# Advanced Controls and Communication Systems for Demand Response and Energy Efficiency in Commercial Buildings

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# Presentation Overview

- **Demand Response Basics and DR in US**
- **Demand Response Potential in Commercial Buildings**
- **Advanced Controls for Commercial Buildings**
- **Research in California**
  - Automation of DR
- **Research in New York**
  - New York Times Office Building
- **National R&D Opportunities**

# Demand Response Definition

- **Demand Response (DR) is the action taken to reduce load when:**
  - Contingencies (emergencies & congestion) occur that threaten supply-demand balance, and/or
  - Market conditions occur that raise supply costs
- **DR typically involves peak-load reductions**
  - DR strategies are different from energy efficiency, i.e., transient vs. permanent

# Demand Side Management

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

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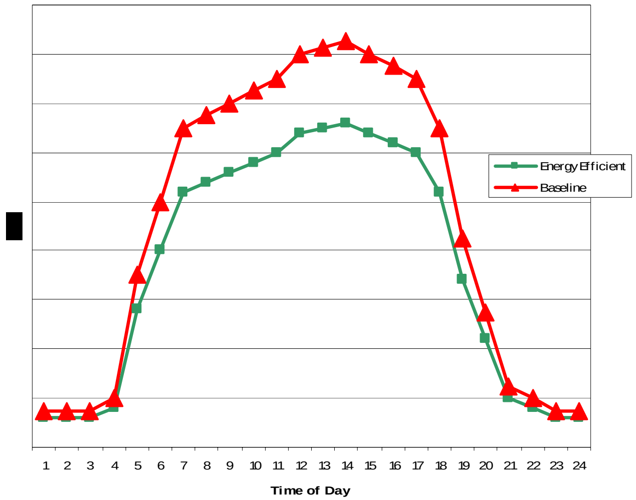
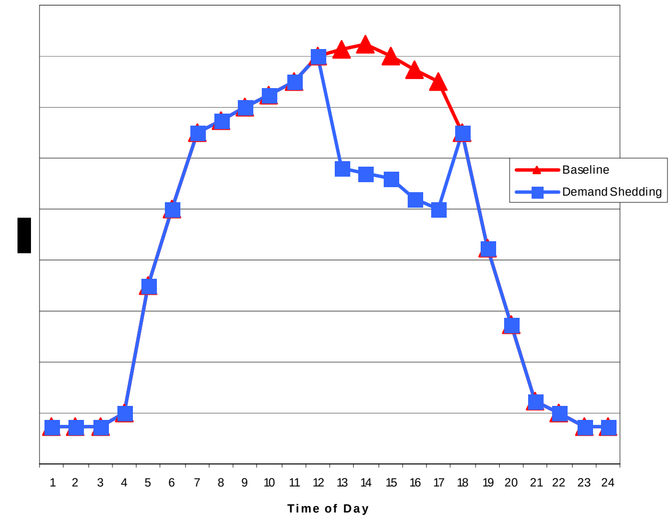
# Load Profiles and Terminology

