Fast Automated Demand Response to Enable the Integration of Renewable Resources

APEC Workshop on Addressing Challenges in AMI Deployment and Smart Grids in APEC Region

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Lawrence Berkeley National Laboratory

Demand Response Research Center

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Demand Response Research Center

Overview

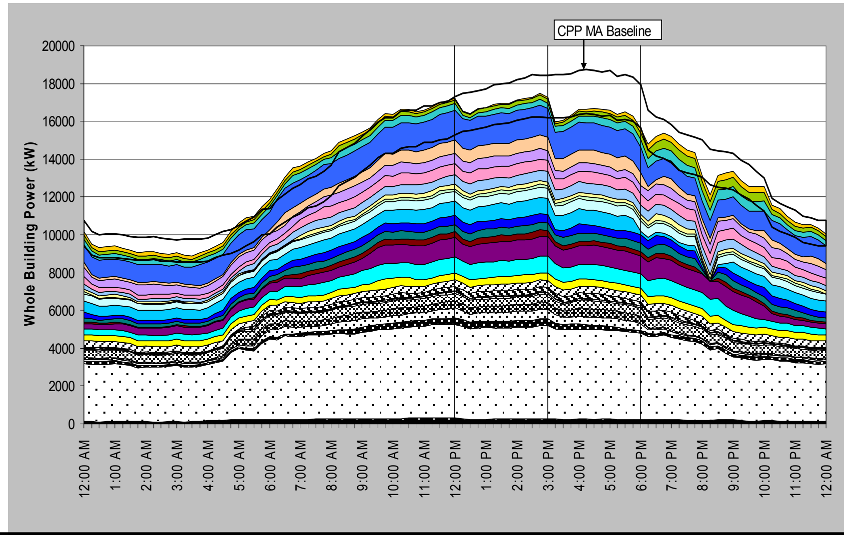
1. Background & Goals
2. Automated DR: Proven Results & Future Challenges
3. Grid Operator Programs
4. AutoDR Resource Estimates
5. Conclusions

Background & Goals

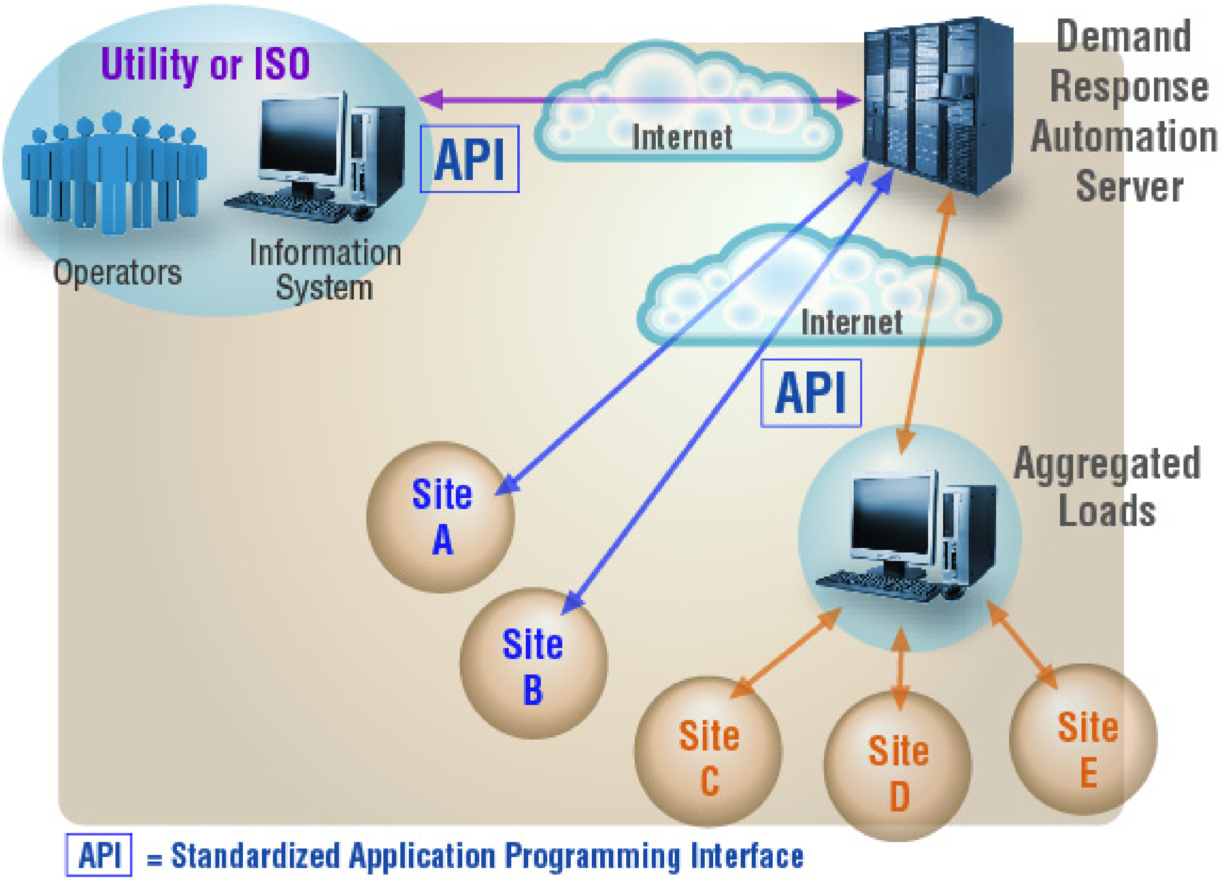
Background

- **California Renewable Portfolio Standards increasing to 33% by 2020**
- **Wind & Solar resources are variable and intermittent**
- **Grid requires over 4 GW of ancillary service to maintain grid stability**
- **Automated Demand Response pilots demonstrated ancillary services**

Goal of Scoping Study – Develop preliminary estimate and feasibility of capacity of AutoDR in California as a resource for renewables integration.



