



**Automated Demand Response Strategies
and Commissioning Commercial Building Controls**

Mary Ann Piette
Lawrence Berkeley National Laboratory
mapiette@lbl.gov
drcc.lbl.gov

National Conference on Building Commissioning
April 20, 2006

Sponsored by U.S. DOE,
California Energy Commission,
New York State Energy Research and Development Authority,
and Pacific Gas and Electric Company

1

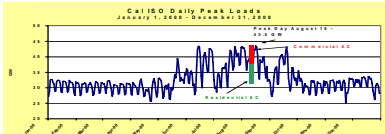
Presentation Overview

- Objectives and Background
- Value of Demand Response
- Building Design and Operations Framework
- Demand Response Control Strategies
- Building Commissioning and DR
- Future Directions

2

Objectives and Background

- **Objectives**
 - Develop demand response control strategies
 - Evaluate role of commissioning in execution of strategies
 - Improve understanding linking demand response and energy efficiency
- **Definition of Demand Response**
 - *Short-term modifications in customer electric use in response to dynamic price or reliability information.*
- **Relevance**
 - Electric systems more vulnerable to outages with age, load factors decreasing, T&D and new capacity investments reduced, real time pricing promoted.



Commercial Buildings and Peak Demand

- Commercial buildings play major role in electric peak demand and may dominate coincident peak, data lacking
- Analysis Results – National Total, All Sectors ~730 GW**
 - Commercial Buildings Energy Consumption Survey (CBECS) peak around 270-320 GW in 1995 scales to 330 to 390 in 2003
 - National Energy Modeling System shows similar results of coincident peak of 330 MW (NEMS - EIA simulation of all energy supplies and demand, of the U.S. economy)

	1995 (GW)	2003 (GW)
CBECS Co-incident	317	387
NEMS Non-coincident	317	363

4

Value of Demand Response

Utility Systems and Societal Value

- Improve Reliability of the System
- Reduce Electricity Costs and Market Efficiency
- Risk Management, Insurance and Option Value
- Environmental Impact



Commercial Sector Value – Peaking Turbine

- 10% of 330 GW x \$75/kW > \$24 Billion

Buildings Industry Opportunity

- Controls** - Leverage investments combining efficiency & DR, dynamic set point control
- Energy Information** - Leverage knowledge of electric load shape and energy use patterns, Link to commissioning

Over 20 States pursuing DR



Building Design and Operations Framework

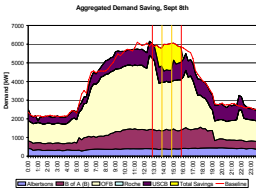
	Efficiency and Conservation (Daily)	Peak Load Management (Daily)	Demand Response (Dynamic Event Driven)
Motivation	- Environmental Protection - Utility Bill Savings	- TOU Savings - Peak Demand Charge savings - Grid Protection	- Economic - Reliability - Emergency - Grid Protection
Design	- Efficient Shell, Equipment & Systems	Low Power Design	Dynamic Control Capability*
Operations	- Integrated System Operations	Demand - Limiting and Shifting	Demand - Limiting, Shifting, or Shedding
Initiation	Local	Local	Remote

*Prefer closed loop strategies, granular control

6

Results on Automated-DR

- Established capabilities of current controls and communications with EMCS and XML
- Demonstrated initial design of signaling infrastructure and system capability
- Demonstrated large sheds can take place without complaints
- Demonstrated range of strategies to produce sheds and capabilities needed
- Average reduction 8% among 28 buildings, up to 50%

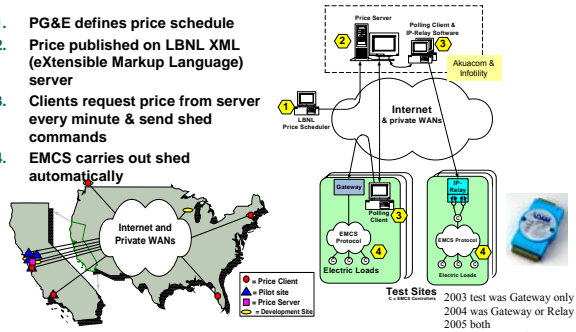


	Number of sites	Avg. Savings (%)	Max. Savings (%)
2003	5	8	28
2004	18	7	56
2005	12	9	38

