CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Indoor Lighting - Retail

2013 California Building Energy Efficiency Standards

California Utilities Statewide Codes and Standards Team October 2011

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

Table of Contents

Table of Figures

1. Purpose

Proposed changes to Title 24 for improvements to the lighting component of building efficiency standards as applied to nonresidential buildings, and retail spaces in particular, using the Tailored Method of compliance are:

1. Reduce the allowed LPD for Floor Display, Wall Display and Ornamental Lighting under the Tailored Compliance (Table 146G T24-2008) based on increased use of Ceramic Metal Halide (CMH) as the primary display lighting source and judicious use of other efficient light sources such as the latest infrared coated halogen lamps and LED based lamps. Lower cost display lighting systems based on advanced halogen IR lighting can comply with this proposed measure provided they target the lower end of the illumination levels recommended in IESNA RP-2. However, stores desiring high light levels and/or accent lighting in high ceilings will need to use high efficacy display lighting sources such as Ceramic Metal Halide.
2. Significantly reduce the space types (Table 146G T24-2008) allowed under the Tailored Method of compliance. Spaces eligible for Tailored compliance would be Retail (Malls, Retail Sales, Grocery, Bank Public Areas, etc.) Hospitality (Hotel, Restaurant, Auditoriums, Lounge etc.) Religious Worship, Galleries/Museums and Public Venues (Convention Center, Auditoriums, Civic Meeting, etc.). All other space type will move to Area Compliance (Table 146F T24-2008) except types with illuminance category IESNA Handbook. IESNA HB types will form a new table within Tailored Compliance.
3. Re-alignment of mounting height adjustment factor (TABLE 146-H T24-2008) to adjust for the proposed use of primarily CMH lamps versus halogen for high ceiling application.
4. Reduce allowed LPD for very valuable display power to account for greater use of CMH lamps for high ceiling heights and LED based lamps for lower ceilings while still allowing some use of halogen for lower ceiling heights.
5. Mandate use of comprehensive lighting controls as a prerequisite to using the Tailored Lighting method of Title 24 compliance under the 2013 standards. Multi-tier lighting zones, multi-level switching, demand responsive load shedding, and vacancy sensors are some of the control types that are applicable. Use of a comprehensive controls will assure that the added power (LPDs) allowed under the Tailored Method will be used only when required for the specific lighting application and will be appropriately monitored. The control mandate must include commissioning and verification.
6. Recommend that additional potential reductions in the LPD's be targeted based on revisions and updates to the IES Lighting Handbook 10th Edition.

2. Overview

a. Measure Title	NR-3 INDOOR LIGHTING TAILORED COMPLIANCE - Proposed Tailored Method Revisions with Retail Lighting Focus
b. Description	Proposed changes to Title 24 for improvements to the lighting component of building efficiency standards as applied to nonresidential buildings, and retail spaces in particular, using the Tailored Method of compliance are: Reduce the allowed LPD for Floor Display, Wall Display and Ornamental Lighting under the Tailored Compliance (Table 146G T24-2008) based on increased use of Ceramic Metal Halide (CMH) as the primary display lighting source and judicious use of other efficient light sources such as the latest infrared coated halogen lamps and LED based lamps. Lower cost display lighting systems based on advanced halogen IR lighting can comply with this proposed measure provided they target the lower end of the illumination levels recommended in IESNA RP-2-2011. However, stores desiring high light levels and/or accent lighting in high ceilings will need to use high efficacy display lighting sources such as Ceramic Metal Halide. Significantly reduce the space types (Table 146G T24-2008) allowed under the Tailored Method of compliance. Spaces eligible for Tailored compliance would be Retail (Malls, Retail Sales, Grocery, Bank Public Areas, etc.) Hospitality (Hotel, Restaurant, Auditoriums, Lounge etc.) Religious Worship, Galleries/Museums and Public Venues (Convention Center, Auditoriums, Civic Meeting, etc.). All other space type will move to Area Compliance (Table 146F T24-2008) except types with illuminance category IESNA Handbook. IESNA HB types will form a new table within Tailored Compliance. Re-alignment of mounting height adjustment factor (TABLE 146-H T24-2008) to adjust for the proposed use of primarily CMH lamps versus halogen for high ceiling application. Reduce allowed LPD for very valuable display power to account for greater use of CMH lamps for high ceiling heights and LED based lamps for lower ceilings while still allowing some use of halogen for lower ceiling heights. Mandate use of comprehensive lighting controls as a prerequisite to using the Tailored Lighting method of Title 24 compliance under the 2013 standards. Multi-tier lighting zones, multi-level switching, demand responsive load shedding, and vacancy sensors are some of the control types that are applicable. Use of a comprehensive controls will assure that the added power (LPDs) allowed under the Tailored Method will be used only when required for the specific lighting application and will be appropriately monitored. The control mandate must include commissioning and verification. Recommend that additional potential reductions in the LPD's be targeted based on revisions and updates to the IES Lighting Handbook 10th Edition

c. Type of Change	**Mandatory Measure -** The controls requirements that would be required if one chooses to use the tailored method for compliance would be mandatory. Mandatory measures must be satisfied with either the prescriptive or performance compliance methods. **Prescriptive Requirement -** The change would add or modify prescriptive requirements in Section 146. Prescriptive requirements must be met for prescriptive compliance and define the Standards baseline building in performance calculations, but are not mandatory when the performance approach is used. **Compliance Option -** Some of the controls requirements would be optional and would add a new means to comply with the standards by adding a new compliance option. This would likely be a simple Power Adjustment Factor applied of the controlled lighting or a different allowance for lighting that is dimmed. **Modeling** - The ACM would only be changed to reflect the changes in the LPD and controls requirements. This proposal does not change the algorithms of how lighting and controls are modeled. The change would modify the calculation procedures or assumptions used in making performance calculations. This change would not add a compliance option or a new requirement, but would affect the way that tradeoffs are made. **Other -** The scope of the standards is not changed by this proposal. The standards have traditionally had the ability to limit the connected lighting power in spaces and to require or give credit for lighting controls. This proposal would result in modifications to the Standards, ACM, manuals, and the compliance forms.

d. Energy Benefits

Lighting Power Density (LPD) will be calculated for various models under the current standard versus the proposed changed standard. Lighting will be compliant with appropriate IESNA standards while saving energy. We are proposing that the wall display be reduced by 2 Watts per linear foot and the floor display be reduced by 0.2 W/sf. In addition we are recommending that advanced lighting controls be installed as a condition of using the tailored lighting method. These controls will reduce full load operating hours by approximately 20% as well as minimize excessive power consumption after store hours and otherwise unoccupied environments.

Energy savings are calculated in units of kWh/yr savings per square foot of floor area by store type in the table below.

Figure 1 Weighted energy savings calculated by space type

Weighting factors	Space Type	Connected Load (W/sf)	Energy (kWh/yr-sf)	TDV kBtu/yr-sf	Dollars/yr-sf
10%	High End Retail	2.65	11.91	238.71	$1.69
50%	Medium Priced Retail	0.57	2.58	51.74	$0.37
40%	Strip Mall Small Business	0.39	1.76	35.24	$0.25
100%	**Area weighted total**	**0.71**	**3.2**	**63.8**	**$0.45**

The savings from these measures results in the following statewide first year savings:

	Total Electric Energy Savings (GWh)	Total Gas Energy Savings (MMtherms)	Total TDV Savings (kBTU)
Tailored Method	40.3	N/A	1,027,000,000
Area Category Method	37.0	N/A	10,272,000,00

e. Non-Energy Benefits

Potential non-energy benefits include:

Reduction in air emissions that results from any energy savings measure and the increase in electric system reliability that accompanies the reduction in peak electrical demand.

Increased reliance on higher efficacy sources such as fluorescent and ceramic metal halide (CMH) which have longer lamp life and as a result lower maintenance costs.

Improved lighting performance including better lumen maintenance (10-15% improvement) and color stability. (All environments)

The evaluation of non-energy benefits is based on recent and current IESNA research studies as well as other l industry publicly available testing and research.

f. Environmental Impact

The proposed changes/measures will not result in any adverse environmental impact. On the contrary several of the changes/measures will actually impact environmental issues in a positive vein. Such as use of the latest lamp/ballast technologies (required to meet the standards) will most likely result in less mercury and other hazardous materials.

Material Increase (I), Decrease (D), or No Change (NC): (All units are lbs/year)

	Mercury	Lead	Copper	Steel	Plastic	Wood
Per Square Foot	(D) - 0.00012879	(D) -2.9178E-05	(D) - 0.00134	(D) - 0.03607	NC	NC
Statewide	(D) -7904	(D) -2832	(D) - 127921	(D) - 3302614	NC	NC

Water Consumption:

	On-Site (Not at the Powerplant) Water Savings (or Increase) (Gallons/Year)
Per Prototype Home	NA

Water Quality Impacts:

	Mineralization (calcium, boron, and salts	Algae or Bacterial Buildup	Corrosives as a Result of PH Change	Others
Impact (I, D, or NC)	NA	NA	NA	NA

g. Technology Measures	**Measure Availability:** The following technologies enable the increased stringency of the proposed lighting energy standards change: For aggressive energy reduction in directional lighting applications, promote use of CMH lamps as energy efficient alternative to IR halogen. Maturity of Ceramic Metal Halide (quality, performance and cost effectiveness) warrant use of CMH over Halogen where/when dimming of the directional lighting is not required. For dimming applications improved IR designs with 14% to 20% efficiency over previous IR lamps as well as LED based luminaire systems and lamps are available. Latest generation T8 and T5 fluorescent systems allow reduced general and ambient lighting connected load. The wide range of ballast factors and lamp lumen output options, with improved efficacy, results in lower LPD's while maintaining required illumination levels. Furthermore, encourage development of tunable and dimming ballast and lamp options for both T8 and T5 lighting systems. Encourage use of LED lights versus fluorescent and neon for some signage, markers, visual effects, casework, under shelf and other specialty lighting applications. Also encourage LED lamps versus halogen for specially and accent lighting in lower ceilings and casework lighting. Improved lighting design tools as well as revised IESNA design criteria allow designers to more accurately model their spaces and fine tune their lighting designs to the need of the retailer to present their product within the lighting budget constraints of Title 24. **Useful Life, Persistence, and Maintenance:** Life, frequency of replacement, and maintenance procedures related to the measure will be based on data gathered from the limited base of current users (where/ when available). Manufacturers' technical data and recommendations will also be used when/as available. Persistence energy savings related to the measure will be based on life of the equipment. Persistence is related to performance verification. Proper maintenance or lack of will have limited effect on persistence but may drastically affect the non-energy related issues such as lighting quality. Projected life and required maintenance is based upon manufacturer's information and feedback from clients who are using various lighting products. Persistence of savings from CMH, LED System and Fluorescent products is higher than for their halogen counterparts in that CMH and fluorescent ballasts and LED drivers typically serve only one wattage type per lamp. Thus it is harder to increase lamp wattage without replacing the whole fixture.

	Persistence is related to performance verification in that the installer must verify that the system is in compliance and working. A licensed electrical contractor or the electrical engineer of record can accomplish the required verification. Cost impact will be minimal as such functions are often, if not always in the contractor's and/or consultant's contract agreement as part of implementation.

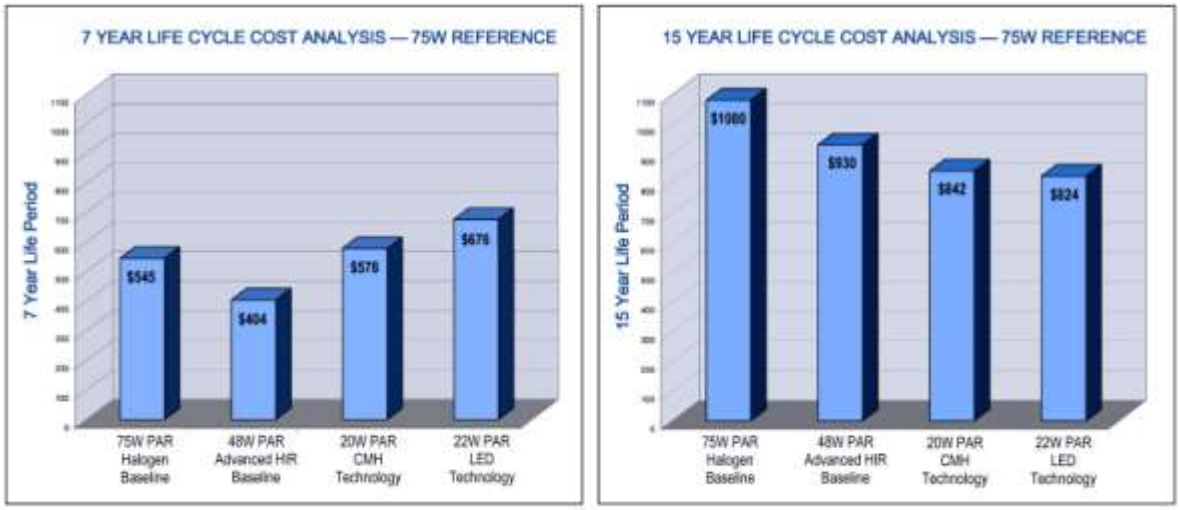
i. Cost Effectiveness

The proposed changes for T24-2013, "Tailored" method includes 15% to 25% lower LPD allowances for retail spaces versus allowances under the T24-2008 tailored compliance. Reductions of 5% to 15% in allowed maximum LPDs can also occur for other "Tailored" method" spaces and several categories under the "Area Category" compliance method. Increased implementation cost (design, equipment, etc.) is anticipated for those projects which set lighting standards to IESNA recommended practice. However, reduced cost of operation (lower maintenance and utility costs) will more than off set increased first cost when analyzed on a "life cycle" basis.

Cost analysis modeling on the latest available Ceramic Metal Halide and Light Emitting Diode technologies for feature lighting (accent, display, wall-wash, etc.) was one of the key drivers to proposed LPD reductions. Cost analysis demonstrated that cost effectiveness for many of the options studied is feasible within a seven year period. The seven year cost effectiveness is well under luminaire life expectancy and conforms to the typical retail space where these systems are used. Furthermore; the seven year period is far more conservative than the 15 year cost effective period considered acceptable by the CEC for non residential non-envelope compliance measures.

Other sources (most recent fluorescent and halogen IR technologies) driving LPD reductions are anticipated to have significantly shorter payback periods than the CMH and LED as demonstrated by the cost analysis conducted on the AGI-32 model spaces and other model comparisons. The expanded use of controls, as mandated under this proposal, is also cost effective and further reduces energy consumption.

The following table indicate cost effectiveness for equivalent performance, including light output, of a 20W CMH, 23W LED and 48W Halogen IR (advanced) versus a 75W Halogen baseline accent light.



Additional lamp cost effectiveness analysis as well as cost effectiveness of design models used in developing this case proposal are found Section 4 Analysis and Results Sub Section on Life Cycle Costing Results

j. Analysis Tools	The tools used to perform the analysis for this CASE report fall under three categories: Spreadsheets (MS Excel) to approximate what lighting power densities are used under different retail space types and categories. This will build on the spreadsheets used in the developing the 2008 standards. AGi32 lighting software to evaluate the lighting conditions of various lighting designs, especially in terms of how changes to lighting technology or design affect compliance. New proposed design guidelines for modeling are based on the soon to be released RP-2 2011 edition of retail lighting recommendations and the IESNA Lighting Handbook 10th Addition. Spreadsheet to keep track of results from AGi32 runs the PV energy costs of operating the system, the life cycle maintenance costs and the incremental first cost. These figures are used to calculate the benefit/cost ratio of the system. MS Access database and Excel spread sheet software for processing designer surveys and store on site evaluation surveys.
k. Relationship to Other Measures	None

3. Methodology

This section describes the methodology that we followed to assess the savings, costs, and cost effectiveness of the proposed code change. The CASE Team chose the eight major study areas based on consideration of factors that affect the lighting of complex retail space and on maintaining the relative light levels (footcandles) of the space over time.

The eight study areas are:

- Interviews with Designers, Contractors, Manufacturers, and End Users
- Life Cycle Cost Analysis of Big Box and General lighting technologies as well as CMH and LED Lamps versus Incandescent (Halogen Baseline) lamps for accent and display lighting and decorative lighting.
- Visual Observation, Survey and Analysis of Recently Permitted Retails Stores
- Computer modeling of seven (7) uniquely different retail stores types
- New Technology and Design Comparison Computer Models
- Comparative Studies of Title 24-2008, ASHRAE 90.1 2010 and 2010 Washington Energy Codes
- Controls Evaluation
- Ornamental Lighting Comparisons and Evaluation Model

This work was publicly vetted through our stakeholder outreach process, which through in-person meetings, webinars, email correspondence and phone calls, requested and received feedback on the direction of the proposed changes. The stakeholder meeting process is described in section 3.10.

3.1 Surveys with Designers, Manufacturers, and End-users

The CASE Team conducted a survey of designers, end users, and manufacturers with the goal of understanding the level of acceptance of current technology affecting lighting design, controls, luminaire and lamps in retail settings. The sample was not intended to be a formal population-based sample with weights developed for each respondent. Instead, we used our experience with the local and national lighting market to contact the key players who have the most comprehensive understanding of the market, available equipment, and the requirements of various codes. Data collection consisted of telephone interviews and an online survey. The survey questionnaire contained 18 questions with a section to record the interviewee type, interview date, interviewer, etc. The full text of the questionnaire is included in Appendix I--Designer, End-User and Manufacturer Interview.

Interviewees were asked questions in a numbered scale format, so the results could be more easily quantified.

The interview covered the following issues:

- Interviewees' experience with Title 24 in terms of finding it clear or contradictory / confusing.
- A rank of 14 measures as most desirable to achieve LPD reductions
- The prevalence and limits of new lighting technologies such as CMH and LED.
- Usefulness of the tailored method
- Use of track limiters

3.2 *Life Cycle Cost Analysis of Big Box and General lighting technologies as well as CMH and LED Accent Lighting and Decorative Lighting*

Life Cycle Costing on both a 7 year cycle and 15 year cycle was conducted on the lighting pallet used to develop the seven (7) Retail Models as well as the Technology Floor and wall Display models. In addition life cycle cost effectiveness was studied for Ornament lighting.

We conducted costing analysis on both 7 year and 15 year cycles. The 7 year analysis was used to demonstrate to retailers (who usually remodel in this period and not 15 years) that the majority of the alternate technologies being used in the modeling are cost effective in the 7 year window. However, based on CEC criteria for cost effectiveness the 15 year analysis is used to demonstrate the cost effectiveness of our proposals.

Detailed results for the analysis are shown in Section .3.0 Analysis and Results and consist of the following comparisons:

- PSMH versus CMH, T5/HO and Super T8 Systems for Primary Big Box Retail
- Standard T8 versus Super T8 for secondary Big Box and General Lighting
- Standard T8 versus T5 and Super T 8 for Wall-Wash and Perimeter Lighting
- Halogen and standard T8 versus T5/T8 with dimming and LED (shelf and casework)
- Halogen IR versus CMH and LED for boutique, low, medium and high ceiling configurations (floor and wall accent light applications)
- Incandescent versus Halogen Incandescent, CFL, CMH and LED for Ornamental and Decorative Lighting

Various cost factors were determined for small retail establishments (low volume purchasing) and large corporate high volume purchases. Luminaire and lamps first costs for low volume pricing was determined using pricing data obtained from reputable on line merchants and national lighting distributors. High volume pricing was determined by documentation from a large Retailer Stakeholder as well as several National Accounts sales representatives.

Analysis was run at a 3% real discount rate as defined by the CEC in the 2011 Life Cycle Costing Methodology Report (AEC 2010).

3.3 Visual Observation of Recently Permitted Retail Stores

Field observations were conducted of 168 newly constructed and/or renovated stores, with a goal to determine the extent to which non-mandated new technology was being employed in current designs. The stores included 160 shops and 8 anchor stores. The store sites were located at three new and four recently renovated malls completed between November 2007 and August of 2009 located in Northern California, Southern California, Washington and Arizona.

All 168 stores visited were visually inspected and a technology report generated. The stores that were visited had been permitted under Title 24 2005, The Washington Energy Code and ASHRAE/IESNA 90.1 2004.

Sixty of the 168 stores visited were studied in more detail to compare design watts and code compliance against the governing code. This included an analysis of the stores total LPD as well as the LPDs for General, Wall and Display lighting. Efficiency models were created using Microsoft Excel to determine code compliance..

3.4 Retail Store Computer Modeling

The team created computer models of several existing stores with the goal of comparing the LPDs and foot candle levels used prior to the implementation of Title 24 – 2008 to those of the newest technology available for commercial use. Seven complete and several partial store models were constructed using the computer program AGi32 v2.17 from Lighting Analysts, Inc., Littleton, CO. The design input for each model was from existing CAD drawing files or from observation and measurement. Luminaires were matched to the current design specification by downloading the necessary IES file data from manufacturers. When exact luminaire data was unavailable Photometric Toolbox, Professional Edition from Lighting Analysts was used to make modifications to existing similar IES files to obtain the suitable and correct luminaire file. Photometric analysis was run on each model.

Spaces were selected that best represented technology available prior to the implementation of Title 24-2008 and that would be good candidates for conversion to the most current lighting technology. Varied room cavity ratios (RCR, i.e. the ratio of the wall area to the floor area of the space) were an additional consideration in choosing the various stores to allow us to review the RCR effect on lighting power density and appropriate light levels retail stores.

After base (reference) models were constructed and analyzed each was subjected to lighting design changes. These changes incorporated the latest in fixture and lamp technology and were reanalyzed.

We concentrated on results for LPD, foot-candle levels on display cases and wall displays as well as the effect of ambient lighting on the overall model LPD. Light levels were measured to compare the older reference models with models using the newest technology available for commercial use.

Each model was designed to be compliant with Illuminating Engineering Society of North America (IESNA) Recommended Practices for Lighting for Retail Environments (RP-2-2011) as well as to meet, thorough economic analysis, CEC approved 15 year period of analysis for evaluating Title 24 2013 proposals. Visibility requirements that translate into specific foot-candle levels, and lamp color rendering index (CRI) were components of the model design procedure. Good color quality is a must if the retail community is to accept any major changes to the traditional lamp selection. We chose lamps that had high CRI's (80+) color quality over the life of the lamp as well as providing adequate light levels.

3.5 Luminaire Photometric File Data

All photometry used for store modeling and partial space models was downloaded from each manufacturer's IES file database. Total Light Loss Factors (LLFs) were calculated for each luminaire. Dust depreciation was kept at a constant 0.90 for purposes of this study unless otherwise noted. The following tables for each model describe the various luminaires and/or lamps along with fixture data and quantities used. Note that for each model there is a REFERENCE (Title 24-2008) MODEL and a NEW TECHNOLOGY MODEL which forms the basis for code change recommendations,

Model	Space Description
Model A	Big Box Retail. See Appendix II -Big Box Store (Model A)
Model B	Store with Atrium. See Appendix III High Atrium Store
Model C	Jewelry Store See Appendix IV High End Jewelry Store
Model D	Designer Shop Inside of Store See Appendix V High Designer Shop
Model E	Small Store in Strip Mall See 6.6 Appendix VI Small Store in Strip Ma
Model F	Furniture and Home Accessories See 6.7 Appendix VII Furniture and Home Accessories Store
Model G	Kitchen Accessories See 6.8 Appendix VIII Kitchen Accessories and Tableware

Figure 2: Summary Description of Retail Store Computer Models

Model A represents the typical big box retail. This store type usually employs a monolithic lighting system with higher level general lighting and little or no accent lighting. Costco, Home Depot and Sam's Club are examples of this store category.

Model B represents a large store with a high center atrium. A prototype similar to a book store is used which includes a variety of sub-area lighting design opportunities. Many other retail stores fit this category using a center light-well to use daylighting. The higher ceilings allow the designer to take advantage of Ceramic Metal Halide (CMH). A CMH luminaire with narrow beam optics is very effective at ceiling heights between 15 to 25 feet.

Model C is a high end jewelry store, with an open fascia within an interior mall setting. There is a high case to floor surface ratio, many wall displays and cove fluorescents used extensively for ambient lighting.

Model D is a typical designer shop that carries expensive suits, dresses, gowns and/or accessories within a larger "High End" specialty department store. This model is like Neiman Marcus, Saks or Bloomingdales. Some accent lighting is contributed from the circulation area outside of the shop.

Models E is representative of typical retail stores in a strip mall. The model was constructed to study the interplay of ambient lighting with accent lighting on floor displays or cases. Choices for luminaries were made from data gained from the 168 store technology surveys defined in Section 3.3 above. Baseline lighting developed using Title 24 2008 compliance targets was evaluated against several new luminaire technology options.

Models F - Furniture and Home Accessories is typical of a high mid-range retail establishment. The Furniture and Home Accessory Model has specific illumination requirements because of the large pieces contrasted by smaller accessory items. Track lighting was used throughout the store in combination with some puck lights in millwork and minimal use of fluorescent fill lighting. Baseline lighting developed using Title 24 2008 compliance targets were evaluated against several new luminaire technology options. The role of current limiters with track lighting was also evaluated.

Model G: Kitchen Accessories and Tableware Store. The Kitchen Accessories & Tableware Model is similar to Williams Sonoma or Crate and Barrel. It uses a non-uniform illumination approach with little accent lighting. The two demonstration areas are highlighted using a combination of fluorescent and down lights. Track lighting was used extensively for flexibility.

3.6 New Technology and Design Comparison Computer Models

Partial computer models were constructed using AGi32 to simulate various feature lighting situations that are encountered in most retail locations. Models included wall and floor accent lighting simulations as well as simulations for casework, shelf and decorative lighting elements. Some of these models were previously created for Title 24-2008 standards and updated for this 2013 upate. Others were specifically created for this 2013 study.

Models for the New Technology and Design Comparison are:

- Model H: Floor Accents Comparing CMH, LED, Advanced Halogen IR and Baseline Halogen
- Model I: Wall Accents Comparing CMH, LED, Advanced Halogen IR and Baseline Halogen
- Model J: Mounting Height vs. Throw Distance for Various Lamp Wattages and Lamp Types
- See Appendix IX New Technology and Design Comparison Computer Models

A format similar to Section 3.4 Retail Store Computer Modeling was used for each analysis. Our goal was to examine each design model for the best application of the latest lamp technology and determine the strength and weakness of the currently available lamps and luminaires with respect to foot-candle levels as they relate to ceiling (or luminaire) height and/or throw distance.

Model I compared vertical wall accent lighting with advanced technology options to a baseline model using conventional halogen and MR-16 lamp options. Advanced technology option included Halogen IR PAR and IR MR16 lamps, PAR38 self-ballasted CMH lamps and screw-in LED lamps. Lamps were placed at 10 feet from the floor with 3 foot spacing 3 feet from the wall and at a 30 degree angle.

Model J: looks at the effects of mounting heights on accent and display lighting. Halogen IR , Ceramic Metal Halide and Light Emitting Diode accent lights were studied to determine limitations, if any, of CMH and LED lamps to provide a balanced design alternates to Halogen.

Only three CMH lamp wattages (20W, 39W, 70W) are available as alternates to replace the wide variety of wattages (45W to 250W) of the popular PAR38 lamp for accent lighting. Based on the limited CMH offerings we knew that there would be a gap at certain ceiling heights where the 20W was not enough and the 39W and 70W CMH would be in excess of the desired foot-candle levels on various targets.

Light Emitting Diode (LED) accent lighting lamps are limited to lower wattages and lower lumen outputs. Based on current LED output we knew that there would be a limit to the effectiveness of LED accent lights at certain ceiling heights. The model was used to determine those limits.

3.7 Review & Analysis of Retail Spaces Permitted under Title 24 2005, ASHRAE 90.1-04 and the Washington State Energy Code

We selected specific retail spaces that complied with Title 24 2005 and ASHRAE 90.1 2004. We analyzed these spaces for their ability to comply with Title 24 2008 and the 2010 Washington Energy Code using current, higher efficacy technologies. Analysis and comparison of ASHRAE 90.1 2010 against the base models and Title 2402008 was also conducted. This information was then used to extrapolate the possible LPD level recommendations for Title 24 2013.

3.8 Controls Evaluation

Lighting controls are an effective way to save energy without impacting the appearance of a space. By its very nature the tailored lighting method is used when designers wish to install higher connected lighting loads. A code requirement for additional controls when the tailored lighting method is used helps minimize the energy impact of this method. In addition, since the lighting power densities are higher in tailored method space, there is more wattage available to control and this helps accelerate payback of control systems.

We have selected a prototypical control system for a small 2,500 sf retail space to evaluate the cost-effectiveness of requiring controls that automatically reduce light levels in layers and turn off all lights after hour. A presentation of the model and potential cost savings are discussed in the Results Section. Additional savings can be achieved by integrating demand response controls and daylight harvesting controls with the controls evaluated in this proposal.

3.9 Ornamental Lighting Evaluation for Title 24 2013

Ornamental lighting allowances in both the area category method and the tailored method are, at present, based on incandescent light sources. This light source is often a medium or candelabra based conventional incandescent lamp. There is now an array of halogen replacement lamps as well as several CFL and LED options for most of these lamps.

