CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Control of Egress Lighting

2013 California Building Energy Efficiency Standards

California Utilities Statewide Codes and Standards Team October 2011

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1. Purpose

The CASE proposal is based on the premise that egress lighting in buildings is a significant end-use of lighting energy in California, as egress lighting is often held on for 24 hours a day, seven days a week, every day of the year even when buildings are not occupied. Title 24 2008 currently allows 0.3 W/sf of lighting along the path of egress to be exempt from the requirement for shut-off controls under Section 131(d); we are proposing to reduce this allowance to 0.05 W/sf (on average, per floor of the building) or to remove it entirely.

Note that the scope of this CASE Report is for the building interiors and does not include the path of egress from a building exit to a public way; the scope also does not include exit signage, only the illumination of the egress path under egress and emergency conditions.

Several organizations and governmental agencies have already codified the energy and money saving opportunity to control egress illumination including the State of Oregon, The City of Seattle as well as the Illuminating Engineering Society of North America (IESNA) (In conjunction with the American National Standards Institute (ANSI)). The method employed by these organizations is to require the egress lighting (also known as night lighting) to be switched off when the building is unoccupied. However, the California Utilities Statewide Codes and Standards Team has identified an alternative path that may achieve significant savings while avoiding some of the difficulties of complete shut-off of interior lighting.

This CASE report proposes two possible levels of shut-off during unoccupied periods:

- "Level One", in which the emergency lighting remains on while the building is unoccupied, using no more than 0.05 W/sf and providing 1fc average illumination along the exist path. In this case the egress lighting is all on a dedicated "third circuit" that is switched on and off by the building's automatic shut-off system.
- "Level Two", in which the emergency lighting is also shut off, to save additional energy during unoccupied periods. Note that to achieve this control, the emergency lighting would be connected to U.L. 924 rated switchgear to ensure that the emergency lighting is energized if the building's electrical supply fails.

The present California Building Code and Fire Code already allow building managers to turn off all egress lighting. The California Utilities Statewide Codes and Standards Team is proposing to require that, for new construction, allowable egress lighting power densities in unoccupied buildings be based on the same illumination standard as emergency lighting (or an average of 1 foot-candle). This level of illumination can be provided by using 0.05W/sf in conjunction with properly switched standard fluorescent lighting. And in the case of photoluminescent exit signs - the lamps that keep these photoluminescent signs "charged" would remain on as currently required. For retrofits of existing buildings (through activities that trigger Title 24, Part 6, such as modifying electrical circuits) the owners would also be required to control egress lighting power consumption during unoccupied times.

2. Overview

<table>
<tr><td>a. Measure Title</td><td>Egress Lighting</td></tr>
<tr><td>b. Description</td><td>The proposed measure will reduce the allowed lighting power density that is exempt from the requirement for area controls and automatic shut-off controls under Sections 131(a) and (d) respectively.

Under 2008 code, 0.3 W/sf in the egress pathway of all commercial buildings is exempt from the requirement for area controls or automatic shut off controls, i.e. that lighting is allowed to remain on 24/7.

The proposed measure reduces the exception for Area Controls to 0.2[1] W/sf. It also reduces the exception for Shut-off Controls to 0.05 W/sf in office buildings, and to zero for other building types.

Note that under Section 146(a)3K, exitway or egress illumination that is normally off and that is subject to the California Building Code is exempt from all requirements for control and lighting power density.</td></tr>
<tr><td>c. Type of Change</td><td>The proposed change is a mandatory measure. Buildings using both the prescriptive and performance method would need to comply.</td></tr>
<tr><td>d. Energy Benefits</td><td>Analysis was done for two office buildings—a small office (8,200 sf) and a large office (34,000 sf). This proposed measure used the same office models as the other lighting measures proposed for 2014 Code.

For details of the energy savings calculations, see section 4.7.4.

<table>
<tr><th></th><th></th><th>Electricity Savings

(kwh/sf/yr)</th><th>Demand Savings (kw/sf)</th><th>Natural Gas Savings

(Therms/sf/yr)</th><th>TDV Electri-city Savings ($/sf)</th><th>TDV Gas Savings ($/sf)</th></tr>
<tr><td rowspan="2">Level one control (emergency lighting remains on 24/7)</td><td>Small Office Building</td><td>0.16</td><td>0</td><td>NC</td><td>$0.29</td><td>NC</td></tr>
<tr><td>Large Office Building</td><td>0.16</td><td>0</td><td>NC</td><td>$0.29</td><td>NC</td></tr>
</table>
</td></tr>
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[1] The 0.2W/sf allowance for area controls in each space is higher than the 0.05W/sf allowance for the floor as a whole, because some individual spaces may contain a large area of egress path as a percentage of their floor area.

	Level two control (emergency lighting is shut off)	Small Office Building	0.23	0	NC	$0.41	NC
		Large Office Building	0.23	0	NC	$0.41	NC

The proposed change will not significantly affect natural gas use. The savings will occur in the evenings and on Sundays, when commercial thermostats will be set back.

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

Total Electric Energy Savings (GWh)	Total Gas Energy Savings (MMtherms)	Total TDV Savings ($)	Total TDV Energy (kBTU)
62.3	0.0	$93,200,000	1,050,000,000

e. Non-Energy Benefits	The non-energy benefits of the proposed measure are reduced lighting trespass.

f. The proposed change has small negative impacts associated with added wiring and additional ballasts, and a very large positive environmental impact associated with reduced energy consumption. There are no water impacts from this measure outside the reduced water usage associated with reduced energy consumption.

	Mercury	Lead	Copper	Steel	Plastic	Others (Identify)
Statewide impact	192(I)	192(I)	90000(I)	156777(I)	15998(I)	NC

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

Water Consumption

	On-Site (Not at the Powerplant) Water Savings (or Increase) (Gallons/Year)
Statewide	NC

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)	NC	NC	NC	NC
Comment on reasons for your impact assessment	See explanation above			

g. Technology Measures

The cost analysis for this measure is based in part on the use of U.L. 924 compliant switching devices for emergency lighting, which allow the lighting to be used in "normally on" mode. In practice, an alternative approach is often viable, which is to use normally-off emergency fixtures that do not require a switching device.

Measure Availability:

U.L. 924 compliant emergency switching devices are available from many large manufacturers, and have been available for many years. Major manufacturers include Philips Bodine, Chloride and Liebert-Emerson.

Useful Life, Persistence, and Maintenance:

These switching devices are not typically rated for a maximum life. We have assigned them a 15-year measure life in line with other lighting controls.

h. Performance Verification of the Proposed Measure	The proposed requirements should be verified on site to ensure that egress lighting is switched off automatically and that the LPD limits are met. The nonresidential lighting compliance forms LTG-3C and LTG-2A and acceptance form LTG-1C should be modified accordingly.

i. Cost Effectiveness

The following shows the cost effectiveness of the proposed change. The supporting calculations are presented in Section 4.7.

a	b	c		d		e		f	g	
Measure Name - Automatic Shut-off of non-egress lighting during unoccupied times	Measure Life (Years)	Additional Costs– Current Measure Costs (Relative to Basecase) ($)		Additional Cost– Post-Adoption Measure Costs (Relative to Basecase) ($)		PV of Additional Maintenance Costs (Savings) (Relative to Basecase) (PV$)		PV of Energy Cost Savings – Per Proto Building (PV$)	LCC Per Prototype Building ($)	
		Per square foot	Per Proto Bldg	Per Unit	Per Proto Bldg	Per Unit	Per Proto Bldg		(c+e)-f Based on Current Costs	(d+e)-f Based on Post-Adoption Costs
Level One Small Office Building	15	$0.09	$762	0	0	0	0	$2,378	($1,615)	($2,378)
Level One Large Office Building	15	$0.07	$2,278	0	0	0	0	$9,860	($7,582)	($9,860)
Level Two Small Office Building	15	$0.15	$1,254	0	0	0	0	$3,362	($2,107)	($3,362)
Level Two Large Office Building	15	$0.09	$2,958	0	0	0	0	$13,940	($10,982)	($13,940)

j. Analysis Tools	This measure is proposed as mandatory. Analysis tools are not relevant, since this measure would not be subject to whole building performance trade-offs.
k. Relationship to Other Measures	This measure will not have a significant impact on other measures. Because lighting will be reduced, the heating needs of a building will increase slightly and the cooling needs will decrease slightly. However, because commercial buildings' cooling loads typically outweigh their heating loads in California, the interaction with HVAC measures would create additional savings, therefore the analysis presented here is conservative. In calculating the savings, we have reduced the available lighting power by 15%, to account for the "tuning" energy savings claimed by the Controllable Lighting CASE

3. Methodology

This section describes the methodology that we followed to assess the savings, costs, and cost effectiveness of the proposed code change. The key elements of the methodology were as follows,

- Scoping Interviews with Manufacturers, Designers, Code Developers and Other Experts
  - Defining “egress” vs. “emergency” lighting
- Online Survey of Manufacturers, Designers, Code Developers and Other Experts
- Egress Lighting Code Review
- Phone Consultations with State Fire Officials
- Development of Prototype Buildings
- Engineered lighting layouts
- Cost Analysis
  - Informal Interviews with Egress Control Equipment Manufacturers
- Energy Savings Analysis
  - Night-Time Lighting Survey
- Cost-Effectiveness and Statewide Savings
- Stakeholder Meeting Process

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 at the end of the Methodology section.

3.1 Scoping Interviews

We conducted 15 phone (scoping) interviews using an interview guide to focus the discussion. The purpose of these scoping interviews was to identify the issues and challenges regarding the control of egress lighting, so that the formal online survey could ask more specific questions about how those challenges could be addressed. The full text of the scoping interview guide is shown in Appendix II: Outline for Scoping Interview. During each interview we asked each interviewee the questions that were relevant to their practice. The interviewee list was compiled by HMG staff and includes a diverse group of respondents, including:

- Committee chairs and members from the relevant ASHRAE 90.1 and IESNA committees
- Lighting designers
- Manufacturer and industry group representatives
- California’s Senior Deputy Fire Marshal

The interview covered the following issues:

- Egress lighting control requirements in other state and local building codes

- Egress control system types and market share
- Egress control system performance
- Discussion of potential code change proposals

The full list of interviewees is available on request.

3.2 Online Surveys

We distributed an online survey to 140 building professionals. The purpose of the online survey was to ask specific questions for which we needed quantitative or categorical answers, for instance to understand typical practice or to obtain a more accurate estimate of costs or market share. The survey included questions about the following issues:

- Types of emergency lighting system
- Types of egress lighting control
- Types of shut-off control
- Egress and emergency lighting illuminance requirements
- Proportion of luminaires designated egress and emergency

The full text of the online interview is shown in Appendix III: Text of Online Survey. There were 23 respondents to the survey, plus additional comments collected from BOMA members and summarized by the Chair of BOMA California's Energy Committee. As with the scoping interviews, the respondents included a wide range of professionals including lighting designers, building owner representatives, fire safety experts and a number of lighting manufacturer executives from throughout the United States.

3.3 Egress Lighting Code Review

We carried out an extensive review of state and city building codes that contain requirements for emergency lighting, egress lighting, and the control of egress lighting. This review included the following documents:

- California Building Code (Title 24 Part 2)
- California Fire Code (Title 24 Part 9)
- California Electrical Code (Title 24 Part 3)
- California Energy Code (Title 24 Part 6)
- Oregon Building Code
- Seattle Building Code
- American Institute of Architects' (AIA) Egress Lighting proposal to the International Code Council (ICC).

To further investigate the requirements and intent of these codes we also conducted phone interviews with code officials from American Society of Heating, Refrigerating and Air-Conditioning Engineers

(ASHRAE), Illuminating Engineering Society of North America (IESNA), plus an Oregon Energy Code committee member.

3.4 Phone Consultations with State Fire Officials

We held two scheduled phone conversations with a State of California Office of the State Fire Marshal, Senior Deputy Fire Marshal and two discussions with a Fire Life Safety Head Officer with the Division of the State Architect. These conversations were intended to confirm the information that we had already collected regarding the requirements of the Building Code and Fire Code, and regarding the enforcement of these requirements.

3.5 Development of Prototype Buildings

To assess the energy savings, cost, and cost effectiveness of the proposed requirement, we developed prototypes of a small office building and a large office building. The layouts of the prototype buildings allowed us to calculate the length of wire runs and the equipment counts required to implement egress lighting controls. Figure 1 shows the basic characteristics of the small and large office prototypes.

	Occupancy Type (Residential, Retail, Office, etc)	**Area (Square Feet)**	**Number of Stories**	**Other Notes**
Prototype 1	Small Office	8,200	1	Rectangular in shape, consists of several open office areas and one- and two-person offices linked by corridors
Prototype 2	Large Office	34,000	1	Rectangular in shape, consists of a core surrounded by a large concentric open office area, with some perimeter private offices.

Figure 1 Description of Prototype Office Buildings Used for Analysis

We chose to use these office buildings as prototypes for two reasons. First, offices are very common type of building, and second it is usually more expensive to install wiring and controls in offices than in the other common building types (retail stores, warehouses). This is because offices are often subdivided into many small spaces, and because they have complex routing for wiring. If egress controls are installed as a retrofit measure, there could be added costs to gain access to (and refinish) areas behind sheetrock or other permanent finishes. Although some buildings such as retail stores or warehouses are likely to include high spaces that incur increased wiring costs (due to the need for lifts to access the ceiling), if those spaces are being wired anyway, it is comparatively inexpensive to run additional circuits at the same time. Therefore, the measure costs calculated for offices are likely to be at least as high (per square foot) as for other building types, and therefore provide a conservative estimate of cost-effectiveness. The layouts of the two prototype offices are shown in Appendix I: Egress Lighting Circuit Layouts in Prototype Buildings.

Small Office Prototype

The small office prototype is a building that was surveyed in 2005 by HMG, as part of a study on photocontrol systems conducted for the California investor-owned utilities, and the Northwest Energy Efficiency Alliance. This building was chosen because it is typical of the layout of many small California offices, which have a number of open office areas and single-person or multi-person offices around the perimeter, linked together by internal corridors. This specific building was also chosen because as part of the 2005 study we collected very comprehensive data on its lighting and control systems, and because we have both a reflected ceiling plan and a furniture layout for the entire building, which allows the egress paths to be accurately defined.

Large Office Prototype

This building was chosen because, unusually, it has a mix of both perimeter private offices and perimeter open office areas. These different configurations result in very different "paths of egress", so this allowed us to accommodate both those common configurations within the same building model, rather than using two models. The layout is arranged around a central core, like the vast majority of larger office buildings. A reflected ceiling plan and furniture layout were also available for this building.

3.6 Engineered Lighting Layouts

We used the layouts of the prototype buildings described above as the basis for designing egress and emergency lighting systems, and calculating the cost of providing wiring and equipment for the control of egress lighting.

Part of the purpose of designing these emergency and egress lighting layouts was to investigate how much the emergency and egress LPDs could be reduced from current code allowances, by using a single lamp (rather than two lamps) per fixture to provide the illumination. I.e., by using fixtures in which one of the lamps provides emergency illumination while the other one or two are controlled by the "regular" control system Using luminaires that have only one emergency lamp on a slightly finer grid improves the uniformity of illuminance and therefore allows the minimum illuminance requirement to be met by using a lower average illuminance, and therefore less lighting power. It also results in a more uniform appearance and therefore lower contrasts, which likely improve the perception of hazards such as changes of level or objects in the path of egress.

An electrical and lighting engineering firm with extensive experience of egress lighting requirements and a close involvement in code development provided lighting equipment layouts for two office building templates as shown below in Appendix I: Egress Lighting Circuit Layouts in Prototype Buildings.

3.7 Informal Interviews with Egress Control Equipment Manufacturers

We conducted a series of informal interviews with technical staff from several major controls manufacturers. In these interviews, we established the following:

- Which of their systems and components are most commonly installed to control egress lighting

- Which systems provided the least expensive or most easily installed solution
- Exactly which pieces of equipment should be installed where in the two prototype buildings, to achieve compliance with the requirements of the California Building Code and Fire Code.
- The typical contractor price for the equipment
- How much labor is typically associated with installing each piece of equipment

3.8 Night-Time Lighting Survey

A night time field survey was conducted of office buildings to estimate the percentage of lighting that was switched on during a weeknight, and the hours of operation. This was done to estimate savings for automatic shut-offs for egress *and* non-egress lighting. The survey of commercial buildings was conducted at four separate locations in the state, on a weekday evening in the fall of 2010. Observations were made hourly between 6 pm and 11 pm.

A surveyor walked around the building and estimated what percentage of lights were on in the areas of the building that could be seen. Usually it was not clear from the vantage point at ground level whether the spaces being observed were private offices or open offices, conference rooms etc, so the type of space was not recorded. Lighting load was recorded for each floor or each building, at each time interval. Observations were conducted in downtown commercial districts in:

- Sacramento
- Oakland
- Santa Monica
- San Diego

The percentage of lighting switched on was recorded for 770 floors in 71 buildings, resulting in a total of 3,627 observations. (Due to survey constraints not all floors were recorded at all time intervals). A copy of the survey instrument is provided in Appendix V: Surveyor's Forms for Night-Time Lighting Survey.

3.9 Energy Savings Analysis

In line with the California Energy Commission’s 2013 cost-effectiveness method, we calculated energy savings using time-dependent valuation (TDV) assuming a 15-year measure life and the proposed change in the lighting schedule.

3.10 Cost Analysis

To develop cost estimates, we combined data from manufacturers and distributors with equipment costs and labor rates provided by RS Means CostWorks Online Construction Cost Data.

RS Means contains accurate figures for the purchase price and labor cost formany common lighting and electrical equipment systems., Since many of the systems considered in this CASE report are uncommon, RS Means does not have cost data for these atypical systems. Therefore, to calculate costs for specific pieces of equipment we used manufacturers’ and distributors’ quotes and estimates of typical price and labor requirements. As much as possible, we did not inform manufacturers or distributors that we were conducting research for a proposed code change, and we tried to contact people who would not take a strategic view of pricing, i.e. would not inflate or deflate prices to try to influence our research.

3.11 Cost Effectiveness and Statewide Savings

We calculated the cost-effectiveness for the proposed measure by comparing the calculated TDV savings with the calculated measure costs. We also estimated of the resulting annual statewide savings. The cost-effectiveness calculation is a direct comparison between:

- Measure costs per square foot (for equipment and labor)
- Measure savings per square foot over the 15-year measure life, calculated using the 2013 TDV method

The statewide estimate of savings was based on new construction square footage forecasts by building type, obtained from the California Energy Commission, together with estimates of the typical hours of use and lighting power density of egress lighting, as obtained from our data analysis.

3.12 Stakeholder Meeting Process

All of the main approaches, assumptions and methods of analysis used in this proposal have been presented for review at one of three public Lighting Stakeholder Meetings..

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 can be found at www.calcodes.com. Stakeholder meetings were held on the following dates and locations:

- First Lighting Stakeholder Meeting: March 18th, 2010, Pacific Energy Center, San Francisco, CA
- Second Lighting Stakeholder Meeting: September 21st 2010, California Lighting Technology Center, Davis, CA
- Third Lighting Stakeholder Meeting: February 24th, 2011, UC Davis Alumni Center, Davis CA

In addition to the Stakeholder Meetings, a Stakeholder Work Session was held on December 8th, 2010.to allow detailed review of this and other lighting topics.

3.13 Statewide Savings Estimates

The statewide energy savings associated with the proposed measures were calculated by multiplying the energy savings per square foot with the statewide estimate of new construction in 2014. Details on the method and data source of the nonresidential construction forecast are in Appendix VII: Non-Residential Construction Forecast details.

4. Analysis and Results

This section presents the analysis and results of the methodology provided in the previous section:

- Results of Scoping Interviews
- Results of Online Survey
- Codes and Standards Context
- Engineered Lighting Layouts
- Energy Savings
- Costs
- Cost-effectiveness and Statewide Savings

4.1 Results of Scoping Interviews

In the scoping interviews we asked the interviewees about the requirements of code, the enforcement of those requirements, and how emergency lighting and egress lighting are typically implemented and controlled in commercial buildings. The scoping interview is provided in Appendix II: Outline for Scoping Interview.

Because the scoping interviews did not contain specific, quantifiable questions, we have organized the findings of the scoping interviews around certain key themes, as described below.

4.1.1 Defining the Difference between Egress Lighting and Emergency Lighting

Several interviewees drew our attention to the fact that NFPA 101 contains separate definitions for "Illuminating the Means of Egress" (Section 7.8) and "Emergency Lighting" (Section 7.9). Note that NFPA 101 is not a mandatory code in California, but is widely referred to in other codes and is considered a best practices guide. The difference is that egress lighting "shall be continuous[2] during the time that the conditions of occupancy require that the means of egress be available for use", whereas emergency lighting "shall be provided for a minimum of 1.5 hours in the event of failure of normal lighting."

The difference between egress lighting and emergency lighting is defined in exactly the same way in the California Building Code and Fire Code. A table showing the four possible states of these two systems is shown in Figure 2.

	Occupied	**Unoccupied**
Normal power	Egress on, emergency off	Egress off, emergency off
Power failure	Egress on, emergency on	Egress off, emergency on

Figure 2. State Diagram for Separate Egress and Emergency Systems

[2] Unlike emergency lighting, egress lighting does not have to be provided by electric luminaires. Egress lighting can be provided by daylight, which is why Title 24 Section 131(c), which contains the requirements for photocontrols, does not include the 0.3 W/sf exception that is found in other parts of Section 131.

In practice, both these needs are often met by a combined system that fulfills the coverage and illuminance requirements for both egress and emergency lighting, and remains on under both sets of circumstances, as shown in Figure 3. Furthermore, to reduce the initial cost of the system, it simply remains on all the time, rather than switching off when the building is unoccupied and supplied by normal mains power.

	Occupied	**Unoccupied**
Normal power	On	Off
Power failure	On	On

Figure 3. State Diagram for Combined Egress and Emergency System

Several interviewees stated that it is best not to mix the terms "emergency" and "egress." Staff from the City of Portland, Oregon, did combine these terms in a proposed code change and, according to one interviewee, it caused "a lot of difficulty."

4.1.2 Areas Required to have Egress Lighting

The California Building Code (Title 24, Part 2) Section 1006.3 states that egress lighting is required from "any occupied portion of a building or structure to a public way". A literal reading of this section suggests that egress lighting is required in private offices and other spaces that have only one means of egress. However, in discussion with code officials we determined that egress lighting is not required in these spaces, and therefore that egress lighting and emergency lighting are required in exactly the same spaces.

