Portland General Electric
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PortlandGeneral.com

July 10, 2018

Email
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Public Utility Commission of Oregon
201 High Street, S.E., Suite 100
P.O. Box 1088
Salem, OR 97308-1088

Attn: Commission Filing Center

Re: UM 1708 Cadmus Evaluation of PGE's Residential Pricing Pilot

Enclosed is Cadmus' evaluation of PGE's Residential Pricing Pilot (also known as Flex). PGE contracted with Cadmus to evaluate the load impacts and customer satisfaction associated with different pricing and behavioral demand response program designs for Flex. Flex is intended to test the load impacts and residential customer acceptance of various demand response approaches. The Cadmus evaluation reviewed two winter seasons (2016/2017 and 2017/2018) and two summer seasons (2016 and 2017) and involved analysis of randomized control trials for twelve demand response (DR) treatments including peak-time rebates (PTR), time-of-use (TOU) pricing, behavioral demand response (BDR), and combinations of these treatments. Cadmus performed the research design, peak demand impact analysis, program staff interviews, and customer surveys. Cadmus' evaluation report is provided as Attachment A.

The Cadmus evaluation confirms that PGE can obtain customer demand savings through pricing and behavior-based DR programs to manage its system peak demand while delivering a positive customer experience. Based on the Cadmus findings and recommendations for increasing demand savings and customer satisfaction, PGE will propose a combination of offerings that achieve high customer satisfaction and will support PGE's goal of at least 77 megawatts of DR by end-of-year 2020. The offerings will likely include the following:

- Opt-in PTR – Customers receive notifications asking them to shift energy use during peak-time events (16-20 events per year). As a reward, they receive an on-bill credit based on the difference between actual versus expected usage.

- Opt-in TOU and PTR Hybrid – Customers can save on their daily energy costs by shifting usage to off-peak times when rates are lower. They also receive notifications asking them to shift energy use during peak-time events (16- 20 events per year). As a reward, they receive an on-bill credit based on the difference between actual versus expected usage.

- BDR Public Alert Strategy – Residential customers learn of *critical* PTR events via public alerts (e.g., radio, television, web) and are encouraged to shift energy use during critical peak events (one or two times per year). Customers will be informed of, and encouraged to enroll in, the higher-frequency PTR program to support ongoing DR goals.

Opt-in PTR

Of the twelve scenarios tested, Opt-in PTR produced the second highest demand savings during events and had the highest customer satisfaction rating. Opt-in PTR customers also had the lowest un-enrollment rates of the opt-in scenarios, which is promising for customer retention moving forward.

PGE tested three incentive "tiers" for Opt-in PTR customers:

- PTR1 $0.80C/kWh;
- PTR2 $1.55/kWh; and
- PTR3 $2.25 kWh.

PGE's proposal for the Pricing Program will likely include Opt-in PTR as one of the core offerings with revisions to the tested incentive tiers.

Opt-in TOU/PTR Hybrid

Hybrid treatments, which combined TOU pricing with PTR incentives, resulted in the highest demand savings of those scenarios tested. Satisfaction was also high for those customers who saved on the hybrid plan. TOU/PTR hybrid customers had lower satisfaction in winter, as demand saving or shifting proved challenging for them in this season and they voiced concern about winter bill increases. Satisfaction was lowest and opt-out was highest for those customers who faced a negative financial impact. PGE is currently conducting detailed analysis of the TOU structures to see where revisions could potentially be made to mitigate issues in winter while maintaining resource value.

Using the Cadmus findings and recommendations, to inform our target participants, PGE is conducting further segmentation to profile those customers who could benefit most from the rate plan, those with a neutral impact, and those who could be negatively impacted.

Opt-Out Behavioral Demand Response (BDR)

Customers in this group received a subset of PTR event notifications but were not incented for their participation. Opt-out BDR achieved the lowest demand shift and satisfaction ratings of the scenarios tested. Many participants did not understand DR program goals or the value of their participation. However, the size of this potential population (400,000 to over 700,000) provides opportunity for limited engagement that could yield significant load shift.

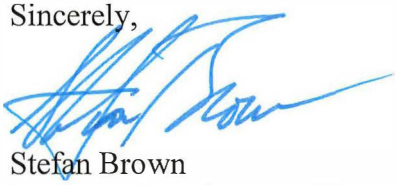
Demand Response Education

As Cadmus reported, PGE's opt-in rates were significantly lower than those achieved by other utilities such as Sacramento Municipal Utility District (SMUD). It's likely that PGE customers are less familiar with the concept of DR and time varying rates, and customer feedback from the pilot supports that theory.

If you have any questions or require further information, please call me at (503) 464-7805 or Kalia Savage at (503) 464-7432.

Please direct all formal correspondence and requests to the following e-mail address pge.opuc.filings@pgn.com.

Sincerely,



Stefan Brown
Manager, Regulatory Affairs

Encls

cc: UM 1708 Service List

Flex Pricing and Behavioral Demand Response Pilot Program

EVALUATION REPORT

June 25, 2018

Prepared for:

Portland General Electric

121 SW Salmon St.

Portland, OR 97204

CADMUS

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Acknowledgements

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Acronyms, Terms, and Definitions

Acronym/Term	Definition
AMI	Advanced Metering Infrastructure
BDR	Behavioral Demand Response
CI	Confidence Interval
Conversion rate	Measures a given marketing channel's effectiveness in spurring enrollment, calculated by taking the number of customers who enrolled from a given channel and dividing this by the total number of customers that the channel reached.
CDH	Cooling Degree Hours
Flex	Pricing and Behavioral Demand Response Pilot Program
HDH	Heating Degree Hours
OLS	Ordinary Least Squares
OO	Opt-Out – Opt-out customers are automatically enrolled in the pilot and given the opportunity to opt out of the pilot; an alternative to opt-in program design format.
Opt-in rate	The ratio of the number of customers who enrolled in a treatment to the total number of customers invited to participate.
Opt-out rate	The ratio of the number of enrolled customers who opted out of treatment to the total number enrolled.
PGE	Portland General Electric
PTR	Peak-Time Rebate
QC	Quality Control
RCT	Randomized Control Trial
TOU	Time-of-Use

Abstract

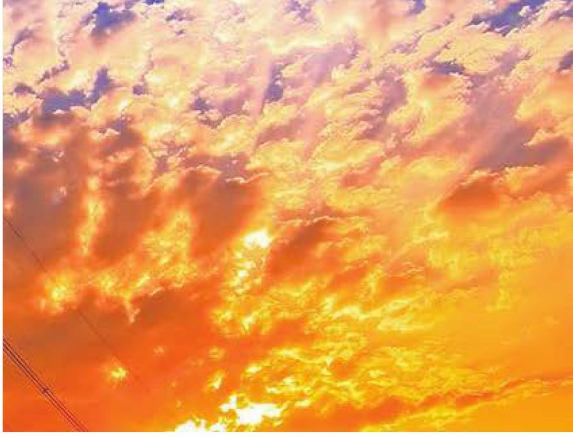
Through its residential Pricing and Behavioral Demand Response Pilot program (Flex), Portland General Electric (PGE) sought to assess the load impacts from and customer satisfaction with different pricing and behavior-based demand response treatments. Findings from the pilot would be used to inform offerings for a future, large-scale rollout of a PGE demand response program.

In 2015, PGE contracted with Cadmus to evaluate Flex. The evaluation covered two winter seasons (2016/2017 and 2017/2018) and two summer seasons (2016 and 2017) and involved analysis of randomized control trials (RCT) for 12 demand response treatments including peak time rebates (PTR), time-of-use (TOU) pricing, behavioral demand response (BDR), and combinations of these treatments. Cadmus performed the research design, peak demand impact analysis, program staff interviews, and customer surveys.

Opt-in PTR produced demand savings during Flex events ranging from 17%–21% in summer and 7%–12% in winter. Opt-out PTR and BDR yielded event demand savings of 7% and 2% in summer, and 5% and 1% in winter, respectively. Two of three TOU rates delivered demand savings during peak periods of 5%–8% in summer. In winter, none of the TOU rates produced statistically significant savings. Hybrid treatments combining TOU and either PTR or BDR achieved peak period demand savings of 8%–23% in summer and 1%–5% in winter. During summer and winter Flex events, TOUxPTR treatments tended to produce less demand savings than opt-in PTR-only customers. For many treatments, the estimated load impacts equaled or surpassed PGE planning estimates.

In general, Flex customers were satisfied with the pilot. Opt-in PTR customers consistently had the highest satisfaction (79%–92%). TOU and opt-out customer automatically enrolled in the pilot tended to have lower satisfaction (51%–82%). TOU and TOU-hybrid customers had lower satisfaction in winter, as demand saving or shifting proved challenging for them in this season.

These findings demonstrate that PGE can deploy pricing and behavior-based demand response to manage its system peak demand while delivering a positive customer experience. This report makes recommendations for increasing Flex demand savings and improving the customer experience.



Executive Summary

In 2016, Portland General Electric (PGE) launched Flex, a pricing and behavioral demand response pilot program. PGE launched the program to test the load impacts and customer acceptance of various demand response strategies. The program enrolled 14,000 customers and tested 12 pricing and behavior-based program design options (referred to as "treatments" in this report) aimed at reducing residential peak demand during summer and winter months. The treatments featured three time-of-use (TOU) rates, three peak-time rebates (PTR), behavioral demand response (BDR), four hybrid demand response treatments (TOU pricing in combination with PTR or BDR), and opt-out (OO) BDR and PTR demand response that automatically enrolled customers.

PGE called upon customers enrolled in PTR or BDR treatments to reduce loads during a limited number of Flex events in summer and winter. PGE paid rebates of $0.80/kWh, $1.55/kWh, or $2.25/kWh to PTR customers for reducing consumption during Flex events below individual-customer baselines, and PGE provided encouragement to BDR customers to save during Flex events, but did not compensate them for saving or shifting their demand. In contrast to event-based PTR and BDR, TOU pricing always was in effect. PGE moved participating customers on a standard flat rate to rate schedules that varied the cost of electricity as a function of the day of the week and hour of the day. Table 1 shows the three rate schedules (TOU1, TOU2, and TOU3) that PGE tested for the Flex pilot.

Table 1. Flex Pilot Summer and Winter TOU Rate Schedules

Summer	TOU1	TOU2	TOU3
Off Peak	7.5¢/kWh	8.3¢/kWh	6.9¢/kWh
	10:00 pm–6:00 am	8:00 pm–3:00 pm	10:00 pm–11:00 am
Mid Peak			11.9¢/kWh
			11:00 am–3:00 pm 8:00 pm–10:00 pm
On Peak	13.6¢/kWh	17.6¢/kWh	18.0¢/kWh
	6:00 am–10:00 pm	3:00 pm–8:00 pm	3:00 pm–8:00 pm
Winter	**TOU1**	**TOU2**	**TOU3**
Off Peak	8.0¢/kWh	8.8¢/kWh	7.4¢/kWh
	10:00 pm–6:00 am	8:00 pm–7:00 am; 11:00 am–3:00 pm	10:00 pm–7:00 am
Mid Peak			12.4¢/kWh
			11:00 am–3:00 pm; 8:00 pm–10:00 pm
On Peak	14.1¢/kWh	18.1¢/kWh	18.5¢/kWh
	6:00 am–10:00 pm	7:00 am–11:00 am; 3:00 pm–8:00 pm	7:00 am–11:00 am; 3:00 pm–8:00 pm

*TOU rates in effect as of August 1, 2016.

TOU customers paid a higher unit price to consume electricity during peak periods (e.g., weekday afternoon hours) when electricity was most costly to supply and a lower unit price during off-peak periods (weekday morning, weekend, and evening hours). The TOU3 rate also included a mid-peak period, when the retail electricity price was about midway between the off-peak and on-peak prices.

Evaluation Context

As presented in its 2016 Integrated Resource Plan, in the next several years, PGE expects to face a shortfall in generating capacity from the planned closure of its Boardman facility in 2020 and the expiration of wholesale power contracts.[1] At the same time, PGE plans to increase its production of electricity from intermittent renewable energy resources to comply with the requirements of Oregon Senate Bill 1547. In consideration of these developments, PGE's Integrated Resource Plan (2016) calls for the use demand response to help manage system peak loads and to assist with integration of

[1] PGE's integrated resource plan for 2016 is available at https://www.portlandgeneral.com/our-company/energy-strategy/resource-planning/integrated-resource-planning/2016-irp

renewable energy resources. The IRP sets a goal of adding demand response capacity of 77 MW in winter and 69 MW in summer.

An important source of future demand response capacity for PGE will come from residential customers. These customers contribute to PGE's system peak demand through weather-driven increases in demand for air conditioning in summer and demand for space heating in winter. By deploying demand response programs to residential customers, PGE can manage its peak system loads and reduce its costs of electricity supply. Between 2010 and 2013, PGE ran a critical peak pricing (CPP) pilot and obtained demand savings between 10%–12%. To lay the groundwork for a full-scale launch of residential pricing and behavior-based demand response offerings, PGE implemented the Flex pilot and hired Cadmus to conduct an evaluation. The evaluation sought to assess a range of program design options, including different peak rebates, time-of-use rate schedules, behavioral demand response, and customer opt-in and opt-out designs.

This evaluation report presents findings addressing the Flex pilot's design and delivery, load impacts, and customer experience, and provides recommendations to help PGE optimize its future demand response program offerings. Cadmus evaluated four seasons of the Flex pilot (Summer 2016, Winter 2016/2017, Summer 2017, and Winter 2017/2018), but this report focuses on Summer 2017 and Winter 2017/2018 as PGE did not reach its customer recruitment targets until summer 2017, and PGE changed some aspects of the program's delivery during the first two seasons.

Key Findings

Table 2 presents findings from the Flex pilot evaluation regarding peak demand savings, customer satisfaction, and customer opt-out rates across treatments for Summer 2017 and Winter 2017/2018. The table shows demand savings during Flex events for all treatments and on-peak period demand savings for all TOU and Hybrid treatments. Although PGE did not notify TOU-only customers of Flex events, Cadmus estimated Flex event savings for these customers to assess the peak capacity impacts of TOU pricing.

The most significant findings follow:

- Opt-in PTR treatments produced demand savings during Flex events ranging from 17%–21% in summer and 7%–12% in winter.
- Opt-out PTR and BDR treatments reduced loads during Flex events by 7% and 2% in summer and 5% and 1% in winter, respectively.
- The TOU1 rate, which defined on-peak periods as weekday hours between 6:00 a.m. and 10:00 p.m., did not result in shifting of loads from on-peak periods to off-peak periods or demand savings during Flex events. The TOU1 load impacts were not statistically different from zero.
- In summer, the TOU2 and TOU3 rates, which defined a shorter on-peak period on weekdays from 3:00 p.m. to 8:00 p.m., resulted in demand savings from 5%–8% during on-peak periods and Flex event hours. In winter, neither TOU2 nor TOU3 resulted in statistically significant Flex event demand savings or shifting of loads from peak to off-peak hours.

- During on-peak TOU periods, Hybrid treatments, which combined PTR or BDR with TOU pricing, resulted in demand savings from 8%–23% in summer and 1%–5% in winter. During summer Flex events, Hybrid treatments saved 10%–20% of peak demand. During winter Flex events, TOU2 and TOU3 hybrid treatments saved about 13%.
- None of the TOU-only or Hybrid treatments led to changes in total energy consumption. Estimates of changes in total energy consumption were close to zero and not statistically significant.
- Opt-in PTR customers were those most satisfied with the pilot. In summer and winter, 80% or more of PTR customers reported a satisfaction rating of 6 or higher on a 10-point scale.
- TOU-only customers and opt-out customers were the least satisfied with Flex. Among TOU-only customers, 76% were satisfied with Flex in summer and 61% were satisfied in winter. For opt-out customers, 56% were satisfied in summer and 61% were satisfied in winter. Some TOU customers reported less-than-expected bill savings, and some opt-out customers were not interested in participating.
- TOU customer satisfaction with the pilot depended on perceived bill savings. Satisfied customers (those giving 6–10 ratings on a 10-point scale) most often noted that the program delivered bill savings. Unsatisfied customers (those giving 0–5 ratings a 10-point scale) most often noted seeing little to no difference in their bills.
- Customers opting into the pilot exhibited high engagement with Flex events. Depending on the season, 93% to 96% of opt-in PTR-only respondents and 94% to 97% of opt-in Hybrid respondents remembered receiving event notifications. Also, 76% to 86% of opt-in respondents reported conserving electricity during events in both seasons.
- Opt-out customers automatically enrolled in the pilot exhibited lower awareness of Flex events compared to opt-in customers. Depending on the season, 77% to 89% of opt-out respondents remembered receiving event notifications, and 48% to 63% reported conserving electricity during events in both seasons.
- TOU customers did not have strong awareness of their rate schedules. Only about one-half of TOU and Hybrid respondents (52%) correctly identified their rate schedules from a list of three rate schedule images, a result only slightly better than customers guessing at random.
- During the first season, PGE experienced challenges in providing accurate and timely feedback to participants about savings during Flex events. However, with improvements in the baseline calculation methodology and data QC procedures, PGE increased the feedback's accuracy and shortened the time required to send customers feedback to less than 24 to 48 hours after the event.
- Around one-half of customers (48%) did not know they could change their event notification channel preferences on the Flex website. PGE received complaints from BDR-OO customers that they received too many event notifications.

- TOU and Hybrid customers, who faced financial risks from participating in the pilot, opted out of the pilot at higher rates (8%–11%) than opt-in PTR, opt-out PTR, and BDR customers (2%–6%), who did not face such risks.
- PGE experimented with three marketing channels (email, postcard, and business letter) and three messaging themes (economics, control, and community) to determine which marketing strategies converted to higher customer enrollment. The two paper-based channels (business letter 4.5% and postcard 2.5%) had a higher conversion rate than email (1.5%).
- PGE found that financial-focused messaging resonated more with customers as PGE enrolled a higher percentage of customers when it emphasized the opportunity to earn bill credits or savings. In surveys, customers reported that saving money on electric bills was the top reason for enrollment (78%).

Table 2. Flex Evaluation Findings by Treatment and Season*

Category	Treatment		Summer				Winter					Program Opt-Out Rate****
			Savings**		Satisfaction***		Savings**			Satisfaction***		
			Planning	Evaluation	Satisfied (6-10)	Delighted (9-10)	Planning	Evaluation AM	Evaluation PM	Satisfied (6-10)	Delighted (9-10)	
PTR-Only	PTR1		13%	18%	79%	46%	14%	13%	7%	80%	44%	4%
	PTR2			22%	92%	42%		0%	8%	89%	55%	6%
	PTR3			17%	84%	52%		3%	12%	89%	58%	5%
Opt-Out	PTR2-OO		6%	7%	73%	40%	7%	0%	6%	79%	35%	2%
	BDR-OO		3%	2.3%	51%	23%	3%	-0.7%	1%	57%	25%	3%
TOU-Only	TOU1	On-Peak	5%	2%	57%	23%	6%	-1%		54%	23%	8%
		Flex Event		-1%				2%	0%			
	TOU2	On-Peak		8%	82%	45%		3%		62%	23%	9%
		Flex Event		5%				2%	2%			
	TOU3	On-Peak		5%	82%	42%		0%		68%	23%	9%
		Flex Event		6%				3%	-1%			
Hybrids	TOU1xPTR2	On-Peak	5.2% TOU; 12.9% PTR	3%	72%	34%	5.8% TOU; 14.2% PTR	1%		69%	38%	11%
		Flex Event		10%				10%	5%			
	TOU2xPTR2	On-Peak	5.2% TOU; 12.9% PTR	24%	70%	27%	5.8% TOU; 14.2% PTR	5%		73%	18%	10%
		Flex Event		20%				12%	13%			
	TOU2xBDR	On-Peak	5.2% TOU; 3.0% BDR	8%	81%	37%	5.8% TOU; 3.3% BDR	1%		71%	36%	8%
		Flex Event		11%				-1%	1%			
	TOU3xPTR2	On-Peak	5.2% TOU; 12.9% PTR	9%	88%	50%	5.8% TOU; 14.2% PTR	4%		72%	46%	10%
		Flex Event		8%				4%	13%			

* Seasonal results presented only for Summer 2017 and Winter 2017/2018.

**Impact values reflect percentage demand reduction during Flex peak-time events (and on-peak periods for TOU rates); green font indicates significance at 90%.

*** Satisfaction values represent participant survey respondents' satisfaction with Flex on a 0-10 rating scale.

**** Opt-out rates show the percentage of customers enrolled in a specific treatment who have unenrolled through February 2018.

Conclusions and Recommendations

Key takeaways from the Flex pilot evaluation include the following:

Peak-Time Rebates

Larger rebates did not yield more Flex event savings.
Opt-In PTR customers saved about 20% of consumption during summer Flex events and between 7% and 12% of consumption during winter Flex events. No statistically significant differences in savings appeared by rebate amount. In summer, customers receiving a $0.80/kWh rebate achieved the same savings as customers receiving a $2.25/kWh rebate.

Of 12 treatments, Opt-In PTR-only customers were most satisfied with the Flex pilot.
In both seasons, Opt-In PTR-only respondents had the highest satisfaction rates with Flex (83% reported a program satisfaction score of 6 or higher on a 10-point scale in winter; 86% in summer) compared to Hybrids (71% in winter; 79% in summer) and TOU-only (61% in winter; 76% in summer).[2] Opt-In PTR2 treatment achieved the highest satisfaction rate of 92% in the summer survey. Opt-In PTR2 (89%) and PTR3 (89%) treatments also achieved high satisfaction rates in the winter survey. PTR customers may have been most satisfied as they faced no financial risk from participation. Customers could earn rebates for saving energy during Flex events, but were not penalized if their consumption increased.

Larger rebates (greater than $1.55/kWh) increased customer satisfaction with the Flex pilot.
PTR1 customers, who received the smallest rebate ($0.80/kWh), had lower satisfaction with Flex for both winter and summer seasons than PTR2 ($1.55/kWh) or PTR3 ($2.25/kWh) customers. In summer, 79% of PTR1 customers expressed satisfaction with the program, while 92% of PTR2 customers and 84% of PTR3 customers expressed satisfaction. In winter, PTR1 had a satisfaction rate of 80%, about 10 percentage points lower than that of PTR2 (89%) and PTR3 (89%).

Flex event savings from peak-time rebates did not depend on outside temperatures.
A statistical relationship was not found between PTR savings and outside temperatures during Flex events in winter or summer. Outside temperatures during Flex events ranged between 82°F and 96°F in summer and 28°F and 45°F in winter.

PTR Recommendation

- When setting rebates for future PTR programs, PGE should consider the tradeoff arising from offering a higher rebate: over the lower range of rebates tested ($0.80/kWh to $1.55/kWh), there were positive effects on customer satisfaction but no impacts on Flex event savings

[2] Respondents rated their overall satisfaction with the program on a 0–10 scale, where 0 meant *extremely dissatisfied* and 10 meant *extremely satisfied*. PGE defined a 6–10 rating as *satisfied*.

from increasing the rebate. This suggests that larger rebates may raise customer satisfaction, but lower program cost-effectiveness.

TOU Rates

Customers under the TOU1 rate schedule encountered difficulties in shifting consumption from peak to off-peak hours.

The TOU1 rate used "day/night" off-peak and on-peak period definitions. As the on-peak period was set from 6:00 a.m. to 10:00 p.m., many customers were awake only during peak hours and asleep during off-peak hours, making load shifting inconvenient or difficult. Shifting loads would require many customers to adjust their sleep schedules or to have appliances programmed to run at night. Among TOU customers, those on the TOU1 rate had the lowest program satisfaction rates (57% in summer and 54% in winter) and did not achieve peak savings in either season. TOU1 respondents dissatisfied with Flex most often mentioned the rate schedule being difficult for their households; these respondents said it was not convenient or worth changing one's sleep time to do chores during off-peak periods.

TOU rate schedules with short peak-period definitions yielded peak savings and high satisfaction in summer.

In summer, TOU2 and TOU3 customers achieved significant savings during peak periods (8% and5%, respectively). They also saved 5%–6% during Flex event hours, which Cadmus used as a proxy for the peak capacity impact of TOU, even though TOU customers did not receive Flex event notifications or incentives. In summer, the TOU2 and TOU3 schedules had relatively short peak periods, from 3:00 p.m. to 8:00 p.m., which coincided with PGE's summer system peak and enabled customers to shift loads to off-peak periods. In summer, TOU2 and TOU3 customers had relatively high customer satisfaction ratings of 82%.

The simpler TOU rate schedule achieved the same peak period savings and satisfaction as the more complex one.

In summer, the TOU3 rate, with peak (3:00 p.m.–8:00 p.m.), mid-peak (11:00 a.m.–3:00 p.m.), and off-peak periods, reduced loads by 5% during the mid-peak period. However, no differences emerged in peak period savings between the simpler TOU2 rate, which only had peak (3:00 p.m.–8:00 p.m.) and off-peak periods, and the more complex TOU3 rate. TOU2 and TOU3 showed statistically similar program satisfaction rates in summer (TOU2 82%; TOU3 82%) and winter (TOU2 62%; TOU3 68%).

In winter, TOU customers experienced difficulties in shifting loads from peak to off-peak periods and achieving bill savings.

During winter, none of the TOU-only treatments produced statistically significant reductions in or shifts in peak-period loads. Either TOU did not affect customer loads, or the load impacts were too small to detect with the existing sample sizes. TOU customers also reported relatively low satisfaction with Flex (54%–68%) because of adverse bill impacts and the rate schedule being difficult for their households. TOU schedules had morning *and* evening peak periods. Notably in the survey's open-ended comments, TOU-only and Hybrid customers mentioned the program was more difficult to participate in during winter than summer. Moreover, TOU-only and Hybrid treatments showed significantly lower program

satisfaction rates in winter (61%–71%) than in summer (76%–79%).[3] This seasonal pattern in program satisfaction for TOU-only and Hybrid treatments suggests that the TOU aspect may be more challenging for customers in winter than in summer.

TOU Recommendations

- Unless an economic case justifies shifting customer loads from mid-peak to off-peak hours, PGE should implement the TOU2 rate schedule, which is simpler for customers to understand.
- PGE should consider redesigning the winter TOU rate schedules by removing the morning peak period. This would minimize the potential for adverse customer bill impacts and simplify the customer experience.
- PGE should redesign the TOU1 rate schedule or offer TOU1 customers enabling technology to facilitate load shifting from peak to off-peak periods.
- PGE did not test the impacts of pairing enabling technology with TOU pricing, but studies of other TOU pricing programs suggest that enabling technology such as price-responsive smart thermostats can increase load shifting. PGE should consider testing the load impacts of enabling technology in the future.
- PGE should consider enhancing customer screening during the enrollment process to determine whether a customer is a good fit for a TOU rate.
- Given TOU customers' challenges in achieving winter bill savings, PGE should offer them more education about how to save energy or shift loads from peak to off-peak periods.

Opt-Out Behavioral Demand Response

Behavior-based treatments caused PGE customers to save energy during Flex events.
BDR-OO customers saved an average of 2.3% of consumption in summer and 1.2% of consumption in winter. PGE sent opt-out BDR customers Flex event alerts, encouragement to reduce consumption, and individualized post-event feedback but did not charge them higher electricity prices or provide them with rebates during Flex events, demonstrating that residential customers responded to non-price interventions.

Opt-out BDR program design yielded capacity benefits, but resulted in relatively low customer satisfaction.
PGE automatically enrolled over 12,000 residential customers in the BDR-OO treatment. While average savings per treated customer were small (only 1%–2% of consumption), total program demand savings were large due to the size of the treated population. In the future, PGE can deploy the BDR program to help manage system peaks, but at the potential cost of lower customer satisfaction: only 51% of BDR-OO customers in winter and 57% in summer rated the program a 6 or higher on a 10-point scale.

[3] Significant difference with 90% confidence (p≤.10).

Satisfaction ratings were likely low due to the opt-out program design and the unfamiliarity of many customers with behavioral demand response and the costs of supplying energy during utility system peaks. The program sent event notifications to many customers who had little interest in receiving them or participating in a BDR program. PGE also mentioned in the interviews that it received feedback from some BDR customers that it dispatched too many events and that these customers had not been aware that they could change their event notification settings.

BDR Recommendations

- PGE should consider using opt-out BDR for achieving capacity savings targets, given its success with BDR in reducing loads during this pilot; but it should consider possible changes to program design to increase customer satisfaction, such as:
  - Limiting the frequency of future BDR events, which would also limit the number of event notifications customers received.
  - Shortening the duration of future BDR events to lessen the burden on customers.
  - Spacing out future BDR events to avoid calling back-to-back events or multiple events in the same week.
  - Sending BDR customers a handy reminder magnet or sticker about BDR events and how to save, akin to the clock sticker PGE sent to TOU customers.
- PGE should clearly inform opt-out BDR customers that they can opt out of treatment, and should make it relatively easy for customers to opt out if they do not want to participate.

Opt-Out Peak-Time Rebates

The opt-out participation program design significantly increased program participation.
PGE attained a much higher participation by presenting customers with a choice to opt out of the program rather than opt in. PGE automatically enrolled approximately 1,600 customers in the PTR2-OO program. By the end of the Winter 2017/2018 season, only 2.3% of customers had opted out. In comparison, at the end of the recruitment period for opt-in PTR treatments, less than 7% of PGE customers accepted offers to participate in a PTR1 (4.3%), PTR2 (2.8%), or PTR3 (6.2%) treatment.[4] Of customers opting in to PTR treatment, between 4.5% and 6.3% subsequently opted out. The opt-out design took advantage of customers who were expected to be "complacent": they would neither opt in nor opt out of a demand response program, if given the choice. Cadmus estimated that 92% of opt-out customers were complacent customers. By making participation the default choice, PGE obtained program participation and peak capacity that it would not have achieved otherwise.