In other cases ornamental lighting includes fairly high wattage incandescent lamps such as in theatrical projectors. Projector luminaires are now available with higher efficiency metal halide sources and in some cases LED lamping. These luminaire/lamp options not only offer vastly improved efficacy they also exhibit longer lamp life and reduced maintenance.

Models created to evaluate options for Ornamental lighting are:

- Large Chandelier (Baseline incandescent versus Halogen, CMH and High Lumen CFL)
- Small Chandelier (Baseline incandescent versus Halogen and CFL)
- Wall Sconce (Baseline incandescent versus Halogen, CFL and LED)
- Decorative Pendant (Baseline incandescent versus Halogen, CFL and LED)
- Luminous Panels (Baseline fluorescent, advanced dimming fluorescent and LED)

3.10 Stakeholder Involvement

All of the main approaches, assumptions and methods of analysis used in this proposal have been presented for review at a series of public stakeholder meetings. The goal of the stakeholder meetings was to present CASE Study findings, solicit comments from the stakeholders and work to identify potential concerns or issues before the California Energy Commission's public workshops. At each meeting, the utilities' CASE team invited feedback on the proposed language and analysis thus far, and sent out a summary of what was discussed at the meeting, along with a summary of outstanding questions and issues. A record of the Stakeholder Meeting presentations, summaries and other supporting documents was catalogued on www.calcodesgroup.com.

Three stakeholder meetings were held This topic was presented on the same dates and at the same venues as the other lighting topics. The Statewide Utilities CASE Team organized and publicized the meetings through www.calcodesgroup.com and through and email campaign. Key staff from the California Energy Commission attended each meeting.

The goal of the first meeting was to present the scope and broad direction of the code change as well as to request data and feedback on proposed methodology from stakeholders. The goal of the second stakeholder meeting was to present the results of data collection and analysis as well as a potential straw man of the code language. The final stakeholder meeting was an opportunity to present the proposed code language as it will be presented to the California Energy Commission prior to their public workshops in April. CASE Authors solicited all input prior to the final meeting.

4. Analysis and Results

4.1 Interviews with Designers, Contractors, Manufacturers, and End Users

A survey of designers, end users, contractors and manufacturers was conducted to understand the prevalence of the use of the tailored method, the use of track limiters and the use of the latest technologies in practice. This section summarizes the survey results from all respondents and, where appropriate, compares the responses of the different groups.

Over 500 people were contacted via e-mail, online survey and telephone survey. 108 individuals from seven interested stakeholder groups responded to the survey, as shown in Figure .

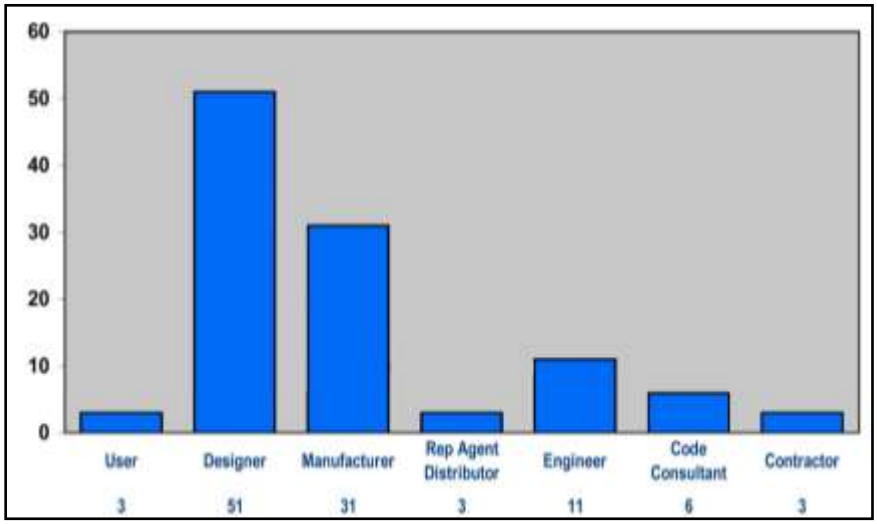


Figure 1: Profile of the 108 respondents by stakeholder group

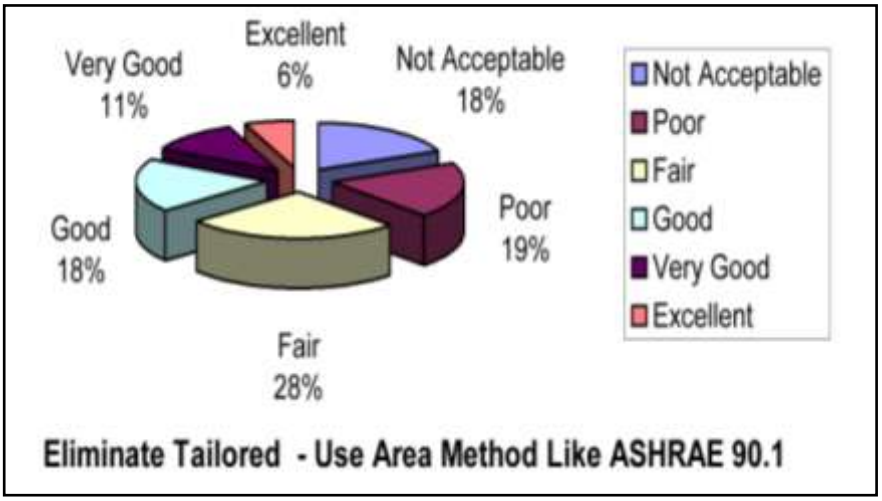


Figure 3: Rank eliminating the tailored method of compliance as a practical and feasible means of achieving LPD reduction in the 2013 Code

Those surveyed were asked to rate a variety of measures as practical and feasible means for reducing LPD in the 2013 code. One of the measures rated was "Totally eliminate (do away with) Tailored Method under 2013 standards and replace with limited power add-ons (similar to ASHRAE/IES 90.1) specialized spaces / needs only.". There was not a clear majority opinion on replacing the tailored method with a space by space method similar to ASHRAE/IES 90.1. 35% thought it was a good to excellent option, 28% thought it was only fair and 37% felt it was a poor to unacceptable option. Based on these finding respondents, while not totally enamored with Title 24's Tailored Method, are not ready to abandon it either.

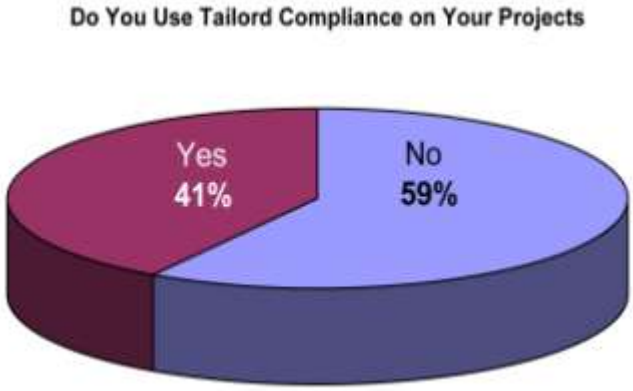


Figure 4: Response to use of tailored method of compliance on projects subject to Title 24

Asked the question "Have you used Tailored Method Compliance in the past year 41% of the respondents indicated having used Tailored Compliance. If they responded YES they were then asked "Where do you use Tailored Compliance"?

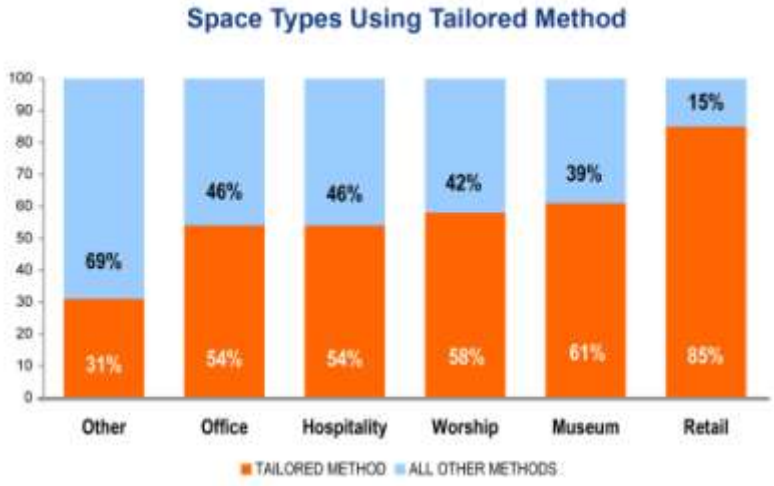


Figure 5: Space types where you most often use Tailored Method Compliance?

In response to the questions "Where do you use Tailored Compliance" and when used for a space type "How often do you use it for that type of space" 85% of the respondents identified retail. Of the 85% responding that they used it for retail, 56% of respondents use it 75% or more of the time. Tailored Compliance is also used frequently for Museums 61%, Hospitality 54% and Worship 58%. The only other space type with notable use of Tailored Compliance was Offices. However while by volume 54% used it in offices only 4 respondents used 75% or more for offices.

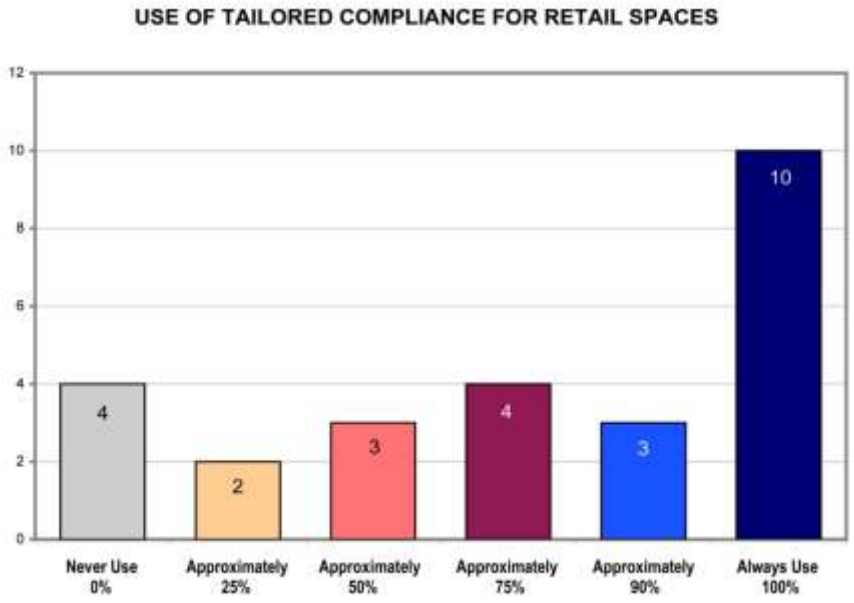


Figure 6: Question: How often do you use the Tailored Method for Retail Space?

Looking closer at the use of Tailored compliance for Retail Spaces, over 1/3 (34%) of respondents surveyed use Tailored Method Compliance 100% of the time. Only 19% reported never using it for retail projects.

Responses to questions related to the use of Tailored Compliance influence this case study as follows:

- Keep Tailored Compliance as a component of Title 24 for 2013
- Focus on Tailored compliance with respect to retail, hospitality, museum and worship
- Remove all other spaces from Tailored Compliance and relocate to Area Method Compliance

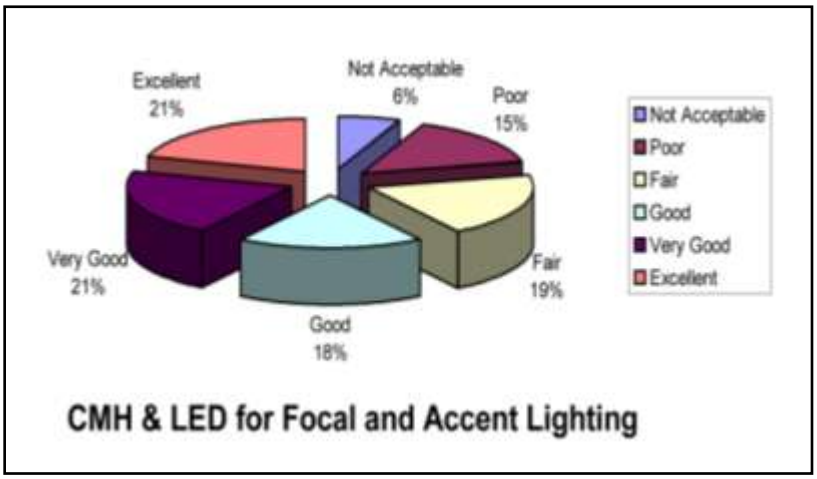


Figure 7: Are CMH and LED acceptable for focal/feature lighting a practical and feasible measure for reducing LPD in Title 24 2013?

When respondents were asked if Ceramic Metal Halide (CMH) and Light Emitting Diode (LED) lighting were suitable alternatives to Halogen for accent and display lighting the majority were in agreement. Sixty percent (60%) rated these sources as good or better while only 21% rated them poor or not acceptable. While the question did not specifically ask respondents to rate CMH suitably versus LED's for accent lighting a large number of respondents footnoted that they were more comfortable with CMH than LED at this juncture. Respondent's main concerns with LED lighting were high cost, limited availability and reliability.

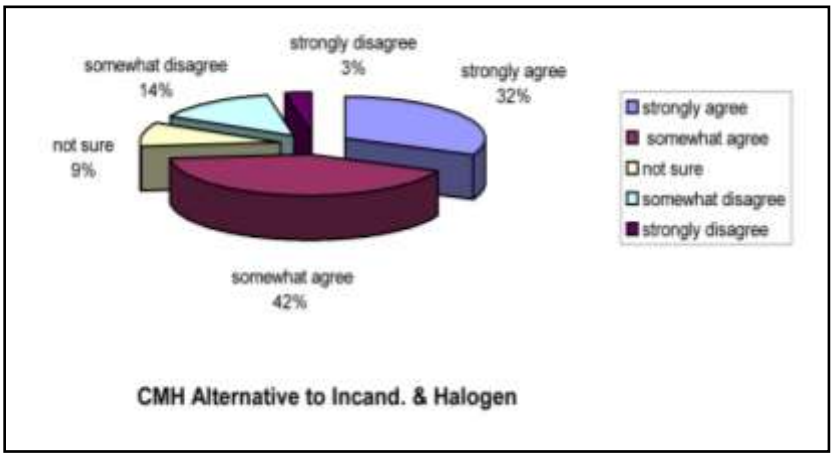


Figure 8: Question: Will CMH be an acceptable alternative to Halogen by 2013

When the question focused on CMH as an alternative to halogen an overwhelming majority (74%) agreed, with 1/3 of the respondents "Strongly" agreeing. However a concern footnoted by a respondent is that first cost of CMH lamps and luminaires remains high.

Responses to questions related to use of CMH and LED sources influence this case study as follows:

- Explore greater use of CMH versus halogen for focus and accent lighting
- Base retail lighting models on heavy use of CMH and adjust LPD's for display and accent
- allowances downward accordingly
- Study LED lighting as a means of reducing lighting power but do not use it as a basis for compliance

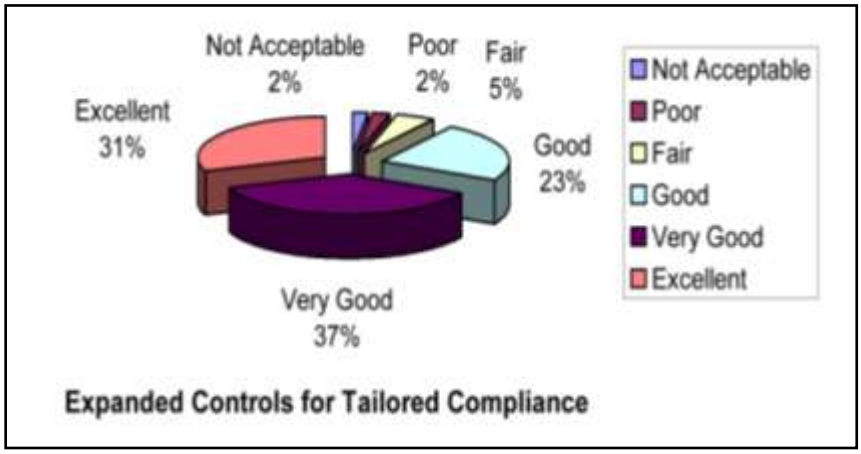


Figure 9: Should comprehensive lighting controls be a Tailored Compliance prerequisite?

Almost all the respondents surveyed (91%) were in favor (good to excellent responses) of adding the use of comprehensive controls to Tailored Method Compliance as a prerequisite of using the Tailored Compliance option.

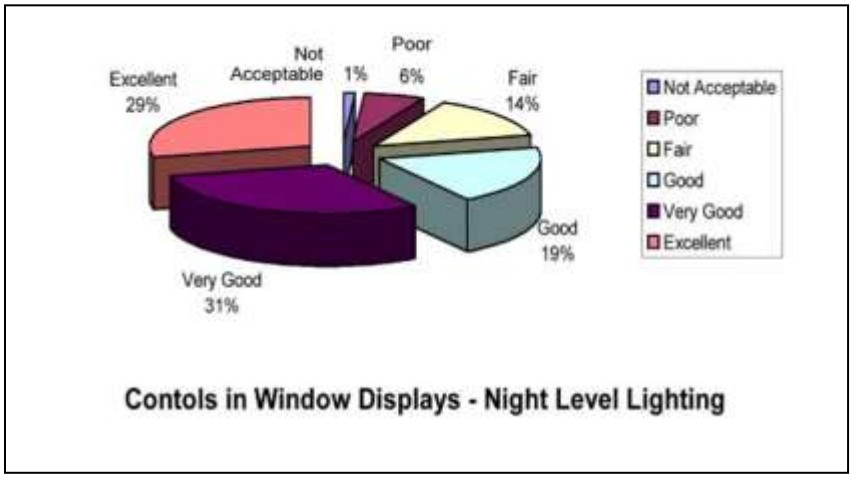


Figure 10: Should additional control of window display lighting

Many of those surveyed (79%) were in favor (good to excellent responses) of adding the use of controls to exterior facing display widows as one of the specific comprehensive lighting controls required as a prerequisite of using the Tailored Compliance option. This control would govern nighttime lighting as well as windows exposed to direct day lighting.

It is clear from the responses to our interview questions that those surveyed are willing to add more controls and move toward CMH as lighting source as long as they can maintain the flexibility of the Tailored Method with provisions for additional LPD's where appropriate. An emphasis on use of CMH as the primary display lighting component and comprehensive controls as a prerequisite to using Tailored Compliance under Title 24 2013 will therefore be an area of focus for this case study. The complete survey questions can be found at: http://www.h-m-g.com/T24/Lighting_surveys.htm

4.2 Life Cycle Cost Analysis of Big Box and General lighting technologies as well as CMH and LED Accent Lighting and Decorative Lighting

Life Cycle Costing results for both a 15 year cycle is presented in this section. Cost effect analysis for the lighting pallet used to develop the seven (7) Retail Models as well as the Technology Floor and wall Display models is included. In addition life cycle cost effectiveness for the decorative and Ornament lighting is presented. While we looked at cost effectiveness for both High Volume use and low volume use only the 15 year TDV low volume use is presented here. The purchasing power associated with high volume use will only improve the cost effectiveness results. That is to say that if it's cost effective under low volume scenarios it will also be cost effective under the high volume scenarios.

Detailed results for the analysis are shown as follows:

- PSMH versus CMH, T5/HO and Super T8 Systems for Primary Big Box Retail
- Standard T8 versus Super T8 for secondary Big Box and General Lighting
- Standard T8 versus T5 and Super T 8 for Wall-Wash and Perimeter Lighting
- Halogen and standard T8 versus T5/T8 with dimming and LED (shelf and casework)
- Halogen IR versus CMH and LED for boutique, low, medium and high ceiling configurations (floor and wall accent light applications)
- Incandescent versus Halogen Incandescent, CFL, CMH and LED for Ornamental and Decorative Lighting

PSMH versus CMH, T5/HO and Super T8 Systems

The current base lighting for a typical "Big Box" retail space is often pulse start metal halide. PSMH is required by Title 20 and was the basis for which "Big Box" retail lighting power was established under Title 24 2008. The Title 24 2013 alternative models (Model A studies) however are based on CMH and T5/HO as well as use of some Super T8 fluorescent. The results gained from the "Big Box" model demonstrate LPD targets as low as 1.0 watts per square foot are possible when high quality (CMH and T5/HO) higher efficacy lighting is employed. The life cycle costing results in this section proves these systems to be cost effective under a 15 year cost cycle for low volume procurement.

Baseline Technology 1: PSMH (Big Box Retail) – Per Single luminaire Results					
Alternates to PSMH		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 1a	350W CMH	$285.00	$778.11	-$208.11	Yes
Alt. 1b	356W T5/HO	-$173.00	$956.23	-$1,129.23	Yes
Alt 1c	296W Super T8	-$90.00	$1,518.71	-$,1608.71	Yes

Figure 11: Cost Effectiveness of Big Box Luminaire Alternates

Standard T8 versus Super T8 for secondary Systems

"Big Box" retail sometimes uses a secondary layer of lighting to provide additional task illumination of identity illumination. The base lighting system currently is standard T8 fluorescent lighting. Similar fluorescent lighting is also often used in many other retail spaces for general illumination. Title 24 2008 modeling used this type of T8 system as well. The Title 24 2013 alternative models (Model A, B and E studies) however use T8 fluorescent lighting within their design pallets. The use of these systems contributed to the lower LPD targets possible when high quality, higher efficacy lighting is employed. The life cycle costing results for the super T8 system prove cost effective under low volume 15 year cost cycles.

Baseline Technology 2 Standard T8 (Big Box Secondary & Other) – Single Luminaire					
Alternates to Standard T8		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 2a	48W Super T8	$92.00	$112.50	-$20.00	Yes

Figure 12: Cost Effectiveness of Big Box Secondary Luminaire Alternates

Wall-washing and Perimeter Systems

Standard T8 fluorescent lighting is often the baseline for wall and perimeter illumination in retail spaces. Title 24 2008 modeling used this type of T8 system as the main perimeter lighting component. The Title 24 2013 alternative models (Model B, C and G studies) however use Super T8 and/or T5 fluorescent lighting within their design pallets. The use of these systems contributed to the lower LPD targets with high quality, higher efficacy lighting. The life cycle costing results for the super T8 and T5 systems prove cost effective under the 15 year cost cycle for low volume procurement.

Baseline Technology 3 Standard T8 (Wall-Wash & Perimeters) – Single Luminaire					
Alternates to Standard T8		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 3a	44W Super T8 WM	$83.00	$281.24	-$198.24	Yes
Alt. 3b	30W T5/T8 Wall-washer	$213.00	$337.49	-$124.49	Yes

Figure 13: Cost Effectiveness of Wall-Wash Luminaire Alternates

Halogen and standard T8 versus T5/T8 with dimming and LED Shelf and Casework Systems

Standard T8 fluorescent lighting is as the baseline for shelf and casework illumination when sparkle is not required. When requiring sparkle the baseline becomes halogen incandescent lighting. Also puck lights, when used are traditionally halogen. Title 24 2008 modeling used these systems for shelf and casework illumination. The Title 24 2013 alternative models (Model C, F and G studies) however use Super T8/T5 fluorescent and fluorescent with dimming ballasts as well as LED's versus halogen for sparkle light within their design pallets. The use of these systems resulted in lower LPD targets

Life cycle costing results were positive under the 15 year Low Volume scenarios except for the Advanced Super T8 Watt-miser shelf light.. However, without exception, under 15 year cycles (high volume) this alternative is also cost effective.

Baseline Technology 4A 4-foot Halogen shelf/Cabinet light– Single Luminaire					
Alternates to Standard T8		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 4Aa	4-foot LED Shelf/Cabinet Light	-$891.25	$393.74	-$1,284.99	Yes

Figure 14: Cost Effectiveness of Shelf/Cabinet Linear LED Alternate

Baseline Technology 4B 4-foot T8 shelf/Cabinet light– Single Luminaire					
Alternates to Standard T8		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 4Aa	4-Ft 24W Super T8 WM Strip	$57.20	$56.25	$0.95	No
Alt. 4Ab	4-Ft T8/T5 - Dimming Ballast	$77.27	$112.50	-$35.23	Yes

Figure 15: Cost Effectiveness of Shelf/Cabinet Linear Fluorewscent Alternates

Baseline Technology 5 20W Halogen shelf/Cabinet Puck Light– Single Luminaire					
Alternates to Standard T8		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 5a	6W LED Shelf/Cabinet Puck	$24.63	$131.25	-$106.62	Yes

Figure 16: Cost Effectiveness of Shelf/Cabinet LED Puck Light Alternate

Halogen IR versus CMH and LED for boutique, low, medium and high ceiling configurations (floor and wall accent light applications)

Primary cost analysis studies focused on the Ceramic Metal Halide (CMH) and Light Emitting Diode (LED) light sources as their use as an alternate to incandescent accent and display lighting will have the most impact on the lighting power density (LPD) of a retail store. The results of this cost analysis showed that at a low volume procurement 15 year cost recovery interval using CMH and LED technologies as the basis for accent and display lighting will greatly reduce energy consumption while at the same time be a cost effective option. As more stores adopt these newer and currently more expensive technologies prices will drop as volume sales increase. This will further reduce the payback time as we have seen with the introduction of other new lamp technologies in the past.

Baseline Technology 11A: 50W PAR30 Lamp Holder & Lamp – Single luminaire Results					
Alternates to 50W PAR 30		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 11Aa	PAR30 12-15W LED Screw In	$26.00	337.49	-$311.49	Yes
Alt. 11Ab	PAR30 12-15W LED System	$190.00	299.99	-$109.99	Yes

Alt 11Ac	15W Mini CMH	$715.00	299.99	$415.01	NO

Figure 17: Cost Effectiveness CMH & LED Accent Lights Versus PAR-30 Halogen

Baseline Technology 11B: 35WMR16 Lamp Holder & Lamp – Single luminaire Results					
Alternates to 35W MR16		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 11Ba	PAR30 12-15W LED Screw In	-$96.50	196.87	-$293.37	Yes
Alt. 11Bb	PAR30 12-15W LED System	$67.50	159.37	-$91.87	Yes
Alt 11Bc	15W Mini CMH	$592.50	159.37	$433.13	NO

Figure 18: Cost Effectiveness CMH & LED Accent Lights Versus MR-16 Halogen

Alternate 11Ac and 11Bc did not prove cost effective. This relatively new 15W "Ceramic Mini Metal Halide" has an excessively high first cost as well s very high re-lamping cost. While it has higher lumen output than the LED systems we compared this higher performance is not critical for use in the boutique ceiling modeling.

Baseline Technology 12A: 55W/HIR PAR38 Lamp Holder & Lamp – Single luminaire Results					
Alternates to 55W/HIR PAR 38		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 12Aa	23-25W PAR38 CMH Screw In	-$5.00	290.62	-$295.62	Yes
Alt. 12Ab	20W PAR/T4 CMH	$195.00	290.62	-$95.62	Yes
Alt 12Ac	22W High Output LED	$195.00	309.37	-$114.37	Yes

Figure 19: Cost Effectiveness CMH & LED Accent Lights Versus PAR-38 Halogen

Baseline Technology 12B: 45W/IRC MR16 Lamp Holder & Lamp – Single luminaire Results					
Alternates to 45W/IRC MR16		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 12Ba	23-25W PAR38 CMH Screw In	-$55.00	196.87	-$251.87	Yes
Alt. 12Bb	20W PAR/T4 CMH	$145.00	196.87	-$51.87	Yes
Alt 12Bc	22W High Output LED	$145.00	215.62	-$70.62	Yes

Figure 20: Cost Effectiveness CMH & LED Accent Lights Versus MR-16 IRC Halogen

Baseline Technology 13: 100W/HIR PAR38 Lamp Holder & Lamp – Single luminaire Results					
Alternates to 100W/HIR PAR38		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 13a	PAR30/38 70W CMH	$175.00	515.61	-$340.61	Yes

Figure 21: Cost Effectiveness CMH Accent Lights Versus PAR-38 IR Halogen

Baseline Technology 14: 250W/Q PAR38 Lamp Holder & Lamp – Single luminaire Results					
Alternates to 250W/Q PAR38		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 14a	PAR30/38 70W CMH	$75.00	1,640.59	-$1,565.59	Yes

Figure 22: Cost Effectiveness CMH Accent Lights Versus PAR-38 Quartz Halogen

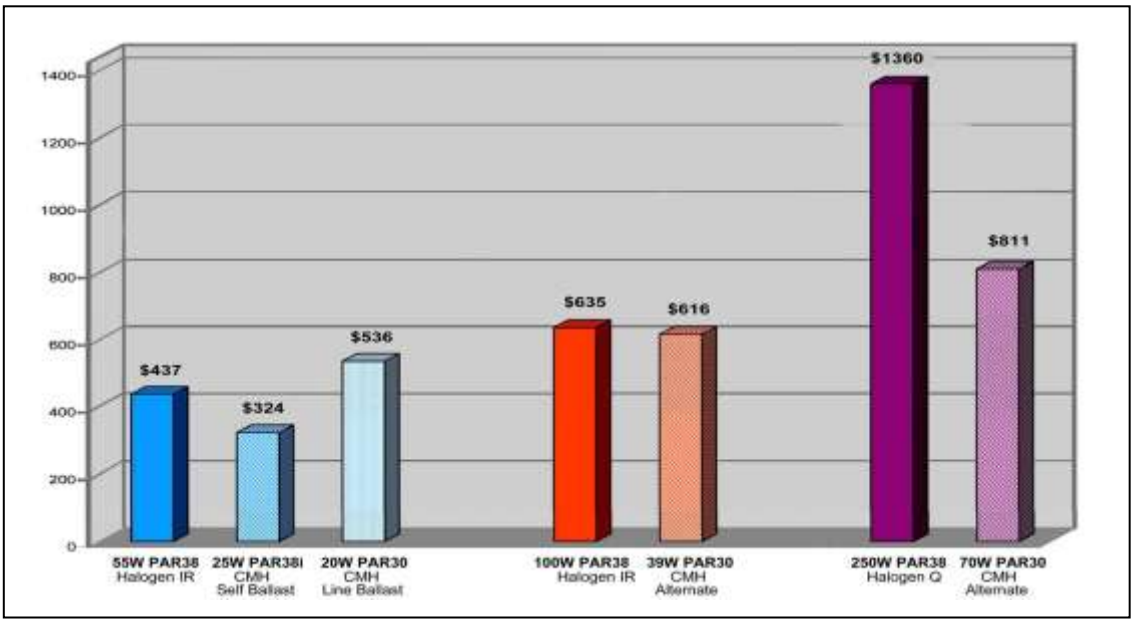


Figure 23: Halogen IR reference lamps versus equivalent light output CMH lamps

Figure 10 summarizes the CMH Cost Analysis showing total comparative cost for operating the Base Line Technology Type 12A (55W HIR), Type 13 (100W HIR) and Type 14 (250W Quartz) versus Alternate Technologies 12Aa and 12Ab, Alternate 13a and Alternate 14a over a 7 year cost recovery period. It should be noted that the CMH lamps used in this comparison have similar center-beam candlepower and mean beam candlepower to their halogen equivalents.

