

Codes and Standards Enhancement (CASE) Initiative For PY2008: Title 20 Standards Development

Analysis of Standards Options for Portable Lighting Fixtures

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Version: Preliminary CASE Report

Last Modified: April 3, 2008

This report was prepared by Pacific Gas and Electric Company and funded by the California utility customers under the auspices of the California Public Utilities Commission.

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1 Executive Summary

The Pacific Gas and Electric Company (PG&E) Codes and Standards Enhancement (CASE) Initiative Project seeks to address energy efficiency opportunities through development of new and updated Title 20 standards. Individual reports document information and data helpful to the California Energy Commission (CEC) and other stakeholders in the development of these new and updated standards. The objective of this project is to develop CASE Reports that provide comprehensive technical, economic, market, and infrastructure information on each of the potential appliance standards. This CASE report covers standards and options for portable lighting fixtures.

Nationwide, residential lighting used about 208 TWh (billion kWh) in 2001, which is about 17% of residential sector electricity consumption in that year. About 90% of this energy consumption is by incandescent lamps (DOE 2002). Energy use by incandescent lamps can be reduced by about 70% with use of compact fluorescent lamps (CFLs). Proponents of LEDs expect similar savings from their products in a few years time.

In order to capture some of these available savings, the CEC has addressed residential lighting use through specific Title 24 (building code) and Title 20 (equipment efficiency) standards. For example, Title 24 requires use of high efficiency hard-wired fixtures in kitchens, baths, garages, laundry rooms, and utility rooms with an exception provided for fixtures controlled by an occupancy sensor. Title 20 caps the Watts consumed by torchiere lighting fixtures at 190 Watts. The intent was to promote CFL-type fixtures, but in practice this standard has cut the power use of a typical torchiere from 300+ Watts to 150-180 Watts. In addition, the federal Energy Independence and Security Act, adopted in December, 2007, sets efficiency standards for general service incandescent lamps, effective 2012-2014 (varying by lamp light output). Under these standards, conventional incandescent lamps will be phased out in favor of CFLs, LEDs and more efficient incandescent lamps (e.g. a 40-43 W lamp will replace today's 60 W lamp).

Still, despite these steps, a substantial number of conventional incandescent lighting fixtures continue to be sold in California. New updates of Title 24 can address many of the hardwired fixtures; in this proposal we address portable fixtures, such as floor and table lamps.

We analyze a two-pronged compliance approach which requires fixtures to meet a maximum wattage limit or to meet the ENERGY STAR specification for lighting fixtures. Our findings suggest that such a standard will save 901 GWh of electricity annually and avoid 84 MW of peak demand in California after entire stock turnover. These savings could be achieved cost-effectively with a lifecycle benefit-cost ratio of 18 and an average net present value savings of \$43 per unit.

2 Product Description

The portable fixture designation encompasses a wide variety of lighting fixture types using different light sources and lamp socket types. Fixtures, lamps, and sockets are covered in turn in the following sections.

2.1 Portable Fixtures Styles

Portable fixtures are lighting fixtures that incorporate a power cord and outlet plug allowing the user to relocate the fixture without any rewiring. Portable fixtures are typically controlled with a switch located on the fixture itself. The ready ability to move the fixture distinguishes a portable fixture from a hard-wired fixture which is connected directly to the home's electrical system and typically operated by a wall switch. The most common portable fixtures are floor, table, and desk lamps although they may also be wall- or ceiling-mounted. For the purposes of this CASE report and the standards recommendations, portable fixtures do not include torchiere lamps which are a separate category of fixture covered under federal standards. Figure 1 presents a variety of common portable fixtures.

