
Proposal Information Template for:
**Three-way and High-luminance
General Service Lamps**

DOCKET

11-AAER-1

DATE OCT 19 2011

RECD. OCT 19 2011

Submitted to:

California Energy Commission

In consideration for the 2011 Rulemaking Proceeding on Appliance Efficiency Regulations,
Docket number 11-AAER-1

Prepared for:

Pacific Gas and Electric Company
Southern California Edison



Prepared by:

Laura Moorefield, Luke Mason, Kevin Simonson, and Brendan Trimboli
Ecos

Last Modified: October 19, 2011

This report was prepared by the California Statewide Utility Codes and Standards Program and funded by the California utility customers under the auspices of the California Public Utilities Commission.

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Please note: all savings estimates and information in this document are preliminary and are based on data available to the authors at the time of the report. If the CEC moves forward with this topic, we anticipate updating our estimates and recommendations based upon additional input from stakeholders.

Proposal Information Template – Three-way and High-luminance Lamps

2011 Appliance Efficiency Standards

Prepared for: Pacific Gas and Electric Company & Southern California Edison

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Purpose

This document is a report template to be used by researchers who are evaluating proposed changes to the California Energy Commission's (Commission) appliance efficiency regulations (Title 20, Cal. Code Regulations, §§ 1601 – 1608). This report specifically covers two lamp types: high-luminance (2601-3300 lumens) and three-way.

Background

The Energy Independence and Security Act of 2007 (EISA) created federal mandatory efficiency standards for general service incandescent lamps. California was permitted to implement these standards one year ahead of the federal timeline, which it did under Title 20. Some types of general service lamps were excluded from immediate regulation under EISA, and therefore also under Title 20. Two of these excluded lamp types commonly found in residential buildings—three-way lamps and high-luminance general service lamps, (specifically 2,601–3,300 lumen output, commonly designated as 150 W lamps)—present an attractive savings opportunity for California because halogen incandescent technologies already employed in other general service lamps can be employed in or adapted for these lamp types to meet the proposed standards.

According to EISA, Section 321, the term “general service incandescent lamp” means a standard incandescent or halogen type lamp that is intended for general service applications; has a medium screw base; has a lumen range of not less than 310 lumens and not more than 2,600 lumens; and is capable of being operated at a voltage range at least partially within 110 and 130 volts.

This definition describes the main scope of the federal legislation. However, EISA also includes high-luminance lamps under this definition. Although the statute does not provide a specific definition of 2,601–3,300 lumen general service incandescent lamps, DOE interprets this term to be a “general service incandescent lamp that emits between 2,601 and 3,300 lumens.” In this lumen range, the wattages of covered are between 140 and 170 watts. The high-luminance lamps we propose to be covered under Title 20 are considered to be general service lamps.

According to EISA, three-way lamps are excluded from the definition of general service lamps, and are considered to be a type of incandescent lamp that contains two separate filaments. See the description below. We propose that since three-way lamps are commonly used in general service lighting applications, they should also be covered under Title 20.

Though both these lamps are currently exempt for coverage under the federal standard, EISA contains provisions for future rulemaking and minimum efficiency requirements if their reported annual sales, from 2010 through 2025, are at least 100 percent higher than predicted unit sales for that year. If these sales

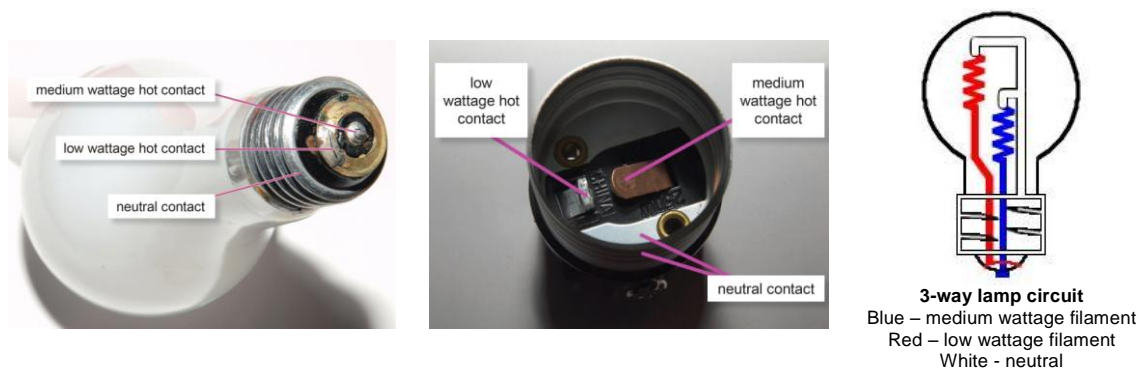
levels are met, EISA defines regulation options for each exempted lamp type separately. These are explained in the individual lamp sections below. However, we do not expect that these sales targets will be reached in the coming years. Furthermore, even if their sales do meet the 100 percent increase for a given year, thereby granting the DOE the authority to regulate them, it may be years before such regulations take effect. We propose the state of California considers these two lamps types for coverage under Title 20 now to maximize the near-term savings opportunity.