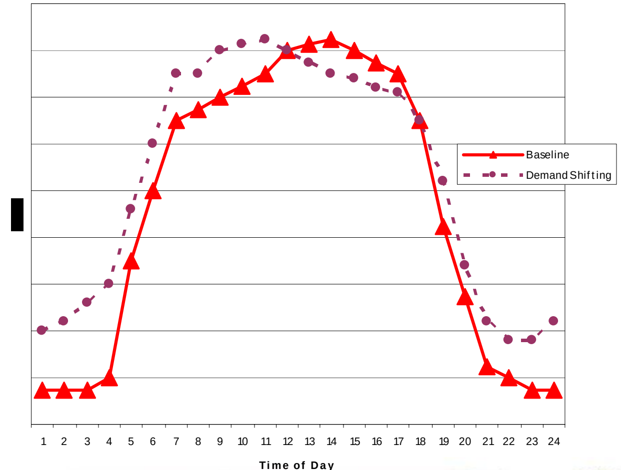
## Efficiency and Conservation




## Load Shedding




## Load Shifting



# Value of Demand Response

## Utility Systems and Societal Value

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

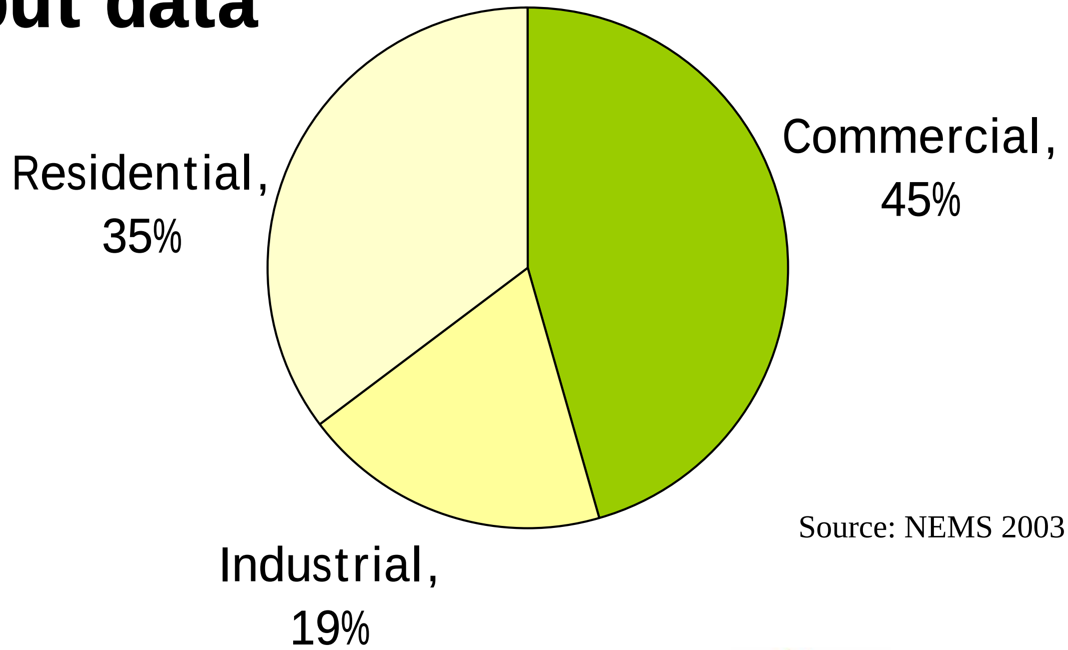
# Value of Demand Response

## Buildings Industry Opportunity

- **Controls - Leverage investments combining efficiency and DR capabilities, facilitate Zero Energy Buildings (ZEB)**
- **Energy Information - Leverage knowledge of electric load shape and energy use patterns, Link to commissioning**