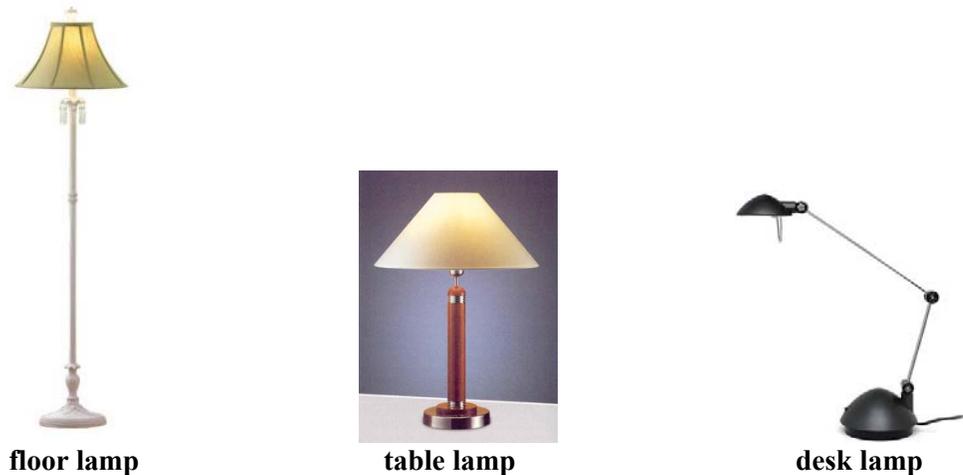


Figure 1: Common Portable Fixtures

2.2 Portable Fixtures: Lamp Base and Socket Types

Portable fixtures come equipped with different sockets to accommodate different lamp bases. These sockets determine the type of lamps that can be used in the fixture. In some cases the socket type may limit consumers to using one specific type of lamp, in other cases, consumers can choose from a variety of lamp types and light sources representing a wide range of efficiencies, light output, and other variables. Figure 2 presents a variety of lamp bases.

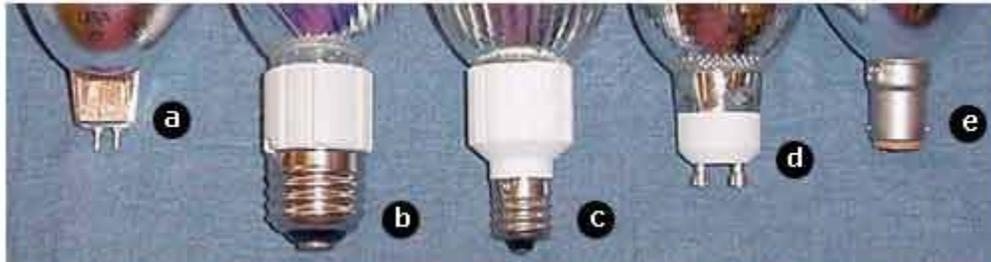
2.2.1 Screw Base

Portable fixtures most commonly have screw-based lamp sockets. While the majority of portable fixtures use the medium (or Edison) screw base—identified as E-26, some fixtures, particularly small table lamps, use the candelabra base (identified as E-12) to allow the use of smaller candle-style lamps.

Screw-based sockets allow the user to choose from a number of widely available lamp types. Incandescent lamps as well as some halogen, compact fluorescent lamps (CFLs), and new LED lamps are available with a medium screw-base. Incandescents and CFLs can be found with candelabra bases. In the case of CFLs, screw-based units incorporate the required ballast in the base of the lamp itself.

2.2.2 Plug Base

Plug-based sockets are designed to work with a specific lamp type. Plug-based lamps generally do not incorporate any ballast or transformer needed to operate the lamp; these components are incorporated into the fixture. Different types of plug-bases include pin-based (or bi-pin), bayonet, and turn and lock.



(a) 2-pin; (b) medium screwbase; (c) intermediate screwbase; (d) turn and lock; (b) and (e) bayonet

Source: Lighting Research Center

Figure 2: Lamp Base Types

2.2.3 GU-24 Base

The GU-24 is a line voltage socket that can accommodate different lamps and or ballasts outfitted with a GU-24 base including incandescent and CFL lamps. GU-24 based CFLs are available as an integrated lamp/ballast unit or as a separate ballast with a GU-24 base that can accept a pin-based lamp. Figure 3 shows an integral CFL with GU-24 base and the associated GU-24 socket.



Figure 3: GU-24 Base CFL with Socket

2.3 Portable Fixtures: Common Lamp Types

A variety of lighting sources are available for use in portable fixtures. The most common light sources are incandescent, CFL, and halogen. New fixtures designed to use LED sources are beginning to reach the market, as are LED lamps for use in conventional fixtures. Figure 4 and 5 present a sample of lamp types used in portable fixtures.

2.3.1 Incandescent

At present, the most common type of lamp used in portable fixtures is the incandescent A-lamp with a medium screw base. As noted above, small candelabra base lamps are also found in portable fixtures, particularly table lamps. Common wattages range from 40W to 150W.

