PG&E

CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

2008 California Energy Commission Title 24 Building Energy Efficiency Standards
July 7, 2006

Draft Report
Demand Responsive Controls For Indoor Lighting

This report was prepared by Pacific Gas and Electric Company and funded by the California utility customers under the auspices of the California Public Utilities Commission.

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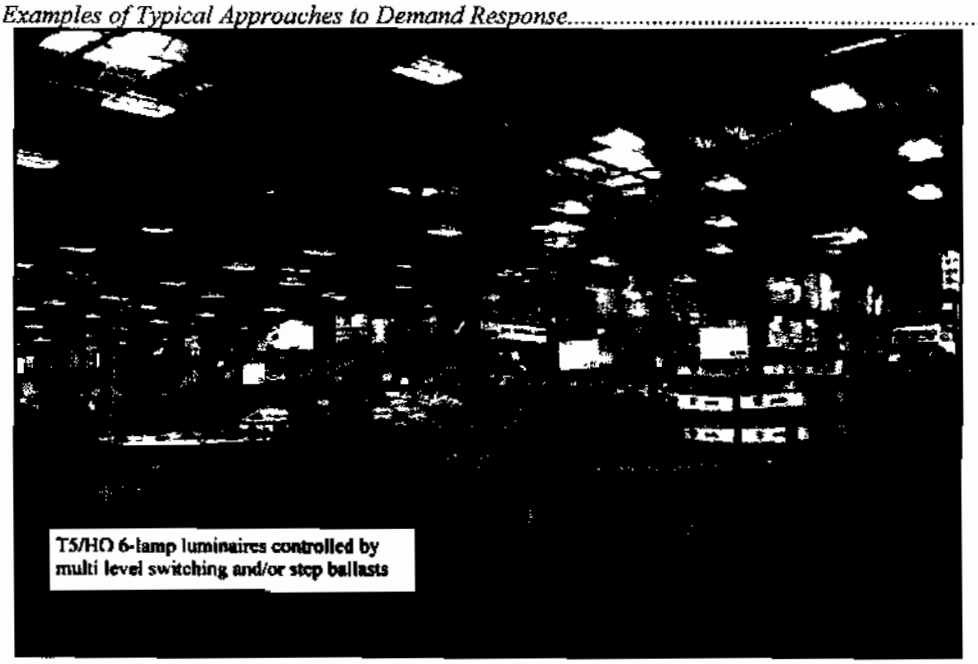

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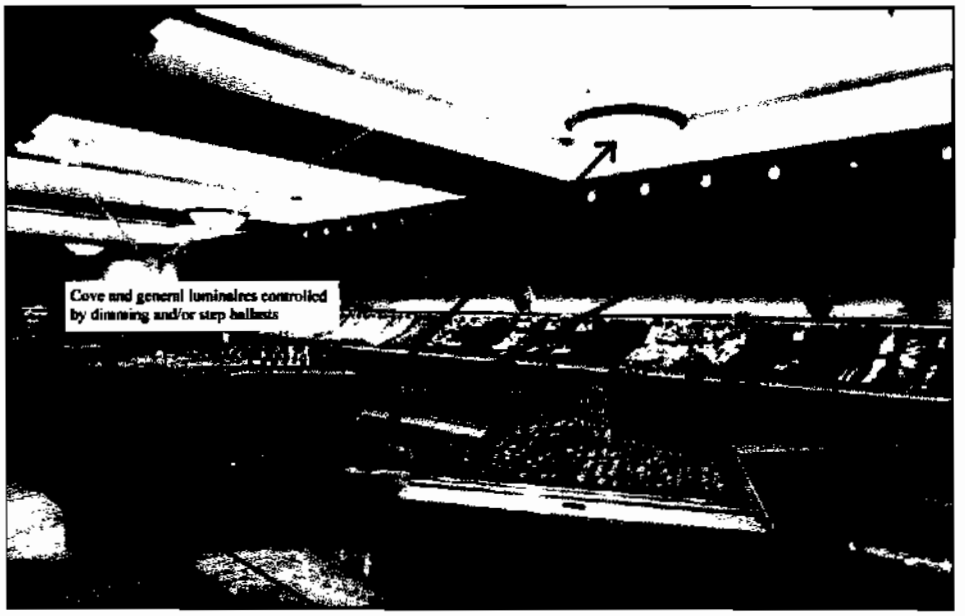

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Document Information

Category: Codes and Standards

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Overview

This proposal investigates the feasibility and cost-effectiveness of requiring automated demand responsive controls on selected indoor lighting loads. This demand responsive control would enable users to control their electricity costs during highest cost periods by automatically reducing their lighting electricity consumption upon receipt of an electronic signal from their local electric utility.

In addition this same control could increase system reliability by automatically reducing lighting energy consumption during electrical system emergency events. These events are predicted to occur on average 24 hours per 10 years or on average 2.4 hours per year. The current response to these events is the utility enforcing rolling blackouts where all loads are interrupted temporarily. Instead of turning all of the power off on some customers, this proposed method would turn off some of the power on all customers.

By turning off less critical loads for a few hours per year, this system could more effectively protect the reliability of electricity supply to critical loads.

Another parallel measure is being proposed for stand-alone single zone HVAC systems in residences and non-residential buildings. This is a proposal for a Programmable Communicating Thermostat (PCT) that will automatically raise the set point of air conditioning thermostats upon receipt of a demand response signal from the local utility. Curtailing lighting energy consumption has the added benefit of reducing air conditioning loads as all of the energy using to light buildings ultimately ends up as heat that has to be rejected during the cooling season.

Description

The proposal recommends a mandatory requirement for demand responsive controls in spaces greater than 100,000 Sf. These spaces would further be defined as a continuous building footprint or in the case of office buildings, malls, theaters, the common areas greater than 100,000 Sf would be affected by the recommended requirement. It is also recommended that new construction and renovated spaces with square footages from 25,000 to 100,000 be encouraged through incentives to include circuiting for eventual incorporation in the demand response rate structure. Rational for these recommendations will be discussed in this proposal.

These controls would receive two types of signals from the local utility:

1. An economic response signal. This signal indicates the cost of electricity on a regular basis or perhaps as a signal when the cost of electricity rises above some amount jointly agreed by the customer and the local utility. Curtailment of lighting loads in response to this signal is voluntary but provides significant economic rewards.