[4] PGE experimented with different marketing strategies during the first two waves and obtained higher rates of acceptance during the third wave after improving its approach. Also, PGE stopped recruiting for the opt-in PTR2 treatment after the second wave.

The design of the pilot participation choice (opt-in vs. opt-out) presents a tradeoff between savings per customer and number of participants.

Depending on the rebate amount, opt-in PTR customers saved 17% to 21% of consumption during summer Flex events and from 7% to 12% of consumption during winter Flex events. Customers automatically enrolled in PTR2 saved an average of 7% during summer Flex events and 5% during winter Flex events.[5] Cadmus estimated that in Summer 2017, "complacent customers"—who would neither opt in nor opt out of a PTR program if given the choice—saved 6% during Flex events. While opt-in PTR customers saved more, the opt-out design enrolled many more customers. As noted above, fewer than 6% of PGE customers took up offers to participate in the PTR program. In contrast, more than 97% of customers defaulted onto PTR2-OO remained in treatment through the end of the Winter 2017/2018 season.

Adding a peak-time rebate to behavior-based demand response increased Flex event demand savings and customer satisfaction.

The opt-out BDR treatment and the opt-out PTR treatment only differed in the rebate paid to customers for saving energy during Flex events. PTR customers received the same notifications, tips for saving energy, and individualized feedback about savings as BDR-OO customers. Opt-out PTR customers, however, saved significantly more during Flex events than BDR-OO customers (5% in winter and 7% in summer vs. 1% and 2%, respectively), demonstrating that the rebate lifted savings and complemented the behavior-based treatment. The rebate also increased customer satisfaction. PTR2-OO customers reported 73% program satisfaction in summer and 79% in winter—high customer satisfaction rates for customers automatically enrolled in a program. In contrast, BDR-OO customers only reported program satisfaction rates of 51% in summer and 57% in winter.

Opt-Out PTR Recommendation

- Given the tradeoff between savings per customer and numbers of participants, PGE should analyze whether the opt-in or opt-out PTR design proved more cost-effective, and whether each design will generate the desired aggregate demand response capacity.

Hybrid Treatments

TOU pricing did not enhance (and possibly diminished) savings from PTR during Flex events and customer satisfaction (TOUxPTR vs. PTR).

[5] The surveys also found that a higher percentage of opt-in (75% in summer, 89% in winter) than opt-out (37% in summer, 75% in winter) PTR2 customers reported participating in Flex events.

During Summer Flex events, opt-in PTR customers saved 17% to 21% of consumption, but TOUxPTR customers only saved 9% to 19%[6]. During Winter Flex events, opt-in PTR customers saved 7% to 12%, but TOUxPTR customers only saved 4% to 12%. TOU pricing may cause PTR customers to become inattentive to Flex event alerts, or TOUxPTR customers may have less incentive to save energy during Flex events because their consumption baseline used for calculating rebates is lower. In summer and winter, satisfaction with Flex was 10 to 20 percentage points lower for TOUxPTR customers than for PTR-only customers.

Adding peak-time rebates to TOU pricing increased customer satisfaction and Flex event savings (TOUxPTR and TOUxBDR vs. TOU-Only).
Peak-time rebates had positive impacts on customer satisfaction for TOU customers. Depending on the TOU rate, TOU-only customers reported program satisfaction ranging from 57% to 82% in summer and 54% to 68% in winter. In contrast, TOUxPTR customers reported satisfaction levels ranging from 70% to 88% in summer and from 69% to 73% in winter, suggesting that the PTR enhanced customer satisfaction with the program.

During Flex events (i.e., hours used in this report to approximate system capacity conditions), TOUxPTR customers also saved more than TOU-only customers. In summer, TOUxPTR or TOUxBDR customers saved from 8% to 19% of Flex event demand, while TOU-only customers saved from 2% to 8%. During Winter events, TOU2xPTR2 and TOU3xPTR2 customers saved 12% of consumption, while TOU-only customers did not save any demand.

Hybrid Treatment Recommendations

- If PGE's primary objective is to save demand during system peaks, it should consider enrolling more customers in PTR-only treatments than hybrid TOUxPTR treatments to maximize the impact on system peak.
- If PGE deploys TOU rates on a wide scale, it should consider pairing TOU rates with a peak-time rebate to raise customer satisfaction and Flex event savings.

Customer Experience

TOU and Hybrid customers reported higher satisfaction with the Flex pilot in summer than winter, primarily due to greater summer bill savings.

[6] The Flex event savings estimate for Hybrid customers indicates the combined effects of TOU and PTR during Flex events. The savings are estimated relative to customers who are treated with neither PTR nor TOU pricing.

Overall, participant respondents were more satisfied with the Flex pilot in Summer 2017 (74% *satisfied*) than Winter 2017/2018 (69% *satisfied*).[7] The seasonal satisfaction differences, however, were greatest for treatments involving TOU pricing, which typically produced annual bill savings, with most or all savings occurring in summer. For TOU-only and Hybrid treatments, respondents reported significantly higher program satisfaction in summer (76%–79% *satisfied*) than in the winter (61%–71% *satisfied*).[8] Summer and winter respondents giving the program satisfied ratings most often noted that the program delivered bill savings. Respondents giving a less-than-satisfied rating most often noted seeing little to no difference in their bill savings. In summer, 16% of TOU survey respondents said they saved on their electric bills, compared to 9% of TOU survey respondents in winter. These program satisfaction results align with demand savings estimates showing participants achieved higher peak-period load reductions in summer than winter.

Although PGE automatically enrolled them, opt-out PTR and BDR customers showed high event awareness and engagement with the pilot.

As expected, customers opting into the pilot exhibited high awareness of and engagement with Flex events. Depending on the season, 93% to 96% of opt-in PTR-only respondents and 94% to 97% of opt-in Hybrid respondents remembered receiving event notifications. Also, 76% to 86% of opt-in respondents reported conserving electricity during events in both seasons. These awareness and engagement levels were higher than for BDR-OO and PTR2-OO customers automatically enrolled in the pilots. and 89% of opt-out respondents remembered receiving event notifications. Also, 48% of opt-out respondents in summer and 63% of respondents in winter reported conserving energy during these events. This suggests that PGE can engage customers in achieving demand savings who are automatically enrolled in demand response programs.

PGE has an opportunity to increase peak period and Flex event demand savings from TOU rates through additional education with existing TOU customers.

TOU2 and TOU3-only and Hybrid treatments saved 5% to 8% of demand during peak periods and 8% to 20% of demand during Flex events, indicating that TOU treatments proved effective. TOU customers, however, did not have strong awareness of their rate schedules. Only about one-half of TOU and Hybrid respondents (52%) correctly identified their rate schedules from a list of three rate schedule images. That was only slightly better than results one would expect (33%) if all customers guessed at random. This suggests TOU customers could save more if they knew of their rate schedules. PGE might be able to increase TOU customer demand savings through doing additional education and outreach.

PGE identified several pilot implementation issues that negatively affected customer experiences and either corrected the issues or will correct them in future Flex deployments.

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[7] Respondents rated their overall satisfaction with the program on a 0–10 scale, where a zero meant *extremely dissatisfied* and a 10 meant *extremely satisfied*. PGE defined a 6–10 rating as *satisfied*.

[8] Significant differences at the 90% level (p≤.10).

In interviews with Cadmus, PGE managers and implementation contractors described several program implementation issues:

- PTR and BDR customers received inaccurate and delayed feedback regarding their demand savings during Flex events. The inaccurate feedback may have discouraged some customers from saving, and the delay in providing feedback prevented PGE from calling additional events until these issues resolved. By the start of Winter 2016/2017, PGE had resolved the savings calculation issues and managed to deliver feedback to participants within 24 to 48 hours of events.
- Another issue concerned communication about event notification settings. Some customers complained that they received too many notifications or that the notifications did not arrive through their preferred delivery channels. Many customers reported being unaware that they could change their notification settings. In the future, PGE plans to communicate more proactively with participants about options for program communications and will simplify the process for changing the settings.

Pairing technology with Flex treatments may improve customer's ability to achieve load reduction. While the Flex pilot did not test the impacts of pairing enabling technologies, such as smart thermostats, advanced water heaters, or in-home displays, with the pricing or behavior-based treatments, other studies have found the pairing of these technologies enhances peak demand savings. The experience of TOU1 customers illustrates the potential benefits of enabling technology. TOU1 customers reported challenges in shifting loads from daytime on-peak periods to nighttime off-peak periods; programmable or price-responsive enabling technologies may facilitate shifting of loads and increase TOU1 on-peak demand savings.

Customer Experience Recommendations

- PGE should consider modifying the TOU design and delivery for the winter season to help customers save or shift more electricity consumption. This would improve customer satisfaction and increase load impacts. Modifications could include eliminating the morning on-peak period, shortening the length of the on-peak periods, or automatically enrolling TOU customers in the PTR program. A conjoint analysis of the TOU program offering could examine tradeoffs between different rate schedule designs, customer satisfaction, and load impacts.
- PGE should provide TOU customers with additional education about their rate schedules. This information should be simple and easy to understand. One idea is delivering educational information through alternative media, such as online video.
- PGE should consider opt-out demand response programs as a component of its demand response portfolio. The Flex pilot demonstrated that opt-out programs can reach large numbers of customers and that 50% or more of customers automatically enrolled in PTR or BDR remained engaged, as measured by self-reported rates of Flex event awareness and conservation.

- PGE should conduct test events before the start of each season to assess readiness of its customer communications and data analytics platforms. Testing will allow PGE to correct issues before the season starts, refamiliarize customers with the program, and give customers a chance to change their communications preferences.
- PGE should consider conducting pilots to test the impacts of pairing enabling technologies such as smart thermostats or advanced water heaters with time-based rates or behavior-based treatments if PGE expects the technologies would be cost effective.

Marketing

Paper-based marketing and bill-savings messaging resonated most with customers.
PGE experimented with email, postcard, and business letter marketing, and found business letters achieved the highest customer marketing conversion rate (4.5%), followed by postcards (2.5%), and then email (1.5%).[9]

Business letters emphasized financial messaging (i.e., rate comparison information and a bill savings pitch). PGE initially used economic, control, and community messaging in the emails and post cards, but those approaches proved unsuccessful in enrolling customers. The recruitment survey also found a large majority of participants enrolled to save money on their electric bills (78%); far fewer respondents indicated enrolling to save energy (46%) or help the environment (28%).

Marketing Recommendation

- PGE should consider employing business letter marketing approach for future demand response programs to increase the cost-effectiveness of its marketing. This approach would include leading with bill savings and rate comparisons rather than energy savings or community as primary messages in postcards, emails, or other marketing channels.

[9] A conversion rate measures a given marketing channel's effectiveness in spurring enrollment, calculated by taking the number of customers who enrolled from a channel and dividing this by the total number of customers that the channel reached.

Introduction

In the next several years, PGE will face a shortfall in generating capacity from the planned closure of its Boardman facility in 2020 and the expected expiration of wholesale power contracts. At the same time, PGE plans to increase its production of electricity from intermittent renewable energy resources to comply with the requirements of Oregon Senate Bill 1547. In consideration of these developments, PGE's Integrated Resource Plan (2016) calls for the use of dispatchable resources including demand response to help manage system peak loads and to assist with the integration of renewable energy resources. The IRP sets a goal of adding demand response capacity of 77 MW in winter and 69 MW in summer.

Residential customers participating in demand response programs will provide an important source of Portland General Electric's (PGE) future demand response capacity. These programs use price signals, direct load control, behavior-based treatments, or combinations of these to encourage customers to reduce demand during periods when it is costly for the utility to supply or distribute electricity.

Demand response represents a fundamental shift in the utility's relationship with its customers. Customers participating in demand response programs do not simply just consume utility-supplied electricity; they also provide peak capacity to utilities. To take full advantage of this evolving "prosumer" role, PGE will need to offer its customers new retail electricity rates or other incentives as well as compelling education, marketing, and program experience to encourage customers to participate.

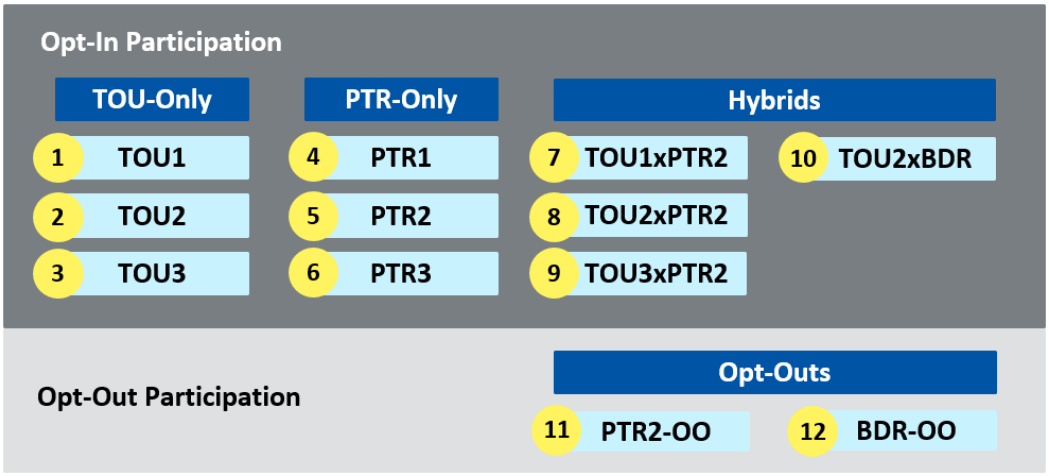
In 2015, PGE launched the Flex pilot program to test the effectiveness and customer acceptance of different demand response program offerings, including time-of-use (TOU) pricing, peak-time rebates (PTR), and behavioral demand response (BDR). By assessing a range of program treatment designs involving different incentive levels, rate structures, and recruitment approaches, PGE sought to understand its options and to lay the groundwork for a future where most of its residential customers participate in demand response programs.

This evaluation report assesses the design and delivery, load impacts, and customer experiences of 12 demand response treatments. PGE tested the demand response treatments as randomized control trials (RCTs), providing highly credible evidence about the treatment effects. The evaluation provides PGE with feedback about the pilot's performance in these areas, and presents insights that can be used to optimize PGE's future demand response program offerings.

Pilot Program Description

In 2016, PGE launched the Pricing and Behavioral Demand Response Pilot Program. The pilot enrolled approximately 14,000 residential customers and tested 12 pricing and behavior-based program design options (treatments), aimed at reducing residential peak demand during summer and winter months. The treatments featured TOU pricing, peak-time rebates (PTR), behavioral demand response (BDR), hybrid demand response (TOU in combination with PTR or BDR), and opt-out demand response (OO) that automatically enrolled customers. PGE offered the 12 treatments as the Flex Pilot Program. Figure 1 shows a diagram of the Flex Pilot Program's multi-treatment program design.

Figure 1. Twelve Treatments Tested in the Flex Pilot Program



PGE outlined the following Flex Pilot Program objectives:

- Implement the program over four seasons (e.g., Summer 2016, Winter 2016/2017, Summer 2017, and Winter 2017/2018), with six to 10 peak demand events per season
- Identify treatment(s) that could be cost-effective at scale, with 10% of customers participating
- Help customers achieve lower or cost-neutral rates
- Achieve positive customer experiences

To facilitate evaluation and planning for a future, full-scale rollout of Flex, PGE established planning estimates for expected demand reduction during Flex events (shown in Table 3). PGE developed the planning estimates based on load impacts reported by utilities operating similar demand response programs.

Table 3. Flex Pilot Program Demand Reduction Planning Estimates

Treatment	Summer	Winter
TOU-Only: TOU1, TOU2, TOU3	5.2%	5.8%
PTR-Only: PTR1, PTR2, PTR3	12.9%	14.2%
Hybrids (PTR): TOU1xPTR2, TOU2xPTR2, TOU3xPTR2	5.2%–12.9%	5.8%–14.2%
Hybrids (BDR): TOU2xBDR	3.0%–5.2%	3.3%–5.8%
PTR2-OO	6.4%	7.1%
BDR-OO	3.0%	3.3%

Note: Table shows PGE planning estimate of percentage demand savings during Flex events.

PGE also set total enrollment goals of approximately 3,850 customers for the 10 opt-in treatments and 13,610 customers for the two opt-out treatments. These enrollment goals ensured sufficient statistical power for testing the various treatments.

PGE designed and implemented the pilot program with assistance from CLEAResult and AutoGrid as the implementation contractors. CLEAResult co-managed day-to-day program implementation and executed program marketing, while subcontracting with AutoGrid to provide the program's technology platform software and data services. PGE selected Cadmus as the program evaluator, assisting PGE with research design, savings analyses, and customer surveys.

Treatments Tested

The Flex Pilot Program tested 12 treatments, consisting of TOU, PTR, BDR, Hybrids, and Opt-Out program designs. This section summarizes these five program designs and the 12 different treatments.

Time-of-Use Rates

Customers enrolled in a TOU treatment paid a different unit price for electricity depending on when the electricity was consumed. TOU rates encourage customers to shift electricity consumption from periods when the utility's cost of supplying electricity is high to periods when the cost is low.

PGE tested three TOU rate schedules: TOU1, TOU2, and TOU3. Table 4 shows TOU rate schedules for summer and winter seasons under Flex.[10] TOU1 and TOU2 only had off-peak and on-peak periods, with TOU1 charging lower on- and off-peak rates, but having a longer on-peak period than TOU2. TOU3 had off-peak, mid-peak, and on-peak periods, with the off-peak rate below and the on-peak rate above those of TOU1 and TOU2. The TOU rate schedules also varied by season. During winter, each TOU rate included morning and afternoon peak periods, while, during summer, the TOU rates only included an afternoon peak period.

[10] Summer TOU rates are in effect from May 1 to October 31. Winter TOU rates are in effect from November 1 to April 30. This evaluation estimated TOU pricing impacts in summer between June 1 and September 30 and in winter between December 1 and February 28.

In summer, the peak-to-off-peak price ratio equaled 1.8 for TOU1, 2.1 for TOU2, and 2.6 for TOU3. In winter, the peak-to-off-peak price ratios were essentially unchanged, equaling 1.8 for TOU1, 2.1 for TOU2, and 2.5 for TOU3. A higher peak-to-off-peak price ratio should encourage greater load shifting, all else equal.

During the first year of participation, TOU customers could request refund if their annual electricity bills exceeded what they would have paid under the standard PGE residential rate. After the first year of participation, the bill protection lapsed and customers could not request a refund.

Table 4. Flex Schedule: TOU Summer and Winter Rates*

Summer	TOU1	TOU2	TOU3
Off Peak	7.5¢/kWh	8.3¢/kWh	6.9¢/kWh
	10:00 pm–6:00 am	8:00 pm–3:00 pm	10:00 pm–11:00 am
Mid Peak			11.9¢/kWh
			11:00 am–3:00 pm 8:00 pm–10:00 pm
On Peak	13.6¢/kWh	17.6¢/kWh	18.0¢/kWh
	6:00 am–10:00 pm	3:00 pm–8:00 pm	3:00 pm–8:00 pm
Winter	**TOU1**	**TOU2**	**TOU3**
Off Peak	8.0¢/kWh	8.8¢/kWh	7.4¢/kWh
	10:00 pm–6:00 am	8:00 pm–7:00 am; 11:00 am–3:00 pm	10:00 pm–7:00 am
Mid Peak			12.4¢/kWh
			11:00 am–3:00 pm; 8:00 pm–10:00 pm
On Peak	14.1¢/kWh	18.1¢/kWh	18.5¢/kWh
	6:00 am–10:00 pm	7:00 am–11:00 am; 3:00 pm–8:00 pm	7:00 am–11:00 am; 3:00 pm–8:00 pm

* TOU rates in effect as of August 1, 2016.

TOU customers received a rate schedule (the Flex schedule), depicting these various costs and times. Each month during summer and winter seasons, PGE sent TOU customers a report on how much money they saved under the TOU rate, with comparisons to the previous month, and tips on how to conserve or shift energy. For the first year, PGE provided bill protection to customers on TOU rates. This insured that TOU customers would not pay more than they would have if they remained on the standard flat rate. Bill protection was applied to a customer's annual—not monthly—consumption.

Peak-Time Rebate

Customers enrolled in a PTR treatment received cash rebates for reducing electricity consumption during Flex time events. PGE tested three rebate amounts[11]:

- PTR1 customers received $0.80 per kWh of savings
- PTR2 customers received $1.55 per kWh
- PTR3 customers received $2.25 per kWh

A customer's PTR savings were calculated relative to his or her baseline consumption, which was an estimate of what normal consumption would have been during the event hours.

One day in advance, PGE dispatched event notifications via email, text, and voice mail to customers, with another notification on the day of the event. These event notifications came with tips on conserving or shifting energy.

Within two days after an event, PGE provided PTR customers with feedback regarding their performance, showed them how much electricity they saved and incentives earned. Within two weeks after the season's end, PGE mailed a report (along with a rebate check) to customers, addressing the total amount of electricity they saved during the season's events. The end-of-season report also showed energy savings for the customer and all Flex Program participants.

Behavioral Demand Response

The BDR treatment used behavior-based strategies to encourage customers to reduce electricity consumption during Flex events. PGE sent BDR customers event notifications, similar to those for PTR treatment, asking them to reduce electricity during specific hours of high demand. BDR customers, however, did not receive rebates or other financial incentives for reducing consumption during events. Rather, PGE provided BDR customers with social-normative peer comparisons and appeals to participate in collective actions to reduce electricity demand during peak periods. BDR customers received an end-of-season report similar to that provided for the PTR treatment, but they did not receive a rebate check.

Hybrids

Customers in Hybrid treatment received a combination of TOU and PTR treatments or a combination of TOU and BDR treatments:

- **TOUxPTR**: PGE tested three TOU rate treatments paired with the PTR2 treatment: TOU1xPTR2, TOU2xPTR2, and TOU3xPTR2. Customers in this Hybrid treatment paid different unit prices for electricity, depending on the day of week and time of day, *and* became eligible to receive a rebate for reducing consumption below baseline levels during Flex events.

[11] PTR incentives reflect pricing as of August 1, 2016.

- **TOU2xBDR**: PGE tested TOU2 paired with BDR. Customers in this Hybrid treatment paid the TOU2 rate *and* were asked to reduce consumption during Flex events, without financial incentive.

Opt-Out Participation

PGE tested BDR as an opt-out treatment, automatically enrolling customers but allowing them to opt out at any time. PGE also tested PTR2 as an opt-out and opt-in treatment to determine how the framing of the participation choice affected enrollments, demand savings, and customer satisfaction. PGE administered the PTR2 treatments identically to opt-out and opt-in customers.

Research Design and Program Set-Up

PGE implemented a large, randomized field experiment to test the Flex Pilot Program, using recruit-and-deny randomized controlled trials (RCT) to test the 10 opt-in treatments and a standard RCT to test the two opt-out treatments. Randomized field experiments serve as the gold standard for demand-side management program evaluation and are expected to produce unbiased estimates of treatment effects.

Customer Eligibility Requirements

PGE identified 246,000 residential customers eligible to participate in the pilot. To receive an invitation to participate or to be automatically enrolled in the pilot, customers had to meet the following criteria:

- Receive electricity service from PGE and the current service address for at least the previous 12 months
- Not be a solar energy customer (i.e., did not have solar panels installed on the premises and on a net metering rate)
- Not be a participant in the Rush Hour Rewards thermostat control demand response program
- Provide PGE with a valid email address
- Have a functioning interval consumption meter that records and communicates energy consumption to PGE

PGE did not impose eligibility requirements regarding minimum or maximum energy consumption or peak demand levels, allowing customers with low or high consumption levels to participate. However, PGE screened all eligible customers for expected bill savings from TOU treatments. Only customers expected to reduce their annual electricity bill payments with TOU pricing were given the opportunity to participate.[12]

[12] Only customers with positive bill savings under the assumption that they shifted 7% of load from peak period to off-peak period were invited to participate in a TOU or Hybrid treatment.

Random Assignment to Treatment

PGE randomly assigned eligible customers to a pricing treatment (e.g., TOU2 or PTR1) and to a test or control group, and then invited them to participate in the pilot. Customers who opted into the pilot and had been randomly assigned to a test group were placed into treatment, while customers who opted in and had been assigned to the control group were not enrolled. Customers assigned to an opt-out treatment test group were automatically enrolled and received the assigned treatment unless they opted out. Customers assigned to the control group of an opt-out pricing treatment did not receive that treatment or any program-related communications. None of the customers assigned to a control group could participate in the Flex pilot.

Marketing and Recruitment

Customer recruitment for 10 opt-in treatments began in mid-February 2016 and continued through Spring 2017. PGE recruited customers to the pilot in three waves: Spring 2016; Summer/Fall 2016; and Spring 2017.

PGE and CLEAResult developed marketing materials and messaging for the pilot. This messaging focused on economics (personal gains, including bill savings), control (taking charge of your consumption), and community (the greater good). For customers invited to participate in a TOU treatment, the marketing presented expected bill savings under the assumptions of 7% and 15% shifts in consumption from the peak to off-peak period. For TOUxPTR hybrid customers, the marketing also presented bill savings with expected PTR-earnings.

In marketing the program to customers, PGE employed the following communication channels:

- **Email.** PGE sent multiple emails to customers with valid email addresses.
- **Direct mail.** PGE first sent postcards and then later sent business letters.
- **Flex website:** PGE established a customer engagement web portal, where customers could enroll in the program, review their current pricing plan, view information on ways to save, and obtain information about their household's electricity consumption.

Opt-In Treatment Recruitment and Enrollment Process

As discussed, PGE and Cadmus randomly preassigned eligible customers to one of 10 opt-in treatments and to either a test group or a control group. All eligible customers received an email and postcard invitation to enroll in Flex. The email and postcard included rate comparison information pertaining to the customer's assigned pricing option. The email and postcard provided customers with an activation code to sign up through the Flex website. Customers received a reminder email to enroll a week after the initial email and were given up to 45 days to enroll.

After logging into the Flex website, a customer completed enrollment by accepting the assigned pricing treatment. Test group customers who accepted their assigned pricing treatment became program participants. Control customers who accepted their pricing treatment were not placed into treatment,

but rather received a message saying they did not qualify to enroll currently, but may be able to do so in the future.

PGE initially offered test and control customers a reward for enrolling during the early 2016 recruitment period. Enrolled customers could choose between an Amazon gift card and a pair of zoo tickets. After seeing very little enrollment impact, however, PGE eliminated the enrollment reward.

Test group customers participating in the 10 opt-in pricing treatments could opt out at any time by contacting the pilot's call center.

Opt-Out Treatment Enrollment Process

PGE automatically enrolled randomly-chosen customers into one of two opt-out treatments: a peak-time rebate (PTR2-OO); or a behavioral demand response (BDR-OO). Customers randomly assigned to an opt-out treatment test group received a welcome email and postcard in mid-June 2016. The email and postcard included a link to access the Flex website.

Test-group customers participating in an opt-out treatment could opt out of the program in two ways: unsubscribing to the emails; or contacting the program's call center.

Recruitment Targets and Actual Enrollments

Table 5 shows PGE's enrollment targets, the number of customers enrolled in each Flex test group at the beginning of each season, and historical maximum enrollment as a percentage of the target. The enrollment targets were determined through statistical power analysis, with the objective of enrolling enough customers to detect the expected load impacts through statistical analysis. At first, recruitment proceeded slower than expected. In Summer 2016, only 50% of the targeted customers had enrolled, but, by Summer 2017, the program exceeded its targets, with many treatments reaching 150% or more of the sample size targets.[13] All treatments except for BDR-OO met their enrollment targets.

[13] Because PTR2 had recruitment priority to achieve a sample size large enough to support analysis for the Summer 2016 season, PGE stopped recruiting for PTR2 after Spring 2016.

Table 5. Flex Customer Recruitment Targets and Enrollments

Treatment	Number of Customers (N)				Target (N)	Percent of Target Achieved (Maximum)
	Summer 2016	Winter 2016/2017	Summer 2017	Winter 2017/2018		
PTR1	112	144	368	344	220	167%
PTR2	243	227	225	206	220	110%
PTR3	165	219	456	414	220	207%
TOU1	136	152	413	386	390	106%
TOU1xPTR2	132	146	346	329	220	157%
TOU2	480	564	1013	946	875	116%
TOU2xBDR	184	217	898	833	875	103%
TOU2xPTR2	251	234	220	202	220	114%
TOU3	130	158	432	401	390	111%
TOU3xPTR2	126	147	321	292	220	146%
PTR2_OO	375	703	631	564	430	163%
BDR_OO	6,233	11,215	10,089	9,095	13,180	85%
Total Opt-In	**1,959**	**2,208**	**4,692**	**4,353**	**3,850**	**122%**
Total Opt-Out	**6,608**	**11,918**	**10,720**	**9,659**	**13,610**	**88%**

Table 6 shows target and enrolled numbers of control group customers by treatment and season for the Flex pilot study. The control group sizes for individual treatments largely mirror those for the test groups. All treatments except BDR-OO achieved their targets by Summer 2017.

Table 6. Flex Control Group Sizes

Treatment	Number of Customers (N)				Target (N)	Percent of Target Achieved (Maximum)
	Summer 2016	Winter 2016/2017	Summer 2017	Winter 2017/2018		
PTR1	121	155	363	343	220	165%
PTR2	212	199	191	181	220	96%
PTR3	160	218	453	422	220	206%
TOU1	114	128	454	417	390	116%
TOU1xPTR2	118	123	326	302	220	148%
TOU2	388	453	554	513	390	142%
TOU2xPTR2	230	208	189	171	220	105%
TOU3	108	136	460	422	390	118%
TOU3xPTR2	126	159	309	287	220	140%
PTR2_OO	405	730	662	605	430	170%
BDR_OO	6,186	11,178	10,087	9,081	13,180	85%
Total Opt-In	**1,577**	**1,779**	**3,299**	**3,058**	**2,490**	**132%**
Total Opt-Out	**6,591**	**11,908**	**10,749**	**9,686**	**13,610**	**87%**

Event and Data Management

CLEAResult subcontracted with AutoGrid to operate the Flex Pilot Program's technology platform and to provide PGE with program management software and data management services. AutoGrid built and configured an online system to handle data from three different program designs (TOU, PTR, and BDR), employing a two-part system to manage the program's demand response events and data:

- The engagement portal (Flex website), which houses and tracks customer-facing program data and information
- The demand response management system, designed to schedule events and measure consumption at short time intervals

AutoGrid's system communicated with PGE's customer information system to gather up-to-date customer account information and, through PGE's advanced metering infrastructure (AMI), to gather customer interval consumption data at the meter level. PGE scheduled and dispatched events via the AutoGrid system, which sent event notifications to customers on the day before the scheduled event. On the day after the event, the AutoGrid system received and analyzed interval consumption data and estimated the load impacts. After reviewing the event performance results, PGE released them to customers, usually within 24-48 hours.