2.3.2 Halogen

A range of halogen lamps are used in portable fixtures, including halogen IR (HIR) lamps designed to serve as a direct replacement for conventional incandescent A-lamps, common halogen reflector lamps such as MR16 and PAR lamps, and quartz-tube halogens for desk lamp and similar reading light fixtures. Wattage ranges from 20W or less to 150W.

2.3.3 Compact Fluorescent

Compact fluorescent lamps make up a growing share of lamps used in portable fixtures. Screw-based CFLs are available to replace medium screw-base and candelabra screw-base incandescent. Wattages for screw-based CFLs range from 9W to 30W.

A growing number of fixtures designed specifically for CFLs are available. These fixtures are sold with the ballast incorporated into the fixture. Pin-based CFLs for these fixtures come in multitube, multibend, spiral, and circline styles. Wattages range from 13W to 70W.

2.3.4 Solid State Lighting

Lamps incorporating light emitting diodes (LEDs) are being introduced into the market. Although many emerging solid state lighting fixtures incorporate the LEDs as part of the

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luminaire, a few LED lamps—including a screw-based lamp as seen in Figure 5—have been introduced. These lamps can be used in conventional fixtures.



Figure 4: Halogen IR, Incandescent, and Compact Fluorescent Lamps



MR16



LED



Spiral CFL



Circline CFL



Pin-base CFL

Figure 5: Portable Fixture Lamp Types

3 Manufacturing and Distribution Channel Overview

The U.S. market for portable fixtures is very diffuse with hundreds of firms selling thousands of product styles manufactured in the U.S. and abroad. For example, the American Lighting Association represents a membership of more than 1200 lighting fixture and ceiling fan manufacturers. Energy Star-qualified fixtures make up a relatively small number of available fixture models, yet more than 10,000 products are listed in the Energy Star database. For portable fixtures, 19 manufacturers produce approximately 350 qualified models.

Portable lighting fixtures are sold through diverse market channel including mass merchandisers, specialty retailers, and interior designers, among others.

4 Energy Usage

4.1 Test Methods

4.1.1 Current Test Methods

There is no established test procedure for determining the energy consumption of portable lighting fixtures. In setting similar standards in the past, specifically standards for torchiere lamps, neither the federal government nor California specified a test procedure when adopting a maximum allowable wattage for operation of these fixtures. DOE considers the torchiere standard to be a design requirement which does not require a test procedure, but instead requires manufacturers to report on the features that have been incorporated into fixtures to limit power draw to the maximum allowed.

The Energy Star Residential Lighting Fixture specification references a number of test procedures related to lamp, ballast, and luminaire performance.

4.1.2 Proposed Test Methods

For screw-base portable fixtures, we propose a certification requirement similar to that used by DOE for torchieres to establish compliance with the wattage limit under the proposed standard. Test methods for Energy Star-qualified products would be included by reference to the Energy Star specification.

4.2 Baseline Energy Use Per Product

The energy consumption of a portable lighting fixture depends predominantly on lamp system wattage and daily operating hours. System wattage is determined by the rated wattage of the lamp (and ballast or transformer, if required) and the number of lamps in the system. The two most common types of portable lighting fixtures in California homes are table and floor lamps. Our base case assumes an average table lamp with fixture wattage of 67W and an average floor lamp with fixture wattage of 90W (RLW 2005).

Table 1. Baseline Energy Use Per Unit

Fixture Type	Average Fixture Wattage ^a	Annual Operating Hours ^b	Unit Electricity Consumption (kWh/yr)
Table lamp	67	726	48
Floor lamp	90	840	76

^a Average fixture wattage (RLW 2005) inclusive of all light sources and number of lamps per fixture. Incandescents account for more than 80% of all lamps used in portable fixtures.

^b Daily operating hours for table and floor lamps from HMG 1999.

4.3 Efficiency Measures

There are two relatively straightforward ways to improve the efficiency of a portable lighting fixture: 1) a power limiter or similar component can be added to control the maximum wattage at which the fixture can be operated; or 2) the type of lamp that can be used in the fixture can be limited to high efficiency sources, such as CFLs, through requirements for socket type, etc. The lighting industry has had some experience with the first approach as power limiters were developed for compliance with minimum efficiency standards for torchiere lamps. In the majority of torchieres, a power limiter will not allow the fixture to operate a lamp with wattage exceeding the mandated maximum. At least one manufacturer has developed a control that will allow the fixture to operate with a higher wattage lamp, but will limit the power consumption and result in lower light levels. For approach number two, the ENERGY STAR Residential Lighting Fixture program offers a ready-made specification establishing energy efficiency and performance criteria for CFL fixtures. Specifications for portable LED desk task lights have been finalized and are set to take effect in September 2008; requirements for additional LED luminaires for general illumination are expected to take effect in 2011.

