NASEO-NARUC Grid-Interactive Efficient Buildings (GEB) Working Group

April 10, 2019   1:30 pm EDT

Welcome and NASEO-NARUC GEB Working Group

- ***Rodney Sobin**, NASEO, Senior Program Director*

Grid-Interactive Efficient Buildings Overview

- ***Monica Neukomm**, Buildings Technology Office, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy*

Overview of R&D Related to Grid-Interactive Efficient Buildings and Automated Demand Response

- ***Mary Ann Piette**, Senior Scientist and Director of the Building Technology and Urban Systems Division, Lawrence Berkeley National Laboratory*

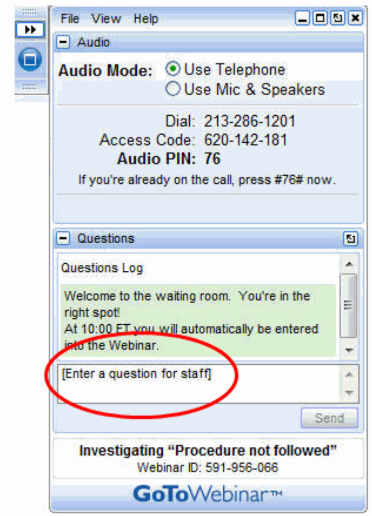
Q&A

NASEO Grid-Interactive Efficient Buildings (GEB) Initiative

April 10, 2019 1:30 pm EDT

Logistics:

- All attendees are muted.
- Please use the GoToWebinar question box to ask questions.
- Webinar recording and slides will be posted.
  - Access via NASEO webpage (www.naseo.org); go to "EVENTS," then "Past Webinars"



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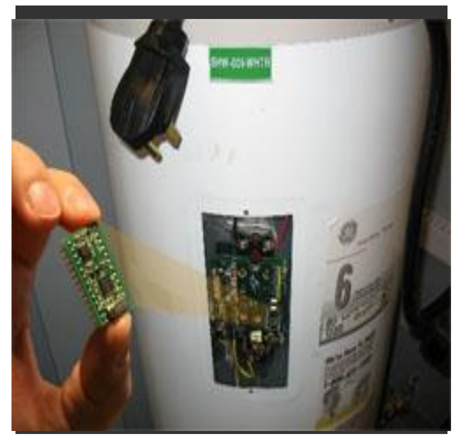
NASEO-NARUC Grid-Interactive Efficient Buildings Working Group

NASEO
National Association of State Energy Officials

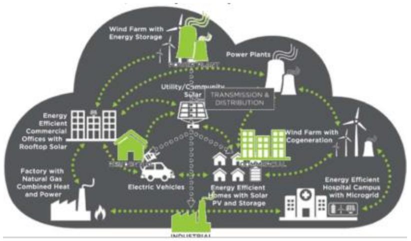


Rodney Sobin
Senior Program Director
National Association of State Energy Officials

NASEO-NARUC GEB Working Group:
GEB and Automated Demand Response Webinar
April 10, 2019

NASEO-NARUC Grid-Interactive Efficient Buildings Working Group

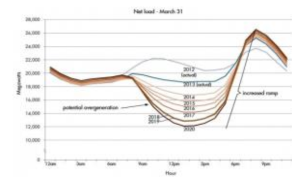
- Advancing technologies open opportunities for more flexible building/facility load management:
  - Reduce costs, enhance resilience, reduce emissions
  - Reduce peaks, moderate ramp rates, provide grid services
  - Enhance energy efficiency
  - Integrate distributed and renewable resources



- **How can we optimize facility interactions with the grid?**
- **How can states fashion policies, programs, and regulations to advance such optimization through GEB?**

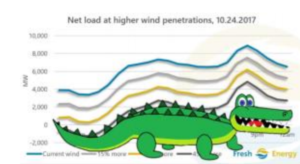
NASEO-NARUC Grid-Interactive Efficient Buildings Working Group

- NASEO-NARUC GEB Working Group



  - Supported by DOE BTO
  - Inform states about GEB technologies and applications
  - Identify opportunities and impediments
    - Non-technical and technical
  - Identify and express state priorities, concerns, interests
  - Recognize temporal and locational value of EE and other DERs
  - Enhance energy system reliability, resilience, and affordability

  - **Inform state planning, policy, regulations, and programs**



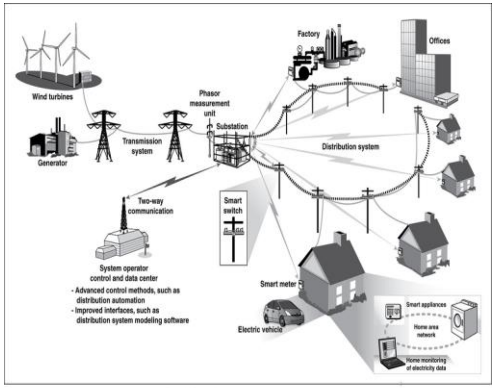
    - Advance potential roadmaps and pilots

+ NASEO-NARUC Grid-Interactive Efficient Buildings Working Group

- NASEO-NARUC GEB Working Group
  - Webinar series—available to all states
  - Briefing papers planned
    - Non-technical and technical considerations
  - Working Group state engagement
    - State specific calls
    - Topical calls and exchanges
    - Workshop
  - Scoping of model GEB road mapping kit
    - Help states to explore GEB in their state contexts
  - Scoping potential state pilots
    - Inform development of pilots to explore priority issues

NASEO-NARUC Grid-Interactive Efficient Buildings Working Group

- Potential National Laboratory help for Working Group states
  - Scope potential pilots, roadmaps
    - Outline elements, questions, considerations for GEB pilot projects
    - Support state convenings, research, technical consultations
    - Identify policy and regulatory options to facilitate GEB pilots/demonstration
    - May lead to policy and regulatory pilots
    - May lead to physical pilots/demonstrations



Source: GAO analysis.

NASEO-NARUC Grid-Interactive Efficient Buildings Working Group

- Working Group co-chairs:
  - Kaci Radcliffe, Oregon Dept. of Energy
  - Hanna Terwilliger, Minnesota PUC staff
- Working Group states:

Colorado	New Jersey
Connecticut	New York
Florida	Oregon
Hawaii	South Carolina
Massachusetts	Tennessee
Michigan	Wisconsin
Minnesota	

Grid-Interactive Efficient Buildings

Resources

- DOE GEB page https://www.energy.gov/eere/buildings/grid-interactive-efficient-buildings

- 2018 NASEO Annual Meeting (Detroit) https://annualmeeting.naseo.org/agenda
  - Grid-Interactive Efficient Buildings: Energy Efficiency & Grid Optimization - David Nemtzow (U.S. DOE)
  - What's Next for Energy Efficiency: Grid Interaction - Chris Baker (The Weidt Group)
  - Grid Interactive Efficient Buildings - Jan Berman (PG&E)
  - Smart Neighborhood - James Leverette (Southern Co.)

- 2019 NASEO Energy Policy Outlook Conference https://energyoutlook.naseo.org/pre-conference-meetings
  - Grid-interactive Efficient Buildings - David Nemtzow
  - Buildings-to-Grid: Critical Issues for Decision Makers - Natalie Mims Frick

+ NASEO-NARUC Grid-Interactive Efficient Buildings Working Group

Questions/inquiries:

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Danielle Sass Byrnett dbyrnett@naruc.org

U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Grid-interactive Efficient Buildings

