DOCKETED

Docket Number:	16-BSTD-02
Project Title:	2016 Nonresidential Lighting Alteration Enforcement
TN #:	210739
Document Title:	CA IBEW-NECA LMCC Comments on NonRes Compliance Manual Lighting Alterations Section
Description:	N/A
Filer:	System
Organization:	Adams Broadwell Joseph & Cardozo/Thomas Enslow
Submitter Role:	Public
Submission Date:	3/15/2016 2:52:53 PM
Docketed Date:	3/15/2016

Comment Received From: Thomas Enslow
Submitted On: 3/15/2016
Docket Number: 16-BSTD-02

CA IBEW-NECA LMCC Comments on NonRes Compliance Manual lighting alterations section

Additional submitted attachment is included below.

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March 15, 2016

VIA E-FILING

California Energy Commission
Dockets Office, MS-4
Re: Docket No. 16-BSTD-02
1516 Ninth Street
Sacramento, CA 95814-5512
https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=16-BSTD-02

Re: Docket No. 16-BSTD-02 - Comments on 2016 Title 24 Non-residential Lighting Alteration Compliance Manual Sections, Chapter 5, Subchapter 9

Dear Commissioners and Commission staff:

The following are the comments of the California State Labor Management Cooperation Committee for the International Brotherhood of Electrical Workers and the National Electrical Contractors Association ("LMCC") on the proposed 2016 Non-residential Compliance Manual Chapter 5, Non-residential Indoor Lighting, Subchapter 9, Additions and Alterations and the proposed 2016 Certificate of Compliance, Indoor Lighting Alterations (collectively "the Lighting Alteration Compliance Documents"). The LMCC represent over a 1,000 contractors and over 30,000 electricians who install lighting systems in California.

The LMCC strongly objects to the proposed Lighting Alteration Compliance Documents. The documents are misleading and contain significant inaccuracies. In addition, they fail to address significant verification and enforcement issues that stakeholders have raised concerning the new power reduction compliance path for alterations and modifications. In adopting this new compliance path, the Commission committed to addressing these concerns prior to the effective date of the 2016 Code. None of the concerns raised by stakeholders have been addressed by the proposed Lighting Alteration Compliance Documents. To the contrary, these documents heighten the concerns that have been raised.

As part of its 2016 Title 24 code update, the California Energy Commission approved an amendment to the California Energy Code that exempted non-residential lighting alteration or modification projects from the requirement to install advanced lighting controls (i.e., multi-level controls, daylighting controls and automated demand response controls) if the alteration or modification reduced the lighting system's overall power consumption by 50% for retail, commercial or office occupancies, or 35% for all other occupancies ('the 35/50% compliance pathway").

The LMCC and other stakeholders, including numerous inspectors, 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. The Commission's response was to commit to address enforcement issues prior to the effective date of the new exemption.

As a result of this commitment, staff held a workshop on enforcement of the 2016 non-residential alteration and modification standards on February 9, 2016 ("the Workshop"). At the Workshop, numerous inspectors and other stakeholders testified that merely requiring a contractor to sign a document verifying compliance would not be sufficient to ensure compliance since there would be no way to verify if someone was lying about the original existing conditions unless a pre-installation visual inspection was made. Numerous stakeholders recommended using Acceptance testers to conduct this pre-installation visual inspection.

Based on the comments of Commission staff and other stakeholders regarding the need to ensure the cost-effectiveness of any enforcement requirements such as new acceptance testing mandates, the LMCC engaged the University of California, Davis, California Lighting Technology Center ("CLTC") to prepare 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. A copy of the report is attached as Exhibit B.

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.

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 under a variety of metrics. Moreover, such acceptance testing would be less costly than the acceptance testing of advanced lighting controls that is already required under the alternative alteration and modification compliance pathways because it is a much simpler process.

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 now proposed enforcing compliance with the 35/50% compliance pathway by simply requiring contractors to fill out, sign and submit a compliance form. No verification of existing conditions is required at all.

Furthermore, the proposed 2016 Non-residential Compliance Manual on lighting alterations contains precisely the exact misrepresentations regarding power consumption savings that stakeholders have warned will be widespread if verification of existing conditions is not required. For example, the Compliance manual assumes that replacing HID luminaires with LED luminaires will "automatically" result in greater than 50% power reduction savings. In reality, one-to-one replacements of HID luminaires with LED luminaires in retail occupancies will never result in greater than 50% power reduction savings unless overall lumens are also substantially reduced. In some cases, replacements of HID luminaires with LED luminaires will actually result in *greater* energy use.

Contrary to the commitment that was made by the Commission, the enforcement requirements set forth in the 2016 Non-residential Compliance Manual fail to address, at all, any of the enforcement concerns raised by stakeholders over the 35/50% compliance pathway. We know from numerous studies and years of enforcement experience that, without verification, there will be widespread fraud and substantial lost energy savings.

I. IMPORTANCE OF STRONG ENFORCEMENT OF TITLE 24 LIGHTING ALTERATION AND MODIFICATION REQUIREMENTS

California's energy efficiency and greenhouse gas reduction goals cannot be met solely by increasing efficiency in new buildings. New buildings are a small percentage of the total building stock. There is approximately 8 billion square feet of existing, non-residential space in California. Approximately half of this stock was built prior to the establishment of the Building Energy Efficiency Standards. In order to achieve California's energy efficiency and greenhouse gas reduction goals, the CPUC's 2008 *Long Term Energy Efficiency Strategic Plan* calls for reducing energy consumption in existing residential buildings by 40% by 2020 and for 50% of California's existing commercial buildings to be zero net energy by 2030. In addition, the Governor has mandated doubling the efficiency of existing buildings over the next 15 years. NECA, IBEW and the LMCC strongly support these goals. These mandates are not achievable, however, unless energy efficiency standards for existing building alterations and modifications are enforced and verified.

