Demand Response and Research Activities in California

Mary Ann Piette

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Lawrence Berkeley National Laboratory
Demand Response Research Center

http://drrc.lbl.gov

Sponsored by California Energy Commission
Public Interest Energy Research Program

Presentation Outline

- **Demand Response Basics and Introduction**
- **DR Research Center Overview**
- **Automating Demand Response**
  - Introduction
  - Status
  - Future Directions
- **Additional DR Research in California**

Integrated Smart Grid Considerations

Transmission

- Real time system improvements
- Congestion control
- Intelligent Agent integration and application
- Implementing RPS
- Advanced grid communications and control
- Extreme event planning and response
- CA ISO market redesign (MRTU)
- Automatic network reconfigurations
- Rapidly deployable systems
- Self healing grid

Distribution

- Distribution automation
- Advanced grid communications and control
- Congestion control
- Self healing grid
- Implementing Microgrids
- Integration of DER
- Reliability, availably, PQ improvements
- Reduce peak demand
- Low carbon network benefits

DER Integration

- Integrating renewables
- Integration of DER
- Implementing Microgrids
- Advanced grid connected power electronics
- Advanced communications and control

Demand Response

- AMI systems and implementation
- CAISO MRTU Implementation of DR
- Advanced communications and control
- Integration of DR automated technologies
- Development of enabling DR technologies

Energy Storage

- Renewable firming and dispatchability
- Reduce peak demand
- Low carbon network benefits
- Advanced grid connected power electronics
- Advanced communications and control

Security

- Wireless Network Field Demo
- Network survivability
- Self healing systems
- Rapidly deployable systems
- Automatic network reconfigurations

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

Policy Context

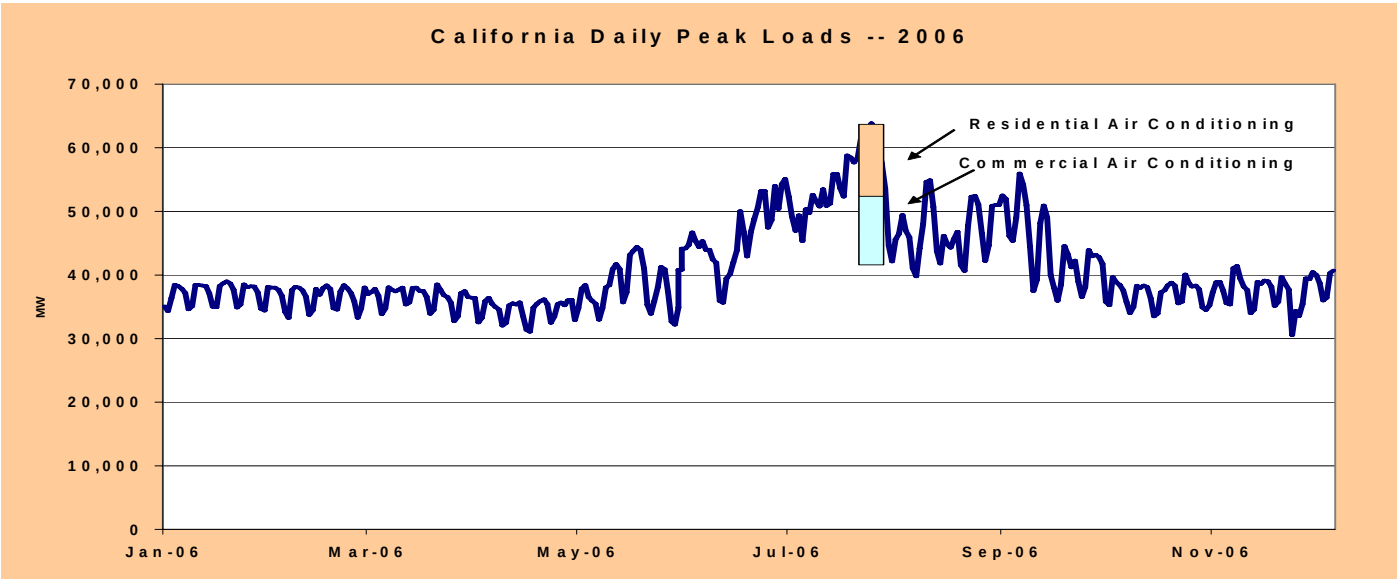
- **Supply-side solutions** to provide peak power **cost more** than load reduction solutions
- **A real-time control and communications infrastructure** is needed to support price and emergency signals
- **It doesn't take much** "automated" load reduction to avoid blackouts
- **Air conditioning** is the low-hanging fruit

Demand Response Options

- **Reliability programs (utility operated)**
  - Air conditioning cycling
  - Interruptible/curtailment
- **Economic programs (customer choice)**
  - Demand bidding
  - Demand reserves
- **Signals (price and emergency)**
  - Automatic demand response

Demand Response R&D Vision

- Create a **real-time, automated DR infrastructure** that is simple to use and can adaptively respond to changing contingency and market conditions
- A DR infrastructure must **coexist with legacy systems, allow for future technology and tariff improvements**, and have near-, medium-, and long-term benefits to California ratepayers



What Are We Trying to Achieve?

- Previous proceedings – CEC and CPUC (R.02-06-001)
  - Early goal for price sensitive DR: 5% of peak by 2007

Residential	Default CPP
Small Commercial (< 200 kW)	Default CPP
Medium Commercial (< 999 kW)	Default CPP
Large C&I (> 1 MW)	2-part RTP

- IOU business plans for Automated Meter Infrastructure
- Long term success → DR as business as usual
- Research needs
  - DR value, potential, technologies, programs, policies
  - How much DR do we need? Relation between price response and reliability?

CAISO Ancillary Services

- CAISO procures **regulation, spinning reserve and non-spinning reserve** ("ancillary services") in day-ahead and hour-ahead markets

- CAISO market participants can **self-provide any or all of these A/S products**, bid into CAISO markets, or purchase them from CAISO

- **Spinning Reserves**: A contingency reserve provided by generation that is running ("spinning") with additional capacity that is capable of ramping over a specified range within 10 minutes and running for at least 2 hours

- Future - Fast Demand Response may be a significant portion of future A/S products

Demand Response Research Center Research Areas

- **Energy Systems and Strategic Issues**
  - **Valuing Demand Response**
  - **Dynamic Tariffs and Rate Design**
  - ***Communications Infrastructure***
- **Buildings**
  - ***Automation, Communications and Control***
  - ***End-Use Control Strategies and Models***
  - **Behavior –response to dynamic tariffs**
- **Industry**
  - **Automation, End-Uses and Controls**

