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| Docket Number: | 16-BSTD-01 |
| Project Title: | 2013 Compliance Option for Nonresidential Lighting Alterations |
| TN #: | 210768 |
| Document Title: | LMCC Comments: Opposition to Proposed Adoption of 2016 Lighting Alteration Standards as a 2013 Additional Compliance |
| Description: | N/A |
| Filer: | System |
| Organization: | Adams Broadwell Joseph & Cardozo/Thomas Enslow |
| Submitter Role: | Public |
| Submission Date: | 3/17/2016 1:23:05 PM |
| Docketed Date: | 3/17/2016 |

Comment Received From: Thomas Enslow

Submitted On: 3/17/2016

Docket Number: 16-BSTD-01

**Opposition to Proposed Adoption of 2016 Lighting Alteration Standards as a 2013
Additional Compliance Path**

Additional submitted attachment is included below.

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March 17, 2016

VIA E-FILING

California Energy Commission

Dockets Office, MS-4

Re: Docket No. 16-BSTD-01

1516 Ninth Street

Sacramento, CA 95814-5512

<https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=16-BSTD-01>

Re: Docket No. 16-BSTD-01 – Opposition to Proposed Adoption of 2016 Lighting Alteration Standards as a 2013 Additional Compliance Path

Dear Commissioners and Commission staff:

I am writing on behalf of the California State Labor Management Cooperation Committee for the International Brotherhood of Electrical Workers and the National Electrical Contractors Association (“LMCC”) in opposition to the proposal to allow the 2016 Title 24, Part 6, revisions to Section 141.0 related to non-residential lighting alterations (“the 2016 Lighting Alteration Standards”) to go into effect as an additional compliance path prior to the January 1, 2017 effective date of the rest of the 2016 Building Energy Efficiency Standards.¹ The LMCC opposes adoption of the 2016 Lighting Alteration Standards as an additional compliance path on the grounds that these standards fail to meet the legal requirements for an additional compliance path. The LMCC also opposes adoption on the grounds that these standards included a very controversial 35/50% power reduction path that raises unique enforcement issues that have not had time to be fully addressed at the state or local level. In

¹ The Notice only refers to luminaire alterations and only describes (albeit inaccurately) the differences between the 2013 requirements for luminaire alterations and the 2016 requirements for luminaire alterations. Accordingly, the LMCC assumes that this proposal does not apply to luminaire modifications or lighting wiring alterations.

addition, the notice for this proposed regulatory adoption is deficient because it misrepresents the new compliance path being proposed. For all these reasons this proposal must be rejected.

I. THE 2016 LIGHTING ALTERATION STANDARDS FAIL TO MEET THE STANDARDS FOR ADOPTION AS AN ADDITIONAL COMPLIANCE PATH

Public Resources Code section 25402.1 and Title 24, Part 1, Section 10-109 authorize the Commission to approve additional compliance paths if the following criteria are met:

1. Provide an additional compliance path to the existing requirements, without deleting or amending any part of the existing requirements;
2. Not result in increased energy consumption, compared to the existing requirements, for affected buildings; and
3. Follow the public review and Commission approval requirements of Section 10-110, including a 60-day comment period, before Commission approval.

In this case, none of those standards have been met.

A. The Proposed Compliance Path Deletes or Amends Existing Requirements

Under the 2013 Code, lighting alterations must meet maximum lighting power density (“LPD”) requirements (i.e., watts per square feet), and must install applicable automatic shutoff, area, multi-level, daylighting and demand response controls and acceptance testing is required for these controls.

The 2013 Code provides a couple of exemptions from this requirement for lighting alterations that do not change the area of the enclosed space, do not change the space occupancy type, **and** do not increase the lighting power in the enclosed space. Alterations that meet those three requirements are completely exempt from energy efficiency requirements if they alter less than 10% of the existing luminaires in an enclosed space. Alterations that meet those three requirements, but alter 10% or more of the existing luminaires, are also exempt from the requirement to install

multi-level, daylighting and demand response controls if they maintain an LPD of 85% or less of the maximum allowed for the function area (“the 85% LPD Exemption”). Alterations and modifications under the 85% LPD Exemption must still install all applicable Section 130.1(a) area controls and Section 130.1(c) automatic shutoff controls. They also require installation of two-step (bi-level) lighting controls in place of multi-level controls unless the applicant voluntarily chooses to install multi-level controls.

The 2016 Lighting Alteration Standards make a number of significant deletions and amendments to these requirements.

First, it created a new alternative compliance pathway that exempts lighting alterations from otherwise applicable control and power allowance requirements if the altered or modified luminaires collectively have at least 35% lower rated power than the existing luminaires, or 50% lower if the altered or modified light is located in a retail, commercial or hotel/motel space. Like the 85% LPD Pathway, alterations taking the new 35/50% compliance pathway are required to install area and automatic shutoff controls, but are exempt from multi-level, daylighting and demand response control requirements. However, the 35/50% compliance pathway also deletes a number of additional requirements that are required under the 2013 or 2016 85% LPD pathway.

- a) The 35/50% compliance pathway does not require the installation of the two-step lighting controls that is required under the 85% LPD pathway if multi-level controls are not installed.
- b) Alterations taking the 35/50% compliance pathway are not required to comply with maximum LPD allowance requirements. In contrast, the 2013 Code requires all alterations to comply with maximum LPD allowance requirements.
- c) The 35/50% compliance pathway does not require certain shut-off controls for hallways, stairwells, hotel rooms or display cases that are required for all alterations under the 2013 code. The 2013 Code requires lighting system alterations to comply with *all* the shut-off control requirements set forth in Section 130.1(c). The 2016 35/50% compliance pathway, however, exempts alterations from compliance with numerous provisions of Section 130.1(c), including 130.1, subdivisions (c)(1)(d) [separate controls form general, display, ornamental, and display case lighting], (c)(6)(B) [Library book stack aisle occupancy sensors], (c)(6)(C) [corridor and stairwell occupancy sensors],

(c)(7)(A) [hotel/motel corridor and stairwell occupancy sensors], and (c)(8) [hotel/motel guest room occupancy sensors].

Second, the 2016 Lighting Alteration Standards also add several additional new exemptions that apply to all three of the compliance pathways for lighting alterations.

The 2013 Code requires compliance with *all* the area control requirements set forth in Section 130.1(a). The 2016 Lighting Alteration Standards, however, exempt alterations from compliance with the area controls under Section 130.1(a)(4). This section requires that: (A) General lighting shall be separately controlled from all other lighting systems in an area; (B) Floor and wall display, window display, case display, ornamental, and special effects lighting shall each be separately controlled on circuits that are 20 amps or less; and (C) When track lighting is used, general, display, ornamental, and special effects lighting shall each be separately controlled.

Both the 2013 Code and the 2016 Lighting Alteration Standards exempted alterations from any code-compliance requirements if the alteration involved less than 10% of existing luminaires. The 2013 Code, however, states that this 10% exemption does not apply where the lighting alteration also involved changing the “space type” or would “increase the lighting power in the enclosed space.” The 2016 Code removes these limitations from the 10% full exemption provision and thus expands the universe of projects that are completely exempt from energy efficiency requirements.

The 2013 Code also did not permit application of the 85% LPD control exemption where the lighting alteration would change the “area of the enclosed space,” change the “space type” or “increase the lighting power in the enclosed space.” The 2016 Code removes these limitations from the 85% LPD control exemption provision and thus expands the universe of projects that are not required to install advanced lighting controls.

The 2016 Lighting Alteration Standards also include a new exemption for enclosed spaces where two or fewer luminaires are replaced or installed. This exemption is not dependent at all on the amount of power that the luminaires consume. This again expands the universe of projects that are completely exempt from energy efficiency requirements.