Open Automated Demand Response (OpenADR)

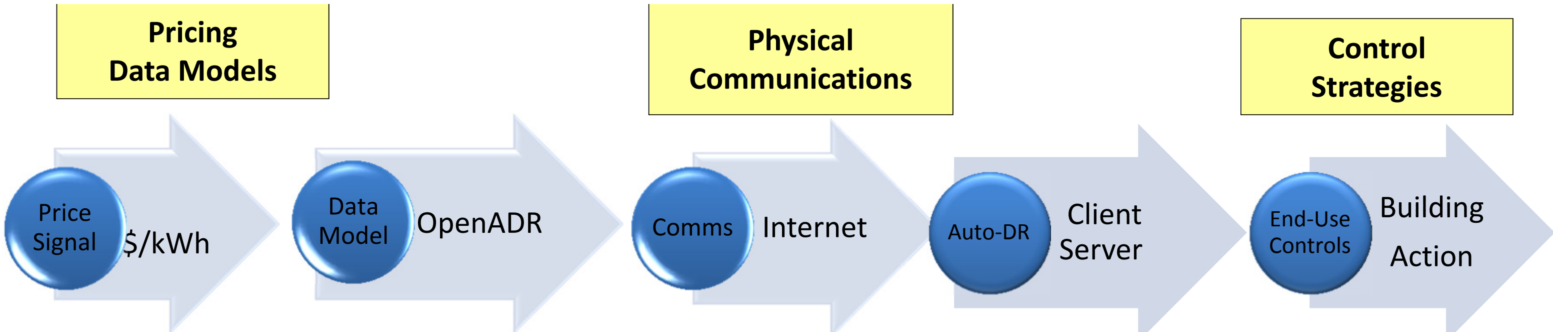


Signaling- continuous, 2-way, secure messaging system for dynamic prices, emergency and reliability signals. One-way applications are under development

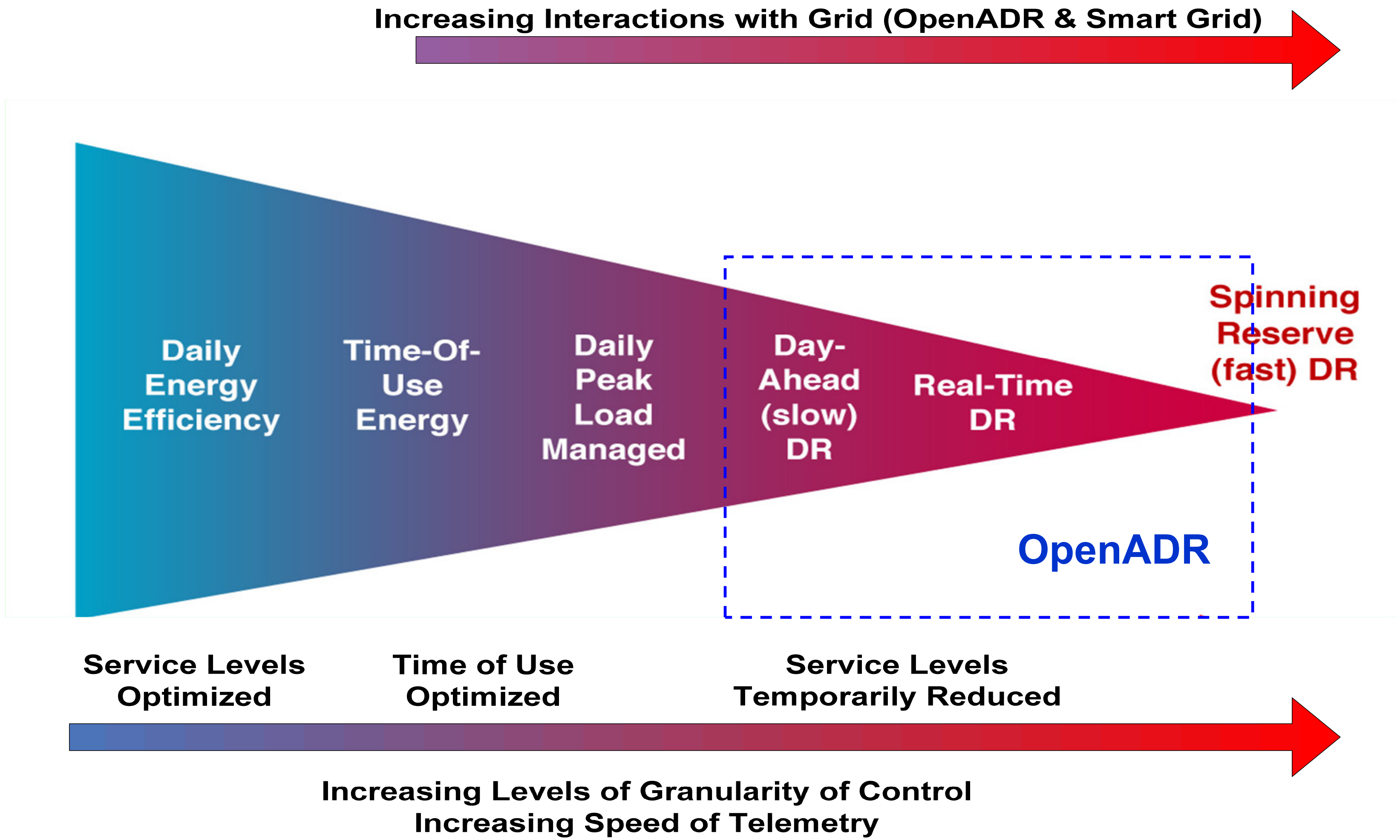
Client-server architecture - uses open interfaces to allow interoperability with publish and subscribe systems

Current system - uses internet available at most large facilities or broadcasting points.

Hardware retrofit or embedded software - many clients fully implemented with existing XML software



Efficiency and DR Continuum



Traditional Ancillary Services & OpenADR

1. Traditional A/S methods:

- **Thermal generation plants use fossil fuels, & high cost.**
- **Grid-scale storage is environmental friendly, but cost is high (US$1500 - $4000 / kW)**

2. Potential Advantages of AutoDR systems:

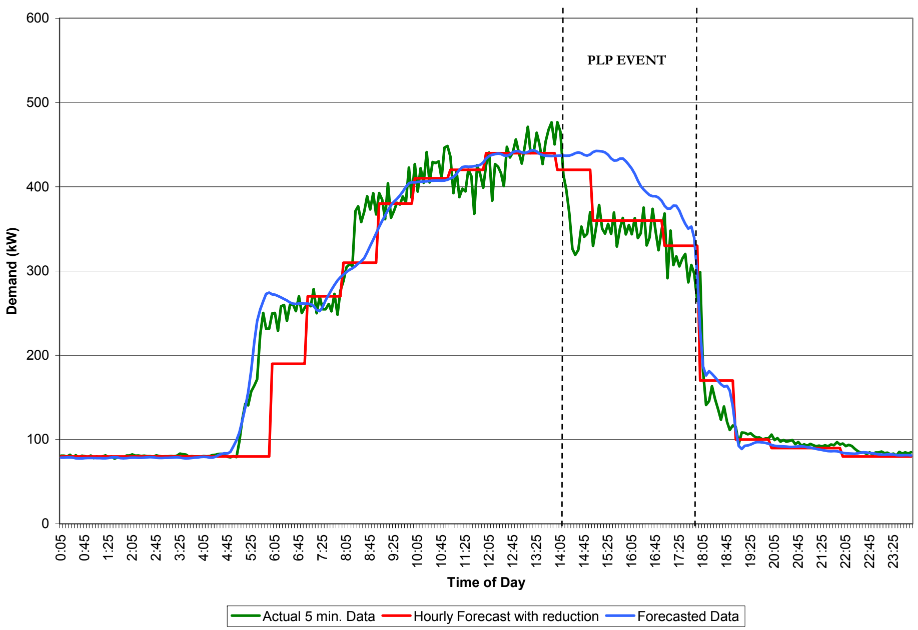
- **Lower first cost (US$75 - $300 / kW) for current programs**
- **Lower operating costs**
- **Lower carbon footprint**
- **Leverages multi-purpose systems for energy efficiency**

