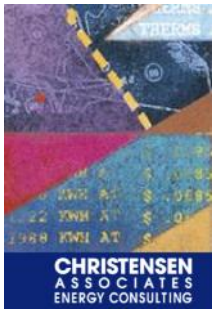

Load Impact Evaluation: *PG&E's Residential SmartRate*

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Presentation Outline

1. Program Description
2. *Ex-Post* Methodology
3. *Ex-Post* Load Impacts
4. *Ex-Ante* Methodology
5. *Ex-Ante* Load Impacts
6. Reconciliations
7. Summary and Conclusions

1. Program Description

- Voluntary Critical Peak Pricing ("CPP") program for PG&E's residential customers
- Participants receive *bill credits* on non-event days from June 1 through September 30
- On "SmartDays" (hereafter called "event days"), customers pay a 60 cents/kWh "High-Price Period Charge" from 2:00 to 7:00 p.m.
  - Target of 12 event days per summer (max of 15)
- *Bill protection* is available through the first full season
- SmartRate customers can also participate in SmartAC
  - 24% dually enrolled

2. *Ex-Post* Methodology

- Primary results are based on a *matched control group* + difference-in-differences evaluation methodology
  - Matched on event-like non-event day loads using Euclidean Distance
  - Matches segmented by: SmartAC enrollment status; LCA; climate zone; CARE status; and (for dual only) CAC likelihood
  - Two 24-hour average load profiles used for matching: core summer days and approximate *school-year* days
- This method was chosen for two reasons:
  - A large pool of residential (non-SmartRate) customers available from which to select matches
  - Control group of similarly situated (but non-participating) customers improves load impact estimates by providing a proxy for participants' event-day usage if no event had been called
- Separate individual regressions are used to examine the distribution of load impacts across customer types

3. *Ex-Post* Load Impacts:
Load Impacts by event

Events	Day of Week	SmartRate™ Only				Dually-Enrolled			
		Enrolled	Per-Cust. Load Impact (MW)	% Load Impact	Ave. Event Temp.	Enrolled	Per-Cust. Load Impact (MW)	% Load Impact	Ave. Event Temp.
1-Jun-16	Wed	110,580	0.12	10%	89	35,856	0.39	22%	93
3-Jun-16	Fri	110,510	0.13	10%	96	35,763	0.52	25%	99
27-Jun-16	Mon	111,093	0.15	10%	95	35,549	0.58	25%	99
28-Jun-16	Tues	111,116	0.14	9%	94	35,503	0.57	25%	98
30-Jun-16	Thurs	111,098	0.11	8%	92	35,435	0.42	22%	96
14-Jul-16	Thurs	111,475	0.13	10%	93	35,279	0.32	15%	97
15-Jul-16	Fri	111,447	0.11	9%	91	35,246	0.35	19%	95
26-Jul-16	Tues	111,739	0.15	10%	97	35,117	0.53	23%	101
27-Jul-16	Wed	111,754	0.15	9%	97	35,080	0.56	23%	101
28-Jul-16	Thurs	111,787	0.13	9%	95	35,033	0.51	22%	99
17-Aug-16	Wed	111,889	0.10	7%	91	34,792	0.34	18%	95
26-Sep-16	Mon	112,177	0.09	7%	95	34,384	0.32	19%	96