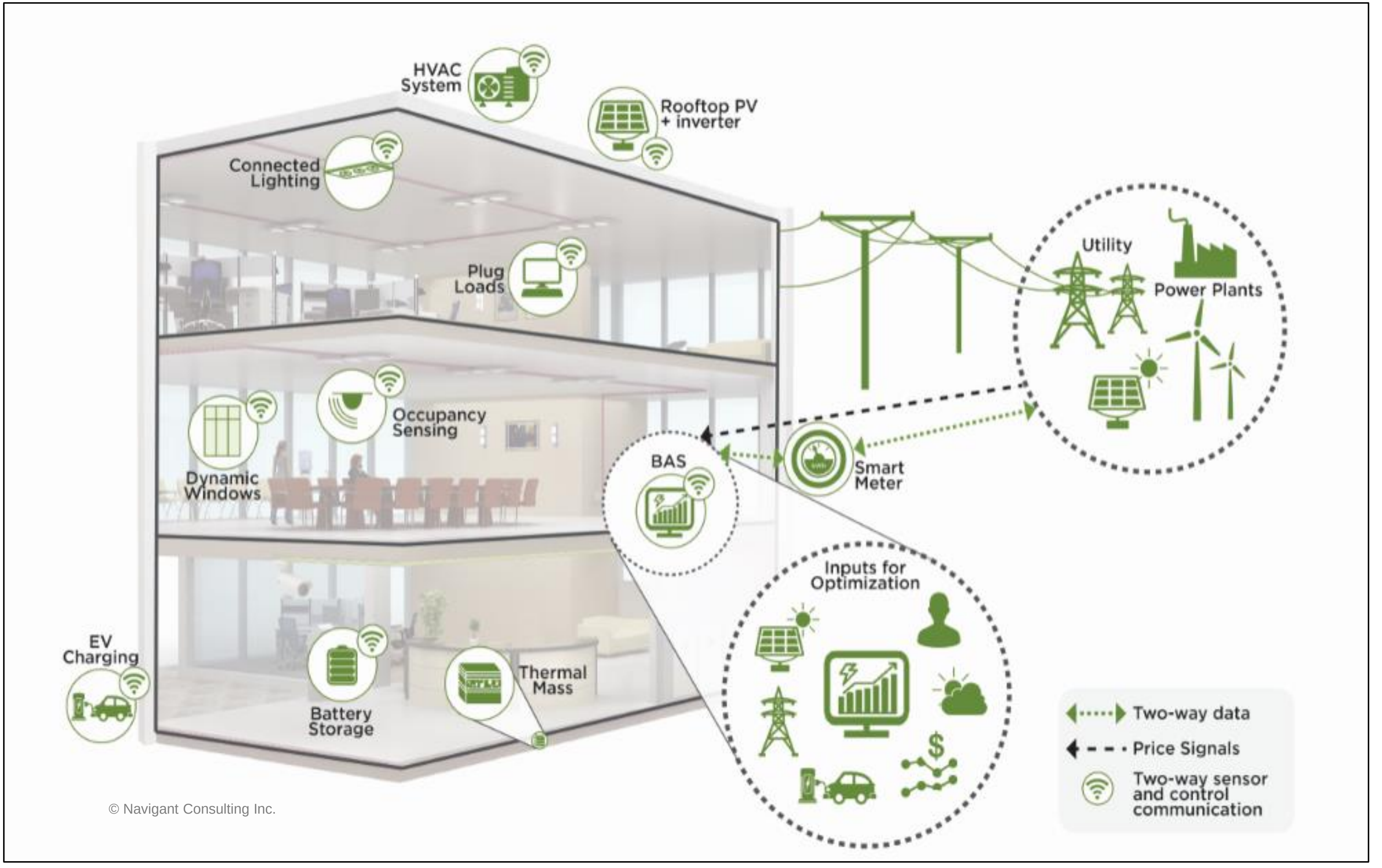
NASEO-NARUC GEB Working Group

Monica Neukomm

Building Technologies Office, DOE

www.energy.gov/eere/buildings/geb

Grid-interactive Efficient Building



Key Characteristics of GEB

EFFICIENT

Persistent low energy use minimizes demand on grid resources and infrastructure

CONNECTED

Two-way communication with flexible technologies, the grid, and occupants

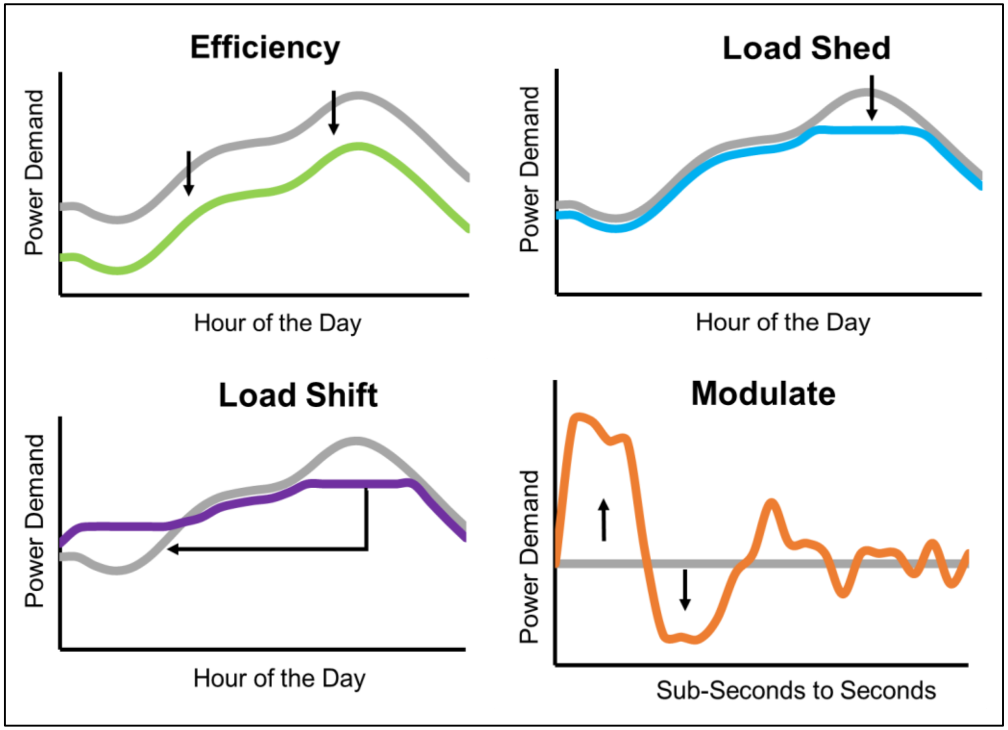
SMART

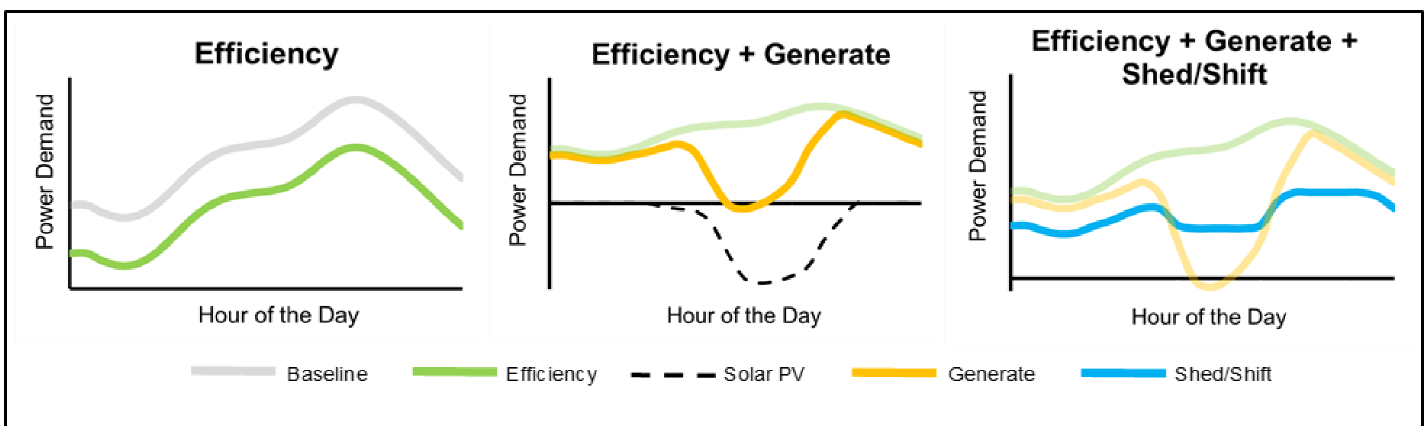
Analytics supported by sensors and controls co-optimize efficiency, flexibility, and occupant preferences

FLEXIBLE

Flexible loads and distributed generation/storage can be used to reduce, shift, or modulate energy use

Demand Flexibility Provided by GEB





Demand Flexibility from a Building Owner's Perspective

Flexibility Mode	Load Change Characteristics	Example Measure	Example Requirements for Grid Services
Efficiency	Install technologies that provide ongoing reduction in the annual energy use	Building has insulated, tight envelope and efficient HVAC system to reduce heating/cooling needs.	The building must sustain reduced energy use, as verified by metered energy use data.
Shed Load	Building reduces demand for a short time period during peak demand or emergency events.	Building dims lighting system by a preset amount in response to grid signals while maintaining occupant visual comfort	To provide contingency reserves, the building must reduce a load within minutes of receiving a signal and may need to sustain load reduction for up to 1 hour.
Shift Load	Building changes the timing of energy use to minimize peak demand/ take advantage of renewable resources.	Connected water heaters pre-heat water during off-peak periods in response to grid signals.	To reduce peak capacity, the building must reduce load within minutes of receiving a signal and sustain for 2-4 hours.
Modulate Load	Building automatically increases /decreases power demand or reactive power in response to signals.	Batteries and inverters autonomously modulate power draw	To provide power support and ramping services, the building must modulate power within seconds/ sub-seconds and receive automatic control signals.
Generate	Building generates electricity to use onsite or to dispatch to the grid.	Rooftop solar PV dispatches electricity to the grid.	To reduce peak, the building must reduce load through generation and/or dispatch excess electricity with minutes of receiving a signal and sustain for 2-4 hours.

Benefits of Demand Flexibility

Benefit	Utility System	Building Owners/Occupants	Society
Reduced operation & maintenance costs	✓	-	-
Reduced generation capacity costs	✓	-	-
Reduced energy costs	✓	-	-
Reduced T&D costs	✓	-	-
Reduced T&D losses	✓	-	-
Reduced ancillary services costs	✓	-	-
Increased resilience	✓	✓	✓
Increased DER integration	✓	✓	-
Improved power quality	-	✓	-
Reduced customer utility bills	-	✓	-
Increased customer satisfaction	-	✓	-
Increased customer flexibility and choice	-	✓	-
Environmental benefits	-	-	✓

BTO's grid-interactive efficient buildings portfolio

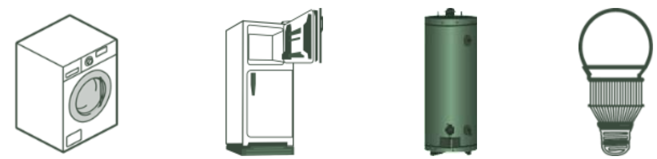
VALUATION

How do *time & the interaction of flexibility options* impact value?

Identify values to stakeholders, quantification of national value.

TECHNOLOGY OPTIONS

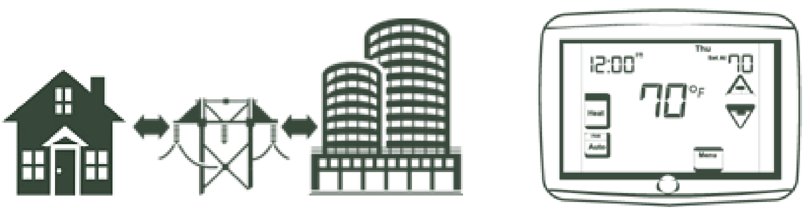
Which end use technologies provide solutions to specific grid needs?



Prioritize technologies / solutions based on grid services.

OPTIMIZATION

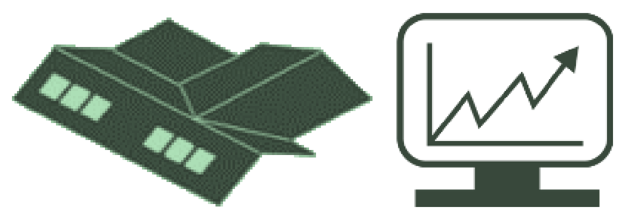
How to while maintaining or improving optimize for flexibility building operation?



Solutions that meet grid operator & building occupant needs.

VALIDATION

Do technologies perform as predicted and meet grid & occupant needs?



Verification of technologies / strategies, increasing confidence in the value of energy flexibility.

Relevant BTO projects

- **Publish report series establishing demand flexibility framework, evaluating technologies and assessing value and performance.**
  - **GEB Technical Report Series (April – August)**
  - **SEE Action GEB Series (July-November)**
- **Engage key stakeholder for ongoing feedback**
  - **ACEEE Utility working group**
  - **NASEO- NARUC working group**
  - **Better Buildings Renewable Integration Alliance**
- **Explore critical elements through numerous research and validation projects**
  - **GEB Potential Study**
  - **Metrics Framework**
  - **Occupant comfort**
  - **Standardization**

Overview of R&D Related to Grid Interactive Efficient Buildings and Automated Demand Response

NASEO-NARUC Grid-Interactive Efficient Buildings Working Group

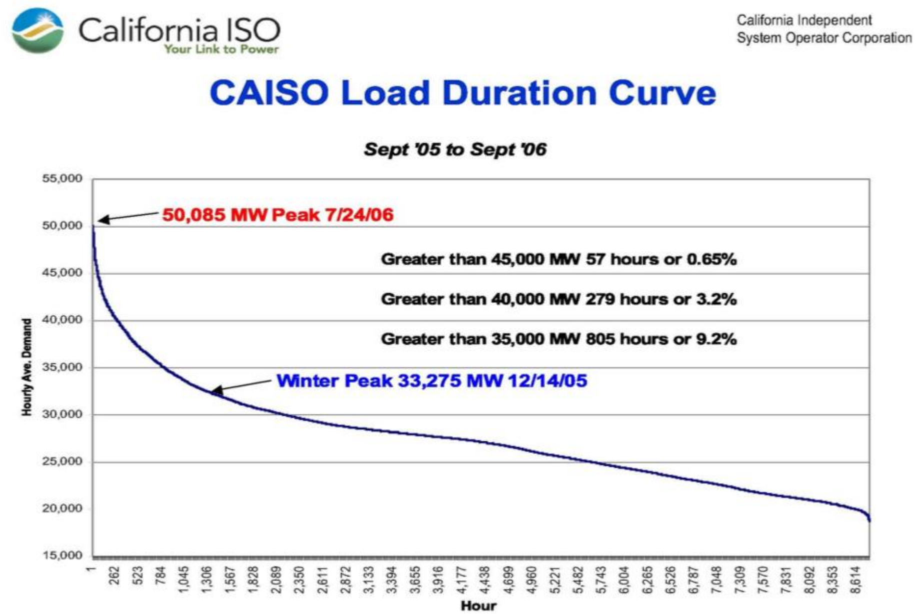
April 10, 2019 – Mary Ann Piette – Lawrence Berkeley National Laboratory