Three-way Lamps

According to EISA, Section 321, the term “three-way incandescent lamp” includes an incandescent lamp that employs two filaments, operated separately and in combination, to provide three light levels; and is designated on the lamp packaging and marketing materials as being a three-way incandescent lamp.

For example, a typical 30-70-100 W three-way lamp contains a “low” power 30 W filament mounted alongside a separate “medium” power 70 W filament. When both filaments are energized together, the lamp operates on “high” power of 100 W. Three-way lamps require a three-way switch to provide three levels of light; however, a three way lamp will default to the middle light output (and power) level when installed in a socket with a typical on/off switch. Common three-way lamp wattages are 30-70-100, 50-100-150, and 100-200-300. See Figure 1 below for examples of three-way lamp base, socket and filament configurations.

Figure 1. How a three-way lamp works



Source: http://en.wikipedia.org/wiki/3-way_lamp

EISA states that if three-way reported lamp sales for any year between 2010 and 2025 exceeds the predicted unit sales for that year by 100 percent, an accelerated rulemaking will be completed to establish a conservation standard for 3-way incandescent lamps. If no rulemaking is completed, then the requirement will be that each filament in a three-way incandescent lamp meet the new maximum wattage requirements for the respective lumen range established for general service lamps (EISA subsection (i)(1)(A)), and may be sold only in single packages.

High-luminance Lamps

General service incandescent lamps that provide a lumen output between 2,601-3,300 are often employed in applications where only a few sockets are available to illuminate large areas. The Title 20 statute does not provide a definition of 2,601-3,300 lumen general service incandescent lamps, however, DOE interprets this term to be a general service incandescent lamp that emits between 2,601 and 3,300 lumens. In this lumen range, the wattages of standard (non-halogen) general service incandescent lamps are between 140 and 170 W, with the most common wattage being 150 (Federal Register, Volume 76 Issue 64).

Though these lamps are currently exempt from coverage under EISA, EISA states that if their reported annual sales rate demonstrates actual unit sales at least 100 percent higher than modeled unit sales for any year between 2010 and 2025, the Secretary shall impose a maximum 95-watt limitation on general service incandescent lamps in the lumen range of 2,601 through 3,300 lumens. This will also include a requirement that those lamps be sold at retail only in packages containing one lamp.

We propose that California consider mandatory lamp standards to reduce energy consumption of three-way and high-luminance lamps. The proposed standard is described below, and would require the use of halogen incandescent technology that is more efficient than the standard incandescent technology widely employed today in these lamp types. The proposed standard would not require the use of alternative technologies, such as compact fluorescent lamps (CFLs) or light-emitting diodes (LEDs). In the proposed standards, three-way and 2,601 – 3,300 lumen lamps would be subject to different EISA-like efficiency requirements. We estimate the total saving for these measures after entire stock turnover to be 30 GWh per year for high-luminance lamps and 215 GWh per year for three-way lamps for a total savings of 245 GWh per year.

