DRRC Demand Response Research Center

BERKELEY LAB

Demand Response Automation Around the US: Tech Trends and Practical Issues for Facility Operations

NSF BEST CENTER NATIONAL WORKSHOP

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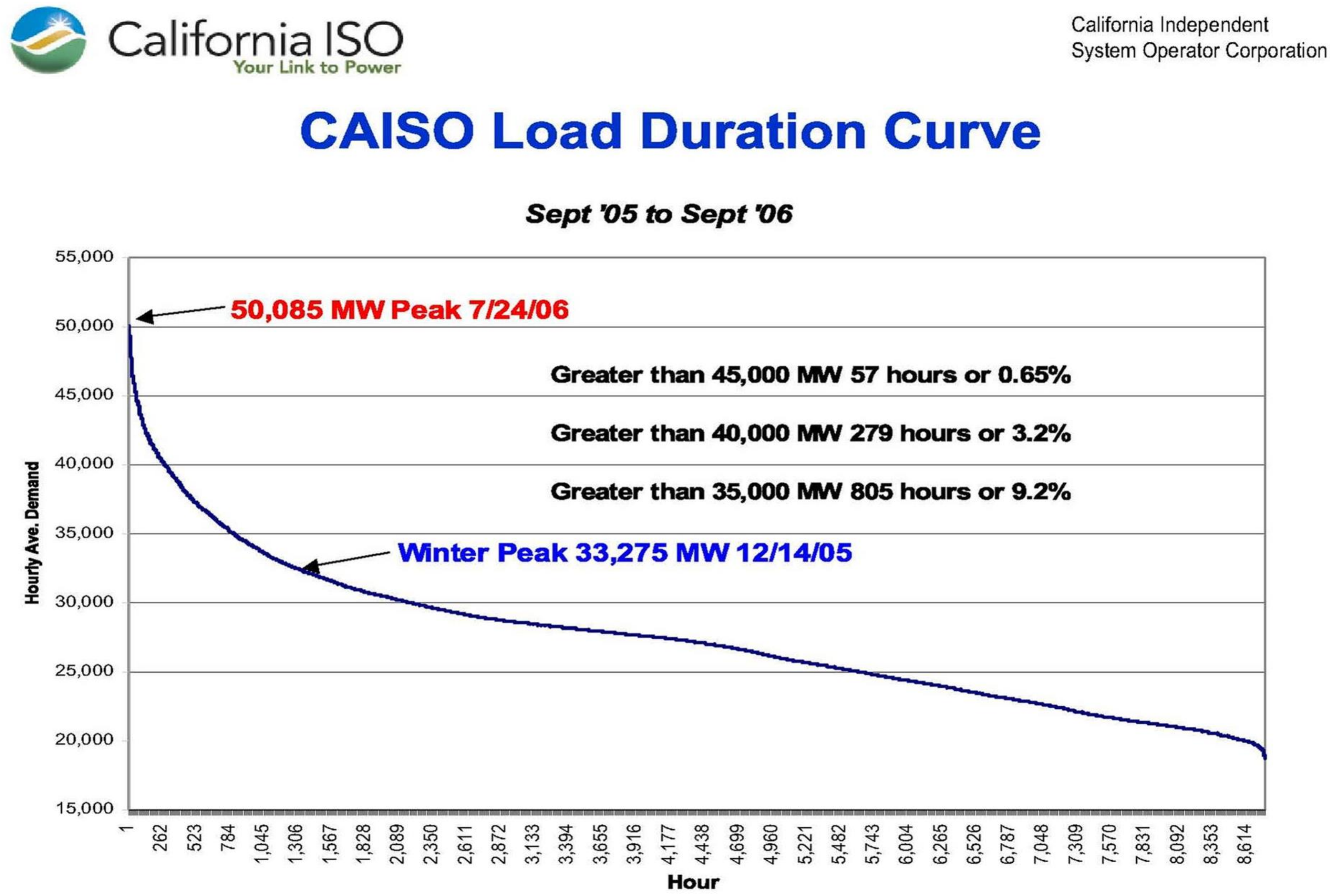
Presentation Outline

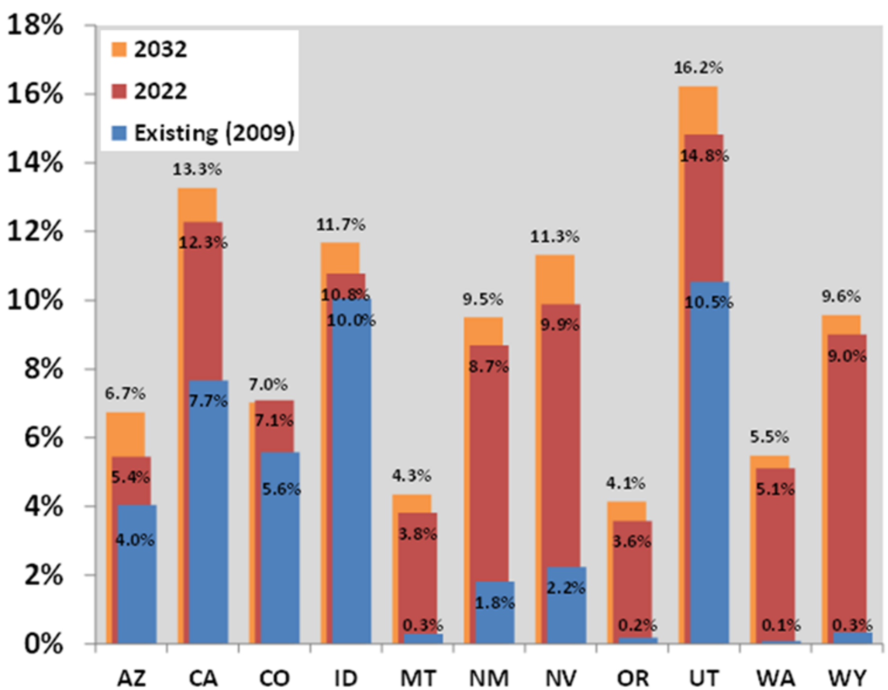
- Introduction to Demand Response
- Automation and Hot Summer Day DR
- Future – Any Time DR
- Summary

Demand Response for Extreme Events

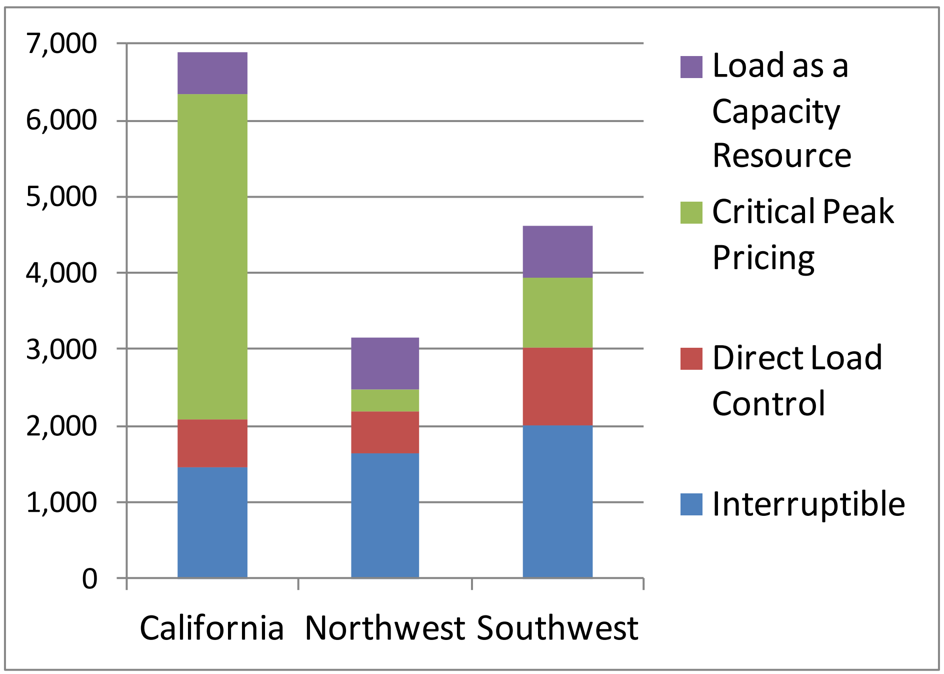


DR Potential Estimates for Western U.S. States

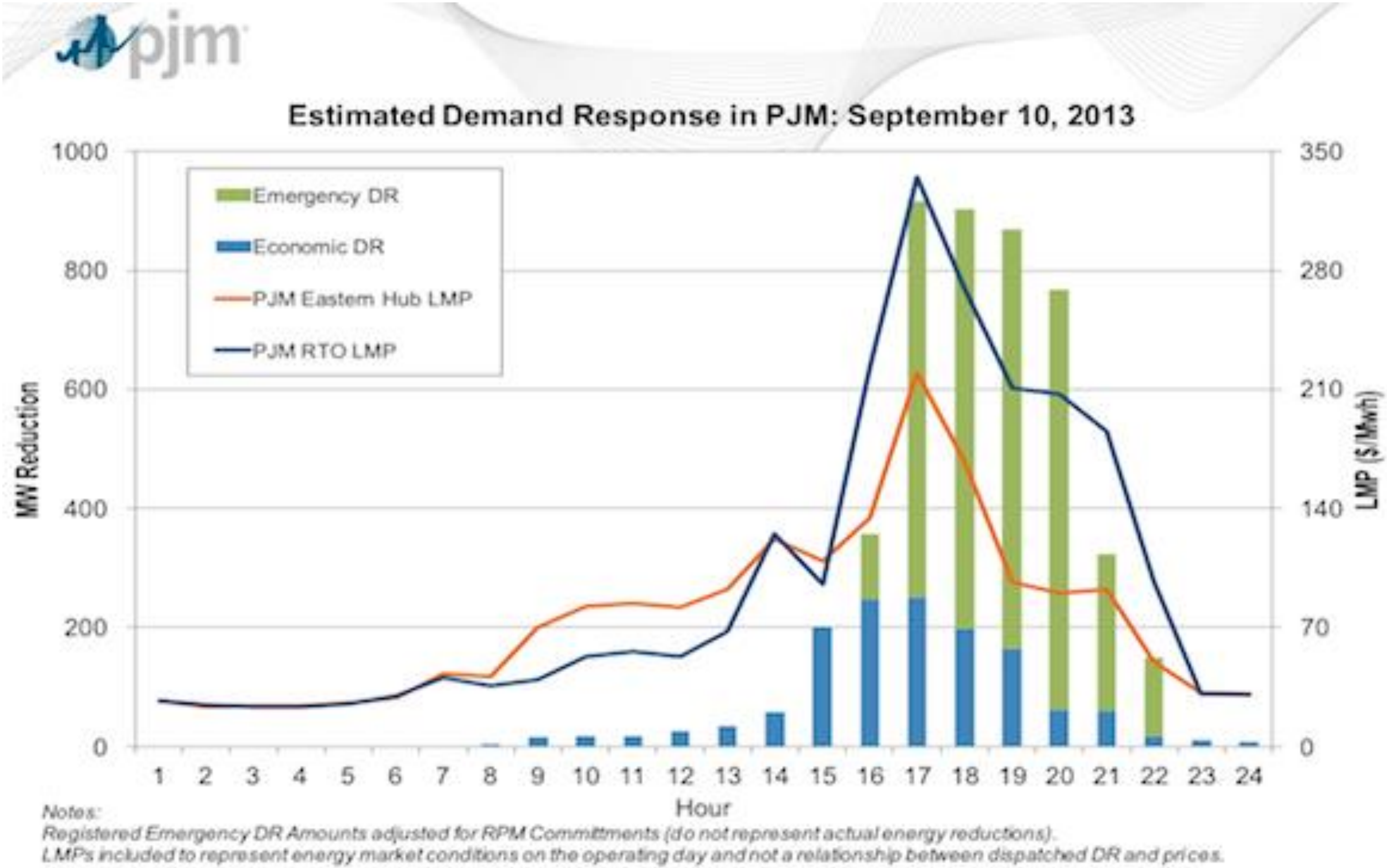
DR Capability (% of Peak Demand) in High DSM Case