OpenADR: Proven Results

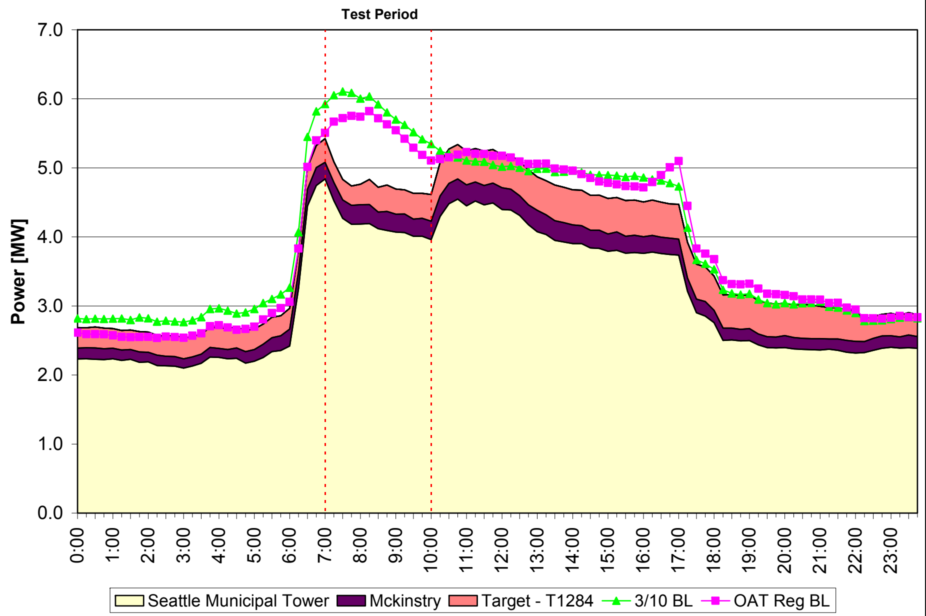
AutoDR Research & Commercialized Deployments have proven:

- **Multi-year performance during Peak Periods (~100 MW existing capacity)**
- **Fast response: < 5 min. (Participating Load Pilot)**
- **Cold winter mornings: 7:00 AM – 10 AM (Pacific Northwest Pilots)**

Fast



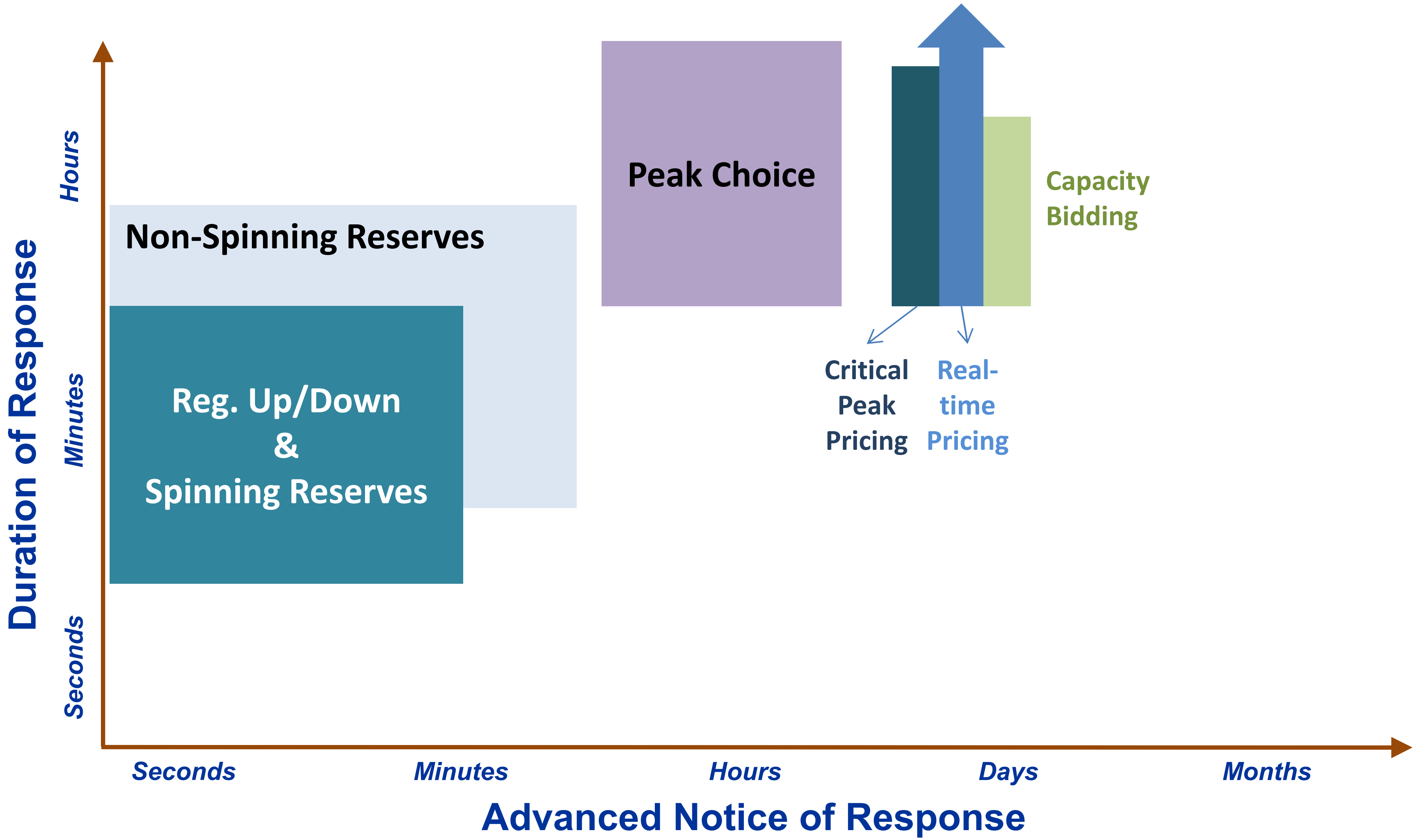
Early & Cold



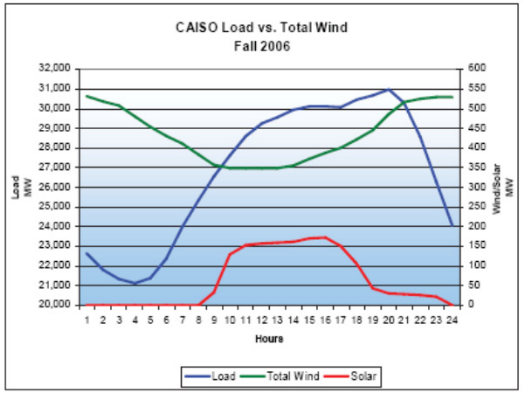
Challenges for AutoDR as Ancillary Services

