CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

2008 CEC Title 24 Building Energy Efficiency Standards Rulemaking Proceeding
July 7, 2006

Draft Report
Requirements for Signs

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Overview

This CASE proposal addresses the energy savings opportunities available in outdoor signs. The key elements of the proposal are as follows:

- Turn off lights in signs when no one is around or when the light is imperceptible because there is vastly more daylight than the light produced by the sign. This is accomplished by requirements for automatic time and daylight responsive lighting controls for all outdoor signs.
- The amount of light needed to see an unfiltered sign during the day is substantially greater than that needed at night. Require automatic dimming controls for outdoor signs that are illuminated during daytime hours.
- Using high efficiency power supplies for neon and cold cathode sources in accordance with temperature limitations of the technology.
- Using electronic high efficiency power supplies for LED signs.
- Dimming loads or turning off a fraction of the load for a few hours per year can help prevent loss of utility service and yield significant cost savings for the owner. Require demand responsive controls for larger signs illuminated during the day.

Description

In Section 132 add a new subsection (c) to require automatic time schedule lighting controls for all outdoor signs. The control strategy required will vary based on sign usage patterns. Photoelectric controls combined with time switches will be required for all signs not used in the daytime. Dimming controls will be required for signs that are illuminated during daytime hours, to enable a minimum of 65 percent reduction in lighting power at night.

Requirements for high efficiency power supplies in neon and cold cathode signs. When complying with the alternative to Section 148 (a) or (b) , high efficiency power supplies are required to drive neon and cold cathode lamps for all signs in conditioned spaces and all outdoor signs in climate zones 1 through 9. High efficiency power supplies can reduce overall energy use by approximately 25% for indoor applications and by approximately 22% for outdoor applications when operated within designed temperature ranges. For outdoor signs the high efficiency power supplies are designed for an operating temperature of -30 degrees F to 122 degrees F (-34 degrees C to 50 degrees C)., For indoor signs the high efficiency power supplies are designed for an operating temperature of 32 degrees F to 104 degrees F (0 degrees C to 40 degrees C), and are suitable for use in conditioned spaces in all climate zones.

Requirements for high efficiency power supplies in LED signs. When complying with the alternative to Section 148 (a) or (b), high efficiency power supplies are required to drive LED sources. High efficiency switching power supplies are 15 to 35% more efficient than their low efficiency counterparts.

Energy Benefits

The following table illustrates the energy savings per square foot of each major sign category for which we are proposing efficiency upgrades.

Efficiency Upgrade	Energy Savings
Automatic Controls for Outdoor Signs	6 to 47 kWh/SF
Dimming Controls for Outdoor Signs Operated during Daytime Hours	176 to 196 kWh/SF
High efficiency Power Supplies for Neon and Cold Cathode Sources	1.9 to 4.2 KWh/LF
High efficiency Power Supplies for LED Sources	9.8 kWh/SF

Non-energy Benefits

The implementation of lighting controls will reduce operating time and/or lighting power, leading to longer lamp life and reduced maintenance. The implementation of high efficiency power supplies in neon and cold cathode signs will reduce the quantity of materials used in sign equipment.

Statewide Energy Impacts

The statewide energy impacts will be estimated in the final CASE report when the estimates of energy savings are refined and applied to the statewide estimates of new signs added in the state. The statewide estimate of new sign construction is based on the PIER Outdoor Lighting survey.

Environmental Impact

No direct environmental impact is anticipated from implementation of these measures.

Primary environmental impacts are based upon air emissions reductions from power plants due to electricity savings... We will base these estimates of reduced emissions by multiplying the statewide energy savings by the emissions factor values generated by the California Energy Commission for evaluating the environmental impacts of the 2005 standards as shown in Table 1 below.[1]

Table 1: Emissions Factors used to calculate the air emissions reductions resulting from end-use reductions in electricity and natural gas consumption

Emissions factors	NOx	CO	CO2	PM10
Natural Gas, California (lbs/MMBtu)	0.094	0.03	115	0.01
Electricity, Western States (lbs/MWh)	0.383	0.23	1200	0.06

Statewide estimates of savings will be developed for the final report.

Type of Change

All of the measures described here mandatory, they cannot be by-passed by saving more energy somewhere else in the permit application.

[1] Table 1, Appendix B page 2, Initial Study/Proposed Negative Declaration for the 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings September 2003 P400-03-018. Values provided by the CEC System Assessment and Facilities Siting Division http://www.energy.ca.gov/reports/2003-09-12_400-03-018.PDF

Proposed Measure	**Type of change**	**Impact on standards**	**Documents to be modified**
Require combination of time scheduling and daylight responsive lighting controls for all outdoor signs.	Mandatory measure	Expands the scope of the existing standards. There currently is no requirement for time scheduling lighting controls.	Standards, Manuals and Compliance Forms
Require dimming controls for outdoor signs that are illuminated during daytime hours.	Mandatory measure	Expands the scope of the existing standards. There currently is no provision for lighting controls	Standards, Manuals and Compliance Forms
Mandate high efficiency power supplies for neon and cold cathode sources.	Mandatory measure	Expands the scope of the existing standards. Transformer type currently is not regulated.	Standards, Manuals and Compliance Forms
Mandate high efficiency power supplies for LED signs.	Mandatory measure	Expands the scope of the existing standards. Power supply type currently is not regulated.	Standards, Manuals and Compliance Forms
Require demand responsive lighting controls for all signs on during the day.	Mandatory measure	Expands the scope of the existing standards.	Standards, Manuals and Compliance Forms

Currently the performance approach calculations contained in the Alternative Compliance Method (ACM) Manual do not include outdoor lighting or sign lighting energy consumption. This proposal would not change this approach and thus this measure will not impact the ACM manual.

Technology Measures

The energy savings from this proposal are based on the added energy efficiency of the following technologies.

1. The use of time switches or photoelectric controls for the control of outdoor signs.
2. The use of dimming controls for the reduction of power in outdoor signs that are illuminated during daytime hours.
3. The use of high efficiency power supplies for neon and cold cathode sources.
4. The use of high efficiency power supplies for LED sources.
5. The use of demand responsive controls for larger signs illuminated during the day.

