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

PG&E Codes & Standards Program

CEC Staff Workshop July 13, 2006

Pacific Gas and Electric Company

Codes & Standards Enhancement Project

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

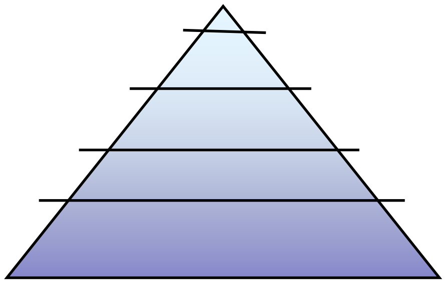
- Prioritize non-residential building electrical loads
  - By demand response level on electrical plans
- Designate Demand Response (DR) Priority Level:
  - **A.** Non-Interruptible life safety load (battery back-up)
  - **B.** Minimum base operating load
  - **C.** Emergency curtailment load
    - ≥10% 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.

Acknowledgements

- Sponsored by California Ratepayers though
  The Pacific Gas and Electric Company
  Codes & Standards program
  - Steve Blanc, Project Manager SLB4@pge.com
- Project management, Heschong Mahone Group
  - Jon McHugh mchugh@h-m-g.com
  - Lisa Heschong lheschong@h-m-g.com
  - Heather Larson larson@h-m-g.com

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	kWh/SF	(W/SF)	SF	%SF	
Small Office	2,113.34	4,048.80	0.49	12.42	6.20	12,656	0.0849	0.46
Large Office	4,942.61	23,605.90	0.21	20.69	4.36	14,612	0.0977	0.42
Retail	2,940.00	12,330.20	0.24	10.89	2.56	24,440	0.1644	0.44
Service	933.55	8,048.30	0.11	13.26	1.48	21,656	0.1470	0.22
Storage	693.80	3,480.80	0.20	13.26	2.64	37,604	0.2526	0.67
School	624.62	2,958.60	0.21	6.37	1.34	16,394	0.1093	0.14
College	693.24	3,173.70	0.22	11.20	2.46	1,277	0.0086	0.02
Hotel / Motel	471.26	3,001.60	0.16	12.16	2.07	6,001	0.0456	0.10
Miscellaneous	3,034.40	12,132.10	0.25	13.26	3.30	13,666	0.0916	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.