2032 DR Capability by Program Type



PJM Market Emergency and Economic

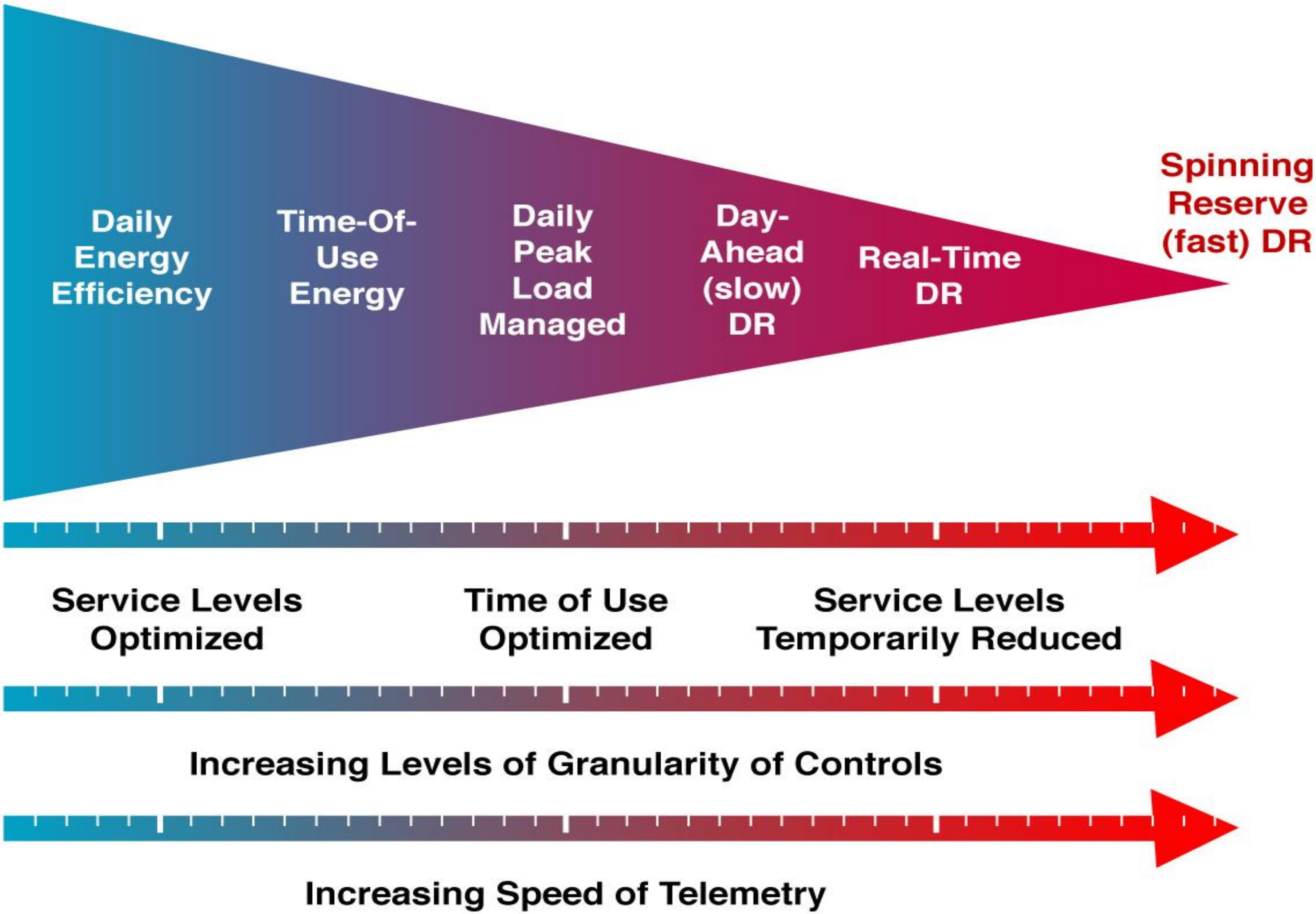


Opt-in & Opt-out Rates: Selected Time-Based Pricing Pilots

*Source: EPRI 2012(a)

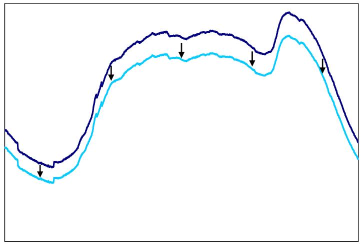
Name of Pilot	Opt-in Rate	Opt-out Rate
BG&E – Smart Energy Pricing Pilot (CPP, PTR) (Summer 2008)	18.0%	NA
CL&P – Plan It Wise Energy Pilot (CPP, PTR, TOU) (Summer 2009)	Residential: 3.1% C&I: 4.5%	NA
ComEd Residential RTP Program (rate option since 2007) (Response to marketing campaigns)	Avg. direct mail: 0.27% $100 sign-up bonus: 1.08% Free smart meters: 0.15%	NA
ComEd Customer Applications Program (smart-grid initiative) (June 2010-Apr 2011)	NA	2%
Hydro One Networks, Inc. (TOU) (May-Sept 2007)	13.0%	NA
PG&E SmartRate™ Tariff (CPP) (Summer 2008)	Residential: 7.5% Small Commercial: 5.0%	NA
PowerCentsDC™ Power Program (CPP, PTR) (Jul 2008-Oct 2009)	Residential: 6.4% Low Income: 7.6%	NA
PSE&G myPower Pricing (TOU+CPP) (Summer 2006-Summer 2007)	Residential, response to direct mail offer: 4.0%	NA

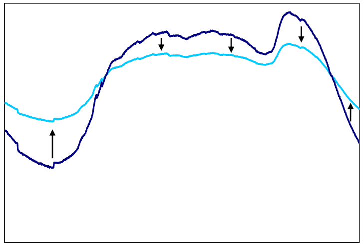
Linking Energy Efficiency and DR

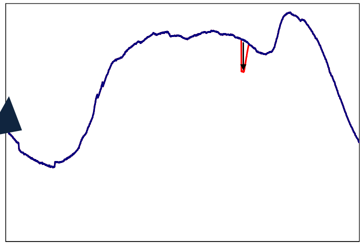


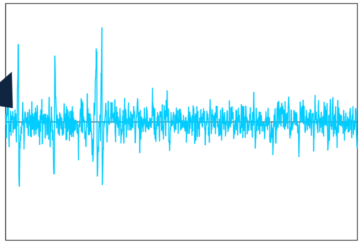
Grid Integration and Load Shaping Objectives

1. **Energy Efficiency -** reduce overall electricity use.
2. **Price Response -** move consumption from times of high to times of low prices) – expand to address transmission distribution congestion management.
3. **Peak Shaving** – requires response during peak hours and focuses on high-system load days – expanded to address transmission distribution congestion management.
4. **Reliability Response** (contingency response) requires fastest, shortest duration response. Only required during power system "events." – New and developing area.
5. **Regulation Response -** continuously follows minute-to-minute commands from grid to balance aggregate system load and generation – Niew and promising for certain loads.