2. Emergency curtailment signal. This signal indicates that the reserve capacity in the region is extremely low. Response to this signal is mandatory. This signal is rarely invoked (outside of an annual test signal to assure the system is working) and helps avoid all out blackouts.

The key functional characteristic of such a demand responsive control are that it be able to receive the utility demand response signal and that it be able to curtail a fraction of electric lighting load so that business can still be conducted albeit at lower illuminance levels. The California Investor Owned Utilities (IOUs) will likely transmit their signal via the automated meter infrastructure (AMI) to the customer's meter. This meter will in turn communicate to a control device that will control lighting and perhaps other devices.

This report describes the types of lighting that can be controlled as well as the achievable lighting load fractions that can be reasonably controlled during times of electrical system stress.

Energy Benefits

Energy savings benefits are numerous and provide economic relief for both the customer and the utilities. The building owner or occupant paying utility bills will benefit from a reduced rate structure that could be layered to provide increased cost savings depending on the level of participation. An additional benefit for the building owner would arise from the reduced rate structure that could give the owner a competitive advantage over other owners who did not fully participate in the available voluntary programs. The savings could be passed onto the tenants through a reduced rate structure and therefore attract more tenants. In California there would also be an advertising benefit promoting the building as being energy friendly similar to the LEED building program.

Utilities will also see an economic benefit from being able to control peak energy loads thereby preventing costly power interruptions. In the past some uncontrolled brown or black out situations have had widespread unintended consequences resulting in customer dissatisfaction, injuries, and costly repairs for both the customers and the utilities. With active control over these peak load period's energy demands can be handled in an orderly fashion allowing everyone (both residential and business customers) to maintain an adequate level of power to continue to operate in a relatively normal way. This preplanning by the utilities will be looked upon favorably by the customers and will have an indirect positive economic impact.

Energy savings would be substantial over the long term for the customer. The continued reduced cost of energy will free up money for other business uses. Initially this will help to offset the cost for installing systems that are capable of accepting demand response signals. Many businesses already have multiple layered circuiting. The added equipment and controls for these spaces can be easily installed with transition cost minimal.

This measure when adopted can increase the interest in sky lighting (daylighting) for new construction projects and on a retrofit basis. The maximum availability of natural light exactly coincides with the peak demand load for electricity (noon to 5 PM). The use of daylighting will actually increase the available energy to allow for new construction without the most severe effect on total energy consumption. The use of daylighting will allow business to shed lighting load voluntarily since proper sky lighting can provide most if not all ambient light. These businesses can be offered additional incentives to cut their use of accent or other lighting during the most severe energy demand times. Extending the utilities ability, under proper over site, to control the energy environment will benefit everyone.

The various benefits are detailed in the Results section of this proposal.

Non-energy Benefits

Past experience has made it clear that there are unexpected consequences from random and uncontrolled power outages or brown outs. Potential damage to equipment, infrastructure, and the cascade effect of damage to property (real estate, food storage facilities, etc.) and people (the elderly in particular) is just one. Utilities having the ability to reduce energy demands from some customers during peak periods will eliminate this cost and the resulting public disorder and expense due to damage or loss.

Reducing power consumption will reduce the use of the fuels that produce the needed electricity resulting in a positive statewide impact on power plant emissions. Air quality will improve reducing related illnesses and improving community health in general which in turn should have an impact on the demand for health care services. The economic side benefit that results from cleaner air is increased commerce (productivity) which benefits everyone. Productivity is also increased because business will remain open during times when they may have been inadvertently shut down by a blackout. This also reduces the amount of land and resources that must be dedicated to a larger electricity infrastructure.

All businesses participating in the demand response program should see increased property values because they have reduced the operating cost of the buildings they own or lease. This will make there property more attractive to future tenants or buyers since there could be increased profit through the lower cost of operation.

Statewide Energy Impacts

[redacted]

Environmental Impact

To implement demand responsive lighting controls, additional wiring and additional lighting contactors are needed. Thus slightly more copper and plastic are used in indoor wiring systems. The benefits of this measure are a reduction in the number of power plants needed and a reduction in the size of the transmission and distributions system. This reduces the amount of land and resources that must be dedicated to a larger electricity infrastructure.

The emissions impacts of this measure are calculated by multiplying the change in statewide electricity and natural gas consumption by the hourly emissions factors. [redacted].

Type of Change

Requirement for demand responsive controls would be mandatory for occupancies and sizes of buildings where they are most cost-effective. As a mandatory measure, these controls do not affect the performance method and they are not involved in trade-off calculations. These controls like most of the other automated lighting controls in the standards and would require an acceptance test to assure they are correctly working at time of installation.

Technology Measures

This measure both requires and encourages the use of lighting control technology as it relates to controlling the consumption of energy on a 24 hour basis and at peak periods. This measure addresses a philosophy of design more than the use of existing new technology. The measure will recommend the use of currently available and tested systems coupled with a different and more effective building wiring plans to allow for tiered circuiting in place of zone circuiting. This technology could be as simple as a contact closure located at the building service or could be a more complex digital interface. Once this is translated into something like a contact closure, there are already many lighting controls that can make use of this signal and turn lights off in response. Lighting contactor and relays have existed for decades and are reliable. This measure is compatible with newer lighting control technologies such as DALI (digital addressable lighting interface), wireless mesh etc but does not require the use of these technologies. The costing of control systems is based on the use of simpler, relay-based control systems.

Measure Availability and Cost

Equipment, materials, design strategy and installation techniques are currently available from multiple manufacturers, suppliers, and the construction industry. Many luminaires in current use are well suited for demand response systems. Some luminaire (lamp) types such as HID will require that restart time is considered during the planning process for demand response. Manufacturers as well as the design and construction industry posses the ability to meet the demand associated with the possible change in Standards.

Changing the Standards for 2008 as proposed in this report and including an implementation schedule will ensure that there will be available resources to design and install the needed systems to use demand response. This schedule will also give the energy suppliers to do tandem scheduling to install the equipment needed to call on demand response locations when needed. Failure to adopt these new Standards in 2008 would push out any viable demand response network until 2011 or later. Based on current demand and studies this would be an unacceptable scenario.

There are six (6) to eight (8) major manufacturers that specialize in lighting control systems. These manufacturers are capable of providing the type of comprehensive lighting controls associated multi function, multi level lighting and Demand Response potential. Equipment from these manufactures can be installed either by specialty electrical contractors, who focus on controls, or the vast number of general electrical contractors with commercial and industrial electrical installation expertise. In addition there are many electrical contractors that can assemble components (switches contactors, wire, etc.) and install them to create a simple load shedding approach.

