Brightness	500 lumens
Estimated Yearly Energy Cost	\$0.96
<small>Based on 3 hrs/day, 180 days</small>	
<small>Cost depends on rates and use</small>	
Life	22.8 years
<small>Based on 3 hrs/day</small>	
Light Appearance	Cool
Watts	8 watts
Energy Used	8 watts

Brightness 500 lumens
Estimated Energy Cost \$0.96 per year

Lighting Facts icons: Energy Star, Dimmable, Mercury Free, Instant On

PHILIPS

SlimStyle

360° light all-around*

10.5w replaces **60w**

Dimmable Atenuable

Lasts 22.8 Years**

22.8 Años de vida

Saves **\$136.13** in energy cost***
Ahorra \$136.13 en costos de energía

Soft white light
Luz blanca suave

Brightness/Brillo 800 lumens/lúmenes

Estimated Energy Cost/Costo Estimado de Energía \$1.26 per year/por año

CREE

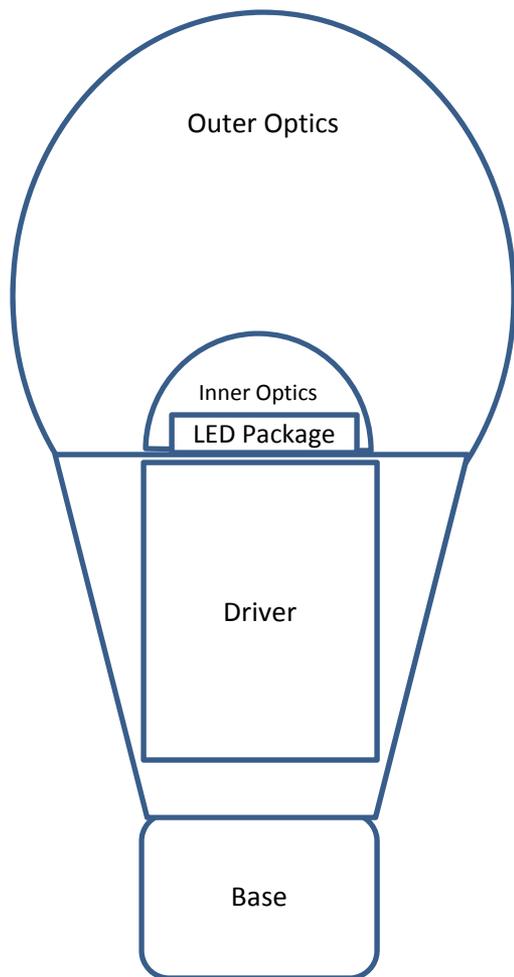
soft white **LED 60w** replacement uses only 9.5 Watts