Effective implementation of Title 24 energy efficiency standards for lighting system alterations and modification represent a particularly critical component to meeting these greenhouse gas reduction and energy efficiency goals. Lighting accounts for almost 40% of a commercial building's electrical use. This is double the energy used for cooling.

Under the 2013 Code, lighting alterations and modifications 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. Lighting controls significantly increase a retrofit's energy savings over just putting in more efficient LED luminaires. A study of the commercial lighting sector found that lighting controls reduce commercial buildings' energy use for lighting by up to an additional 38%.[1]

The 2013 Code provides an alternative compliance path for lighting alterations and modifications that do not involve moving walls or ceilings or otherwise change the size or use of a space. These alterations and modifications are exempt from the requirement to install multi-level, daylighting and demand response controls if they

[1] Jackson, et al, ACEEE Summer Study Proceedings, *California's Advanced Lighting Controls Training Program: Building a Skilled Workforce in the Energy Efficiency Market* (2012), http://www.aceee.org/files/proceedings/2012/start.htm.

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 area controls and 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.

In addition, the 2013 Code requires acceptance testing for all retrofits that require installation of controls affecting more than 20 luminaires.

II. NEW ALTERNATIVE 35/50% COMPLIANCE PATHWAY FOR ALTERATIONS

The 2016 Code Proposal 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.

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. In addition to a different threshold, the 35/50% compliance pathway differs from the 85% LPD pathway in three significant ways. First, 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. Second, alterations taking the 35/50% compliance pathway are not required to demonstrate that they meet lighting power allowance requirements. Third, the 35/50% compliance pathway does not require certain area or occupancy controls for hallways, stairwells, hotel rooms or display cases that would be required under all other compliance pathways.

Adoption of the new 35/50% compliance pathway for alteration and modification requirements was highly controversial because many stakeholders saw this compliance path as a step backwards rather than a step forward. The three main objections that LMCC has with this proposal are: (1) our experts believe that the 35/50% compliance pathway saves less energy than the 2013 requirements; (2) the adoption of a new, easier pathway for avoiding advanced controls is inconsistent with need to increase

automated demand response controls in existing buildings;[2] and (3) the 35/50% compliance pathway creates inherent enforcement and verification difficulties which is likely to result in widespread fraud and lost energy savings unless reliable verification requirements are imposed.

While the Commission approved the 35/50% compliance pathway over these objections, the Commission committed at the adoption hearing that enforcement concerns would be addressed prior to the effective date of the 2016 Code update.

III. THE 35/50% POWER REDUCTION PATH CREATES AN INCENTIVE TO OVERSTATE ACTUAL POWER REDUCTION SAVINGS

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.

Without reliable verification, however, we know with almost certainty that there will be widespread misrepresentation of the power consumption of existing systems in order to claim to have met the 35% or 50% thresholds.

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[2] Advanced lighting controls coupled with automated demand response controls provide important grid management capabilities necessary to allow increased reliance on less predictable wind and solar energy sources. Increasing automated demand response capabilities in existing buildings will thus be one of the keys to meeting the Governor's mandate to increase the Renewable Portfolio Standard to 50% within the next 15 years. Providing new incentives to avoid the installation of demand response controls in existing buildings creates an unnecessary barrier to achieving the increased renewable energy goal.

First, the CLTC cites numerous studies that have found that, without reliable verification and enforcement methods, non-compliance with building code requirements is extremely common. Evidence shows that code compliance rates across the country vary broadly, but average around just 40%. This means that 60% of projects fail to fully comply with code requirements related to safety, quality or energy efficiency. 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/staffing shortages.

Compliance with Title 24 energy efficiency standards is even lower than this average rate. Findings from independent analysis sponsored by the California Public Utilities Commission show that commercial retrofits and certain new construction projects fail to comply with the mandated Standards in 65% of cases, on average – meaning that only 35% are in compliance. These retrofits consisted of projects that replaced equipment triggering code requirements or installed new equipment regulated by the Standards.

Second, we know 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 regularly 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.

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 savings in order to rely on the control exemptions contained in the 35/50% compliance pathway.

The high percentage of non-compliance cited by the CLTC report is not a surprise to the LMCC's contractors. The LMCC's contractors know first-hand that the vast majority of contractors and owners cannot be trusted to comply with Title 24 energy efficiency requirements without effective verification and enforcement. Without effective verification, most contractors simply cannot compete for jobs if they follow all the requirements of Title 24. Indeed, LMCC contractors regularly find themselves competing against bids that would not even cover the cost of materials were the requirements of Title 24 actually followed.

Fundamentally, this is because most non-residential customers are more concerned with current up-front costs than with the savings that advanced controls would provide over the long-term. Non-residential customers are often not interested in paying higher up-front costs for more efficient lighting systems if they will not recoup that cost within two or three years. If that wasn't the case, we wouldn't need mandatory Title 24 energy requirements.

On top of this, contractors are under tremendous pressure to provide low-bids in order to get hired. This means that there is an enormous financial incentive to overestimate a project's energy savings in order to trigger the advanced lighting control exemption that is provided where power consumption is claimed to be reduced by 35% or 50%. Without reliable enforcement measures, the 35/50% compliance pathway will result in widespread fraud by contractors in order to lower their bids.

IV. THE 35/50% COMPLIANCE PATHWAY RAISES INTRINSIC COMPLIANCE AND ENFORCEMENT ISSUES THAT REQUIRE ON-SITE VISUAL VERIFICATION OF EXISTING BASELINE CONDITIONS

Without a verifiable compliance mechanism, the 35/50% compliance pathway will just result in paper savings. Fundamental to any enforcement of the 35/50% compliance pathway is verification of the power consumption of the original lighting system. The need to verify existing baseline conditions, however, poses an intrinsic compliance and enforcement issue because it is inconsistent with current building code inspection practices.