# Commercial Buildings' Contribution to Peak Demand

- **Commercial sector major role, may dominate peak demand, but data lacking**



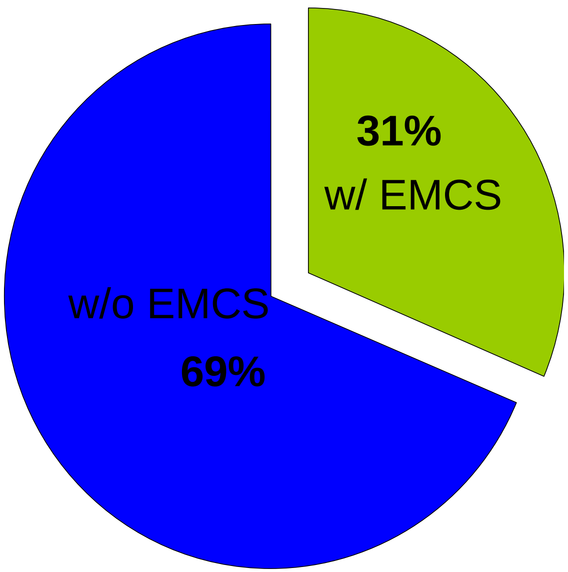

Source: NEMS 2003 Simulation

# Commercial Buildings' Contribution to Peak Demand

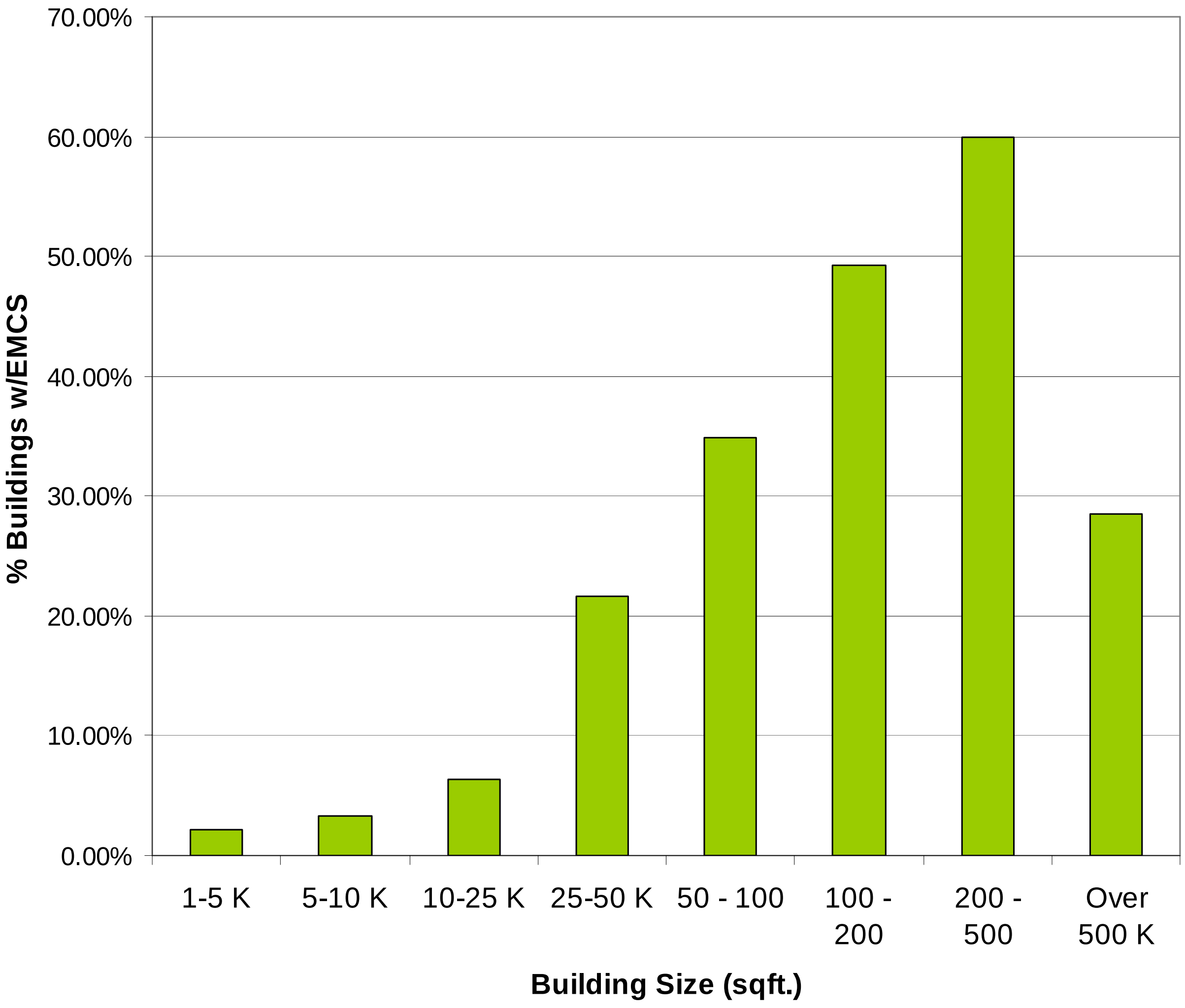
- Commercial Buildings Energy Consumption Survey (CBECS) vs. National Energy Modeling System (NEMS)

| | 1995 (GW) | 2003 (GW) |
|---|---|---|
| CBECS (1) | 273 | 333 |
| CBECS (2) | 317 | 387 |
| NEMS Coincident | 291 | 328 |
| NEMS Non-coincident | 317 | 363 |