4.4 Standards Options

4.4.1 Description of Options

For this CASE study, we examined standards options for new portable lighting fixtures that would effectively lead consumers to choose alternatives to conventional incandescent lamps and new incandescent lamps meeting the federal minimum standards which will be phased-in beginning in 2012 to 2014. To this end, we settled on a maximum power limit of 35W.¹ At this level, neither conventional incandescent lamps nor those compliant with the new federal standards will generate sufficient light to meet most consumer demands for portable fixtures (unlike a 40W cap which would permit some HIR lamps intended as 60W incandescent replacements). While discouraging the use of

¹ We also considered the feasibility of requiring manufacturers to ship screw-based portable fixtures with a high efficiency light source, but dismissed this option because of the likelihood of significant lost energy savings from consumers who do not use the high efficiency lamp shipped with the fixture and those who replace the high efficiency lamp with a less efficient alternative once the first lamp burns out.

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incandescents, a 35W cap will allow consumers to select from a range of higher efficiency light sources including screw-based CFLs and LEDs and to adopt new sources as they become available—an important consideration given the long lifetimes of many portable lighting fixtures. The 35W limit will permit the use of two screw-based CFLs with combined light output equivalent to two 60W incandescent lamps (e.g., two 15W CFLs) or a single CFL with light output midway between conventional 100W and 150W lamps (e.g., one 34W CFL). Even greater lumen output screw-based options (e.g., LED) are expected in a few years.

In addition to the 35W power maximum, we examined a second compliance option to permit fixtures complying with the ENERGY STAR Residential Lighting Fixture specification. This would allow consumers to select portable fixtures with a higher lumen output than that allowed by the 35W maximum, but maintain the energy efficiency and performance requirements developed by ENERGY STAR. The majority of ENERGY STAR-qualified fixtures sold fall under the 35W power limit, however there are a number of table and floor lamps, approximately 30% of qualified models, designed to use one or two CFLs with a total wattage of 36W to 130W. This option would also permit fixtures meeting the Energy Star LED specification. The spec requires desk task lights to provide a minimum of 200 initial lumens with an efficacy of at least 29 lumens per watt—a baseline fixture would use less than 7W.

We also considered a higher wattage limit for portable fixtures designed for non-screw-based halogen lamp types (e.g., non-screw based MR16, etc.). Specifically, we examined a 40W maximum for these fixtures to allow for a 35W lamp with 3W for the transformer. These fixtures represent a relatively small part of the market. Overall, halogen accounts for less than 4% of residential lighting energy use in California (RLW 2005). Halogen lamps are primarily used found in recessed cans, track lighting, under-cabinet lighting, and torchieres. Portable fixtures using halogen lamps are mostly comprised of desk lamps, floor lamps designed for reading, or other specialty or decorative fixtures (RLW 2005). The 40W maximum would maintain a market in the near term for small directional light sources, such as lower wattage MR16 lamps, until such time as LEDs or other technologies are available as replacements. Given the low average wattage of these lamps (39.5W for halogen MR lamps per RLW 2005) and their limited market share, we do not expect this allowance to have much impact—positive or negative—on lighting energy use in California.

Table 2. Summary of Standard Options for Portable Fixtures

Fixture Type	Performance Requirements
Portable Fixtures (excluding non screw based halogens)	1) Certified to meet current ENERGY STAR fixture specification, OR 2) Maximum operable wattage \leq 35 watts
Non Screw Based Halogen Fixtures	Maximum operable wattage \leq 40 watts

4.4.2 Energy Use of Standard Options

The estimated energy use for the standards discussed above is summarized in Table 3.

Table 3. Energy Use for Standard Options

Fixture Type	Fixture Watts ^a	Annual Operating Hours ^b	Annual Energy Consumption kWh/yr)
Portable table lamp (excluding non screw-base halogen)	18	726	13
Portable floor lamp (excluding non screw-base halogen)	23	840	19
ENERGY STAR fixture (exceeding 35W maximum)	55	840	46
Non screw-base halogen fixture	38	726	28

Sources: DOE 2002, RLW 2005, EPA 2008

^aAccording to the California Statewide Lighting and Appliance Saturation Study (RLW 2005), average fixture wattage for table lamps is 67W and the most common CFL wattage found in the study is 18W, which will provide a slightly higher lumen level. For floor lamps, the average fixture wattage is 90W, corresponding to a 23W CFL. The majority of available ENERGY STAR portable fixture models fall below the 35W cap, of those exceeding the cap the most common wattage is 55W. A typical non screw-base halogen fixture using a 35W lamp will have a system wattage (including lamp and transformer) of 38W.