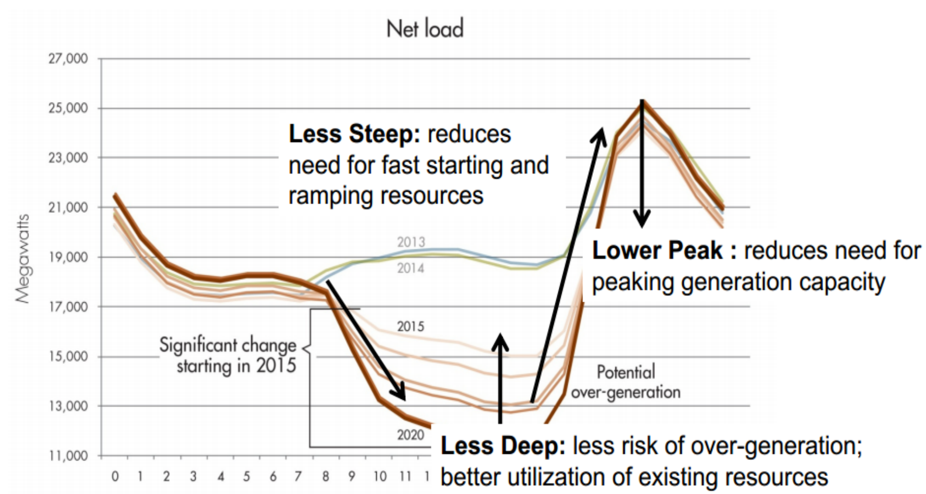
Presentation Outline

- The Need for Grid Services
- Development and Testing of DR Automation
- California DR Potential Study
- New DOE BTO Projects at LBNL
- SEE Action Report – State & Local Govt Opportunities for Grid-Interactive Efficient Buildings
- Summary and Future Directions

Challenges with the Grid

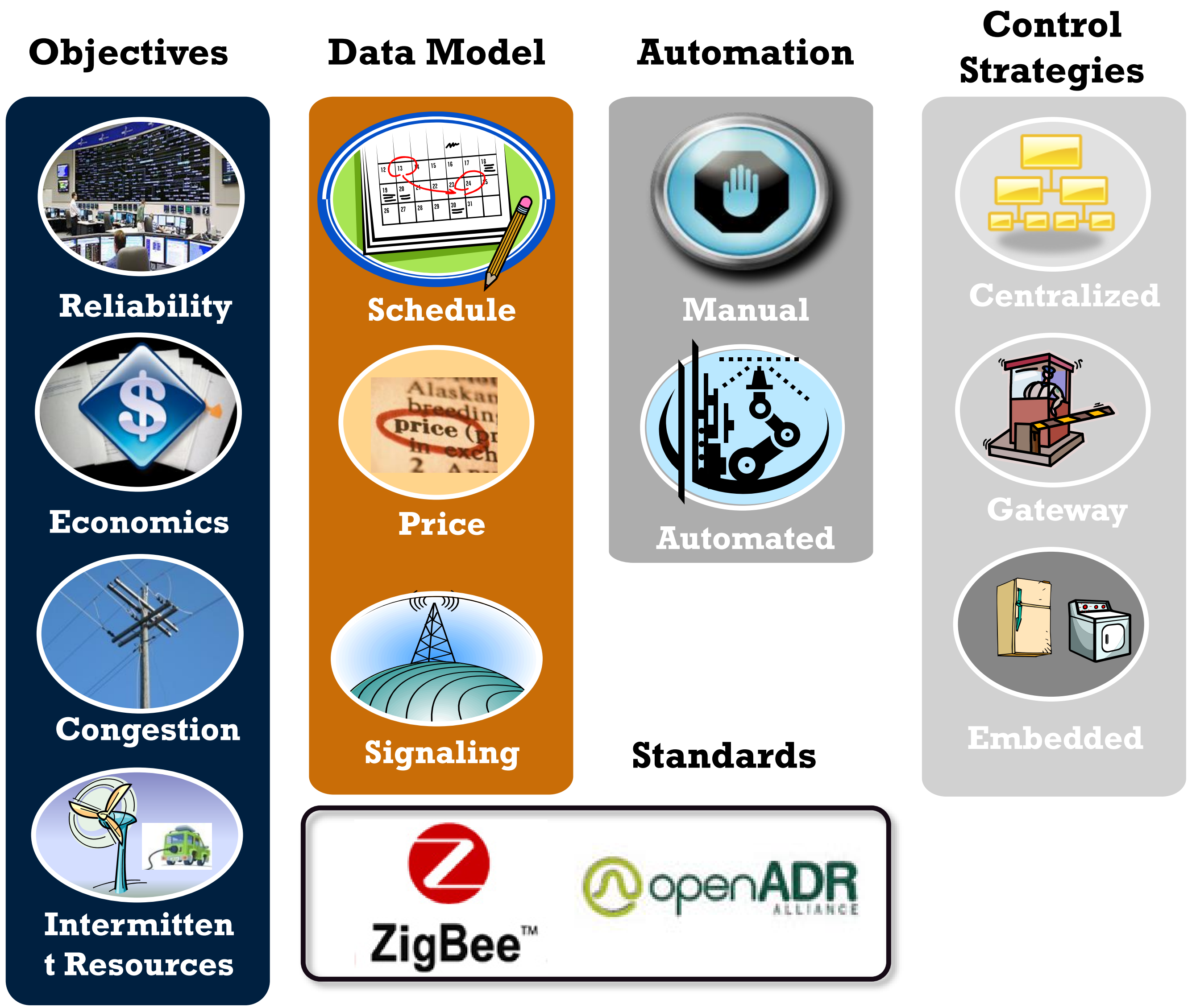
- Manage Peak Capacity During Hot Summer Days
- Improve Affordability of Electricity
- Improve Grid Reliability
- Enable More Renewables on Grid





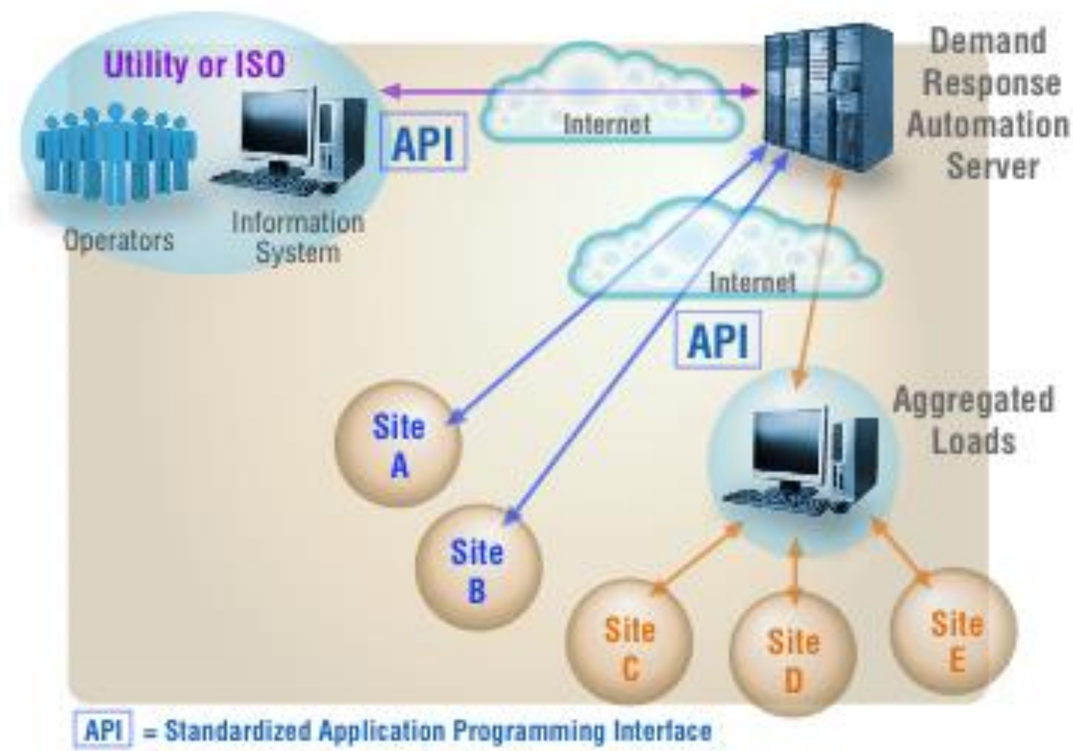
Note, this curve is being updated, it is used here to represent how we should look at what we are trying to accomplish

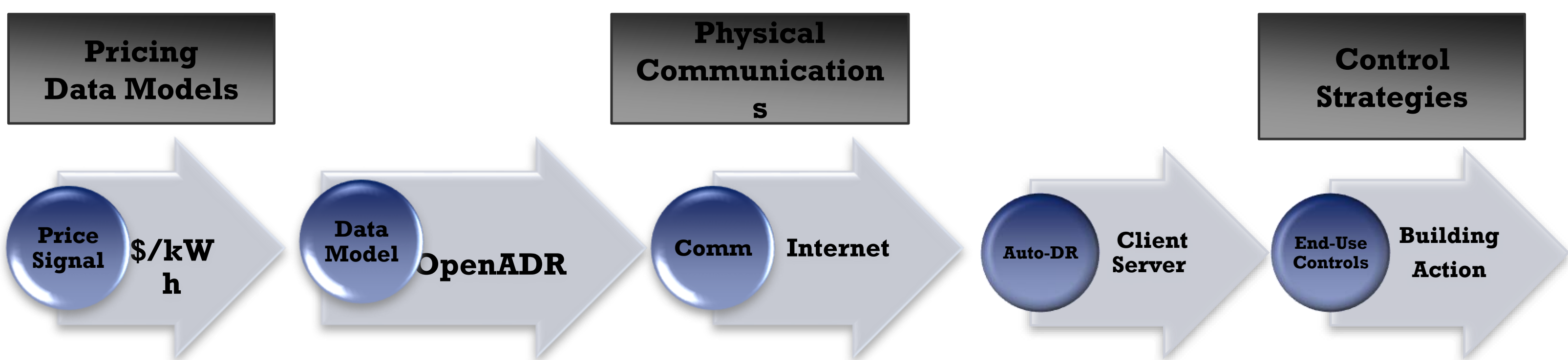
Motivation and Framework for Grid Services