1. **Economic incentive structure unclear**
2. **Resource varies based on time, temperature**
   - Few data about off-peak DR
3. **A/S requirements may increase cost of AutoDR**
   - Monitoring, verification, telemetry
   - Dedicated network connections
4. **Portfolio management**
   - Load shaping
   - Geographic issues (Sub-LAP)

Grid Operator Programs in California (CAISO): Advanced Notice and Duration of Response



CAISO Programs and AutoDR



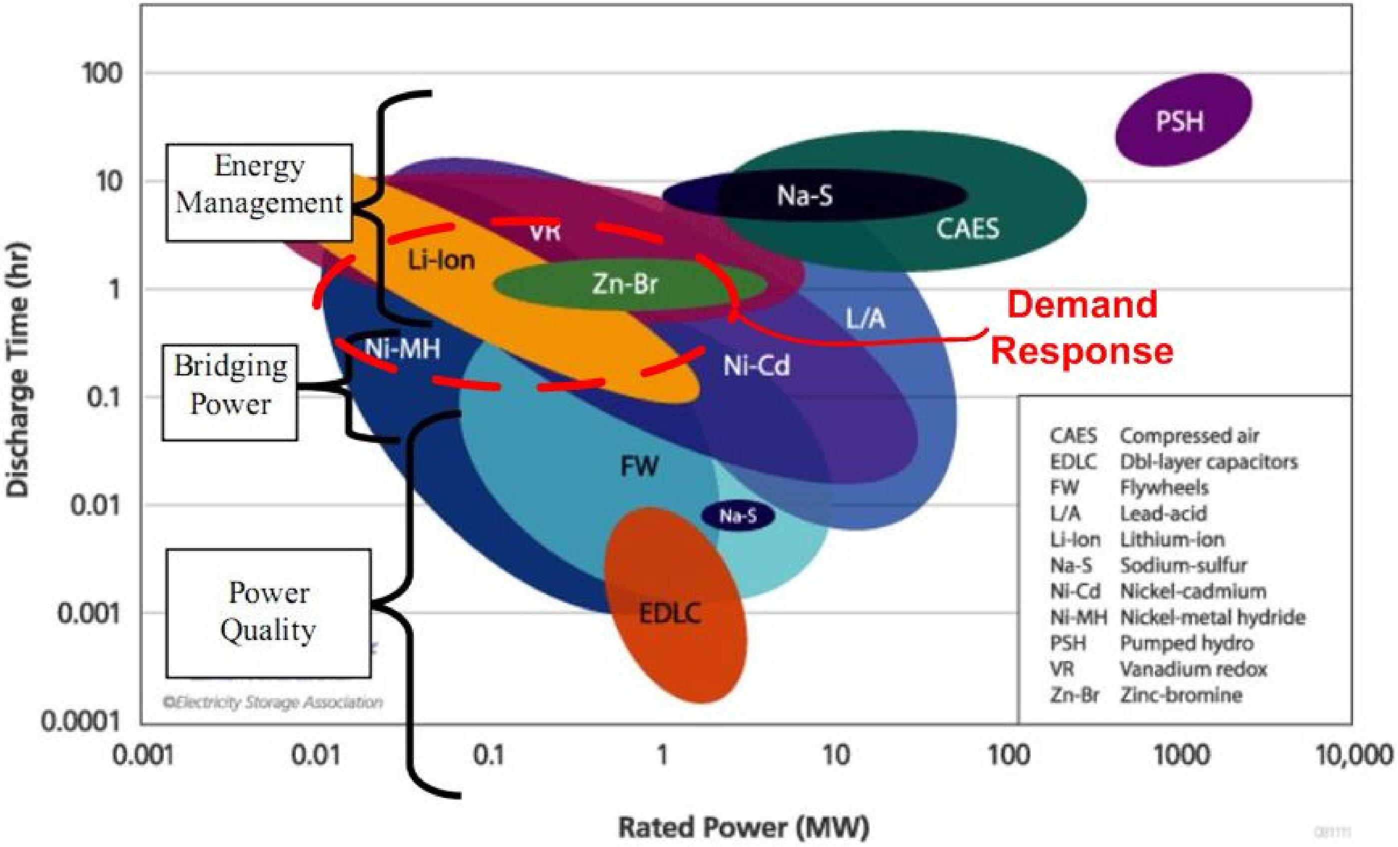
Examples of Needs for AutoDR

- Shift Load to Night
- Daily Peak Management
- Ramp Smoothing

AutoDR for Existing CAISO products	Service	Response Time	Duration
AutoDR	Reg Up	Start <1 min. Reach bid <10 min	15 - 60 min
AutoDR	Reg Down	Start <1 min. Reach bid <10 min	15 - 60 min
AutoDR	Non-Spin	< 10 min	30 min
Future	Spin	~ Instant Start Full Output <10 min	30 min

AutoDR Terminology & Link to Batteries

Shed	Energy reduced during specified period (e.g., reduced lighting) - net energy reduction
Shift	Energy moved to different time period- minimal change in consumption
Charge	Energy use to store load (e.g., pre-cool or charge batteries)
Discharge	Energy storage supplies local loads (thermal or electrical) or provides power to grid

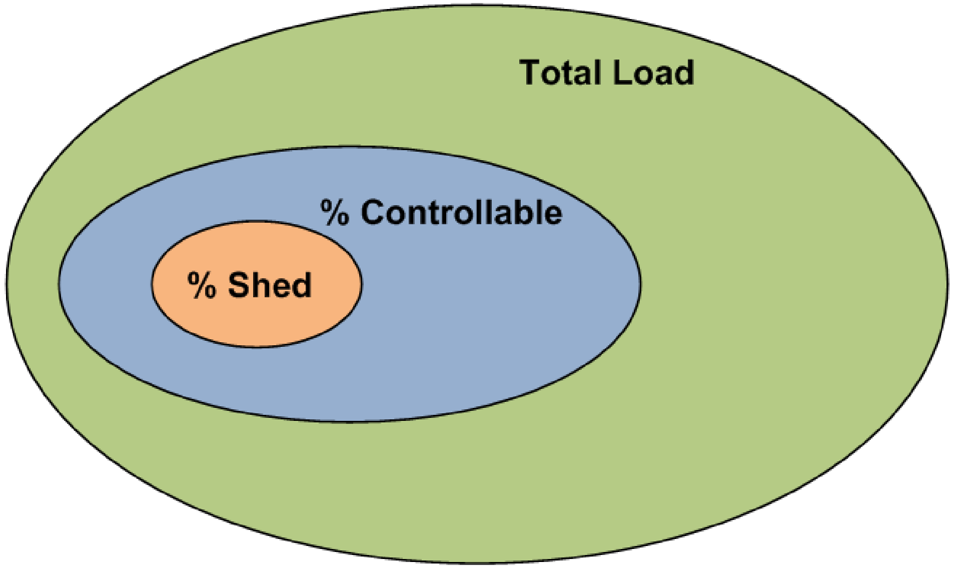


Methodology for Resource Analysis

1. Determine total electric load profiles for commercial and industrial sectors & key end-uses

1. Determine % of loads that could be controlled using current site infrastructure, and AutoDR technology

1. Determine % shed for each controllable load



Estimated Shed = (Load) x (%Controllable) x (%Shed)

