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Response to Invitation to Submit Proposals - General Service Lamps (Expanded Scope)

Additional submitted attachment is included below.

General Service Lamps (Expanded Scope)

Codes and Standards Enhancement (CASE) Initiative
For PY 2017: Title 20 Standards Development

Analysis of Standards Proposal for
General Service Lamps (Expanded Scope)
17-AEER-07

September 18, 2017

Prepared for:

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1. Purpose

The Codes and Standards Enhancement (CASE) Initiative presents recommendations to support California Energy Commission's (Energy Commission) efforts to update California's Appliance Efficiency Regulations (Title 20) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric (SDG&E), Southern California Edison (SCE), and SoCalGas® – sponsored this effort (herein referred to as the Statewide CASE Team). The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve the energy and water efficiency of various products sold in California. This report and the code change proposal presented herein is a part of the effort to develop technical and cost-effectiveness information for potential appliance standards. This CASE Report covers a proposal for the expansion of the scope of general service lamps.

2. Product Description

General service lamps (GSLs) are recognized as everyday lighting products, used for "general service" applications. They include general service incandescent lamps (GSIL), compact fluorescent lamps, and general service light-emitting diodes (referred to in Title 20 as state-regulated light-emitting diodes, herein referred to as LED lamps).[1] They were defined in the Energy Independence and Security Act of 2007 (EISA), with Title 20 mirroring this definition, as follows:

(BB) General service lamp.—

(i) In general.—The term "general service lamp" includes—

(I) general service incandescent lamps;

(II) compact fluorescent lamps;

(III) general service light-emitting diode (LED or OLED) lamps; and

(IV) any other lamps that the Secretary determines are used to satisfy lighting applications traditionally served by general service incandescent lamps.

(ii) Exclusions.—The term "general service lamp" does not include—

(I) any lighting application or bulb shape described in any of subclauses (I) through (XXII) of subparagraph (D)(ii); or

(II) *any general service fluorescent lamp or incandescent reflector lamp.*

Absent from mention in the explicit definition are candelabra and intermediate-base lamps, which, as federally covered products, are defined separately by EISA. The federal definition also explicitly lists lamp types that are excluded: the 22 lamp types exempted from GSIL standards codified in EISA (any lighting application or bulb shape described in any of subclauses (I) through (XXII) of subparagraph (D)(ii), herein referred to as EISA-exempt lamps), general service fluorescent lamps, and incandescent reflector lamps (IRL). However, this federal definition allows the Secretary of the U.S. Department of Energy (U.S. DOE) to define as GSLs other lamps that are not already explicitly stated. A corresponding provision in EISA specifies a procedure for which U.S. DOE must determine whether any of these lamp types should maintain exemption, or exclusion,[2] from the GSL definition.

[1] In this report, the term LED refers to the semiconductor component, and LED lamp refers to the lighting product.

[2] U.S. DOE established in the January 2017 Final Rules that "exclusions" and "exemptions" can be treated synonymously for the purposes of regulatory definitions.

On January 19, 2017, U.S. DOE released two final rules that established a new federal definition for GSLs, after considering whether any of the explicitly stated exemptions should be maintained (U.S. DOE 2017). In short, U.S. DOE ruled that GSLs should be defined broadly by base type, operating voltage, and light output (measured in lumens), with exceptions granted for several narrowly defined 'specialty' lamp types. Along with the lamps already defined as GSLs, the new definition now includes IRLs, candelabra bases, and intermediate bases, and some newly defined GSILs[3] (U.S. DOE discontinued the GSIL exemption for 7 of the 22 EISA-exempt lamps, effectively including them in the new GSL definition). This updated definition, effective January 1, 2020, is as follows:

> *"General service lamp" means a lamp that has an ANSI base;[4] is able to operate at a voltage of 12 volts or 24 volts, at or between 100 to 130 volts, at or between 220 to 240 volts, or of 277 volts for integrated lamps (as defined in this section), or is able to operate at any voltage for non-integrated lamps (as defined in this section); has an initial lumen output of greater than or equal to 310 lumens (or 232 lumens for modified spectrum general service incandescent lamps) and less than or equal to 3,300 lumens; is not a light fixture; is not an LED downlight retrofit kit; and is used in general lighting applications. General service lamps include, but are not limited to, general service incandescent lamps, compact fluorescent lamps, general service light-emitting diode lamps, and general service organic light-emitting diode lamps. General service lamps do not include:*
>
> *(1) Appliance lamps;*
>
> *(2) Black light lamps;*
>
> *(3) Bug lamps;*
>
> *(4) Colored lamps;*
>
> *(5) G shape lamps with a diameter of 5 inches or more as defined in ANSI C79.1–2002;*
>
> *(6) General service fluorescent lamps;*
>
> *(7) High intensity discharge lamps;*
>
> *(8) Infrared lamps;*
>
> *(9) J, JC, JCD, JCS, JCV, JCX, JD, JS, and JT shape lamps that do not have Edison screw bases;*
>
> *(10) Lamps that have a wedge base or prefocus base;*
>
> *(11) Left-hand thread lamps;*
>
> *(12) Marine lamps;*
>
> *(13) Marine signal service lamps;*
>
> *(14) Mine service lamps;*
>
> *(15) MR shape lamps that have a first number symbol equal to 16 (diameter equal to 2 inches) as defined in ANSI C79.1–2002, operate at 12 volts, and have a lumen output greater than or equal to 800;*
>
> *(16) Other fluorescent lamps;*
>
> *(17) Plant light lamps;*
>
> *(18) R20 short lamps;*

[3] In this report, "newly defined GSIL" refers to a subset of "newly defined GSL". The former is further discussed in Section 5.1, while the ladder refers to the entire scope of the report.

[4] ANSI Bases are defined by the American National Standards Institute.

(19) Reflector lamps that have a first number symbol less than 16 (diameter less than 2 inches) as defined in ANSI C79.1– 2002 and that do not have E26/E24, E26d, E26/50x39, E26/53x39, E29/28, E29/53x39, E39, E39d, EP39, or EX39 bases;

(20) S shape or G shape lamps that have a first number symbol less than or equal to 12.5 (diameter less than or equal to 1.5625 inches) as defined in ANSI C79.1–2002;

(21) Sign service lamps;

(22) Silver bowl lamps;

(23) Showcase lamps;

(24) Specialty MR lamps;

(25) T shape lamps that have a first number symbol less than or equal to 8 (diameter less than or equal to 1 inch) as defined in ANSI C79.1–2002, nominal overall length less than 12 inches, and that are not compact fluorescent lamps;

(26) Traffic signal lamps;

The scope of this report, further discussed in Section 5.1, will be limited to the lamps that are newly defined as GSLs per the above definition. The scope shall include one addition: lamps with light output between 150 and 310 lumens, herein referred to as low-lumen lamps. The Statewide CASE Team, along with several energy-efficiency advocates (see Section 5.7), expressed to the Energy Commission, in the recent 'Invitation to Participate' of this rulemaking (CEC 2017a), that the Title 20 standards for state-regulated LED lamps will apply to some lamps in this lumen range. Without standards for low-lumen lamps, the market for these lamps may shift toward inefficient incandescent technology in order to bypass Title 20 standards (California Energy Commission 2017b). As such, the Statewide CASE Team believes that the Energy Commission should also cover these lamps under the GSL standards. These lamps will be further discussed in Section 5.2.4.

3. Code Proposal Overview

Table 1: Summary of Proposal

Topic	Description
Description of Code Proposal	The Statewide CASE Team proposes that the Energy Commission exercise the rights granted to California by EISA and adopt the new federal GSL definition established by U.S. DOE in the January 19, 2017, Final Rules as "state-regulated general service lamps", herein referred to as "general service lamps (GSLs)." This new definition will re-categorize several lamp types as GSLs, which will effectively expand the scope of the current Title 20 standards for GSLs.
Technical Feasibility	U.S. DOE defined GSLs by excluding certain specialty lamps that cannot be constructed with non-incandescent technology. Thus, the Statewide CASE Team believes that expanding the minimum efficacy requirement of 45 lumens/watt to include the newly defined GSLs will be technically feasible. In addition, the Statewide CASE Team provides several examples of lamps that may suitably serve as replacement products.
Energy Savings and Demand Reduction	The proposed measure will save 2.8 terawatt-hours (TWh) in the first year with a peak demand reduction of 450 megawatts (MW).
Environmental Impacts and Benefits	The proposed measure will reduce greenhouse gas emissions by 1.2 million metric tons of carbon-dioxide equivalent (MTCO2e) in the first year without any adverse effected to the environment
Economic Analysis	The proposed measure will save California $766 million in the first year and over $7 billion throughout the life of the qualifying product.
Consumer Acceptance	Consumers are likely to accept since LED lamps are already popular and decreasing in cost.
Other Regulatory Considerations	The U.S. DOE federal definition for GSLs will be effective on January 1, 2020. EISA mandates U.S. DOE to implement a minimum efficacy requirement of 45 lumens/watt starting January 1, 2020.

4. Proposed Code and Recommendations

4.1 Proposal Description

The Statewide CASE Team proposes that the Energy Commission exercise the rights granted to California by EISA and adopt the new federal GSL definition established by U.S. DOE in the January 19, 2017, Final Rules as "state-regulated general service lamps," herein referred to as "general service lamps (GSLs)."[5] This new definition will re-categorize several lamp types as GSLs, which will effectively expand the scope of the current Title 20 standards for GSLs. The Title 20 standards for GSLs, which will be further discussed in Section 5.9.2, include a 45 lumens/watt minimum luminous efficacy requirement that cannot be achieved by traditional incandescent technologies, including halogen lamps.[6] Thus, this scope expansion will also effectively prohibit the sales of incandescent versions of the lamps that are newly defined as GSLs. The impacts of this expansion will be discussed in Section 5.

The updated definition established by U.S. DOE includes lamps that can be used in both commercial and residential sectors, as long as the lamps may be used for "general service" applications. It also narrowly defines exempted lamp

[5] The legal authority for California to adopt the new GSL definition will be discussed in Section 5.9.2.

[6] For the purposes of this report, "incandescent" shall include "halogen".

types so as to minimize the risk of "loophole" products entering the market. In revising the Title 20 GSL definition, the Energy Commission must also update the definitions of these exempted lamp types to remain consistent with U.S. DOE definitions. The Statewide CASE Team proposes these additional changes to definitions of non-GSL lamps, which align with those defined by U.S. DOE, so that the new GSL definition is clear and consistent. These non-GSL lamps are: bug lamp, colored incandescent lamp, infrared lamp, LED downlight retrofit kit, marine lamp, mine service lamp, other fluorescent lamp, plant light lamp, reflector lamp, showcase lamp, sign service lamp, silver bowl lamp, specialty MR lamp, and traffic signal lamp.

In addition to defining "state-regulated general service lamp," the Statewide CASE Team proposes that the Energy Commission modify the definition to include lamps with brightness as low as 150 lumens. The Energy Commission may revise this aspect of the GSL definition, because lamps with brightness less than 310 lumens are not federally covered products.

4.2 Proposal History

During the 2008 Phase I rulemaking for Title 20, the Energy Commission adopted a minimum luminous efficacy requirement of 45 lumens/watt for all state-regulated GSLs, effective January 1, 2018. At the time of this rulemaking, the definition for "federally regulated general service lamp" still required U.S. DOE to determine whether certain lamp types should have exemptions maintained (see Section 2). As discussed, U.S. DOE has since finalized the federal definition of GSLs, which will become effective January 1, 2020. As discussed in Section 5.9.2, EISA grants the Energy Commission the authority to adopt this federal definition up to two years earlier, thus setting the premise of this CASE Report.

4.3 Proposed Changes to the Title 20 Code Language

The proposed changes to the Title 20 standards are provided below. Changes to the 2017 standards are marked with underlining (new language) and ~~strikethroughs~~ (deletions).

§ 1602. Definitions.

(k) Lamps.

~~"Black Light Lamp" means a lamp that emits radiant energy in the UV-A band (315-400 nm) and is designated and marketed as a "black light". The designation shall be on the lamp packaging, and marketing materials shall identify the lamp as a black light lamp.~~

"Black light lamp" means a lamp that is designed and marketed as a black light lamp and is an ultraviolet lamp with the highest radiant power peaks in the UV-A band (315 to 400 nm) of the electromagnetic spectrum.