800 lumens \$1.14 per year

Examples of Current labels



Technical Feasibility



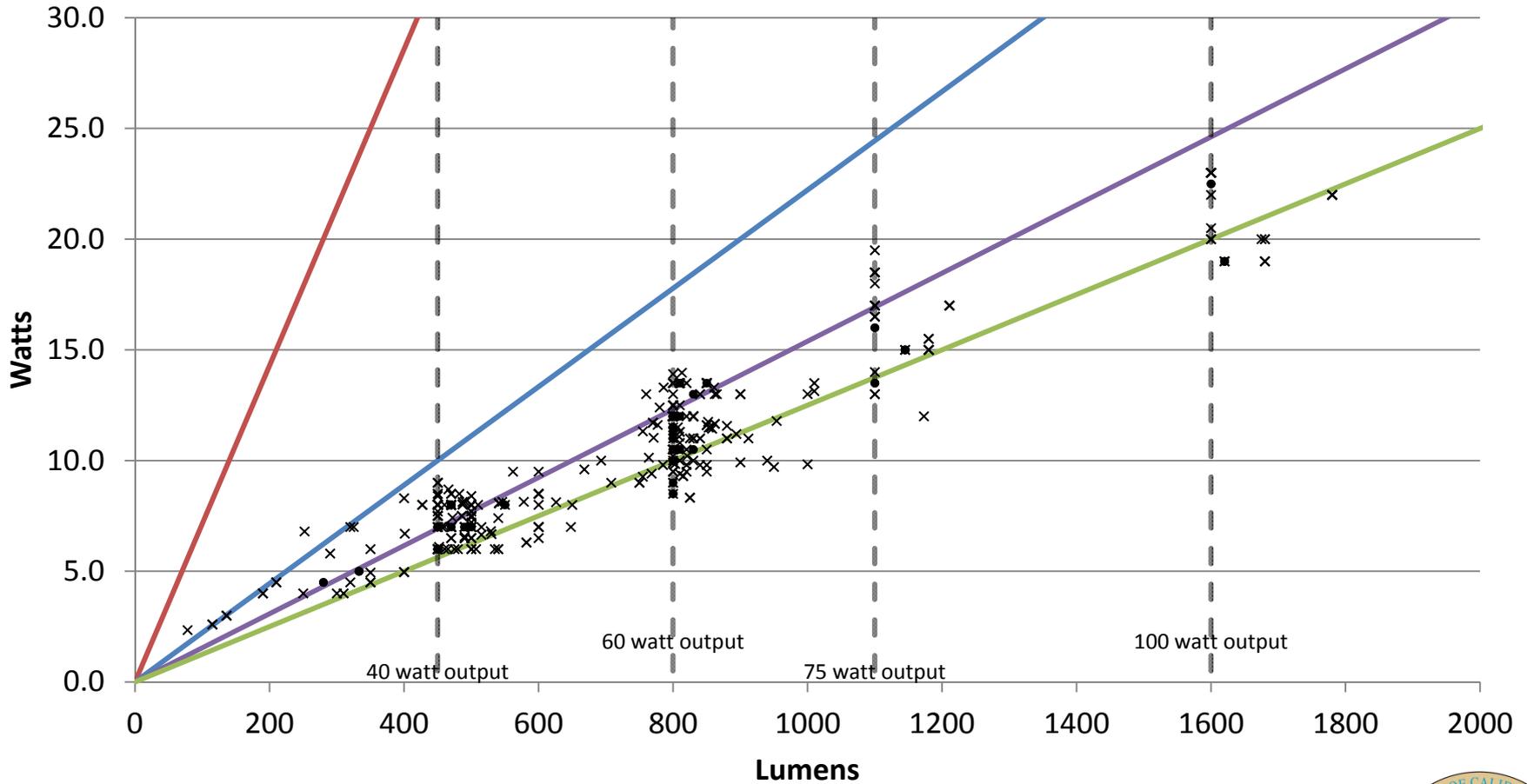
Improvements to LED efficiency can be made by improving the driver efficiency and lumen per watt output of the LED package.

CRI improvements can be made in the LED package and phosphors.