Overview

<p>Description of Standards Proposal</p>	<p><i>Three-way</i> We propose that both filaments in three-way lamps sold in the state of California shall meet the maximum wattage requirements according to lumen output as laid out in EISA/Title 20, as well as the minimum 1,000 hour lifetime EISA requirement.</p> <p><i>High-luminance</i> We propose all 2,601 – 3,300 lumen general service lamps sold in the state of California meet EISA's backstop requirement of a 95 W maximum power limit for this lumen category, as well as the minimum 1,000 hour lifetime EISA requirement.</p> <p>Alternatively, for 2,601 – 3,300 lumen lamps, we could develop an efficiency metric that follows typical halogen incandescent lamp performance characteristics such that minimum efficacy requirements increase with light output. This would address some of the weaknesses in the structure of EISA's general service lamp standards for other light output categories.</p> <p>These stringency levels require higher efficiency halogen incandescent technology. CFL and LED technology would not be required to meet the proposed standards.</p>
<p>California Stock and Sales</p>	<p>Annual California Sales</p> <ul style="list-style-type: none"> • Three-way: 3.1 million • High-luminance: 0.7 million <p>Total California Stock</p> <ul style="list-style-type: none"> • Three-way: 5.2 million (based on average lamp lifetime of 1.7 years) • High-luminance: 0.8 million (based on average lamp lifetime of 1.1 years)
<p>Energy Savings and Demand Reduction</p>	<p><i>Per unit annual energy savings:</i></p> <ul style="list-style-type: none"> • Three-way: 41 kWh/yr • High-luminance: 38 kWh/yr <p><i>Total annual energy savings after entire stock turnover:</i></p> <ul style="list-style-type: none"> • Three-way: 215 GWh/yr (weighted mid-level wattage) • High-luminance: 30.4 GWh/yr (150 W equivalent lamps) <p><i>Total annual energy cost savings after entire stock turnover:</i></p> <ul style="list-style-type: none"> • Three-way: \$31.9 million • High-luminance: \$4.5 million <p><i>Peak demand reduction:</i></p> <ul style="list-style-type: none"> • Three-way: 26 MW • High-luminance: 4 MW <p>Note – Using the multiplier of 0.12 kW/MWh, residential sector, miscellaneous (Brown & Koomey, 2002)</p>

Economic Analysis	<p>Both measures are cost-effective.</p> <p>We do not have data for precise incremental costs for the lamps that meet the proposed standards since these lamps are not available today. However, we can infer an approximate price range because the technology needed to meet the proposed standards is in use in other types of lamps.</p> <p>The proposed three-way lamp standard would save a customer more than \$5 per year per lamp in the first year of the measure. We anticipate an incremental cost of approximately \$2, based on similar products available today.</p> <p>The proposed high-luminance lamp standard would save a customer more than \$5 per year per lamp in the first year of the measure. Therefore, an incremental cost of up to \$5 per lamp would pay back during the first year. We anticipate an incremental cost of \$1 - 2, based on similar products available today.</p>
Non-Energy Benefits	<p>High-luminance lamps that pass the proposed standard will have longer lifetimes than today's lamps in this category (1,000 hours instead of 750), meaning fewer bulb replacements.</p> <p>Typical lamp lifetime for three-way lamps today is already above 1,000 hours, so lamps that pass the proposed standard will have similar lifetimes.</p>
Environmental Impacts	<p>We have not identified any negative environmental impacts of a Title 20 standard for either of the two proposed lamp types.</p>
Acceptance Issues	<p>Potential positive acceptance issues of a Title 20 standard for the two proposed lamp types include:</p> <ul style="list-style-type: none"> • Consumers will still be able to purchase incandescent lamps that save energy and money over today's models. • The technology needed to meet the proposed standards is already in use today in other lamp types, and could easily be adapted for these applications. <p>Potential negative acceptance issues of a Title 20 standard for the two proposed lamp types include:</p> <ul style="list-style-type: none"> • Consumers often focus on first cost rather than lifetime costs and may not immediately realize that lamps that comply with the proposed standards save money over their lifetimes. However, the lamps that are covered by EISA/Title 20 lamps standards already cost more than traditional incandescent lamps, so three-way and high-luminance prices will be similar to other regulated incandescent lamps. • Manufacturers may not want to develop California-specific lamps in these categories, although for years they have had to do so for other lamp types. • General service lamps that produce more than 3,300 lumens would remain unregulated; a small number of customers may gravitate to these extremely bright lamps if they are less expensive than regulated lamps.