"Buildings" Side of Demand Side Management

	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

Automation Goals and Definition

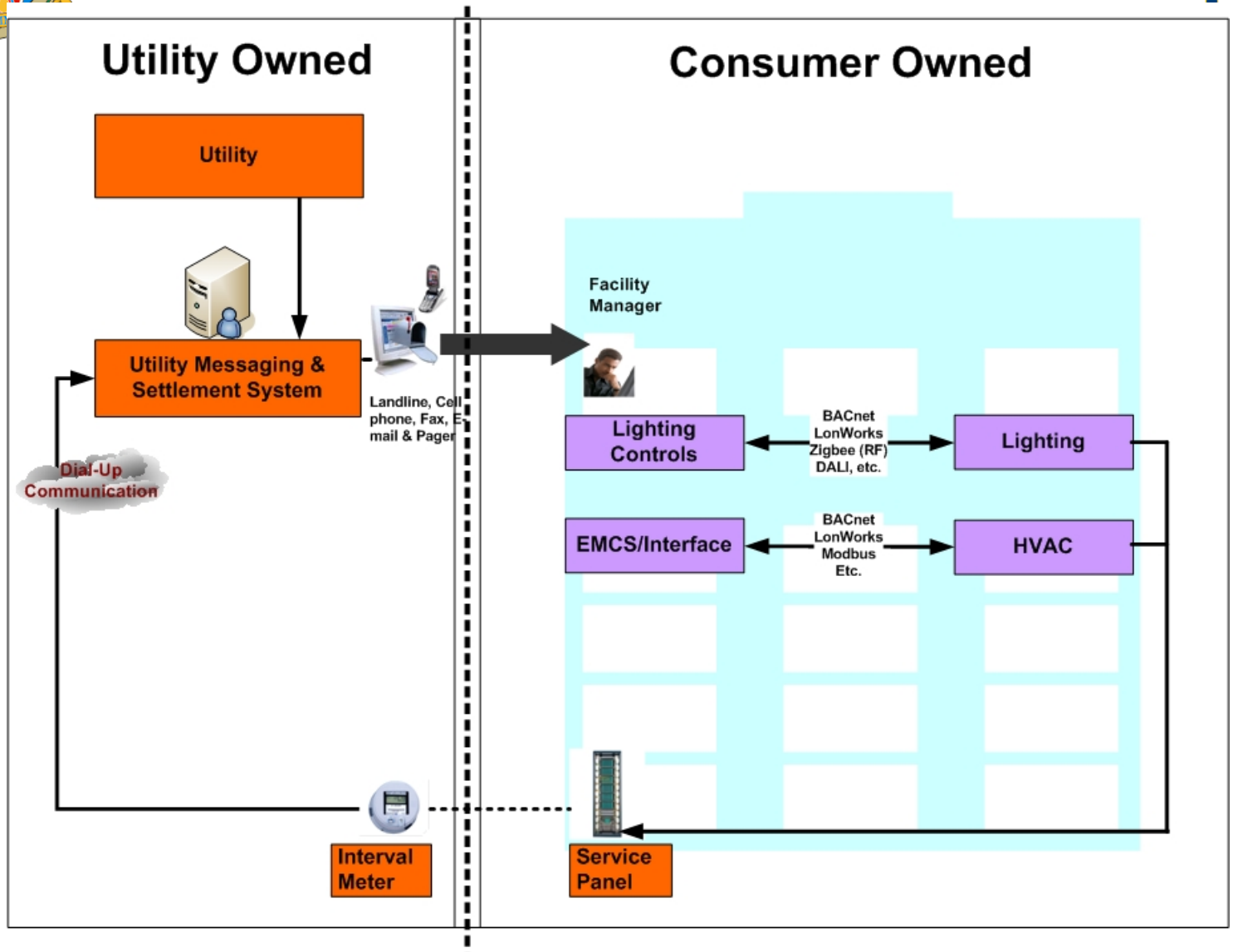
Recent Research Goals

- **Cost -** Develop low-cost, automation infrastructure to improve DR capability in California
- **Technology -** Evaluate "readiness" of commercial buildings to receive signals
- **Capability -** Evaluate capability of control strategies for current and future buildings

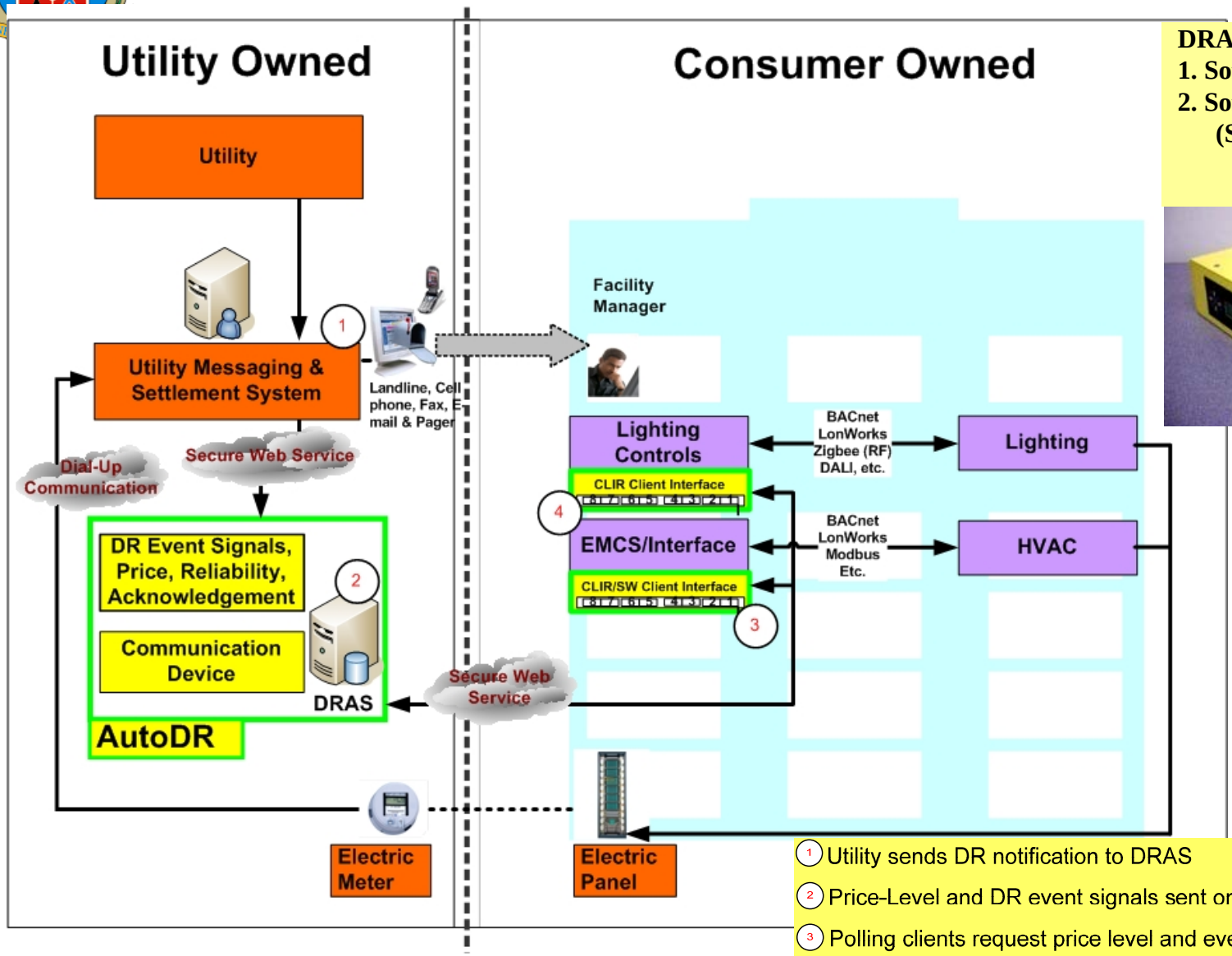
Auto-DR Definition - Fully automated signals for end-use control

- **Signaling –** Continuous, secure, reliable, 2-way comms; listen and acknowledge
- **Industry Standards -** Open, interoperable communications to integrate with both common EMCS and other end-use devices that can receive a relay or similar signals (such XML)
- **Timing of Notification -** Day ahead and day of signals facilitate diverse strategies