	Required to have egress lighting when occupied?	**Required to have emergency lighting?**
Private offices and other spaces with only 1 means of egress	No	No
Open areas and other spaces with 2 or more means of egress	Yes	Yes
Corridors, exit areas	Yes	Yes

Figure 4. Spaces required to have egress and emergency lighting

4.1.3 Use of Occupancy Sensors to Control Egress Lighting

The 2007 California Building Code (Title 24, Part 2, Section 1006 Means of Egress Illumination, 1006.1 Illumination Required) requires that "The means of egress, including the exit discharge, shall be illuminated at all times the building space served by the means of egress is occupied3." This requirement means that whenever anyone is present in the building, the entire path of egress must be illuminated. This, in turn, means that the use of "local" occupancy sensors would not be adequate in open areas and corridors, because local sensors would only illuminate the path of egress immediately

3 Note that the California code mirrors NFPA 101 (a code which is mandatory in some jurisdictions and voluntary in California). NFPA 101 states "All means of egress must be illuminated by artificial lighting during the entire time the building is occupied."

in front of the occupant. However, it should be noted that a network of occupancy sensors, that kept the egress lighting on until all of the sensors were in an "off" state, would be compliant in these spaces. "Standalone" occupancy sensors would be compliant in private offices and other spaces with only one means of egress, according to the California Fire Code, Title 24 Part 2 Section 1006.3.

Opinion was divided among interviewees about whether it was "best practice" to use occupancy sensors for the control of egress lighting. On one hand, we were told that occupancy sensors avoid the potential problem of occupants not knowing where the override switches are, but on the other hand occupancy sensors, like any electronic equipment, can potentially fail and not detect an occupant. We believe that the concern about occupancy sensor failure would be reduced by the use of networked sensors, because the chance of all the sensors in an area failing would be extremely small. Also, a 2008 survey of electrical contractors found that, based on callbacks, they consider occupancy sensors to be highly reliable4.

Whether a timeclock or occupancy sensors are used, under Title 24 Part 6 Section 131(d), override devices (switches) are also required. Therefore networked occupancy sensors would always represent an increase in amenity over a timeclock system, because they would detect occupants under many circumstances, and reduce the need for occupants to get up and push manual override switches.

Several interviewees informed us that there is currently not a U.L. standard that can be used as a basis for demonstrating "fail-safe operation" of occupancy sensors (fail safe operation is recommended in NFPA 101 for emergency lighting equipment, although it should be noted that the occupancy sensors would not be part of the emergency lighting system, only of the egress lighting system). These interviewees were uneasy about specifying occupancy sensors, although some specified them anyway. We were told that an alternative to occupancy sensors (in stairwells) may be to use U.L. Listed (all-in-one) stairwell-specific units such as Lamar's Voyager fixture or Prudential's Snap fixture with integral occupancy sensors that are built so if the power fails the units default to the on position.

From what the interviewees told us, although occupancy sensors would not be required to be U.L. listed, we believe it may be desirable for U.L. to create a standard for fail-safe operation for both standalone and networked occupancy sensors, in advance of Title 24 2013 being implemented (if possible). This would allow occupancy sensors to be used as part of *emergency* systems, thereby savings even more energy. The California utilities and/or an organization such as BOMA would likely need to propose this change for it to occur in time for 2013 Title 24 implementation. A NEMA standard would not be an option in this case, since NEMA publishes performance standards but does not publish safety standards.

One interviewee told us that the State of Washington had passed a code in 2010 (WAC 51-11-1515) requiring egress lighting controls stating that: "*Emergency lighting and means of egress illumination that is normally on during normal building operation shall, during periods that the space served by the means of egress is unoccupied, be shut off and controlled by a combination of listed emergency relay and occupancy sensors*." The interviewee stated that, under pressure from developers who filed a lawsuit, in November 2009 the State of Washington removed this section from the rule, noting that "the intended switching mechanisms that will be used in this proposal have not been tested and approved by U.L. or any other listing agency to meet the more stringent criteria associated with life

4 DiLouie, C. 2008. *Lighting Controls Handbook*, p.33. Accessible through www.archenergy.com/lrp/articles/Lighting_Control_Study.pdf

safety devices". The California Senior Deputy Fire Marshal concurred with this statement, saying that any devices used to control emergency lighting would need to be U.L. listed, or listed by some other authority. We believe that the wording of this proposed change to the Washington code did not distinguish adequately between emergency and egress systems, and that it was correct to withdraw the requirement. Because this Title 24 proposal does not require the emergency lighting to be controlled by occupancy sensors, the concern about the lack of a U.L. standard is not relevant. Note that the State of Washington has since adopted mandatory egress lighting controls as part of their code.

4.1.4 Equipment for the Control of Emergency Lighting

Equipment that allows emergency lighting to be controlled by regular lighting controls, but to switch back to emergency power when the utility power fails, has been readily available from a wide variety of manufacturers, including "major" manufacturers, for several decades.

There are two commonly available types of equipment that allow emergency lighting fixtures to be controlled by the general lighting control system, while still preserving the ability of the emergency lighting to respond in an emergency:

- *Emergency ballasts.* These replace the regular ballast inside the luminaire, and contain a battery or transfer switch.
- *Dual source transfer switches* Mounted in the electrical room, these devices provide power to several egress luminaires on one or more circuits, and can transfer between normal utility power and emergency power. Dual source transfer switches can typically handle one or two 20 amp distribution circuits.

These devices have to be U.L. Listed (U.L. 924 for emergency lighting equipment and U.L. 1008 for transfer switch equipment). In both cases, a small amount of additional power wiring is required (compared to 24/7 egress lighting), since these devices must be wired to two or three separate power sources in order to determine whether the egress lighting should be energized.

Both these types of devices use an unswitched hot lead from the grid to monitor utility power for outages or brownouts. Under normal utility power, the emergency luminaires are powered from the regular hot supply, but if utility power fails, the transfer switch connects the emergency luminaires to circuits leading from the generator, inverter or battery.

4.1.5 "Building Security" Lighting

One potential challenge for floor-wide egress lighting is that there may be areas of the building that the owner wishes to remain illuminated after business hours, for security reasons.

The 2008 Title 24 language allows an exception for "building security" lighting. Because this term is not defined in Title 24 and is not common terminology, we believe that this creates a loophole that could be used inappropriately to avoid the use of egress lighting controls. On the other hand, there are areas (especially in larger buildings) that are continuously staffed (even overnight) for security reasons. We believe that these areas are covered by the existing exception under Exception 1 to Section 131(d)1:

"Where the lighting system is serving an area that is in continuous use, 24 hours per day/365 days per year."

4.1.6 Typical Practice

According to interviewees (and to the online survey results), by far the most common practice in commercial buildings is to use the same luminaires to provide emergency lighting and egress lighting, and also to use these luminaires as part of the general lighting grid. Thus, these luminaires remain on continuously. We refer to these luminaires as emergency/egress luminaires. This solution has developed over time because it provides the lowest upfront cost and the least complicated wiring and controls. However, the various codes that cover egress and emergency lighting could be met by using other approaches that consume significantly less power.

Egress controls are available in the market that are U.L. 924 rated and allow the emergency/egress luminaires to be switched off by "regular" lighting controls under non-emergency conditions. .

A concern voiced by several interviewees (in various ways) is that building occupants should not be "plunged into darkness" if they are still in the building. This could result in a trip or fall hazard as the occupant finds their way out under extremely low light. To avoid this potential, systems could be set to shut off the lights in two stages, to give people additional notice, or it could be set to keep some egress lighting on continuously. An alternative would be to provide a network of occupancy sensors to ensure that even if an occupant does not know to actuate the light switch, they would still be detected by the system. Both these approaches are allowed under the present and proposed Title 24 code.

The California State Fire Marshal's office said that the Building Energy Efficiency Standards need to consider life safety for firefighters and other emergency personnel that might be entering a building under emergency conditions, i.e., that emergency personnel would not want to enter a completely dark building.

4.1.7 Options for Egress Lighting Controls

Egress lighting controls are compliant with existing fire codes, and although there have been several failed attempts to require them in other state and city energy codes, there are many organizations and individuals that expressed no reservations about the adoption of a requirement for egress controls within the energy code. California's Senior Deputy Fire Marshal said that "California has been thinking outside of the box for many years, and how we address egress lighting is probably just another step with regards to energy usage and safety.

Based on a detailed review of the requirements of the California Fire Code (Title 24 Part 2), and discussions during the scoping interviews, we believe that the most likely shut-off control system choices are shown in Figure 5.

	Timeclock control with overrides	Networked occupancy sensors with overrides	Standalone occupancy sensors
Private offices and other spaces with only one means of egress			✓
All other spaces (open areas and corridor)	✓(1)	✓	

(1) Manual override switches must be located and zoned to ensure that the entire path of egress remains illuminated, whichever switch is pushed.

Figure 5. Anticipated egress lighting control solutions

Based on the interviews, and in keeping with current typical practice, we anticipate that a building-wide control system for shutoff of egress lighting would be set to "flash" a signal to people still in the building, several minutes before shutting off the lights. If the override switch were pushed it would keep the lights on full output for up to two hours (as required by Title 24 2008).

One possible variation on this control sequence is to have the lighting reduce down to a lower level of output (ether by dimming, or by leaving only the egress luminaires energized). The lighting might stay in this reduced state for a period of time, before switching off completely. We anticipate that, especially in larger buildings, many facilities managers would specify a system with this feature in order to avoid an abrupt shutoff of all the lighting, and give occupants a second opportunity to actuate the manual override switches before the general lighting shut off completely. This approach may still not be acceptable in all cases, but would be compliant with the proposed code language, as long as both control steps occurred within the 2-hour time window allowed by Title 24 2008 Section 131(d)4.

4.2 Results of Online Survey

In this section we present the survey responses related to the savings, costs and feasibility of the proposed measure. The questions that are directly relevant to the proposed code change are shown in this section; the remaining questions are shown in Appendix IV: Responses to Additional Online Survey Questions.

4.2.1 Egress Lighting Control Types

The respondents were asked how frequently they specify controls to shut off egress lighting. There was a large degree of variation in responses, i.e. some people said "never" and some people said "all the time", but on average these systems appear to be installed infrequently. Several people said that they installed "other" systems, but did not provide details of what types of systems they installed.

The responses to this question reinforce the finding from the scoping interviews that egress control systems are an established part of the controls market, but are not installed in the majority of buildings

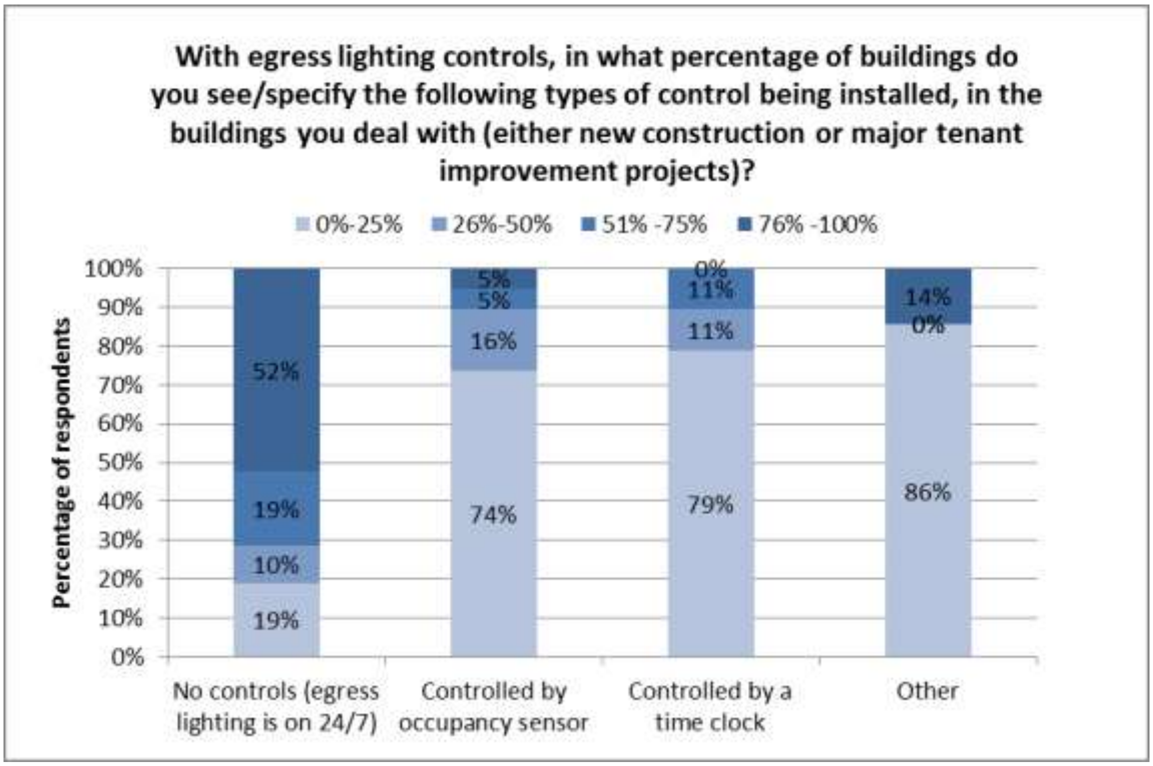


Figure 6. Egress Lighting Control Types

Responses by System Type

Timeclock control. 16 out of 22 respondents listed at least one predominant building type in relation to timeclock use. These included a variety of commercial building types including offices as well as retail and warehouses. One of the respondents noted that these types of controls are "used less and less each year due to their limitations…" Another said that timeclocks are used in "some older high-rise buildings."

Occupancy Sensor Only (No Timeclock). 17 out of 22 respondents listed at least one predominant building type in regards to sole use of occupancy sensor shut-off control. 66% of these respondents listed office buildings and/or commercial buildings. Other building types included; hotels, schools as well as some manufacturers. There were very different opinions on use of occupancy sensors in a given building type, from "very limited" to "most buildings these days".

An Automatic Signal From Another building system (e.g. Security system). 15 out of 22 respondents answered this question and, of those five, said "none" leaving about 45% of the respondents that identified at least one building type. Four (about 27%) answered campuses (corporate or education-based); other building types included: large office buildings and large retail. One person noted that the fire marshal and inspectors will not allow other systems to tap into the fire alarm system, but this "might" work in tandem with "security systems".

4.2.2 Egress Lighting Control Performance

THE ANSWERS TO THIS QUESTION HAVE NOT YET BEEN TABULATED

4.2.3 Types of Emergency Transfer Switch

Respondents were asked, when they install emergency/egress lighting controls, what type of power transfer switch do they specify? We asked this question to inform the costing exercise for the proposed measure, i.e., so that the egress control system used for costing is consistent with typical practice. Figure 6 shows that transfer switches in fixtures are approximately as common as transfer switches mounted in an electrical room. Some respondents said that they use "other" types of transfer switch, but none of them indicated the type of switch in the box provided for this response in the survey.

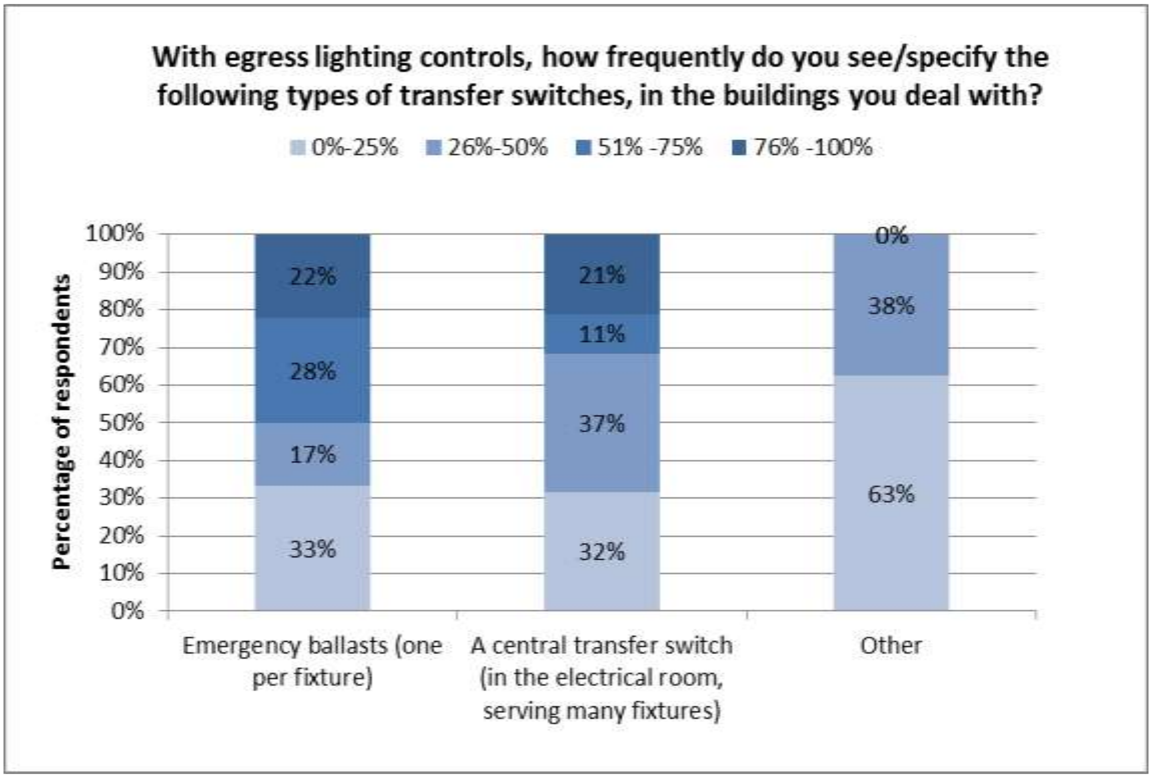


Figure 7. Types of Emergency Transfer Switch

4.2.4 Average or Minimum Egress Illuminance

Respondents were asked whether their local authority having jurisdiction (AHJ) enforces 1 footcandle *average* for egress lighting, or 1 footcandle *minimum*. Note that the California Building Code Section 1006.1 requires one footcandle minimum along the path of egress. Figure 8 shows that, of those who gave an answer, two-thirds said that their jurisdiction enforces 1 footcandle minimum.

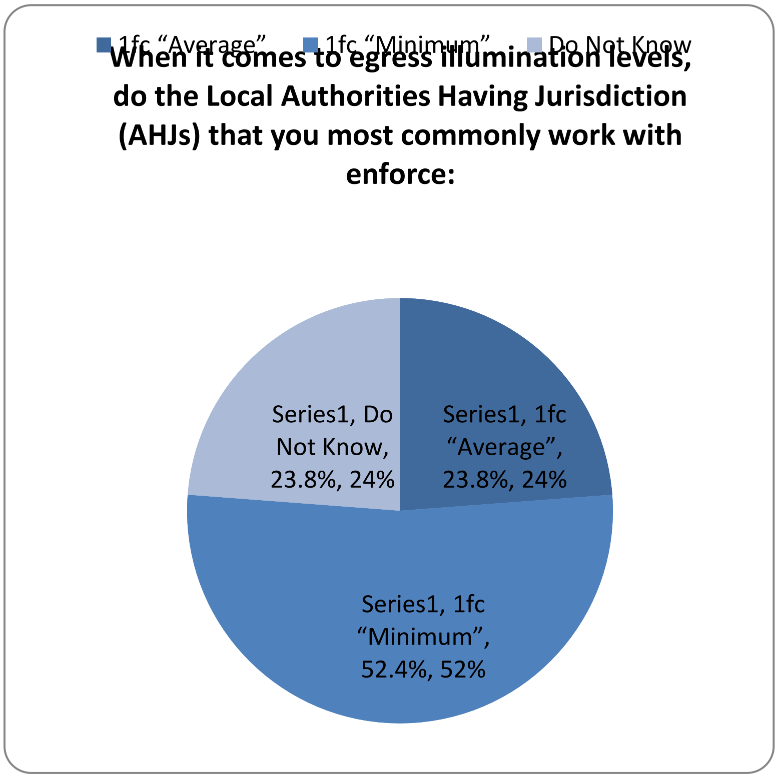


Figure 8. Enforcement of Egress Illumination levels

4.2.5 Proportion of Luminaires that are Egress

We asked how many egress / emergency luminaires are typically installed in office buildings, both in terms of "per square foot" lighting power, and "proportion of fixtures." Respondents were allowed to respond either way. Figure 9 shows the averaged responses.

The "per square foot" responses showed several errors: people responded with illuminance levels rather than LPDs, and people gave answers that are out of bounds. Therefore we believe that the "proportion of fixtures" answers are more reliable.

The responses show that egress lighting typically uses most or all of the power density allowed under Title 24 2008--approximately 0.23 W/sf along the egress pathway, which, assuming a whole-building LPD of 0.85 W/sf translates to approximately 0.16 W/sf for the whole building, assuming the values for the area of the egress path as a percentage of the area of the whole building, given in Section 4.5.2.

	Per square foot		Proportion of fixtures		
	Entire building	**Egress path only**	**Entire building**	**Egress path only (open areas)**	**Egress path only (corridors)**
Average of survey responses	0.16 W/sf	0.21 W/sf	19%	18%	27%
Average LPD assuming 0.85 W/sf total	No data	No data	**0.16 W/sf**	**0.15 W/sf**	**0.23 W/sf**

Figure 9. Typical Amount of Lighting that is Egress Lighting: From Online Survey

4.3 Codes and Standards Context

Egress lighting and emergency lighting are heavily regulated by the Building Code and Fire Code, so an important element of this code change proposal is to ensure that everything in the proposal is consistent with the requirements of those codes.

Another relevant consideration is that other codes (national, state, and city codes) either require or have considered requiring controls for egress lighting. The wording of those codes and the experience of the people who were involved in developing them is of direct relevance to this proposal.

4.3.1 Requirements of California Building Code, Electrical and Fire Code

The relevant sections of California Codes are shown in Appendix VI: Relevant Code Sections, organized into "key" vs. "ancillary" sections.

4.3.2 Egress Control Requirements in Other Energy Codes

This section provides an overview of how other building codes handle the requirement for egress lighting controls, at the city, state and national level. Interviewees told us that the history of adoption of egress controls in other codes is an important issue for Title 24. This is because several other codes have failed in their attempts to adopt egress controls, either due to conflicts with other elements of code, or due to the requirements being wrongly worded. Understanding this history will be critical for successful adoption within Title 24.

State of Oregon Energy Code

The State of Oregon code requires egress illumination to be shut off when a portion of the building is unoccupied. This closely follows the language in NFPA 101. Section 505.2.1.1, Oregon code states: "Egress illumination should be controlled by [the] combination of listed emergency relay and occupancy sensor to shut off during the period when the portion of the building served by the egress lighting is unoccupied."

ASHRAE/IESNA Standard 90.1 Proposed Addendum and Current Status

The 2010 version of ASHRAE/IESNA Standard 90.1 proposed by the lighting subcommittee sought to require occupancy sensors to control egress lighting at all times of the day. However, the proposed version was voted down and will not be part of the 2010 code. The proposal states, in part *"This proposal will control the 'night lights' that are part of the emergency system when there are no occupants in the space. This has definite energy savings and is not prohibited by the electrical codes. There is nothing in the National Electric Code that dictates that emergency lighting be ON when normal power is present or the building is unoccupied"*. We believe this proposed language is flawed because it confuses "night lights" (which typically provide both egress and emergency illumination) with single-purpose emergency lights. NPFA and state codes do in fact require "night lights"(i.e., egress lighting) to be on when normal power is present and the building is occupied. The present status of this proposed change is that Addendum cu was sent back to the ASHRAE 90.1 lighting subcommittee for further review.