Local building inspectors only inspect after rough installation has been finished. At that point, the original lighting components are already gone, making it impossible to confirm that the new system actually reduced the lighting power consumption by 35% or 50%. By creating a code requirement that relies on verification of existing conditions, the Commission has created an enforcement gap that is ripe for fraud.

Numerous building inspectors raised this issue during the code adoption proceedings. They testified that their job is to verify that the altered or modified lighting systems meet code requirements. They viewed the 35/50% compliance pathway to be unenforceable under current enforcement schemes since the original luminaire or luminaire components will be gone before an inspector inspects the project.

Because the Commission chose to adopt standards that are based on existing conditions, it now needs to address how to address the enforcement gap that this new pathway created.

V. MEANINGFUL ENFORCEMENT OF THE 35/50% COMPLIANCE PATHWAY REQUIRES VISUAL INSPECTION OF BASELINE CONDITIONS

At the February 9, 2016 Workshop, numerous inspectors testified that reliable verification of the 35/50% compliance pathway requires visual inspection of the existing baseline conditions. The inspectors cautioned strongly against relying on affidavits or photographs to verify the original conditions. In their experience, declarations and photographs have never been found to be an acceptable replacement for on the job inspections because they are not reliable. Inspectors simply are not able to confirm that a photograph of the model numbers on a lamp and ballast is actually a photograph of the lamp and ballast that has been replaced.

The geo-tagging requirement suggested at the Workshop does not make photographs any more reliable. Geo-tags are very easily faked or changed. Software and smartphone apps are readily available for altering geo-tags.[3] Simply put, if a contractor were already inclined to use a fake photograph to hide his non-compliant work, a geo-tag requirement would provide very little in the way of reliable verification of its veracity.

Because they are so easy to add or alter, the LMCC believes that a geo-tagging requirement with no on-site visual verification would actually embolden more fraud. Faked geo-tags would be almost impossible to detect, yet at the same time would create a false sense of greater trustworthiness.

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[3] See, e.g, https://play.google.com/store/apps/details?id=com.cxdeberry.geotag&hl=en; https://itunes.apple.com/us/app/mappr-latergram-location-editor/id602795211?mt=8; https://itunes.apple.com/us/app/mapic-geotag-location-editor/id1006440603?mt=8

VI. VERIFICATION OF THE 35/50% COMPLIANCE PATHWAY REQUIREMENTS SHOULD BE CONDUCTED BY ACCEPTANCE TESTERS

As discussed above, the 35/50% compliance pathway creates an enforcement gap due to the need to verify baseline conditions before the lighting components are altered or modified. Because building departments generally only inspect a lighting project after the alteration or modification has been installed, numerous inspectors testified that it would be impossible for them to verify the baseline conditions. In addition, many inspectors have told us that they do not have the time and resources to verify that the correct product specifications have been used and the power consumption properly calculated.

The solution suggested by numerous inspectors at the February 9, 2016 Workshop was to make use of the Commission's existing certified acceptance tester process. Acceptance test technicians could provide the pre- and post- installation inspection, verify the manufacturer power consumption specifications and verify the power savings calculations.

Since a requirement to use certified acceptance testers has already been adopted to verify the compliance of alterations and modifications with Title 24 lighting control requirements, it makes sense to use that same enforcement scheme to validate compliance with the reduced power pathway requirements. The use of an acceptance test requirement would be consistent with current compliance and enforcement practices and would provide verification in a form already relied upon and accepted by building departments.

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. In many jurisdictions, LMCC contractors have found that building officials only enforce life safety code requirements. Title 24 energy efficiency requirements are often not enforced or are provided only cursory inspection. This contributes to the high rate of non-compliance cited in the CLTC Report. Acceptance testing has addressed this issue by allowing building inspectors to simply confirm that the acceptance test form has been filled out and signed by a certified acceptance test technician.

LMCC contractors depend on these acceptance test requirements to allow them to make competitive bids while complying with the code. Without verification, LMCC

contractors cannot compete against contractors who perform cheap, substandard work. Even though acceptance test technicians may be employed directly by the contractor, they still provide a high degree of reliability. They are trained and certified by Commission-approved third-party certification bodies and are subject to quality assurance audits by the third-party certification bodies, including on-site verification.

The Commission has already determined that there are sufficient numbers of acceptance testers available throughout the State to provide acceptance testing for lighting system work. In adopting the requirement to use certified acceptance test technicians, the Commission set a threshold of 300 certified technicians as the minimum necessary for contractors to be able to comply with this requirement without disruption. Currently, there are over 1000 trained acceptance technicians available throughout California.

VII. LACK OF MEANINGFUL ENFORCEMENT WILL RESULT IN SIGNIFICANT LOST ENERGY 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. The below discussion is excerpted from the attached CLCTC report:

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. In offices and retail establishments, which make up more than 50 percent of all lighting retrofits in the State, 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.

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 building 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 the appendices to the CALCTP report. These products, on average, consume 160 kilowatt-hours ("kWh") per year in electricity, assuming 250 hours per year of use. 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.

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 1: Average performance of LED retrofit lighting products

	Average Performance of Products Surveyed				
LED Project Type	Power (W)	Efficacy (Lu/W)	Lumens (Lu)	Annual Energy Use (kWh)	# of Products Surveyed
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% 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% noncompliance rate previously discussed, this would result in the following annual and lifecycle losses:

- **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 individual cost of lost savings for business owners and tenants is also 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% 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 2 shows estimated costs and lost savings attributed to multiple types of LED lamp retrofits for linear fluorescent technology. Figure 3 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 4.

In all cases, the average LED retrofit fails to achieve the 50% savings necessary to meet code requirements.

