



2016 PG&E SmartAC™ Load Impact Evaluation

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Reimagine tomorrow.



Program Overview



AC load control through installation of control devices that limit the duty cycles of AC units

- Two types of devices: Switches and PCTs (50% cycling)
- Only switches are currently offered for new customers

Residential and small/medium businesses (SMB)

- Nearly 170,000 control devices belonging to over 153,000 customers
- No SMB events since 2011

Events can be called for testing purposes or in response to emergency conditions

- Events occur between May 1st and October 31st, for up to 6 hours or less in each event
- Program Availability
 - 100 hours of availability (38 actual)
 - No maximum number of events (14 event days in 2016)

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Ex Post

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SmartAC™ Experimental Design

Randomized Control Trial (RCT) for each event

- SmartAC™ population randomly divided into ten groups of approximately equal size based on the last digit of a device's serial number
- On a typical event day, some groups are called to have their A/C units cycled (treatment group)
- The groups that are not called serve as a control group whose load can be compared to the treatment group to estimate load impacts

Why does it work?

- Serial number is unrelated to any features of A/C or home that determine energy use
- Because serial number is effectively random, usage of the uncalled groups provide an unbiased estimate of what usage would have been for the controlled devices had they not been called (counterfactual)

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2016 Group M&E Events

Event Date	Treatment Groups	Start Time	Stop Time
June 27	0, 1, 2	4:00 PM	7:00 PM
June 27	3	5:00 PM	7:00 PM
June 27	4	1:00 PM	3:00 PM
June 27	9	3:00 PM	4:00 PM
July 14	1, 2	5:00 PM	8:00 PM
July 14	3	6:00 PM	7:00 PM
July 14	6	8:00 PM	9:00 PM
July 14	9	2:00 PM	5:00 PM
July 25	2	3:00 PM	6:00 PM
July 25	3	4:00 PM	5:00 PM
July 27	1, 2	3:00 PM	6:00 PM
July 27	3	5:00 PM	6:00 PM
July 28	4	1:00 PM	4:00 PM
July 28	5	4:00 PM	7:00 PM
July 28	7	11:00 AM	1:00 PM
July 29	6	2:00 PM	5:00 PM
July 29	7	12:00 PM	2:00 PM
July 29	8	5:00 PM	6:00 PM
September 7	2	5:00 PM	8:00 PM
September 7	3	6:00 PM	7:00 PM
September 19	5	1:00 PM	3:00 PM
September 19	0, 1, 2	4:00 PM	7:00 PM
September 19	3	4:00 PM	5:00 PM
September 19	6	7:00 PM	8:00 PM

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Summary of Ex Post Impacts for 5-6 PM

Event Date	SmartRate™ Day	Group Called	Ref Load (kW)	Avg. Impact (kW)	% Impact	Avg. Temp (°F)
6/27/2016	Yes	0, 1, 2	2.92	0.61	21%	98.2
		3	2.92	0.59	20%	98.2
7/14/2016	Yes	1, 2	2.63	0.46	17%	96.1
7/25/2016	No	2	2.53	0.48	19%	94.9
7/27/2016	Yes	1, 2	3.14	0.67	21%	99.5
		3	3.14	0.65	21%	99.5
7/28/2016	Yes	5	2.93	0.54	19%	98.2
7/29/2016	No	8	2.86	0.52	18%	98.2
9/7/2016	No	2	1.86	0.25	13%	93.4
9/19/2016	No	0, 1, 2	2.37	0.41	17%	95.8
Average			2.73	0.52	19%	97.2

- The average load impact during HE 17 on 7/27 (CAISO peak) was 0.62 kW and the aggregate impact was 12.4 MW.
- The average load impact during HE 18 on 7/27 (PG&E peak) was about 0.70 kW and the aggregate impact was 21 MW.

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2016 subLAP Events

Event Date	Treatment Groups	Start Time	Stop Time
June 20	PGLP, PGF1	5:00 PM	7:00 PM
June 28	PGF1, PGLP, PGNV, PGSA, PGSI, PGST	5:00 PM	7:00 PM
August 15	PGNV	5:00 PM	7:00 PM
August 16	PGNC, PGSA	5:00 PM	7:00 PM
August 17	PGEB, PGSI	5:00 PM	7:00 PM
September 26	All subLAPs except PGCC, PGSF, PGHB, and PGSN	5:00 PM	7:00 PM