84 CRI lamps are already common in lamps manufactured today, and 90 CRI lamps are being rebated in California.



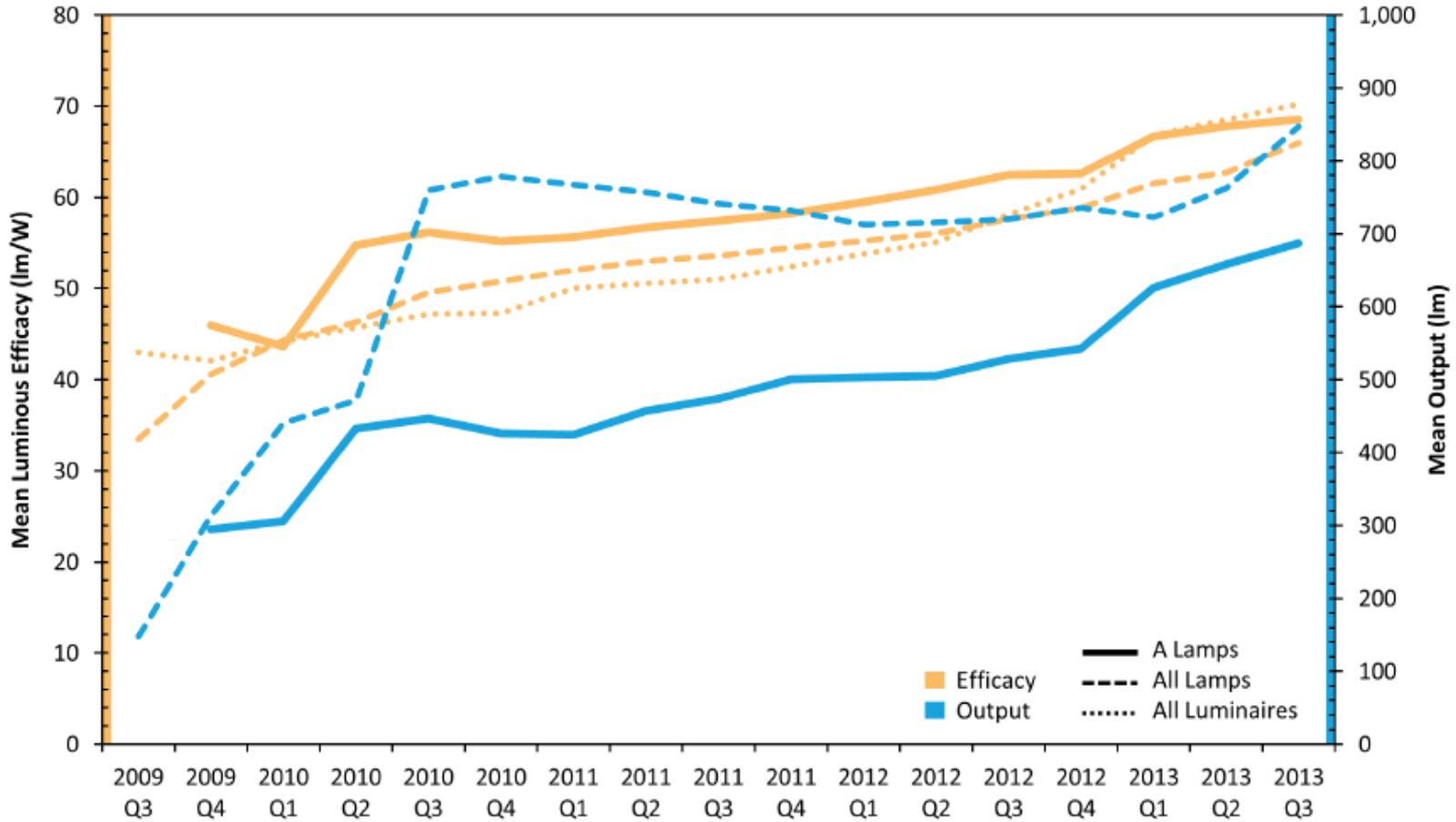
Efficiency of Current LED GSLs



— 14 LPW — 45 LPW — 65 LPW — 80 LPW • Estar Data × Lighting Facts Data



Efficiency Trends in LED Lamps



Source: US DOE, "CALiPER Snapshot Light Bulbs,"
October 2013



Cost Trends

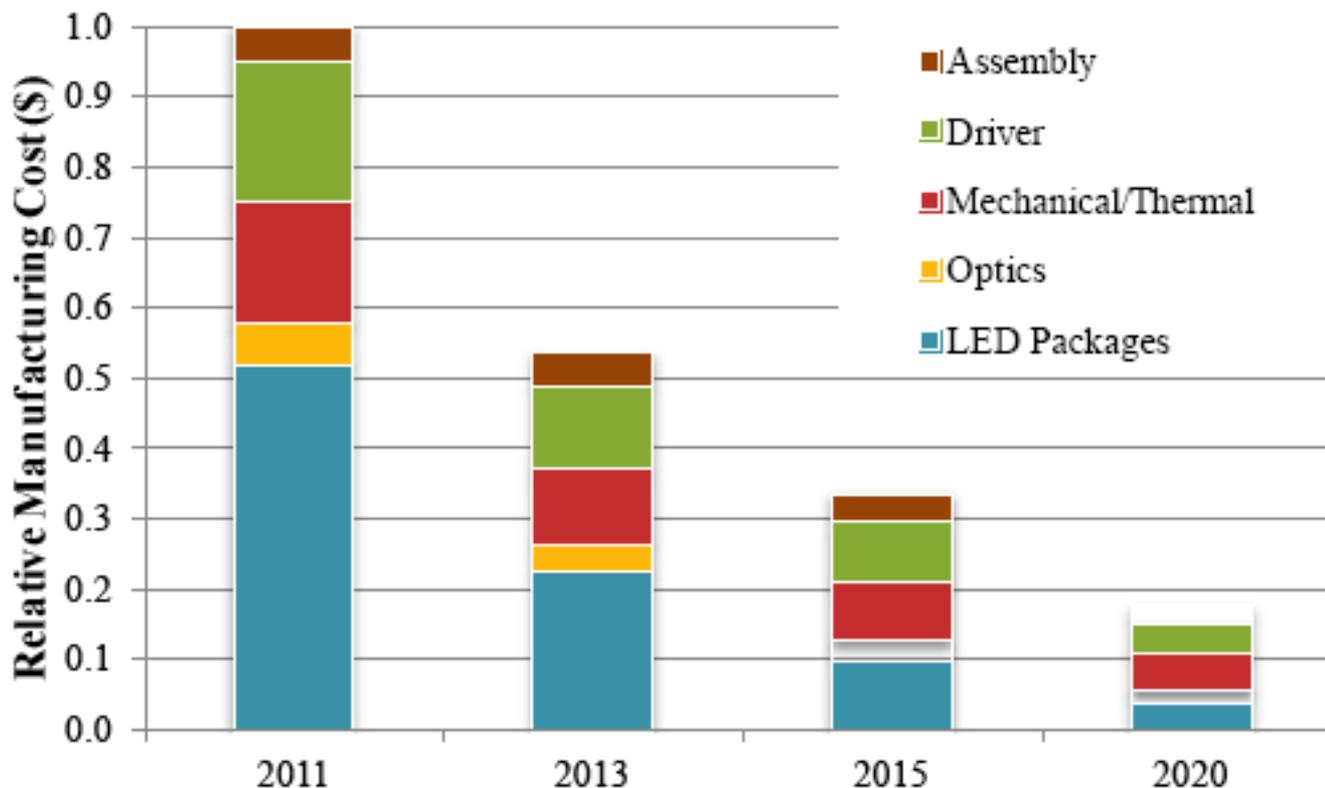


Figure 1-1. Projected cost track for an LED-based A19 60W replacement lamp

Source: data provided by the 2011 Manufacturing Roundtable attendees

US DOE, *Solid State Lighting Research and Development: Manufacturing Roadmap*, August 2012.



Incremental Costs

Incremental cost trends from the marketplace are not clear, with some compliant lamps being less expensive than those that do not comply.

Some tradeoffs in cost exist, with more efficient LED packages leading to less expensive drivers and thermal dissipation.

Staff compared savings to the incremental costs estimated by the California IOUs in its *CASE Report on LED Replacement Lamp Quality*, July 2013. These costs are estimated based on improving CRI to 90, which is one pathway to compliance with the staff proposal.



Cost Effectiveness

Lamp Type	Incremental Cost	Lifetime Savings	Cost to Benefit Ratio
General Service	\$1.84	\$10.57	5.8
Directional	\$3.15	\$22.67	7.2
Decorative	\$2.47	\$11.33	4.6

Cost effectiveness analysis was based on LED to LED replacement with use of 2.5 hours per day and a lifetime of 25,000 hours. All payback periods were less than 5 years.



Statewide Savings

Lamp Type	LED Stock (Millions)	Average Baseline Efficacy	Average Tier 2 Efficacy	Energy Savings (GWh for the year 2030)
General Service	308.1	65	97.2	1,372
Directional	47.8	50	97.2	380.9
Decorative	110.6	50	97.2	440.7
Total	-	-	-	2,194

In 2030, Californians would be saving \$351 M per year from the proposed standard assuming a rate of \$0.16 per kWh.

The 2030 savings are estimated reduce green-house gas emissions by 0.678 MMTCO_{2e} per year.



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