Demand Response:

The Demand-Side "Peaker"

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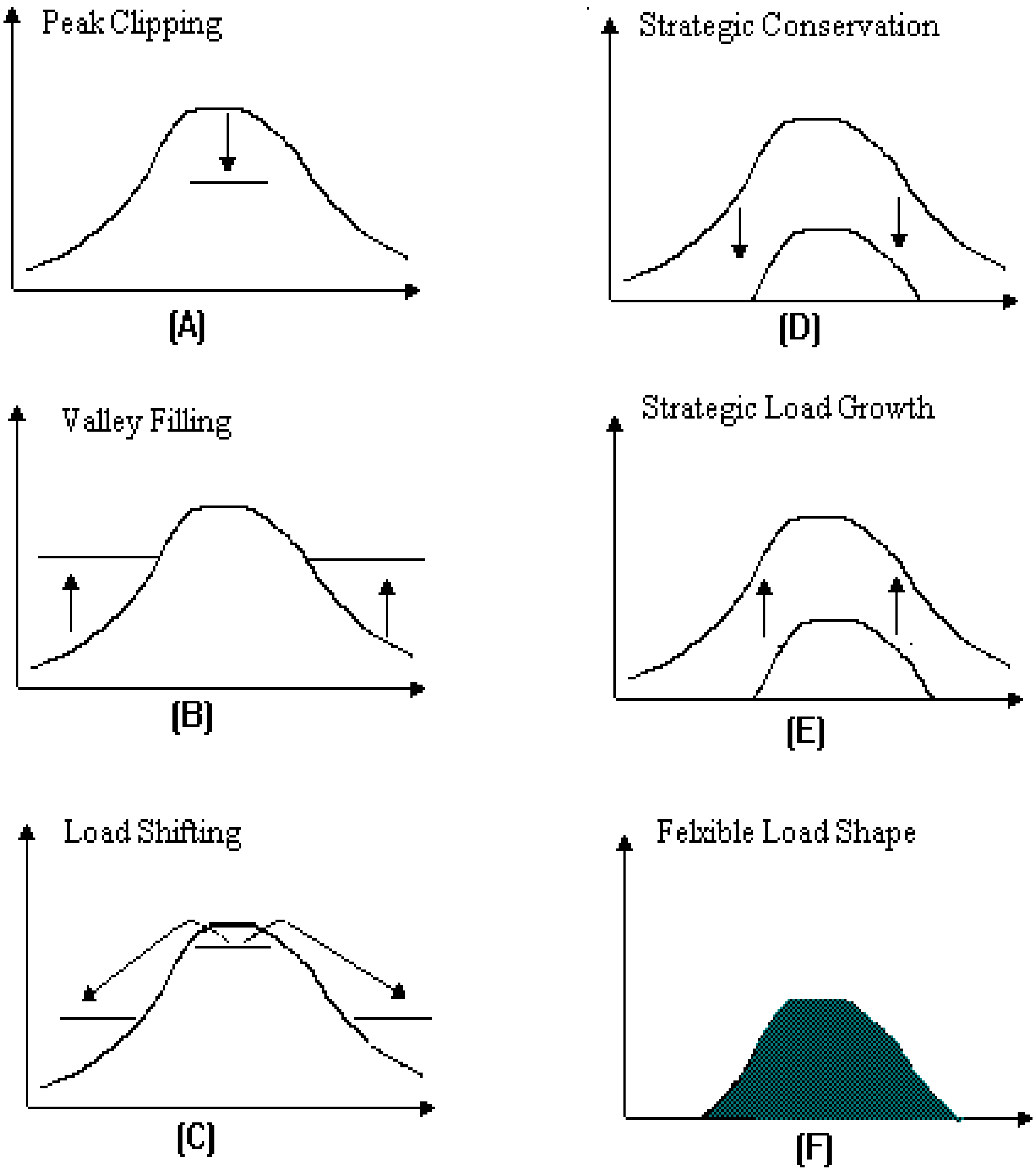
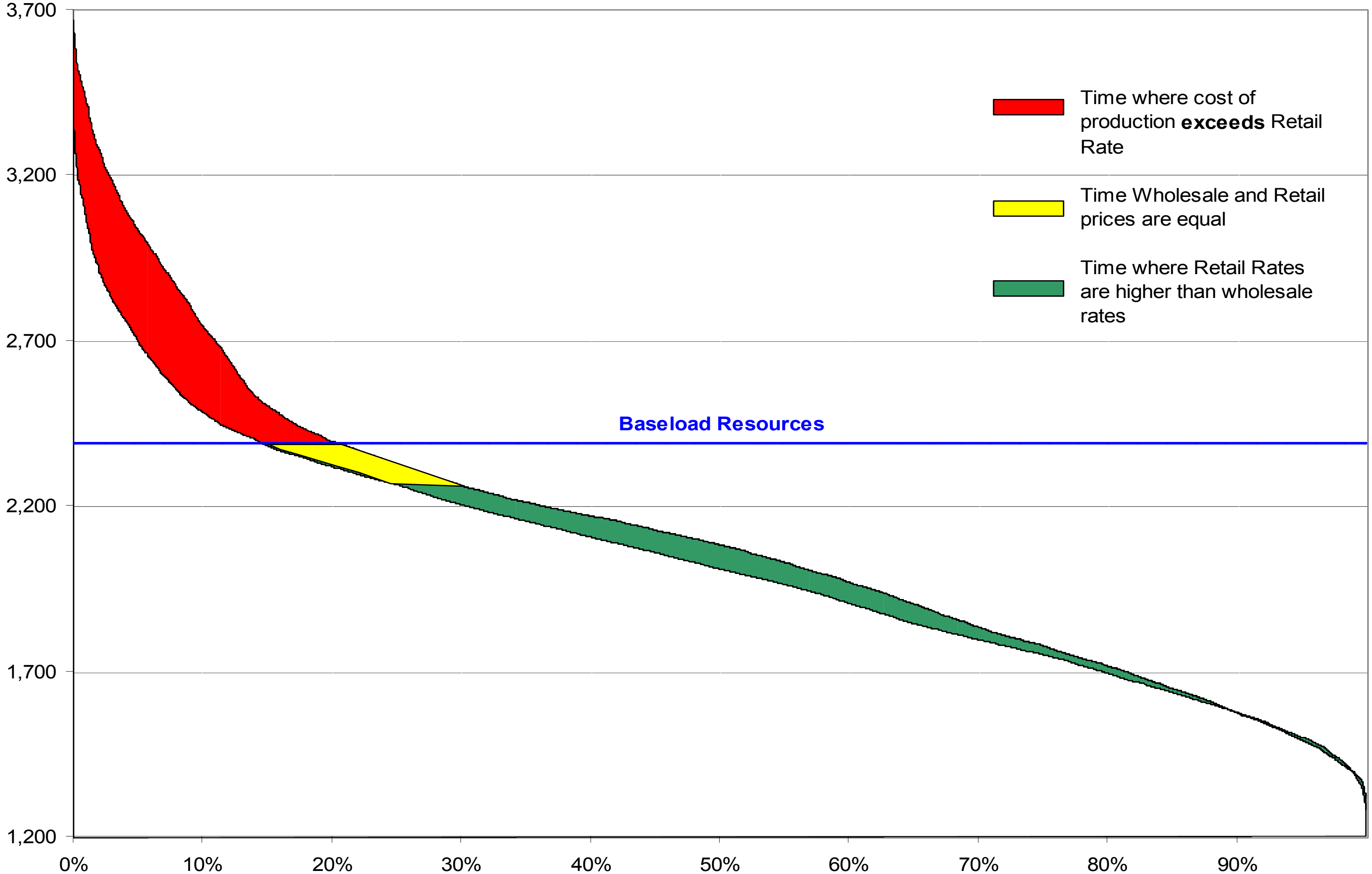
Demand response addresses the DSM goals of peak clipping and load shifting



DSM load shape objectives: (EPRI, 1990)

Typical Load Duration Curve: During Maximum Peak Hours, Production Cost Exceeds Retail Rates - The Utility Loses Money on These Sales!



Demand response programs, also known as load management programs, can be broadly categorized along two dimensions:

- Trigger criteria: system reliability or economic trigger
- Notification method: load response or price response

Trigger criteria		Notification Method: Load Response	Notification Method: Price Response
	Reliability	Direct Load control Curtailable Load Interuptible Load	Critical Peak Pricing Demand Bidding
	Economic	Direct Load control Curtailable Load	Time of Use Pricing Critical Peak Pricing Real Time Pricing Demand Bidding

Load Response
Overview

Load Response: Utilities offer customers payments for reducing their demand for electricity for specified periods of time. Program participants can be considered "sellers," since they provide load reductions in exchange for various prices offered by the utility.

