



Load Impact Evaluation: *PG&E's SmartAC™ Program*

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Presentation Outline

1. Program Description
2. Ex-post Methodology
3. Ex-post Load Impacts
4. Planned versus Actual Device Swap-outs
5. Ex-ante Methodology
6. Enrollment Forecast
7. Ex-ante Load Impacts
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1. SmartAC™ Program Description

- Direct load control AC cycling program for residential customers
- Participants receive one-time incentive, can opt-out of events
- SmartAC integrated into CAISO wholesale market in PY2018
- Events up to 6 hours per day (May – October)
- Sub-LAP Events: all customers within a sub-LAP dispatched
- Serial Number Events: random sample of full territory
- 74,000 enrolled (May 2022), 6,400 dually enrolled SmartRate™
- The CPUC approved swap out of remaining one-way devices for two-way devices by 2024 (D.21-12-015)
- Enrollment in SmartAC will be closed starting in 2024¹

¹ PG&E proposed closing the SmartAC program to new enrollments in its “Application for Pacific Gas and Electric Company (U 39 E) for approval of its demand response programs, pilots, and budgets for programs years 2023-2027.” See <https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M472/K478/472478718.PDF>.

2. Ex-post Methodology

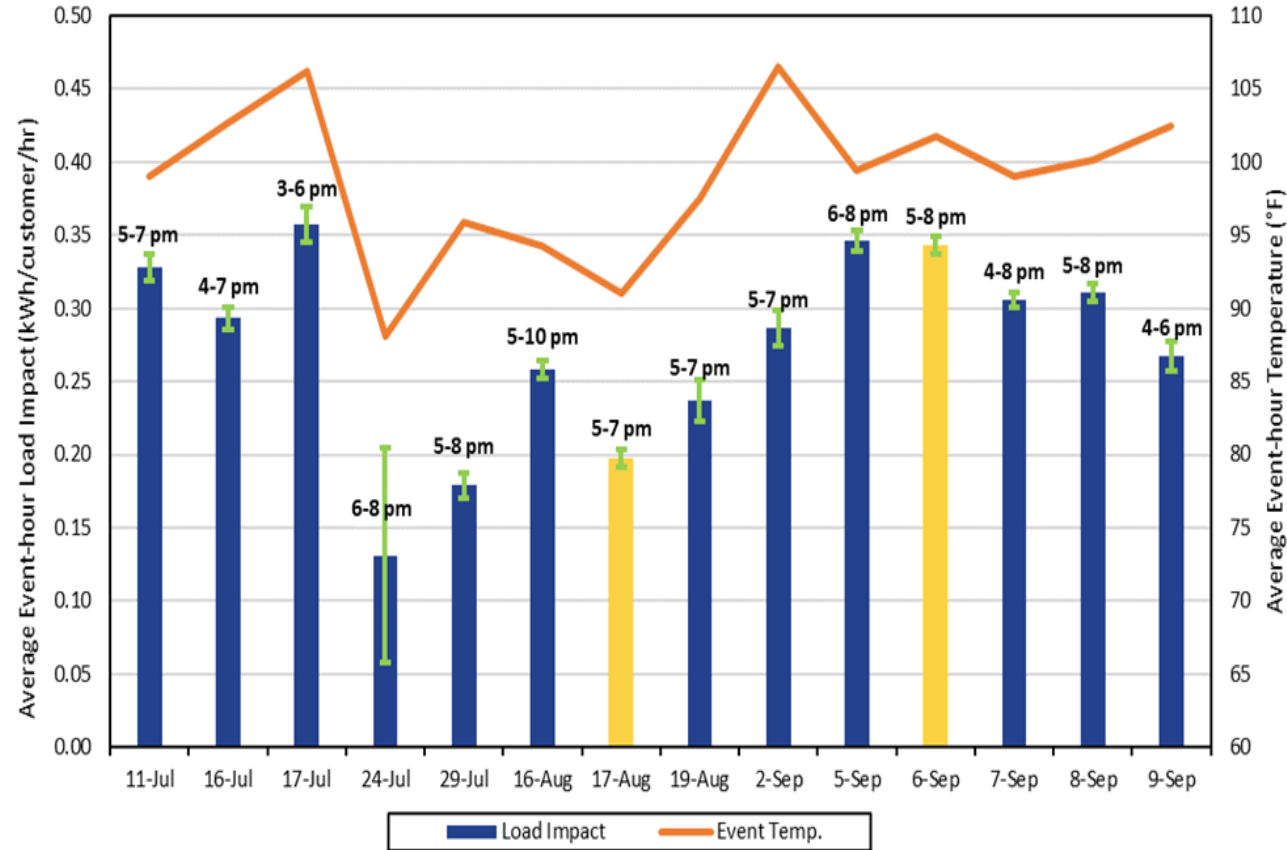
- Matched control group + difference-in-differences
- Two-Stages of Matching:
 - 1) 3-to-1 matching using all potential control customers
 - Nearest neighbor matching on average monthly usage, weather station, CDD, CARE, NEM, dwelling type, AC usage level, rate schedule
 - 2) 1-to-1 matching on selected controls from first stage
 - Propensity score matching using interval load data for non-event day loads, CARE, NEM, dwelling type, and AC usage level
 - Matches segmented by sub-LAP and similar rate schedules
 - Two 24-hour average load profiles used for matching: hot days (top 10%) and a selection of cooler days (25th to 50th percentile)
- In the difference-in-differences model, we allow the relationship between weather and loads to vary by AC usage level