Information about the availability, cost, and performance of the technology is readily available and were compiled from the following sources:

- Sign product manufacturers’ and sign industry association websites.

- Communication with sign manufacturers' associations.

- Communication with sign manufacturers and fabricators.

- Sign Industry Workshops facilitated by Southern California Edison (SCE) in December 2005 and February 2006.

- Attendance at the Western Sign Show in San Diego on February 10 and 11, 2006.

- Research institutions including the California Lighting Technology Center (CLTC) which is performing internally lit sign research for SCE

For the proposed use of automatic time schedule lighting controls with all signs the measure compares those cases where signs are controlled dusk on , dusk off to a dusk-on and time-off, time on, dawn-off control strategy. Astronomic time switches are readily available and currently are regulated by the standards for interior and exterior lighting. Dimming controls and time scheduling software are readily available for signs that are illuminated during the daylight hours (message centers) and can provide the capability to reduce the power input by as much as 90 % during nighttime use.

For the proposed use of high efficiency power supplies with neon and cold cathode sources the measure compares the commonly used ferromagnetic transformers to high efficiency power supplies. Ferromagnetic transformers are used predominately because they are suitable for use in all temperature applications. High efficiency power supplies are readily available; however outdoor temperatures in excess of 100°F for more than 1% of the hours per year limits the use of high frequency electronic power supplies to CTZ 1- 9 for outdoor signs and indoor sign in conditioned spaces in all climate zones.

For the proposed use of high efficiency power supplies with LED sources the measure compares low efficiency ac input / dc output power supplies to high efficiency switching mode power supplies. High efficiency switching mode power supplies are readily available and provide increased efficiency. Typical efficiency for a low efficiency power supply is 60% or less. Typical efficiency for a high efficiency switching mode power supply is 80%.

Measure Availability and Cost

To develop the costs for this proposal we contacted these major manufacturers for electric sign components.

1. Automatic time schedule lighting controls: Intermatic, Tork and others.

2. Automatic dimming controls: Daktronics, Barco, Vantage and others.

3. High efficiency neon and cold cathode power supplies: Ventex, Philips, France and Allanson.

4. High efficiency power supplies for LED sources: Philips, Osram Sylvania, General Electric and others.

The costs of automatic time scheduling controls combined with daylight sensing (astronomic or photoelectric) add to the costs of sign installations as compared to the installation of photoelectric controls only. The analysis assumes a $1,000 cost. Since the cost of controls is fairly fixed regardless of size and number of loads, the cost per sign is inversely proportional; to the number of signs on a single meter. The analysis assumes the smallest sign load which will be cost effective for implementation of this measure. This sign load is 500 Watt.

The provision of automatic dimming controls adds to the cost of LED signs without dimming controls. For a basic outdoor LED message center with a monochromatic four-module display, these controls add approximately $1000 to the cost of the sign installation. This represents approximately 27% of the cost of the sign installation used in the analysis. For larger signs, the proportional cost of the dimming controls relative to the total cost of the sign will be less. The analysis assumes the smallest signs for a range of viewing distances from 110 to 500 feet. This sign load varies from 240 to 960 Watt.

The costs of high efficiency power supplies for neon and cold cathode compare favorably to the costs of ferromagnetic transformers. The initial evaluation shows that high power factor high efficiency power supplies are equivalent in price to normal power factor ferromagnetic transformers and are less costly than high power factor ferromagnetic transformers. The analysis found a savings of $0.64 per lineal foot. If a high efficiency power supply is misapplied in a high temperature application, then premature failure could occur, resulting in the cost of replacement of the failed power supply. For this reason it is anticipated that increased maintenance costs will result from the use of high efficiency neon power supplies. For the nighttime operation scenario, the analysis assumes replacing 25% of the high efficiency power supplies in years 5 and 10. For the 24 hour operation scenario, the analysis assumes replacing 25% of the high efficiency power supplies in years 5 and 10 and full replacement of standard transformers and high efficiency power supplies in year 15.The additional maintenance cost is $1.41 per lineal foot for the 24 hour scenario and $2.26 for the nighttime scenario. The results show that in spite of anticipated increased maintenance costs the measure is cost effective because of lower first costs and energy savings.

For LED power supplies, the use of high efficiency switching mode power supplies is prevalent, and as a result, the cost is comparable to that of linear LED power supplies. The analysis, however, assumes an incremental cost increase of $0.33 per Watt. This additional cost is based on a 60 watt power supply.

For demand response controls, the costs assume the addition of a control relay for switched loads and a control program for LED message centers per electric meter. For switched loads the analysis assumes a cost increase of $400. For programmed loads the analysis assumes a cost increase of $1,000.

Table 2: Summary of Unit Measure Costs

Measure Description	**Cost ($)**	**Unit**
Time scheduling controls	$1,000	Site
Automatic dimming controls	$1,000	Sign
High efficiency (comparable to electronic) power supplies - neon and cold cathode	-$ 0.64	Lineal foot
High efficiency power supplies - LEDs	$0.33	Watt
Demand response controls	$400 – $1,000	Meter

Useful Life, Persistence and Maintenance

Sign Lighting Controls

A photoelectric switch control (dusk on / dusk off) is assumed to be the base case. It is assumed that 25% of the installation cost for the proposed automatic time schedule lighting controls will be incurred midway through the 15 year life of the system to maintain the lighting controls. For the base case photoelectric switch control, a maintenance cost of 100% of the installation cost is assumed midway through the 15 year life of the system. The energy savings will persist for the entire life of the measure provided it receives proper maintenance (replacement units must include all features of the measure) and the control schedule follows the model schedule. Performance verification will be required during initial compliance and may be useful after installation to determine actual scheduling practice. Commissioning including programming of the time scheduling controls and required inspection by the authority having jurisdiction are necessary with this measure. Since the performance of the measure is dependent on properly installed and programmed applications, performance verification may affect persistence of savings. It is essential that the installations are inspected to meet the requirements of the Energy Standards and the California Electrical Code. Compliance verification at the time of building permit issuance and inspection are essential to the persistence of this measure.