The primary result of this analysis is that all of the larger CMH lamps are cost-effective as compared to their halogen counterparts. Only the 20 W CMH lamp with dedicated CMH fixture has a higher life cycle cost than halogen infrared reflecting (HIR) lamps at a seven year cost recovery. As the wattages of lamps increase, the relative benefit of CMH increases relative to halogen lighting. The life cycle cost of a 70W CMH lighting system is less than half that of a 250 W halogen lighting system with comparable light output.

Typically a 15 year period of analysis is used for evaluating Title 24 nonresidential lighting proposals.

If this 15 year period of analysis were used, the economics for CMH would look even better than the 7 year analysis conducted here. In addition the 20 W CMH system, which did not pass the 7 year cost recovery, is cost effective when evaluated using the 15 year cost recovery interval.

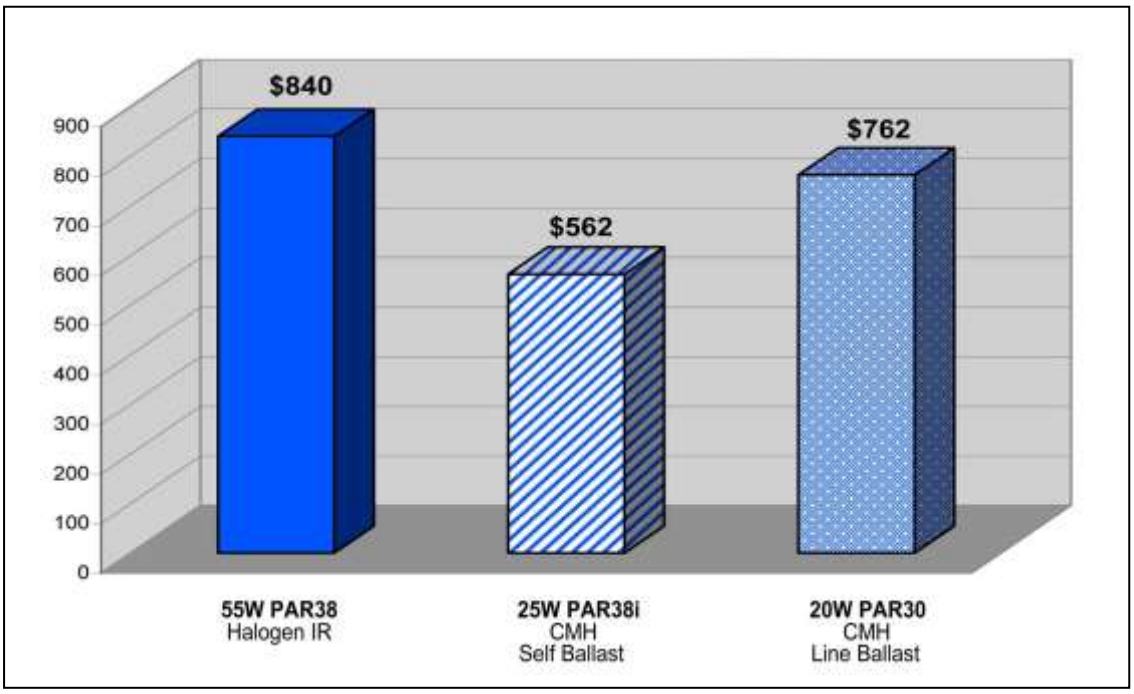


Figure 24: 55W Halogen IR reference lamps versus equivalent light output 20W CMH lamps

This CMH Cost Analysis Graph summarizes the comparative cost for operating the 55W Halogen and low wattage (20W) CMH lamp types over a 15 year cost recovery period. The result of this analysis is that at a 15 year recovery cycle the 20 W CMH lamps are cost-effective as compared to their halogen counterparts. However the dedicated CMH fixture has a higher life cycle cost than the CMH self-ballasted lamp.

Incandescent versus Halogen Incandescent, CFL, CMH and LED Ornamental and Decorative Lighting

Current Title 24 allocation for Decorative and Ornamental lighting LPD's dates back to the Title 24 2001 code when standard incandescent was the baseline for decorative and ornamental lighting. An abundance of higher efficacy light sources are now available and are often now used in lieu of incandescent. The Title 24 2013 Decorative and Ornamental luminaire models use these alternative higher efficacy sources to demonstrate the significant drop in LPD when using these alternates in decorative and ornamental luminaire design.

Life cycle costing results for Halogen and CFL sources is cost effective with in the 15 year low volume scenarios. Most of the alternates are also cost effective under the low volume 7 year analysis except for some of the LED alternatives. LED alternative were not cost effective under the 7 year analysis because of the current high first cost of most LED systems versus their conventional technology counterparts.

Baseline Technology 6: Large Incandescent Chandelier – Single luminaire Results					
Alternates to Incandescent		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 6a	Halogen lamps	$600.00	$2,812.43	-$2,212.43	Yes
Alt. 6b	High Output CFL lamps	-$400.00	$6,562.34	-$6,962.34	Yes
Alt 6c	T6 CMH lamps/ballast	-$420.00	$6,749.84	-$7,169.84	Yes

Figure 25: Cost Effectiveness Alternate Technologies for Large Chandeliers

Baseline Technology 7: Medium Incandescent Chandelier – Single luminaire Results					
Alternates to Incandescent		***Incremental Cost***	***15 Year TDV***	***LCC***	***Cost Effective***
Alt. 7a	*Halogen lamps*	*$300.00*	*$937.48*	*-$637.48*	*Yes*
Alt. 7b	*High Output CFL lamps*	*$120.00*	*$2,624.94*	*-$2,504.94*	*Yes*

Figure 26: Cost Effectiveness Alternate Technologies for Medium Chandeliers

Baseline Technology 8: Incandescent Sconce – Single luminaire Results					
Alternates to Incandescent		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 8a	Halogen lamps	$50.00	$281.24	-$231.24	Yes
Alt. 8b	CFL lamps/Ballast	$20.00	$562.49	-$542.49	Yes
Alt 8c	LED lamps/Driver	$10.00	$656.23	-$646.23	Yes

Figure 27: Cost Effectiveness Alternate Technologies for Sconces

Baseline Technology 9: Incandescent Pendant – Single luminaire Results					
Alternates to Incandescent		**Incremental Cost**	**15 Year TDV**	**LCC**	**Cost Effective**
Alt. 9a	Halogen lamp	$25.00	$140.62	-$115.62	Yes
Alt. 9b	CFL lamp/Ballast	$10.50	$276.56	-$266.06	Yes
Alt 9c	LED lamp/Driver	$3.50	$342.18	-$338.68	Yes

Figure 28: Cost Effectiveness Alternate Technologies for Decorative Pendants

Baseline Technology 10 Luminous Wall T8 Lamp Light panel – Single 6 ft X 12 Ft Wall

Alternates to Standard T8		Incremental Cost	15 Year TDV	LCC	Cost Effective
Alt. 10a	LED Light Panels	$215.00	$515.61	$300.61	Yes

Figure 29: Cost Effectiveness Alternate Technology for Luminous Walls

4.3 Visual Observations of New Relevant Spaces

Field observations were conducted on 168 newly constructed and/or renovated stores, which included 160 shops and 8 anchor stores. The store sites were located at three new and four recently renovated malls completed between November 2007 and August of 2009. Geographic local included Northern California, Southern California, Washington and Arizona. The objective of these observations was to determine the level of advanced and high efficacy lighting used by the stores. The visual appearance of the store (dark, bright, etc.) was also noted. Additionally, in the case of 61 stores we conducted detailed surveys to document the specific lighting equipment used and the lighting power density.

The additional data collected on these 61 stores was used as part of the data in Comparative Studies of ASHRAE 90.1 1999 through 2004 versions and Title 24-2005 as reviewed in Sub-Section 4.7.

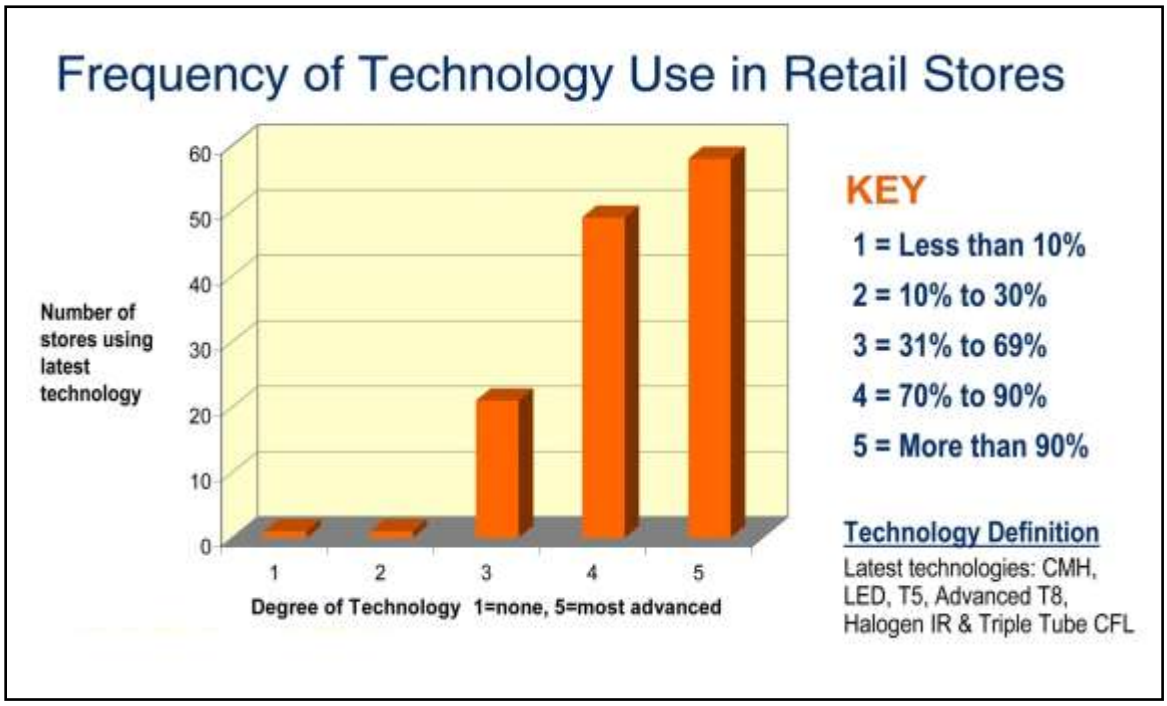


Figure 30: High Efficacy and Advance Lighting use by Surveyed Retail Spaces

Of the 168 retail stores visually surveyed at least one high efficacy and/or advance lighting component was observed in 130 (77.4%) of the stores. Furthermore, 106 stores (63%) had at least 70% of their lighting generated by high efficacy and/or advance lighting components. Finally over 1/3 of the stores surveyed 58 stores were using more than 90% high efficacy and/or advance lighting technologies for their lighting. The above graph summarizes our observations by placing each store in a category (1 through 5) based on the extent of high efficacy and advance lighting in the store. Categories 1 and 2

have almost no high efficacy sources and would be unlikely to pass the current Title 24 2008 tailored lighting standard much less the more restrictive Title 24 2013 standard. Many of the stores in category 4 would comply with Title 24 2008 requirements with only minor design modifications. While most of the stores in category 5 should pass Title 24-2008 and would probably pass the proposed Title 24-2013 standards with little or no design modifications.

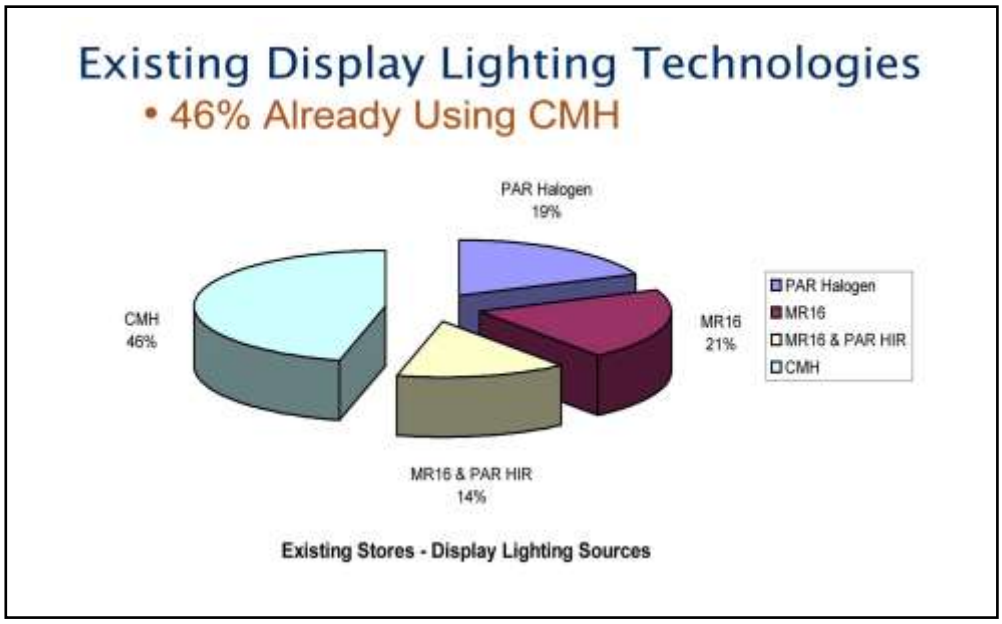


Figure 31: High Efficacy and Advanced Accent Lighting used in Surveyed Retail Spaces

Almost half (46%) of the stores observed had Ceramic Metal Halide technology as part of their lighting design. The extent of CMH usage varied between stores, from token lighting in front windows to 100% CMH accent lighting sometimes combined with triple tube and/or T5 fluorescent general lighting. This suggests that retail store designers and owners are willing to use CMH in place of more traditional halogen or HIR technology. It further suggests that the high CRI produced by ceramic metal halide renders it acceptable as a light source.

From our observations, however, it was apparent that in some stores CMH was not being used to reduce power consumption but to boost light levels while maintaining the same LPD. When used properly stores using CMH lamps can reduce LPDs to meet proposed Title 24-2013 standards.

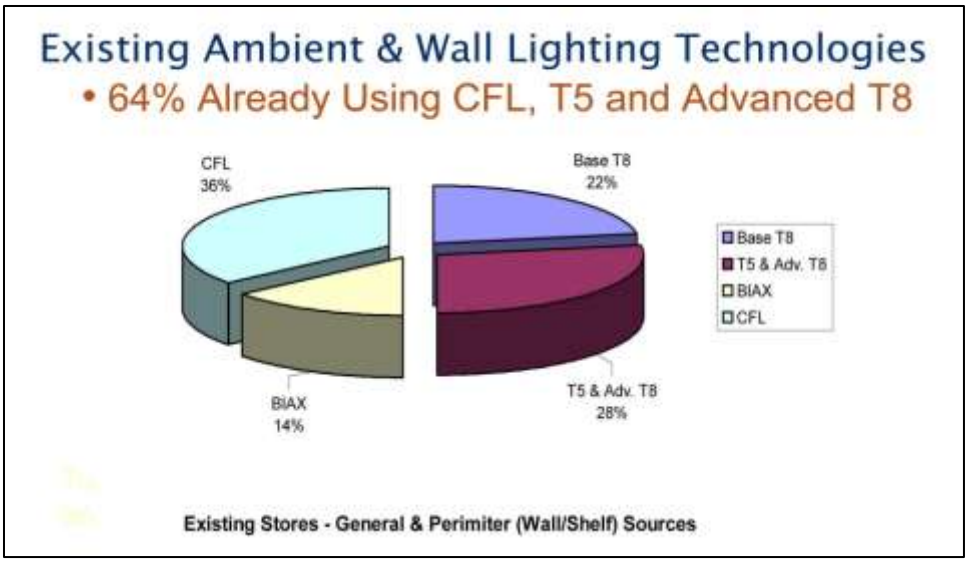


Figure 32: High Efficacy and Advanced Ambient and Wall Lighting in Surveyed Retail Spaces

Many of the stores surveyed (64%) were employing the latest fluorescent lamp and luminaire technologies for general illumination as well as perimeter, shelf and casework lighting. These technologies consisted of triple tube CFL lamps, latest generation advanced T8 lamps and ballasts and T5 lamps and ballasts. High lumen T5 lamps in particular were often used for shelf and casework linear lighting. While in "Big Box" and similar high ceiling applications T5/HO fluorescent lighting was used in place of more conventional Metal Halide illumination.

Results and findings from store surveys indicate that the move toward CMH as well as several other higher efficacies advanced lighting types has already begun voluntarily. Therefore use of CMH as the primary display lighting component should be a viable component in efforts to further reduce the accent and display lighting LPD component within retail spaces under Title 24 2013 standards. Furthermore, use of advanced fluorescent technology as basis for setting standards for retail spaces while having less impact than the CMH component is also viable.

The complete store survey documentation is provided in appendix section in a later draft of this report.

4.4 Retail Store Computer Modeling

Results from the computer modeling of the seven selected spaces detailed in the Methodology Section are presented in 4.4 Analysis and Results. Each space was studied using a base lighting model that conformed to Title 24 2008. The “under Title 24-2008” models (configured to pass the current standards) were compared with the best available “new luminaire technology” concepts in fixture and lamp design to determine if they would pass the proposed Title 24-2011 standards. In addition, the Big Box model and High Atrium model were studied using current Title 24 2008 based technologies but using the reduced foot-candle targets as defined in the soon to be released IESNA RP-2 Recommended Practices for Retail Lighting.

It would be helpful at this point to discuss and define the terms “average foot-candles” and “ambient lighting”. An average foot-candle measurement is the average of a grid of data points on either vertical, horizontal, or counter top surfaces. Ambient lighting refers to the light in a space from “non accent lighting” and is the general lighting level needed in that space depending on the merchandise and purpose of that space. A high level of accent lighting is usually accompanied by a low level of ambient lighting. When there is little or no accent lighting then the ambient/general lighting serves the

dual purpose of lighting the merchandise and the space at the same time.

We compared the ambient (general) and accent lighting in five of the models. Compared were High End Jewelry, Designer Shops (High End Retail), Strip Center Independent Retail, Furniture and Home Accessories Retail and Kitchen Accessories and Tableware Retail. All of these spaces use a high level of accent lighting with reduced general lighting. A similar comparison for Big Box and High Center Atrium stores was not done since these models typically use a high foot-candle level of general lighting (ambient) with little or no accent lighting. These two models however were studied with a reduce recommended general lighting component as defined in IESNA RP-2-2011

The LPD improvements for each model when "new luminaire technology" was used reflected significant positive drops in LPD as compared to the "under Title 24-2008" lighting. While achieving these reductions we did not sacrifice foot-candles accent light ratios or visual impact and quality of illumination.

Cost analysis results are not complete for these lighting models at issue of this draft of the report. The models are being evaluated on both a 7 year cost recovery interval as the CEC approved 15 year period of analysis for evaluating Title 24 proposals. Presentation and results of this analysis will be added to this report in the next draft issue.

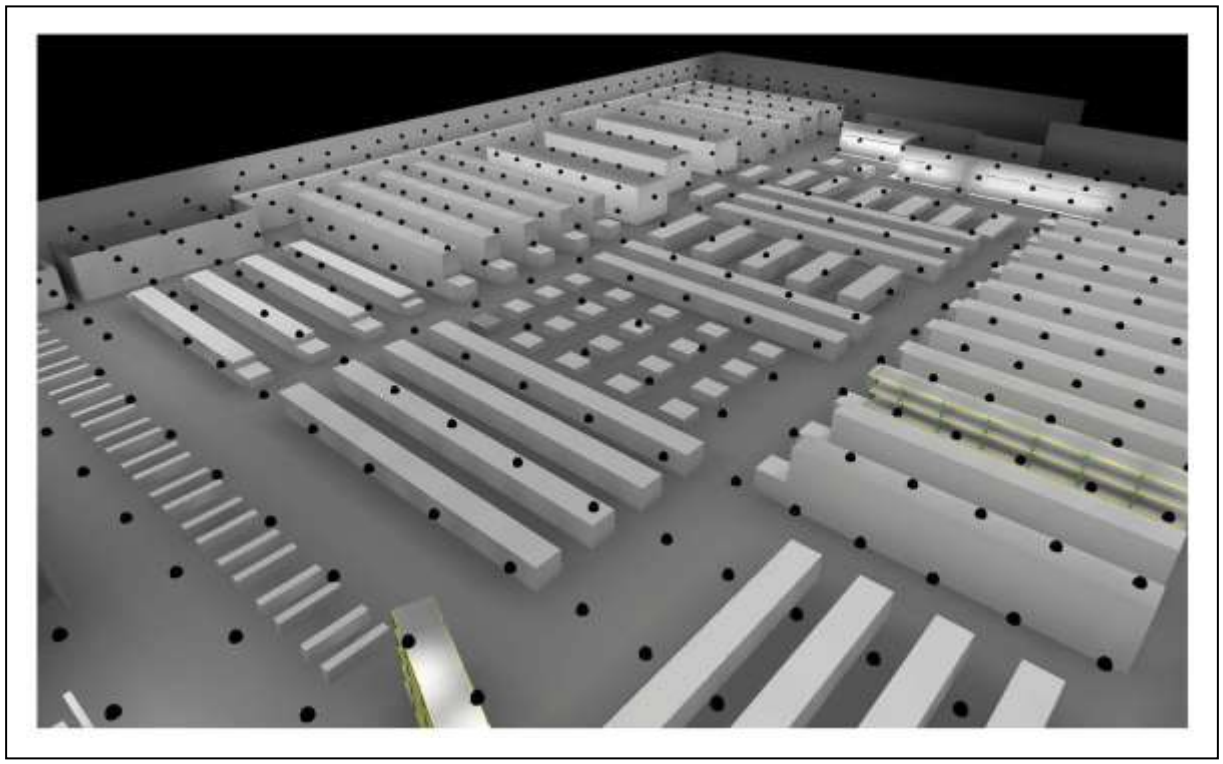


Figure 33: MODEL A - Big Box Model

MODEL A: Big Box Retail - Area Method Compliance			
Allowed maximum wattage per Title 24-2008 Area Compliance for this model			1.60 W
Model Variations	FC Target	Design FC	LPD
2008 Compliance Base Design (RP-2 2001)	75-80	73.5	1.69
2008 Compliance with RP-2 2011 Criteria	50	59.1	1.28
2013 Model RP-2 2011 and CMH/T8 Technologies	50	49.9	1.17
2013 Model RP-2 2011 and T5/T8 Technologies	50	58.6	1.00

Figure 34: Big Box Retail Model Variations

The results gained from the "Big Box" model suggests that retail spaces that typically use monolithic lighting systems and target primarily a uniform higher level general lighting can be designed with as little as 1.0 watts per square foot when high quality (CMH and T5/HO) higher efficacy lighting is employed.. It is apparent from this study that retail spaces with monolithic lighting such as used in this model do not require the 1.6 W per square foot LPD currently allowed under Title 24 2008.

Figure 35: MODEL B – High Atrium

MODEL B: High Atrium Retail - Area Method Compliance			
Allowed maximum wattage per Title 24-2008 Area Compliance for this model			1.60 W
Model Variations	FC Target	Design FC	LPD
2008 Compliance Base Design (RP-2 2001)	75-80	47-65	1.59
2008 Compliance with RP-2 2011 Criteria	50	46-53	1.59
2013 Model RP-2 2011 and CMH/T8 Technologies	50	46-53	1.4

Figure 36: High Atrium Model Variations

High Atrium Retail model results suggests that retail spaces that typically use more complex lighting systems but still target a more uniform higher light level can be designed to comply with Title 24 under the Area method versus Tailored. Use of higher efficacy lighting when employed in these spaces can result in an LPD with as little as 1.4 watts per square foot.

Using lower efficacy commodity light sources such as standard halogen, first generation T8 lamps and luminaires and incandescent decorative lighting the High Atrium model will need to use Tailored Lighting to comply with T24 2008 code. However if high efficacy advanced lighting components are used it can easily comply with current code using the Area Compliance method. It would also comply with our proposed Title 24 2013 Area Method LPD target

Figure 37: MODEL C – High End Jewelry

MODEL C: High End Jewelry Retail - Tailored Method Compliance				
Allowed maximum wattage per Title 24-2008 Tailored Compliance for this model				4.46 W
Model Variations	Ambient Foot-candles	Wall Illumination	Display Illumination	LPD
2008 Compliance Base Design (RP-2 2001)	25	1:1 and 2:1	3:1 and 10:1	4.12
2013 Model RP-2 2011 CMH/LED Designs	25	1:1 and 2:1	3:1 and 10:1	2.27

Figure 38: High End Jewelry Model Variations

Model C results demonstrates that the historically high LPD of spaces such as upscale retail can lowered by use of new amp and luminaire technology. The 2013 Model RP-2 2011 CMH/LED Designs reflects significant a positive drop in LPD as compared to allowed maximum wattage per Title 24-2008 Tailored Compliance and the 2008 Compliance Base Design. This LPD reduction is achieved without sacrificing foot-candles, accent light ratios or visual impact and quality of illumination.

Figure 39: MODEL D – High End Designer Shop

MODEL D: High End Fashion Retail - Tailored Method Compliance				
Allowed maximum wattage per Title 24-2008 Tailored Compliance for this model				3.65 W
Model Variations	Ambient Foot-candles	Wall Illumination	Display Illumination	LPD
2008 Compliance Base Design (RP-2 2001)	25	1:1 to 3:1	10:1	3.59
2013 Model RP-2 2011 CMH Designs	25	1:1 to 3:1	10:1	2.47
2013 Model RP-2 2011 LED Design	25	1:1 to 3:1	10:1	2.19

Figure 40: High End Fashion Model Variations

Model D analyses another prevalent high end retail space with a historically high LPD " High End Fashion retail. Results are similar to these of model C. The 2011 Model RP-2 2011 CMH Design and alternate LED design reflects significant a positive drop in LPD as compared to allowed maximum wattage per Title 24-2008 Tailored Compliance and the 2008 Compliance Base Design. This LPD reduction is achieved without sacrificing foot-candles, accent light ratios or visual impact and quality of illumination.

Figure 41: MODEL E – Independent Retail

MODEL E: Small Strip Center Independent Retail - Tailored Method Compliance				
Allowed maximum wattage per Title 24-2008 Tailored Compliance for this model				3.45 W
Model Variations	Ambient Foot-candles	Wall Illumination	Display Illumination	LPD
2008 Compliance Base Design (RP-2 2001)	40	1:1 to 2:1	5:1	2.81
2013 Model RP-2 2011 CMH Designs	40	1:1 to 2:1	5:1	1.53
2013 Model RP-2 2011 LED Design	40	1:1 to 2:1	5:1	1.36

Figure 42: Independent Retail Model Variations

Model E was developed to study a less elaborate and typically not high end retail space where first cost often drive design and as a result increased LPD. A Track lighting solution (with addition of current limiter and EMS control) was the primary accent lighting component. This design solution allowed for use of high efficacy display lighting with a lower first cost than that associated with recess luminaires using dedicated ballasts and drivers.

Results for model E. demonstrate that lower cost options with respect to use of CMH and LED accent lighting are available. The 2013 Model RP-2 2011 CMH Design and alternate LED design reflects significant positive drops in LPD as compared to allowed maximum wattage per Title 24-2008 Tailored Compliance and the 2008 Compliance Base Design. This LPD reduction is achieved without sacrificing foot-candles, accent light ratios or visual impact and quality of illumination. Furthermore, the two high efficacy design option will qualify under Area Compliance if desired.

