PG&E

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Draft Report:
Demand Responsive Building Plan

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Table of Contents

Table of Figures

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Overview

Description

This report and analysis describes the economic, technical, cost-effectiveness and feasibility issues associated with a requirement for prioritizing the demand response (DR) of building loads for nonresidential buildings in the Title 24 standards. If this proposal were accepted, the electrical designer would be required to segregate specific loads or circuits by their ability to be curtailed for economic or electrical system reliability reasons. The designer would be required to designate on the electrical plans four types of loads, by their demand response priority level:

A. non-interruptible loads due to specific life-safety and other code requirements (i.e. already required to be on emergency back-up systems)

B. minimum base loads for building systems and equipment, which will sustain minimal building operation, business continuity and equipment protection during extreme power emergencies

C. loads which can be curtailed during power emergencies (Stage 2 or 3 power alerts) in response to mandatory dispatch signals

D. loads which could be voluntary curtailed in response to economic signals, such as high demand charges or voluntary dispatch signals, and also curtailed during power emergencies in response to mandatory dispatch signals

This proposal involves two levels of requirements, one for all commercial buildings greater than 5,000 SF, and an additional requirement for very large commercial buildings, those greater than 100,000 SF:

1.) **Demand Response Building Plan (DRBP):** For all commercial buildings[1] (or separately metered spaces) greater than 5,000 SF the Title 24 documents shall indicate how the building electrical loads are segregated according to the four levels above. Each building plan would designate at least 10% of the connected load to level D, and at least another 10% to level C, for a total minimum requirement for 20% curtailable load. In buildings less than 100,000 SF, all of the curtailable load may be designated level C only. Building circuits and sub-circuits shall be segregated into at least three end use categories, HVAC, lighting, and other. These designations of DR priority level and end use shall be clearly shown both on the building plans and at the electrical panels. Each group of loads so designated will have the capability to be logically connected to a manual or automatic control device according to one of the four levels above.

2.) **Demand Response Building Implementation (DRBI):** For commercial buildings greater than 100,000 SF the communicating control devices and software necessary to automatically implement both voluntary and automatic load shedding for levels C and D will be installed and commissioned. The electrical plans for these buildings would describe how each curtailable component is attached to a demand response signaling device, which loads are grouped for each level of curtailment and how the demand response device can be tested.

Demand response or direct load control is a desirable capability for controlling system peak demand. The first requirement of this proposal, to declare demand response load priorities for all commercial buildings >5,000 SF, would create a large infrastructure of buildings that could be more quickly and cost effectively retrofitted with automatic demand response controls in the future. It would also greatly facilitate any manual response in a power emergency. During the 2001 power emergency, almost all demand response was via manual curtailment of discretionary loads. This was especially true when it was easy to identify and turn off discretionary loads, with few

[1] Buildings covered under OSHPD or deemed necessary for local emergency response, i.e. hospitals, police stations, 911 call centers, etc., will be excluded from both these requirements.

negative effects, such as voluntary reduction in lighting levels in retail and office buildings. Given the widespread public understanding of the emergency, participation was surprisingly high, for example among chain retail stores. Pre-existing code requirements for bi-level switching of lighting greatly facilitated this response. We believe that a DRBP, although depending on manual voluntary response to a request for demand reduction, may have at least a similar rate of demand reduction participation during true power emergencies, and potentially higher due to greater ease of implementation. Additionally, it will be significantly easier and less expensive to retrofit automated demand response capability, at some future date, into a building with a DRBP.

The automatic demand response capability that would be required for buildings >100,000 SF would immediately enable large buildings to participate in voluntary economic dispatch programs, plus give the utilities the ability directly reduce demand further during a power emergency. Under a voluntary economic program, building loads would be preset to be shed when peak demand is especially high, according to a threshold determined by the building owner based on the economic incentives offered by the utility. Under emergency response, all previously identified curtailable loads would be shed based on a direct signal from the utility, preventing larger scale outages.

Issues Identification and Barriers

In order to address the technological feasibility & code integration issues for this proposal, we investigated the foreseeable barriers. In addition to a conducting a review of current literature, we interviewed five electrical engineers, seven program mangers at utilities who were involved in demand response studies, six researchers in state sponsored programs.

This proposal attempts to address one of the key barriers we identified to implementation of demand response in commercial buildings that we identified: the cost of identifying and organizing the appropriate loads in a building into a DR system. Currently, each building retrofitted with a DR system poses a complex and time consuming detective problem, verifying which loads are connected to which circuits, and how they could best be organized into a DR system. The electrical systems in buildings are uniquely (sometimes even idiosyncratically) organized and therefore must be re-mapped, and sometimes re-wired, in order to create a logical demand response system. By requiring that electrical engineers pre-plan for demand response capability early in the design stage, and so label the electrical system on the plans and in the field, the cost-effectiveness of future DR capability will greatly improve, and thus participation in utility demand response programs is also likely to increase.

In Mary Ann Piette's paper *Development and Evaluation of Fully Automated Demand Response in Large Facilities* one item in the Recommendations for Future Research summarizes LBNL's experience with pilot DR projects, identifying a need for consideration of demand response in the general electrical organization of the building:

> "many of the control and communications systems accrete technology over time, additional features are added and layered on to existing systems controls in a messy fashion. This messiness is a leading cause of the technical support needed. The systems are unique, with multiple layers of legacy systems that suffer from the obscurity and use of proprietary hardware and software. The research team spent considerable time deciphering the layers (Piette, et. al.) The outsourcing of the controls technology along with the adoption of control technologies over time, the fact that the enabling technologies are located at some distance from each other and the complexity of the systems makes implementation of changes to the controls technology difficult…. Again, an impediment now widespread in these large institutions is that the knowledge about many technical functions is now outsourced to specialty vendors and subcontractors. Related to this is the fact that these specialty companies are in the business of selling services to the institution and while their opinion is valued, it is often discounted as sales talk."

In response to these barriers, this measure helps address the "messiness" of commercial facilities for future implementation of automated control strategies. It would address the complexity and location of loads in the system by grouping controllable technologies for identification and attachment to control equipment. In addition, by asking that an electrical engineer specify the load segregations, it co-ordinates and facilitates the control equipment providers' roles, and validates and distinguishes the DR organizational process as part of professional practice in the state.

Steve Giampaoli, Chief Energy Engineer at Kema Xenergy[2] reported that feedback from market acceptance studies of demand response program participants indicate that "customers are more likely to accept and participate in curtailment arrangements if they have control to decide what equipment will be curtailed and if they have advance (a full day ahead preferred) notice."

We received very similar input from other electrical engineers and DR program managers that we interviewed: that customers wanted control of which loads would be shed, and that each building operation was unique. We believe that by providing maximum flexibility in which loads will be designated as curtailable, the customer will be able to tailor their response to improve overall customer acceptance and minimize reductions in comfort and productivity.

Responses from electrical engineers and DR specialists indicated that there would not be any significant conflict between this curtailment strategy and other standards including the National Electrical Code, the Life Safety Code and the Fire Code. Limitations on the number of circuits allowed per given device by the NEC would be consistent with current practice, including other needs for circuit protection, phase balancing and general organization

In our surveys with practitioners we were told that creating such a load priority organizational structure in the design and construction phase was not particularly difficult. For example, it is very similar to emergency response circuit priorities required for medical buildings regulated by OSHPD. However, the practitioners believed that owners would never pay for such an organizational effort unless it was required, since the benefits are more at the social level in overall system reliability rather than in highly predictable cost reductions for the owners. Estimates of increased design and coordination costs for such a prioritized electrical system varied from negligible up to an additional 10% on top of current electrical design fees. We have assumed 10% in our cost benefit analysis.

We also found that current market penetration for building wide energy management systems is quite widespread, especially among larger buildings. According to the *CEC Enhanced Automation Technical Options Guidebook*, 75% of buildings larger than 50,000 sf have some form of energy management system. While most of these existing energy management systems are not DR enabled, it does illustrate that installation of sophisticated controls of the level envisioned in this proposal is already common practice in the market.