Automatic dimming controls are part of time scheduling software available for LED message centers and displays. It is likely that dimming LED displays will increase the maintained life of the LED modules. For the purpose of analysis, the assumed life for the LEDs is 100,000 hours as stated in manufacturers' product literature. In service, this assumed life depends on electrical operating characteristics and temperature. By definition, at the end of rated life, the LEDs are operating at 50% of rated output. Therefore, for the purpose of analysis, it is assumed that 50% of the modules will be replaced at 70% of rated life (70,000 hours) for the base case and the remaining 50% of the modules will be replaced at 100% rated life (100,000 hours). Since the proposed case significantly reduces the average energy and operational temperatures during the measures' lifetime, it is assumed that 50% of the modules will be replaced at the end of rated life (100,000 hours) and the remaining 50% of the modules will be replaced at 120% rated life (120,000 hours).. The energy savings will persist for the entire life of the measure provided it receives proper maintenance (replacement units must include all features of the measure) and the control schedule follows the model schedule. Performance verification will be required during initial compliance and may be useful after installation to determine actual dimming practice. Commissioning including programming of the dimming controls and required inspection by the authority having jurisdiction are necessary with this measure. Since the performance of the measure is dependent on properly installed and programmed applications, performance verification may affect persistence of savings. It is essential that the installations are inspected to meet the requirements of the Energy Standards and the California Electrical Code. Compliance verification at the time of building permit issuance and inspection are essential to the persistence of this measure.

High Efficiency Neon / Cold Cathode Power Supplies

From our experience with the relative failure rates between earlier versions of electronic ballasts and their magnetic counterparts, we expect that neon high efficiency power supplies will require more frequent replacement than their ferromagnetic counterparts. For the purpose of comparison, the analysis assumes 25% of the high efficiency neon power supplies would be replaced at a five year life and another 25% would be replaced at a 10 year life. At the end of the useful life (15 years), the analysis assumes 100% of both the ferromagnetic transformers and high efficiency neon power supplies would be replaced. The energy savings will persist for the entire life of the measure provided it receives proper maintenance (replacement units must be high efficiency). Verification that the correct equipment is installed is needed initially and this can be solved with a label that indicates compliance with either the W/sf requirements or the efficiency of the installed components. Commissioning other than required inspection by the authority having jurisdiction is unnecessary with this measure. Since the performance of the measure is inherent in properly installed applications, performance verification will not affect persistence of savings. It is essential however that the installations are inspected to meet the requirements of the Energy Standards and the California Electrical Code. Compliance verification at the time of building permit issuance and inspection is essential to the persistence of this measure.

High Efficiency LED Power Supplies

We expect that high efficiency switching mode power supplies for use with LED sources will perform in service comparably to low efficiency LED power supplies. The assumption embedded in this analysis is that both low efficiency and high efficiency power supplies will be replaced after 50,000 hours of service. The energy savings will persist for the entire life of the measure provided it receives proper maintenance (replacement units must be high efficiency power supplies). Performance verification will be required during initial compliance but should not be necessary after installation. Commissioning other than required inspection by the authority having jurisdiction is unnecessary with this measure. Since the performance of the measure is inherent in properly installed applications, performance verification will not affect persistence of savings. It is essential however that the installations are inspected to meet the requirements of the Energy Standards and the California Electrical Code. Compliance verification at the time of building permit issuance and inspection is essential to the persistence of this measure.

Performance Verification

The performance of automatic time scheduling lighting controls and dimming controls (for signs on during the day) are based on effective commissioning and programming of the controls. Performance verification may include monitoring a representative sample of installations for actual operating schedules. The existing acceptance tests for time switches could be applied to this type of control.

The performance verification for high efficiency transformers for neon and cold cathode lamps as well for LED high efficiency power supplies are based primarily on making sure they are installed. This activity is a function of the building permit compliance verification and installation inspection.

Cost Effectiveness

The cost-effectiveness of each measure is described in detail in the “Results” section of this report.

- The automatic time schedule lighting controls measure is demonstrated cost effective. The benefit/cost 1.1 for a sign of 500 Watt. The measure is cost effective when the sign load controlled is greater than 500 Watt.

- The automatic dimming controls measure for LED signs operated during daytime hours is demonstrated cost effective. For the smallest physical size signs for a range of viewing distances from 110 feet to 500 feet, the range of benefit/cost ratios is between 1.1 and 4.1. The measure is cost effective when the sign load is greater than 240 watts.

- The high efficiency neon power supply mandatory measure is demonstrated cost effective for both nighttime and 24-hour operation; the benefit/cost ratio is immediate. The measure is cost effective for an aggregation of signs of various sizes ranging in wattage above 67 Watt.

- The LED high efficiency power supplies’ measure is extremely cost effective. As shown in the example calculation in the “Results” section, for a 60 watt power supply, the benefit/cost ratio is 9.5. For larger power supplies the benefit cost ratio is expected higher.

- The demand response measures are assumed to be cost effective at a benefit/cost ratio of 1.5 for large signs. This measure would apply only to very large installations of signs on a single electric meter.

Analysis Tools

The analysis to quantify energy savings and peak electricity demand reductions uses a spreadsheet developed to compare alternative lighting technologies for use in sign illumination based on input power and time of day (TDV) cost values for each hour of the year. This spreadsheet kept track of the sunset times by day. We based this on a site in Fresno which is near the middle latitude of the population in California.

Relationship to Other Measures

No other measures are anticipated to be impacted by this change.

Methodology

The evaluation of proposed technologies and operating strategies included assumptions of number of operating hours for signs supported by studies conducted by Southern California Edison in 2005 and 2006. Sign manufacturers and sign component manufacturers provided information regarding the power characteristics, operational limitations and costs of proposed technologies. The results of SCE's sign control survey are tabulated in Table 3. It should be noted that this survey did not differentiate between standard time only time switches and those that are astronomical based (i.e. turn lights on and off relative to sunrise and sunset times calculated based on date and latitude and longitude).