~~"Bug lamp" means a lamp that contains a filter to suppress the blue and green portions of the visible spectrum and is designated and marketed as a "bug light". The designation shall be on the lamp packaging, and marketing materials shall identify the lamp as being a bug lamp.~~

"Bug lamp" means a lamp that is designed and marketed as a bug lamp, has radiant power peaks above 550 nm on the electromagnetic spectrum, and has a visible yellow coating.

~~"Colored fluorescent lamp" means a fluorescent lamp designated and marketed as a colored lamp, and not designed or marketed for general illumination applications with either of the following characteristics:~~

~~(1) a CRI less than 40, as determined according to the method given in CIE publication 13.3- 1995, or~~

~~(2) a correlated color temperature less than 2,500K or greater than 7,000K as determined according to the method set forth in IES LM-9-09.~~

~~"Colored incandescent lamp" means an incandescent lamp designated and marketed as a colored lamp that has:~~

~~(1) a CRI of less than 50, as determined according to the test method given in CIE publication 13.3-1995 13.3; or~~

~~(2) a correlated color temperature less than 2,500K, or greater than 4,600K 7,000K., where correlated color temperature is computed according to the Journal of Optical Society of America, Vol. 58, pages 1528-1595 (1968).~~

"Colored lamp" means a colored fluorescent lamp, a colored incandescent lamp, or a lamp designed and marketed as a colored lamp with either of the following characteristics (if multiple modes of operation are possible [such as variable CCT], either of the below characteristics must be maintained throughout all modes of operation):

(1) CRI less than 40, as determined according to the method set forth in CIE Publication 13.3; or

(2) CCT less than 2,500 K or greater than 7,000 K.

"Designed and marketed," when referencing a federally regulated lamp, means exclusively designed to fulfill the indicated application and, when distributed in commerce, designated and marketed solely for that application, with the designation prominently displayed on the packaging and all publicly available documents (e.g., product literature, catalogs, and packaging labels). This definition is applicable to terms related to the following federally covered lighting products: fluorescent lamp ballasts; fluorescent lamps; general service fluorescent lamps; general service incandescent lamps; general service lamps; incandescent lamps; incandescent reflector lamps; medium base compact fluorescent lamps; and specialty application mercury vapor lamp ballasts.

"State-regulated 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 wattage rating no less than 25 watts and no greater than 150 watts;~~ has a lumen range of not less than 150 lumens and not more than 2,600 lumens or, in the case of a modified spectrum lamp, not less than 232 lumens and not more than 1,950 lumens; and ~~has a rated~~ is capable of being operated at a voltage range at least partially within 110 and 130 volts. ~~has a A-15, A-19, A-21, A-23, A-25, PS-25, PS-30, BT-14.5, BT-15, CP-19, TB-19, CA-22, or equivalent shape as defined in ANSI C78.20-2003; and has a bulb finish of the frosted, clear, or soft white type.~~ The following incandescent lamps are not state-regulated general service incandescent lamps: appliance, black light, bug, colored, G shape lamp with a diameter of 5 inches or more as defined in ANSI C79.1-2002, infrared, left-hand thread, marine, marine signal service, mine service, plant light, ~~reflector, rough service, shatter resistant,~~ an R20 short lamp, sign service, silver bowl, showcase, ~~three-way,~~ and traffic signal~~, and vibration service or vibration resistant~~.

"State-regulated general service lamp" means a lamp that has an ANSI base; is able to operate at a voltage of 12 volts or 24 volts, at or between 100 to 130 volts, at or between 220 to 240 volts, or of 277 volts for integrated lamps, or is able to operate at any voltage for non-integrated lamps; has an initial lumen output of greater than or equal to 150 lumens (or 232 lumens for modified spectrum general service incandescent lamps) and less than or equal to 3,300 lumens; is not a light fixture; is not an LED downlight retrofit kit; and is used in general lighting applications. State-regulated general service lamps include, but are not limited to, state-regulated general service incandescent lamps, compact fluorescent lamps, state-regulated

light-emitting diode lamps, and general service organic light-emitting diode lamps. General service lamps do not include:

(1) Appliance lamps;

(2) Black light lamps;

(3) Bug lamps;

(4) Colored lamps;

(5) G shape lamps with a diameter of 5 inches or more as defined in ANSI C79.1-2002 (incorporated by reference);

(6) General service fluorescent lamps;

(7) High intensity discharge lamps;

(8) Infrared lamps;

(9) J, JC, JCD, JCS, JCV, JCX, JD, JS, and JT shape lamps that do not have Edison screw bases;

(10) Lamps that have a wedge base or prefocus base;

(11) Left-hand thread lamps;

(12) Marine lamps;

(13) Marine signal service lamps;

(14) Mine service lamps;

(15) MR shape lamps that have a first number symbol equal to 16 (diameter equal to 2 inches) as defined in ANSI C79.1-2002 (incorporated by reference), operate at 12 volts, and have a lumen output greater than or equal to 800;

(16) Other fluorescent lamps;

(17) Plant light lamps;

(18) R20 short lamps;

(19) Reflector lamps (as defined in this section) that have a first number symbol less than 16 (diameter less than 2 inches) as defined in ANSI C79.1-2002 (incorporated by reference) and that do not have E26/E24, E26d, E26/50x39, E26/53x39, E29/28, E29/53x39, E39, E39d, EP39, or EX39 bases;

(20) S shape or G shape lamps that have a first number symbol less than or equal to 12.5 (diameter less than or equal to 1.5625 inches) as defined in ANSI C79.1-2002 (incorporated by reference);

(21) Sign service lamps;

(22) Silver bowl lamps;

(23) Showcase lamps;

(24) Specialty MR lamps;

(25) T shape lamps that have a first number symbol less than or equal to 8 (diameter less than or equal to 1 inch) as defined in ANSI C79.1-2002 (incorporated by reference; see § 430.3), nominal

overall length less than 12 inches, and that are not compact fluorescent lamps (as defined in this section);

(26) Traffic signal lamps;

"General service organic light-emitting diode (OLED) lamp" means an integrated or non-integrated OLED lamp designed for use in general lighting applications and that uses organic light-emitting diodes as the primary source of light.

~~"Infrared lamp" means a lamp that radiates predominately in the infrared region of the electromagnetic spectrum, and where visible radiation is not of principal interest. The designation shall be on the lamp packaging, and marketing materials shall identify the lamp as being an infrared lamp.~~

Infrared lamp means a lamp that is designed and marketed as an infrared lamp; has its highest radiant power peaks in the infrared region of the electromagnetic spectrum (770 nm to 1 mm); has a rated wattage of 125 watts or greater; and which has a primary purpose of providing heat.

"LED downlight retrofit kit" means a product designed and marketed to install into an existing downlight, replacing the existing light source and related electrical components, typically employing an ANSI standard lamp base, either integrated or connected to the downlight retrofit by wire leads, and is a retrofit kit. LED downlight retrofit kit does not include integrated lamps or non-integrated lamps.

~~"Left-handed thread lamp" means a lamp on which the base screws into a lamp socket in a counter-clockwise direction, and screws out of a lamp socket in a clockwise direction.~~

"Left-hand thread lamp" means a lamp with direction of threads on the lamp base oriented in the left-hand direction.

~~"Marine lamp" means a lamp specifically designed to operate in a marine. The designation shall be on the lamp packaging, and marketing materials shall identify the lamp as being a marine lamp or similar designation.~~

"Marine lamp means a lamp that is designed and marketed for use on boats and can operate at or between 12 volts and 13.5 volts."

~~"Marine Signal Lamp" means a lamp specifically designed to provide signals to marine vessels for seaway safety. The designation shall be on the lamp packaging, and marketing materials shall identify the lamp as being a marine signal lamp or similar designation.~~

"Marine signal service lamp" means a lamp that is designed and marketed for marine signal service applications.

~~"Mine service lamp" means a lamp specifically designed for use in mine applications. The designation shall be on the lamp packaging, and marketing materials shall identify the lamp as being a mine service lamp or similar designation.~~

"Mine service lamp" means a lamp that is designed and marketed for mine service applications.

"Other fluorescent lamp" means low-pressure mercury electric-discharge sources in which a fluorescing coating transforms some of the ultraviolet energy generated by the mercury discharge into visable light, including circline lamps, and including double-ended lamps with the following characteristics: Lengths from one to eight feet; designed for cold temperature applications; designed for use in reprographic equipment; designed to produce radiation in the ultraviolet region of the spectrum; impact-resistant; reflectorized or aperture; or a CRI of 87 or greater.

~~"Plant light lamp" means a lamp that contains a filter to suppress yellow and green portions of the spectrum, and is designated and marketed as a "plant light." The designation shall be on the lamp packaging, and marketing materials shall identify the lamp as being a plant light.~~

"Plant light lamp" means a lamp that is designed to promote plant growth by emitting its highest radiant power peaks in the regions of the electromagnetic spectrum that promote photosynthesis: Blue (440 nm to 490 nm) and/or red (620 to 740 nm), and is designed and marketed for plant growing applications.

"Reflector lamp" means a lamp that has ~~a reflective coating applied directly to part of the bulb surface and that reflects light in a forward direction away from the lamp base. The designation shall be on the lamp packaging, and marketing materials shall identify the lamp as being a reflector lamp or similar designation.~~ an R, PAR, BPAR, BR, ER, MR, or similar bulb shape as defined in ANSI C78.20-2003 and ANSI C79.1-2002 and is used to provide directional light.

~~"Showcase lamp" means a lamp that has a tubular bulb with a conventional screw base. The longer lamps have filaments with supports similar to linear incandescent lamps. The designation shall be on the lamp packaging, and marketing materials shall identify the lamp as being a showcase lamp.~~

"Showcase lamp" means a lamp that has a T shape as specified in ANSI C78.20–2003 and ANSI C79.1–2002, is designed and marketed as a showcase lamp, and has a maximum rated wattage of 75 watts.

~~"Sign service lamp" means a lamp and of the vacuum type or gas-filled with sufficiently low bulb temperature to permit exposed outdoor use on high-speed flashing circuits, and is. The designation shall be on the lamp packaging, and marketing materials shall identify the lamp as being a sign service lamp.~~

"Sign service lamp" means a vacuum type or gas-filled lamp that has sufficiently low bulb temperature to permit exposed outdoor use on high-speed flashing circuits, is designed and marketed as a sign service lamp, and has a maximum rated wattage of 15 watts.

~~"Silver bowl lamp" means a lamp that has a reflective coating applied directly to part of the bulb surface and that reflects light in a backward direction toward the lamp base. The designation shall be on the lamp packaging, and marketing materials shall identify the lamp as being a silver bowl lamp or similar designation.~~

"Silver bowl lamp" means a lamp that has an opaque reflective coating applied directly to part of the bulb surface that reflects light toward the lamp base and that is designed and marketed as a silver bowl lamp.

"Specialty MR lamp" means a lamp that has an MR shape as defined in ANSI C79.1-2002, a diameter of less than or equal to 2.25 inches, a lifetime of less than or equal to 300 hours, and is designated and marketed for a specialty application.

~~"Traffic signal lamp" means a lamp that is designed with lifetime, wattage, focal length, filament configuration, mounting, lamp glass, and lamp base characteristics appropriate for use in traffic signals.~~

"Traffic signal lamp" means a lamp that is designed and marketed for traffic signal applications and has a lifetime of 8,000 hours or greater.

5. Analysis of Proposal

5.1 Scope

The scope of this proposal analysis is limited to incandescent lamps that are newly defined as GSLs per the U.S. DOE Final Rules issued on January 19, 2017. Starting the effective date of the proposed code change, these lamps will be subject to a minimum efficacy requirement that cannot be met by incandescent technology. The proposal analysis will address the technical feasibility, statewide energy savings, and cost-effectiveness of effectively prohibiting these newly defined GSLs from being incandescent. For the purposes of this report, the Statewide CASE Team assumes that replacement lamps will be LED.

Other lamp types that are newly defined as GSLs (e.g., LED lamps and small diameter direction lamps) will already be subject to more stringent Title 20 requirements prior to the effective date of this proposed code change, and are thus not included in the scope of this analysis.