Type of Program	Brief Definition	Party Controlling Reduction	Typical Target Size	Voluntary/ Mandatory (No Overrides)	Incentives	Advance Notification	Need Enabling Technology?	Billing System Change?	Settlement
Load Response									
Direct Load Control	End use loads turned off for limited periods of time	Provider/ Utility	<200 kW	M	$0.014-0.40/ton of cooling	None	Load switches, 2-way commu-nication (opt)	No	Fixed credit on monthly bill
Curtailable Load	End use loads reduced or turned off for limited periods of time	Provider/ Utility or Customer	>100 kW	M or V	$0.15-0.53/kWh	Minutes to Hours	Interval meters, 2-way commu-nication (opt)	No	Monthly bill adjustments, penalties for non-performance
Interruptible Load	All or major portions of customer total load turned off for periods of time	Provider/ Utility or Customer	$\geq$1 MW	M	$7-45/kW	Minutes to Hours	Backup generator (opt)	No	Reflected on monthly bills. Penalty for non-performance
Scheduled Load	Load reductions scheduled or planned ahead of time between utility and customer	Customer	All	M	$0.10/kWh	Months – Contractual	No	No	Reflected on monthly bills. Penalty for non-performance

Price Response
Overview

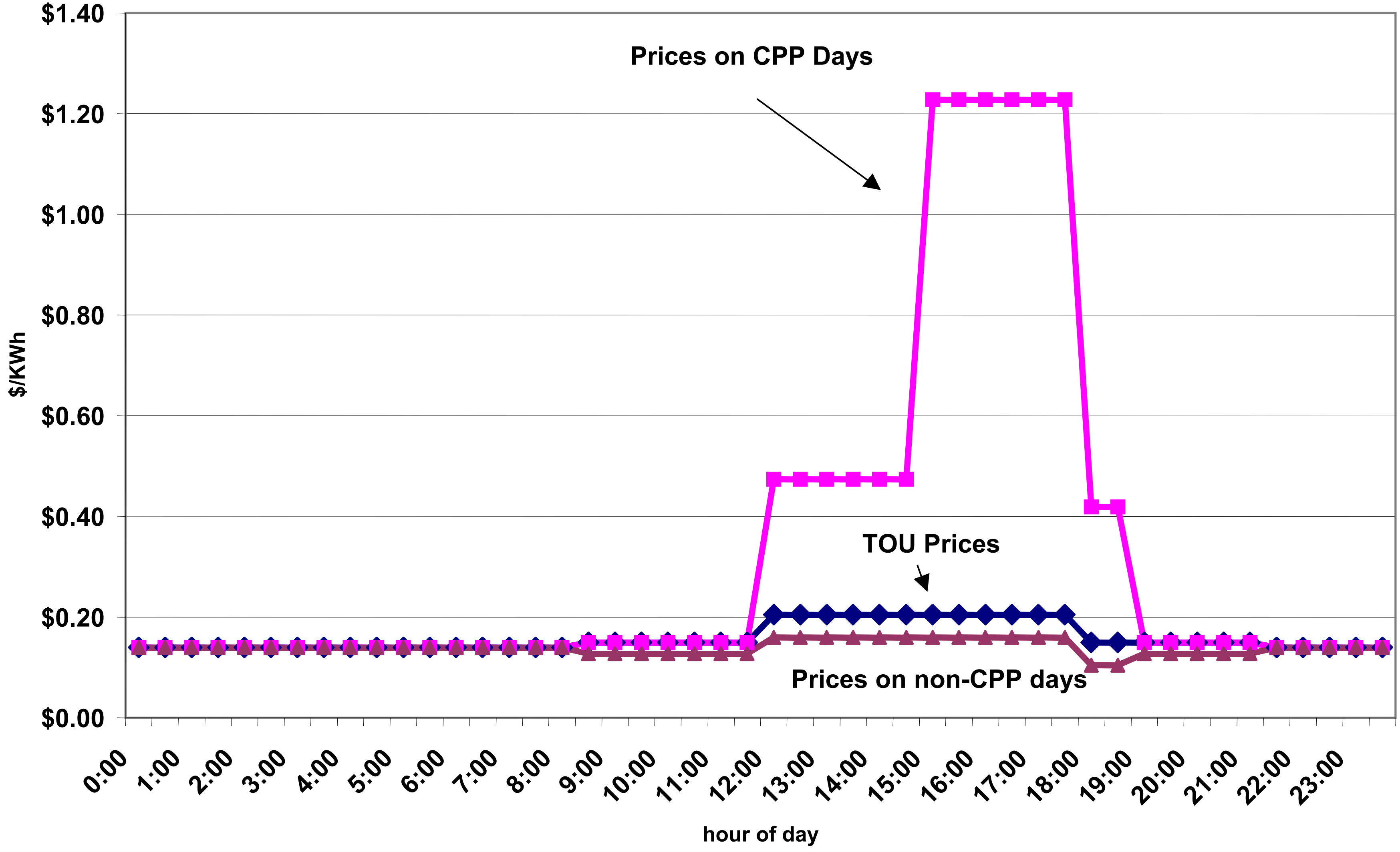
Price Response Definition: Demand response programs in which customers voluntarily reduce their demand in response to economic signals.

Type of Program	Brief Definition	Party Controlling Reduction	Typical Target Size	Voluntary/ Mandatory (No Overrides)	Incentives	Advance Notification	Need Enabling Technology?	Billing System Change?	Settlement
Price Response									
Time of Use	Load management based on stepped rate structure including peak rate, off-peak rate, and sometimes should peak rate	Customer	All	M or V	5% bill reduction premium + payment per event	None	TOU meters, real time or prior day energy information via Internet	Yes, TOU/CP P rate structure	Monthly bill adjustments
Dynamic Pricing (Critical Peak or Real Time Price)	Load management based on dynamic tariff	Customer	All	V	Locational marginal price, $0.10/kWh	Day ahead	Interval meters, 2-way commun-ication, real time energy information via Internet	Yes, RTP or dynamic tariff	Monthly bill adjustments
Demand Bidding	1) Customers bid load reduction based on provider proposed price, or 2) customer bid load reduction at certain prices	Customer	All*	V	Locational marginal price, $0.15-0.50/kWh	Hours or Day ahead	Interval meters, web-based trading/market, spot price information via Internet	No	Separate payment based on bid price, additional reductions beyond bid paid locational marginal price

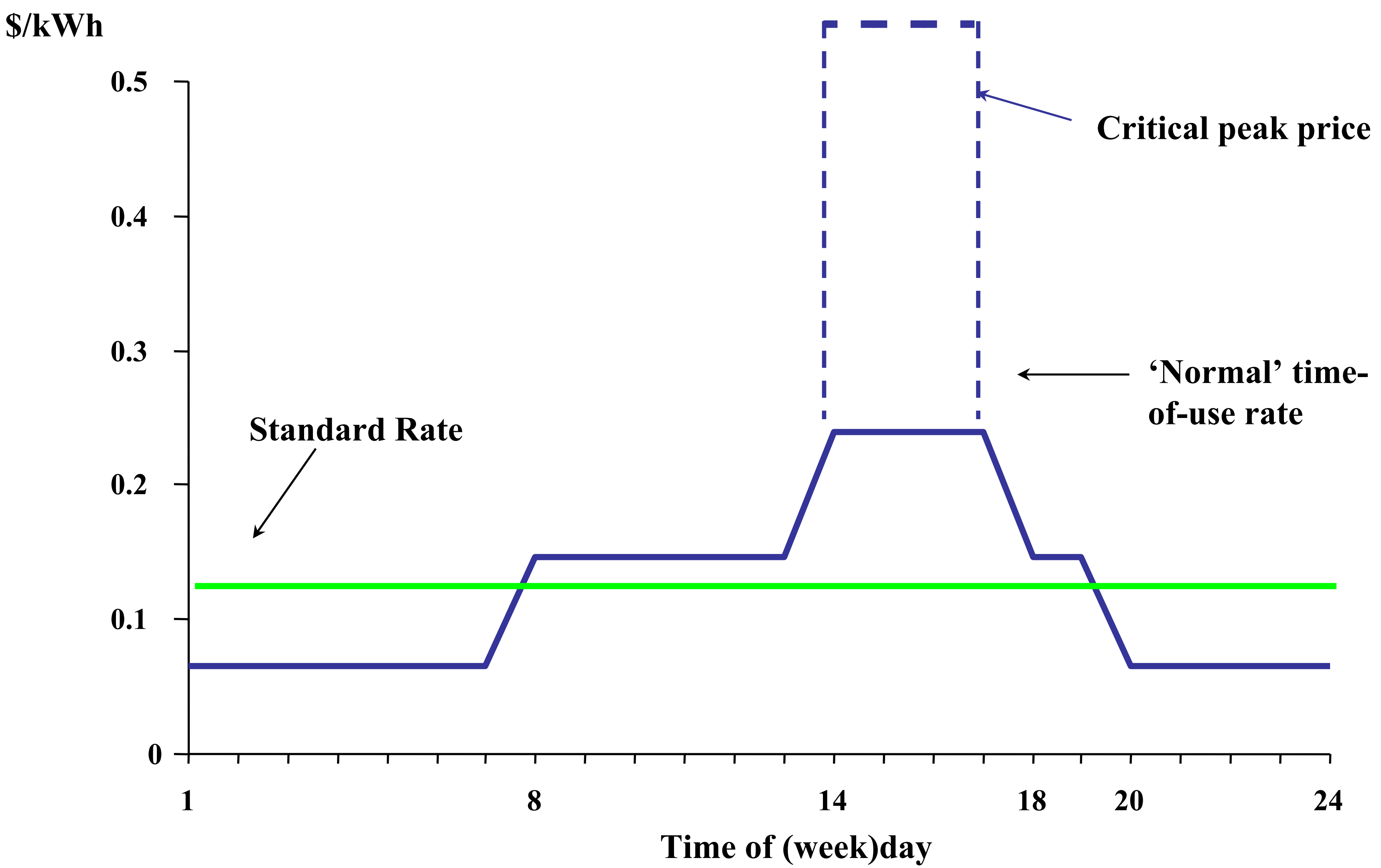
TOU Pricing vs. Dynamic Pricing (CPP & RTP)