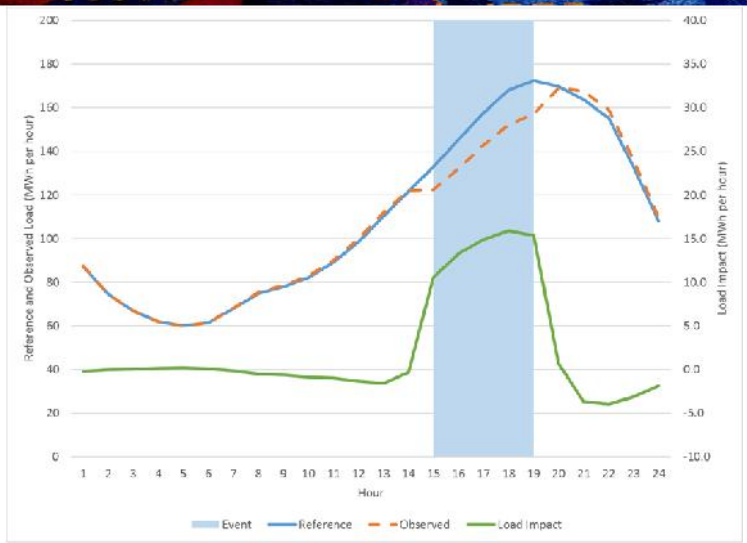
- All events last from 2:00 to 7:00 p.m.
- Notice that temperatures are higher for dually enrolled customers because they tend to be located in hotter areas where AC loads are higher.
- Load Impacts are substantially larger for dually-enrolled customers.

3. *Ex-Post* Load Impacts:
Summary – Key Event Hours

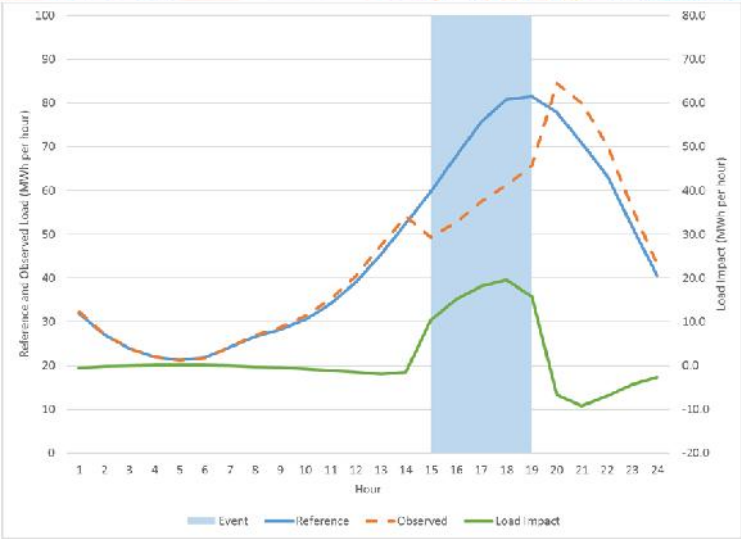
Result Type	Hour Type	SmartRate Only			SmartRate + SmartAC		
		Load Impact	# Custs	Temp. °F	Load Impact	# Custs	Temp. °F
Aggregate (MW)	Avg. Event Hour	14.0	111,389	93.9	15.8	35,253	97.7
	PG&E Peak Hour	17.9	111,754	96.8	24.5	35,080	101.0
	CAISO Peak Hour	17.0	111,754	98.4	23.4	35,080	102.2
Per customer (kW)	Avg. Event Hour	0.13	111,389	93.9	0.45	35,253	97.7
	PG&E Peak Hour	0.16	111,754	96.8	0.70	35,080	101.0
	CAISO Peak Hour	0.15	111,754	98.4	0.67	35,080	102.2

PG&E peak hour = July 27, 2016, HE 18 (5 to 6 p.m.)
CAISO peak hour = July 27, 2016, HE 17 (4 to 5 p.m.)