Based on historic lamp categorization, the Statewide CASE Team divided the incandescent lamps that are within the scope of this report into four different classes:

1. Incandescent reflector lamps (IRL), which does not include lamps with diameters smaller than 2.25 inches.
2. Decorative lamps, which include candelabra lamps of all base types and intermediate-base lamps of all shapes.
3. Newly defined GSILs, which includes six of the seven lamps that were previously exempt from EISA (three-way incandescent lamps; shatter-resistant lamps; vibration service lamps; rough service lamps; T-shape lamp of 40 W or less or length of 10 inches or more; and B, BA, CA, F, G16-1/2, G25, G30, or S lamps; but not 'reflector lamps' since they are included in the IRL product type) and lamps of light output between 2,600 and 3,300 lumens.
4. Low-lumen lamps, which include lamps with a lumen range of 150 lumens or greater and less than 310 lumens.

5.2 Technical Feasibility

The newly defined GSLs will be required by Title 20 to meet a minimum efficacy requirement of 45 lumens/watt, which can be achieved by compact fluorescent lamps (CFL) or LED lamps.[7] LED replacement lamps are generally available for all but the most obscure incandescent lamps. When updating the definition of GSL in the January 19, 2017, Final Rules, U.S. DOE reviewed product availability and determined certain specialty lamps that could not be constructed with non-incandescent technology. U.S. DOE excluded these lamps from the GSL definition, and thus believes it technically feasible to produce LED versions of all GSLs (U.S. DOE 2017).

Compared to incandescent lamps that use filaments encased in glass bulbs, solid-state LED lamps have superior physical durability and longer product life. These attributes allow LED lamps to replace traditional incandescent bulbs, making specially designed incandescent lamps (namely, shatter-resistant, vibration service, and rough service, discussed further below) obsolete. Additionally, LED lamps function more efficiently – they produce less heat – and are thus safer to touch.

LED lamps also have more utility options, compared to incandescent lamps. For example, the electronic characteristics of LED lamps allow for [light dimming and color-tuning. Additionally, their low operating power

[7] The Statewide CASE Team assumes that incandescent lamps will switch to LEDs, and that CFL lamps will not switch. Thus, while CFL lamps are also capable of meeting the 45 lumens/watt requirement, the scope of this report will be limited to LED replacement products.

requirements have enabled Power over Ethernet (PoE) use for smart lighting applications.[8] This operational flexibility and enhanced capabilities, along with increased lamp lifetimes, have given rise to "smart bulb" products, the discussion for which is beyond the scope of this report.

The subsequent sections discuss in detail the product types identified in Section 5.1.

5.2.1 Incandescent Reflector Lamps

Figure 1: LED version of incandescent reflector lamps (PAR30, left, and BR30, right)

Sources left to right: 1000 Bulbs: http://www.1000bulbs.com/product/99879/TCP-14P30D30KFL.html; https://www.1000bulbs.com/product/100011/TCP-10BR3027K.html.

IRLs currently have their own federal energy conservations standards, as shown in Table 20. U.S. DOE determined in the January 1, 2017, Final Rules that these lamps can be used for general service applications. Moreover, U.S. DOE determined that EISA grants it the authority to discontinue the exemption status of reflector lamps, effectively including IRLs within the GSL definition (U.S. DOE 2017).

LED lamps are well suited to replace reflector lamps due to their directional nature, high efficacy, large range of lumen outputs, CCTs, shapes, and sizes. In 2016, the Statewide CASE Team identified LED large diameter (greater than 2.25 inches) directional LED lamps with efficacies greater than 68 lumens/watt available from 47 different manufacturers on eight major retail websites (e.g., HomeDepot.com, Lowes.com, 1000bulbs.com), including 532 products with the following performance metrics in Table 2. In addition to the performance metrics listed, there are also directional LED lamps with beam angles as low as 8,[9] 9,[10] and 10[11] degrees, as well as CRI values of 95.

[8] Power over Ethernet (PoE) describes any of several standardized or ad hoc systems which pass electric power along with data on twisted pair Ethernet cabling. This allows a single cable to provide both data connection and electric power to devices, such as wireless access points, IP cameras, and VoIP phones.
[9] https://www.1000bulbs.com/product/117014/LED-01475.html.
[10] https://www.1000bulbs.com/product/114121/LED-00763.html.
[11] https://www.1000bulbs.com/product/117812/LED-01599.html.

Table 2: Summary of Directional Lamps Available from Eight Major Online Retailers

LED Shape	Number of Unique Models	Average Efficacy (lm/W)	Median Lumens	Min Lumens	Min CCT	Max CCT
BR20	7	74.2	550	450	2,700	5,000
BR30	169	74.5	650	525	2,700	6,500
BR40	67	76.8	1,000	550	2,700	6,500
PAR20	39	77.3	500	200	2,700	5,000
PAR30	90	75.2	8,60	320	2,700	5,000
PAR38	130	81.2	1,200	620	2,700	6,500
R30	14	76.1	800	650	2,700	5,000
R40	16	78.8	1,230	800	2,700	6,500

5.2.2 Decorative Lamps (Intermediate-Base and Candelabra Lamps)

Figure 2: LED lamps of various shapes (B, CA, G)

Source left to right: 1000 Bulbs: https://www.1000bulbs.com/product/192118/CM-CM134501830BC.html; https://www.1000bulbs.com/product/192121/CM-CM134501830FC.html; https://www.1000bulbs.com/product/115237/TCP-8G25D30KF.html.

In general, the Statewide CASE Team found that LED lamps are offered in many shapes and sizes. The Statewide CASE Team conducted a product search and identified thousands of LED products with intermediate (E17) or candelabra (E11 or E12) base types offered by several retailers. From a subset of these products, the Statewide CASE Team identified the application for which the products should be used as advertised by the retailer. Table 3 summarizes the findings, which suggest that most lamps in this product class are used for decorative purposes.

Table 3: Applications of Candelabra and Intermediate-Base Types

Shape\Base	E11	E12	E17
A	-	Decorative, GSL	GSL
C	Night Light	Night Light, Sign, Candelabra, Cold Start, Decorative	Decorative
G	-	Decorative, GSL	Decorative
MR16	Indoor Floodlight	-	Indoor Floodlight
R	-	Fan	Indoor Floodlight
S	-	Sign	Sign
ST	-	Decorative, GSL, Filament, Decorative	-
T-Shape	Bathroom, Decorative, Pendants, Fixtures, Sconces	Candelabra, Sconces, Fixtures, Sign, Filament, Exit Signs, Appliance, Decorative	Sign, Appliance
B	-	Candelabra, Decorative	-

Moreover, the product availability of the bulb shapes identified may serve as a proxy for the popularity of that bulb type. The Statewide CASE Team found that less than five percent of the thousands of product offerings are for intermediate-base lamps, which suggests that candelabra-base lamps are far more popular. Of the candelabra-base lamps, Figure 3 shows the fraction of each bulb shape that is offered with intermediate or candelabra base types. Ninety-six percent of products offered are B, C, CA, or G shape lamps, which, as shown in Table 3, are predominantly for decorative applications.

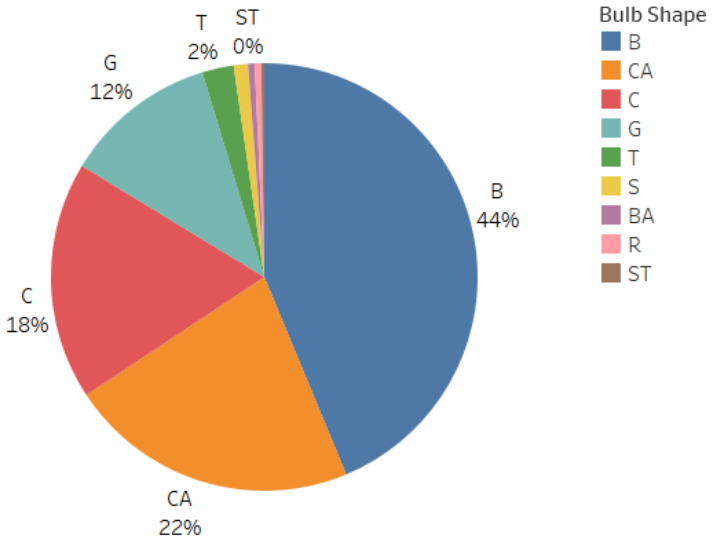

Figure 3: Fractions of candelabra bulb shapes from thousands of retail product offerings

Source: Statewide CASE Team.

When assessing thousands of product offerings from online retailers, the CASE Team found hundreds of LED lamps meeting the Title 20 definition of state-regulated LED. Of these lamps, candelabra base products started being offered in the third quarter of 2016. As can be seen in Figure 5, the fraction of candelabra base LED products offered through these retailers continues to grow through 2017.

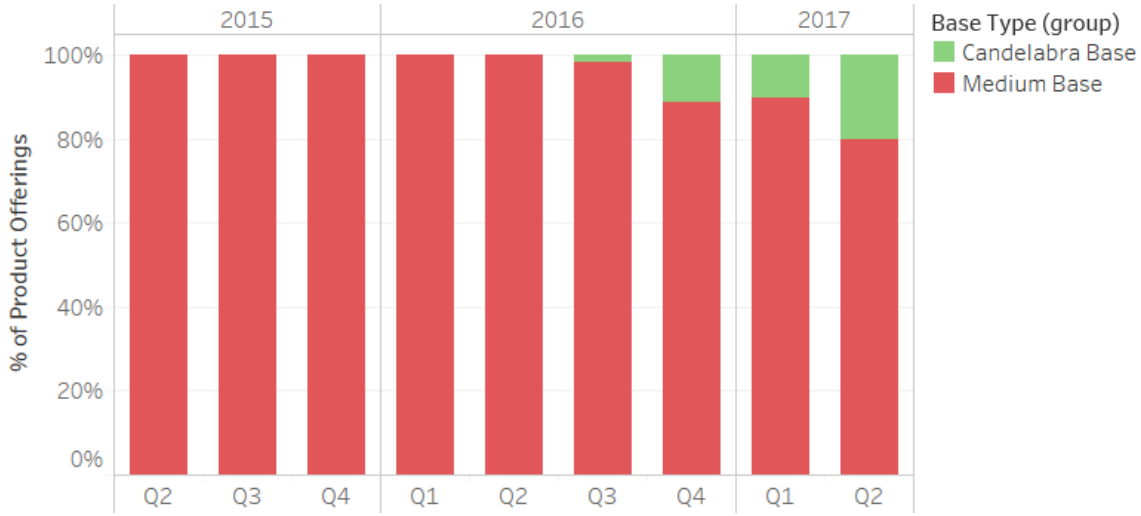

Figure 4: Fractions of candelabra base LED products from thousands of retail product offerings over time

Source: Statewide CASE Team.

5.2.3 Newly Defined General Service Incandescent Lamps (GSILs)

5.2.3.1 Rough Service Lamps

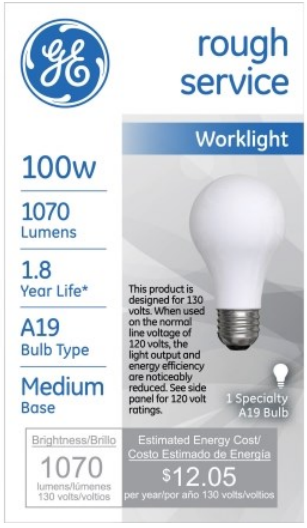

Figure 5: A rough service lamp (incandescent)

Source: Ace Hardware: http://www.acehardware.com/product/index.jsp?productId=3808053.

Since rough service lamps are defined by filament configuration, they are inherently incandescent lamps. Specifically, they are designed and marketed for "rough service" applications. A rough service lamp is defined in Title 20 as follows:

> *"Rough service lamp" means a lamp that:*
>
> *(1) has a minimum of 5 supports with filament configurations that are C-7A, C-11, C-17, and C-22 as listed in Figure 6-12 of the 9th edition of the IES Lighting Handbook, or similar configurations where lead wires are not counted as supports; and*
>
> *(2) is designated and marketed specifically for 'rough service' applications, with:*
>
> *A. the designation appearing on the lamp packaging; and*
>
> *B. marketing materials that identify the lamp as being for rough service.*

Rough service lamps are commonly available at less than 10 lumens per watt (lm/W).[12] These lamps may be replaced by LED lamps, since LED lamps are inherently more durable due to their solid-state electronics composition. The U.S. DOE Final Rules acknowledged that rough service lamps do not serve any unique utility that cannot be served by standard LED lamps, and that these lamps are likely being purchased as replacement GSILs (i.e., for use in general service applications) despite being marked and labeled for rough service applications.