IESNA RP-1 Current Status

IES Office Lighting Committee RP-1 "Recommended Practice for Office Lighting, RP-1." RP-1 is not a code or a standard, but is cited as guidance on best/typical practices for office lighting.

The proposed language in RP-1 is similar to NFPA 101"Emergency egress lighting systems must illuminate the pathway leading to exits, including all passageways, turns, corridor intersections, stair treads and landings, exit doors, and additionally, the exit discharge. Emergency egress lighting must be artificial lighting (not natural daylight) and must be available any time a building is occupied." The IES/ANSI revised RP-1 will be published in March or April 2011.

City of Seattle Building Code

The City of Seattle requires the use of" *Automatic Shut-Off Controls, Interior*" as outlined in the quotation below, in code sections 1513.6, 1513.6.1, 1513.6.2, and 1513.7.

"*1513.6 Automatic Shut-Off Controls, Interior: Buildings greater than 5,000 ft2 and all school classrooms shall be equipped with separate automatic controls to shut off the lighting during unoccupied hours. Within these buildings, all office areas less than 300ft2 enclosed by walls or ceiling-height partitions, and all meeting and conference rooms, and all school classrooms, shall be equipped with occupancy sensors that comply with Section 1513.6.1. For other spaces, automatic controls may be an occupancy sensor, time switch or other device capable of automatically shutting off lighting that complies with Section 1513.6.1 or 1513.6.2".*

Washington State Energy Code

The State of Washington had passed a code in 2010 (WAC 51-11-1515) requiring egress lighting controls, stating that: "*Emergency lighting and means of egress illumination that is normally on during normal building operation shall, during periods that the space served by the means of egress is unoccupied, be shut off and controlled by a combination of listed emergency relay and occupancy sensors.*" One of the scoping interviewees described the code adoption process, and stated that, under pressure from developers who filed a lawsuit, in November 2009 the State of Washington removed this section from the rule, noting that "*the intended switching mechanisms that will be used in this proposal have not been tested and approved by U.L. or any other listing agency to meet the more stringent criteria associated with life safety devices*". We believe that the wording of the Washington code did not distinguish adequately between emergency and egress systems, and that it was correct to withdraw the requirement. Because this Title 24 proposal does not require the emergency lighting to be controlled by occupancy sensors, the concern about the lack of a U.L. standard is not relevant.

The adopted language in the 2009 Washington State code is as follows.:

> 1513.6 **Automatic Shut-Off Controls, Interior**: All buildings shall be equipped with separate automatic controls to shut off the lighting in all spaces during unoccupied hours. Within these buildings, all office areas less than 300 ft^2 enclosed by walls or ceiling-height partitions, and all meeting and conference rooms, and all school classrooms, and warehouse and storage spaces shall be equipped with occupancy sensors that comply with Section 1513.6.1. For other spaces, automatic controls may be an occupancy sensor, time switch or other device capable of automatically shutting off lighting. For hotel and motel guestrooms, see Section 1513.7.

EXCEPTIONS:

1. Areas that must be continuously illuminated (e.g., 24-hour convenience stores), or illuminated in a manner requiring manual operation of the lighting.

2. Emergency lighting and means of egress illumination as required by code that are automatically OFF during normal building operation

3. Switching for industrial or manufacturing process facilities as may be required for production.

4. 24-hour occupancy areas in hospitals and laboratory spaces.

5. Areas in which medical or dental tasks are performed are exempt from the occupancy sensor requirement.

6. Dwelling units.

4.4 Results of Night Time survey

This section analyses the results of the night-time lighting survey. It discusses the patterns and trends in the data, potential sources of error, potential energy savings, and other relevant information.

The main potential source of error in the study is that the surveyors were walking around the buildings at ground level and could seldom be sure whether the space they were looking at was a private office, an open office, or another kind of space. Because private offices are likely to make up a significant portion of the visible perimeter of a building, this study may be capturing mostly private office space which is not part of the egress pathway, rather than open spaces, corridors and stairwells which are part of the pathway.

4.4.1 Lighting Loads

As can be seen in Figure 10 there was a great deal of variety in how much lighting was switched on at night, on each floor of the surveyed buildings. Many buildings had no lighting switched on at all (except for exit signage); a few had all of their lighting switched on, and there was a broad spread in between those two extremes. The percentages shown are the percentage of observed stories, not th percentage of observed buildings).

Figure 10 also shows that there was a trend of lighting being switched off over time (from 6pm to 10pm), i.e., the lower-percentage bands (towards the bottom of the chart) get progressively wider over the five time periods, while the higher-percentage bands get narrower.

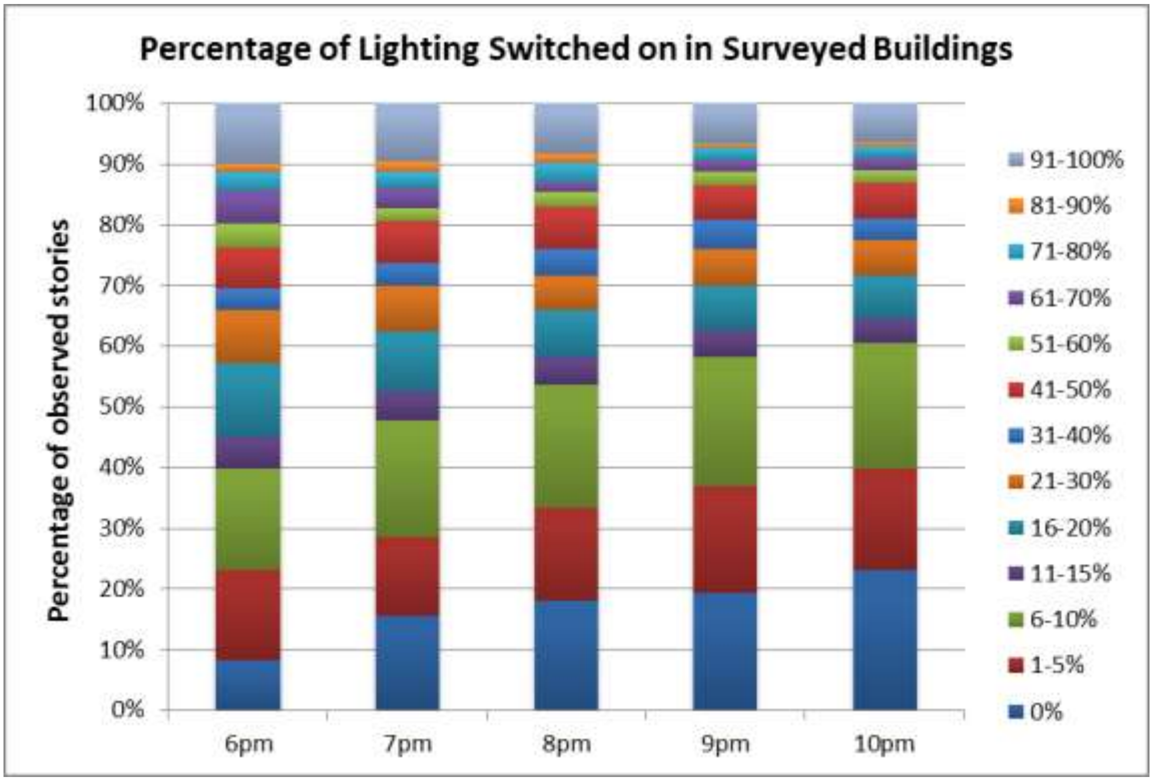


Figure 10. Percentage of Lighting Switched on in Surveyed Buildings

An estimate of the egress lighting load was made based on the following assumptions:

- If 10% or less of the lighting was switched on, that load was counted as being egress lighting.
- If more than 10% of the lighting was switched on, the first 10% of the load was counted as egress lighting.

An estimate of the non-egress lighting load was made by using the following algorithm:

- The egress lighting load (see above) was subtracted from the total load

Figure 11 shows how the estimates of egress and non-egress lighting changed over time from the beginning to the end of the survey time period. The amount of egress lighting switched on remained approximately constant (at around 7%), since in practice most egress lighting is held on 24/7. This value of 7% is used in the final cost-effectiveness analysis below. Conversely, the amount of non-egress lighting declined steadily (from 24% to 15%) over the survey period. The fact that egress lighting declined much less over time than non-egress lighting gives us confidence that the analysis algorithms (above) are successfully separating egress from non-egress loads.

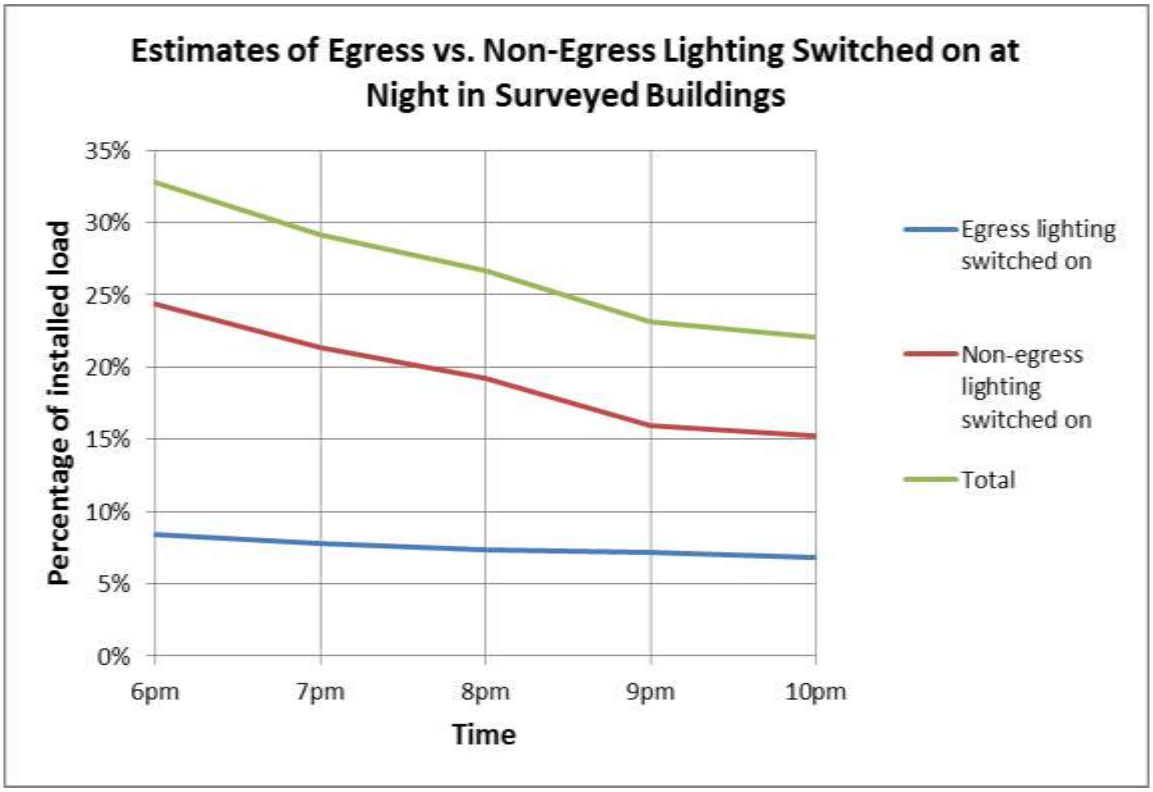


Figure 11. Estimates of Egress vs. Non-Egress Lighting Switched on at Night in Surveyed Buildings

4.4.2 Sensitivity Analysis for Lighting Loads

To work out a "confidence interval" for the estimate of egress lighting load, we looked at the effect of changing the egress lighting percentage, from our assumed value of 10%, up or down by 5%. Figure 12 shows that changing the assumed value up or down by 5% results in approximately a 2% change in the egress lighting load estimate.

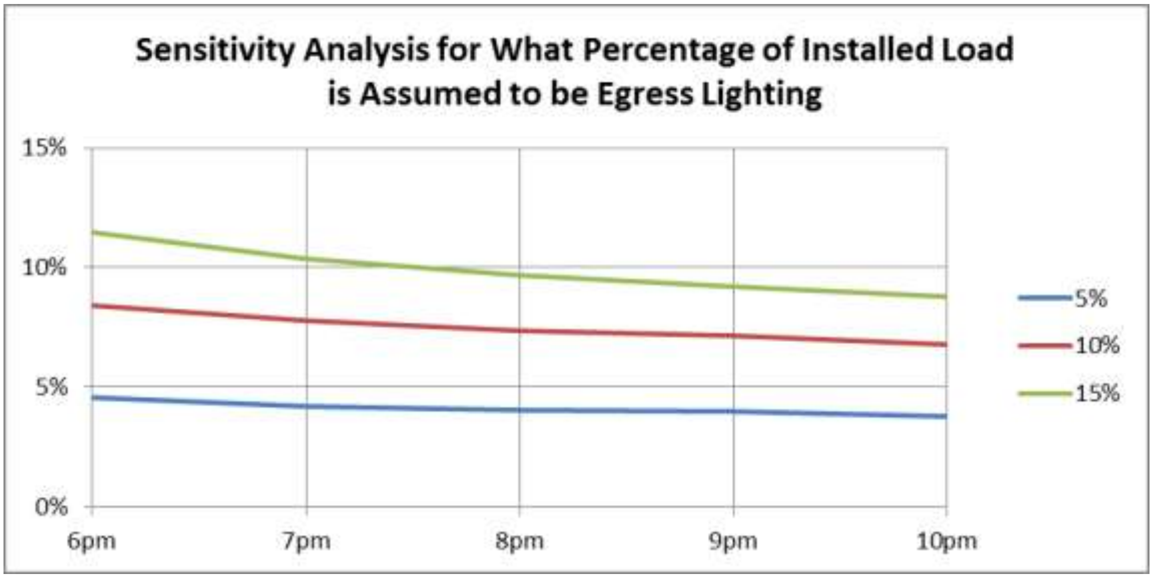


Figure 12. Sensitivity Analysis for What Percentage of Installed Load is Assumed to be Egress Lighting

4.4.3 Number of Stories with Lighting Totally Shut Off

Although we do not believe that egress lighting controls are common in office buildings, it does appear from the survey data that egress lighting is sometimes shut off manually (either by occupants or by security staff) sometime after the last occupant leaves. Figure 13 shows that 8% of stories had their lighting totally shut off at 6pm, and that this percentage rose steadily to 24% by the 10pm observation.

	6pm	7pm	8pm	9pm	10pm
Number of stories with 2% or less of their lighting on	8%	16%	19%	20%	24%

Figure 13. Percentage of Observed Stories that have 2% or less of their Lighting On

4.4.4 Comparison with CEUS Data

The California Commercial End-Use Survey[5] (CEUS) conducted in 2005 includes hourly short-term metering data on indoor lighting, from a subsample of buildings. The number of buildings for which STM data was obtained in shown in Figure 14.

[5] California Energy Commission. 2006. California Commercial End-Use Survey. Report prepared by Itron, Inc. Published by the California Energy Commission, report number CEC-400-2006-005. Retrieved in January 2011 from http://www.energy.ca.gov/ceus/index.html.

Building type	Number of "short term metering" (STM) sites in the CEUS data set
Small office	71
Large office	38
Retail	100
Refrigerated warehouse	10
Non-refrigerated warehouse	46

Figure 14. CEUS Sample of Short-Term Metering Data

Figure 15shows hourly lighting energy use profiles from the CEUS dataset. It is not clear from the CEUS report whether these profiles were derived directly from the monitored data, or whether they were modified to take account of other factors.

The profiles for each building type indicate that the CEUS data is in agreement with the findings of the night-time survey conducted for this CASE study. The CASE night-time survey sample was comprised mostly of large offices, with a number of smaller offices included. The night-time survey found that an average of 22% of lighting was switched on at 10pm, whereas the CEUS data shows 38% for large offices and 15% for small offices at 10pm.

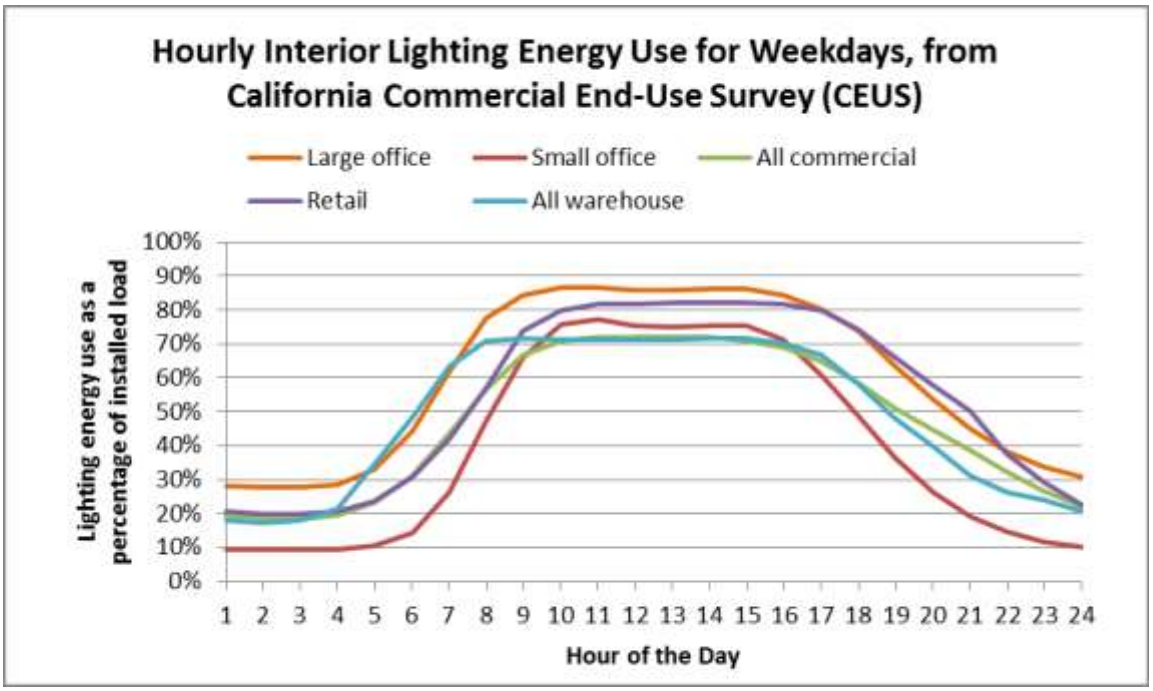


Figure 15. Hourly Interior Lighting Energy Use for Weekdays, from CEUS

4.5 Energy Savings

In this section we estimate energy savings from the night time lighting survey (see Section 4.4), and from the engineered lighting layouts, which show the reductions in emergency and egress lighting power density obtained by using a single lamp per fixture.

4.5.1 Potential Energy Savings from Night-Time Field Study

This section discusses the potential savings from automatically shutting off egress lighting, based on the night-time survey of existing office buildings. The proposed code language allows 0.05W/sf to remain on in office buildings, but for the cost-effectiveness calculation we have assumed that all of the egress lighting is shut off overnight.

Using the value of 7% of installed load left on overnight (obtained from the analysis in Section 4.4), the potential savings from switching off egress lighting is approximately 0.23 kWh/sf/yr., assuming:

- Egress lighting can be switched off for 9 hours overnight and all day Sunday, for a total of 4,056 hours per year
- A complete building LPD of 0.80 W/sf
- 10% of installed fixtures are emergency/egress fixtures
- None of the spaces in the survey had 24-hour occupancy (we do not believe that any of the buildings were occupied 24 hours)

To put this in the form of an equation:

$$E_p = F_{overnight} \times LPD_{NC} \times T_{unoccupied}$$

Where:

E_p = Energy savings potential from egress lighting controls (kWh/sf/yr)

$F_{overnight}$ = the fraction of installed lighting that is on overnight

LPD_{NC} = The installed lighting power density in new construction

$T_{unoccupied}$ = The number of hours per year that the building is unoccupied

$$0.23\ kWh/sf/yr = 0.07 \times 0.80\ W/sf \times 4{,}056\ hours$$

To put the magnitude of these savings in context, this value of 0.23 kWh/sf/yr is approximately 9% of the annual lighting energy use of a new construction Title-24 compliant building (≈ 2.7 kWh/sf/yr).

The Time-Dependent Valuation (TDV) value of the potential savings from complete shut-off of emergency and egress lighting, assuming the hours of control described above, is approximately $0.41/sf.

It should be noted that the survey of buildings was a random sample, and therefore includes some buildings that *already have* automatic shut-off of non-egress lighting, as required by Title 24. Therefore the potential savings estimate from shutting off non-egress lighting is likely to be conservative. The savings estimate for egress lighting is probably close to correct, since we believe that automatic shut-off of egress lighting is uncommon and therefore unlikely to be present in the sample of buildings.

4.5.2 Lighting Power Density Reduction from using Single-Lamp Emergency and Egress Fixtures

The egress and emergency circuit layouts are shown in Appendix I: Egress Lighting Circuit Layouts in Prototype Buildings. The layouts were developed by M Neils Engineering to ensure compliance with the average illuminance and uniformity requirements of the Fire Code. The illuminance levels are shown in the appendix, but have not been reproduced in this section because they are spatial distributions and therefore are not easy to quantify in a meaningful numerical way. The layouts developed by M Neils result in the statistics and equipment counts shown in Figure 16 below.

	Large Office	**Small Office**
Building area (sf)	34,000	8,200
Emergency lighting load (W)	1032	239
Emergency and egress lighting load (W)	2184	580
Emergency and egress lighting area square footage (sq ft)	21,805	5871
Emergency lighting load per square foot (W/sq ft)	0.05	0.04
Emergency lighting and egress lighting load per square foot (W/sq ft)	0.10	0.10
Number of emergency lights	33	10
Number of egress lights	36	13
Additional #12 wire for separate egress lighting circuit (ft)	1008	360

Figure 16. Summary of Egress and Emergency Lighting in Prototype Office Buildings

As shown in Figure 16, by using single-lamp emergency and egress fixtures to increase the uniformity of lighting, the average lighting power density per floor, in the prototype office buildings was reduced from the 0.3 W/sf along the path of egress (as allowed under the Building Energy Efficiency Code 2008), down to 0.05 W/sf for emergency and 0.05 W/sf for egress (a total of 0.1 W/sf).

Because the emergency and egress lighting requirements in some spaces are much higher than in others, we propose to retain a higher LPD allowance of 0.2W/sf for each individual space (In code section 131(a)), while reducing the average across the whole floor to 0.05W/sf.