The construction industry is currently in a position to implement the proposed Standards for newly permitted construction since it would only require the incorporation of additional or re-routed wiring and the addition of a few control systems into the present designs. If demand response were required for retrofit applications, this would

increase pressure on both manufacturing and installation suppliers. Ramping up retrofit implementation through staggered incentives can control the rate of growth and mitigate potential pressure on the effected industries.

Increased use of demand response may or may not result in reduction in first cost. The availability of product and people will drive market prices. The state can play a major roll to ensure that the marketplace is robust enough to offer price competition. Since the adoption of new Standards occurs approximately 12 months before the new code implementation date, this valuable time could be used to prepare the marketplace for demand response products via voluntary programs, incentives and some form of critical peak pricing or real time rates.

The cost of the recommended measures is tiered based on building or space size and the sophistication of the proposed new lighting design (e.g. Advanced lighting controls). Since Title 24 has long standing requirements for automatic shut-off controls and bi-level switching, this reduces the costs for those space types that have night sweep controls and bi-level switching. Initial cost and maintenance cost will vary by location. For a more detailed analysis of cost and cost recovery and maintenance costs see the Results section of this proposal.

Useful Life, Persistence and Maintenance

Data available to ascertain the life, frequency of replacement, and maintenance procedures related to the measure are limited since use of demand response systems at present is not widespread. Data available for and maintenance of the materials and equipment used in a demand response installation should provide the needed information. The major component of a basic Demand Response system is the layered circuits (contacts, switches and wiring). Procedures for performance verification and proper maintenance are already established for building components of this type. Manufacturers' technical data and recommendations will also be used when/as available for the switches and other devices. For a comprehensive Demand Response system the addition of multi level, multi function lighting control is required in addition to layered circuits. Typical life expectancy for the control system and components is 15 years or longer. Persistence energy savings related to the measure will be based on life of the equipment. Persistence is related to performance verification, which can be monitored annually by the utility. Proper maintenance or lack of maintenance should have limited effect. Projected life and required maintenance is based upon manufacturer's information and feedback from clients who are using various lighting control products. Persistence of savings from utility incentive cost structure is not guaranteed unless rate structures are maintained that provide sufficient incentives to participate.

Performance Verification

Retrofitting of existing spaces (Remolding) and new construction verification of installation and performance can be included in the currently established permitting and site inspection process. Annual performance verification will be done by the utilities remotely. In a demand response environment, the utility will have the capability of testing system reliability through live field tests at specified intervals.

Cost Effectiveness

Proposed recommendations are cost effective for the selected space types (see Methodology for a list of spaces under consideration for demand response). New construction and retrofit/remodeling should be analyzed separately. Proposed recommendations will be cost effective for most space types planning to use advanced lighting controls in new construction. It will be cost effective for retrofit applications depending on space type and size.

First cost will vary for retrofit and remodels depending on the installed circuiting and fixtures in the existing spaces. Many space types in the above mentioned list are already using multiple circuiting in their buildings to reduce the cost of energy. Minimal additional equipment will be needed to provide demand response for these sites. For buildings that are remodeling and using the tailored method of compliance under Title 24-2008 the additional cost should be minimal assuming the new code is adopted as proposed since they will already have the additional lighting controls and circuiting as part of their overall lighting design and that will make it easier and less expensive to add demand response.

The first cost increases for new construction will be proportionally limited since new construction will already have mandates from T 24-2008 to reduce LPD. In 2008 the advanced lighting control requirements (necessitating

additional wiring) will be increased for some space types and offered and incentives for others that wish to increase their allowed Lighting Power Density (LPD). That will make it more feasible to add demand response control systems since layered circuiting will already be part of the building design. Total square footage under construction will have a proportional impact and thus vary by building size. This is a complex variable since larger buildings are already adding new lighting technology and multiple circuits to cut energy costs while keeping desired illuminance levels. At the present time many locations (over 43%) have already designed stores taking advantage of this newer technology and the associated cost savings.

See the Results section for a thorough analysis by building (space) size and type for both new construction and retrofit (remodel) scenarios.

Proposed recommendations will be cost effective for many space types (see Methodology for a list of spaces under consideration for demand response). New construction and retrofit/remodeling should be analyzed separately. Proposed recommendations will be cost effective for those space types planning to use advanced lighting controls. It will also be cost effective for retrofit applications depending on space type and size.

First cost will vary for retrofit and remodels depending on the installed circuiting and fixtures in the existing spaces. Many space types in the above-mentioned list are already using multiple circuiting in their buildings to reduce the cost of energy. Minimal additional equipment will be needed to provide demand response for these sites. For buildings that are using the tailored method of compliance under Title 24-2008 the additional cost should be minimal assuming the code adopts measures from the PG&E Indoor Lighting proposal as additional lighting controls and circuiting as part of their overall lighting design will make it easier and less expensive to add demand response.

Analysis Tools

Spreadsheet analysis was used to quantify energy savings as well as calculate peak electricity demand reductions using data obtained from LPD allowances for typical space footprint square footage in the categories chosen. Outside of the value of demand reduction developed for the PCT CASE study, the primary inputs are the LPD of the space, the fraction of lights that can be controlled and the cost of installing the controls.

Relationship to Other Measures

There is a direct relationship to other measures in this proposal for reduced LPDs as it pertains to the Tailored Method and the addition of more robust lighting control systems. Addition of these control systems will result in minimal additional cost to include demand response in the building design.

Proposals to require skylights (daylighting) in new buildings 100,000 square feet or larger will have an impact on demand response effectiveness. Daylighting will reduce the available load to shed as more of these larger locations rely on skylights for general lighting and reduce their LPD as a result. We will recommend that we begin the demand response program with buildings greater than 100,000 square feet. This can be expanded to smaller size spaces in voluntary programs to prepare the way for expanding the scope of this measure in 2011.

This proposal is very similar to the proposal for "Programmable Communicating Thermostats" (PCTs) except this proposal is recommending controlling lighting instead of air conditioning. If electric lighting is curtailed at the same time as the PCTs, then it is possible to curtail longer or have less comfort complaints as turning off lights will reduce HVAC loads. It may be also true that PCT deemed savings may reduce slightly if demand controlled lighting is considered as part of the "base case."