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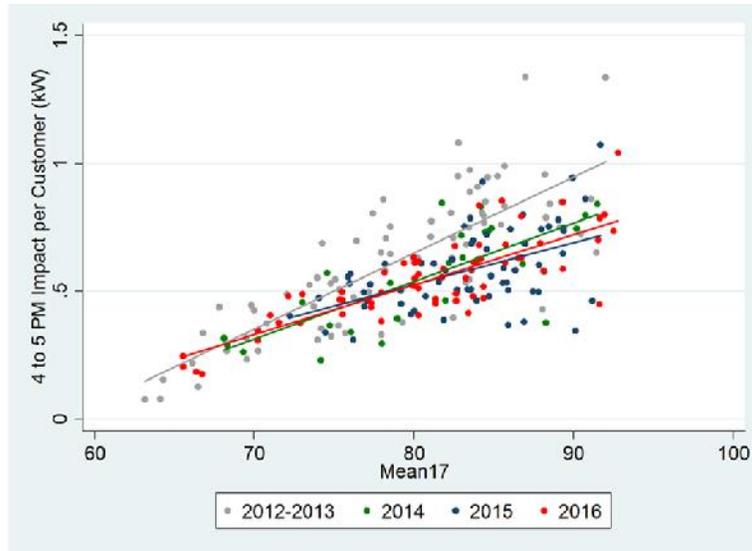


Summary of Ex Post Impacts for subLAP Events

Date	subLAPs Called	Number of Customers Called	Ref. Load (kW)	Avg. Impact (kW)	Std. Err. of Impact (kW)	% Impact	Aggregate Impact (MW)	Avg. Temp (°F)
June 20	PGF1, PGLP	33,325	2.55	0.31	0.01	12%	10.3	97.4
June 28	PGF1, PGLP, PGNV, PGSA, PGSI, PGST	64,337	3.36	0.72	0.01	21%	46.1	101.9
August 15	PGNV	6,319	2.73	0.32	0.02	12%	2.1	95.7
August 16	PGNC, PGSA	19,646	2.23	0.32	0.01	14%	6.3	94.9
August 17	PGEB, PGSI	31,710	2.15	0.23	0.01	11%	7.3	88.8
September 26	PGEB, PGF1, PGFG, PGLP, PGNB, PGNC, PGNV, PGP2, PGSA, PGSB, PGSI, PGST	113,065	2.26	0.25	0.00	11%	28.4	94.1

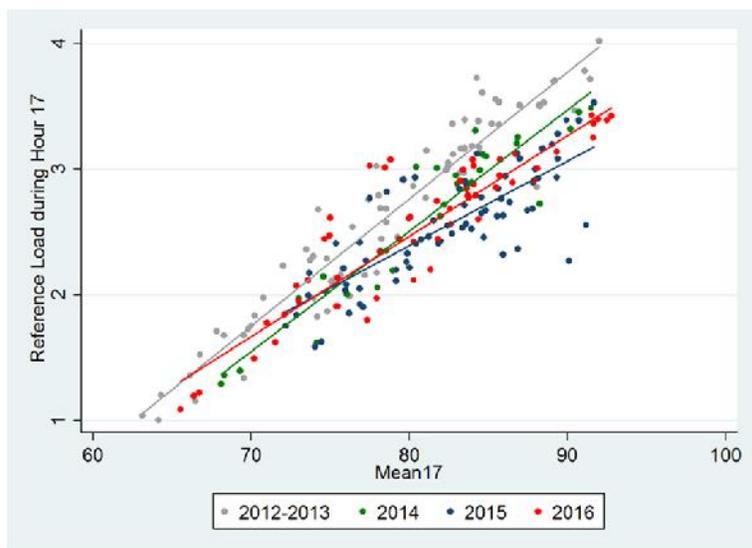
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2016 Impacts are Lower than 2012-2013 Impacts at Comparable Temperatures



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Reference Loads are Also Lower



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Ex Ante

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Four Fundamental Steps to Produce Ex Ante Forecasts

1. Estimate the relationship between load impacts and weather conditions for each hour in the resource adequacy window and all subsequent hours (snapback) using historical ex post results (2012-2016)
2. Estimate relationship between usage and temperature on event days and hot, non-event days (to expand the number of observations) for control customers to predict reference loads under ex ante weather conditions
3. Combine reference loads with impact estimates to infer load shapes for SmartAC™ participants
4. Scale up average customer impacts to aggregate impacts using forecasted enrollment provided by PG&E

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Enrollment Forecast (Single and multi-device, SmartAC™-Only and Dually Enrolled)

LCA	2017	2018	2019	2020	2021	2022	2023-2027
Greater Bay Area	40,414	40,756	41,087	41,406	41,714	42,011	42,108
Greater Fresno	16,328	16,634	16,929	17,213	17,489	17,754	17,841
Humboldt	731	746	761	775	789	802	807
Kern	8,054	8,324	8,585	8,837	9,080	9,315	9,392
Northern Coast	7,601	7,601	7,602	7,602	7,603	7,603	7,603
Other	28,506	29,069	29,612	30,137	30,644	31,134	31,293
Sierra	14,346	14,543	14,733	14,916	15,093	15,264	15,320
Stockton	13,316	13,654	13,981	14,296	14,600	14,894	14,989
Total	129,296	131,327	133,288	135,182	137,011	138,778	139,353