These lighting power densities were achieved assuming semi-specular deep louver recessed fixtures, which give very poor uniformity for sparse grids, so these LPDs are conservative (i.e., high) values. Standard lighting design software (AGI32) was used for the modeling. The spacings between the emergency fixtures was irregular because the fixture locations were chosen to maximize uniformity in spaces that were mostly irregular. The exact layouts can be seen in Appendix I: Egress Lighting Circuit Layouts in Prototype Buildings.

The results of the online survey suggest that, in practice, buildings typically use around 0.16 W/sf for emergency/egress lighting, so the proposed total LPD of 0.1 W/sf represents a savings compared to typical practice, as well as compared to current code maximums.

4.6 Costs

We have analyzed two levels of cost involved in controlling progressively more of the egress and emergency lighting:

- **Level one**: Adding a "third circuit" to control *egress* lighting on and off according to building occupancy.
- **Level two**: Adding a “third circuit” as per level one, and also adding power transfer equipment to control *emergency* lighting on and off according to building occupancy.

The cost of both proposed control systems is calculated relative to typical baseline practice under Title 24 2008. A schematic of the baseline wiring that we have assumed for the 2008 Code is shown in Figure 17. Note that all the emergency / egress fixtures are connected to the emergency circuit, i.e. there is no "third circuit". An illustration of the “layers” of control for this baseline situation is shown on the left hand side of Figure 18. In this baseline case all emergency and egress lighting is kept on 24/7.

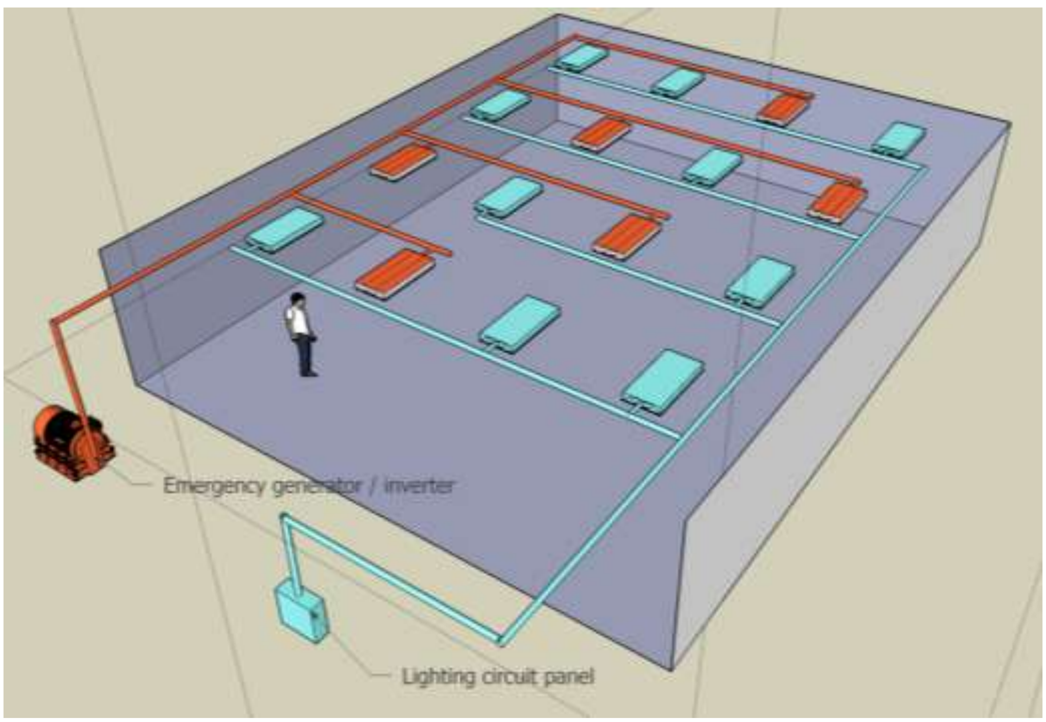


Figure 17. Circuit Schematic for Baseline Emergency/Egress Wiring under 2008 Building Energy Efficiency Standards

4.6.1 Costs for “Level One” Control

The Level One control strategy moves the egress luminaires to a separate circuit, so they can be controlled according to occupancy by the building's automatic lighting shut-off system. A schematic of how these controls are layered is shown in Figure 18.

This shows that 0.05 W/sf is held on 24/7 as emergency lighting or "night lighting"; 0.05 W/sf (egress lighting) is controlled according to building occupancy, and the remaining power (approximately 0.70

W/sf) is general lighting. The egress circuit would be switched on with the rest of the lighting when the building is first occupied (typically first thing in the morning), and would remain on without any manual shut-off until the building is unoccupied. Egress luminaires would be "protected" from shut-off by manual wall switches or occupancy sensors simply because they are powered by their own dedicated circuit that is supplied directly from the electrical panel with no intervening switching devices.

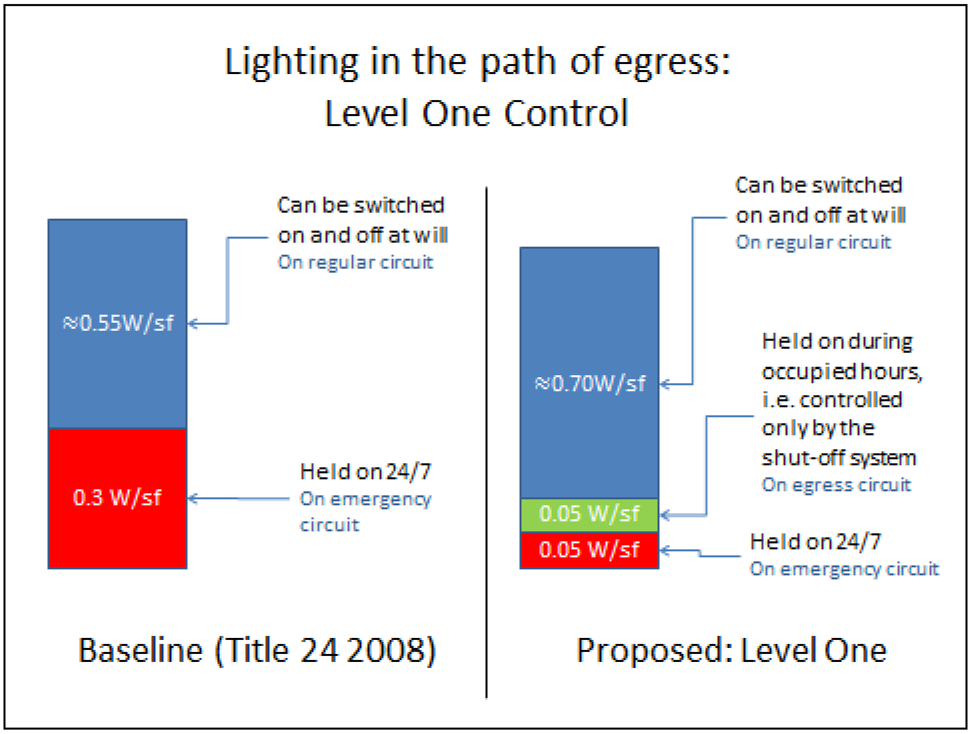
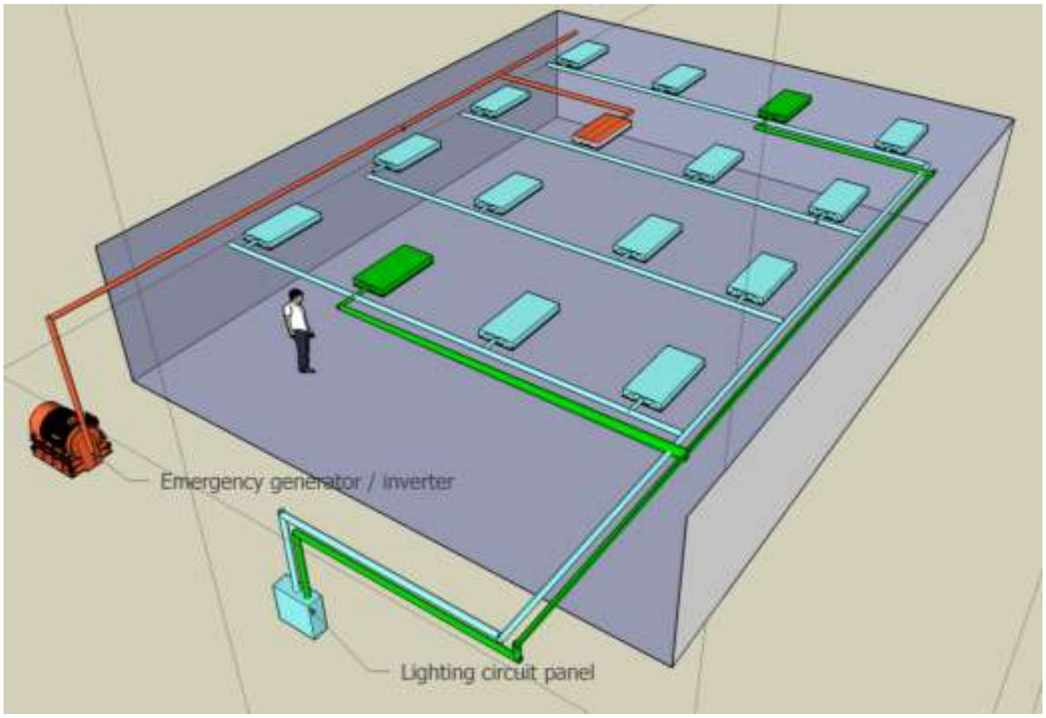


Figure 18. Layers of Control for "Level One" Egress Lighting Control

Figure 19 shows a schematic of the physical layout. The exact layout used for costing is shown in Appendix I: Egress Lighting Circuit Layouts in Prototype Buildings.

The lighting layouts assume that in each emergency or egress fixture, one lamp is dedicated to emergency/egress, while the other lamp is controlled by the general lighting control system. This means that there are two single-lamp ballasts in these fixtures, rather than a twin-lamp ballast. This layout was chosen because it maximizes uniformity and therefore minimizes the total lighting power density required for emergency and egress lighting.



Note that the (red) emergency luminaires and (green) egress luminaires all contain n-1 lamps for general lighting, in addition to one lamp for emergency or egress lighting

Figure 19. Circuit Schematic for "Level One" Control

The increased cost for this option is the cost of installing the wiring and breaker(s) for a “third circuit” and extra ballasts for the egress lighting as well as a networked control of egress lighting so the entire path of egress is lit when any portion of the egress path has the override turned on.. The incremental cost is the total cost for wiring the egress and emergency circuits separately, less the cost that would have been incurred for wiring the egress and emergency fixtures together on the same circuit.

The costs for this measure do *not* include any additional lighting control equipment; since the "third" egress circuit could simply be connected to the building's existing automatic shut-off circuit as long as the override switches were located and zoned appropriately to ensure that all necessary portions of the egress path remained illuminated, whichever override switch was pushed.

The costs for this measure do *not* include the avoided cost of being able to reduce the size of the generator/inverter and batteries that are required under the base case for all 0.3 W/sf of emergency/egress lighting, so this is a conservative assumption.

This wiring arrangement is not impacted by the anticipated requirement for “controllable lighting” in the 2013 standards. Neither the emergency circuit nor the egress circuit would be connected to the dimming control.

	Large Office Prototype		Small Office Prototype	
	Count (n)	**Cost ($)**	**Count (n)**	**Cost ($)**
Building area (sf)	34,000	-	8,200	-
Number of emergency lights	33	*$660*(1)	10	*$200*
Number of egress lights	36	*$720*	13	*$260*
Additional #12 wire for separate egress lighting circuit (ft)	1008	*$781*(2)	360	*$279*
Number of additional circuit breakers required for "third circuit"	1(3)	*$100*(4)	1	*$100*
Total additional cost per square foot of building ($/sf)	**-**	**$0.067**	**-**	**$0.093**

(1) Assumes $20 increment for swapping a twin-lamp for two single-lamp ballasts, installed by luminaire manufacturer.

(2) From RS Means, the cost for purchase and installation of #12 wire is $77.51 per 100 linear foot

(3) This is calculated as the number of breakers required for the proposed controls, minus the number of breakers required if the egress and emergency fixtures had been on the same circuit(s)

(4) From RS Means, the cost for purchase and installation of an additional breaker is $100

Figure 20. Incremental Costs for "Level One" Control in Large and Small Office Prototypes

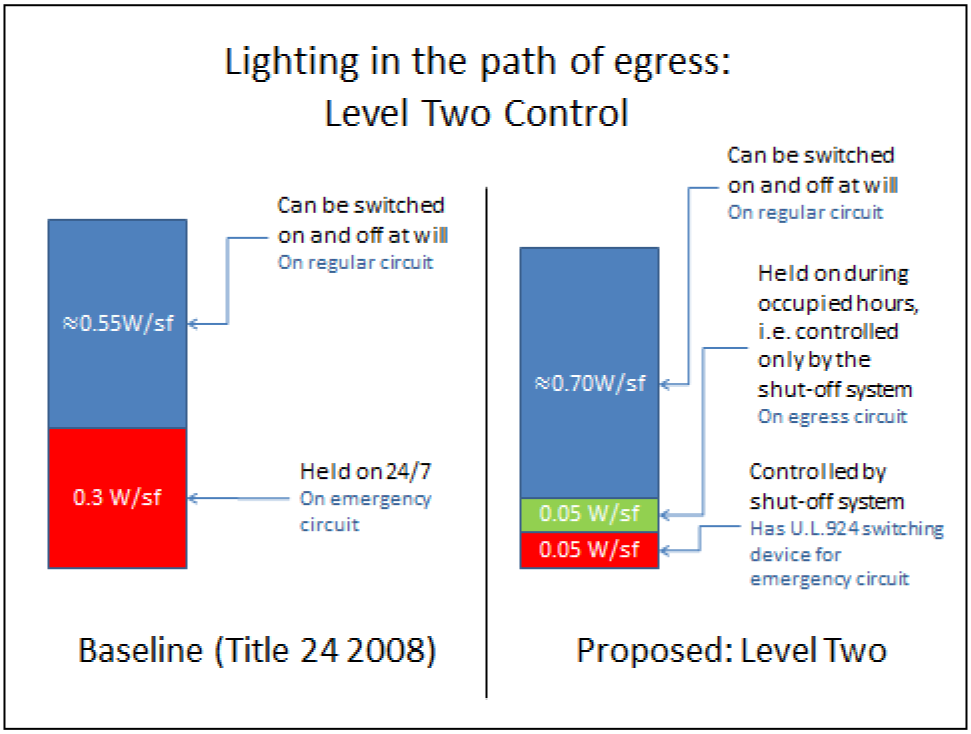
4.6.2 Costs for "Level Two" Control

The Level Two control strategy puts the egress luminaires on a separate circuit (as per "level one"), but uses this circuit to also control the emergency luminaires, so that the emergency luminaires shut off when the building is unoccupied. To facilitate this control, the emergency luminaires have U.L.924 listed power transfer devices in them to switch over to emergency power when the normal (utility) power fails.

Level Two saves more energy than Level One because when the building is unoccupied, the lighting is completely shut off.

A schematic of how these controls are layered is shown in Note that the (red) emergency luminaires and (green) egress luminaires all contain n-1 lamps for general lighting, in addition to one lamp for emergency or egress lighting

Figure 21. This shows that the emergency lighting is controlled according to building occupancy in the same way as the egress lighting. As with "level one", the remaining power (approximately 0.70 W/sf) is general lighting.



Note that the (red) emergency luminaires and (green) egress luminaires all contain n-1 lamps for general lighting, in addition to one lamp for emergency or egress lighting

Figure 21. Layers of Control for "Level Two" Egress Lighting Control

Figure 22 shows a schematic of the physical layout. The exact layout used for costing is shown in Appendix I: Egress Lighting Circuit Layouts in Prototype Buildings.

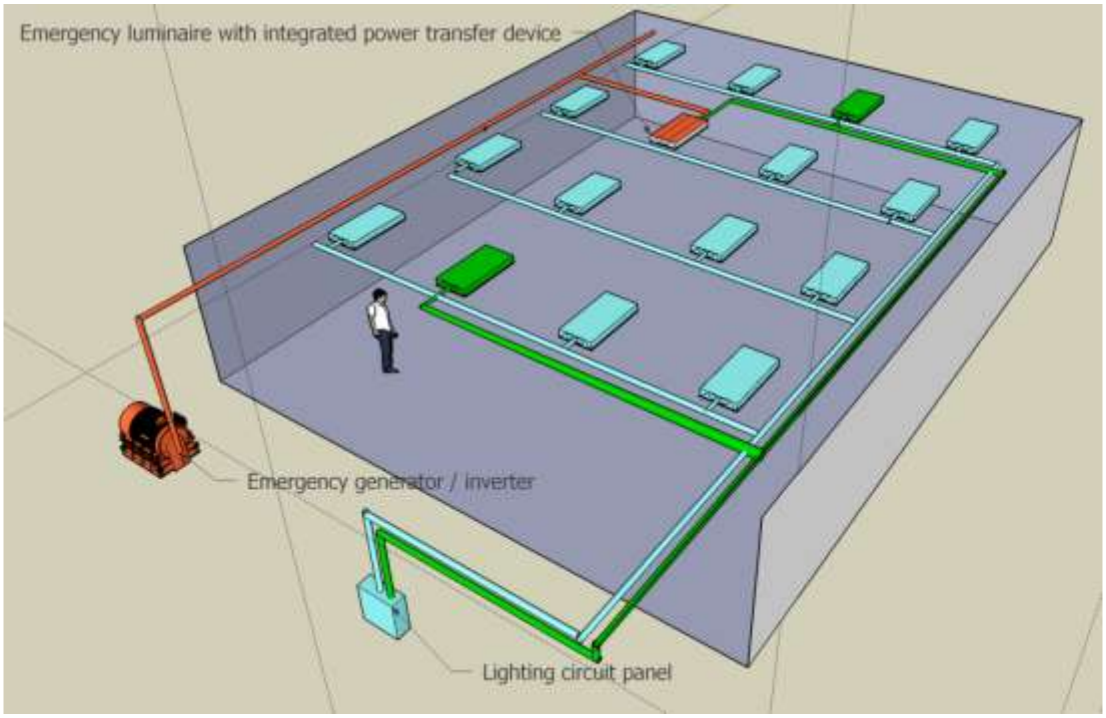


Figure 22. Circuit Schematic for "Level Two" Control

The increased cost for Level Two control is the cost of installing the wiring and breaker(s) for a "third circuit" for the egress lighting, additional ballasts in the controlled luminaire **and** the cost of installing emergency power transfer devices for the emergency fixtures and adding network override controls for both egress and emergency lighting control panels.

The incremental cost is the total cost for wiring the egress and emergency circuits separately, less the cost that would have been incurred for wiring the egress and emergency fixtures all together on the same circuit.

Note that the costs for this measure do *not* include any additional lighting controls cost, since the "third" egress circuit could simply be connected to the building's existing automatic shut-off circuit.

The costs for this measure do *not* include the avoided cost of being able to reduce the size of the generator/inverter and batteries that are required under the base case for all 0.3 W/sf of emergency/egress lighting.

The total incremental costs for implementing "level one" egress control in the office prototypes are shown in Figure 23.

	Large Building	**Small building**
Building area (sf)	34,000	8,200
Number of emergency lights	33	10
Cost of additional ballasts for emergency lights6	*$660*	*$200*
Number of egress lights	36	13
Cost of additional ballasts for egress lights	*$720*	*$260*
Additional #12 wire for separate egress lighting circuit (ft)	1411	540
Cost of additional #12 wire ($)7	*$1094*	*$419*
Number of additional circuit breakers required for "third circuit"[8]	1	1
Cost of additional breakers ($)9	*$100*	*$100*
Number of additional fixture-mounted emergency transfer switches required	0	0
Cost of fixture-mounted emergency transfer switches	-	-
Number of additional panel-mounted emergency transfer switches required	1	1
Cost of panel-mounted emergency transfer switches	*$395*	*$395*
Total additional cost per square foot of building ($/sf)	**$0.087**	**$0.153**

Figure 23. Incremental Costs for "Level Two" Control in Large and Small Office Prototypes

Unit Cost for Power Transfer Equipment

Prior to costing the Level Two approach (adding power transfer equipment so that emergency lighting can be controlled according to building occupancy), the per-unit cost for the required equipment was calculated

To obtain a conservative (i.e., high) estimate of the unit cost for emergency power transfer equipment, we obtained a quote from an electrical distributor. This quote was for retail pricing (i.e., the "walk-in" price for small orders), so to create an estimate of price for larger orders we reduced the quoted price by 30%.

We obtained prices for the following equipment:

> **Emergency Ballast:** Replaces the regular ballast. Has integral battery (does not need to be connected to emergency power supply). Works with one or two lamp linear fluorescent and CFL fixtures. Has remote control testing capability. U.L. 924 Listed, CSA Certified
>
> **Dual power transfer switch (fixture-mounted):** Works with any load (i.e., multiple light fixtures) up to 3A. Transfers hot and neutral supply to an emergency source. U.L. 924 Listed, CSA Certified

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[6] Assumes $20 increment for swapping a twin-lamp for two single-lamp ballasts, installed by luminaire manufacturer.

[7] From RS Means, the cost for purchase and installation of #12 wire is $77.51 per 100 linear foot

[8] This is calculated as the number of breakers required for the proposed controls, minus the number of breakers required if the egress and emergency fixtures had been on the same circuit(s)

[9] From RS Means, the cost for purchase and installation of an additional breaker is $100

Dual power transfer switch (mounted in circuit panel): Works with any load (i.e., multiple light fixtures) up to 20A. Transfers hot and neutral supply to an emergency source. U.L. 924 Listed, CSA Certified

	Retail price	**Estimated price for larger orders**(3)	**Labor hours to install**	**Total cost per unit**(4)
Emergency Ballast	$300	$210	0.1(1)	$218.50
Dual power transfer switch (fixture-mounted)	$95	$65	0.1(1)	$73.50
Dual power transfer switch (mounted in circuit panel)	$200	$140	3(2)	$395.00

(1) Factory installed by luminaire manufacturer.

(2) Installed by electrician on site.

(3) In line with typical pricing practice we have estimated a 30% reduction in price for multiple unit orders from a contractor who has an account with the distributor, compared to walk-in pricing.

(4) We have used RS Means labor cost of $85/hour for an electrician, based on RS Means' average value for California cities.