Table 7 shows Flex events that PGE called over the two summer and winter seasons.

Table 7. Flex Time Events by Season

Season	Date	Event Period	Notes
Summer 2016	7/27/2016	4:00 p.m.–7:00 p.m.	
	7/29/2016	4:00 p.m.–7:00 p.m.	
	8/11/2016	4:00 p.m.–7:00 p.m.	
	8/12/2016	4:00 p.m.–7:00 p.m.	
	8/18/2016	4:00 p.m.–7:00 p.m.	
	8/25/2016	4:00 p.m.–7:00 p.m.	
Winter 2016/2017	12/6/2016	4:00 p.m.–7:00 p.m.	
	12/8/2016 (snow day)	4:00 p.m.–7:00 p.m.	
	12/15/2016 (snow day)	4:00 p.m.–7:00 p.m.	BDR-OO not dispatched.
	1/3/2017	4:00 p.m.–7:00 p.m.	
	1/4/2017	4:00 p.m.–7:00 p.m.	
	1/11/2017	5:00 a.m.–8:00 a.m.	
	2/1/2017	7:00 a.m.–10:00 a.m.	
	2/3/2017 (snow day)	7:00 a.m.–10:00 a.m.	TOU2xBDR and BDR-OO not dispatched.
Summer 2017	7/25/2017	4:00 p.m.–7:00 p.m.	
	8/1/2017	5:00 p.m.–8:00 p.m.	
	8/3/2017	4:00 p.m.–8:00 p.m.	
	8/7/2017	4:00 p.m.–7:00 p.m.	TOU2xBDR and BDR-OO not dispatched.
	8/9/2017	3:00 p.m.–6:00 p.m.	
	8/28/2017	4:00 p.m.–8:00 p.m.	
	9/5/2017 (fire day)	4:30 p.m.–7:30 p.m.	Air quality issue from Eagle Creek fire.
Winter 2017/2018	1/3/2018	5:00 p.m.–8:00 p.m.	
	1/9/2018	5:00 p.m.–7:00 p.m.	TOU2xBDR and BDR-OO not dispatched.
	1/18/2018	5:00 p.m.–8:00 p.m.	
	1/25/2018	5:00 p.m.–8:00 p.m.	TOU2xBDR and BDR-OO not dispatched.
	1/31/2018	5:00 p.m.–8:00 p.m.	TOU2xBDR and BDR-OO not dispatched.
	2/20/2018	5:00 p.m.–8:00 p.m.	
	2/23/2018	7:00 a.m.–10:00 a.m.	

Evaluation Objectives

PGE specified the following evaluation objectives for the Flex pilot:

- Estimate the load impacts for each treatment and compare the estimated treatment effects.
- Assess customer enrollments in and satisfaction with the different treatments, including opt-in and opt-out treatments.
- Assess whether customer opt-in rates, satisfaction, and estimated load reductions depend on the PTR incentive amount or TOU pricing schedule.
- Determine whether behavior-based treatments result in significant and sustained reductions in customer demand.
- Assess whether Hybrid treatments result in larger peak demand reductions than single treatments.
- Identify implementation challenges, improvement opportunities, and potential for expanding the pilot.
- Assess program successes, challenges, and areas for improvement and scalability.

PGE's research objectives did not include cost-effectiveness analysis, as PGE planned to conduct the cost-effectiveness analysis using the study's results as inputs.

Evaluation Activities

Evaluation Background

In October 2015, PGE hired Cadmus to evaluate the Flex pilot. At the beginning, Cadmus assisted with the research design for the evaluation, which involved selecting demand response treatments, designing the randomized field experiments, and determining minimum sample sizes. After selecting the 12 treatments for testing, PGE began implementing the pilot. Cadmus assisted by randomly assigning eligible customers to one of the 12 treatments and to a test or control group. In March 2016, PGE began recruiting customers for enrollment; this was the first of three recruitment waves, with subsequent waves launching in summer/fall 2016 and spring 2017.

This Flex evaluation covers two summers and two winters, beginning in June 2016 and ending in February 2018. While Cadmus evaluated the pilot during all four seasons, this report focuses on Summer 2017 and Winter 2017/2018 seasons because the pilot did not reach its customer recruitment targets until summer 2017 and PGE changed some aspects of the program's delivery during the first two seasons.

To assess program delivery, design, and the customer experience, Cadmus performed a series of participant surveys (for treatment and control groups), including just after recruitment, during seasons after a peak-saving events, and at the end of a season, after all events had been completed. Cadmus also conducted multiple interviews with program and implementation staff at various points across the evaluation cycle.

Cadmus estimated pilot load impacts by analyzing hourly AMI customer consumption data. This involved performing separate regressions by season and treatment to assess differences in loads between test and control customers.

Table 8 summarizes the Flex pilot evaluation activities and how each relates to PGE's evaluation objectives. Below, we discuss each of these evaluation activities in greater detail, except for the research design, which was discussed already.

Table 8. Flex Pilot Evaluation Activities

Activity	Description	Outcomes	Relevance to Study Research Objectives
Research design	Designed recruit-and-deny RCT for opt-in treatments and RCT for opt-out treatments. Determined sample sizes for each treatment required to detect expected savings.	Randomized field experiment design and required sample sizes to obtain accurate and precise estimates of treatment effects.	1, 2, 3, 4, 5
Data collection and preparation	Collecting and preparing analysis of individual-customer AMI meter interval consumption data.	Final analysis sample for estimation of load impacts.	1
Load impact analysis	Regression analysis of individual-customer AMI meter interval consumption data.	Estimates of Flex event savings for 12 treatments and for peak and off-peak load impacts for TOU pricing.	1, 3, 4, 5, 6
PGE manager and implementation contractor interviews	Interviewed managers and contractors regarding program design, implementation, successes, and challenges.	Documentation of pilot implementation and lessons learned.	1, 6, 7
Customer surveys	Recruitment, event, and customer experience surveys.	Findings about customer satisfaction with the program and PGE, customer engagement, and event awareness.	2, 3, 6, 7

Data Collection and Preparation

Cadmus collected and prepared the following data for analysis:

- Individual-customer AMI meter electricity consumption data for all test and control group customers
- Weather data for each customer from the NOAA weather station closest to each customer's residence.
- Pilot enrollment, program participation, and account closure data for customers who received an invitation to participate in Flex, were automatically enrolled in the pilot (opt-out BDR or PTR), or assigned to the opt-out BDR control group or PTR control group.
- Dates and times of all Flex events and rate schedules for all Flex TOU pricing treatments

The AMI meter data recorded a customer's electricity consumption at 15 or 60-minute intervals and covered 12 months before the customer first received treatment (i.e., the customer's TOU rate became active) and all post-treatment months while the customer's account remained active. Cadmus

aggregated all 15-minute interval consumption data to the customer-hour level. We performed standard data-cleaning steps to address duplicate observations, extreme outliers, and missing values. These data cleaning steps are discussed in Appendix A.

The weather data were high-frequency, asynchronous temperature and humidity readings from seven NOAA weather stations across PGE's service area. Cadmus aggregated the weather data to the hourly level and merged them with the hourly interval consumption data.

The pilot enrollment and program participation data included the following fields for each customer:

- Assignment to treatment (e.g., BDR, TOU1, etc.), assignment to test or control group, and indicator for recruiting wave (Wave 1, Wave 2, or Wave 3)
- For opt-in customers an indicator for whether the customer opted into the pilot and the date when the customer opted in.
- The official enrollment date if the customer opted into the pilot and had been assigned to the test group
- For customers assigned to receive an opt-out treatment, the date when the customer was automatically enrolled in the pilot.
- The account closure date if the customer's account closed during the pilot.
- The date the customer unenrolled from the pilot if the customer opted out of treatment.

Cadmus used the pilot enrollment and program participation data to identify customers in the test and control groups for each treatment, to define different variables for the load impact analysis, such as treatment and test-group indicator variables, to develop survey sample frames, and to calculate treatment opt-out rates.

In cleaning and preparing the AMI meter data, Cadmus encountered several issues that had to be addressed before the data could be analyzed. These issues included:

- Some AMI datasets were recorded on Coordinated Universal Time (UTC) instead of Pacific Time (UTC -8 or UTC -7).
- During the pre-treatment period, some customers' AMI meter data were recorded as integer kWh instead of as watt-hours.
- PGE did not provide pretreatment data for the same 12 months for all pilot customers

Appendix A discusses Cadmus' solutions to these issues. Robustness checks of the Flex treatment savings estimates indicate that the estimates were not sensitive to the specific solutions Cadmus developed.

Analysis Samples

Table 9 shows the initial and final analysis samples for each treatment in Summer 2017 and Winter 2017/2018 seasons. The initial analysis sample includes all customers who were randomly assigned to a test or control group and whose billing account remained active at the beginning of the Flex season.

Customers who opted out of treatment were included in both total enrollment and final analysis customer counts. Customers who moved or discontinued electricity service before the season began were excluded from samples.

Table 9. Flex Pilot Final Analysis Sample Sizes

Treatment	Summer 2017			Winter 2017/2018		
	Initial Analysis Sample (N)	Final Analysis Sample (N)	Analysis Sample Percentage	Initial Analysis Sample (N)	Final Analysis Sample (N)	Analysis Sample Percentage
PTR1	731	722	99%	687	678	99%
PTR2	416	408	98%	387	380	98%
PTR3	909	889	98%	836	823	98%
PTR2-OO	1,293	1,256	97%	1,169	1,149	98%
BDR-OO	20,176	19,587	97%	18,176	17,889	98%
TOU1	867	827	95%	803	787	98%
TOU2	1,567	1,510	96%	1,459	1,406	96%
TOU3	892	849	95%	823	805	98%
TOU1xPTR2	672	638	95%	631	612	97%
TOU2xPTR2	409	385	94%	373	354	95%
TOU2xBDR	1,452	1,398	96%	1,346	1,317	98%
TOU3xPTR2	630	598	95%	579	559	97%

The final analysis sample includes customers used in the impact estimation. The analysis sample excluded only a small number of test and control group customers in each treatment. For most treatments, the analysis included more than 97% of enrolled customers in the analysis. The main drivers of customer attrition from the analysis sample included lack of pre- or post-period AMI data.

Cadmus verified that there were not statistically significant differences in pre-treatment consumption between test and control group customers in the final analysis sample. For almost all treatments, the test and control groups were well balanced. Appendix C provides detailed balance test results.

Savings Estimation Approach

Cadmus estimated savings for each Flex treatment by collecting individual-customer AMI interval consumption data from before and after the customer enrolled in the Flex pilot and by comparing the peak demand of customers in the randomized test and control groups. This evaluation reports the following impacts:

- Flex event demand savings for all treatments, including TOU rates
- Peak period and off-peak period load impacts for TOU-based treatments, including TOU-only and hybrid treatments

We provide an overview of the estimation approach but a more detailed description is found in Appendix B.

Event-Based Treatments

Cadmus estimated the demand savings from event-based treatments (e.g., PTR1, opt-out BDR) by comparing demand during Flex events of customers in the randomized test and control groups. Using data for event hours during each winter or summer season, Cadmus estimated a multivariate panel regression of customer hourly energy demand on control variables for pretreatment hourly average demand, hour-of-sample fixed effects, and assignment to treatment. We estimated a separate model for each treatment.

The pretreatment demand variables controlled for average differences in electricity demand between customers during Flex event hours. Cadmus calculated separate mean pretreatment demand for morning and evening hours for each season, using AMI interval data for days before the beginning of the Flex season. Cadmus did not calculate mean pre-treatment demand using non-event days during the demand response season in consideration of evidence from other studies showing that event-based treatment can produce savings on non-event days. The hour-of-sample fixed effects controlled for weather and other unobserved factors specific to each event hour.

Cadmus estimated the models by ordinary least squares (OLS) and clustered the standard errors on customers to account for correlation over time in customer demand. Given the random assignment of customers to test and control groups, the regression was expected to produce an unbiased estimate of the treatment effect. Cadmus estimated alternative model specifications to test the estimates' robustness to specification changes, and found the results were very robust. Cadmus tested specifications that included indicator variables for a customer's recruitment wave (i.e., Wave 1, Wave 2, or Wave 3) as standalone variables and interacted with other explanatory variables and that dropped the pre-treatment consumption variables from the regression.

Time of Use Rate and Hybrid Treatments

Cadmus estimated treatment effects for TOU rate and hybrid-TOU rate treatments by comparing demand of customers in each treatment's randomized test and control groups. Using interval data on customer demand for each winter or summer season, Cadmus estimated a multivariate panel regression of customer hourly energy demand on control variables for pretreatment demand, peak and off-peak hours, day-of-the-week, weather, and assignment to treatment. We estimated treatment effects for Summer 2017 using data from June 1, 2017 to September 30, 2017 and for Winter 2017/2018 using data from December 1, 2017 to February 28, 2018. We estimated a separate model for each treatment.

Cadmus estimated the TOU and Hybrid models by OLS and clustered the standard errors on customers. Again, because of random assignment of customers to test and control groups, the regression was expected to produce unbiased savings estimates. Cadmus also estimated alternative model specifications to test the robustness of estimates to specification changes. For example, Cadmus tested specifications that included indicator variables for a customer's recruitment wave (i.e., Wave 1, Wave 2,

or Wave 3) as standalone variables and interacted with other explanatory variables. The results proved robust to this and other specification changes. To estimate the treatment effect for the TOU3 rate, which included a mid-peak period, Cadmus added an indicator variable for the mid-peak period to the specification.

To estimate treatment effects for the Hybrid treatments such as TOU1xPTR2 or TOU2xBDR, Cadmus specified a model that allowed the effect of peak period hours to depend on whether the hour was a Flex event hour.

Adjusting the Treatment Effects for Customer Opt-Outs

Estimation of the average treatment effect using data for all customers who were randomly assigned to the test or control groups and whose account remained active provides an estimate of the intent-to-treat (ITT) effect. However, not all customers assigned to treatment received treatment or treatment for the duration of the study. Over the randomized field experiment's course, some customers opted out of the pilot, ending their participation. Including these opt-outs in the analysis yields a savings estimate across customers who remained in treatment and those who opted out.

To estimate the average treatment effects for customers randomly assigned to and remaining in treatment, Cadmus scaled the intent-to-treat (ITT) savings estimates by dividing them by one minus the percentage of customers assigned to treatment who opted out before or during the season.[14] This produces an estimate of savings for treated customers. Since, in general, the opt-out rates for individual treatments were small, scaling of the ITT savings estimates had little effect.

Staff Interviews

Over the course of two summer and winter Flex seasons, Cadmus conducted five interviews with PGE and CLEAResult managers of the Flex pilot. The first interview occurred prior to Summer 2016 and focused on documenting and understanding the program design, recruitment, marketing, and delivery plan for the individual treatments. After each subsequent summer and winter season, Cadmus conducted additional interviews, focused on implementation changes and new perspectives on program successes, challenges, and learnings. Cadmus also used information from the interviews to design and refine the customer surveys for each season.

[14] This scaling produces an unbiased estimate of the treatment's effect for treated customers (i.e., those not opting out) if customers who opt out do not continue to save demand. If opt-out customers continue to save, the treatment effect estimate will be biased upward. Although customers did not receive event notifications after opting out, they could continue to save demand if they had programmed thermostats or other household appliances to run during off-peak periods and do not adjust the settings after opting out.

Customer Surveys

Cadmus designed and administered the following six customer surveys online:

- Recruitment survey (fielded in May 2016)
- Summer 2016 event survey (fielded in August 2016)
- Summer 2016 experience survey (fielded in November/December 2016)
- Winter 2016/2017 experience survey (fielded in April 2017)
- Summer 2017 experience survey (fielded in January 2018)[15]
- Winter 2017/2018 experience survey (fielded in April 2018)

The recruitment survey asked test group customers in the 10 opt-in treatments about how they heard about Flex, their awareness of TOU pricing and Flex events, about their satisfaction with PGE, and questions designed to establish demographics.

The event surveys asked test group customers in PTR and BDR treatments about event notifications and participation, load-shifting and conservation behaviors, and satisfaction with Flex and PGE. Control group customers were surveyed at the same time to collect comparative data on satisfaction with PGE.

The experience surveys asked test group customers in all 12 treatments about program awareness and participation, load-shifting and conservation behaviors, satisfaction with Flex and PGE, and demographics. Control group customers were surveyed at the same time to collect comparative data on satisfaction with PGE and demographics.

Each survey took respondents, on average, five minutes to complete and were fielded for a two-week period. Respondents did not receive an incentive or reward for completing a survey. For more details on the customer survey design, see Appendix E.

Survey Sampling and Response Rates

The number of test and control customers available at the time of survey fielding in each of the 12 treatments determined the sampling method for customer surveys. For all treatments except BDR-OO, Cadmus surveyed the census of active customers. For BDR-OO, however, Cadmus surveyed a random sample of 3,333 customers due to the very large number of customers in this treatment. Table 10 shows the number of test group customers contacted for each survey and the response rates by opt-in and opt-out treatment type. Table 11 shows the number of control group customers contacted and the response rate by opt-in and opt-out treatment types. For sampling and response rate details on each of the 12 treatments, see Appendix E.

[15] Cadmus fielded the Summer 2017 experience survey late compared to the previous summer experience survey due to survey instrument revisions and coordination with PGE on customer contact approval.

Table 10. Customer Survey Samples and Response Rates: Test Group

	Recruitment Survey 2016	Summer 2016 Event Survey	Summer 2016 Experience Survey	Winter 2016/2017 Experience Survey	Summer 2017 Experience Survey	Winter 2017/2018 Experience Survey
Opt-In Treatments						
Number of Contacted	865	969	1,467	1,659	3,828	3,635
Number of Completes	458	348	319	328	817	833
Response Rate	53%	36%	22%	20%	21%	23%
Opt-Out Treatments						
Number of Contacted	–	3,610	3,551	3,679	3,895	3,840
Number of Completes	–	329	119	160	202	277
Response Rate	–	9%	3%	4%	5%	7%
Total (Opt-In and Opt-Out Treatments Combined)						
Number of Contacted	865	4,579	5,018	5,338	7,723	7,475
Number of Completes	458	677	438	488	1,019	1,110
Response Rate	53%	15%	9%	9%	13%	15%

Table 11. Customer Survey Samples and Response Rates: Control Group

	Summer 2016 Event Survey	Winter 2016/2017 Experience Survey	Winter 2017/2018 Experience Survey
Opt-In Treatments			
Number of Contacted	–	–	2,647
Number of Completes	–	–	599
Response Rate	–	–	23%
Opt-Out Treatments			
Number of Contacted	3,602	3,729	3,926
Number of Completes	389	345	362
Response Rate	11%	9%	9%
Total (Opt-In and Opt-Out Treatments Combined)			
Number of Contacted	3,602	3,729	6,573
Number of Completes	389	345	961
Response Rate	11%	9%	15%

Survey Data Analysis

Cadmus compiled frequency outputs, coded open-end survey responses, and ran statistical tests to determine whether survey responses differed significantly between treatments and groups. Cadmus also compared survey responses between seasons.

Detailed Findings

Customer Enrollment and Retention

Opt-In Rates

Table 12 provides the cumulative opt-in rates for each opt-in treatment through the Summer 2017 season when PGE stopped recruiting customers for Flex. These rates indicate the number of customer who opted into the pilot compared to the total number of customers invited to participate. Cadmus calculated opt-in rates across all three waves of recruitment that received enrollment offers via mail or email and included opt-in rates for customers who were assigned to the control group. Note that in Table 12 the TOU2 and TOU2xBDR treatments are combined, since PGE randomly assigned some customers who opted into the TOU2 treatment to receive the BDR treatment. Note also that the opt-in rates are identical in Winter 2017/2018 as they were for Summer 2017 because there were no new enrollments.

Table 12. Opt-In Rates by Treatment*

Treatment	Through Summer 2017	
	Invited Customers Who Opted In (%)	Count of Customers Who Opted In (N)
PTR Only		
PTR1	4.3%	790
PTR2	2.8%	481
PTR3	6.2%	986
TOU Only		
TOU1	3.5%	932
TOU2 and TOU2xBDR**	3.4%	2,656
TOU3	3.7%	937
Hybrids		
TOU1xPTR2	4.5%	720
TOU2xPTR2	2.4%	489
TOU3xPTR2	4.5%	675

* Results presented here include both test and control participants

** TOU2 and TOU2xBDR are presented together because PGE randomly assigned TOU2 customers to receive the BDR treatment.

The opt-in rates reflect customer enrollments over three waves of recruitment. These rates varied over time, as PGE experimented and experienced different degrees of success with various marketing and messaging strategies. In general, PGE experienced greatest success in recruiting in Wave 3, as it incorporated important marketing lessons learned during Waves 1 and 2. These lessons are discussed below in the *Implementation Challenges and Lessons Learned* section. Also, PGE prioritized recruiting of

certain treatments and stopped recruiting for some treatments before others. This meant that PGE did not recruit customers to some treatments during Wave 3.

The opt-in rates ranged between 2.4% and 6.2%. Overall, opt-in rates were higher for treatments that included peak-time rebates. The highest opt-in rate was for PTR3, which offered the most generous rebate of $2.25 per kWh of savings. The PTR2 and TOU2xPTR2 treatments experienced the lowest opt-in rates because PGE had stopped recruiting for these treatments after completing Wave 2. PGE customer opt-in rates were lower than those achieved by SMUD, which obtained opt-in rates ranging between 16% and 19% for a TOU and CPP program.[16] A likely explanation for the difference is that PGE customers are less familiar with the concepts of demand response and time varying rates than SMUD customers. As PGE educates its residential customer population more about peak demand and its demand response program offerings, it is expected that a higher percentage of PGE customers will opt into future pricing programs.

Opt-Out Rates

Table 13 provides the cumulative opt-out rates by treatment and season. These rates pertain to enrolled customers who opted-out of each treatment between June 1, 2016 and the last day of the summer or winter season (September 30, 2017 and February 28, 2018, respectively). Customers could opt out of the program by contacting PGE customer service and asking to be un-enrolled. Customers who moved residences were removed from the program but were not counted as opt-outs.[17]

Table 13. Cumulative Opt-Out Rates by Treatment and Season

Treatment	Summer 2017		Winter 2017/2018	
	%	Count of Customers	%	Count of Customers
PTR Only				
PTR1	4.2%	15	4.5%	16
PTR2	4.6%	11	6.3%	15
PTR3	5.1%	21	5.4%	22
Opt-Outs				
PTR2-OO	1.7%	13	2.3%	18
BDR-OO	1.9%	241	3.2%	398
TOU Only				
TOU1	7.0%	28	8.0%	32

[16] Potter, Jennifer, Stephen George, and Lupe R. Jimenez. 2014. *SmartPricing Options Final Evaluation, Sacramento Municipal Utility District*, p. 106. Available at https://www.smartgrid.gov/files/SMUD-CBS_Final_Evaluation_Submitted_DOE_9_9_2014.pdf

[17] Due to limitations in the availability of accurate opt-out dates across the entire evaluation period, these rates constitute an upper bound on the true opt-out rate. The true opt-out rates may be lower.

Treatment	Summer 2017		Winter 2017/2018	
	%	Count of Customers	%	Count of Customers
TOU2	7.3%	68	8.6%	80
TOU3	8.1%	33	8.6%	35
Hybrids				
TOU1xPTR2	9.9%	32	10.6%	34
TOU2xPTR2	9.4%	22	9.9%	23
TOU2xBDR	7.2%	63	8.3%	72
TOU3xPTR2	8.7%	26	9.7%	29

Cumulative opt-out rates through Winter 2017/2018 ranged between 2.3% and 10.6%. The most important differences in opt-out rates were between treatments of different types: opt-in vs. opt-out treatments and PTR vs. TOU or Hybrid treatments. In general, only small differences existed between treatments of a given type. For example, opt-rates ranged between 7.0% and 8.1% for TOU-only customers and 4.6% and 5.1% for PTR-only customers. Most differences in opt-out rates between treatments of a given type were random and not statistically significant.

Opt-out rates for opt-in treatments were higher than those for opt-out treatments. For opt-in treatments, opt-out rates through the end of W2017/2018 season ranged from 4.5% (PTR1) to 10.6% (TOU1xPTR2). For the opt-out PTR2 and BDR treatments, opt-out rates were 2% and 3%, respectively. The opt-out rates were lower for opt-out treatments than opt-in treatments because many customers automatically enrolled in the program are complacent: they will neither opt in nor opt out of a program if given the opportunity. Also, opt-out customers may be less likely to know how to opt-out of treatment.

Among opt-in treatments, opt-out rates were higher for TOU and Hybrid treatments than for PTR treatments. The opt-rates for TOU and Hybrid treatments ranged between 8% and 11% through W17/18, almost twice as high as those for PTR customers. The higher opt-out rates for TOU and Hybrid customers aligns with the lower rates of customer satisfaction with these treatments as documented below in the *Customer* Experience section.

Load Impacts

The following section provides load impact estimates by Flex treatment for the Summer 2017 and Winter 2017/2018 events seasons. Table 14 summarizes the average load reductions during Flex events and on-peak TOU periods. Reporting is focused on the most current Flex event seasons due to two factors:

- The final wave of Flex recruitment occurred in March 2017. PGE did not achieve its recruitment targets until summer 2017, and previous seasons had participation levels significantly below the targets.
- During the first two pilot seasons, PGE implemented major improvements in the program delivery (e.g., in deploying events, messaging customers, and providing participants with feedback); by summer 2017, PGE had these refinements in place, and the pilot better reflected how a full-scale program will be implemented.

Load impacts from two initial Flex seasons are provided in the Appendix D. PGE plans additional research to estimate load impacts as a function of customer demographic and housing characteristics. PGE will use research about the relationships between demand savings and customer characteristics will inform future demand response program design, marketing, and delivery.

Prior to the Flex pilot, PGE ran a critical peak pricing (CPP) pilot between 2011 and 2013, which achieved demand savings during summer and winter afternoon events of 10% and 12%, respectively. In comparison to the Flex PTR-only treatments, the CPP pilot achieved lower savings in summer, but higher savings in winter.

Table 14. Flex Demand Savings by Treatment and Season*

Category	Treatment		Summer Demand Savings**				Winter Demand Savings**						
			Planning (%)	Evaluation (%)	Abs. Precision at 90% Conf.	Evaluation (kW)	Planning (%)	Evaluation (%)		Abs. Precision at 90% Conf.		Evaluation (kW)	
								AM	PM	AM	PM	AM	PM
PTR-Only	PTR1		13%	18%	±4%	0.41	14%	13%	7%	±7%	±4%	0.23	0.13
	PTR2			22%	±6%	0.48		0%	8%	±8%	±5%	-0.01	0.14
	PTR3			17%	±4%	0.39		3%	12%	±7%	±3%	0.05	0.22
Opt-Out	PTR2-OO		6%	7%	±3%	0.16	7%	0%	6%	±5%	±3%	0.00	0.10
	BDR-OO		3%	2.30%	±1%	0.05	3%	-0.7%	1%	±1%	±1%	-0.01	0.02
TOU-Only	TOU1	On-Peak	5%	2%	±3%	0.02	6%	-1%		±4%		-0.02	
		Flex Event		-1%	±6%	-0.02		2%	0%	±7%	±5%	0.03	0.00
	TOU2	On-Peak		8%	±3%	0.12		3%		±3%		0.04	
		Flex Event		5%	±5%	0.10		2%	2%	±6%	±4%	0.04	0.04
	TOU3	On-Peak		5%	±4%	0.07		0%		±3%		0.00	
		Flex Event		6%	±6%	0.13		3%	-1%	±9%	±5%	0.05	-0.01
Hybrids	TOU1xPTR2	On-Peak	5.2% TOU; 12.9% PTR	3%	±4%	0.04	5.8% TOU; 14.2% PTR	1%		±5%		0.01	
		Flex Event		10%	±7%	0.21		10%	5%	±11%	±6%	0.17	0.08
	TOU2xPTR2	On-Peak	5.2% TOU; 12.9% PTR	24%	±5%	0.33	5.8% TOU; 14.2% PTR	5%		±5%		0.08	
		Flex Event		20%	±8%	0.43		12%	13%	±13%	±6%	0.22	0.25
	TOU2xBDR	On-Peak	5.2% TOU; 3.0% BDR	8%	±3%	0.12	5.8% TOU; 3.3% BDR	1%		±4%		0.02	
		Flex Event		11%	±5%	0.23		-1%	1%	±7%	±5%	-0.02	0.02
	TOU3xPTR2	On-Peak	5.2% TOU; 12.9% PTR	9%	±5%	0.12	5.8% TOU; 14.2% PTR	4%		±4%		0.06	
		Flex Event		8%	±7%	0.17		4%	13%	±10%	±6%	0.08	0.25

* Seasonal results presented only for Summer 2017 and Winter 2017/2018. Percentage demand savings estimated as kW demand savings estimate divided by average control customer demand.

**Impact estimates are percentage demand savings during Flex peak-time events and on-peak savings for TOU rates; green indicates significance at 90%.