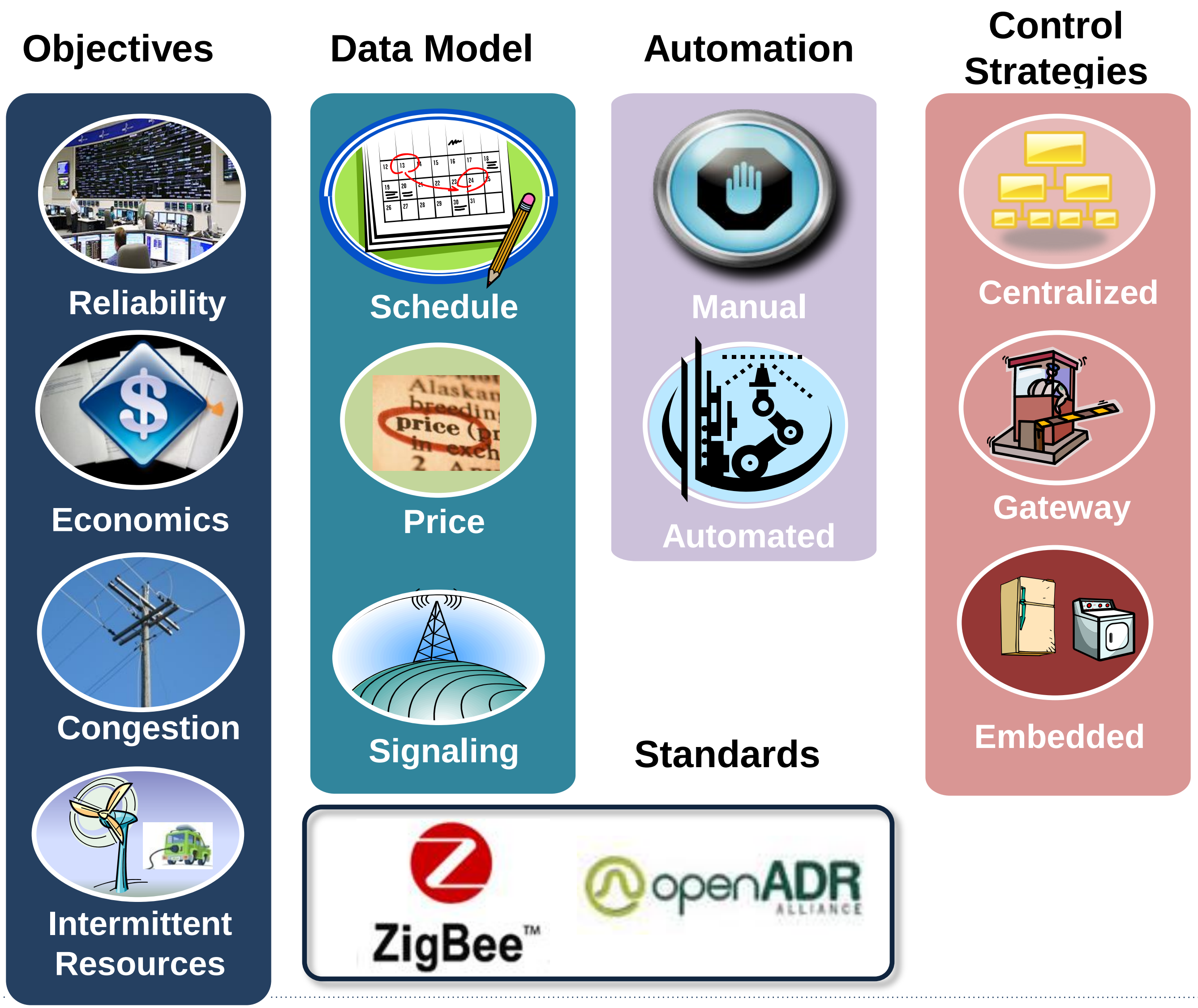




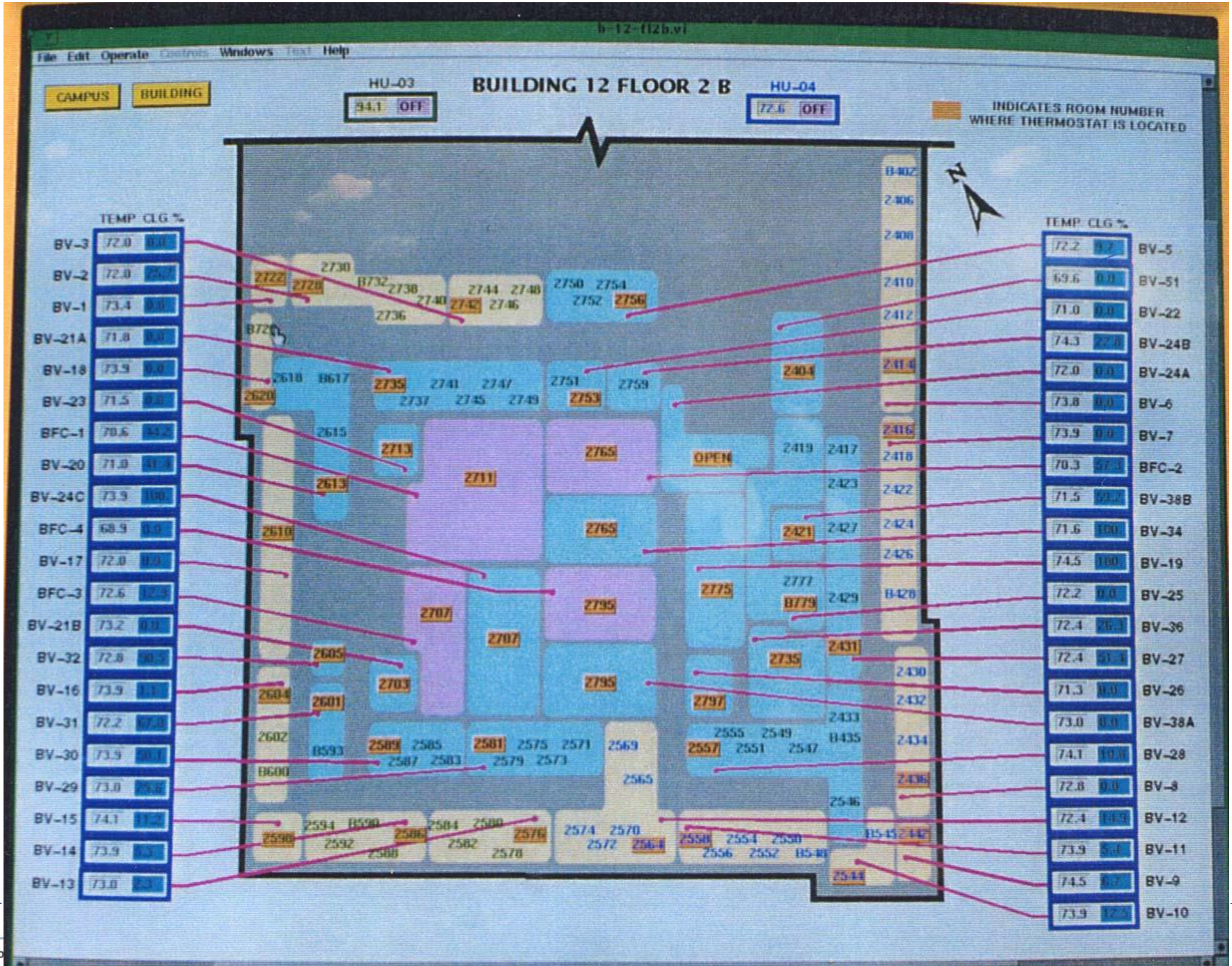
Future - continuously energy-aware locally transactive control

1. Adapted from: Demand Response Spinning Reserve Demonstration Project, Consortium for Electric Reliability Technology, LBNL, Joseph Eto presentation October 19, 2009.

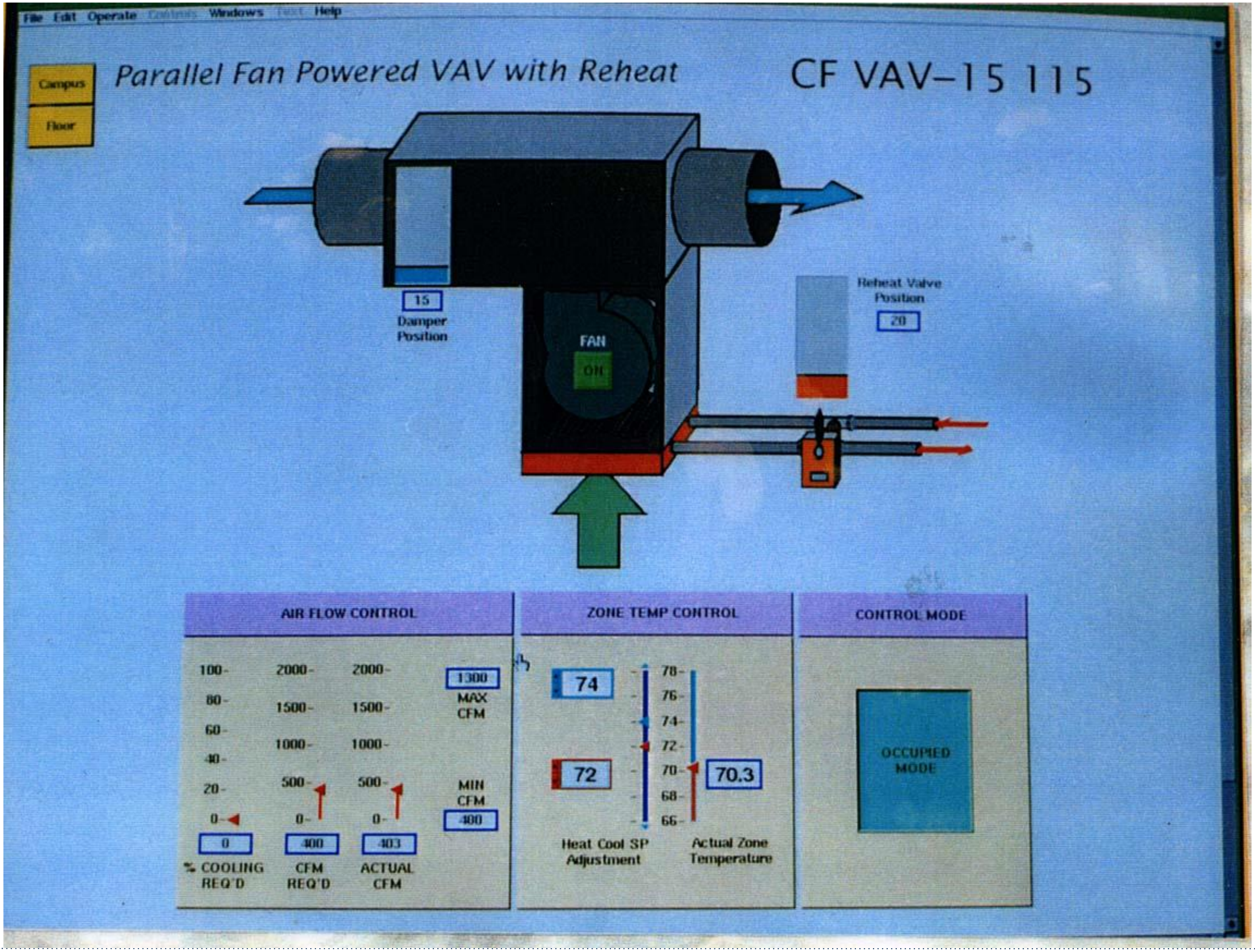
Demand Response Simplified



Typical EMCS – Individual zones

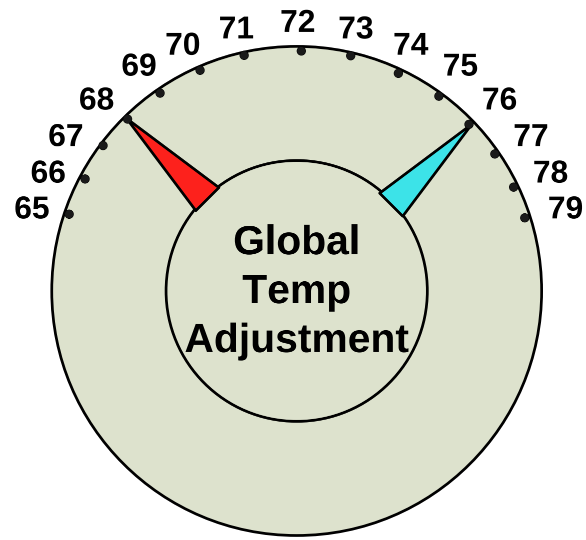


Typical EMCS – Individual zones Adjustment

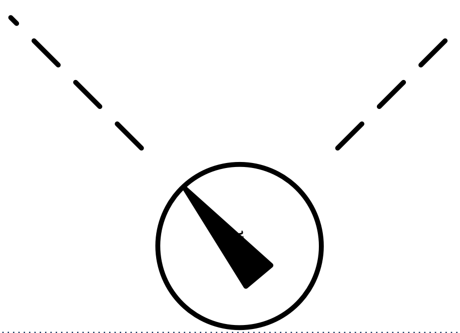


GTA – Conceptual Implementation #1 (Absolute)

Normal Mode



DR Mode



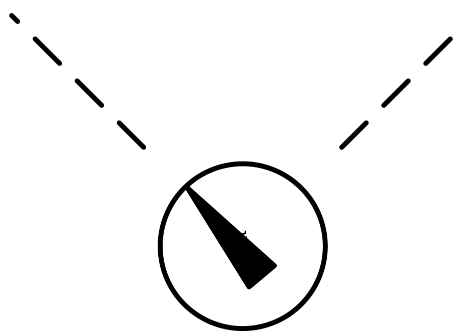
GTA – Conceptual Implementation #2 (Relative)