Federal Preemption or other Regulatory or Legislative Considerations	Three-way and high-luminance lamps may be covered by federal standards only if their sales exceed 100% of projections and the DOE takes action to regulate these lamp types; they are not immediately covered by EISA. Therefore, they do not appear to be preempted from coverage by Title 20 at this time.
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Methodology and Modeling used in the Development of the Proposal

We first evaluated the halogen incandescent technology used in EISA-compliant general service light bulbs to determine if that same technology could also be used in three-way and 2,601 – 3,300 lumen lamps. We did not find any technical reasons that EISA-compliant halogen incandescent technology could not be used in these two exempt lamp types. One manufacturer already advertises an EISA-compliant three-way bulb. (See [Bulbrite website](#))

The values used to create an estimate of savings potential are summarized in Table 1. Notes below the table give rationale, methods and sources for the values presented.

Table 1. Assumptions

Lamp Type	Annual CA Sales (millions)	Total CA Stock (millions)	Duty Cycle (hrs/day)	Duty Cycle (hrs/yr)	Baseline Lamp Lifetime (hours)	Replacement Lamp Lifetime (hours)	Baseline Power (W)	Replacement Power (W)
Three-way	3.1	5.2	1.9	694	1,200	1,200*	30 - 70 - 100 50 - 100 - 150 100 - 200 - 300	18 - 43 - 61 29 - 53 - 82 53 - 95 - 148
High Luminance (2,610 – 3,300 lumens)	0.7	0.8	1.9	694	750	1,000	150	95

* Lifetime of the replacement lamp is assumed to be 1,200 hours, although EISA's minimum requirement will be 1000 hours. This a conservative estimate based on typical usage patterns of simultaneous and alternate use of two capsules, which will each be subject to minimum rated life of 1,000 hours if used individually in other general service lamps. Using two 1,000 hour halogen capsules will extend the overall useful life of the lamp as a three-way system. Note that the measure is still cost-effective with a minimum 1,000 hour lifetime assumption.

To determine annual sales for both bulb types, we used the U.S. sales data that EISA requires NEMA to report each year for sales tracking. The NEMA data we used for sales modeling is from 2010, the most recent year for which data are available. We then scaled NEMA's U.S. sales data based on California households to arrive at estimates for 2010 California sales for both lamp types. We developed stock estimates based on annual sales data and lamp lifetimes.

Note that using the 2010 NEMA sales data to predict three-way and 2,601 – 3,300 lumen lamp sales is a very conservative approach. The 2010 data is derived from lamp sales prior to the time that any general

purpose lamps were regulated. Now that general service lamps are starting to be regulated under Title 20 and EISA, their prices will increase slightly, while 150 W (high luminance, 2,601 – 3,300 lumen) and three-way lamp pricing and technology will remain unchanged. We expect sales of both bulb types to increase in the coming years for this reason. We do not know if or when sales of these lamp types will exceed the 100% increase over projections that will enable them to be covered by EISA. However, even if they reach that threshold, it is likely that any federal coverage would not take effect for several years.

For today's lamp lifetimes, we used the most common lifetimes of products that are available today. For lamps that comply with the standards, we assumed the minimum lifetime requirement from EISA of 1,000 hours. For hours of use per day, we used 1.9 hours based on KEMA's 2011 Upstream Lighting Program Evaluation Report. For analysis purposes, we assumed three-way lamps operate for 1.9 hours per day at the medium power setting. This is consistent with the approach used the *Lighting Pattern Book for Homes*. (Leslie, 1996)

We assumed all of today's incandescent three-way and high-luminance general purpose lamps would be replaced with halogen incandescent lamps that comply with Title 20. CFLs in the 2,601 – 3,300 lumen range are bulky and expensive, and general purpose LED lamps that provide this amount of light do not yet exist. Three-way CFLs do exist for lower light output levels, and are in use today. We do not anticipate a significant migration to three-way CFLs, especially at the higher levels of light output that today's 50-100-150 W and 100-200-300 W three-way lamps provide.

Three-way Lamps

To estimate savings for three-way lamps, we gathered data on typical lamp wattages and light output levels for today's most common models: 30-70-100 W, 50-100-150 W, 100-200-300 W. Then, based on light output (lumens) associated with the middle power value (70, 100, or 200 W), we determined what EISA's maximum wattage requirements would be for a filament in this light output range. We then compared the existing middle lamp wattages with the reduced wattage requirements for the same lumen bin to determine savings. See Table 2, below, for EISA's maximum rated wattage allowances according to rated lumen ranges. See Table 3 for overview of common lamp wattages, light output levels, and proposed replacement wattages. All traditional and replacement wattages are included in this table for reference; however, as noted above, our savings analysis relied on the middle values only.