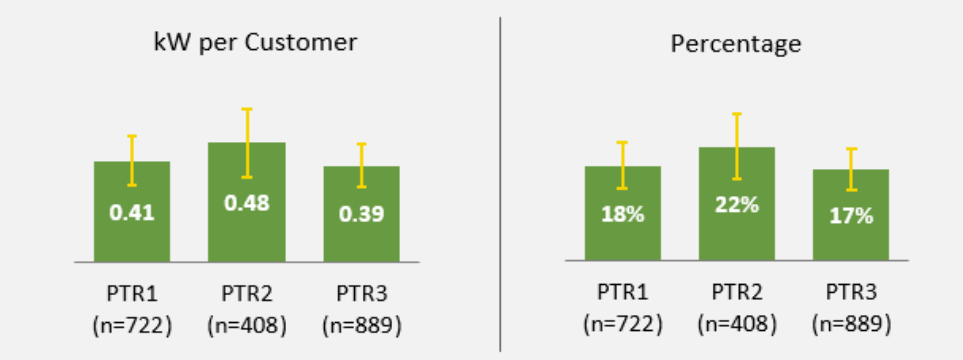
Peak-Time Rebates—Summer

Figure 2 shows the kW and percentage demand savings during Flex events for opt-in PTR treatments during summer 2017. PGE tested the load impacts of three peak rebates ($0.80/kWh, $1.55/kWh, and $2.25/kWh) during seven Flex events. The PTR treatments saved between an average of 0.39 kW per customer and an average of 0.48 kW per customer, or about 20% of demand. All PTR load impacts surpassed PGE's planning estimate of 13% for summer seasons.

Despite large differences in rebate levels, significant differences did not emerge between PTR treatments in the estimated demand savings. The $0.80/kWh and the $2.25/kWh rebates produced approximately the same demand savings. This demonstrates that PGE customers reduced consumption in response to the higher opportunity cost of consuming electricity during Flex events, but the rebate amount did not determine the magnitude of the response. In a recent study of a California critical peak-pricing program, Gillan (2017) made a similar finding, showing that customers were not sensitive to marginal changes in critical peak prices.[18]

Although the rebate did not influence the estimated demand savings, it affected customer satisfaction, as discussed demonstrate in the Customer Satisfaction with Flex section.

Figure 2. PTR-Only Demand Savings During Flex Events—Summer 2017



Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during Flex events. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers.

Figure 3 shows estimated PTR demand savings and ambient outdoor temperature in °F for each of seven events during summer 2017. Peak-time rebates produced similar average demand savings per customer across events, between 0.3 kW and 0.5 kW. No correlation occurred between outdoor temperatures and demand savings during events.

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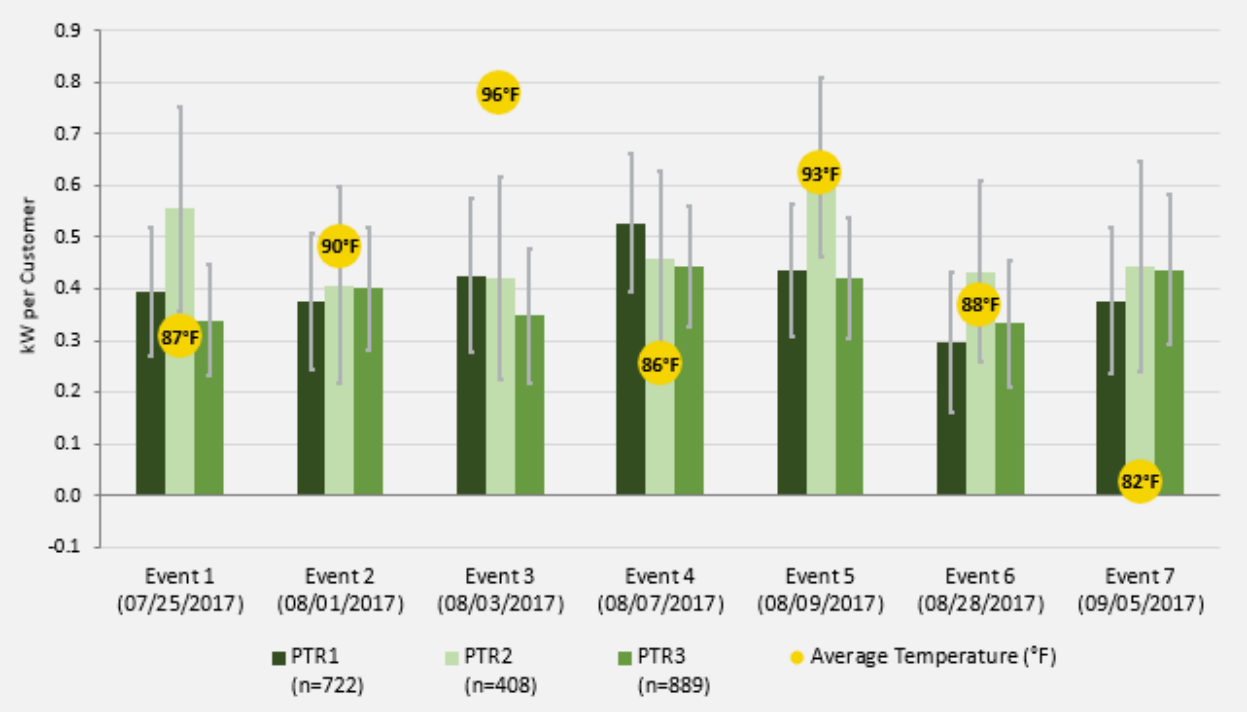
[18] Gillan, James, 2017. Dynamic Pricing, Attention, and Automation: Evidence from a Field Experiment in Electricity Consumption. Energy Institute at Haas Working Paper 284. Available at: https://ei.haas.berkeley.edu/research/papers/WP%20284.pdf

Figure 3. PTR-Only Demand Savings by Flex Event—Summer 2017



Notes: Figure shows by Flex event the average outdoor temperature during event hours and estimates of average kW savings per customer. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers.

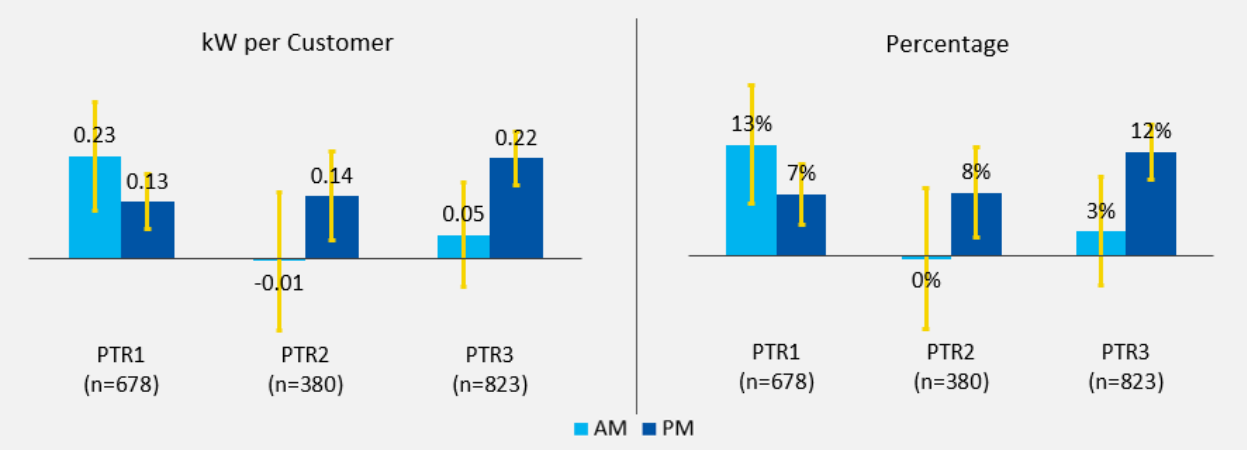
Peak-Time Rebates—Winter

Figure 4 shows demand savings during Winter 2017/2018 Flex events for the opt-in PTR treatments. Six afternoon PTR events and one morning event occurred. The figure presents separate savings estimates for the morning (AM) and afternoon (PM) events. Unlike the summer season, all PTR treatments during the winter season produced point estimates of savings lower than PGE's planning estimates (14%). The PTR savings estimates may have been lower than PGE expected because the Winter 2017/2018 season was milder than normal.[19]

During the morning event, opt-in PTR customers saved between 0% (PTR2) and 13% (PTR1) of demand. During the six afternoon events, opt-in PTR customers saved between 7% (PTR1) and 12% (PTR3). As in summer, no relationship between savings and the rebate amount became evident. While PTR3 customers, who received the largest rebate, saved the most during evening events, PTR1 customers, who received the smallest rebate, saved the most during the morning event.

[19] See *Mean Temperature Departures from Average* in NOAA National Climate Report for December 2017, January 2018, and February 2018. Available at: https://www.ncdc.noaa.gov/sotc/national/.

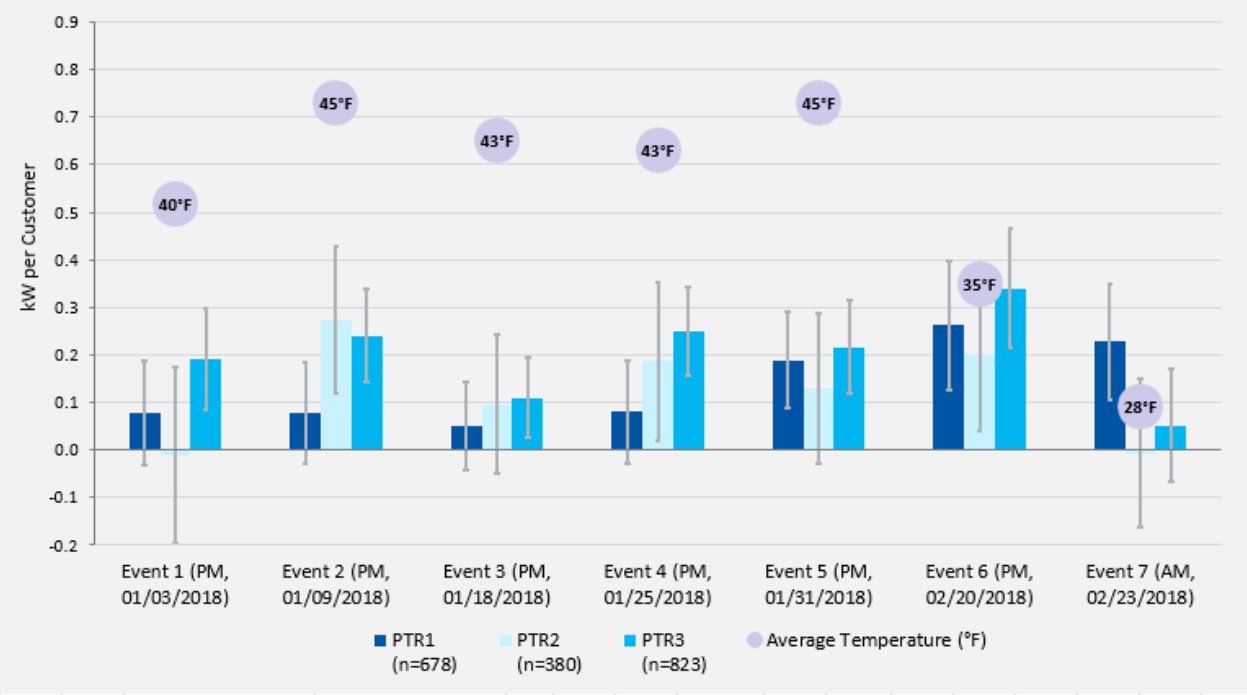
Figure 4. PTR-Only Demand Savings During Flex Events—Winter 2017/2018



Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during Flex events. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers.

Figure 5 shows demand savings for opt-in PTR customers and outdoor ambient temperatures (°F) during each of the seven events in winter 2017/2018. There was more variation in average demand savings per customer between PTR treatments and across events in winter than summer. PTR3 customers tended to save the most and PTR1 customers the least, but this relationship did not hold for all events. As in summer, no relationship emerged between outdoor temperature and demand savings.

Figure 5. PTR-Only Demand Savings by Flex Event—Winter 2017/2018



Notes: Figure shows by Flex event the average outdoor temperature during event hours and estimates of average kW savings per customer during Flex events. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers.

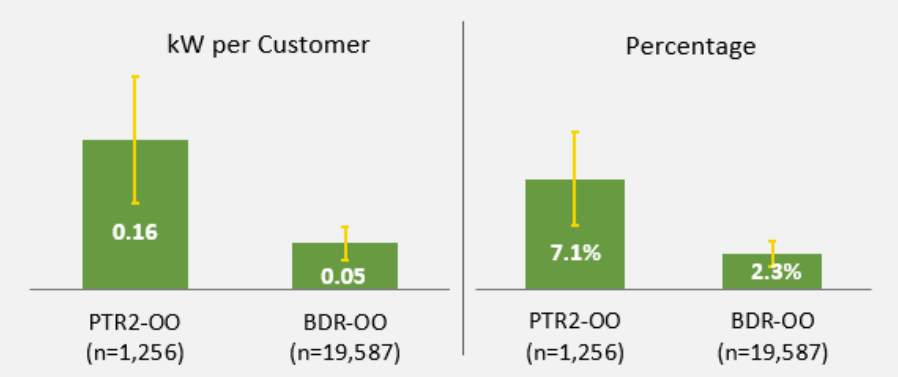
Opt-Out Treatments—Summer

PGE also tested opt-out BDR and PTR2 treatments. PGE automatically enrolled customers in these treatments but gave them opportunity to opt-out, which less than 3% of customers did. Though not all PTR-OO customers who remained in the pilot attempted to save during PTR events, as discussed below, many customers did save, including those who would not have enrolled if given the choice. Except for the rebate, the BDR and PTR treatments were similar: opt-out customers received event notifications, encouragement to reduce demand, and personalized feedback about their savings. By comparing the BDR and PTR treatments, Cadmus could isolate the incremental effect of providing a rebate on peak demand savings.

Figure 6 shows the estimated demand savings for opt-out treatments during summer 2017 Flex events. Opt-out PTR2 customers saved an average of 0.16 kW per customer (or 7% of demand); and BDR saved an average of 0.05 kW per customer (or 2% of demand). While load impacts for PTR2-OO slightly surpassed PGE's 6% planning estimate, the load impacts for BDR-OO savings fell short of PGE's planning estimate (3%).The rebate's incremental effect was about 0.12 kW per customer or 5% of demand. In addition to increasing Flex event demand savings, the rebate increased customer satisfaction with the Flex pilot. As shown in Figure 20 below, PTR2-OO participants reported being more satisfied (6 to 10 ratings) and delighted (9 to 10 ratings) than BDR-OO participants by significant margins.

Opt-out PTR2 customers saved substantially less during Flex events than opt-in PTR2 customers, who, as Figure 2 shows, saved about 20% of demand; however, the group of treated opt-out customers included a large percentage of customers who would not have opted into treatment if given the choice. These customers included *complacent* customers, who stayed in treatment after PGE automatically enrolled them, and *never-takers*, who opted out after enrollment. A back-of-the envelope calculation suggests that the average *complacent* PTR customer saved about 6% of demand during Flex events.[20]

Figure 6. Opt-Out Treatments Demand Savings During Flex Events—Summer 2017

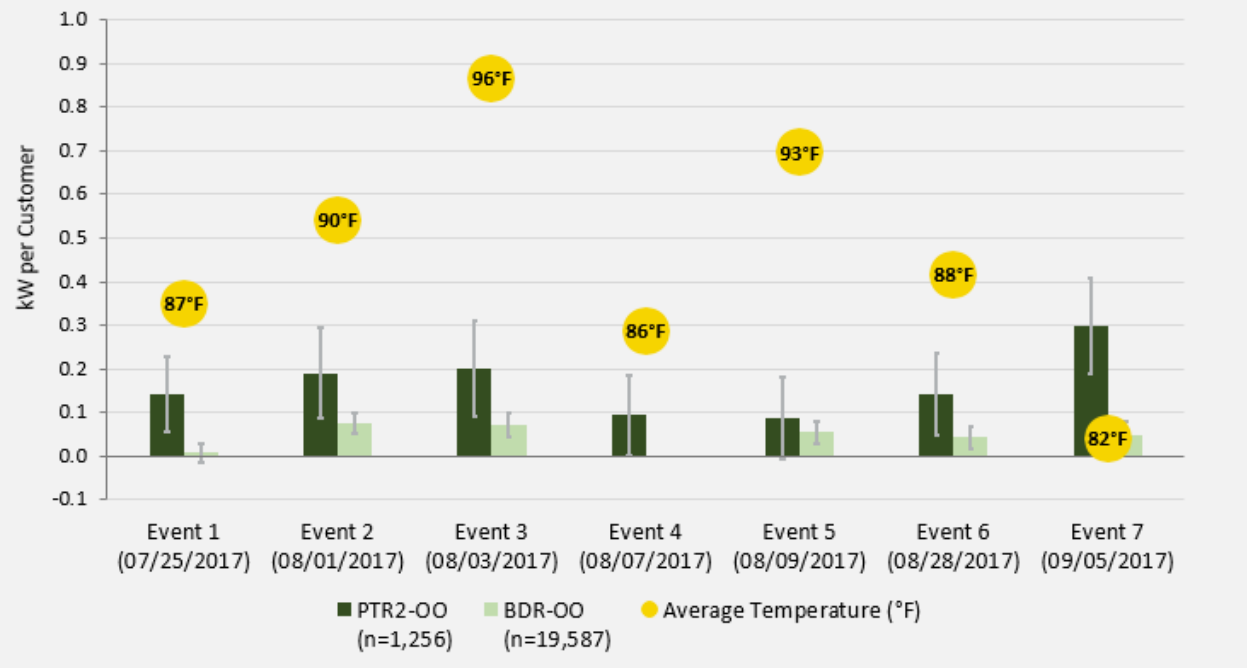


Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during Flex events. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers.

Figure 7 shows PTR2-OO and BDR-OO demand savings and ambient outdoor temperatures during Flex events for each of the seven events during summer 2017. PGE did not dispatch BDR-OO for Event 4 (August 7, 2017). Across the events, PTR2-OO produced average demand savings per treated customer between 0.1 kW per customer and 0.3 kW per customer; BDR-OO produced savings between 0.01 kW per customer and 0.08 per customer. No relationships between outdoor temperatures and savings became evident in the event impact estimates.

[20] The 7% savings estimate for the opt-out PTR2 treatment represented an average of savings across the following customer types: (1) *always-takers*—customers who would opt into the pilot if given the opportunity; (2) *complacents*—customers who would neither opt-in nor opt-out of treatment if given the choice, but who nevertheless might save when enrolled; and (3) *never-takers*—customers who would never enroll and always opted out given the choice. Our estimate assumed never-takers would not save and the 22% savings estimate for opt-in PTR2 customers was a reasonable estimate of PTR2 savings for always-takers. Additionally, from Table 11 and Table 12, *always-takers* constituted about 5% of the population (i.e., average opt-in rates for PTR1, PTR2, and PTR3 treatments), and *never-takers* constituted about 3% of the population (i.e., opt-out rate for opt-out PTR2). This implies that *complacent* customers constituted 92% of the customers defaulted into PTR2 treatment; and that *complacent* customers saved an average of 6.4% of demand.

Figure 7. Opt-Out Treatments Demand Savings by Flex Event—Summer 2017



Notes: Figure shows estimates of average kW savings per customer. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers. During event 4, PGE did not dispatch BDR-OO customers.

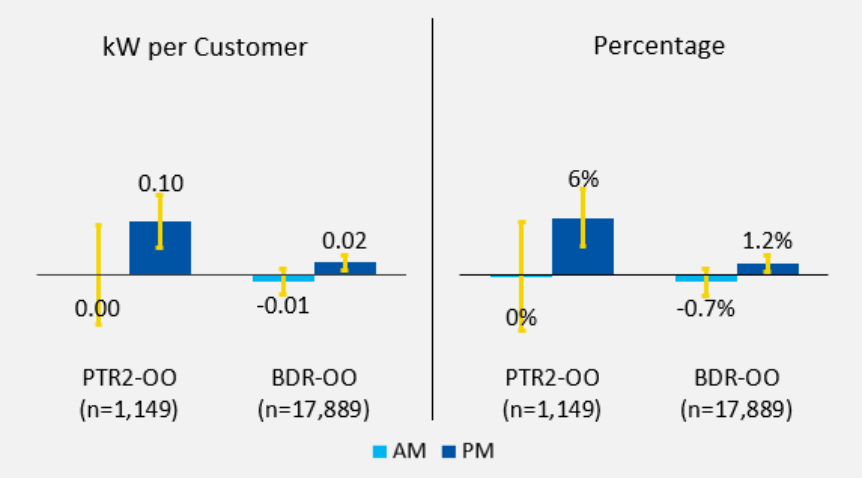
Opt-Out Treatments—Winter

Figure 8 shows demand savings estimates during winter 2017/2018 Flex events, which included six afternoon events and one morning event, for PTR2-OO and BDR-OO treatments.

During morning events, neither opt-out treatment achieved demand savings. The savings point estimates were small and statistically indistinguishable from zero. During evening events, PTR2-OO customers saved 6% of demand and BDR-OO customers saved 1% of demand, with both estimates statistically significant. For both opt-out treatments, demand savings were slightly less than PGE planning estimates for winter (7% for PTR-OO and 3% for BDR-OO). Based on a comparison of PTR2-OO and BDR-OO impacts, the rebate increased Flex events savings by about 4%. As in summer, the rebate enhanced customer satisfaction with Flex, lifting the percentage of satisfied customers by about 10%.

The opt-out PTR and BDR treatments saved less in winter than summer. One hypothesis explaining the smaller winter savings is that PGE customers had a lower tolerance for cold than heat and therefore were less willing to adjust their thermostat settings in winter. Another hypothesis holds that PGE customers had fewer opportunities to save. Many PGE customers heat with natural gas, eliminating the potential for demand savings from the largest home energy end use.

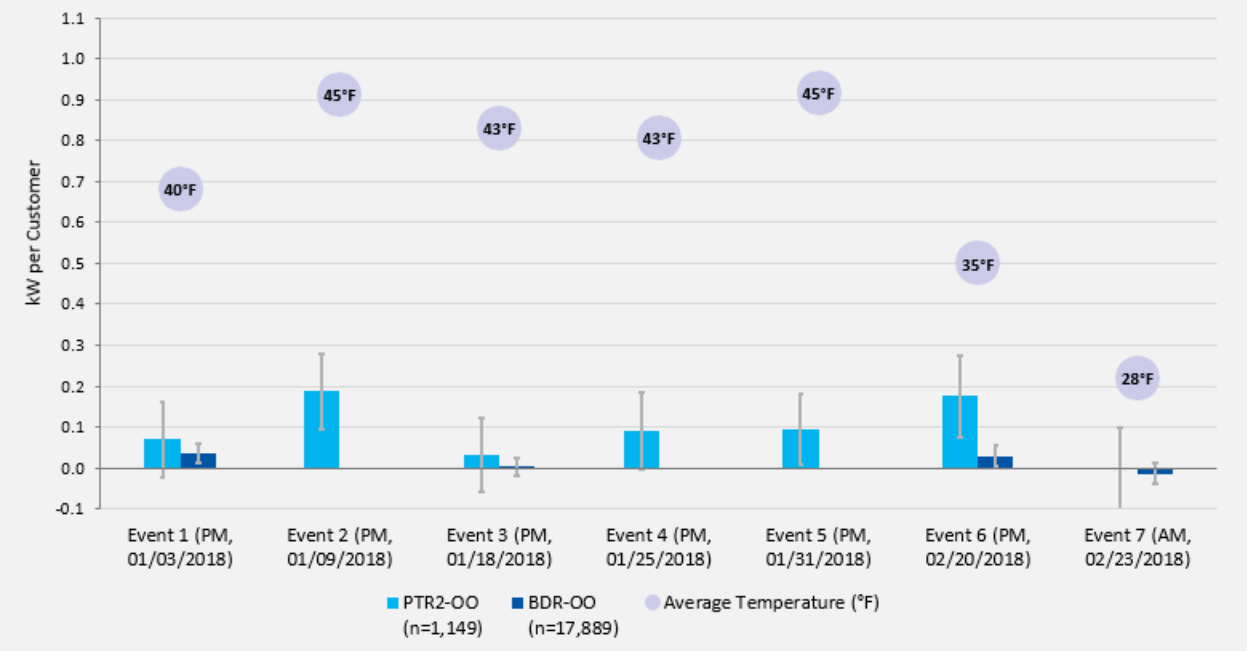
Figure 8. Opt-Out Treatments Demand Savings During Flex Event—Winter 2017/2018



Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during Flex events. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers.

Figure 9 shows PTR2-OO and BDR-OO demand savings and ambient outdoor temperatures for each winter 2017–2018 event. PGE did not dispatch BDR-OO for events 2, 4, and 5 (January 1, 2018, January 25, 2018, and January 31, 2018). PTR2-OO demand savings ranged from zero kW per customer (Event 7) to 0.2 kW per customer (Event 2). As with opt-in PTR, no relationship emerged between outdoor temperatures and demand savings.

Figure 9. Opt-Out Treatments Demand Savings by Flex Event—Winter 2017/2018



Notes: Figure shows estimates by event of average kW savings per customer. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. During events 2, 4, and 5, PGE did not dispatch BDR-OO customers.

PGE Payments for Savings Caused by Peak Time Rebates

PTR customers earned rebates for saving energy relative to a customer-specific baseline but were not penalized for exceeding the baseline.[21] PGE paid customers for savings whether the savings were caused by the rebate, naturally-occurring, or from random variation in the customer's consumption. Since PGE pays for some savings that are not caused by the rebate and there is no corresponding financial penalty for increasing consumption above the baseline, PGE will overpay for savings at the program level.

As Table 15 reports, in Summer 2017, PGE paid an average of between $10 and $30 in rebates per PTR customer, depending on the rebate amount. In Winter 2017/2018, PGE paid an average of $6 and $20 in rebates per PTR customer. To estimate how much of the savings that PGE paid for represented savings caused by the program, Cadmus compared the evaluation's estimate of PTR savings per customer with PGE's estimate of average PTR savings per customer from its performance calculations.

Table 15 compares the savings estimates from PGE's performance calculation and the evaluation. For PTR-only treatments, the ratio of evaluated average PTR savings per customer to performance-calculated average savings per customer ranged between 67% and 83% in summer and 25% and 44% in

[21] The PTR is an asymmetric incentive. Customers face a higher effective marginal price for electricity equal to the sum of the rebate and the standard rate when their consumption is below the baseline and a lower effective marginal price for electricity equal to the standard rate when consumption is above the baseline.

winter. For the PTR hybrid treatments, the ratio ranged from 37% to 108% in summer and from 27% to 74% in winter.

Table 15. Evaluated Demand Savings vs. PGE Performance-Calculated Savings – Opt-In PTR

Treatment	Summer 2017			Winter 2017/2018		
	Performance-Calculated (kWh)	Evaluated Savings (kWh)	Ratio	Performance-Calculated (kWh)	Evaluated Savings (kWh)	Ratio
PTR1	12.59	9.38	75%	7.97	2.82	35%
PTR2	13.36	11.04	83%	9.20	2.33	25%
PTR3	13.27	8.91	67%	8.98	3.95	44%
TOU1xPTR2	10.20	4.73	46%	7.11	1.95	27%
TOU2xPTR2	9.27	9.96	108%	6.69	4.95	74%
TOU3xPTR2	10.33	3.85	37%	7.15	4.47	63%

Notes: Performance-calculated savings are average savings per customer per season verified by PGE for calculating customer rebates. Evaluated savings are the average savings per customer per season estimated by Cadmus.

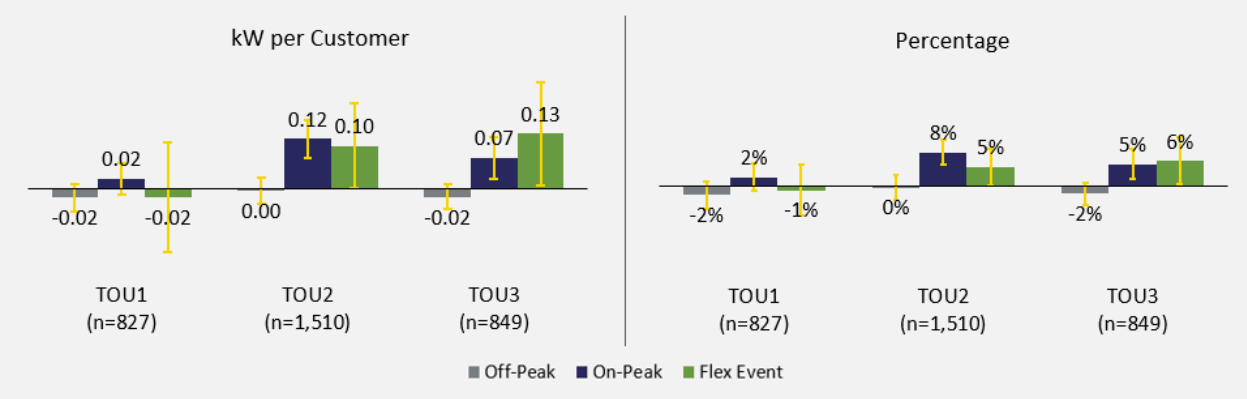
These results confirm that at least some savings for which PGE paid customers were naturally occurring and not caused by the rebates. For PTR-only customers, between one-third and one-fifth of performance-calculated savings in summer and one-half and three-quarters of performance-calculated savings in winter were not attributable to the program. Note, these overestimates of savings apply only to the performance-calculated figures used to pay customers, not to the evaluated savings shown in this report.

PGE may have overpaid for savings more in winter than summer for two reasons. First, as comparison of Figure 2 and Figure 4 show, PTR customers tended to save less in winter than summer, suggesting that a higher percentage of customers who PGE estimated to have saved did not in fact save. Second, customer demand during Flex events tended to be more variable in winter than summer, which could also increase PGE's payments for savings not caused by the pilot.