Energy Benefits

The primary benefits of this proposal is demand reduction, measured in MW. The energy benefit, measured in GWh is small relative to the demand reduction, because the emergency curtailment is done only a few hours per year. Emergency curtailment would occur only power emergencies, estimated to occur for only one day every ten years, or an average of 2.4 hrs/year, and the economic curtailment is done only during the days and hours of highest energy price (10 summer peak weekdays during the hours of 1-5pm), estimated at 40 hours per year.

Emergency dispatch: Our analysis assumes all new commercial buildings >5,000sf will be available for curtailment during a future emergency or reliability event. This curtailment may be via manual response (as it typically was during the 2001 power emergencies) or automatic direct response devices. We assumed different response rates for different building sizes. This yields significant demand reductions during system emergencies such as California ISO Stage 2 or 3 emergencies. The additional improvement in 'Reliability Benefits' during system emergencies associated implementing the DRBP is based upon the Value of Lost Load (VOLL) analysis described in the methodology section.

Economic dispatch: In addition, energy savings were calculated for very large new buildings (>100,000 sf) with installed DR controls (DRBI) for a voluntary cost-based program that would send out a curtailment or price signal for a few peak hours per year. The savings associated with voluntary programs are computed in the same manner as other Title 24 measures using Time-Dependent Valuation (TDV). (While some of the smaller DRBP buildings might also choose to implement a voluntary system to take advantage of those savings, we have ignored them in our analysis.)

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[2] Personal communication May 13, 2006. In support of PG&E's and SCE's demand response programs, Kema has conducted recent market acceptance studies of customer acceptance of demand response scenarios.

Both economic dispatch and emergency dispatch have associated economic values. In our analysis, we used values developed in the CASE Draft Report *Demand Responsive Control of Air Conditioning via Programmable Communicating Thermostats (PCTs)* and the *TDV Valuation of DR from E-3 report* (Southern California Edison and PIER. Feb. 2006).

Non-energy Benefits

Increased reliability in the electrical distribution system through reduced peak demand is the primary non-energy benefit resulting from a Demand Response Building Plan, which enables manual or automated response to emergency power events. System reliability has both individual benefits and social benefits. We have accounted for the individual benefits in the Value of Lost Load (VOLL) analysis mentioned above. The social benefits of avoiding the social disruption and dislocation, and the political and business repercussions, due to wide spread power outages as experienced in 2001, are considerable, but we did not attempt to monetize them in this analysis.

Another indirect benefit is the increased speed and cost effectiveness with which automated demand response could be implemented in the future, since new buildings would already be logically organized and so documented to receive these systems We expect that any future DR programs would see significant front-end savings, reducing design, installation and transaction costs considerably, and thereby greatly increasing the cost effectiveness and penetration of any such programs. However, we do not have an estimate of the value associated with these savings, and so we have not included them in our cost benefit analysis.

In addition to the system reliability and DR program cost benefits previously described, we estimated the expected reduction in air emissions associated with DRBP and DRBI. Since the demand reduction will only occur on rare occasions the air emissions reductions from power plants is relatively small, but positive. See the Methodology section for more discussion.

In our surveys we also investigated the potential negative non-energy benefits associated with load curtailment such as occupant discomfort and/or lost productivity. As discussed earlier, practitioners and program managers both believed that the key to minimizing negative impacts was allowing customer choice as to which loads would be curtailed. In general, it was believed that lighting would be the easiest load to shed with minimal discomfort or loss in productivity, especially in buildings with sufficient daylight. Many other loads, such as escalators, automatic doors, special hood ventilators, refrigeration, or process loads might be temporarily shed depending on the specifics of operation in a given building.

As a conservative assumption we have adopted the same values for lost comfort and productivity used by E3 in their economic analysis for the PCT CASE proposal (SCE and PIER, 2006). These include a 20% reduction in the value of peak energy savings in a voluntary program, and $2.50/kW reduction in value of emergency demand reduction. The value is derived from value of service studies from customers which assess a customer's willingness to pay to avoid an interruption, specifically of cooling. With a choice of all equipment in the building to curtail, it is likely that customers might be able to further avoid losses in comfort and productivity.

Statewide Energy Impacts

In statewide impacts for new construction, we reference an average of four years' non-residential data from the NRNC construction database (RLW, 1999). We deleted two categories of building types from the analysis, Medical and Government, to account for the building types excluded under the emergency responder provision of this proposal. This is probably a slightly conservative assumption, since not all buildings in these two categories need necessarily be excluded from the requirements of this provision.

Figure 1: Non-Residential New Construction Estimates for Statewide Analysis[3]: Annual average building activity PY 2000-2003 (1,000 sf per year)

AMUSEMENT	ASSEMBLY	EDUCATION	[redacted]	HOTEL	[redacted]	OFFICE	RETAIL	SCHOOL	SERVICE	STORAGE	OTHER	Total (Excluding Govt & Medical)
5,776	1,990	1,277	[redacted]	6,901	[redacted]	27,380	24,410	15,334	21,965	37,504	6,227	148,765

As described in the Methodology section, the estimated coincident peak W/sf for each building type was derived from data for each building type in the NRNC Database. First, the average kWh/sf (from CEC Forecast Data, Appendix I) for each building type by utility territory was weighted by the relative proportion of new construction square footage for that territory, as reported in the 2002 NRNC Market Characterization Study (RLW 1999). This statewide kWh/sf by building type was then multiplied by the ratio of coincident peak MW to Annual GWh reported in the CEC forecast co-incident peakata (California Energy Commission; 2003.) to estimate the coincident peak W/sf by building type.

Economic (voluntary) energy and demand savings during peak hours were estimated using the method developed for the PCT proposal (SCE and PIER 2006) and applied only to those large buildings >100,000 SF. It was assumed that only 7% of the population responded to the economic dispatch signal with a 10% reduction in peak coincident demand, based on large building commercial response rates observed in the 20/20 program (Energy Market Innovations, 2006).

Emergency demand savings were similarly derived,. It was assumed that 90% of the large building population will respond to a automated emergency dispatch signal with a 20% reduction in peak coincident demand (less the economic response already calculated), and 33% of the small buildings population will respond manually to a broadcast signal with a 20% reduction in their peak coincident demand.

These assumptions show much larger savings under emergency conditions than under voluntary economic conditions. This is because we assume that there will be a much larger response to an emergency, as happened during the 2001 power crisis. Of course, with suitable marketing and financial incentives, the voluntary component could become substantially higher than observed in the past. However, our analysis shows favorable results even with these conservative assumptions.

The energy savings estimate details are shown in Figure 2 below. The Methodology section includes a detailed description of how the statewide energy impacts were calculated.

Figure 2: Summary of Estimated Statewide Energy, Demand and Cost Savings per Year of New Construction

Building Category	1,000 sf	Energy Savings GWh/yr	Emergency Demand Impact MW	Non-Emergency Demand Impact MW	Total Value PV$Millions
Small bldgs Emergency	68,432	28.97	12.07		$ 13.62
Large Bldgs Emergency		97.60	40.67		$ 45.88
Large Bldgs Economic	78,845	59.00		1.48	$ 0.48
Total first year new construction	147,277	185.57	52.74	1.48	$ 59.98

Environmental Impact

Since there is no difference in materials between a building using current standard practice electrical design, and one organized to facilitate demand response installations, there would be negligible incremental environmental impacts from a Demand Response Building Plan.

The DRBI for larger buildings may involve slightly more wiring, automated controls, central energy management system and software per building, but again, the environmental impact of the manufacture and installation of such products is expected to be negligible, especially given that 75% of large buildings (large buildings defined as >100,000 SF in the case of this proposal) already include similar equipment according to the Enhanced Automation Technical Options guidebook: " EMS vendors report that existing systems are found in approximately 75 percent of commercial facilities that are over 50,000 square feet." (California Energy Commission, 2002. "Enhanced Automation Technical Options Guidebook." P. 24)

Since the operation of the DRBI differs from the base case of "no system" only during the approximately 40 hours per year when voluntary curtailment is desired, or the estimated 1 day of emergency response every 10 years, the air emissions reductions from power plants is relatively small, but positive.