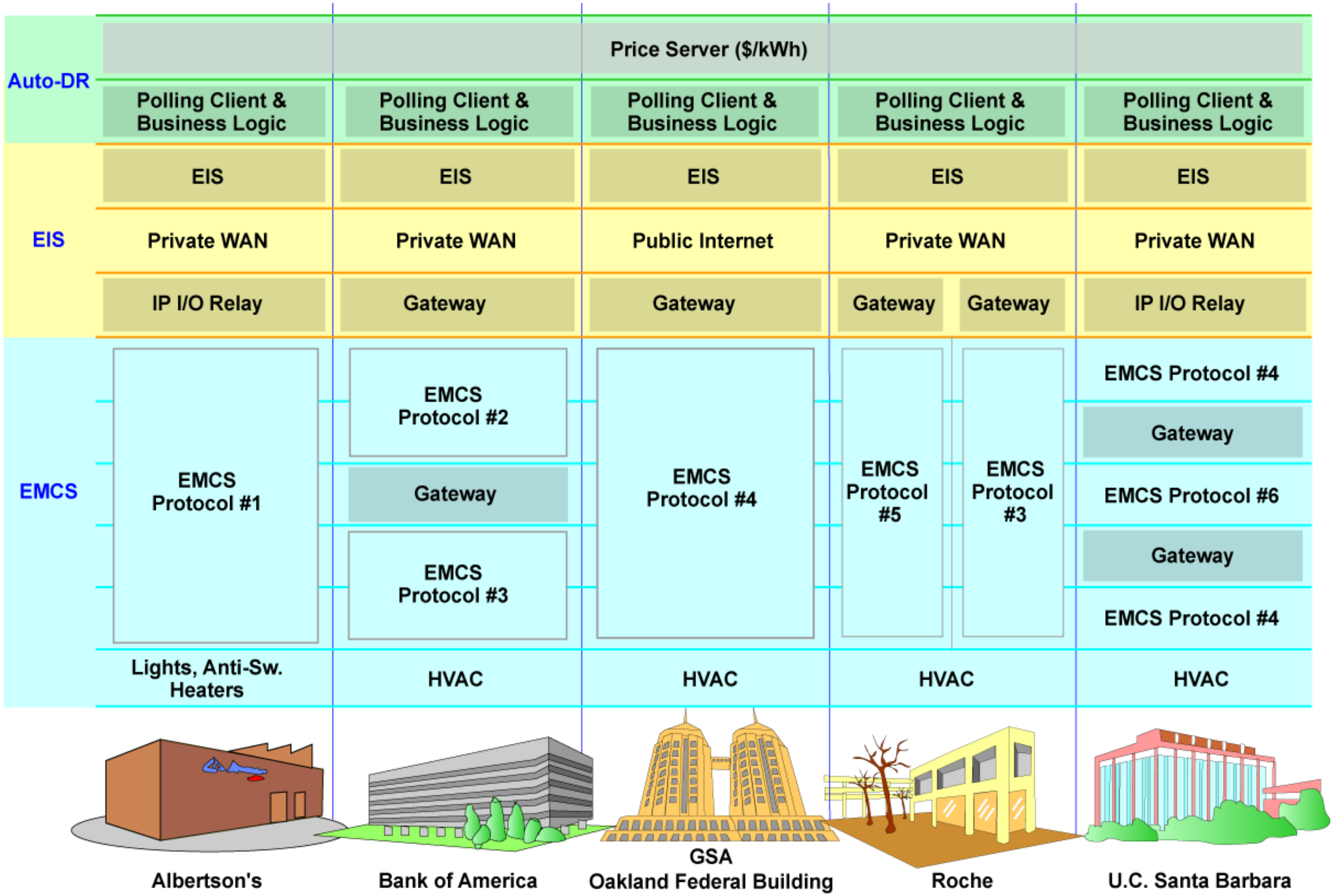
Open Automated Demand Response

- Open standardized DR interface
- Allows elec providers to communicate DR signals to customers
- Uses XML language and existing communications, Internet