Methodology

The primary research method for this study was visual observation with documentation of findings. The lighting design and installation of these existing spaces was observed and evaluated as to potential for demand response (load shedding). IES recommended practices were used to establish a bench mark for appropriate levels of lighting in each of the space types used for the study. Surveys were conducted in a variety of retail, hospitality, office, and sales with service structures Government buildings were surveyed to a lesser degree since specific recommendations for this category are not part of this proposal. The following partial list is an overview of these locations by category. We limited the scope of our work to spaces there was a potential to effectively employ demand response systems.

We further sub-categorized this list to determine those space types that would provide the greatest energy savings during high demand periods. End user cost effectiveness was used as important additional criteria for selection. Therefore all the spaces on in Table 1 were not studied in depth. See the Results Section for the list of spaces analyzed.

Table 1: Spaces surveyed having potential for demand response implementation

RANGE OF POTENTIAL SPACES SUITABLE FOR DEMAND RESPONSE SYSTEM IMPLEMENTATION			
CATEGORY	**TYPES OF SPACES**	**EXAMPLES**	**SQUARE FOOTAGE RANGE**
Retail	Grocery	Safeway, Albertsons, Ralphs, Whole Foods, Trader Joe, Vons, Pavailions	20,000 to 55,000
	Department Store	Kohls, Macy, J.C. Penny, Gottschalks, Sears, TJ Maxx, Big Lots	30,000 to 175,000
	Electronics	Best Buy, Frys, Circuit City, Comp USA	25,000 to 125,000
	Auto Delearships	Ford, Chevy, Honda, Toyota, BMW, Hundi, etc. located at Auto Malls throughout the state	20,000 to 70,000
	Big Box	Lowe's, Home Depot, Costco, Food 4 Less	60,000 to 140,000
	Super Merchandising	Target, Wal-Mart	60,000 to 140,000
		SuperCenters (Target, Wal-Mart)	180,000 to 225,000
	Drugstores	Rite Aid, Walgreen's, CVS	11,000 to 15,000
	Bookstores	Barnes & Nobel, Borders	25,000 to 45,000
	High End Retail	Nordstrom, Saks, Neiman Marcus	80,000 to 175,000
	Medium Size Chain Retail	Ross, Marshalls, Bed Bath & Beyond, Mervyns Pet Smart, Petco, Williams Sanoma, Gap, Cost Plus, etc.	20,000 to 70,000
	Malls (Enclosed Space)	Common Areas in Major Malls throughout the state	35,000 to 175,000
Hospitality	Hotels, Resorts, Banquet Facilities, Movie Theatres	Lodging, Banquet, Edwards, Mann, Regal, and Event, Conference & Resort Hotels such as Disneyland	15,000 to 80,000
Office	Stand Alone Office or Office with Retail shops on Levels 1-3 Common Areas Only	Embarcadaro Center San Francisco, Downtown High Rise Offices, Community Medium Rise Space	20,000 to 1,000,000
Sales with Service	Auto Parts, Tires	Pep Boys Automotive Supercenters, 4 Day Tire, Just Tires,	5,000 to 15,000
Government Buildings	City, County, and State Public Service Offices, Elected Representative Offices	County Goverenment Centers, City Offices, State Capital Government buildings and offices	2,000 to 150,000

The key factors considered in the store observations were:

- Was current lighting as designed and in place capable of accepting a demand response system without adverse effect, assuming appropriate controls were implemented?
- What are potential challenges and rewards for implementing demand response systems within observed spaces or new space types?

- What is or what will be required to implement a responsible demand response plan for each of the observed space types?
- What can we learn from current construction practices that will be beneficial in our recommendations for new construction implementation of demand response building designs?
- What is the difference by space type and/or total square footage in their current lighting plans that would either benefit or detract from the implementation of demand response systems?

We assume that most if not all of the recommendations for reduced LPD as well as lighting control improvements (recommended for Tailored Method calculations) will be adopted in Title 24-2008. The code for new construction and remodeling that requires advanced lighting controls is the platform from which we will add any additional wiring or hardware to implement demand response in the various building type scenarios.

STORE SIZE ANALYSIS

Limiting candidates for Load Shed compliance to stores with foot-prints of 100,000 sf. or larger rules out a vast majority of retail space that could potentially contribute significantly to a comprehensive load shed plan. Many national chains and regional retailers operate millions of square feet with individual store footprints between 10,000 sf and 75,000 sf. This retail segment includes almost all drug, hardware, grocery, office supply, home store and mid size specialty retail. Some department stores and appliance/electronic outlets also operate stores of less than 100.000 sf. Thus the requirements for demand responsive controls should be reviewed and considered for a broader range of store sizes over the long term. The range of store sizes is included in Table 1.

The 25,000 sf size and larger is practical and cost effective for most retail spaces, even those permitting under the "Area" or "Whole Building" method of Title 24 compliance. For those retailers permitting under the Tailored Method of Title 24-2008 participation in load shed should be extremely cost-effective assuming the proposal of comprehensive controls being required for tailored lighting spaces. Cost for adding the load-shed component under this scenario should be very minimal. Since we scaled the comprehensive control component of proposed T24-2008 "Tailored Method" to spaces as small as 2,500 Square feet, load shed could conceivably apply to spaces that small as well.

Thus this proposal is fairly conservative and would have little impact on the building industry or lighting controls suppliers. Each store considered would have a substantial economic incentive to shed their lighting load for a couple of hours per week in the summer. This would also reduce air conditioning loads when they are the highest. In general, for retail stores, this is not a peak sales period.

Results

In this section, we summarize the findings of our visual observations as they relate to potential load shedding for the various space types. From our research, we determined that the level of potential load shed through demand response systems as well as the lighting systems subject to load shed must be space type specific. We further determined that not all space types can equally respond to demand response signals and that any demand response plan as well as design implementation for demand response must be space type specific.

The range of potential load shed using demand response systems appears to be almost nil (0%) for some space types with extensive daylighting to as much as 40% in some retail markets. Using our observational data of existing space types we categorized locations further based on lighting design (complexity) as it would relate to adding demand response. These sub-category space types are:

- Big Box, single luminaire source supplemented with mature daylight harvesting (daylighting)
- Big Box, single luminaire source with limited/little daylight harvesting
- Discount, no daylighting, multiple luminaire types; ceiling & perimeter lighting
- Grocery/Food, no daylighting multiple luminaire systems with ceiling mounted lighting, perimeter lighting and select feature and display lighting
- Department Store, no daylighting, multiple luminaire systems with general and feature ceiling mounted lighting, perimeter lighting and feature and display lighting
- High End Specialty, no daylighting, multiple luminaire systems with general and feature ceiling mounted lighting, multi layered perimeter lighting and feature and display lighting
- Government Buildings, no daylighting multiple luminaire systems found in newer county government centers and city offices including meeting rooms, quiet court rooms, and common areas.