Methodology Assumptions

1. Statewide load data, field test results & engineering judgment used to estimate potential

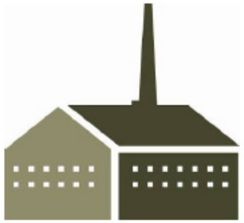
2. Multipliers selected based on existing or planned CAISO products for renewables integration

Duration	Ramp time
2 hour	15 min.
20 min.	5 min.

1. Commercial building type and end-uses evaluated

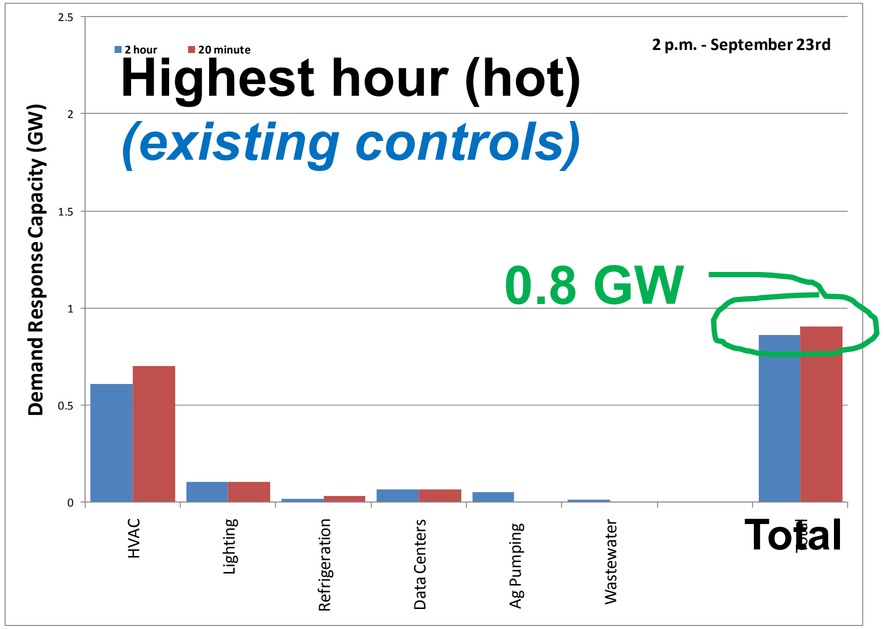
2. Industrial load shapes evaluated based on case studies and scoping studies