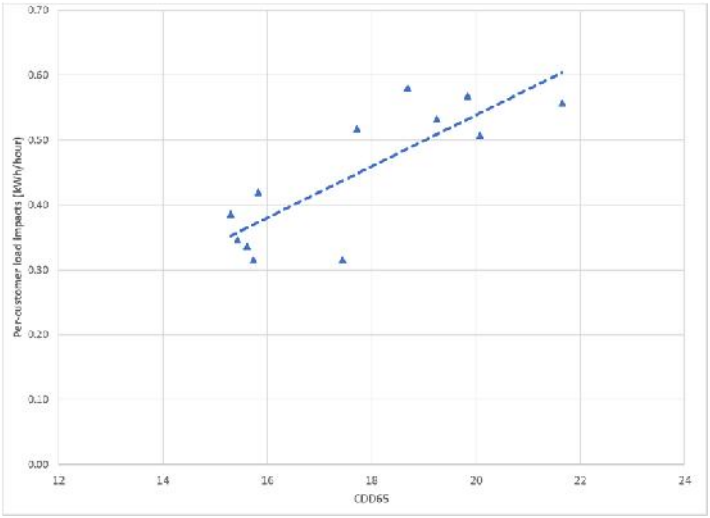
3. *Ex-Post* Load Impacts:
Average Event, SmartRate™-Only



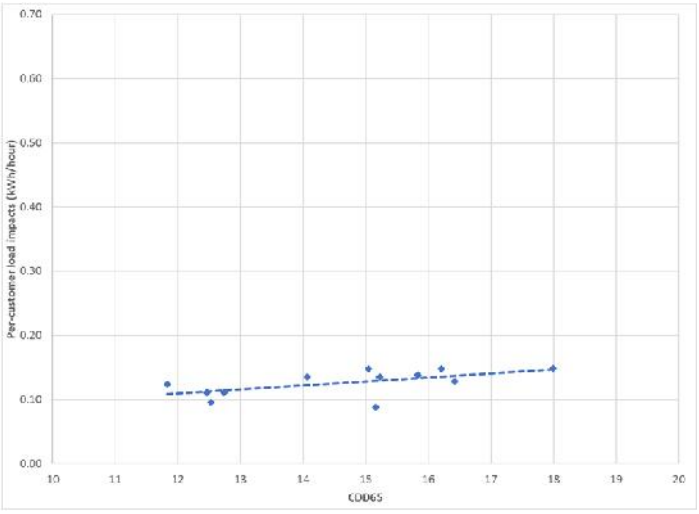
3. *Ex-Post* Load Impacts:
Average Event, Dually-Enrolled



3. *Ex-Post* Load Impacts:
Ave. Load Impact vs. CDD (Dually Enrolled)



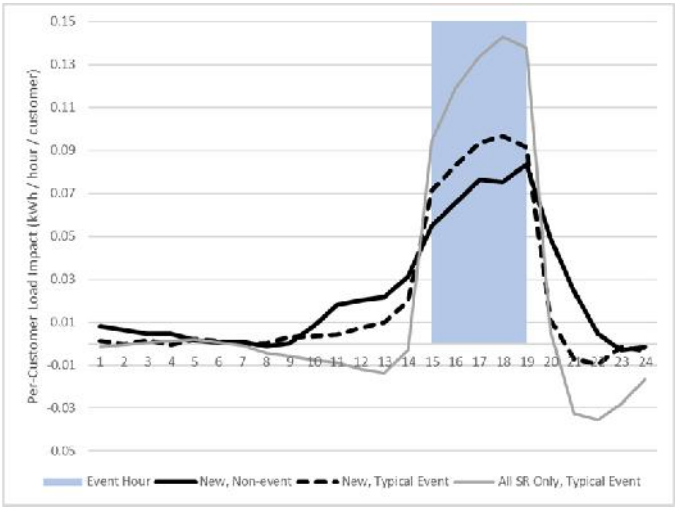
3. *Ex-Post* Load Impacts:
Ave. Load Impact vs. CDD (SR-only)