Normal Mode

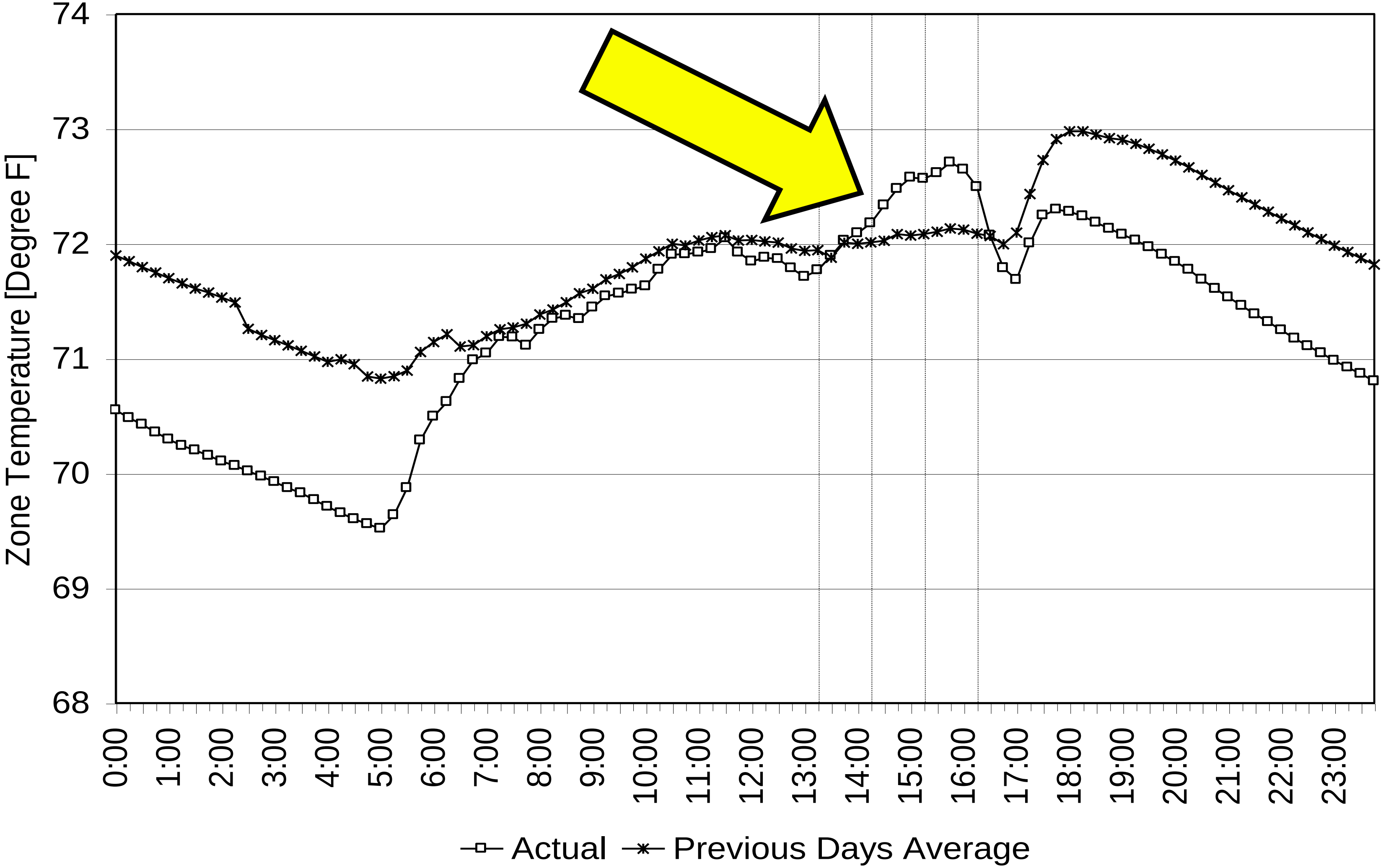
Global Temp Adjustment
(Relative)

"Relax" each zone
by __**2**__ deg.F

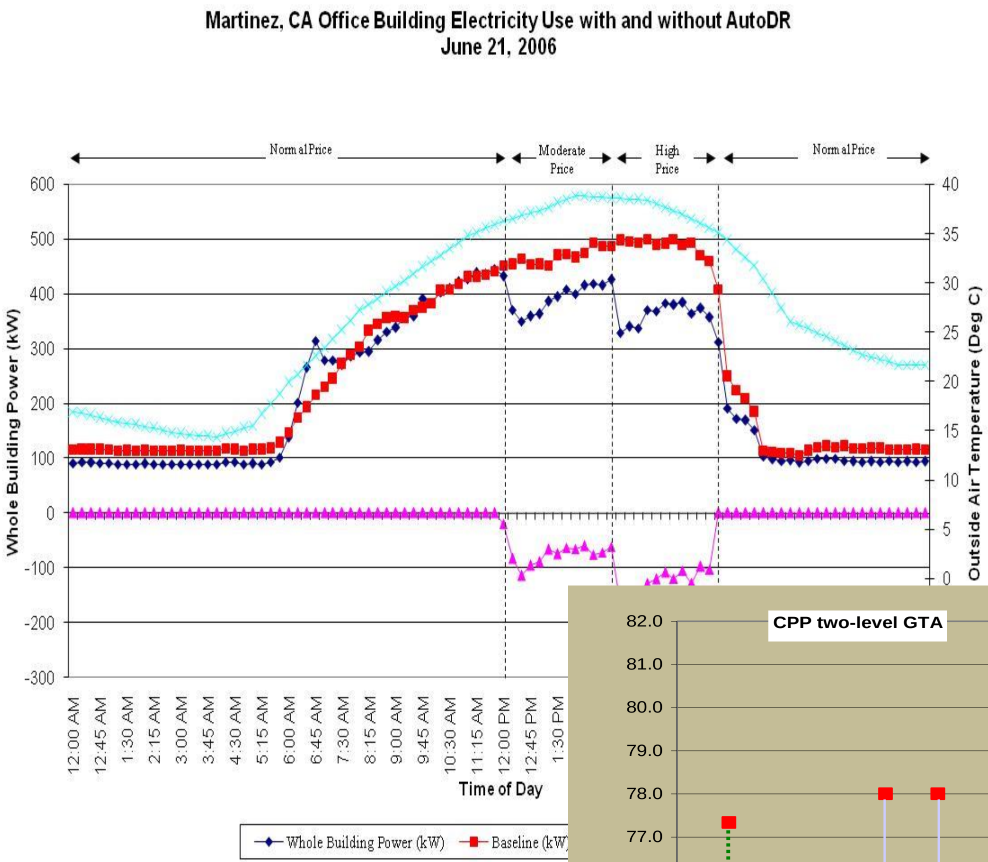
DR Mode

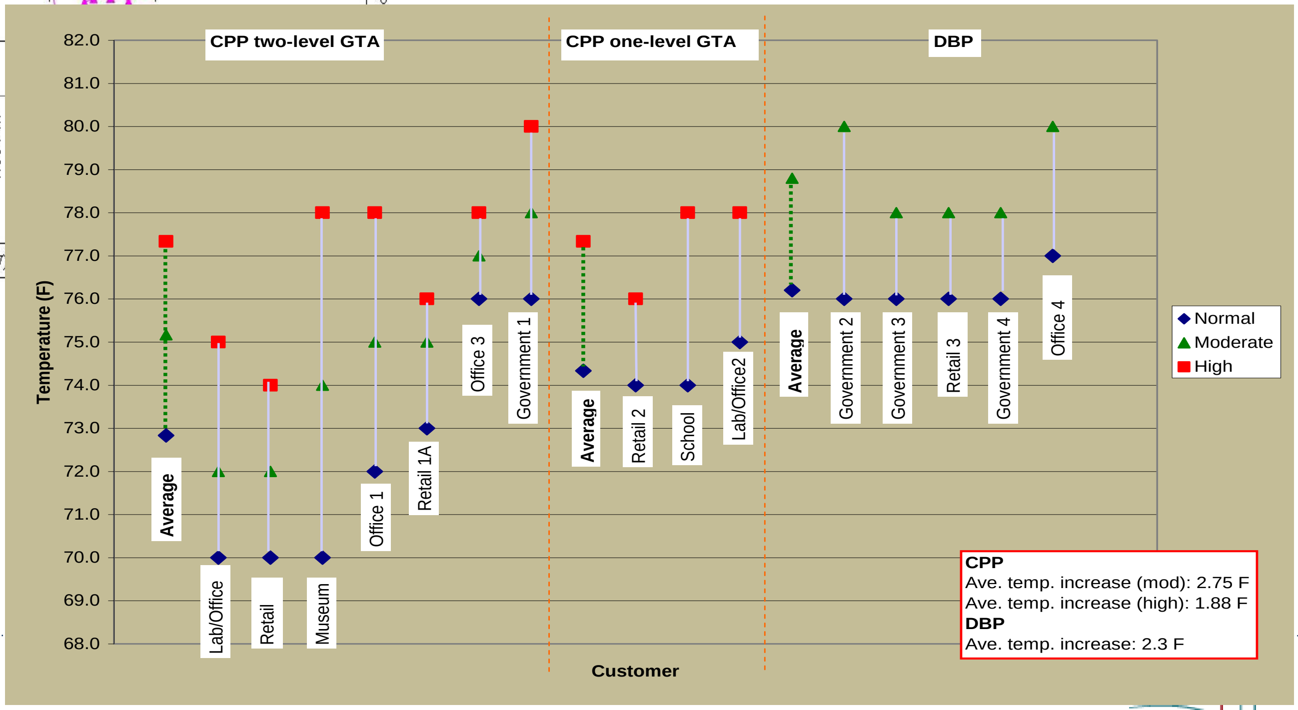


Comfort: 1.5 deg. F° Temperature Rise at GSA (39 zone average) (1 of 2)