In addition, acceptance testing under the 2013 Code was required for all controls added under the alterations section. The 2016 Lighting Alteration Standards exempt alterations from acceptance test requirements where lighting controls are added to control 20 or fewer luminaires.

As shown above, the 2016 Lighting Alteration Standards delete or amend numerous requirements of the 2013 Code. Accordingly, the 2016 Lighting Alteration Standards are not eligible for adoption as an additional compliance path.

B. Adoption of the 2016 Lighting Alteration Standards as an Additional Compliance Path Will Result in Increased Energy Consumption Compared to the Existing Requirements for Affected Buildings

The 2016 Lighting Alteration Standards are also not eligible for adoption as an additional compliance path because these standards will result in increased energy consumption compared to the existing requirements for affected buildings.

First, the deletions and alterations laid out in the prior section would each result in increased energy consumption compared to the existing requirements for affected buildings, including: (1) the elimination of two-step lighting controls, (2) the elimination of certain area or occupancy controls for hallways, stairwells, hotel rooms or display cases, (3) the application of exemptions for controls to lighting alterations that change the “space type” or “increase the lighting power in the enclosed space”; (4) the application of the 10% luminaire alteration exemption to lighting alterations that change the “space type” or “increase the lighting power in the enclosed space”; (5) the creation of a new exemption where two or fewer luminaires are replaced; and (6) the creation of a new exemption for acceptance testing where lighting controls are added to control 20 or fewer luminaires.

In adopting the 2016 Lighting Alteration Standards, the Commission claimed that the lost energy savings from these changes would be offset as a whole by other changes in the 2016 Lighting Alteration Standards, including: (1) changing the definition of an alteration to include one-to-one replacements of whole luminaires – the 2013 Code treats these alterations as Luminaire Modifications; and (2) reductions in LPD requirements for certain occupancies. These offsets would not apply to the adoption of the 2016 Lighting Alteration Standards as an additional 2013 compliance path because they would not be required under the 2013 Code.

Moreover, adoption of an additional compliance path requires that, for the “affected building”, no increase in energy use will occur when compared to compliance with the 2013 Code. Whether or not overall energy efficiency would be the same or greater then viewed in context of the entire 2016 Code requirements for lighting alterations is not relevant in this analysis. As discussed above, there are numerous scenarios under the 2016 Lighting Alteration Standards where alterations in an affected building would be exempt or would be subject to less stringent energy efficiency requirements than if the building were subject to the 2013 Code requirements. This is particularly true for alterations that change the size or occupancy type of a space or that increase power consumption. It is also true for alterations that include hallways, stairwells, hotel rooms or display cases and choose the 2016 35/50% compliance path which exempts hallways, stairwells, hotel rooms and display cases from area and shut-off controls required under the 2013 code.

The 2016 Lighting Alteration Standards would also result in increased energy consumption compared to the existing requirements for affected buildings because the Commission has not adopted any effective verification requirements for the 35/50% power reduction pathway. Unlike the 2013 lighting alterations requirements which are easily verified through inspection of the final alterations, the 2016 35/50% power reduction pathway is premised upon a comparison of pre-alteration conditions with post-alteration conditions.

The LMCC and other stakeholders, including numerous inspectors, have raised concerns over enforcement of the 35/50% compliance pathway because its reliance on a comparison with existing conditions does not fit within current building code enforcement schemes. Inspectors verify that the final product meets code. To suddenly adopt building standards based upon existing conditions creates an enforcement gap that is ripe for fraud. When the 2016 Lighting Alteration Standards were adopted, the Commission’s response to the concern over enforcement of this new compliance pathway was to commit to address enforcement issues prior to the effective date of the new exemption. To date, the Commission has not adopted any verification requirements for the 35/50% compliance pathway.

The University of California, Davis, California Lighting Technology Center (“CLTC”) has prepared an independent report on the likelihood and the cost of non-compliance with the new 35/50% compliance pathway for non-residential lighting alterations and modifications if meaningful verification requirements are not imposed. The CLTC is a not-for-profit research, development and demonstration facility dedicated to accelerating the development and commercialization of next-

generation, energy-efficient lighting technologies. The center includes full-scale laboratories for research and development, as well as prototype and product testing. A copy of their report “The Real Cost of Noncompliance” is attached.

Citing numerous studies, the CLTC found that, without reliable compliance verification mechanisms, approximately 65% of projects that rely on the 35/50% compliance pathway are likely to fail to actually achieve the asserted savings. The CLTC also found that in most cases of non-compliance, actual savings would only be half of the asserted savings.

To address this issue, the CLTC recommended verifying compliance through the use of certified acceptance test technicians that conduct both pre-installation and post-installation on-site visual inspections of the project. Based upon estimates provided by currently-certified lighting control acceptance test technician employers, the CLTC determined that requiring such acceptance testing would be cost-effective. Moreover, such acceptance testing would be less costly than the acceptance testing of advanced lighting controls that is already required under the 2013 Code alteration compliance pathways, but would be avoided under the 35/50% compliance pathway.

Despite the commitment to address stakeholder enforcement concerns and despite the submittal of evidence demonstrating that meaningful enforcement would be cost-effective and would result in substantial energy savings, the Commission has not yet adopted any requirements to verify existing conditions when the 35/50% compliance pathway is chosen. Without such verification, actual energy savings under the 2016 35/50% compliance pathway will be substantially less than energy savings under the 2013 Code.

Because the 35/50% compliance pathway significantly reduces up-front compliance costs compared to the other two pathways, it provides an economic incentive to overstate the actual power reduction savings in order for non-residential owners to avoid the additional upfront expense of advanced control requirements and in order for contractors to win jobs through low-cost bids. The 35/50% compliance pathway reduces compliance costs by eliminating the multi-level, daylighting and demand response controls required under the full LPD pathway and eliminating the bi-level controls required under the 85% LPD pathway. In addition, it eliminates the requirement to calculate lighting power densities and eliminates numerous shut-off controls required under both the full LPD and the 85% LPD pathways. In approving the 35/50% compliance pathway, the CEC relied upon proponents’ claim that the

35/50% power reduction would be sufficient to counter lost savings resulting from its reduced requirements.

The CLTC also found that the 35/50% compliance pathway creates a structural incentive to misrepresent power savings because very few existing non-residential occupancies would be able to meet the 35/50% power reduction requirements solely by switching to LEDs or more efficient fluorescent lamps. In its attached report, the CLTC determined that the only retrofits that would potentially be able to meet these requirements would be change-outs of T12 systems to either LED systems or high-efficiency T8 or T5 fluorescent systems. However, even alterations of those systems would not always meet the 35/50% power reduction requirements unless overall lumens are also reduced. For example, a manufacturer brochure on energy savings from replacing HID luminaires with LED luminaires shows that the 50% power reduction requirement would never be met without also reducing lumens – and *in some cases simply replacing the HID luminaires with LED luminaires would actually result in increased energy use.*²

Because very few T12 systems remain installed in California non-residential systems, the vast majority of non-residential lighting systems altered or modified under the 2016 Code will be older T8 fluorescent systems. The CLTC report finds that the average retrofit of an inefficient T8 system to an LED system or higher-efficiency T8 or T5 fluorescent system would only reduce power by around 25%.

This means that most lighting or alteration jobs would either need to also significantly re-design the entire lighting system or would need to misrepresent the power consumption of the original luminaires in order to rely on the control exemptions contained in the new 2016 35/50% compliance pathway.

Accordingly, without a verifiable compliance mechanism, the 35/50% compliance pathway will just result in paper savings. The CLTC finds that, without reliable compliance verification mechanisms, projects that rely on the 35/50% compliance pathway in order to avoid the up-front costs of advanced controls are likely to actually realize only half the savings required under this pathway.

² Exhibit B; also available at <http://www.howard-lighting.com/Documents/ProductLiterature/HIDToLEDCrossReference.pdf>.