3. Special Analysis of Customers New to SmartRate™ in 2016

- 19,300 customers enrolled between 2015 and 2016
  - 94 percent were SmartRate only
  - Geographic distribution differs from average – more Greater Bay Area; fewer in Kern
- Availability of pre-treatment loads allowed pre/post and treat/control analysis
  - Matched control customers using 2015 loads
  - Estimated load impacts for both event and non-event days
- Findings:
  - New customers substantially smaller than existing (1.0 vs 1.4 kW)
  - Similar % load impacts (8.5 vs 9.0%); smaller level (0.09 vs 0.13 kW)
  - (Hot) **Non-event day** load impacts nearly as large as event-day (7.2%, 0.07 kW); load impact profile is similar to an event day

3. Load Impact Comparison:
New vs. Existing Customers & Non-event day



4. *Ex-Ante* Methodology

- *Ex-ante* per-customer load impacts were developed from the *ex-post* load impacts from the 12 events of PY2016
- Estimated the effect of weather conditions (CDD65) on per-customer load impacts
  - For each hour of the day (24)
  - For each LCA (8)
  - Separately for SmartRate-only and dually-enrolled customers (2)
  - 24 x 8 x 2 = 384 estimated models
- Combined estimates with the relevant weather scenario (*e.g.*, CAISO 1-in-2 weather conditions on an August peak day) to simulate per-customer *load impacts* for every scenario / hour / customer-type

4. *Ex-Ante* Methodology (2)

- *Reference loads* were developed for each month and LCA using:
  - Parameters obtained from regressions of per-customer hourly usage as a function of weather and load shape variables
  - *Ex-ante* weather data and day-type characteristics (*e.g.*, temperatures on a CAISO 1-in-2 June peak day)
- Per-customer reference loads and load impacts were scaled using PG&E's forecast enrollments (by month, year, and dual enrollment status)

4. *Ex-Ante* Methodology (3)
Non-summer load impacts

- While we only observe *summer* load impacts, we are required to forecast *non-summer* load impacts as well (events may be called at any time of the year)
- Because non-summer temperatures tend to be low relative to *ex-post* event temperatures, simulated load impacts are correspondingly low
  - They are defined by the constant term (*a*) in our estimated load impact equation (Load impact = *a* + *b* x *CDD65* + *e*)

5. *Ex-Ante* Load Impacts
Enrollment Forecast

LCA	SmartRate™-only 2017	SmartRate™-only 2018-2027	Dually enrolled 2017	Dually enrolled 2018-2027	Total 2017	Total 2018-2027
Greater Bay Area	42,530	28,699	10,110	8,166	52,640	36,865
Greater Fresno	7,959	7,959	3,335	3,335	11,294	11,294
Humboldt	1,221	1,221	175	175	1,396	1,396
Kern	6,603	6,603	1,773	1,773	8,376	8,376
Northern Coast	1,838	1,838	510	510	2,348	2,348
Other	20,124	20,097	6,599	6,599	26,723	26,696
Sierra	5,797	5,797	3,753	3,753	9,550	9,550
Stockton	6,451	6,451	3,619	3,619	10,070	10,070
Total	**92,523**	**78,665**	**29,874**	**27,929**	**122,397**	**106,594**

August enrollments are shown.
Enrollment is forecast to decline somewhat relative to 2016.

5. *Ex-Ante* Load Impacts: *Summary*

Group	Result Type	Time Period	# Custs	Ref. Load	Event Load	Load Impact	% Load Impact	Avg. Temp.
SmartRate Only	Agg (MW)	RA Window (1-6 pm)	78,665	132.5	123.4	**9.1**	7%	95.0
		Event Hours (2-7 pm)		123.3	111.5	**11.8**	10%	94.9
	Per cust (kW)	RA Window (1-6 pm)		1.68	1.57	**0.12**		
		Event Hours (2-7 pm)		1.57	1.42	**0.15**		
Dual Enrolled	Agg (MW)	RA Window (1-6 pm)	27,929	57.6	46.3	**11.3**	20%	98.8
		Event Hours (2-7 pm)		62.9	48.5	**14.4**	23%	98.8
	Per cust (kW)	RA Window (1-6 pm)		2.06	1.66	**0.40**		
		Event Hours (2-7 pm)		2.25	1.74	**0.52**		

Table reflects PG&E 1in2 August peak day, 2018.
Note that the RA-window load impacts are lower than the event-hour load impacts because the RA-window impacts include one non-event hour (1 to 2 p.m.).