3. Ex-post Load Impacts: *Events*

Date	Smart-Rate™ Event?	Reason	Event Hours (p.m.)	Sub-LAPs/Serial Groups Dispatched	# Customers Dispatched
7/11	Yes	Market	5:00-7:00	PGNP, PGSI, PGKN, PGZP, PGNC	24,871
7/16	No	Market	4:00-6:00	PGSI, PGST, PGKN, PGF1, PGZP	34,570
			5:00-7:00	PGNP	10,636
7/17	No	Market	3:00-5:00	PGF1	12,479
			4:00-6:00	PGKN, PGZP	5,215
7/24	No	Market	6:00-8:00	PGNC	463
7/29	No	Market	5:00-7:00	PGKN, PGF1, PGZP, PGNC	18,110
			6:00-8:00	PGNP	10,604
8/16	Yes	Market	5:00-7:00	PGEB, PGSB, PGP2	23,453
			6:00-8:00	PGKN, PGF1, PGNC, PGNB	15,819
			7:00-9:00	PGNP, PGST	13,503
			8:00-10:00	PGSI	10,670
8/17	Yes	Test	4:30-7:00	All Sub-LAPs, Serial Group 1 withheld	58,998
8/19	Yes	Market	5:00-7:00	PGSI	10,655
9/2	No	Market	5:00-7:00	PGKN, PGF1, PGZP	17,513
9/5	Yes	Market	6:00-8:00	All Sub-LAPs	66,044
		Emergency	8:01-9:18	All Sub-LAPs	66,044
9/6	Yes	Test	5:00-8:00	All Sub-LAPs, Serial Group 2 withheld	58,553
		Emergency	8:01-8:42	All Sub-LAPs	65,963
9/7	Yes	Market	4:00-8:00	All Sub-LAPs except PGFG	64,550
9/8	Yes	Market	5:00-7:00	PGNP, PGST, PGKN, PGFG, PGNB, PGEB, PGCC	33,379
			5:00-8:00	PGSI, PGF1, PGZP, PGNC, PGSB, PGP2	32,478
9/9	No	Market	4:00-6:00	PGNP, PGSI, PGST, PGNC	27,554

