Automated Demand Response Programs: *Load Impacts and Cost Effectiveness Tests*

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Agenda

- Description of Automated Demand Response Programs (Auto-DR)
- 2009 Program Year Load Impacts
  - Methods
  - Results
  - Total vs. Incremental Load Impacts
- Cost Effectiveness Tests
  - Methods
  - Results
- Conclusions

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Auto-DR Program Description

Auto-DR Program Description

- Commercial and industrial program that offers incentives to install equipment that enhances and automates a customer's demand response during program events
- Incentive payments are as high as $300 per kW, as measured in a load shed test

Auto-DR Program Description (2)

- Steps for participation:
  - Preliminary assessment of demand response opportunities
  - Technical audit
  - Implementation (installation and testing)
  - Enrollment in a demand response (DR) program (e.g., Critical Peak Pricing or the Demand Bidding Program)

Auto-DR Program Description (3)

Examples of Auto-DR technology:

- Wired and wireless controls for lighting, HVAC, motors, pumps, fans, air compressors, process equipment, audio/video equipment, etc.;
- Energy Management software;
- Energy Management Systems, including repairs/upgrades/reprogramming of existing controls;
- Thermostats, plug strips, occupancy sensors and other devices capable of receiving curtailment signals; and
- Appliances and vending machines capable of receiving curtailment signals.

Auto-DR Enrollments

Utility	DR Program	# Service Accounts	Load Shed Test kW
PG&E	CPP	43	4,317
	DBP	20	25,415
SCE	CPP	19	5,869
	DBP	19	6,554
SDG&E	CPP	10	1,697
	CBP	66	3,720
	Total	**177**	**47,572**

Demand Response Program Events in 2009

Utility	DR Program	# Event Days
PG&E	CPP	12
	DBP	1 (test)
SCE	CPP	12
	DBP	15
SDG&E	CPP	8
	CBP	7

2009 Program Year Load Impact Estimates

Load Impact Estimation Methods

- Our methods differ from program settlement methods
- Program settlement methods:
  - 3-in-10 baseline
  - 10-in-10 baseline, with and without adjustment
- Our report uses regression-based methods to estimate load impacts
  - Consistent with load impact protocols, and therefore the cost effectiveness protocols

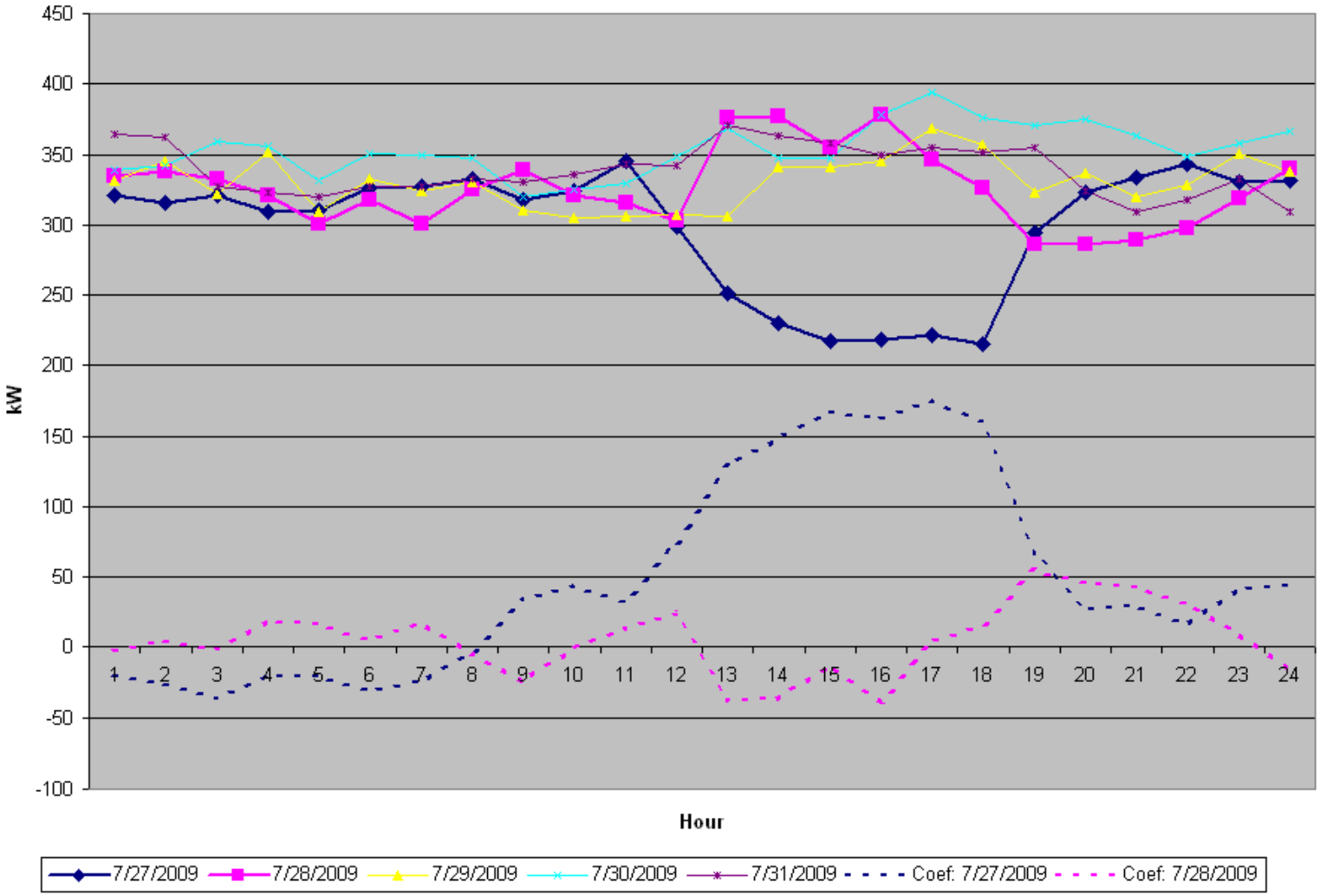
Load Impact Estimation Methods: *Regression Model*