In reality, much of the generation sources brought on line during power emergencies tend to have higher levels of emissions than base loads, but this is not considered in our calculations. Inefficient, more polluting and more expensive power plants are dispatched during times of high demand and high electricity cost. As a conservative approach in our estimate of the air quality impact of this measure, we have used the annual average emissions per kWh, not the peak conditions.

Air emissions reductions are calculated and tabulated in Figure 3. These results are comparable to removing 1053 cars from the road for CO_2 emissions, and 78 cars from the road for NO_x (Nitrous Oxides)[4] for each year the measure is implemented. Thus in 10 years the annual savings, due to cumulative new construction implementation of this measure, would be ten times these values.

Hourly emissions factors (lbs of NO_x, lbs of particulate matter or Tons of CO_2 per kWh) are multiplied by the TDV hourly energy savings estimates for large and small buildings in the economic and emergency scenarios to yield an estimate of environmental benefits of DRBP (see Methodology).

Figure 3: First Year Air Emissions Reductions from DRBP & DRBI Measures

Building Category	Statewide NO_x Reduction (Lbs)	Statewide PM10 Reduction (Lbs)	Statewide CO_2 Reduction (Tons)
Small bldgs Emergency	311.16	721.08	937.12
Large Bldgs Emergency	1,048.36	379.26	3,157.36
Large Bldgs Economic	1,602.48	229.26	1,908.60
Total first year new construction	**2,961.99**	**1,329.60**	**6,003.08**
Equivalent # of Cars	78	233	1,053

[4] Automobiles emit a greater proportion of nitrous oxides to carbon dioxide than do electric generation stations. The typical passenger car emits 38.2 lbs/yr of Nitrous Oxides and 5.7 tons of CO2 during a typical year's driving (12,500 miles). From USEPA "Emission facts" http://www.epa.gov/otaq/consumer/f00013.htm

Type of Code Change

The suggested mechanisms for connecting designated electric loads to an automated load curtailment system within the T-24 standards are:

Mandatory Measures:

The Title 24 energy standards would require a Demand Response Building Plan (DRBP) as a mandatory measure for all non-residential buildings >5,000 SF.

Demand Response Building Implementation (DRBI) would also be mandatory for buildings >100,000 SF.

The DRBP portion of this proposal expands the scope of the Standards to include the organization, prioritization, labeling of end-use loads, along with associated reporting requirements. The DRBI portion of this proposal expands the scope of the standards to include the installation and commissioning of building level and end-use devices that can respond to automated dispatch signals. This would be the first requirement in the Standards for a building level energy management system.

This measure is appropriate for inclusion in the building efficiency standards rather than the appliance efficiency standards because it addresses requirements for whole-building system design which will vary per each construction project's electrical loads, as opposed to addressing requirements for a particular piece of equipment. Enforcement of this measure should be via review of compliance documents, plans and specifications submitted for Building and Occupancy Permits.

Technology Measures

The Demand Response Building Plan requires no new technologies. Rather it is simply an organizational and labeling system consistent with other current engineering practices. New technologies, however, may indeed evolve in the future to meet new market demand for simple and flexible segregation of electrical loads by demand response priority. This proposal does not inhibit the development of any new technology to increase the ease of load segregation.

The Demand Response Building Implementation (DRBI) requirement builds on existing control and energy management system (EMS) technology. For example, there are existing EMS and equipment level control systems which would satisfy the DRBI requirement. The proposal is designed to maximize flexibility in the type of method that could be used to provide the level of control envisioned— separate circuiting, distributed relays, addressable devices with wireless mesh communications, DALI, PCT—several of which are already commercially available, low-cost and reliable.

The communication protocol for DRBI, similar to the PCT measure, has the greatest uncertainty regarding availability, reliability and cost. There are two levels of communication systems for this measure; from the Utility to the building meter and from the building meter to the systems and devices in the building.

Measure Availability and Cost

In order to asses the availability of the communication technology necessary for this measure we interviewed utility Demand Response technical experts. We produced a summary of existing building automation and dispatch demand response programs, and equipment and communication protocols available per utility. We interviewed electrical engineers to help identify the most appropriate, reliable and least-cost methods of providing the control. We interviewed electrical designers and contractors in order to identify potential increased design and construction costs due to new technology and design practices.

The cost impact of the DRBP is primarily on the design services of the electrical engineer. In our interviews, we were told that the increase in cost for design services might vary from 5% to 10%, depending on the building type, and the complexity of the electrical system. We have assumed a 10% increase in average electrical design fees throughout[5], as shown in Figure 4: Design Cost Assumptions by Building Type.

Figure 4: Design Cost Assumptions by Building Type

Estimated Design Costs Per Building Type ($/SF)

	AMUSEMENT	ASSEMBLY	EDUCATION	HOTEL	OFFICE	RETAIL	SCHOOL	SERVICE	STORAGE	OTHER
$/SF Total for Elec System										
	$ 7.98	$ 7.90	$ 10.75	$ 5.75	$ 5.95	$ 3.75	$ 8.25	$ 5.00	$ 3.04	$ 6.49
EE Design Fee (small Bldg)										
	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
EE Design Fee (large Bldg)										
	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Addnl Design Cost for DRBP										
	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Small Bldgs										
	$ 0.03	$ 0.03	$ 0.04	$ 0.02	$ 0.02	$ 0.02	$ 0.03	$ 0.02	$ 0.01	$ 0.03
Large Buildings										
	$ 0.02	$ 0.02	$ 0.02	$ 0.01	$ 0.01	$ 0.01	$ 0.02	$ 0.01	$ 0.01	$ 0.01

RS Means Building Construction Cost Data 2002 Western addition. RS Means Company Inc. Kingston Massachusetts.

It is possible, but not obvious, that creating a building with an electrical system that meets the requirements of the Demand Response Building Plan might require some additional circuits, sub-circuits, breaker panels or other electrical equipment in order to fully segregate loads. In order to account for this possibility we have assumed a 3% increase in building electrical system costs overall for all buildings, large and small. This amounts to$ 0.09 to $0.32 per SF, depending upon the type of building. For our analysis, we used an average additional construction of $0.22/sf. To test this assumption, we tested costs for a 150' x 150' building module totaling 22,500sf. Approximately 16 control points, ranging in cost from $400-$600 per control point, will be necessary to achieve a 20% reduction in power, with 8 of these control points already necessary for current code options or requirements (such as bi-level switching). By multiplying the 8 additional control points by $600 and dividing by the total 22,500sf we get $0.21/sf, very similar to the $0.22/sf cost based on a 3% increase in electrical construction costs reported above.

For the DRBI systems, DR responsive controls and communicating equipment will need to be installed and activated. We have assumed these costs to be similar to current EMS systems, which range from $0.50/sf to $1.00/sf in large buildings as shown in Figure 5. The cost of additional Demand Response Priority is assumed to be negligible, since it is primarily a software function. Because market surveys have reported that 75% of large buildings already have an EMS system, we have assumed that the high end cost of $1.00/sf would apply to only the additional 25% of the large building market that is not currently employing an EMS system.

Activation of dispatched DRBI will require automated meter infrastructure (AMI) . In general, there are some doubts that all of the two way dispatch communication infrastructure will be available statewide by 2008, though is widely assumed that it will be fully available by 2011. Our proposal is not dependent upon the DR communication infrastructure being fully available by 2008. Rather, this proposal is intended to facilitate the rapid implementation of such communication equipment whenever it becomes available, by assuring that all new commercial buildings will be DR-ready.