- **Time-of-Use** (TOU) is typically 3 time blocks published in advance for entire season
  - Peak, Shoulder, Off-Peak
  - Cannot address unforeseen weather or equipment failures
- **Critical Peak Pricing** (CPP) is a high price imposed on a few days a year when energy is expensive or system conditions are critical or near critical
  - Non-CPP hours are less expensive as a result
  - Customer pays the critical price when invoked by the utility
  - Day-ahead forecast of CPP offers added time for response
- **Real-Time Pricing** (RTP) charges the hourly marginal energy cost
  - Reflects hot weather, scarcity, or equipment failure
  - Notification can be day-ahead or hour ahead (w/ automation)

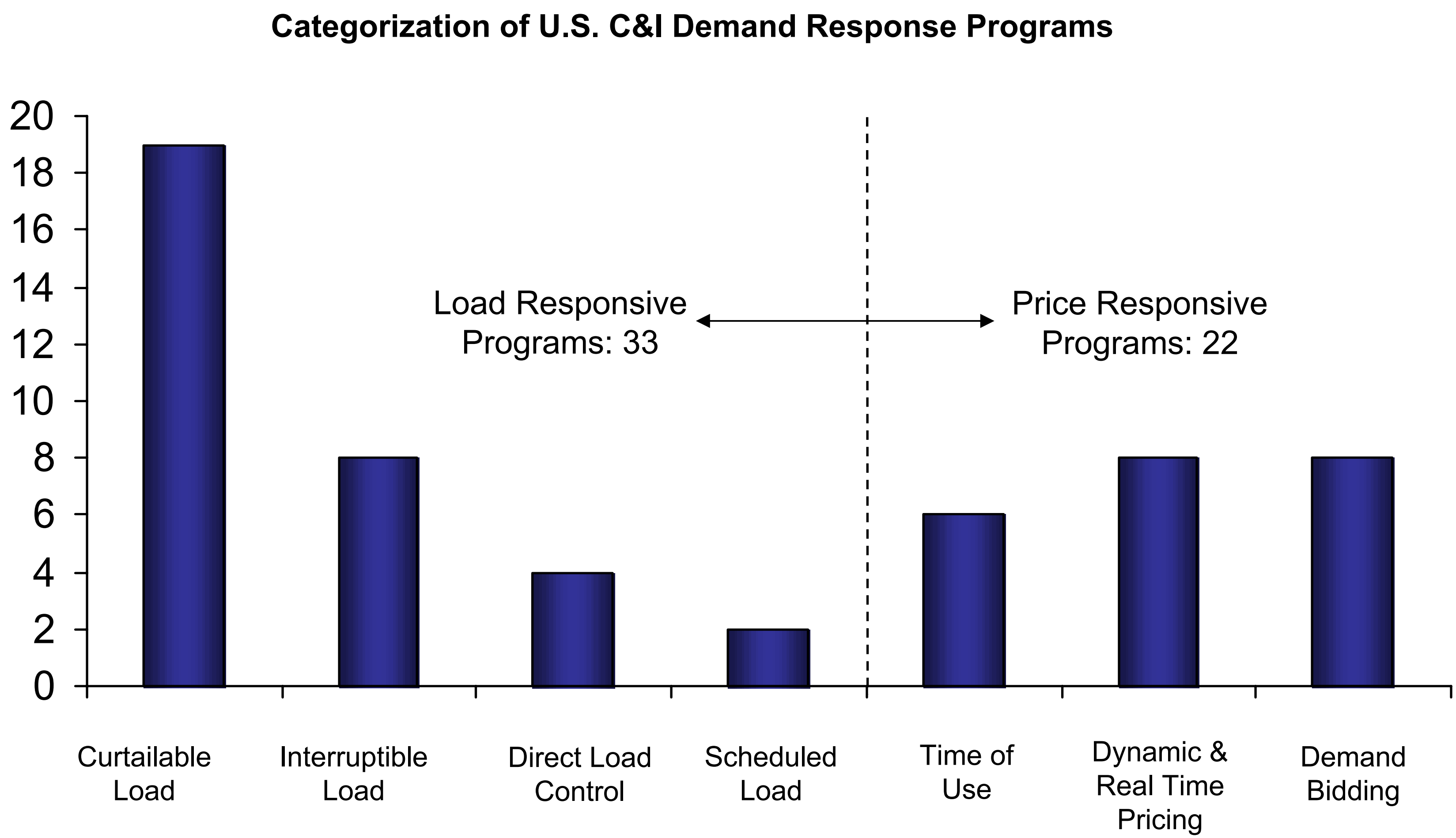
Example of a Utility CPP Summer Tariff



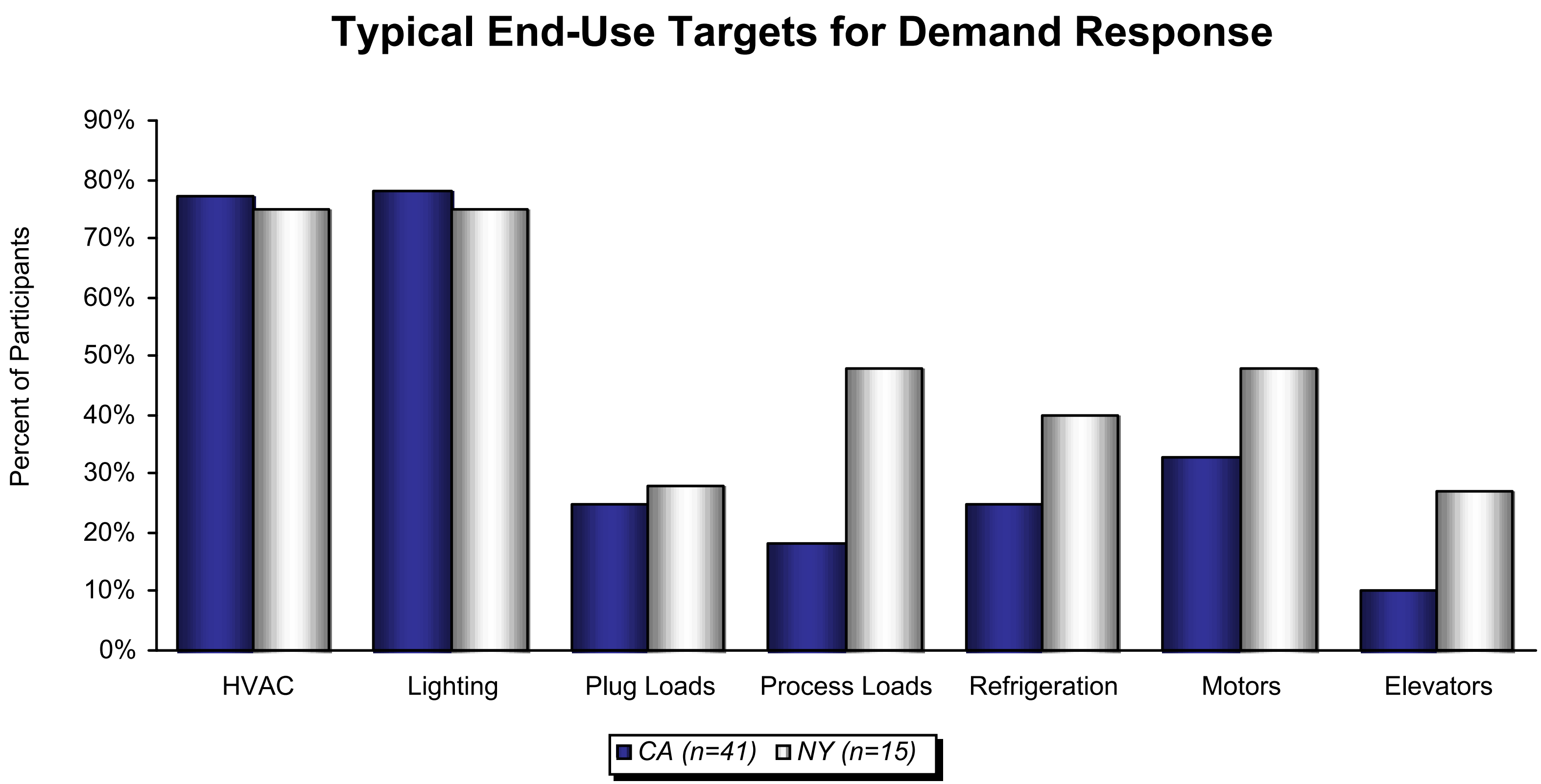
Critical-peak pricing vs. standard TOU rate design