# 1/3 of Commercial Building Stock has Energy Management Control System (some "DR Ready")




Source: CBECS 2003

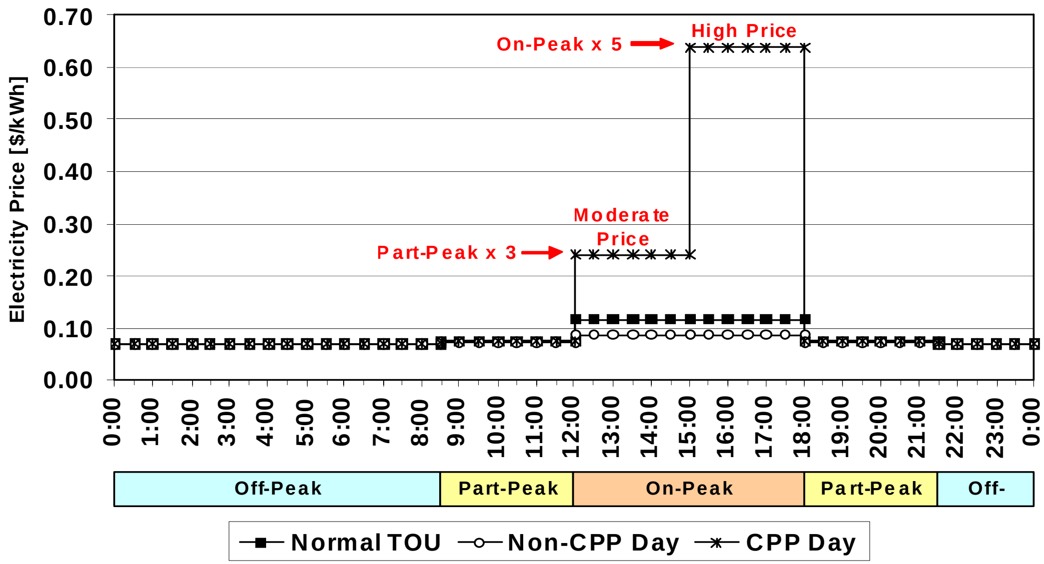


# Automated Demand Response in Large Facilities

**Goal: Evaluate feasibility of Automated DR hardware & software systems in large facilities**

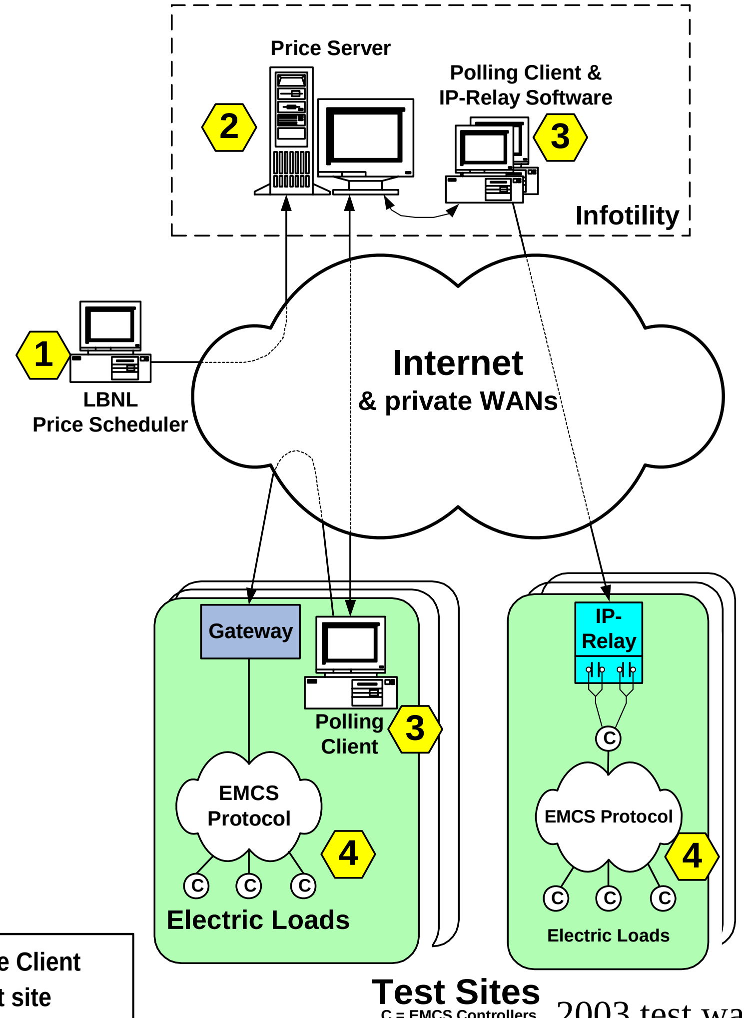
- Can control & communications systems receive signals & execute automated shedding?
- Control strategies for max load sheds & min service loss?

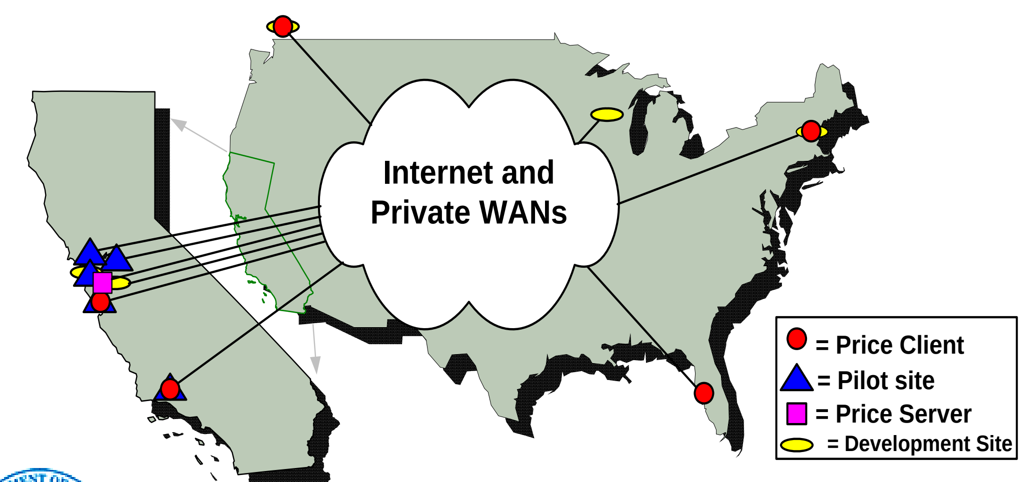
**R&D Team:** LBNL, Infotility, Akuacom, Shockman Consulting



# 2003, 2004 and 2005 Auto-DR System

1. LBNL defines price schedule
2. Price published on XML (eXtensible Markup Language) server
3. Clients request price from server every minute & send shed commands
4. EMCS carries out shed automatically