- Variables included in the regression model:
  - Each hour of every event day
  - Weather (hourly cooling degree hours)
  - Hourly load shape
    - Mondays, Tuesday-Thursday, Friday
  - Day type, month, and summer "shift" variables
  - Indicator for event hours for other DR programs in which the customer is enrolled
  - Morning load (average usage from hours 1 through 10)

Load Impact Estimation Methods: *Results Screening*

- Hourly load impact estimates are screened for reasonableness
  - Compare estimates to observed hourly loads on event and non-event days
  - Relatively few modifications made to results for Auto-DR customers
- A study of our estimates (for SCE) found that the regression-based load impacts most closely resembled results from the 10-in-10 adjusted baseline method

Load Impact Estimation Methods:
Results Screening Example



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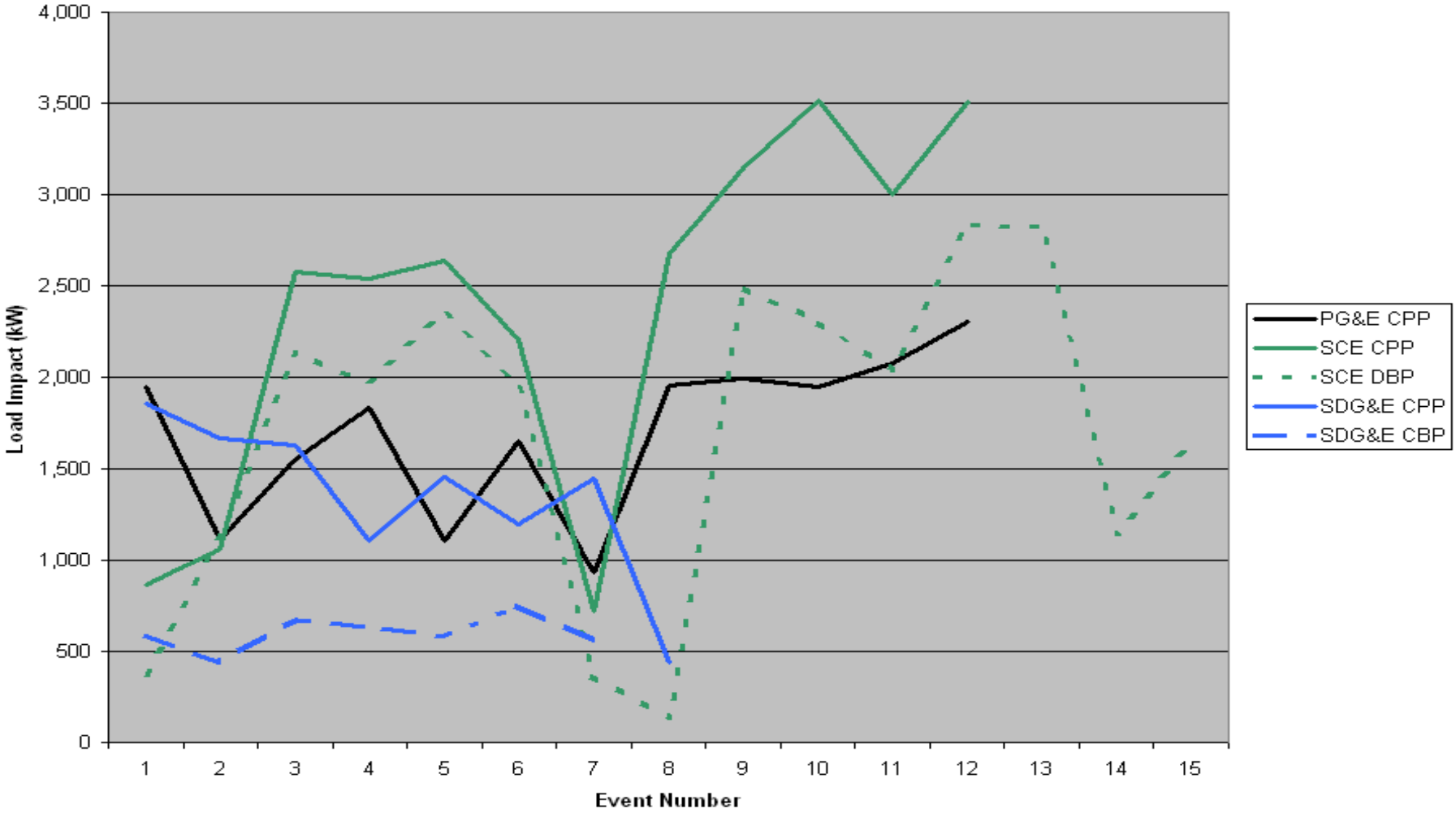
Estimated Load Impacts



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Estimated Load Impacts: *Summary Table*

Utility	Program	Load Impact (kW)	Reference Load (kW)	% Load Impact	LI / Tested kW	Bid kW	2009 CV
PG&E	CPP	1,701	27,836	6.1%	42%	n/a	0.26
	DBP	19,066	41,794	45.6%	89%	25,156	n/a
SCE	CPP	2,369	7,765	30.5%	40%	n/a	0.41
	DBP	1,712	7,820	21.9%	28%	4,498	0.52
SDG&E	CPP	1,349	6,998	19.3%	79%	n/a	0.33
	CBP	605	5,299	11.4%	16%	n/a	0.16

Estimated Load Impacts: *PG&E CPP*

- Less variable load impacts than some other Auto-DR programs
- Still, 3 of 12 events had significantly lower load impacts than other days (July 27th was particularly low)
- Percentage load impacts were low compared to other Auto-DR programs (also true of load test kW as a percentage of reference load)

Estimated Load Impacts: *PG&E DBP*

- Only one test event called in 2009 (also the case in 2008)
- First 2 of 4 event hours were also BIP event hours
- BIP/DBP overlapping customers constitute the vast majority of the load impact
  - With BIP customers = 19 MW
  - Without BIP customers = 2.5 MW
  - 2009 event = 5.7 MW (no overlap with BIP)