Utilities do not uniformly prefer one type of DR program: Load responsive programs are slightly more common But price responsive programs are also widely used



DR technologies most often target HVAC and lighting for load reductions, but frequently target additional end uses (Residential programs target A/C, water heater, pool pumps)



Source: Goldman, Charles, M. Kintner-Meyer, and G. Heffner. Do "Enabling Technologies" Affect Customer Performance in Price-Responsive Load Programs? Environmental Technologies Division, Lawrence Berkeley National Laboratory. August 2002.

Customers have a variety of technologies available to them to enable load flexing for demand response

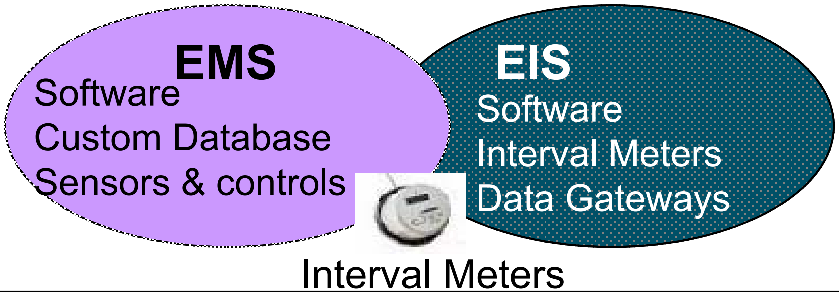
Control Devices

✓Load control switches

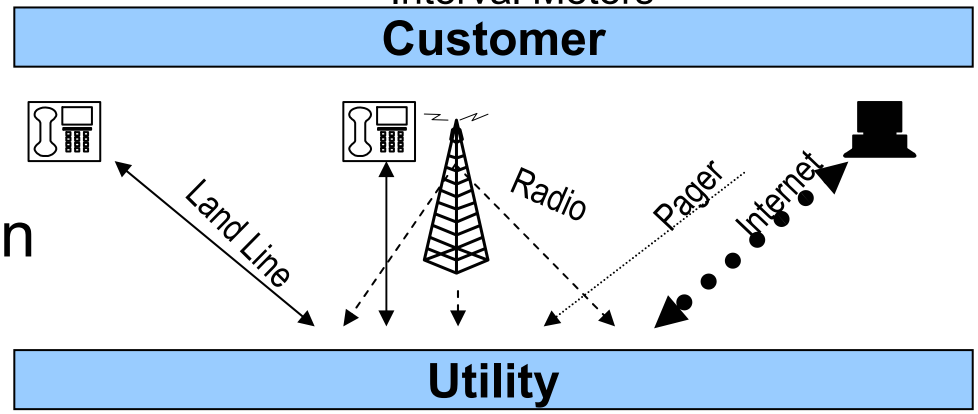
✓Smart thermostats

✓Other controls integrated into EMS/EIS

Monitoring Systems



Communication Systems



Technology options for demand response

What is Needed

SMART THERMOSTAT

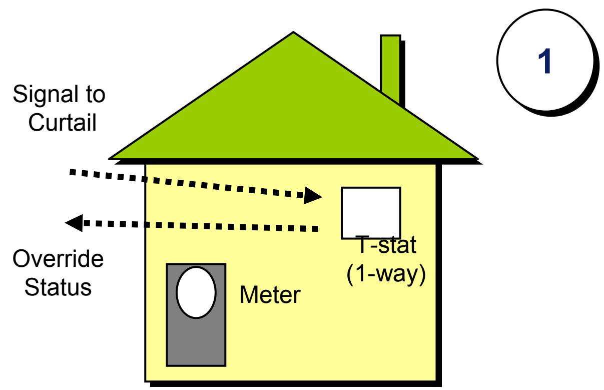
Allows utility to verify customer receipt of signal and monitor overrides

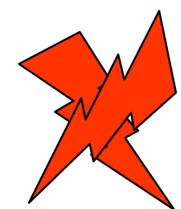
GATEWAY SYSTEM

Allows communicatioon to, from, and between devices on local area network (LAN). Utility can verify signal reception and monitor overrides in real time.

BASIC METER

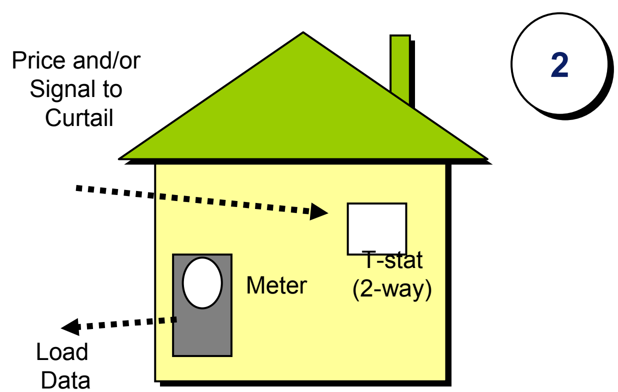
- Load impacts and incentives must be estimated based on average customer
- Not real time, end of day M&V of impact

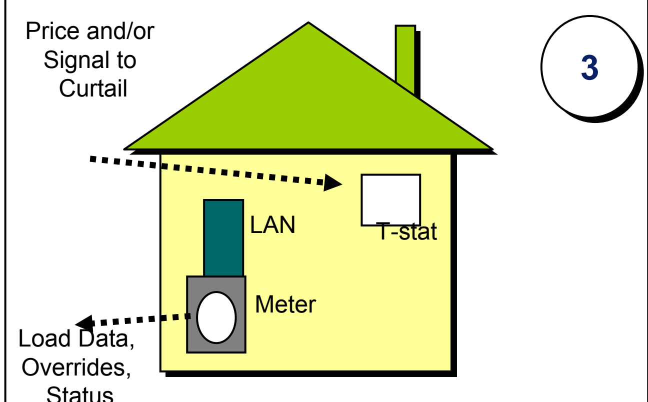




ADVANCED METER

- One-to-one correlation between measured load impacts and incentives
- Incentive to conserve is integrated into tariff
- 1-hour delayed response