2003 test was Gateway only
2004 was Gateway or Relay
2005 both

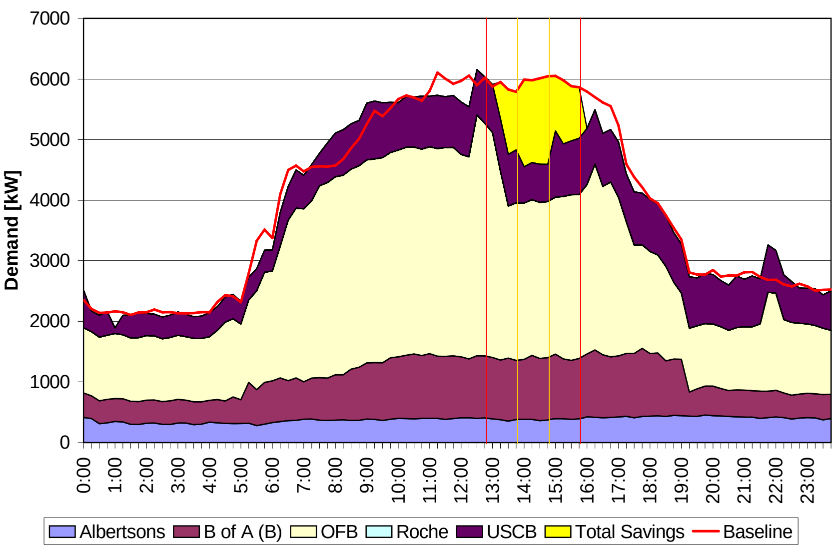
# Project Phases

- **2003 – 5 Sites (all Gateway Connectivity)**
  - Demonstrated basic concept and technical feasibility
- **2004 – 18 sites (13 Gateway, 5 Internet Relay)**
  - Demonstrated greater diversity in building systems and DR shed strategies
- **2005 – 12 sites, Automated CPP with PG&E**
  - Demonstrated compatibility with utility DR programs
  - 3 XML Gateways, 9 Internet Relays
- **2006 – Plans to Scale Up Field Tests with California Utilities**
  - Target 40 sites with PG&E, discussions with SCE and SDG&E
  - Evaluate economics, reliability, market size, market barriers

# 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%
- Range up to 56% reduction

Aggregated Demand Saving, Sept 8th




| | Number of sites | Average Savings (%) | Max. Savings (%) |
|---|---|---|---|
| 2003 | 5 | 8 | 28 |
| 2004 | 18 | 7 | 56 |
| 2005 | 12 | 10 | 38 |