Because effective methods for verifying that an alteration has met the 35/50% power reduction requirement have not yet been identified or adopted by the Commission or local jurisdictions, early approval of the 2016 Lighting Alteration Standards as an additional compliance path will likely result in actual energy savings that are significantly lower than would be achieved under the 2013 Code. Accordingly, the proposal to approve the 2016 Lighting Alteration Standards as an additional 2013 compliance path must be rejected.

C. The Notice an Additional Compliance Path Is Deficient because It Misrepresents the New Compliance Path Being Proposed

The proposal to approve the 2016 Lighting Alteration Standards as an additional 2013 compliance path is also deficient because the notice for this proposal misrepresents the new compliance path being proposed. Adoption of an additional compliance path requires a noticed public comment period in compliance with the Commission approval requirements of Section 10-110. The notice for this proposal, however, fails to accurately set forth the new standards being proposed for adoption as an alternative compliance path. The notice states that “Table 1 compares the new 2016 Standards alternative compliance path for luminaire alterations to the two existing 2013 Standards paths.”³ Table 1, however, misrepresents the differences between the 2013 requirements and the 2016 Lighting Alteration Standards and thus conceals the fact that the 2016 Lighting Alteration Standards include deletions and alterations to the 2013 standards.

Table 1 represents that the area control and shut-off control requirements are the same regardless of whether the 2013 compliance requirements are implemented or the 2016 Lighting Alteration Standards are used. This is incorrect. The 2016 Lighting Alteration Standards provides substantial exemptions from the area controls and shut-off controls required under the 2013 Code. They also provide numerous other new exemptions that are not disclosed in Table 1 or in the notice.

The 2013 Code requires lighting system alterations under the full LPD and the 85% LPD compliance paths to comply with *all* the area control requirements set forth in Section 130.1(a), including Section 130.1(a)(4). Table 1, however, claims that the 2013 Code only requires compliance with Sections 130.1(a)(1), (2) and (3). Table 1 thus fails to disclose that the 2016 Lighting Alteration Standards exempt alterations from compliance with the area controls under Section 130.1(a)(4) that would

³ Notice at p. 3.

otherwise be required under the 2013 Code. Section 130.1(a)(4) requires that: (A) General lighting shall be separately controlled from all other lighting systems in an area; (B) Floor and wall display, window display, case display, ornamental, and special effects lighting shall each be separately controlled on circuits that are 20 amps or less; and (C) When track lighting is used, general, display, ornamental, and special effects lighting shall each be separately controlled. As a result, the notice conceals that alterations to these lighting systems under the 2013 Code would result in greater energy savings than alterations under the 2016 Lighting Alteration Standards.

In addition, the 2013 Code requires lighting system alterations under the full LPD and the 85% LPD compliance paths to comply with *all* the shut-off control requirements set forth in Section 130.1(c). The 2016 Lighting Alteration Standards, however, exempts the 35/50% compliance pathway from compliance with numerous provisions of Section 130.1(c), including 130.1, subdivisions (c)(1)(d) [separate controls form general, display, ornamental, and display case lighting], (c)(6)(B) [Library book stack aisle occupancy sensors], (c)(6)(C) [corridor and stairwell occupancy sensors], (c)(7)(A) [hotel/motel corridor and stairwell occupancy sensors], and (c)(8) [hotel/motel guest room occupancy sensors]. Table 1 fails to disclose these exemptions and instead incorrectly states that the 35/50% compliance pathway is subject to all Section 130.1(c) shut-off controls. This again conceals that the 2016 Lighting Alteration Standards delete, alter and reduce energy efficiency requirements contained in the 2013 Code, and thus are not eligible for adoption as an additional 2013 compliance path.

II. EARLY ADOPTION OF THE 2016 LIGHTING ALTERATION STANDARDS DEPRIVES LOCAL AGENCIES SUFFICIENT TIME TO ADDRESS HOW THEY WILL ENFORCE THESE NEW REQUIREMENTS

As discussed above, the 2016 Lighting Alteration Standards create unique enforcement issues not previously encountered by local building officials because compliance with the 35/50% compliance pathway is premised upon a comparison of pre-installation conditions with post-installation conditions. At the Commission's February 9, 2016 Workshop on enforcement of the 2016 Lighting Alteration Standards, numerous building officials from some of the largest jurisdictions in the State objected to this new compliance pathway on the grounds that it did not fit

within current enforcement schemes that relied solely on inspection of the final installation. Building officials are required to inspect, enforce and confirm compliance with Title 24 energy efficiency requirements. Jurisdictions that are concerned over how they will enforce this compliance path should not be rushed into having to enforce compliance before they are ready.

California Building Standards Law provides that substantive building standards do not become effective until 180 days after publication.⁴ The whole point of requiring publication of new building standards 180 days prior to the effective date of new building standards is to provide time for stakeholders, including both installers and local building officials, to be ready to successfully implement the standards. Furthermore, the California Building Standards Code makes a distinction between substantive building standards and building standards related to enforcement and compliance. Building standards related to enforcement and compliance are only required to be published 30 days before they are effective.⁵ The Legislature thus intended the 180 day waiting period to be used, in part, to address enforcement and implementation issues.

Because adoption and enforcement of the 2016 Lighting Alteration Standards has been highly controversial, local jurisdictions should be provided the entire 180 days after publication to determine how they will enforce compliance with standards that raise brand new and unique enforcement issues. By proposing to allow implementation of the 2016 Lighting Alteration Standards immediately, the Commission is depriving jurisdictions from their statutorily mandated time to learn the new code requirements and determine how the locality will inspect and enforce the requirements.

III. CONCLUSION

The 2016 Lighting Alteration Standards eliminated and altered numerous energy efficiency requirements and raised new and unique enforcement and verification concerns. As a result, the adoption of these requirements was highly controversial. The proposal to allow early implementation of these changes is tone deaf to the controversy surrounding these regulations and the continued concerns

⁴ Health & Saf. Code § 18938, subd. (c).

⁵ Health & Saf. Code § 18938, subd. (c).

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that local building officials have raised over enforcement. Moreover, the 2016 Lighting Alteration Standards do not, in any way, meet the legal requirements for adoption of an additional compliance path. This proposal should be rejected.

Sincerely,

A handwritten signature in blue ink that reads "Thomas A. Enslow". The signature is written in a cursive style with a long horizontal stroke at the end.

Thomas A. Enslow

TAE:ljl
Attachment

cc: Commissioner Robert Weisenmiller
Commissioner Andrew McAllister
Peter Strait
Simon Lee
Gabriel Taylor

The Real Cost of Noncompliance

Anticipated Lost Energy and Cost Savings Associated with Noncompliance among Projects following the Reduced Power Compliance Pathway contained in the 2016 Energy Standards for Lighting Alterations (Title 24, Part 6, §141.0)

Prepared by: California Lighting Technology Center, UC Davis

February 20, 2016

Energy savings lost from noncompliance with building energy-efficiency standards represents a real cost to California consumers and business owners. Effective January 1, 2017, new California Building Energy Efficiency Standards will allow three code-compliance pathways for lighting alterations and additions. One of these pathways is new and it allows projects to achieve compliance by reducing the installed input power between existing and retrofit luminaires. The CEC estimates that energy savings from this alternative pathways will mitigate other energy savings losses resulting from relaxation of various lighting requirements contained in the new Standards. The problem is existing lighting retrofit technology, on average, cannot achieve the savings needed to meet these new code requirements. Therefore, a verification program is deeply needed to ensure that lighting retrofit projects following the new 50% power reduction compliance pathway meet the energy savings goals relied upon by the State. Without a comprehensive compliance enforcement program, savings will be 25 percent less than estimated, costing building owners and tenants thousands of dollars each year. A simple, cost-effective solution consisting of pre and post-project checks conducted by Lighting Controls Acceptance Test Technicians is estimated to add only 0.4 to 5 percent in costs to a standard lighting retrofit. A verification program will better ensure retrofit projects taking the 50% power reduction pathway deliver the energy savings needed and expected by California ratepayers.