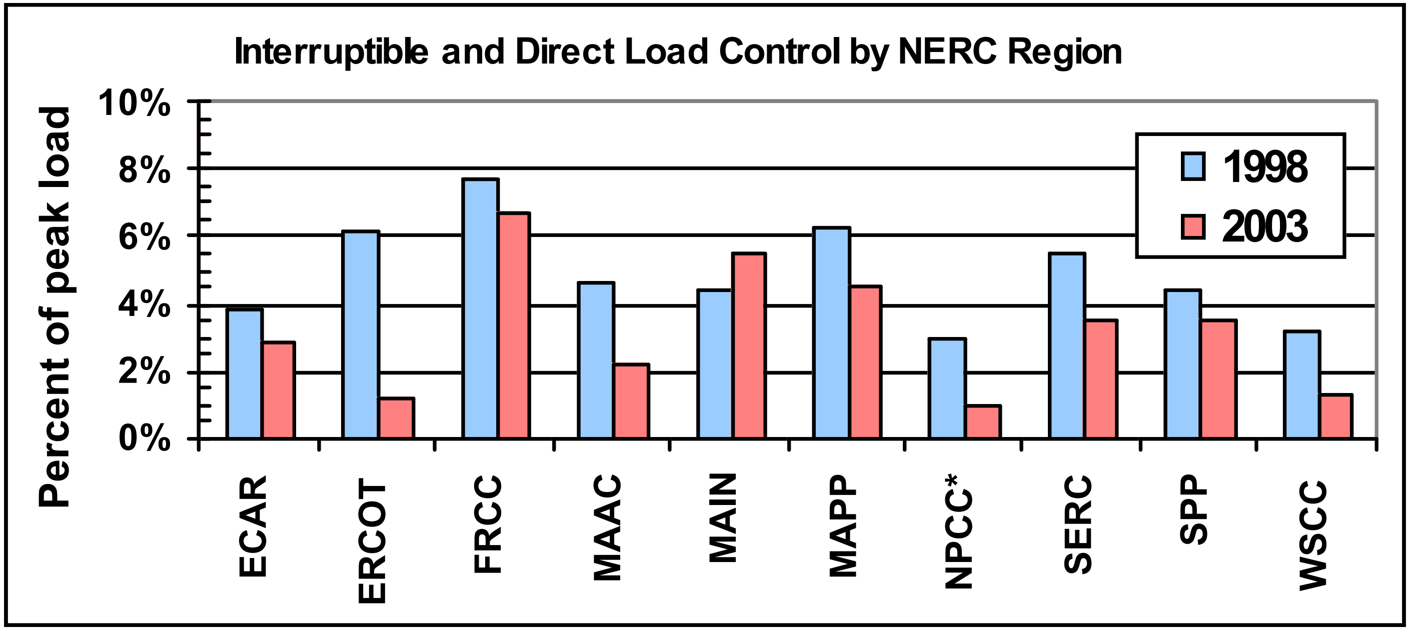
Snapshot of Current DR Products for Small Customers

Technology	Initial cost ($)	Average load reduction (kW)	Cost/kW ($)
One-way switch	165	0.8 to 1.1	165
One-way thermostat	300 to 325	1.2 to 1.3	270
Two-way thermostat	450 to 650	1.2 to 1.3	460

Notes: kW = kilowatt.

Source: Platts; data from vendors

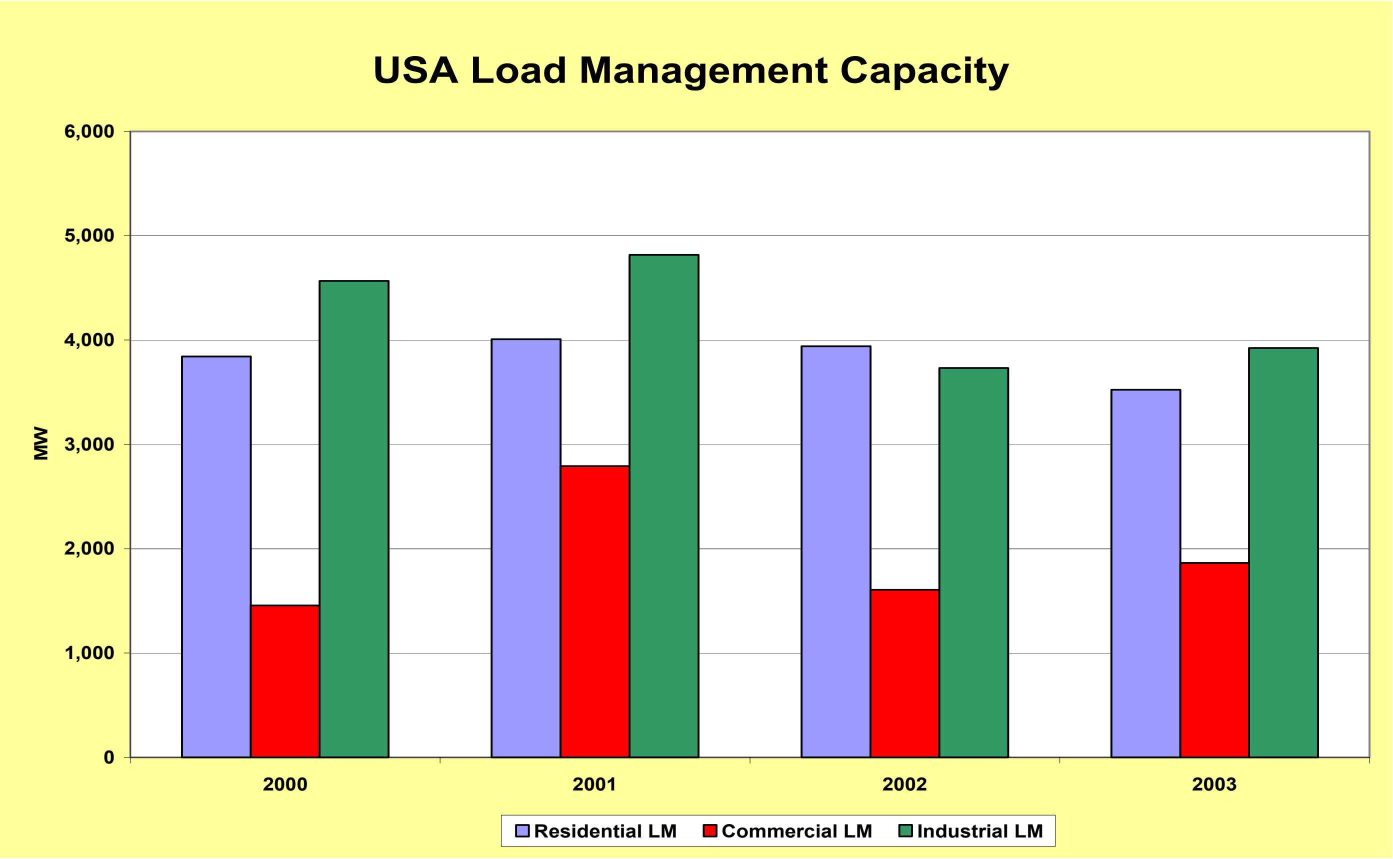
Several of the NERC regions (e.g., FRCC, MAIN, MAPP) have achieved a minimum of 3-5 percent of peak capacity reductions from load response. (FRCC averages 7 percent reduction)



*NPCC data is for 1998 and 2002

Source: Goldman, Charles and Roger Levy. 2005. Demand Response in the U.S. Opportunities, Issues and Challenges. *Presentation at National Town Meeting on Demand Response*, June 21.

Gross committed demand response capacity by sector in the U.S: More loads subscribed in residential and industrial sectors than commercial sector