Figure 43: MODEL F – Furniture and Home

MODEL F: Furniture and Home Accessories Retail - Tailored Method Compliance				
Allowed maximum wattage per Title 24-2008 Tailored Compliance for this model				4.28 W
Model Variations	Ambient Foot-candles	Wall Illumination	Display Illumination	LPD
2008 Compliance Base Design (RP-2 2001)	56.3	1:2 to 1:4	1:1 to 1:3	4.21
2013 Model RP-2 2011 & CMH/LED	45.2	1:1 to 1:3	1:2 to 1:3	3.14

Figure 44: Furniture and Home Model Variations

MODEL F Furniture and Home Accessories Retail is an updated version of a model previously studied under Title 24 2008 code development. This model was updated to reflect Title 24-2008 Tailored Compliance as its base design with an alternate model variation reflecting the use of high efficacy sources. Results are consistent with those of models C trough E. The alternate design reflects a significant positive drop in LPD as compared to allowed maximum Title 24 2008 wattage and the 2008 Complainant Base Design. Furthermore as with the other models, this LPD reduction is achieved without sacrificing foot-candles, accent light ratios or visual impact and quality of illumination.

Figure 45: MODEL G – Kitchen and Tableware

MODEL G: Kitchen Accessories and Tableware Retail - Tailored Method Compliance				
Allowed maximum wattage per Title 24-2008 Tailored Compliance for this model				4. 50 W
Model Variations	Ambient Foot-candles	Wall Illumination	Display Illumination	LPD
2008 Compliance Base Design (RP-2 2001)	52.1	1:1 to 1:2	1:2 to 1:4	4.47
2013 Model RP-2 2011 & CMH/LED	45.6	1:1 to 1:2	1:2 to 1:5	2.80

Figure 46: Kitchen and Tableware Model Variations

MODEL G Kitchen Accessories and Tableware Retail is another updated version of a model previously studied under Title 24 2008 code development. Again, the model was updated to reflect Title 24-2008 Tailored Compliance as its base design with an alternate model variation reflecting the use of high efficacy sources. Results are similar to that of Model F. The alternate design reflects a significant positive drop in LPD as compared to allowed maximum Title 24 2008 wattage and the 2008 Complainant Base Design. Furthermore as with the other models, this LPD reduction is achieved without sacrificing foot-candles, accent light ratios or visual impact and quality of illumination.

4.5 New Technology Lighting Models

Models H, I, J and K are technology models that document results of studies undertaken to look at the improved efficiency and performance of CMH and LED lamps to provide accent lighting in retail environments. The effects of mounting heights on accent and display lighting using Halogen IR versus Ceramic Metal Halide and LED (light emitting diode) was also explored using these models. The objective of the mounting height study was to determine limitations of CMH and LED lamps to provide a balanced design alternative to Halogen.

LPD improvements for each "new luminaire technology" model reflected significant positive drops in LPD as compared to "Title 24-2008" base case lighting. Achieving these reductions did not sacrifice foot-candles, accent light ratios or visual impact and quality of illumination.

Other models (Models L, M, N and O) within this new technology evaluation explore opportunities to reduce LPD's of ornamental, special effects and decorative lighting by use of higher efficacy light sources. Current Title 24-2008 allowed LPD's for these lighting classifications were carried over from Title 24-2005 and in some instances date back to 2001 Tile 24 compliance standards. Historically LPD's are based on incandescent for decorative lighting and cold-cathode or standard fluorescent for most of the special effects lighting. These new models use Halogen incandescent as well as CFL, LED, CMH and advanced T8 and T5 fluorescent. The LPD improvements for each model when "new luminaire/lamp technologies" was used reflected significant positive drops in LPD's as compared to the base line technologies commonly associated with the typical design application. These reductions were achieved while maintaining visual impact and quality of illumination. Detail of analysis and results for models K, L, M, N and O can be found in 3.8 - Results of Ornamental Lighting Evaluation for Title 24-2013 located within this results section of our proposal.

Cost effectiveness results for lighting components used in models H, I and J as well as those for models K, L, M, N and O are found in 4.2 - Life Cycle Cost Analysis within the Cost Analysis section of the case study.

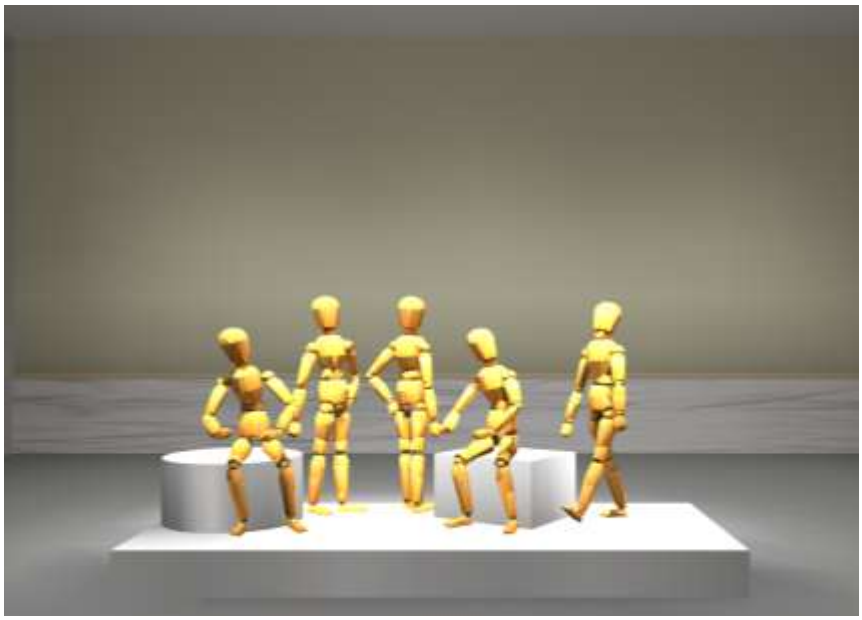


Figure 47: Model H Floor Accents Comparisons

Luminaire Description	Foot Candle Average	Mounting Height (Feet)	Ave/Min	Quantity
48W PAR38 HIR Spot	255	10	3.2	4
55W PAR38 HIR Spot	311	10	3.2	4
83W PAR38 HIR Spot	132	15	1.6	4
250W PAR38 Q Spot	290	20	1.2	4

Figure 48: Computer Model H – Floor Accents Baseline Technology Options

Luminaire Description	Foot Candle Average	Mounting Height (Feet)	Ave/Min	Quantity
20W CMH PAR38 Spot	568	10	2.5	4
19 W LED Med Spot	465	10	3.8	4
39W CMH PAR38 Spot	163	15	1.7	4
70W CMH PAR38 Spot	290	20	1.5	4

Figure 49: Computer Model H – Floor Accents Advanced Technology Options

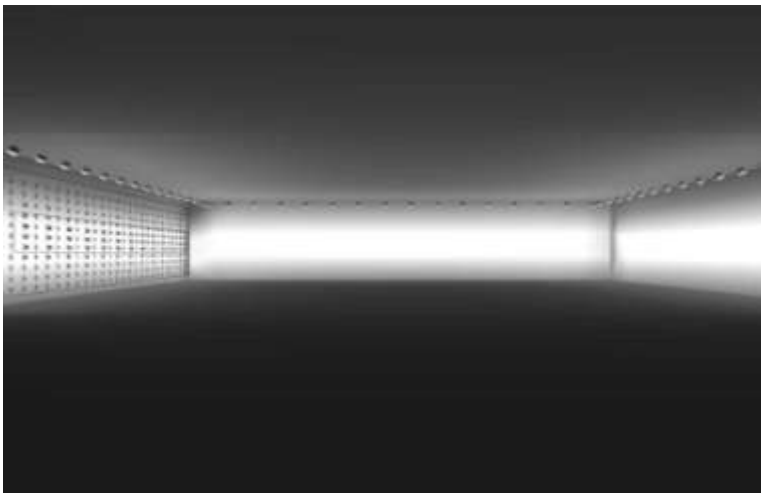


Figure 50: Model I Wall Accents Comparisons

Model I: Vertical Wall Accent Lighting comparisons with a baseline model using conventional halogen. Advanced technologies option using Halogen IR PAR and IR PAR38 self-Ballasted CMH lamps and screw in LED lamps. Lamps were placed at 10 feet from the floor with 3 foot spacing 3 feet from the wall and at a 30 degree angle. The foot-candle averages stated for Model I are the average for the total wall illumination. The center beam focal light is significantly higher (as much as 12 to one) versus the average. These high ratios create hot spots which can be appropriate for some wall merchandise display lighting but not for all applications. Therefore, we ran a supplemental Model I using a blend of high lumen CFL and LED spot lights. The supplemental model is a better option when the wall or in this example wall shelving is to be illuminated more uniformly.

Luminaire Description	Foot Candle Average	Mounting Height (Feet)	Ave/Min	Quantity
75W PAR38 9 degree Spot	55	10	1.4	44
55W PAR38 10 degree Spot	61	10	1.4	44

Figure 51: Computer Model I – Wall Accents Baseline Technology Options

Luminaire Description	Foot Candle Average	Mounting Height (Feet)	Ave/Min	Quantity
23W PAR38 CMH 10 degree Spot	80	10	1.3	44
19 W LED Med Spot	78	10	1.4	44

Figure 52: Computer Model I – Wall Accents Advanced Technology Options

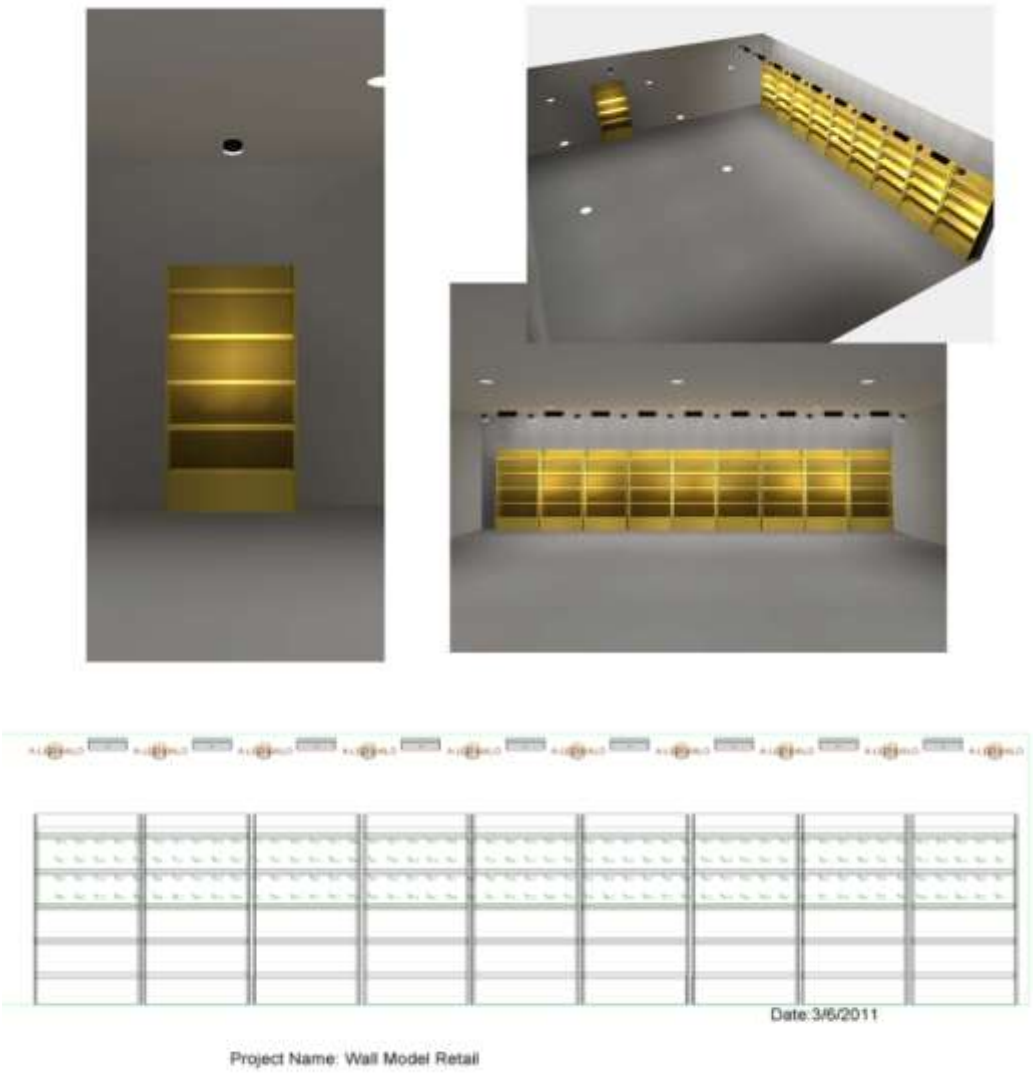


Figure 53: Model I Wall Accents Supplemental – Shelving Model

Luminaire Description	Foot Candle Average	Mounting Height (Feet)	Ave/Min	Quantity
19 W LED Med Spot	232	11	6.5	11
42W CFL –PLT				9

Figure 54: Computer Model I – Wall Accents Advanced Technology Options

Figure 55: Model J Mounting Heights Comparisons

Model J; Effects of mounting heights on accent and display lighting impact of Halogen IR versus Ceramic Metal Halide and Light Imitating Diode accent lights were studied to determine limitations, if any, of CMH and LED lamps to provide a balanced design alternate to Halogen.

Only three CMH lamp wattages (20W, 39W, 70W) are available as alternates to replace the wide variety of wattages (45W to 250W) of the popular PAR38 lamp for accent lighting. Based on the limited CMH offerings we knew that there would be a gap at certain ceiling heights where the 20W wasn't enough and the 39W and 70W CMH would be in excess of the desired foot-candle levels on various targets.

Light Emitting Diode (LED) accent lighting lamps are limited to lower wattages and lower lumen outputs. Based on current LED output we knew that there would be a limit to the effectiveness of LED accent lights at certain ceiling heights. The model was used to determine those limits.

Distance From Wall	Ceiling Height				
5 Feet	10 Feet				
6 Feet		12 Feet			
8 Feet			15 Feet		
9 Feet				17 Feet	
10 Feet					20 Feet

Figure 56: Mounting Height vs. Throw Distance Study – Layout Grid

Luminaire Description	Foot Candle Average	Mounting Height (Feet)	Ave/Min	Quantity
48W PAR38 HIR Spot	283	10	1.9	3
55W PAR38 HIR Spot	137	15	2.0	3
83W PAR38 HIR Spot	101	20	1.2	3

Figure 57: Computer Model J – Mounting Height vs. Throw Distance Baseline Technology

Luminaire Description	Foot Candle Average	Mounting Height (Feet)	Ave/Min	Quantity
23W CMH PAR38 Spot	544	10	2.8	3
39W CMH PAR38 Spot	197	15	2.0	3
70W CMH PAR38 Spot	290	20	1.4	3
19 W LED Med Spot	442	10	4.5	3
19 W LED Med Spot	147	15	2.6	3

Figure 58: Computer Model J – Mounting Height vs. Throw Distance Advanced Technology

4.6 Assessment of Lighting Controls

We conducted a review of lighting controls that itemizes the first costs, energy savings, maintenance effects and life cycle savings associated with installing lighting controls in a 2,500 sf small retail space. The specific controls evaluated were those that would likely be required of a retail space that makes use of the tailored lighting method for compliance. This analysis is based on an annual energy cost of $0.14/kWh, which is the average TDV electricity cost during typical retail hours of operation.

The evaluation showed that use of more advanced control systems will produce an annual energy savings of approximately $2,000. The controls consist of multiple circuiting for general lighting (selling, stock, and circulation on separate circuits) and accent lighting (theme/deco, store front, wall, and floor two to three circuits) along with an appropriate digital timer. The cost to install the additional equipment and circuits is approximately $4,200. Therefore the cost recovery time for this upgrade is about 2 ¼ years. Below is the diagram for the space used for this study. Below is a diagram for the space used in this study.

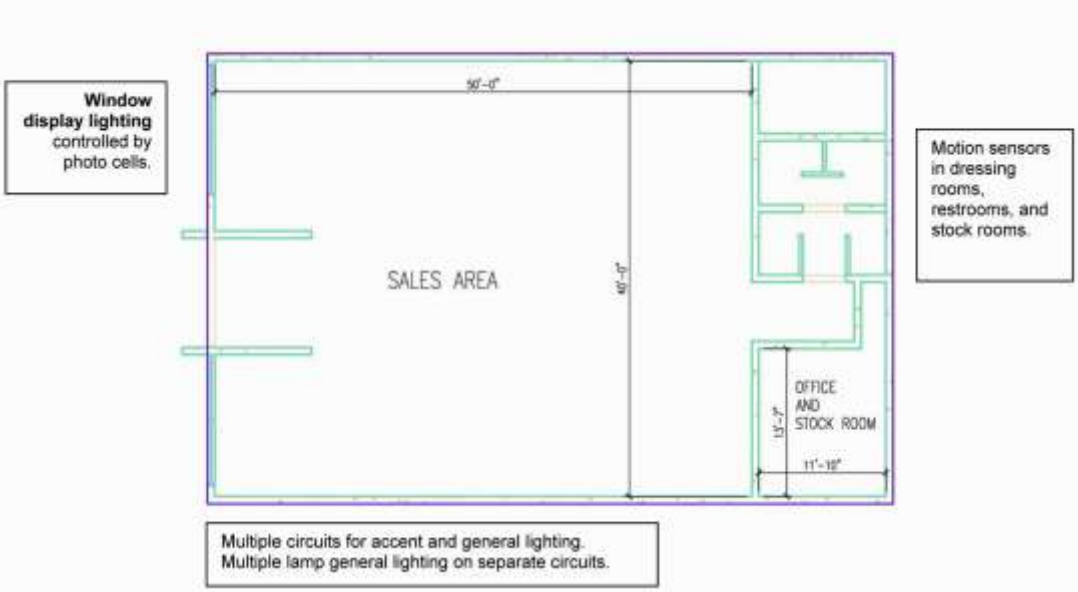


Figure 59: Diagram for Advanced Lighting Controls Cost Analysis Model

The costs and savings of these controls are explained in the following four tables. These savings are achieved by using some or all of the controls in the above diagram. An additional advantage of this strategy is the added flexibility to control lights and switch off unnecessary lights. This will reduce energy usage and save money as less frequently used areas will use reduced or no lighting when not occupied.

	MINIMUM LIGHTING CONTROLS - TIMER ONLY					
	Location	Code Allowance W/SqFt	Area SqFt	Maximum Allowed Watts	Hours of Lighting Per Year	Kilowatts Per Year
General Lighting Component	Selling	0.9	2,000	1,800	4,600	8,280
	Office/Stock	1.1	250	275	4,600	1,265
	Dressing Room	0.9	200	180	4,600	828
	Misc/Circulation	1.0	50	50	4,600	230
					Sub-Total	10,603
Accent Lighting Component	Floor Display	1.0	2,000	2,000	4,600	9,200
	Wall Display	16	130	2,080	4,600	9,568
	Theme/Deco(Dressing)	n.a.	n.a.	500	4,600	2,300
	Store Front Display	n.a.	n.a.	500	4,600	2,300
					Sub-total	23,368
	Minimum Contol (Time Clock Only) Yearly kW TOTAL:					33,971
	Cost elec/kWHour:					$ 0.14
	Total Annual Cost of Electricity for Lighting:				**A**	$ 4,755.94

Figure 60: Annual Energy Cost To Operate 2500 sq. ft. Retail Space with Time Clock Controls

	ADVANCED LIGHTING CONTROLS - MULTIPLE ZONES/CIRCUITS					
	Location	Code Allowance W/SqFt	Area SqFt	Maximum Allowed Watts	Hours of Lighting Per Year	Kilowatts Per Year
General Lighting Component	Selling	0.9	2,000	1,800	4,600	8,280
	Office/Stock	1.1	250	275	2,300	633
	Dressing Room	0.9	200	180	2,415	435
	Misc/Circulation	1.0	50	50	4,600	230
					Sub-Total	9,577
Accent Lighting Component	Floor Display	1.0	2,000	2,000	3,450	6,900
	Wall Display	16	130	2,080	3,833	7,973
	Theme/Deco(Dressing)	n.a.	n.a.	500	2,415	1,208
	Store Front Display	n.a.	n.a.	500	1,680	840
					Sub-Total	16,921
	Minimum Contol (Time Clock Only) Yearly kW TOTAL:					26,498
	Cost elec/kWHour:					$ 0.14
	Total Annual Cost of Electricity Using Advanced Controls:				**B**	$ 3,709.72

Figure 61: Annual Energy Cost To Operate 2500 sq. ft. Retail Space with Time Advanced Controls

ANNUAL SAVINGS USING ADVANCED CONTROLS	
Net Annual Savings by Switching to Advanced Lighting Control Systems **(A-B)**:	$ 1,046.22
HVAC Annual Cost Avoidance:	$ 250.00
Re-Lamping Annual Cost Avoidance:	$ 650.00
TOTAL POTENTIAL SAVINGS USING ADVANCED LIGHTING CONTROLS:	$ 1,946.22

Figure 62: Annual Cost Savings From Using Advanced Lighting Controls

INCREMENTAL COST OVER MINIMUM CONTROLS (TIME CLOCK)	
DIGITAL MULTI-FUNCTION CONTROL SYSTEM:	$ 3,600.00
MOTION AND PHOTO SENSORS:	$ 600.00
INCREMENTAL ADDITIONAL COST FOR ADVANCED CONTROLS:	$ 4,200.00

Figure 63: Incremental Cost Of Advanced Lighting Controls

The advanced lighting controls payback for a small (2,500 square foot) retail space, as demonstrated by this model can be little as 2.1 years. Further cost analysis to be conducted with respect to 7 year and 25 year cost effectiveness should prove as effective and positive as this simple payback analysis. Therefore, the requirement for a more comprehensive (EMS type) control for all retail submitting to permit under Tailored Method is a justifiable addition to Title 24-2013.

4.7 Comparative Studies of ASHRAE 90.1 2004 and 2010, Title 24-2005 and 2008, and the Washington Energy Code including Washington 2010

The results of the comparative study calculations using the more recent lighting power density (LPD) codes are summarized below. The results confirm the expectation that gradual reduction in allowed LPD over the past several years makes it impossible for older technology designs to pass the new more energy efficient requirements. On the other hand a number of the stores documented in the store surveys results (Section 4.4.3) where significant use of high efficacy sources were employed could potentially meet both the latest ASHRE/IESNA 90.1 and Washington Code requirements as well as the proposed Title 24 2013 standards.

The modeling results from Sections 4. 4.4 and 4.4.5 suggest that by using a combination of CMH, T5/T5HO, and possibly LED fixtures accent and display lighting LPDs can be reduced by as much as 50% in some cases without sacrificing illuminance (fc). Furthermore, by using lamp and luminaire combinations better suited to tasks such as T5 lamps with asymmetrical reflectors for cove lighting and/or valence lighting or LED under shelf and specialty lighting additional performance enhancements are possible, with even lower LPDs.

The results of the comparison of the various ASHRAE 90.1 standards as well as California Title 24-2005 and 2008 and the Washington Codes can be found in the second tables below.

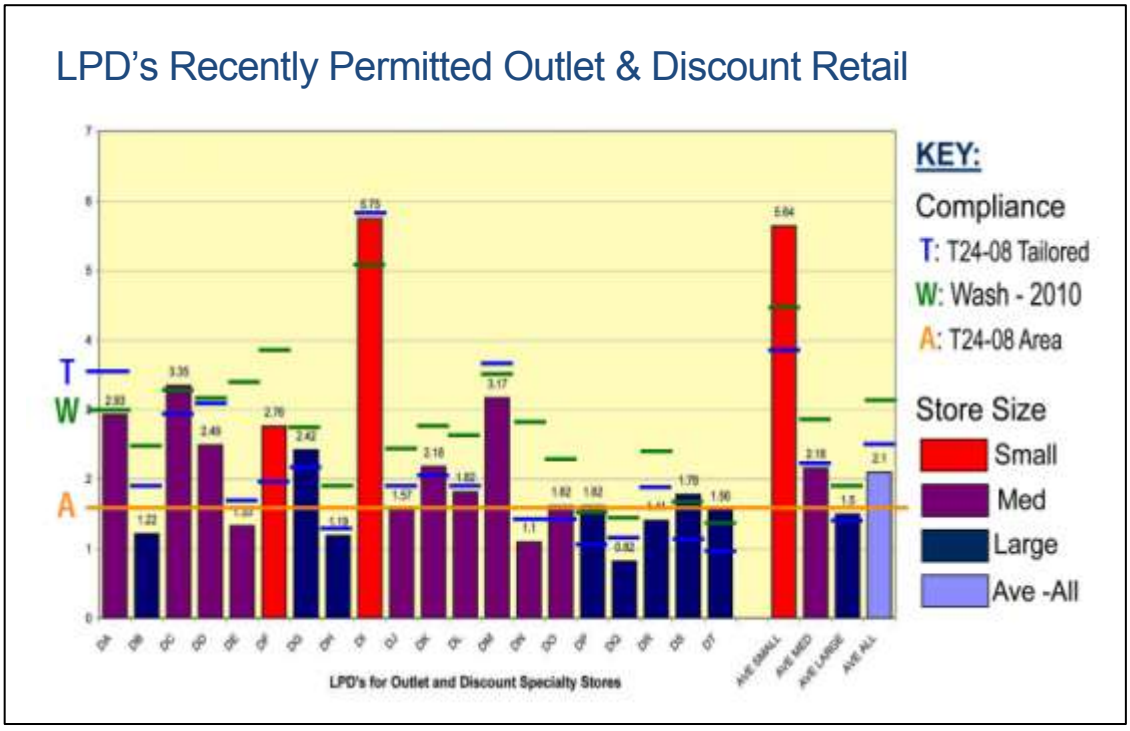


Figure 64: Comparison of Recently Permitted Outlet and Discount Retail

Lighting power density (LPD) of twenty (20) outlet and discount retail stores, located in California were compared to current Title 24 2008 and the newly introduced Washington Energy Code 2010. Since Title 24 2008 did not take effect until January of 2010 all the California stores surveyed very early in 2010 were permitted under Title 24 2005. Furthermore from the best of our determination the 20 stores were all in compliance with Title 24 2005 Tailored Method and more than half of the stores met compliance under the Title 24 2005 Area Method.

Twelve (12) of the 20 stores could meet Title 24 2008 compliance as currently designed and another three could meet Title 24 2008 with minor fine tuning. Only five of the 20 sore would require substantial re-design to meet Title 24 2008 compliance. The twenty outlet and discount stores comply with a greater margin with Washington's new 2010 Code. Fifteen of the stores would comply with Washington Code if built today. Of the five stores that would not pass as built, three would only require fine tuning while the other two would require some design modification.

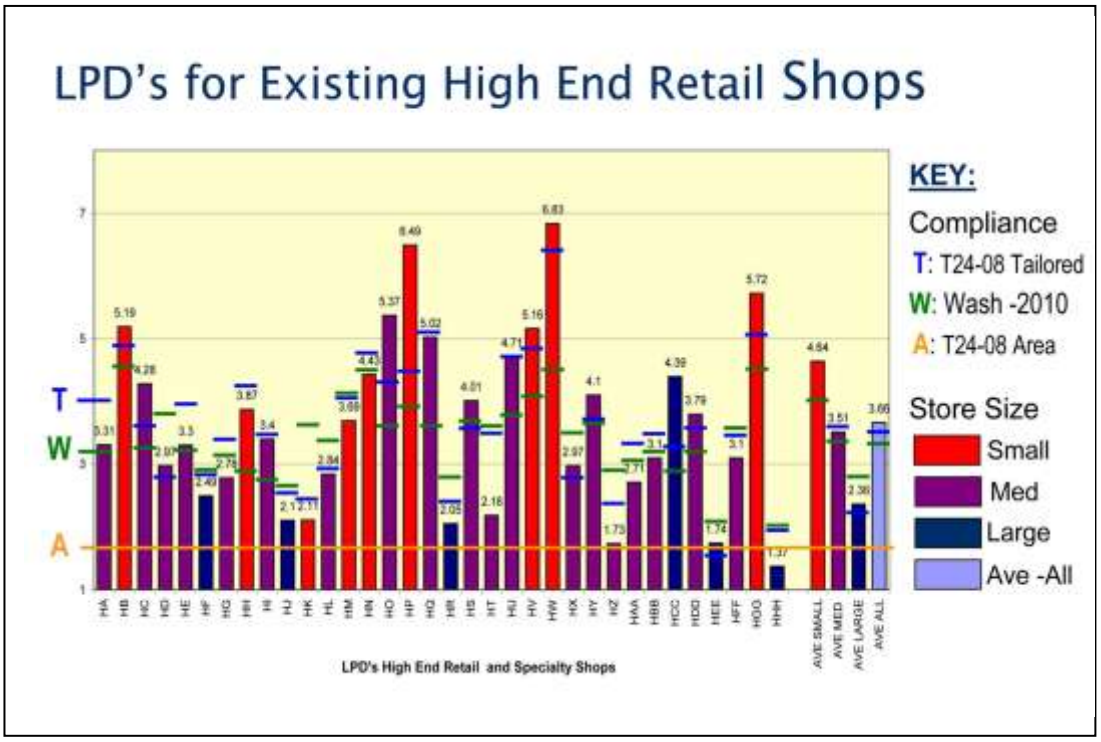


Figure 65: Comparison of recently permitted High End and Designer Retail

Lighting power density (LPD) of thirty four (34) high end retail shops , located in, California, Washington and Arizona, were compared to current Title 24 2008 and the newly introduced Washington Energy Code 2010. The California stores surveyed, were permitted under Title 24 2005 while the Washington stores were permitted prior to the 2010 Washington code and the Arizona stores were permitted under ASHRAE/IESNA 90.1 2004. All stores surveyed were compliant under their respective codes at time of permitting. All but 13 of the 24 stores would comply with Title 24 2008 if permitted in California today. Of the 13 stores that would not comply, 10 stores require only minor revisions to meet compliance. Three (3) stores would require substantial re-design to meet Title 24 2008 compliance. The thirty four (34) high end shops faired less favorably against the 2010 Washington Code. Seventeen (17) of the stores would not comply with Washington 2010 Code if built today. Of those not complying, all but three of the stores would require significant modification or redesign.