3. Ex-post Load Impacts

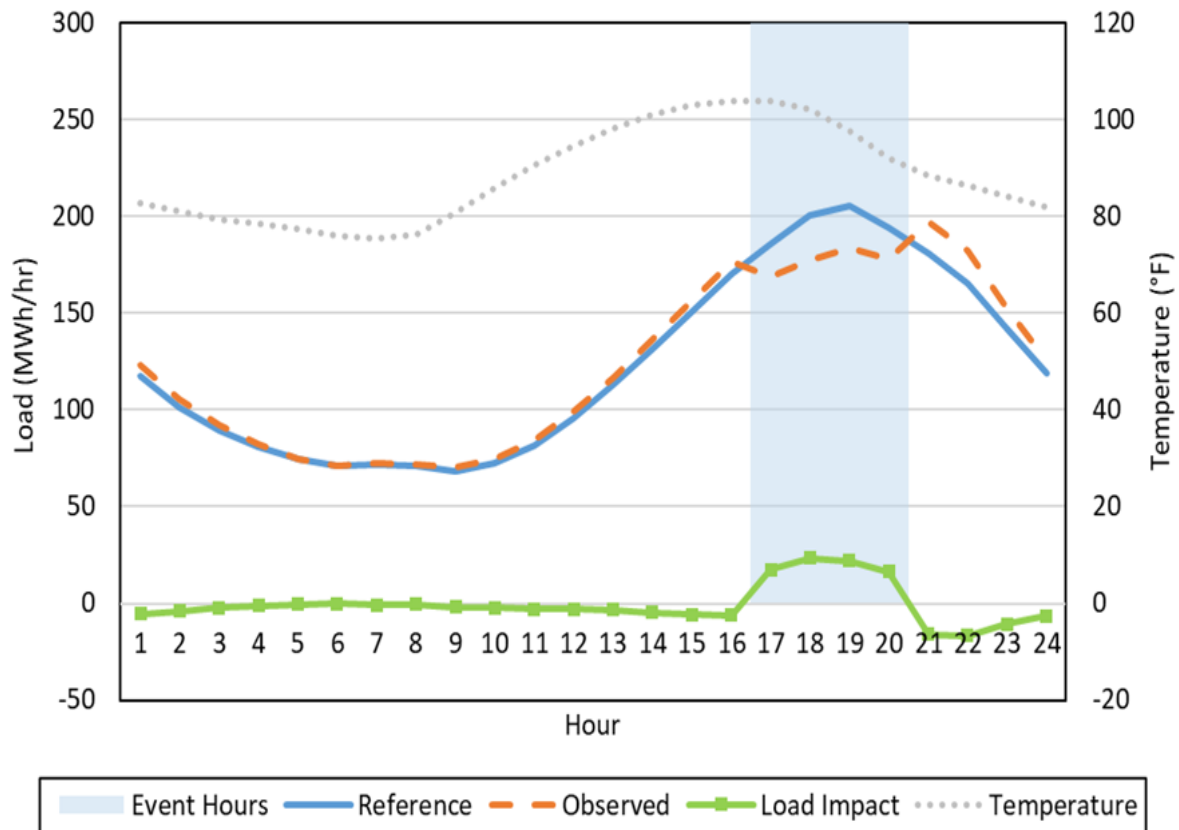
Average Event-Hour Load Impacts by Event



- Overall: 0.13 - 0.36 kWh/customer/hour
- Drivers of variation
 - sub-LAPs called
 - event temperatures
 - hours of the day
- Serial event on Sep 6th has lower load impact than the serial event in PY2020 with similar temperatures
- Dispatch issues for two-way devices in 2022

3. Ex-post Load Impacts

Hourly Load Impacts for sub-LAP event on September 7, 2022



- 97% of customers dispatched (64,550)
- 4-8 p.m.
- Peak load impact of 23.3 MWh/hour occurs during hour 2 of event (5-6 p.m.)
- Average per-customer load impact of 0.31 kWh/customer/hour

3. Ex-post Load Impacts

PY2021 vs. PY2022

Program Year	# Customers Dispatched	Reference Load (kWh/customer/hour)	Load Impact (kWh/customer/hour)	Load Impact (MWh/hour)	Average Temperature (°F)
2021	67,792	3.16	0.41	27.8	105.5
2022	59,646	3.14	0.31	18.5	100.6