5.2.3.2 Shatter-Resistant Lamps

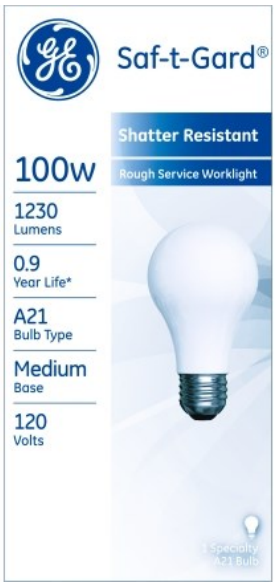

Figure 6: A shatter-resistant lamp (incandescent)

Source: Ace Hardware: http://www.acehardware.com/product/index.jsp?productId=1287880.

[12] Philips Rough Service 75W Lamp at Home Depot (9.5 lm/W): http://www.homedepot.com/p/Philips-75-Watt-Incandescent-A19-120-130-Volt-Rough-Service-Frosted-Light-Bulb-12-Pack-293605-0/204148590;
SunLite Rough Service 60W Lamp at Wal-Mart (9.7 lm/W): http://www.walmart.com/ip/2-Pk-SUNLITE-60w-120v-A-Shape-Rough-Service-Clear-light-bulb/46434702?reviews_limit=10&.

Shatter-resistant lamps are defined by their ability to contain the glass envelope of a lamp should it rupture. They are thus pertinent to only lighting technologies that employ glass casings. Specifically, they are designed and marketed as being shatter-resistant, shatter-proof, or shatter-protected. A shatter-resistant lamp is defined in Title 20 as follows:

> *"Shatter-resistant lamp, shatter-proof lamp, or shatter-protected lamp" means a lamp that:*
>
> *(1) has a coating or equivalent technology that is compliant with the NSF/ANSI 51 and is designed to contain the glass if the glass envelope of the lamp is broken; and*
>
> *(2) is designated and marketed for the intended application, with:*
>
> *A. the designation on the lamp packaging; and*
>
> *B. marketing material that identify the lamp as being shatter-resistant, shatter-proof, or shatter-protected.*

Shatter-resistant incandescent lamps are typically less efficacious effective than other incandescent lamps due to the outer coating surrounding the glass envelope. These lamps may be replaced by LED lamps, since most LED lamps are enclosed by envelopes that do not shatter. The U.S. DOE Final Rules acknowledged that shatter-resistant lamps do not serve any unique utility that cannot be served by standard LED lamps, and that these lamps are likely being purchased as replacement GSILs.

Shatter-resistant lamps are one of five lamps that U.S. DOE monitors, as directed by EISA, using sales provided annually by the National Electrical Manufacturers Association (NEMA). While sales for shatter-resistant lamps have not surpassed the predetermined sales threshold, U.S. DOE concluded that shatter-resistant lamps will likely fill the market currently occupied by rough service and vibration service lamps. Therefore, shatter-resistant lamps are included in the new U.S. DOE Final Rules definition of GSL.

5.2.3.3 Three-way Lamps

Figure 7: An LED three-way lamp

Source: CREE. http://creebulb.com/30-60-100-watt-replacement.

Three-way lamps are defined as lamps that utilize two filaments to provide three distinct levels of brightness. These lamps thus require a distinct type of luminaire capable of controlling both filaments separately. A three-way lamp is defined by Title 20 as follows:

> *"Three-way lamp" includes an incandescent lamp that employs two filaments, operated separately and in combination, to provide three light levels. The designation shall be on the lamp packaging, and marketing materials shall identify the lamp as being a three-way lamp.*

The Title 20 definition of three-way lamps defines them as inherently incandescent. However, manufacturers also produce three-way CFLs as a more efficient option.[13] Additionally, three-way LED lamps are also available (Figure 7) for consumers who wish to continue using their three-way luminaire while replacing their incandescent three-way lamps.

U.S. DOE conducted testing of an LED three-way lamp and found it had an efficacy of 111.4 lm/W at its middle setting. In addition, highly efficacious LED three-way lamps were already widely available from multiple manufacturers in 2016, including Philips (89 lm/W, middle setting), Cree (103 lm/W, middle setting), and Westinghouse (90 lm/W, middle setting). These lamps provide the same functionality as their incandescent counterparts; they can provide light at three distinct light levels.

5.2.3.4 Vibration Service Lamps

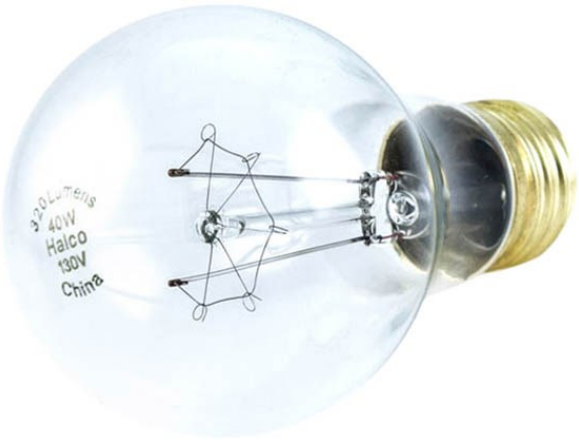

Figure 8: A vibration service lamp (incandescent)

Source: Bulbs.com: http://www.bulbs.com/product/A19CL40-VS.

Like rough service lamps, vibration service lamps are defined by filament configuration, and are thus inherently incandescent lamps. Specifically, they are designed and marketed for "vibration-resistant" applications. A vibration service lamp is defined in Title 20 as follows:

[13] https://www.lightbulbs.com/product/sylvania-29913/?source=GooglePPC-ProductAds&gclid=CjwKEAjwsLTJBRCvibaW9bGLtUESJAC4wKw1IPgTke9lsHlY0WOkLIYMvDFhPBSpcF1FLHoTZmq2nxoCTjXw_wcB.

"Vibration service lamp" means a lamp that:

(1) has filament configurations that are C-5, C-7A, or C-9, as listed in Figure 6-12 of the 9th Edition of the IES Lighting Handbook or similar configurations;

(2) has a maximum wattage of 60 watts;

(3) is sold at retail in packages of two lamps or less; and

(4) is designated and marketed specifically for vibration service or vibration-resistant applications with:

a. the designation appearing on the lamp packaging; and

b. marketing materials that identify the lamp as being vibration service only.

Through review of retailer websites, the Statewide CASE Team found that many retailers do not make clear distinctions between rough service or vibration service.[14] They are sometimes advertised for use as a garage light or ceiling fan light. These lamps may be replaced by LED lamps, since LED lamps are inherently more vibration-resistant due to their solid-state electronics composition. The U.S. DOE Final Rules acknowledged that vibration service lamps do not serve any unique utility that cannot be served by standard LED lamps, and that these lamps are likely being purchased as replacement GSILs despite being marked and labeled for "vibration service" applications.

Vibration service lamps are one of five lamps that U.S. DOE monitors, as directed by EISA, using sales provided annually by NEMA. Like sales of rough service lamps, U.S. DOE found that in 2015, vibration service lamps surpassed their predetermined sales threshold. U.S. DOE considers the GSL Final Rules to be the "accelerated rulemaking" required to regulate vibration service lamps.[15] These lamps are thus included in the new U.S. DOE Final Rules definition of GSL.

5.2.4 Low-Lumen Lamps

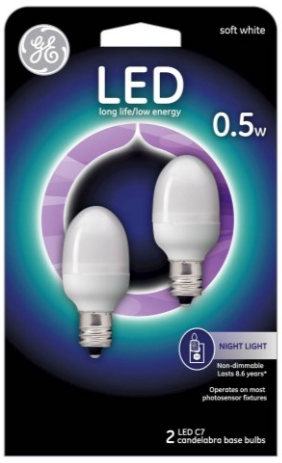

Figure 9: An LED night light

Source: Target: https://www.target.com/p/ge-led-2-watt-nightlight-light-bulb-2-pack-soft-white-white-bulb/-/A-13783767.

[14] Top Bulb: http://www.topbulb.com/light-bulbs/rough-service.

[15] In a lawsuit settlement with NEMA, DOE has agreed to initiate a separate rulemaking to adopt standards for vibration and rough service lamps. As of the publication date of this report, DOE has not yet initiated this process.

As reported in Section 4.1, the U.S. DOE Final Rules definition for GSLs does not include lamps that have light output values of less than 310 lumens (or 232 lumens for modified spectrum general service incandescent lamps). Such lamps are typically used for decorative purposes, or often advertised as night lights (Figure 9). The Statewide CASE Team believes that the Energy Commission should consider an efficacy requirement of 45 lm/W for low-lumen lamps since these lamps are technologically identical to GSLs. The incandescent versions of low-lumen lamps offer no additional utility when compared to the LED versions, which are as abundant as any of the product classes presented in this response.

5.3 Statewide Energy Savings

This section describes the methodology the Statewide CASE Team used to estimate statewide energy and environmental impacts. The Statewide CASE Team calculated the impacts of the proposed code change by comparing non-qualifying products to qualifying products for the lamp types that would be newly defined as GSLs under the proposed code change, as described in the previous section. For the purposes of this report, the Statewide Case Team considered available incandescent and LED lamps to be non-qualifying and qualifying products, respectively.

5.3.1 Per Unit Energy Savings Methodology

The Statewide CASE Team calculated the per unit energy savings of each product type identified in Section 5.1 by calculating the difference in per unit annual energy consumption (AEC) of non-qualifying (incandescent) and qualifying (LED) products. The per unit AEC is generally calculated by the following, Equation 1.

Equation 1: General formula to calculate annual energy consumption

$$AEC = \sum (P \times h_s \times f_s)$$

P = representative wattage
h_S = annual hours of use for a given sector (residential or commercial)
f_S = fraction of products in a given sector (residential or commercial)

To determine the representative wattages for non-qualifying incandescent lamps, the Statewide CASE Team used the calculated values that were determined by the Lawrence Berkeley National Laboratory (LBNL 2017) for IRLs (reported as "medium-screw-base reflector lamps"). In the case of decorative lamps, the LBNL report separates this product class into 40 W and 60 W lamps; the Statewide CASE Team assumed an average value of 50 W for all decorative lamps. For low-lumen lamps and the newly defined GSILs, the Statewide CASE Team conducted a product search, as described in Section 5.2, and averaged the most relevant products to determine the non-qualifying wattage.

To determine the representative wattages for qualifying LED lamps, the Statewide CASE Team reviewed recent product offerings from several retailer websites for lamps with attributes that are comparable to the corresponding non-qualifying products. For qualifying IRLs, since the LBNL report identified BR30 lamps as the representative lamp type, the Statewide CASE Team determined the average wattage of several BR30-shape LED directional lamps with light output comparable to a 65 W incandescent version (1,000 lumens). Likewise, for qualifying decorative lamps, the Statewide CASE Team averaged the wattages of E12-base LEDs that can replace 40 W and 60 W incandescent lamps. For low-lumen lamps and the newly defined GSILs (except for shatter-resistant, rough service, and vibration service lamps), the Statewide CASE Team determined the representative wattages for the LED

versions by the same means used to determine the non-qualifying versions. For the three remaining newly defined GSILs, the Statewide CASE Team assumed the qualifying products to be typical A-Type LED lamps, as determined by the LBNL report. The summary of representative wattage for non-qualifying and qualifying products is shown in Table 4.

Table 4: Representative Wattages for Non-qualifying and Qualifying Products

	Representative Wattage	
	Non-qualifying (Incandescent)	**Qualifying (LED)**
IRLs	65	8.5
Decorative Lamps	50	5
Newly Defined GSILs		
Three-Way Incandescent Lamps	139	27
Shatter-Resistant Lamps[a]	60	11
Vibration Service Lamps[a]	60	11
Rough Service Lamps[a]	60	11
2,601–3,300 Lumen GSILs	175	55
T-shape lamp of 40 W or less or length of 10 inches or more	40	3
B, BA, CA, F, G16-1/2, G25, G30, or S Lamps	32	5
Low-Lumen Lamps	22	2

Source: LBNL 2017.

[a] Qualifying products assumed to be typical A-Type LED lamps.