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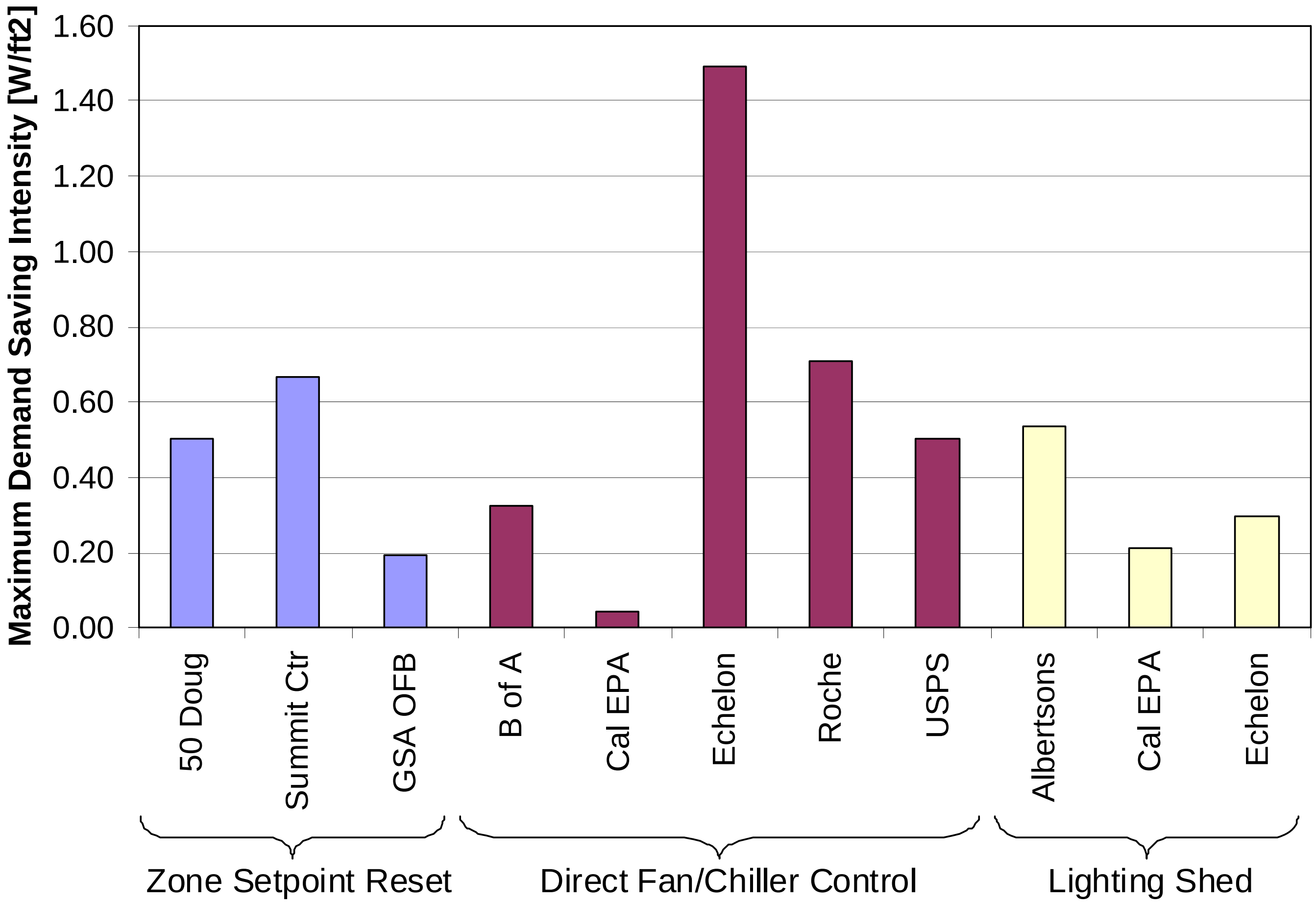
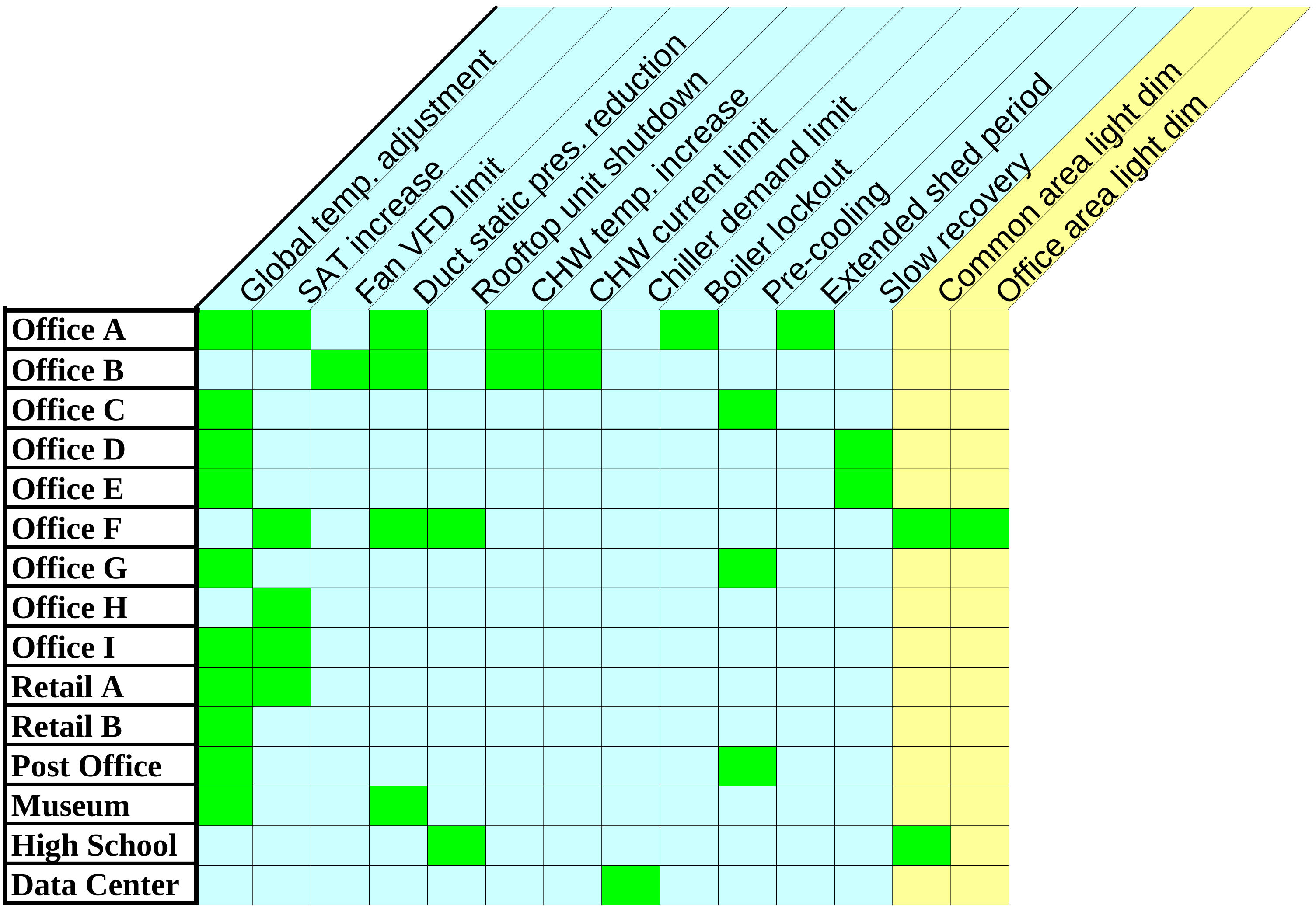
# End-Use Data for Selected Sub-sample Need Additional Field Studies