Manual DR - Common Practice



DR Automation Server and Client

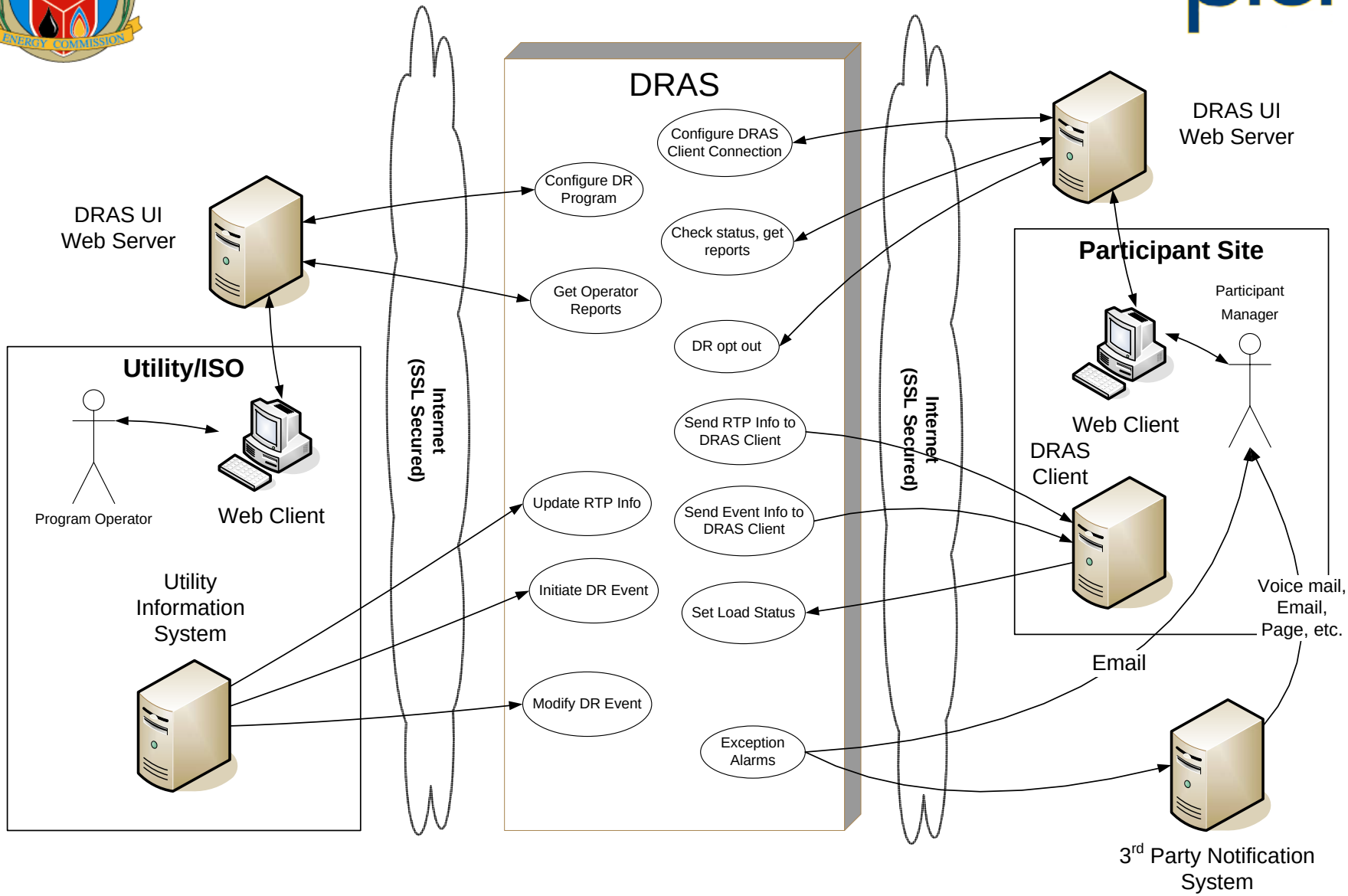


DRAS Clients –

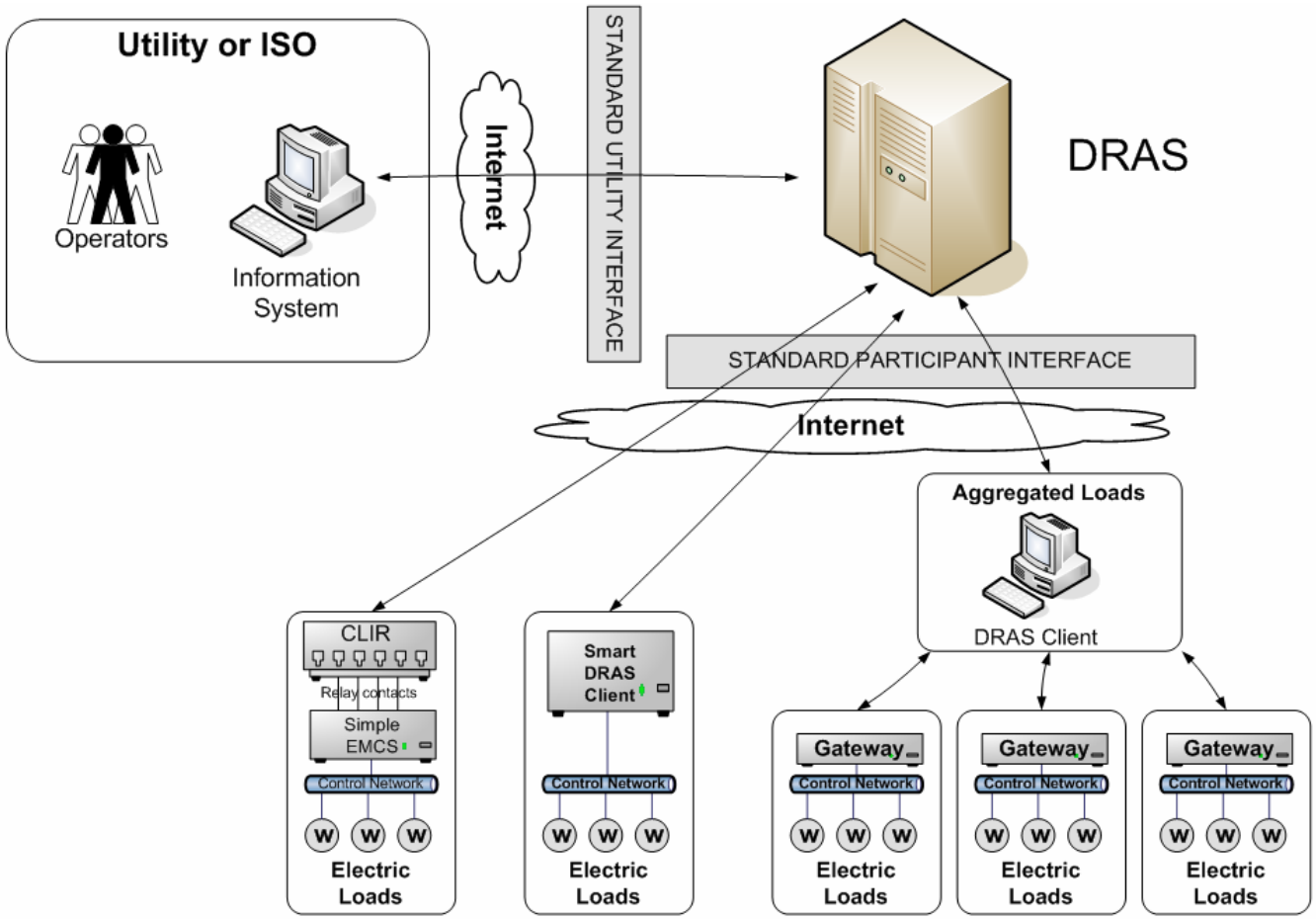
1. **Software only (Smart)**
2. **Software & Hardware (Simple)**

1. Utility sends DR notification to DRAS
2. Price-Level and DR event signals sent on DRAS
3. Polling clients request price level and event data every minute
4. Energy Management Control System (EMCS) and other systems carry out shed based on pre-programmed strategies.

DR Automation Server Event Architecture



Demand Response Automation Architecture



Features of Open Automated DR Communications (OpenADR) Standards

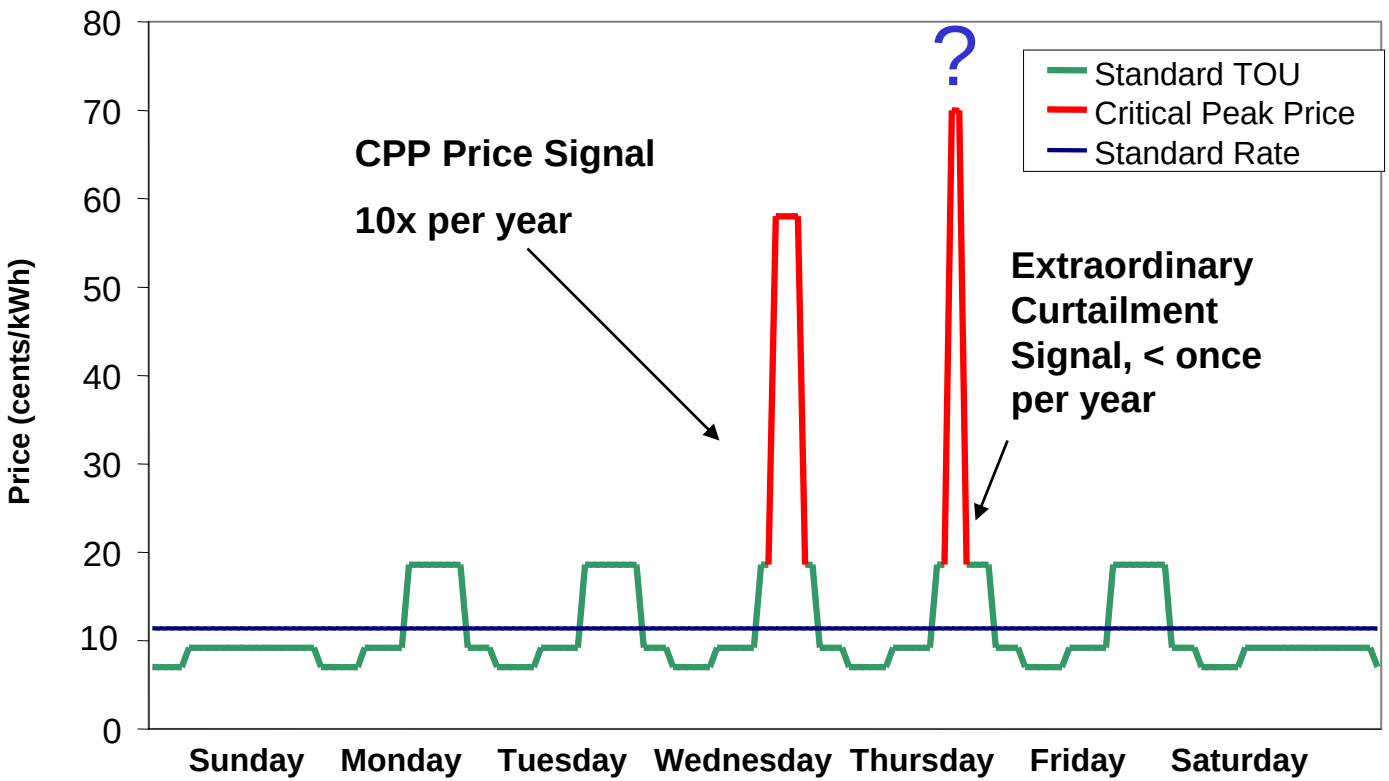
- **Continuous and Reliable -** Provides continuous, secure, and reliable 2 communications infrastructure
- **Translation** - Translates DR event information to continuous internet signals
- **Automation -** Receipt of the signal is design to initiate automation
- **Opt-Out -** Provides opt-out or override function
- **Complete Data Model –** Describes model and architecture to communicate price, reliability, and other DR activation signals.
- **Scalable –** Provides communications architecture scalable to many forms of DR programs and tariffs