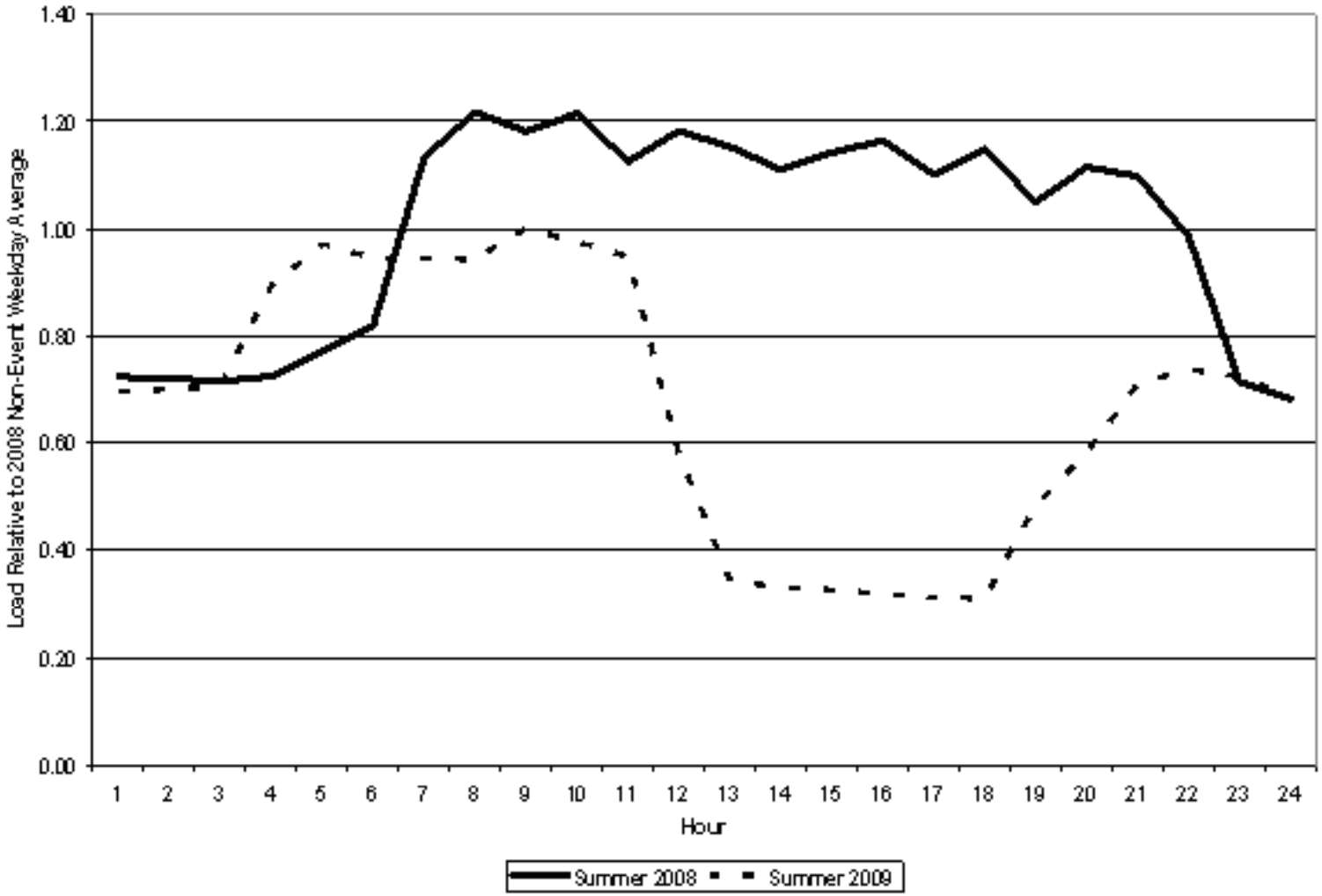
Estimated Load Impacts: *PG&E DBP (2)*

- One DBP customer has a load shed test kW of over 5 MW
- They are very flexible, and use very little during TOU peak hours; can only participate in DBP events from 6 to 8 p.m.
- PG&E's DBP test events have ended at 6 p.m., so we have not observed this customer's behavior during actual events

Estimated Load Impacts: *SCE CPP*

- Load impacts are heavily dependent on the performance of one customer
  - Not activated on Auto-DR for 1st two events, then "sat out" two other events
  - "Normal" response about half of load shed test kW
- A second customer is a large share of the load shed test kW, but responded at about 11% of that level
  - Baseline affected by economic conditions and/or conservation measures
- Load impacts less variable for other service accounts
  - CV = 0.41 for whole program
  - CV = 0.30 for all but two largest customers