TOU-Only Treatments—Summer

Figure 10 shows kW and percentage load impacts for TOU-only treatments in summer 2017. The figures show estimated average load impacts per treated customer during off-peak hours, on-peak hours, and Flex event hours. Although TOU-only customers did not receive notification of Flex events, Cadmus measured load impacts during Flex hours to estimate impacts of TOU pricing on reducing system peak demand. The figures show reductions in demand or savings as positive impacts, and show load increases as negative impacts.

Figure 10. TOU-Only Demand Savings—Summer 2017



Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during TOU off-peak, TOU on-peak, and Flex event hours (i.e., a proxy for system-peak demand hours). Reductions in demand (savings) are shown as positive values and increases in demand are shown as negative values. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers. The TOU3 rate also had a mid-peak period. During the mid-peak period, TOU3 customers demanded 0.05 kW or 5% less on average, with a 90% confidence interval of [0.01 kW, 0.09 kW] or [1%, 8%].

Estimated load impacts for TOU1 customers were small and not statistically significant. In summer 2017, TOU1 customers reduced their consumption during on-peak hours by 2% and increased their consumption by 2% during off peak hours, but neither impact proved statistically significant, as shown by the 90% confidence intervals (CI), which were tightly estimated and included zero. TOU1 customers also did not save demand during Flex events, which proxy for hours of PGE system-peak demand.

The TOU1 rate schedule's design likely explained the small estimated impacts. The on-peak period occurred on non-holiday weekdays, from 6:00 a.m. to 10:00 p.m., covering waking hours for many customers, and making it difficult for them to shift loads from on-peak to off-peak periods. Many customers would need to adjust their routines to accommodate the TOU1 schedule or to schedule their household appliances (e.g., dishwashers, washing machines) to run at night. It remains unclear, however, how many Flex customers could schedule when their appliances would operate. In surveys, many TOU1 customers reported dissatisfaction with Flex due to the rate schedule being difficult for their households to adopt; these customers said it was not convenient or worth changing sleep schedules to do chores during off-peak periods.

While TOU1 did not yield the desired load shifting, the TOU2 and TOU3 rates, having shorter on-peak periods, did so. Both rates defined on-peak periods as hours during non-holiday weekdays, from 3:00 p.m. to 8:00 p.m. In addition, the TOU3 rate defined the mid-peak period as non-holiday weekday hours from 11:00 a.m. to 3:00 p.m. and 8:00 p.m. to 10:00 p.m. During the mid-peak period, customers faced a lower retail rate for electricity than the on-peak period rate, but had a rate higher than the off-peak period rate.

The TOU2 and TOU3 rates produced similar off-peak and on-peak load impacts. During on-peak hours, TOU2 customers reduced demand by about 0.12 kW per customer (or 8%), and TOU3 customers reduced demand by about 0.07 kW per customer (or 5%). The difference in these estimates was not

statistically significant. Only weak evidence emerged of load shifting. TOU2 customers increased off-peak consumption by less than 0.5%, and TOU3 customers increased consumption by about 2%, but neither estimate proved statistically different from zero. This suggests customers tended to reduce demand during peak periods by, for example, adjusting their thermostat settings or turning off lights, rather than shifting consumption from peak to off-peak periods by, say, delaying dishwashing and laundry. As Figure 18 shows, approximately 50% of TOU participants reported having turned off lights or adjusted thermostat settings during peak periods.

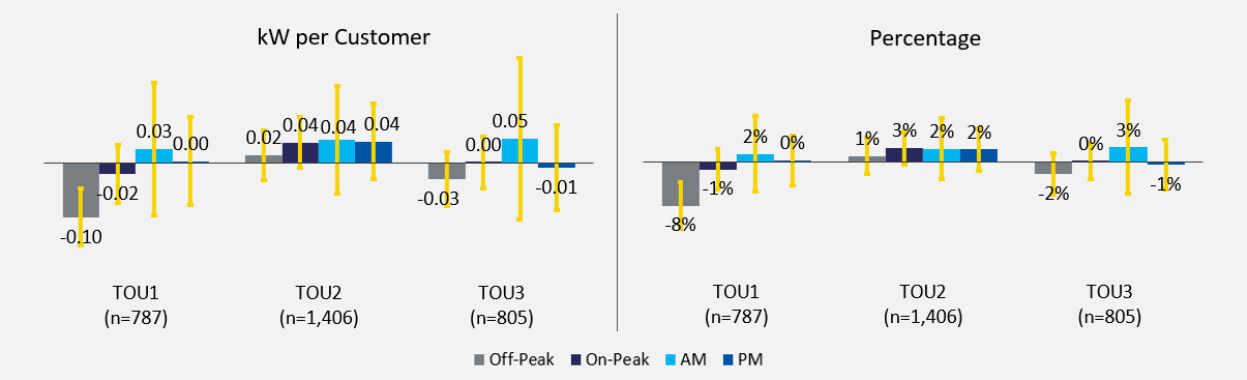
Estimated load impacts during Flex event hours (i.e., a proxy for system-peak demand hours) were about the same as those during on-peak hours. TOU2 and TOU3 customers saved about 5% and 6% of demand. Again, PGE did not notify TOU-only customers of Flex events; so it was expected that demand savings during event hours would not be significantly greater. For TOU2 and TOU3, load impacts for on-peak and Flex event periods met or surpassed the 5% PGE planning estimate.

TOU-Only Treatments—Winter

Figure 11 shows load impacts during peak, off-peak, and Flex event hours (again, a proxy for system-peak demand hours) for TOU1, TOU2, and TOU3 treatments. In winter, PGE scheduled morning and afternoon on-peak periods. Although TOU-only customers were not notified of Flex events, Cadmus estimated the average TOU savings per customer during seven Flex events to assess the impacts of TOU pricing during periods approximating system peak demand.

TOU pricing produced smaller reductions in demand in winter than summer. Except for TOU1 during off-peak hours, none of the TOU-only treatments reduced loads during on-peak hours or shifted loads to off-peak hours. In general, impact estimates were small, and confidence intervals for all estimated impacts included zero. None of the TOU-only treatments saved demand during Flex events, or the savings were too small to detect with the available sample sizes. The savings estimates were small and statistically insignificant. Peak period and Flex event saving for all TOU treatments were lower than PGE's planning estimate of 6% reduction for winter. Based on the estimated confidence intervals, it is possible to reject the hypothesis that demand savings during on-peak and Flex hours were greater than or equal to 6% for each TOU rate.

Figure 11. TOU-Only Demand Savings—Winter 2017/2018



Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during TOU off-peak, TOU on-peak, and a.m. and p.m. Flex event hours. Reductions in demand (savings) are shown as positive values and increases in demand are shown as negative values. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers. The TOU3 rate also had a mid-peak period. During the mid-peak period, TOU3 customers demanded 0.03 kW or 2% less on average, with a 90% confidence interval of [-0.02 kW, 0.07 kW] or [-2%, 5%].

Why did TOU2 and TOU3 customers reduce demand during peak hours and Flex events in summer but not winter? Two explanations seem possible. First, according to surveys completed with TOU customers, a significant source of peak savings comes through adjustments to thermostat settings. In winter, savings could have been achieved by setting thermostats at a lower temperature during peak periods. PGE customers, however, may have had less tolerance for cold than for heat, and therefore been less willing to make such adjustments. Second, many TOU customers heated their homes with gas (approximately 60% of TOU-only and 53% of Hybrid customers, per the Winter 2017/2018 survey), eliminating a large, potential source of savings from home heating.

TOU Conservation Impacts

TOU pricing encourages customers to shift demand from on-peak, high-price periods to off-peak, low-price periods. However, the expected effect of TOU pricing on total energy consumption is ambiguous. Depending on the customer's elasticity of demand and the changes in relative and absolute prices, total energy consumption could increase, decrease, or stay the same. In Summer 2017, the TOU2 and TOU3 treatments reduced demand during on-peak periods, but there were not statistically significant demand increases during the off-peak periods. This suggests that TOU pricing may have led to a small decrease in overall electricity consumption for the average customer.

Table 16 presents estimates of the total electricity consumptions impacts of TOU pricing in summer and winter. Cadmus estimated the impacts by regressing customer daily electricity consumption on an indicator for assignment to the test group, day-of-sample fixed effects, recruitment-wave fixed effects, customer pre-treatment average daily consumption, and daily cooling degrees. We tested the sensitivity of the estimates to different model specifications and found that the estimates were robust. The impacts shown in the table are adjusted for opt-outs.

Table 16. TOU-Only Energy Conservation Impacts

Treatment	Daily Energy Savings, Summer 2017		Daily Energy Savings, Winter 2017-2018	
	kWh	Abs. Precision at 90% Conf.	kWh	Abs. Precision at 90% Conf.
TOU1	0.08	±0.82	-1.27	±1.35
TOU2	0.02	±0.83	0.38	±1.21
TOU3	0.37	±0.86	-0.39	±1.14

Notes: The table reports the average daily energy savings per treated customer. Positive values indicate energy savings. The precision was estimated based on standard errors clustered on customers.

TOU pricing did not result in statistically significant changes in energy consumption. In summer, the impacts for TOU1 and TOU2 were small and not statistically significant, as the estimated confidence intervals included zero. TOU3 customers saved an average of 0.37 kWh per customer per day, but, as with the other TOU-only treatments, the estimate was not statistically significant. In winter, none of the energy savings estimated was statistically different from zero. The point estimates show that relative to control group customers, TOU1 and TOU3 customers increased energy consumption, while TOU2 customers reduced their consumption.

When Cadmus calculated the average daily energy savings per TOU customer using the on-peak period and off-peak period demand impact estimates in Figure 10 and Figure 11, we also obtained small and statistically insignificant savings.

Hybrid Treatments—Summer

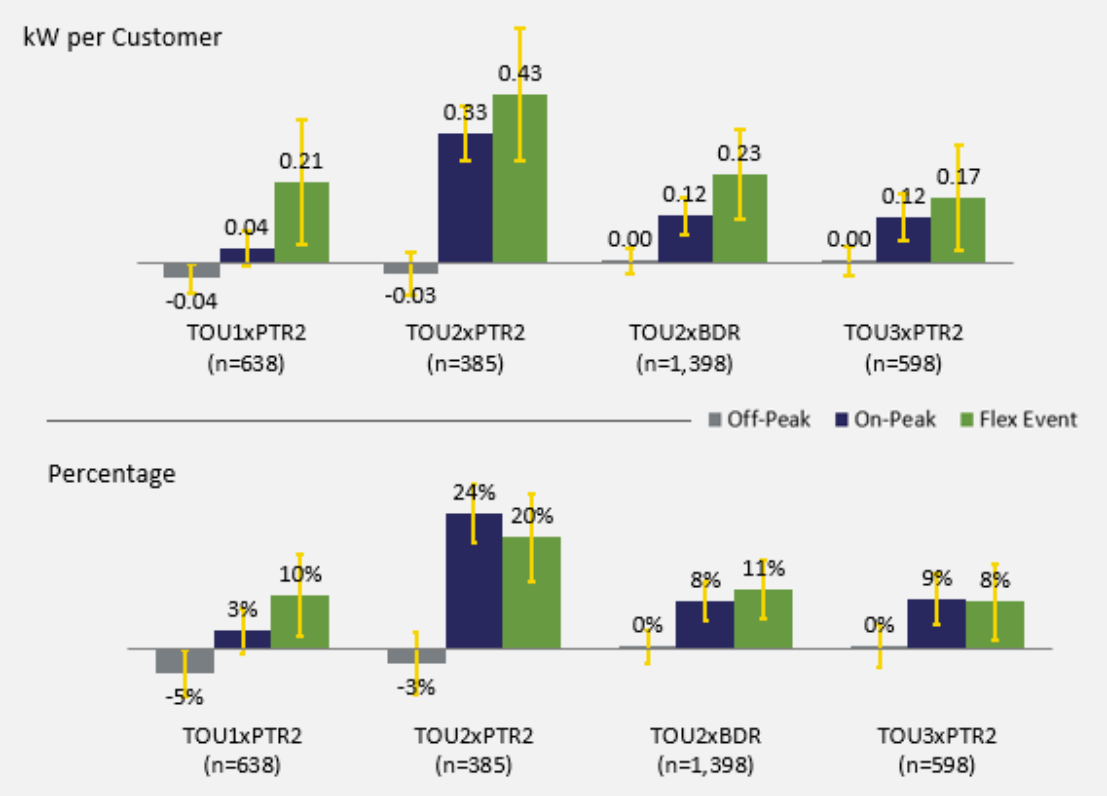
Figure 12 shows load impacts for Hybrid treatments in summer 2017, including TOU pricing with PTR and TOU pricing with BDR.

In general, the Hybrid treatments produced load reductions during on-peak periods similar to those for TOU-only treatments. The TOU1xPTR2 treatment did not produce statistically significant peak savings. Customers on TOU2xPTR2, TOU2xBDR, and TOU3xPTR2 saved, respectively, 0.33 kW per customer (24%), 0.12 kW per customer (8%), and 0.12 kW per customer (9%). The TOU2xBDR and TOU3xPTR2 impacts during on-peak hours were similar to those for TOU2 and TOU3 treatments. Customers on TOU2xPTR2, however, saved more than TOU2 (8%) customers. These peak savings estimates exceeded PGE's planning estimate of 5% for TOU rates in summer. None of the Hybrid treatments produced statistically significant load shifting from peak to off-peak hours. The load impact estimates for off-peak hours were close to zero and statistically insignificant. While generating approximately the same peak-period demand savings as the TOU-only treatments, the TOUxPTR2 treatments tended to produce higher customer satisfaction Table 34.

During Flex events, the Hybrid treatments produced savings between 8% and 20% of demand. TOU1xPTR2, TOU2xBDR, and TOU3xPTR3 yielded Flex event savings of approximately 10%, results close to and not statistically different from demand savings estimates during on-peak periods. TOU2xPTR2 saved about 20% of demand—about twice as large as Flex event savings estimates for other Hybrid treatments and four times as large as the Flex event savings for TOU2-only treatment. Except for

TOU2xPTR2, the Hybrid PTR treatments did not exceed PGE's planning estimate of 13% savings for opt-in PTR treatments in summer.

Figure 12. Hybrid Demand Savings—Summer 2017



Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during TOU off-peak, TOU on-peak, and a.m. and p.m. Flex event hours. Reductions in demand (savings) are shown as positive values and increases in demand are shown as negative values. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers. The TOU3 rate also had a mid-peak period. During the mid-peak period, TOU3xPTR2 customers demanded 0.10 kW or 9% less on average, with a 90% confidence interval of [0.05, 0.15 kW] or [4%, 13%].

In comparison to PTR2-only treatment, TOU-PTR hybrid treatments tended to generate smaller savings during Flex events (i.e., a proxy for system-peak demand hours). TOU2xPTR2 yielded approximately the same Flex event savings (20%) as PTR2 (22%), but TOU1xPTR2 and TOU3xPTR2 treatments produced much smaller savings than PTR2 only (10% and 8% vs. 22%). TOU1xPTR2 and TOU3xPTR2 treatments also produced smaller Flex event savings than PTR1 (18%), which offered customers a smaller rebate per kWh of savings than PTR2.

Hybrid treatments may have produced smaller Flex event savings than PTR-only for two reasons:

- Hybrid customers who reduced peak period consumption or shifted consumption to off-peak periods would have had lower baselines than PTR-only customers for calculating PTR savings, decreasing rebate payments and reducing the incentives for saving during Flex events. PGE used non-event days during Summer 2017 to establish the consumption baseline for calculating a

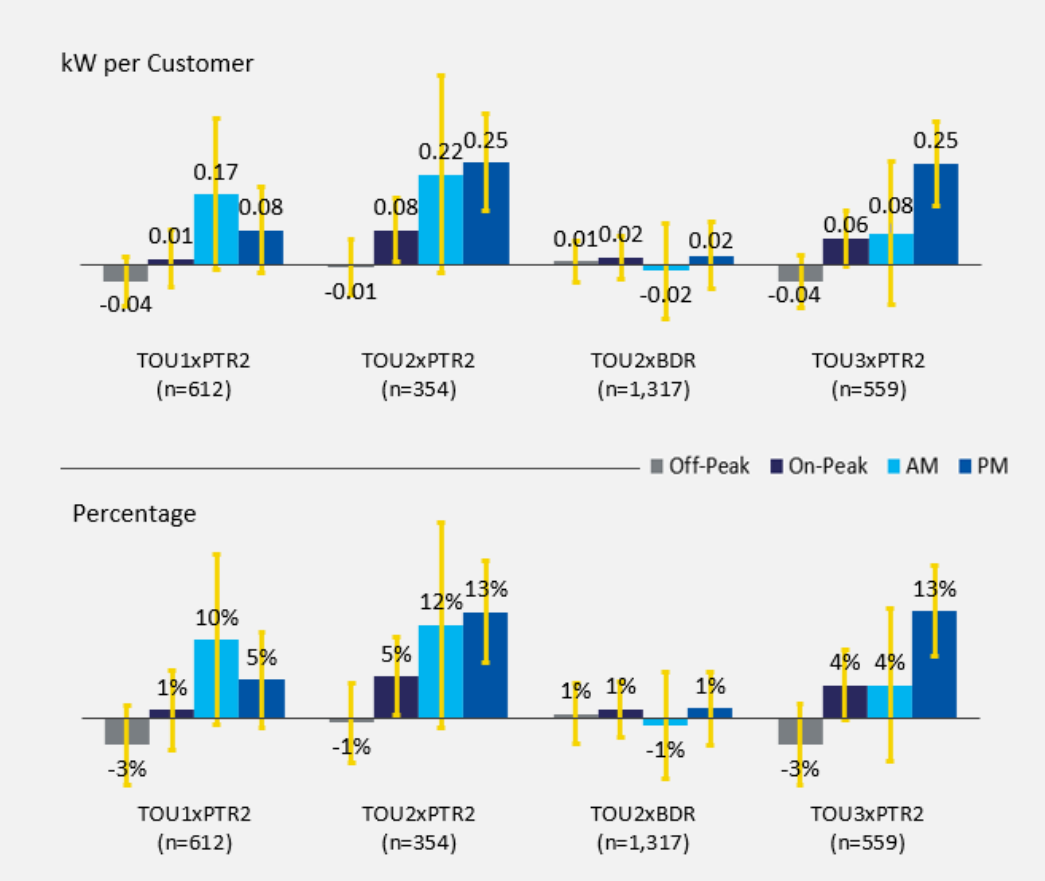
customer's PTR savings, which would tend to result in lower baselines for TOU customers who saved during peak periods.

- Hybrid customers may have become inattentive to Flex events, having formed energy consumption habits (e.g., programming thermostats) to save demand during TOU on-peak periods that would have been costly from a time, effort, or psychic perspective to change during Flex events. For example, customers may have adjusted their thermostat settings to save during TOU on-peak periods, and it may have been easier for TOU customers simply to ignore event notifications than to make further adjustments to their settings. As discussed below, many TOUxPTR customers' surveys reported that they already conserved regularly and did not feel they needed to do more during events.

Hybrid Treatments—Winter

Figure 13 shows load impacts for TOU Hybrid treatments in Winter 2017/2018. In many ways, the results mirrored those for summer 2017, though load impacts tended to be smaller. As with TOU1-only treatment, TOU1xPTR2 treatment proved difficult for PGE customers; TOU1xPTR2 treatment did not result in peak savings or load shifting from peak to off-peak periods in winter. As discussed below, however, TOU1xPTR2 customers experienced higher satisfaction than TOU1-only customers, suggesting PTR lifted customer satisfaction. TOU2xPTR2 and TOU3xPTR2 customers reduced demand during peak periods by 0.08 kW per customer (5%) and 0.06 kW per customer (4%), but TOU2xBDR treatment did not produce statistically significant demand savings. TOU2xBDR was the only hybrid treatment that did not provide rebates to customers for reducing demand during Flex events, and it produced demand savings during on-peak periods and Flex events very similar to the savings from TOU2-only. None of the Hybrid treatments resulted in statistically significant increases in demand during off-peak hours.

Figure 13. Hybrid Demand Savings—Winter 2017/2018



Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during TOU off-peak, TOU on-peak, and a.m. and p.m. Flex event hours. Reductions in demand (savings) are shown as positive values and increases in demand are shown as negative values. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers. The TOU3 rate also had a mid-peak period. During the mid-peak period, TOU3xPTR2 customers demanded 0.05 kW or 2% less on average, with a 90% confidence interval [-0.02, 0.12 kW] or [-1%, 8%].

During Flex events, all Hybrid treatments except TOU2xBDR produced significant demand savings. During the morning Flex event, TOU1xPTR2 saved an average of 0.17 kW per customer (10%), TOU2xPTR2 saved an average of 0.22 kW per customer (12%), and TOU3xPTR2 saved an average of 0.08 (4%), though only the savings estimates for TOU2xPTR2 and TOU3xPTR2 were close to being statistically significant at the 10% level. During afternoon Flex events, TOU1xPTR2 treatment saved 0.08 kW per customer (5%) and TOU2xPTR2 and TOU3xPTR2 treatments saved 0.25 kW per customer (13%). These estimated impacts were close to those for PTR-only treatments in winter.

Hybrid Conservation Impacts

Table 17 presents estimates of the energy conservation impacts in Summer 2017 and Winter 2017/2018 for the Hybrid treatments.

Table 17. Hybrid Treatment Energy Conservation Impacts

Treatment	Daily Energy Savings, Summer 2017		Daily Energy Savings, Winter 2017-2018	
	kWh	Abs. Precision at 90% Conf.	kWh	Abs. Precision at 90% Conf.
TOU1xPTR2	0.14	±1.14	0.22	±1.67
TOU2xPTR2	0.35	±1.47	0.75	±1.82
TOU2xBDR	0.36	±0.87	0.20	±1.29
TOU3xPTR2	0.70	±1.06	0.57	±1.62

Notes: The table reports the average daily energy savings per treated customer. Positive values indicate energy savings. The precision was estimated based on standard errors clustered on customers.

The point estimates suggest that in summer and winter Hybrid treatments may have reduced energy consumption by less than an average of 0.7 kWh per customer day, but none of the estimates were statistically significant. For example, it was estimated TOU2xPTR2 treatment reduced consumption by an average of 0.35 kWh per customer per day, but the estimated confidence interval [-1.12, 1.82] is wide and includes zero. The confidence intervals for the other treatments are similarly wide and include zero.

When Cadmus calculated the average daily energy savings per TOU customer using the on-peak period and off-peak period demand impact estimates in Figure 12 and Figure 13 and, we also obtained small and statistically insignificant savings.

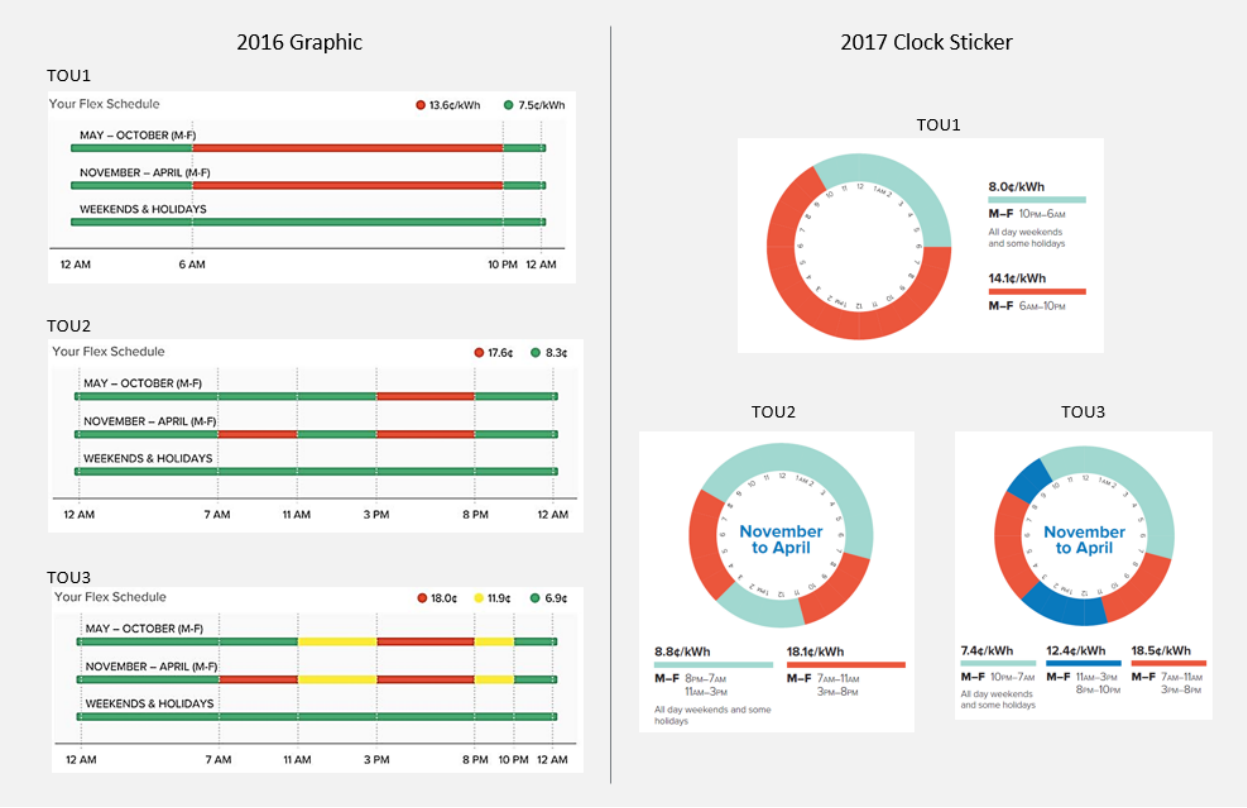
Customer Experience

The summer and winter experience surveys asked Flex customers about their awareness of rates and event notifications, efforts to reduce or shift loads, participation challenges, satisfaction with Flex, and satisfaction with PGE. Respondents rated their satisfaction on a 0–10 scale, where zero meant *extremely dissatisfied* and 10 meant *extremely satisfied*. PGE defined a 6-10 rating as *satisfied* and a 9-10 rating as *delighted*. The following section describes the major findings from the surveys.

Pricing Awareness

TOU customers could manage electricity costs by either: (1) reducing consumption during high-cost periods; or (2) shifting consumption from high-cost periods to lower-cost periods. Therefore, educating TOU customers about the Flex schedule (i.e., the rates and times) would prove crucial for program success. PGE educated TOU customers in two ways. First, PGE posted rate schedules online, allowing customers to review them on the Flex website. Also, in 2016, PGE distributed a rate schedule diagram to customers and, in 2017, a rate schedule clock sticker (see Figure 14).

Figure 14. Flex Schedule Educational Materials Distributed to TOU Customers

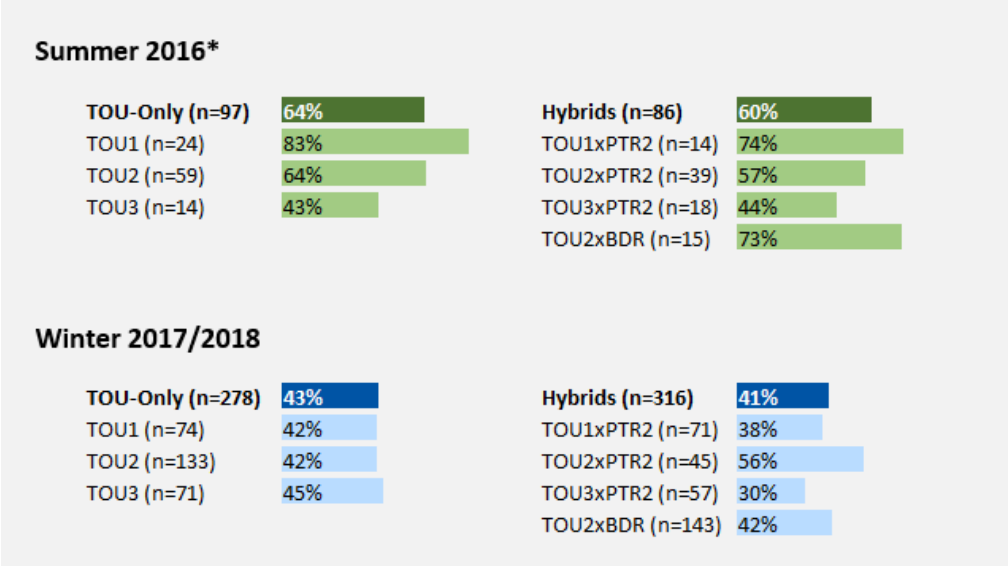


The summer and winter experience surveys asked customers in TOU-only and Hybrid treatments to identify their rate schedule from a list of three schedule images (i.e., the 2016 graphic shown in Figure 14). The surveys, administered online, displayed the 2016 rate schedule images and did not use the 2017 clock sticker images.

Figure 15 shows the percentage of respondents who correctly identified their rate schedules by season and TOU treatment. Due to the small number of respondents per treatment in the summer survey, caution should be exercised in making comparisons between treatments and seasons.

Across treatments and seasons, only 52% of respondents correctly identified their rate schedules. The relatively low rate of correct identification suggests that PGE could do more to educate customers about their TOU rates.

Figure 15. Percentage of Correct Rate Schedule Identification



Survey Question: Which image describes the rates you pay for electricity on the Flex Program?
*The Summer 2017 experience survey did not ask the rate schedule identification question. Results from the Summer 2016 experience survey are reported here instead. Appendix F contains the survey results for Winter 2016/2017.