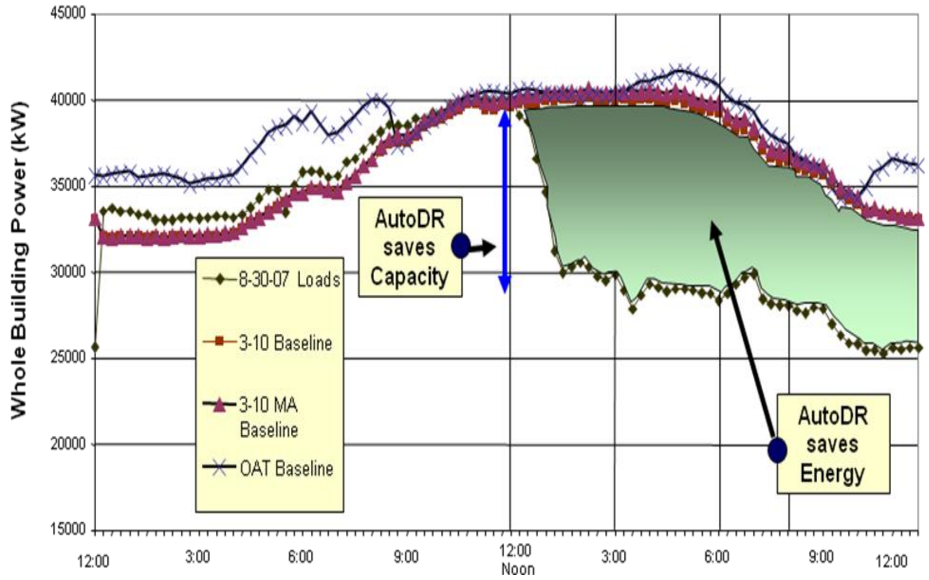


First 5 Auto-DR Tests - 2003

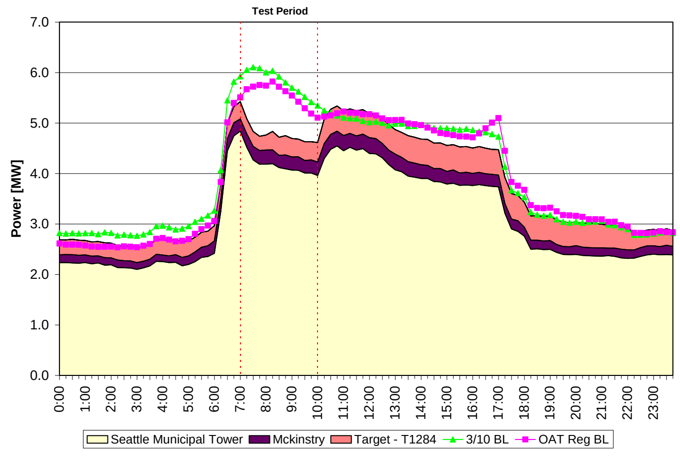


Historic focus on Seasonal Grid Stress

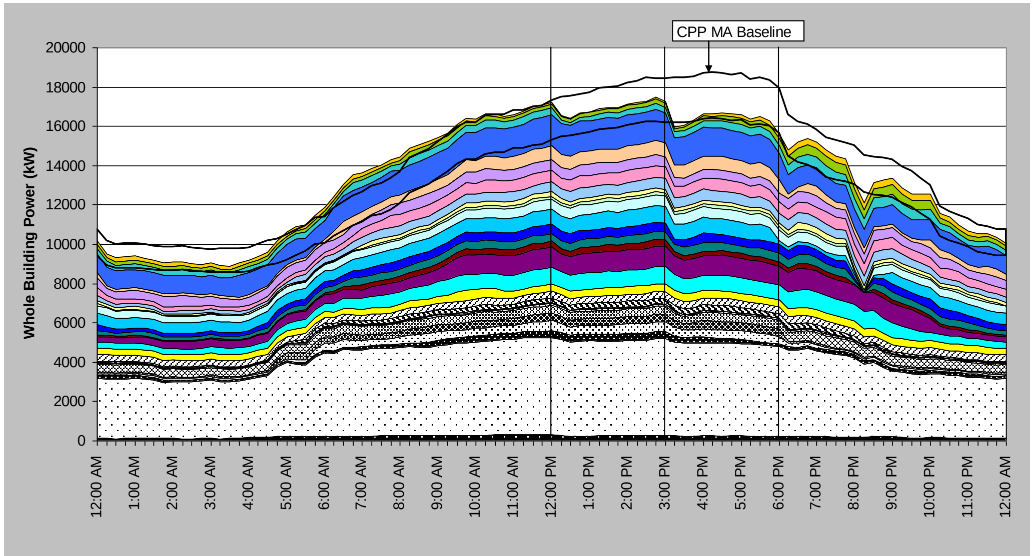
OpenADR PG&E Demand Bid Test Day



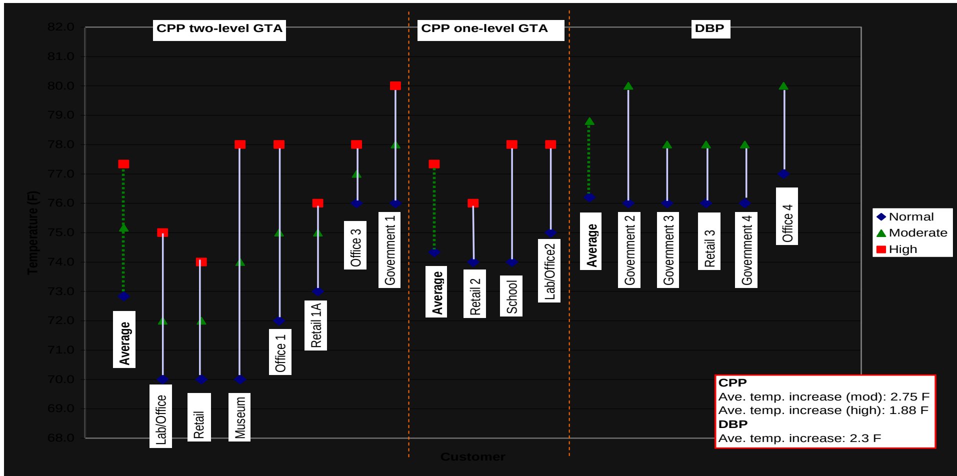
OpenADR Northwest Test on Cold Morning

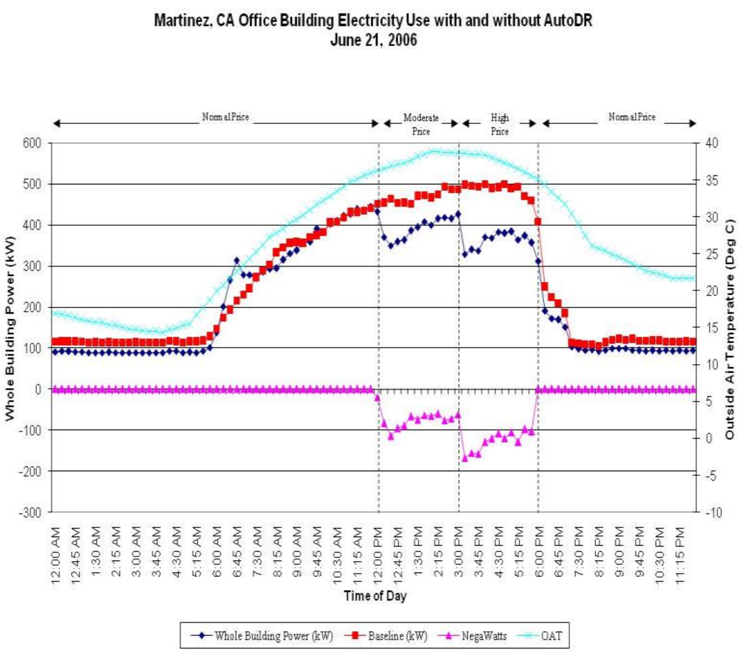


OpenADR Cumulative Shed



Control Strategies Evaluated in Previous Demos

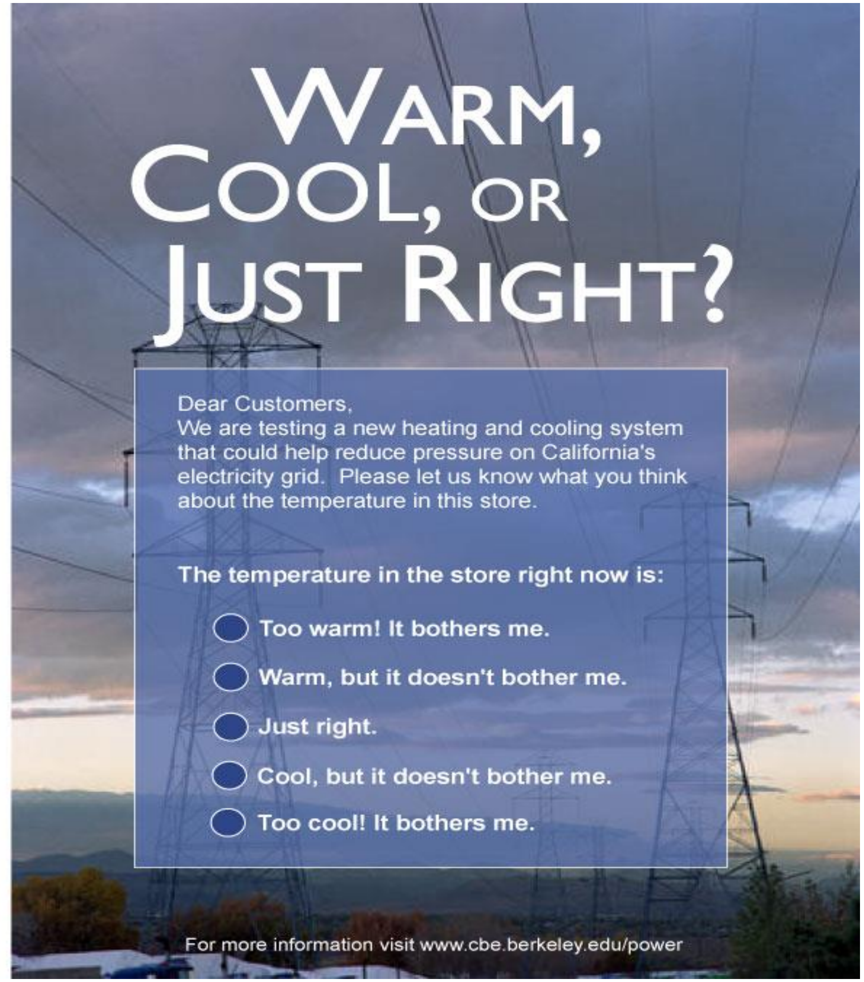




	Building use	HVAC											Lighting					Other
		Global temp. adjustment	Duct static pres. Increase	SAT Increase	Fan VFD limit	CHW temp. Increase	Fan qty. reduction	Pre-cooling	Cooling valve limit	Boiler lockout	Slow recovery	Extended shed period	Common area light dim	Office area light dim	Turn off light	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	

Demand Shifting with Thermal Mass

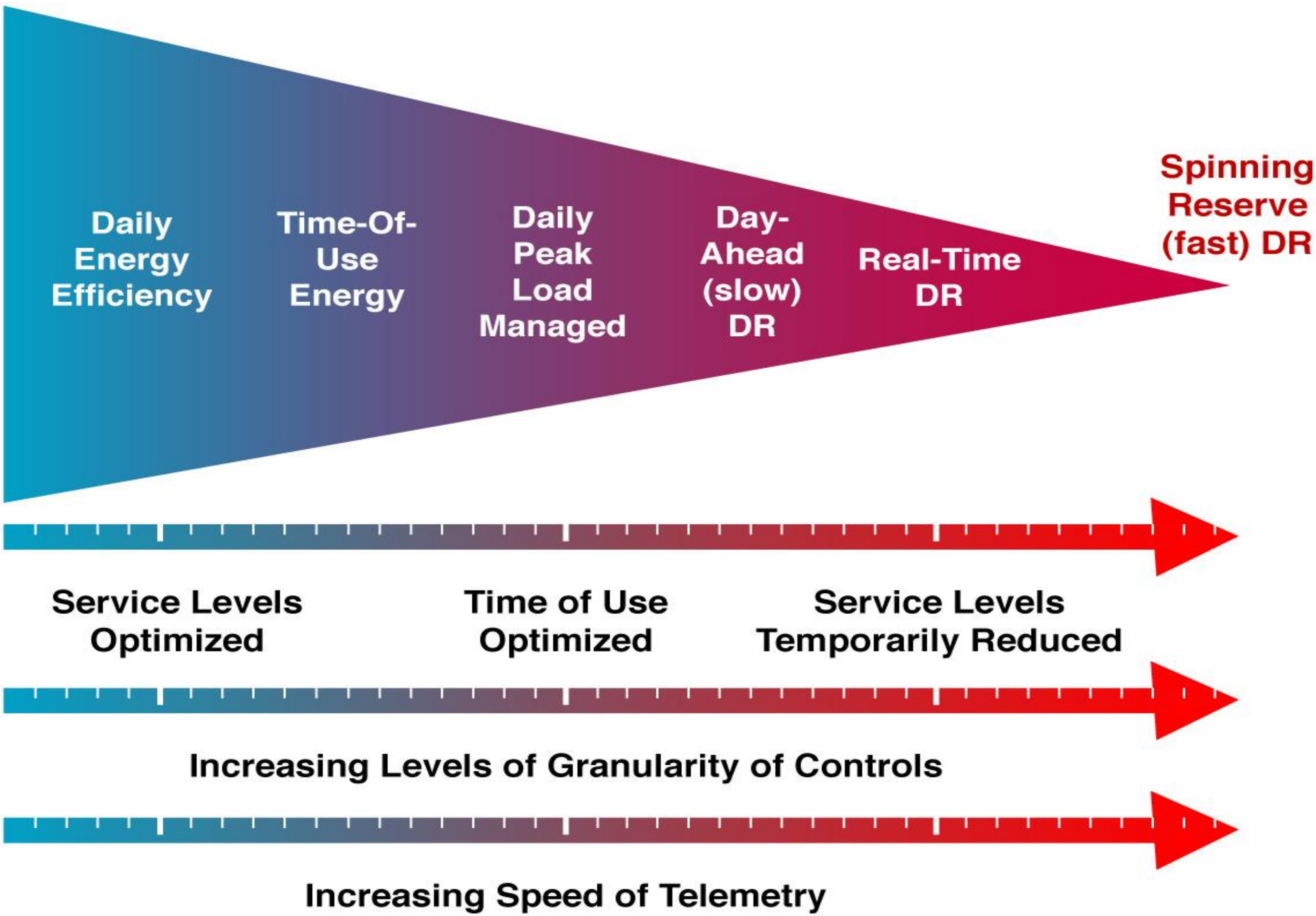
- **Goal** – evaluate demand shifting with mass
- **Past Work** –commercial building field studies
- **Results** –2003 Santa Rosa demo shifted afternoon chiller power (2 W/ft^2)



Concrete Floor

Thermal Capacity
~ 3 Watts-Hours/ft^3 - F

Linking Energy Efficiency and DR



History of OpenADR

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*

Fast DR Pilots

Over 250 MW automated in California

National outreach with USGBC

2002 to 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2018

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

EI 1.0 standards
- OpenADR profiles

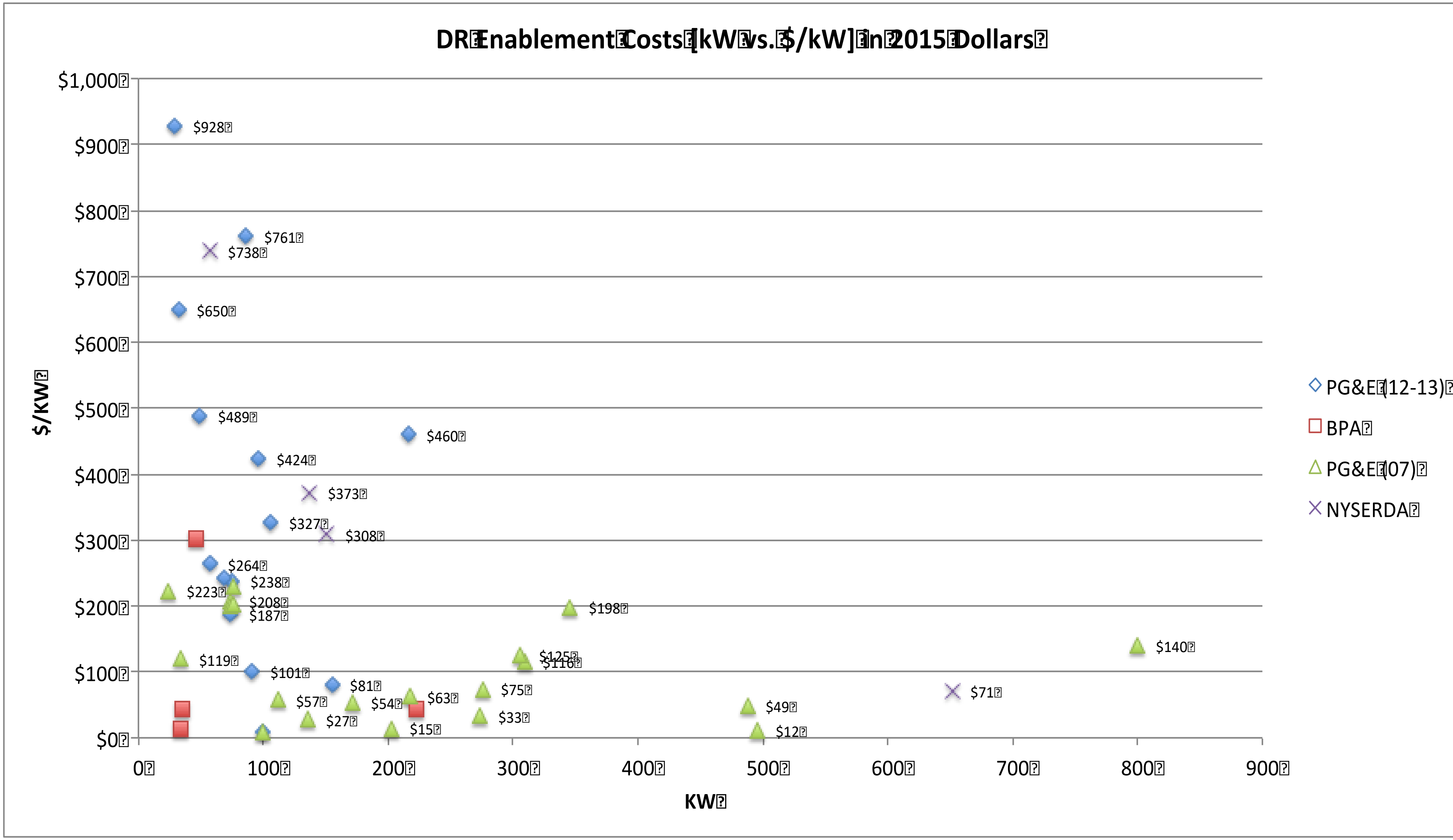
OpenADR 2.0 specification
- Products, commercialization