Commercialization of OpenADR Client

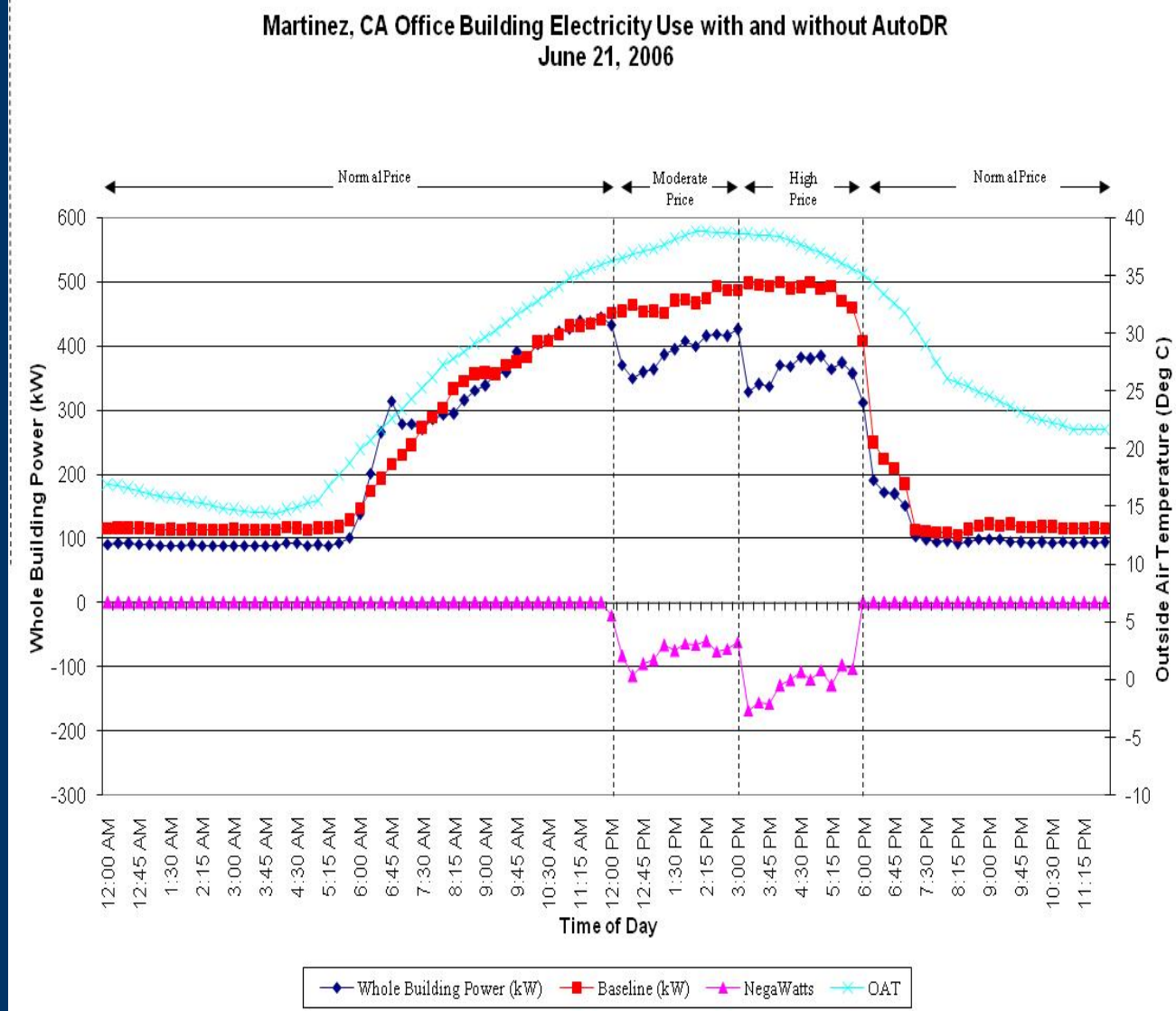
Client-server architecture with

- Single DR Automation Server (DRAS)
- Several client designs
  - Software (XML)
  - Hardware software – Client and Logic with Integrated Relay (CLIR)

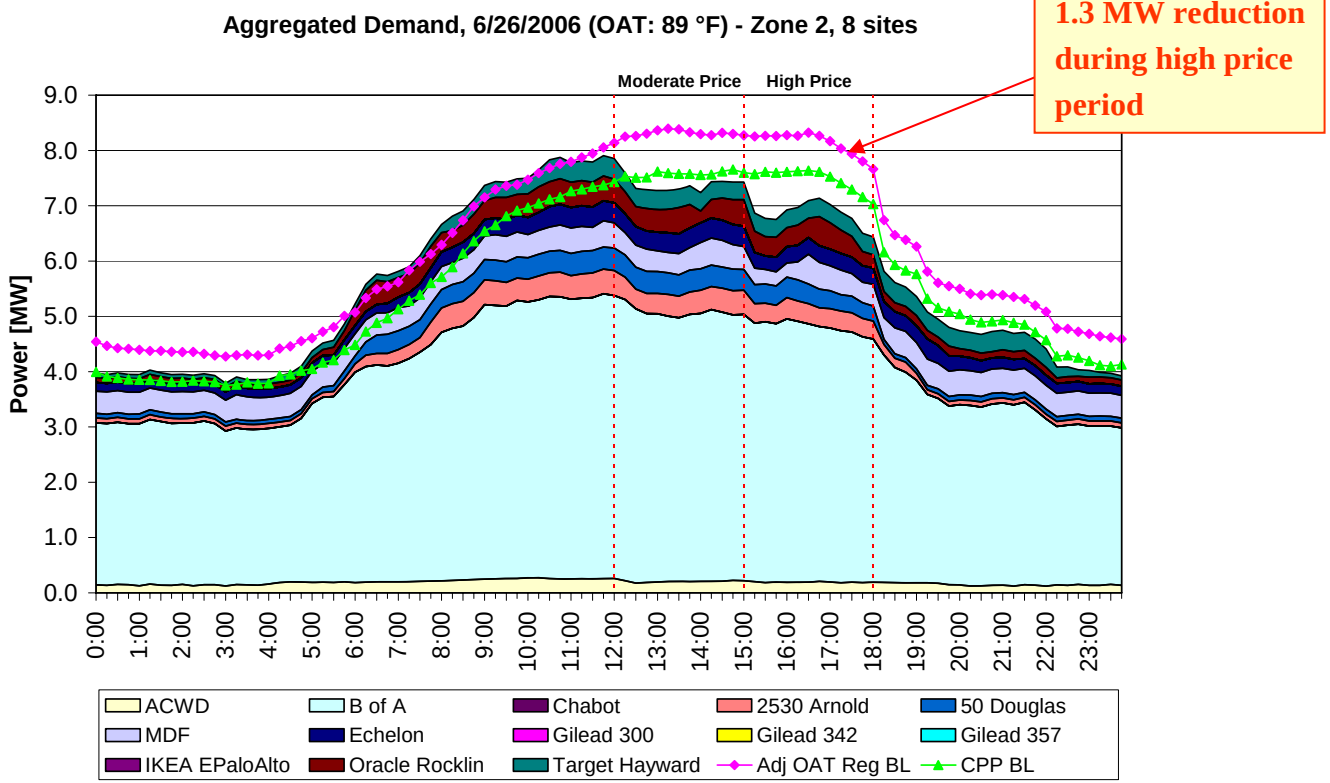
Critical Peak Pricing (CPP) with additional curtailment option