Figure 2: Estimated Savings Lost - LED lamp retrofit of standard linear fluorescent system

			LED Lamp Retrofit		
Qty Luminaires	Baseline Annual Operating Cost (T8 LF)	*50% Savings - code compliant 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 3: Estimated Savings Lost - LED Retrofit Kit for a Linear Fluorescent Troffer

			LED Retrofit Kit		
Qty Luminaires	Baseline Annual Operating Cost (T8 LF)	*50% Savings - code compliant retrofit*	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 4: Estimated Savings Lost - LED Luminaire replacement of a linear fluorescent troffer

			LED Luminaire (full replacement)		
Qty Luminaires	Baseline Annual Operating Cost (T8 LF)	*50% Savings - code compliant retrofit*	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

VIII. PROPOSED VERIFICATION PROCEDURES

Based upon the LMCC's consultation with CLTC and the LMCC's numerous conversations with inspectors, contractors, installers and lighting system experts, it is clear that effective enforcement of the 35/50% compliance pathway requires: (1) a visual, on-site pre-installation verification of the model numbers of the original lamps and ballasts; (2) a visual, onsite post-installation verification of the model numbers for the altered or modified lamps and ballasts; (3) verification of the power consumption of the original and altered or modified lighting system by reference to the product specifications for the lamps and ballasts; and (4) verification of the power consumption savings calculations. The vast majority of stakeholders have testified that it is unlikely that building inspectors would be able to perform such verifications and recommended that, instead, these steps should be performed by acceptance test technicians.

Taking into account these recommendations, the LMCC proposed that the following verification process be required by the Commission:

(1) The owner and contractor shall provide the acceptance tester and the authority having jurisdiction the model numbers of the original and

replacement lamps and ballasts, and a copy of the product specifications and power consumption reduction calculations.

(2) A 35/50% compliance pathway Acceptance Test Form shall be completed by a certified acceptance test technician ("ATT") that: (a) affirms the ATT has verified the model numbers of the original lamps and ballasts through an on-site pre-installation visual inspection; (b) affirms the ATT has verified the model numbers of the altered or modified lamps and ballasts through an on-site post-installation visual inspection; (c) verifies the power consumption of the original and altered or modified lighting system by reference to the product specifications for the lamps and ballasts; and (d) verifies the power consumption savings calculations. The Acceptance Test Form shall also be executed, under penalty of perjury, by the contractor and owner. For projects involving 20 or fewer luminaire alterations, the Acceptance Test form may be filled out and executed, under penalty of perjury, solely by the contractor and owner – without use of an acceptance tester.

(3) The authority having jurisdiction shall be provided a copy of the Acceptance Test form and, for projects involving more than 20 luminaire alterations, verify that it has been executed by a certified acceptance tester.

IX. ACCEPTANCE TEST COST

The LMCC asked the California Advanced Lighting Controls Training Program ("CALCTP") to contact current Acceptance Test Technician Employers ("ATTEs") to obtain an estimate for the cost of providing an acceptance test for the 35/50% compliance pathway. The cost estimate covered pre- and post- installation inspection, verification of the manufacturer power consumption specifications, and verification of the power savings calculations.

For projects at the 20 luminaire alterations threshold where the contractor had an in-house acceptance tester on-site, CALCTP found that an acceptance test for the 35/50% compliance pathway would cost around $210, including both pre- and post-inspection on-site visual verifications and confirmation of the power savings.

For projects at the 20 luminaire alterations threshold that required third party acceptance testing, CALCTP found that an acceptance test for the 35/50% compliance pathway would cost around $500, including both pre- and post-inspection on-site visual verifications. Quotes for third-party acceptance testing at this level were between $450 and $525.

For projects at the 70 luminaire modification threshold where the contractor had an in-house acceptance tester on-site, CALCTP found that an acceptance test for the 35/50% compliance pathway would cost around $260. For projects at the 70 luminaire modification threshold that required third party acceptance testing, CALCTP found that an acceptance test would cost between $530 and $600.

For 250 luminaires where the contractor had an in-house acceptance tester on-site, CALCTP found that an acceptance test would cost around $310. For projects at the 250 luminaire modification threshold that required third party acceptance testing, CALCTP found that an acceptance test would cost between $600 and $700.

For 500 luminaires where the contractor had an in-house acceptance tester on-site, CALCTP found that an acceptance test would cost around $520. For projects at the 500 luminaire modification threshold that required third party acceptance testing, CALCTP found that an acceptance test would cost between $800 and $900.

For 1,000 luminaires where the contractor had an in-house acceptance tester on-site, CALCTP found that an acceptance test would cost around $720. For projects at the 1,000 luminaire modification threshold that required third party acceptance testing, CALCTP found that an acceptance test would cost between $1350 and $1500.

These quotes do not include third party acceptance test rates from ATTE electrical contractors that indicated that they preferred to exclusively perform acceptance testing for their own projects. Quotes from those contractors for third party acceptance testing were generally double the price quoted from ATTEs that more regularly provided third party testing – indicating the premium they would require to deviate from their standard practice of only performing in-house acceptance testing.

ATTEs also indicated that the cost of providing an acceptance test for the 35/50% compliance pathway would generally be cheaper or equivalent to the cost of providing acceptance tests for lighting controls. While an acceptance test for the 35/50% compliance pathway would require an added pre-inspection visit, the actual

verification steps would be much simpler and quicker than the verifications required for lighting controls.

X. ACCEPTANCE TESTING HAS ALREADY BEEN DETERMINED TO BE COST-EFFECTIVE WHERE MORE THAN 20 LUMINAIRES HAVE BEEN ALTERED OR MODIFIED

At the February 9, 2016 Staff Workshop on 2016 Non-residential Lighting Alteration Enforcement, staff claimed that the Commission had not taken into account the cost of acceptance testing when determining the cost-effectiveness of the requirements for non-residential lighting alterations and modifications. This is not correct. Acceptance testing was expressly considered and determined cost-effective for all alterations involving more than 20 controlled-luminaires. Modifications of less than 70 luminaires are not subject to any energy efficiency requirements, so the effective threshold for modifications is 70 luminaires. The same thresholds should apply for acceptance testing of the 35/50% compliance pathway.