The Statewide CASE Team also used the daily hours of use values calculated in the LBNL report (2017). The newly defined GSILs were all assumed to have 2.3 and 10.7 daily hours of use for residential and commercial sectors, respectively, the values determined by LBNL for miscellaneous A-Type lamps. As explained in the LBNL report, the residential daily hours of use values for IRLs and decorative lamps differ slightly, despite being used in general service applications, due to the preference of using these lamps in certain room and space types. Due to lack of information, the Statewide CASE Team assumed that low-lumen lamps have a daily hours of use value of 10.7 for both sectors, the value used for commercial miscellaneous A-Type lamps. The Statewide CASE Team believes that this value is reasonable since these lamps are commonly used as 'night lights' and thus are operated throughout the night. The resulting hours of use values are shown in Table 5.

Table 5 also shows the stock share of lamps by sector in order to determine f_s in Equation 1. The Statewide CASE Team calculated the stock share by sector using The U.S. DOE 2010 Lighting Market Characterization (DOE 2010), which disaggregates lamp inventory by lamp type and sector. For the purposes of this report, with regard to the 2010 Lighting Market Characterization, the Statewide CASE Team combined the incandescent and halogen stock to mean incandescent stock, and commercial and industrial sectors to mean commercial. Also, IRLs include incandescent and halogen reflector lamps (but not low-voltage halogen lamps, since these may be inferred to mean small-diameter direction lamps, which are not within the scope of this report); decorative lamps include only

incandescent general service decorative lamps;[16] and the remaining lamp types, including low-lumen lamps, are considered miscellaneous incandescent and halogen lamps.

Table 5: Daily Hours of Use and Market Sector Share Assumptions

	Daily Hours of Use		Stock Share by Sector	
	Residential	**Commercial**	**Residential**	**Commercial**
IRLs	2.9	10.7	96%	4%
Decorative Lamps	2.6	10.7	100%	0%
Newly Defined GSILs (Medium Base)				
Three-Way Incandescent Lamps	2.3	10.7	84%	16%
Shatter-Resistant Lamps	2.3	10.7	84%	16%
Vibration Service Lamps	2.3	10.7	84%	16%
Rough Service Lamps	2.3	10.7	84%	16%
2,601–3,300 Lumen GSILs	2.3	10.7	84%	16%
T-shape lamp of 40 W or less or length of 10 inches or more	2.3	10.7	84%	16%
B, BA, CA, F, G16-1/2, G25, G30, or S Lamps	2.3	10.7	84%	16%
Low-Lumen Lamps	10.7	10.7	84%	16%

Source: LBNL 2017.

5.3.2 Peak Demand Methodology

Peak demand was calculated by dividing the average annual power draw and assumed load factor.[17] A load factor is the ratio of average annual load to coincident peak load. The Statewide CASE Team obtained end-use load factors through consultations with the Energy Commission. The load factors used in this report were developed by the Energy Commission using an hourly energy and load model (Brown and Koomey 2002) on 2013 utility-level energy demand data. A complete table of updated values for several end-uses is included in Appendix B: Load Factors.

For the purposes of this report, the Statewide CASE Team used a load factor of 0.72, which is the calculated value for commercial indoor lighting, since no value for residential lighting exists.

5.3.1 Summary of Per Unit Energy Use Impacts

Annual per unit energy impacts, as calculated using the methodology described in the previous section, are presented in Table 6. As previously described, non-qualifying products are incandescent lamps that would not meet the existing GSL standard of 45 lumens/watt, and qualifying products are their LED counterparts.

[16] The U.S. DOE 2010 Lighting Market Characterization does not disaggregate general service halogen lamps into a "decorative" category. Since the total general service halogen stock is less than 1 percent of the total general service incandescent lamp stock, all general service halogen lamps were assumed to be A-type.

[17] Average annual power draw is calculated by dividing the AEC by the number of hours per year (8,766 hours per year).

Table 6: Annual Per Unit Energy Use and Potential Savings from Qualifying Products

	Electricity Use (kWh/yr)			Peak Demand (W)		
	Non-qualifying	Qualifying	Savings	Non-qualifying	Qualifying	Reduction
IRLs	59.1	11.8	47.3	9.35	1.87	7.48
Decorative Lamps	47.5	9.5	38	7.51	1.5	6.01
Newly Defined GSILs (Medium Base)						
Three3-Way Incandescent Lamps	202	39.2	163	32	6.21	25.8
Shatter-Resistant Lamps	87.2	13.1	74.1	13.8	2.07	11.7
Vibration Service Lamps	87.2	14.5	72.7	13.8	2.3	11.5
Rough Service Lamps	87.2	14.5	72.7	13.8	2.3	11.5
2,601–3,300 Lumen GSILs	254	80	174	40.3	12.7	27.6
T-shape lamp of 40 W or less or length of 10 inches or more	95	7.12	87.8	15	1.13	13.9
B, BA, CA, F, G16-1/2, G25, G30, or S Lamps	75.1	11.2	64	11.9	1.77	10.1
Low-Lumen Lamps	31.8	3.01	28.8	5.03	0.476	4.56

Source: Statewide CASE Team.

5.3.2 Current and Future Stock

California stock is derived from the national stock provided by the U.S. DOE (2017) and LBNL (2017). For the base case, the Statewide CASE Team determined the 2015 California stock by multiplying the 2015 national stock by the ratio of the 2015 California to national population per the U.S. Census Bureau (12.18%). The total stock of IRLs, decorative lamps, and their LED replacements were assumed to be constant in future years; the estimate is thus conservative. However, for the newly defined GSILs, shipments, as reported by U.S. DOE, were multiplied by the product lives. For future years, the Statewide CASE Team determined the stock by projecting the growth in shipments (discussed in the next section) and subtracting an estimated number of retired lamps.

For the standards case, the Statewide CASE Team assumed that for the first year that the standard is effective (estimated to be 2019), the lamp stock and shipments would remain the same, except that the incandescent lamps would switch to LED lamps. In subsequent years, the stock is determined by adding the projected shipments and subtracting the projected retired lamps.

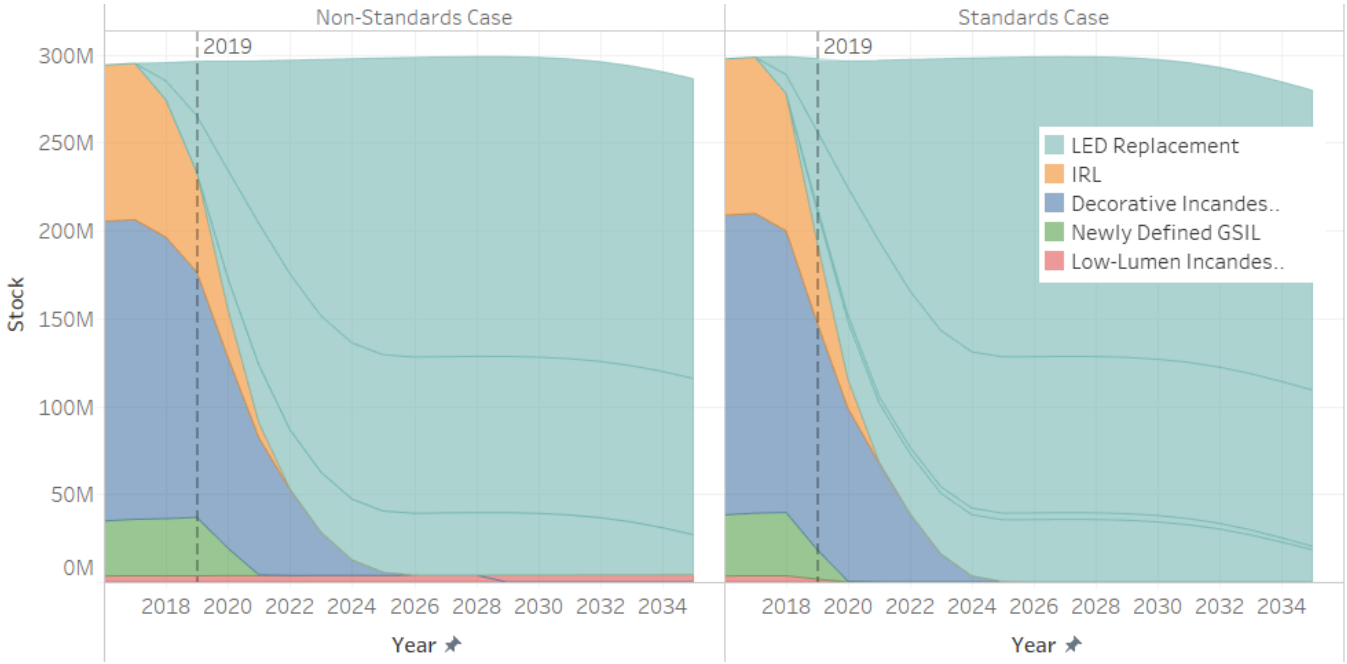

Figure 10: Lamps stock by year for base and standards case

Figure 10 shows the resulting stock of IRLs, decorative lamps, newly defined GSILs, and their LED replacement counterparts. In both scenarios, LED lamps will eventually replace the other lamp types completely, due to impending federal standards. However, in the standards case, this replacement occurs sooner. Additionally, in the non-standards case, the stock of low-lumen incandescent lamps is expected to continue indefinitely since these lamps would not be federally regulated.

5.3.3 Current and Future Shipments

In the base case, the Statewide CASE Team calculated shipments of IRLs and decorative lamps by dividing the stock by the product life. These shipments were thus assumed to be constant, which is a conservative estimate. The shipments of the newly defined GSILs were determined by extrapolation of shipments reported by U.S. DOE. For those lamps, the Statewide CASE Team assumed that the shipments will drop to zero in 2020, the date the federal GSL definition goes into effect.

For the standards case, the Statewide CASE Team assumed that the shipments would drop to zero in 2019. The shipments that would have occurred in 2019 are assumed to have switched to LED. For subsequent years, the Statewide CASE Team used a Weibull distribution (alpha = 6, and beta = the product life) to determine the number of lamps that would retire in any given year. The Statewide CASE Team assumed that any lamp that is retired would be replaced with an LED lamp.

Table 7: California Shipments and Stock

Product Class	2017 Shipments	2017 Stock
IRLS	32,400,000	88,800,000
Decorative Lamps	30,900,000	170,000,000
Newly Defined GSILs	19,100,000	35,000,000
Total	**82,400,000**	**293,800,000**

Source: Statewide CASE Team.

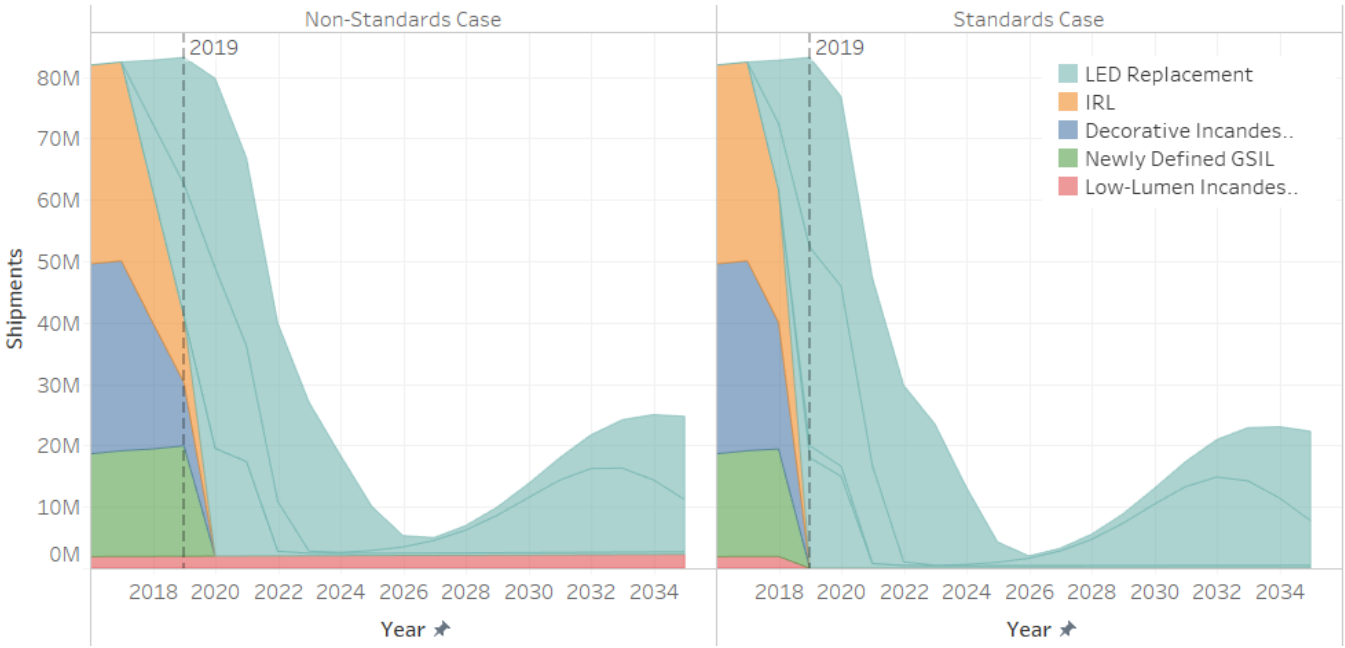

Figure 11: Lamp shipments by year for standards and base case

Figure 11 shows the resulting lamp shipments by year and lamp type. In both the standard and base case, lamp shipments eventually convert to LED. Due to the longer product life of LED lamps, the Statewide CASE Team projects that lamp shipments will drastically decrease in the next ten years. Only when the LED lamps begin to retire do lamp shipments increase. A vertical bar is overlaid in each graph to show the effective date of the proposed code. As can be seen, in the standards case, incandescent lamp types are replaced by LED lamps sooner. In the case of low-lumen lamps, the absence of a standard would mean that shipments of incandescent low-lumen lamps continue indefinitely, since these lamps are not likely to be federally regulated.