- Eight sub-LAPs were dispatched in both program years
- Aggregate load impacts are 33% lower in PY2022
- 8,100 fewer customers dispatched (program attrition)
- Lower per-customer load impacts in PY2022
 - Average event temperature is 5 degrees cooler in PY2022
 - Two-way customers dispatch issues in PY2022
 - 41% of the 13,226 two-way customers
 - 28% to 57% across sub-LAPs (PGEB, PGF1, PGST highest share)
 - Dispatch issues reduced the average load impact from 0.60 kWh/customer/hour (17.7%) to 0.36 kWh/customer/hour (11.4%)

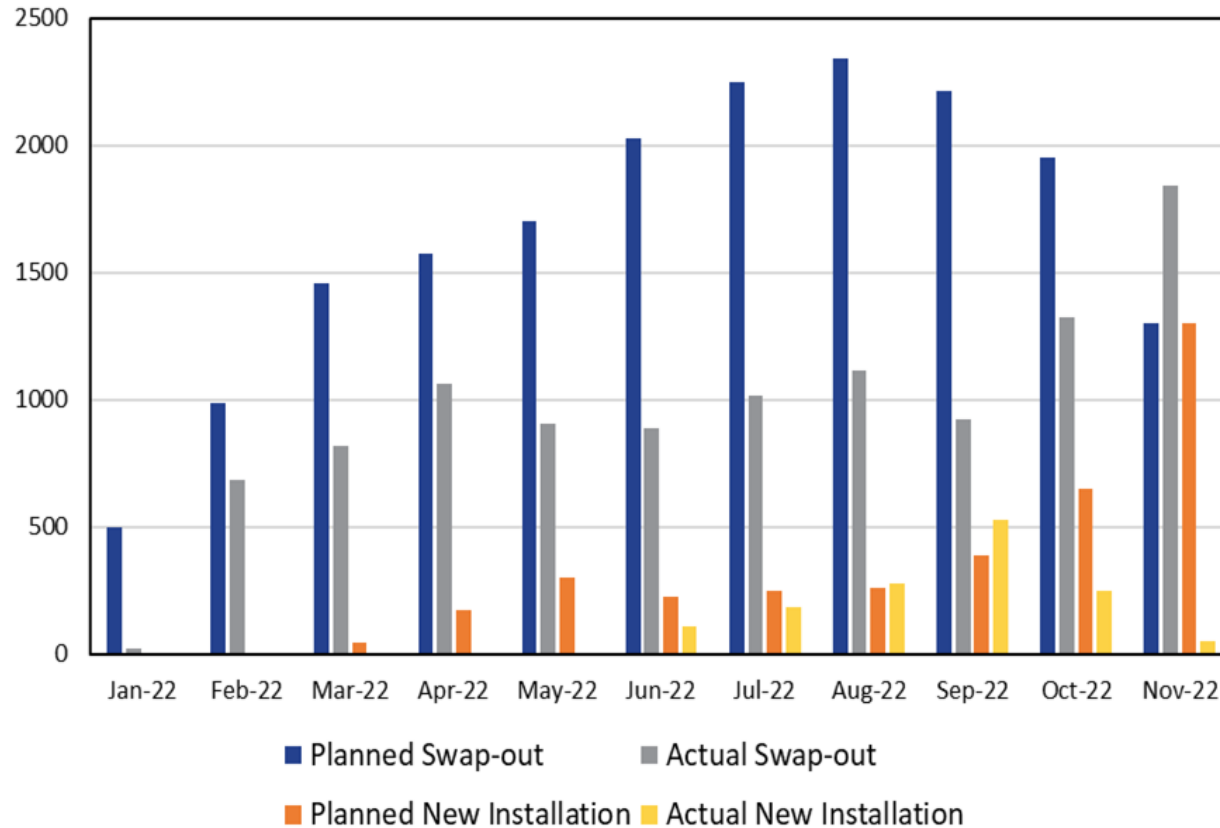
3. Ex-post Load Impacts

PY2021 Ex-Ante vs. PY2022 Ex-Post

Level	Outcome	PY2021 Ex-Ante		PY2022 Ex-Post
		PG&E 1-in-2 July Peak Day	PG&E 1-in-10 July Peak Day	
Total	Enrollments	69,301	69,301	66,044
	Reference (MW)	181.5	205.1	222.6
	Load Impact (MW)	25.2	31.6	22.8
	Avg. Evt Hour Temp (°F)	98.2	100.1	99.4
	Avg. Daily Temp (°F)	85.6	90.0	89.5
	% Load Impact	13.9%	15.4%	10.3%
Per-Participant	Reference (kW)	2.62	2.96	3.37
	Load Impact (kW)	0.36	0.46	0.35