[5] Costs of electrical design fees and electrical systems were taken from Means Construction Cost Data, Western Edition, 2002, with the median range of values applied. Accounting for inflation might increase these values by about 10%, given historical data available from Means. Given the uncertainty of other cost data, we did not apply an inflation factor.

Metering Infrastructure Availability

All of the IOUs, SMUD, and Anaheim Power are offering enhanced automation and/or demand response incentive programs, with small pilot price dispatch programs currently in operation. Silicon Valley Power Authority has 21 of their largest customers (>200kW - 2MW) enrolled in a "Power Pull" program to curtail a predetermined amount of load only in local system emergency events (last occurring in 2001). LADWP does not currently have active DR programs. Several of the small rural municipal utilities (Muni's) have limited energy efficiency programs for their non-residential customers with no DR programs in place. The IOU and large Muni programs have helped to enable the interval data meter's market penetration and all Municipal and Investor Owned Utilities contacted will have interval data meters, capable of 5-15 minute interval reads fully implemented by 2008. AMI (with two-way communication capability) is estimated to be installed and widely available in the IOU service territories by 2011.

Various AMI communications technologies (FM radio, digital, power line internet, wireless internet, packet carrier) are being considered and employed with variation in the appropriateness of each per the independent service conditions. In the survey of demand response service providers, FM radio signal was most frequently reported to be the most likely and cost-effective protocol for the metering infrastructure to communicate to the building level meter.

The primary venue for coordination between companies who have released this technology is called Open AMI. A useful description of the Model AMI platform is referenced from *Advanced Metering and Demand Responsive Infrastructure: A Summary of the PIER/ CEC Reference Design, Related Research and Key Findings.*

Building Level Communication Systems Availability and Cost

Various building level communication and control system technologies have an open architecture which interfaces and employs IP protocol, LAN, FM signal, and hardwired relays simultaneously. The appropriateness of each of these communication protocols is related to the requirements and desired resolution of the curtailable devices. There are a multitude of products available with proven reliability.

Equipment costs are related to the complexity of the building systems, number of control points, control types, and the layering and sequencing of points in various technologies,. When a project employs large global points, the cost will be reduced. Cost depends upon many factors (making it difficult to identify exact numbers) including the size of the project, where large complex projects benefit from an economy of scale ($50-300/point with hundreds of points), versus for a small system or a complex office building with multiple tenants ($500-1500/point). We generated a range of costs per square foot by building size, as shown in Figure 5, and used the highest values our analysis.

Figure 5: Summary of Installed Equipment Cost from Surveys

Building Size Categories	Range of Cost / SF	Range of Cost / Control Point
Under 5,000 SF	$2-4/sf	$600-$1000/Point
Btwn 5,000-100,000	$1-4/sf	$400-$600/Point
Over 100,000 sf	$0.5-$1/sf	$50- $300/Point

Useful Life, Persistence and Maintenance

DRBP will organize the basic electrical infrastructure of a building. Therefore it should last the life of the electrical system infrastructure, or 40-50 years—certainly beyond the term of the 15 year span of our economic analysis. The goal of the DRBP requirement is to create a flexible electrical infrastructure that will allow building owners to easily identify and re-organize building load priorities. This flexibility should encourage greater persistence. DRBP persistence may degrade with any renovation to the electrical system, caused by change in tenants or use of the building. However, any such change that would trigger a requirement for a new building permit is also likely to trigger a requirement for a new Title 24 submittal, which would reinforce persistence.

AMI infrastructure is assumed to have a 30 year useful life. The DRBI control system is assumed to have a 15 year useful life in accordance with the mechanical systems in commercial buildings. Ongoing maintenance of building control systems for DRBI is anticipated, however the assumption that most large buildings will already require an energy control system negates the impact of this cost.

Performance Verification

We propose to establish a set of protocols for DRBI performance verification to assure that the installed devices are receiving the dispatch signal, and that the loads are being shut off. This performance verification protocol for non-residential buildings would be similar to the acceptance testing requirements currently in the standards for other building controls. Likewise, it would be wise to include an annual testing protocol in the maintenance manual provided with any DR enabled equipment. The broad scope of acceptance tests assumed in this CASE report coincide with those set forward in the CEC technical potential report for enhanced automation of non-residential facilities.

Analysis Tools

The primary analysis tool necessary to quantify energy savings and peak electricity demand reductions are Microsoft Excel spreadsheets, the TDV hourly energy savings estimates, and TDV environmental emission factors. The assumptions in our economic analysis of the value of peak demand reduction and Value of Lost Load were developed by E3 in the Programmable Communicating Thermostat (PCT) CASE report (SCE &PIER, 2006). Please refer to the Appendix of that report for further information on these values.

Relationship to Other Measures

Demand Response measures here proposed are complemented by the proposal for demand responsive control of Air Conditioning Via PCTs (Programmable Communicating Thermostats). The communication system developed in order to dispatch a control signal from the Utilities (or CEC or ISO) to the building systems would employ the same technology for the PCT and other demand response measures. The DRBP here described could include classification of some of the air conditioning loads into one of the segregated loads for PCT control.

The PCT measure addresses small, stand-alone AC Units. The DRBP and DRBI could potentially include all types of AC units, since they do not dictate which end-uses or controls will be prioritized for curtailment. Since all equipment and end-uses could potentially be classified at priority Level C or D, according to the choice of the building owner and designer, much larger centralized AC units are likely to be included in any DRBP and DRBI.

In addition, all lighting control measures also have a relationship to the DRBP and DRBI since they are likely measures which can be classified as curtailable.

To the extent that a building with a DRBI also uses dimming ballasts, there maybe some overlap between the current 25% lighting control credit for "manual dimming with automatic load control of dimmable electronic ballasts" and the new requirement for DR responsive controls, even though the type of control and end uses are not specified. Logically, all such lighting fixtures with "manual dimming with automatic load control of dimmable electronic ballasts" are likely to be classified as DR priority level C or D.

Likewise, any other measure adopted to provide additional demand response capability in non-residential buildings would have a relationship to this proposal.

Methodology

This section contains the assumptions used for the analysis of the costs and the energy impacts of the proposed measures.

Energy and Demand Analysis

In order to calculate an average statewide W/SF necessary to find the total peak coincident kW by building type for new construction, we created a ratio of Coincident Peak MW to Annual GWh hours with 2008 data from the CEC Coincident Peak.xls files (California Energy Commission; 2003). We then multiplied the ratio of peak coincidence/annual energy times the kWh/sf values for new construction building types across all service territories from the CEC 2008 Forecast Data in Appendix I. This gives an estimate of the total coincident peak Watts/sf attributable to new construction statewide per year. [kWh/sf * MW/GWh = Watts/sf].

The coincident peak demand Watts/sf were weighted by the total square feet of applicable non-residential new construction (shown in 1000's of sf in Figure 6) by building type to estimate a statewide weighted average of **2.77 W/sf** attributable to 148,491,000 sf of new construction in 2008.

Figure 6: Coincident Peak W/sf Calculations

	CEC Forecast Peak Coincidence	CEC Forecast Annual Energy	Ratio of Peak Coincidence to /Annual Energy	CEC Forecast Appendix I	Estimated Co-incident Peak by Bldg Type	Total Statewide SF by Building Type	Fraction of total SF	Weighted W/SF
	2008	2008	2008	2008				
	MW	GWH	MW/GWH	kWh/SF	(W/SF)	SF	%SF	
Small Office	2,113.34	4,948.60	0.43	12.42	5.30	12,595	0.0848	0.45
Large Office	4,942.51	23,505.90	0.21	20.66	4.35	14,512	0.0977	0.42
Retail	2,946.00	12,230.20	0.24	10.99	2.65	24,410	0.1644	0.44
Service	993.65	8,648.30	0.11	13.25	1.52	21,965	0.1479	0.23
Storage	683.86	3,426.80	0.20	13.25	2.64	37,504	0.2526	0.67
School	624.52	2,968.50	0.21	6.37	1.34	15,334	0.1033	0.14
College	683.24	3,173.70	0.22	11.30	2.43	1,277	0.0086	0.02
Hotel / Motel	471.36	3,001.50	0.16	13.15	2.07	6,901	0.0465	0.10
Miscellaneous	3,024.40	12,129.10	0.25	13.25	3.30	13,993	0.0942	0.31
Totals:						**148,491**		**2.77**

The statewide weighted average of **2.77 W/sf** was used to calculate energy and demand benefits for economic and emergency curtailments. This energy and demand benefit was then compared against the average design and equipments costs by building type detailed in Figure 4 and Figure 5.