# Auto-CPP DR Strategies by Sites (2005)

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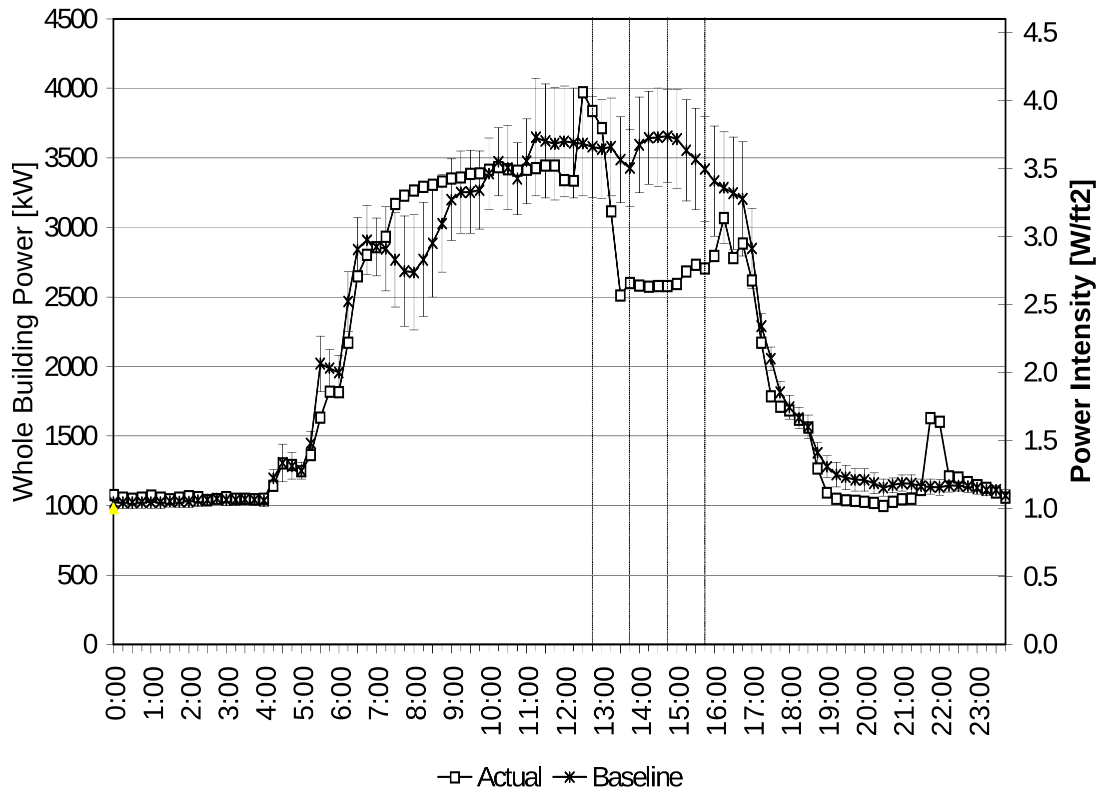
# Greatest Potential from Global Temperature Adjustment

Global Temperature Adjustment of EMCS proposed for 2008 California Building Energy Efficiency Standards

(Title 24)

| ASHRAE 55-2004, Paragraph 5.2.5.2 Change in Temp |
| --- |
| **Time Period**<br>2 ºF -15 minutes<br>3 ºF - 30 minutes<br>4 ºF - 1 hour<br>5 ºF - 2 hours<br>6 ºF - 4 hours |




**Average of ~800 kW, 0.8 W/ft² > 20% shed for 3 hrs. by set point increase 72 F to 78 F**

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# New York Times HQ Building

**NY Times/ Renzo Piano/**
**Fox & Fowle/ Gensler/ Flack+Kurtz/**
**Susan Brady Lighting**

## The Challenge

- Integrated shading & dimming
- Under floor air systems
- Commissioning in mockup
- Field test supported by NYSERDA, DOE, and CEC

## Demand Response

- EnergyPlus simulations of DR strategies
- Commissioning and controls plans for DR strategies

# The New York Times Building

## Strategies -> Sequence of operations

- **Lighting Level 1:** Reducing lighting to 50% in core, 70% in PC dominated interior and perimeter zones.
- **Lighting Level 2**: Reducing lighting to 50% in core, 70% in interior zones and off in perimeter zones.
- **Temperature Setup 1**: Cooling set point increase from 74F to 76.5F
- **Temperature Setup 2:** Cooling set point increase to 78.5F
- **Fan Box:** Reduce perimeter fan boxes to 30% capacity from 2pm. to 6pm.
- **Supply Temperature**: Cooling supply temperature is set to 54 F until 2 pm. At 2 pm, it is increased to 59.5 F until 6pm.