Estimated Load Impacts:
SCE CPP & DBP, Customer B



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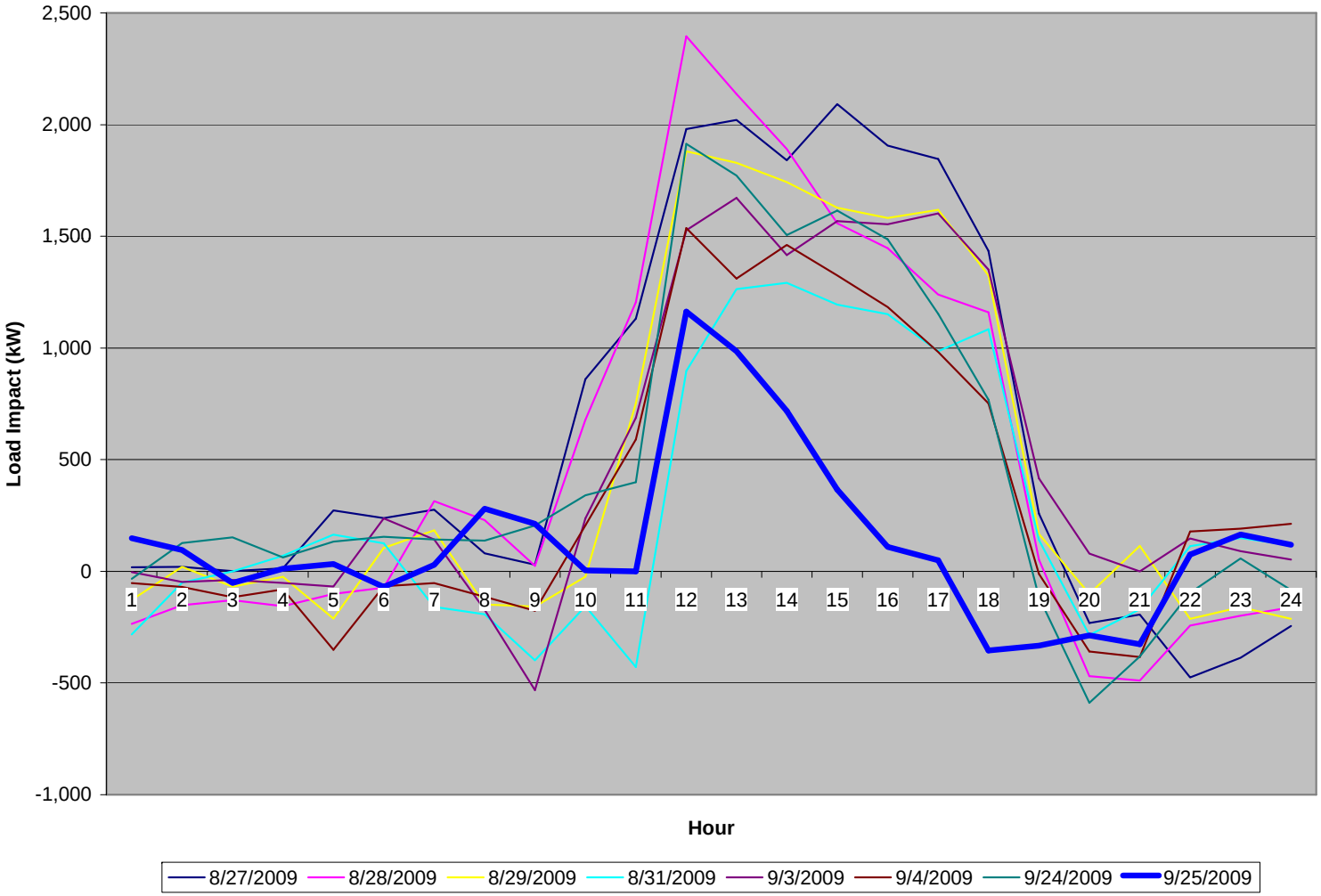
Estimated Load Impacts: *SCE DBP*

- Same issue as in CPP is present for DBP
  - Two service accounts are dually enrolled
  - Affects variability of load impacts and difference between estimated load impacts and the load shed text kW
- Remaining service accounts also have highly variable load impacts
  - Variation is not related to overlap with CPP event days, changes in bid amount, or the number of hours in which the customers bid

Estimated Load Impacts: *SDG&E CPP*

- Fairly stable load impacts
  - Last event is the exception – it appeared that Auto-DR customers thought the event ended early
  - 5 of the 10 service accounts accounted for 92% of the load impact – all department stores

Estimated Load Impacts: *SDG&E CPP (2)*



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Estimated Load Impacts: *SDG&E CBP*

- Stable load impacts
- Much lower load impacts in 2009 than 2008
  - Only one event in 2008
  - Lighting customers not happy with results, did not perform as well for the seven 2009 events
  - SDG&E educated customers prior to PY2010
  - Preliminary results indicate some improvement in performance, but still well below 2008 level

Incremental Load Impacts

- Previous slides described *total* load impacts, or what the Auto-DR customers did on event days
- For cost effectiveness studies, may want to use *incremental* load impacts
  - The difference between total Auto-DR load impacts and what load impacts would have been in the absence of Auto-DR