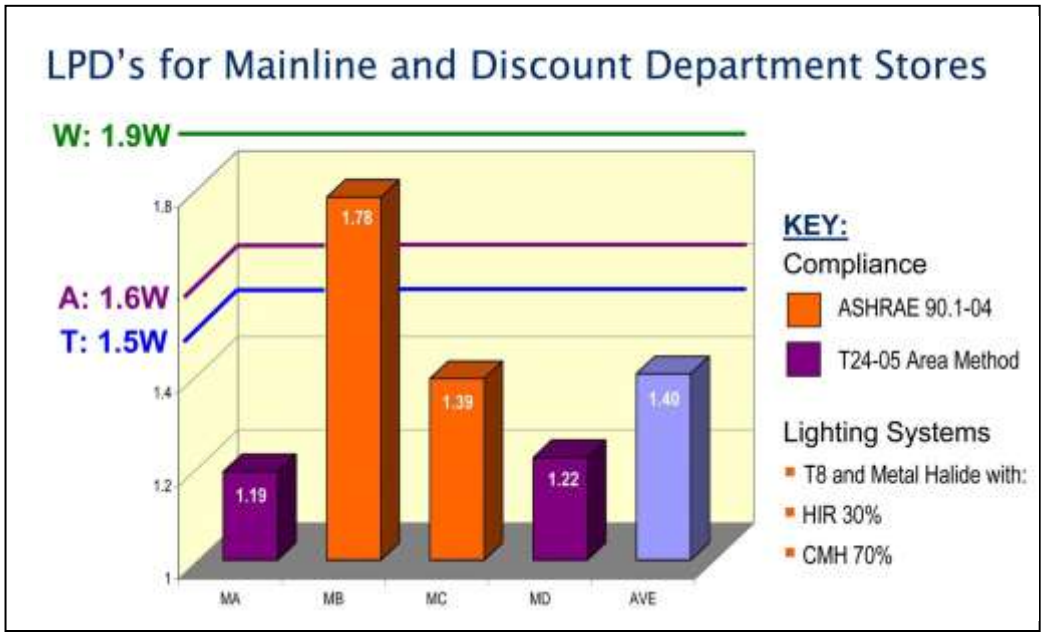


Figure 66: Comparison of Recently Permitted Department Stores

Four department store retail spaces (three in California and one in Arizona) were compared to current Title 24 2008 and the newly introduced Washington Energy Code 2010. The California stores surveyed, were permitted under Title 24 2005 while the Arizona store was permitted under ASHRAE/IESNA 9-.1 2004. All stores surveyed were compliant under their respective codes at time of permitting. All but one of the stores would comply with Title 24 2008 if permitted in California today. The one store that would not comply requires only minor revisions (ballast types and next generation lamps) to meet compliance. All the stores when compared against the Washington Energy Code 2010 would comply with the Washington code as built.

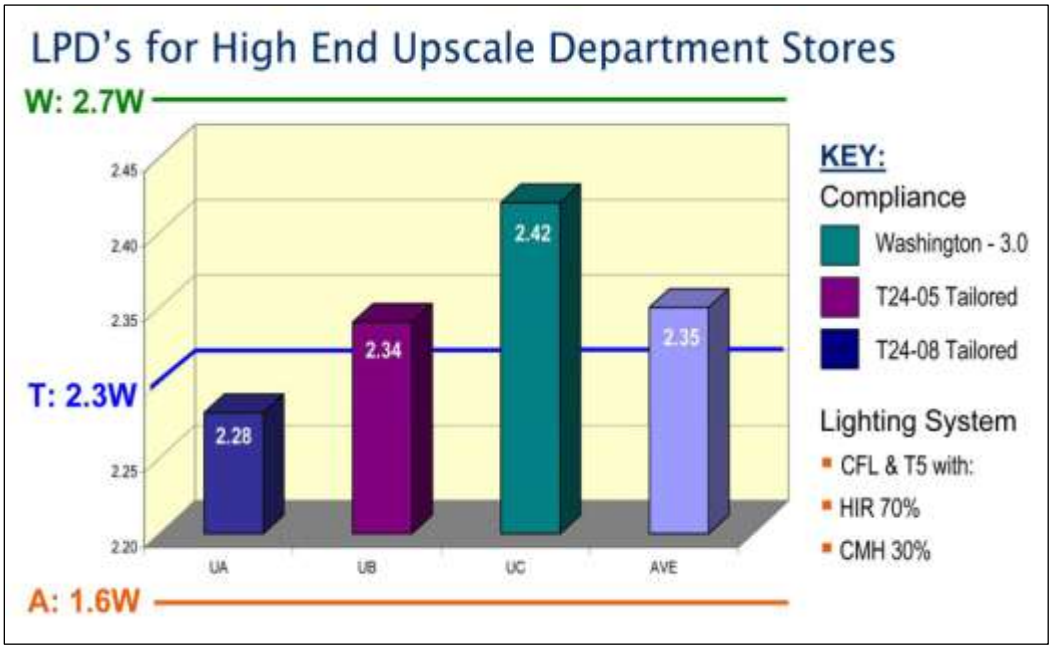


Figure 67: Comparison of recently permitted Upscale Department Stores

Three up-scale department stores (two in California and one in Washington) were compared to current Title 24 2008 and the Washington Energy Code 2010. One California store surveyed was permitted under Title 24 2005 and the other under Title 24 2008 while the Washington store was permitted just prior to introduction of the Washington Energy Code 2010. All stores surveyed were compliant under their respective codes at time of permitting. Only the permitted Title 24 2008 store would comply with Title 24 2008 if permitted in California today. The other two sores would require some revisions to current California Title 24 compliance. When compared against the Washington Energy Code 2010, all of the stores would comply as built.

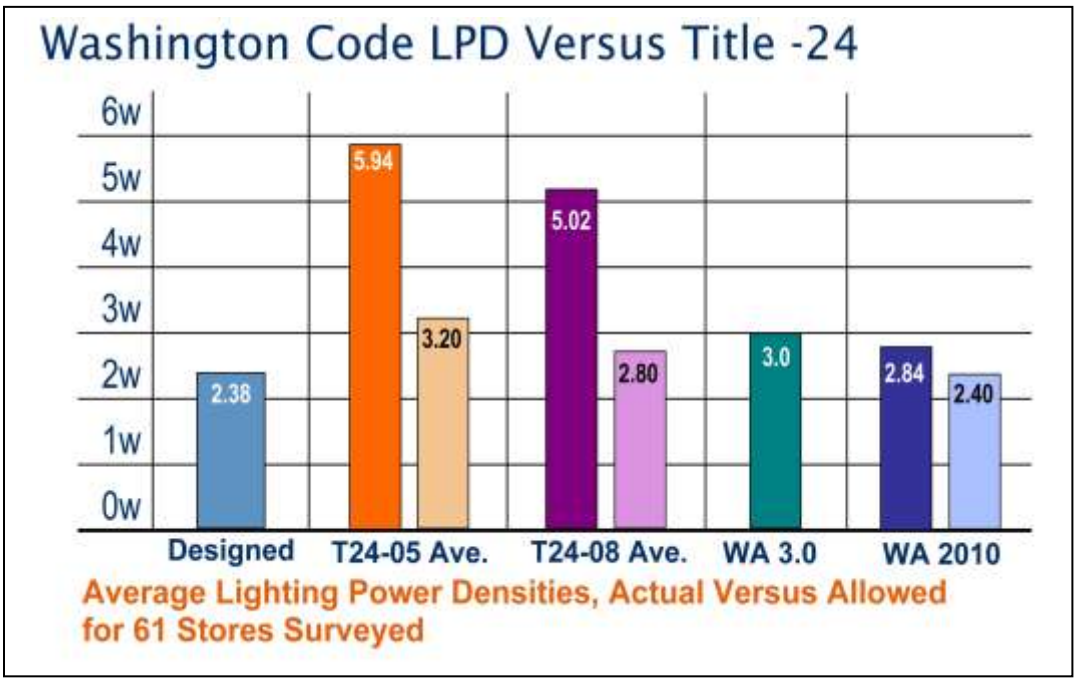


Figure 68: Comparison of Washington Energy Code to Title 24 for Retail Store Compliance

The analysis in **Error! Reference source not found.** compares average design watts for 61 stores, with compiled detailed LPD analysis, against Title 24 2005, Title 24 2008, the earlier 3.0W Washington Energy Code and Current Washington Energy Code 2010. For Title 24 comparisons and Washington 2010 Code, the average hypothetical maximum allowed LPD and actual average allowed LPD wattages are shown because Title 24 Tailored Compliance and Washington Energy Code 2010 use it or lose it component can result in the permitted allowed wattage that is lower than the hypothetical maximum allowed.

While, in theory both Title 24 2005 and Title 24 2008 would allow substantially more LPD than either of the Washington Code scenarios practical application proves otherwise. Title 24 2005 actual average allowed LPD was only 6% greater than Washington Code until the introduction of Washington Energy Code 2010. The current Title 24 2008 is on average LPD allowed under Tailored lighting is 7% less than the older Washington code and 16% greater than Washington 2010.

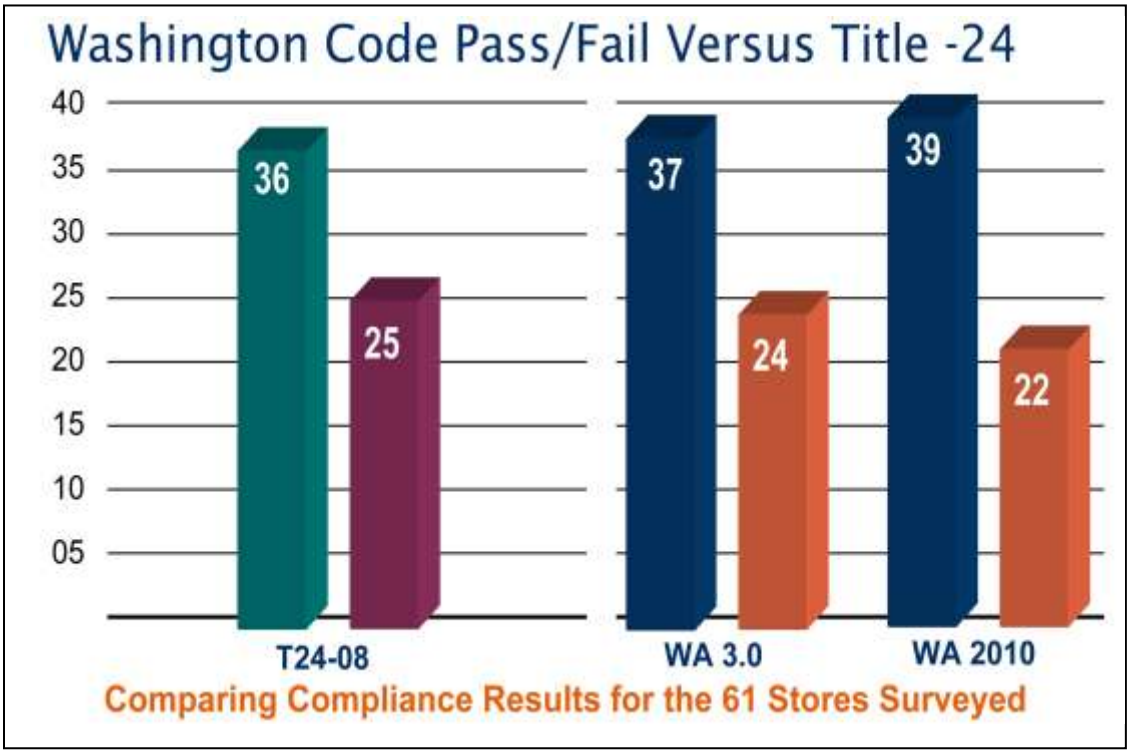


Figure 69: Washington Code Pass / Fail as compared to Title 24 for Retail Store Compliance

We compared each of the 61 store's design LPD against the allowed LPD under Title 24 2008 Tailored Method and the two Washington Codes allowed LPD under compliance, as shown in Figures 27 and 28 of this document.

Although Title 24 2008 average allowed LPD's under the Tailored Method (**Error! Reference source not found.** 23) was 16% greater than the Washington Energy Code 2010, fewer of the 61 spaces met compliance with their current design watts. This result was also true under the less stringent prior Washington code.

Finally we explored comparisons of current Title 24 2008 and our proposed Title 24 2013 to the most current ASHRAE/IESNA 90.1 2010 and the WASHINGTON 2010 Code using the results of the seven AGI-32 computer designed models. The objective of this analysis and comparison was to assure that our proposed Title 24 2013 Tailored Lighting component for retail spaces is at least as effective as ASHRAE/IESNA 90.1 2010 and WASHIGTON 2010. In addition as a result of this study we validated that given the design changes (the primary one being CMH baseline for display lighting) our models pass our proposed Title 24 2013 LPD targets.

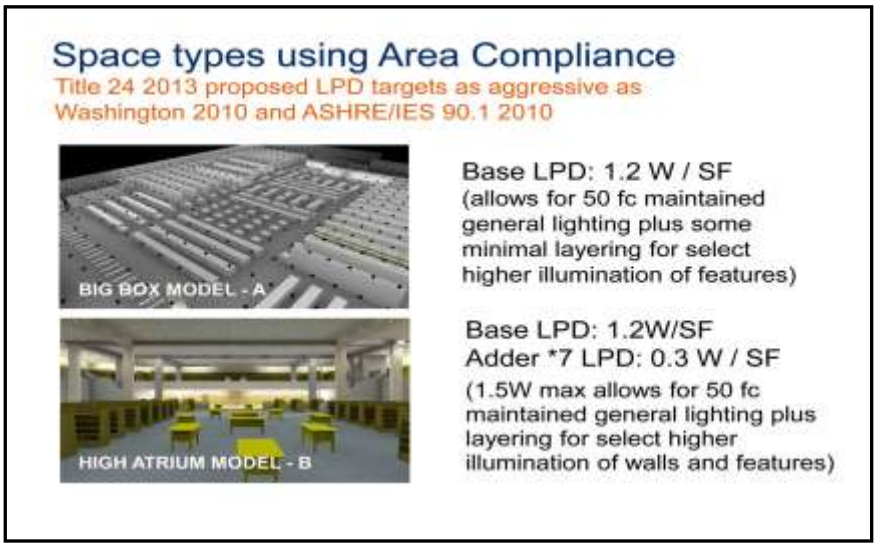


Figure 70: Models A and B Comply with T24 2013 Area Method

The "Big Box" retail model would be allowed a maximum 1.2W per square foot under our proposed Title 24 2013 LPD for 'Retail Lighting in the Area Category Compliance. Using cost effective advanced lighting as modeled the LPD of Model A is between 1.0W and 1.17W per square foot. This power density allows for the 50FC maintained general illumination as well as some additional secondary illumination with higher foot-candles for feature areas or detail task functions.

Model B, High Atrium Model, also complying under Title 24 2013 Area Category is allowed a maximum of 1.5W per square foot. In this scenario there is the base allowance of 1.2W per square foot as well as an additional 0.3W maximum for wall and or floor feature lighting (use-it or loose-it). Using cost effective advanced lighting Model B is 1.4W per square foot. This power density allows for 46 to 53FC maintained general illumination as well as a high level of Wall-Washing and some secondary illumination with higher foot-candles for feature areas or detail task functions.

Figure 71: Models C, D E, F and G Comply with T24 2013 Tailored Method

Models C trough G complying under Title 24 2013 Tailored Method. They would be allowed between 2.68W to 3.82W per square foot. The wide range of LPD's is contributed to the "Use-it-Loose it" aspects of all but base (general) lighting when using Tailored Compliance. All of the models, using the advanced technologies pass our Title 24 2013 targets. They all also are under the maximum allowed LPD's as defined in ASHRAE/IES 90.1 2010. From a quality perspective they also all meet or exceed their design standards as define in IESNA RP-2 2001 which was used as our designs standard document in producing these models.

Lighting Power Density (LPD) Comparison Title 24 Versus Washington Code and ASHRAE/IES 90/1
Using Retail Models Developed For Title 24 2013 Development and Analysis

Model ID and Description		Title 24 - 08 Allowed LPD	Title 24-08 Design LPD	Title 24-13 Design LPD	Title 24-13 Proposed LPD	Wash. 2010 Allowed LPD	ASHRAE 2010 Allowed LPD
Model A *7	Big Box Retail *1	1.60W Sq. Ft.	1.69W Sq. Ft.	1.17W Sq. Ft.	1.20W Sq. Ft.	1.33W Sq. Ft.	1.50W Sq. Ft.
Model B*7	High Atrium *2	1.60W Sq. Ft.	1.59W Sq. Ft	1.4W Sq. Ft.	**1.70W Sq. Ft**	1.33W Sq. Ft.	1.50W Sq. F*6t.
Model C	Precious Jewel *3	4.46W Sq. Ft.	4.12W Sq. Ft.	2.27W Sq. Ft.	3.82W Sq. Ft	4.05W Sq. Ft.	4.58W Sq. Ft.
Model D	High End Designer *4	3.65W Sq. Ft.	3.59W Sq. Ft.	2.47W Sq. Ft.	3.16W Sq. Ft.	3.60W Sq. Ft.	3.78W Sq. Ft.
Model E	Local Basic Retail *5	3.45W Sq. Ft.	2.81W Sq. Ft.	1.53W Sq. Ft.	2.68W Sq. Ft.	2.90W Sq. Ft.	3.50W Sq. Ft.
Model F	Furniture & Home *6	4.28W Sq. Ft.	4.21W Sq. Ft.	3.14W Sq. Ft.	**3.25W Sq. Ft.**	2.80W Sq. Ft.	3.30W Sq. Ft.
Model G	Kitchen/Table Top *6	4.50W Sq. Ft.	4.47W Sq. Ft.	2.80W Sq. Ft.	**3.38W Sq. Ft.**	2.80W Sq. Ft.	3.30W Sq. Ft.

*1: Big Box Design model with monolithic lighting *(high general lighting 50FC)* plus minimum layered additional lighting
*2: High Atrium Design model with high *(50FC)* general lighting plus layers of wall/perimeter and some additional feature lighting (1.2W base + allowed adds)
*3: CMH & LED design model with LPD of 2.47W Sq. Ft. - Alternate model using lower ambient, lower ceiling and Advanced Halogen IR probable at 3.83W target
*4: Alternate LED design model with lower LPD of 2.19W Sq. Ft. possible – Higher LPD allowed *(3.56 max)* with ornamental lighting adder
*5: Alternate LED design model with lower LPD of 1.39W Sq. Ft. possible – Higher LPD allowed *(3.18 max)* with ornamental lighting adder
*6: Proposed Title 24-2013 max LPD preliminary estimate – Detailed Tailored calculation still pending
*7: Models A and B evaluated on T24 Area Category (space by space) Compliance and comparable Washington and ASHRAE Building/Space compliance – Applying the lowest retail category adder to Washington and ASHRAE results in respective LPD of 1.75 for the Washington Code and 2.10 for ASHRAE

Figure 72: Models Comparison of the Seven Models to Title 24 2008, Proposed Title 24 2013, Washington 2010 Code and ASHRAE/IES 90.1 2010

All of the models actual lighting power densities (LPD) are within the maximum allowed LPD as defined in both our T24 2003 proposal and ASHRAE/IES 90.1 2010. While Models B, F and G as designed (2013 compliance models) are under the maximum allowed ASHRAE 90.1 2010 our proposed maximum allow Title 24 2013 targets are slightly higher than ASHRAE as well as higher than Washington 2010. One must remember however, that the allowed maximums assume all use-it loose it components area applied to their maximums. In most, if not all, actual design scenarios this would not happen. As was indicated by our actual; store surveys the stores are usually under the max allowed LPDs. their design standards as define in IESNA RP-2 2001 which was used as our designs standard document in producing these models.

4.8 Results of Ornamental Lighting Evaluation for Title 24 2013

The primary objective of the decorative and ornamental lighting evaluation was to demonstrate that most decorative and ornamental lighting applications can be achieved at significantly lower lighting power density (LPD) with use of energy efficient alternative technologies versus baseline standard incandescent and older fluorescent lighting. Since, as implied by Title 24 code, decorative and ornamental lights are supplemental lighting for visual effect or ambiance and not functional illumination, our models do not attempt to provide equal lumen output. The alternate high efficacy models do however; provide equivalent visual brightness and dynamics to the base line models. Cost effectiveness results for these models are found in 4.2 "Life Cycle Cost Analysis" within this Results section of the case study.

Ornamental lighting Models evaluated were:

- K - Large Chandelier (Baseline incandescent versus Halogen, CMH and High Lumen CFL)
- L - Small Chandelier (Baseline incandescent versus Halogen and CFL)
- M- Wall Sconce (Baseline incandescent versus Halogen, CFL and LED)
- N- Decorative Pendant (Baseline incandescent versus Halogen, CFL and LED)
- O- Luminous Panels (Baseline fluorescent, and LED)

Figure 35: Large Chandelier

MODEL K: Large Chandelier		
Design Model	WATTS	Watts Savings over Base
Standard – 6 150W A lamps	900W	No savings (baseline)
Option 1 – 6 100W Halogen A lamps (dimmable)	600W	300 watts
Option 2 – 4 High output CFL lamps & Ballasts	200W	700 watts
Option 3 – 4 39W CMH lamps and Ballasts	180W	720 watts

Figure 73: Model K Technologies Variations

Model K – Large Chandelier demonstrates that at minimum (using halogen lamping) the lighting power for this type of luminaire can be reduced by about 33% (option 1 alternate) while maintaining equivalent visual appearance and the potential for dimming when needed When/where dimming is not required additional lighting power reduction (75% to 80%) can be obtained by use of high output CFL or Ceramic Metal Halide systems. All the Large Chandelier options are cost effective under the 7 year cycle. [Refer to 4.2 for cost effectiveness results]

Figure 74: Medium Size Chandelier

MODEL L: Medium Size Chandelier		
Design Model	WATTS	Watts Savings over Base
Standard – 4 100W A lamps	400W	No savings (baseline)
Option 1 – 4 75W Halogen A lamps (dimmable)	300W	100 watts
Option 2 – 4 26W CFL lamps & Ballasts	120W	280 watts

Figure 75: Model L Technologies Variations

Model L – Medium Chandelier demonstrates that with using halogen lamping the lighting power for this type of luminaire can be reduced by 25% (option 1 alternate) while maintaining equivalent visual appearance and the potential for dimming when needed When/where dimming is not required a lighting power reduction of 75% can be obtained by use of CFL systems. The Medium Sized Chandelier options are also cost effective under the 7 year cycle. [Refer to 4.2 for cost effectiveness results]

Figure 76: Wall Sconce

MODEL M: Wall Sconce		
Design Model	WATTS	Watts Savings over Base
Standard – 2 40W Candelabra base lamps	80W	No savings (baseline)
Option 1 – 2 25W Candelabra base Halogen lamps	50W	30 watts (dimmable)
Option 2 – 2 9W CFL lamps & Ballasts	20W	60 watts
Option 3 – 2 5W LED lamps and driver	10W	70 watts

Figure 77: Model M Technologies Variations

Model M –Decorative Wall Sconce demonstrates that with using halogen lamping the lighting power for this type of luminaire can be reduced by 37% (option 1 alternate) while maintaining equivalent visual appearance and the potential for dimming when needed When/where dimming is not required a lighting power reduction of 75% can be obtained by use of CFL systems. Even greater power reduction (87%) and the ability to maintaining dimming is possible with LED systems (option 3). All of the Decorative Wall Sconce options are cost effective under the 7 year cycle. [Refer to 4.2 for cost effectiveness results]

Figure 78: Small Decorative Pendant

MODEL N: Small Decorative Pendant		
Design Model	WATTS	Watts Savings over Base
Standard – 1 40W Candelabra base lamps	40W	No savings (baseline)
Option 1 – 1 25W Candelabra base Halogen lamps	25W	15 watts (dimmable)
Option 2 – 1 9W CFL lamps & Ballasts	10.5W	29.5 watts
Option 3 – 1 3W LED lamps and driver	3.5W	36.5 watts

Figure 79: Model N Technologies Variations

Model N –Small Decorative Pendant demonstrates that with using halogen lamping the lighting power for this type of luminaire can be reduced by 37% (option 1 alternate) while maintaining equivalent visual appearance and the potential for dimming when needed When/where dimming is not required a lighting power reduction of close to 75% can be obtained by use of CFL systems. Even grater power reduction of up to 90% is possible with LED systems (option 3). Options 1 and 2 are cost effective within the 7 year cycle. The LED option (#3) is not cost effective at 7 years but is at 15 years.. [Refer to 4.2 for cost effectiveness results]

Figure 80: Luminous Wall Panel

MODEL O: Luminous Wall Panel		
Design Model	WATTS	Watts Savings over Base
Standard – 6 FT X 12 FT Back lighted Decorative Luminous Wall ((Standard T8 lamp and ballasts)	270W	No savings (baseline)
Option 1 – 6 FT X 12 FT Back lighted Decorative Luminous Wall ((Standard T8 lamp and ballasts)	215W	55 watts (dimmable)

Figure 81: Model O Technologies Variations

Model O – Luminous Wall Panels using fluorescent lighting often use higher levels of illumination to resolve uniformity issues than is needed for visual effect. This approach also results in higher power densities. LED light panels however can produce the desired uniformity while achieving desired light levels all at a lower power density. Furthermore LED panels are dimmable allowing for even greater flexibility with minimal additional cost. The alternate model (option 1) uses 20% less energy than the fluorescent base design. Even grater reduction is possible with the addition of the dimming complement. Additional "non energy" advantages of LED light panels over fluorescent light boxes are minimal to no maintenance and less complex wall sub structure. Because of significantly higher first cost, LED panel walls are not cost effective in the 7 year cycle. They are however cost effective under the 15 year scenario.

4.9 Eliminating Loopholes and Changes to IES Handbook

The 2008 code contained the potential for loopholes because some spaces were allowed to comply *either* under the Area Category Method *or* the Tailored Method. This resulted in a loophole because in at least one case (offices) the *base* LPD under Tailored was higher than the LPD allowed under Area Category. These potential loopholes have been eliminated in the proposed language in section 146(c)3, because it limits the use of the Tailored Method to only those spaces for which there is *no* Area Category type. I.e., to the types listed in Table 146-D and section 146(c)3H, or any space types not listed Tables 146-C or 146-D.

Furthermore, Title 24-2008 lighting power densities are based on recommended illuminance levels taken from the Ninth Edition of the IES Lighting Handbook. The IES has now released a 10th Edition of the IES Handbook with significant revisions to recommended illuminancesd as well as illuminance classifications. Proposed LPD's for Title 24-13 must take into account therecommended illuminances as defined in the new IES Handbook 10th Edition. Table 27 shows a comparison of recommended illuminance levels between the existing Title 24 Table 146-D, and the Ninth and Tenth Editions of the IES Lighting Handbook. Note that recommendations are listed in lux values, and not in lettered "Illuminance Categories." The latest edition of the IES Handbook uses a new system of lettered illuminance categories that do not correspond with the previous edition. In addition, because the space types listed in Table 146-D do not always correspond directly with IES Handbook categories, please reference the endnotes for the sources of the values listed

There appear to have been a number of typos in Title 24 2008, such that certain space types were put into the wrong illuminance categories. These include

- Auditorium areas
- Dining areas
- Exhibit, museum areas
- Financial transaction area
- Grocery store area (already covered under Bernie Bauer's work for Title 24 2013)
- Religious worship area
- Theater Area:
  - Motion Picture
  - Performance

Of these areas, most could have their LPD values reduced to a lower level for the 2013 code.

Addtionally, there are some space types for which the IES has revised its illuminances recommendations downward in the 10th Edition Handbook:

- Financial Transaction Area (see list above)
- Lounge/recreation area
- Malls and Atria (already covered under Retail Lighting Modeling for Title 24 2013)
- Waiting Area

Most of these area types could have their LPDs reduced for the 2013 code.