Auto-DR in 130,000 ft^2 County Office Current Practice

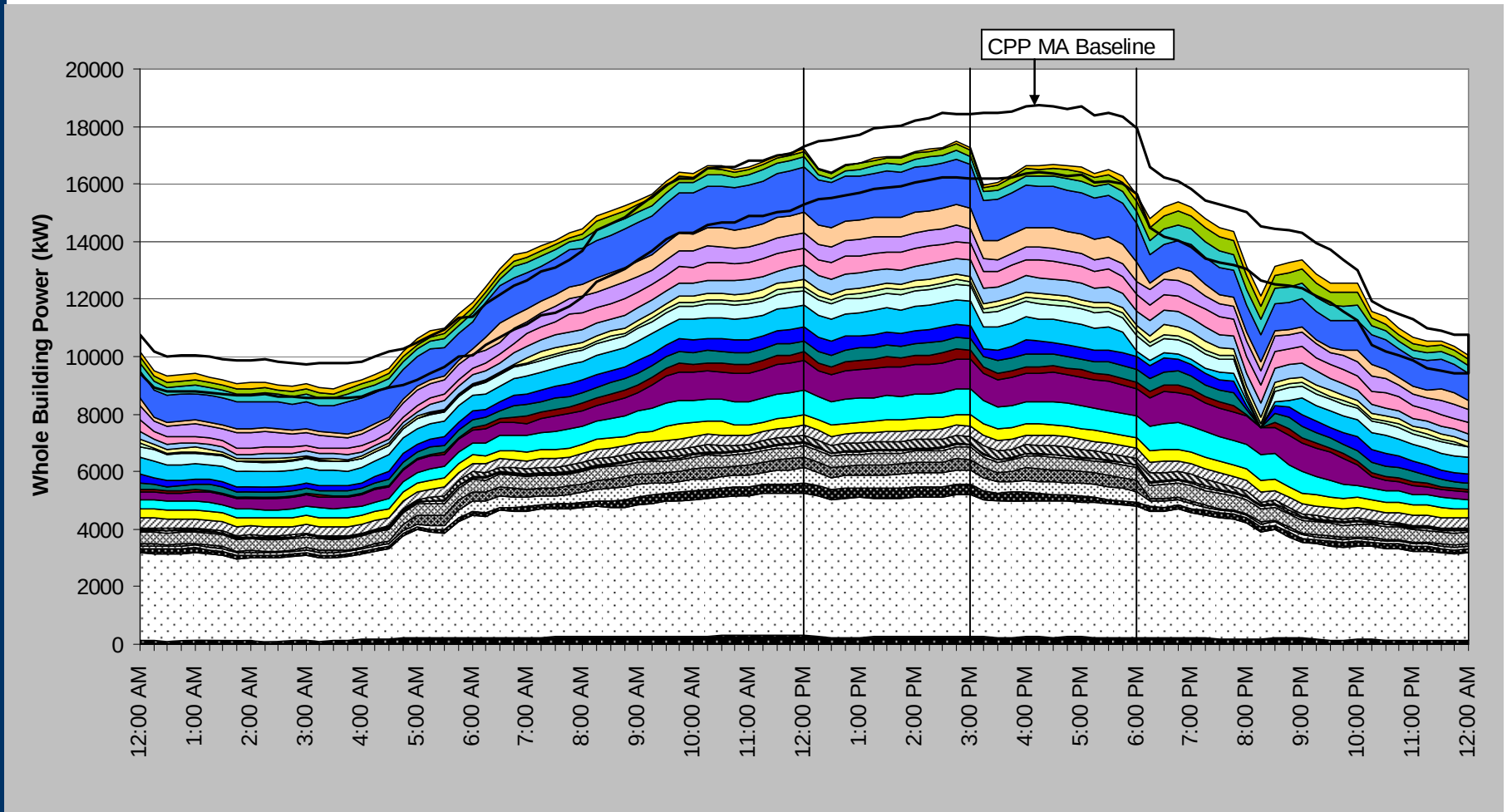


Aggregated Auto-DR Results – June 26, 2006



	Average kW		Average %		Average W/ft²	
	Moderate	High	Moderate	High	Moderate	High
ACWD	78	91	28%	32%	1.53	1.78
B of A	478	604	9%	12%	0.67	0.85
2530 Arnold	102	140	20%	29%	0.78	1.07
50 Douglas	57	94	13%	22%	0.63	1.04
MDF	90	155	17%	30%	0.52	0.90
Echelon	-2	80	0%	22%	-0.02	1.07
Oracle Rocklin	85	60	17%	14%	0.85	0.60
Target Hayward	59	56	15%	15%	0.45	0.43
Aggregated	946	1281	11%	16%	0.65	0.88

Results From PG&E Auto-DR
2008 CPP Event

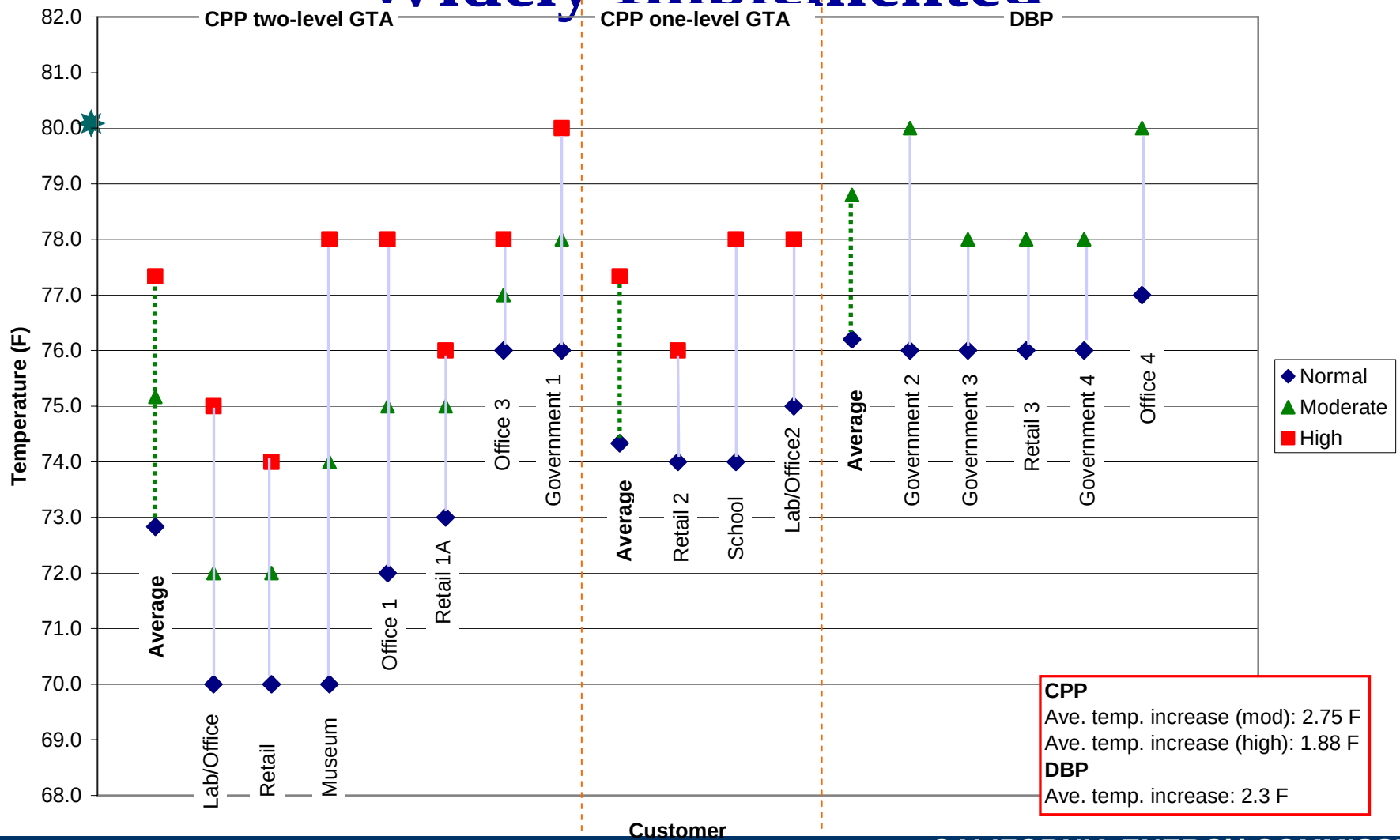


Comparison of End-Use Strategies

Global temperature reset migrating to State Energy Code

		HVAC											Lighting					Other
	Building use	Global temp. adjustment	Duct static pres. Increase	SAT Increase	Fan VFD limit	CHW temp. Increase	Fan qty. reduction	Pre-cooling	Cooling valve limit	Boiler lockout	Slow recovery	Extended shed period	Common area light dim	Office area light dim	Turn off light	Dimmable ballast	Bi-level switching	Non-critical process shed
ACWD	Office, lab	X	X	X		X			X	X		X						
B of A	Office, data center		X	X	X	X			X									
Chabot	Museum	X						X										
2530 Arnold	Office	X									X							
50 Douglas	Office	X									X							
MDF	Detention facility	X																
Echelon	Hi-tech office	X	X	X			X						X	X	X	X		
Centerville	Junior Highschool	X						X										
Irvington	Highschool	X						X										
Gilead 300	Office			X														
Gilead 342	Office, Lab	X		X														
Gilead 357	Office, Lab	X		X														
IKEA EPaloAlto	Furniture retail	X																
IKEA Emeryville	Furniture retail	X																
IKEA WSacto	Furniture retail																	
Oracle Rocklin	Office	X	X															
Safeway Stockton	Supermarket																X	
Solectron	Office, Manufacture	X													X			
Svenhard's	Bakery																	X
Sybase	Hi-tech office														X			
Target Antioch	Retail	X					X											
Target Bakersfield	Retail	X					X											
Target Hayward	Retail	X					X						X				X	
Walmart Fresno	Retail	X															X	

Global Zone Temperature Adjustment Widely Implemented



DRRC pier Akuacom

DR AUTOMATION SERVER 3

logged in as: Target | logout | help

Summary | My Site | Options | About

Target

Control	Auto-CPP	Opt Out (NORMAL)	Forced Moderate	Forced High

Save

Upcoming Automated CPP Events for PGE_CPP_ZONE2

Received Event	Start	End
Fri Nov 10 09:22:20 PST 2006	Wed Nov 15 12:00:00 PST 2006	Wed Nov 15 18:00:00 PST 2006

Communication

Comm. Method	SOFTWARE
Event Level	normal
Last Contact	Fri Nov 10 09:24:55 PST 2006
Comm. Status	
Event Pending	NONE

Preparation Status

CPP Program	CPP sign-up	InterAct setup	Notify test	Activate
Target Antioch	Yes	No	Yes	05/01/2006
Target Bakersfield	Yes	Yes	Yes	05/01/2006
Target Hayward	Yes	Yes	Yes	05/01/2006

Technical Prep	Site survey	EMCS program	Server comm. test	Control test
Target Antioch	No	No	No	No
Target Bakersfield	No	No	No	No
Target Hayward	Yes	Yes	Yes	Yes