# Existing and New Dynamic Operational Modes

- **Operational modes implemented with EMCS**
  - **Current Systems**
    - Occupied/Unoccupied
    - Maintenance/Cleaning
    - Warm up/Cool down
    - Night purge
  - **Advanced- Integrated Master Controls → FINANCIAL FEEDBACK**
    - Daily cost minimization and IEQ optimization- non-DR Day
    - Cost Minimization in Demand Response Mode (modify IEQ for short term)
    - Cost minimization for On-Site Generation (dynamic control)
- **Master Controls needed to integrate HVAC, Lighting, Façade - Currently not intelligent, no decision making is required**
- **Zero Energy Buildings – Same dynamic control needed for grid power or on-site power**

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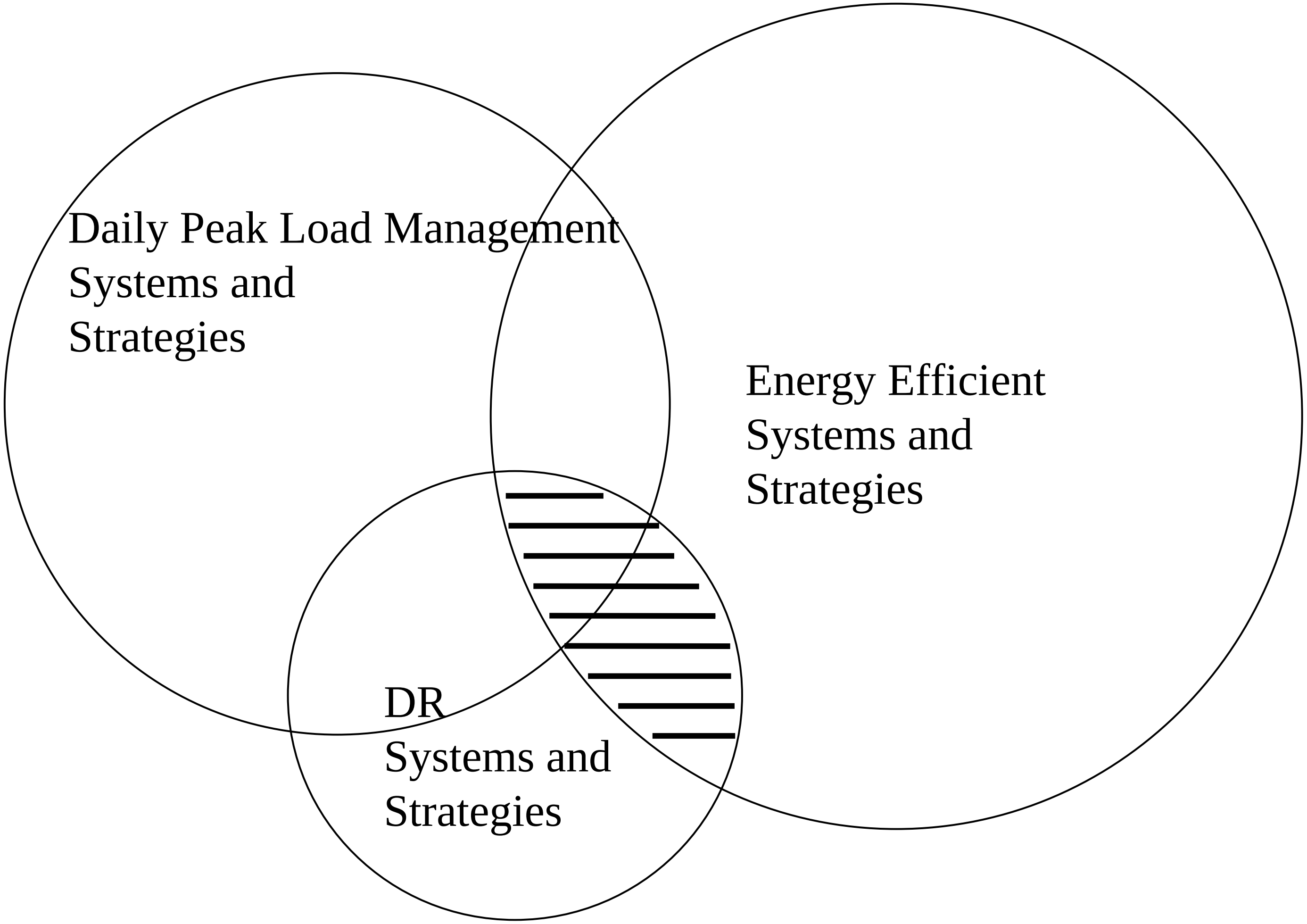
# National R&D Opportunities
# Advanced Controls for DR and Efficiency

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# Summary

- **Demand Response and Dynamic Pricing growing nationwide**
- **DR capabilities in buildings revolve around controls!**
- **Field tests show DR potential 5-10% in many buildings with EMCS, yet limited knowledge on how to develop strategies**
- **Research needed to evaluate DR control capabilities in broader stock, control vintage, upgrade capabilities, market segments, and new construction.**
- **National and Regional leadership needed to collaborate with controls, engineering, and buildings industries, government buildings early adopters**
- **DR is not driver, high performing buildings are:**
  - Low energy costs, well-commissioned, low maintenance costs
  - Key is advanced controls, feedback systems, integrated performance
  - Controls for Zero Energy Buildings have common goals as DR controls