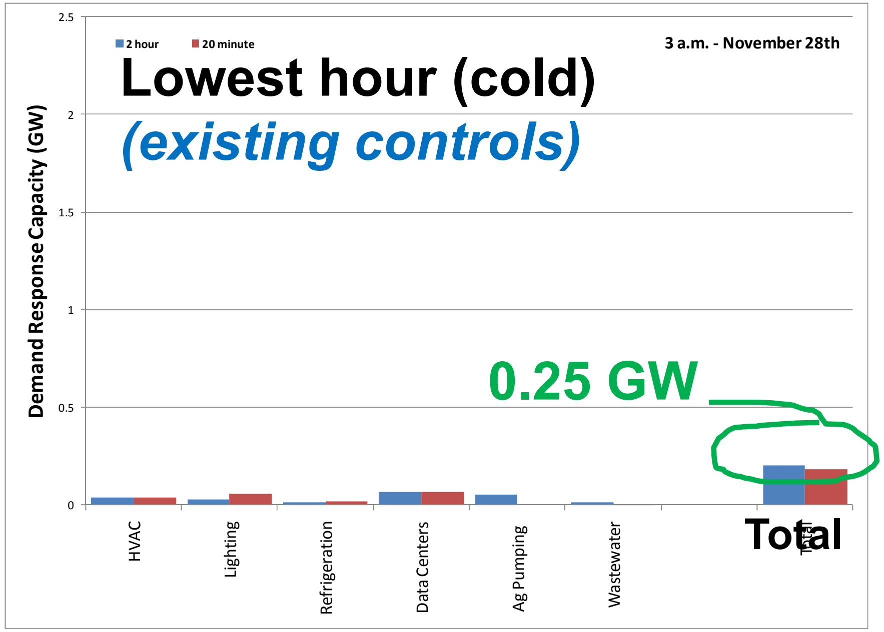
End Uses & Response

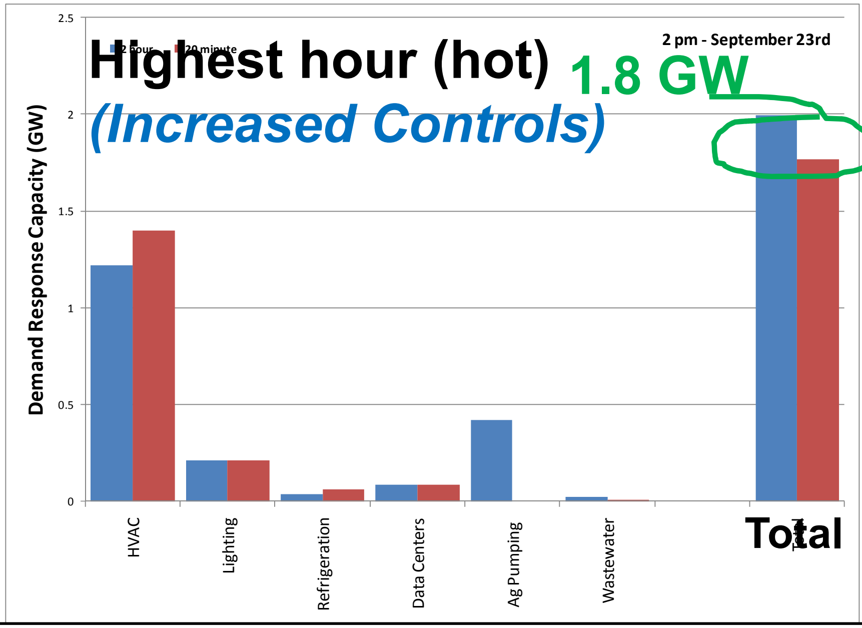


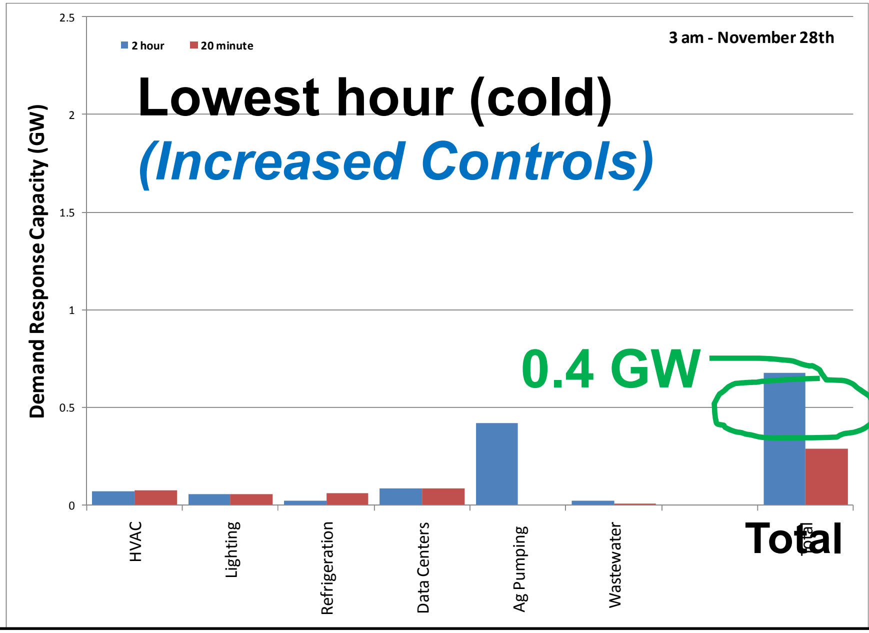
End Use	Type	Modulate	On/Off	Max. Response Time
HVAC	Chiller Systems	Setpoint Adj.		15 min.
	Package Unit	Setpoint Adj.	Disable Compressors	5 min.
Lighting	Dimmable	Reduce Level		5 min.
	On/Off		Bi-Level Off	5 min.
Refrig/Frozen Warehouse		Setpoint Adj.		15 min.
Data Centers		Setpoint Adj., Reduce CPU Processing		15 min.
Ag. Pumping			Turn Off selected pumps	5 min.
Wastewater			Turn Off selected pumps	5 min.

Shed Estimates: Highest & Lowest hours of the Year



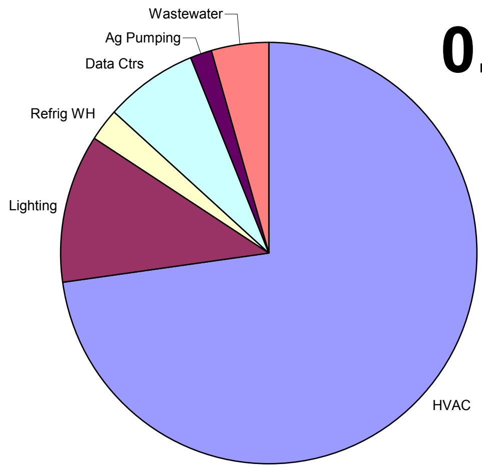




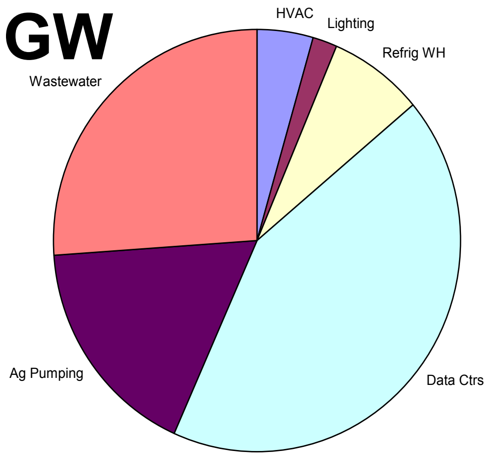


Shed Estimates by End Use

0.8 GW



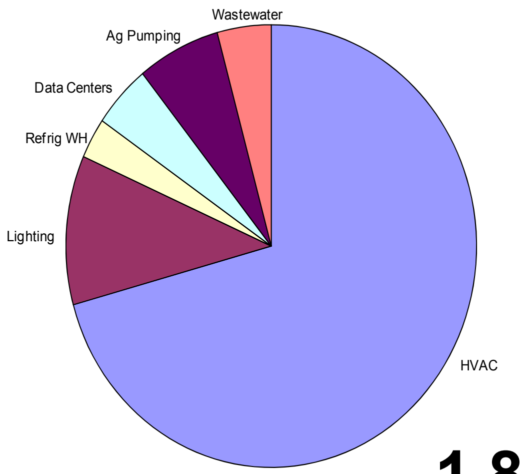
0.25 GW



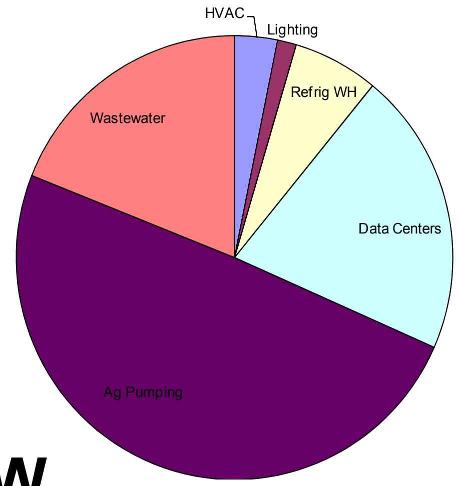
Now

Hottest Hour

Coldest Hour



Future



1.8 GW

0.4 GW

Summary and Conclusions

- Preliminary estimate: AutoDR could provide 0.25 to 0.8 GW of AutoDR ancillary services in the existing stock throughout CA
- Investments to improve controls that are currently “unreachable” to AutoDR could double the shed potential to 0.4 to 1.8 GW
- Use of open interoperable standards (OpenADR) lowers initial cost and assures persistence of DR resources
- Need to link advanced controls for efficiency and DR

Future Research

- Additional end-use load evaluations, especially ancillary services
- Closer analysis of economics
- Continue to explore load and DR predictions
- Additional off-peak data from field tests & surveys
- Geographic considerations

Questions? Comments?