Figure 7: Energy Savings, Demand Impact and Benefit Cost Analysis

Net value of emergency DR PV$/kW	$ 1,128.12	2.4	hrs per year
Net economic value PV$/kW	$ 327.74	40	hrs per summer
New comm building stock, million sf/yr	148		
Building Category	Large buildings > 100,000 sf	5,000 sf < Small Bldg < 100,000	Total Large and Small Bldg
DR Measure category	DRBI	DRBP	
Fraction of building stock	53%	46%	
Million sf/yr	78.44	68.08	
Coincident peak demand W/sf	2.77	2.77	
Fraction participating in economic program	7%	0%	
Fraction participating emergency event	93%	33%	
Fraction of peak shed economic	10%		
Fraction of peak shed emergency	20%	20%	
Fraction where signal works	97%	97%	
Estimated Peak Reduction			
Emergency peak savings MW	40.67	12.07	52.74
Economic peak savings MW	1.48	0.00	1.48
Total Peak Savings MW	**42.14**	**12.07**	**54.21**
Estimated Value of Peak Reduction			
Emergency net savings PV$ Millions	$45.88	$13.62	
Economic net savings PV$ Millions	$0.48	$0.00	
Total Net Savings 1st year Construction $PV Millions	**$46.36**	**$13.62**	**$59.98**
Emmision Reduction Calculation			
Emergency Energy Reduction MWh/yr	97.60	28.97	
Economic Energy Reduction MWh/yr	59.00	0.00	
Total Energy Reduction MWh/yr	**156.60**	**28.97**	**185.57**
First year initial cost			
Design Cost per sf	$0.013	$0.026	
Fraction with pre-exting ECMS	75%		
Fraction without ECMS	25%		
Pre-existing ECMS - make DR ready $/sf	$ 0.22		
No pre-existing ECMS - make DR ready $/sf	$1.00	$ 0.22	
Millions of $ total cost	**$33.46**	**$16.62**	**$50.08**
B/C Ratio	**1.39**	**0.82**	**1.20**

Emergency Analysis

For emergency response, the Net Present Value of Lost Load is taken to be \$42 /kWh-\$2.50/kWh= \$39.50/kWh*11.9 = \$1128.12. \$42/kWh represents the average value of lost load across all classes of utility customers, since all customers would loose power if the system went down. By shedding a kW, the commercial building owners are providing that overall value to the state. The \$2.50/kWh represents an estimate of value of loss of comfort and productivity to the commercial building owner. The factor of 11.9 represents the net present value of 15 years of accumulated events. All of these estimates of value were derived by E3 for the PCT CASE report (SCE &Pier, 2006) , presented as a separate Title 24 proposal. The reader is referred to the appendix of the PCT CASE report for further explanation of this analysis.

It is assumed that emergency demand reduction will be required for only one day (24 hrs) over the course of ten years, or an average of 2.4 hours per year. Thus, this translates into a value of approximately \$1,128.12 for each kW that can be reliably controlled over the analysis period.

For our emergency benefit analysis, we assumed that only 33% of all small buildings (>5,000 SF and <100,000 SF) would voluntarily respond to an emergency demand reduction request (Energy Market Innovations 2006) to shed 20% of their peak load (approximately equivalent to 10% of their connected load), whereas 90% of larger buildings, which would be required to have DRBI with automated direct response, would respond. Another qualifier is an assumption that the emergency signal to reduce demand only gets through to 97% of the properties, whether by direct electronic (DRBI) or media broadcast (DRBP) communication.

Economic Analysis

We assumed, in a voluntary program with economic dispatch to the large buildings with DRBI, that 7%(Bender, Lutzenhiser,Moezzi, Gossard 2002) of the peak load for each building could be shed * 20% participation (from PCT analysis) * \$ value of TDV energy savings * % of new construction SF which is >100,000 SF. These same large buildings could then shed another 10% of that peak load under emergency direct dispatch * \$ value of service * 90% participation (assuming 10% of DR response systems are down at the time of emergency).

For the value of voluntary economic response, Figure 8 shows the assumptions about the value of four hours of peak demand reduction for the ten highest cost days per year, based on Present Value of TDV energy costs. For the 40 hours of anticipated curtailment (10 days * 4 hrs) for the voluntary program we estimated an average statewide value for economic response of \$410/kWh after weighting by total non-residential new construction square feet per Climate Zone (CZ). This value is then reduced by 20% to account for the value of lost services, for a net of \$327.74/kWh in reduced energy use.

Figure 8: Economic Value of Control between 1- 5 pm on Highest Cost Days from 1 to 10 days

Cumulative TDV energy costs of highest cost days 15 year PV $/kWh controlled										
Start hour	14	14	14	14	14	14	14	14	14	14
End hour	17	17	17	17	17	17	17	17	17	17
# of days	1	2	3	4	5	6	7	8	9	10
CZ1	$ 51.40	$ 100.25	$ 146.71	$ 197.76	$ 236.03	$ 277.05	$ 313.77	$ 345.90	$ 371.31	**$ 397.68**
CZ2	$ 52.20	$ 103.62	$ 152.49	$ 198.93	$ 247.07	$ 290.83	$ 331.07	$ 371.79	$ 403.95	**$ 428.89**
CZ3	$ 51.55	$ 100.06	$ 149.05	$ 195.16	$ 234.62	$ 271.48	$ 308.59	$ 342.17	$ 374.45	**$ 406.17**
CZ4	$ 62.77	$ 122.00	$ 175.11	$ 224.99	$ 273.93	$ 310.74	$ 347.80	$ 380.03	$ 410.30	**$ 436.94**
CZ5	$ 51.52	$ 100.50	$ 146.58	$ 183.42	$ 221.82	$ 263.53	$ 300.61	$ 332.87	$ 359.71	**$ 383.40**
CZ6	$ 48.20	$ 94.34	$ 136.77	$ 173.01	$ 207.91	$ 241.84	$ 275.62	$ 304.41	$ 334.77	**$ 359.21**
CZ7	$ 57.15	$ 104.25	$ 150.85	$ 194.73	$ 232.10	$ 275.34	$ 315.53	$ 351.72	$ 387.55	**$ 420.51**
CZ8	$ 50.79	$ 101.75	$ 151.47	$ 198.51	$ 239.20	$ 273.13	$ 303.75	$ 336.28	$ 370.05	**$ 400.41**
CZ9	$ 67.96	$ 114.97	$ 161.83	$ 206.66	$ 240.00	$ 275.44	$ 311.64	$ 347.39	$ 380.30	**$ 413.35**
CZ10	$ 46.82	$ 95.14	$ 141.21	$ 184.79	$ 225.65	$ 261.81	$ 296.64	$ 328.46	$ 360.31	**$ 387.20**
CZ11	$ 69.24	$ 134.31	$ 190.92	$ 242.65	$ 289.20	$ 333.53	$ 371.29	$ 412.17	$ 447.43	**$ 480.97**
CZ12	$ 54.35	$ 105.75	$ 158.83	$ 209.74	$ 248.85	$ 287.93	$ 324.65	$ 358.32	$ 390.89	**$ 426.69**
CZ13	$ 58.34	$ 110.75	$ 159.73	$ 205.15	$ 244.09	$ 281.53	$ 318.62	$ 354.55	$ 383.38	**$ 413.43**
CZ14	$ 59.10	$ 113.77	$ 167.01	$ 215.01	$ 250.61	$ 284.46	$ 320.52	$ 356.43	$ 386.72	**$ 416.27**
CZ15	$ 52.14	$ 104.04	$ 146.56	$ 188.39	$ 225.72	$ 262.28	$ 296.13	$ 329.82	$ 364.56	**$ 394.26**
CZ16	$ 52.95	$ 103.37	$ 159.07	$ 209.37	$ 253.97	$ 297.65	$ 339.50	$ 378.05	$ 417.94	**$ 457.54**