^bAverage daily operating hours for table and floor lamps are 1.99 and 2.30, respectively (HMG 1999).

5 Market Saturation and Sales

5.1 Current Market Situation

5.1.1 Baseline Case

The most recent California Statewide Lighting and Appliance Saturation Study (RLW 2005) found an average of 4.43 portable fixtures in California homes. This translates into an existing stock of 58.4 million portable lighting fixtures in operation in California’s 13.2 million housing units (Census Bureau 2006). Table lamps make up a large majority of these fixtures (81%); floor lamps account for the remainder. A variety of specialty and decorative lighting fixtures can also be classified as portable fixtures, although each of these makes up a small portion of the overall market. Given projected population growth in California, the number of portable fixtures in operation will grow to 74.8 million in 2030. Assuming a typical fixture life of 20 years, annual fixtures sales from 2006 to 2030 will average 3.7 million units.

According to the Census Bureau, more than 220 million residential indoor fixtures were sold in the U.S. in 2006. Sales of Energy Star-qualified indoor fixtures in 2006 totaled 8.1 million or approximately 4% (Sanchez et al 2007). These figures include hard-wired fixtures and torchieres as well as portable fixtures.

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Table 4 presents estimated statewide baseline sales, stock, and energy use for MH fixtures in California.

Table 4. California Statewide Baseline Sales, Stock and Energy Use

Product	California Annual Sales ^a	California Stock ^b	Annual Operating Hours ^c	% On at Peak ^d	California Energy Use and Demand ^e	
	Units (millions)	Units (millions)			MW	GWh/year
Portable lighting fixtures	3.7	58.4	748	7%	291	3,113

^a Annual sales based on 2006 Census Data, an average of 4.43 portable fixtures per California household (RLW 2005), and ACEEE estimate of 20 year typical fixture lifetime.

^b California existing stock data from 2006 Census data and average number of portable fixtures per household (RLW 2005).

^c Daily operating hours for California table and floor lamps, weighted average (HMG 1999).

^d Peak coincidence of 7% derived from HMG 1999.

^e Based on weighted average fixture wattage of 71.3 W (derived from RLW 2005)

5.1.2 High Efficiency Options

In the near term, the leading high efficiency alternative to typical incandescent and halogen lamps found in portable lighting fixtures is the CFL. LED lamps and fixtures are being introduced to offer another attractive, high efficiency option.

5.2 Future Market Adoption of High Efficiency Options

The market share for CFLs has been growing rapidly in recent years and is expected to continue as conventional incandescent lamps are phased out in accordance with federal standards (which may be accelerated in California). Likewise, rapid improvements in the efficacy of LED technologies and the introduction of LEDs in an increasingly diverse range of lighting applications hold great promise for future adoption of these high efficiency options. As of 2005, 15% of table lamps and 16% of floor lamps in California already used CFLs (RLW 2005). In the absence of further data, we estimate that as a result of the new federal standards for general service lamps, 50% of the market will adopt CFLs (or equivalent high efficiency products) and 50% will adopt HIR technology.

6 Savings Potential

6.1 Statewide California Energy Savings

Using the standards option outlined in Section 4.4, Table 5 estimates annual statewide energy savings in the year the standard takes effect and upon turnover of the stock in 2030.

Table 5. California Statewide Energy Savings from Proposed Standards

CA Portable Fixture Sales (millions)	% CFL	Lamp Standard Savings (W/fixture)	Fixture Std Savings (W/fixture)	% on at Peak	For First-Year Sales		After Entire Stock Turnover	
					Coincident Peak Demand Reduction (MW)	Annual Electricity Savings (GWh/yr)	Coincident Peak Demand Reduction (MW)	Annual Electricity Savings (GWh)
3.7	50%	19	32	7%	4.2	45	84	901

Assumes 90% of sales are screw-based table and floor lamps (75% table, 15% floor), 5% are Energy Star-compliant fixtures, and 5% are non-screw-based halogen. Savings due to federal lamp standard and the proposed fixture standards are sales weighted averages.

