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)**

<table>
<thead>
<tr>
<th>Building Category</th>
<th>Statewide NO\textsubscript{x} Reduction (Lbs)</th>
<th>Statewide PM10 Reduction (Lbs)</th>
<th>Statewide CO\textsubscript{2} Reduction (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small bldgs Emergency</td>
<td>311.16</td>
<td>721.08</td>
<td>937.12</td>
</tr>
<tr>
<td>Large Bldgs Emergency</td>
<td>1,048.36</td>
<td>379.26</td>
<td>3,157.36</td>
</tr>
<tr>
<td>Large Bldgs Economic</td>
<td>1,602.48</td>
<td>229.26</td>
<td>1,908.60</td>
</tr>
<tr>
<td><strong>Total first year new construction</strong></td>
<td><strong>2,961.99</strong></td>
<td><strong>1,329.60</strong></td>
<td><strong>6,003.08</strong></td>
</tr>
<tr>
<td>Equivalent # of Cars</td>
<td>78</td>
<td>233</td>
<td>1,053</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Building Size Categories</th>
<th>Range of Cost / SF</th>
<th>Range of Cost / Control Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 5,000 SF</td>
<td>$2-4/sf</td>
<td>$600-$1000/Point</td>
</tr>
<tr>
<td>Btwn 5,000-100,000</td>
<td>$1-4/sf</td>
<td>$400-$600/Point</td>
</tr>
<tr>
<td>Over 100,000 sf</td>
<td>$0.5-$1/sf</td>
<td>$50- $300/Point</td>
</tr>
</tbody>
</table>
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 through 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

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

\[
\text{[ kWh/sf } \times \text{ MW/GWh} = \text{ Watts/sf }] \times \left[ \frac{\%\text{NRNC sf}}{\text{Total NRNC sf}} \right]
\]
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:**
  
  $1128.12 / kWh = (\$42 /kWh - \$2.50/kWh) \times 11.9$
  
  - $\$42/kWh = \text{average value of lost load across all classes of utility customers}$
  - $\$2.50/kWh = \text{value of loss of comfort and productivity to the com. bldg. owner}$
  - $11.9 = \text{NPV factor for 15 years of accumulated events.}$

- **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.