Table 3: Sign controls: Frequency of use and resulting hours of operation

Type of Control	Controlled			Uncontrolled	Total
	% of controls	Hours of operation	Weighted average hours of operation	Hours of operation	Weighted average hours of operation
Time Switch	78%	9.59	7.5		
Photocell	4%	13.81	0.6		
Manual	15%	11.62	1.77		
Other	2%	6.33	0.14		
Total	100%		10.01	24	
Percent Controlled / Uncontrolled			79%	21%	
Weighted Hours Controlled / Uncontrolled			7.91	5.04	12.9

Controls

Automatic time schedule lighting controls

The use of automatic time schedule lighting controls was investigated as a proposed mandatory measure. The proposed measure will require automatic time schedule controls with astronomic feature or used in conjunction with photoelectric controls to preclude daytime operation of signs intended to operate at night only. The proposed measure was compared to a base case with photoelectric controls. The information in the table below from the sign survey completed by Southern California Edison in November 2005 (Phase 1) and June 2006 (Phase 2) was used to establish the baseline for existing sign operation.

As a comparison to the base cases, an automatic time switch lighting control schedule was modeled. As compared to the base cases operating signs from approximately 6 to 14 hours per day on average, the proposed case simulated sign operation sign from dusk to midnight and from 4 am to dawn.

Automatic dimming controls

The use of automatic dimming controls for outdoor LED signs operated during the day was investigated. If an LED sign is operated during the day then the required sign luminance should be reduced at night to provide readability. The sign industry generally supplies dimming for these types of signs, however data obtained from surveys conducted by the city of Anchorage, Alaska in 2004 and the Heschong Mahone Group in 2006 indicate that not all LED signs operated during the day are dimmed at night. Sign manufacturers provide software with time scheduling and dimming capabilities. To model automatic dimming controls on LED signs, two 4-module signs rated 240 watts, designed for viewing distances from 110 to 235 feet and 245 to 350 feet respectively, and one 8-module sign rated 960 watts, designed for viewing distances up to 500 feet were selected. To simulate the effect of dimming on LED signs operated during the day the load was decreased to 35% of maximum rated load for the dusk to dawn period. These signs were selected as representative of small signs for outdoor applications.

Demand response controls

The use of demand response controls for indoor cabinet signs and outdoor message centers was investigated. Under a demand response condition, sign owners could opt to receive an incentive from the electric utility. Two options would be available. The first option would allow the electric utility to control the sign for the hours from 1 pm to 5 pm, inclusive, 10 days per year. The present value of turning off 1 kW for 10 days for these four hours over the course of 15 years is $250/kW. The second option would allow the electric utility to control the sign for 2.4 hours during the most severe demand conditions annually. The present value of turning off 1 kW for 2.4 hours per year over the course of 15 years is $366/kW. The total societal value of demand response per kW of load is $616 present worth over 15 years. The analysis considers two measures. The first measure is the application of demand response controls to indoor cabinet signs. The measure assumes that the cabinet sign would be turned off in response to receipt of the utility's load shed signal. The second measure is the application of demand response controls to outdoor LED message centers.

Neon

The use of high efficiency neon power supplies as an alternative to ferromagnetic transformers was investigated. Based on the initial findings that 22% to 25% energy could be saved using high efficiency neon power supplies to replace ferromagnetic transformers, a detailed evaluation of the measure ensued. Because of temperature limitations of high efficiency neon power supplies, the measure is limited to climate zones (1 – 9) and cases where high efficiency neon power supplies could be applied properly within allowable temperature ranges. Climate data provided by CEC staff for 800 cities in California associated with the 16 climate temperature zones (CTZs) in the state was used to evaluate which climate zones would be appropriate for electronic power supplies. The minimum of the 0.6% winter design temperatures for all of these cities per climate zone and the maximum of the 2% summer design temperatures are tabulated in Table 4. These temperatures (less than 98°F and greater than 0°F) are the basis of selecting CTZs 1-9 as the

Table 4:Maximum and minimum teperatures of citites in California climate temeprature zones (CTZs)

Climate Zone	Max Of DB 2%	Min Of Design Drybulb (06%)
1	92	18
2	94	26
3	85	29
4	95	23
5	88	33
6	93	34
7	86	23
8	88	34
9	96	29
10	**102**	21
11	**108**	22
12	**98**	21
13	**100**	21
14	**114**	20
15	**110**	30
16	**99**	**-13**

climates where electronic transformers can be required outdoors.

To simplify the analysis, it is assumed that the tubing use is 12 mm in diameter and that the operating current is 30 mA, To perform the analysis, the power capacity in watts was determined for both ferromagnetic transformers and high efficiency neon power supplies from information provide by the sign component manufacturers. The capability in linear feet of tubing driven was determined using industry standard performance tables for both ferromagnetic transformers and high efficiency neon power supplies. Costs of typical signs and components were obtained from sign manufacturers. Several measures are analyzed – indoor applications, outdoor applications and varying schedules depending on the application (i.e. filtered or unfiltered). To develop a representative measure several signs containing various lengths of tubing were aggregated into one measure. This required a range of transformer / power supply configurations. The total power input, cost and cost of maintenance of the measure were compared to the base case.

LED (Light Emitting Diode) Power Supply

To compare the use of a high efficiency power supply to a low efficiency power supply, a 60 watt power supply is evaluated. The typical efficiency of a linear power supply is 60%. Although the typical efficiency of a high efficiency power supply may exceed 80%, the analysis assumes 70% efficiency. The analysis assumes a full nighttime schedule.

Results

The research demonstrated that available product operating and performance data is inconsistent. One overriding issue with respect to lighting products used in signs is the interdependency between electrical operating characteristics, performance and temperature. The products available to the sign industry vary widely in efficiency and performance. One significant barrier to the wide use of electronic ballasts is operating temperature.

Although not included in any of the measures presented, there appears to be a significant opportunity to improve the efficiency of fluorescent systems used in cabinet signs. The sign industry currently uses T12 high output fluorescent technology powered by ferro-magnetic ballasts as a fundamental technology. The current standards address measures which encourage the use of more efficient technology such as electronic ballasts and rare earth phosphor lamps. To further improve the efficiency of these systems will require the cooperation of the sign product manufacturers, sign manufacturers, electric utilities, end users and industry associations. Information, such as watts input, ballast factor, power factor and relative light output, needs to be reported by all parties in a consistent manner to enable performance evaluation. Typical cabinet signs utilize fluorescent lamps as a light source to illuminate a translucent image on the face(s) of the sign. In addition to the improvement of technology efficiencies, there appears to be an opportunity to develop new designs for cabinet signs that utilize alternative optical system design to the typical fluorescent array. For larger signs, there are alternative high intensity discharge systems available. For smaller signs, there are signs, edge-lit with T5 fluorescent lamps that are significantly more efficient than the typical back-lit signs.