Figure 12 summarizes well the effects of the proposed standard: 1) the rapid increase in LED shipments occurs sooner, leading to an earlier increase in the stock of efficient lighting products, and 2) the subsequent decline in LED shipments (due to longer product life) occurs sooner, allowing consumers to begin saving money on replacement bulbs.

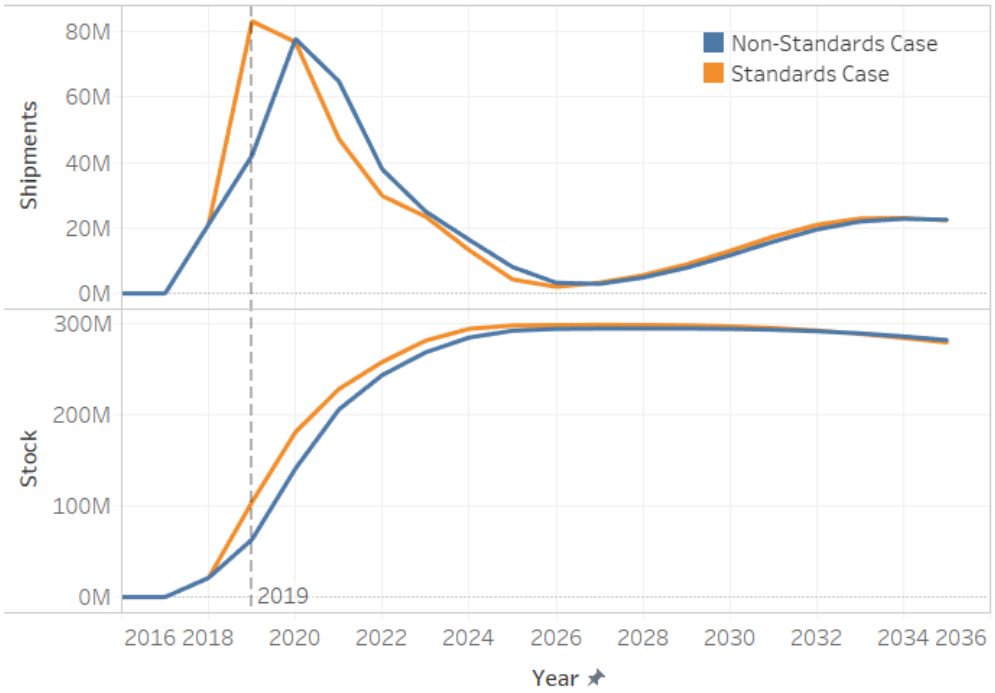

Figure 12: Shipment and stock trend of LED lamps

5.3.4 Statewide Energy Savings - Methodology

Statewide savings estimates were calculated by applying the per unit energy savings to the statewide stock and sales forecast presented in Table 8 of the report.

Table 8: California Statewide Energy Use – Non-Standards Case (After Effective Date)

Product Class	Annual Shipments		Stock	
	Electricity Use (GWh/yr)	Electricity Demand (MW)	Electricity Use (GWh/yr)	Peak Demand (MW)
2019 (effective year)				
IRLs	1,040	165	4,660	738
Decorative Lamps	588	93	6,770	1,070
Newly Defined GSILs	1,910	302	3,490	552
Low-Lumen Lamps	166	26.3	305	48.2
Total	*3,710*	*586*	*15,200*	*2,410*
2021 (after stock turns over)				
IRLs	189	29.9	1,450	229
Decorative Lamps	145	23	4,140	655
Newly Defined GSILs	324	51.3	734	116
Low-Lumen Lamps	169	26.8	310	49.1
Total	*828*	*131*	*6,640*	*1,050*

Source: Statewide CASE Team.

[a] Statewide demand (and demand reduction) is quantified as coincident peak load (and coincident peak load reduction), the simultaneous peak load for all end users, as defined by Brown and Koomey (2002).

Table 9: California Statewide Energy Use – Standards Case (After Effective Date)

Product Class	Annual Shipments		Stock	
	Electricity Use (GWh/yr)	Electricity Demand (MW)	Electricity Use (GWh/yr)	Peak Demand (MW)
2019 (effective year)				
IRLs	325	51.4	3,940	624
Decorative Lamps	147	23.2	6,250	989
Newly Defined GSILs	379	60	1,970	312
Low-Lumen Lamps	15.7	2.5	154	24.4
Total	*866*	*137*	*12,300*	*1,950*
2021 (after stock turns over)				
IRLs	160	25.3	928	147
Decorative Lamps	145	23	4,320	684
Newly Defined GSILs	15.5	2.45	708	112
Low-Lumen Lamps	0.3	0.1	29.3	4.6
Total	*321*	*50.7*	*5,990*	*947*

Source: Statewide CASE Team.

[a] Statewide demand (and demand reduction) is quantified as coincident peak load (and coincident peak load reduction), the simultaneous peak load for all end users, as defined by Brown and Koomey (2002).

Table 10: California Statewide Energy Savings (After Effective Date)

Product Class	Annual Shipments		Stock	
	Electricity Savings (GWh/yr)	Peak Demand Reduction (MW)	Electricity Savings (GWh/yr)	Peak Demand Reduction (MW)
2019 (effective year)				
IRLs	720	114	720	114
Decorative Lamps	441	69.7	521	82.4
Newly Defined GSILs	1,530	242	1,520	240
Low-Lumen Lamps	151	23.8	151	23.8
Total	*2,840*	*449*	*2,910*	*460*
2021 (after stock turns over)				
IRLs	29.4	4.65	521	82.5
Decorative Lamps	0	0	0	0
Newly Defined GSILs	309	48.8	25.3	4
Low-Lumen Lamps	169	26.7	281	44.4
Total	*507*	*80.2*	*650*	*103*

Source: Statewide CASE Team.

5.4 Cost-Effectiveness

This section describes the methodology and approach the Statewide CASE Team used to analyze the economic impacts of the proposed standard. Two separate analyses are presented: the case where cost-effectiveness is calculated using the stock turnover of the non-qualifying incandescent products (conventional method), and one where it is calculated using that of the qualifying LED product (unconventional method). The latter case is for informational purposes only, and is included to emphasize the more realistic benefits of the proposed code change.

5.4.1 Design Life

The design life is directly relevant in the conventional cost-effective analysis for two reasons: to determine the stock turnover period, and for the shipments model (discussed in Section 5.3.2). In the unconventional analysis, the design life also influences the incremental product cost, which will be discussed in the next section. The Statewide CASE Team used the design life values that were reported by LBNL (2017). In the case of the newly defined GSILs, except for shatter-resistant and vibration service lamps, the Statewide CASE Team used the values for miscellaneous A-Type lamps. This is because, through the product searches conducted (see Section 5.2), the Statewide CASE Team found the rated hours of most newly defined GSILs to be similar to that of miscellaneous A-Type lamps, as reported by LBNL (1,000–1,500 hours range). However, shatter-resistant and vibration service lamps were found to have higher rated hours of about 3,500 and 5,000, respectively. The Statewide CASE Team thus estimated the residential design lives of these products to be 2.8 and 3.5 years, respectively, with commercial design lives proportionally larger as well. The resulting values are shown in Table 11.

Table 11: Design Life of Non-qualifying and Qualifying Products

	Non-qualifying (Incandescent)		Qualifying (LED)	
	Residential Design Life (years)	**Commercial Design Life (years)**	**Residential Design Life (years)**	**Commercial Design Life (years)**
IRLs	2.5	0.5	13	4.4
Decorative Lamps	5.4	1.5	17	5.1
Newly Defined GSILs				
Three-Way Incandescent Lamps	1.5	0.5	17	3.7
Shatter-Resistant Lamps	1.7	1.7	17	3.7
Vibration Service Lamps	1.7	1.7	17	3.7
Rough Service Lamps	1.7	1.7	17	3.7
2,601-3,300 Lumen GSILs	1.7	1.7	17	3.7
T-shape lamp of 40 W or less or length of 10 inches or more	1.5	0.5	17	3.7
B, BA, CA, F, G16-1/2, G25, G30, S, M-14 lamp of 40 W or less	1.5	0.5	17	3.7
Low-Lumen Lamps	1.7	0.5	17	3.7

5.4.2 Incremental Cost

The Statewide CASE Team assessed incandescent and LED products offered through web-retailers to determine the typical retail cost per unit of the various lamp types. The costs were adjusted to 2019 estimates using price-learning experience curves predicting one percent and three percent annual reductions in price for non-qualifying and qualifying products, respectively. Table 12 show the final 2019 incremental costs.

Table 12: Incremental Product Cost in 2019 (Conventional Method)

	Non-qualifying (Incandescent)	Qualifying (LED)	Incremental Cost[a]
IRLs	$2.33	$3.33	$1.00
Decorative Lamps	$1.24	$5.99	$4.75
Newly Defined GSILs			
Three-Way Incandescent Lamps	$2.32	$16.98	$14.66
Shatter-Resistant Lamps	$2.49	$2.50	$0.01
Vibration Service Lamps	$2.49	$3.00	$0.51
Rough Service Lamps	$1.00	$3.00	$2.00
2,601–3,300 Lumen GSILs	$3.47	$13.77	$10.30
T-shape lamp of 40 W or less or length of 10 inches or more	$7.04	$9.99	$2.95
B, BA, CA, F, G16-1/2, G25, G30, S, M-14 lamp of 40 W or less	$3.38	$8.23	$4.85
Low-Lumen Lamps	$2.24	$10.12	$7.88

[a] The incremental cost is calculated as the difference between the qualifying and non-qualifying product cost.

For informational purposes, the Statewide CASE Team included the cost of multiple incandescent lamps over the life of an LED-equivalent lamp. For example, if an LED equivalent lamp lasts six times longer, and then six incandescent lamps would be required for the same amount of service, and the non-qualifying cost in this scenario would be six times the cost of an incandescent lamp. The net result, as shown in Table 13, is a negative incremental cost for nearly all lamp types, which the Statewide CASE Team considers to be zero incremental cost.

Table 13: Incremental Product Cost (Unconventional Method)

	Non-qualifying (Incandescent)[a]	Qualifying (LED)	Incremental Cost[b]
IRLs	$12.19	$3.33	$0
Decorative Lamps	$3.90	$5.99	$2.09
Newly Defined GSILs			
Three-Way Incandescent Lamps	$24.83	$16.98	$0
Shatter-Resistant Lamps	$22.89	$2.50	$0
Vibration Service Lamps	$22.89	$3.00	$0
Rough Service Lamps	$9.19	$3.00	$0
2,601–3,300 Lumen GSILs	$31.90	$13.77	$0
T-shape lamp of 40 W or less or length of 10 inches or more	$110.02	$9.99	$0
B, BA, CA, F, G16-1/2, G25, G30, S, M-14 lamp of 40 W or less	$52.82	$8.23	$0
Low-Lumen Lamps	$23.98	$10.12	$0

[a] Calculated by multiplying the per unit cost by the ratio of the qualifying to non-qualifying design life.
[b] The incremental cost is calculated as the difference between the qualifying and non-qualifying product cost.