Incremental Load Impacts: *Estimation Issues*

- It can be difficult to estimate incremental load impacts:
  - Don't often observe before / after load impacts
  - Can be difficult to find a reasonable "control" group (e.g., don't know whether non-Auto-DR customers have enabling technology)
- If Auto-DR induces customers to participate in DR programs, then total = incremental load impact

Incremental Load Impacts: *Estimation Method*

- Compare percentage load impacts for Auto-DR and non-Auto-DR customers at a narrowly defined industry level
- Multiply the difference in percentage load impacts by the Auto-DR customer reference loads

Incremental Load Impact Example: *SDG&E CPP Characteristics*

NAICS Code	NAICS Description	Basis of Comparison	Number of SAIDs		Average Reference Load (kW) / SAID	
			No AutoDR	AutoDR	No AutoDR	AutoDR
452111	Department Stores	6-digit NAICS	10	6	461	837
512131	Motion Picture Theaters	6-digit NAICS	17	1	256	511
721110	Hotels and Motels	6-digit NAICS	47	2	274	493
721120	Casino Hotels	6-digit NAICS	2	1	561	546

Incremental Load Impact Example: *SDG&E CPP Load Impacts*

NAICS Code	NAICS Description	Basis of Comparison	Average Load Impact (kW) / SAID		Average Percentage LI	
			No AutoDR	AutoDR	No AutoDR	AutoDR
452111	Department Stores	6-digit NAICS	10.7	214.7	2.4%	34.5%
512131	Motion Picture Theaters	6-digit NAICS	3.8	17.8	1.5%	3.6%
721110	Hotels and Motels	6-digit NAICS	12.8	13.3	4.9%	2.8%
721120	Casino Hotels	6-digit NAICS	136.5	18.3	32.1%	3.5%

Incremental Load Impact Example: *SDG&E CPP Calculation*

NAICS Code	NAICS Description	Average Percentage LI		Reference Load (kW)	Incremental LI (kW)
		No AutoDR	AutoDR		
452111	Department Stores	2.4%	34.5%	5,024	1,171
512131	Motion Picture Theaters	1.5%	3.6%	511	10
721110	Hotels and Motels	4.9%	2.8%	987	-19
721120	Casino Hotels	32.1%	3.5%	478	-100
Total					**1,062**

Incremental Load Impacts: *Summary*

Program	Total LI	Incremental LI
PG&E CPP	1,701	1,452
PG&E DBP	19,066	-239
SCE CPP	2,369	1,446
SCE DBP	1,712	1,614
SDG&E CPP	1,349	1,062
SDG&E CBP	605	138

Incremental Load Impacts: *Summary (2)*

- PG&E DBP:
  - Incremental load impact is *negative*
  - Wrong-signed difference between percentage load impacts of the largest group (corporate managing offices)
  - 7.6% for non-Auto-DR; 1.7% for Auto-DR
- Highlights the difficulty in finding a reasonable comparison group

Cost Effectiveness Tests

Cost Effectiveness Tests

- Developed a cost effectiveness (CE) model framework, which was applied to each utility's Auto-DR program
- Conducts Total Resource Cost (TRC) and Program Administrator Cost (PAC) tests
- Examines 10-year lifespan of Auto-DR equipment
  - Includes equipment installed in 2007-2009

Cost Effectiveness Tests (2)

- Spreadsheet model is less complex than utility models
  - Requires utility inputs, the calculation of which is part of what makes the utility models more complex
  - More transparency in calculations / methods
  - Facilitates scenario analysis

Cost Effectiveness Tests: *Model Elements*

- Avoided capacity costs =
  $Q * C * (1 + reserves) * loss\ factor * A * B * E$

- Avoided energy costs =
  $Q * MC * Hrs * Evts * loss\ factor$

- Avoided T&D costs =
  $Q * TD * loss\ factor * A * B * E * R$

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Cost Effectiveness Tests: *Model Elements (2)*

- Program and incentive costs
  - Auto-DR administrative costs
  - Auto-DR incentive costs
  - DR program incentive costs
- Auto-DR administrative costs are allocated to the DR programs
  - by share of load shed test kW for PG&E and SDG&E
  - by share of service accounts for SCE