The LED industry is emerging as a dynamic element of the sign market. Message centers provide a significant opportunity to display multiple messages, graphics and video content on a 24 hour per day, 7 day per week basis. Currently these displays have average input power densities ranging from nearly 15-20 watts per square foot to over 85 watts per square foot. Maximum power densities can exceed 300 watts per square foot. The industry is progressively developing more efficient LEDs. As the technology improves, it is anticipated that LEDs will approach the efficacy of fluorescent systems. There is a particular need for standardization of LED products, as the current variability of products from manufacturer to manufacturer makes it difficult for the industry to adopt LED technology. As the technology improves, it will be increasingly important to have testing standards to evaluate system performance relative to other technologies.

Energy, Cost Savings and Cost-effectiveness

The energy cost savings was calculated via a spreadsheet that had statewide average costs per hour for all hours of the year. These were then aggregated into weekday daytime values for each hour of the day, weekend daytime values, weeknight values and weekend night values. By entering the schedule that signs are on during days and nights one can compare the kWh and time-of-day value (TDV) costs over the course of a year. The TDV energy cost savings are then compared to the incremental costs of each measure. Cost-effectiveness is calculated by the following relation:

Cost-effectiveness = Life cycle O&M cost savings / Incremental cost

Often life cycle savings is merely the energy savings multiplied by the present value of the energy cost over 15 years at a 3% discount rate. In other cases where the maintenance or replacement costs or periods change then these costs are also considered as part of the life cycle savings. When the maintenance occurs, impacts its present valued cost as the maintenance cost is derated by a future worth factor.

Following is a series of tables showing an example savings calculation for the measure of using an astronomic time switch (or combination of photoelectric switch in conjunction with a time switch so that both scheduling and presence of sunlight is the function of the control) to replace a photoelectric switch (presence of sunlight only function of control). Table 5 shows the assumed schedule of operation for the photoelectric cell control, the "base case," as derived from SCE study data, the installed cost and the load in kilowatts and then that of the "proposed case" control, the astronomic time switch. Note that for the "daytime base" column the kWh and TDV kBtus are calculated the day time hours during this schedule. Similarly, for the "nighttime base" column only night time hours during this schedule are kWh or TDV calculated. The proposed case table shows the assumed schedule of operation for the proposed case (i.e. lights can be turned off later at night) and the installed cost. The schedule indicates that the load will be on from dusk to midnight, off at midnight and then back on from 4 am to dawn.

Table 5: Day and night schedules for Astronomical Time Switch measure

Base case Description:			Photoelectric (PE) Cell Controlled Sign			
	Installed cost:		$200.00			
Enter kW schedule for base case						
	Daytime base			Night time base		
Hour	M-F	Sat	Sun	M-F	Sat	Sun
1				0.5	0.5	0.5
2				0.5	0.5	0.5
3				0.5	0.5	0.5
4				0.5	0.5	0.5
5				0.5	0.5	0.5
6				0.5	0.5	0.5
7				0.5	0.5	0.5
8				0.5	0.5	0.5
9				0.5	0.5	0.5
10				0.5	0.5	0.5
11				0.5	0.5	0.5
12				0.5	0.5	0.5
13				0.5	0.5	0.5
14				0.5	0.5	0.5
15				0.5	0.5	0.5
16				0.5	0.5	0.5
17				0.5	0.5	0.5
18				0.5	0.5	0.5
19				0.5	0.5	0.5
20				0.5	0.5	0.5
21				0.5	0.5	0.5
22				0.5	0.5	0.5
23				0.5	0.5	0.5
24				0.5	0.5	0.5
	Only day time hours during this schedule are kWh or TDV calculated			Only night time hours during this schedule are kWh or TDV calculated		

Proposed case description:			Astronomic Time Switch Control / PE			
	Installed cost:		$1,000.00			
Enter kW schedule for proposed case						
	Daytime proposed			Night time proposed		
Hour	M-F	Sat	Sun	M-F	Sat	Sun
1						
2						
3						
4						
5				0.5	0.5	0.5
6				0.5	0.5	0.5
7				0.5	0.5	0.5
8				0.5	0.5	0.5
9				0.5	0.5	0.5
10				0.5	0.5	0.5
11				0.5	0.5	0.5
12				0.5	0.5	0.5
13				0.5	0.5	0.5
14				0.5	0.5	0.5
15				0.5	0.5	0.5
16				0.5	0.5	0.5
17				0.5	0.5	0.5
18				0.5	0.5	0.5
19				0.5	0.5	0.5
20				0.5	0.5	0.5
21				0.5	0.5	0.5
22				0.5	0.5	0.5
23				0.5	0.5	0.5
24				0.5	0.5	0.5
	Only day time hours during this schedule are kWh or TDV calculated			Only night time hours during this schedule are kWh or TDV calculated		

Table 6: Maintenance cost calculation including 3% real discount rate

				Future
	Maintenance Costs		Maint Savings	Value
Year	Base case	Proposed case	PV $	Multiplier
1			$0.00	97%
2			$0.00	94%
3			$0.00	92%
4			$0.00	89%
5			$0.00	86%
6			$0.00	84%
7			$0.00	81%
8	$ 200.00	$ 250.00	-$39.47	79%
9			$0.00	77%
10			$0.00	74%
11			$0.00	72%
12			$0.00	70%
13			$0.00	68%
14			$0.00	66%
15			$0.00	64%
Total			-$39.47	

Table 6 shows the assumed maintenance costs for the base and proposed cases. In the base case, the photocell is replaced and it is assumed that the entire of the cost of the initial installation will be spent. In the proposed case, it is assumed that either a photoelectric cell is replaced or that the astronomic time switch has to be reprogrammed and that this will cost slightly more. For the purpose of the analysis, it is assumed in both cases that the maintenance will occur at the halfway point of the system's life. Since the maintenance cost is higher for the proposed system, it is represented as a negative maintenance cost savings for this measure

Table 7 summarizes the energy and cost savings. For each hour of the day, the table shows the savings for total kWh, TDV kBtu, energy cost PV $, maintenance PV $ and total PV $. It also shows the incremental cost for the measure and the benefit / cost (B/C) ratio. The objective is to select measures which have positive PV $ savings and a B/C ratio greater than 1.0, which indicates that the measure has life cycle savings greater than its cost and therefore is cost effective.