A large number of the spaces observed in our survey already have in place lighting designs that, with proper circuiting and controls could comply with demand response requirements. We also determined that when a comprehensive lighting control system is planned for new construction or remodels the cost for additional labor and equipment needed add a demand response component is minimal. Therefore it is our determination that the costs associated with adding a demand response component to designs with integral advanced lighting controls are prohibitive and do not presents any significant financial burden or hardship to the building owner, tenant and/or property developer.

Examples of Typical Approaches to Demand Response

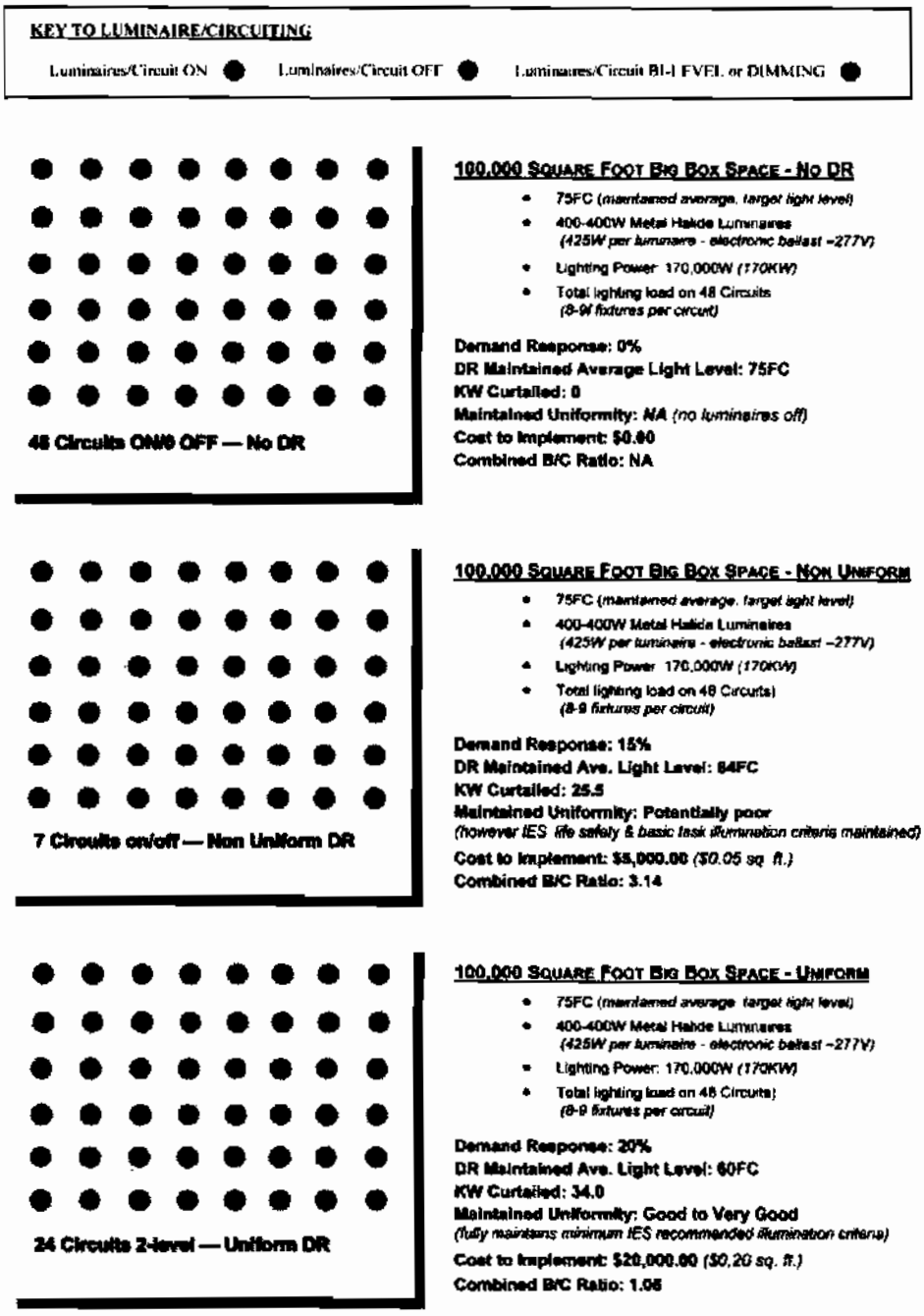
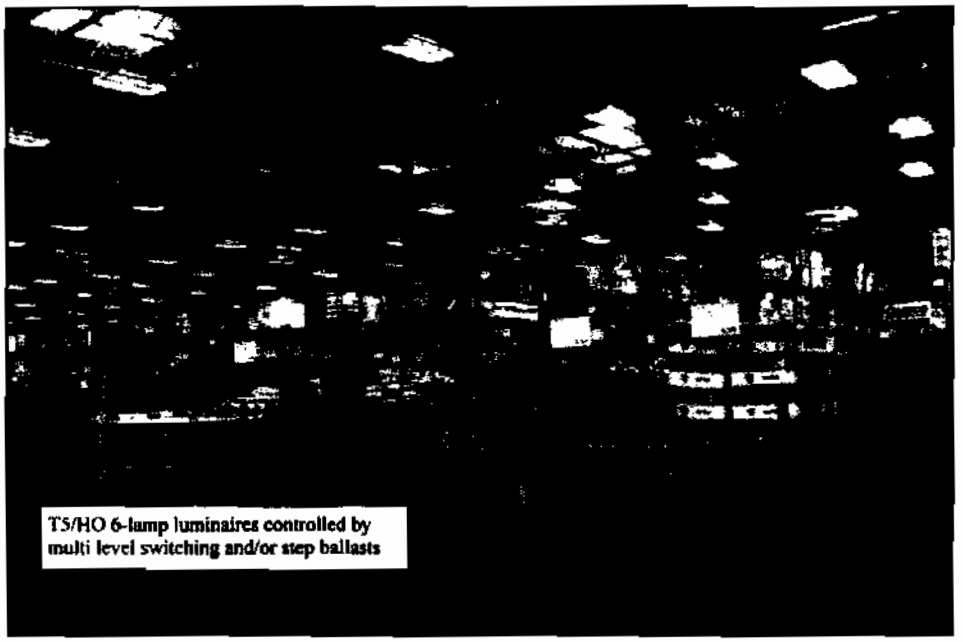