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Residential Ex Ante Forecasts (2018)

LCA	2016 Ex Post (3-6 PM, Jul. 25, Group 2)			2016 Ex Ante (1-6 PM, PG&E Aug. 2018 1-in-2)			2015 Ex Ante (1-6 PM, PG&E Aug. 2018 1-in-2)		
	Enrollment	Per Customer (kW)	Aggregate (MW)	Enrollment	Per Customer (kW)	Aggregate (MW)	Enrollment	Per Customer (kW)	Aggregate (MW)
Greater Bay Area	50,183	0.29	1.3	40,756	0.47	19.0	49,320	0.36	17.8
Greater Fresno	17,341	0.69	1.0	16,634	0.66	11.0	17,719	0.68	12.1
Humboldt	893	0.71	0.1	746	0.21	0.2	920	0.15	0.1
Kern	8,002	0.77	0.5	8,324	0.67	5.6	8,432	0.65	5.5
Northern Coast	8,727	0.21	0.2	7,601	0.45	3.4	8,483	0.30	2.6
Other	32,165	0.55	1.6	29,069	0.60	17.4	32,805	0.55	18
Sierra	16,468	0.49	0.7	14,543	0.52	7.5	16,834	0.48	8.1
Stockton	14,958	0.58	0.8	13,654	0.60	8.2	15,511	0.56	8.6
Total	148,737	0.48	6.3	131,327	0.55	72.3	150,024	0.48	72.7

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Residential Ex Ante Forecasts

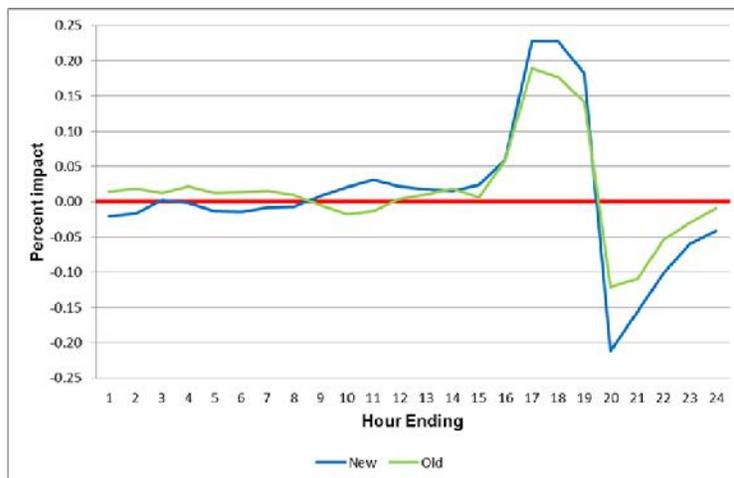
Year	PG&E August 1-in-2 Hourly Impact, 1-6 PM		
	Enrollment	Per Customer (kW)	Aggregate (MW)
2017	129,296	0.55	70.9
2018	131,327	0.55	72.3
2027	139,353	0.56	78.1

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Ex Post by Segment

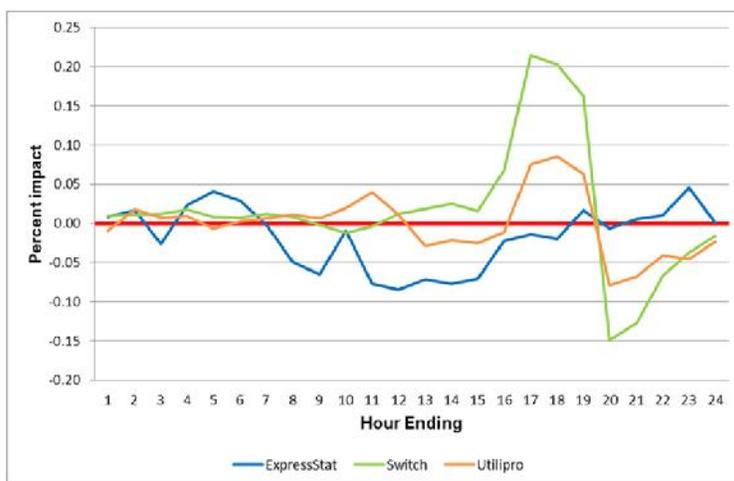
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Marketing Strategy (Single device, SmartAC™-only and Dually Enrolled)



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Device Type (Single device, SmartAC™-only and Dually Enrolled)



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End-of-summer Survey

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End-of-summer Survey Compared Customer Satisfaction, Thermal Comfort and Awareness