7

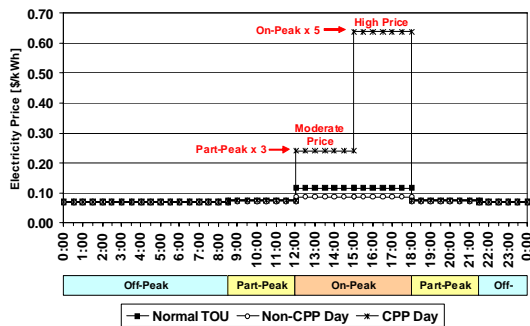
Automating Demand Response

- PG&E defines price schedule
- Price published on LBNL XML (eXtensible Markup Language) server
- Clients request price from server every minute & send shed commands
- EMCS carries out shed automatically



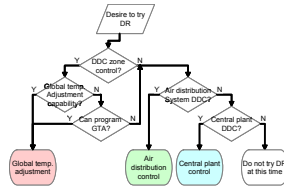
8

Critical Peak Pricing (PG&E Example)



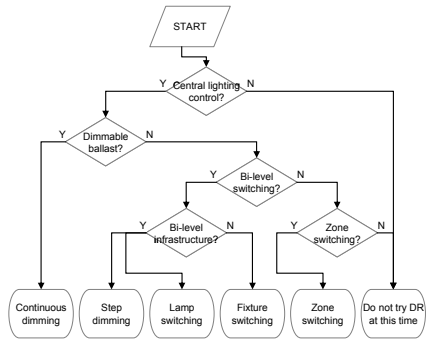
DR Control Strategy Categorization

- Developed DR Control Categorization Framework
- Evaluated 32 Sites
- Most successful strategy -
 - Direct digital control global temperature adjustment
 - In process for Title 24 2008
 - Closed loop
- Lighting Strategies - Zone Switching, Fixture Switching, Lamp Switching, Stepped Dimming, Continuous Dimming
- Need to link to Retro-Commissioning



Zone control	Global Temperature Adjustment
	Thermal Mass Storage
	Reheat Lockout
Air distribution	Duct Static Pressure Reset
	Fan VFD Limit
	Supply Air Temp Reset
	Fan Quantity Reduction
Central plant	Cooling Valve Limit
	Chilled Water Temp Reset
	Chiller Demand Limit
Recovery	Chiller Quantity Reduction
	Slow Recovery Strategies

Lighting DR Control Strategies



14

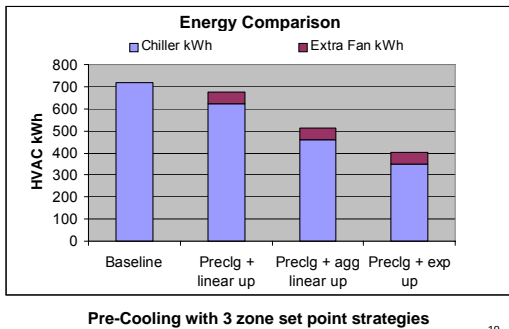
Links to Commissioning

- Common question : *If I can use a strategy for demand response, why not use it all the time?*
- Answer: *Maybe you can!*
- Examples from actual buildings
 - Air balancing
 - Duct static pressure reset
 - Zone temp reset
 - Night time fans left on

Continuum from energy efficiency, load management and demand response

15

HVAC Energy Reduced with Pre-Cooling



19

Evaluating Occupant Comfort with Survey

Please answer the following questions based on your experience *right now*:

How would you rate the current temperature in your workspace?