Ancillary Services Benefit

- The CE model does not include any benefits associated with the ability of automated resources to provide load impacts with short notice
- This could allow Auto-DR customers to participate in the ancillary services market (assuming the availability of a suitable program)
- Avoided capacity costs ($ per kW year) would need to be adjusted to remove this value
  - Right now, all DR resources are treated as though they can respond as quickly as a CT

Cost Effectiveness Tests: *Model Parameters*

Parameter	PG&E DBP	PG&E CPP	SCE DBP	SCE CPP	SDG&E CBP	SDG&E CPP
Hours per event	8	4	8	4	4	7
Events per year	1	10	15	12	9	9
A factor	85.9%	72.7%	79.0%	53.0%	73.0%	86.0%
B factor	100%	100%	99%	95%	90%	90%
E factor	83.9%	93.7%	81.0%	98.8%	97.0%	96.1%
R factor	0%	0%	0%	0%	79.2%	57.9%

A adjusts avoided costs for DR program availability; *B* adjusts for DR program notice time; *E* adjusts for DR load response variability; and *R* adjusts for T&D "right time, right place" criteria.

Cost Effectiveness Tests: *Equivalence of TRC and PAC Tests*

- Both TRC and PAC tests include the following as benefits:
  - Avoided capacity costs
  - Avoided energy costs
  - Avoided T&D costs
- TRC test includes the following costs:
  - Administrative costs
  - Customer costs
- PAC test includes the following costs:
  - Administrative costs
  - Incentive costs

Cost Effectiveness Tests: *Equivalence of TRC and PAC (2)*

- We do not observe customer costs, so (per protocols) they are assumed to be equal to the incentive costs
  - Already done in utility CE models for ongoing DR program incentives
  - We also included up-front Auto-DR incentives, which are assumed to reduce customer costs associated with responding to event days
- Therefore, TRC and PAC test results are the same

Cost Effectiveness Tests: *Scenarios*

- Examined a variety of scenarios
  - Total load impacts, load shed test kW, incremental load impacts
  - Some alternative total load impacts
    - PG&E DBP at 2008 vs. 2009 levels
    - SDG&E CBP at 2009 vs. 2010 levels
  - Accounting for variability of load impacts
    - "E" factor, for 70th percentile exceedance factor
    - Based on variability of load impacts across events
    - From treatment of wind and solar resources (proposed in resource adequacy proceeding)

Cost Effectiveness Tests:
2009 Total Load Impacts, PG&E

Benefits	**DBP**	**CPP**	**Total**
Avoided Capacity	$4,199,591	$1,843,396	$6,042,987
Avoided Energy	$27,926	$64,480	$92,405
Avoided T&D	$0	$0	$0
Total Benefits	$4,227,517	$1,907,876	$6,135,393
Costs			
Administrative Costs	$4,882,895	$887,023	$5,769,918
Customer Costs	$4,817,275	$828,852	$5,646,127
Total Costs	$9,700,170	$1,715,875	$11,416,044
Benefit to Cost Ratio	0.44	1.11	**0.54**

Cost Effectiveness Tests:
2008 Total Load Impacts, PG&E

Benefits	**DBP**	**CPP**	**Total**
Avoided Capacity	$24,346,843	$1,843,396	$26,190,239
Avoided Energy	$164,316	$64,480	$228,796
Avoided T&D	$0	$0	$0
Total Benefits	$24,511,159	$1,907,876	$26,419,036
Costs			
Administrative Costs	$4,882,895	$887,023	$5,769,918
Customer Costs	$5,396,751	$828,852	$6,225,603
Total Costs	$10,279,646	$1,715,875	$11,995,521
Benefit to Cost Ratio	2.38	1.11	**2.20**

Cost Effectiveness Tests: *PG&E Total Load Impacts*

- Using 2008 vs. 2009 Auto-DBP load impacts for one customer is the difference between a benefit-cost ratio of 0.54 and 2.20
- So the behavior of one customer for four hours of one event day determines Auto-DR cost effectiveness for PG&E
- Indicates need for larger sample of customers and event days to assess cost effectiveness

Cost Effectiveness Tests:
2009 Total Load Impacts, SCE

Benefits	**DBP**	**CPP**	**Total**
Avoided Capacity	$1,768,353	$1,508,089	$3,276,442
Avoided Energy	$138,224	$73,494	$211,718
Avoided T&D	$0	$0	$0
Total Benefits	$1,906,577	$1,581,583	$3,488,160
Costs			
Administrative Costs	$1,324,826	$2,097,640	$3,422,466
Customer Costs	$2,832,765	$814,941	$3,647,705
Total Costs	$4,157,590	$2,912,581	$7,070,171
Benefit to Cost Ratio	0.46	0.54	**0.49**