Introduction

Energy savings lost from noncompliance with building energy-efficiency standards represents a real cost to California consumers and business owners. Multiple studies illustrate the exceptionally high rates of noncompliance among permitted construction projects. Across the country, evidence shows that code compliance rates vary broadly, but on average, industry experts agree that compliance averages around just 40 percent (Building Codes Assistance Project, 2009) meaning 60 percent of projects fail to fully realize intended safety, quality or energy benefits. Reasons for noncompliance vary, but those often cited are misapplication of the requirements on the part of contractors, lack of training for building inspectors and plans examiners, and limited enforcement at the local level due to funding and staffing shortages (Burby, May, & Paterson, 1998).

In particular, compliance with Building Energy Efficiency Standards (Title 24 or Standards) lag significantly behind life and safety standards compliance. In California, the most recent estimates show that energy code compliance for retrofit measures even fails to achieve the low 40 percent nationwide estimate. Evaluation of findings from independent analysis sponsored by the California Public Utilities Commission (CPUC) shows that commercial retrofits and certain new construction projects failed to comply with the mandated Standards in 65 percent of cases¹, on average (Quantec, LLC., 2007). These retrofits consisted of projects that replaced equipment triggering code requirements or installed new equipment regulated by the Standards.

It is widely recognized that certain groups will elect to avoid compliance and complete projects without necessary permits. However, this is just one type of noncompliance. Projects that elect to follow legal requirements and then obtain a building permit while failing to achieve satisfactory compliance, form a second type of noncompliance. Savings estimates used to support adoption of new California Building Energy Efficiency Standards are reduced to account for such projects. In support of the 2005 Standards, for example, CEC estimated that 30 percent of projects would fail to comply with the Standards and savings estimates were reduced accordingly (Quantec, LLC., 2007). However documentation shows this estimate is substantially low when compared to studies of actual noncompliance across the state (Quantec, LLC., 2007). Assumed rates of noncompliance for more recent iterations of the Standards could not be identified in the literature or documents provided by the California Energy Commission (CEC).

The Issue

Effective January 1, 2017, new Building Energy Efficiency Standards will allow three alternative compliance pathways for lighting alterations and additions. As compared to the 2013 Standards, lighting controls requirements have been reduced and a new option related to relative input power thresholds is now available. Under the new Standards, lighting alterations may achieve compliance under any of the following scenarios:

1. Comply with the Lighting Power Density (“LPD”) allowances contained in the 2016 Standards prescriptive, new construction requirements *and*
 - a. Install all applicable Section 130.1(a) 1, (a) and (a)(3) Area lighting controls
 - b. Install all applicable Section 130.1 (c) Shut-off lighting controls

¹ Estimate based on compliance rates for cool roof replacements, duct sealing for replacement ducts and installation of lighting controls under skylights.

- c. Install all applicable Section 130.1 (b) multilevel lighting controls (except for enclosed spaces 100 square feet or less, or connected lighting loads of 0.5 watts per square foot or less.)
 - d. Install all applicable Section 130.1 (d) automatic daylighting controls in applicable daylit zones
 - e. For lighting alterations that exceed 10,000 square feet and either change the area of the space, changes the occupancy type of the space or increases the lighting power, install applicable Section 130.1(e) demand response controls.
2. Achieve a lighting power density (LPD) that is at least 15 percent lower than the LPD allowances contained in 2016 Standards prescriptive, new construction requirements *and*
 - a. Install all applicable Section 130.1(a) 1, (a) and (a)(3) Area lighting controls
 - b. Install all applicable Section 130.1 (c) Shut-off lighting controls
 - c. Install bi-level lighting controls that deliver one control step between 50 and 70% of full power
 3. Achieve a minimum 35 percent (or 50 percent for office, retail or hotel occupancies) power reduction between new/retrofit luminaires and existing luminaires *and*
 - a. Install all applicable Section 130.1(a) 1, (a) and (a)(3) Area lighting controls
 - b. Install the following Shut-off lighting controls, where applicable: Section 130.1 (c)1A through (c)1C, 130.1(c)2, 130.1(c)3, 130.1(c)4, 130.1(c)5, 130.1(c)6A, and for parking garages 130.1(c)7B.

The third compliance pathway is new and, according to CEC, intended to make compliance easier and more cost-effective for certain types of lighting alterations. The CEC estimates that savings from retrofit projects electing to follow the third option, which is a reduced power compliance path (50% compliance path) will total 225 Gigawatt-hours (GWh) per year. An excerpt of the savings calculation workbook provided by CEC is shown in Figure 1. CEC estimates that Entire Luminaire Alterations following the 50% compliance path will achieve savings of 171 GWh per year and luminaire component modifications will achieve 54 GWh per year.

CEC estimates that savings from these two new measures will be enough to counter numerous instances of savings lost due to other new, reduced requirements and relaxation within the 2016 lighting alteration Standards. For example, see lost savings noted in red below, for elimination of automatic daylighting control standards and various Shut-OFF controls requirements. These calculations demonstrate the CEC's reliance on **realized savings** from the 50% power reduction compliance pathway to mitigate other losses that will be forthcoming due to other adopted code rollbacks contained the new Standards.

Figure 1: CEC Workbook showing Savings Estimates for Alternate Paths of Compliance to Section 141.0 – Alterations to Lighting Systems

| Lighting Alteration Sub-Category | Section 140.6 LPD | Section 130.1(a) Area Controls | Section 130.1(b) Multi-level Controls | Section 130.1(c) Shut-off Controls | Section 130.1(d) Daylighting Controls | Total | | | |
|--|-------------------|--------------------------------|---------------------------------------|------------------------------------|---------------------------------------|-------|------------------------|-----|--|
| 1a. Entire Luminaire Alterations. Section 141.0(b)2i i. > 85% LPD | 1 | 0 | 0 | 1 | 0 | 2 | | | |
| 1b. Entire Luminaire Alterations. Section 141.0(b)2i i. < 85% LPD | 3 | 0 | 0 | 3 | 0 | 6 | | | |
| 1c. Entire Luminaire Alterations. Section 141.0(b)2i ii. 50% power reduction | 171 | 0 | 0 | 11 | -27 | 155 | 1c: % Power reduction | 50% | |
| 2a. Luminaire Comp. Modifications. Section 141.0(b)2i i. >70 Luminaire / floor, meet LPD | -3 | 0 | 0 | -3 | -9 | -15 | Section J: threshold | 70 | |
| 2b. Luminaire Comp. Modifications. Section 141.0(b)2i ii: >70 Luminaire / floor, 50% power | 54 | 0 | 0 | -5 | -13 | 35 | 2b: % Power reduction | 50% | |
| 2c. Luminaire Comp. Modifications. Section 141.0(b)2i ii: <70 Luminaire / floor | 0 | 0 | 0 | 0 | 0 | 0 | 2b: include 130.1 c 5? | Yes | |
| 3. Lighting Wiring Alterations. | 0 | 0 | 0 | 0 | -1 | -1 | | | |
| 4. Exempted entire luminaire alterations, luminaire component modifications, and lighting wiring alterations | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| Sub-Total | 225 | 0 | 0 | 6 | -49 | 182 | | | |
| Total Energy Impact Reduction | 182 GWh/year | | | | | | | | |

Source: California Energy Commission

The real issue surrounding these new measures is centered on compliance enforcement. How does a local government or building department ensure that alterations following the new 50% power reduction path actually achieve 50% savings? The only real way is through verification. Verification is vital to ensure that California fully realizes the savings necessary to mitigate other savings losses looming from the elimination of previous 2013 energy-efficiency requirements. Assuming that noncompliance averages 65 percent among retrofit projects, the lack of verification has costly consequences for commercial building owners and tenants.