5.4.3 Lifecycle Cost / Net Benefit

The per unit and total lifecycle costs and benefits of the proposed standard are presented in Table 14 and Table 15 for the conventional and unconventional calculation methods, respectively.

Table 14: Costs and Benefits per Unit for Qualifying Products in 2019 (conventional)[a]

Product Class	Lifecycle Costs per Unit (Present Value $)[a]			Lifecycle Benefits per Unit (Present Value $)		Net Present Value per Unit ($)
	Incremental Cost[b]	Add'l Cost	Total PV Costs	Electricity Savings [c]	Total PV Benefits	Electricity
IRLs	$0.86	$0.00	$0.86	$23.01	$23.01	$22.16
Decorative Lamps	$4.46	$0.00	$4.46	$15.86	$15.86	$11.40
Newly Defined GSILs	$6.98	$0.00	$6.98	$31.54	$31.54	$24.56
Low-Lumen Lamps	$7.39	$0.00	$7.39	$28.73	$28.73	$21.34
Grand Total[d]	$3.67	$0.00	$3.67	$22.33	$22.33	$18.66

[a] PV = Present Value. Calculated using Energy Commission's average statewide PV statewide energy rates that assume a three percent discount rate (California Energy Commission 2016a).
[b] Incremental cost is the cost difference between the baseline non-qualifying product and the qualifying product.
[c] Cost savings will be realized through lower electricity bills. Average annual electricity was used, starting in the effective year.
[d] Per unit values are shipment-weighted

Table 15: Costs and Benefits per Unit for Qualifying Products in 2019 (unconventional)[a]

Product Class	Lifecycle Costs per Unit (Present Value $)[a]			Lifecycle Benefits per Unit (Present Value $)		Net Present Value per Unit ($)
	Incremental Cost[b]	Add'l Cost	Total PV Costs	Electricity Savings[c]	Total PV Benefits	Electricity
IRLs	-$8.89	$0.00	-$8.89	$190.95	$190.95	$199.84
Decorative Lamps	$1.83	$0.00	$1.83	$131.59	$131.59	$129.77
Newly Defined GSILs	-$24.56	$0.00	-$24.56	$261.66	$261.66	$286.22
Low-Lumen Lamps	-$16.22	$0.00	-$16.22	$238.41	$238.41	$254.63
Grand Total[d]	**-$8.47**	**$0.00**	**-$8.47**	**$185.28**	**$185.28**	**$193.74**

[a] PV = Present Value. Calculated using Energy Commission's average statewide PV statewide energy rates that assume a three percent discount rate (California Energy Commission 2016a).
[b] Incremental cost is the cost difference between the baseline non-qualifying product and the qualifying product.
[c] Cost savings will be realized through lower electricity bills. Average annual electricity was used, starting in the effective year.
[d] Per unit values are shipment-weighted

5.5 Environmental Impacts/Benefits

5.5.1 Greenhouse Gases

Table 16 presents the annual and stock greenhouse gas (GHG) savings for the first year the standard takes effect (2019) and the year of full stock turnover (2021). The Statewide CASE Team calculated the avoided GHG emissions from the adoption of the standard, assuming a 2020 emissions factor of 353 metric tons of carbon dioxide equivalent ($MTCO_2e$) per GWh of electricity savings (CARB 2010).

The Statewide CASE Team used California Air Resources Board (CARB) data to determine an avoided carbon dioxide emission factor. CARB prepared an analysis of increasing California's Renewables Portfolio Standard from 20 percent renewables by 2020 to 33 percent renewables by 2020 with different future electricity demand scenarios.[18] The emissions factor used in this report is intended to provide a benchmark of emissions reductions attributable to energy-efficiency measures that would help achieve the low load scenario. The emissions factor is calculated by dividing the difference between California emissions in the high- and low-generation forecasts by the difference between total electricity generated in those two scenarios. While emission rates may change over time, 2020 is a representative year for this measure.

As shown in Table 16, the estimated annual statewide GHG savings is 1,260,000 $MTCO_2e$ the first year the standard is in effect and 140,000 $MTCO_2e$ after full stock turnover in 2021. The stock GHG savings is also 1,260,000 $MTCO_2e$ the first year the standard is in effect, and 413,000 $MTCO_2e$ in year 2021.

Table 16: Estimated California Statewide Greenhouse Gas Savings for Standards Case

Product Class	Annual GHG Savings (MTCO2e/yr)	Stock GHG Savings (MTCO2e/yr)
2019 (first year standard is in effect)		
Incandescent Reflector Lamps	223,000	223,000
Decorative Lamps	171,000	171,000
EISA-Exempt Lamps	862,000	862,000
Total	***1,260,000***	***1,260,000***
2021 (product stock turns over)		
Incandescent Reflector Lamps	15,100	161,000
Decorative Lamps	108	171,000
EISA-Exempt Lamps	126,000	81,000
Total	***140,000***	***413,000***

5.5.2 Hazardous Materials

The Energy Commission previously analyzed potential environmental impacts related to LEDs and determined they will not have any significant adverse effect on the environment.[19]

[18] CARB calculated GHG emissions for two scenarios: (1) a high load scenario in which load continues at the same rate and (2) a low load rate that assumes the state will successfully implement energy-efficiency strategies outlined in the AB 32 (Global Warming Solutions Act) scoping plan, which would reduce overall electricity load in the state (CARB 2010).The Statewide CASE Team calculated the emissions factors of the incremental electricity savings between the low and high load scenarios.

[19] Initial Study and Proposed Negative Declaration http://docketpublic.energy.ca.gov/PublicDocuments/15-AAER-06/TN206371_20151015T152721_Negative_Declaration.pdf

5.6 Consumer Utility/Acceptance

The Statewide CASE Team believes that consumers will accept LED replacement lamps since they can be utilized in nearly all applications traditionally served by lower efficacy lighting. In reviewing retailer products, the Statewide CASE Team, in agreement with U.S. DOE analysis, found that most lighting retailers are also shifting to LED.

5.7 Impact on California's Economy

Due to the decreasing product costs of LED lamps, and because they use substantially less power, the lifecycle benefit-cost ratios for all lamp types are positive. The combined benefit-cost ratio is 6.1. The first-year shipments of all lamp types have a combined net present value of $766 million. The net present value for stock turnover is similar since federal standards are expected to preempt California minimum efficiency standards for LEDs (discussed in Section 5.9.1) in 2020. Thus, only the first-year shipments are considered in the stock turnover, except for low-lumen lamps, which would not be preempted in the base case.

Table 17: Statewide Total Lifecycle Costs and Benefits for Standards Case (conventional)[a]

Product Class	Lifecycle Benefit/Cost Ratio[b]	Net Present Value ($)[c]	
		For First Year Shipments ($ million)	Stock Turnover[d] ($ million)
IRLs	26.9	$239	$239
Decorative Lamps	3.6	$118	$118
Newly Defined GSILs	4.5	$442	$442
Low-Lumen Lamps	3.9	$42	$78
Grand Total	**6.1**	**$766**	**$796**

[a] The analysis does not include cost savings associated with embedded energy savings.

[b] Total present value benefits divided by total present value costs. Positive value indicates a reduced total cost of ownership over the life of the appliance.

[c] It should be noted that while the proposed standard is cost-effective, it may be more cost-effective if using alternative rate structures. For example, marginal utility rates may more accurately reflect what customers save on utility bills as result of the standard.

[d] Stock Turnover net present value (NPV) is calculated by taking the sum of the NPVs for the products purchased each year following the standard's effective date through the stock turnover year (i.e., the NPV of "turning over" the whole stock of less efficient products that were in use at the effective date to more efficient products, plus any additional non-replacement units due to market growth, if applicable). For example, for a standard effective in 2015 applying to a product with a 5 year design life, the NPV of the products purchased in the fifth year (2019) includes lifecycle cost and benefits through 2024, and therefore, so does the Stock Turnover NPV.

The previously discussed unconventional method for determining incremental cost yields significantly larger net present values. Since this method considers the product life of the qualifying product (as opposed to the non-qualifying product), leading to zero incremental cost for most of the lamp types considered in this report, the lifecycle benefit-cost ratio is infinite for these products. When considering the first-year shipments and stock turnover in this manner, the net present values are about $8 billion for both cases.

Table 18: Statewide Total Lifecycle Costs and Benefits for Standards Case (unconventional)[a]

Product Class	Lifecycle Benefit/Cost Ratio[b]	Net Present Value ($)[c]	
		For First Year Shipments ($ million)	Stock Turnover[d] ($ million)
IRLs	∞	$2,157	$10,498
Decorative Lamps	72.1	$1,338	$11,836
Newly Defined GSILs	∞	$5,149	$16,984
Low-Lumen Lamps	∞	$495	$18,010
Grand Total	∞	**$7,951**	**$8,336**

[a] The analysis does not include cost savings associated with embedded energy savings.
[b] Total present value benefits divided by total present value costs. Positive value indicates a reduced total cost of ownership over the life of the appliance.
[c] It should be noted that while the proposed standard is cost-effective, it may be more cost-effective if using alternative rate structures. For example, marginal utility rates may more accurately reflect what customers save on utility bills as result of the standard.
[d] Stock Turnover net present value (NPV) is calculated by taking the sum of the NPVs for the products purchased each year following the standard's effective date through the stock turnover year (i.e., the NPV of "turning over" the whole stock of less efficient products that were in use at the effective date to more efficient products, plus any additional non-replacement units due to market growth, if applicable). For example, for a standard effective in 2015 applying to a product with a 5 year design life, the NPV of the products purchased in the fifth year (2019) includes lifecycle cost and benefits through 2024, and therefore, so does the Stock Turnover NPV.

5.8 Stakeholder Positions

On May 17, 2017, the Energy Commission held a webinar to solicit comments from stakeholders on the adoption of the federal definition/expansion of scope. Several stakeholders submitted comments.

The Statewide CASE Team, the Appliance Standards Awareness Project, American Council for an Energy-Efficient Economy, Northeast Energy Efficiency Partnership, Northwest Energy Efficiency Alliance, Alliance to Save Energy, Consumer Federation of America, and National Resource Defense Council agreed that the Energy Commission should adopt the new federal definitions, and urged the Energy Commission to adopt the definitions as early as possible.

NEMA and LEDVance commented that they did not believe that state standards were required, because GSLs are federally regulated products and thus covered by federal preemption provisions. In a lawsuit filed August 4, 2017, by NEMA against the Energy Commission, NEMA clarified its position: the Energy Commission has the authority to adopt the January 19, 2017, federal definitions, but NEMA challenged the Commission's authority to adopt the 45 lumens/watt standard, despite having done so in 2008.[20]

5.9 Other Regulatory Considerations

5.9.1 Federal Regulatory Background

EISA established minimum energy-efficiency standards for GSILs, based on rated wattage, which included statutory exemptions for 22 lamp types (known in this CASE Report as EISA-exempt lamps). In 42 United States Code (USC) 6925, EISA also defined the GSL lamp as a broad classification for all lamps that can serve as general service lighting, including GSILs, and included provisions for updating energy conservation standards for GSLs through a rulemaking process. Within this rulemaking, U.S. DOE may also determine whether previous lamp exemptions,

[20] Case 2:17-cv-01625-KJM-AC Filed 08/04/17, U.S. District Court California Eastern Division.

including the EISA-exempt lamps, are warranted based in part on whether the lamps may be used for general service applications.

EISA also directed U.S. DOE to establish a benchmark unit sales estimate for five other lamp types – rough service lamps, vibration service lamps, three-way incandescent lamps, 2,601–3,300 lumen GSILs, and shatter-resistant lamps – by collecting, analyzing, and monitoring unit sales for these lamp types, as provided by NEMA. If, in any year, any of these lamps surpass a predetermined sales threshold, EISA directs U.S. DOE to establish energy conservation standards for that lamp type through an "accelerated rulemaking" process.

U.S. DOE released a Preliminary Technical Support Document on December 11, 2014, to update federal energy conservation standards for GSLs (U.S. DOE 2014). However, a "rider" in the House Energy and Water appropriation bill, herein referred to as the "Burgess Rider," would prohibit U.S. DOE from using funds to implement or enforce standards for GSILs. On March 17, 2016, U.S. DOE released a Notice of Proposed Rulemaking that proposed standards for the GSLs that were not blocked by the Burgess Rider, i.e., non-GSILs (U.S. DOE 2016a).