Control Strategies Evaluated in Previous Demos

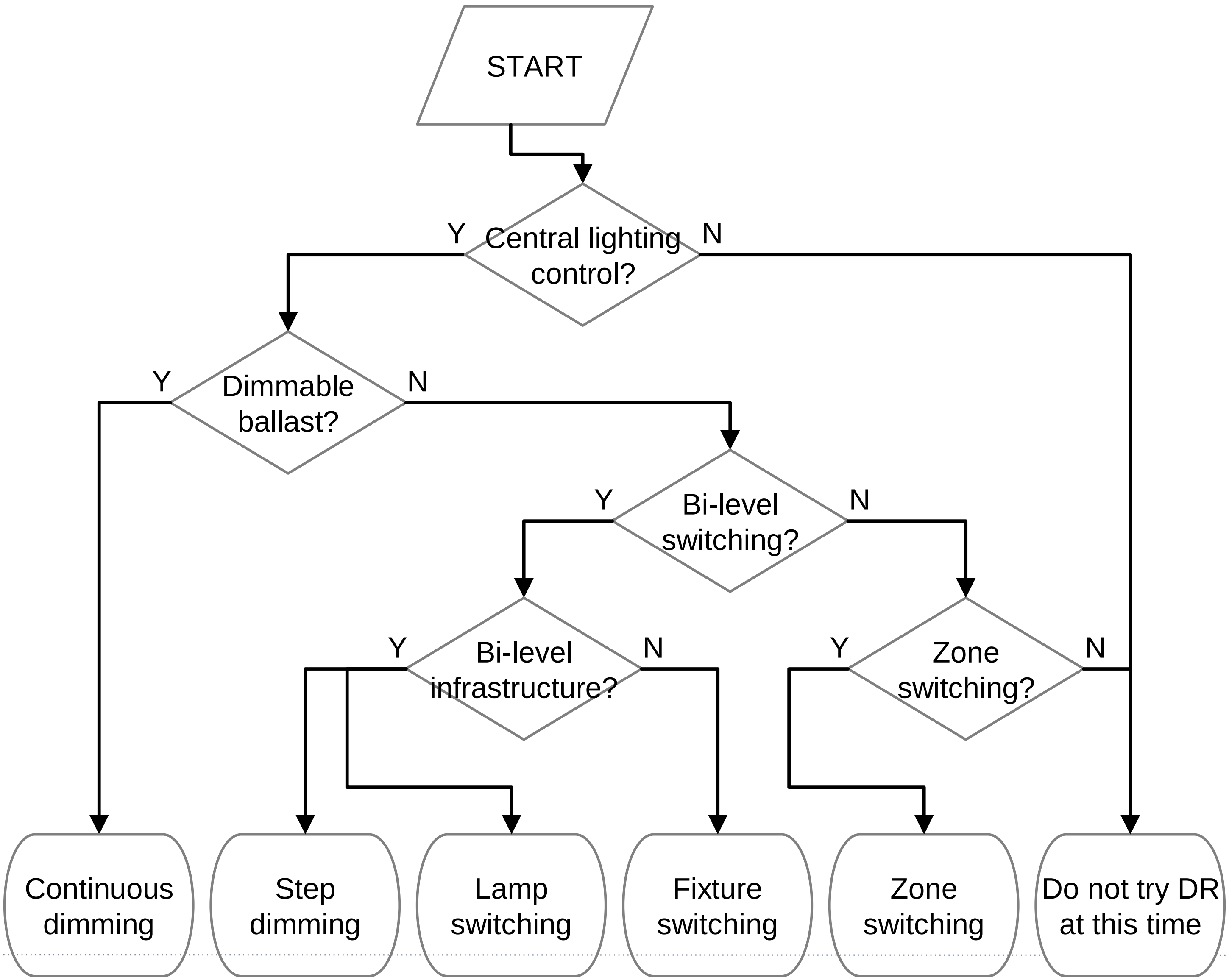




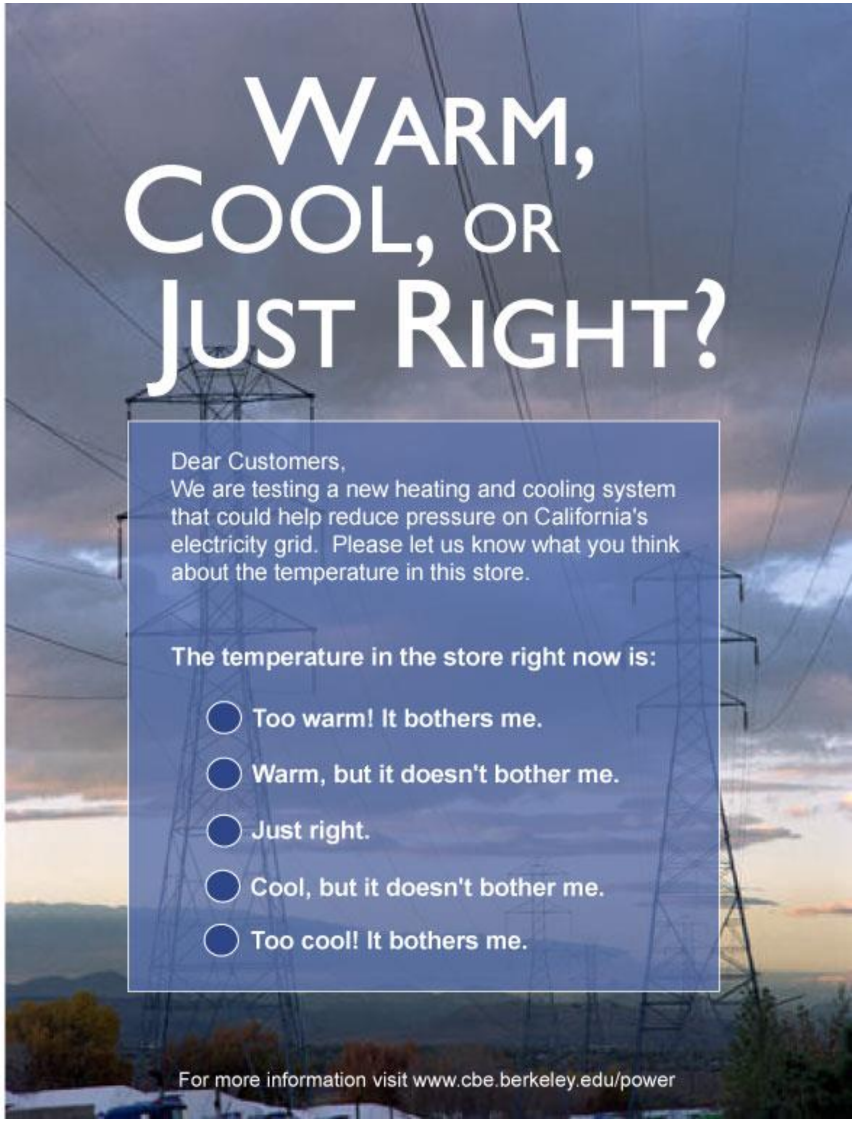
Strategies used in DR Field Tests

				Participation			HVAC														Light, Misc.				
	Building use	Total conditioned area	# of bldg	2003	2004	2005	Global temp. adjustment	Fan-coil unit off	SAT reset	Fan VFD limit	Duct static pres. reset	Fan quantity reduction	Electric humidifier off	CHW temp. reset	CHW current limit	Chiller demand limit	Boiler lockout	Pre-cooling	Extended shed period	Slow recovery	Common area light dim	Office area light dim	Anti-sweat heater shed	Fountain pump off	Transfer pump off
300 CapMall	Office	383,000	1		X		X			X		X		X										X	
ACWD	Office, lab	51,200	1			X	X		X		X			X	X		X		X						
Albertsons	Supermarket	50,000	1	X																	X		X		
B of A	Office, data center	708,000	4	X	X	X			X	X	X			X	X										
Chabot	Museum	86,000	2			X	X											X							
Cal EPA	Office	950,000	1		X						X										X	X			
CETC	Research facility	18,000	1		X							X	X												
Cisco	Office, tech lab	4,466,000	24		X		X	X									X				X	X			
2530 Arnold	Office	131,000	1		X	X	X													X					
50 Douglas	Office	90,000	1		X	X	X													X					
Echelon	Corporate Headquarter	75,000	1		X	X	X		X		X	X									X	X			
GSA 450 GG	Federal office	1,424,000	1		X		X																		
GSA NARA	Archive storage	202,000	1		X		X																		
GSA Oakland	Federal office	978,000	1	X	X		X																		
Gilead 300	Office	83,000	1			X			X																
Gilead 342	Office, Lab	32,000	1			X	X		X																
Gilead 357	Office, Lab	33,000	1			X	X		X																
Irvington	Highschool	N/A	1			X	X											X							
IKEA	Retail	300,000	1			X	X																		
Kadent	Material process	-	1		X																				X
LBNL OSF	Data center, Office	70,000	1			X	X											X							
Monterey	Office	170,000	1		X																X				
Oracle	Office	100,000	2			X	X				X														
OSIsoft	Office	60,000	1		X		X																		
Roche	Cafeteria, auditorium	192,000	3	X	X							X													
Target	Retail	130,000	1			X						X									X				
UCSB Library	Library	289,000	3	X	X					X	X				X										
USPS	Postal service	390,000	1		X	X										X				X					

DR Strategies: Lighting

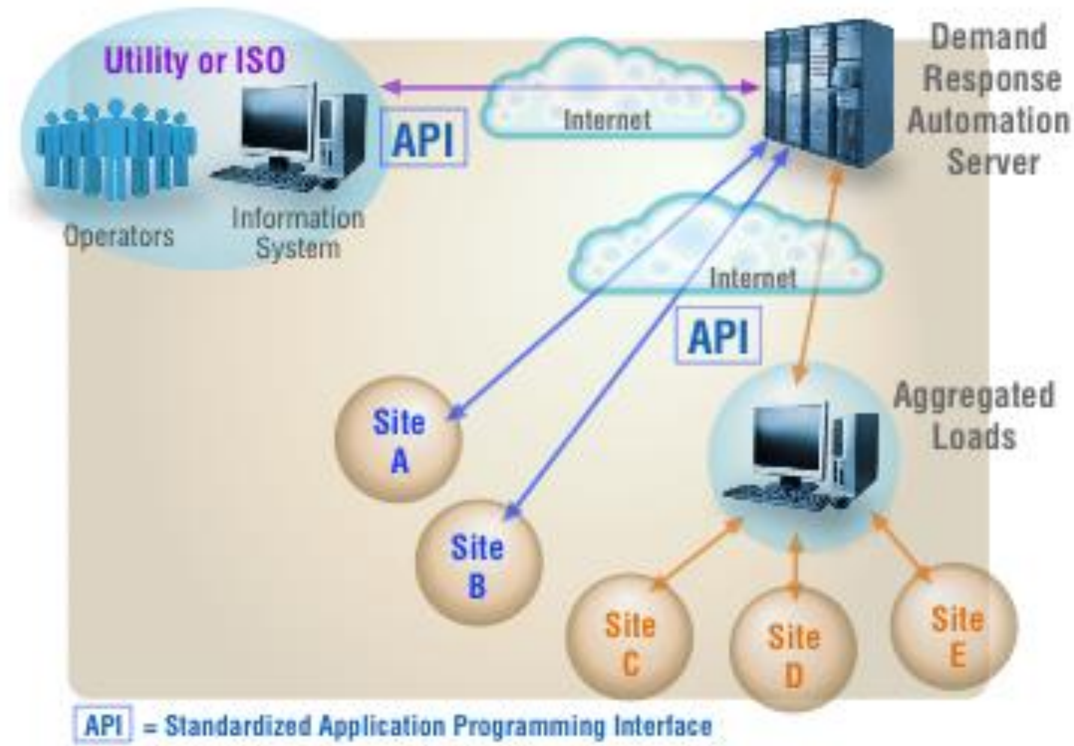


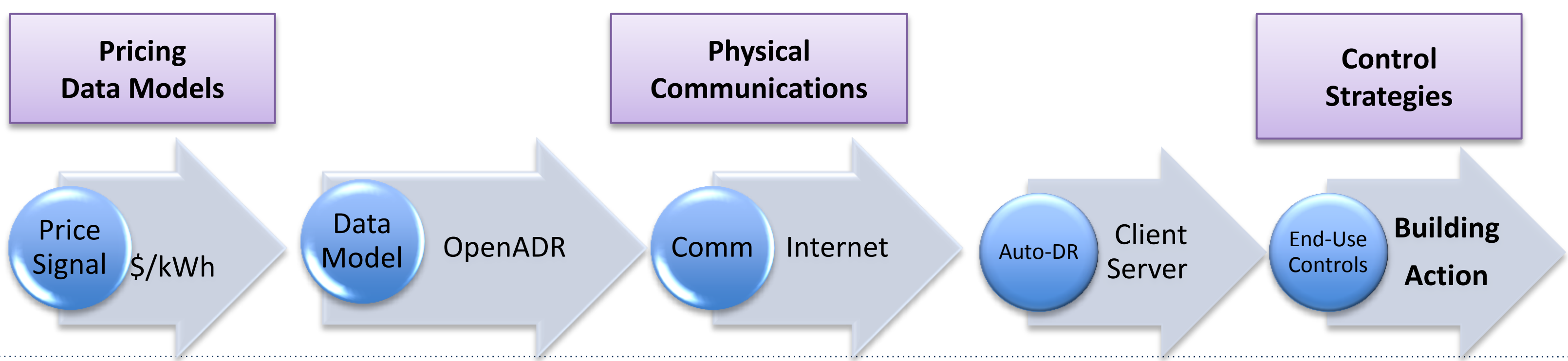
Comfort: Online Tennant Survey (2 of 2)



