# 2008 Title 24 Nonresidential CASE **Demand Response Building Plan** Proposal

**PG&E Codes & Standards Program**

**CEC Staff Workshop July 13, 2006**

# Concept:

- Create "Demand-Ready" Buildings (non-res)
  - Pre-organize building electrical systems to facilitate future demand response
  - Require documentation of DR capability as part of Title 24 plan check

# Methodology

- Industry interviews, literature review, to determine:
  - DR needs, case studies to date
  - Feasibility
  - Equipment availability
  - Potential code and construction barriers
- Benefit : Cost analysis
  - GWh and MW impacts
  - Value of demand reduction and energy savings /SF
  - Customer loss of productivity, air quality (not valued),
  - Estimated costs /SF

# Research Findings

Based on literature review and interviews with 7 utility DR program managers, 6 researchers, 5 electrical engineers (+ plan reviews)

- Primary barrier to DR implementation is "messiness" of existing building electrical systems
  - Time consuming (i.e. expensive) job to decipher existing electrical organization
- Building owners want maximum choice and warning for DR participation
- Not particularly difficult or costly to organize priorities during design
  - But owners unlikely to do unless required
  - Sometimes additional wiring or panels may be needed
  - Lighting and HVAC typically only half of building's connected load
- 75% of large buildings, >50K SF, have some form of EMS
  - EMS software not currently DR enabled, but not difficult
  - AMI equipment still under development -- 2010?
- No other negative barriers identified
  - No code barriers identified, other than OSHPD
    - Proposal similar to organization required by OSHPD for emergency backup in hospitals

# Goals of Proposal:

- Give building owners maximum flexibility in selecting loads for demand response
  - Escalators, office equip, task lighting, PCTs, or …?
- Pre-organize new buildings for DR
  - When it is easiest and cheapest to do so !
  - Create an infrastructure of "DR-ready" buildings
    - With capability to easily shed 15% of peak load
- Make DR priority standard

  electrical engineering practice

# Overview of proposal

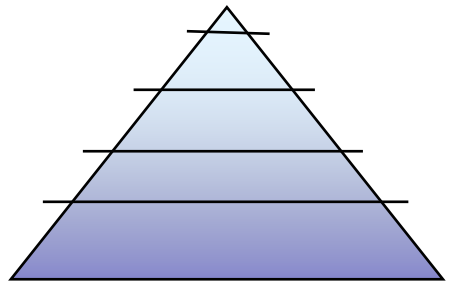
- Prioritize non-residential building electrical loads
  - By demand response level on electrical plans
- Designate Demand Response (DR) Priority Level:
  - **A.** Non-Interruptible life safety load (battery back-up)
  - **B.** Minimum base operating load
  - **C.** Emergency curtailment load
    - ≥10% of connected load
  - **D.** Voluntary economic curtailment load
    - ≥ 10% of connected load
- Exclude hospitals, fire stations, other essential buildings
  - Regulated by OSHPD, or other emergency response regulations

# Two Types of Requirements:

- Demand Response Building Plan (DRBP)
  - Non-residential Buildings > 5,000sf
    - Electrical loads organized by DR Priority Levels
      - shown on plans and compliance documents
      - and labeled on site
- Demand Response Building Initiation (DRBI)
  - Non-residential Buildings > 100,000sf
    - EMS system with automated DR software capability
      - Controls installed and commissioned
      - Automated Meter Infrastructure (AMI) ready

# Building Size Choices

- < 5,000 SF = 1% of SF and kWh
- > 5,000 SF = outlets for many major retail and office chains
  - FedEx, AAA, 7/11, CVS, mortgage offices, banks….
- > 22,500 SF = modular size of circuits
  - >150’ x 150’
- > 50,000 SF = “large” per IOU databases
  - 75% already have some form of EMS
- > 100,000 SF = largest buildings
  - roughly 50% of commercial SF and kWh usage
  - substantial quantum effect cost reductions



# Benefit : Cost Analysis

- > 1 : 1 ratio required
  - for 15 yr Net Present Value
- $ energy savings based on TDV (10 peak days/yr)
  - $410/kWh, less 20% productivity loss (weighted by NRNC SF per CZ)
- $ demand reduction based on "Value of Lost Load"
  - $42/kW* across all customers, less productivity loss * 15 yr NPV
- Aggressive cost assumptions:
  - Additional design and construction costs
  - Does not include reduced costs for future DR programs
  - Does not include other savings with use of EMS
- Conservative participation assumptions:
  - Based on observations during 2001 power emergency

* Derived by E3 for PCT (Programmable Communicating Thermostats) CASE Proposal

# Energy Benefits

For one year of new construction

Per CEC NRNC SF / yr forecast, less hospital and government buildings

- Voluntary economic dispatch (40 peak hr/yr)
  - 7%* participation DRBI, i.e. only large buildings >100,000 SF
  - **1.48 MW**
  - **59 GWh / yr**
    - per yr of new construction, 10x more per yr after 10 yrs
- Emergency dispatch (1 day/10 yrs)
  - 33%* participation DRBP + 93% of DRBI
  - **52.8 MW** = 12.1 + 40.7
  - **127 GWh / yr** = 29 + 98
    - per yr of new construction, 10x more per yr after 10 yrs

* Based on participation rates during 2001 Flex Your Power program:

33% of manual peak reductions were not motivated by economic drivers.

7% of largest buildings participated in voluntary peak reduction per economic incentives.