Figure 24. Unit Prices and Installed Costs for Emergency Power Transfer Equipment

4.7 Cost Effectiveness and Statewide Savings

4.7.1 Summary of Costs

The summary of costs shown in the second and fourth columns of Figure 25 is obtained from the cost analysis section of this report (section 4.6), for two levels of control:

- Level One Control: "third circuit" for egress lighting, emergency lighting held on 24/7
- Level Two Control: "third circuit" for egress lighting, emergency lighting controlled by egress circuit and U.L. 924 transfer device

4.7.2 Summary of Savings

The results from the night-time lighting survey (see section 4.4) show that the amount of emergency/egress lighting that is left on overnight is equal to approximately 7% of a typical building's installed lighting load. This equates to approximately 0.23 kWh/sf/yr in a typical newly constructed building. The TDV value of this energy is approximately $0.41/sf. Detailed savings calculations are shown in Section 4.5.

This amount of energy is the amount that could be saved if *all* emergency and egress lighting were shut off while the building is unoccupied. The "Level One" and "Level Two" control scenarios save some or all of this energy, as described below.

Savings from Office "Level One" Control

The savings from Level One control are less than the potential savings described above, because under Level One control, the emergency lighting is left on while the building is unoccupied, rather than being shut off.

To estimate the savings from Level One control, we reduced the potential savings in proportion to the LPD left on overnight under this control scheme (0.05 W/sf), in comparison to the LPD typically left on overnight in newly-constructed buildings (0.16 W/sf, see Section 4.2.5).

Thus:

$$\text{Annual savings per square foot} = \frac{0.16-0.05}{0.16} \times 0.23 = 0.16 \text{ kWh/sf/yr}$$

The TDV value of this energy reduction, assuming the same hours of use, is approximately $0.29/sf.

Savings from Office "Level Two" Control

Assuming Level Two control, the emergency/egress lighting energy use is reduced to zero during the unoccupied period, so the full potential savings above are realized, equal to the full TDV value of the energy use, i.e. $0.41/sf.

4.7.3 Cost-Effectiveness

Both Level One and Level Two egress controls are cost-effective in both the large and small prototype office buildings, i.e., the TDV savings are substantially higher than the measure costs, as shown in Figure 25.

The benefit:cost ratio for the proposed measure ranges from 2.7 to 4.7 depending on the control strategy and the prototype building. All the benefit:cost ratios are greater than one, and are therefore cost-effective.

	Large office prototype			**Small office prototype**		
Strategy	**Scenario Cost ($/sf)**	**Scenario Savings (TDV$/sf)**	**Benefit: Cost Ratio**	**Scenario Cost ($/sf)**	**Scenario Savings (TDV$/sf)**	**Benefit: cost Ratio**
Office: Level One Control (“third circuit” for egress lighting, emergency lighting held on 24/7)	$0.067	$0.29	4.3	$0.093	$0.29	3.1
Office: Level Two Control (“third circuit” for egress lighting, emergency lighting controlled by egress circuit and UL 924 transfer device)	$0.087	$0.41	4.7	$0.153	$0.41	2.7

Figure 25. Summary of Cost-Effectiveness

4.7.4 Statewide Annual Savings

The total energy savings potential for this measure is 62.3 GWh/yr, as shown in Figure 26. This calculation makes the following assumptions:

- The 15% of non-egress lights in the night-time survey that were left on overnight anyway will continue to be left on under the proposed measure
- Egress lighting that was left on overnight in night-time survey will be shut off except for 0.05 allowance in offices
- Office buildings currently have approx.. 0.16W/sf of egress lighting, which is 19% of the connected load.
- Office buildings will be allowed to keep up to 0.05W/sf of egress lighting overnight
- Baseline egress lighting left on overnight is equal to 7% of the connected lighting load
- Baseline number of hours for which egress lighting is left on overnight = 78 (9 hours per night and 24 hours on Sunday)

For details of the assumptions used in the statewide construction forecast, see Appendix VII: Non-Residential Construction Forecast details.

Footnotes to Figure 26:

1. Assumes that 75% of warehouses are 24-hour, therefore no egress lighting savings
2. Assumes that retailers, in practice, will leave lights on over 25% of their floor area for advertising reasons
3. From Complete Building method proposed values for 2013 where possible, from area category method otherwise
4. Based on the night-time survey, an average 7% of connected load was egress lighting left on overnight. If connected egress lighting is 19% of connected load on average, then 37% of egress lighting is left on overnight
5. We have assumed, conservatively, that schools already switch off as much of their lighting as they are able to, due to their tight budgets, and that therefore this measure would not achieve significant additional savings in schools.

		OFF-SMALL	OFF-LRG	REST	RETAIL	FOOD	NWHSE	RWHSE	SCHOOL	COLLEGE	MISC	TOTAL
Total existing floorspace (Msf)	A	396.5	1286.4	190.8	1176.4	311.4	1056.6	58.8	553.9	348.9	1272.4	7335.9
Lifespan of lighting installation (years)	B	15	10	10	10	10	20	20	20	20	20	
Percentage of retrofit projects done under T24 permit (%)	C	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	
Retrofit floorspace per year (Msf)	D=(A*C)/B	13.2	64.3	9.5	58.8	15.6	26.4	1.5	13.8	8.7	31.8	263.6
New construction floorspace per year (Msf)	E	9.1	27.7	5.1	32.4	8.5	32.1	1.8	10.0	7.4	31.7	183.3
Percentage of building floorspace affected by measure (%)	F	100%	95%	100%	75%[2]	100%	25%[1]	25%[1]	100%	95%	0%	
Total affected floorspace per year (Msf)	G=(D+E)*F	22.3	87.4	14.6	68.4	24.1	14.6	0.8	23.8	15.3	0.0	271.4
Baseline LPD of building (W/sf)[3]	H	0.80	0.80	1.20	1.20	1.50	0.60	0.60	1.00	1.00	N/A	
Baseline percentage of connected load that is egress lighting (%)	I	19%	19%	19%	19%	19%	19%	19%	19%	19%	N/A	
Baseline LPD for egress lighting (W/sf)	J=(I*H)	0.15	0.15	0.23	0.23	0.29	0.11	0.11	0.19	0.19	N/A	
Proposed LPD for egress lighting left on overnight (W/sf)	K	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	
Baseline percentage of building space in which egress lighting is left on overnight (%)	L	37%[4]	37%	37%	37%	37%	37%	37%	37%	37%	N/A	
Baseline egress lighting use (hours/wk)	M	168	168	168	168	168	168	168	50	168	N/A	
Anticipated egress lighting use under proposed measure (hours/wk)	N	90	90	90	90	90	90	90	50	90	N/A	
Savings from proposed language (kWh/sf/yr)	O=52*(J-K)*L*(M-N)/1,000	0.15	0.15	0.34	0.34	0.43	0.17	0.17	0.00[5]	0.28	N/A	
Savings from proposed language (GWh/yr)	P=G*O	3.40	13.32	4.98	23.32	10.26	2.49	0.14	0.00	4.34	N/A	62.3

Figure 26. Statewide Savings Estimate

4.8 Materials Impacts

The total number of luminaires in any building is likely to be unchanged by this measure. This is because most luminaires are part of a regular grid that is determined by the illuminance and uniformity required for general illumination, not by the requirement for egress and emergency lighting. However, the revised LPD allowance for egress lighting in office buildings is predicated on fixtures that use only *one* of their lamps (rather than all two or three or four) for egress illumination. This means that egress luminaires are likely to contain two ballasts instead of one. The materials impact therefore assumes one additional ballast per egress luminaire, along with the additional wiring required to provide power to non-egress lamps within the egress luminaire (assume 10' of wiring per luminaire).

The materials impacts per component are shown in Appendix VIII: Data for Materials Impacts.

Component	**Basis for calculation**	**Number of square feet per component**	
		Large office prototype	Small office prototype
Additional ballast in each egress luminaire	One additional electronic ballast per egress luminaire	36 ballasts per 34,000sf = 944 sf/ballast (see Figure 20).	13 ballasts per 8,200sf = 630sf/ballast (see Figure 20).
Additional power wiring for each egress luminaire	See section 4.6.1	1008' of wire per 34,000sf = 3,400sf per 100' of wire	360' of wire per 8,200sf = 2,300sf per 100' of wire

Figure 27. Basis for Calculation of Materials Impacts

Component	**square feet per component**	**Materials impact (lbs/year)**					
		Mercury	**Lead**	**Copper**	**Steel**	**Plastic**	**Others (Identify)**
Large office prototype			87.4	Million square feet per year			
Additional ballast in each egress luminaire	944	139	139	13888	113416	11573	0
Additional power wiring for each egress luminaire	3400	0	0	51412	0	0	0
Small office prototype			22.3	Million square feet per year			
Additional ballast in each egress luminaire	630	53	53	5310	43361	4425	0
Additional power wiring for each egress luminaire	2300	0	0	19391	0	0	0
Statewide total		**192**	**192**	**90000**	**156777**	**15998**	**0**

Figure 28. Statewide Materials Impact

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

5.1 Summary of Code Change Proposals

This section summarizes the code language initially recommended by the IOU team.

The exception for egress lighting in Section 131(a) (automatic or manual area controls) is proposed to be retained, because to meet the requirements of the California Fire Code Section 1006.1, the means of egress "shall be illuminated at all times the building space served by the means of egress is occupied." Therefore occupants cannot be given the ability to switch the egress lighting off using a wall switch while they are still occupying the space, or while others are occupying space served by that egress path. This exception would, in practice, apply to many open areas and all corridors, but not to private offices.

The exception for egress lighting in Section 131(d) (automatic shut-off controls for each floor) is proposed to be either removed or reduced, because the intention of the shut off control requirement is that the lighting should be shut off when the building is unoccupied. This is possible for both egress and emergency lighting under current code.

Override switches are required to be provided under Section 131(d)2, which allow the lighting to remain on for up to two hours after the main lighting has been switched off. These override switches could be used, if desired, to implement a two-stage switching sequence where the main lighting would switch off after (for instance) one hour, and the egress lighting would switch off after one more hour, if the system did not detect occupancy.

The exception for "building security" lighting is proposed to be removed, on the basis that this is not defined either in Part 6 or Part 1 of Title 24 and is therefore a loophole.

We propose to add to the definition of "automatic controls" in Section 131(d), to make it clear that the lighting can be automatically shut down by another building system, such as a security system. This is an important issue in buildings such as assembly buildings, which do not have fixed schedules.

Note that the Statewide Utilities are proposing, in a separate CASE report, that at least 50% of the lighting load in corridors and stairwells should be controlled in response to occupancy. Those proposed changes are not shown here but would modify some of the exceptions in Section 131(d) below.

5.2 Code Language Recommended by the Investor-Owned Utilities Codes and Standards Team

This is the language that was originally proposed to the CEC by the IOU Codes and Standards team as a result of the stakeholder meetings and analysis described in this report, and as a result of initial discussions with the CEC. This language was presented in the Draft CASE report.

In the following proposed language additions are shown underlined and deletions are shown in strikeout, using the 2008 code as the base text.

SECTION 131 – INDOOR LIGHTING CONTROLS THAT SHALL BE INSTALLED

(a) Area Controls.

1. Each area enclosed by ceiling-height partitions shall have an independent switching or control device. This switching or control device shall be:

   A. Readily accessible; and

   B. Located so that a person using the device can see the lights or area controlled by that switch, or so that the area being lit is annunciated; and

   C. Manually operated, or automatically controlled by an occupant-sensor that meets the applicable requirements of Section 119.

2. Other devices may be installed in conjunction with the switching or control device provided that they:

   A. Permit the switching or control device to manually turn the lights off in each area enclosed by ceiling-height partitions; and

   B. Reset the mode of any automatic system to normal operation without further action.

EXCEPTION 1 to Section 131(a): Up to 0.**2**[10]~~*3*~~ watts per square foot of lighting in any area within a building ~~*that must*~~ **may** be continuously illuminated **during occupied times to allow** for~~*reasons of building security or*~~ emergency egress, if:

   A. The area is designated an ~~*security or*~~ emergency egress area on the plans and specifications submitted to the enforcement agency under Section 10-103(a)2 of Title 24, Part 1; and

   B. The ~~*security or*~~ egress lighting is **not** controlled by switches accessible ~~*only*~~ to **un**authorized personnel.

EXCEPTION 2 to Section 131(a): Public areas with switches that are accessible only to authorized personnel.

(d) Shut-off Controls.

1. 1. In addition to the manual controls installed to comply with Section 131(a) and (b), for every floor, all indoor lighting systems shall be equipped with separate automatic or manual controls to shut off the lighting. These automatic controls shall meet the requirements of Section 119 and may be an occupant sensor, automatic time switch, **or a signal from another building system** or device capable of automatically shutting off the lighting **in response to occupancy conditions**.

EXCEPTION 1 to Section 131(d)1: Where the lighting system is serving an area that~~*must be continuously lit*~~ **is in continual use**, 24 hours per day/365 days per year.

---

(1) [10] Because the emergency and egress lighting requirements in some spaces are much higher than in others, we propose to retain a higher LPD allowance of 0.2W/sf for each individual space (In code section 131(a)), while reducing the average across the whole floor to 0.05W/sf.

EXCEPTION 2 to Section 131(d)1: Lighting in corridors, guestrooms, **and** dwelling units of high-rise residential buildings and hotel/motels, and **lighting in** parking garages.

EXCEPTION 3 to Section 131(d)1: **In office buildings,** up to 0.**05**~~3~~ watts per square foot of lighting in any area within a building **may**~~that~~ ~~must~~ be continuously illuminated **to allow** for ~~reasons of building security or emergency~~ egress, provided that the area is designated a**n** ~~security or~~ emergency egress area on the plans and specifications submitted to the enforcement agency under Section 10-103(a)2 of Title 24, Part 1.

EXCEPTION 4 to Section 131(d)1: Lighting in stairwells.

[The remainder of Section 131 is not proposed to be changed under this proposal]

5.3 Code Language Proposed by the California Energy Commission

This is the text of the code language proposed by the California Energy Commission for section 131. This language was sent by the CEC to the California investor-owned utilities Codes and Standards Team on August 17, 2011.

SECTION 131 – INDOOR LIGHTING CONTROLS THAT SHALL BE INSTALLED

(a) Area Controls.

1. All luminaires shall be functionally controlled with manual ON and OFF switching devices. Each area enclosed by ceiling-height partitions shall be independently controlled.

EXCEPTION to Section 131(a)1: Up to 0.2 watts per square foot of lighting in any area within a building may be continuously illuminated during occupied times to allow for emergency egress, if:

A. The area is designated an emergency egress area on the plans and specifications submitted to the enforcement agency under Section 10-103(a)2 of Title 24, Part 1; and
B. The egress lighting is not controlled by switches accessible to unauthorized personnel.

2. These switching devices shall be:

C. Readily accessible; and
D. Located in the same room or area with the lighting that is controlled by that device.

EXCEPTION to Section 131(a)2: In malls, auditoriums, retail and wholesale sales floors, industrial facilities, convention centers, and arenas, the switching or control device shall be located so that a person using the device can see the lights or area controlled by that switch, or so that the area being lit is annunciated.

3. Other Lighting Controls. Other lighting controls may be installed in addition to the manual switching provided they do not override the functionality of Section 131(a)1, 2, or 4.

4. Separately Switched Lighting Systems

A. General lighting shall be separately switched from all other lighting systems in an area.
B. Floor and wall display, window display, case display, ornamental, and special effects lighting shall each be separately switched on circuits that are 20 amps or less.
C. When track lighting is used, general, display, ornamental, and special effects lighting shall each be separately switched, and shall be on separate track lighting circuits.

(c) Shut-off Controls

1. In addition to the manual controls installed to comply with Section 131(a) and (b), all installed indoor lighting systems shall be equipped with controls that meet the following requirements:

A. Are capable of automatically shutting off all of the lighting when the space is unoccupied.
B. Separately controls the lighting on each floor
C. Separately controls a space enclosed by ceiling height partitions not exceeding 5,000 square feet.
   EXCEPTION to Section 131(c)1C: In the following function areas the area controlled may not exceed 20,000 square feet: Malls, auditoriums, single tenant retail, industrial, convention centers, and arenas.
D. Separately control general, display, ornamental, and display case lighting.
E. Meets the requirements of Section 119
F. May be an occupant sensor, automatic time switch, signal from another building system, or other device capable of automatically shutting off all of the lighting in response to occupancy conditions.

EXCEPTION 1 to Section 131(c)1: Where the lighting is serving an area that is in continuous use, 24 hours per day/365 days per year.

EXCEPTION 2 to Section 131(c)1: Lighting complying with Section 131(c)5, 6, or 7.

EXCEPTION 3 to Section 131(c)1: In office buildings, up to 0.05 watts per square foot of lighting in any area within a building may be continuously illuminated, provided that the area is designated an emergency egress area on the plans and specifications submitted to the enforcement agency under Section 10-103(a)2 of Title 24, Part 1.

5.4 Differences between the Recommended and Proposed Language

This section highlights the key differences between the language recommended by the IOU team (Section 5.2) and the language proposed by the CEC (Section 5.3).CEC language relocated Shut-off controls requirements

The shut-off controls requirements have been moved from section 131(d) to section 131(c). This change does not affect the code language.

CEC language revised area control text in Section 131(a)

The revised language changes how the requirements are laid out, and is intended to make the code easier to read and understand. This change is simply to clarify the language, and does not affect the code requirement.

CEC language revised shut-off control text in Section 131(c)

The revised language changes how the requirements are laid out, and is intended to make the code easier to read and understand. This change is simply to clarify the language, and does not affect the code requirement.

6. Bibliography and Other Research

California Energy Commission. 2006. California Commercial End-Use Survey. Report prepared by Itron, Inc. Published by the California Energy Commission, report number CEC-400-2006-005

7. Appendix I: Egress Lighting Circuit Layouts in Prototype Buildings

This appendix shows the actual illuminance plots, isolux contours and fixture placements for the four lighting calculations conducted by M Neils Engineering for this study. Dark blue contours show the 0.1fc level; light blue contours show the 1fc level; green contours show the 5fc level. Figure 29 shows a close-up of one of the illuminance plots, in which the office partitions can be seen (dark blue) along with the emergency fixtures (RF1 fixtures with diagonal fill). Point-by-point illuminance values are shown in dark red.

M Neils Engineering confirmed that the lighting layouts shown create sufficient illuminance and uniformity to meet the requirements of the Fire Code for emergency illumination and egress illumination.