No significant differences emerged between TOU-only and Hybrid respondents, but in general survey respondents more successfully identified their rate schedule correctly in summer than winter: average correct identification rates were 64% for TOU-only and 60% for Hybrids in summer, while 43% for TOU-only and 41% for Hybrids in winter. Across TOU treatments (except TOU3), a significantly higher percentage of summer respondents correctly identified their rate schedules than winter respondents.[22] The summer and winter surveys used the same rate schedule images from 2016. The rate schedule clock sticker that PGE distributed to customers in 2017 did not look like the images found in the survey and may have confused respondents who were used to seeing a clock graphic.

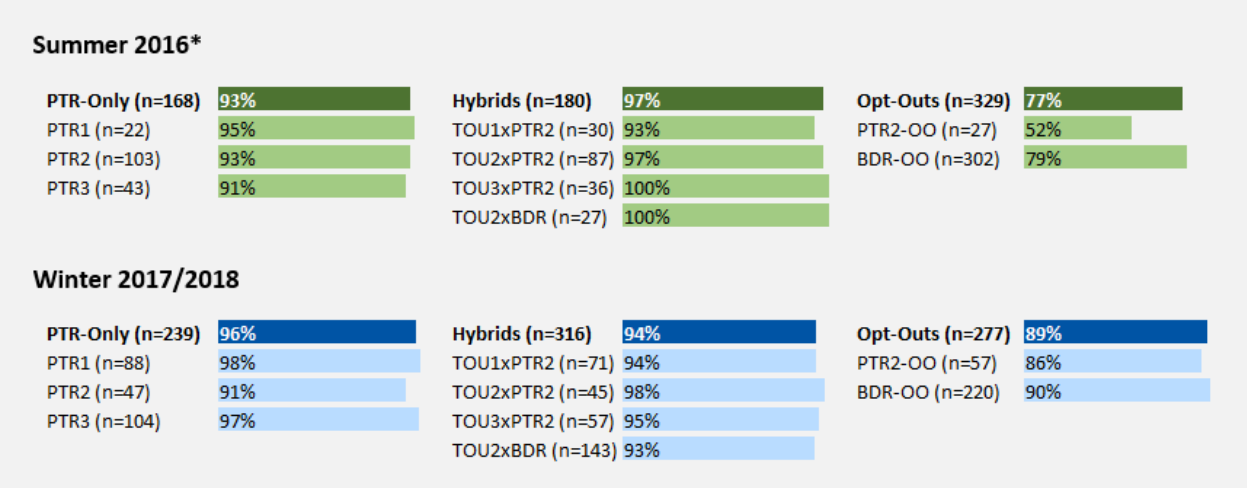
Flex Event Notifications

PGE called approximately seven Flex events per season (see Table 7 for further details). PTR, Hybrid, and BDR customers received an event notification on the day before and day of the event through their

[22] Significant difference with 90% confidence (p≤.10).

preferred communication channels (i.e., email, text, or voice message). The surveys asked customers in PTR and BDR treatments whether they remembered receiving event notifications. Figure 16 shows the percentage of respondents who recalled receiving event notifications by season and treatment.

Figure 16. Percentage of Event Notification Recall



Survey Question: Do you remember being notified of Flex Time events prior to their occurrence?

*As the Summer 2017 experience survey did not ask the event notification question, results from the Summer 2016 event survey are reported here instead.

Most respondents, especially PTR-only and Hybrids, remembered being notified of events. Recall was close to 100% for Hybrid (94%–97%) and PTR-only (93%–96%) respondents, but was significantly less (though still high) for Opt-Out respondents (77%–89%), suggesting those voluntarily enrolling in the program were more likely to look for notifications.[23]

The winter survey asked respondents to rate their satisfaction with their chosen event notification channels (email, text message, and/or voice mail) on a 0–10 scale, where zero meant *extremely dissatisfied* and 10 meant *extremely satisfied*. The survey question before this rating question asked respondents how they received notifications about Flex events; the response to this question determined which notification channels respondents rated on. As shown in Table 18, respondents were most satisfied with text message notifications, followed by email notifications, and voice mail notifications.

[23] The difference in recall rates between PTR or Hybrid respondents and Opt-Out respondents was significant, with 90% confidence ($p \leq .10$).

Table 18. Satisfaction with Flex Event Notifications by Channel Type

Notification Channel	Satisfied (6-10 rating)	Delighted (9-10 rating)	n
Text Message	95%	77%	253
Email	88%	62%	685
Voice Mail	64%	48%	103

Survey Question: How satisfied were you with Flex Time event notifications? Please use a 0 to 10 scale where 0 means "extremely dissatisfied" and 10 means "extremely satisfied." A) Satisfaction with email notification, B) Satisfaction with text notification, C) Satisfaction with voice notification.

In open-ended comments about customer satisfaction with the Flex Program, several recurring themes pertaining to event notifications emerged in the summer and winter surveys:

- ***Awareness of Changing Notification Preferences***: Several respondents did not know they could change their notification channel preferences on the Flex website and suggested that PGE allow customers to select their preferred channels. The Summer 2016 event survey also found that 48% (n= 822) of respondents did not know they could change their notification preferences on the Flex website.
- ***Notification Reminders***: Several respondents wanted more notification reminders and/or earlier notifications, varying from a few days' notice to a few weeks' notice.
- ***Accidental Changes to Notification Settings***: Twenty-four respondents said they received notifications in summer but not in winter, or their notification preference settings changed without their knowledge. PGE confirmed that it reset Wave 3 customers' notification settings after realizing it set Wave 3 customers to receive all three types of notifications (e.g., email, text, and voice); PGE reset settings to email notifications for these customers.

Efforts to Reduce or Shift Loads

PTR or BDR customers were asked to reduce loads during Flex events, while TOU customers were encouraged to reduce loads and/or shift loads from peak to off-peak hours. To facilitate these efforts, PGE provided PTR and BDR customers with energy conservation one-liner tips in event email notifications as well as event performance results addressing how their household performed; tips focused on cooling, heating, and hot water – the high energy-consuming end-uses for the residential sector. PGE provided TOU customers with load-shifting and energy conservation tips, and provided household consumption performance in monthly reports.

Flex Event Participation and Behaviors

The Summer 2016 and Winter 2017/2018 experience surveys asked PTR, Hybrid, and BDR customers whether their household did anything to conserve energy during Flex events. Overall, the majority of respondents said "yes" to participating in Flex event conservation in both seasons (68% summer, 81% winter). A significantly higher percentage of winter respondents (78%, n=832) participated in Flex event

conservation than summer respondents (63%, n=677).[24] The higher participation rate in winter can be explained by the surveys used to draw the comparison and customer habituation to the program. Cadmus did not ask the Flex event participation question in the Summer 2017 experience survey and used the Summer 2016 survey data instead. This created a one-and-a-half year gap between the Summer 2016 and Winter 2017/2018 surveys in which customers from Summer 2016 had fewer event feedback, tips, encouragement, and time to act on the tips compared to customers from Winter 2017/2018.

These self-reported Flex event participation results contradict the demand savings results whereby customers saved more during summer events than winter events. Although customers reported taking more actions in winter, it may be that customers took more of the low-saving actions and less of the high-saving actions struggling to manage the high-saving actions. In open-ended comments from the Summer 2017 and Winter 2017/2018 experience surveys, 40 respondents (a mix of PTR-Only, Hybrids, and Opt-Outs) mentioned that the Flex events were more difficult to participate in during winter than summer. The following quotes from these respondents demonstrate customers' difficulty in winter compared to summer:

- "It is much harder to reduce use during winter Flex hours. Unless we dine out, there is no way to reduce during Flex time because I routinely aim for lower demand hours for laundry, dishwasher, etc. Driving to a restaurant or fast food place would negate the energy reduction at the house and, unlike during summer, we don't want a cold dinner."
- "Works for me in the summer. Managing AC is doable. Managing heat and light in the winter is not as workable. I think my bills are higher in the winter due to Flex."
- "We are very conscientious about shifting our energy use, and our warm weather savings reflect that. However, a household member is disabled, home most of the day, and needs the thermostat kept at 68 degrees. During the winter, that heating requirement just kills our savings."

A significantly higher percentage of Opt-In respondents (76%) than Opt-Out respondents (48%) participated in summer events and winter events (89% Opt-In, 63% Opt-Out).[25] The Opt-In customers' participation rate was higher than that of Opt-Out customers because opt-in programs typically attract the most engaged customers.

As shown in Figure 17, PTR-only respondents (75%) did not differ from Hybrid respondents (78%) in summer, but significantly differed in winter, when more PTR-only respondents (89%) than Hybrid respondents (83%) reported conserving during events.[26] In both seasons, PTR3 respondents showed the highest event participation rates.

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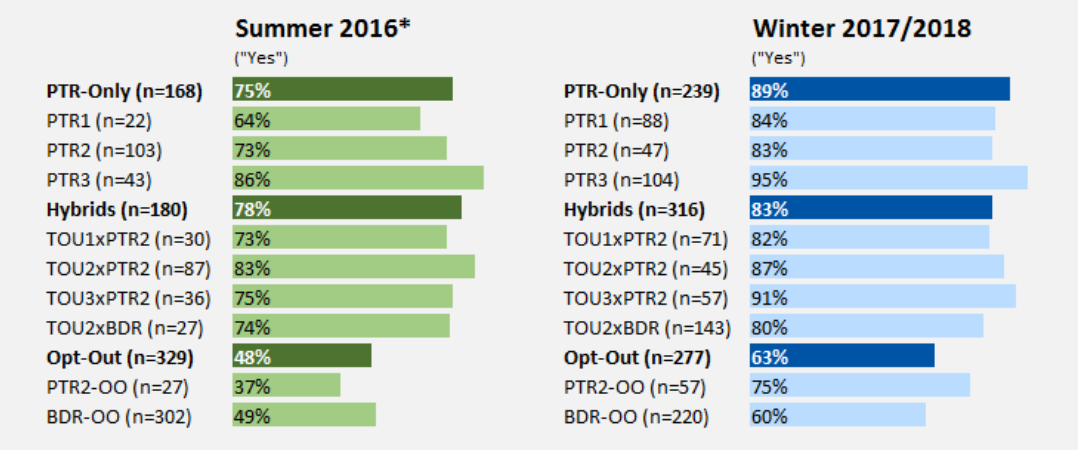
[24] Significant difference with 90% confidence (p≤.10).

[25] Significant difference with 90% confidence (p≤.10).

[26] Significant difference with 90% confidence (p≤.10).

Figure 17. Flex Event Energy Conservation Participation Rates



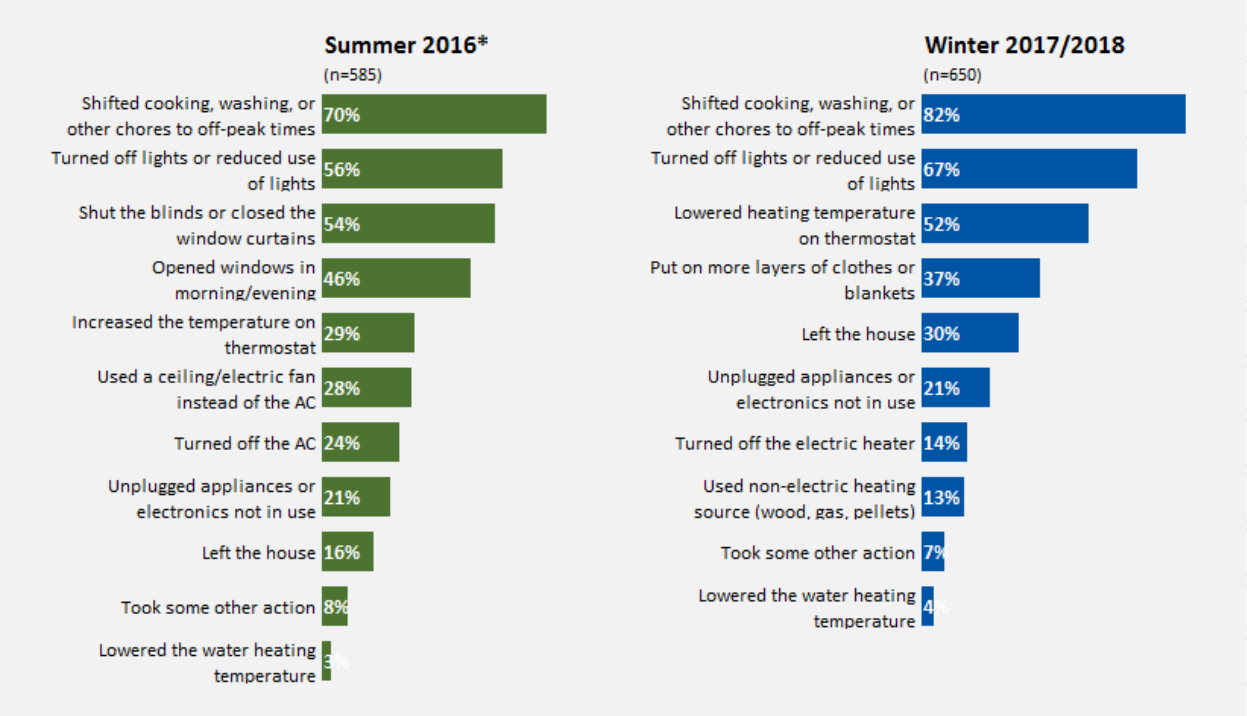
Survey Question: Did you and your household do anything to conserve energy during the Flex Time event?
* The Summer 2017 experience survey did not ask the event participation question. Results from the Summer 2016 event survey are reported here instead. Appendix F contains the survey results for Winter 2016/2017.

The surveys also asked respondents answering "yes" to participating in event energy conservation how their household conserved. Figure 18 shows self-reported customer conservation actions by season.

In both seasons, respondents most frequently reported using one of two strategies: shifting chores to off-peak times; or turning off or reducing use of lights. In summer, 70% of respondents reported shifting their chores to off-peak times, and 56% reported reducing lighting. In winter, 82% of respondents reported shifting their chores to off-peak times, and 67% reported reducing lighting. In both seasons, large percentages of respondents reported reducing use of lighting, even though savings from such behaviors will be low due to the prevalence of efficient CFLs and LEDs in residential customer homes. This presents PGE with an opportunity to educate customers about strategies for producing larger demand savings or shifting such as managing space conditioning and water heating loads. The differences between summer and winter in proportions of respondents employing these strategies were statistically significant.[27] Higher activity rates in winter aligned with findings in Figure 17, indicating event participation was higher in winter than summer. Other actions tended to differ by season, such as adjusting a thermostat's temperature up or down.

[27] Significant difference with 90% confidence (p≤.10).

Figure 18. How Customers Conserved During Events



Survey Question: How did you and your household conserve energy during Flex Time events? (Select all that apply)
*The Summer 2017 experience survey did not ask the event participation question. Results from the Summer 2016 event survey are reported here instead. Appendix F contains the survey results for Winter 2016/2017.
Note: This survey question was asked to customers in the event-based treatments (PTR-only, Hybrids, and Opt-Outs).

In summer, respondents saying they did not conserve during events (n=134) most often cited the following three reasons:

1. Did not know there was an event. (36%)
2. It was too hot or feeling cool was of high priority. (29%)
3. Forgot there was an event. (18%)

In winter, respondents saying they did not conserve during events (n=86) most often cited the following three reasons:

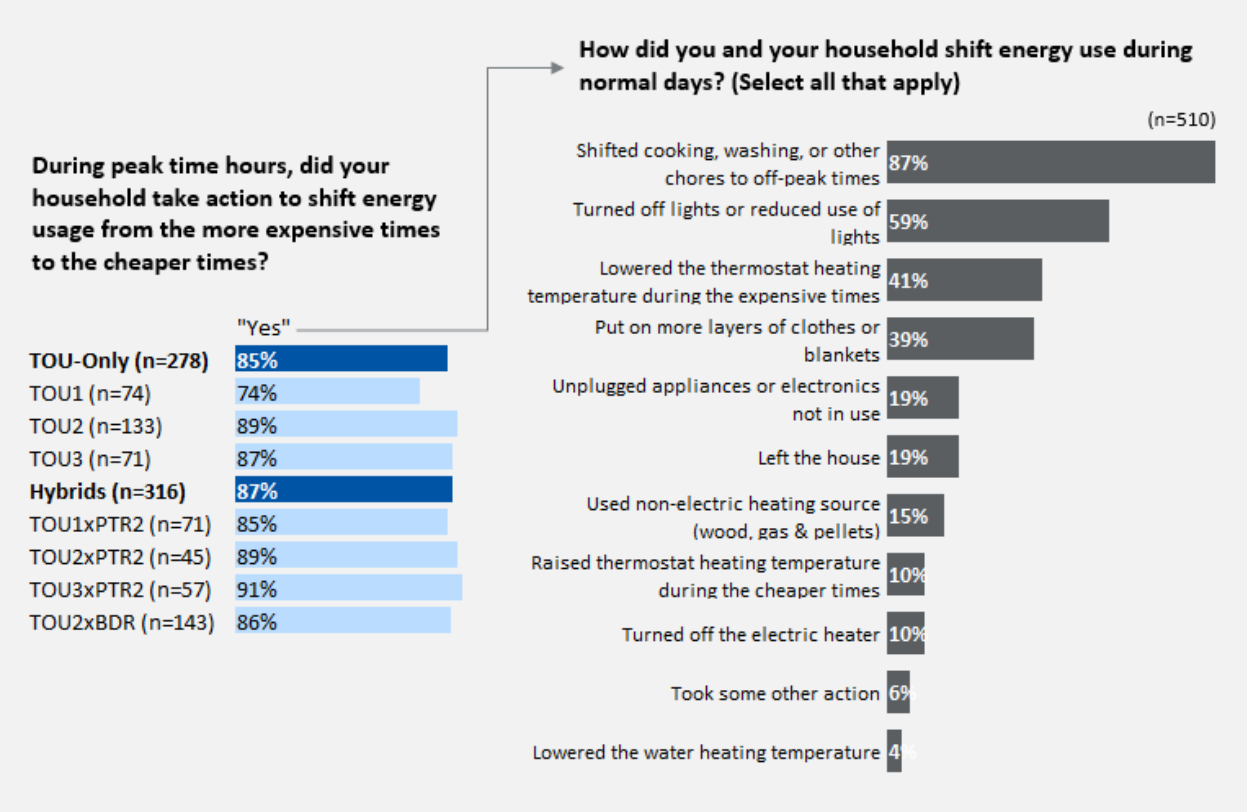
1. The event timing did not work for them. (26%)
2. Already conserving on a regular basis, so did not feel the need to do more on event days. (24%)
3. Forgot there was an event. (17%)

Time of Use Participation and Behaviors

The Winter 2017/2018 experience survey asked TOU customers whether their households took actions to shift energy consumption from more expensive to less expensive times. This question was not asked in the summer surveys. As shown in Figure 19, a similarly high percentage of TOU-only respondents (85%) and Hybrid respondents (87%) reported shifting their energy consumption. For TOU-only and Hybrid treatments, TOU2 and TOU3 respondents showed a significantly higher percentage of shifting

energy consumption than TOU1 respondents.[28] The relatively low percentage of TOU1 customers who reported shifting consumption might reflect the TOU1 rate's day/night schedule, which made load shifting challenging for customers. Among Hybrid treatments, participation rates for shifting energy consumption (87%) were not significantly different from winter event participation rates (83%).

Figure 19. Customer Efforts to Reduce Load During Normal Days – Winter 2017/2018



Note: A comparison to summer is not available. The Summer 2016 and 2017 experience surveys did not ask the two load-shifting questions; these two questions were added to the winter 2017/2018 experience survey.

The winter survey also asked respondents who said "yes" to shifting energy consumption how their households took action. As shown in Figure 19, respondents most frequently shifted their chores to off-peak times and turned off or reduced use of lights—the same top two actions for events. TOU respondents showed one notable behavioral difference from event-based respondents: a significantly lower percentage of TOU respondents reported leaving the house (19% vs. 30%).[29] The TOU program design encourages customers to shift or reduce energy consumption on a regular basis, making leaving the home an impractical strategy. In contrast, PTR and BDR program designs asked customers to shift or reduce demand on event days only, making it easier for them to leave during periods of high demand.

[28] Significant difference with 90% confidence (p≤.10).

[29] Significant difference with 90% confidence (p≤.10).

In winter, respondents saying they did not participate in shifting energy consumption (n=65) most often cited the following three reasons:

1. Particular members in my household make it difficult to shift energy use. (20%)
2. Feeling comfortably warm is a high priority. (14%)
3. Inconvenient/hard to remember to do every day. (14%)

Customer Satisfaction with Flex

The summer and winter experience surveys asked Flex customers to rate their overall satisfaction with the program on a 0–10 scale, where zero meant *extremely dissatisfied* and 10 meant *extremely satisfied*. Figure 20 shows the percentage of satisfied (6–10 rating) and delighted (9 –10 rating) participants across treatments for Summer 2017 and Winter 2017/2018. Appendix F contains survey results for Summer 2016 and Winter 2016/2017.

In assessing Flex satisfaction, the results from PGE's CPP pilot (2011-2013) are a useful point of reference. Using a similar 0–10 rating scale as the Flex evaluation, PGE reported that 68% of customers were satisfied (6–10 rating) and 40% of customers were delighted (9 –10 rating) with CPP. As evident below, overall, PGE customers gave the Flex pilot higher satisfaction ratings. Perhaps because of risk of or actual energy bill increases from CPP and the absence of such risk for PTR, satisfaction proved significantly lower for CPP.

Over 50% of respondents in each Flex treatment expressed satisfaction, with the highest program satisfaction observed for PTR-only (83%–86%),[30] followed by Hybrids (71%–79%), TOU-only (61%–76%), and Opt-Outs (56%–61%). Opt-In PTR2 treatment achieved the highest program satisfaction rate at 92% in the summer survey. Opt-In PTR2 (89%) and PTR3 (89%) treatments also achieved high program satisfaction rates in the winter survey. On the other hand, BDR-OO and TOU1 treatments showed the lowest satisfaction rates in the summer survey (BDR-OO 51%; TOU1 57%) and in the winter survey (TOU1 54%; BDR-OO 57%). The higher program satisfaction rates among PTR-only treatments suggest that providing financial incentives without risk of penalty boosts customer satisfaction with the program.

Opt-In treatments showed significantly higher program satisfaction rates than Opt-Out treatments. In the summer survey, a significantly higher percentage of Opt-In treatment respondents (79%) than Opt-Out treatment (56%) respondents expressed satisfaction. [31] In the winter survey also, a significantly higher percentage of Opt-In treatment respondents (72%) than Opt-Out treatment respondents (61%) expressed satisfaction. [32] Opt-In treatments showing higher satisfaction with the program was expected

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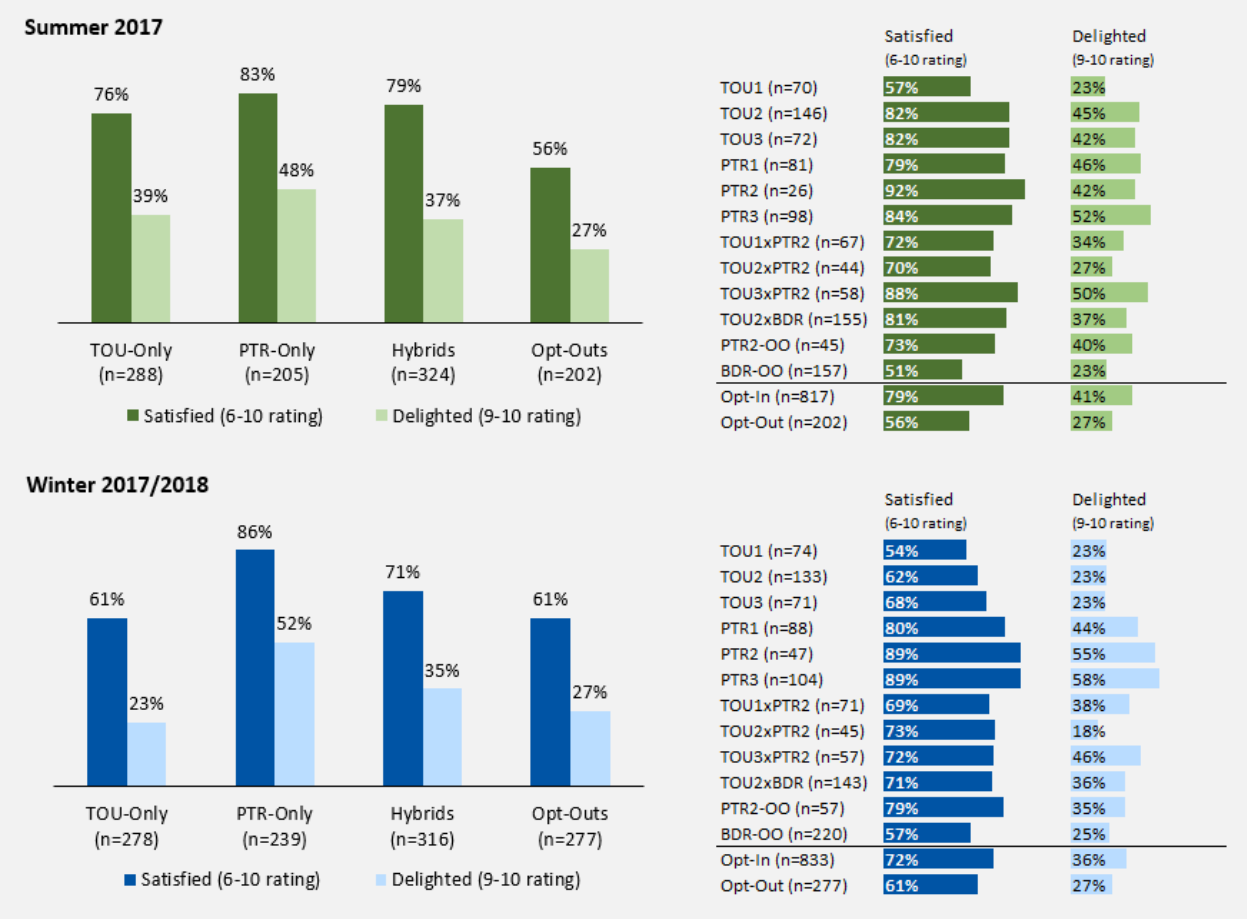
[30] In comparison to the 2013-2015 PGE CPP pilot, PGE reported that 68% of customers were satisfied (6–10 rating) and 40% of customers were delighted (9 –10 rating) with CPP

[31] Significant difference with 90% confidence (p≤.10).

[32] Significant difference with 90% confidence (p≤.10).

as customers who opt in to a program are more engaged than customers who are automatically enrolled in a program (opt-out program design).

Figure 20. Overall Satisfaction with Flex



Survey Question: Please rate your overall satisfaction with the Flex Program using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Program satisfaction tended to be higher in summer than in winter. As shown in Figure 20, seven of the 12 treatments exhibited higher satisfaction rates in summer than winter. In particular, TOU-only and Hybrid treatments showed significantly higher satisfaction rates in summer (76%–79%) than in winter (61%–71%).[33] This seasonal pattern for TOU-only and Hybrid treatments suggests that the TOU pricing may have been more challenging for customers in winter than in summer.

Additionally, the summer and winter experience surveys asked respondents to explain their program satisfaction ratings. Satisfied respondents most often said the program delivered bill savings, helped their household manage energy use, brought education and awareness about energy conservation, and helped the environment. Respondents not satisfied most often said they saw little to no difference in

[33] Significant difference with 90% confidence (p≤.10).

their bill savings, and found the Flex schedule or events difficult for their households. In particular, BDR-OO respondents most often mentioned the Flex events being difficult and TOU-only respondents (especially TOU1) most often mentioned the Flex schedule being difficult for their households.

Notably, respondents found the program more difficult to participate in during winter than summer, especially TOU-only and Hybrid respondents: 16% of respondents in the summer survey said the program helped them save on their electric bills, compared to 9% of respondents in the winter survey. Specifically, respondents said winter on-peak hours and event times occurred when household members were often home and needed to heat the home to stay warm. No respondents found the program more difficult in summer than in winter. PGE could lessen customer concerns about the seasonality of bill savings by encouraging them to enroll in *Equal Pay*, a payment option that allows customers to smooth their payments over months of the year. Another strategy, which PGE has already implemented, is to present cumulative, rather than monthly, bill savings to customers. Even if customers do not reduce their bills in winter, most do so over 12 months.