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OpenADR Alliance
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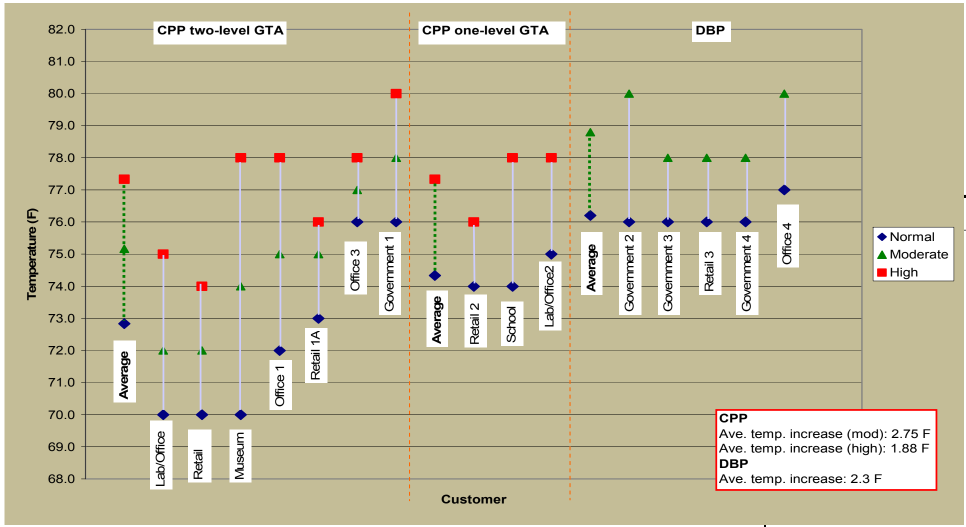
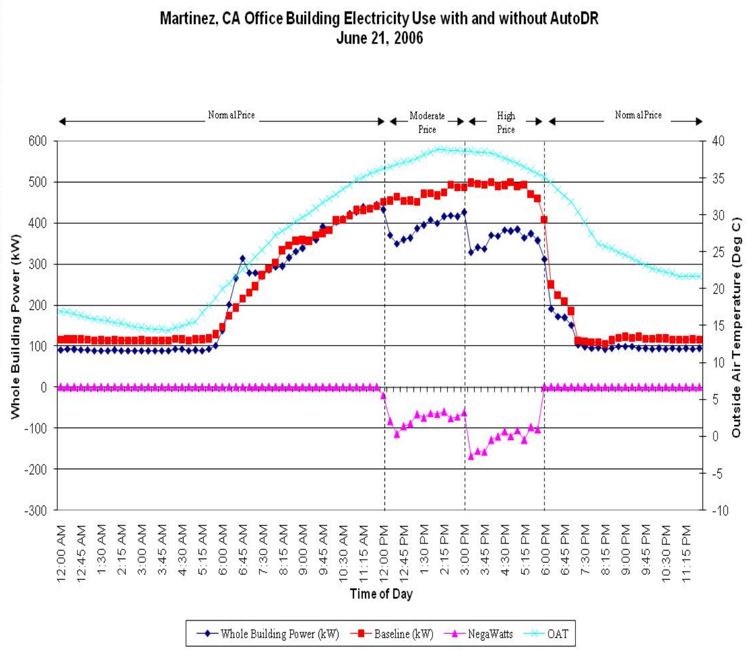
DR Control Strategies Evaluated in Previous Research