Figure 1: Demand Response Design Scenarios for Big Box RetaiL



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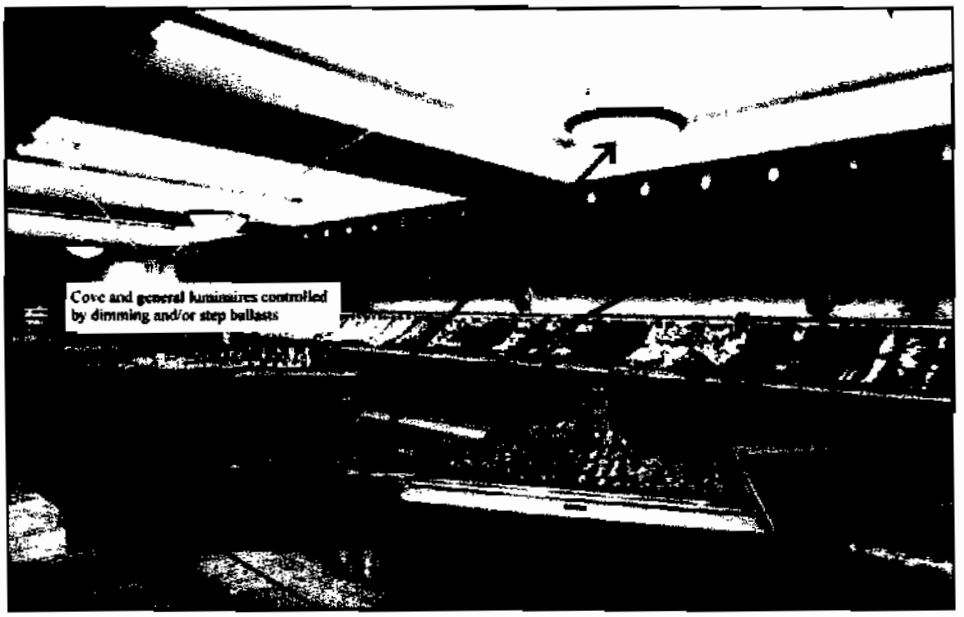

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Figure 2: Examples of DR Control Options in Big Box and Food Market Retail

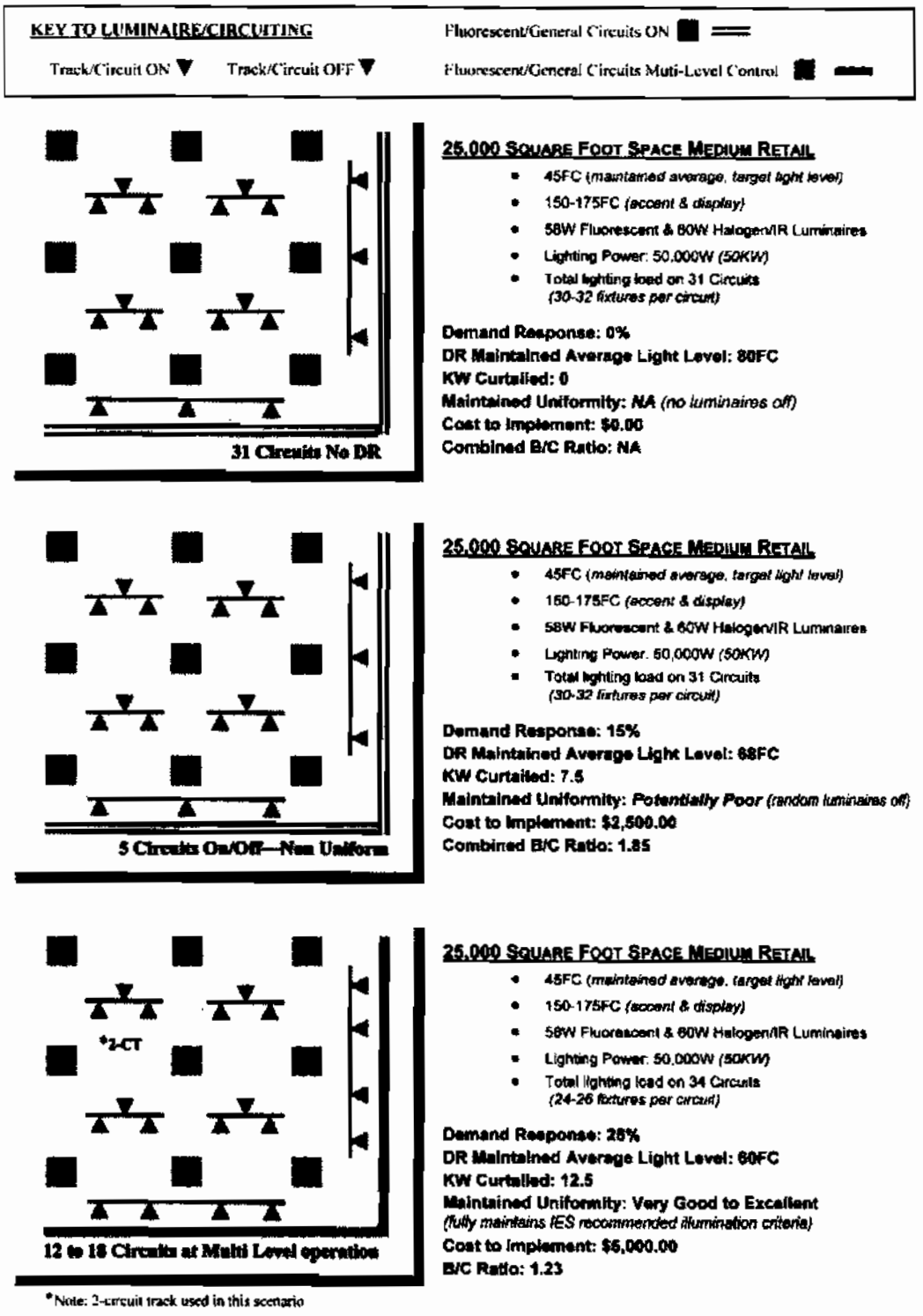
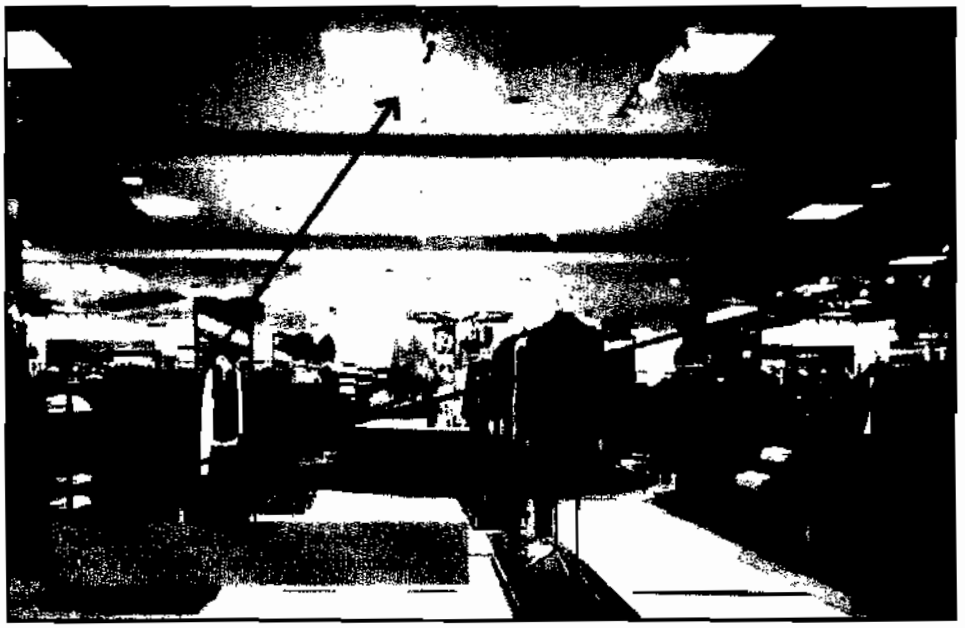