LBNL Auto-CPP Newsletters

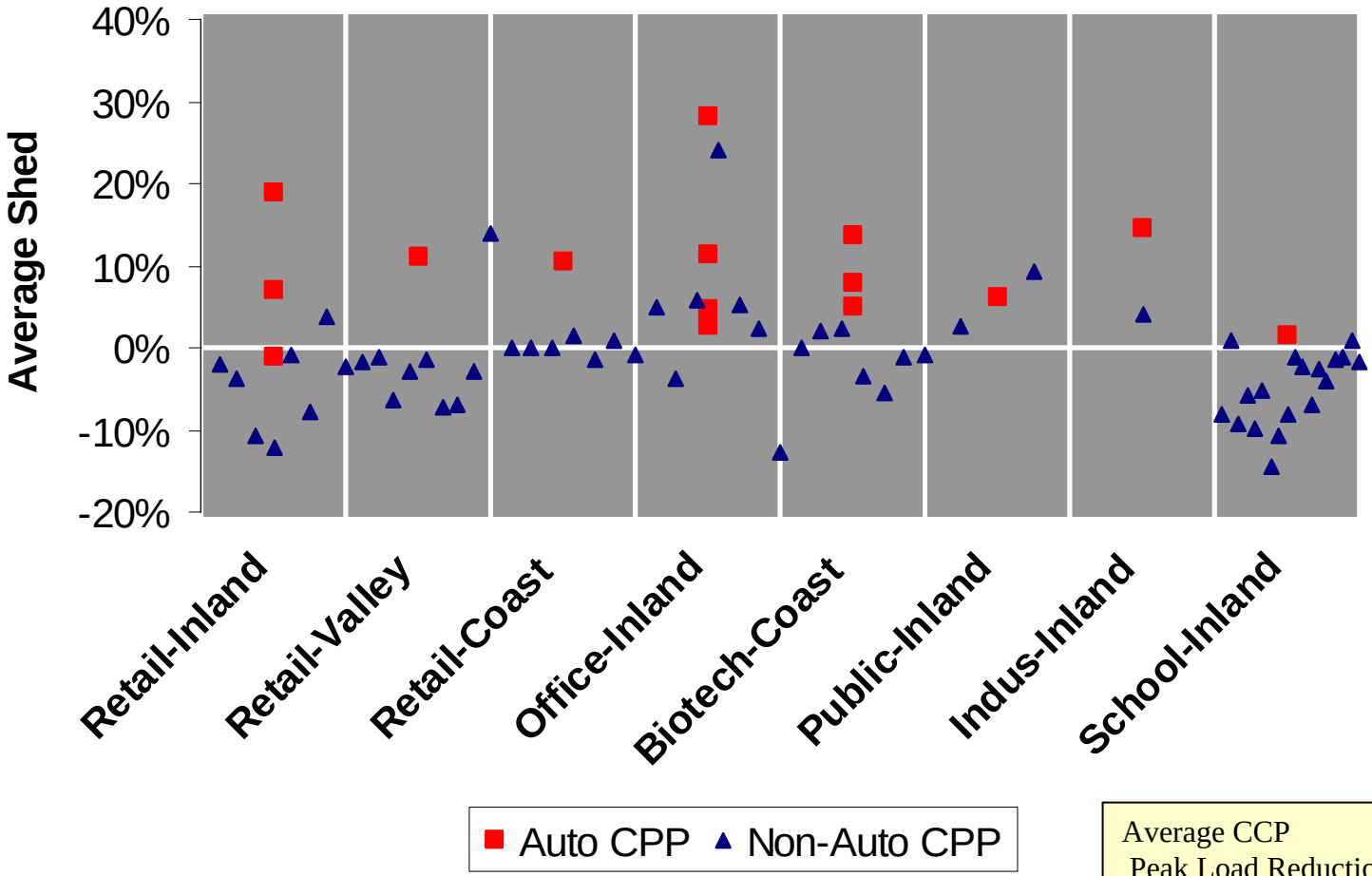
Done | Internet

Results by Utility for 2007 Over 40 MW for 2008

	Pacific Gas and Electric Company	Southern California Edison	SDGE
Participants 2006	13 CPP	0	0
Peak Load Reduction (MW)	1.1	--	--
Peak Load Reduction (%)	13%	--	--
2007 Peak Reduction Goal	15MW	5MW	0
Participants 2007	29 CPP / 52 DBP	8 CPP	62 CBP
Peak Load Reduction (MW)	1 / 21	2	1
Peak Load Reduction (%)	14% / 35%	49%	50%
2007 Peak Reduction (MW)	22MW	2MW	1MW

* Includes in-production and estimated impacts of in-process sites

Auto-DR Customer CPP Performance

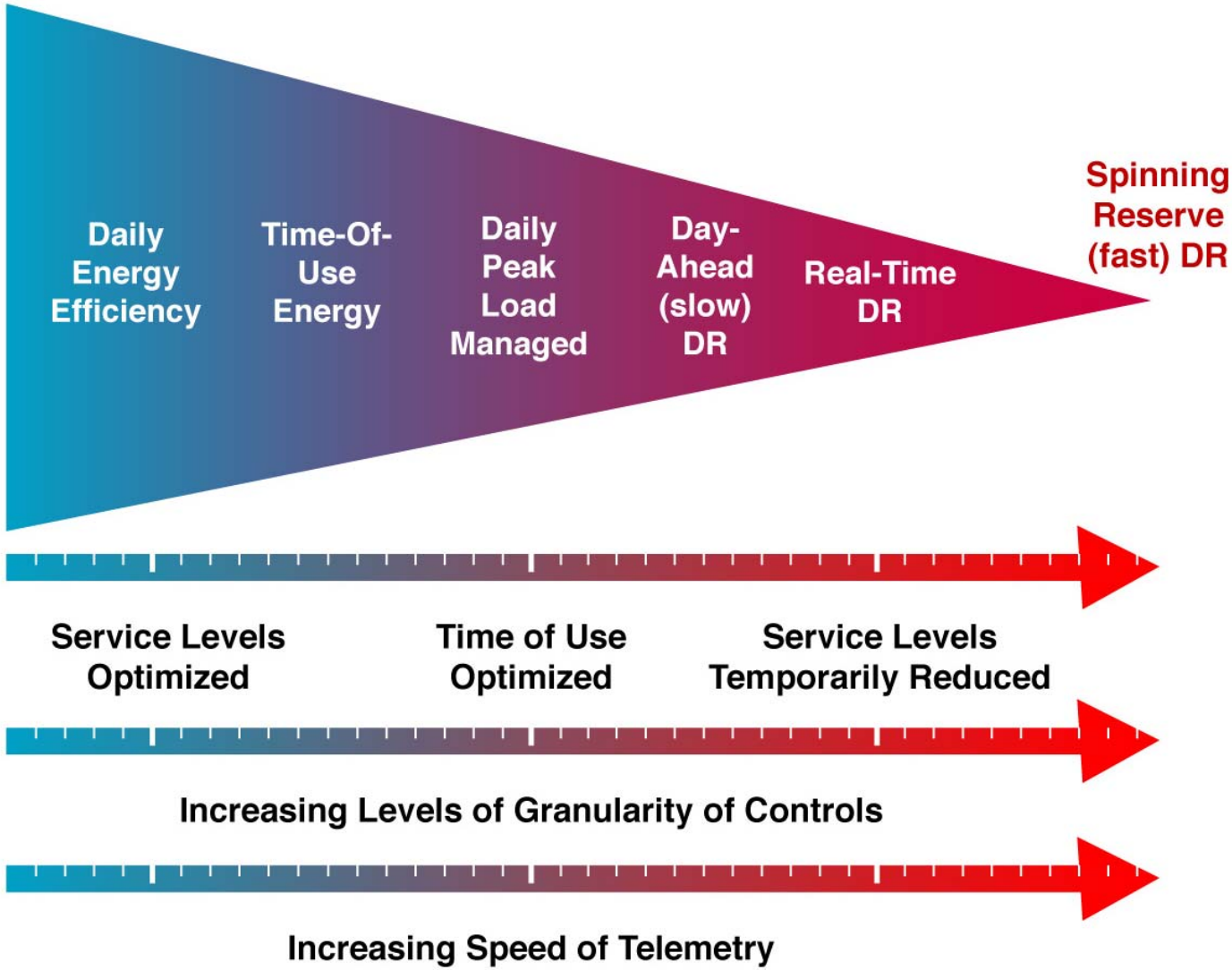


Average CCP
Peak Load Reduction

8% w/Auto-DR

-1% w/o Auto-DR

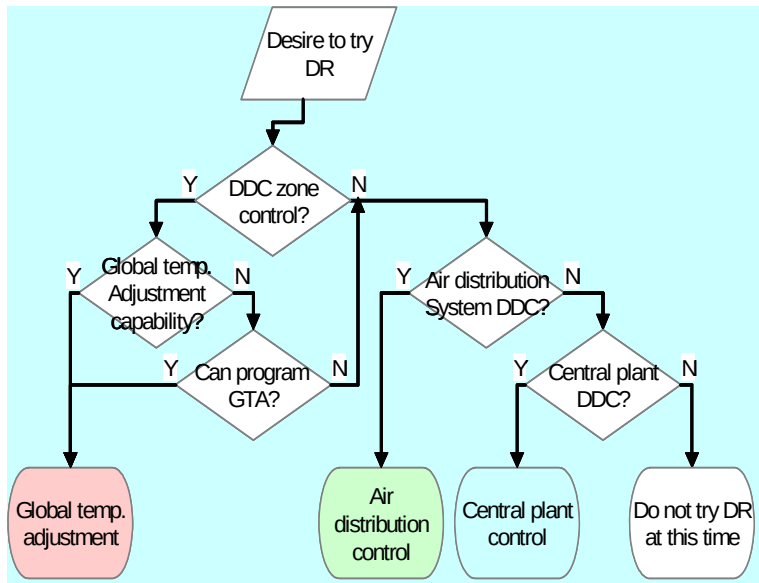
Time Scales of Demand Side Energy Management