Cost Effectiveness Tests:
Load Shed Test kW, SCE

Benefits	**DBP**	**CPP**	**Total**
Avoided Capacity	$5,611,047	$3,418,857	$9,029,904
Avoided Energy	$435,288	$166,189	$601,477
Avoided T&D	$0	$0	$0
Total Benefits	$6,046,335	$3,585,046	$9,631,381
Costs			
Administrative Costs	$1,324,826	$2,097,640	$3,422,466
Customer Costs	$4,779,485	$814,941	$5,594,425
Total Costs	$6,104,310	$2,912,581	$9,016,891
Benefit to Cost Ratio	0.99	1.23	**1.07**

Cost Effectiveness Tests: *SCE Total Load Impacts*

- SCE's Auto-DR program is not cost effective at 2009 load impact levels
- It is cost effective if customers reach their load shed test kW levels
- Recall that two customers are a large percentage of load shed test kW (70%+)
  - Baseline has gone down since test because of economic conditions and conservation

Cost Effectiveness Tests:
2009 Total Load Impacts, SDG&E

Benefits	**CBP**	**CPP**	**Total**
Avoided Capacity	$550,812	$1,301,549	$1,852,362
Avoided Energy	$26,622	$94,274	$120,896
Avoided T&D	$137,076	$236,772	$373,848
Total Benefits	$714,511	$1,632,595	$2,347,106
Costs			
Administrative Costs	$717,346	$161,111	$878,457
Customer Costs	$1,896,054	$274,594	$2,170,648
Total Costs	$2,613,399	$435,705	$3,049,105
Benefit to Cost Ratio	0.27	3.75	**0.77**

Cost Effectiveness Tests:
Load Shed Test kW, SDG&E

Benefits	**CBP**	**CPP**	**Total**
Avoided Capacity	$3,359,134	$1,637,309	$4,996,443
Avoided Energy	$162,367	$118,594	$280,961
Avoided T&D	$835,961	$297,852	$1,133,813
Total Benefits	$4,357,463	$2,053,754	$6,411,217
Costs			
Administrative Costs	$717,346	$161,111	$878,457
Customer Costs	$4,294,577	$274,594	$4,569,171
Total Costs	$5,011,923	$435,705	$5,447,628
Benefit to Cost Ratio	0.87	4.71	**1.18**

Cost Effectiveness Tests: *SDG&E Total Load Impacts*

- SDG&E's Auto-DR program is not cost effective at 2009 load impact levels
- It is cost effective if customers reach their load shed test kW levels
- Benefit-cost ratio improves from 0.77 to 0.82 using preliminary 2010 Auto-CBP load impacts (and 2009 Auto-CPP load impacts)

Cost Effectiveness Tests: *Accounting for Variability*

	PG&E	SCE	SDG&E
Benefit-cost ratio if $E = 1$	0.54	0.49	0.77
Benefit-cost ratio if $E < 1$	0.47	0.44	0.74

Cost Effectiveness Tests: *Incremental Load Impacts*

	PG&E	SCE	SDG&E
Total Load Impacts	0.54	0.49	0.77
Incremental Load Impacts	0.14	0.36	0.54

Conclusions

Conclusions

- Percentage load impacts for Auto-DR customers are quite high
  - Low of 6%, high of 46%
- Load shed tests imply even higher percentage load impacts
  - Customers provide 16% to 82% of load shed test kW across DR programs
- Auto-DR incentives are paid based on the results of the load shed tests
- The difference between estimated load impacts and the load shed test kW values makes it difficult for Auto-DR to be cost effective

Conclusions (2)

- Potential causes for the difference between estimated load impacts and load shed test results:
  - Changes in the baseline over time
    - In response to economic conditions
    - Because the customer implements conservation in all hours
  - Difference between load shed test conditions and DR event conditions
  - Small sample sizes
    - Program load impacts can be affected by the behavior of one customer on one event day

Conclusions (3)

- Recommendations:
  - Re-evaluate cost effectiveness when the sample size is larger
  - Revisit the load shed test methodology to ensure that the results reflect DR program load impacts as well as possible
  - Evaluate Auto-DR incentive payment levels ($ per kW from the load shed test)