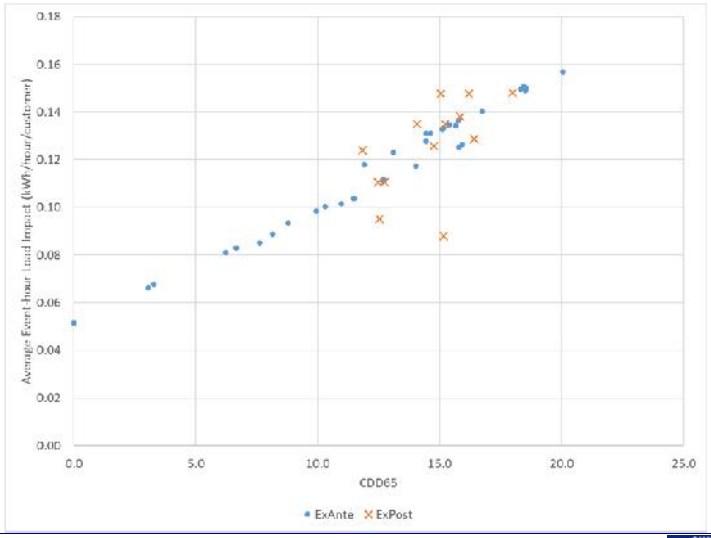
6. *Reconciliations (1)*:
Ex-Post (2016) vs. Ex-Ante (2017)

Enrollment Type	Typical Event Day	Enrollment	Aggregate (MW)		Per-Customer (kW)		% Load Impact	Avg. Event Temp.
			Ref. Load	Load Impact	Ref. Load	Load Impact		
SmartRate™ Only	ExPost (2016)	111,389	155.3	14.0	1.39	0.13	9.0%	94
	ExAnte (2017)	92,523	143.3	13.0	1.55	0.14	9.1%	94
Dually Enrolled	ExPost (2016)	35,253	73.1	15.8	2.07	0.45	21.6%	98
	ExAnte (2017)	29,874	66.0	15.2	2.21	0.51	23.1%	98

Ex-post reflects the average 2016 event day.
Ex-ante reflects PG&E 1in2 August peak day, 2017.
Both results reflect **event hours** (2 to 7 p.m.) for comparability.

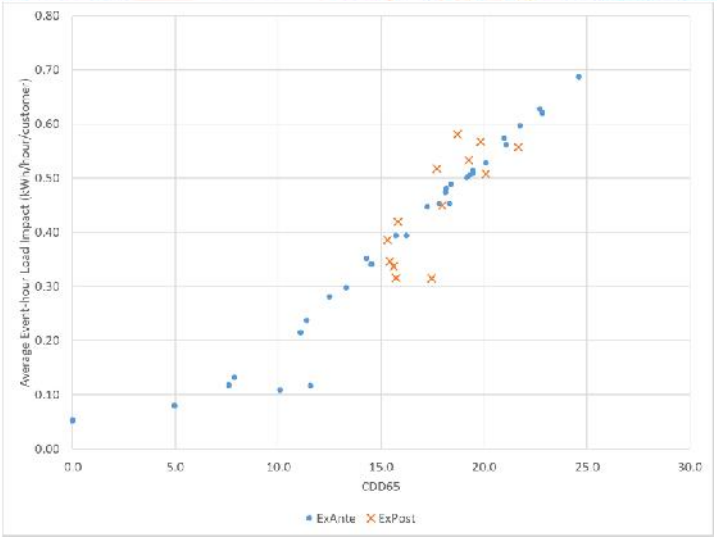
6. Reconciliations:

SR Only, Consistency of Ex-Post vs. Ex-Ante



6. Reconciliations:

Dual Enroll, Consistency of Ex-Post vs. Ex-Ante



6. Reconciliations:
Previous vs. Current Ex-Ante *Forecast (RA hrs)*

Enrollment Type	Program / Portfolio	Year of Forecast	Enrolled	Aggregate (MW)		Per-Cust. (kW)		% Load Impact	Avg. Event Temp.
				Ref. Load	Load Impact	Ref. Load	Load Impact		
SmartRate™ only	Program =Portfolio	2015	110,200	149.1	**18.3**	1.35	**0.17**	12.3%	94
		2016	92,523	133.4	**10.0**	1.44	**0.11**	7.5%	94
Dually-enrolled	Program	2015	34,800	59.9	**16.0**	1.72	**0.46**	26.7%	98
		2016	29,874	60.2	**11.9**	2.02	**0.40**	19.7%	98
	Portfolio	2015	34,800	59.9	**3.4**	1.72	**0.10**	5.6%	98
		2016	29,874	60.2	**2.5**	2.02	**0.08**	4.1%	98

PG&E 1in2 scenario for August 2017 forecasts.
Results shown for the **RA window** (1 to 6 p.m.).

6. Reconciliations:
Comments

- Current forecast of total SmartRate load impacts for August 2017 (PG&E 1in2 peak day) is lower than previous forecast
  - Current = 21.9 MW during RA window
  - Previous = 34.3 MW during RA window
- Enrollment differences are significant
  - 16% drop in enrollment between forecasts (~22,600 customers)
  - Larger % drop in Greater Bay Area enrollments, down 26%
  - LCA composition increases average usage
- However, some the reduction reflects differences in the ex-post load impacts
  - PY2016 ex-post load impacts are lower than those of PY2015
  - For SmartRate-only customers, percentage load impact went from 13.2% to 9.0%
  - For dually enrolled customers, percentage load impact went from 25.5% to 21.6%

6. Factors Affecting Differences Between *PY2015 and PY2016 Ex-post (1)*

- We investigated potential reasons for differences in PY2015 and PY2016 *ex-post* per-customer load impacts
- Regressions (by enrollment status) of average event-hour load impact as a function of potential contributing factors:
  - Weather (CDD65)
  - Whether the prior day was also an event day ("Consecutive Event")
  - Whether the event date is when school is in session (before mid-June or later than mid-August)
  - Whether the event date is in 2015 or 2016

6. Factors Affecting Differences Between *PY2015 and PY2016 Ex-post (2)*

Variable	SmartRate™ Only	Dually-enrolled
CDD65	0.007 (0.001)	0.036 (0.000)
Consecutive Event	-0.017 (0.018)	-0.048 (0.080)
School	-0.015 (0.031)	-0.048 (0.084)
PY2016 Event	-0.076 (0.000)	-0.072 (0.011)
Constant	0.102 (0.003)	-0.090 (0.493)

Notes:
p-values in parentheses.
- Dependent variable is average event-hour load impact in kWh/hour/customer.
- Load impacts are strongly affected by weather conditions (not surprising).
- SmartRate™–only load impacts smaller when previous day also event day.
- Load impacts are *lower* when school is in session.
- Controlling for the above variables, PY2016 load impacts are *lower* than PY2015.

7. Summary and Conclusions

- SmartRate™ load impacts continue to be strongly related to temperatures
  - Particularly so for customers dually enrolled in SmartAC™, whose load impacts are substantially larger than SmartRate™–only customers
- *Ex-post* per-customer load impacts for 2016 continue downward trend from 2014 and 2015
- Enrollment forecasts are also down from current levels
- Newly enrolled customers smaller than existing, with correspondingly smaller load impacts (similar %)
  - Intriguing finding of event-like load impacts on *non-event* days

Questions?

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