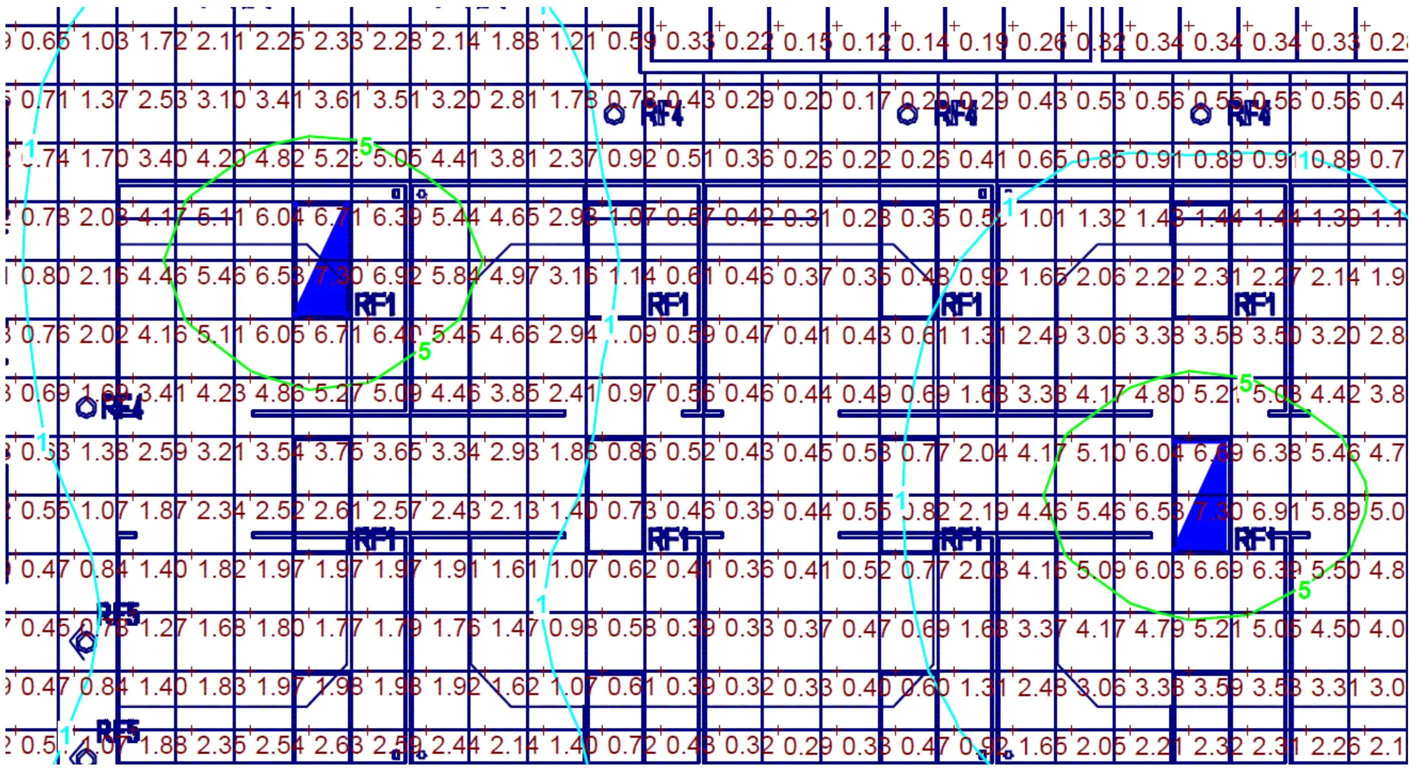


Figure 29. Close-up of Illuminance Plot

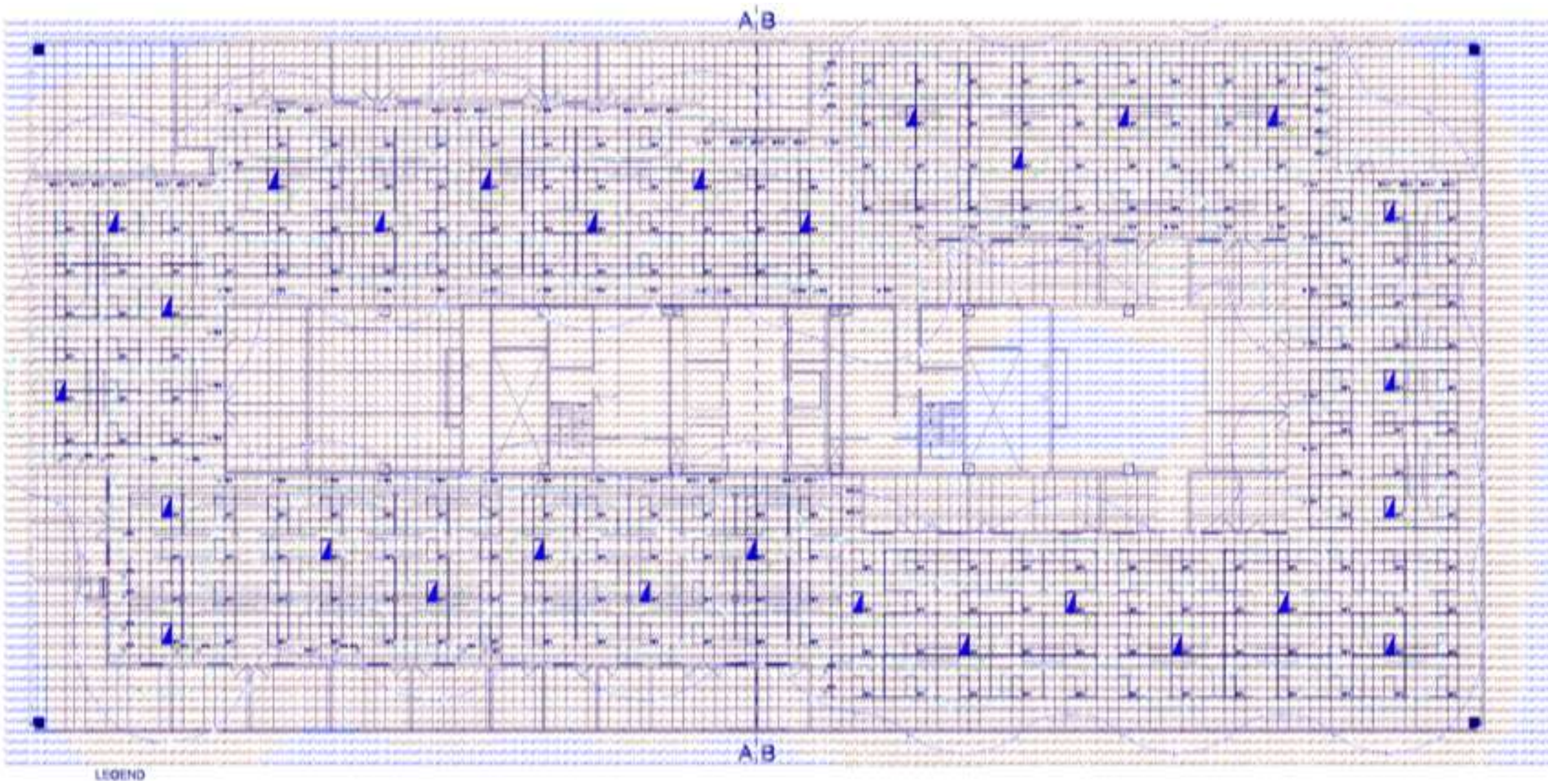


Figure 30. Emergency Lighing Large Office Building Layout

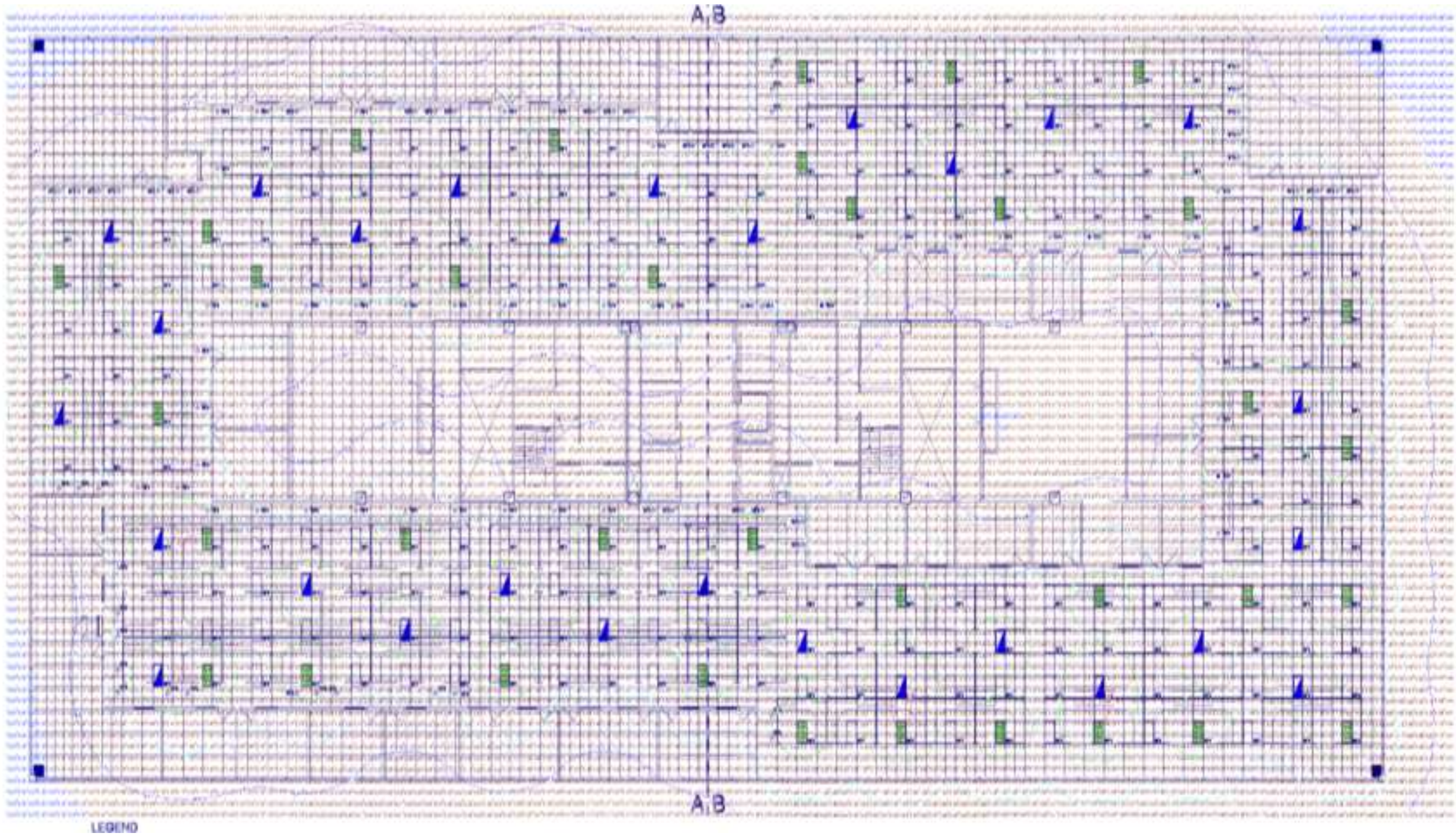


Figure 31. Emergency and Egress Lighting Large Office Layout

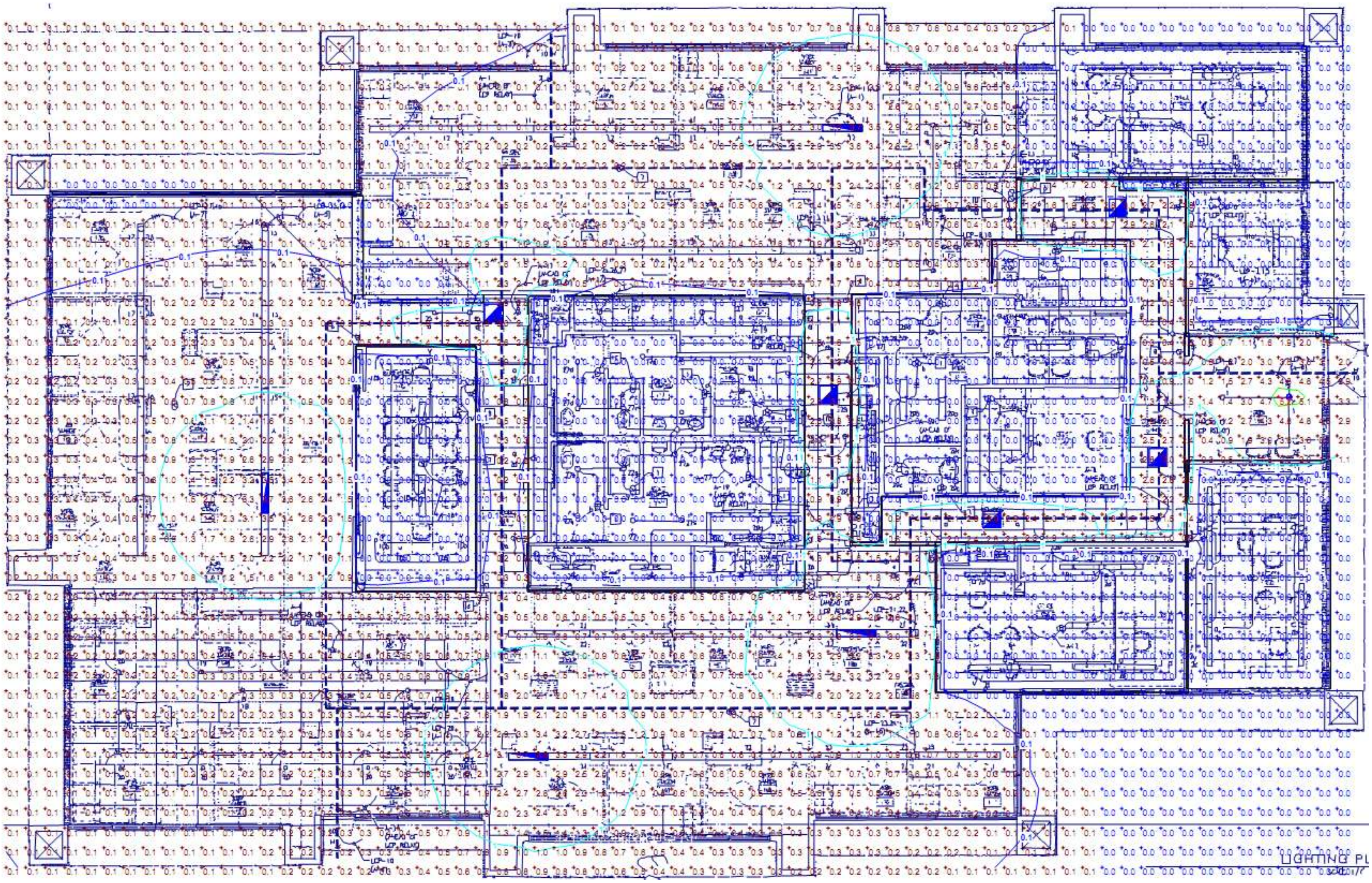


Figure 32. Small Office Emergency Lighting Layout

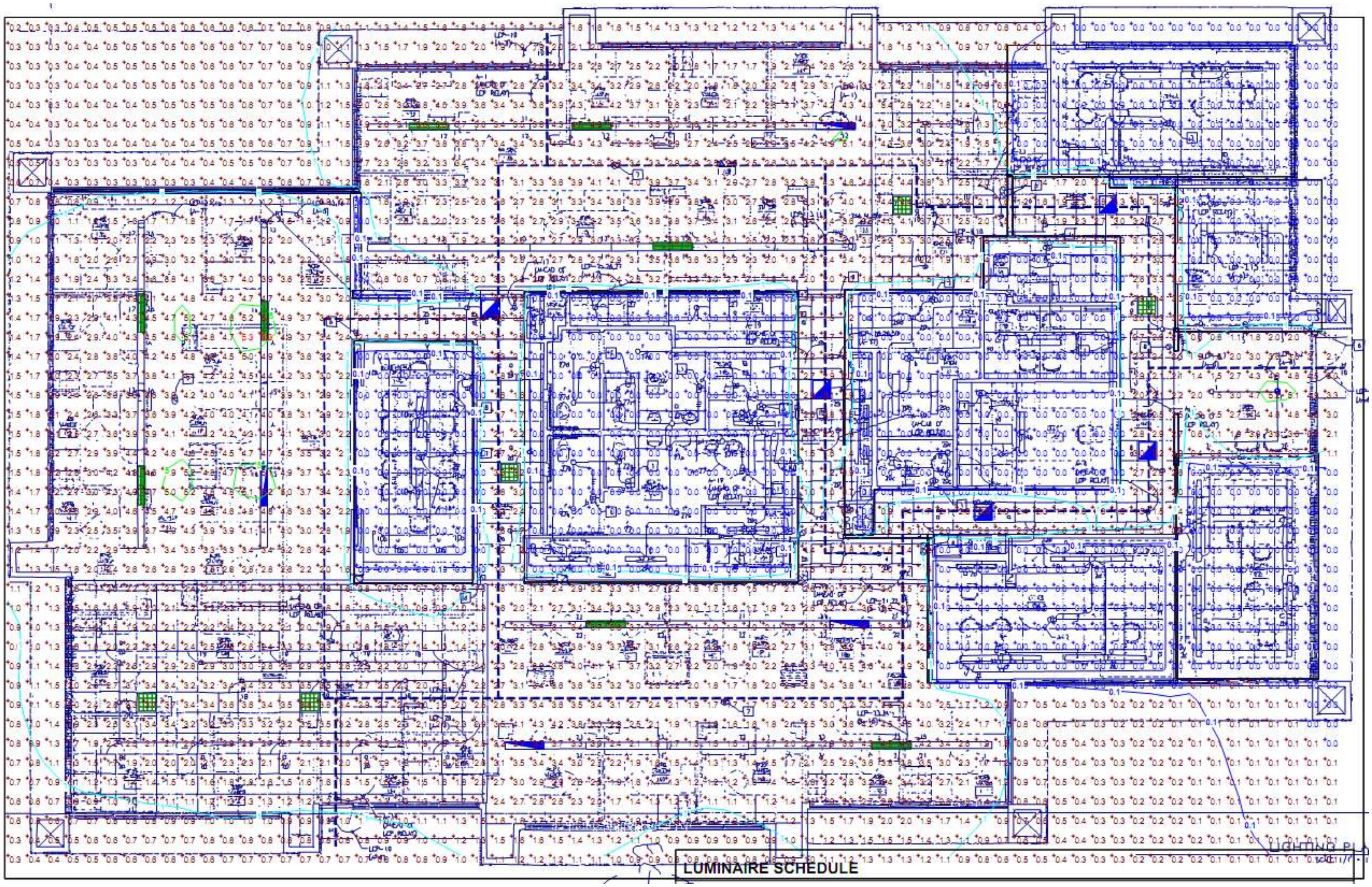


Figure **33**. Small Office Emergency and Egress Lighting Layout

8. Appendix II: Outline for Scoping Interview

I'm contacting you on behalf of the California Utilities Statewide Codes and Standards Team. We're conducting research for a proposed change to the Title 24 energy code, which would require the emergency egress lighting in buildings to be switched off when not required, to save energy. This would apply only to the egress lighting, not to emergency signage. The main method for doing this would be to require overrides are wall switches at various locations throughout the building; when they're pressed, the lights will stay on for another hour or two. Then they automatically turn of after that time period. To be consistent with Title 24 these are called "manually operated override switching device".

Which other organizations or governmental entities have/or are attempting to codify similar actions?

What is your role? If you haven't been involved in egress lighting code development, can you tell me about experience with code compliance? (Interviewer if the interviewee is involved with egress lighting code development ask them questions 3-9, in addition to any other applicable questions).

What is the process?

Was expert and/or public comment required?

What are the related statute names/numbers /dates?

What code changes were proposed? Was the code changed? If not, what were the objections?

Have costs and benefits been quantified? If so, which tools were used?

Have technical feasibility studies been done?

How are life and safety concerns being addressed?

System Types

We believe that there are three common types of egress lighting system in use; can you confirm that each of these is considered to be typical or good practice? And if so, what percentage of buildings has each kind of system?

Good Practice?

Wall mounted equipment with a rechargeable battery pack
A central auxiliary power system powering a dedicated egress circuit
Rechargeable battery packs in ceiling mounted luminaires.

System types--Market Share

	Wall mounted equipment with a rechargeable battery pack	A central auxiliary power system powering a dedicated emergency egress circuit.	Rechargeable battery packs in ceiling mounted luminaires
0%-25%			
26%-50%			
51% -75%			
76-100%			

System types--Other issues

What safety/performance/maintenance issues have come up either in practice or in discussions of best practices or code development with this type of equipment?

Types of Control

We believe that there are two common types of egress lighting control in use; can you confirm that each of these is considered to be typical or good practice? And if so, what percentage of buildings has each kind of system?

Good Practice?
Controlled by occupancy sensor so that the emergency egress lighting circuit can be automatically turned off when not needed?
Controlled by a time clock (with manual overrides) so that the emergency egress lighting is automatically switched off when not needed?
No controls (egress lighting is ON 24/7)?
No controls (dedicated egress lighting that is OFF 24/7)

Types of Control--Market Share

How Frequent	Controlled by occupancy sensor	Controlled by a time clock (with manual overrides)	No controls and egress lighting is on 24/7	No controls and egress lighting is off 24/7
0%-25%	N/A	N/A	N/A	N/A
26%-50%	N/A	N/A	N/A	N/A
51% -75%	N/A	N/A	N/A	N/A
76-100%	N/A	N/A	N/A	N/A

Types of Control—Other Issues

What safety/performance/effectiveness/maintenance issues have come up either in practice or in discussions of best practices or code development with this type of equipment?

Conservation Mode Power Usage

Does the emergency egress lighting still consume some residual power in conservation mode?

☐ Yes
☐ No

Other Contacts

We are trying to ensure that we identify all possible technical or safety hurdles to the use of egress lighting controls, especially in offices, retail and warehouses. Who else do you suggest we should talk to?

People who have vocally, or quietly, support this approach
☐ Yes
☐ No

____
____

People who have vocally, or quietly, opposed this approach
☐ Yes
☐ No

____
____

Other Considerations?

Is there anything else you'd like the Statewide Utility Codes and Standards Team to consider regarding the proposed code changes?

☐ Yes
☐ No

Thank you for your time. Also would you like to be added to our Cal Codes update email list? Also, would you like to be added to our Cal Codes update email list?

☐ Yes
☐ No

9. Appendix III: Text of Online Survey

9.1 Introduction

We’re contacting you on behalf of the California Investor Owned Utilities (IOU) Statewide Codes and Standards Team. The “Calcodes” team is working on a number of proposed changes to Title 24, and more information can be found at www.calcodesgroup.com.

We are conducting research for a proposed change to the Title 24 energy code, that would require the egress lighting (“night lighting)”) in buildings to be switched off when the building is unoccupied, to save energy. This would apply only to the egress lighting (not to emergency signage) and the egress lighting would still come on in response to a power failure or an alarm.

There are several types of technology already available on the market that can control egress lighting in the way that would be required by the proposed code. The purpose of this survey is to ask whether you have experience of using these systems, and if so what your experiences have been. It also asks about the enforcement of code in your jurisdiction.

If there are any questions that do not apply to you, please just click “Do not know”.

The link below provides access to a memo that summarizes the propose code change, and discusses some of the key issues surrounding the specification and use of egress lighting control systems. You do not need to read the memo to answer the questions in this survey, but it provides background information that you may wish to review.

<< LINK TO ONLINE MEMO >>

This survey contains twelve structured questions.

Q1 Emergency Power Supply Types—Market share

How frequently do you see each of these types of emergency egress lighting specified, in the buildings you work with (either new construction or major tenant improvement projects)?

Wall mounted equipment (“bug eyes”) equipped with a rechargeable battery pack

In what percentage of buildings? 0%-25%, 26%-50%, 51% -75%, 76& -100%

Do you find this type of power supply predominately used in certain building types or space types? If so what building types or space types ? ______________________________

A central auxiliary power system powering a dedicated emergency egress circuit.

In what percentage of buildings?   0%-25%, 26%-50%, 51% -75%, 76&   100%

Do you find this type of power supply predominately used in certain building types or space types? If so what building types or space types ? ______________________________

Rechargeable battery packs in ceiling mounted luminaires, as part of the general lighting grid.

In what percentage of buildings? 0%-25%, 26%-50%, 51% -75%, 76& -100%

Do you find this type of power supply predominately used in certain building types or space types? If so what building types or space types ? ____________________________

Q2. Emergency Power Supply Types —Performance

Identify what safety/performance/maintenance issues have come up with any of these systems either in practice or in discussions of best practices or code development.

Central auxiliary power system

What are the safety issues?

____

____

What are the Performance issues?

____

____

What are the Maintenance issues?

____

____

Rechargeable battery packs in ceiling mounted luminaires

What are the Safety issues?

____

____

What are the Performance issues?

____

____

What are the Maintenance issues?

____

____

Q3—Shut-off Control Types—Market share

Title 24 already requires "automatic shut-off controls" for each floor of a building. Typically this is achieved by a time clock control (with manual override switches), by occupancy sensors, or by a signal from another building system.

How frequently do you see/specify the following types of shut-off control, in the buildings you work with (either new construction or major tenant improvement projects)?

(Please quote your answer as a percentage of all buildings. The total may be more than 100%)

Time clock controls (or time signal from building management system) with manual override switches?
In what percentage of buildings? 0%-25%, 26%-50%, 51% -75%, 76& -100%

Does this control predominately apply to certain building types or sizes? If so which building types or sizes?

Occupancy sensor control only (no time clock)?
In what percentage of buildings? 0%-25%, 26%-50%, 51% -75%, 76& -100%

Does this control predominately apply to certain building types or sizes? If so which building types or sizes?

An automatic signal from another building system (e.g. fire or security system)?

In what percentage of buildings?) 0%-25%, 26%-50%, 51% -75%, 76& -100%

Specify the other building system: fire, security, other

Does this control predominately apply to certain building types or sizes? If so which building types or sizes?

Do not know

Q4—Egress Lighting Control Types—Market Share

With egress lighting controls, how frequently do you see/specify the following types of control being installed, in the buildings you work with (either new construction or major tenant improvement projects)?

(Please quote your answer as a percentage of all buildings that have egress control systems. The total may be less or more than 100%)

No controls (egress lighting is on 24/7)?
In what percentage of buildings? 0%-25%, 26%-50%, 51% -75%, 76& -100%

Controlled by occupancy sensor so that the emergency egress lighting circuit can be automatically turned off when the space is not occupied?
In what percentage of buildings? 0%-25%, 26%-50%, 51% -75%, 76& -100%

Controlled by a time clock so that the emergency egress lighting is automatically switched off when the space is not occupied?
In what percentage of buildings? 0%-25%, 26%-50%, 51% -75%, 76& -100%

Other (specify) 0%-25%, 26%-50%, 51% -75%, 76& -100%

Do not know

For buildings where egress lighting controls have been used, was there any specific reason why the controls were installed, or a specific condition that made that building suitable?

Q5. Egress Lighting Control Types--Performance

Identify what safety/performance/maintenance issues have come up either in practice or in discussions of best practices or code development.

Egress lighting shut off by occupancy sensor

What are the Safety issues?

What are the Performance issues?

_

What are the Maintenance issues?

Egress lighting shut off by timeclock

What are the Safety issues?

What are the Performance issues?

What are the Maintenance issues?