6.2 Other Benefits and Penalties

Improved fixtures will use high efficiency lamps with long lifetimes, reducing the inconvenience of having to regularly replace bulbs.

7 Economic Analysis

7.1 Incremental Cost

The incremental cost of the standard options presented above includes any additional first cost for the portable fixture and the required lamps relative to conventional fixtures and lamps. We estimate no change in the purchase price of portable fixtures meeting the 35W cap or halogens meeting the 40W cap. To meet the standard, manufacturers will be required to add a power limiter or similar low-cost components to conventional portable fixtures at an estimated cost of less than \$2 per fixture. For the purpose of our analysis, we assume these fixtures will be used with CFLs. While we estimate a higher purchase price for CFLs than the base case HIR lamps they will replace (\$3 versus \$1.50), the longer lifetimes of the CFLs translate into fewer lamp replacements over the life of the fixture and, therefore, a lower overall lamp cost. Portable fixtures complying with the standards under the provision for Energy Star qualified products have an estimated incremental cost of \$40.

7.2 Design Life

The typical design life for portable lighting fixtures is 20 years (Sanchez et al 2007, McGowan 2008).

7.3 Lifecycle Cost / Net Benefit

Table 6 summarizes the projected life cycle cost savings based on incremental cost and present value of lifetime energy savings calculations. Net present value estimates are

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based on average statewide present value electricity prices, supplied by the California Energy Commission. Screw-based table and floor lamps make up the

Table 6. Costs and Benefits per Unit

Basecase	Annual Energy Savings per unit (kWh)	Life (yrs)	Incremental Cost (\$) ^a	Present Value of Lifetime Energy Savings (\$) ^b	Lifecycle Benefit / Cost Ratio ^c	Net present Value per unit (\$) ^d
Screw based fixture	25	20	\$0	\$41	18.3	\$43
Energy Star fixture	43	20	\$40	\$71	3.6	\$33

^a Based on manufacturer data and estimates

^b Calculated using the CEC's average statewide present value statewide energy rates that assume a 3% discount rate (CEC 2004).

^c Total present value benefits divided by total present value costs.

^d Positive value indicates a reduced total cost of ownership over the life of the appliance

8 Acceptance Issues

8.1 Infrastructure issues

The proposed standards will require moving to CFL, LED, or other high-efficiency technologies. While most consumers accept these light sources, some consumers prefer incandescent lamps.

Also, if the 35W maximum demand compliance pathway is used by a manufacturer for a product (e.g., a 35W circuit breaker is used in conjunction with a medium screw base), some consumers may be confused when the fixture does not operate as expected if they use a high-wattage conventional bulb. This represents a potential consumer satisfaction issue and product return risk to retailers. To address this, manufacturers, retailers, utilities and others should provide educational information leading up to and after the effective date of this standard. This educational effort should also address proper disposal of CFLs.

8.2 Existing Standards

8.2.1 Federal Standards

Portable lighting fixtures are not listed as “covered products” in federal law with the exception of torchiere fixtures which are covered under federal standards established by the Energy Policy Act of 2005.

8.2.2 Preemption

Portable fixtures are not listed as “covered products” in federal law and thus do not appear to be preempted. As noted above, torchieres are covered under federal standards and thus state standards on those products are preempted.

8.2.3 *Interaction with Title 24 of California's Building Code*

Portable fixtures are furnishings supplied by occupants. In this way, they are more like other plug loads—consumer electronics, small appliances—than the hard-wired fixtures installed by builders that contribute to a home's base load. As a result, these products are not covered by the Title 24 Building Code and the Code cannot capture the energy savings opportunity in this product type.

8.3 Stakeholder Positions

[This section will be completed after stakeholder review of the report and further discussions.]

9 Recommendations

9.1 Recommended Standards Options

Based on the cost-effective energy savings available, standards on portable fixtures are warranted. We recommend adoption of a standard to require portable fixtures that are either 1) certified to meet current Energy Star fixture specifications or 2) have a maximum operable wattage of less than or equal to 35W. For non-screw-based halogen portable fixtures, we recommend a higher wattage allowance of 40W. Assuming the rule is completed in 2008, we recommend an effective date of January 1, 2010.

9.2 Proposed Changes to the Title 20 Code Language

[To be prepared later]

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