# Non-Energy Benefits

- Increased reliability of electrical distribution system
- Negative Individual benefits:
  - Value of Lost Load (VOLL)
  - Reduced productivity
- Societal benefits:
  - Avoid social disruption power outage, with associated political and business repercussions
- Indirect benefits:
  - DR programs increased cost-effectiveness and penetration from reduced design, installation and transaction costs
- Emissions Reductions (modest but positive)

| 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 |

# Cost Assumptions

- Additional +10% on electrical engineering design fee
- Additional electrical system construction cost
  - $0.22/SF (highest estimate)
    - i.e. Doubled circuits for 22,500 SF space
- EMS system cost
  - $1/SF (highest estimate)
    - for 25% of large buildings which will need to add

| 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 |

# Benefit Cost Conclusions

- Overall Proposal = 1.2
  - DRPI (> 100,000 SF) = 1.4
  - DRBP (> 5,000 SF) = 0.8
    - Sensitivity Analysis > 1:1 benefit cost ratio
      - If emergency participation increases from 33% to 40%, or
      - If construction costs $0.05 / SF less, or
      - If economic participation included, or
      - If existing EMS employed, or
      - If cost savings for future DR implementation included, etc…

# Conclusion

- This is a wise, and low-cost, first step to take toward managing our statewide risks of electrical capacity limitations in the future.
  - It is cost effective
    with the most conservative assumptions
  - We encountered no strong objections
    during our interviews
  - It does not depend upon any new technology…
    only a change in routine design practices.

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# New Code Language

- Section 10-103 Documentation:
  - EE Plans show DR load priority levels
  - DRBP compliance forms identify and tally loads assigned to each priority level
- Section 110 (b) Systems & Equipment (General)
  - Required that at least 20% of connected load be identified for emergency load shed
  - Large buildings also required to have EMS system with automated demand response capability
    - And to further identify 10% (1/2 of 20%) for voluntary load shed

# Description of Benefit Cost

- Benefits:
  - Energy Savings
  - Demand Reduction
- Costs:
  - Design
  - Equipment

| | | | |
|---|---|---|---|
| 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** |

# Coincident Peak W/SF Calculation

Statewide weighted average of **2.77 W/SF** attributable to 148,491,000 SF of non-residential new construction in 2008.

**[ kWh/sf * MW/GWh = Watts/sf ] * [ %NRNC sf / Total NRNC sf ]**

| | 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 | MW/MW | (W/SF) | SF | % SF | |
| Small Office | 2,113.34 | 4,048.60 | 0.49 | 12.42 | 6.20 | 12,696 | 0.0848 | 0.49 |
| Large Office | 4,042.51 | 19,605.00 | 0.21 | 20.69 | 4.36 | 14,612 | 0.0977 | 0.42 |
| Retail | 2,049.00 | 12,230.20 | 0.24 | 10.09 | 2.06 | 24,410 | 0.1631 | 0.44 |
| Service | 663.86 | 6,048.30 | 0.11 | 13.28 | 1.62 | 21,096 | 0.1410 | 0.23 |
| Storage | 663.86 | 3,483.80 | 0.20 | 13.28 | 2.64 | 37,604 | 0.2513 | 0.67 |
| School | 694.62 | 2,908.60 | 0.24 | 6.37 | 1.34 | 16,394 | 0.1096 | 0.14 |
| College | 663.24 | 3,173.70 | 0.22 | 11.30 | 2.49 | 1,377 | 0.0092 | 0.02 |
| Hotel / Motel | 471.28 | 3,001.60 | 0.16 | 13.16 | 2.07 | 6,031 | 0.0403 | 0.10 |
| Miscellaneous | 3,094.40 | 12,159.10 | 0.25 | 13.28 | 3.30 | 13,993 | 0.0943 | 0.31 |
| Totals: | | | | | | 148,491 | | 2.77 |

# Economic Analysis Details

- Voluntary program with economic dispatch to the large buildings with DRBI, assumes 7% participation (Bender, Lutzenhiser, Moezzi, Gossard 2002) * 10% of the peak load for each building * TDV energy savings $ value (from PCT analysis) * % of new construction SF which is >100,000 SF.
  - For the value of 40 hours of anticipated voluntary curtailment (10 days * 4 hrs) we estimated an average statewide TDV value of $410/kWh, weighted per NRNC SF per Climate Zone (CZ).
  - This value was then reduced by 20% to account for the value of lost services, for a net of $327.74/kWh in reduced energy use.
- These same large buildings could then shed another 10% of that peak load under emergency direct dispatch * $ value of lost load * 97% participation (assuming 3% of DR response systems are down at the time of emergency).

# Emergency Analysis Details

- Net Present Value of Lost Load:

  $1128.12 / kWh = ($42 /kWh - $2.50/kWh) * 11.9

  - $42/kWh = average value of lost load across all classes of utility customers
  - $2.50/kWh = value of loss of comfort and productivity to the com. bldg. owner
  - 11.9 = NPV factor for 15 years of accumulated events.
- Participation Assumptions:
  - 33% of all small buildings (>5,000 SF and <100,000 SF) voluntarily respond to an emergency demand reduction request (Energy Market Innovations 2006)
    - shedding 20% of their peak load
    - approximately equivalent to 10% of their connected load
  - 93% of larger buildings respond
    - those required to have DRBI automated direct response
  - 97% of the properties receive DR signal
    - whether by direct electronic (DRBI) or media broadcast (DRBP) communication.