Q6—Types of Emergency Transfer Switch

Transfer switches are the pieces of equipment that switch the egress luminaires from regular power to emergency power, in the event of a power failure. Some ballasts have integral switches; some egress fixtures are controlled at the circuit level. With egress lighting controls, how frequently do you see/specify the following types of transfer switch, in the buildings you deal with?

(Please quote your answer as a percentage of all egress control systems, not as a percentage of all buildings. This should sum to 100%)

Emergency ballasts (one per fixture)?
0%-25%, 26%-50%, 51% -75%, 76& -100%

A central transfer switch (in the electrical room, serving many fixtures)?
0%-25%, 26%-50%, 51% -75%, 76& -100%

Other (specify) 0%-25%, 26%-50%, 51% -75%, 76& -100%

Do not know

Q7—Average or Minimum Egress Illuminance

The National Fire Protection Association (NFPA) 101 recommends egress lighting to provide an average of 1fc and a minimum of 0.1fc, measured along the path of egress. The California Building code requires not less than 1 foot-candle but does not state whether this is an average or a minimum level.

When it comes to egress illumination levels, do the Local Authorities Having Jurisdiction (AHJs) that you most commonly work with enforce:

1fc "Average"

1fc "Minimum"

Do not know

Do you feel that there is a trend toward using "minimum" instead of "average"?

Yes

No

Do not know

Do you typically design/build/advise to the "average" or the "minimum"?

1fc "average"

1fc "minimum"

Do not know

Q8—Proportion of Luminaires that are Egress

Title 24 Part 6 allows up to 0.3 W/sf for egress lighting along the path of egress.

Do you know how much installed power your building(s) typically use per square foot for egress lighting? (Either per sf of the entire building or per sf of egress path?)

Per sf of the entire building: ____

Per sf of the egress path: ____

Do not know

Instead of a W/sf value, do you find that a certain proportion of ceiling fixtures in open areas are egress fixtures? If so, what proportion? (Either in the building as a whole, or in open areas/egress paths).

For the entire building: ____

For open areas: ____

For egress corridors: ____

Do not know

Q9—NFPA Recommendation for 10fc in Stairwells

NFPA 101 recommends 10 foot-candles in stairwells as measured at the walking surface for new stairs. Has your local Authority Having Jurisdiction adopted this ruling?

Yes

No

Do not know

If this NFPA requirement has not been adopted, have you heard discussion about the possibility of it being adopted in future?

Yes

No

Do not know

If yes, please give details:__________________________________

Q10—Occupancy Sensors for Egress Lighting

The California Building Code requires egress illumination in each portion of a building while it is occupied, and NFPA 101 specifically identifies occupancy sensors as a valid means of controlling egress lighting.

Does your local Authority Having Jurisdiction allow the use of occupancy sensors to control egress lighting?

Yes (explain any restrictions)

____

No (explain why not, if known)

Does your local Authority Having Jurisdiction allow the use of individual occupancy sensors to control egress in sections along the entire path of egress.?

____

Does your local Authority Having Jurisdiction allow the use of occupancy sensors when they are networked to control egress lighting uniformly along the entire path of egress.?

____

Q11—Time Clock Control for Egress Lighting

Both the California Building Code and NFPA 101 require egress lighting to be lit while a portion of a building is occupied. Time clock control is a common way of implementing shut-off control for egress lighting.

Does your local Authority Having Jurisdiction allow the use of time clock control (with suitable manual overrides) to control egress lighting?

Yes (explain any restrictions)

____

No (explain why not, if known)

____

Q12—Security Lighting

The proposed code language provides an exception to the requirement for egress lighting controls, in areas that are "continuously occupied, 365 days per year" (i.e., buildings in which the egress controls would not save any energy).

Are there other areas of building(s) in which you would like to see an exception in the code to the requirement for egress controls?

Area(s) for exception: ____

Reason(s) for exception: ____

Q13—Other Issues

Is there anything else you'd like the Statewide IOUCodes and Standards Team to consider regarding the proposed code changes?

Yes

No

Please explain your answer in more detail:____
____
____
____

Q14—Further Contacts

Who else can you recommend for us to contact regarding this effort?

Name____
_____Organization____
__________Contact
Information____

Name____
_____Organization____
___________Contact
Information____

Q15—Thank you for your time.

Would you like to be added to our Cal Codes update email list for lighting code changes?

This email list provides notification of upcoming meetings, access to white papers and other background information for the code changes process. It also allows you to comment on the proposed code changes prior to adoption of the 2013 Title 24 code language. You can also stay updated through the California Energy Commission's website at www.energy.ca.gov/title24.

10. Appendix IV: Responses to Additional Online Survey Questions

This appendix shows the answers to the online survey questions that are *not* presented in the analysis (see Section 4.2).

Market Share of Shut-off Control Types

Respondents were asked in what percentage of buildings they install various types of shut-off control: Time clock controls, occupancy sensors, and automatic signals from other building systems.

Figure 34 shows that both occupancy sensors and time clock controls are frequently specified, but a connection to another type of automatic signal, such as a BMS or security system is less common.

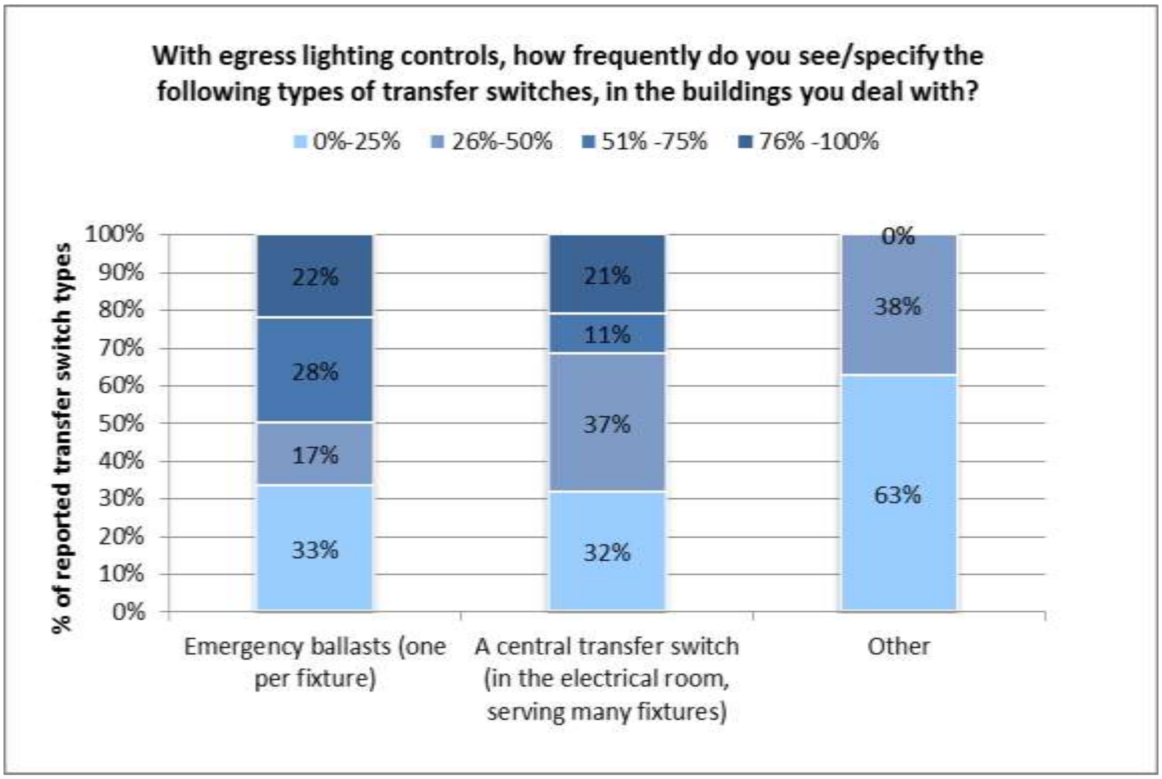
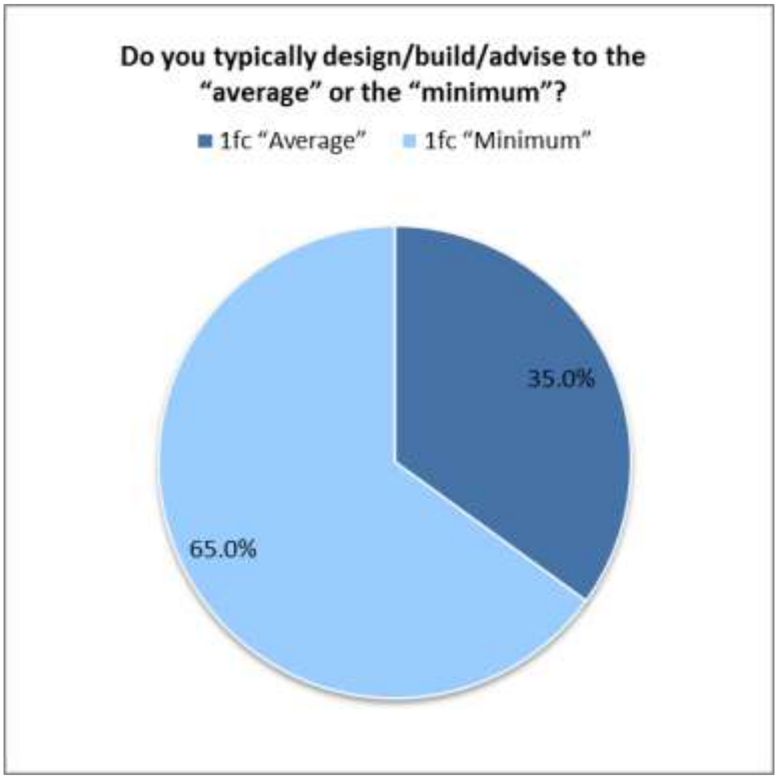


Figure 34. Market Share of Shut-off Control Types


Do you typically design/build/advise to the "average" or the "minimum"?
1fc "Average"
1fc "Minimum"
35.0%
65.0%

11. Appendix V: Surveyor's Forms for Night-Time Lighting Survey

6:00-7:00pm Percentage of light fixtures switched on

Story number

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A															
B															
C															
D															
E															
F															
G															
H															
I															
J															
K															
L															
M															
N															
O															
P															
Q															
R															
S															
T															

Parking structure

A															
B															
C															
D															

E															
F															

Parking lot

A		B		C		D		E		F		G		H	

Survey Reminders:

- Take: Clipboard, Two Mechanical Pencils, Camera (set date/time stamp),
- Print out Templates, Take Extras just in case. Note Pad, Charged Cell Phone
- Take a Flashlight and Business Cards
- Choose your Route, Note Streets of Route as you Walk
- Route Should Include: Low, Middle, High-Rise Buildings
- Route Should also Include: Surface Parking Lots or Parking Garages
- Route Should take you One Hour to Walk & Take Data and Notes
- Route Should Be Contiguous so when one hr. is up Your back at Bldg. A
- A Rectangular Route Will Be Easiest to Navigate Bldg. (A close to Bldg. T)
- Note Vintage of Building within 10 Years
- Note Building Type, if Retail on First Floor, Etc. on Note Pad
- Check Template by Floor (up to 15) Noting Which has Lighting On
- (Count Floors With Ceiling Lights on Only, Do Not Count Task Ltg.)
- On Note Pad Match Street Name and Address with Table Letter
- Take One photo of each Building, from the vantage you're counting from.

12. Appendix VI: Relevant Code Sections

This section collects together the egress-related sections of the California 2010 Building Code (Title 24, Part 2) and Fire Code (Title 24 Part 9), the 2008 ICC Means of Egress Final Action Agenda, and the 2007 California Electrical Code, Title 24, Part 3.

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12.1 Key Sections of the 2010 California Fire Code

Section 604 (Separate circuits and luminaires)

604.2.14.2 Separate circuits and luminaires. Separate lighting circuits and luminaires shall be required to provide sufficient light with an intensity of not less than 1 foot-candle (11 lux) measured at floor level in all means of egress corridors, stairways, smokeproof enclosures, elevator cars and lobbies, and other areas that are clearly a part of the escape route.

604.2.4 Means of egress illumination. Emergency power shall be provided for means of egress illumination in accordance with Section 1006.3.

Section 1001 (General)

1001.1 General. Buildings or portions thereof shall be provided with a means of egress system as required by this chapter. The provisions of this chapter shall control the design, construction and arrangement of means of egress components required to provide an approved means of egress from structures and portions thereof. Sections 1003 through 1029 shall apply to new construction. Section 1030 shall apply to existing buildings.

[B] SECTION 1002 (ACCESSIBLE MEANS OF EGRESS)

Section 1003 (Applicability)

1003.1 Applicability. The general requirements specified in Sections 1003 through 1013 shall apply to all three elements of the means of egress system, in addition to those specific requirements for the exit access, the exit and the exit discharge detailed elsewhere in this chapter.

Section 1006 (Means of Egress Illumination)

1006.1 Illumination required. The means of egress, including the exit discharge, shall be illuminated at all times the building space served by the means of egress is occupied.

Exceptions:

1. Occupancies in Group U.

2. Aisle accessways in Group A.
3. Dwelling units and sleeping units in Groups R-1, R-2 and R-3.
4. Sleeping units of Group I, R-2.1 and R-4 occupancies.

1006.2 Illumination level. The means of egress illumination level shall not be less than 1 foot-candle (11 lux) at the walking surface.

Exception: For auditoriums, theaters, concert or opera halls and similar assembly occupancies, the illumination at the walking surface is permitted to be reduced during performances to not less than 0.2 foot-candle (2.15 lux), provided that the required illumination is automatically restored upon activation of a premises' fire alarm system where such system is provided.

1006.3 Illumination emergency power. The power supply for means of egress illumination shall normally be provided by the premises' electrical supply. In the event of power supply failure, an emergency electrical system shall automatically illuminate all of the following areas:

1. Aisles and unenclosed egress stairways in rooms and spaces that require two or more means of egress.
2. Corridors, exit enclosures and exit passageways in buildings required to have two or more exits.
3. Exterior egress components at other than their levels of exit discharge until exit discharge is accomplished for buildings required to have two or more exits.
4. Interior exit discharge elements, as permitted in Section 1027.1, in buildings required to have two or more exits.
5. Exterior landings as required by Section 1008.1.6 for exit discharge doorways in buildings required to have two or more exits.

The emergency power system shall provide power for a duration of not less than 90 minutes and shall consist of storage batteries, unit equipment or an on-site generator. The installation of the emergency power system shall be in accordance with Chapter 27 of the California Building Code.

1006.4 Performance of system. Emergency lighting facilities shall be arranged to provide initial illumination that is at least an average of 1 foot-candle (11 lux) and a minimum at any point of 0.1 foot-candle (1 lux) measured along the path of egress at floor level. Illumination levels shall be permitted to decline to 0.6 foot-candle (6 lux) average and a minimum at any point of 0.06 foot-candle (0.6 lux) at the end of the emergency lighting time duration. A maximum-to-minimum illumination uniformity ratio of 40 to 1 shall not be exceeded.

Section 1024 (Luminous Egress Path Markings)

1024.5 Illumination. Exit enclosures where photoluminescent exit path markings are installed shall be provided with the minimum means of egress illumination required by Section 1006 for at least 60 minutes prior to periods when the buildings is occupied.

Section 4604 (Means of Egress for Existing Buildings)

4604.1 General. Means of egress in existing buildings shall comply with the minimum egress requirements when specified in Table 4603.1 as further enumerated in Sections 4604.2 through

4604.23, and the building code that applied at the time of construction. Where the provisions conflict, the most restrictive provision shall apply. Existing buildings that were not required to comply with a building code at the time of construction shall comply with the minimum egress requirements when specified in Table 4603.1 as further enumerated in Sections 4604.2 through 4604.23 and, in addition, shall have a life safety evaluation prepared, consistent with the requirements of Section 104.7.2. The life safety evaluation shall identify any changes to the means of egress that are necessary to provide safe egress to occupants and shall be subject to review and approval by the fire code official. The building shall be modified to comply with the recommendations set forth in the approved evaluation.

4604.5 Illumination emergency power. The power supply for means of egress illumination shall normally be provided by the premises' electrical supply. In the event of power supply failure, illumination shall be automatically provided from an emergency system for the following occupancies where such occupancies require two or more means of egress:

Group A having 50 or more occupants.
Exception: Assembly occupancies used exclusively as a place of worship and having an occupant load of less than 300.

Group B buildings three or more stories in height, buildings with 100 or more occupants above or below a level of exit discharge serving the occupants or buildings with 1,000 or more total occupants.

Group E in interior stairs, corridors, windowless areas with student occupancy, shops and laboratories.

Group F having more than 100 occupants.
Exception: Buildings used only during daylight hours which are provided with windows for natural light in accordance with the International Building Code.

Group I.

Group M.
Exception: Buildings less than 3,000 square feet (279 m2) in gross sales area on one story only, excluding mezzanines.

Group R-1.
Exception: Where each sleeping unit has direct access to the outside of the building at grade.

Group R-2.
Exception: Where each dwelling unit or sleeping unit has direct access to the outside of the building at grade.

Group R-4.
Exception: Where each sleeping unit has direct access to the outside of the building at ground level.

12.2 Ancillary Sections from the 2010 California Fire Code

Section 1002 (Definitions [selected definitions only])

1002.1 Definitions. The following words and terms shall, for the purposes of this chapter and as used elsewhere in this code, have the meanings shown herein.

ACCESSIBLE MEANS OF EGRESS. A continuous and unobstructed way of egress travel from any accessible point in a building or facility to a public way.

(MARKED PENDING IN THE CODE) AISLE. An unenclosed exit access component that defines and provides a path of egress travel.

AISLE ACCESSWAY. That portion of an exit access that leads to an aisle.

AREA OF REFUGE. An area where persons unable to use stairways can remain temporarily to await instructions or assistance during emergency evacuation.

COMMON PATH OF EGRESS TRAVEL. That portion of exit access which the occupants are required to traverse before two separate and distinct paths of egress travel to two exits are available. Paths that merge are common paths of travel. Common paths of egress travel shall be included within the permitted travel distance.

CORRIDOR. An enclosed exit access component that defines and provides a path of egress travel to an exit.

EGRESS COURT. A court or yard which provides access to a public way for one or more exits.

EMERGENCY ESCAPE AND RESCUE OPENING. An operable window, door or other similar device that provides for a means of escape and access for rescue in the event of an emergency.

(MARKED PENDING IN THE CODE) EXIT. That portion of a means of egress system which is separated from other interior spaces of a building or structure by fire-resistance-rated construction and opening protectives as required to provide a protected path of egress travel between the exit access and the exit discharge. Exits include exterior exit doors at the level of exit discharge, vertical exit enclosures, exit passageways, exterior exit stairways, exterior exit ramps and horizontal exits.

EXIT ACCESS. That portion of a means of egress system that leads from any occupied portion of a building or structure to an exit.

(MARKED PENDING IN THE CODE) EXIT ACCESS DOORWAY. A door or access point along the path of egress travel from an occupied room, area or space where the path of egress enters an intervening room, corridor, unenclosed exit access stair or unenclosed exit access ramp.

EXIT DISCHARGE. That portion of a means of egress system between the termination of an exit and a public way.

(MARKED PENDING IN THE CODE) EXIT DISCHARGE, LEVEL OF. The story at the point at which an exit terminates and an exit discharge begins.

EXIT ENCLOSURE. An exit component that is separated from other interior spaces of a building or structure by fire-resistance-rated construction and opening protective, and provides for a protected path of egress travel in a vertical or horizontal direction to the exit discharge or the public way.

EXIT, HORIZONTAL. A path of egress travel from one building to an area in another building on approximately the same level, or a path of egress travel through or around a wall or partition to an area on approximately the same level in the same building, which affords safety from fire and smoke from the area of incidence and areas communicating therewith.

(MARKED PENDING IN THE CODE) EXIT PASSAGEWAY. An exit component that is separated from other interior spaces of a building or structure by fire-resistance-rated construction and opening protectives, and provides for a protected path of egress travel in a horizontal direction to the exit discharge or the public way.

MEANS OF EGRESS. A continuous and unobstructed path of vertical and horizontal egress travel from any occupied portion of a building or structure to a public way. A means of egress consists of three separate and distinct parts: the exit access, the exit and the exit discharge.

(MARKED PENDING IN THE CODE) PHOTOLUMINESCENT. Having the property of emitting light that continues for a length of time after excitation by visible or invisible light has been removed.

(MARKED PENDING IN THE CODE) SELF-LUMINOUS. Illuminated by a self-contained power source, other than batteries, and operated independently of external power sources.

STAIR. A change in elevation, consisting of one or more risers.

STAIRWAY. One or more flights of stairs, either exterior or interior, with the necessary landings and platforms connecting them, to form a continuous and uninterrupted passage from one level to another.

STAIRWAY, EXTERIOR. A stairway that is open on at least one side, except for required structural columns, beams, handrails and guards. The adjoining open areas shall be either yards, courts or public ways. The other sides of the exterior stairway need not be open.

STAIRWAY, INTERIOR. A stairway not meeting the definition of an exterior stairway.

STAIRWAY, SPIRAL. A stairway having a closed circular form in its plan view with uniform section-shaped treads attached to and radiating from a minimum-diameter supporting column.

Section 1024 (Luminous egress path markings)

(MARKED PENDING IN THE CODE) [B] SECTION 1024 LUMINOUS EGRESS PATH MARKINGS

1024.1 General. Approved luminous egress path markings delineating the exit path shall be provided in buildings of Groups A, B, E, I, M and R-1 having occupied floors located more than 75 feet (22 860 mm) above the lowest level of fire department vehicle access in accordance with Sections 1024.1 through 1024.5.

Exceptions:

Luminous egress path markings shall not be required on the level of exit discharge in lobbies that serve as part of the exit path in accordance with Section 1027.1, Exception 1.

Luminous egress path markings shall not be required in areas of open parking garages that serve as part of the exit path in accordance with Section 1027.1, Exception 3.

1024.2 Markings within exit enclosures. Egress path markings shall be provided in exit enclosures, including vertical exit enclosures and exit passageways, in accordance with Sections 1024.2.1 through 1024.2.6.

1024.2.1 Steps. A solid and continuous stripe shall be applied to the horizontal leading edge of each step and shall extend for the full length of the step. Outlining stripes shall have a minimum horizontal width of 1 inch (25 mm) and a maximum width of 2 inches (51 mm). The leading edge of the stripe shall be placed at a maximum of ½ inch (12.7 mm) from the leading edge of the step and the stripe shall overlap the leading edge of the step by not more than ½ inch (12.7 mm) down the vertical face of the step.

Exception: The minimum width of 1 inch (25 mm) shall not apply to outlining stripes listed in accordance with U.L. 1994.

1024.2.2 Landings. The leading edge of landings shall be marked with a stripe consistent with the dimensional requirements for steps.