OpenADR Fundamentals

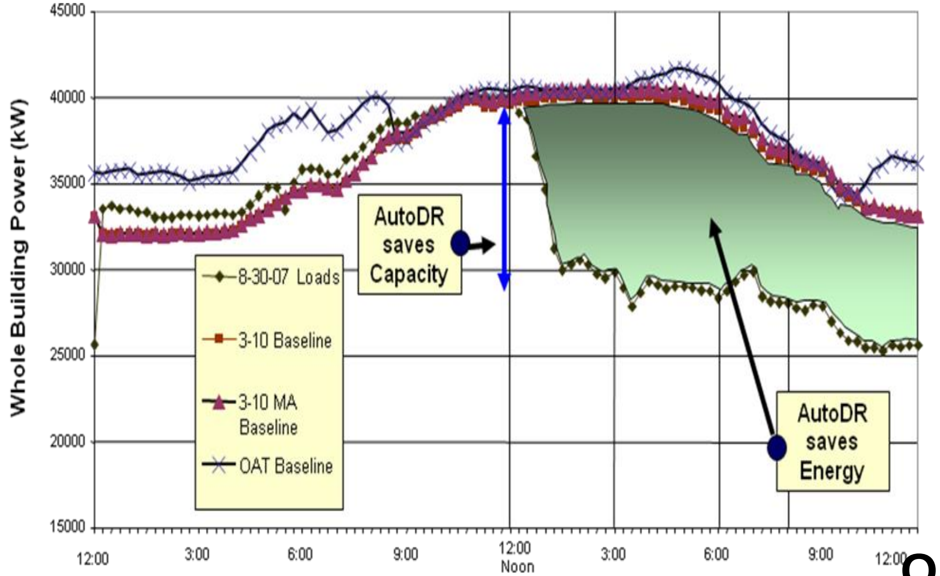
- Provides non-proprietary, open standardized DR interface
- Allows electricity providers to communicate DR signals directly to existing customers
- Uses common XML language and existing communications such as the Internet



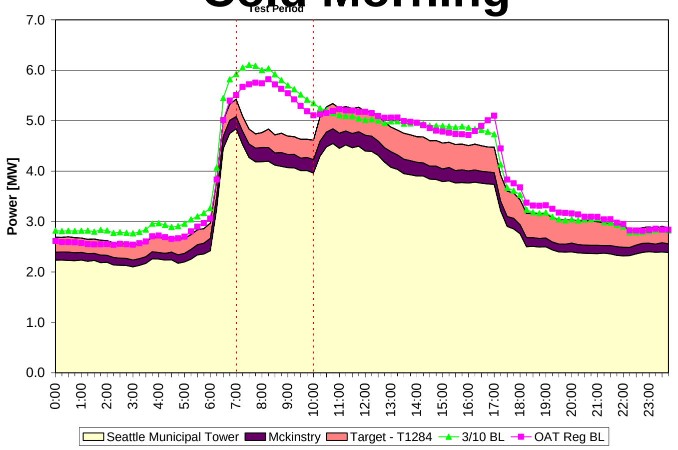


Historic focus on Seasonal Grid Stress

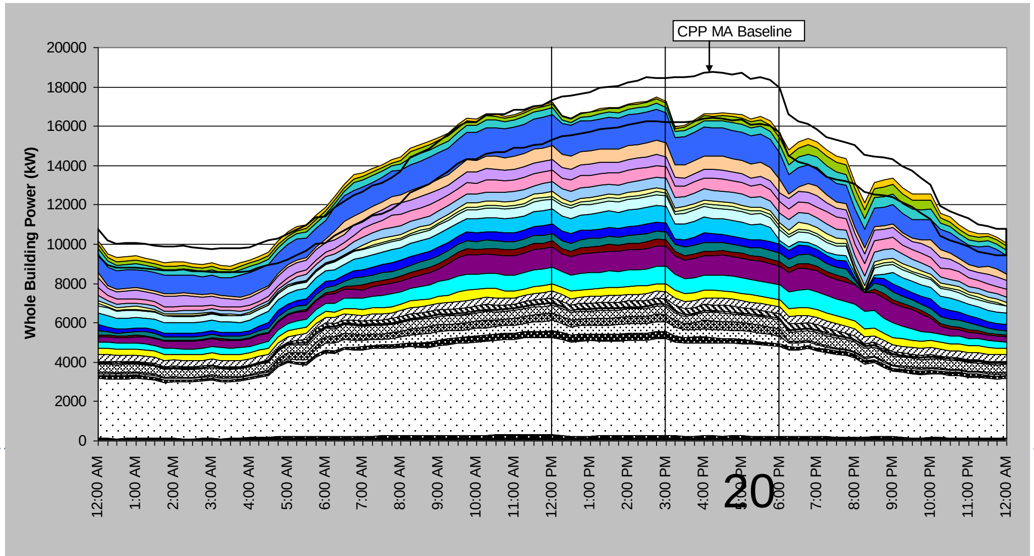
OpenADR PG&E Demand Bid Test Day



OpenADR Northwest Test on Cold Morning



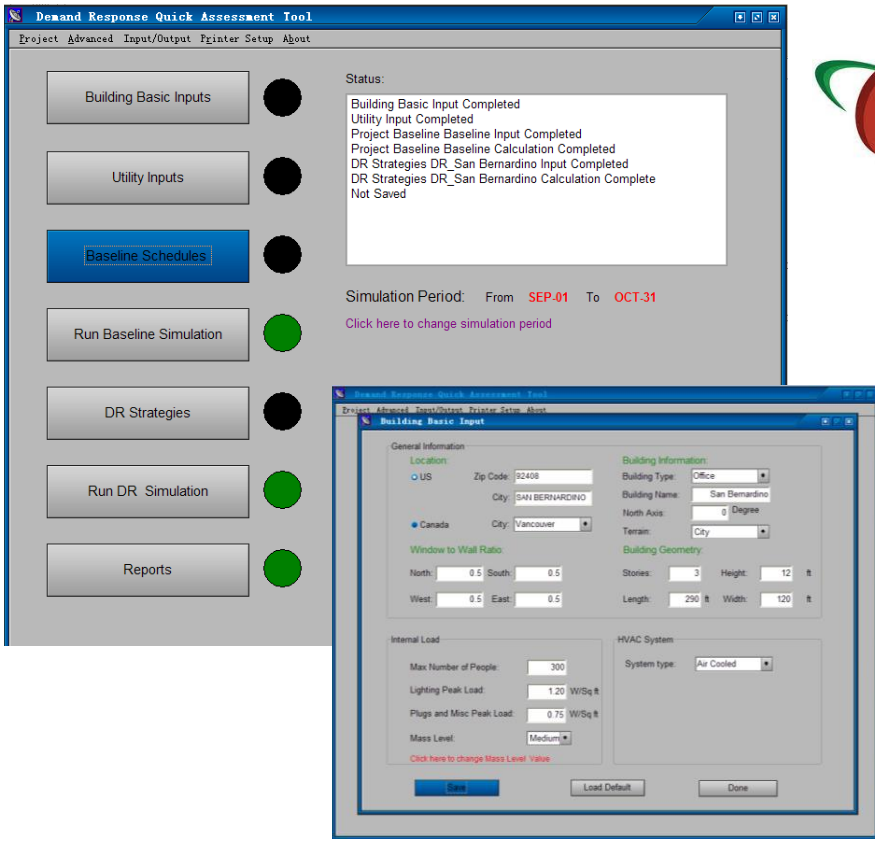
OpenADR Cumulative Shed in July 2008

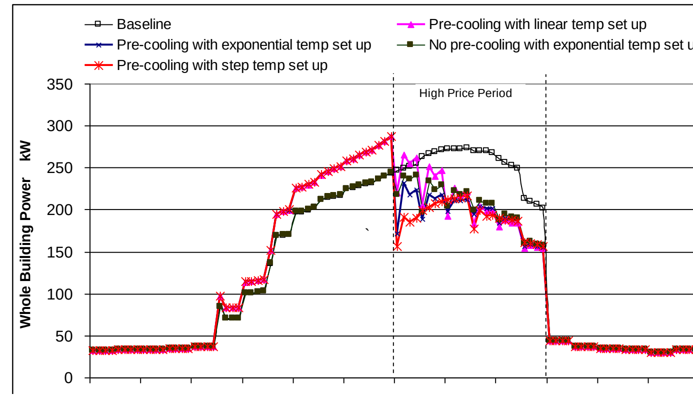


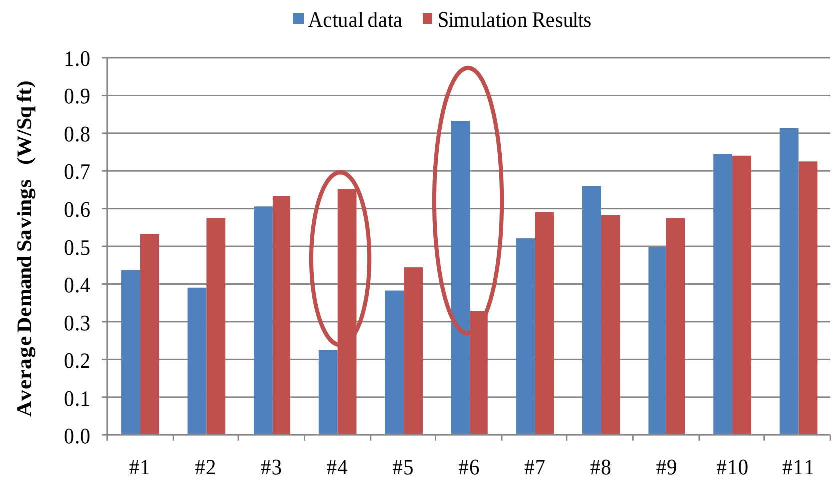
Demand Response Strategies Guide for Commercial Buildings

DR Quick Assessment Tool

Simple free EnergyPlus tool for retail and office buildings to provide DR estimates for common HVAC and lighting strategies







Excellent performance predicting DR in southern Calif.
Included modeling pre-cooling strategies

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OpenADR Interoperability Progress

Research initiated by LBNL/ CEC

Pilots and **field trials**
Developments, tests (Utilities)

OpenADR 1.0 **Commercialization**
(PG&E, SCE, and SDG&E)

Official **OpenADR specification (1.0)** by LBNL/CEC*

1. **Anytime DR Pilots**
   - Wholesale markets
   - International demonstrations
   - Dynamic pricing, renewables
2. **All end-use sectors**

Over 250 MW automated in California

National outreach with USGBC

2002 to 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012

1. OpenADR **Standards Development**
   - OASIS (EI TC), UCA, IEC
2. NIST **Smart Grid**, PAP 09

EI 1.0 standards
- OpenADR profiles

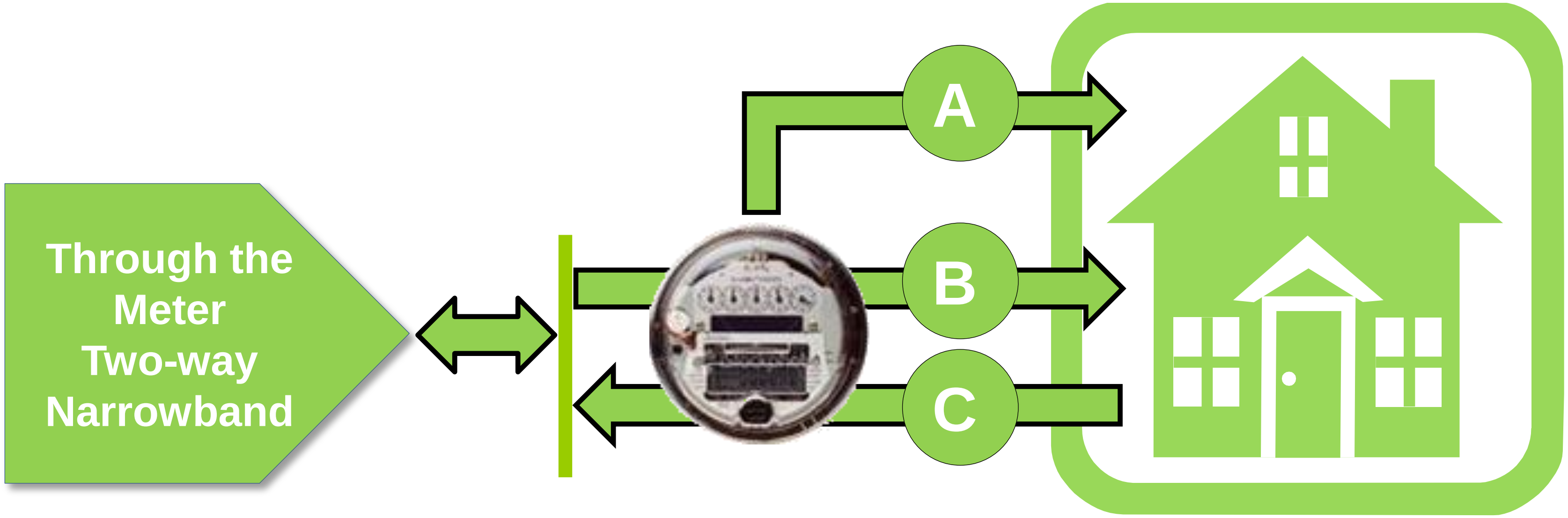
OpenADR 2.0 specifications
- Products, commercialization
- **International standards** (IEC)