Table 7: Hourly energy and cost savings and B/C ratio summary

Energy and Cost Savings Summary: Astronomic Time Switch Control / PE					
	Savings	Savings	Savings		
Hour	Total kWh	TDV kBtu	Energy Cost PV $		
1	183	2,839	$ 239		
2	183	2,726	$ 230		
3	183	2,645	$ 223		
4	183	2,636	$ 222		
5	0	0	$ -		
6	0	0	$ -		
7	0	0	$ -		
8	0	0	$ -		
9	0	0	$ -		
10	0	0	$ -		
11	0	0	$ -		
12	0	0	$ -		
13	0	0	$ -		
14	0	0	$ -		
15	0	0	$ -		
16	0	0	$ -		
17	0	0	$ -		
18	0	0	$ -		
19	0	0	$ -		
20	0	0	$ -		
21	0	0	$ -		
22	0	0	$ -		
23	0	0	$ -	PV Savings	Cost Savings
24	0	0	$ -	Maint. PV $	Total PV $
Total	**730**	**10,846**	**$ 915**	**-39**	**$876**
				Incremental Cost	**$800**
				B/C ratio	**1.1**

Table 8 below summarizes all of the proposed measures for signs. As shown, all of the measures have a B/C ratio greater than 1.0 or are “immediate.” If the B/C ratio is immediate, then the measure costs less than the base case.

For the neon high efficiency power supply measure, a group of neon signs of varying tube lengths was compared. In the base case, the signs were supplied by standard neon transformers. In the proposed case, the signs were supplied by high efficiency power supplies. Power values were obtained from manufacturers’ literature. Two scenarios were considered for energy savings. In one scenario, 24 hour operation was evaluated. In the second scenario, nighttime operation was evaluated. As shown in the table, the savings are positive and the incremental cost is negative which results in an immediate benefit.

For the astronomic time switch measure the base case schedule was derived from SCE data as described in the example for the Astronomic Time Switch Control / PE measure above. For all of the proposed measures, the load schedule was assumed on from dusk to midnight, off at midnight and then back on from 4 am to dawn. The load was varied in the various measures to determine a threshold value for application into the Standards. As shown in the table, the savings are positive and the B/C ratios are greater than 1.0 which results in cost effective measures.

Table 8:Sign efficiency measure summary - energy savings and B/C ratios

Energy and Cost Savings Summary: Signs								
	Size	**Energy Savings**					**Incremental Cost**	**Benefit / Cost Ratio**
Sign Measure Description	**kW**	**Total kWh**	**TDV kBtu**	**Energy Cost PV $**	**Maint. PV $**	**Total PV $**	**PV $**	
Neon High efficiency Power Supply - 24 Hr	1.6	1,480	28,621	$2,415	-$498	$1,917	-$225	Immediate
Neon High efficiency Power Supply - Night	1.6	677	11,417	$963	-$800	$163	-$225	Immediate
Astronomic Time Switch Control / PE	0.5	730	10,846	$915	-$39	$876	$800	1.1
1 x 4 LED Monochromatic Short Range Dimming	0.24	625	10,539	$889	$172	$1,029	$1,000	1.0
1 x 4 LED Monochromatic Medium Range Dimming	0.24	625	10,539	$889	$367	$1,187	$1,000	1.2
2 x 4 LED Monochromatic Long Range Dimming	0.96	2,501	42,156	$3,556	$498	$3,959	$1,000	4.0
Switched 60 Watt LED Power Supply	0.06	125	2,419	$204	-$14	$190	$20	9.5
Switched 100 Watt LED Power Supply	0.100	435	8,411	$710	-$21	$689	$30	23.0

For the LED dimming measures, the use of automatic dimming controls was evaluated for three cases as shown in the table above. Small monochromatic outdoor message centers for short, medium and long range viewing were chosen for the analysis. In the base cases, it was assumed that the signs would operate at 100% output 24 hours per day. In the proposed cases it was assumed that the signs would operate at 100% output during daytime hours and at 35% output during nighttime hours. The loads were obtained from manufacturer's literature. As shown in the table, the savings are positive and the B/C ratios are greater than 1.0 which results in cost effective measures.

For the LED high efficiency power supply measure a 60 watt high efficiency switching power supply was evaluated against a comparative 60 watt low efficiency power supply in the table above. Data was obtained on relative efficiencies from manufacturers' websites. The analysis assumes 60% efficiency for the low efficiency power supply and 70% efficiency for the high efficiency switching power supply. The assumed schedule is 24 hours operation at 100% power. As shown in the table, the savings are positive and the B/C ratio is greater than 1.0 which results in a cost effective measure.

Demand response results

The California investor owned utilities are installing an automated meter infrastructure (AMI) that includes the capability of signaling customers when electricity process are exceptionally high and also when there is a system reliability emergency. The societal value of controls that can respond to this demand response signal is given in Table 9.

Table 9: Value of economic and emergency demand response

Value of Economic DR Resource	
Economic program top 10 days 1 -5 pm	
Resource value PV$/kW	$409.67
Productivity loss	20%
Net resource value PV$/kW	$327.74
Adjustment factors	
Participation rate	70%
Signal received	97%
Signal not over ridden	90%
Fraction ON during DR event	100%
Combined economic adjustment Factor	61%
Adjusted Net Resource Value PV$/kW	**$250**
Value of emergency DR	
Value of loss of service per kWh	$42.00
Negative impact on productivity	$2.50
Average outage time per year (h/yr)	2.4
annual net impact $/kW	$94.80
15 year present worth multiplier	$11.94
15 year discounted net impact PV $/kW	$1,132
Adjustment factors	
Fraction not participating in economic program	30%
Fraction in economic program normally overriding	7%
Total impacted by mandatory control	37%
Fraction of emergency signal not over ridden	90%
Fraction receiving the DR signal	97%
Fraction ON during DR event	100%
Combined emergency adjustment factors	32%
Adjusted net impact PV$/kW controlled	**$366**
Emergency and Economic Value PV$/kW	**$616**

This value is made up of two components:

1) the economic value of the capacity offered by customers who participate in demand response programs or rates and

2) the value of responding to system emergencies to prevent blackouts. This value is based on the economic distress that results from a loss of service (blackout).