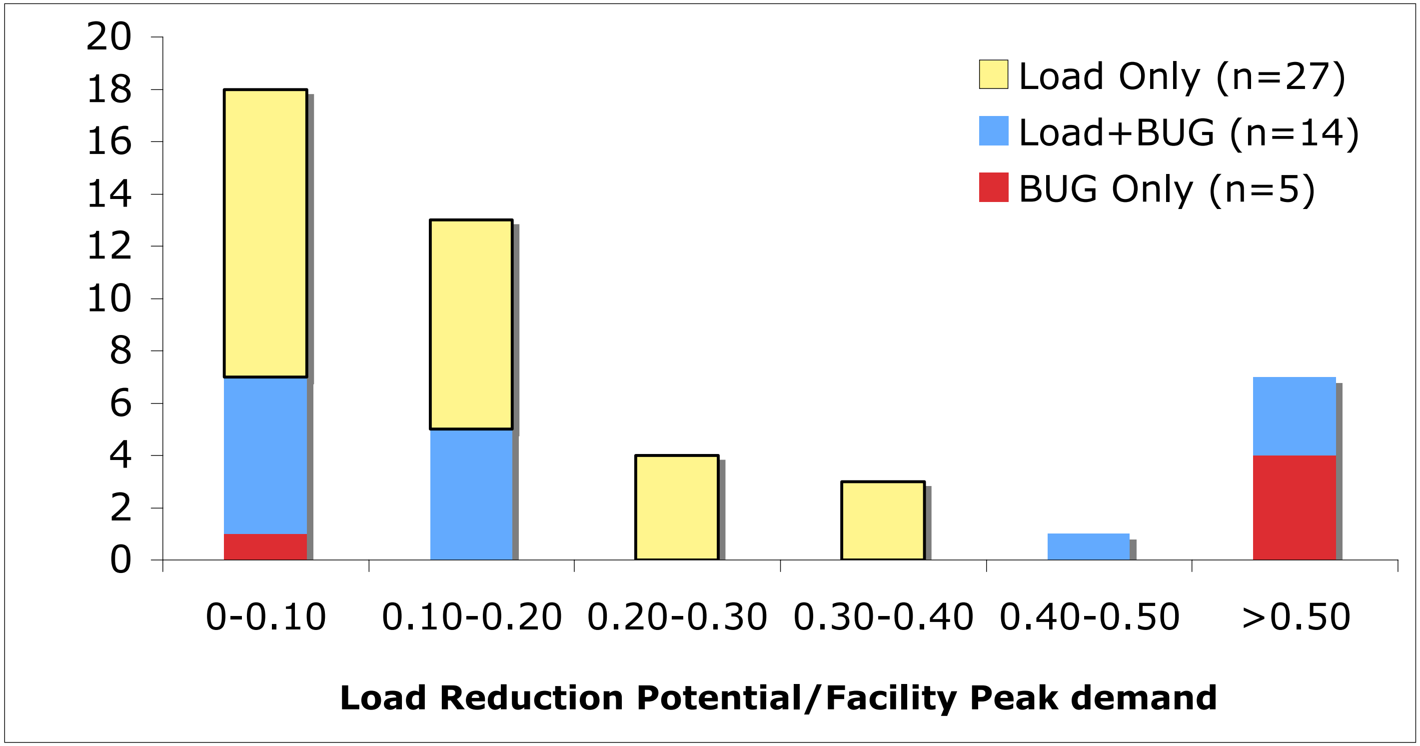


Source: Welch, Tom. 2005. Reflections on the Role of Demand Response in Electricity Markets. *Presentation at National Town Meeting on Demand Response*, June 21.

Customers on average can achieve 10-20% load reductions when called upon by the utility, using manual reduction strategies and simple controls.

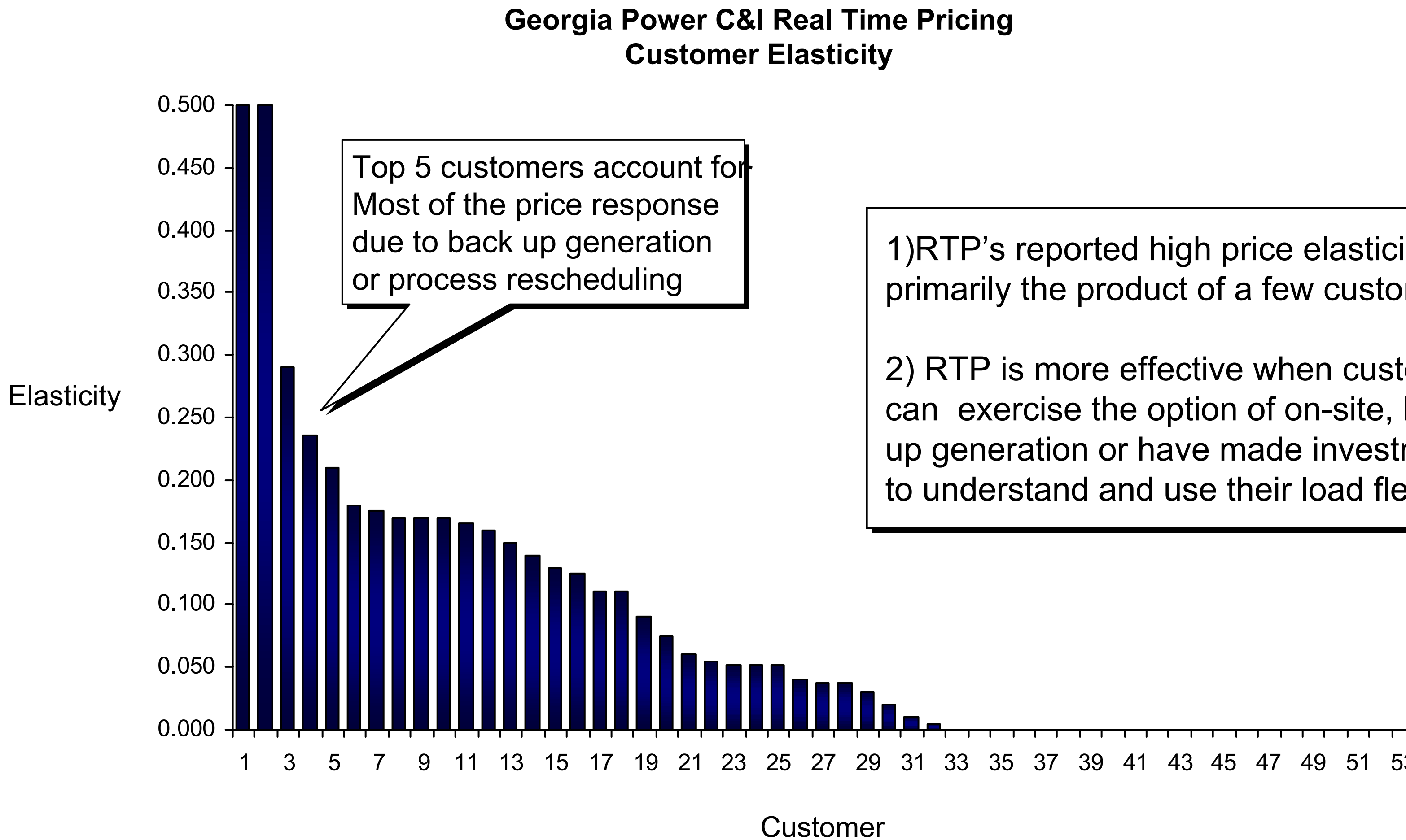
For commercial customers with more advanced demand response technologies including automated response, load reductions of 20-40% are possible.

Participants who also use backup generation can achieve 50% or more.



Source: Goldman, Charles, M. Kintner-Meyer, and G. Heffner. 2002. Do ŅEnabling TechnologiesÓ Affect Customer Performance in Price-Responsive Load Programs? Environmental Technologies Division, Lawrence Berkeley National Laboratory.

The jury is still out on the efficacy of RTP



1)RTP's reported high price elasticity is primarily the product of a few customers

2) RTP is more effective when customers can exercise the option of on-site, back-up generation or have made investments to understand and use their load flexibility

Source: Reiss, Rachel. 2004. A Sampling of Price Responsive Demand Response Programs. Presented at Platts teleconference on Price-Responsive Demand Response Programs, June 16.

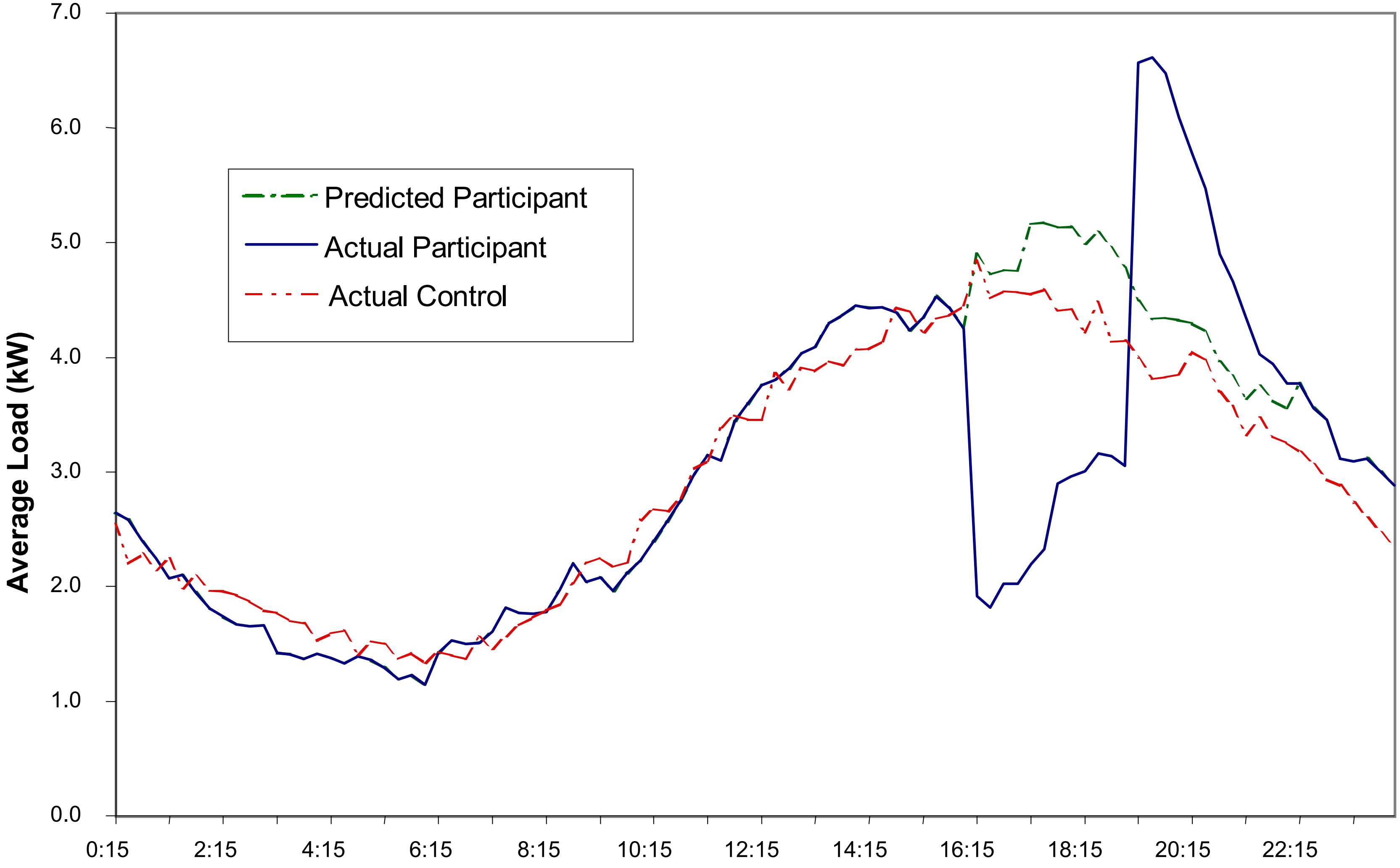
Comparison of Automated Residential Demand Response Programs with Flat (Nevada) and Dynamic (Calif.) Pricing