1024.2.3 Handrails. All handrails and handrail extensions shall be marked with a solid and continuous stripe having a minimum width of 1 inch (25 mm). The stripe shall be placed on the top surface of the handrail for the entire length of the handrail, including extensions and newel post caps. Where handrails or handrail extensions bend or turn corners, the stripe shall not have a gap of more than 4 inches (102 mm).

Exception: The minimum width of 1 inch (25 mm) shall not apply to outlining stripes listed in accordance with U.L. 1994.

1024.2.4 Perimeter demarcation lines. Stair landings and other floor areas within exit enclosures, with the exception of the sides of steps, shall be provided with solid and continuous demarcation lines on the floor or on the walls or a combination of both. The strips shall be 1 to 2 inches (25 mm to 51 mm) wide with interruptions not exceeding 4 inches (102 mm).

Exception: The minimum width of 1 inch (25 mm) shall not apply to outlining stripes listed in accordance with U.L. 1994.

1024.2.4.1 Floor-mounted demarcation lines. Perimeter demarcation lines shall be placed within 4 inches (102 mm) of the wall and shall extend to within 2 inches (51 mm) of the markings on the leading edge of landings. The demarcation lines shall continue across the floor in front of all doors.

Exception: Demarcation lines shall not extend in front of exit doors that lead out of an exit enclosure and through which occupants must travel to complete the exit path.

1024.2.4.2 Wall-mounted demarcation lines. Perimeter demarcation lines shall be placed on the wall with the bottom edge of the stripe no more than 4 inches (102 mm) above the finished floor. At the top or bottom of the stairs, demarcation lines shall drop vertically to the floor within 2 inches (51 mm) of the step or landing edge. Demarcation lines on walls shall transition vertically to the floor and then extend across the floor where a line on the floor is the only practical method of outlining the path. Where the wall line is broken by a door, demarcation lines on walls shall continue across the face of the door or transition to the floor and extend across the floor in front of such door.

Exception: Demarcation lines shall not extend in front of exit doors that lead out of an exit enclosure and through which occupants must travel to complete the exit path.

1024.2.4.3 Transition. Where a wall-mounted demarcation line transitions to a floor-mounted demarcation line, or vice versa, the wall-mounted demarcation line shall drop vertically to the floor to meet a complementary extension of the floor-mounted demarcation line, thus forming a continuous marking.

1024.2.5 Obstacles. Obstacles at or below 6 feet 6 inches (1981 mm) in height and projecting more than 4 inches (102 mm) into the egress path shall be outlined with markings no less than 1 inch (25 mm) in width comprised of a pattern of alternating equal bands, of luminescent luminous material and black, with the alternating bands no more than 2 inches (51 mm) thick and angled at 45 degrees (0.79 rad). Obstacles shall include, but are not limited to, standpipes, hose cabinets, wall projections and restricted height areas. However, such markings shall not conceal any required information or indicators including, but not limited to, instructions to occupants for the use of standpipes.

1024.2.6 Doors from exit enclosures. Doors through which occupants within an exit enclosure must pass in order to complete the exit path shall be provided with markings complying with Sections 1024.2.6.1 through 1024.2.6.3.

1024.2.6.1 Emergency exit symbol. The doors shall be identified by a low-location luminous emergency exit symbol complying with NFPA 170. The exit symbol shall be a minimum of 4 inches (102 mm) in height and shall be mounted on the door, centered horizontally, with the top of the symbol no higher than 18 inches (457 mm) above the finished floor.

210 1024.2.6.2 Door hardware markings. Door hardware shall be marked with no less than 16 square inches (406 mm2) of luminous material. This marking shall be located behind, immediately adjacent to or on the door handle and/or escutcheon. Where a panic bar is installed, such material shall be no less than 1 inch (25 mm) wide for the entire length of the actuating bar or touchpad.

1024.2.6.3 Door frame markings. The top and sides of the door frame shall be marked with a solid and continuous 1-inch-wide to 2-inch-wide (25 mm to 51 mm) strip. Where the door molding does not provide sufficient flat surface on which to located the stripe, the stripe shall be permitted to be located on the wall surrounding the frame.

1024.3 Uniformity. Placement and dimensions of markings shall be consistent and uniform throughout the same exit enclosure.

1024.4 Self-luminous and photoluminescent. Luminous egress path markings shall be permitted to be made of any material, including paint, provided that an electrical charge is not required to maintain the required luminance. Such materials shall include, but are not limited to, self-luminous materials and photoluminescent materials. Materials shall comply with either:

U.L. 1994; or

ASTM E 2072, except that the charging source shall be 1 foot-candle (11 lux) of fluorescent illumination for 60 minutes, and the minimum luminance shall be 30 millicandelas per square meter at 10 minutes and 5 millicandelas per square meter after 90 minutes.

1024.5 Illumination. Exit enclosures where photoluminescent exit path markings are installed shall be provided with the minimum means of egress illumination required by Section 1006 for at least 60 minutes prior to periods when the buildings is occupied.

12.3 Key Sections from the 2007 California Electrical Code

Section 89.101 (General)

89.101.1 These regulations are from the 2007 version of the California Electrical Code "which incorporates by adoption the 2005 National Electrical Code of the National Fire Protection Association with necessary California amendments." Under 89.101.2 Purpose. It is noted that the purpose of this code includes: safeguard the public health, means of egress facilities, and energy conservation.

Section 700 (Emergency Systems)

700.1 (Scope)

700.1 Scope. The provisions of this article apply to the electrical safety of the installation, operation, and maintenance of emergency systems consisting of circuits and equipment intended to supply, distribute, and control electricity for illumination, power, or both, to required facilities when the normal electrical supply or system is interrupted. Emergency systems are those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction. These systems are intended to automatically supply illumination, power, or both, to designated areas and equipment in the event of failure of the normal supply or in the event of accident to elements of a system intended to supply, distribute, and control power and illumination essential for safety to human life.

700.15 (Loads on Emergency Branch Circuits)

700.15 Loads on Emergency Branch Circuits. No appliances and no lamps, other than those specified as required for emergency use, shall be supplied by emergency lighting circuits.

700.16 (Emergency Illumination)

700.16 Emergency Illumination. Emergency illumination shall include all required means of egress lighting, illuminated exit signs, and all other lights specified as necessary to provide required illumination. Emergency lighting systems shall be designed and installed so that the failure of any individual lighting element, such as the burning out of a light bulb, cannot leave in total darkness any space that requires emergency illumination. Where high-intensity discharge lighting such as high-and low-pressure sodium, mercury vapor, and metal halide is used as the sole source of normal illumination, the emergency lighting system shall be required to operate until normal illumination has been restored. Exception: Alternative means that ensure emergency lighting illumination level is maintained shall be permitted.

700.20 (Switch Requirements)

700.20 Switch Requirements. The switch or switches installed in emergency lighting circuits shall be arranged so that only authorized persons have control of emergency lighting. Exception No.1: Where two or more single-throw switches are connected in parallel to control a single circuit, at least· one of these switches shall be accessible only to authorized persons. Exception No.2: Additional switches that act only to put emergency lights into operation but not disconnect them shall be permissible. Switches connected in series or 3- and 4-way switches shall not be used.

700.21 (Switch Location)

700.21 Switch Location. All manual switches for controlling emergency circuits shall be in locations convenient to authorized persons responsible for their actuation. In facilities covered by Articles 518 and 520, a switch for controlling emergency lighting systems shall be located in the lobby or at a place conveniently accessible thereto. In no case shall a control switch for emergency lighting be placed in a motion-picture projection booth or on a stage or platform. Exception: Where multiple switches are provided, one such switch shall be permitted in such locations where arranged so that it can only energize the circuit, but cannot de-energize the circuit.

12.4 Ancillary Sections from the 2007 California Electrical Code

Section 700 (Emergency Systems)

700.9 Wiring. Emergency System

(B) Wiring. Wiring of two or more emergency circuits supplied from the same source shall be permitted in the same raceway, cable, box, or cabinet. Wiring from an emergency source or emergency source distribution overcurrent protection to emergency loads shall be kept entirely independent of all other wiring and equipment, unless otherwise permitted in (1) through (4):

6. Wiring from the normal power source located in transfer equipment enclosures
7. Wiring supplied from two sources in exit or emergency luminaires (lighting fixtures)
8. Wiring from two sources in a common junction box, attached to exit or emergency luminaires (lighting fixtures)
9. Wiring within a common junction box attached to unit equipment, containing only the branch circuit supplying the unit equipment and the emergency circuit supplied by the unit equipment

700.12 (General Requirements)

700.12 General Requirements. Current supply shall be such that, in the event of failure of the normal supply to, or within, the building or group of buildings concerned, emergency lighting, emergency power, or both shall be available within the time required for the application but not to exceed 10 seconds. The supply system for emergency purposes, in addition to the normal services to the building and meeting the general requirements of this section, shall be one or more of the types of systems described in 700.12(A) through 700.12(E). Unit equipment in accordance with 700.12(F) shall satisfy the applicable requirements of this article. (A Storage Batteries, (B)

Generator Set, (C) Uninterruptible Power Supply (D) Separate Service, (E) Fuel Cell System, (F) Unit Equipment).

(F) Unit Equipment. Individual unit equipment for emergency illumination shall consist of the following: (1) A rechargeable battery (2) A battery charging means (3) Provisions for one or more lamps mounted on the equipment, or shall be permitted to have terminals for remote lamps, or both (4) A relaying device arranged to energize the lamps automatically upon failure of the supply to the unit equipment The batteries shall be of suitable rating and capacity to supply and maintain at not less than 87.5 percent of the nominal battery voltage for the total lamp load associated with the unit for a period of at least 1.5 hours, or the unit equipment shall supply and maintain not less than 60 percent of the initial emergency illumination for a period of at least 1.5 hours. Storage batteries, whether of the acid or alkali type, shall be designed and constructed to meet the requirements of emergency service. Unit equipment shall be permanently fixed in place (i.e., not portable) and shall have all wiring to each unit installed in accordance with the requirements of any of the wiring methods in Chapter 3. Flexible cord-and-plug connection shall be permitted, provided that the cord does not exceed 900· mm (3 ft.) in length. The branch circuit feeding the unit equipment shall be the same branch circuit as that serving the normal lighting in the area and connected ahead of any local switches. The branch circuit that feeds unit equipment shall be clearly identified at the distribution panel. Emergency luminaires (illumination fixtures) that obtain power from unit equipment and are not part of the unit equipment shall be wired to the unit equipment as required by 700.9 and by one of the wiring methods of Chapter 3.

Exception: In a separate and uninterrupted area supplied by a minimum of three normal lighting circuits, a separate branch circuit for unit equipment shall be permitted if it originates from the same panel board as that of the normal lighting circuits and is provided with a lock-on feature. (Note some unit equipment is U.L. Listed).

700.17 (Circuits for Emergency Lighting)

Branch circuits that supply emergency lighting shall be installed. to provide service from a source complying with 700.12 when the normal supply for lighting is interrupted. Such installations shall provide either of the following:

1. An emergency lighting supply, independent of the general lighting supply, with provisions for automatically transferring the emergency lights upon the event of failure of the general lighting system supply
2. Two or more separate and complete systems with independent power supply, each system providing sufficient current for emergency lighting purposes.

Unless both systems are used for regular lighting purposes and are both kept lighted, means shall be provided for automatically energizing either system upon failure of the other. Either or both systems shall be permitted to be a part of the general lighting system of the protected occupancy if circuits supplying lights for emergency illumination are installed in accordance with other sections of this article.

701.7 (Transfer Equipment)

General. Transfer equipment, including automatic transfer switches, shall be automatic and identified for standby use and approved by the authority having jurisdiction. Transfer equipment shall be designed and installed to prevent the inadvertent interconnection of normal and alternate sources of supply in any operation of the transfer equipment. Transfer equipment and electric power production systems installed to permit operation in parallel with the normal source shall meet the requirements of Article 705.

Bypass Isolation Switches. Means to bypass and isolate the transfer switch equipment shall be permitted. Where bypass isolation switches are used, inadvertent parallel operation shall be avoided.

Automatic Transfer Switches. Automatic transfer switches shall be electrically operated and mechanically held.

701.8 Signals. Audible and visual signal devices shall be provided, where practicable, for the purposes described in 701.8(A), (B), and (C).

Derangement. To indicate derangement of the standby source.

Carrying Load. To indicate that the standby source is carrying load.

Not Functioning. To indicate that the battery charger is not functioning.

FPN: For signals for generator sets, see NFPA 110-2002, Standard/or Emergency and Standby Power Systems.

12.5 2008 ICC Means of Egress Code Change Proposals

In 2008 the American Institute of Architects (AIA) and the Building Owners and Managers Assoication (BOMA) submitted proposed code changes to the International Code Council (ICC).

The AIA proposal would have required occupancy sensor control of lighting in the means of egress. The proposal was disapproved on the following basis:

There is a lack of specification and standardization for the motion sensors. This creates a potential conflict with the photoluminescent requirements in the new Section 1027 in the 2007 supplement. Having the lights off in all locations could be a security concern in areas of high crime.

AIA then submitted a public comment suggesting that occupant sensors should be allowed to reduce the means of egress lighting level to 0.2fc (rather than fully off). This item appeared not to have been voted on.

The BOMA proposal would have allowed no emergency lighting to be provided in exit enclosure and pathways that are provided with photoluminescent marking. The proposal was disapproved on the following basis:

The triple redundancy (e.g. means of egress lighting, emergency lighting and photoluminescent strips) may be too much; however, studies or documentation should be presented that demonstrate what system combinations would provide an equivalent level of safety for lighting and egress path identification during emergency situations. The effectiveness of the photoluminescent markings has not been proven, therefore, emergency lighting is required for redundancy. An exception for having the lights off would make the stairways less safe due to possible obstructions that would not be visible with just photoluminescent strips.

The relevant sections of the “Final Action Agenda” for the Means of Egress meeting is shown below.

ICC Means of Egress Final Action Agenda 2008

ICC Means of Egress Final Action Agenda 2008

E21-07/08

E21-07/08

1006.1 (IFC [B] 1006.1

Proposed Change as Submitted:

Proponent: Dave Collins, AIA, The Preview Group, Inc., representing the AIA Codes Committee

Revise as follows:

1006.1 (IFC [B] 1006.1) Illumination required. The means of egress, including the exit discharge, shall be illuminated at all times the building space served by the means of egress is occupied.

Exceptions:

1. Occupancies in Group U.
2. Aisle accessways in Group A.
3. Dwelling units and sleeping units in Groups R-1, R-2 and R-3.
4. Sleeping units of Group I occupancies.

Means of egress lighting shall be controlled by motion sensors and shall turn on the egress lighting system in the corridor, stair or exit discharge only when the corridor, stair or exit discharge or other such egress element is occupied.

Reason: The use of motion sensors or other activating devices to help control the amount of energy used in buildings is gaining in use and popularity. Making it clear that the egress lighting can be activated when persons enter the element of the means of egress is an important clarification of the code. ASHRAE 90.1 has called for the use of this type of energy savings in occupied spaces and to carry that forward to the egress lighting in literally millions of buildings will have a significant impact on energy savings in buildings.

In a related change to the IECC, we are requiring a 50% reduction in the energy use of buildings. To achieve this will require significantly more aggressive design solutions for buildings of all types. Requiring that the corridor, stair or exterior light be illuminated even when it is not being used is counter productive to a policy of energy savings at all levels

Cost Impact: The code change proposal will increase the cost of construction.

Committee Action: **Disapproved**

Committee Reason: There is a lack of specification and standardization for the motion sensors. This creates a potential conflict with the photo luminescent requirements in the new Section 1027 in the 2007 Supplement. Having the lights off in all locations could be a security concern in areas of high crime.

Assembly Action: **None**

Individual Consideration Agenda

Public Comment:

David S. Collins, FAIA, The Preview Group, Inc., representing The American Institute of Architects, requests Approval as Modified by this public comment.

Modify proposal as follows:

1006.1 (IFC [B] 1006.1) Illumination required. The means of egress, including the exit discharge, shall be illuminated at all times the building space served by the means of egress is occupied.

Exceptions:

1. Occupancies in Group U.
2. Aisle accessways in Group A.
3. Dwelling units and sleeping units in Groups R-1, R-2 and R-3.
4. Sleeping units of Group I occupancies.

Means of egress lighting shall be permitted to be reduced to a minimum of 0.2 foot-candles. Activation of approved ~~controlled by~~ motion sensors located at the entrance to corridors, stairs and exit discharges ~~and~~ shall turn on the egress lighting system to provide the illumination required by Section 1006.2 in the corridor, stair or exit discharge only when the corridor, stair or exit discharge or other such egress element is occupied.

Commenter's Reason: This reduced lighting level is consistent with the lighting levels permitted in places of assembly during a performance. Reducing the constant power demand from the egress lighting is one way in which building energy can be drastically reduced. Today's social and political environment requires creative and improved methods to save energy. Leaving lights on constantly is a tremendous drain on our resources. ASHRAE 90.1 has already recognized this and requires that general lighting be installed using such devices. This will help close the loop on wasted electrical power used for lighting in buildings.

Final Action: AS AM AMPC____ D

E23-07/08
1006.3 (IFC [B] 1006.3)

Proposed Change as Submitted:

Proponent: Lawrence G. Perry, AIA, representing Building Owners and Managers Association (BOMA) International

Revise as follows:

1006.3 (IFC [B] 1006.3) Illumination emergency power. The power supply for means of egress illumination shall normally be provided by the premises' electrical supply.

In the event of power supply failure, an emergency electrical system shall automatically illuminate the following areas:

1. Aisles and unenclosed egress stairways in rooms and spaces that require two or more means of egress.
2. Corridors, exit enclosures and exit passageways in buildings required to have two or more exits.

   Exception: An emergency electrical system is not required to automatically illuminate exit enclosures and exit passageways that are provided with exit path markings in accordance with Section 1027.

3. Exterior egress components at other than the level of exit discharge until exit discharge is accomplished for buildings required to have two or more exits.
4. Interior exit discharge elements, as permitted in Section 1024.1, in buildings required to have two or more exits.
5. Exterior landings, as required by Section 1008.1.5, for exit discharge doorways in buildings required to have two or more exits.

The emergency power system shall provide power for a duration of not less than 90 minutes and shall consist of storage batteries, unit equipment or an on-site generator. The installation of the emergency power system shall be in accordance with Section 2702.

Reason: This proposal seeks to eliminate the requirement for emergency illumination in exit enclosures and exit passageways where photoluminescent exit path markings are provided. With the approval of a public comment to Code Change E84-07/08 at the Rochester Final Action Hearings, there is now a requirement for photoluminescent exit path markings in all exit enclosures and exit passageways in new high-rise buildings. If these newly required systems perform as well as the proponents have indicated, it is an unnecessary initial and ongoing expense to also provide emergency lighting in the same enclosures and passageways.

As written, this proposal would also provide the option for non high-rise buildings to provide photoluminescent exit path marking complying with Section 1027 in lieu of emergency lighting.

Cost Impact: The code change proposal will not increase the cost of construction.

Committee Action: **Disapproved**

Committee Reason: The triple redundancy (e.g. means of egress lighting, emergency lighting and photo luminescent strips) may be too much; however, studies or documentation should be presented that demonstrate what system combinations would provide an equivalent level of safety for lighting and egress path identification during emergency situations. The effectiveness and reliability of photo luminescent markings has not been proven, therefore, emergency lighting is required for redundancy. An exception for having the lights off would make the stairways less safe due to possible obstructions that would not be visible with just photo luminescent strips.

Assembly Action: **None**

Individual Consideration Agenda

This item is on the agenda for individual consideration because a public comment was submitted.

Public Comment:

Lawrence G. Perry, AIA, representing Building Owners and Managers Association (BOMA) International, requests Approval as Modified by this public comment.

Modify proposal as follows:

1006.3 (IFC [B] 1006.3) Illumination emergency power. The power supply for means of egress illumination shall normally be provided by the premises' electrical supply.

In the event of power supply failure, an emergency electrical system shall automatically illuminate the following areas:

1. Aisles and unenclosed egress stairways in rooms and spaces that require two or more means of egress.
2. Corridors, exit enclosures and exit passageways in buildings required to have two or more exits.

   Exception: In buildings that are not high-rise buildings, an emergency electrical system is not required to automatically illuminate exit enclosures and exit passageways that are provided with exit path markings in accordance with Section 1027.

3. Exterior egress components at other than the level of exit discharge until exit discharge is accomplished for buildings required to have two or more exits.
4. Interior exit discharge elements, as permitted in Section 1024.1, in buildings required to have two or more exits.
5. Exterior landings, as required by Section 1008.1.5, for exit discharge doorways in buildings required to have two or more exits.

The emergency power system shall provide power for a duration of not less than 90 minutes and shall consist of storage batteries, unit equipment or an on-site generator. The installation of the emergency power system shall be in accordance with Section 2702.

Commenter's Reason: This comment seeks to provide an alternative to the current requirement for emergency lighting in exits in non-high-rise buildings. The new package of photoluminescent exit path markings has been touted as being a superior method of marking exits. The original code change proposal sought to allow the elimination of emergency lighting in any building where exit path markings were provided, including high-rise buildings. Two main objections were raised to the original proposal:

1. That the photoluminescent exit path markings were new, somewhat untested, and maybe not yet ready to substitute for emergency lighting, and
2. That in very tall buildings, there might be a need for emergency lighting, and then, after the emergency lighting runs out, then an additional time period under photoluminescent 'mode'.

By limiting this exception to other than high-rise buildings, this comment responds to the main concerns raised in Palm Springs. Buildings eligible for the proposed exception would not be tall enough to warrant a need for multiple hours of exit illumination/marking in an incident. If the photoluminescent markings aren't ready to be used in smaller buildings as a substitute for battery pack or generator lighting, why would we be adding them as a mandated third level of lighting in taller buildings?
Note: this comment uses the term 'high-rise buildings' consistent with another successful code change this cycle. If that change is not sustained, the intent was for the typical 'occupied floor more than 75' above the lowest level of fire department vehicle access" to be used.

Final Action: AS AM AMPC____ D

Appendix VII: Non-Residential Construction Forecast details

Summary

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, the demand forecast office future generation facility planning data, and building permit office data.

All CASE reports should use the statewide construction forecast for 2014. The TDV savings analysis is calculated on a 15 or 30 year net present value, so it is correct to use the 2014 construction forecast as the basis for CASE savings.

Additional Details

The demand generation office publishes this dataset and categorizes the data by demand forecast climate zones (FCZ) as well as building type (based on NAICS codes). The 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 to or subtracted 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 (new construction); 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). The CEC non-residential construction forecast is the best publicly available data to estimate statewide energy savings.

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)

Appendix VIII: 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 35. Materials Content of Typical Lighting Components, by Weight

Note that in Figure 35 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[11] 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

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

www.ballastshop.com, and corroborated by the Lighting Research Center's Specifier Report on electronic ballasts[12].

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[13].

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.

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

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