Linking DR and Energy Efficiency

Ideal start - good commissioning, retro-commissioning, advanced/new controls

- **HVAC -** Direct digital control (DDC) global temperature adjustment
  - In process for Title 24 2008
  - Closed loop
- **Lighting Continuum** - Zone Switching, Fixture Switching, Lamp Switching, Stepped Dimming, Continuous Dimming
- **Maybe you "can" use a strategy every day?**



Multi-Objective Optimization

Energy
- On/off mode/control
- Weather/solar/wind
- Occupancy/comfort/schedule
- Equipment loads
- Continuous diagnostics

Operating Costs
- Rate $/kWh, TOU, demand charges
- Dynamic – critical, variable peak, RTP
- DR program – shed frequency, duration
- Maintenance and operations

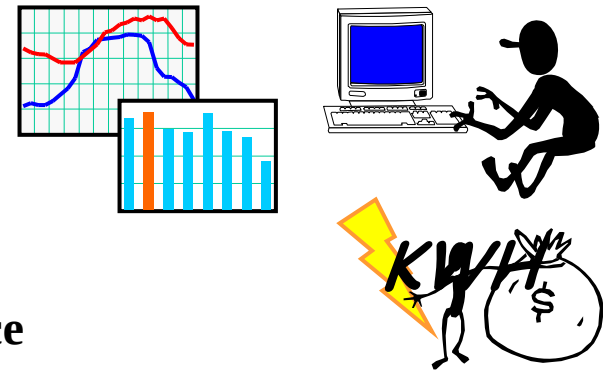
Emissions
- Real-time CO_2/kWh (time of day)
- Grid or on-site power
- Energy source

Demand Response/Grid
- Loads to limit, shift, shed
- Service level control capability
- Service level requirements
  Duration, frequency of DR participation
- Spinning reserve participation

	Energy (kWh)	Operating Costs ($)	Emissions (CO_2)	Demand Response ($/kW)
Conventional Variable Air Volume				
Ice/Chilled Water Storage				
VAV with Pre-Cooling				

Future Directions
DR strategies as a "Mode" in Optimized Control

- **Orchestrate modes using schedules, signals, optimization algorithms:**
  - Occupied/Unoccupied
  - Maintenance/Cleaning
  - Warm up/Cool down
  - Night purge/Pre-cooling
  - Low power DR mode

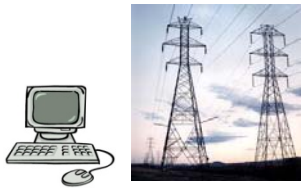


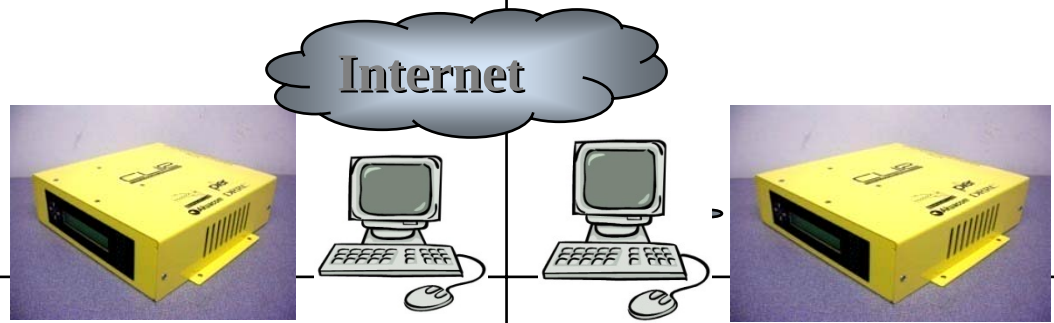
- **Intelligence needed for decision making**
- **Customized, simple and transparent interface**
- **Financial feedback systems need to present operational value**
- **Embed DR Communications in EMCS**
- **Need more sensors, algorithms, real-time simulations, feedback!**

Related OpenADR Projects

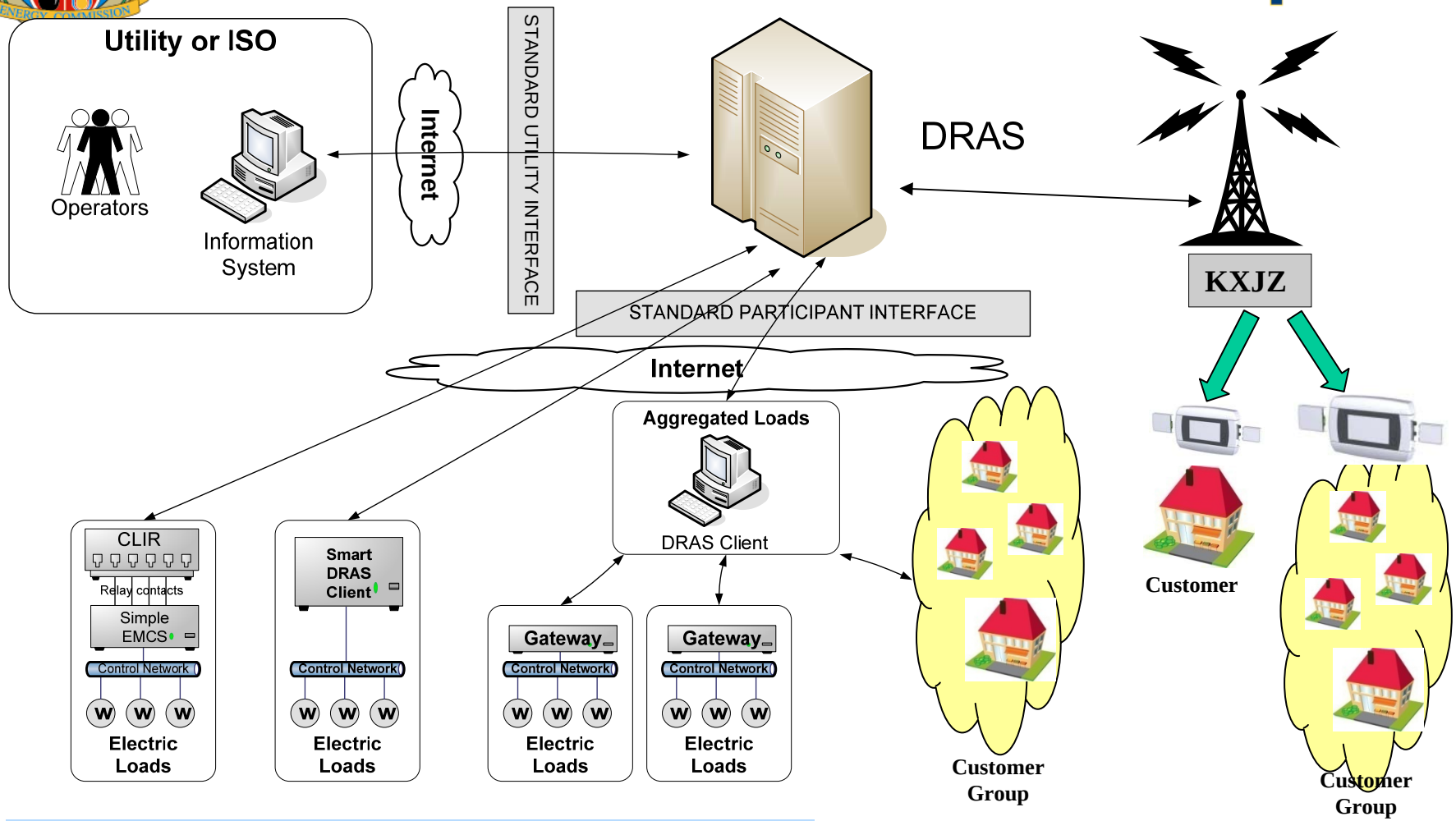
- **Embedding** Auto-DR Clients in control systems
- **Piloting small commercial** Auto-DR systems using low-cost communicating thermostats
- **Developing large commercial pre-cooling** field studies and simulation tools
- **Testing dimmable lighting systems,** designs to provide efficiency and DR
- **Evaluating industrial processes -** case studies on refrigerated warehouses**,** wastewater, controls
- **Planning implementation** of OpenADR in Title 24

Automation by Sector



Programmable Communicating Thermostat	Demand Response Automation Client	Demand Response Automation Client
		
		