Getting to 50% Savings

Nearly all commercial buildings in California utilize linear fluorescent lamps. A recent study completed on behalf of the California Public Utilities Commission estimates that 82 percent of all lighting energy use is attributed to linear fluorescent technology (Itron, 2014). In offices and retail establishments, which make up more than 50 percent of all lighting retrofits in the State (California Utilities Statewide Codes and Standards Team, 2011), this value is much higher. Ninety-two percent of lighting energy use in offices and retailers is attributed to linear fluorescent lighting.

Linear fluorescent lighting products can range in size and power consumption. The most typical product installed in commercial businesses is the linear T8 fluorescent lamp with a nominal lamp power of 32 Watts (W). Lamp lengths typically vary between two and eight feet. Between 90 and 96 percent of T8 lamps are four feet in length depending on the size of the business. Lamp wattage can also vary from 32 W down to low-wattage alternatives at 25 W each. Beyond T8, legacy technology, which includes linear T12 lamps and magnetic ballasts, constitute 4 and 29 percent of the installed based depending on business size. Very small establishments had a higher occurrence of legacy technology as compared to larger establishments. Other alternatives include linear T5 lamps and

light-emitting diode (LED) lamps designed to replace fluorescent products. These products constitute less than eight percent and one percent of the installed commercial lighting base per business size, respectively (Itron, 2014).

Therefore, considering the majority of installed products are T8 linear fluorescents, a market snapshot of this product category illustrates the estimated baseline energy consumption in California commercial buildings today. Energy consumption of linear fluorescent lighting is best estimated by the input power required by the ballast to which the lamps are connected. The ballast serves to regulate the current and voltage to the lamps, and also consumes some power to do this job. A snapshot of 48 possible lamp/ballast combinations is provided in Appendix A: Linear Fluorescent Product Snapshot. These products, on average, consume 160 kilowatt-hours (kWh) per year in electricity, assuming 250 hours of use per year. This snapshot is typical and representative of the breadth of linear fluorescent products on the market today.

Lighting retrofits can save significant amounts of energy simply by changing the lamps and/or ballasts to a more efficient technology. In addition, lighting retrofit kits, which replace the lamps, ballasts and optical components, can improve savings as compared to lamp/ballast retrofits alone. Entire luminaire replacements represent another retrofit alternative. The problem is most of these retrofit technologies cannot achieve 50 percent savings when used to retrofit linear fluorescent, T8 products unless they do so at significantly reduced light output. Such a compromise in light levels and/or quality to achieve 50% energy savings is a real possibility given the lack of performance requirements and proper enforcement associated with the new 50% compliance pathway.

A survey of more than 5000 LED lighting products marketed as replacements for linear fluorescent lamps and/or troffer luminaires, shows that, on average, these products use between 20 and 41 watts. At 2500 operating hours per year, this represents 51 kWh to 103 kWh of annual energy use.

Figure 2: Average performance of LED retrofit lighting products

| LED Project Type | Average Performance of Products Surveyed | | | | # of Products Surveyed |
|-------------------------|--|-----------------|-------------|-------------------------|------------------------|
| | Power (W) | Efficacy (Lu/W) | Lumens (Lu) | Annual Energy Use (kWh) | |
| LED Replacement Lamp | 20.5 | 111.1 | 2268.7 | 51.3 | 1604 |
| LED Retrofit Kit | 36.7 | 99.4 | 3610.3 | 91.7 | 521 |
| LED Luminaire (Troffer) | 41.1 | 95.1 | 3883.9 | 102.7 | 3508 |

Source: Design Lights Consortium, database accessed February 16, 2016.

When compared to an average linear fluorescent baseline of 160 kWh per year, savings range between 15 and 24 percent. **This means that approximately 25 percent of the savings expected for lighting alteration projects following the 50% power reduction pathway could be lost when retrofitting to LED technology.** Assuming the 65 percent noncompliance rate previously discussed, consider the following statistics:

- Estimated Savings under 2016 Standards: Entire Luminaire Alterations: 155 GWh
- Estimated Savings under 2016 Standards: Luminaire Component Modifications: 35 GWh
- Average, documented rate of Noncompliant Projects: 65%
- Estimated Savings Lost per Project due to noncompliance: 25%

- Annual Lost Savings: 30.87 GWh
- Average Cost of Electricity – Commercial Customers: \$0.1481 per kWh
- Annual Cost of Lost Savings: \$4,571,847
- Lifecycle Lost Savings over 15 years: 463.05 GWh
- Lifecycle Cost of Lost Savings: \$68,577,705

The cost of lost savings for business owners and tenants is high. For retrofits of 70 or more luminaires, the compliance threshold forthcoming in the 2016 Standards, annual energy costs will be increased by more than \$500 per year as compared to a fully compliant retrofit achieving 50 percent savings. **Over the life of the new system, owners will spend approximately \$7700 in excess electricity costs.** Larger retrofits will see increased costs and decreased savings. Figure 3 shows estimated costs and lost savings attributed to multiple types of LED lamp retrofits for linear fluorescent technology. Figure 4 shows estimated costs and lost savings for LED retrofit kits replacing an average T8 linear fluorescent system. Costs for LED luminaire replacements of these systems are shown in Figure 5. **In all cases, the average LED retrofit fails to achieve the 50% savings necessary to meet code requirements.**

Figure 3: Estimated Savings Lost - LED lamp retrofit of standard linear fluorescent system

| Qty Luminaires | Baseline Annual Operating Cost (T8 LF) | 50% Savings - code compliant retrofit | LED Lamp Retrofit | | |
|----------------|--|---------------------------------------|-----------------------|--|--|
| | | | Annual Operating Cost | Annual Savings (compared to code-compliant retrofit) | Life Cycle Savings (compared to code-compliant retrofit) |
| 1 | \$ 23.78 | \$ 11.89 | \$ 19.26 | (\$7.37) | (\$110.57) |
| 10 | \$ 237.81 | \$ 118.90 | \$ 192.61 | (\$73.71) | (\$1,105.67) |
| 70 | \$ 1,664.64 | \$ 832.32 | \$ 1,348.30 | (\$515.98) | (\$7,739.70) |
| 700 | \$ 16,646.44 | \$ 8,323.22 | \$ 13,483.02 | (\$5,159.80) | (\$77,397.04) |
| 1000 | \$ 23,780.63 | \$ 11,890.31 | \$ 19,261.46 | (\$7,371.15) | (\$110,567.20) |

Source: CLTC

Figure 4: Estimated Savings Lost - LED Retrofit Kit for a Linear Fluorescent Troffer

| Qty Luminaires | Baseline Annual Operating Cost (T8 LF) | 50% Savings - code compliant retrofit | LED Retrofit Kit | | |
|-------------------|---|---|--------------------------|--|--|
| | | | Annual Operating Cost | Annual Savings (compared to code-compliant retrofit) | Life Cycle Savings (compared to code-compliant retrofit) |
| 1 | \$ 23.78 | \$ 11.89 | \$ 17.98 | (\$6.08) | (\$91.27) |
| 10 | \$ 237.81 | \$ 118.90 | \$ 179.75 | (\$60.85) | (\$912.71) |
| 70 | \$ 1,664.64 | \$ 832.32 | \$ 1,258.25 | (\$425.93) | (\$6,388.97) |
| 700 | \$ 16,646.44 | \$ 8,323.22 | \$ 12,582.53 | (\$4,259.31) | (\$63,889.67) |
| 1000 | \$ 23,780.63 | \$ 11,890.31 | \$ 17,975.04 | (\$6,084.73) | (\$91,270.95) |