Table 2. EISA's general service incandescent lamp maximum wattage requirements (p. H.R. 6-86)

Today's Traditional Incandescent Wattage	Traditional Incandescent Light Output (lumens)	EISA Maximum Wattage	EISA Lumen Ranges	% Wattage Reduction from EISA
100 W	1690	72 W	1490 - 2600	28%
75 W	1170	53 W	1050 - 1489	28%
60 W	840	43 W	750 - 1049	28%
40 W	490	29 W	310 - 749	28%

Table 3. Example three-way wattages and light output levels

Today's Common Three-Way Lamp Power (W)	Average of Today's Common Three-Way Lamp Light Outputs (lm)	Proposed Title 20 Maximum Power (W)
100 - 200 - 300	1318 – 3,124 – 4,442	53 – 95 – 148

50 - 100 – 150	539 – 1,386 – 1,925	29 – 53 – 82
30 - 70 – 100	284 – 893 – 1,178	18 – 43 – 61

Notes:

- The lumen level associated with the 30 W filament is below EISA's lowest light output of coverage (310 lumens). To address that, we recommend Title 20 develop a 150 – 309 lumen category (roughly 25 W equivalent) for three-way lamps only. The maximum power for this lumen bin would be 18 W, which follows EISA's protocol of a 28% wattage reduction over today's common wattages.
- The third wattage and light output levels are sums of the low- and mid-levels, so they do not conform to EISA's established wattages.
- The 200 W filament produces light in the 2,601 – 3,300 lumen range, so it would be subject to the 95 W limit established by EISA for that lumen range. See section below for explanation.

High-Luminance Lamps

For high-luminance lamps, EISA establishes a maximum 95 watt limit that could take effect if sales of these lamps increase substantially. Therefore, to determine savings for this category, we gathered power and light output data from today's general purpose lamps in this category, and then compared the most common wattage in this category, 150 W, to the 95 W limit designed by EISA. See Table 4 for lamp power assumptions.

Table 4. Common high-luminance incandescent wattages and light output

Today's Common 2601-3300 Lamp Power (W)	Today's Common 2601-3300 Lamp Light Output (lm)	Proposed Title 20 Maximum Power (W)
150	2,780	95

Data, Analysis and Results

Our findings show that the proposed Title 20 standards for three-way and high-luminance general service lamps are cost-effective, and offer significant savings to California. See Table 5. Customers would realize a savings of more than \$6 per year for each three-way bulb replaced, and more than \$5 per year for each high-luminance general service lamp replaced.

Table 5. Estimated energy consumption and savings

Lamp Type	Baseline Annual Energy Use per Lamp (kWh)	Replacement Annual Energy Use per Lamp (kWh)	Annual Savings Per Lamp from Standard (kWh)	Total annual energy savings after Stock Turnover (GWh)	Total annual energy cost savings after entire stock turnover (million)	Peak demand reduction (MW)
Three-way	85	44	41	215	\$32	26

High-luminance	104	66	38	30	\$4.5	4
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Proposed Standards and Recommendations

Three-Way Lamps

All filaments in three-way lamps sold in the state of California shall meet the maximum wattage requirements according to lumen output as specified in EISA/Title 20 as well as the minimum operating hours specified in EISA for GSIL.

In some cases, the lowest light output level from 3-way lamps is less than 310 lumens, the minimum covered by EISA. In this case, we recommend a reduced wattage for the lumen range of 150 – 309 (light output provided by today's 25 W lamps) using the same 28% power reduction that EISA uses for the 40 W – 100 W categories. This would mean that a 25 W (200 – 309 lumen) filament would have a maximum power limit of 18 W (28% lower than 25 W).

High-luminance Lamps

Option 1: All filaments in general service 2,601 – 3,300 lamps sold in the state of California shall meet the 95 W maximum power backstop requirement as specified in EISA, as well as the minimum operating hours specified in EISA for GSIL.

Option 2: With further research, develop an efficiency metric that follows typical incandescent lamp performance characteristics such that minimum efficacy requirements increase as lumens increase.

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