LIGHT LEVELS IN LUX USD TO DETERMINE ALLOWED LPD

	Current Title 24 Table 146-D	IES Handbook, Ninth Edition	IES Handbook, Tenth Edition
Auditorium Area	300 lux	100 lux[i]	100 lux[ii]
Civic Meeting Place	300 lux	300 lux[iii]	300 lux[iv]
Convention, Conference, Multipurpose, and Meeting Center Areas	300 lux	300 lux[v]	300 lux[vi]
Dining Areas	50 lux	100 lux[vii]	Varies by type[viii]
Exhibit, Museum Areas	100 lux	300 lux[ix]	50-200-1000 lux[x]
Financial Transaction Area	300 lux	500 lux[xi]	300 lux[xii]
Grocery Store Area	300 lux	500 lux[xiii]	500 lux[xiv]
Hotel Function Area	300 lux	300 lux[xv]	300 lux[xvi]
Lobby Area:			
Hotel Lobby	100 lux	100 lux[xvii]	100 lux[xviii]
Main Entry Lobby	100 lux	100 lux[xix]	100 lux[xx]
Lounge/Recreation Area	100 lux	100 lux[xxi]	40 lux[xxii]
Malls and Atria	300 lux	300 lux[xxiii]	100 lux[xxiv]
Religious Worship Area	300 lux	100 lux[xxv]	100 lux[xxvi]
Theater Area:			
Motion Picture	100 lux	50 lux[xxvii]	50 lux[xxviii]
Performance	300 lux	100-200 lux[xxix]	100 lux[xxx]
Transportation Function Area	300 lux	300 lux[xxxi]	300 lux[xxxii]
Waiting Area	100 lux	100 lux[xxxiii]	40 lux[xxxiv]

Figure 82: Comparison of recommendations between 9th and 10th editions of the IES Handbook

References for Figure 82

[i] See "Auditoriums, Assembly," page Interior-1, IES Handbook, Ninth Edition
[ii] See Table 24.2, "Auditoria, Multipurpose, Assembly, Audience, No AV," page 24.4, IES Handbook, Tenth Edition
[iii] See "Conference Rooms, Meetings," page Interior-2, IES Handbook, Ninth Edition
[iv] See Table 22.2, "Conferencing, Meeting, Discourse," page 22.14, IES Handbook, Tenth Edition
[v] See "Conference Rooms, Meetings," page Interior-2, IES Handbook, Ninth Edition
[vi] See Table 22.2, "Conferencing, Meeting, Discourse," page 22.14, IES Handbook, Tenth Edition
[vii] See "Food Service Facilities, Dining," page Interior-5, IES Handbook, Ninth Edition
[viii] Recommends 100 lux for "Casual dining," 200 lux for "Fast food dining," 30 lux for "Fine dining," 150 lux for "Cafeterias," 100 lux for "Coffee shops," etc. See Table 22.2, "Food Service, Dining," page 22.18, IES Handbook, Tenth Edition.
[ix] See "Museums, Exhibit Cases," page Interior-12, IES Handbook, Ninth Edition. Note that all exhibit or display recommendations are 300 lux depending on vertical or horizontal display.
[x] Values for "High Sensitivity to Light," "Low Sensitivity to Light," and "No Sensitivity to Light," respectively. See Table 21.2, "Exhibits and Galleries, Objects," page 21.4, IES Handbook, Tenth Edition.
[xi] See "Banks, Tellers' stations," page Interior-1, IES Handbook, Ninth Edition
[xii] See Table 31.2, "Financial Facilities, Banking Lobbies, Teller Window," page 31.6, IES Handbook, Tenth Edition
[xiii] See "Merchandising Spaces, Supermarkets," page Interior-12, IES Handbook, Ninth Edition
[xiv] See Table 34.2, "Retailing, Indoor, Grocery/Supermarket, General retail," page 34.12, IES Handbook, Tenth Edition
[xv] See "Conference Rooms, Meetings," page Interior-2, IES Handbook, Ninth Edition
[xvi] See Table 22.2, "Conferencing, Meeting, Discourse," page 22.14, IES Handbook, Tenth Edition
[xvii] See "Hotels, Lobby, General Lighting," page Interior-10, IES Handbook, Ninth Edition
[xviii] See Table 22.2, "Transition Spaces, Lobbies, General, At building entries, Day," page 22.28, IES Handbook, Tenth Edition. Note that recommendation for "Night" is 50 lux.
[xix] See "Offices, Lobbies, lounges, and reception areas," page Interior-13, IES Handbook, Ninth Edition
[xx] See Table 22.2, "Transition Spaces, Lobbies, General, At building entries, Day," page 22.28, IES Handbook, Tenth Edition. Note that recommendation for "Night" is 50 lux.
[xxi] See "Offices, Lobbies, lounges, and reception areas," page Interior-13, IES Handbook, Ninth Edition
[xxii] See Table 22.2, "Transition Spaces, Lounges, Clubs and Game Rooms, General," page 22.28, IES Handbook, Tenth Edition
[xxiii] See "Merchandising Spaces, Shopping mall areas, Main concourse," page Interior-12, IES Handbook, Ninth Edition
[xxiv] See Table 34.2, "Malls, Indoor, Concourses," page 34.8, IES Handbook, Tenth Edition
[xxv] See "Houses of Worship, Congregational areas," page Interior-10, IES Handbook, Ninth Edition
[xxvi] See Table 37.2, "Traditional Form, Congregation, Pre/Post-Worship," page 37.8, IES Handbook, Tenth Edition. Note that there are a wide variety of recommendations depending on the type of worship activity.
[xxvii] See "Motion Picture Theatre Auditoriums," page 15-12, IES Handbook, Ninth Edition
[xxviii] See Table 28.2, "Theaters, Film, House, Audience, Pre/Post-show, Intermission," page 28.16, IES Handbook, Tenth Edition
[xxix] See "Seating Area," page 15-8, IES Handbook, Ninth Edition
[xxx] See Table 28.2, "Theaters, Stage, House, Audience, Pre/Post-show, Intermission," page 28.18, IES Handbook, Tenth Edition.
[xxxi] See "Transportation Terminals, Baggage checking," page Transportation-6, IES Handbook, Ninth Edition. Note that "Ticket counters" recommend 500 lux, "Waiting room and lounge" and "Boarding area" recommend 50 lux, and "Concourse" recommends 30 lux.
[xxxii] See Table 36.2, "Aviation Terminals, Ticketing, Agent Counter," page 36.8, IES Handbook, Tenth Edition. Note wide range of values for other "transportation" space types.
[xxxiii] See "Health Care Facilities, Waiting areas, General" page Interior-9, IES Handbook, Ninth Edition
[xxxiv] See Table 22.2, "Transition Spaces, Lounges, Social/Waiting Areas," page 22.28, IES Handbook, Tenth Edition

4.10 Statewide Savings

Statewide savings estimates for the recommended measures are based on statewide new construction forecasts for retail buildings and estimates of lighting retrofit rates. Figure 83, below, describes the total retail square footage that will be subject to the code changes.

ANNUAL CODE CONTROLLED SQUARE FOOTAGE	
Retail Space	**Square Feet (Millions)**
Retail existing construction*	702.0
10% retail lighting retrofitted per year	70.2
Retail new construction per year**	32.4
Annual Square Footage Subject to Code	**102.6**
* California Commercial End-Use Survey 2006	
** Non Res Construction Forecast	

Figure 83: Retail Construction Estimates for Statewide Savings

Based on an analysis performed for the previous round of code revisions, 7% of retail construction uses the Tailored Method, with the balance of 93% using the Area Category Method. The retail store models described in section 0 and in the appendices were used to describe the types of retail store construction that would typically use each calculation method. Jewelry, Designer, Small Store, Furniture and Kitchen and Tableware models (Models C, D, E, F and G) were assumed to fall under the Tailored Method, and the Big Box and High Atrium models (Models A and B) were associated with the Area Category Method. Estimates of the percentage of the total square footage assigned to each retail was based on survey results discussed in section 4.1, as well as the relative sizes of each typical store type. For the purpose of estimating statewide savings, the Jewelry and Designer models were combined to represent "High End Retail," and the Furniture and Kitchen and Tableware models were combined to represent "Medium Priced Retail." Additionally, while the Area Category Method is expected to be used in more scenarios than just the Big Box and High Atrium models, the High Atrium model is representative of a wide range of smaller stores that might also use the Area Category Method.

Statewide savings calculations were performed using the LPD savings reported in section 0 to determine TDV savings for each model type. The resulting TDV savings was then weighted to correspond to the statewide square footage estimates.

Figure 84 and Figure 85, below, show statewide savings estimates for the proposed measures. As shown, the proposed Tailored Method measures will result in a total statewide demand savings of 9.663 MW and an energy savings of 40.316 GWh/year. Proposed Area Category Method measures will result in a total statewide demand savings of 37.022 MW and an energy savings of 154.547 GWh/year. In Figure 84 below, Model C and Model D sum together to comprise "High End Retail" space types, while Model G and Model F sum to comprise "Medium Priced Retail" space types.

TAILORED METHOD STATEWIDE SAVINGS						
Weighting factors	**Space Type**	**SqFt in Millions At 7% of State Total**	**Demand Savings (MW)**	**Energy Savings (GWh/yr)**	**Million TDV kBtu/yr**	**TDV Dollars (Millions/yr)**
5%	Model C - Jewelry	0.3591	0.664	2.772	70.616	6.285
5%	Model D - Designer	0.3591	0.402	1.678	42.751	3.805
10%	High End Retail	0.7182	1.067	4.450	113.368	10.089
25%	Model G - Kitchen	1.7955	2.998	12.510	318.727	28.366
25%	Model F - Furniture	1.7955	1.921	8.015	204.214	18.174
50%	Medium Priced Retail	3.5910	4.920	20.525	522.941	46.540
40%	Model E - Small Store	2.8728	3.677	15.341	390.870	34.786
100%	Weighted Sum	7.1820	9.663	40.316	1,027.178	91.416

Figure 84: Tailored Method Statewide Savings

AREA CATEGORY METHOD STATEWIDE SAVINGS						
Weighting factors	**Space Type**	**SqFt in Millions At 93% of State Total**	**Demand Savings (MW)**	**Energy Savings (GWh/yr)**	**Million TDV kBtu/yr**	**TDV Dollars (Millions/yr)**
60%	Model A - Big Box	57.2508	29.770	124.202	3,164.475	281.628
40%	Model B - High Atrium	38.1672	7.252	30.254	770.834	68.602
100%	Weighted Sum	95.4180	37.022	154.457	3935.309	350.230

Figure 85: Area Category Method Statewide Savings

4.11 Conclusions and Assumptions

1) The effectiveness of Tailored Method to address special needs for higher LPDs while tightest collator of lighting power density compliance is evident as proven from these results.

2) "Use it or lose it" provisions of the Tailored Method do work and are an effective deterrent to casually over lighting and/or using LPDs indiscriminately.

3) Retail spaces that truly require additional lighting power can obtain them using Tailored Method

4) Tailored Compliance should remain a component of Title 24 2013.

5) Current allowed maximum LPDs as defined under Tile 24 2008 Tailored Method can be reduced under Title 24 2013 while still maintaining the benefits for spaces requiring higher LPDs for special conditions and unique design environments.

6) Recommended Lighting Power Density reductions should be comprised of reductions feasible because of technology advancements over technology available in 2008 as well as adjustments based on IES Handbook 10th Edition illuminance recommendations and design strategies.

5. Recommended Language for the Standards Document, ACM Manuals, and the Reference Appendices

5.1 Code Change Proposals

Proposed changes to Title 24 building efficiency standards as applied to nonresidential buildings are:

1: Remove all but a few space types within (Table 146G T24-2008) from using Tailored Method. Spaces currently allowed Tailored Method Compliance under Title 24-2008, to be disallowed under the Proposed Title 24-2013 Tailored Compliance and moved to Area Method Compliance.

Within Area Method the spaces removed from Tailored Method will be added to the existing spaces allowed to comply under Area Method (Table 146F24-2008). Area Method (Table 146F24-2008) will also be updated to reflect lighting power adjustments (LPDs) generated from adding these new spaces as well as adjustments generated because of technology improvements and IESNA design recommended practices updates (IESNA RP_2 2011 and IESNA Handbook 10th Addition).

2: Reduce the allowed LPD for accent display and feature lighting under the Tailored Method (Table 146G T24-2008) based on use of Ceramic Metal Halide (CMH) as the primary light source for such lighting and Light Emitting Diode (LED) an additional optional light source for several types of display lighting. The current standards are based on primarily halogen lighting with some CMH, mostly for higher ceilings. Use of primarily CMH versus Halogen as the light source for this application will result in 30% to 50% LPD reductions for this category when applied to retail spaces.

Reduction within this category for other spaces is expected to be significantly less than for retail and may not be appropriate to all space types. However even spaces where use of CMH may not be applicable, because of the need to dim the accent display and feature lighting, using the latest generation of HIR lamping can produce 10% reductions. LED lighting where appropriate can produce further reductions in excess of 50% when compared to halogen lighting.

3: Reduce the allowed additional LPD for lighting "Valuable Merchandise" under Tailored Method. Use of primarily CMH and LED versus Halogen as the light source for this application will result in 40% to 60% LPD reductions for this category when applied to retail spaces.

4: Realign and/or update the mounting height adjustment factor (TABLE 146-H T24-2008) based on the most current high efficacy CMH, LED and IR Halogen lamp wattage range and optics. This adjustment will allow use of low wattage (20-25W) CMH lamps, LED lamps and Halogen IR lamps in lower ceilings while allowing adequate increased power with CMH (35/39W and 70W) applications when and or where appropriate at higher ceilings.

5: Reduce the allowed LPD for ornamental/special effect lighting under the Tailored Method (Table 146G T24-2008) and "Chandeliers & Sconces" Area Method (Table 146F24-2008). This reduction is based on use of newer technology candelabra and medium socket based halogen decorative lamps, increased options for CFL lamps, and low wattage CMH and LED options for decorative lighting. Use of these improved efficacy light sources can reduce LPDs in this category by 20% to 50%.

6: Mandate use of comprehensive lighting controls as a prerequisite to using the Tailored Lighting Method of Title 24 compliance under the 2013 standards. Multi-tier lighting zones, multi-level switching, demand responsive load controls, and occupancy sensors are some of the control types that are applicable. Use of a comprehensive set of controls will assure that the added power (LPDs) allowed under the Tailored Method will be used only when required for the specific lighting application and will be appropriately monitored. The control mandate must include commissioning and

verification.

Details of proposed language and revised tables and foot notes/comments to the Title 24-2008 standard is shown in 5.2:

5.2 Recommended Code Language

SECTION 146 – PRESCRIPTIVE REQUIREMENTS FOR INDOOR LIGHTING

(c) **Calculation of Allowed Indoor Lighting Power Density.** The allowed indoor lighting power density for each building type of use or each primary function area shall be calculated using one and only one of the methods in Subsection 1, 2 or 3 as applicable.

2. Area Category Method. Under the Area Category Method, the total allowed lighting power for the building is the sum of all allowed lighting powers for all areas in the building. For purposes of the Area Category Method, an "area" shall be defined as all contiguous spaces which accommodate or are associated with a single one of the primary functions listed in TABLE 146-F . Where areas are bounded or separated by interior partitions, the floor space occupied by those interior partitions shall be included in any area. If at the time of permitting a tenant is not identified for a multi-tenant space, the tenant leased space allowance from TABLE 146-F shall be used. When the Area Category Method is used to calculate the allowed total lighting power for an entire building, main entry lobbies, corridors, restrooms, and support functions shall be treated as separate areas.

Additional lighting power for functions listed in TABLE 146-F is permitted provided the functions LPD has a footnote attached to the function's base allowed LPD. The additional allowances:

- **a. Are use it or lose it**
- **b. Cannot be traded off between function areas**
- **c. The lesser of the actual power of the qualified lighting or the maximum allowed additional LPD**

Maximum allowed additional LPD for those functions with footnotes is as defined within the footnote attachment at the end of TABLE 146-F

3. **Tailored Method.** The Tailored Method shall be used only on projects with primary function areas that do not use the Area Category Method. **As a prerequisite to use of the Tailored Method of Compliance all lighting within the tailored spaces shall be controlled via an EMS (Energy Management System) with separate control for floor and wall display, casework and specialty lighting and Ornamental Special effects lighting. Specific control requirements for the Tailored Compliance are found in Section _____.**

Under the Tailored Method, the allowed indoor lighting power shall be calculated according to primary function type as permitted in column 1 of TABLE 146-G.

A. For all spaces, determine the general lighting allowance according to Section 146(c)3A. If a specific IESNA Illuminance Category is listed in Column 2 of TABLE 146-G, then such illuminance Category shall be used. ~~*Otherwise, determine the illuminance category for each lighting primary function type according to categories specified in the IESNA Lighting*~~

~~*Handbook (IESNA HB), using the "Design Guide" for illuminance. Tasks that are performed less than 2 hours a day or poor quality tasks that can be improved shall not be employed to justify use of Illuminance Categories E, F, or G.*~~

i. Determine the area of each primary function. .

ii. Determine the room cavity ratio (RCR) for each primary function area. The RCR shall be calculated using either Equation 146-G or Equation 146-H.

iii. Multiply the area of each primary function by the allowed lighting power density for the illuminance category and RCR for each primary function area according to TABLE 146-I. The product or the actual installed lighting power for the primary function, whichever is less, is the Allowed General Lighting Power for the space.

B. Determine additional allowed power for display and decorative lighting according to Sections 146(c)3B. Displays that are installed against a wall shall not qualify for the floor display lighting power allowances. Floor displays shall not qualify for the wall display allowances.

i. Separate wall display lighting power is permitted if allowed by column 3 of TABLE 146-G. The allowed wall display lighting power is the smaller of:

d. The product of the room wall lengths and the listed allowed power density watts per linear foot (W/lf) in column 3 of TABLE 146-G, if applicable, or

e. The actual power of wall lighting systems.

The length of display walls shall include the length of the perimeter walls, including closable openings and permanent full height interior partitions. Permanent full height partitions are those which extend from the floor to within 2 feet of the ceiling or are taller than 10 feet, and are permanently anchored to the floor. Commercial and industrial storage stacks are not permanent full height partitions. For lighting mounting height of 11 feet 6 inches above the finished floor or higher, this amount may be increased by multiplying the product by the appropriate factor from TABLE 146-H. Qualifying wall lighting systems shall be mounted within 10 feet of the wall and shall be of a lighting system type appropriate for wall lighting including a lighting track, wallwasher, valance, cove, or accent light including adjustable or fixed luminaires with PAR, R, MR, AR, or other projector lamp types.

ii. Separate floor display lighting power is allowed if allowed by column 4 of TABLE 146-G. The allowed floor display lighting power is the smaller of:

a. The product of the area of the primary function and the allowed floor display lighting power density listed in column 4 of TABLE 146-G, if applicable, or

b. The actual power of floor display lighting systems.

For display lighting mounting of ~~*11 feet 6 inches*~~ **12 feet** above finished floor or higher, this amount may be increased by multiplying the product by the appropriate factor from TABLE 146-H. Qualifying floor display lighting systems shall be mounted no closer than 2 feet to a wall and shall be a lighting system type such as track lighting, adjustable or fixed luminaires with PAR, R, MR, AR, or other projector lamp types or employing optics providing directional display light from non-directional lamps. Except for lighting that is external to display cases as defined below, lighting mounted inside of display cases shall also be considered floor display lighting.

iii. Separate ornamental/special effects lighting power is permitted if allowed by column 5 of TABLE 146- G. If so, the allowed ornamental/special effects lighting power is the smaller of:

a. The product of the area of the primary function and the allowed ornamental/special effects lighting power density specified in column 5 of TABLE 146-G, if applicable, or

b. The actual power of allowed ornamental/special effects lighting luminaires.

Qualifying ornamental luminaires include chandeliers, sconces, lanterns, neon and cold cathode, light emitting diodes, theatrical projectors, moving lights, and light color panels when used in a decorative manner that does not serve as display lighting. Ornamental/special effects lighting shall not be the only light source in the space.

iv. In retail merchandise sales, museum, and religious worship, the smallest of the following separate lighting power for display cases presenting very valuable display items is permitted:

a. The product of the area of the primary function and ~~*1.0*~~. **0.8** watt per square foot; or

b. The product of the area of the display case and ~~*16*~~ **12.0** watts per square foot, or

c. c. The actual power of lighting for very valuable displays.

Qualifying lighting includes internal display case lighting or external lighting employing highly directional luminaires specifically designed to illuminate the case or inspection area without spill light. To qualify for this allowance, cases shall contain jewelry, coins, fine china or crystal, precious stones, silver, small art objects and artifacts, and/or valuable collections the display of which involves customer inspection of very fine detail from outside of a locked case.

v. Only the general portion of the lighting power determined in Section 146(c)3A above shall be used for tradeoffs among the various occupancy or task types of the permitted space. The allowed wall display lighting power, the allowed floor display lighting power, the allowed ornamental/special effect lighting power, and the allowed lighting power for very valuable displays are "use it or lose it" power allowances that shall not be traded off.

C. **For those function types without a pre-determined illuminance category listed in Table 146 G column 2 refer to Table 146-J. From Table 146J:**

i. Select the primary function type for which the illuminance category is to be determined.

ii. Refer to the IESNA Lighting Handbook (IESNA HB) 10th Addition.

a. Using the "Design Guide" determine the appropriate illuminance category.

b. Tasks that are performed less than 2 hours a day or poor quality tasks that can be improved shall not be

employed to justify use of Illuminance Categories E, F, or G.

TABLE 146-F AREA CATEGORY METHOD - LIGHTING POWER DENSITY VALUES (WATTS/FT^2)

PRIMARY FUNCTION	ALLOWED LIGHTING POWER (W/ft^2)	PRIMARY FUNCTION		ALLOWED LIGHTING POWER (W/ft^2)
Auditorium	1.5 ~~1~~ **4**	Laboratory, Scientific		1.4 ~~4~~ **1**
Auto Repair	0.9 **2**	Laundry		0.9
Beauty Salon	1.7	Library	Reading areas	1.2 **3**
Civic Meeting Place	1.3 ~~1~~ **4**		Stacks	1.5 **3**
Classrooms, lecture, training, vocational room	1.2 **6**	Lobbies	Hotel lobby	1.1 1
~~Commercial and industrial storage (conditioned. & unconditioned.)~~	~~0.6~~		Main entry lobby	1.5 1
Commercial and industrial storage (refrigerated)	0.7	Locker/dressing room		0.8
Convention, conference, multipurpose and meeting meeting centers	1.4 ~~1~~ 4	Lounge/recreation		1.1
Corridors, restrooms, stairs, and support areas	0.6	Malls and atria		1.2 ~~1~~ **4**
Dining	1.1 ~~1~~ 4	Medical and clinical care		1.2
Electrical, mechanical, telephone rooms	0.7 2	**Offices** > 250 square feet		~~.9~~ **0.75**
Exercise center, gymnasium	1.0	**Offices** < 250 square feet		~~1.1~~ **1.0**
Exhibit, museum	2.0	Parking garage	Parking Area	0.2
Financial transactions	1.2 ~~1~~ **4**		Ramps and Entries	0.6
General commercial and industrial work	Low bay 0.9 2	Religious worship		1.5 ~~1~~ **4**
	High bay 1.0 2	Retail merchandise sales, wholesale showrooms		~~1.6~~ **1.2** **7 - 8**
	Precision 1.2 ~~3~~ **5**	Tenant lease space		1.0
Grocery sales	~~1.6~~ 1.2 **7 - 8**	Theaters	Motion picture	0.9 ~~1~~ **4**
Hotel function area	1.5 ~~1~~ **4**		Performance	1.4 ~~1~~ **4**
Housing, Public and Commons Areas	Multi-family, Dormitory 1.0	Transportation Function		1.2
	Senior ~~*Housing*~~ **Sleeping Area** 1.5	Waiting area		1.1 ~~1~~ **4**
Kitchen, food preparation	1.6	All other		0.6

FOOTNOTES:

1. The smallest of the ~~*following values*~~ **actual design watts or the value listed below** may be added ~~*to the allowed lighting power for ornamental chandeliers and sconces that are in addition to and switched or dimmed on circuits different from the circuits for general lighting*~~ **when using the Area Category Method of Compliance.**

   a. ~~*One watt per square foot times the area of the task space that the chandelier or sconce is in; or*~~
   b. ~~*The actual design wattage of the chandelier or sconce.*~~

~~*2. The smallest of the following values may be added to the allowed lighting power for specialized task work:*~~

~~a. *0.5 watt per square foot times the area of the task space required for an art, craft assembly or manufacturing operation; or*~~
~~b. *The actual design wattage of the luminaire(s) providing illuminance to the specialized task area. For spaces employing this allowance, the plans shall clearly identify all task spaces using these tasks and the lighting equipment designed to*~~

~~*illuminate these tasks. Tasks that are performed less than two hours per day or poor quality tasks that can be improved are not eligible for this*~~

~~*specialized task work allowance.*~~

~~*3. The smallest of the following values may be added to the allowed power for precision commercial and industrial work:*~~

~~a. *One watt per square foot times the area of the task space required for the precision work; or*~~
~~b. *The actual design wattage of the luminaire(s) providing the illuminance to the precision task area. For spaces employing this allowance, the plans shall clearly identify all task spaces using these tasks and the lighting equipment designed to illuminate these tasks. Tasks that are performed less than two hours per day or poor quality tasks that can be improved are not eligible for this precision task work allowance.*~~

~~*4. The smallest of the following values may be added to the allowed lighting power for specialized task work:*~~

~~a. *0.2 watt per square foot times the area of the task space required for a lab in a school; or*~~
~~b. *The actual design wattage of the luminaire(s) providing illuminance to the specialized task area.*~~

Only those primary function areas listed in the Area Category Table having one of the following footnote numbers after the allowed lighting power are allowed this added lighting power. The plans shall clearly identify all task spaces using these tasks and the lighting equipment designed to illuminate these tasks. Tasks that are performed less than two hours per day or poor quality tasks that can be improved are not eligible for these allowances. This added lighting power shall not be used when using the Complete Building or Tailored Lighting methods of compliance

Footnote No.	**Type of lighting system**	**Highest allowed added lighting power**	
1	**specialized task work**	**0.2**	**W/ft² area of the task space**
2	**specialized task work**	**0.5**	**W/ft² area of the task space**
3	**ornamental or special effects lighting**	**0.5**	**W/ft² area of the task space**
4	**ornamental chandeliers and sconces**	**.5**	**W/ft² area of the task space**
5	**precision commercial and industrial work**	**1.0**	**W/ft² area of the task space**
6	**white board or chalk board**	**5.5**	**W/ linear foot**
7	**accent, display and feature lighting **1**	**0.3**	**W/ft² area of the task space**
8	**decorative lighting **2**	**0.2**	**W/ft² area of the task space**
References for Footnotes 7 & 8: **1 Use it or lose it and luminaires must be adjustable and/or directional ****1 Use it or lose it and luminaires primary function must decorative and in addition to general illumination luminaires**			

TABLE 146-G TAILORED METHOD SPECIAL LIGHTING POWER ALLOWANCES

1	2	3	4	5
Primary Function	Illumination Category	Wall Display Power (W lin. ft)	Allowed Floor Display Power (W sq.ft[2])	Allowed Ornamental! Special Effect Lighting
Auditorium	D	2.25	0.3	0.5
Civic Meeting Place	D	3.15	0.2	0.5
~~Commercial and industrial storage~~ ~~Inactive~~ ~~Active: bulky items; large labels~~ ~~Active: small items; small labels~~	 ~~B~~ ~~C~~ ~~D~~			
Convention, conference, multipurpose and meeting centers	D	2.5	0.4	0.5
~~Correction Facility cells and day rooms~~	~~D~~	~~0~~	~~0~~	~~0~~
Dining	B	1.5	0.6	~~0.6~~ 0.5
~~Dressing room~~	~~D~~	~~0~~	~~0~~	~~0~~
~~Education facilities~~ ~~Classrooms, lecture, training, vocational room~~ ~~Science Labs~~	 ~~D~~ ~~E~~	 ~~5.5~~ ~~5.5~~	 ~~0~~ ~~0~~	 ~~0~~ ~~0~~
~~Exercise center, gymnasium~~	~~IESNA HB~~	~~0~~	~~0~~	~~0~~
Exhibit, museum	C	~~20.0~~ 15.0	~~1.4~~ 1.2	~~0.7~~ 0.5
Financial Transactions	D	3.15	0.2	~~0.6~~ 0.5
~~Food Service Facilities~~ ~~Butcher Shop, Food Display, Galley, Kitchen, Scullery~~ ~~All other~~	 ~~E~~ ~~C~~	 ~~0~~ ~~0~~	 ~~0~~ ~~0~~	 ~~0~~ ~~0~~
Grocery store	D	9.9	1.1	0
~~Housing, Public and Commons Areas~~ ~~Multi-family~~ ~~Dormitory, Senior Housing~~	 ~~D~~ ~~D~~	 ~~0~~ ~~0~~	 ~~0~~ ~~0~~	 ~~0.9~~ ~~0.9~~
Hotel function area	D	2.25	0.2	0.5
~~Laundry~~	~~D~~	~~0~~	~~0~~	~~0~~
~~Library (Reading areas, Stacks)~~ [1]	~~D~~	~~0~~	~~0~~	~~0.6~~
Lobbies: Hotel lobby Main entry lobby	 C C	3.15	 0.2 0.2	~~0.6~~ 0.5
~~Locker~~ [1]	~~C~~	~~0~~	~~0~~	~~0~~
Lounge, recreation	C	7	0	~~0.7~~ 0.5
Malls and atria	D	3.5	0.5	~~0.6~~ 0.5
~~Medical and clinical care~~	~~IESNA HB~~	~~0~~	~~0~~	~~0~~
~~Office~~ ~~Open office; Intensive VDT use~~ ~~Open office; Intermittent VDT use~~ ~~Private Office~~	 ~~D~~ ~~E~~ ~~E~~	~~0~~	~~0~~	~~0~~
~~Police or fire stations~~	~~IESNA HB~~	~~0~~	~~0~~	~~0~~
Religious worship	D	1.5	0.5	0.5
Retail merchandise sales, wholesale showrooms	D	~~17.0~~ 14.0	~~1.2~~ 1.0	~~0.7~~ 0.5
Public rest areas along state and federal roadways	IESNA HB	0	0	0
~~Stairways and corridors; toilets and washrooms~~	~~B~~	~~0~~	~~0~~	~~0~~
~~Tenant lease space~~	~~C~~	~~0~~	~~0~~	~~0~~

1	2	3	4	5
Primary Function	Illumination Category	Wall Display Power (W/ft)	Allowed Floor Display Power (W/ft^2)	Allowed Ornamental/ Special Effect Lighting
Theaters: Motion picture Performance	 C D	 3 6	 0 0	 ~~0.6~~ 0.5 ~~0.6~~ 0.5
Transportation Function	D	3.15	0.3	~~0.6~~ 0.5
Waiting area	C	3.15	0.2	~~0.6~~ 0.5
~~All other not included above~~	~~IESNA HB~~	~~0~~	~~0~~	~~0~~
~~[1]Library stacks and locker rooms may use a room cavity ratio (RCR) of > 7 in Table 146-I.~~				

TABLE 146-H ADJUSTMENTS FOR MOUNTING HEIGHT ABOVE FLOOR

Height in feet above finished floor and bottom of luminaire(s)	Floor Display - Multiply by	Wall Display – Multiply by
~~11' 6"~~ 12' or less	1.0	1.0
>~~11' 6"~~ 12'	1.~~2~~ 15	1.15
>16'	1.~~4~~ 3	1.3

TABLE 146-I ILLUMINANCE CATEGORIES A THROUGH G LIGHTING POWER DENSITY VALUES (WATTS/FT^2)

IESNA Illuminance Category	**RCR<3.5**	**3.5<RCR<7.0**	**RCR>7.0**
A	0.2	0.3	0.4
B	0.4	0.5	0.7
C	0.6	0.8	1.1
D	0.9	1.2	1.4
E	1.3	1.8	2.5
F	2.7	3.5	4.7
G	8.1	10.5	13.7

TABLE 146-J TAILORED METHOD LIGHTING POWER ALLOWANCES USING IES CRITERIA

1	2
Primary Function	Illumination Category
Exercise center, gymnasium	IES HB
Medical and clinical care	IES HB
Police or fire stations	IES HB
Public rest areas along state and federal roadways	IES HB
All other not included above	IES HB

6. Appendices

6.1 Appendix I--Designer, End-User and Manufacturer Interview

PG & E CASE STUDY

TITLE 24-2013 TAILORED METHOD

UPDATE & REVISIONS

Designer, End User and Manufacturer Survey Form

Prepared by Integrated Lighting Concepts November 14, 2009

[Version II revised March 15, 2010]

Introduction

I am interviewing people to understand ways that the California Title 24 building energy code can be improved to save more energy and become easier to use. This project is funded by PG&E in support of their Codes and Standards program.