Auto-DR System Architecture – Possible Integration with Residential

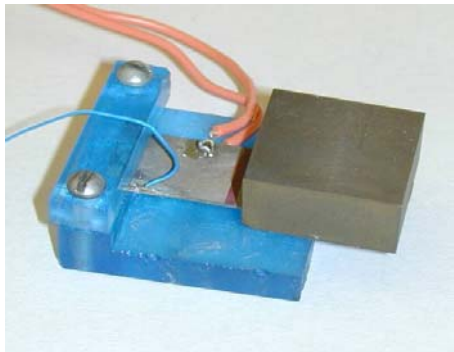


Commercial and Industrial Customers

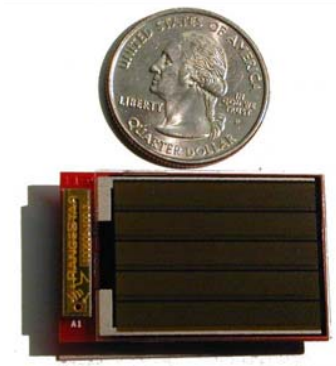
Residential – Small Commercial Customers

UCB Technologies for Lower-Power Wireless Sensing

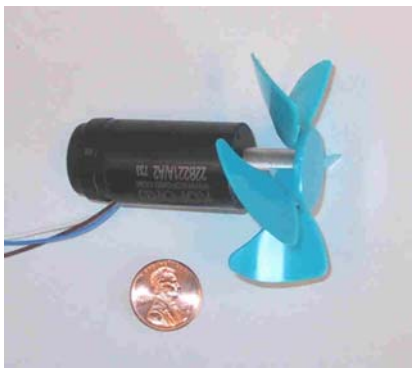
Energy Scavenging



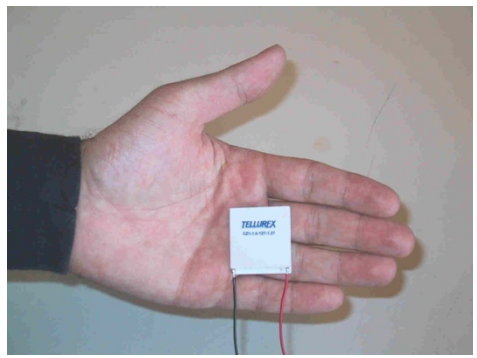
From vibration
(10 – 80 μW/cm^2)



From light
(15mW/cm^2 in sunlight;
6 μW/cm^2 indoors)

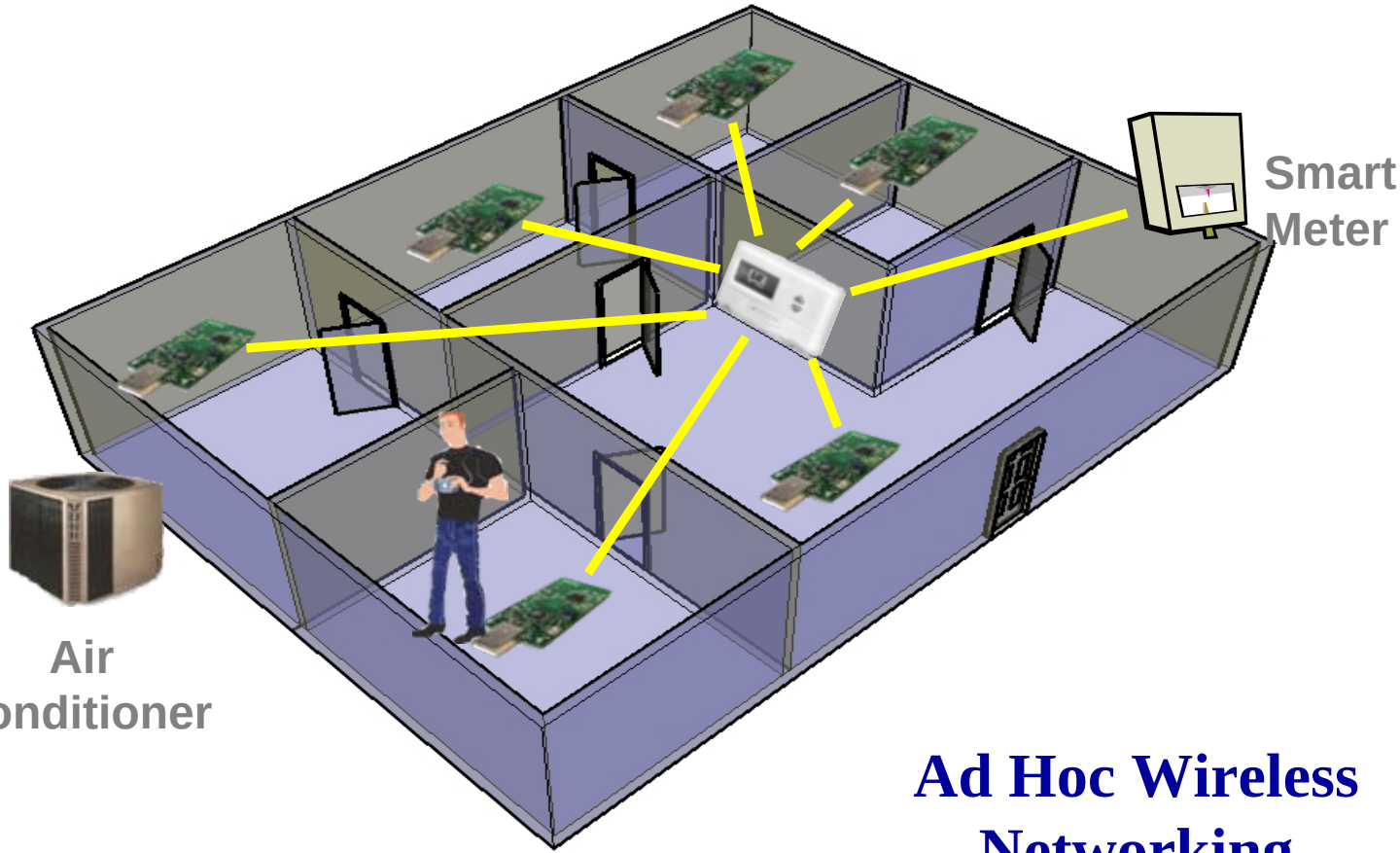


From flow
(3 mW/cm^2 at 1200 fpm)



From heat transfer
(8000 mW/cm^2 from steam pipe)

UCB Distributed Thermostats



Ad Hoc Wireless Networking

CERTS

CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Home | FAQs | Test Plan (PDF) | Overview (PPT) | Team Members | Topology | Links | Test Details (team members only)

CERTS Demand Response Demonstration

This website provides real-time and archived information from a precise, statistically significant test of demand response for a representative SCE distribution circuit (see project overview). The next test is scheduled for dynamic update.

The test is intended to demonstrate the capabilities of load management technologies to provide spinning reserve to the California ISO and to defer distribution enhancements for SCE. In the test, residential air conditioning clustered within a single SCE distribution circuit is being curtailed using a dispatch signal from a central control location (see topology). Daily tests are being planned for the entire month of September.

The test has two basic goals (see Test Plan):

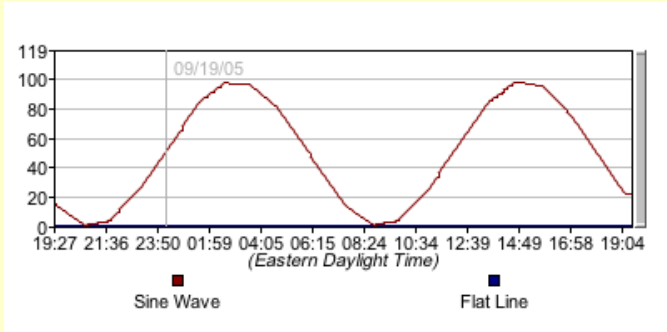
1. Demonstrate that the load can be curtailed reliably and quickly on the issuance of a dispatch signal. The load shed is expected to start within 10 seconds of the signal and be fully implemented within two minutes.

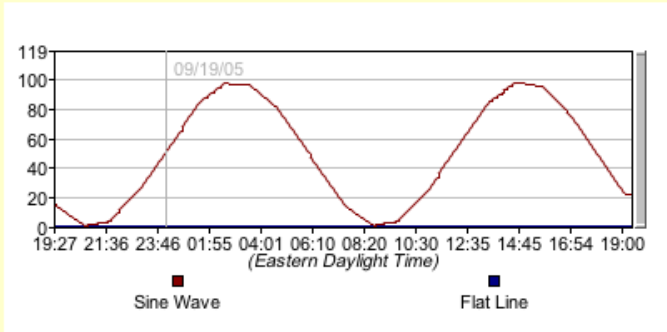
2. Demonstrate that when load is curtailed by a dispatch signal, the available MW demand response of a specific circuit can be precisely predicted with a 90% statistical confidence level using three variables: time of day, day of week, and temperature.

This project is coordinated by the Consortium for Electric Reliability Technology Solutions and the California ISO under a research grant from the CEC PIER program. Contact John Kueck, Oak Ridge National Laboratory, for more information about this project. Contact Joe Eto, Lawrence Berkeley National Laboratory for more information about CERTS.

Real-Time Data

Next curtailment time: **In-progress** | Current temp: °





Date	Time of curtailment	Average MW saved per home
07-26-05	8:00pm PST	12 MW

Powered By: Connected Energy Corp.

SOUTHERN CALIFORNIA EDISON | OAK RIDGE NATIONAL LABORATORY | RLW ANALYTICS | Connected Energy Corp. | CALIFORNIA ISO | pier

Thank You

Mary Ann Piette

mapiette@lbl.gov

http://drrc.lbl.gov