Nevada Power Two-Way ACLM Pilot

- Utility initiates load control events on extreme summer days
- No change in prices or tariff structure, annual incentive only
- A/C thermostat raised 4^{o}F, customer may override
- 202 Residential customers in Las Vegas
- Stratum classifications of ACLM pilot populations:

Stratum	Minimum monthly consumption (kWh)	Maximum monthly consumption (kWh)
1	0	799
2	800	1,249
3	1,250	1,749
4	1,750	3,499
5	3,500	

Average load profile of ACLM participant and control homes, curtailment event weekdays



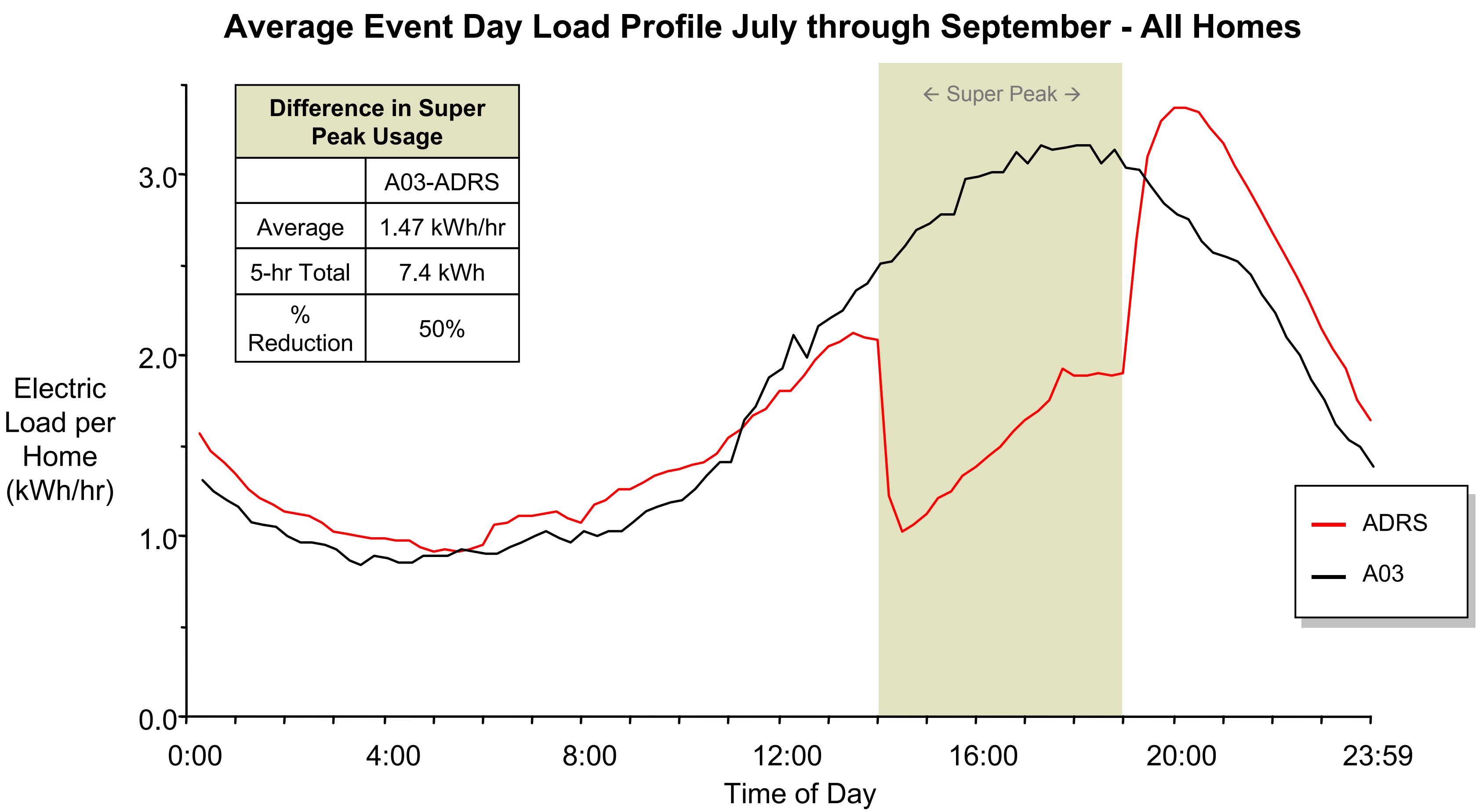
Summary: Automated, two-way ACLM delivered reliable load reduction of ~2.5 kW per home

- The automated load management system consistently delivered average 3-hour load reduction of 2.5 kW/home from the population of pilot homes across the valid curtailment events
- In more energy intensive homes with peak demand >5kW, two-way ACLM delivered 2.8 kW
- In terms of instant load shed, which is useful for emergency system reliability, two-way ACLM drops 3.5 kW per home
- Pool pumps contributed approximately 0.54 kW/home of coincident peak reduction in 2004 (1.1 kW in 2003)
- Overrides averaged 20% (10% on ‘placebo’ event days)

California ADRS Pilot

- Statewide, three utilities: PG&E, SoCal Edison, SDG&E
- Pilot sample of 175 customers, 80% > 24 kWh/day
- Participant and control homes in same climate, all A/C
- Critical Peak Pricing (CPP): Time-of-use tariff increases rate 3x during 5-hour on-peak interval, 8x during selected ‘Super Peak’ events
- Technology programmed to respond to price signal
- Due to influence of price signal on non-event days, it is not possible to estimate baseline load profile for the participant homes, can only compare to control homes

Average load profile of ADRS participant and A03 control homes, super-peak event weekdays



Difference in Super Peak Usage	
	A03-ADRS
Average	1.47 kWh/hr
5-hr Total	7.4 kWh
% Reduction	50%

Summary: ADRS homes use ~0.8 kW less on-peak energy than control homes, and ~1.7 kW less on Super Peak days

- ADRS technology-enabled homes reduced load by ~50% during summer Super Peak events, relative to homes without the technology or CPP rates (~20% reduction from CPP rate alone)
- Technology enabled-ADRS homes' reduction of Super Peak load decreased over the five-hour Super Peak period, but the load reduction was sustained better in September than in July-August
- Total daily energy consumption of ADRS houses was 5% lower than that of the comparable subset of control homes, as much of the on-peak savings were compensated by usage during the evening 'recovery' period.
- About 10% of the ADRS population are "Supersavers," reducing load by more than 30% consistently across the summer months.

Next steps: Communicating thermostats in 2008 Title-24 standards; Statewide CPP rates to be adopted - opt-in or opt-out?