The Commission expects the 35/50% compliance pathway to save approximately the same amount of energy savings as installing advanced controls. At the same time, the 35/50% compliance pathway eliminates the cost of acceptance testing for multi-level, daylighting and demand response controls since those controls are not required under that pathway. Since both pathways are estimated by the Commission to provide approximately the same level of energy savings, the cost-effectiveness determination already adopted for these requirements would apply to acceptance testing for the power reduction pathway as long as it didn't cost more than the cost for acceptance testing multi-level, daylighting and demand response controls. Even if acceptance testing to verify that a project actually reduces power consumption by 35% or 50% did cost slightly more than acceptance testing of multi-level, daylighting and demand response controls, it would still be cost-effective because such costs also would be additionally offset by the avoidance of the cost of installing those controls.

Accordingly, the cost of requiring acceptance testing of the 35/50% compliance pathway clearly falls within the costs taken into account when determining the overall cost-effectiveness of the requirements for non-residential lighting alterations and modifications.

XI. ACCEPTANCE TESTING IS COST-EFFECTIVE WHEN COMPARED TO OVERALL PROJECT COSTS OR TO THE COST OF LOST ENERGY SAVINGS FROM NON-COMPLIANCE PROJECTS

As with acceptance testing for the controls required under the full LPD compliance pathway, acceptance testing of the 35/50% compliance pathway is cost effective when compared to the overall cost of the project or to the cost of lost energy savings from non-compliant projects.

As shown by the attached CLTC Report, acceptance testing of the power reduction pathway would result in just a nominal increase of project costs for any projects. For 20 luminaire alterations (the acceptance test threshold for alterations), the average cost of acceptance testing the 35/50% compliance pathway would be 5% of the total project cost. For 70 luminaire modifications (the threshold for modifications to be subject to acceptance test and other code requirements), the average cost of acceptance testing the 35/50% compliance pathway would be 3.6% of the total project cost.

These percentages go down rapidly as luminaires are added. For 100 luminaire alterations, the average cost of acceptance testing the 35/50% compliance pathway would be 1.5% of the total project cost. For 500 luminaire alterations, the average cost of acceptance testing would be approximately 0.5% of the total project cost. For 1,000 luminaire alterations, the average cost of acceptance testing the 35/50% compliance pathway would be approximately 0.4% of the total project cost.

The CLTC report also shows that the value of lost energy savings from projects that fail to fully meet the power reduction pathway requirements greatly exceeds the cost of acceptance testing of the power reduction pathway. The life cycle value of lost energy savings from non-compliant projects that incorrectly claim to meet the 35/50% power reduction requirement are estimated by CALCTP to average around $123 per luminaire replacement and between $91 and $110 per luminaire modification. At the 20 luminaire alteration threshold, that results in lost energy savings in the amount of $2460. At the 70 luminaire modification threshold, that results in lost energy savings for modifications between $6370 and $7700 ($8610 for alterations). At 500 luminaires, the lost energy savings for alterations and modifications range between $45,500 and $61,500. These lost savings greatly exceed the expected cost for acceptance test verification.

XII. COST-EFFECTIVENESS IS NOT A VALID REASON TO AVOID IMPOSITION OF MEANINGFUL BASELINE VERIFICATION BECAUSE OTHER COST-EFFECTIVE COMPLIANCE PATHS EXIST

The proponents of the 35/50% compliance pathway represented to staff that this new exemption path was more cost-efficient and thus would result in more lighting alterations. They claimed that it was more burdensome to calculate a lighting alteration or modification project's lighting power density than to determine if the power consumption of altered or modified luminaires is 35/50% greater than a project's baseline consumption. Many stakeholders disputed that claim.

From the beginning, the LMCC has cautioned that the real appeal of the new 35/50% compliance option was the less restrictive (and in our view less effective) standards that this path offered – including eliminating bi-level control requirements, eliminating hallway and stairway control requirements and proposing power reduction percentages that were initially much lower than the final 35/50% requirements even though those proposed reduction percentages would have resulted in much higher lighting power densities than allowed under the 2013 Code.

Tellingly, the proponents of the 35/50% compliance pathway are now arguing against the imposition of meaningful requirements for the verification the 35/50% power reduction threshold on the grounds that this new control exemption path will not be cost-effective if the Commission requires pre-installation verification of the existing baseline. It seems that the proponents' original claim that this alternative pathway would be more cost-effective was based on the assumption that there would be no verification of these power reductions.

The fact that enforcement of the 35/50% compliance pathway will result in additional costs is not a new issue. The Commission was told again and again that adopting an existing-condition-based exemption requires enforcement in a fundamentally different manner than under the current code enforcement system. If the Commission is now claiming that it can't impose effective enforcement because it did not take into account the additional cost of enforcement when they adopted this standard, then the commitment it made at the approval hearing to address enforcement concerns was a sham. (Moreover, as discussed supra, the cost of acceptance testing enforcement was, in fact, taken into account as part of the adoption of the non-residential lighting alteration and modification requirements – a cost that acceptance testing of the 35/50% compliance path would not exceed).

The Commission should adopt meaningful and reliable verification requirements and let the market determine cost-effectiveness. If enforcement of a particular 35% to 50% power reduction lighting project is not cost-effective – the code provides other cost-effective paths to compliance. A project can always use the 85% LPD exemption instead or add controls – both of which have been demonstrated to be cost-effective pathways that do not require the additional cost of pre-installation baseline verification. Accordingly, even if meaningful baseline verification requirements were not cost-effective at some levels, requiring such verification would not violate the Commission's mandate to ensure standards are cost-effective since other alternative cost-effective compliance options would be available in those cases.