- PG&E 1-in-2 scenario for July Peak Day has cooler temperature
 - Comparable per-customer load impacts
- Aggregate load impact is 28% lower than PG&E 1-in-10 scenario for July Peak Day
 - Enrollments: 3,257 lower
 - Temperature: Only slightly lower
 - Per-customer load impacts: 0.11 kWh/customer/hour lower
 - Two-way device dispatch issues
 - Fewer device swap-outs than assumed in the forecast (lower share of two-way devices)

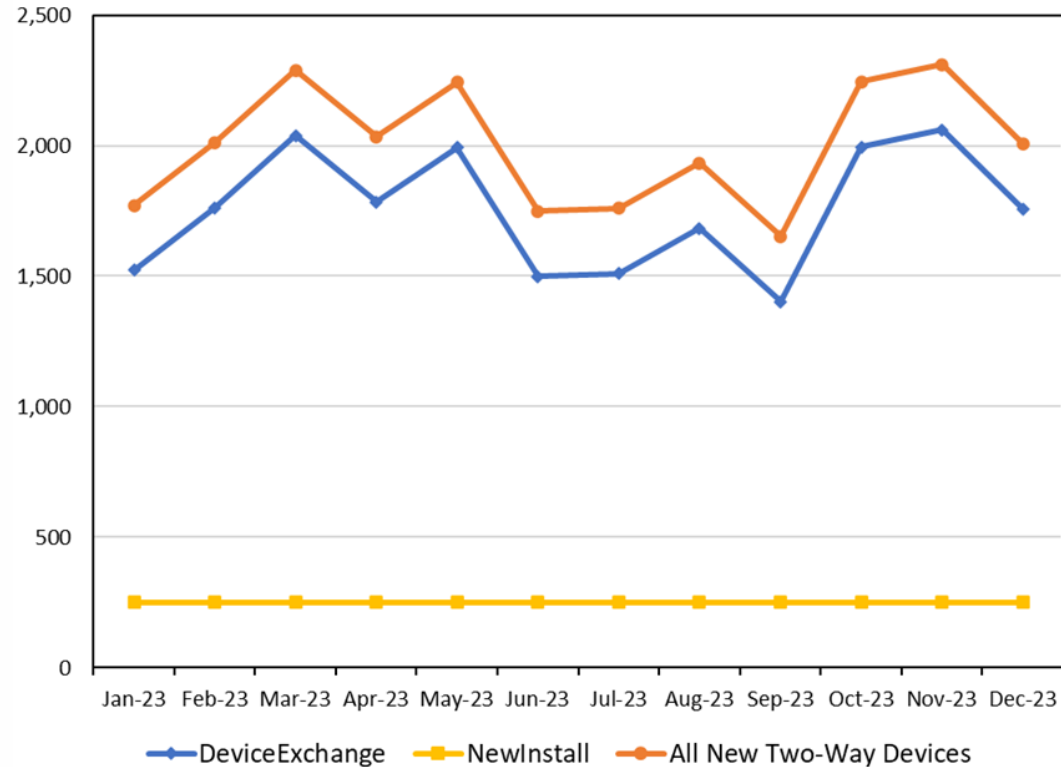
4. Planned vs. Actual Device Swap-outs



- Fewer two-way devices installed in 2022 than planned
 - 8,000 fewer swap-outs of one-way devices for two-way devices
 - 2,200 fewer new customers recruited
- Main drivers
 - Shortage of technicians
 - Higher than anticipated number of customers declining to have a device swap-out
 - Higher than anticipated number of customers that were not reachable