Summary: Automated DR technology reduces peak demand by ~50%, and total summer usage by ~5% in both programs

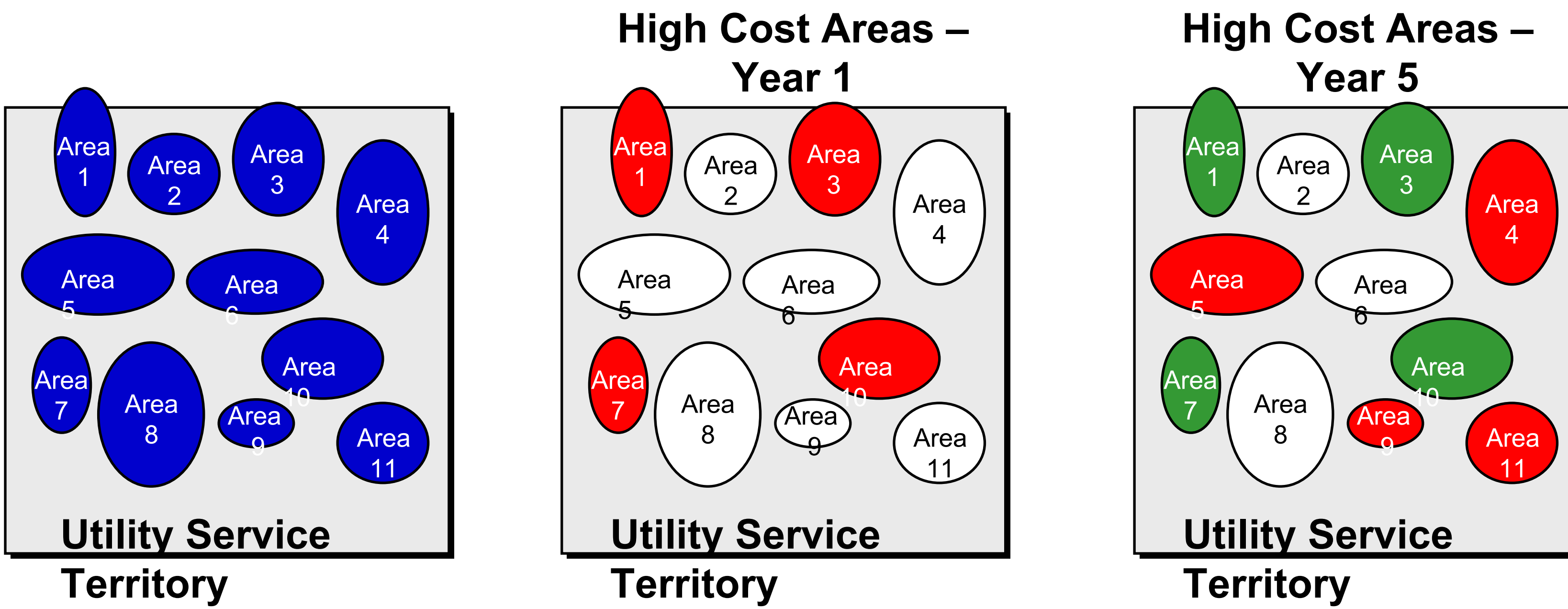
- Absolute savings were greater in the Nevada ACLM program, due to the higher baseline A/C loads in the hotter Las Vegas climate.
- Initial findings from these programs suggest that either automated technology or dynamic pricing can deliver significant demand response in low-consumption houses, but that the combination of both technology or dynamic pricing might not be necessary.
- Since the cost-effectiveness of a demand response program depends most directly on the magnitude of the peak kW reduction achieved, these results suggest a strategy of targeting a technology-enabled residential demand response to higher-usage customers.
- Especially in the California ADRS program, with lower baseline usage and dynamic pricing in place, the benefit of peak load reduction due to the technology will be greater for these customers.
- This targeting strategy can thus improve the economic performance of automated residential demand response. Larger scale programs can benefit from using this strategy in program design.

Planning Implications of Demand Response

- Demand response = load response + price response
  - Savings triggered (and funded) by rates or incentive programs
  - Both can be enabled by automated technology
- Demand response completes a demand-side portfolio
  - DR is the 'peaking' capacity; can be a reliability resource
  - Commercial lighting, HVAC efficiency are the 'shoulder' resource
  - Residential lighting and appliances are the 'baseload' resource
- Demand response has option value to the utility
  - DR programs can be planned, piloted, recruited in advance at low cost, to secure the 'option'
  - Later, full-scale roll-out of technology, incentives when needed in response to cost signals, to exercise the 'option'
- Demand response is most cost-effective when targeted
  - Larger customers with more responsive loads (higher kW/site)
  - High-cost area due to grid constraints, deferrable capacity needs

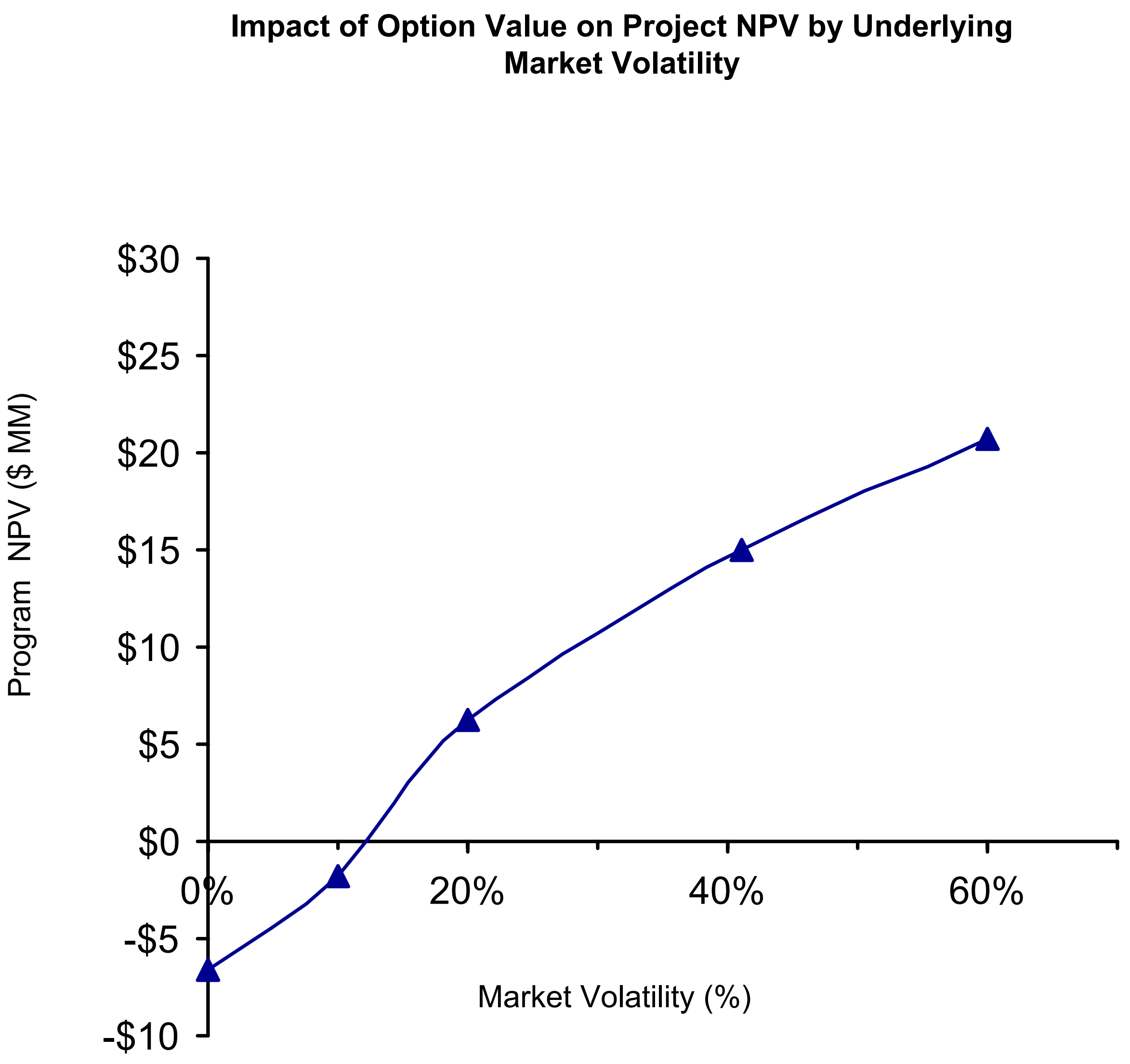
High-cost distribution 'hot spots' change over time, so a targeted approach is needed

Conventional approach:	Distributed generation or targeted DSM:
Based on system-level costs	Based on area- and time-specific costs
Each area looks the same!	High-cost (red) areas move around in time!



To achieve T&D deferral value, DR must displace the area load growth for at least one year. Minimum capacity is typically in the range of 500-2500 kW.

Option Value: The Choice of Timing of Full Scale Rollout Creates Value in a Market with Price Volatility



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