Certification/Testing (v2.0)

Communication Standards Development:

1. Research and development
2. Pilots and field trials
3. Standards development
4. Conformance and interoperability

	Function	Source	Application
A	Provide real-time meter data (kW, kWh)	Meter	In-home display
B	Provide price, reliability, and event signals	Utility	In-home display; Demand response
C	Retrieve device IDs, settings, event overrides	Consumer devices	Demand response; Tech support

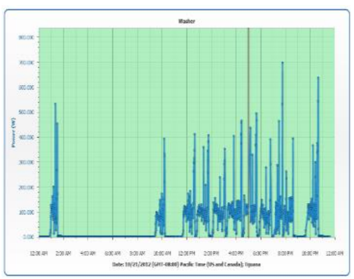


Thermostats and Plug Load Meters

- Sub-metering of the attached device or appliance at 10second frequency
- Remote on-off control
- The SmartPlug supports 110 Volt and 15 Amp or less

- **Demonstrate DR capabilities using OpenADR enabled Wi-Fi Thermostats**
- **OpenADR client and logic native to the device**
- **DR events triggered with OpenADR 1.0 Servers AutoGrid DROMS or Akuacom DRAS.**

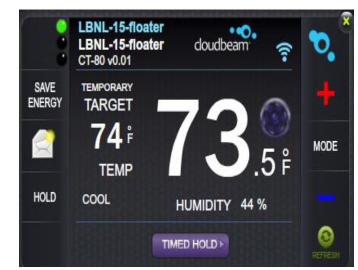
Smart Plug



Historical Energy Analytics

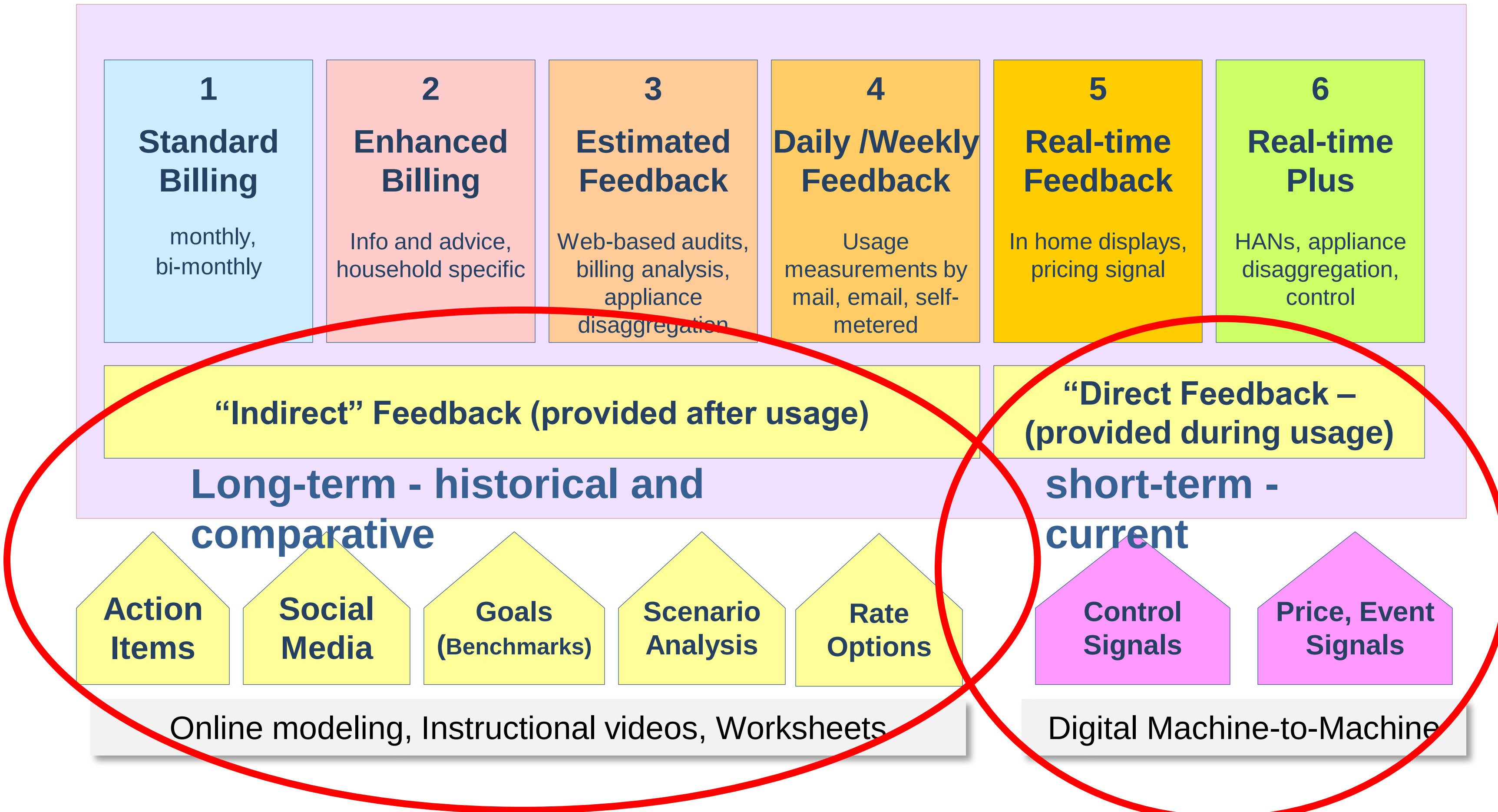
Web based Monitoring/Control

Programmable Communicating Thermostats



Web based Monitoring/Control

EPRI Study on Energy Data Feedback Delivery Mechanism Spectrum [5]



Source: EPRI

Title 24 - SECTION 120.2 –CONTROLS FOR SPACE-CONDITIONING SYSTEMS

(h) Automatic Demand Shed Controls.

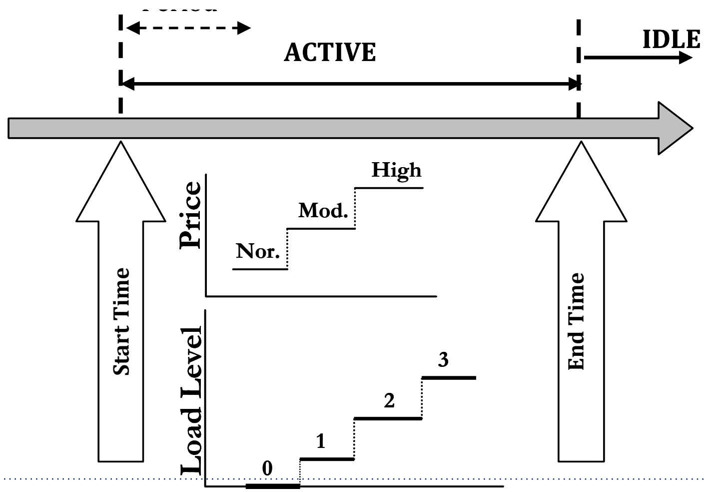
DDC to Zone level be programmed to allow centralized demand shed for non-critical zones:

Controls have capability to

- **remotely setup cooling temp by 4 F or more in non-critical zones with EMCS**

Controls require following features:

- **Manual control. Manual control by authorized facility operators to allow adjustment of heating and cooling set points globally from a single point in the EMCS; and**
- **Automatic Demand Shed Control. Upon receipt of a DR signal, space-conditioning systems conduct a centralized demand shed, as specified in Sections 120.2(h)1 and 120.2(h)2.**



Occupant Controlled Smart Thermostat in Title 24

OCSTs are self-certified by manufacturer to Energy Commission to meet T24. Spec focuses on 3 interfaces:

Communications, User Display and HVAC System Interface

Appendix JA5.2.3.1 Price Signals

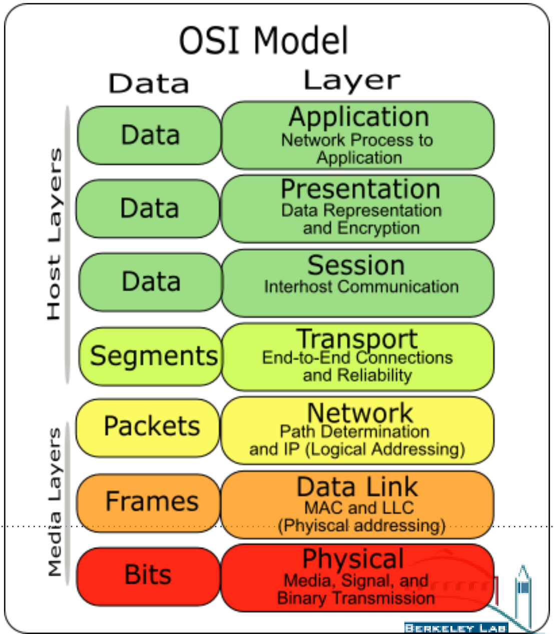
Price signals allow utility or entity to send a signal or message to occupant's OCST to provide pricing info to occupant and initiate DR Control for DR Period utilizing a DR Signal.