The analysis in Table 9 assumes a participation rate of 70% in a program that gives incentives within the customer rate to curtail loads during the most expensive hours of the year. This assumption is based on a scenario that when the sign starts operating, the default utility rate is either real time based or a critical peak pricing type rate that passes through most of the costs on an hour by hour basis. In addition, this scenario assumes that regardless of participation in a rate or other program to voluntarily shed loads, that the utility can invoke an emergency load shed of lighting during the few hours per year that electrical system reliability is in peril. On average this occurs only 2.4 hours per year. Avoiding blackouts has a societal benefit of $42/kWh. When discounted over 15 years and accounting for productivity losses during this time period, this has a net value of $1,132/kW. When all of the derating factors are included, the overall direct economic benefit to the overage customer is PV$250/kW controlled and another PV$366/kW due to avoiding losses associated with blackouts for a total societal (economic + emergency) value of PV$616/kW.

The measure is based on reducing the power consumption of signs by 30% during the demand response period in response to receipt of the utility's load shed signal. Since this demand response period is typically during the summer between the hours of noon and 6pm, this measure applies to signs that are normally on during the day. We considered two sign types: cabinet signs and message centers. Some cabinet signs are illuminated during the day in indoor locations. Message centers could be either indoor or outdoors.

To identify the sign size at which a demand responsive control would be required, the fixed costs of installing a demand responsive control was compared to the life cycle savings of the control. To assure the outcome was conservative (i.e. the life cycle cost savings was greater than the initial cost) the threshold value of minimum sign size was calculated based on a Benefit/Cost ratio of 1.5.

Table 10 below shows the results of the analysis. For each scenario and demand response option there is a corresponding load in kW and size of sign. For cabinet signs, the analysis assumes a load of 12 W/sf. For LED message centers, the analysis assumes a load of 50 W/sf. If the full societal benefits are calculated, the minimum total sing power rating that could be cost-justify demand responsive controls with a 1.5 B/C ratio is 3.2 kW for cabinet signs and 8.1 kW for message centers. That is to say that the life cycle energy cost savings and value of blackouts avoided is worth $600 for a 3.2 kW cabinet sign, while the incremental implementation cost is only $400.

If one considers only the economic value of the energy displaced by reducing sign power consumption by 30% for the 10 days with the highest electricity costs for four hours per day, a minimum cabinet sign size of 8 kW and a minimum LED message center size of 20 kW would be required to justify the expense of the controls while maintaining a 1.5 Benefit /Cost ratio.

Table 10:Demand response – threshold sign size to assure a 1.5 B/C ratio

			Cost-effective Threshold @1.5 B/C ratio		Sign Size	
			Economic Value @ PV$250/kW	Economic + Emergency @PV$616/kW	Economic Value	Emergency Response
Sign Type	**Fraction Controlled**	**Implementation Cost**	**kW**	**kW**	**SF**	**SF**
Cabinet Sign	30%	400	8.0	3.2	666	271
LED Message Center	30%	1000	20.0	8.1	399	162

Statewide Energy Savings

Statewide energy savings estimates are based on unit energy savings multiplied by estimates of statewide quantities of signs. This statewide analysis will be included in the final Signs CASE report.

Recommendations

Summarize the specific recommendations changing the Standards. This section should have specific recommended language for the Standards and/or the ACM approval manual. This section should contain enough detail to develop the draft standard in the next phase of work.

The following revisions to the Standards are recommended:

Proposed Mandatory Requirements

1. Require time schedule lighting controls for all outdoor signs.

2. Require automatic dimming controls for outdoor signs that are illuminated during daytime hours.

3. Require demand responsive controls for larger signs that are illuminated during daytime hours.

Proposed Prescriptive Requirements

1. Mandate use of high efficiency power supplies for neon and cold cathode sources in accordance with temperature limitations of the technology.

2. Mandate use of high efficiency power supplies for LED sources.

Proposed Standards Language

Original standards language is in black font, the proposed deleted text is ~~in red text with hard strikeouts~~ and added language contained is in blue font and underlined

SECTION 101 – DEFINITIONS AND RULES OF CONSTRUCTION

DEMAND RESPONSE PERIOD is a period of time during which the local utility is curtailing electricity loads by sending out a demand response signal.

DEMAND RESPONSE SIGNAL is an electronic signal sent out by the local utility indicating a request to their customers to curtail electricity consumption.

SECTION 132 – OUTDOOR LIGHTING CONTROLS AND EQUIPMENT

(a) **Outdoor Lighting.** All permanently installed outdoor luminaires employing lamps rated over 100 watts shall either: have a lamp efficacy of at least 60 lumens per watt; or be controlled by a motion sensor.

EXCEPTIONS to Section 132 (a):

1. Lighting required by a health or life safety statute, ordinance, or regulation, including but not limited to, emergency lighting.
2. Lighting used in or around swimming pools, water features, or other locations subject to Article 680 of the California Electrical Code.
3. Searchlights.
4. Theme lighting for use in theme parks.
5. Lighting for film or live performances.
6. Temporary outdoor lighting.
7. Light emitting diode, neon and cold cathode lighting.

(b) **Luminaire Cutoff Requirements.** All outdoor luminaires that use lamps rated greater than 175 watts in hardscape areas including parking lots, building entrances, sales and non-sales canopies, and all outdoor sales areas shall be designated Cutoff for light distribution. To comply with this requirement the luminaire shall be rated Cutoff in a photometric test report that includes any tilt or other non-level mounting condition of the installed luminaire. Cutoff is a luminaire light distribution classification where the candela per 1000 lamp lumens does not numerically exceed 25 at or above a vertical angle of ninety degrees above nadir, and 100 at or above a vertical angle of eighty degrees above nadir. Nadir is in the direction of straight down, as would be indicated by a plumb line. Ninety degrees above nadir is horizontal. Eighty degrees above nadir is 10 degrees below horizontal.