INTERVIEW QUESTIONS

1. Are you familiar with the lighting requirements in the California Title 24 building energy code?

Yes No

2. Do you find any parts of the lighting requirements in Title 24 confusing or contradictory? If yes, please explain what aspects.

Yes No

What aspects? Please provide details:

Please explain how the aspects noted could be improved?

3. Do you use current limiters with track lighting for Title 24 compliance? Yes No

If yes, what type/types are used?

Attached to track end Current limiter sub panel Other system/type (explain below)

_____

_____

_____

_____

_____

4: Do you have any recommendations or suggestions that if included as part of Title 24 – 2011 could lower power consumption and result in energy savings? Please note recommendations and comments below:

_____

_____

_____

_____

_____

_____

(add attachments as needed)

5. Accepting the premise that reducing power densities under the 2011 code version must (will) occur rank the following measures regarding practical or feasible means for achieving LPD reductions.

(please rate practicability or feasibility of each as follows: 5 = Excellent 4 = Very Good 3 = Good 2 = Fair 1 = Poor 0 = Not Acceptable)

Use Ceramic Metal Halide and/or LED as the basis for most focal/feature lighting such as accent and display lighting artwork and architectural feature wall washing.

Eliminate, or at minimum, substantially reduce most exemptions for special applications

Expand control requirements and use of controls, especially in tailored compliance

Totally eliminate (do away with) Tailored Method under 2011 standards and replace with limited power add-ons (similar to ASHRAE/IES 90.1) - specialized spaces/needs only

Limit Retail Lighting to 3W Sq. Ft. (1.5W + 1.5W exempt display) similar to the Washington State Energy Code

Base new lighting wattage limitations (LPD's) on Metal Halide equipment on electronic ballasts and Pulse Start or Ceramic Metal Halide lamps

Base new lighting wattage limitations (LPD's) on fluorescent equipment with electronic ballasts and latest generation of T8 and or T5 lamps

Base new lighting wattage limitations (LPD's) on incandescent equipment with IRC MR16 lamps and electronic transformers (low voltage incandescent) and next generation Halogen IR lamps for all other incandescent lamps

Expand the mandate for uses of "Day-lighting" to more application types and smaller footprints

Increase stringency of base lighting power densities and add more control credits to offset the lower LPD's so as to encourage higher use of automatic control of lighting

Reduce ambient lighting in spaces with abundant display lighting

Less uniformity of display lighting

Lower light levels but use color to attract customer attention

Utilize automatic controls in window displays to reduce light levels at night time

6. Have you used the tailored method within the last year? Yes No

<skip questions 7-9 if they answer NO>

<Use questions 7, 8 & 9 to fill out table - see below>

7: For which space types and/or applications do you use the Tailored Method compliance?

Retail Hospitality Museum Worship Offices

Other (Explain space type & application) _____

8: What percentage of time do you currently use the Tailored method of compliance for the project? (% for each of the various space types)

Space Type Used Y/N % of time Why tailored?

Retail

Hospitality

Museum

Worship

Offices

Other(s) describe below

1.

2.

3.

4.

9. Why is the tailored lighting method needed? <check all that apply>

a) Tall narrow rooms have high RCR – lot of losses in space

b) Low reflectance surfaces in space or cavities that are hard to light

c) Need for display lighting with high contrast

d) Need high light levels for design

e) Need to use incandescent or halogen lighting

f) Specialized high-resolution task

g) Need high light levels for space to stand out

g) Other (explain) _____

10: Ceramic Metal Halide lighting is a feasible alternative to incandescent and halogen lighting for commercial and retail applications. <check box to indicate your level of agreement>

Strongly Agree Somewhat Agree Not Sure/Don't Know

Somewhat Disagree Strongly Disagree

11: LED lighting will become a feasible alternative to incandescent and halogen lighting for commercial and retail applications by 2011. <check box to indicate your level of agreement>

Strongly Agree Somewhat Agree Not Sure/Don't Know

Somewhat Disagree Strongly Disagree

12. What, if any, are current limitations to the feasibility of replacing incandescent or halogen lighting with ceramic metal halide? <check all that apply>

a) Color quality

b) Beam control

c) Variety of wattages and beam spreads

d) First cost

e) Maintenance cost

f) Other (please explain) _____

13. What, if any, are current limitations to the feasibility of replacing incandescent or halogen lighting with LED lighting? <check all that apply>

a) Color quality

b) Beam control

c) Variety of wattages and beam spreads

d) First cost

e) Maintenance cost

f) Other (please explain) _____

14: If California were to set compliance standards which resulted in increased use of CMH lamps and luminaires, how soon could luminaire and lamp manufactures respond to increased demand (equivalent to ½ of the current halogen luminaire market) for these products in California? <check one>

Six (6) months or less

Six (7) to Nine (9) Months

Nine (10) months to One (1) year

More than one (1) year to Eighteen (18) months

Nineteen (19) Months to Two (2) years

More than Two (2) years

More than Three (3) years

Possibly never

15: If California were to set compliance standards which resulted in increased use of LED lamps and luminaires, how soon could luminaire and lamp manufactures respond to increased demand (equivalent to ½ of the current halogen luminaire market) for these products in California?

Six (6) months or less

Six (7) to Nine (9) Months

Nine (10) months to One (1) year

More than one (1) year to Eighteen (18) months

Nineteen (19) Months to Two (2) years

More than Two (2) years

More than Three (3) years

Possibly never

16. What is the typical lifespan of lighting equipment used in retail? _____ Years

Other Commercial spaces? _____ Years

17: What do you believe are/is the greatest challenges/challenge and/or barriers to potential changes in the energy code for 2011?

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____.

6.2 Appendix II -Big Box Store (Model A)

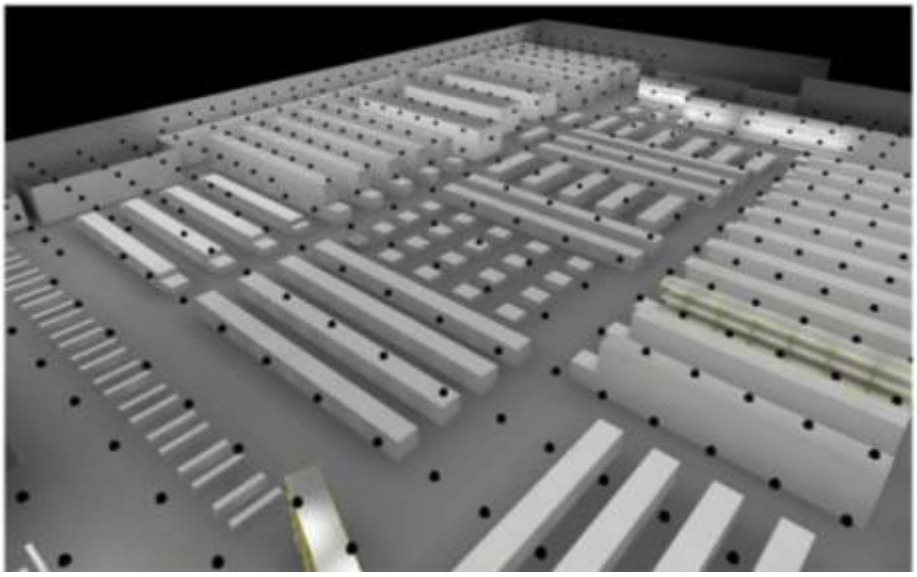


Figure 86: Big Box Store (Model A)

Model A represents the typical big box retail store as shown in **Error! Reference source not found.**Figure 86: Big Box Store (Model A) This type of space was chosen because of common use of daylight harvesting to reduce LPD during daylight hours. The connected load that was measured for purposes of this study was during evening hours during complete outside darkness. This model is also suitable for doing advanced daylight harvesting modeling.

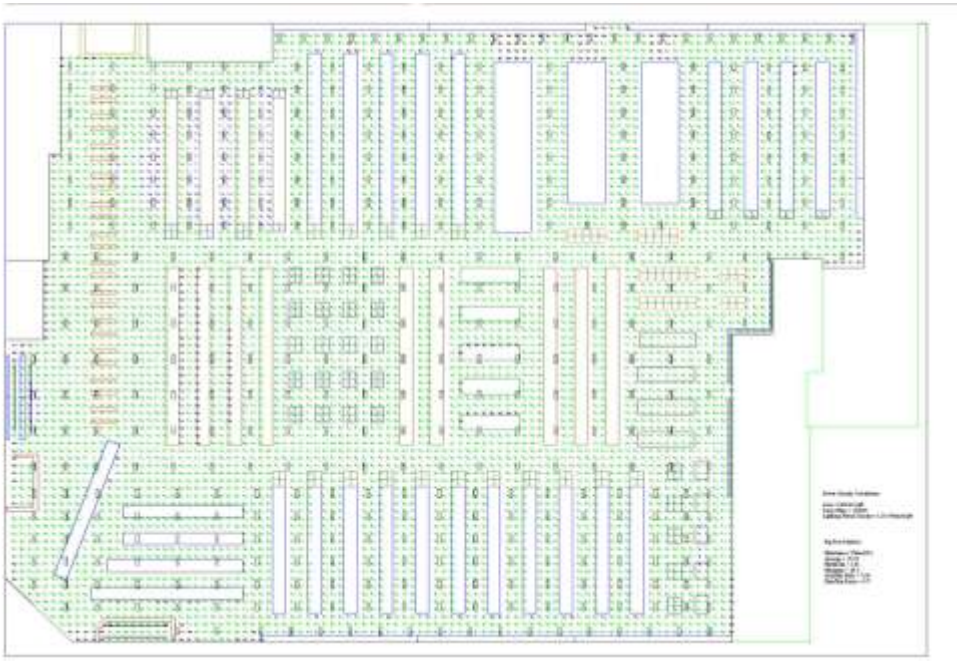


Figure 87: Big Box Lighting RCP (Model A)

Luminaire Description	Watts per Fixture	Fixture Lumens	LLF	Quantity
4 Ft 2 Lamp T8 Industrial Fluorescent Electronic Ballast	68	5,900	0.68	63
High Bay Fixture w/ Refractor - Pulse Start Magnetic Ballast	458	36,000	0.56	452

Figure 88: Computer Model A – Big Box Store Under Title 24 2008 Compliance

Luminaire Description	Watts per Fixture	Fixture Lumens	LLF	Quantity
4 Ft 2 Lamp T5/HO Industrial Fluorescent Electronic Ballast	88	10,000	0.72	63
4 Ft 6 Lamp T5/HO Specular Reflector Electronic Ballast	324	30,000	0.72	452

Figure 89: Computer Model A1 – Big Box Store New Luminaire Technology & IES Standards

6.3 Appendix III High Atrium Store

Figure 90: High Center Atrium Store (Model B)

Model B represents a large store with a high center atrium. A prototype similar to a book store is used which includes a variety of sub-area lighting design opportunities. Many other retail stores fit this category using a center light-well to use daylighting. The higher ceilings allow the designer to take advantage of Ceramic Metal Halide (CMH). A CMH luminaire with narrow beam optics is very effective at ceiling heights between 15 to 25 feet.

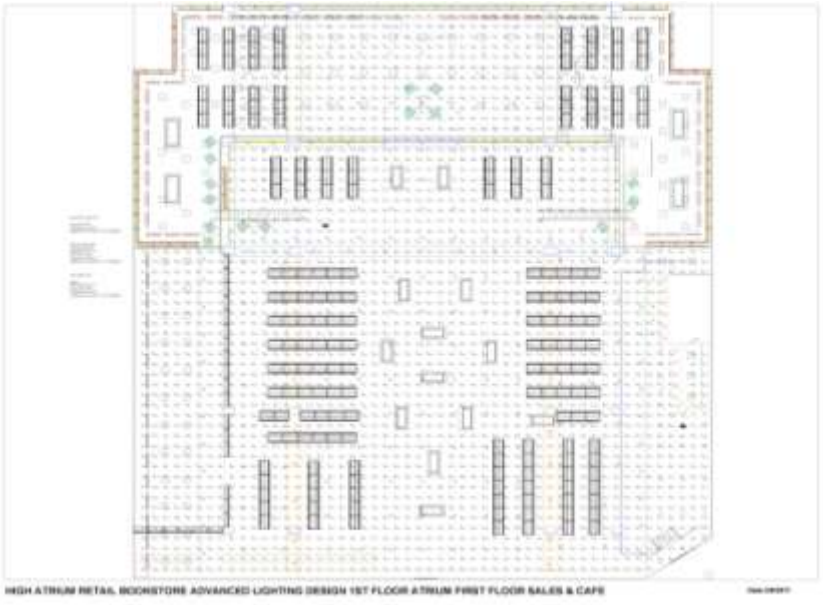


Figure 91: High Atrium Lighting RCP (Model B)

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
150W PSMH ED17	165	6869	0.63	157
Parabolic 2x2 3 Lamp Biax	126	6102	0.72	156
2 F32 T8 1x4 Louvered	61	3820	0.63	119
2 26W Biax Downlight	62	1587	0.72	120
70W PSMH ED17	77	3174	0.63	24
2 42W Triple Tube CFL	93	3548	0.72	29

Figure 92: Computer Model B – High Atrium Retail Under Title 24-2008

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
100W CMH PAR38 WFL	110	5602	0.72	146
2x2 2 Lamp F40 Indirect	68	4794	0.72	122
F32 T8 Wallwasher	32	1991	0.72	86
7" PLT 42W CFL Downlight	46	2085	0.72	80
7" PLT 32W CFL Downlight	37	1489	0.72	40
70W CMH PAR38 WFL	78	4166	0.72	24
2 32W Triple Tube CFL	76	3482	0.72	29

Figure 93: Computer Model B1 – High Atrium New Luminaire Technology & IES Standards

6.4 Appendix IV High End Jewelry Store

Figure 94: High End Jewelry Store (Model C)

Model C is a high end jewelry store, with an open fascia within an interior mall setting. There is a high case to floor surface ratio, many wall displays and cove fluorescents used extensively for ambient lighting.

Figure 95: High End Jewelry Lighting RCP (Model C)

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
75W Recessed PAR30 HIR Accent Spot	75	1000	0.79	82
42W Single Triple Tube CFL Downlight	44	3200	0.64	21
4 Foot Field Staggered T8 Fluorescent Cove	37	2900	0.68	39

Figure 96: Computer Model C – High End Jewelry Under Title 24 2008

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
Recessed PAR20 CMH Accent Light	39	2100	0..68	82
Single Tube Fluorescent Downlight	42	3200	0..64	21
Field Stagger High Lumen Fluorescent Cove	35	3100	0.68	39

Figure 97: Computer Model C1 - High End Jewelry New Luminaire Technology

6.5 Appendix V High Designer Shop

Figure 98: Model D High Designer Shop (High End & Designer Fashions)

Model D is a typical designer shop that carries expensive suits, dresses, gowns and/or accessories within a larger "High End" specialty department store. This model is like Neiman Marcus, Saks or Bloomingdales. Some accent lighting is contributed from the circulation area outside of the shop.

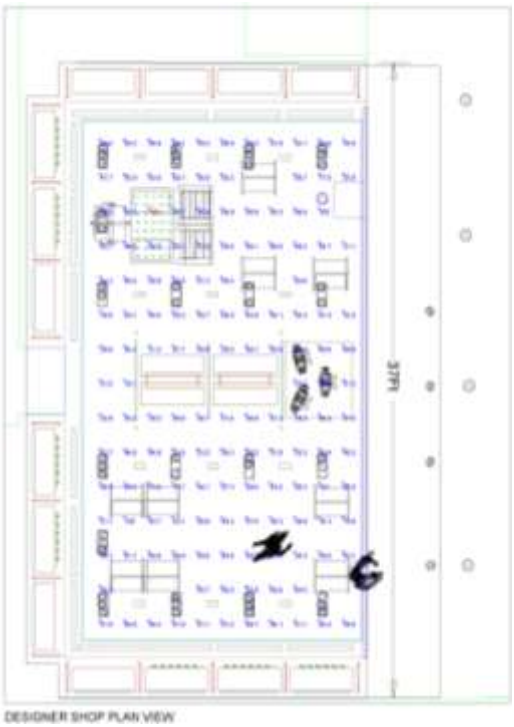


Figure 99: Designer Shop Lighting RCP (Model D)

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
Semi-Recessed Adjustable Spot 60W PAR 38 Accent Light	60	1000	0..79	59
Field Staggered Fluorescent Cove T5	28	2900	0.68	14
Triple Tube CFL Downlight	44	3200	0.64	12

Figure 100: Computer Model D – Designer Shop Under Title 24-2008

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
20W T4 CMH Narrow Spot Reflector Adjustable Accent Light	25	1700	0.68	59
Field Staggered Fluorescent Cove T5	28	2900	068	14
42W Triple Tube CFL Downlight	44	3200	0.64	12

Figure 101: Computer Model D1 - Designer Shop New Luminaire Technology

6.6 Appendix VI Small Store in Strip Mall

Figure 102: Small Store in Strip Mall (Model E)

Models E is representative of typical retail stores in a strip mall. The model was constructed to study the interplay of ambient lighting with accent lighting on floor displays or cases. Choices for luminaries were made from data gained from the 168 store technology surveys defined in 3.3 Baseline lighting developed using Title 24 2008 compliance targets was evaluated against several new luminaire technology options.

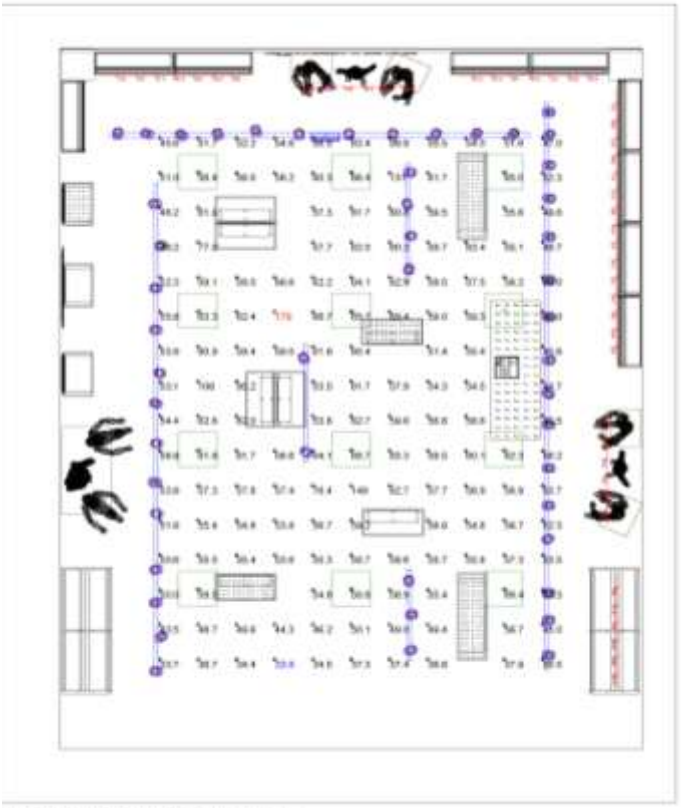


Figure 103: Small Store Lighting RCP (Model E)

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
48W HIR PAR38	48	1072	0.63	49
2x4 F32 T8 Louver 12 Cell	51	5238	0.72	12
42W CFL Wallwasher	48	2243	0.72	1

Figure 104: Computer Model E – Small Strip Mall Retail Store Under Title 24-2008

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
20W CMH PAR38	23	1240	0.72	49
2x2 F40 Twin Tube FL	68	4794	0.72	12
42W CFL Wallwasher	48	2243	0.72	1

Figure 105: Computer Model E1 – Small Strip Mall Retail New Luminaire Technology

6.7 Appendix VII Furniture and Home Accessories Store

Figure 106: Furniture & Home Accessories (Model F)

Models F - Furniture and Home Accessories is typical of a high mid-range retail establishment. The Furniture and Home Accessory Model, **Error! Reference source not found.**, has specific illumination requirements because of the large pieces contrasted by smaller accessory items. Track lighting was used throughout the store in combination with some puck lights in millwork and minimal use of fluorescent fill lighting. Baseline lighting developed using Title 24 2008 compliance targets was evaluated against several new luminaire technology options. The role of current limiters with track lighting was also evaluated.

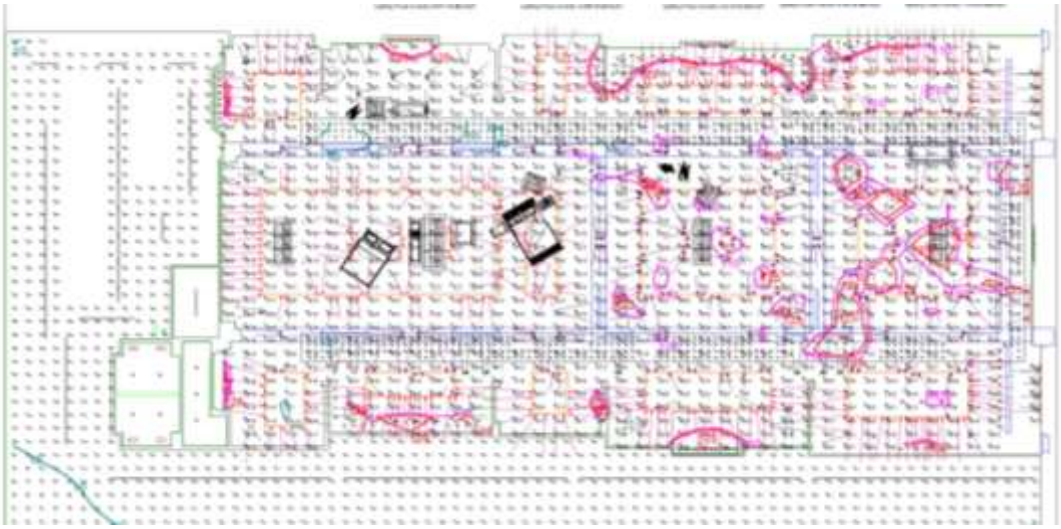


Figure 107: Furniture & Home Accessories Lighting RCP (Model F)

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
20W CMH PAR20 NFL	23	1216	0.72	542
20W MR16 36 Deg Flood	20	687	0.78	46
2 35W MR16 36 degree Flood Directional	74	1222	0.78	70
35W MR16 4" 40 degree Flood Downlight	37	639	0.78	115
13W Quad FL Sconce	32	993	0.72	4
35W MR16 10 degree Spot	37	694	0.78	5

Figure 108: Computer Model F – Furniture & Home Accessories Under Title 24-2008

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
20W CMH PAR20 NFL	23	1216	0.72	265
20W MR16 36 Deg Flood	20	687	0.78	46
2 35W MR16 36 degree Flood Directional	74	1222	0.78	70
35W MR16 4" 40 degree Flood Downlight	37	639	0.78	115
13W Quad FL Sconce	32	993	0.72	4
35W MR16 10 degree Spot	37	694	0.78	5
GE LED 30PAR NFL	11	337	0.72	278

Figure 109: Computer Model F1 – Furniture & Home Accessories New Luminaire Technology

6.8 Appendix VIII Kitchen Accessories and Tableware

Figure 110: Kitchen Accessories & Tableware (Model G)

Model G: Kitchen Accessories and Tableware Store. The Kitchen Accessories & Tableware Model is similar to Williams Sonoma or Crate and Barrel. It uses a non-uniform illumination approach with

little accent lighting. The two demonstration areas are highlighted using a combination of fluorescent and down lights. Track lighting was used extensively for flexibility.