Certification/Testing (v2.0)

Chinese Standard Based on OpenADR Published in 2017

International Electrotechnical Committee – Nov 2018 - IEC TR 62746-2:2015 Systems interface between customer energy and power management system

Cost to Automate DR vs Power Reduction



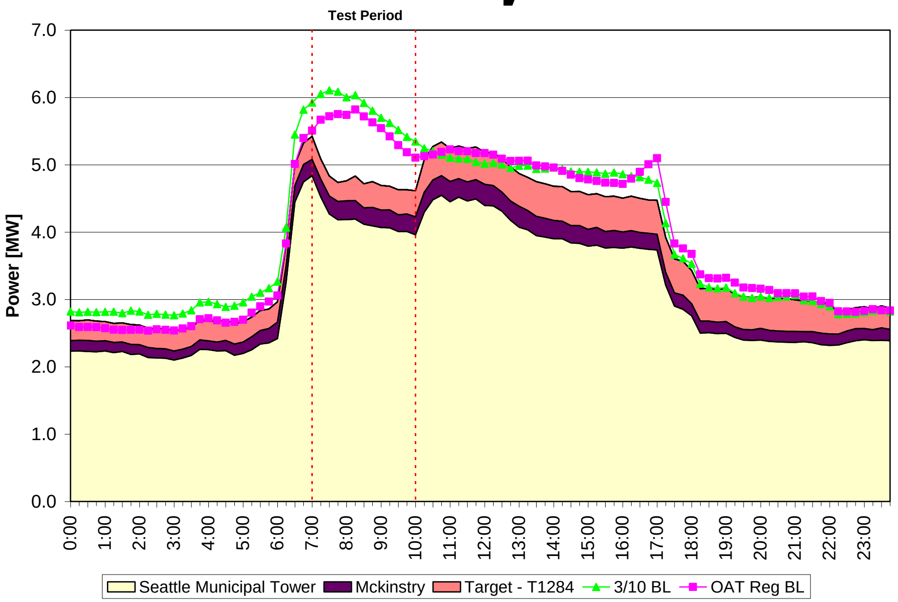
Note- Some projects include efficiency technology and not just DR systems

PG&E EE-DR Measures in 2012-2013

Facility	DR kW	Project Cost ($k)	ADR Incentive ($k)	Ratio of DR Incentive to project cost	$/kW	Measures	Options
College	57	16	20	1.00	288	EMS, duty cycles	EE&DR
Restaurant and Bar	75	29	26	0.90	389	EMS, duty cycles	EE&DR
Hotel	32	34	6	0.19	1063	Shut off ancillary plug load	EE&DR
Hotel	69	27	14	0.51	396	Shut off ancillary plug loads	EE&DR
Big Box	2003	721	701	0.97	360	EMS, duty cycles	EE&DR
Office	264	2,032	94	0.05	7698	Duty cycles, turn off & dim lights, reset temp setpoints	EE&DR
Cinema	49	26	17	0.66	533	EMS, duty cycles	EE&DR
Shopping Mall	106	37	37	0.98	357	EMS, duty cycles	EE&DR
Office	216	163	77	0.46	753	EMS, duty cycles	EE&DR
Office	86	107	30	0.28	1246	EMS, duty cycles	EE&DR
Family Bowl	32	11	11	0.98	356	EMS, duty cycles	EE&DR

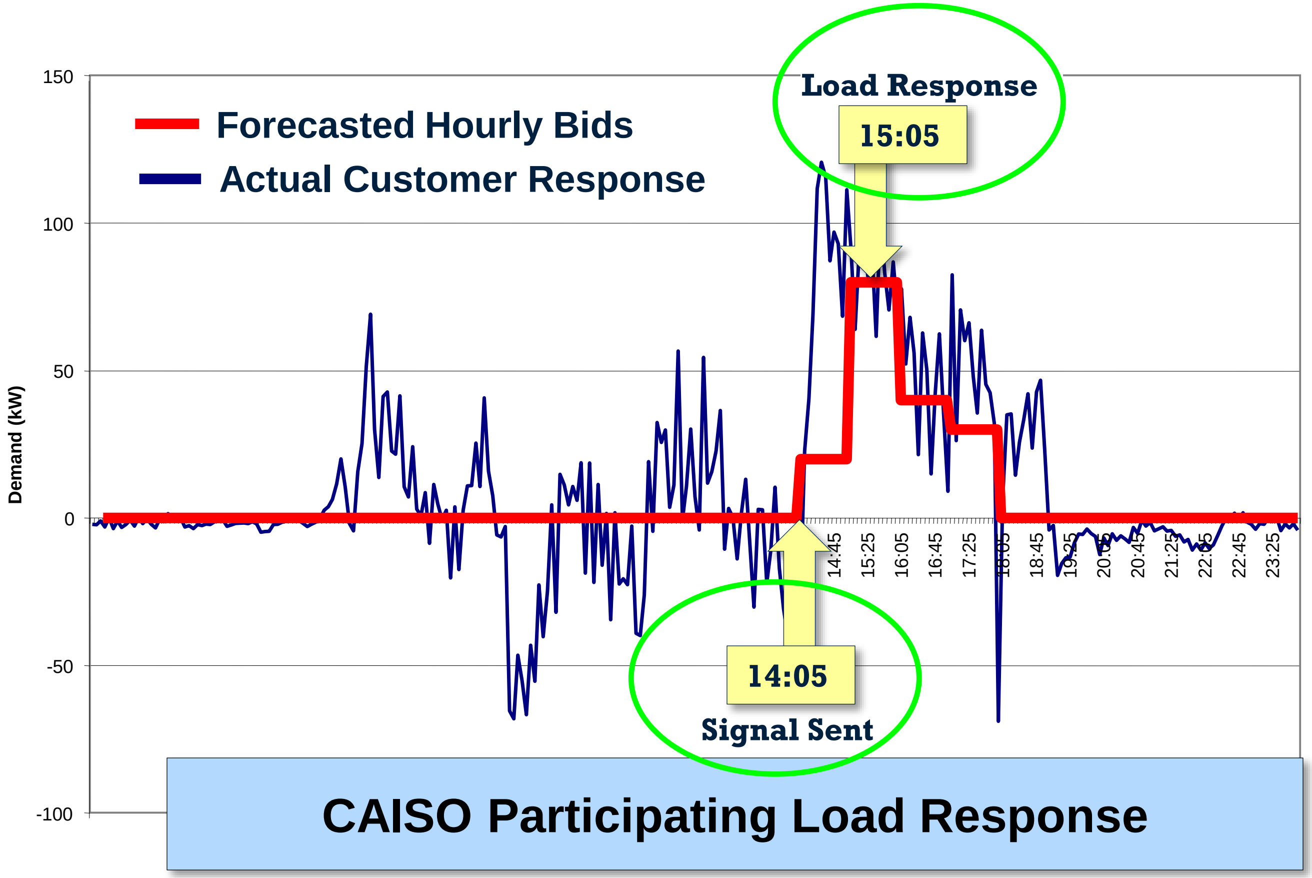
5 Grid Service Studies Beyond Hot Summer Days

- **Cold mornings for winter peak regions (Seattle)**
- **Non-spin reserve ancillary services (No. Cal)**
- **Regulation ancillary services (No. Cal)**
- **Economic dispatch - integrated price signals (NY NY)**
- **Fast telemetry for small commercial (No. Cal.)**



	HVAC													Lighting					Other		
Site	Global temp. adjustment	Duct static pres. decrease	SAT decrease	Fan VFD limit	RTU Shut off	Duty Cycling RTUs	Pre-heating	Pre-cooling	Fan-coil unit off	Cycle electric heaters	Cycle AHU Fans	Cycle VAVs	Set up CO2 Setpoints	Common area light dim	Office area light dim	Turn off light	Dimmable ballast	Bi-level switching	Non-critical process shed	Elevator cycling	Slow Recovery
McKinstry	S					W		S								S					W
Target - T1284	WS				WS													WS			
Seattle Municiple Tower	WS										W	W									WS
Seattle University	WS					W	W	S		W	W	W	W								W

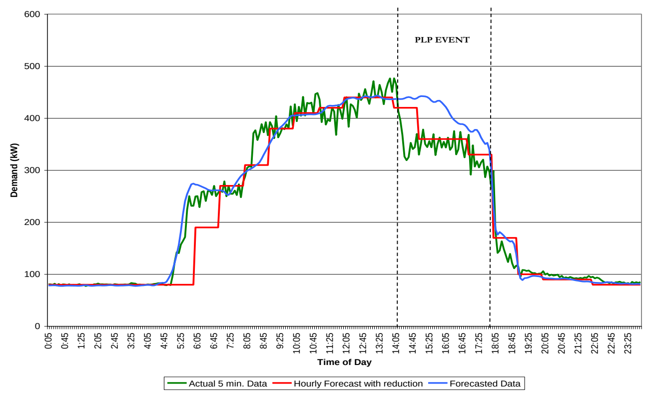
OpenADR with Ancillary Services

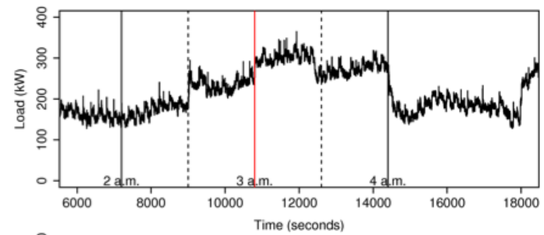


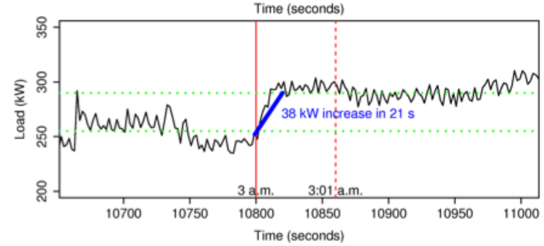
Forecasted vs Actual Ramp Time (MW/ min)	Forecasted vs. Actual Average Hourly Shed (kW)			
	HE 15:00	HE 16:00	HE 17:00	HE 18:00
0.002/ 0.006	20 / 72	80 / 86	40 / 51	30 / 49

Fast DR in Commercial Buildings

- **Buildings can provide ramping**
- **- Costs will be lower if used in many DR programs**
- **- How often can load be called?**