Source: CLTC

Figure 5: Estimated Savings Lost - LED Luminaire replacement of a linear fluorescent troffer

| Qty Luminaires | Baseline Annual Operating Cost (T8 LF) | 50% Savings - code compliant retrofit | LED Luminaire (full replacement) | | |
|-------------------|---|---|----------------------------------|--|--|
| | | | Annual Operating Cost | Annual Savings (compared to code-compliant retrofit) | Life Cycle Savings (compared to code-compliant retrofit) |
| 1 | \$ 23.78 | \$ 11.89 | \$ 20.13 | (\$8.24) | (\$123.57) |
| 10 | \$ 237.81 | \$ 118.90 | \$ 201.28 | (\$82.38) | (\$1,235.70) |
| 70 | \$ 1,664.64 | \$ 832.32 | \$ 1,408.98 | (\$576.66) | (\$8,649.90) |
| 700 | \$ 16,646.44 | \$ 8,323.22 | \$ 14,089.82 | (\$5,766.60) | (\$86,498.98) |
| 1000 | \$ 23,780.63 | \$ 11,890.31 | \$ 20,128.31 | (\$8,238.00) | (\$123,569.97) |

Source: CLTC

The Solution – Retrofit Savings Verification Program

With the lost savings and increased energy costs expected for lighting retrofit projects following the reduced power pathway, an enforcement program should be adopted to increase compliance and better ensure California receives the energy savings intended from the 2016 Standards. Because compliance with the reduced power pathway is premised on a comparison of existing baseline conditions with the new altered or modified conditions, meaningful enforcement would need to include verification of the existing lighting baseline for each project. Since building inspectors

generally do not inspect alterations or modifications until after the original system has been removed and rough installation has been finished, third party verifications or verifications by certified acceptance testers would be needed to address this enforcement gap.

In California, the State has already invested in deployment of the Lighting Controls Acceptance Test Technician (LCATT) program to improve the performance of lighting controls installed in newly constructed buildings, building additions and alterations. Since a requirement to use certified acceptance testers has already been adopted to verify compliance with Title 24 lighting control requirements, a simple solution would be to use that same enforcement scheme to validate compliance with the reduced power pathway requirements. The use of Acceptance Testers has proven to be an effective solution to alleviate building inspection department backlog and increase compliance with Title 24 energy efficiency requirements among construction projects. Over a 1000 trained acceptance technicians are available statewide to check savings claims of lighting retrofit projects following the 50% reduced power compliance path available under the 2016 Standards.

Consider the following high-level summary of this potential program. Trained technicians could perform a pre and post project inspection check to verify the input power of existing and new luminaires. During the pre-check, technicians could verify the input power of existing luminaires using product model numbers and similar information pulled from a sample of luminaires slated for retrofit. This information could be compared to the proposed retrofit technology, which would serve to catch errors or omissions in energy calculations early in the project, prior to equipment installation. Changes, if necessary, could be made at this point, before costly equipment is purchased or installed. Following installation, a post-check would verify that the energy-efficient lighting equipment met requirements and savings achieved.

Such a program would be cost-effective. Under the LPD plus advanced controls pathway (Options 1 and 2 previously described), acceptance testing is mandated for all lighting controls except where the project involves 20 or fewer controlled-luminaires. The Commission has thus already determined that acceptance testing is cost effective for all project involving more than 20 controlled-luminaires. The power reduction pathway eliminates the cost of acceptance testing for multi-level and daylighting controls since those controls are eliminated under that pathway. Since the Commission estimates both pathways will provide approximately the same level of energy savings, acceptance testing for the power reduction pathway would fall under the same cost-effectiveness determination as long as it didn't cost more than the combined cost for acceptance testing of multi-level lighting and daylighting controls.

Acceptance testing of the power reduction pathway would also be cost effective when you compare it to the overall cost of the project or when you compare it to the cost of lost energy savings from non-compliance. As shown by Estimated inspection costs included below were prepared by certified LCATTs based on a high-level project description and the general program guidelines previously described.

Figure 6 and Figure 7, acceptance testing for projects following the power reduction pathway would result in just a nominal increase of project costs for any project involving more than 20 luminaires. As a percentage of a retrofit project's valuation, inspection costs for pre and post retrofit checks will increase overall project costs by approximately 0.4 percent to 5 percent

depending on the type of alteration². In addition, estimates show that the value of lost energy savings for projects that fail to fully meet the power reduction pathway requirements greatly exceeds the cost of acceptance testing of the power reduction pathway. Estimated inspection costs included below were prepared by certified LCATTs based on a high-level project description and the general program guidelines previously described.

Figure 6: Estimated Project Costs for a Lighting Retrofit including Proposed Pre and Post Inspection Checks - Entire Luminaire Replacement

| Entire Luminaire Replacements | | | | |
|-------------------------------|-------------------|---------------|------------------------------------|----------------------------|
| Qty Luminaires | Project Valuation | | Estimated Field Verification Costs | |
| | Low | High | Inspection Cost | Average % Cost Increase |
| 1 | \$ 417.82 | \$ 562.55 | \$ - | 0% |
| 10 | \$ 2,700.66 | \$ 4,153.43 | \$ - | 0% |
| 21 | \$ 5,050.72 | \$ 7,960.03 | \$ 355.00 | 5% |
| 70 | \$ 17,508.07 | \$ 27,365.00 | \$ 405.00 | 2% |
| 100 | \$ 24,788.68 | \$ 38,861.16 | \$ 440.00 | 1.5% |
| 250 | \$ 61,175.44 | \$ 96,224.26 | \$ 480.00 | 0.6% |
| 500 | \$ 121,637.47 | \$ 191,620.43 | \$ 685.00 | 0.5% |
| 1000 | \$ 242,463.81 | \$ 382,420.54 | \$ 1,072.50 | 0.4% |

Source: CLTC

Figure 7: Estimated Project Costs for a Lighting Retrofit including Proposed Pre and Post Inspection Checks - Luminaire Component Modifications

| Component Modifications | | | | |
|-------------------------|-------------------|---------------|------------------------------------|----------------------------|
| Qty Luminaires | Project Valuation | | Estimated Field Verification Costs | |
| | Low | High | Inspection Cost | Average % Cost Increase |
| 1 | \$ 257.50 | \$ 365.78 | \$ - | 0% |
| 10 | \$ 1,365.11 | \$ 2,396.20 | \$ - | 0% |
| 21 | \$ 2,720.66 | \$ 4,994.66 | \$ - | 0% |
| 70 | \$ 8,667.41 | \$ 16,060.50 | \$ 405.00 | 3.6% |
| 100 | \$ 12,287.74 | \$ 22,694.88 | \$ 440.00 | 2.8% |
| 250 | \$ 28,420.60 | \$ 54,360.21 | \$ 480.00 | 1.3% |
| 500 | \$ 55,308.53 | \$ 106,887.18 | \$ 685.00 | 0.9% |
| 1000 | \$ 118,120.34 | \$ 222,376.91 | \$ 1,072.50 | 0.7% |

Source: CLTC

² These estimates assume a retrofit of a standard 2' x 4' fluorescent troffers. For reference, 1000 such troffers serves an areas of approximately 4200 sq. ft. (56' x 76' or a 10 X 10 luminaire grid). This is the size of a small commercial building or medium commercial tenant space.

Conclusion

Energy savings lost from noncompliance with building energy efficiency standards represents a real cost to California consumers and business owners. Effective January 1, 2017, new California Building Energy Efficiency Standards will allow three code-compliance pathways for lighting alterations and additions. One of these pathways is new and it allows projects to achieve compliance by reducing the installed input power between existing and retrofit luminaires. The CEC estimates that energy savings from this alternative pathways will mitigate other energy savings losses resulting from relaxation of various lighting requirements contained in the new Standards.