Event Date	Load Control Group			
	0	1	2	3
6/27/2016	4-7 PM			5-6 PM
7/14/2016	Not Called	5-8 PM		6-7 PM
7/25/2016	Not Called		3-6 PM	4-5 PM
7/27/2016	Not Called	3-6 PM		5-6 PM
9/7/2016	Not Called		5-8 PM	6-7 PM
9/19/2016	4-7 PM			4-5 PM
Total	2 Events / 6 Hours	4 Events / 11.5 Hours	6 Events / 17.5 Hours	6 Events / 6 Hours

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End-of-summer Survey Produced Several Key Insights for AC Load Control Programs



- At 50%, overall response rate for the mixed-mode survey was over three times higher than that of last year's telephone survey
- Satisfaction with PG&E, satisfaction with SmartAC™ and thermal comfort were similar across load control groups
- Group 2, which was called for the most event hours in 2016, was more likely to report that PG&E controlled their AC
- Customers in groups that were called most frequently (groups 2 and 3) had a higher SmartAC™ awareness rate
- De-enrollment increased slightly when the number of 2.5 to 3 hour events increased to four
- Calling six 1-hour events produced similar de-enrollment as calling two 3-hour events

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Conclusions and Recommendations

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2016 SmartAC™ Evaluation Provided Valuable Insights into Program Performance



- New marketing strategy has been effective at identifying customers who provide larger load impacts
- Nonetheless, downward trend in average load impacts that was first apparent in 2014 has continued in 2015 and 2016
 - May be due to physical failure of switches and decline in operability of older switches due to potential issues with the paging networks
- Group that was called for the most event hours in 2016 was more likely to report that PG&E controlled their AC and had a higher SmartAC™ awareness rate, but program de-enrollment was only slightly higher
 - De-enrollment analysis also found that calling six 1-hour events produced similar de-enrollment as calling two 3-hour events

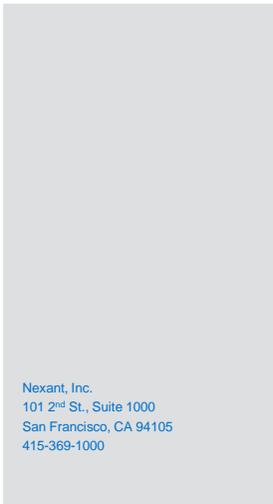
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Nexant Recommendations



- Continue using new marketing strategy
- Use new, two-way communicating LCR switches going forward and replace non-communicating switches (when cost-effective)
- Assess cost-effectiveness of additional event hours relative to incremental de-enrollment that results from more curtailment
 - Also look into whether more frequent, shorter events provide more value
- Continue to call a large number of M&E events in future years to generate more useful data and further increase the robustness of the ex ante results
- Further investigate causes of physical failure and identify how to reduce the rate at which switches break, are removed or are disconnected

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Appendix: Field Assessment of Switches



Completed Physical Assessments by subLAP

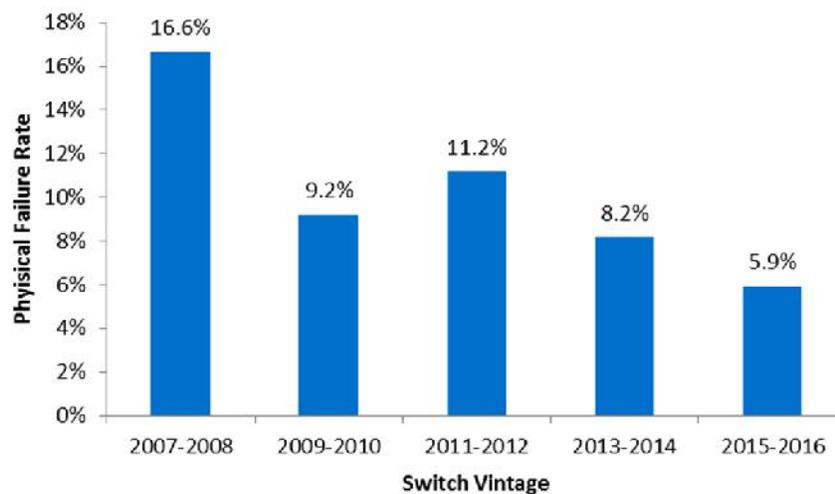
SubLAP	Initial Sample		Physical Assessments	
	Participants	Switches	Switches Completed	% of Sample
East Bay	237	246	208	84.6%
Fresno	287	292	237	81.2%
Los Padres	98	99	74	74.7%
Sacramento Valley	177	180	165	91.7%
Sierra	88	89	73	82.0%
South Bay	80	83	73	88.0%
Stockton	184	189	162	85.7%
Total	1,151	1,178	992	84.2%

- 992 assessments to determine whether switch was present and connected properly
- Incomplete visits due to property access issues or customer opting out
- 834 site visits for which the geo code was also successfully extracted from switches

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SmartAC™ Switch Physical Failure Rates by Vintage



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