Figure 3: Demand Response Design Scenarios for Medium Retail



ANCHOR STORE RETAIL ***(Department Store)*** can Load Shed 25% to 30% through use of comprehensive lighting controls coupled with Demand Response controls. However night time adaptive illumination *(also possible with this system)* could result in a 33% low LPD during evening hours. Night time adaptive reduction power reduction is probably not practical for this store type.

HIGH END RETAIL Load Shed potential can be as aggressive as 30% to 35% using comprehensive lighting controls and Demand Response controls. Night time adaptive scenarios are usually not appropriate and/or practical.

Figure 4: Examples of Potential DR Control Options for Anchor & High End Retail

Energy Cost Savings, and Cost-effectiveness

The cost-effectiveness of this proposal is based on an assumed 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 building begins operation, 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 value of PV$616/kW. These values are detailed in Table 2

Implementation costs used for adding the DR component to a lighting system are based on discussions with engineers, currently designing comprehensive control systems, as well as manufactures who supply the equipment. From these interviews we confirmed the following:

Table 2: Combined emergency & economic value

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**

- $0.05 a square foot (100,000 foot area) and $0.10 a square foot (area 25000 feet and smaller) to design and install a simple (non-uniform) bare bones DR ready platform

- $0.20 a square foot (100,000 foot area) and $0.25 a square foot (area 25000 feet and smaller) where/when multi level multi task lighting controls are already present to design and install the additional comprehensive (uniform) DR ready platform with added benefit of night adaptive control

- $1.25 a square foot for any/all spaces with only the basic time clock and minimum T-24 compliance components. (Both the lighting control system as well as additive DR components are needed for a comprehensive DR design under these conditions)

As shown in Table 3, we considered various building types and likely scenarios. These scenarios are based on the lessons learned from conducting demand response potential surveys of retail buildings for Southern California Edison. The initial costs of installing a demand response system is compared against the life cycle energy cost savings from the control system. Some buildings such as big box retail with skylighting or warehouses with skylighting do not have much demand response

capability because they have already turned off much of the lighting in response to available daylight. Some buildings have a fairly low cost to implement demand responsive controls because they already have automated controls and bi-level circuiting. Most of the cost in these buildings is for adding a few more contactors and in some cases altering the design slightly to realize better uniformity when some lights are turned off during the demand response period.

Table 3: Benefit/Cost Calculation for uniform lighting DR control

DEMAND RESPONSE BENEFIT/COST ANALYSIS - Uniform control								
Space description	**Anchor store**	**Big box retail A**	**Big box retail B**	**Warehouse**	**Medium retail**	**High end retail**	**Large Office**	**Small Office**
DR Controlled Square Footage	100,000	100,000	100,000	100,000	25,000	25,000	100,000	5,000
Daylighting	No	Yes	No	Yes	No	No	No	No
Pre-existing controls	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Pre-existing bi-level circuiting	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Lighting Power Density LPD	1.7	1.7	1.7	0.6	2.0	2.2	1.1	1.1
DR Implementation Costs $/sf	$0.20	$0.20	$0.20	$1.25	$0.25	$0.25	$1.25	$1.25
Potential savings fraction	25%	5%	20%	5%	25%	30%	20%	20%
Savings kW	42.5	8.5	34.0	3.0	12.5	16.5	22.0	1.1
DR Life Cycle Cost Savings Economic Only PV $ (based on PV $250/kW)	$ 10,625	$ 2,125	$ 8,500	$ 750	$ 3,125	$ 4,125	$ 5,500	$ 275
DR Life Cycle Cost Savings Combined Economic + Emergency PV $ (based on PV$616/kW)	$ 26,180	$ 5,236	$ 20,944	$ 1,848	$ 7,700	$ 10,164	$ 13,552	$ 678
Total Cost to Add Demand Response $	$ 20,000	$ 20,000	$ 20,000	$ 125,000	$ 6,250	$ 6,250	$125,000	$ 6,250
B/C ratio for Economic Value Only	0.53	0.11	0.43	0.01	0.50	0.66	0.04	0.04
B/C ratio for Combined Economic & Emergency Value	**1.31**	0.26	**1.05**	0.01	**1.23**	**1.63**	0.11	0.11

As similar analysis was also conducted with a lower cost control scenario that yields less uniformity. This would have a lower first cost, but also lower savings. The building types that are cost effective don't change but it is possible for the control to be cost-effective on customer cost savings alone even without considering the societal benefit of less blackouts.