5. Ex-ante Methodology

Forecast methodology accounts for device swap-outs



- Ex-ante forecast incorporates PG&E's 2023 plan for device swap-outs
 - 1,400-2,100 device swap-outs per month
 - 250 new customers enrolled per month
- Swap-outs completed by 2024

5. Ex-ante Methodology (2)

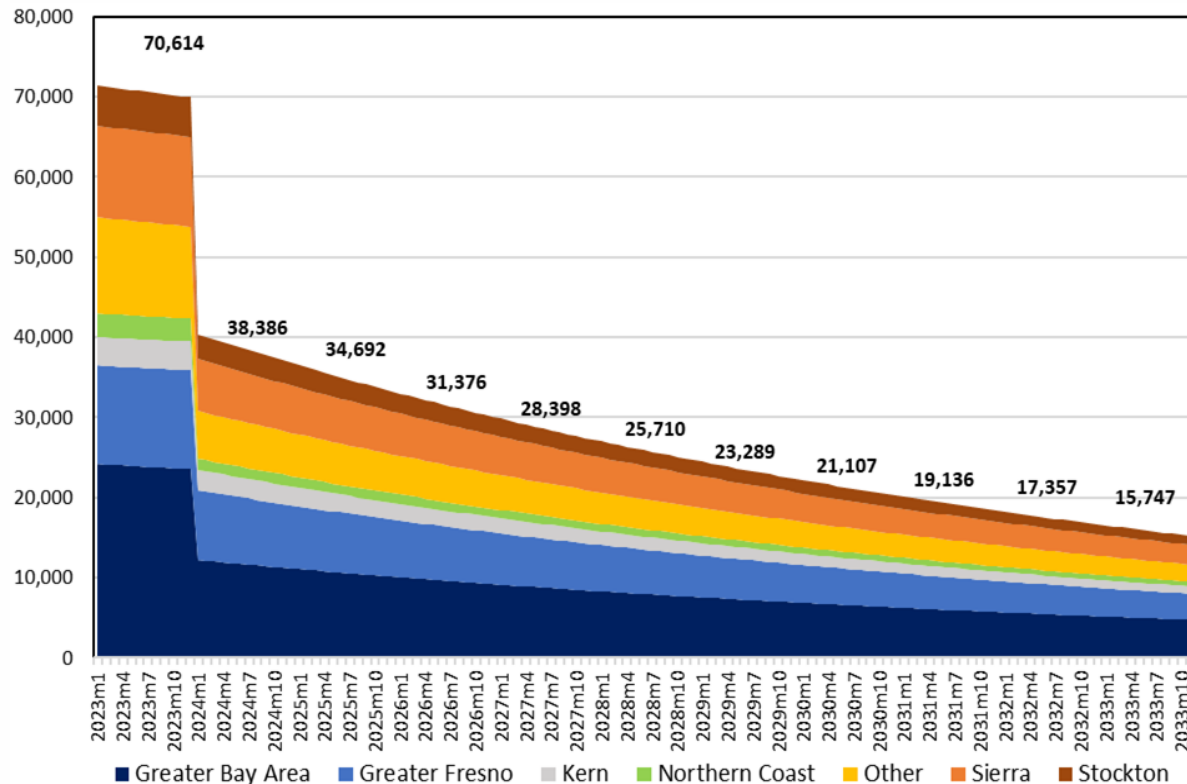
- Per customer load impacts are developed separately for one-way and two-way devices using:
 - Regressions of ex-post per-customer load impacts as a function of weather, hour, sub-LAP and a serial event indicator
 - Based on ex-post load impacts in PY2020, PY2021 and PY2022
 - PY2020 and PY2021 are given twice the weight in the regression as PY2022 load impacts
 - Forecast reflects some level of two-way device operational issues but assumes that most of the impact of 2022 dispatch issues will resolve by 2023
 - Ex-ante weather scenarios (e.g., temperature profile for a CAISO 1-in-2 August peak day)

5. Ex-ante Methodology (3)

- Load impacts by device type are combined to make an average per-customer load impact based on the relative share of two-way devices from PG&E's enrollment forecast
- Reference loads are developed for each month, sub-LAP, and enrollment segment (SmartAC-only and dually enrolled customers) using:
 - Non-event days: Non-holiday weekdays
 - Parameters obtained from regressions of per-customer hourly usage as a function of weather (CDD65) and load shape variables
 - Ex-ante weather data and day-type characteristics