JA5.2.3.2 Demand Response Periods

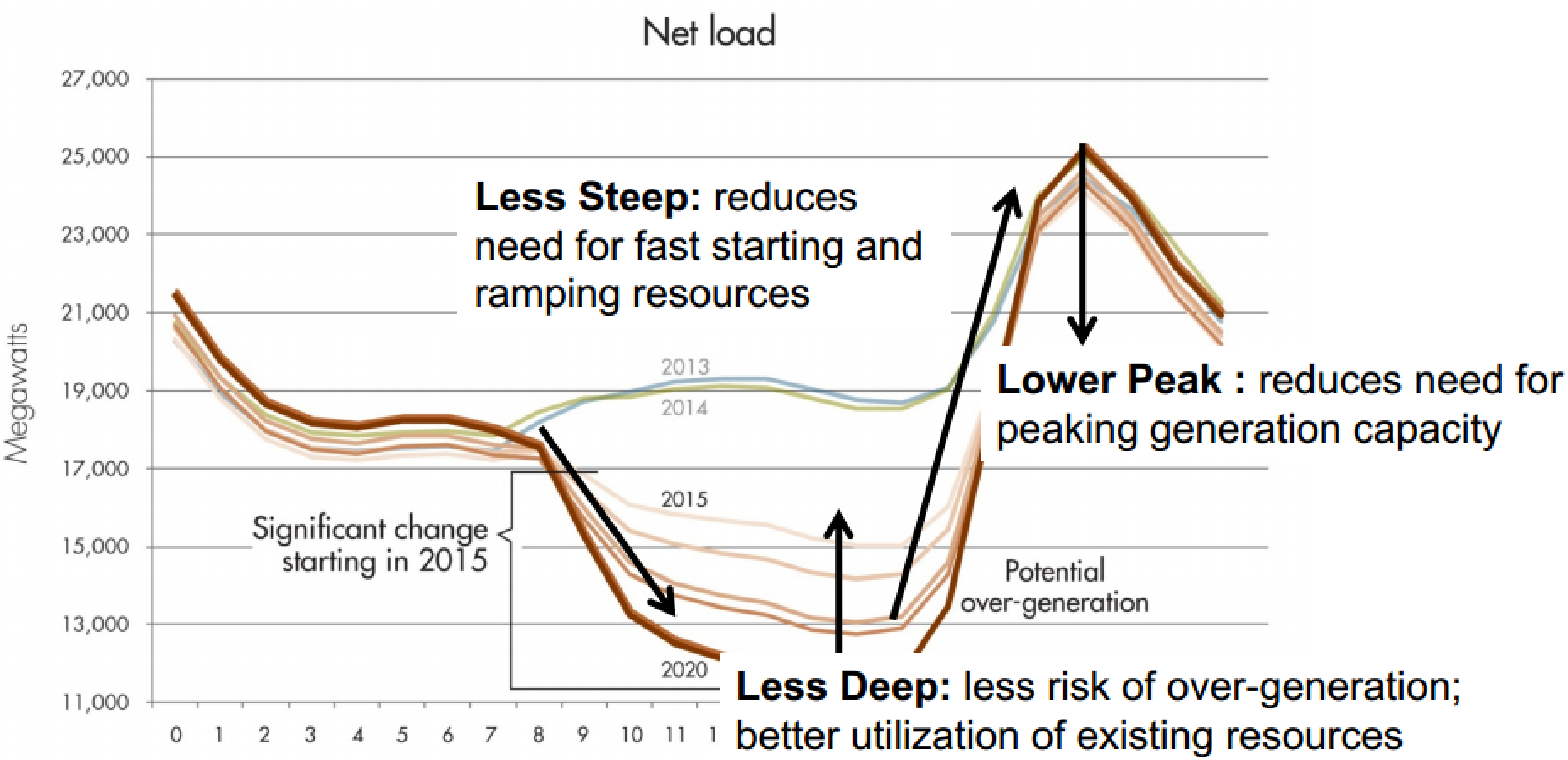
This event class allows utility to initiate DR Control for DR Period utilizing a DR Signal. Signal attributes shall be specified within messaging protocol.

Messaging Protocols in CEC List are Apples and Oranges

ZigBee Wireless Mesh
BACnet MSTP
ANSI 709.1
OpenADR 2.0
Enocean Wireless Protocol



Renewables and Managing the "Duck" Curve



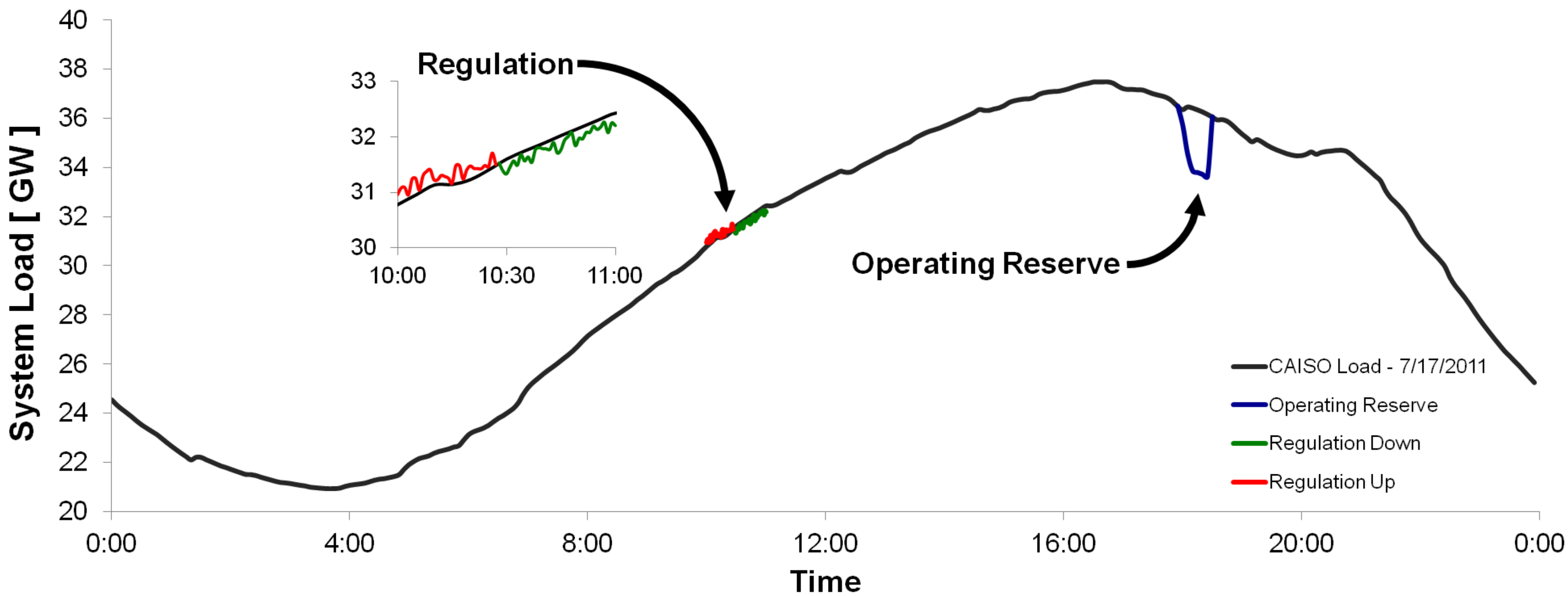
Note, this curve is being updated, it is used here to represent how we should look at what we are trying to accomplish

Source: Sanders, H., "CEC IEPR Demand Response Workshop", June 17, 2013, slide 3.

New Markets for Responsive Loads

Product		Physical Requirements			
Product Type	**General Description**	**How fast to respond**	**Length of response**	**Time to respond**	**How often called**
Regulation	Response to random unscheduled deviations in scheduled net load	30 sec	Energy neutral in 15 min	5 min	Continuous w/in specified bid period
Flexibility	Load following reserve for un-forecasted wind/solar ramps	5 min	1 hr	20 min	Continuous w/in specified bid period
Contingency	Rapid & immediate response to supply loss	1 min	≤ 30 min	≤ 10 min	≤ Once/day
Energy	Shed or shift energy consumption over time	5 min	≥ 1 hr	10 min	1-2 x/day & 4-8 hr notification
Capacity	Ability to serve as an alternative to generation	Top 20 hrs coincident w/balancing authority peak			

Ancillary Services



Operating Reserves respond when a contingency event occurs to restore balance.

- respond within 10 minutes
- event duration typically 10-30 minutes
- Includes Synchronous and Non-Synchronous

Regulation rectifies small discrepancies between load and 5-minute real time dispatch

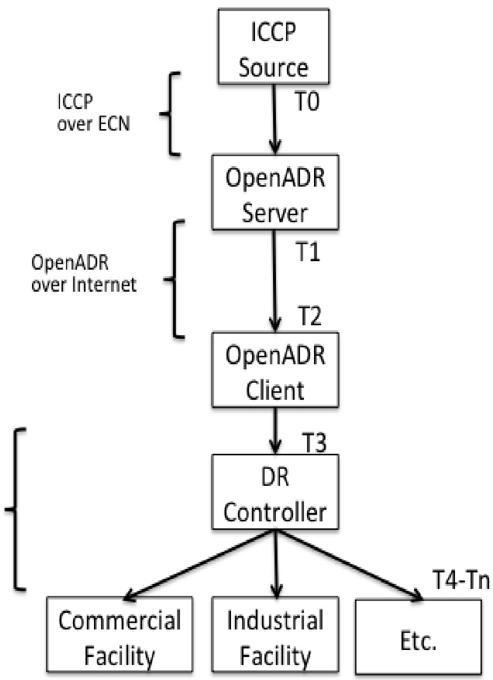
- Receives operating point instruction and responds within 4 sec
- Energy neutral, although not in practice

Using Demand-side Resources for Grid Reliability with DR and Microgrids

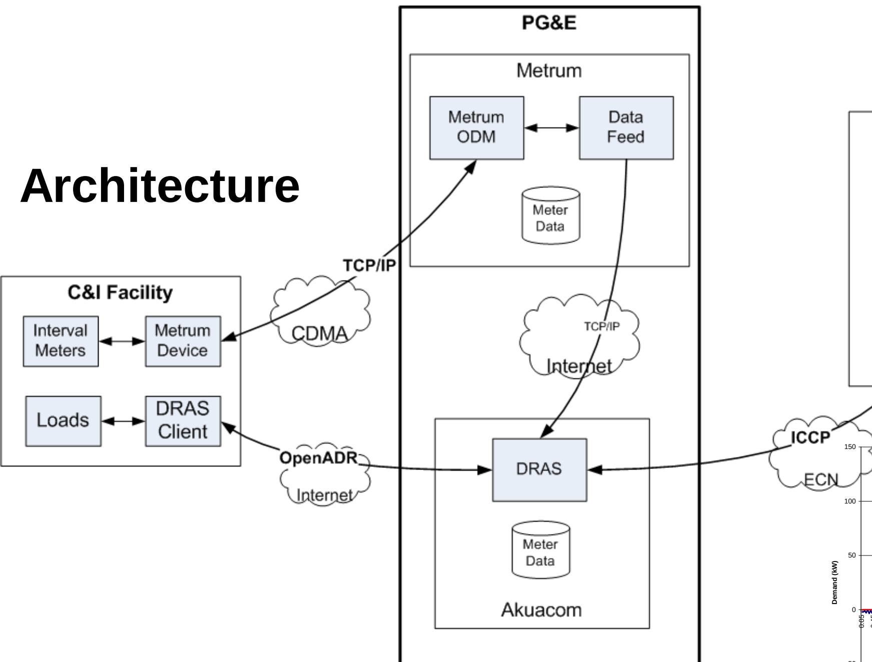
Fast DR – Evaluating how loads can act like generators

- Development of communication, control and telemetry requirements
- Understanding markets and market participation rules
- Research concepts supported with field tests

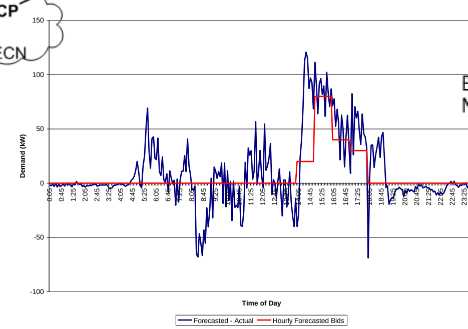
Communication Latency



Architecture



Loads



Summary

Key Issues

- Demand Response is Growing Around US
- Growing capabilities of buildings to provide services to the electric grid
- New telemetry and control systems provide low cost automation
- Large need to education facility managers
- Economics are challenges for bill savings

Acknowledgements / Sponsors –

California Energy Commission, US DOE, Bonneville Power Administration, PG&E, SCE