The problem is existing lighting retrofit technology, on average, cannot achieve the savings needed to meet these new code requirements. Estimates indicate businesses may lose approximately \$7700 over the life of the retrofit lighting system. Therefore, a verification program is deeply needed to ensure that lighting retrofit projects following the new 50% power reduction compliance pathway meet the energy savings goals relied upon by the State. Without a comprehensive compliance enforcement program, savings will be 25% less than estimated, costing building owners and tenants thousands of dollars each year.

A simple, cost-effective verification program consisting of pre and post-project checks conducted by Lighting Controls Acceptance Test Technicians is estimated to cost only 0.5 to 5 percent of costs beyond that of a standard lighting retrofit budget. Prior CEC analysis and documentation has shown that acceptance testing is cost-effective for all retrofit projects of 21 or more luminaires. A verification program will better ensure retrofit projects taking the 50% power reduction pathway delivers the energy savings needed and expected by California ratepayers.

Appendix A: Linear Fluorescent Product Snapshot

| System Type | Lamp Type | Ballast Factor | # of lamps | Lamp Power | Input Power (W) | Annual Energy Use (kWh) |
|---------------------|-----------|----------------|------------|------------|-----------------|-------------------------|
| HIGH-EFFICIENCY | F32T8 | 0.77 | 1 | 32 | 25 | 6.25 |
| | F32TS(ES) | 0.77 | 1 | 28 | 22 | 5.5 |
| | F32TS(ES) | 0.77 | 1 | 25 | 21 | 5.25 |
| | F32T8 | 0.87 | 1 | 32 | 28 | 7 |
| | F32TS(ES) | 0.87 | 1 | 28 | 25 | 6.25 |
| | F32TS(ES) | 0.87 | 1 | 25 | 23 | 5.75 |
| | F32T8 | 1.17 | 1 | 32 | 37 | 9.25 |
| | F32TS(ES) | 1.18 | 1 | 28 | 32 | 8 |
| | F32TS(ES) | 1.17 | 1 | 25 | 31 | 7.75 |
| | F32T8 | 0.77 | 2 | 32 | 48 | 12 |
| | F32TS(ES) | 0.77 | 2 | 28 | 42 | 10.5 |
| | F32TS(ES) | 0.77 | 2 | 25 | 38 | 9.5 |
| | F32T8 | 0.87 | 2 | 32 | 55 | 13.75 |
| | F32TS(ES) | 0.87 | 2 | 28 | 47 | 11.75 |
| | F32TS(ES) | 0.87 | 2 | 25 | 44 | 11 |
| | F32T8 | 1.17 | 2 | 32 | 74 | 18.5 |
| | F32TS(ES) | 1.18 | 2 | 28 | 65 | 16.25 |
| | F32TS(ES) | 1.17 | 2 | 25 | 60 | 15 |
| | F32T8 | 0.77 | 3 | 32 | 73 | 18.25 |
| | F32TS(ES) | 0.77 | 3 | 28 | 64 | 16 |
| | F32TS(ES) | 0.77 | 3 | 25 | 58 | 14.5 |
| | F32T8 | 0.87 | 3 | 32 | 82 | 20.5 |
| | F32TS(ES) | 0.87 | 3 | 28 | 72 | 18 |
| | F32TS(ES) | 0.87 | 3 | 25 | 65 | 16.25 |
| | F32T8 | 1.17 | 3 | 32 | 110 | 27.5 |
| | F32TS(ES) | 1.18 | 3 | 28 | 95 | 23.75 |
| | F32TS(ES) | 1.17 | 3 | 25 | 89 | 22.25 |
| | F32T8 | 0.77 | 4 | 32 | 96 | 24 |
| | F32TS(ES) | 0.77 | 4 | 28 | 84 | 21 |
| | F32TS(ES) | 0.77 | 4 | 25 | 77 | 19.25 |
| F32T8 | 0.87 | 4 | 32 | 109 | 27.25 | |
| F32TS(ES) | 0.87 | 4 | 28 | 96 | 24 | |
| F32TS(ES) | 0.87 | 4 | 25 | 87 | 21.75 | |
| F32T8 | 1.17 | 4 | 32 | 147 | 36.75 | |
| F32TS(ES) | 1.18 | 4 | 28 | 127 | 31.75 | |
| F32TS(ES) | 1.17 | 4 | 25 | 115 | 28.75 | |
| STANDARD EFFICIENCY | F32T8 | 0.91 | 1 | 32 | 29 | 7.25 |
| | F32TS(ES) | 0.91 | 1 | 28 | 25 | 6.25 |
| | F32TS(ES) | 0.91 | 1 | 25 | 23 | 5.75 |
| | F32T8 | 0.89 | 2 | 32 | 56 | 14 |
| | F32TS(ES) | 0.89 | 2 | 28 | 48 | 12 |
| | F32TS(ES) | 0.92 | 2 | 25 | 45 | 11.25 |
| | F32T8 | 0.91 | 3 | 32 | 87 | 21.75 |
| | F32TS(ES) | 0.9 | 3 | 28 | 77 | 19.25 |
| | F32TS(ES) | 0.94 | 3 | 25 | 71 | 17.75 |
| | F32T8 | 0.9 | 4 | 32 | 112 | 28 |
| | F32TS(ES) | 0.89 | 4 | 28 | 100 | 25 |
| | F32TS(ES) | 0.9 | 4 | 25 | 91 | 22.75 |

Source: Philips Lighting

Appendix B: Project Cost Calculator – Calculator Output

| Lighting Fixture Installation Cost Calculator | | Zip Code | Fixtures | | |
|--|--|-----------|----------|---------------------------------------|--|
| | | 95618 | 1 | <input type="button" value="Update"/> | |
| Item | | Quantity | Low | High | |
| Lighting Fixture Cost | | 1 fixture | \$50.02 | \$119.19 | |
| Non-discounted retail pricing for: 18" diameter x 6" tall drum style wit chrome nickel brass finish options. 4 x 60W lights. 120V.FALSE | | | | | |
| Lighting Fixture Labor | | 2 hrs | \$178.13 | \$218.63 | |
| Labor estimate to install lighting fixture. Layout location and cut mounting hole. Add or modify wiring from existing switch or parallel fixture. Place fixture and trim piece. Includes planning, equipment and material acquisition, area preparation and protection, setup and cleanup. | | | | | |
| Lighting Fixture Materials and Supplies | | 1 fixture | \$20.00 | \$25.00 | |
| Cost of related materials and supplies typically required to install lighting fixture including: connectors, fittings and mounting hardware. | | | | | |
| Totals - Cost to Install Lighting Fixture - 1 fixture | | | \$248.15 | \$362.82 | |
| Average Cost Per Fixture | | | \$248.15 | \$362.82 | |

| Lighting Fixture Installation Cost Calculator | | Zip Code | Fixtures | | |
|--|--|-------------|------------|---------------------------------------|--|
| | | 95618 | 10 | <input type="button" value="Update"/> | |
| Item | | Quantity | Low | High | |
| Lighting Fixture Cost | | 10 fixtures | \$500.24 | \$1,191.86 | |
| Non-discounted retail pricing for: 18" diameter x 6" tall drum style wit chrome nickel brass finish options. 4 x 60W lights. 120V.FALSE | | | | | |
| Lighting Fixture Labor | | 16.4 hrs | \$1,398.74 | \$1,797.67 | |
| Labor estimate to install lighting fixture. Layout location and cut mounting hole. Add or modify wiring from existing switch or parallel fixture. Place fixture and trim piece. Includes planning, equipment and material acquisition, area preparation and protection, setup and cleanup. | | | | | |
| Lighting Fixture Materials and Supplies | | 10 fixtures | \$77.70 | \$89.33 | |
| Cost of related materials and supplies typically required to install lighting fixture including: connectors, fittings and mounting hardware. | | | | | |
| Totals - Cost to Install Lighting Fixture - 10 fixtures | | | \$1,976.68 | \$3,078.87 | |
| Average Cost Per Fixture | | | \$197.67 | \$307.89 | |