6. Enrollment Forecast

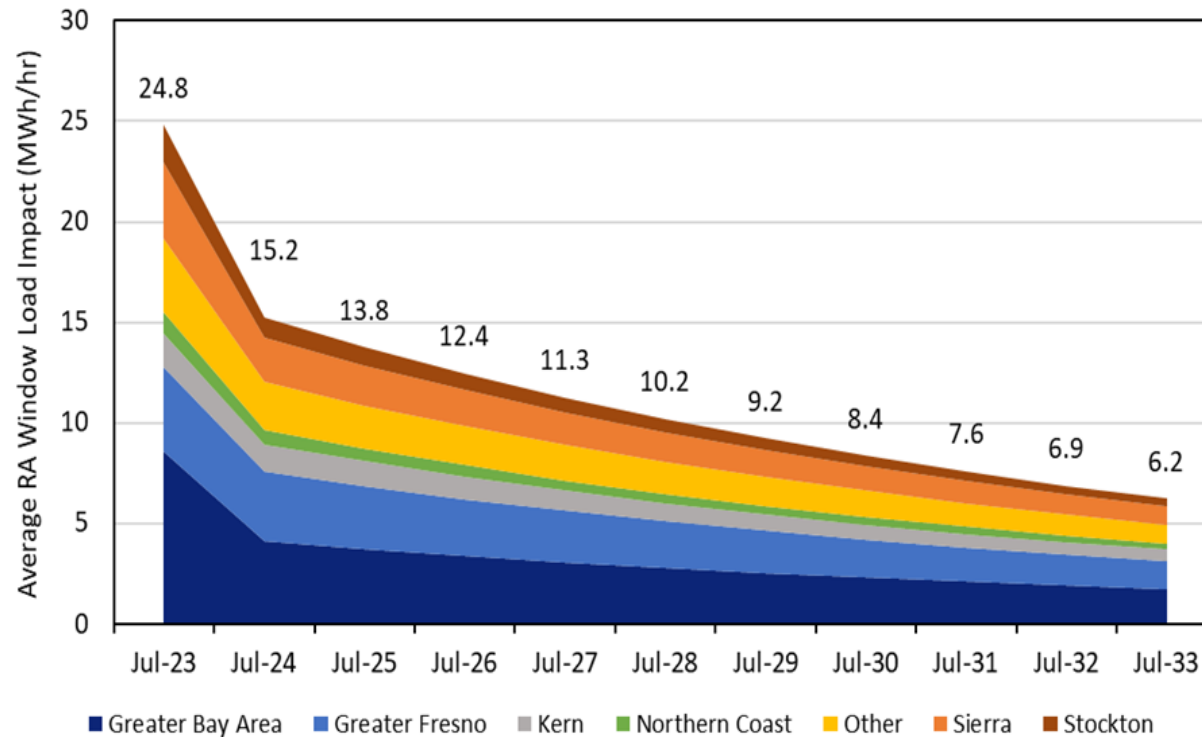
Enrollment Forecast by LCA (2023-2033)



- Enrollments decrease slightly in 2023
- Dramatic drop in enrollments in January 2024
 - PG&E assumes 29,500 customers with one-way devices will be de-enrolled from SmartAC™
- Enrollments decline over the remainder of the forecast
 - New enrollment in SmartAC™ is closed
 - Program attrition

7. Ex-ante Load Impacts

Aggregate RA Window (4-9 p.m.) Load Impacts by LCA for PG&E's 1-in-2 July Peak Scenario (2023-2033)



- 39% decline in aggregate load impacts from July 2023 to July 2024
 - 46% drop in enrollments
 - Mitigated by higher per-customer load impacts from having all two-way devices in 2024
- After 2024, aggregate load impacts decrease by 9.5% per year.