Figure 9: 10 Day Cumulative PV$/kWh Controlled, Weighted by New Construction per CZ

	Cumulative TDV energy costs of highest cost days PV $/kWh	New Construction SF by CTZ	Percentage of Total NC SF	Weighted Fraction by NC CTZ
CZ1	**$ 397.68**	318	0%	$ 1
CZ2	**$ 428.89**	1,934	1%	$ 5
CZ3	**$ 406.17**	15,155	10%	$ 39
CZ4	**$ 436.94**	10,843	7%	$ 30
CZ5	**$ 383.40**	2,121	1%	$ 5
CZ6	**$ 359.21**	10,878	7%	$ 25
CZ7	**$ 420.51**	5,049	3%	$ 13
CZ8	**$ 400.41**	16,808	11%	$ 43
CZ9	**$ 413.35**	10,615	7%	$ 28
CZ10	**$ 387.20**	19,188	12%	$ 47
CZ11	**$ 480.97**	4,149	3%	$ 13
CZ12	**$ 426.69**	20,786	13%	$ 56
CZ13	**$ 413.43**	6,305	4%	$ 17
CZ14	**$ 416.27**	20,518	13%	$ 54
CZ15	**$ 394.26**	9,419	6%	$ 24
CZ16	**$ 457.54**	3,741	2%	$ 11
				$ 410

Emissions Reduction

For the value of emission reductions, we assumed the same four hours of peak demand reduction for the ten highest cost days per year, based on Present Value of TDV energy costs (See Appendices). For the 40 hours anticipated (10 days * 4 hrs) we created a weighted statewide value of 11lbs NOx/kWh, 3.8 lbs PM10/kWh and 32.35 Tons CO_2/kWh using total non-residential new construction square feet per Climate Zone (CZ). The reduction factor numbers for each emission type were then multiplied by the energy savings to get statewide emission reduction totals, as shown in *Figure 3: First Year Air Emissions Reductions from DRBP & DRBI Measure.*

Figure 10: 10 Day Cumulative NOx Emmissions Factors, Weighted by New Construction per CZ

	Cumulative TDV Emmissions: lbs Nox Factors	New Construction by CTZ (SF)	Percentage of Total NC SF	Weighted Factor Fraction by NC CTZ
CZ1	10.95	318	0.20%	0.02
CZ2	10.56	1,934	1.23%	0.13
CZ3	10.97	15,155	9.60%	1.05
CZ4	10.22	10,843	6.87%	0.70
CZ5	10.77	2,121	1.34%	0.14
CZ6	10.98	10,878	6.89%	0.76
CZ7	10.14	5,049	3.20%	0.32
CZ8	10.91	16,808	10.65%	1.16
CZ9	10.17	10,615	6.73%	0.68
CZ10	10.99	19,188	12.16%	1.34
CZ11	10.99	4,149	2.63%	0.29
CZ12	10.57	20,786	13.17%	1.39
CZ13	10.99	6,305	3.99%	0.44
CZ14	10.91	20,518	13.00%	1.42
CZ15	10.91	9,419	5.97%	0.65
CZ16	10.97	3,741	2.37%	0.26
				10.74

Figure 11: 10 Day Cumulative PM10 Emmissions Factors, Weighted by New Construction per CZ

	Cumulative TDV Emmissions: lbs PM10 Factors	New Construction by CTZ (SF)	Percentage of Total NC SF	Weighted Factor Fraction by NC CTZ
CZ1	3.93	318	0.20%	0.01
CZ2	3.85	1,934	1.23%	0.05
CZ3	3.94	15,155	9.60%	0.38
CZ4	3.78	10,843	6.87%	0.26
CZ5	3.89	2,121	1.34%	0.05
CZ6	3.94	10,878	6.89%	0.27
CZ7	3.76	5,049	3.20%	0.12
CZ8	3.92	16,808	10.65%	0.42
CZ9	3.77	10,615	6.73%	0.25
CZ10	3.94	19,188	12.16%	0.48
CZ11	3.94	4,149	2.63%	0.10
CZ12	3.85	20,786	13.17%	0.51
CZ13	3.94	6,305	3.99%	0.16
CZ14	3.92	20,518	13.00%	0.51
CZ15	3.92	9,419	5.97%	0.23
CZ16	3.94	3,741	2.37%	0.09
				3.89

Figure 12: 10 Day Cumulative CO2 Emmissions Factors, Weighted by New Construction per CZ

	Cumulative TDV Emmissions: lbs CO2 Factors	New Construction by CTZ (SF)	Percentage of Total NC SF	Weighted Factor Fraction by NC CTZ
CZ1	32.68	318	0.20%	0.07
CZ2	31.89	1,934	1.23%	0.39
CZ3	32.74	15,155	9.60%	3.14
CZ4	31.18	10,843	6.87%	2.14
CZ5	32.31	2,121	1.34%	0.43
CZ6	32.75	10,878	6.89%	2.26
CZ7	31.01	5,049	3.20%	0.99
CZ8	32.60	16,808	10.65%	3.47
CZ9	31.09	10,615	6.73%	2.09
CZ10	32.76	19,188	12.16%	3.98
CZ11	32.76	4,149	2.63%	0.86
CZ12	32.76	20,786	13.17%	4.31
CZ13	32.76	6,305	3.99%	1.31
CZ14	32.60	20,518	13.00%	4.24
CZ15	32.60	9,419	5.97%	1.95
CZ16	32.74	3,741	2.37%	0.78
				32.35

Analysis and Results

Requiring that new non-residential buildings be designed such that they can operate at 80% of connected load during power emergencies is a reasonable and achievable goal. We did not uncover any insurmountable barriers or costs that might prevent the implementation of such a requirement. All of the technology required to achieve DRBP is standard and unexceptional. The technology required to achieve DRBI is either fully available (addressable controls), easily modified (EMS), or under intensive development (AMI). The more advanced DRBI is proposed to only apply to the largest of buildings, where the additional costs also provide more benefits. Required DRBI for the largest buildings will help to create experience with building level DR controls, and pave the way for their application to smaller buildings in the future.

Using our conservative economic and participation assumptions for this proposal, the overall Benefit to Cost Ratio for this DRBP-and-DRBI proposal was found to be 1.2:1. Using our conservative assumptions, the smaller building, DRBP-only, component alone was found to be less cost effective at 0.82:1 than the larger building, DRBP-only, component at 1.37:1 benefit to cost ratio. However, very slight changes in the cost or participation assumptions quickly raise the DRBP portion above the 1:1 benefit/cost threshold. For example, a $0.05/sf reduction in the construction cost for achieving a Demand Response Building Plan, from $0.22/sf to $0.17/sf pushes the DRBP over the 1:1 threshold. While we applied these construction costs to all buildings, we believe that it is possible in many cases there will be no additional construction costs associated with a DRBP. Likewise a change in participation in the small building emergency response program, from 33% of the population to 40% also pushes the DRBP over the 1:1 threshold. The 33% participation value was used for our analysis based on reports from Flex Your Power evaluations that 33% of those participants were not motivated by economic incentives, but rather reduced their demand purely for social benefit reasons during the 2001 power emergencies. However, if DRBP is successful in making it easier to identify and shed loads under emergency conditions, it is reasonable to believe that manual shedding participation rates might also increase. Emergency participation rates are likely to be as much a function of a successful public communication program as they are of the inclination of building owners to respond to a given request. Given the uncertainty of our analysis, and that we tried to use the most conservative estimates throughout, it is reasonable to believe that a stand-alone DRBP program could also be judged to be cost effective.