- Much too warm
- Too warm
- Comfortably warm
- Comfortable (and neither cool nor warm)
- Comfortably cool
- Too cool
- Much too cool

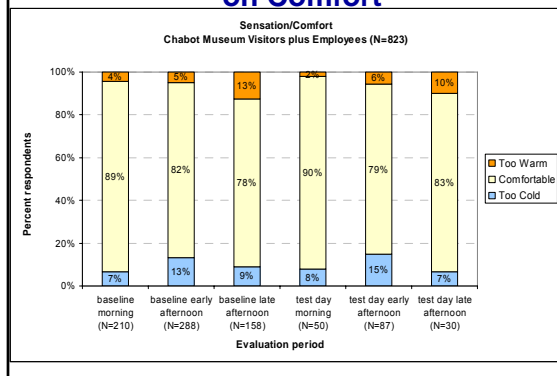
Does the current temperature in your workspace enhance or interfere with your ability to get your job done?

Enhances Interferes

Any additional comments or recommendations about the current temperature?

20

Occupant Surveys – Minimal Impact on Comfort



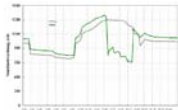
New York Times Building

- **Technology designed for efficiency simulated to develop DR strategies**
 - Efficient features: Integrated movable, shading & dimming, Under floor air systems
 - Commissioning in mockup
- **Demand Response Strategies**
 - Dimming lights beyond daylighting, reset zone temperatures (gradient), reduce perimeter fan speed, raise supply air temperature



Predicted Annual Savings from 400 kW Shed

Program	Predicted Annual Savings
Independent Capacity Program	\$17,632.00
Emergency DR Program	\$1,440.00
Distribution Load Relief Program	\$1,600.00



DR Control Issues

- Reduction in service
- Share burden
- Closed loop
- Granularity
- Return to normal strategies

	Albertsons	B of A	GSA	Roche	UCSB
Number of Auto-DRControl points	2	1	~ 1,400	7	42
Shed control points/10,000 sq.ft.	0.4	0.05	10	0.4	1
Control Granularity	Medium	Coarse	Very Fine	Medium	Fine
Closed loop shedControl	Partial	Partial	Yes	No	No

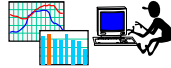
Current EMCS Characterization

Current Control Systems (California Enhanced Automation Guide)			
Controls	Basic	Common	Advanced
Type	Pneumatic / Analog	Pneumatic / Analog	DDC
Alarms	•	•	•
Remote Access		•	•
Oper. Info		•	•
Trend logs			•
Energy Use Info			•
Real-time Mon.			•
Internet Connection			•
Control Capability	Preprogrammed, fixed parameters	Rudimentary capability (e.g., economizer, VFD)	Sophisticated algorithms
Installation Costs Average(\$/ ft²)	\$ 1.75	\$ 3.00	\$ 4.00

Future Control Systems: DR Modes in Control Architecture

- **Orchestrate modes using schedules, signals, optimization algorithms:**

- Occupied/Unoccupied
- Maintenance/Cleaning
- Warm up/Cool down
- Night purge/Precooling
- Low power DR mode



- **Intelligence needed for decision making**
- **Customized, simple and transparent interface**
- **Financial feedback systems need to present operational value**
- **Similar capability for DOE's Zero Energy Buildings**
- **Embed DR Communications from EIS to EMCS**



25

Summary

- Demand Response is new multi-billion dollar opportunity for commercial buildings
- DR capabilities improve with advanced controls that simultaneously support efficiency and require good commissioning
- Field tests show DR potential 5-10% in most buildings with EMCS, yet limited knowledge of DR strategies: automation appears feasible with many existing systems.
- **Need for Commissioning**
 - Need DR control strategy commissioning tests
 - Need combined Retro-Commissioning DR Strategy Procedures
- DR is not driver, high performing buildings are:
 - Low energy costs, well-commissioned, low maintenance costs
 - Key is advanced controls, feedback systems, integrated performance

More information: drc.lbl.gov

26