XIII. THE COMMISSION HAS AMPLE TIME TO ADOPT A NEW ACCEPTANCE TEST REQUIREMENT FOR THE 2016 CODE

California Building Standards Law requires building standards to be published 180 days before they become effective.[4] The 2016 Title 24 California Building Standards Code is scheduled for publication in July 2016 – with an effective date of January 2016.

However, addendum related to enforcement may be adopted after the July 2016 date and still be effective by January 2016. Building standards enforcement requirements are not subject to the requirement that building standards be published for 180 days prior to their effective date. Regulations that implement or enforce building standards become effective 30 days after filing by the California Building Standards Commission with the Secretary of State.[5]

Accordingly, the California Energy Commission has until at least November to adopt enforcement regulations for the 35/50% compliance pathway in order for the enforcement regulations to be part of the 2016 code update.

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

XIV. COMPLIANCE MANUAL MISLEADINGLY AND INCORRECTLY SUGGESTS THAT REPLACING HID LUMINAIRES WITH LED LUMINAIRES WILL AUTOMATICALLY REDUCE POWER CONSUMPTION BY 50 PERCENT

The proposed 2016 Non-residential Compliance Manual Chapter 5, Non-residential Indoor Lighting, Subchapter 9, Additions and Alterations misleadingly and incorrectly states that the 50% power reduction path for a retail occupancy can be met by replacing HID fixtures with LED fixtures "because each new fixture is known to use less than half the power of each fixture." This statement is incorrect. Simply replacing HID fixtures with LED fixtures will almost never result in a 50% power reduction in retail occupancies.

The power reduction from replacing HID fixtures with LED fixtures depends on the HID fixtures that are replaced and the LED lamps and drivers that are being installed in their place. As shown by Exhibit A to this comment letter, 42 of the 64 HID to LED replacement scenarios would result in energy savings less than 50% - with savings varying from a high of 80% to a low of -28%.[6] However, all of the scenarios providing savings greater than 50% rely on scotopic conditions, rather than photopic conditions. Scotopic scenarios are not applicable to retail conditions.

Manufacturers try to manipulate the light output provided by LEDs by saying things like "perceived lumens" or "equivalent lumens" under scotopic conditions. Scotopic scenarios refer to the perceived visual brightness under **very low light conditions** such as outdoors with no other surrounding lighting from cities, etc. This is never going to be found in a retail environment. Photopic refers to the visual brightness and color perception under normal light conditions. Because retail environments are trying to sell products that are on display, they need to avoid sub-par photopic lighting situations. The photopic HID to LED energy savings chart is thus the applicable chart for determining energy savings in retail occupancies – as well as most other indoor occupancies.

The photopic HID to LED energy savings chart shows that one-to-one HID to LED conversions will never result in 50% power reduction – *and in a number of scenarios will actually increase power consumption*. A simple way to understand this is

[6] Exhibit A; also available at http://www.howard-lighting.com/Documents/ProductLiterature/HIDToLEDCrossReference.pdf.

to look at system efficacy. Assuming light levels provided by the HID system and the LED system should be kept constant, the LED system would have to have 50% or more increase in system efficacy to save 50% or more energy. HID system efficacy is 60-100 lumens per watt. LED is 70 to 125 lumens per watt which is no way near an automatic 50% savings. Generally, LED retrofits will only result in 50% or more savings when you deliver less light with the LED than what was there before.

The assumption that LED replacement of HID fixtures will automatically result in 50% savings raises exactly the type of enforcement issue that stakeholders have warned about since this compliance path was first proposed. *Yet this is the example being provided by the Commission in its compliance manual!*

Without any method to verify what types of lamps and ballasts have been replaced, contractors will be emboldened to assert to inspectors that they have achieved the required power reductions simply because they replaced HID or T12 fixtures with LED fixtures. Furthermore, in many cases the fixtures that were replaced are likely to actually have been higher efficiency T-8 fixtures that contractors will claim on their compliance forms to have been HID or T12 fixtures in order to avoid advanced control requirements.

The lack of any sort of verification mechanism creates a strong incentive for fraud because the only evidence remaining after installation will be the contractor's own self-certification. Once the original fixtures are removed, there will be no way to catch contractors who are gaming the system. This will harm honest contractors who will be unable to compete if their bids include complying with control requirements.

XV. TABLE 5-4 IN THE 2016 NON-RESIDENTIAL COMPLIANCE MANUAL IS INACCURATE

The proposed 2016 Non-residential Compliance Manual Chapter 5, Non-residential Indoor Lighting, Subchapter 9, Additions and Alterations fails to accurately set forth the requirements and differences between the various compliance pathways for luminaire alterations and modifications. Table 5-4 represents that the area control and shut-off control requirements are the same regardless of which compliance option is selected. This is incorrect. The 35/50% compliance pathway provides substantial exemptions from the area controls and shut-off controls required under the other two pathways.

The 2016 Code requires lighting system alterations (and modifications) 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). The 35/50% compliance pathway, however, exempts alterations (and modifications) 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.

In addition, the 2016 Code requires lighting system alterations (and modifications) 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 35/50% compliance pathway, however, exempts alterations (and modifications) 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].

The LMCC strongly opposed providing the 35/50% compliance pathway these additional exemptions on the grounds that they lacked any justification and would result in substantial lost energy savings compared to the 2013 Code requirements. The LMCC continues to urge the Commission to take action to eliminate these exemptions. Until such action is taken, however, the Compliance Manuals description of the 2016 Code requirements is inaccurate.

We also note that the 2016 Nonresidential Compliance Manual fails to set forth the compliance requirements for luminaire component modifications or lighting wiring alterations. The Manual defines luminaire component modifications and lighting wiring alterations, but fails to set forth compliance requirements or options for these activities.