Among open-ended responses to the satisfaction rating question, 6% of respondents from the summer survey and 5% of respondents from the winter survey offered the following suggestions to improve the program:

- Provide a bill credit for savings instead of sending a check
- Provide more advanced Flex time event notifications
- Adjust the Flex schedule hours and/or Flex event times
- Provide more personalized information on tips and consumption data

Customer Satisfaction with PGE

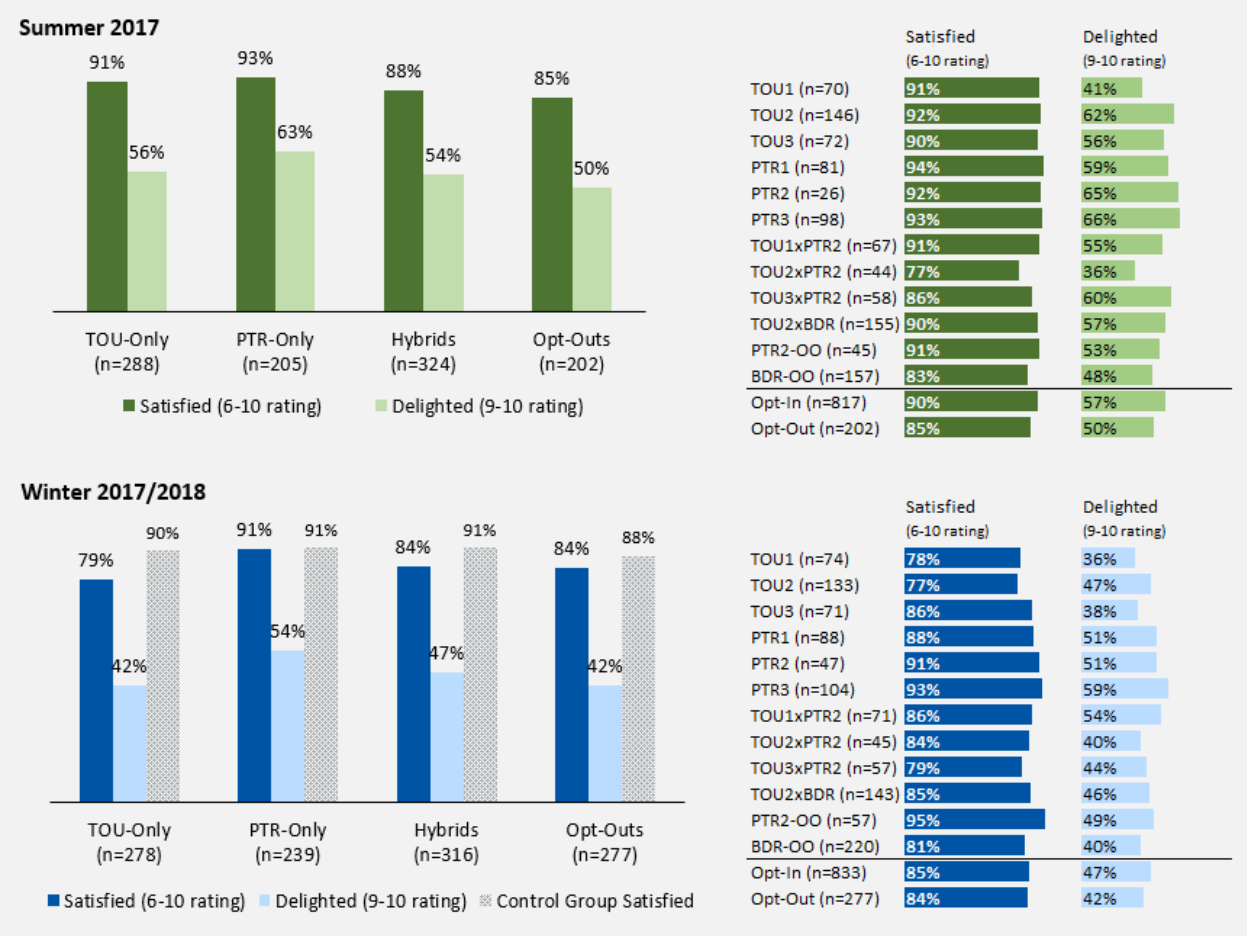
The surveys asked test and control group customers to rate their overall satisfaction with PGE on a 0–10 scale, where zero meant *extremely dissatisfied* and 10 meant *extremely satisfied*. Figure 21 shows the percentage of *satisfied* (6–10 rating) and *delighted* (9–10 rating) customers across treatments and groups for Summer 2017 and Winter 2017/2018. Appendix F contains survey results for Summer 2016 and Winter 2016/2017.

Among test group treatments, PTR-only had the highest PGE satisfaction rates. As shown in Figure 21, PTR-only had a PGE satisfaction rate of 93% in summer and 91% in winter. Opt-Outs had the lowest PGE satisfaction rates (85% in summer and 84% in winter). PGE satisfaction rates significantly differed between PTR-only and Opt-Outs in both seasons.[34] However, when combined, Opt-In customers showed no significant differences from Opt-Out customers in PGE satisfaction rates. In summer, Opt-Ins had a satisfaction rate of 90% and Opt-Outs had a satisfaction rate of 85%. In winter, Opt-Ins had a satisfaction rate of 85% and Opt-Outs had a satisfaction rate of 84%.

[34] Significant difference with 90% confidence ($p \leq .10$).

Customer satisfaction with PGE was lower in winter than summer. Most treatments showed a decrease in PGE satisfaction in winter, with TOU-only showing a significant decrease. TOU-only respondents significantly rated their satisfaction with PGE as lower in winter (79%) than in summer (91%).[35] Hybrid respondents also rated their satisfaction with PGE as lower in winter (84%) than in summer (88%), though this was not a statistically significant difference. The lower PGE satisfaction ratings in winter possibly reflected challenges in saving energy during winter. As discussed in the previous section, TOU-only and Hybrid customers reported the program as more difficult to participate in during winter than summer.

Figure 21. Overall Satisfaction with PGE



Survey Question: Please rate your overall satisfaction with PGE using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

*Note: Cadmus did not survey the control group customers in the Summer 2017 experience survey. Appendix F contains the satisfaction results for Summer 2016 and Winter 2016/2017 as well as the control group's Winter 2017/2018 satisfaction results for all 12 treatments.

[35] Significant difference with 90% confidence (p≤.10).

PGE satisfaction ratings are compared between test and control groups only for winter (see the gray, hatched bars); control customers were not included in the summer survey. As shown in Figure 21, PTR-only had no impact on customer satisfaction with PGE, but other treatments had a negative impact on customer satisfaction with PGE. PTR-only test group and control group both had a PGE satisfaction rate of 91%. TOU-only test group had a significantly lower PGE satisfaction rate (79%) than control group (90%).[36] Hybrid test group also showed a significantly lower PGE satisfaction rate (84%) than control group (91%).[37] Opt-Out test group showed a lower PGE satisfaction rate (84%) than control group (88%), though not a statistically significant difference.

Implementation Challenges and Lessons Learned

PGE enrolled approximately 14,000 residential customers in the Flex pilot, which involved a complex RCT design using multiple treatments. Never having implemented a pilot of this scale or complexity, PGE encountered several implementation challenges, including marketing and providing feedback about demand savings to customers after events. This section documents these challenges and lessons learned, as communicated by PGE and implementation contractor program staff in interviews.

Marketing

Recruitment proceeded more slowly than expected, but still met its overall enrollment target by Summer 2017 (see Marketing and Recruitment and Table 5 for marketing and enrollment details). PGE and CLEAResult struggled at first with finding a marketing and messaging approach that resonated with customers. PGE experimented with marketing through emails, gift card rewards, postcards, and business letters as well as with messaging that emphasized economics (personal gains, including bill savings), control (taking charge of your consumption), and community (the greater good).

PGE reported the following customer conversion rates for Flex marketing channels over the course of the pilot:[38]

- 1.5% enrolled from email
- 2.5% enrolled from postcard
- 4.5% enrolled from business letter

Over the course of the pilot, PGE improved the effectiveness of its marketing through experimentation. PGE learned the types of messaging that resonated most with customers and the most effective marketing channels. It also found that offering a gift card as a reward did not increase the likelihood of

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[36] Significant difference with 90% confidence (p≤.10).

[37] Significant difference with 90% confidence (p≤.10).

[38] A conversion rate measures a given marketing channel's effectiveness in spurring enrollment, calculated by taking the number of customers who enrolled from a channel and dividing this by the total number of customers that the channel reached.

enrollment. PGE reported that during the third and final recruitment wave it had enrolled 4.5% of customers receiving one well-designed email or business letter who had not received a previous Flex solicitation. According to PGE, it enrolled a high percentage of customers in the pilot after "a single touch" because of critical lessons about marketing it had learned during the previous two recruitment waves.

PGE's experiments with marketing approaches revealed two critical lessons:

1. **Customers respond to paper (even after many emails).** Business letters and postcards enrolled customers more effectively than emails. Initially, PGE recruited customers with valid email addresses and only later opened recruitment to customers without email. Recruiting both customer sets helped the pilot program meet its enrollment targets. PGE also reported that it switched to business letters after having emailed customers as much as nine times; notably, when customers not responding by email received the business letter, they responded as if they had seen the program marketing for the first time.
2. **Customers respond to messaging about bill savings.** Business letters more successfully enrolled customers due to comparisons of standard flat rates vs. TOU rates and financial messaging about bill savings. Initially, PGE used control and community messaging in emails and postcards, which proved unsuccessful in converting customers. PGE realized that financial-focused messaging resonated more with customers as the primary participation benefit arose from the opportunity to earn bill credits or savings. Recruitment survey results (n=458) further supported this contention, indicating that saving money on electric bills was the top reason for enrollment (78%), followed by saving energy (46%), and helping the environment (28%).

Event Management

PGE encountered challenges in providing accurate and timely feedback to customers about their success in reducing or shifting loads during Flex events and in dispatching the appropriate number of events. A summary of challenges follows, along with PGE's efforts to address them:

- **PGE delivered inaccurate event savings feedback to some customers during the initial part of the Summer 2016 season.** To provide individualized feedback on event savings to participants, AutoGrid's data management platform performed consumption baseline calculations for each participating customer. During the initial Summer 2016 events, some customers received inaccurate or no feedback about their savings due to misaligned baseline calculation inputs. Inaccurate feedback or absence of feedback may have discouraged some customers from participating in future Flex events. To address these data errors, PGE and AutoGrid worked to refine the baseline calculation methodology and developed a quality control (QC) process to review event data before delivering them to customers. They began implementing the QC process in late Summer 2016.
- **PGE did not deliver event savings feedback to customers within the ideal 24-hour time frame.** PGE intended to send customers their event savings feedback within 24-hours of events, believing that each passing day could diminish the value customers gained from the feedback. PGE reported that, for the first few Summer 2016 events, it took a few days to a week to provide

feedback due to the baseline calculation difficulties and inaccuracies described previously. The delay in feedback also prevented PGE from calling additional events until these issues were resolved. However, by the end of Winter 2016/2017, PGE refined its process flow and managed to achieve 48-hour delivery. Though data management and QC processes made it difficult for PGE to achieve a shorter timeframe, PGE continued to improve its processes for delivering feedback and achieved close to a 24-hour turnaround in Summer 2017.

- **PGE dispatched too many BDR events.** PGE received feedback from some BDR customers that it dispatched too many events. As PGE does not compensate BDR customers, it is mindful of not calling upon them to reduce demand too often. As a result, while BDR saved 1%–2% of demand for thousands of customers, PGE used BDR less frequently over the pilot's course and plans to use it even less frequently in the future. In contrast, PGE is considering dispatching more PTR events in future winter seasons because it is popular with customers and effective at reducing peak demand. Moreover, PGE reported that it could have communicated better with BDR customers about their options for receiving event notifications after receiving feedback that some customers had not been aware that they could change their event notification settings.

Conclusions and Recommendations

Peak-Time Rebates

Larger rebates did not yield more Flex event savings.
Opt-In PTR customers saved about 20% of consumption during summer Flex events and between 7% and 12% of consumption during winter Flex events. No statistically significant differences in savings appeared by rebate amount. In summer, customers receiving a $0.80/kWh rebate achieved the same savings as customers receiving a $2.25/kWh rebate.

Of 12 treatments, Opt-In PTR-only customers were most satisfied with the Flex pilot.
In both seasons, Opt-In PTR-only respondents had the highest satisfaction rates with Flex (83% reported a program satisfaction score of 6 or higher on a 10-point scale in winter; 86% in summer) compared to Hybrids (71% in winter; 79% in summer) and TOU-only (61% in winter; 76% in summer).[39] Opt-In PTR2 treatment achieved the highest satisfaction rate of 92% in the summer survey. Opt-In PTR2 (89%) and PTR3 (89%) treatments also achieved high satisfaction rates in the winter survey. PTR customers may have been most satisfied as they faced no financial risk from participation. Customers could earn rebates for saving energy during Flex events, but were not penalized if their consumption increased.

Larger rebates (greater than $1.55/kWh) increased customer satisfaction with the Flex pilot.
PTR1 customers, who received the smallest rebate ($0.80/kWh), had lower satisfaction with Flex for both winter and summer seasons than PTR2 ($1.55/kWh) or PTR3 ($2.25/kWh) customers. In summer, 79% of PTR1 customers expressed satisfaction with the program, while 92% of PTR2 customers and 84% of PTR3 customers expressed satisfaction. In winter, PTR1 had a satisfaction rate of 80%, about 10 percentage points lower than that of PTR2 (89%) and PTR3 (89%).

Flex event savings from peak-time rebates did not depend on outside temperatures.
A statistical relationship was not found between PTR savings and outside temperatures during Flex events in winter or summer. Outside temperatures during Flex events ranged between 82°F and 96°F in summer and 28°F and 45°F in winter.

PTR Recommendation

- When setting rebates for future PTR programs, PGE should consider the tradeoff arising from offering a higher rebate: over the lower range of rebates tested ($0.80/kWh to $1.55/kWh), there were positive effects on customer satisfaction but no impacts on Flex event savings from increasing the rebate. This suggests that larger rebates may raise customer satisfaction, but lower program cost-effectiveness.

[39] Respondents rated their overall satisfaction with the program on a 0–10 scale, where 0 meant *extremely dissatisfied* and 10 meant *extremely satisfied*. PGE defined a 6–10 rating as *satisfied*.

TOU Rates

Customers under the TOU1 rate schedule encountered difficulties in shifting consumption from peak to off-peak hours.

The TOU1 rate used "day/night" off-peak and on-peak period definitions. As the on-peak period was set from 6:00 a.m. to 10:00 p.m., many customers were awake only during peak hours and asleep during off-peak hours, making load shifting inconvenient or difficult. Shifting loads would require many customers to adjust their sleep schedules or to have appliances programmed to run at night. Among TOU customers, those on the TOU1 rate had the lowest program satisfaction rates (57% in summer and 54% in winter) and did not achieve peak savings in either season. TOU1 respondents dissatisfied with Flex most often mentioned the rate schedule being difficult for their households; these respondents said it was not convenient or worth changing one's sleep time to do chores during off-peak periods.

TOU rate schedules with short peak-period definitions yielded peak savings and high satisfaction in summer.

In summer, TOU2 and TOU3 customers achieved significant savings during peak periods (8% and5%, respectively). They also saved 5%–6% during Flex event hours, which Cadmus used as a proxy for the peak capacity impact of TOU, even though TOU customers did not receive Flex event notifications or incentives. In summer, the TOU2 and TOU3 schedules had relatively short peak periods, from 3:00 p.m. to 8:00 p.m., which coincided with PGE's summer system peak and enabled customers to shift loads to off-peak periods. In summer, TOU2 and TOU3 customers had relatively high customer satisfaction ratings of 82%.

The simpler TOU rate schedule achieved the same peak period savings and satisfaction as the more complex one.

In summer, the TOU3 rate, with peak (3:00 p.m.–8:00 p.m.), mid-peak (11:00 a.m.–3:00 p.m.), and off-peak periods, reduced loads by 5% during the mid-peak period. However, no differences emerged in peak period savings between the simpler TOU2 rate, which only had peak (3:00 p.m.–8:00 p.m.) and off-peak periods, and the more complex TOU3 rate. TOU2 and TOU3 showed statistically similar program satisfaction rates in summer (TOU2 82%; TOU3 82%) and winter (TOU2 62%; TOU3 68%).

In winter, TOU customers experienced difficulties in shifting loads from peak to off-peak periods and achieving bill savings.

During winter, none of the TOU-only treatments produced statistically significant reductions in or shifts in peak-period loads. Either TOU did not affect customer loads, or the load impacts were too small to detect with the existing sample sizes. TOU customers also reported relatively low satisfaction with Flex (54%–68%) because of adverse bill impacts and the rate schedule being difficult for their households. TOU schedules had morning *and* evening peak periods. Notably in the survey's open-ended comments, TOU-only and Hybrid customers mentioned the program was more difficult to participate in during winter than summer. Moreover, TOU-only and Hybrid treatments showed significantly lower program

satisfaction rates in winter (61%–71%) than in summer (76%–79%).[40] This seasonal pattern in program satisfaction for TOU-only and Hybrid treatments suggests that the TOU aspect may be more challenging for customers in winter than in summer.

TOU Recommendations

- Unless an economic case justifies shifting customer loads from mid-peak to off-peak hours, PGE should implement the TOU2 rate schedule, which is simpler for customers to understand.
- PGE should consider redesigning the winter TOU rate schedules by removing the morning peak period. This would minimize the potential for adverse customer bill impacts and simplify the customer experience.
- PGE should redesign the TOU1 rate schedule or offer TOU1 customers enabling technology to facilitate load shifting from peak to off-peak periods.
- PGE did not test the impacts of pairing enabling technology with TOU pricing, but studies of other TOU pricing programs suggest that enabling technology such as price-responsive smart thermostats can increase load shifting. PGE should consider testing the load impacts of enabling technology in the future.
- PGE should consider enhancing customer screening during the enrollment process to determine whether a customer is a good fit for a TOU rate.
- Given TOU customers' challenges in achieving winter bill savings, PGE should offer them more education about how to save energy or shift loads from peak to off-peak periods.

Opt-Out Behavioral Demand Response

Behavior-based treatments caused PGE customers to save energy during Flex events.
BDR-OO customers saved an average of 2.3% of consumption in summer and 1.2% of consumption in winter. PGE sent opt-out BDR customers Flex event alerts, encouragement to reduce consumption, and individualized post-event feedback but did not charge them higher electricity prices or provide them with rebates during Flex events, demonstrating that residential customers responded to non-price interventions.

Opt-out BDR program design yielded capacity benefits, but resulted in relatively low customer satisfaction.
PGE automatically enrolled over 12,000 residential customers in the BDR-OO treatment. While average savings per treated customer were small (only 1%–2% of consumption), total program demand savings were large due to the size of the treated population. In the future, PGE can deploy the BDR program to help manage system peaks, but at the potential cost of lower customer satisfaction: only 51% of BDR-OO customers in winter and 57% in summer rated the program a 6 or higher on a 10-point scale.

[40] Significant difference with 90% confidence (p≤.10).

Satisfaction ratings were likely low due to the opt-out program design and the unfamiliarity of many customers with behavioral demand response and the costs of supplying energy during utility system peaks. The program sent event notifications to many customers who had little interest in receiving them or participating in a BDR program. PGE also mentioned in the interviews that it received feedback from some BDR customers that it dispatched too many events and that these customers had not been aware that they could change their event notification settings.

BDR Recommendations

- PGE should consider using opt-out BDR for achieving capacity savings targets, given its success with BDR in reducing loads during this pilot; but it should consider possible changes to program design to increase customer satisfaction, such as:
  - Limiting the frequency of future BDR events, which would also limit the number of event notifications customers received.
  - Shortening the duration of future BDR events to lessen the burden on customers.
  - Spacing out future BDR events to avoid calling back-to-back events or multiple events in the same week.
  - Sending BDR customers a handy reminder magnet or sticker about BDR events and how to save, akin to the clock sticker PGE sent to TOU customers.
- PGE should clearly inform opt-out BDR customers that they can opt out of treatment, and should make it relatively easy for customers to opt out if they do not want to participate.

Opt-Out Peak-Time Rebates

The opt-out participation program design significantly increased program participation.
PGE attained a much higher participation by presenting customers with a choice to opt out of the program rather than opt in. PGE automatically enrolled approximately 1,600 customers in the PTR2-OO program. By the end of the Winter 2017/2018 season, only 2.3% of customers had opted out. In comparison, at the end of the recruitment period for opt-in PTR treatments, less than 7% of PGE customers accepted offers to participate in a PTR1 (4.3%), PTR2 (2.8%), or PTR3 (6.2%) treatment.[41] Of customers opting in to PTR treatment, between 4.5% and 6.3% subsequently opted out. The opt-out design took advantage of customers who were expected to be "complacent": they would neither opt in nor opt out of a demand response program, if given the choice. Cadmus estimated that 92% of opt-out customers were complacent customers. By making participation the default choice, PGE obtained program participation and peak capacity that it would not have achieved otherwise.

[41] PGE experimented with different marketing strategies during the first two waves and obtained higher rates of acceptance during the third wave after improving its approach. Also, PGE stopped recruiting for the opt-in PTR2 treatment after the second wave.

The design of the pilot participation choice (opt-in vs. opt-out) presents a tradeoff between savings per customer and number of participants.

Depending on the rebate amount, opt-in PTR customers saved 17% to 21% of consumption during summer Flex events and from 7% to 12% of consumption during winter Flex events. Customers automatically enrolled in PTR2 saved an average of 7% during summer Flex events and 5% during winter Flex events.[42] Cadmus estimated that in Summer 2017, "complacent customers"—who would neither opt in nor opt out of a PTR program if given the choice—saved 6% during Flex events. While opt-in PTR customers saved more, the opt-out design enrolled many more customers. As noted above, fewer than 6% of PGE customers took up offers to participate in the PTR program. In contrast, more than 97% of customers defaulted onto PTR2-OO remained in treatment through the end of the Winter 2017/2018 season.

Adding a peak-time rebate to behavior-based demand response increased Flex event demand savings and customer satisfaction.

The opt-out BDR treatment and the opt-out PTR treatment only differed in the rebate paid to customers for saving energy during Flex events. PTR customers received the same notifications, tips for saving energy, and individualized feedback about savings as BDR-OO customers. Opt-out PTR customers, however, saved significantly more during Flex events than BDR-OO customers (5% in winter and 7% in summer vs. 1% and 2%, respectively), demonstrating that the rebate lifted savings and complemented the behavior-based treatment. The rebate also increased customer satisfaction. PTR2-OO customers reported 73% program satisfaction in summer and 79% in winter—high customer satisfaction rates for customers automatically enrolled in a program. In contrast, BDR-OO customers only reported program satisfaction rates of 51% in summer and 57% in winter.

Opt-Out PTR Recommendation

- Given the tradeoff between savings per customer and numbers of participants, PGE should analyze whether the opt-in or opt-out PTR design proved more cost-effective, and whether each design will generate the desired aggregate demand response capacity.

Hybrid Treatments

TOU pricing did not enhance (and possibly diminished) savings from PTR during Flex events and customer satisfaction (TOUxPTR vs. PTR).

[42] The surveys also found that a higher percentage of opt-in (75% in summer, 89% in winter) than opt-out (37% in summer, 75% in winter) PTR2 customers reported participating in Flex events.

During Summer Flex events, opt-in PTR customers saved 17% to 21% of consumption, but TOUxPTR customers only saved 9% to 19%[43]. During Winter Flex events, opt-in PTR customers saved 7% to 12%, but TOUxPTR customers only saved 4% to 12%. TOU pricing may cause PTR customers to become inattentive to Flex event alerts, or TOUxPTR customers may have less incentive to save energy during Flex events because their consumption baseline used for calculating rebates is lower. In summer and winter, satisfaction with Flex was 10 to 20 percentage points lower for TOUxPTR customers than for PTR-only customers.

Adding peak-time rebates to TOU pricing increased customer satisfaction and Flex event savings (TOUxPTR and TOUxBDR vs. TOU-Only).
Peak-time rebates had positive impacts on customer satisfaction for TOU customers. Depending on the TOU rate, TOU-only customers reported program satisfaction ranging from 57% to 82% in summer and 54% to 68% in winter. In contrast, TOUxPTR customers reported satisfaction levels ranging from 70% to 88% in summer and from 69% to 73% in winter, suggesting that the PTR enhanced customer satisfaction with the program.

During Flex events (i.e., hours used in this report to approximate system capacity conditions), TOUxPTR customers also saved more than TOU-only customers. In summer, TOUxPTR or TOUxBDR customers saved from 8% to 19% of Flex event demand, while TOU-only customers saved from 2% to 8%. During Winter events, TOU2xPTR2 and TOU3xPTR2 customers saved 12% of consumption, while TOU-only customers did not save any demand.

Hybrid Treatment Recommendations

- If PGE's primary objective is to save demand during system peaks, it should consider enrolling more customers in PTR-only treatments than hybrid TOUxPTR treatments to maximize the impact on system peak.
- If PGE deploys TOU rates on a wide scale, it should consider pairing TOU rates with a peak-time rebate to raise customer satisfaction and Flex event savings.

Customer Experience

TOU and Hybrid customers reported higher satisfaction with the Flex pilot in summer than winter, primarily due to greater summer bill savings.

[43] The Flex event savings estimate for Hybrid customers indicates the combined effects of TOU and PTR during Flex events. The savings are estimated relative to customers who are treated with neither PTR nor TOU pricing.

Overall, participant respondents were more satisfied with the Flex pilot in Summer 2017 (74% *satisfied*) than Winter 2017/2018 (69% *satisfied*).[44] The seasonal satisfaction differences, however, were greatest for treatments involving TOU pricing, which typically produced annual bill savings, with most or all savings occurring in summer. For TOU-only and Hybrid treatments, respondents reported significantly higher program satisfaction in summer (76%–79% *satisfied*) than in the winter (61%–71% *satisfied*).[45] Summer and winter respondents giving the program satisfied ratings most often noted that the program delivered bill savings. Respondents giving a less-than-satisfied rating most often noted seeing little to no difference in their bill savings. In summer, 16% of TOU survey respondents said they saved on their electric bills, compared to 9% of TOU survey respondents in winter. These program satisfaction results align with demand savings estimates showing participants achieved higher peak-period load reductions in summer than winter.

Although PGE automatically enrolled them, opt-out PTR and BDR customers showed high event awareness and engagement with the pilot.

As expected, customers opting into the pilot exhibited high awareness of and engagement with Flex events. Depending on the season, 93% to 96% of opt-in PTR-only respondents and 94% to 97% of opt-in Hybrid respondents remembered receiving event notifications. Also, 76% to 86% of opt-in respondents reported conserving electricity during events in both seasons. These awareness and engagement levels were higher than for BDR-OO and PTR2-OO customers automatically enrolled in the pilots. and 89% of opt-out respondents remembered receiving event notifications. Also, 48% of opt-out respondents in summer and 63% of respondents in winter reported conserving energy during these events. This suggests that PGE can engage customers in achieving demand savings who are automatically enrolled in demand response programs.

PGE has an opportunity to increase peak period and Flex event demand savings from TOU rates through additional education with existing TOU customers.

TOU2 and TOU3-only and Hybrid treatments saved 5% to 8% of demand during peak periods and 8% to 20% of demand during Flex events, indicating that TOU treatments proved effective. TOU customers, however, did not have strong awareness of their rate schedules. Only about one-half of TOU and Hybrid respondents (52%) correctly identified their rate schedules from a list of three rate schedule images. That was only slightly better than results one would expect (33%) if all customers guessed at random. This suggests TOU customers could save more if they knew of their rate schedules. PGE might be able to increase TOU customer demand savings through doing additional education and outreach.

PGE identified several pilot implementation issues that negatively affected customer experiences and either corrected the issues or will correct them in future Flex deployments.

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[44] Respondents rated their overall satisfaction with the program on a 0–10 scale, where a zero meant *extremely dissatisfied* and a 10 meant *extremely satisfied*. PGE defined a 6–10 rating as *satisfied*.

[45] Significant differences at the 90% level (p≤.10).

In interviews with Cadmus, PGE managers and implementation contractors described several program implementation issues:

- PTR and BDR customers received inaccurate and delayed feedback regarding their demand savings during Flex events. The inaccurate feedback may have discouraged some customers from saving, and the delay in providing feedback prevented PGE from calling additional events until these issues resolved. By the start of Winter 2016/2017, PGE had resolved the savings calculation issues and managed to deliver feedback to participants within 24 to 48 hours of events.
- Another issue concerned communication about event notification settings. Some customers complained that they received too many notifications or that the notifications did not arrive through their preferred delivery channels. Many customers reported being unaware that they could change their notification settings. In the future, PGE plans to communicate more proactively with participants about options for program communications and will simplify the process for changing the settings.

Pairing technology with Flex treatments may improve customer's ability to achieve load reduction. While the Flex pilot did not test the impacts of pairing enabling technologies, such as smart thermostats, advanced water heaters, or in-home displays, with the pricing or behavior-based treatments, other studies have found the pairing of these technologies enhances peak demand savings. The experience of TOU1 customers illustrates the potential benefits of enabling technology. TOU1 customers reported challenges in shifting loads from daytime on-peak periods to nighttime off-peak periods; programmable or price-responsive enabling technologies may facilitate shifting of loads and increase TOU1 on-peak demand savings.

Customer Experience Recommendations

- PGE should consider modifying the TOU design and delivery for the winter season to help customers save or shift more electricity consumption. This would improve customer satisfaction and increase load impacts. Modifications could include eliminating the morning on-peak period, shortening the length of the on-peak periods, or automatically enrolling TOU customers in the PTR program. A conjoint analysis of the TOU program offering could examine tradeoffs between different rate schedule designs, customer satisfaction, and load impacts.
- PGE should provide TOU customers with additional education about their rate schedules. This information should be simple and easy to understand. One idea is delivering educational information through alternative media, such as online video.
- PGE should consider opt-out demand response programs as a component of its demand response portfolio. The Flex pilot demonstrated that opt-out programs can reach large numbers of customers and that 50% or more of customers automatically enrolled in PTR or BDR remained engaged, as measured by self-reported rates of Flex event awareness and conservation.

- PGE should conduct test events before the start of each season to assess readiness of its customer communications and data analytics platforms. Testing will allow PGE to correct issues before the season starts, refamiliarize customers with the program, and give customers a chance to change their communications preferences.
- PGE should consider conducting pilots to test the impacts of pairing enabling technologies such as smart thermostats or advanced water heaters with time-based rates or behavior-based treatments if PGE expects the technologies would be cost effective.

Marketing

Paper-based marketing and bill-savings messaging resonated most with customers.
PGE experimented with email, postcard, and business letter marketing, and found business letters achieved the highest customer marketing conversion rate (4.5%), followed by postcards (2.5%), and then email (1.5%).[46]

Business letters emphasized financial messaging (i.e., rate comparison information and a bill savings pitch). PGE initially used economic, control, and community messaging in the emails and post cards, but those approaches proved unsuccessful in enrolling customers. The recruitment survey also found a large majority of participants enrolled to save money on their electric bills (78%); far fewer respondents indicated enrolling to save energy (46%) or help the environment (28%).

Marketing Recommendation

- PGE should consider employing business letter marketing approach for future demand response programs to increase the cost-effectiveness of its marketing. This approach would include leading with bill savings and rate comparisons rather than energy savings or community as primary messages in postcards, emails, or other marketing channels.

[46] A conversion rate measures a given marketing channel's effectiveness in spurring enrollment, calculated by taking the number of customers who enrolled from a channel and dividing this by the total number of customers that the channel reached.