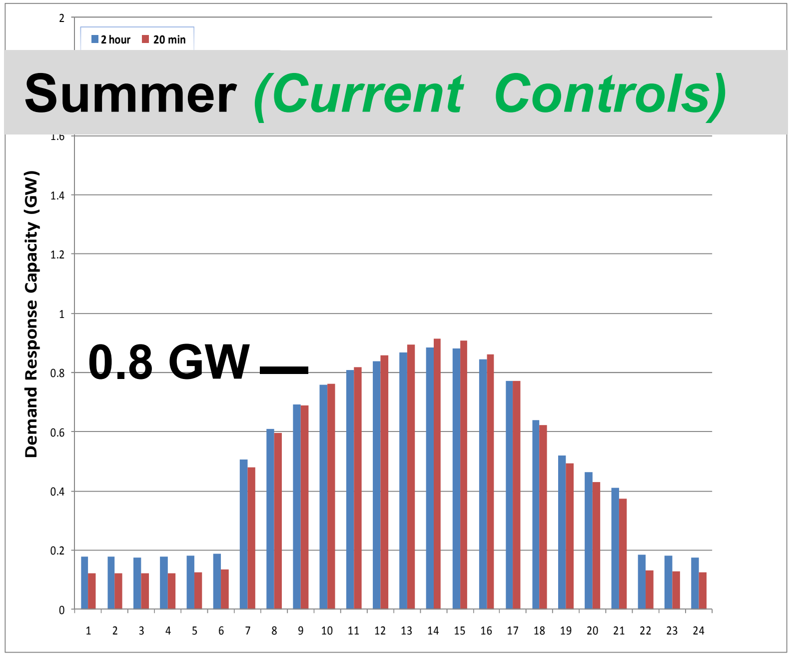


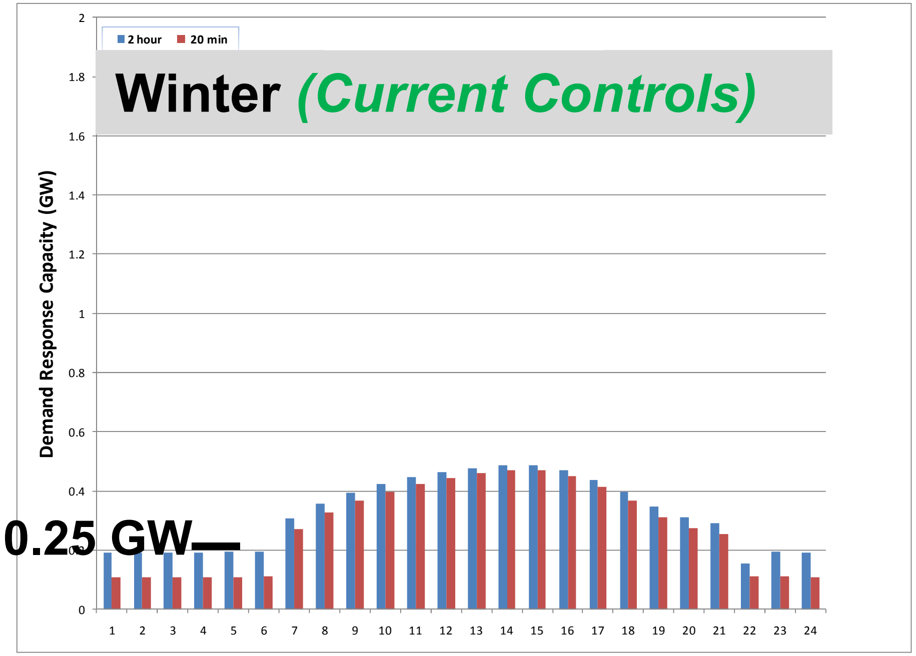


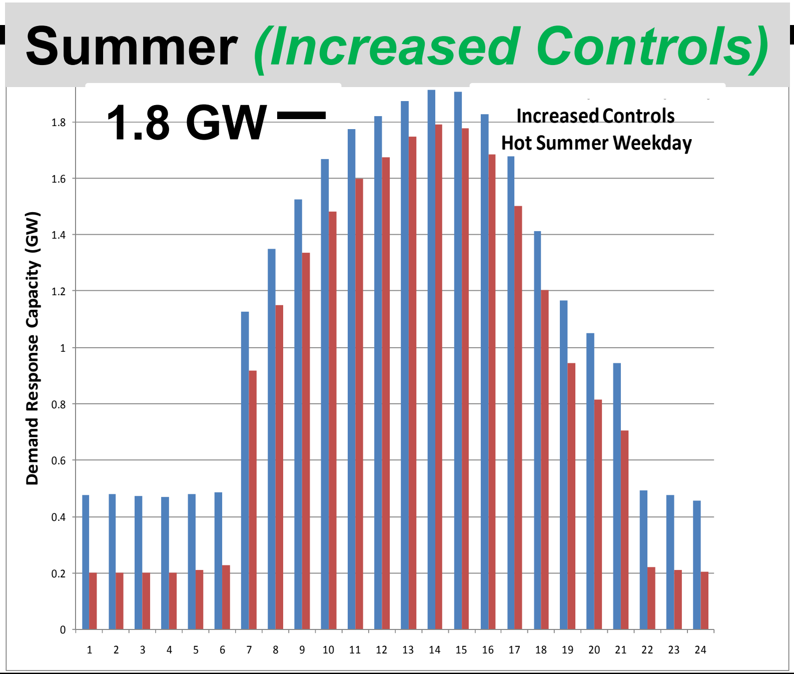
Simulation tools and strategy guides have been developed

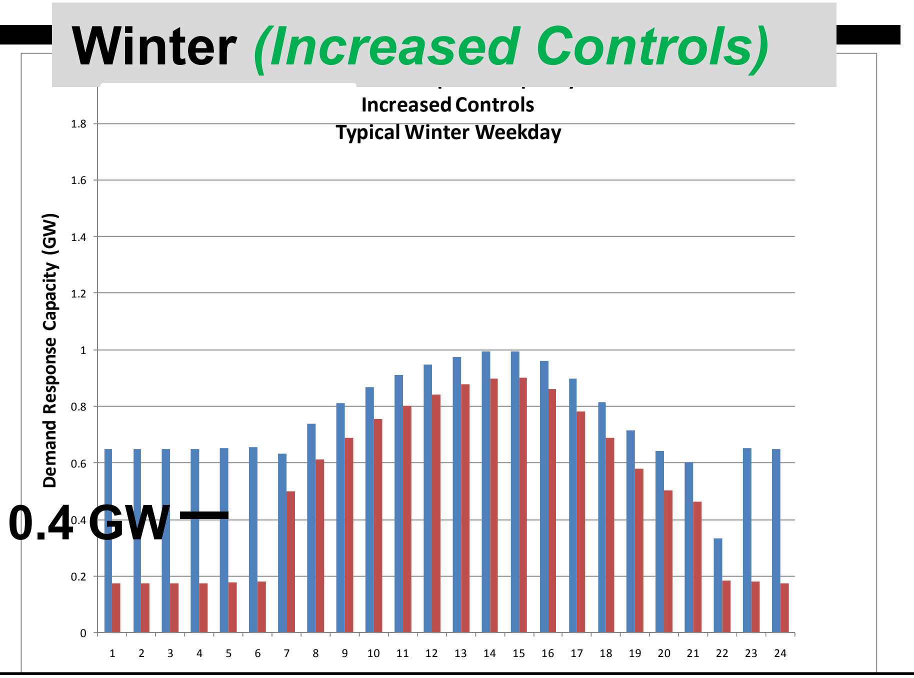
	Building use	HVAC											Lighting					Other
		Global temp. adjustment	Duct static pres. Increase	SAT Increase	Fan VFD limit	CHW temp. Increase	Fan qty. reduction	Pre-cooling	Cooling valve limit	Boiler lockout	Slow recovery	Extended shed period	Common area light dim	Office area light dim	Turn off light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

Shed Estimates: Summer & Winter 24 hr. Profiles









FERC: Demand Response Options

	2010 FERC Survey Program Classifications	Description
1	**Direct Load Control**	Sponsor remotely shuts down or cycles equipment
2	**Interruptible Load**	Load subject to curtailment under tariff or contract
3	**Emergency Demand Response**	Load reductions during an emergency event Combines direct load control with specified high price
4	**Load as Capacity Resource**	Pre-specified load reductions during system contingency
5	**Spinning Reserves***	Load reductions synchronized and responsive within the first few minutes of an emergency event
6	**Critical Peak Pricing w/Control**	Combines direct load control with specified high price
7	**Non-Spinning Reserves***	Demand side resources available within 10 minutes
8	**Regulation Service***	Increase or decrease load in response to real-time signal
9	**Demand Bidding and Buyback**	Customer offers load reductions at a price
10	**Time-of-Use Pricing**	Average unit prices that vary by time period.
11	**Critical Peak Pricing**	Rate/price to encourage reduced usage during high wholesale prices or system contingencies
12	**Real-Time Pricing**	Retail price fluctuates hourly or more often to reflect changes in wholesale prices on day or hour ahead
13	**Peak Time Rebate**	Rebates paid on critical peak hours for reductions against a baseline
14	**System Peak Response Transmission Tariff**	Rates / prices to reduce peaks and transmission charges

79% (bracketing rows 2–5)

***Emphasis of presentation on items in RED.**

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Educational Background	**B.S. Mechanical Engineering California Polytechnic State University** - San Luis Obispo **U.C. Berkeley**– course work: “Software Management and Product Marketing”, “Programming in C”, “Telecommunications for Business”, “Process Control and SCADA Security” course sponsored by **Department of Homeland Security** and **Department of Energy**, presented by **Idaho National Lab**	
Work Experience	Current: Lawrence Berkeley National Lab, program manager, Demand Response Research Center. He previously held product development and management positions at Grid-Net, Honeywell and Echelon Corp. where he helped create hardware and software products for the monitoring, controlling and visualizing the use of energy.	

Autobiography

David is a controls and communications enthusiast. He has conducted research, design and deployment of smart grids, smart buildings and automated demand response systems. In his current role at LBNL, David was a lead software architect of the OpenADR standards based automated demand response system. OpenADR has been used throughout the US and worldwide to shed hundreds of MegaWatts of peak demand. David has contributed to the California energy code (title 24) as well as numerous publications on Demand Response and Energy Information Systems.