Figure 13: Total Benefit to Cost Ratio of DRBP and DRBI Measures

Building Category	Benefit	Cost	B/C Ratio
Small bldgs Emergency	$ 13.62	$ 16.62	0.82
Large Bldgs Emergency	$ 45.88	$ 33.46	1.37
Large Bldgs Econ	$ 0.48		
Total first year new construction	$ 59.98	$ 50.08	1.20

The statewide energy savings attributable only to the DRBI in very large buildings (at a 20% participation rate) resulted in 0.4 GWh savings per year of construction, which would accumulate to 4 GWh per year after 10 years of implementation.

The statewide demand reduction attributable to the voluntary economic response of large DRBI buildings (again, 20% participation rate) was estimated to be 1.48 MW per year of construction, which would accumulate to 15 MW after ten years of implementation.

The statewide demand reduction attributable to the emergency response of both DRBP and DRBI was estimated to be 54 MW per year of construction, which would accumulate to 540 MW per year after ten years of implementation. This 10 year value is about 7% of the current statewide reserve capacity desired by the ISO (i.e. 54,000 MW peak demand * 15% = 8,100 MW). Thus, this proposal could contribute a valuable proportion to the needed statewide capacity reserve, based on this estimate's assumption of only 33% emergency DR participation by DRBP-only buildings and fuller, 90%, participation by the larger DRBI buildings with fully automated demand response.

Thus, the combined DRBP and DRBI measures are cost effective, based on our conservative assumptions about costs and participation in the programs. However, we also believe the primary benefit of this proposal will be to create a "demand-response-ready infrastructure" of non-residential buildings that can be more easily, quickly and cost-effectively retrofitted with demand responsive controls in the future. Thus, it is a wise, and low-cost, first step to take toward managing our statewide risks of electrical capacity limitations in the future.

Recommendations

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

Proposed Standards Language

SECTION 10-103 – PERMIT, CERTIFICATE, INFORMATIONAL, AND ENFORCEMENT REQUIREMENTS FOR DESIGNERS, INSTALLERS, BUILDERS, MANUFACTURERS, AND SUPPLIERS

(a) Documentation.

2. **Application for a building permit.** Each application for a building permit subject to Part 6, shall contain at least one copy of the documents listed in Sections 10-103 (a) 2 A, 10-103 (a) 2 B, and 10-103 (a) 2 C.

   B. Plans and specifications submitted with each application for a building permit shall show the characteristics of each feature, material, component, and manufactured device proposed to be installed in order to have the building meet the requirements of Part 6, and of any other feature, material, component, or manufactured device that Part 6 requires be indicated on the plans and specifications.

   All electrical plans and specifications submitted with each application for a building permit for Nonresidential buildings, High-rise Residential buildings and Hotels and Motels shall show the Demand Response Priority Level, as defined in Section 110(b), for each circuit, sub-circuit and category of equipment in the building. The total connected load assigned to each Demand Response Priority Level will be tallied and reported on the Demand Priority Building Plan Summary compliance documents.

   Plans and specifications submitted with each application for a building shall provide acceptance requirements for code compliance of each feature, material, component or manufactured device when acceptance requirements are required under Part 6. Plans and specifications for Nonresidential buildings, High-rise Residential buildings and Hotels and Motels shall require that within 90 days after the Enforcement Agency issues a final occupancy permit, record drawings be provided to the building owner. If any characteristic is materially changed before final construction and installation, such that the building may no longer comply with Part 6, the building must be brought back into compliance, and so indicated on amended plans, specifications, and Certificate(s) of Compliance and shall be submitted to the enforcement agency. Such characteristics shall include the efficiency (or other characteristic regulated by Part 6) of each device.

   C. All documentation necessary to demonstrate compliance for the building, and of the sections of Part 6 with which the building is intended to comply shall be submitted with each application for a building permit. The forms used to demonstrate compliance shall be readily legible and of substantially similar format and informational order and content to the appropriate forms in the Residential or Nonresidential Manual, as defined in Part 6.

(c) **Operating and Maintenance Information to be provided by Builder.**

1. **Operating information.** The builder shall provide the building owner at occupancy the appropriate Certificate(s) of Compliance and a list of the features, materials, components, and mechanical devices installed in the building and instructions on how to operate them efficiently. These instructions will include identification of the building equipment and circuits by Demand Response Load Priority and instructions for operation of any associated Demand Response Automated Controls. The instructions shall be consistent with specifications set forth by the executive director.

   For low-rise residential buildings, such information shall, at a minimum, include information indicated on forms Certificate of Compliance (CF-1R), Mandatory Measures (MF-1R), Installation Certificate (CF-6R), Insulation Certificate (IC-1), and a manual which provides all information specified in this Section 10-103 (b). The *Home Energy Manual* (P400-92-031, July 1992) may be used to meet the requirement for providing this manual.

For nonresidential buildings, high-rise residential buildings and hotels and motels, such information shall, at a minimum, include information required by the Certificates of Compliance, Certificate of Acceptance, forms ENV-1, MECH-1 and LTG-1, Demand Priority Building Plan Summary, an Installation Certificate and an Insulation Certificate.

For dwelling units, buildings or tenant spaces which are not individually owned and operated, or are centrally operated, such information shall be provided to the person(s) responsible for operating the feature, material, component, or mechanical device installed in the building.

SUBCHAPTER 2
ALL OCCUPANCIES—MANDATORY REQUIREMENTS FOR THE MANUFACTURE, CONSTRUCTION AND INSTALLATION OF SYSTEMS, EQUIPMENT AND BUILDING COMPONENTS

SECTION 110 – SYSTEMS AND EQUIPMENT—GENERAL

(a) Scope: Sections 111 through 119 establish requirements for the manufacture, construction, and installation of certain systems, equipment and building components that are installed in buildings regulated by Title 24, Part 6. Systems, equipment and building components listed below may be installed only if:

~~(a)~~ 1. The manufacturer has certified that the system, equipment or building component complies with the applicable manufacture provisions of Sections 111 through 119; and

~~(b)~~ 2. The system, equipment or building component complies with the applicable installation provisions of Sections 111 through 119.

No system, equipment or building component covered by the provisions of Sections 111 through 119 that is not certified or that fails to comply with the applicable installation requirements may be installed in a building regulated by Title 24, Part 6.

The systems, equipment and building components covered are:

Appliances regulated by the Appliance Efficiency Regulations (Section 111).

Electrical circuits, panels, demand responsive energy management systems and other demand responsive electrical control devices

Other space-conditioning equipment (Section 112).

Other service water-heating systems and equipment (Section 113).

Pool and spa heating systems and equipment (Section 114).

Gas appliances (Section 115).

Doors, windows, and fenestration products (Section 116).

Joints and other openings (Section 117).

Insulation and Cool Roofs (Section 118).

Lighting control devices (Section 119).

(b) Demand Response Load Priority: All equipment in Nonresidential buildings, High-rise Residential buildings and Hotels and Motels using electricity and permanently connected to the external utility power supply for the building, will be identified by Demand Response (DR) Priority Level. Likewise circuits and sub-circuits will also be segregated, identified and labeled at their respective panels by Demand Response Priority Level. Circuits and sub-circuits will be also be segregated by at least three end-use types: HVAC, Lighting and Other.

EXCEPTION to Section 110 (b): Any stand-alone, separately-metered building with less than 5,000 SF in area, any building that is regulated by OSHPD, or any building that is designated essential to local emergency response is excepted from this requirement.