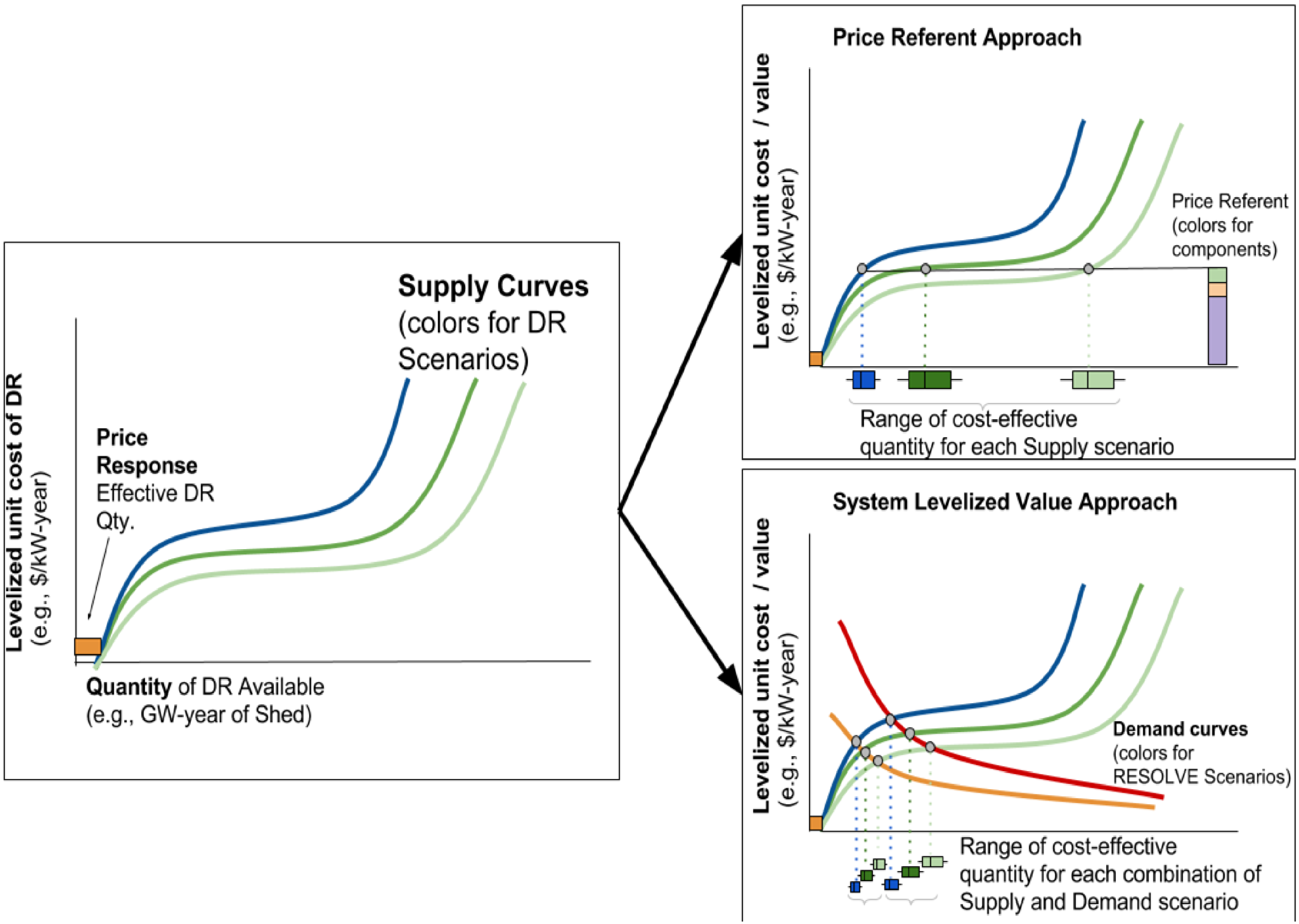




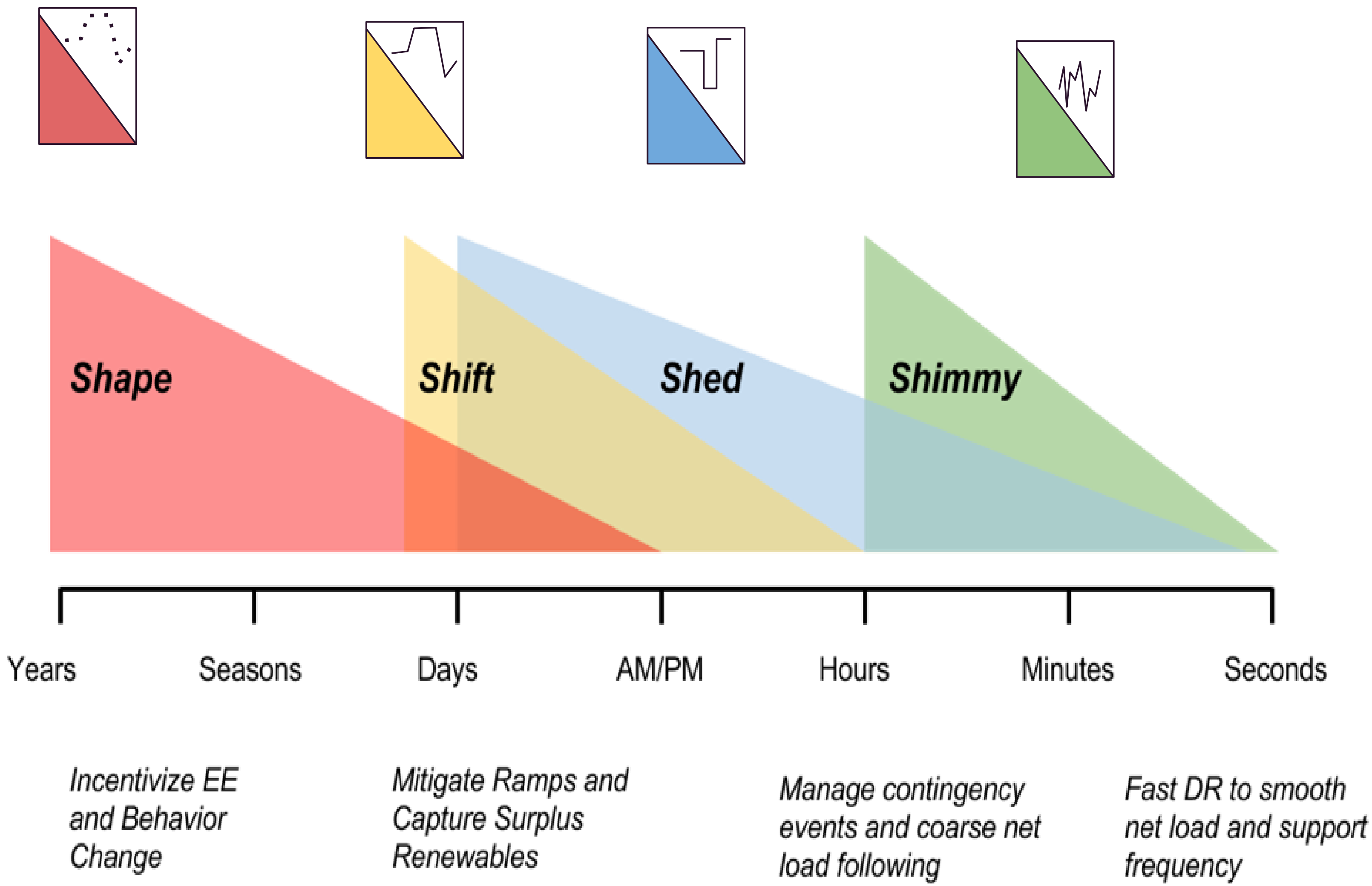


Site	Available Capacity (MW)	Min. Operating Limit (MW)	Max. Operating Limit (MW)	Ramp Rate (MW/min.)
UC Merced	0.16	0	0.17	Reg up: 0.022 Reg down: 0.022
West Hill Farms	0.03	0	0.16	Reg up/down:0.03
SMCC	0.2	0	0.2	Reg up: 0.05 Reg down_1: 0.066 Reg down_2: 0.134

California DR Potential Study - 2 Reference Methods



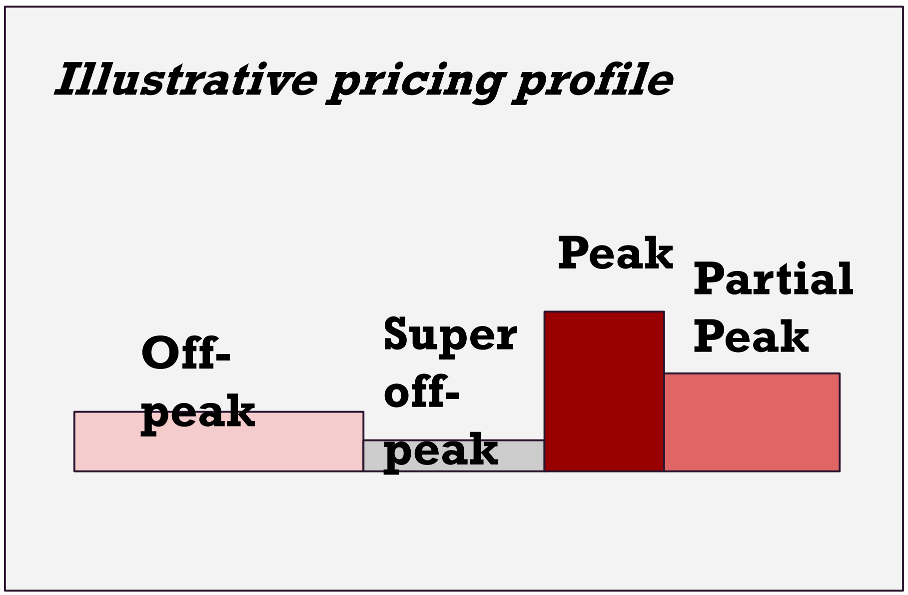
California DR Potential Study Evaluated Four DR Grid Needs

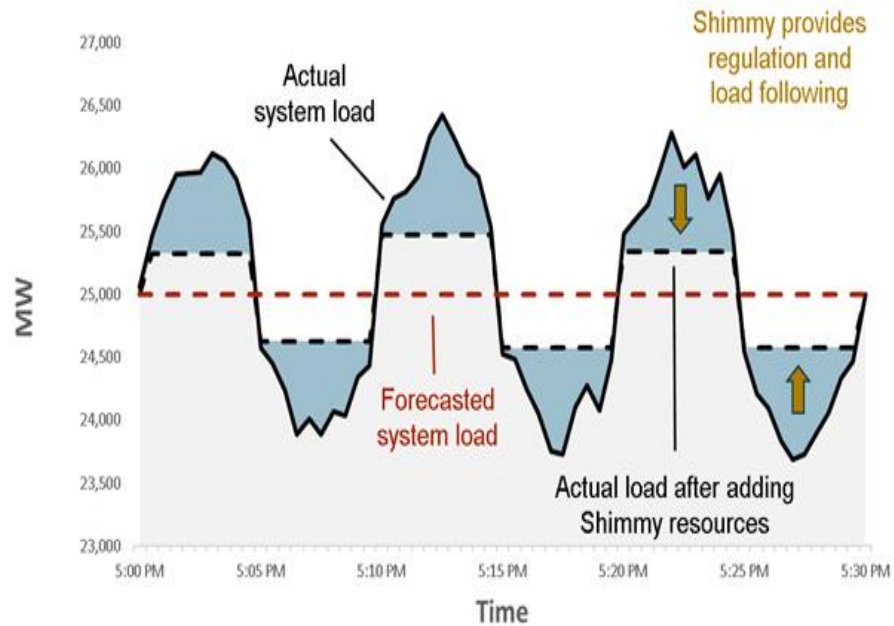


Shape and Shimmy

Shape Service Type as modeled: Accomplishes Shed & Shift with prices & behavioral DR.