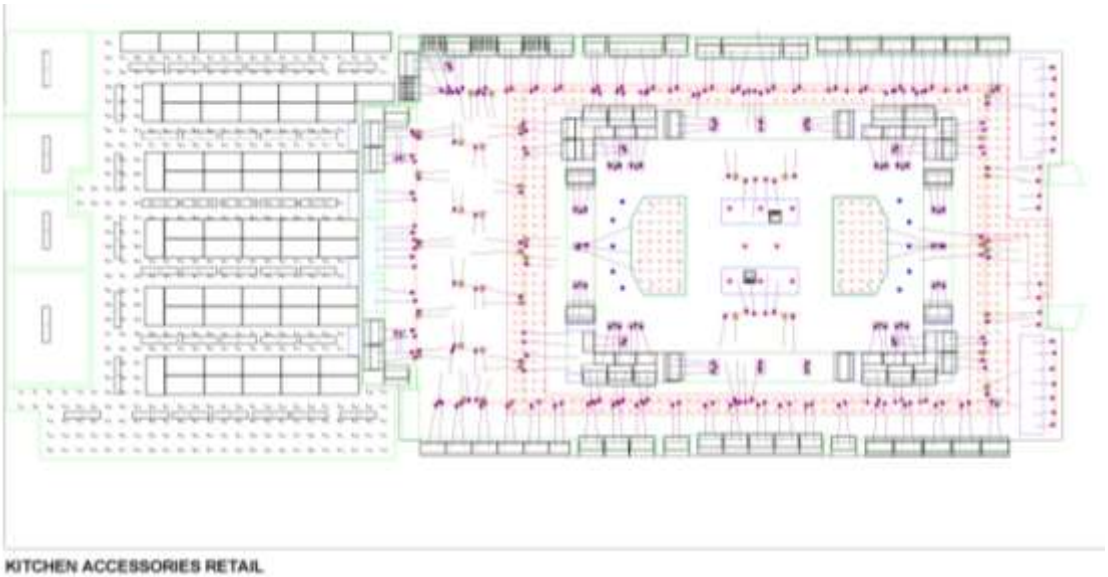


Figure 111: Kitchen Accessories & Tableware Lighting RCP (Model G)

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
35W MR16 36 degree	37	687	0.78	124
35W MR16 24 degree	37	711	0.78	173
35W MR16 10 degree	37	781	0.78	36
42W CFL Downlight	46	1681	0.68	32
35W MR16 24 degree Starpoint	37	753	0.78	16
35W MR16 40 degree Flood Wallwasher	37	408	0.64	10
35W MR16 40 degree Downlight	37	498	0.78	8

Figure 112: Computer Model G – Kitchen Accessories & Tableware Under Title 24-2008

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
20W CMH PAR20 NFL	23	1216	0.72	173
19W LED 10 Degree Spot	19	955	0.72	36
21W LED NFL	21	763	0.72	124
42W CFL Downlight	46	1681	0.68	32
35W MR16 24 degree Starpoint	37	753	0.784	16
35W MR16 40 degree Flood Wallwasher	37	408	0.64	10
35W MR16 40 degree Downlight	37	498	0.784	8

Figure 113: Computer Model G – Kitchen Accessories & Tableware New Luminaire Technology

6.9 Appendix IX New Technology and Design Comparison Computer Models

6.9.1 Model H

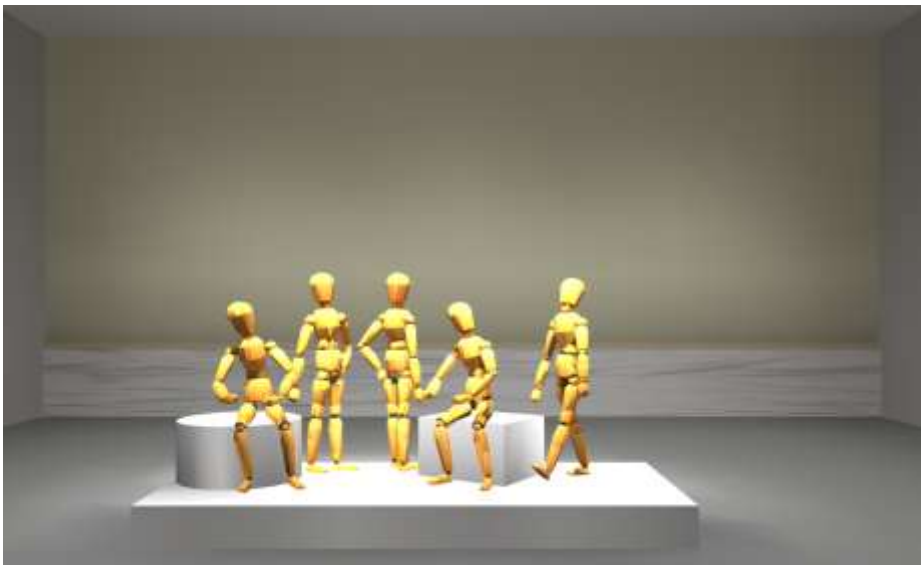


Figure 114: Wall Accents Comparisons (Model H)

Luminaire Description	Watts/	Fixture Lumens	LLF	Quantity

	Fixture			
48W PAR38 HIR Spot	48	1156	0.82	4
55W PAR38 HIR Spot	55	1176	0.82	4
90W PAR38 HIR Spot	90	1310	0.82	4

Figure 115: Computer Model H – Floor Accents Baseline Technology Options

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
20W CMH PAR38 Spot	23	1240	0.72	4
39W CMH PAR38 Spot	45	2237	0.72	4
70W CMH PAR38 Spot	80	2670	0.72	4
19 W LED Med Spot	21.7	955	0.72	4

Figure 116: Computer Model H – Wall Accents Advanced Technology Options

6.9.2 Model I

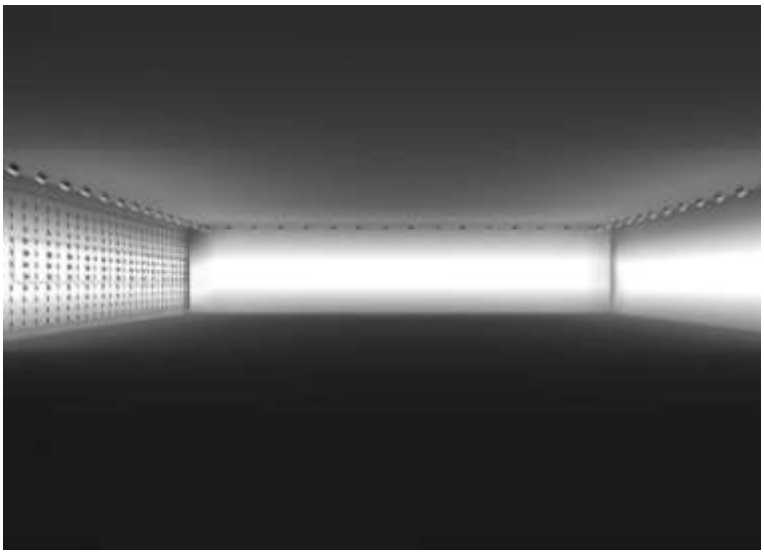


Figure 117: Wall Accents Comparisons (Model I)

Model I compared vertical wall accent lighting with advanced technology options to a baseline model using conventional halogen and MR-16 lamp options. Advanced technology option included Halogen

IR PAR and IR MR16 lamps, PAR38 self-ballasted CMH lamps and screw-in LED lamps. Lamps were placed at 10 feet from the floor with 3 foot spacing 3 feet from the wall and at a 30 degree angle.

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
75W PAR38 9 degree Spot	75	1038	0.77	44
55W PAR38 10 degree Spot	48	1176	0.82	44

Figure 118: Computer Model I – Wall Accents Baseline Technology Options

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
20W PAR38 CMH 10 degree Spot	23	1240	0.72	44
19 W LED Med Spot	21.7	955	0.72	44

Figure 119: Computer Model I – Wall Accents Advanced Technology Options

Model I Supplemental: Shelving Accent Lighting

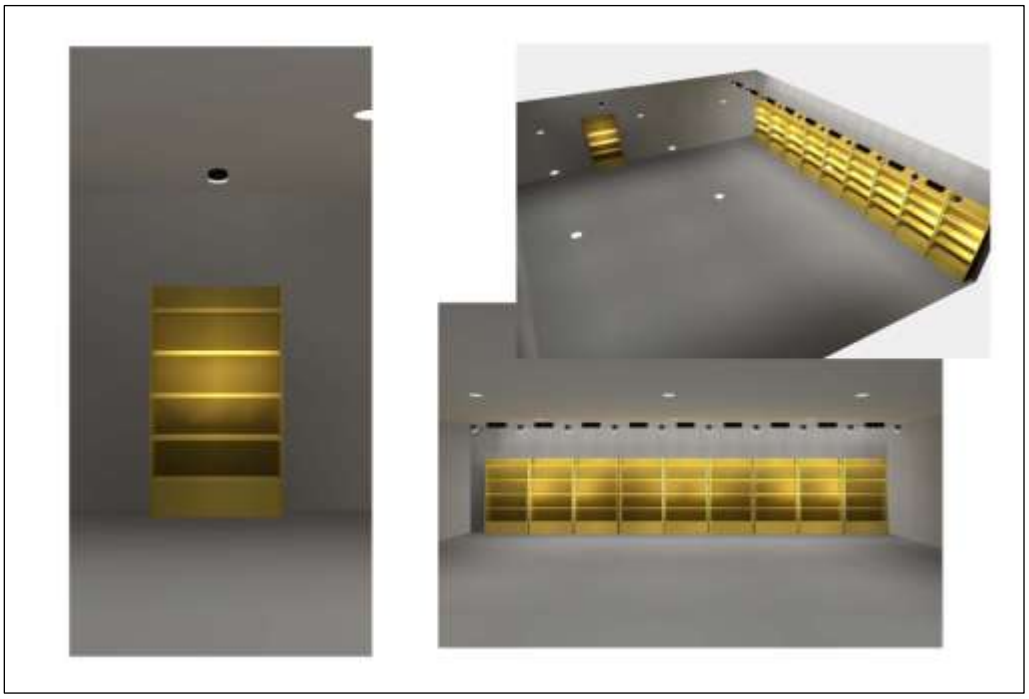


Figure 120: Wall Accents Comparisons (Model I)

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
19 W LED Med Spot	21.7	955	0.72	11
42W CFL –PLT	48	2243	0.88	9

Figure 121: Computer Model I – Wall Accents Advanced Technology Options

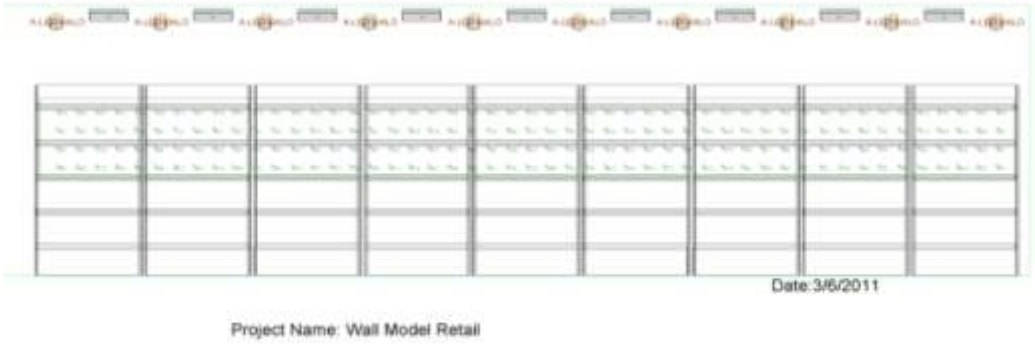


Figure 122: Computer Model I – Wall Accents Advanced Technology Options

6.9.3 Model J

Figure 123: Mounting Heights Comparisons (Model J)

Model J: looks at the effects of mounting heights on accent and display lighting. Halogen IR , Ceramic Metal Halide and Light Emitting Diode accent lights were studied to determine limitations, if any, of CMH and LED lamps to provide a balanced design alternates to Halogen.

Only three CMH lamp wattages (20W, 39W, 70W) are available as alternates to replace the wide variety of wattages (45W to 250W) of the popular PAR38 lamp for accent lighting. Based on the limited CMH offerings we knew that there would be a gap at certain ceiling heights where the 20W was not enough and the 39W and 70W CMH would be in excess of the desired foot-candle levels on various targets.

Light Emitting Diode (LED) accent lighting lamps are limited to lower wattages and lower lumen outputs. Based on current LED output we knew that there would be a limit to the effectiveness of LED accent lights at certain ceiling heights. The model was used to determine those limits.

Distance From Wall	Ceiling Height				
5 Feet	10 Feet				
6 Feet		12 Feet			
8 Feet			15 Feet		
9 Feet				17 Feet	
10 Feet					20 Feet

Figure 124: Mounting Height vs. Throw Distance Study – Layout Grid

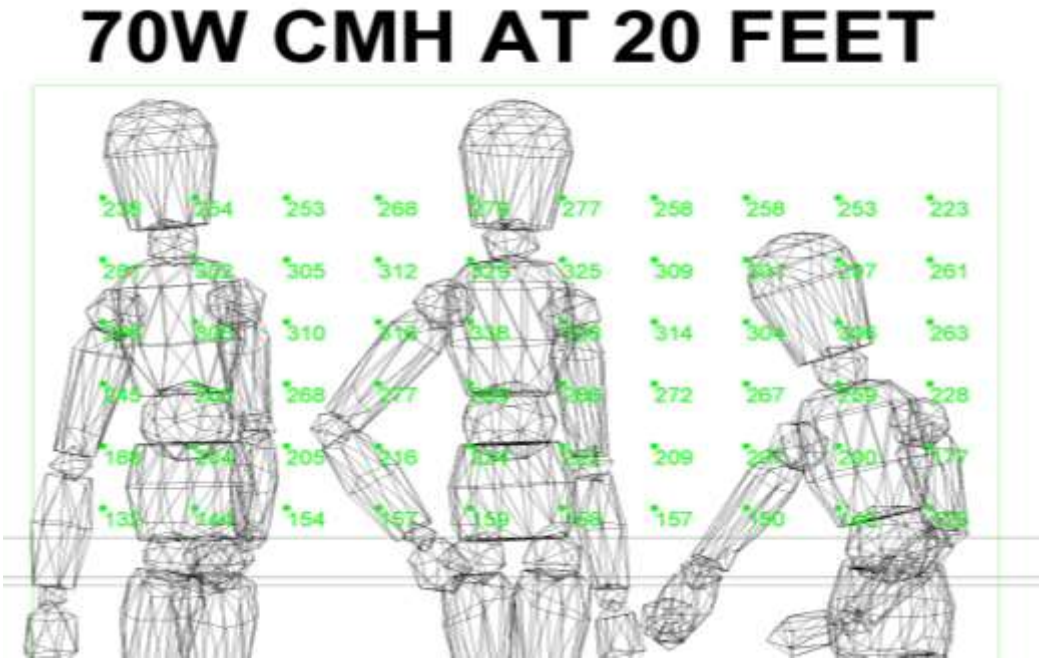


Figure 125: Model J 70W CMH

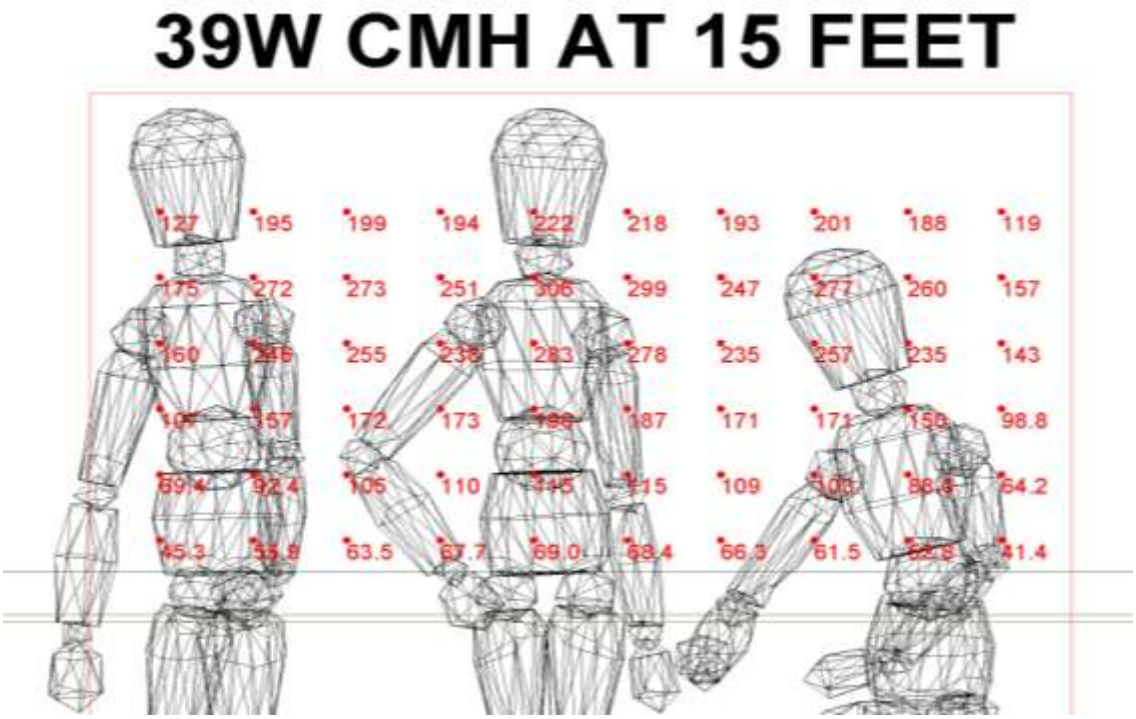


Figure 126: Model J 39W CMH

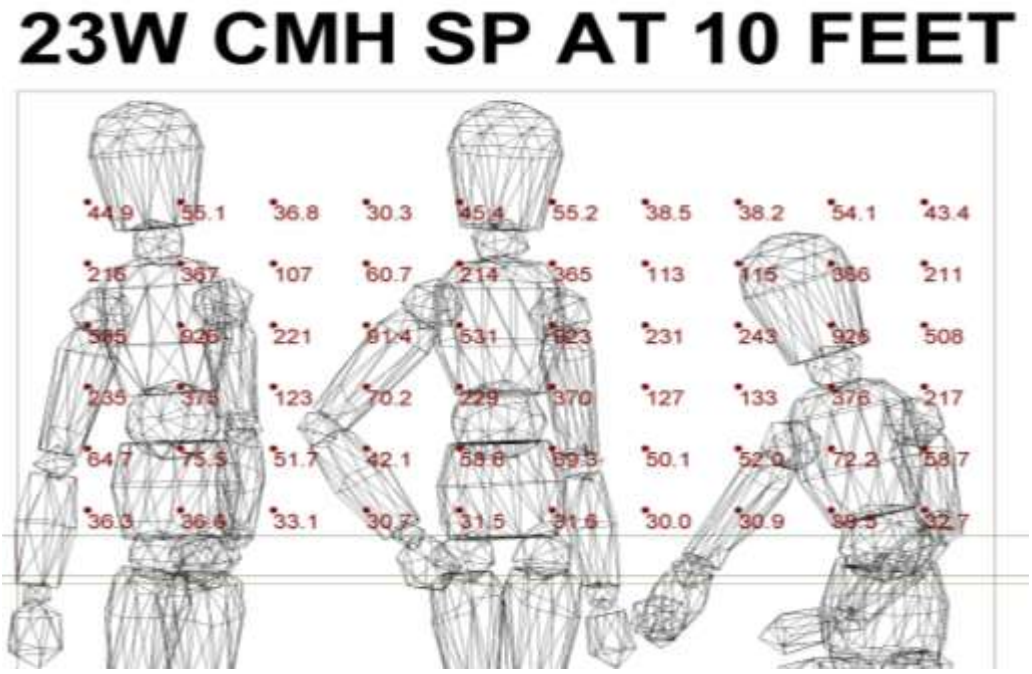


Figure 127: Model J 23W CMH

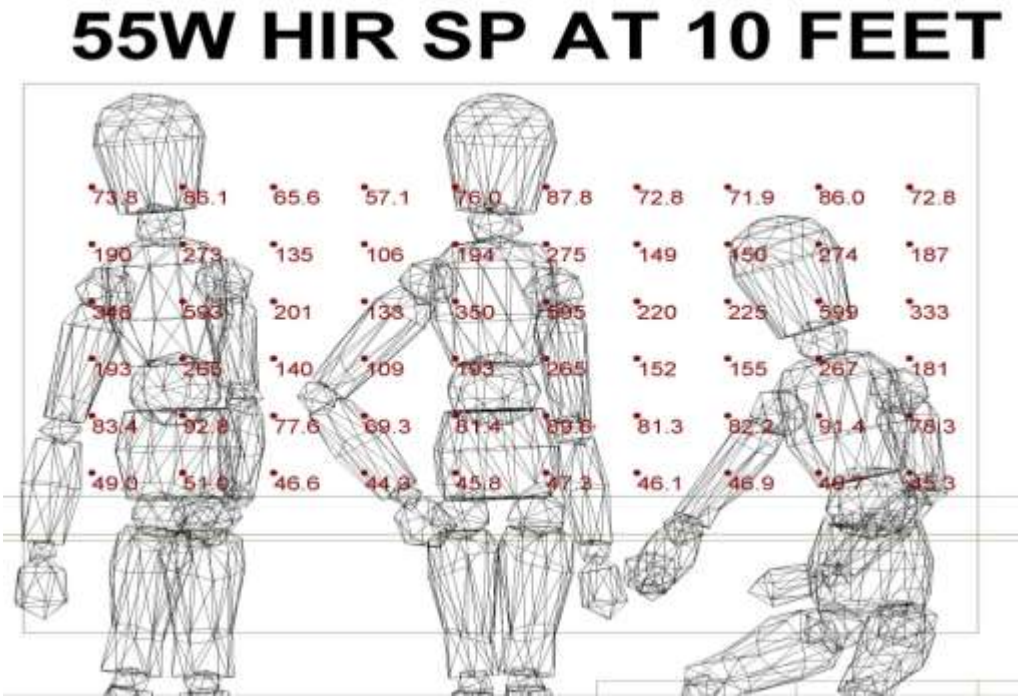


Figure 128: Model J 55W HIR

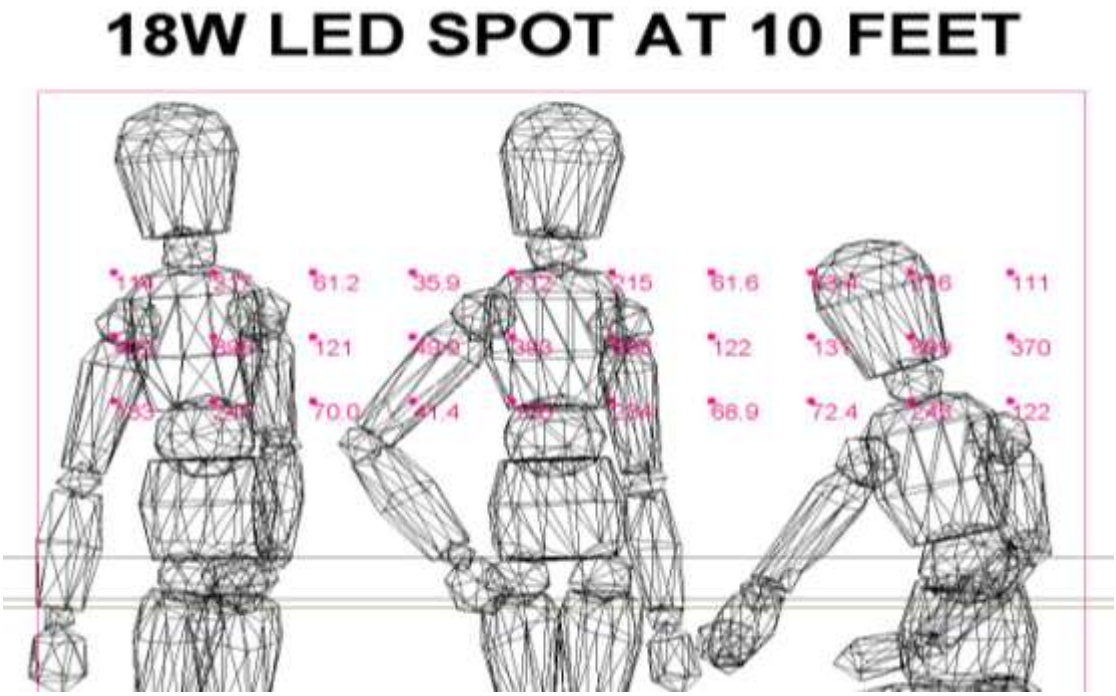


Figure 129: Model J 18W LED

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
48W PAR38 HIR Spot	48	1156	0.82	3
55W PAR38 HIR Spot	48	1176	0.82	3
90W PAR38 HIR Spot	90	1310	0.82	3

Figure 130: Computer Model J – Mounting Height vs. Throw Distance Baseline Technology

Luminaire Description	Watts/ Fixture	Fixture Lumens	LLF	Quantity
20W CMH PAR38 Spot	23	1240	0.72	3
39W CMH PAR38 Spot	45	2237	0.72	3
70W CMH PAR38 Spot	80	2670	0.72	3
19 W LED Med Spot	21.7	955	0.72	3

Figure 131: Computer Model J – Mounting Height vs. Throw Distance Advanced Technology

6.10 Appendix X: Data for Materials Impacts

This section sets out the raw data used to calculate the materials impacts of the proposed measure (see Overview: Section F), and the underlying data and assumptions.

Component	**Weight per component (lbs)**					
	Mercury	**Lead**	**Copper**	**Steel**	**Plastic**	**Others (Identify)**
3-lamp magnetic ballast for linear fluorescent, steel case	0.0080	0.0080	0.50	7.5	0	0
3-lamp electronic ballast for linear fluorescent, steel case	0.0025	0.0025	0.15	2.35	0	0
3-lamp electronic ballast linear fluorescent, plastic case	0.0005	0.0005	0.15	0.1	0.25	0
occupancy sensor	0.0005	0.0025	0.15	0.1	0.25	0
#12 power wiring, 100'	0	0	2	0	0	0
Cat 5 control wire, 100'	0	0	0.94	0	0	0
Linear fluorescent or compact fluorescent lamp	0.00001	0	0	0	0	0
35W PAR30 CMH lamp	0.0055	0	0	0	0	0

70W PAR30 CMH lamp	0.022	0	0	0	0	0
150W T6 CMH lamp	0.031	0	0	0	0	0

Figure 132. Materials Content of Typical Lighting Components, by Weight

Note that in **Error! Reference source not found.** the materials weights for an occupancy sensor are the same as those for an electronic ballast with a plastic case. We made this assumption because these two components are very close to the same size, and both contain electronics that control electrical power, within an insulated plastic case.

Mercury and Lead

The figures for mercury and lead were calculated in one of two ways. For electrical components (ballasts and occupancy sensors) they were calculated by using the maximum allowed percentages, by weight, under the European RoHS[1] requirements, which were incorporated into California state law effective January 1, 2010. The California Lighting Efficiency and Toxics Reduction Act applies RoHS to general purpose lights, i.e. "lamps, bulbs, tubes, or other electric devices that provide functional illumination for indoor residential, indoor commercial, and outdoor use." RoHS allows a maximum of 0.1% by total product weight for both mercury and lead. In practice the actual percentage of mercury and lead in these components may be very much *less* than these values, so the values in the table are conservative overestimates. Values for the total weight of these components (from which the lead and mercury values are calculated) were obtained from the online retailer www.ballastshop.com, and corroborated by the Lighting Research Center's Specifier Report on electronic ballasts[2].

For lamps, the mercury content of the lamp is almost always given by the lamp manufacturer in product cut sheets. The figures in the table are all based on high-volume products from the online catalog for Philips lighting. The amount of lead in a lamp is assumed to be negligible; no information on the presence of these substances in lamps could be found either from product manufacturers or from online sources.

Copper, Steel and Plastics

For ballasts, the amount of copper and steel was estimated by comparing the weight of the electronic plastic-cased ballast with the electronic steel-cased ballast, and assuming that the difference in weight was due to the steel case (i.e., that the electronics inside the two ballasts were the same). For the plastic ballast, a little more than half the weight of the component was assumed to come from the case, with the remaining weight being made up by copper and steel. For the magnetic ballast, the weights for copper and steel were scaled up from the electronic ballast, in proportion to the increase in total component weight (from 2.5lbs up to 8lbs).

For wiring, the weight of copper was calculated using the cross-sectional area of the conductor wires, and multiplying this by the nominal length (100') and by the density of copper (8.94 g/cm^3). The area of the conductor wires was obtained from online sources[3].

[1] http://ec.europa.eu/environment/waste/weee/index_en.htm

[2] http://www.lrc.rpi.edu/programs/NLPIP/PDF/VIEW/SREB2.pdf

[3] http://en.wikipedia.org/wiki/American_wire_gauge, and http://en.wikipedia.org/wiki/Cat_5

For lamps, the amount of copper, steel and plastic in a lamp is assumed to be negligible; no information on the presence of these substances in lamps could be found either from product manufacturers or from online sources.

6.11 NON-RESIDENTIAL CONSTRUCTION FORECAST DETAILS

The Non-Residential construction forecast dataset is data that is published by the California Energy Commission's (CEC) demand forecast office. This demand forecast office is charged with calculating the required electricity and natural gas supply centers that need to be built in order to meet the new construction utility loads. Data is sourced from Dodge construction database, demand forecast office future generation facility planning metrics, and building permit office data.

The demand generation office publishes this dataset and categorizes the data by demand forecast climate zones (FCZ). These 16 climate zones are organized by the generation facility locations throughout California, and differ from the Title 24 building climate zones (BCZ). HMG has reorganized the demand forecast office data using 2000 Census data (population weighted by zip code) and mapped FCZ and BCZ to a given zip code. The construction forecast data is provided to CASE authors in BCZ in order to calculate Title 24 statewide energy savings impacts. Though the individual climate zone categories differ between the demand forecast published by the CEC and the construction forecast, the total construction estimates are consistent; in other words, HMG has not added or detracted from total construction area.

The demand forecast office provides two (2) independent data sets: total construction and additional construction. Total construction is the sum of all existing floor space in a given category (Small office, large office, restaurant, etc.). Additional construction is floor space area constructed in a given year; this data is derived from the sources mentioned above (Dodge, Demand forecast office, building permits).

Additional construction is an independent dataset from total construction. The difference between two consecutive years of total construction is not necessarily the additional construction for the year because this difference does not take into consideration floor space that was renovated, or repurposed.

In order to further specify the construction forecast for the purpose of statewide energy savings calculation for Title 24 compliance, HMG has provided CASE authors with the ability to aggregate across multiple building types. This tool is useful for measures that apply to a portion of various building types' floor space (e.g. skylight requirements might apply to 20% of offices, 50% of warehouses and 25% of college floor space).

The main purpose of the CEC demand forecast is to estimate electricity and natural gas needs in 2022 (or 10-12 years in the future), and this dataset is much less concerned about the inaccuracy at 12 or 24 month timeframe.

It is appropriate to use the CEC demand forecast construction data as an estimate of future years construction (over the life of the measure), however to estimate next year's construction, CEC demand forecast data is not necessarily an accurate data set.

6.11.1 Citation

"NonRes Construction Forecast by BCZ v7"; Developed by Heschong Mahone Group with data sourced August, 2010 from Abrishami, Moshen at the California Energy Commission (CEC)