1. Equipment and circuits shall be categorized according one of the following four DR priority levels:

    A. Life Safety: non-interruptible loads due to specific life-safety and other code requirements (i.e. already required to be on emergency back-up systems)

    B. Base Load: minimum base loads for building systems and equipment, which will sustain minimal building operation, business continuity and equipment protection during extreme power emergencies

    C. Emergency Shed: loads which can be curtailed during power emergencies (Stage 2 or 3 power alerts) in response to mandatory dispatch signals

    D. Voluntary Shed: loads which could be voluntary curtailed in response to economic signals, such as high demand charges or voluntary dispatch signals, and also curtailed during power emergencies in response to mandatory dispatch signals

2. Each building plan shall designate at least 15% of the total connected load to DR priority levels C and D. For buildings larger than 100,000 SF, at least 50% of that percentage shall be designated Level D.

3. Buildings larger than 100,000 SF shall also install communicating demand responsive automated controls on the designated circuits and equipment, such that they are enabled to respond appropriately to an external voluntary or emergency dispatch signal.

    A. Each communicating demand responsive automated control shall undergo an acceptance test to demonstrate response capability before an occupancy permit is issued.

Alternate Calculation Manual

This proposal does not require any changes to the Alternate Calculation Manual.

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Appendices

Figure 14: Average of 2000 - 2003 nonresidential new construction area in 1,000's of sf by climate zone

CTZ	AMUSEMENT	ASSEMBLY	EDUCATION	[redacted]	HOTEL	[redacted]	OFFICE	RETAIL	SCHOOL	SERVICE	STORAGE	OTHER	Total 1,000's sf
1	22	2	5	[redacted]	25	[redacted]	79	40	50	9	28	24	318
2	93	19	23	[redacted]	177	[redacted]	419	241	242	53	259	204	1,934
5	145	31	0	[redacted]	154	[redacted]	356	244	251	245	432	167	2,121
6	405	165	68	[redacted]	566	[redacted]	1,697	1,820	912	1,746	2,400	349	10,878
7	160	49	71	[redacted]	530	[redacted]	1,114	738	524	938	642	85	5,049
8	581	260	114	[redacted]	806	[redacted]	2,498	2,714	1,443	3,010	3,761	458	16,808
11	224	149	5	[redacted]	144	[redacted]	874	1,140	383	207	454	287	4,149
12	577	356	37	[redacted]	799	[redacted]	4,133	3,808	2,498	2,442	4,166	1,205	20,786
13	475	130	46	[redacted]	72	[redacted]	436	1,161	656	327	1,658	447	6,305
15	272	99	85	[redacted]	625	[redacted]	1,416	1,365	951	1,122	2,825	303	9,419
16	179	71	19	[redacted]	112	[redacted]	442	594	369	273	1,117	168	3,741
Totals	5,776	1,980	1,277	[redacted]	6,901	[redacted]	27,380	24,410	15,334	21,965	37,504	6,227	148,765

Figure 15: Reduction in lbs NOx Emmissions 1- 5 pm on highest cost days from 1 day to 10 days

Cumulative Emissions: lbs nox										
Start hour	14	14	14	14	14	14	14	14	14	14
End hour	17	17	17	17	17	17	17	17	17	17
# of days	1	2	3	4	5	6	7	8	9	10
CZ1	1.10	2.20	3.30	4.39	5.49	6.59	7.69	8.79	9.85	10.95
CZ2	1.10	2.20	3.30	4.39	5.49	6.59	7.68	8.78	9.88	10.56
CZ3	1.10	2.20	3.30	4.39	5.49	6.59	7.69	8.79	9.89	10.97
CZ4	1.10	2.20	3.30	4.39	5.49	6.59	7.69	8.79	9.45	10.22
CZ5	1.10	2.20	3.30	4.39	5.49	6.59	7.69	8.79	9.89	10.77
CZ6	1.10	2.20	3.30	4.39	5.49	6.59	7.69	8.78	9.88	10.98
CZ7	1.10	2.20	3.30	4.39	5.49	6.59	7.69	8.79	9.32	10.14
CZ8	1.10	2.20	3.30	4.39	5.49	6.59	7.69	8.71	9.81	10.91
CZ9	1.10	2.20	3.30	4.39	5.46	6.21	7.31	8.29	9.08	10.17
CZ10	1.10	2.20	3.30	4.39	5.49	6.59	7.69	8.79	9.89	10.99
CZ11	1.10	2.20	3.30	4.39	5.49	6.59	7.69	8.79	9.89	10.99
CZ12	1.10	2.20	3.30	4.39	5.41	6.51	7.61	8.71	9.47	10.57
CZ13	1.10	2.20	3.30	4.39	5.49	6.59	7.69	8.79	9.89	10.99
CZ14	1.10	2.20	3.30	4.39	5.49	6.59	7.69	8.79	9.89	10.91
CZ15	1.10	2.20	3.30	4.39	5.49	6.59	7.69	8.79	9.89	10.91
CZ16	1.10	2.20	3.30	4.39	5.49	6.59	7.69	8.79	9.89	10.97

Figure 16: Reduction in lbs PM10 Emmissions 1- 5 pm on highest cost days from 1 day to 10 days

Cumulative Emissions: lbs pm10										
Start hour	14	14	14	14	14	14	14	14	14	14
End hour	17	17	17	17	17	17	17	17	17	17
# of days	1	2	3	4	5	6	7	8	9	10
CZ1	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.15	3.54	3.93
CZ2	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.15	3.54	3.85
CZ3	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.15	3.55	3.94
CZ4	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.15	3.45	3.78
CZ5	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.15	3.55	3.89
CZ6	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.15	3.54	3.94
CZ7	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.15	3.43	3.76
CZ8	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.14	3.53	3.92
CZ9	0.39	0.79	1.18	1.58	1.96	2.29	2.68	3.05	3.38	3.77
CZ10	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.15	3.55	3.94
CZ11	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.15	3.55	3.94
CZ12	0.39	0.79	1.18	1.58	1.95	2.35	2.74	3.14	3.46	3.85
CZ13	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.15	3.55	3.94
CZ14	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.15	3.55	3.92
CZ15	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.15	3.55	3.92
CZ16	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.15	3.55	3.94

Figure 17: Reduction in Tons CO2 Emmissions 1- 5 pm on highest cost days from 1 day to 10 days

Cumulative Emissions: lbs CO2										
Start hour	14	14	14	14	14	14	14	14	14	14
End hour	17	17	17	17	17	17	17	17	17	17
# of days	1	2	3	4	5	6	7	8	9	10
CZ1	3.28	6.55	9.83	13.10	16.38	19.66	22.93	26.21	29.40	32.68
CZ2	3.28	6.55	9.83	13.10	16.38	19.66	22.91	26.18	29.46	31.89
CZ3	3.28	6.55	9.83	13.10	16.38	19.66	22.93	26.21	29.48	32.74
CZ4	3.28	6.55	9.83	13.10	16.38	19.66	22.93	26.21	28.58	31.18
CZ5	3.28	6.55	9.83	13.10	16.38	19.66	22.93	26.21	29.48	32.31
CZ6	3.28	6.55	9.83	13.10	16.38	19.66	22.93	26.19	29.47	32.75
CZ7	3.28	6.55	9.83	13.10	16.38	19.66	22.93	26.21	28.32	31.01
CZ8	3.28	6.55	9.83	13.10	16.38	19.66	22.93	26.05	29.32	32.60
CZ9	3.28	6.55	9.83	13.10	16.31	18.88	22.16	25.19	27.82	31.09
CZ10	3.28	6.55	9.83	13.10	16.38	19.66	22.93	26.21	29.48	32.76
CZ11	3.28	6.55	9.83	13.10	16.38	19.66	22.93	26.21	29.48	32.76
CZ12	3.28	6.55	9.83	13.10	16.38	19.66	22.93	26.21	29.48	32.76
CZ13	3.28	6.55	9.83	13.10	16.38	19.66	22.93	26.21	29.48	32.76
CZ14	3.28	6.55	9.83	13.10	16.38	19.66	22.93	26.21	29.48	32.60
CZ15	3.28	6.55	9.83	13.10	16.38	19.66	22.93	26.21	29.48	32.60
CZ16	3.28	6.55	9.83	13.10	16.38	19.66	22.93	26.21	29.48	32.74