Shimmy Service Type: Load Following & Regulation DR



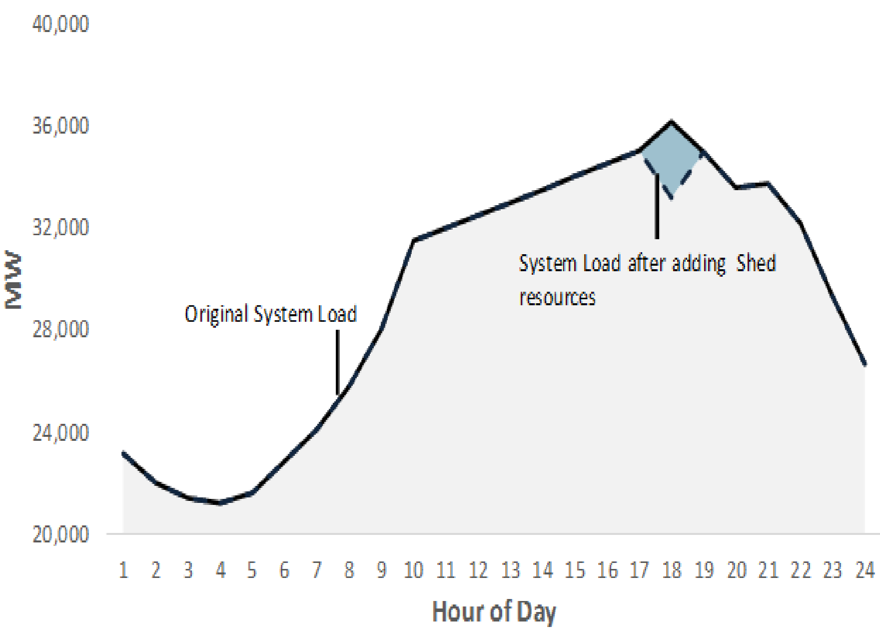


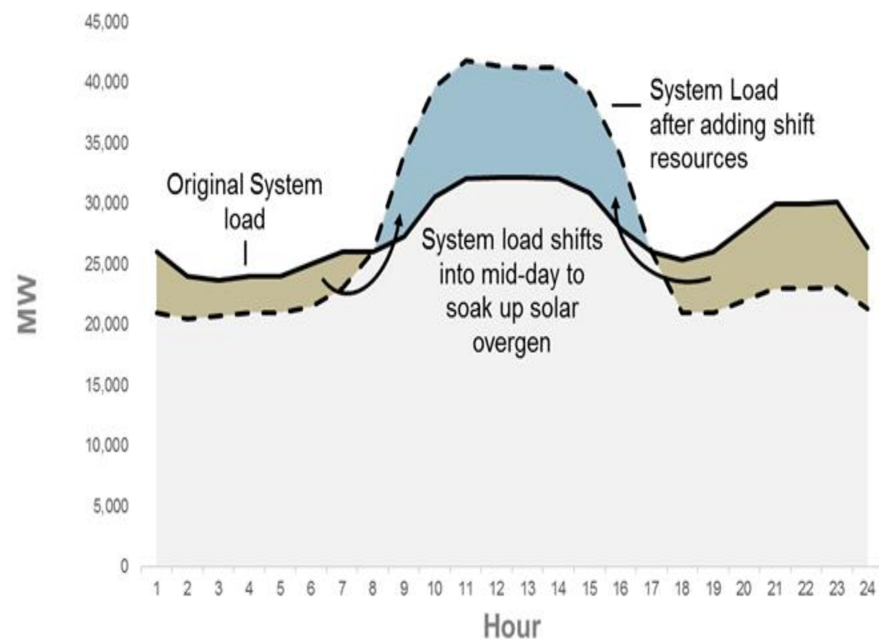
Energy+Environmental Economics

Shed and Shift

Shed Service Type: Peak Shed DR

Shift Service Type: Shifting load from hour to hour to alleviate curtailment/ overgeneration





Energy+Environmental Economics

Methodology

LBNL-Load - IOU-provided load (~220,000 customers) & demographic data (~11 million customers) in 3,500 "clusters," based on similarities. Load profiles for total & end use-specific clusters. Forecasts to 2025.

DR-Path - DR pathways based on load shape and forecasts from LBNL-Load. Pathways represent future DR supply potential, given assumptions on technology adoption, participation & cost for existing & emerging technologies.

E3's Renewable Energy Solutions (RESOLVE) estimates set of benchmarks for each DR type based on avoided investment & operation costs when DR is available. Evaluated for low & high renewable energy curtailment levels.

End Uses and Enabling Technologies

Sector	End Use	Enabling Technology Summary
All	Battery-electric and plug-in hybrid vehicles	Level 1 and Level 2 charging interruption
	Behind-the-meter batteries	Automated DR (Auto-DR)
Residential	Air conditioning	Direct load control (DLC) and Smart communicating thermostats (Smart T-Stats)
	Pool pumps	DLC
Commercial	HVAC	Depending on site size, energy management system Auto-DR, DLC, and/or Smart T-Stats
	Lighting	A range of luminaire-level, zonal and standard control options
	Refrigerated warehouses	Auto-DR
Industrial	Processes and large facilities	Automated and manual load shedding and process interruption
	Agricultural pumping	Manual, DLC, and Auto-DR
	Data centers	Manual DR
	Wastewater treatment and pumping	Automated and manual DR

Phase 2 DR Quantity Findings:
By 2025, Medium DR Scenario Suggests...

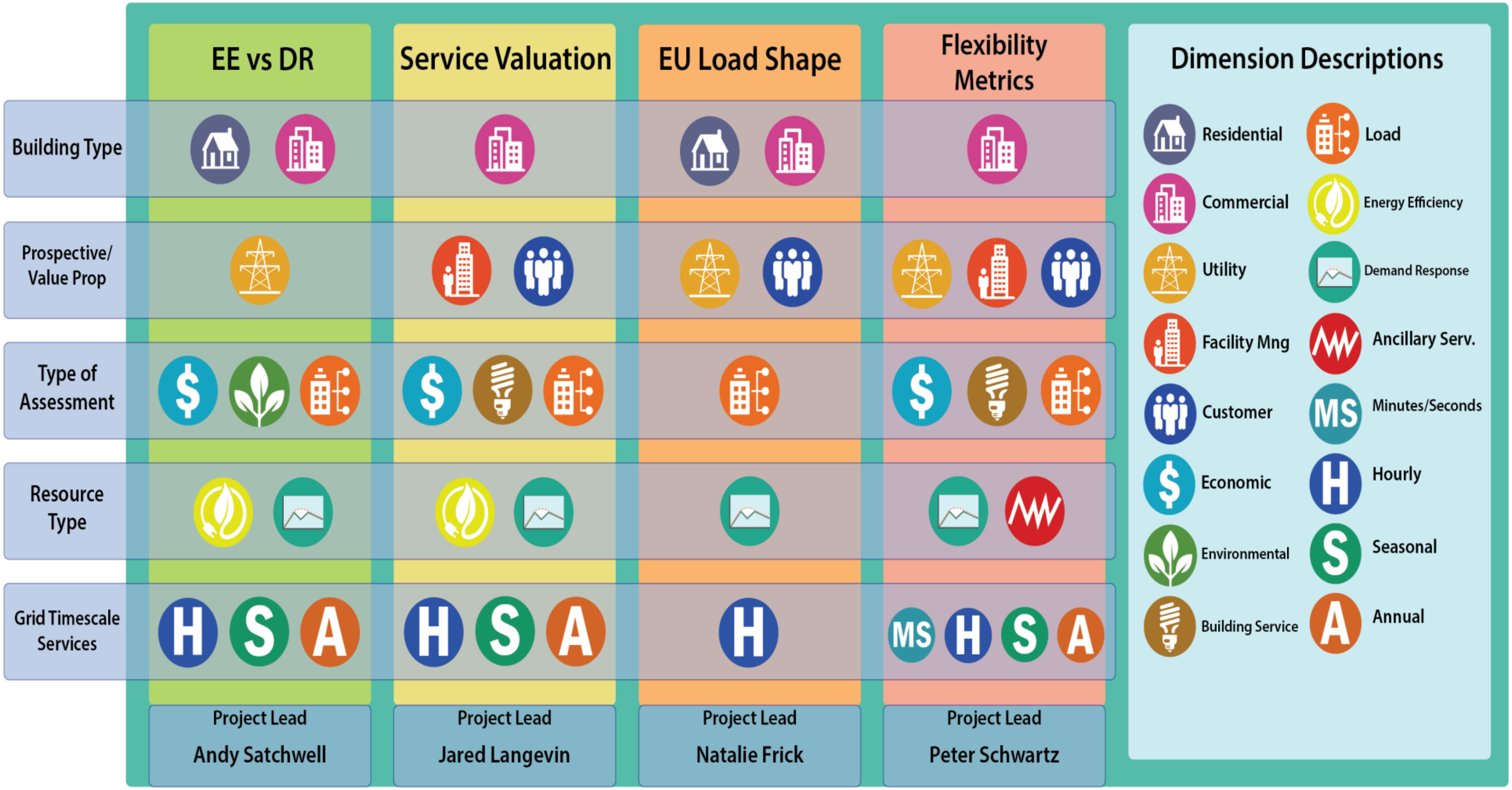
Shape: **Conventional TOU / CPP rates effectively provide 1 GW Shed & 2 GWh Shift at ~zero cost. Deeper potential?**

Shed: **Generation overbuild means ~zero need for system-level shed, but 2-10 GW in cost-effective local Shed & distribution system service.**

Shift: **10-20 GWh of cost-effective daily Shift (2-5% of daily load), with opportunity for system value at ~$200-500+M/year.**

Shimmy: **300 MW Load-following & 300 MW Regulation. Opportunity for system-level total value is ~$25 M/year.**

New LBNL BTO GEB Projects



SEE Action
STATE AND LOCAL ENERGY EFFICIENCY ACTION NETWORK

Report series underway to address key state and local government opportunities for Grid-Interactive Efficient Buildings

In partnership with

Lawrence Berkeley National Lab

About SEE Action

- Professional network of state and local governments and their stakeholders, energy experts and industry representatives

- Facilitated by the US DOE Office of Energy Efficiency and Renewable Energy, Office of Electricity, and US EPA Climate Protection Partnerships Division

www.seeaction.energy.gov

1 Introduction

- Key technology trends
- Value proposition for grid & customers
- Critical actors and their emerging opportunities

2 Assessing Value

- Valuing demand flexibility
- Methods to determine economic value of services provided by GEBs
- Implementation considerations

3 Assessing Performance

- Audiences/needs for performance data
- Practices and protocols, data and analytical tools that are needed
- Putting assessments into practice

Other reports TBD

Summary and Future Directions

- Demonstrated capability of building end-uses to provide grid services
- Research needed on
  - *modeling and capabilities*
  - *field measurement*
  - *cost-benefits*
  - *commissioning, controls, automation, interoperability*
  - *persistence of savings*
- Linking efficiency and DR is synergistic in many cases