XVI. CONCLUSION

Effective and reliable verification is critical to meeting the State's energy efficiency and greenhouse gas reduction goals. Effective and reliable verification is also critical the LMCC's contractors and electricians. Without such verification, they will continue to lose jobs to contractors who offer customers lower prices as the result of cutting corners on code-compliance. Unfortunately, the Lighting Alteration Compliance Documents fail to address this issue at all when it comes to its new, controversial 35/50% compliance pathway. To the contrary, the Lighting Alteration Compliance Documents provides enforcement examples that both highlight and exacerbate stakeholders concerns over enforcement of the 35/50% compliance pathway. The Lighting Alteration Compliance Documents make the very same false assumptions regarding savings that will result from simply changing luminaires to LED lights that stakeholders have repeatedly warned will occur under this compliance path.

This false assumption, along with the resistance of proponents to any meaningful verification requirements, further demonstrates that this pathway has, all along, been based on a fiction that savings equivalent to installing controls can be easily achieved by installing LED lights. This fiction is why proponents have pushed for adoption of this unverifiable pathway even though similar control exemptions exist if they can demonstrate that their lighting will only consume 85% of the LPD allowance. If installers were able to meet the 85% LPD requirement, they wouldn't need the 35/50% compliance pathway. The difference is that the 85% LPD pathway is verifiable while the 35/50% compliance pathway is not.

The LMCC strongly opposes the proposed compliance procedures set forth in the Lighting Alteration Compliance Documents and urges the Commission to keep its commitment to address stakeholder's concerns over enforcement.

Sincerely,

Thomas A. Enslow

TAE:ljl
Exhibits

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

EXHIBIT A

HID to LED Wattage Cross Reference

HID to LED Wattage Cross-Reference

SCHOTOPIC/PHOTOPIC MULTIPLIER METHOD*

HID Fixture Info				LED drive current = 350mA @25°C			LED drive current = 500mA @25°C		
HID Lamp	Lamp Mean Lumens	Visually Effective Lumens Exiting Fixture (Mean)**	System Input Watts	LED Equivalent Input Wattage	Visually Effective Lumens Exiting Fixture**	Energy Savings	LED Equivalent Input Wattage	Visually Effective Lumens Exiting Fixture**	Energy Savings
70W PSMH	4,400	4,589	85	36	4,538	58%	40	4,554	53%
100W PSMH	5,800	6,049	129	48	6,050	63%	53	6,034	59%
150W PSMH	10,000	10,430	186	83	10,462	55%	92	10,474	51%
175W MH	10,800	11,264	210	89	11,218	58%	99	11,271	53%
200W PSMH	16,800	17,522	234	139	17,520	41%	154	17,533	34%
250W MH	17,000	17,731	292	141	17,772	52%	156	17,760	47%
250W PSMH	19,000	19,817	288	157	19,789	45%	174	19,810	40%
320W PSMH	21,000	21,903	364	174	21,932	52%	192	21,859	47%
350W PSMH	27,000	28,161	400	223	28,108	44%	247	28,120	38%
400W MH	23,500	24,511	460	194	24,453	58%	215	24,477	53%
400W PSMH	31,000	32,333	456	257	32,394	44%	284	32,333	38%
70W HPS	5,350	2,322	91	18	2,269	80%	20	2,277	78%
100W HPS	8,550	3,711	129	29	3,655	78%	33	3,757	74%
150W HPS	14,400	6,250	185	50	6,302	73%	55	6,262	70%
250W HPS	27,000	11,718	295	93	11,722	68%	103	11,726	65%
400W HPS	45,000	19,530	464	155	19,537	67%	172	19,582	63%

PHOTOPIC METHOD

HID Fixture Info				LED drive current = 350mA @25°C			LED drive current = 500mA @25°C		
HID Lamp	Lamp Mean Lumens	Lumens Exiting Fixture (mean)**	System Watts	LED Equivalent Input Wattage	Lumens Exiting Fixture	Energy Savings	LED Equivalent Input Wattage	Lumens Exiting Fixture	Energy Savings
70W PSMH	4,400	3,080	85	52	3,063	39%	58	3,248	32%
100W PSMH	5,800	4,060	129	69	4,064	47%	76	4,256	41%
150W PSMH	10,000	7,000	186	119	7,009	36%	132	7,392	29%
175W MH	10,800	7,560	210	128	7,539	39%	142	7,952	32%
200W PSMH	16,800	11,760	234	200	11,780	15%	221	12,376	6%
250W MH	17,000	11,900	292	202	11,898	31%	224	12,544	23%
250W PSMH	19,000	13,300	288	226	13,311	22%	250	14,000	13%
320W PSMH	21,000	14,700	364	250	14,725	31%	276	15,456	24%
350W PSMH	27,000	18,900	400	321	18,907	20%	355	19,880	11%
400W MH	23,500	16,450	460	279	16,433	39%	309	17,304	33%
400W PSMH	31,000	21,700	456	368	21,675	19%	408	22,848	11%
70W HPS	5,350	3,745	91	64	3,770	30%	70	3,920	23%
100W HPS	8,550	5,985	129	102	6,008	21%	113	6,328	12%
150W HPS	14,400	10,080	185	171	10,072	8%	189	10,584	-2%
250W HPS	27,000	18,900	295	321	18,907	-9%	355	19,880	-20%
400W HPS	45,000	31,500	464	535	31,512	-15%	592	33,152	-28%

*Scotopic refers to visual perception in low light , photopic refers to color perception in normal light . The ratio of Scotopic light vs. Photopic light is called the S/P ratio. This ratio determines the apparent visual brightness of a light source. Higher S/P ratios appear brighter to the human eye. See:
"Energy Efficiency Consequences of Scotopic Sensitivity", Dr. Sam Berman, Journal of the IES, Vol 21 No.1, Dec. 1992
"The Coming Revolution in Lighting Practice", Dr. Sam Berman, http://www.lightenergysource.com/ScotopicTechnical.htm
**Scotopic/Photopic ratios used: MH/PSMH = 1.49, HPS = 0.62, LED (6500K) = 2.14. HID fixtures assumed to be 70% optically efficient., actual efficiency will vary. Mean lumens of 95% used for LED.