Cost to Install a Lighting Fixture

Updated: January 2016

| Lighting Fixture Installation Cost Calculator | | Zip Code | Fixtures | Update | |
|--|--|----------|-------------|-------------------|-------------------|
| Item | | 95618 | 21 | Low | High |
| Lighting Fixture Cost | | | 21 fixtures | \$1,050.51 | \$2,502.91 |
| Non-discounted retail pricing for: 18" diameter x 6" tall drum style wit chrome nickel brass finish options. 4 x 60W lights. 120V.FALSE | | | | | |
| Lighting Fixture Labor | | | 34 hrs | \$2,898.16 | \$3,727.61 |
| Labor estimate to install lighting fixture. Layout location and cut mounting hole. Add or modify wiring from existing switch or parallel fixture. Place fixture and trim piece. Includes planning, equipment and material acquisition, area preparation and protection, setup and cleanup. | | | | | |
| Lighting Fixture Materials and Supplies | | | 21 fixtures | \$163.17 | \$187.60 |
| Cost of related materials and supplies typically required to install lighting fixture including: connectors, fittings and mounting hardware. | | | | | |
| Totals - Cost to Install Lighting Fixture - 21 fixtures | | | | \$4,111.84 | \$6,418.12 |
| Average Cost Per Fixture | | | | \$195.80 | \$305.62 |

Cost to Install a Lighting Fixture

Updated: January 2016

| Lighting Fixture Installation Cost Calculator | | Zip Code | Fixtures | Update | |
|--|--|----------|-------------|--------------------|--------------------|
| Item | | 95618 | 70 | Low | High |
| Lighting Fixture Cost | | | 70 fixtures | \$3,501.69 | \$8,343.04 |
| Non-discounted retail pricing for: 18" diameter x 6" tall drum style wit chrome nickel brass finish options. 4 x 60W lights. 120V.FALSE | | | | | |
| Lighting Fixture Labor | | | 112.4 hrs | \$9,577.40 | \$12,324.59 |
| Labor estimate to install lighting fixture. Layout location and cut mounting hole. Add or modify wiring from existing switch or parallel fixture. Place fixture and trim piece. Includes planning, equipment and material acquisition, area preparation and protection, setup and cleanup. | | | | | |
| Lighting Fixture Materials and Supplies | | | 70 fixtures | \$543.89 | \$625.33 |
| Cost of related materials and supplies typically required to install lighting fixture including: connectors, fittings and mounting hardware. | | | | | |
| Totals - Cost to Install Lighting Fixture - 70 fixtures | | | | \$13,622.99 | \$21,292.96 |
| Average Cost Per Fixture | | | | \$194.61 | \$304.19 |

Lighting Fixture Installation Cost Calculator

Zip Code

95618

Fixtures

100

Update

| Item | Quantity | Low | High |
|---|--------------|-------------|-------------|
| Lighting Fixture Cost Non-discounted retail pricing for: 18" diameter x 6" tall drum style wit chrome nickel brass finish options. 4 x 60W lights. 120V.FALSE | 100 fixtures | \$5,002.42 | \$11,918.63 |
| Lighting Fixture Labor Labor estimate to install lighting fixture. Layout location and cut mounting hole. Add or modify wiring from existing switch or parallel fixture. Place fixture and trim piece. Includes planning, equipment and material acquisition, area preparation and protection, setup and cleanup. | 160.4 hrs | \$13,666.74 | \$17,588.05 |
| Lighting Fixture Materials and Supplies Cost of related materials and supplies typically required to install lighting fixture including: connectors, fittings and mounting hardware. | 100 fixtures | \$776.99 | \$893.33 |
| Totals - Cost to Install Lighting Fixture - 100 fixtures | | \$19,446.15 | \$30,400.01 |
| Average Cost Per Fixture | | \$194.46 | \$304.00 |

Cost to Install a Lighting Fixture

Updated: January 2016

Lighting Fixture Installation Cost Calculator

Zip Code

95618

Fixtures

250

Update

| Item | Quantity | Low | High |
|---|--------------|-------------|-------------|
| Lighting Fixture Cost Non-discounted retail pricing for: 18" diameter x 6" tall drum style wit chrome nickel brass finish options. 4 x 60W lights. 120V.FALSE | 250 fixtures | \$12,506.05 | \$29,796.58 |
| Lighting Fixture Labor Labor estimate to install lighting fixture. Layout location and cut mounting hole. Add or modify wiring from existing switch or parallel fixture. Place fixture and trim piece. Includes planning, equipment and material acquisition, area preparation and protection, setup and cleanup. | 400.4 hrs | \$34,113.40 | \$43,905.36 |
| Lighting Fixture Materials and Supplies Cost of related materials and supplies typically required to install lighting fixture including: connectors, fittings and mounting hardware. | 250 fixtures | \$1,942.47 | \$2,233.32 |
| Totals - Cost to Install Lighting Fixture - 250 fixtures | | \$48,561.93 | \$75,935.26 |
| Average Cost Per Fixture | | \$194.25 | \$303.74 |

Lighting Fixture Installation Cost Calculator

Zip Code

95618

Fixtures

1000

Update

| Item | Quantity | Low | High |
|---|---------------|--------------|--------------|
| Lighting Fixture Cost Non-discounted retail pricing for: 18" diameter x 6" tall drum style wit chrome nickel brass finish options. 4 x 60W lights. 120V.FALSE | 1000 fixtures | \$50,024.20 | \$119,186.30 |
| Lighting Fixture Labor Labor estimate to install lighting fixture. Layout location and cut mounting hole. Add or modify wiring from existing switch or parallel fixture. Place fixture and trim piece. Includes planning, equipment and material acquisition, area preparation and protection, setup and cleanup. | 1600.4 hrs | \$136,346.73 | \$175,491.88 |
| Lighting Fixture Materials and Supplies Cost of related materials and supplies typically required to install lighting fixture including: connectors, fittings and mounting hardware. | 1000 fixtures | \$7,769.90 | \$8,933.30 |
| Totals - Cost to Install Lighting Fixture - 1000 fixtures | | \$194,140.83 | \$303,611.48 |
| Average Cost Per Fixture | | \$194.14 | \$303.61 |

Cost to Install a Lighting Fixture - Notes and General Information

Homewyse cost estimates are "ballpark" ranges for basic work performed in normal, serviceable conditions. The estimates should only be used for preliminary planning. Homewyse estimates are NOT substitutes for firm quotes from qualified vendors. Homewyse strongly recommends that you contact reputable professionals for an accurate assessment of work required and costs for your project - before making any decisions or commitments.

The cost estimate **includes**:

- Costs for local material / equipment delivery to and service provider transportation to and from the job site.
- Costs to prepare the worksite for Lighting Fixture Installation, including costs to protect existing structure(s), finishes, materials and components.
- Costs for job cleanup and debris removal at project completion.
- Labor setup time, mobilization time and minimum hourly charges that are commonly included for small Lighting Fixture Installation jobs.

The cost estimate does **NOT include**:

- Costs for removing, relocating, repairing, or modifying existing framing, surfacing, HVAC, electrical, and plumbing systems - or bringing those systems into compliance with current building codes.
- Costs for testing and remediation of hazardous materials (asbestos, lead, etc).
- General contractor overhead and markup for organizing and supervising the Lighting Fixture Installation. Add 15% to 23% to the total cost above if a general contractor will supervise this project.
- Sales tax on materials and supplies.
- Permit or inspection fees (or portion thereof) required by your local building department for your overall project.

Cost to Install a Lighting Fixture - References

- [Unit Pricing Data: Home Depot Electrical Products and Supplies](#) Home Depot, Jan 2016, Website
- [Unit Pricing Data: Essential Hardware Electrical Products](#) Essential Hardware, Jan 2016, Website
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