On April 7, 2016, U.S. DOE released a Notice of Data Available announcing that sales for vibration service lamps had surpassed the predetermined threshold, but gave no clear indication of how U.S. DOE intended to initiate an accelerated rulemaking (U.S. DOE 2016b). On September 20, 2016, U.S. DOE published a memorandum memorializing a discussion between U.S. DOE and NEMA, where NEMA representatives identified an error that miscalculated the sales of rough service lamps, and that rough service lamps had also surpassed their respective sales threshold (U.S. DOE 2016c).

On October 18, 2016, U.S. DOE released a Notice of Proposed Determination and Data Availability (NOPDDA), which proposed to redefine GSLs under the provisions to assess which exemptions should continue (U.S. DOE 2016d). U.S. DOE determined that the Burgess Rider applied only to energy conservation standards, and that U.S. DOE must fulfill its obligations of determining whether GSL exemptions, including the EISA-exempt lamps, should continue. After consideration of comments, U.S. DOE released two Final Rules (the U.S. DOE Final Rules [2017]) on January 19, 2017, that finalized definition changes for GSLs and excluded lamps, effectively expanding the scope of GSLs to the lamp types covered in this response.

5.9.2 California Regulatory Background

California Title 20 Appliance Efficiency Regulations have long regulated GSILs and IRLs. Currently, Title 20 GSIL and IRL standards mirror federal requirements due to the federal preemption provisions in 42 USC 6927. These requirements are shown in Table 19 and Table 20 for GSILs and IRLs, respectively.

Table 19: Standards for Federally Regulated General Service Incandescent Lamps

Rated Lumen Ranges	Maximum Rate Wattage	Minimum Rate Lifetime	Effective Date
1,490 – 2,600	72	1,000 hours	January 1, 2012
1,050 – 1,489	53	1,000 hours	January 1, 2013
750 – 1,049	43	1,000 hours	January 1, 2014
310 - 749	29	1,000 hours	January 1, 2014

Table 20: Standards for Federally Regulated Incandescent Reflector Lamps Manufactured on or After July 15, 2012

Lamp Spectrum	Lamp Diameter (inches)	Rated Voltage	Minimum Average Lamp Efficacy (LPW)[a]
Standard Spectrum	> 2.5	≥ 125	$6.8 \times P^{0.27}$
	> 2.5	< 125	$5.9 \times P^{0.27}$
	≤ 2.5	≥ 125	$5.7 \times P^{0.27}$
	≤ 2.5	< 125	$5.0 \times P^{0.27}$
Modified Spectrum	> 2.5	≥ 125	$5.8 \times P^{0.27}$
	> 2.5	< 125	$5.0 \times P^{0.27}$
	≤ 2.5	≥ 125	$4.9 \times P^{0.27}$
	≤ 2.5	< 125	$4.2 \times P^{0.27}$

[a] P = Rated Lamp Wattage, in watts.

A "carveout" in EISA allows California to adopt a 45 lm/W "backstop" requirement, or any other U.S. DOE Final Rule, effective beginning on or after January 1, 2018. Per 42 USC §6295, the provision reads as follows:

> *(vi) State preemption – Neither section 6297(b) of this title nor any other provision of law shall preclude California or Nevada from adopting, effective beginning on or after January 1, 2018—*
>
> *I. a final rule adopted by the Secretary in accordance with clauses (i) through (iv);*
>
> *II. if a final rule described in subclause (I) has not been adopted, the backstop requirement under clause (v); or*
>
> *III. in the case of California, if a final rule described in subclause (I) has not been adopted, any California regulations relating to these covered products adopted pursuant to State statute in effect as of December 19, 2007.*

In 2008, California adopted the 45 lm/W requirement for GSLs, as shown in Table 21, with an effective date of January 1, 2018. In addition, the Energy Commission announced in a Title 20 Phase II Pre-Rulemaking notice released on April 21, 2017, its intention to consider adoption of the U.S. DOE Final Rules that redefined GSLs, thus expanding its scope to cover additional lamps, such as IRLs and several EISA-exempt lamps [California Energy Commission 2017b).

Table 21: Standards for Federally Regulated General Service Lamps – Tier II

Lumen Ranges	Minimum Lamp Efficacy	Minimum Rated Lifetime	Effective Date
All	45 lumens per watt	1,000 hours	January 1, 2018

5.9.3 Utility and Other Incentive Programs

The GSL product category is a focal point of IOU energy-efficiency program strategies – promotional and incentive programs in support of high-efficiency GSL replacement lamps (i.e., compact fluorescent lamps) have been implemented by the IOUs for many years. The IOUs are also currently running programs in support of LED GSLs. Several of these incentive programs, which include instant rebates from participating distributors, business efficient lighting rebates, and new construction incentives, are listed here:

- https://www.sdge.com/save-money/bright-ideas-savings
- https://www.pge.com/en_US/business/save-energy-money/business-solutions-and-rebates/lighting/lighting.page
- https://www.sce.com/wps/portal/home/business/savings-incentives/express-solutions
- http://www.ledaccelerator.com/[21]

For example, the PG&E 2016 LED Replacement Lamp Incentive Program provided distributors with up to $18 per lamp for ENERGY STAR LED replacement lamp sales to PG&E commercial customers, including PAR, MR, R/BR, A, candelabra, and globe shape lamps.[20] Several electric utilities companies outside of California also offer rebates for ENERGY STAR-certified LED lamps, which the Statewide CASE Team listed in the response to the Energy Commission's Invitation to Participate (CEC 2017a).

5.9.4 Model Codes and Voluntary Standards

The ENERGY STAR Lamps Specification Version 2.0 includes omnidirectional lamps (A, BT, P, PS, S, and T shape), decorative lamps (B, BA, C, CA, DC, F, and G shape), and directional lamps (R, BR, ER, MR, MRX, and PAR shape) in addition to self-ballasted CFLs intended to replace ANSI standard incandescent lamps that do not meet lamp shape dimension requirements (EPA 2017). Inclusion of these lamp types in the Specification addresses several EISA-exempt lamps, including reflector lamps; G-shape lamps with a diameter of five inches or more; T-shape lamps that use less than 40 watts and have a length greater than 10 inches; and A, B, BA, CA, F, G16-1/2, G-25, G30, or S lamps of 40 watts or less.

Leadership in Energy and Environmental Design (LEED) credits for lighting quality can be achieved in the LEED Version 4 Building Design and Construction, Interior Design and Construction, and Operations and Maintenance hospitality rating systems if four of eight potential strategies are used, including 1) where all light sources have a CRI of 80 or higher (except fixtures intended to provide colored lighting, site lighting, or other special uses) and 2) for at least 75 percent of total connected lighting load, light sources have a rated life of at least 24,000 hours (at three-hour per start, if applicable).

[21] PG&E LED Accelerator Program.

6. Conclusion

The Statewide CASE Team proposes that the Energy Commission adopt the new federal definition for GSLs finalized by U.S. DOE on January 19, 2017. In updating the GSL definition, the Energy Commission should also update the definitions for several lamp types that are explicitly exempted from the revised GSL definition, thereby ensuring that such exemptions are narrowly defined, as intended by U.S. DOE. In addition, the Energy Commission should expand the minimum light output for GSLs to include low-lumen lamps (less than 310 lumens), since the LED versions of those lamps will be required to meet stringent standards. Since Title 20 will require that GSLs manufactured on or after January 1, 2018, meet a minimum luminous efficacy requirement of 45 lumens/watt, the updated GSL definition will expand the scope of this existing standard. Moreover, since incandescent lamps are not capable of meeting this upcoming Title 20 GSL requirement, the proposed code change will effectively prohibit the newly defined GSLs from being incandescent.

Through review of publicly available product information, the Statewide CASE Team determined that the proposed expansion of scope is technically feasible and cost-effective. Newly defined GSL that are incandescent lamps may be replaced with LED lamps since LEDs produce light with comparable characteristics at a fraction of the power required by incandescence. The replacement LED products also last six to ten times longer than their incandescent counterparts, and offer additional utility due to durability, tunability, and other unique characteristics. While LED lamps incur an immediate incremental cost upon purchase, the energy savings benefits outweigh this cost throughout the life of the incandescent product. The longer life of LED lamps means that costs are recovered by reducing the number of lamps replacements alone, even if energy savings are not considered.

An effective date of January 1, 2019, for the proposed code change would lead to a prohibition of incandescent lamps in California one year earlier than the presumed date of the identical federal standard. Within this year, the Statewide CASE Team estimates an energy savings of 2.8 TWh relative to the base case, which results from a conversion of 41 million incandescent lamp shipments to LED. Thus, the proposed code change will lead to significant savings in the state of California.

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Appendix A: Electricity Rates

The electricity rates used in the analysis presented in this report were derived from projected future prices for residential, commercial, and industrial sectors in the Energy Commission's "mid-case" projection of the 2017–2027 Demand Forecast (California Energy Commission 2016), which used a three percent discount rate and provided prices in 2015 dollars. The sales weighted average of the five largest utilities in California – Pacific Gas and Electric, Southern California Edison Company, San Diego Gas & Electric, Los Angeles Department of Water and Power, and Sacramento Municipal Utility District – was converted to 2017 dollars using an inflation adjustment of 1.04 (U.S. DOL 2017). See the rates by year in Table A-1.

Table A-1: Statewide Sales Weighted Average Residential Electricity Rates 2017–2027 in 2017 cents/kWh

Year	Residential Electricity Rate (2017 cents/kWh)
2017	17.94
2018	18.08
2019	18.49
2020	18.84
2021	19.03
2022	19.02
2023	19.03
2024	19.20
2025	19.27
2026	19.38
2027	19.48
2028	19.58

Appendix B: Load Factors

Table B-1: 2013 Electricity Consumption and Peak Demand for the Top 5 California Utilities[a]

Sector & End-Use	Coincident Load		Annual Energy		Load Factor[b]
	MW	% of Total	GWh	% of Total	
Residential					
Cooking	581.4	1%	2833.1	1%	56%
Clothes Dryer	759.4	1%	4419.5	2%	66%
Dishwasher	211.1	0%	2237	1%	121%
Freezer	302.4	1%	2132.1	1%	80%
Miscellaneous	2849.3	5%	23139.9	9%	93%
Multi-Family Water Heater	114.2	0%	1189.4	0%	119%
Pool Heater	33.0	0%	155.6	0%	54%
Pool Pump	769.3	1%	3689.7	1%	55%
Refrigerator	1736.4	3%	13996.2	5%	92%
Solar Water Heat - Back-up	0.0	0%	0.2	0%	63%
Solar Water Heat - Pump	0.8	0%	2.3	0%	31%
Spa Heater	64.9	0%	247.6	0%	44%
Spa Pump	261.5	0%	990.4	0%	43%
Single Family Water Heater	196.5	0%	1709.6	1%	99%
Television	807.2	1%	6003	2%	85%
Waterbed Heater	737.0	1%	12003.7	5%	186%
Clothes Washer	122.2	0%	824.6	0%	77%
Air Conditioning	15739.6	28%	8378.51	3%	6%
Space Heating	0.0	0%	3441.46	1%	0%
Commercial					
Other	3344.8	6%	23762.2	9%	81%
Domestic Hot Water	144.5	0%	675.7	0%	53%
Cooking	94.5	0%	721.9	0%	87%
Office Equipment	263.3	0%	1699.2	1%	74%
Refrigeration	888.4	2%	7872.6	3%	101%
Exterior Lighting	40.9	0%	5909.2	2%	1649%
Interior Lighting	4856.2	9%	30686.2	12%	72%
Ventilation	1787.3	3%	10366.1	4%	66%
Air Conditioning	7714.7	14%	15724.95	6%	23%
Space Heating	0.0	0%	2702.77	1%	0%
Subtotal	*19134.6*	*34%*	*100120.82*	*38%*	*60%*

Source: California Energy Commission Demand Analysis Office (CEC 2016b).

[a] The top 5 California utilities are Pacific Gas and Electric, San Diego Gas & Electric, Southern California Edison Company, Sacramento Municipal Utility District, and Los Angeles Department of Water and Power.

[b] Load factor is the ratio of average annual load to coincident peak load. The load factors for commercial exterior lighting and residential waterbed heaters are very high because their consumption is mainly off-peak.