EXHIBIT B

CALIFORNIA LIGHTING TECHNOLOGY CENTER

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 cases[1], 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

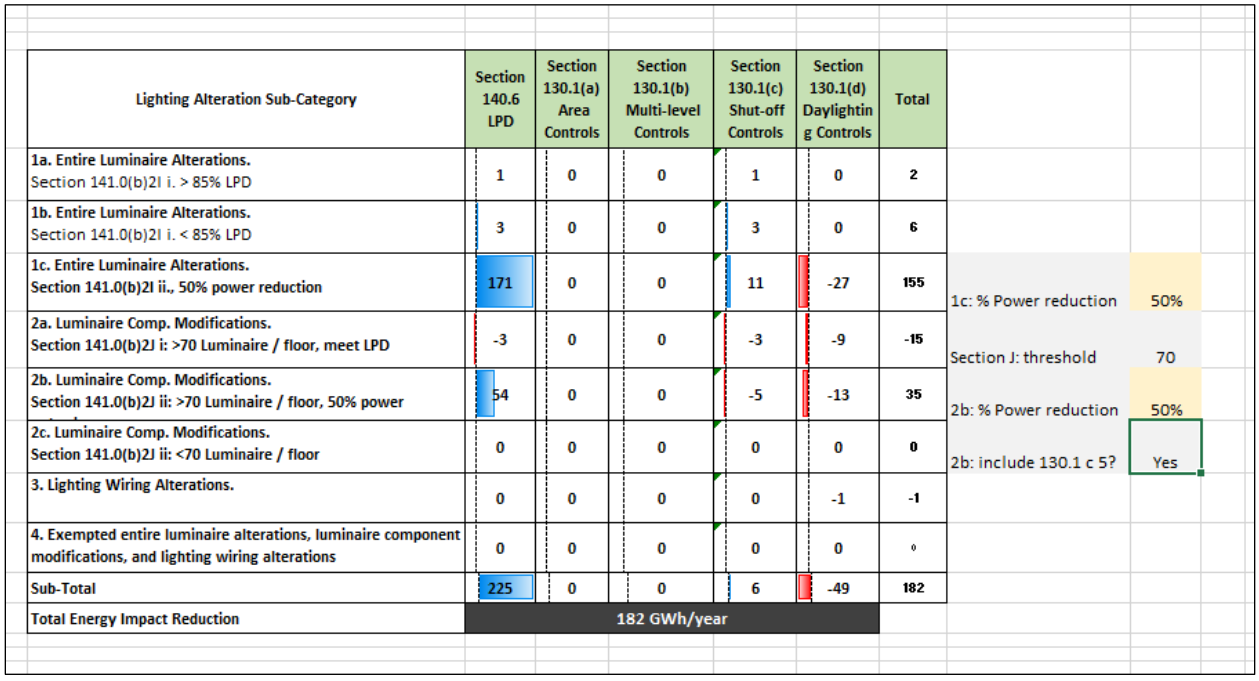
[1] Estimate based on compliance rates for cool roof replacements, duct sealing for replacement ducts and installation of lighting controls under skylights.

    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 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
2a. Luminaire Comp. Modifications. Section 141.0(b)2J i: >70 Luminaire / floor, meet LPD	-3	0	0	-3	-9	-15
2b. Luminaire Comp. Modifications. Section 141.0(b)2J ii: >70 Luminaire / floor, 50% power	54	0	0	-5	-13	35
2c. Luminaire Comp. Modifications. Section 141.0(b)2J ii: <70 Luminaire / floor	0	0	0	0	0	0
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					

1c: % Power reduction	50%
Section J: threshold	70
2b: % Power reduction	50%
2b: include 130.1 c 5?	Yes

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

	Average Performance of Products Surveyed				
LED Project Type	**Power (W)**	**Efficacy (Lu/W)**	**Lumens (Lu)**	**Annual Energy Use (kWh)**	**# of Products Surveyed**
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

			LED Lamp Retrofit		
Qty Luminaires	Baseline Annual Operating Cost (T8 LF)	*50% Savings - code compliant 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

			LED Retrofit Kit		
Qty Luminaires	Baseline Annual Operating Cost (T8 LF)	*50% Savings - code compliant retrofit*	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

			LED Luminaire (full replacement)		
Qty Luminaires	Baseline Annual Operating Cost (T8 LF)	*50% Savings - code compliant retrofit*	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 alteration[2]. 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: 95618 | Fixtures: 1 | 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	1 fixture	$50.02	$119.19
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.	2 hrs	$178.13	$218.63
Lighting Fixture Materials and Supplies Cost of related materials and supplies typically required to install lighting fixture including: connectors, fittings and mounting hardware.	1 fixture	$20.00	$25.00
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: 95618 | Fixtures: 10 | 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	10 fixtures	$500.24	$1,191.86
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.	16.4 hrs	$1,398.74	$1,797.67
Lighting Fixture Materials and Supplies Cost of related materials and supplies typically required to install lighting fixture including: connectors, fittings and mounting hardware.	10 fixtures	$77.70	$89.33
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: 95618 | Fixtures: 21 | 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	21 fixtures	$1,050.51	$2,502.91
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.	34 hrs	$2,898.16	$3,727.61
Lighting Fixture Materials and Supplies Cost of related materials and supplies typically required to install lighting fixture including: connectors, fittings and mounting hardware.	21 fixtures	$163.17	$187.60
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: 95618 | Fixtures: 70 | 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	70 fixtures	$3,501.69	$8,343.04
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.	112.4 hrs	$9,577.40	$12,324.59
Lighting Fixture Materials and Supplies Cost of related materials and supplies typically required to install lighting fixture including: connectors, fittings and mounting hardware.	70 fixtures	$543.89	$625.33
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

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