Table 4: Benefit/Cost analysis for non-uniform DR controls

DEMAND RESPONSE BENEFIT/COST ANALYSIS - Non-uniform control								
Space description	**Anchor store**	**Big box retail A**	**Big box retail B**	**Warehouse**	**Medium retail**	**High end retail**	**Large Office**	**Small Office**
DR Controlled Square Footage	100,000	100,000	100,000	100,000	25,000	25,000	100,000	5,000
Daylighting	No	Yes	Yes	Yes	No	No	No	No
Pre-existing controls	Yes	Yes	Yes	Yes	No	Yes	No	No
Pre-existing bi-level circuiting	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Lighting Power Density LPD	1.7	1.7	1.7	0.6	2.0	2.2	1.1	1.1
DR Implementation Costs $/sf	$0.05	$0.05	$0.05	$0.05	$0.10	$0.10	$0.25	$0.25
Potential savings fraction	15%	3%	15%	3%	15%	20%	15%	15%
Savings kW	25.5	5.1	25.5	1.8	7.5	11.0	16.5	0.8
DR Life Cycle Cost Savings Economic Only PV $ (based on PV $250/kW)	$ 6,375	$ 1,275	$ 6,375	$ 450	$ 1,875	$ 2,750	$ 4,125	$ 206
DR Life Cycle Cost Savings Combined Economic + Emergency PV $ (based on PV$616/kW)	$ 15,708	$ 3,142	$ 15,708	$ 1,109	$ 4,620	$ 6,776	$ 10,184	$ 508
Total Cost to Add Demand Response $	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 2,500	$ 2,500	$ 25,000	$ 1,250
B/C ratio for Economic Value Only	**1.28**	0.26	**1.28**	0.09	0.75	**1.10**	0.17	0.17
B/C ratio for Combined Economic & Emergency Value	**3.14**	0.63	**3.14**	0.22	**1.85**	**2.71**	0.41	0.41

The result of this analysis indicates that it may very well make sense to focus on those stores where savings are the greatest and costs are the lowest. Thus large retail stores that do not have daylighting have the greatest ratio of reward to cost and should be considered for demand responsive controls.

Statewide Energy Savings

Statewide energy savings estimates are based on unit energy savings multiplied by estimates of statewide quantities. Unit energy savings may be in terms of kWh/yr (or therm/sf for gas) savings per square foot of building stock or may be in terms of size of equipment controlled (tons or cooling or hp of motors etc.)

[redacted]

Recommendations

Recommendations applicable to and required for all space types are:

- Initial lighting design must conform to IESNA recommendations for the specific retail environment as defined in IES-RP2
- The design must include provisions for a comprehensive lighting control system as part of the lighting program
- Lighting zones must be planned (designed) with potential load shedding in mind. The design should be circuited accordingly
- Selection of luminaire and lamp types should be influenced by the need for potential load shed requirements.

Recommendations applicable to and unique by specific space type are:

- Anticipated potential load shed by key space types/load shed models:
  - Big Box – Advanced Daylighting – 0% to 10%
  - Big Box – No Daylighting - 5% to 20%
  - Discount – 10% to 25%
  - Grocery/Food – 10% to 25%
  - Department Store – 15% to 30%
  - High End Specialty – 20% to 40%
- Big Box, Discount and Grocery/Food:
  - Light sources with wide distribution and instant on/off capability are preferred when considering load shed potential. Also luminaires with multi-lamp configuration rather than single lamps
  - Designs with lower wattage luminaires on closer spacing are also desirable to accomplish load shedding with minimal dead spots in illumination grid.
  - Include comprehensive daylight harvesting into the lighting design. While load shed potential will drop, day-to-day demand will be reduced significantly. In most instances these spaces will not present meaningful load shed capacity.
- Department Stores & High End Specialty:
  - Apply light layers within the lighting design to assure that basic illumination to the space is maintained even though another layer (accent lighting) is significantly curtailed or off.
  - Luminaires with multi lamp configuration rather than single lamps are more conducive to maintaining base acceptable illumination.
  - Lighting zones as controlled by the lighting control; systems should allow for both system and task separation independently for maximum load shed with minimal loss of effective lighting. This should include micro on/off controls for artwork.

We recommend that utility companies institute voluntary programs for demand response implementation in structures 25,00 square feet and larger to coincide with implementation of Title 24-2008. Including training for the AEC community as well as incentives for owners and tenants will improve acceptance of demand response designs. As daylight harvesting is routinely added to large building it will be paramount that smaller spaces are included in the demand response grid if it is to be effective tool during a peak load emergencies.

Proposed Standards Language

Original standards language is in black font, 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.

DEMAND RESPONSIVE LIGHTING CONTROL is a control that reduces lighting power consumption in response to a demand response signal.

SECTION 131 – INDOOR LIGHTING CONTROLS THAT SHALL BE INSTALLED

(f) Demand responsive lighting controls. If a retail building has a floor area greater than 100,000 sf and is provided a demand response signal by the local utility, demand responsive lighting controls shall be installed that reduces lighting power consumption by 15% while enabling occupied space activities albeit at lower illumination levels.

Exception to 131(f): Buildings where more than 50% of the lighting power is controlled by daylighting controls.

~~(f)~~(g) **Lighting Control Acceptance.** Before an occupancy permit is granted for a new building or space, or a new lighting system serving a building or space is operated for normal use, all lighting controls serving the building or space shall be certified as meeting the Acceptance Requirements for Code Compliance. A Certificate of Acceptance shall be submitted to the building department that:

1. Certifies plans, specifications, installation certificates, and operating and maintenance information meet the requirements of Part 6.
2. Certifies that automatic daylighting controls meet the requirements of Section 119 (e) through Section 119 (g).
3. Certifies that lighting controls meet the requirements of Section 131 (a) through Section 131 (c), Sections 131 (e) and (f), and Section 146(a) 4 D.
4. Certifies that automatic lighting controls meet the requirements of Section 119 (c) and 131 (d).
5. Certifies that occupant-sensors meet the requirements of Section 119 (d) and 131 (d).
6. Certifies that demand responsive lighting controls meet the requirements of Section 131(f)

Alternate Calculation Manual

As this is a mandatory measure, no changes are needed to the ACM.

Bibliography and Other Research

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