EXCEPTIONS to Section 132 (b):

1. Internally illuminated, externally illuminated, and unfiltered signs.
2. Lighting for building facades, public monuments, statues, and vertical surfaces of bridges.
3. Lighting required by a health or life safety statute, ordinance, or regulation, including but not limited to, emergency lighting.
4. Temporary outdoor lighting.
5. Lighting used in or around swimming pools, water features, or other locations subject to Article 680 of the California Electrical Code.

(c) **Controls for Outdoor Lighting**

1. All permanently installed outdoor lighting shall be controlled by a photocontrol or astronomical time switch that automatically turns off the outdoor lighting when daylight is available.

EXCEPTION to Section 132 (c) 1.:

1. Lighting in parking garages, tunnels, and large covered areas that require illumination during daylight hours.
2. Sign lighting as covered by Section 133.

2. For lighting of building facades, parking lots, garages, sales and non-sales canopies, and all outdoor sales areas, where two or more luminaires are used, an automatic time switch shall be installed that (1) turns off the lighting when not needed and (2) reduces the lighting power (in watts) by at least 50% but not exceeding 80% or provides continuous dimming through a range that includes 50% through 80% reduction. This control shall meet the requirements of Section 119 (c).

EXCEPTIONS to Section 132 (c) 2:

1. Lighting required by a health or life safety statute, ordinance, or regulation, including but not limited to, emergency lighting.
2. Lighting for steps or stairs that require illumination during daylight hours.
3. Lighting that is controlled by a motion sensor and photocontrol.
4. Lighting for facilities that have equal lighting requirements at all hours and are designed to operate continuously.
5. Temporary outdoor lighting.
6. ~~Internally illuminated, externally illuminated, and unfiltered signs~~.

SECTION 133 – SIGN LIGHTING CONTROLS

(a) **Designation of Daytime Use**. If an outdoor sign is planned to be illuminated by electric lighting for more than 1 hour per day while the sun is above the horizon, the sign shall be designated as "Normally On during Daytime." Any outdoor sign that is not designated as "Normally On during Daytime," shall be designated as "Normally Off during Daytime."

(b)**Controls for Outdoor Signs Normally Off during Daytime**. All permanently installed outdoor signs that are designated normally off during daytime shall be controlled by a photocontrol and an automatic-time switch complying with Section 119(c) or an outdoor astronomical time switch complying with Section 119(j), that automatically turns off the outdoor signs when daylight is available.

EXCEPTION to Section 133 (b): Outdoor signs in parking garages, tunnels, and large covered areas that require illumination during daylight hours.

(c) **Controls for Outdoor Signs Normally On during Daytime**. All permanently installed outdoor signs that are designated Normally On during Daytime shall be controlled by a photocontrol and an automatic-time switch complying with Section 119(c) or an outdoor astronomical time switch complying with Section 119(j), that automatically dims and reduces sign power draw by a minimum of 65% between the times of 30 minutes after sunset and 30 minutes before sunrise.

EXCEPTION to Section 133 (c): Outdoor signs in parking garages, tunnels, and large covered areas that require illumination during daylight hours.

d) **Controls for All Signs**:

1. All permanently connected signs shall have an automatic time switch control that complies with Section 119(c).

2. Demand Responsive Sign Controls. If the electrical service to a sign is provided with a demand response signal by the local utility, demand responsive sign controls shall be installed under following conditions

ii. Unfiltered signs illuminated during the day and having a total connected load per electric meter greater than 20 kW, shall have controls installed capable of receiving a demand response signal to reduce the sign load by a minimum of 30%.

ii. Filtered signs illuminated during the day and having a total connected load per electric meter greater than 8 kW, shall have controls installed capable of receiving a demand response signal to reduce the sign load by a minimum of 30%.

SECTION 148 – REQUIREMENTS FOR SIGNS

This section applies to all internally illuminated, ~~and~~ externally illuminated and unfiltered signs, both indoor and outdoor. Each sign shall comply with either subsection (a) **or** (b), as applicable~~, or with one of the alternatives that immediately follow subsection (b).~~

(a) For internally illuminated signs, the maximum allowed lighting power shall not exceed the product of the illuminated sign area and 12 watts per square foot. For double-faced signs, only the area of a single face shall be used to determine the allowed lighting power.

~~(b)~~ For externally illuminated signs, the maximum allowed lighting power shall not exceed the product of the illuminated sign area and 2.3 watts per square foot. Only areas of an externally lighted sign that are illuminated without obstruction or interference, by one or more luminaires, shall be used.

~~ALTERNATIVE to 148(a) and (b):~~

(b) The sign complies with this Section if it is: ~~1. Equipped~~ equipped only with one or more of the following light sources:

1. ~~high pressure sodium, pulse start and ceramic metal halide, neon, cold cathode, light emitting diodes, barrier coat rare earth phosphor fluorescent lamps, or compact fluorescent lamps that do not contain a medium base socket (E24/E26), or~~
2. ~~Equipped only with electronic ballasts with a fundamental output frequency not less than 20 kHz.~~

1. high pressure sodium lamps,

2. pulse start ceramic metal halide lamps served by a ballast with a minimum efficiency of 88%,

3. neon, with power supply having an efficiency of 85% or greater and a power factor of 90% or greater.

4. cold cathode or fluorescent lamps with barrier coat rare earth phosphors and equipped only with electronic ballasts having a fundamental output frequency not less than 20 kHz,

5. light emitting diodes with power supply having an efficiency of 85% or greater and a power factor of 90% or greater.

6. compact fluorescent lamps that do not contain a medium base socket (E24/E26)

Exception to Section 148(b) 2, 3, 4, 5 – the requirement for a high efficiency power supply does not apply in climate zones 10 through 16.

Exception to Section 148(b) 5 –power supplies with a power factor less than 90% may be used in flashing applications and dimming applications where sign power is required to be reduced by Section 133(c).

EXCEPTION 1 to Section 148: ~~Unfiltered signs and~~ traffic signs.
EXCEPTION 2 to Section 148: Exit signs shall meet the requirements of the Appliance Efficiency Regulations.

Alternate Calculation Manual

Outdoor lighting is not included in the ACM manual, thus there are not changes proposed.

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