7. Ex-ante Load Impacts

PY2022 Ex-Post vs. PY2022 Ex-Ante

Level	Outcome	PY2022 Sub-LAP Event Load Impacts			PY2022 PG&E 1-in-2 July Peak	
		1-Way	2-Way	All	2023	2024
Total	Enrollments	56,518	14,479	70,997	70,614	38,386
	Reference (MW)	170.7	47.4	218.1	181.9	101.4
	Load Impact (MW)	16.9	5.7	22.6	28.1	16.9
	Avg. Event Temp (°F)	99.1	102.3	99.8	98.9	99.5
	Avg. Daily Temp (°F)	87.1	89.7	87.6	84.7	85.3
	% Load Impact	9.9%	12.0%	10.4%	15.4%	16.7%
Per-Participant	Reference (kW)	3.02	3.28	3.07	2.58	2.64
	Load Impact (kW)	0.30	0.39	0.32	0.40	0.44

- Compare ex-post load impacts with PG&E's 1-in-2 scenario
 - Lower temperatures in forecast
 - Lower load impacts than would be expected at higher temperatures
- Per-customer load impacts in 2024 are higher than 2023
 - All devices are two-way in 2024
- Per-customer load impacts in 2024 are higher than the per-customer load impact of two-way devices in 2022
 - Expected improvement in dispatch issues

7. Ex-ante Load Impacts

PY2021 vs. PY2022

Level	Outcome	2023		2024	
		PY2021	PY2022	PY2021	PY2022
Total	Enrollments	79,852	70,614	60,274	38,386
	Reference (MW)	201.6	171.7	155.8	95.9
	Load Impact (MW)	29.7	24.8	25.4	15.2
	Avg. RA Window Temp (°F)	98.7	96.5	99.1	97.2
	Avg. Daily Temp (°F)	86.1	84.7	86.5	85.3
	% Load Impact	14.8%	14.4%	16.3%	15.9%
Per-Participant	Reference (kW)	2.52	2.43	2.58	2.50
	Load Impact (kW)	0.37	0.35	0.42	0.40

- Compare PG&E 1-in-2 scenario for July Peak Day
- Change in weather scenarios in PY2022 results in cooler temperatures
- Lower per-customer impacts in PY2022
 - Lower temperatures
 - Lower two-way device performance in 2022
- Lower forecasted enrollment in PY2022 drives lower aggregate load impact
- Both PY2021 and PY2022 forecasts show an increase in per-customer impacts between 2023 and 2024
 - Completion of device swap-outs

8. Recommendations

- Continue to:
 - Have system-wide or serial events called in isolation for the purpose of load impact estimation
 - Dispatch events over a variety of temperatures to produce more robust forecast models
- Going forward:
 - Call some SmartAC-only events in isolation to allow analysis of differences between SmartAC-only and dually enrolled customers

Questions?

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Appendix: Ex-post Load Impacts

Two-way device dispatch issues

Sub-LAP	# Dispatched	% with Dispatch Issue	Per-Customer Load Impact		Percentage Load Impact	
			All	Success Only	All	Success Only
PGCC						
PGEB	2,202	47%	0.35	0.63	11.5%	19.1%
PGF1	4,093	45%	0.36	0.63	10.7%	17.3%
PGFG						
PGKN	1,413	28%	0.54	0.73	15.4%	19.7%
PGNB						
PGNC						
PGNP	1,088	33%	0.44	0.61	14.8%	19.5%
PGP2	155	31%	0.47	0.65	14.4%	19.2%
PGSB	519	39%	0.18	0.40	7.3%	14.8%
PGSI	2,011	35%	0.34	0.47	12.3%	16.5%
PGST	1,242	57%	0.16	0.49	4.9%	13.7%
PGZP	293	28%	0.45	0.58	13.5%	17.0%
All	13,226	41%	0.36	0.60	11.4%	17.7%

- Compare results for all two-way customers to successfully dispatched two-way customers
- PGST, PGEB and PGF1 have the largest percentage of 2-way devices with dispatch issues
- For PGST, load impacts are at least 0.3 kwh/customer/hour higher for successfully dispatched two-way devices
- PGEB and PGF1 also have substantial improvements in load impacts