Appendix A. Data Preparation

AMI Meter Data

The AMI data included a mix of 15- and 60-minute interval readings. Cadmus removed a small number of duplicate interval readings from the data. After summing 15-minute interval consumption data to obtain hourly interval consumption, Cadmus dropped a small number of outliers and hourly observations with one or more missing 15-minute interval readings. Specifically, we removed hourly consumption readings greater than 24 kWh from the analysis sample.[47] Also, Cadmus dropped customers with high average monthly consumption, who were unlikely to have been residential customers. We dropped a small number of customers consuming an average of 300 or more kWh per day from the analysis sample.[48]

Cadmus encountered other issues with the AMI meter data and developed solutions to address them. First, the timestamps on the AMI meter datasets were set to different time zones. Some were recorded on Coordinated Universal Time (UTC) instead of Pacific Time (UTC -8 or UTC -7) and required adjustment. In these cases, Cadmus shifted the timestamps to the correct time zone and adjusted for daylight savings time. Cadmus performed a review of the raw, average daily load shapes in each dataset before and after each adjustment to verify the timestamp adjustments.

Second, during the pretreatment period, some customers' AMI interval data were reported in integer kWh instead of in watt-hours. PGE did not switch meters of many participants to record watt-hours until the customer enrolled in the pilot. Cadmus determined these data were not truncated or rounded to the nearest kilowatt hour, but instead represented the change in kilowatt hours between intervals.[49] Since the pretreatment consumption data were measured with error, Cadmus wanted to avoid having pretreatment period hourly consumption directly enter the regression models used to estimate savings. We selected a regression approach that did not require using pretreatment period hourly consumption as a dependent or independent variable. However, to explain variation between customers in hourly consumption during the treatment period, it would be important to control for pre-treatment consumption. We determined that averaging the integer kWh over hours and making an adjustment for expected small errors produced an accurate estimate of a customer's pretreatment mean kWh per hour.

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[47] Twenty-four kWh represented the maximum possible hourly energy consumption of a home with a 100-amp service. Such observations were extremely rare, and more likely reflected bad data (or commercial/industrial activity) rather than true residential consumption. This filter removed any hours with incomplete data or multiple observations for the same period. The hour in fall when DST ended was the exception to this filter, resulting in two 1:00 a.m.–2:00 a.m. periods on the same day.

[48] Customers consuming over 300 kWh per day on average unlikely lived in single-family residential homes. The 300 kWh/day bound is standard practice for evaluation of residential behavioral programs.

[49] For example, if a customer consumed 0.4 kWh per hour for each hour over a three-hour period, the meter data would show 0, 0, and 1 in the kWh field.

Using AMI meter data for customers with consumption reported in watt-hours, we tested the accuracy of our methodology and found that it produced accurate estimates of mean consumption. As noted above, Cadmus included customer pretreatment mean consumption as an independent variable in the regressions to explain variation between customers in energy consumption during the treatment period.

Third, PGE did not provide pretreatment data for the same 12 months for all pilot customers as recruitment lasted longer than one year and PGE only retained interval meter data for the previous 13 months. The date range for the available pretreatment consumption data depended on the customer's recruitment wave. For example, for TOU customers opting into the pilot in spring 2016, PGE provided Cadmus with AMI meter interval data for calendar year 2015, but, for TOU customers opting into the pilot in spring 2017, PGE provided Cadmus with AMI meter interval data for the second half of 2015 and the first half of 2016. This complicated the calculation of each customer's pretreatment mean consumption, which would be included as a control variable.

To obtain comparable estimates of pretreatment consumption for customers from different recruitment waves, Cadmus built a regression model for each customer to predict the customer's pretreatment demand under a standard set of conditions. The standard set of conditions was defined by the specific hours and weather for which Cadmus was attempting to estimate demand savings during the treatment period. For example, to estimate TOU2 demand savings during the on-peak period in Summer 2017 analysis, Cadmus used pretreatment data to predict pretreatment consumption for each customer in the TOU2 test or control group during on-peak hours (between 3:00 p.m. and 8:00 p.m. on non-holiday weekdays) when the outside temperature equaled average outdoor temperatures during on-peak hours in 2017.

Specifically, using available pretreatment consumption data for summer or winter, Cadmus estimated individual customer regressions of hourly energy consumption on a constant and cooling or heating degree hours:

Equation 1

$$kWh_{it} = \alpha_i + \beta_i HD_{it} + \varepsilon_{it}$$

Where:

kWh_{it} =		Electricity consumption of customer i during on-peak hour t of the summer or winter pre-treatment period.
α_i	=	Intercept for customer i indicating average consumption per hour during on-peak or off-peak hours.
β_i	=	Coefficient for customer i indicating average effect of cooling (heating) degree hours during summer (winter) on electricity consumption.
HD_{it}	=	Heating (cooling) degrees for customer i during peak or off-peak hour t using base temperature of 65°F in winter and 75°F in summer.
ε_{it}	=	Error term for consumption of customer i during peak or off-peak hour t.

Cadmus estimated the customer models by OLS and then predicted each customer's consumption for typical weather during on-peak and off-peak hours as follows:

Equation 2

$$\widehat{kWh_{ip}} = a_{ip} + b_i\overline{HD}_{ip}$$

where:

kWh_{ip} = Predicted mean electricity consumption for customer i during on-peak or off-peak hours during the pre-treatment period.

a_i = Estimated intercept for customer i indicating average consumption per hour during on-peak or off-peak hours.

b_i = Coefficient for customer i indicating average effect of cooling (heating) degree hours during summer (winter) on electricity consumption during on-peak or off-peak hours.2.

$\overline{HD}_{ip}$ = Mean cooling (heating) degree hours during on-peak or off-peak hours of the treatment period.

Cadmus included the predicted pre-treatment consumption as an explanatory variable in Equation 2.

Ineligible Customers and Account Closures

A small number of customers opting into the pilot or automatically enrolled in opt-out treatments were determined ineligible for participation. Cadmus removed any customer from the analysis sample if PGE determined they were ineligible (e.g., customers with solar arrays or participants in the Rush Hour Rewards program). Cadmus applied these sample selection criteria identically to customers in the randomized test and control groups.

Also, some customers opting in or automatically enrolled in the pilot moved residences. When a customer moved, their participation in the pilot ceased, and Cadmus removed all AMI data for the period after the customer's move-out date.

Appendix B. Model Specifications

Event-Based Treatments

Cadmus estimated the demand savings from event-based treatments (PTR1-PTR3, opt-out BDR, and Opt-out PTR2) by comparing the hourly consumption of customers in each treatment's randomized test and control groups. Using data for event hours during each winter or summer season, Cadmus estimated a panel regression of customer hourly energy consumption on control variables for pretreatment consumption, hour-of-sample fixed effects, and assignment to treatment. Letting i, i=1, 2, …, N, denote customer, and t, t=1, 2, …, T, denote the Flex hour, the model took the following form:

Equation 3

$$kWh_{it} = \beta_1 Test_i + \mathbf{kWh}^{Pre}{}_{it}'\gamma + \tau_t + \varepsilon_{it}$$

Where:

- kWh_{it} = Electricity consumption of customer i during Flex event hour t.
- β_1 = A coefficient indicating average treatment effect (in kWh) per customer per hour.
- $Test_i$ = An indicator variable for whether customer i was assigned to receive the treatment. This variable equals one if the customer was assigned to the treatment group and zero otherwise.
- $\mathbf{kWh}^{Pre}{}_{it}$ = A vector of variables characterizing mean consumption during the pretreatment period for customer i.
- γ = A vector of coefficients indicating average effect of pretreatment consumption on consumption of customer i during Flex events.
- τ_t = Error term for Flex hour t of the analysis period. Cadmus captured these effects with hour-of-the-sample fixed effects (i.e., a separate dummy variable for each Flex event hour).
- ε_{it} = Error term for consumption of customer i and hour t.

The pretreatment consumption variables account for differences between customers in average consumption during Flex event hours. Cadmus calculated separate morning and evening pretreatment consumption means using data for hours when events typically occur (e.g., 4:00 p.m. to 7:00 p.m.) on non-holiday weekdays before the Flex season began or before the first PTR or BDR event occurred.[50] Cadmus attempted to use days that had low (winter) or high (summer) temperatures to temperatures experienced during Flex events.[51] Cadmus did not calculate mean consumption using non-event days

[50] For Summer 2017, Cadmus selected days between April 1, 2017, and July 23, 2017. For Winter 2017–2018, Cadmus selected days between November 1, 2017, and December 31, 2017. In each case, the last day of the period was the last non-holiday weekday before the first event of the season.

[51] Only days where the mean temperature fell no lower than 10 degrees below the event day mean temperature.

during the demand response season because of evidence from other studies showing that event-based treatment can produce savings on non-event days. The hour-of-sample fixed effects control for weather and other unobserved factors specific to each event hour.

Cadmus estimated a separate model for each treatment by OLS and clustered the standard errors on customers to account for correlation of consumption for individual customers, and estimated alternative model specifications to test the robustness of the estimates to specification changes. These alternative specifications included the following:

- Substituting day-of-the week and hour-of-the-day variables for the hour-of-the-sample fixed effects.
- Adding weather variables such as cooling degree hours (CDH) or heating degree hours (HDH) to the regression.
- Omitting pretreatment mean consumption from the regression equation.
- Adding indicator variables for a customer's recruitment wave (Wave 1, Wave 2, or Wave 3) as standalone variables and interacted with other variables.

These specification changes affected the estimated standard error, but not the point estimates of savings.

Time of Use Rate-Based Treatments

Cadmus estimated treatment effects for TOU rate and hybrid-TOU rate treatments by comparing consumption of customers in each treatment's randomized test and control groups. Using data on customer consumption for event and non-event hours during each winter or summer season, Cadmus estimated a panel regression of customer hourly energy consumption on control variables for pretreatment consumption, peak and off-peak hours, day-of-the-week, weather, and assignment to treatment. Again, letting i, i=1, 2, …, N, denote customer, and t, t=1, 2, …, T, denote the Flex hour, the TOU and TOU-hybrid treatment models took the following form:

Equation 4

$$kWh_{it} = \alpha + \gamma_1 OffPeak_t + \gamma_2 Peak_t + \beta_1 Test_i * OffPeak_t + \beta_2 Test_i * Peak_t + \beta_3 Treatment_i * OffPeak_t * Wkend_t + \mathbf{kWh}^{Pre}{}_{it}'\boldsymbol{\gamma} + \varepsilon_{it}$$

Where:

$(kWh/hour)_{it}$ = Electricity consumption of customer i during hour t of the summer or winter treatment period.

α = Intercept indicating baseline average consumption (kWh) per customer per TOU weekend (off-peak) hour.

γ_1 ` = Coefficient on $OffPeak_t$ indicating baseline average consumption (kWh) per customer per TOU off-peak period hour.

$Offpeak_t$	=	An indicator variable for whether the hour is a TOU off-peak period weekday hour. This variable equals one if the hour was not a peak period hour or weekend hour and zero otherwise.
γ_2	=	Coefficient on $Peak_t$ indicating baseline average consumption per customer (kWh) per TOU peak period hour.
$Peak_t$	=	An indicator variable for whether the hour is a TOU peak period hour. This variable equals one if the hour was a peak period hour and zero otherwise.
$Test_i$	=	An indicator variable for whether customer i was assigned to receive the treatment. This variable equals one if the customer was assigned to the treatment group and zero otherwise.
β_1	=	Coefficient on $Treatment_i$*$OffPeak_t$ indicating average TOU treatment effect per customer during off-peak period hours in kWh per hour.
β_2	=	Coefficient on $Treatment_i$*$Peak_t$ indicating average TOU treatment effect per customer during peak period hours in kWh per hour.
β_3	=	Coefficient on $Treatment_i$*$OffPeak_t$*$Wkend_t$ indicating average TOU treatment effect per customer during period weekend hours in kWh per hour.
$Wkend_t$	=	An indicator variable for whether the hour is a weekend (TOU off-peak) hour. This variable equals one if the hour was a weekend period hour and zero otherwise.
$\mathbf{kWh}^{Pre}_{it}$	=	A vector of variables characterizing mean consumption during the pretreatment period for customer i. This vector included mean off-peak period mean hourly consumption interacted with $Offpeak_t$, on-peak period mean hourly consumption interacted with $Peak_t$, and weekend (non-peak period) mean hourly consumption interacted with $Wkend_t$.
γ	=	A vector of coefficients indicating average effect of pretreatment kWh on consumption of customer i.
ε_{it}	=	Error term for consumption of customer i and hour t.

In the regression equation, the omitted variable is the indicator for the weekend (off-peak) period. The main coefficients of interest are β_1, β_2, and β_3, which indicate, respectively, TOU treatment effects during off-peak, peak, and weekend hours.

Cadmus estimated a separate model for each TOU treatment by OLS and clustered the standard errors on customers. To estimate the treatment effect for the TOU3 rate, which included a mid-peak period, Cadmus added an indicator variable for the mid-peak period to the specification. Again, because of the random assignment of customers to test and control groups, the regression was expected to produce an unbiased estimate of the treatment effect.

Cadmus estimated the following alternative model specifications to test the robustness of the TOU treatment effect estimates to specification changes:

- Substituting hour-of-sample fixed effects for the peak hour and off-peak hour variables.
- Adding weather variables such as cooling degree hours (CDH) or heating degree hours (HDH) to the regression.

- Omitting pretreatment mean consumption from the regression equation.
- Adding indicator variables for a customer's recruitment wave (Wave 1, Wave 2, or Wave 3) as standalone variables and interacted with other variables.

The point estimates of savings proved robust to these specification changes. The main effect was to increase or decrease the estimated standard errors.

Hybrid TOU Treatments

To estimate treatment effects for the hybrid treatments such as TOU1xPTR2 or TOU2xBDR, in Equation 2, Cadmus substituted *Peak*Event* and *Peak**(1-*Event*) *indicator* variables for the *Peak* variable, thereby allowing the effects of *Peak* and *Peak*Test* to depend on whether the hour was a Flex event hour. The *Event* variable equals 1 if the hour is a Flex event hour and equals zero otherwise.

Appendix C. Equivalency Checks and Analysis Sample Summary Statistics

Table 19 presents results from tests of differences in pre-treatment consumption between the randomized test and control groups for each treatment. Cadmus regressed customer mean pre-treatment consumption on an indicator variable for assignment to the test group and separate indicator variables for the different recruitment waves. For the PTR-only, opt-in PTR, and BDR treatments, Cadmus presents balance tests of demand in hours that would have qualified as Flex events during the pretreatment period. For the TOU-based treatments, Cadmus presents separate balance tests of demand in on-peak period and off-peak period hours during the pre-treatment period.

Table 19. Balance Tests for Flex Pilot Randomized Test and Control Groups

	Summer 2017					Winter 2017/2018				
Treatment	N	Control Group kW	ΔkW (T-C)	Std. Error	T-stat	N	Control Group kW	ΔkW (T-C)	Std. Error	T-stat
PTR1	722	1.543	0.127	0.086	1.48	678	0.828	0.020	0.058	0.34
PTR2	408	1.528	0.167	0.116	1.44	380	0.892	0.062	0.092	0.68
PTR3	889	1.608	-0.061	0.076	0.80	823	0.871	-0.047	0.055	0.85
PTR-OO	1,256	1.588	0.057	0.068	0.84	1,149	0.876	0.032	0.050	0.65
BDR	19,587	1.644	-0.006	0.017	0.35	17,889	0.891	-0.006	0.013	0.44
TOU1										
Peak	827	0.932	0.036	0.033	1.09	787	1.459	-0.007	0.052	0.14
Off-Peak	827	0.799	0.037	0.029	1.28	787	1.326	-0.001	0.048	0.01
TOU2										
Peak	1,510	1.209	0.023	0.033	0.70	1,406	1.481	-0.004	0.040	0.09
Off-Peak	1,510	0.951	-0.023	0.025	0.93	1,406	1.320	-0.011	0.037	0.30
TOU3										
Peak	849	1.059	0.002	0.027	0.07	805	1.499	-0.010	0.037	0.27
Off-Peak	849	0.889	-0.020	0.022	0.90	805	1.372	-0.010	0.035	0.29
TOU1xPTR2										
Peak	638	0.981	0.025	0.044	0.57	612	1.451	0.018	0.059	0.30
Off-Peak	638	0.784	0.012	0.037	0.33	612	1.264	0.033	0.055	0.60
TOU2xPTR2										
Peak	385	1.051	0.181	0.064	2.83	354	1.551	-0.073	0.076	0.96
Off-Peak	385	0.899	-0.015	0.042	0.36	354	1.302	-0.074	0.064	1.16
TOU2xBDR										
Peak	1,398	1.209	-0.018	0.071	0.25	1,317	1.481	0.000	0.082	0.00
Off-Peak	1,398	0.951	-0.015	0.056	0.27	1,317	1.320	0.038	0.079	0.48
TOU3xPTR2										
Peak	598	1.076	0.027	0.034	0.80	559	1.501	-0.009	0.045	0.20
Off-Peak	598.0	0.802	-0.009	0.022	0.41	559	1.300	-0.017	0.038	0.45

Notes: N is number of test and control group customers. For PTR, PTR-OO, and BDR treatments, pre-treatment demand was average kW during event hours on 10 warmest (summer) or coldest (winter) non-holiday weekdays during 60 days preceding start of treatment. For TOU and Hybrid treatments, pre-treatment demand was predicted average demand during on-peak (off-peak) hours and was estimated with a separate regression for each customer of hourly demand during peak (off-peak) period hours for summer (winter) in the year before start of treatment. Difference between test and control group demand estimated with regression of customer mean pre-treatment demand on an indicator variable for assignment to the test group and separate indicator variables for the different recruitment waves.

The results of the balance tests show the test and control groups for almost all treatments and periods were well balanced on mean pre-treatment consumption, as expected from the random assignment to treatment. The only statistically significant difference was for the TOU2xPTR2 treatment.

Table 20 presents the sample mean and standard deviation of electricity demand during Summer 2017 and Winter 2017/2018 Flex events for test and control group customers in the PTR-only, opt-in PTR, and opt-in BDR treatments.

Table 20. Analysis Sample Summary Statistics for PTR and BDR Treatments

	Summer 2017				Winter 2017/2018		
Treatment		N	Mean	Std. Dev.	N	Mean	Std. Dev.
PTR1							
	Control	8,577	2.273	1.756	6,780	1.719	1.526
	Test	8,541	2.039	1.823	6,780	1.625	1.551
PTR2							
	Control	4,446	2.222	1.898	3,500	1.826	1.792
	Test	5,178	1.939	1.781	4,100	1.802	1.727
PTR3							
	Control	10,472	2.248	1.838	8,260	1.774	1.639
	Test	10,584	1.818	1.727	8,200	1.505	1.484
PTR-OO							
	Control	15,098	2.287	1.896	11,880	1.841	1.656
	Test	14,508	2.196	1.846	11,094	1.819	1.724
BDR							
	Control	230,912	2.243	1.860	107,210	1.915	1.791
	Test	231,371	2.193	1.840	107,373	1.891	1.803

Notes: Table shows sample means and standard deviations of demand during Flex event hours for event-based treatments. N is the number of observations of hourly demand for customers.

Table 21 presents sample means and standard deviations of electricity demand during Summer 2017 and Winter 2017/2018 on-peak and off-peak hours for test and control group customers in the TOU and Hybrid treatments.

Table 21. Analysis Sample Summary Statistics for TOU and Hybrid Treatments

		Off-peak			On-Peak		
Summer 2017							
Treatment		N	Mean	Std. Dev.	N	Mean	Std. Dev.
TOU1							
	Control	625,512	0.954	1.036	559,632	1.101	1.158
	Treatment	604,901	1.038	1.180	541,227	1.155	1.216
TOU2							
	Control	1,270,420	1.042	1.203	219,965	1.417	1.447
	Treatment	4,463,949	0.990	1.077	772,815	1.306	1.365
TOU3							
	Control	1,008,796	1.019	1.125	174,680	1.352	1.365
	Treatment	1,033,528	0.972	1.099	178,925	1.281	1.297
TOU1xPTR2							
	Control	448,735	0.916	1.014	401,584	1.114	1.193
	Treatment	509,200	0.955	1.100	455,600	1.122	1.234
TOU2xPTR2							
	Control	407,496	0.988	1.088	70,560	1.370	1.376
	Treatment	510,935	0.989	1.050	88,465	1.389	1.345
TOU2xBDR							
	Control	1,270,420	1.042	1.203	219,965	1.417	1.447
	Treatment	2,092,450	0.978	1.072	362,270	1.264	1.339
TOU3xPTR2							
	Control	686,774	0.957	1.030	118,895	1.335	1.318
	Treatment	755,520	0.935	1.041	130,800	1.292	1.388
Winter 2017/2018							
Treatment		N	Mean	Std. Dev.	N	Mean	Std. Dev.
TOU1							
	Control	438,002	1.237	1.321	372,556	1.422	1.467
	Treatment	397,696	1.309	1.347	338,224	1.428	1.377
TOU2							
	Control	720,000	1.344	1.452	251,054	1.520	1.478
	Treatment	2,543,971	1.292	1.381	887,119	1.433	1.450
TOU3							
	Control	606,091	1.314	1.384	211,341	1.466	1.420
	Treatment	569,966	1.309	1.469	198,737	1.439	1.508
TOU1xPTR2							
	Control	306,386	1.221	1.366	260,568	1.450	1.515
	Treatment	344,911	1.272	1.394	293,392	1.466	1.501
TOU2xPTR2							
	Control	239,910	1.363	1.453	83,639	1.607	1.621
	Treatment	277,087	1.213	1.250	96,624	1.402	1.310
TOU2xBDR							
	Control	720,000	1.344	1.452	251,054	1.520	1.478
	Treatment	2,543,971	1.292	1.381	887,119	1.433	1.450
TOU3xPTR2							
	Control	398,239	1.294	1.392	138,865	1.526	1.535
	Treatment	419,036	1.242	1.371	146,113	1.442	1.475

Notes: Table shows sample means and standard deviations of demand during TOU on-peak and off-peak periods for TOU and Hybrid treatments. N is the number of observations of hourly demand for customers.

Appendix D. Load Impact Estimates for Summer 2016 and Winter 2016/2017

Table 22 presents savings estimates for Flex treatments during summer 2016, which was the pilot's first season. At the beginning of summer 2016, PGE had not completed customer recruitment, and many of the treatments were not fully enrolled. As a result, the sample sizes were small and the savings estimates were not precise and not statistically different from zero for many treatments. In particular, almost all TOU impact estimates were statistically insignificant.

Table 22. Flex Evaluation Findings by Treatment – Summer 2016

Category	Treatment		Summer 2016				
			N of customers	PGE Planning Savings Estimate	Evaluation		
					Savings (%)	Abs. Precision at 90% Conf.	Savings (kW)
PTR-Only	PTR1		131	13%	34%	±11%	0.65
	PTR2		447		29%	±7%	0.53
	PTR3		198		33%	±10%	0.65
Opt-Out	PTR2-OO		737	6%	17%	±5%	0.37
	BDR-OO		11,618	3%	1.3%	±1.2%	0.03
TOU-Only	TOU1	On-Peak	241	5%	3%	±6%	0.03
		Flex Event			4%	±15%	0.08
	TOU2	On-Peak	847		1%	±4%	0.01
		Flex Event			2%	±8%	0.03
	TOU3	On-Peak	232		-7%	±10%	-0.08
		Flex Event			-21%	±17%	-0.33
Hybrids	TOU1xPTR2	On-Peak	242	12.9% PTR; 5.2% TOU	6%	±8%	0.05
		Flex Event			3%	±18%	0.05
	TOU2xPTR2	On-Peak	468	12.9% PTR; 5.2% TOU	-2%	±4%	-0.02
		Flex Event			5%	±9%	0.09
	TOU2xBDR	On-Peak	561	3.0% BDR; 5.2% TOU	1%	±4%	0.01
		Flex Event			0%	±10%	0.00
	TOU3xPTR2	On-Peak	245	12.9% PTR; 5.2% TOU	1%	±7%	0.01
		Flex Event			0%	±15%	0.00

Notes: n is the number of customers included in the impact analysis. All estimates were obtained through OLS regression analysis, with standard errors clustered on customers. Green denotes the estimate was statistically significant at the 10% level.

Table 23 presents savings estimates for Flex treatments during winter 2016/2017, which was the pilot's first winter season. At the beginning of this season, PGE had still not completed customer recruitment, and many of the treatments had not met their enrollment targets. As a result, the sample sizes were small and the savings estimates were not precise and not statistically different from zero for many treatments.

Table 23. Flex Evaluation Findings by Treatment—Winter 2016/2017

Category	Treatment		Winter 2016/2017							
			N of customers	PGE Planning Savings Estimate	Evaluation					
					AM			PM		
					Savings (%)	Abs. Precision at 90% Conf.	Savings (kW)	Savings (%)	Abs. Precision at 90% Conf.	Savings (kW)
PTR-Only	PTR1		289	14%	6%	±10%	0.09	6%	±7%	0.13
	PTR2		408		-2%	±9%	-0.03	3%	±7%	0.07
	PTR3		420		1%	±8%	0.01	14%	±7%	0.31
Opt-Out	PTR2-OO		680	7%	-3%	±6%	-0.05	-4%	±5%	-0.09
	BDR-OO		10,665	3%	0.5%	±2%	0.01	0%	±1%	0.01
TOU-Only	TOU1	On-Peak	256	6%	1%	±5%	0.01	1%	±5%	0.01
		Flex Event			-4%	±9%	-0.07	3%	±8%	0.08
	TOU2	On-Peak	919		4%	4%	0.06	4%	±4%	0.06
		Flex Event			2%	±6%	0.04	2%	±5%	0.05
	TOU3	On-Peak	268		-8%	6%	-0.14	-8%	±6%	-0.14
		Flex Event			-17%	13%	-0.30	-14%	±11%	-0.30
Hybrids	TOU1xPTR2	On-Peak	236	14.2% PTR;	13%	9%	0.21	13%	±9%	0.21
		Flex Event		5.8% TOU	17%	14%	0.30	9%	±10%	0.19
	TOU2xPTR2	On-Peak	408	14.2% PTR;	7%	±5%	0.13	7%	±5%	0.13
		Flex Event		5.8% TOU	11%	9%	0.20	7%	±7%	0.15
	TOU2xBDR	On-Peak	615	3.3% BDR;	0%	±5%	0.00	0%	±5%	0.00
		Flex Event		5.8% TOU	-8%	±9%	-0.14	0%	±7%	0.00
	TOU3xPTR2	On-Peak	278	14.2% PTR;	2%	±5%	0.04	2%	±5%	0.04
		Flex Event		5.8% TOU	-2%	±11%	-0.03	8%	±8%	0.17

Notes: n is the number of customers included in the impact analysis. All estimates were obtained through OLS regression analysis, with standard errors clustered on customers. Green denotes the estimate was statistically significant at the 10% level.

Appendix E. Survey Design and Samples

This appendix describes the six customer surveys and samples that Cadmus designed and administered.

Recruitment Survey

Because opt-in control customers were denied enrollment, Cadmus fielded the recruitment survey only to treatment customers in the 10 opt-in treatments. Test group customers in the two opt-out treatments did not receive the recruitment survey as these customers were automatically enrolled rather than recruited. The recruitment survey asked questions about how customers heard about Flex, their familiarity with TOU pricing, reasons for enrolling, and their satisfaction with PGE. Table 24 shows the number of test group customers contacted for the recruitment survey and the response rate.

Table 24. Recruitment Survey Sample and Response Rate

Treatment	Test Group		
	Number of Contacted	Number of Completes	Response Rate
TOU1	62	35	56%
TOU2	158	77	49%
TOU3	49	23	47%
PTR1	38	23	61%
PTR2	144	76	53%
PTR3	65	35	54%
TOU1xPTR2	53	30	57%
TOU2xPTR2	164	80	49%
TOU3xPTR2	58	36	62%
TOU2xBDR	74	43	58%
Total	**865**	**458**	**53%**

Summer 2016 Event Survey

Cadmus fielded the event survey with test customers in the nine treatments with an event component. PGE and Cadmus also decided to field the event survey with control customers in the PTR2-OO and BDR-OO treatments to obtain a baseline metric for satisfaction with PGE. The event survey asked test customers about event notifications, whether they did anything to reduce consumption during the events, and their satisfaction with Flex and PGE. The event survey asked control customers about their familiarity with peak demand, whether they did anything to reduce consumption during days associated with peak demand, and their satisfaction with PGE. Table 25 shows the number of customers contacted for the event survey and the response rate.

Table 25. Event Survey Sample and Response Rate – Summer 2016

Treatment	Test Group			Control Group		
	Number of Contacted	Number of Completes	Response Rate	Number of Contacted	Number of Completes	Response Rate
PTR1	68	22	32%	–	–	–
PTR2	246	103	42%	–	–	–
PTR3	105	43	41%	–	–	–
TOU1xPTR2	90	30	33%	–	–	–
TOU2xPTR2	255	87	34%	–	–	–
TOU3xPTR2	94	36	38%	–	–	–
TOU2xBDR	111	27	24%	–	–	–
PTR2-OO	277	27	10%	269	36	13%
BDR-OO	3,333	302	9%	3,333	353	11%
Total	**4,579**	**677**	**15%**	**3,602**	**389**	**11%**

Summer and Winter Experience Surveys

After the end of each season, Cadmus fielded the experience survey with test customers in all 12 treatments. The experience survey asked questions about events, pricing awareness, load-reducing behaviors, participation barriers, satisfaction with the program, satisfaction with PGE, and suggestions for program improvements. Control customers were also surveyed during the winter seasons to supply comparative data for satisfaction with PGE. Table 26, Table 27, Table 28, and Table 29 show survey samples and response rates for each of the four seasonal experience surveys.

Table 26. Experience Survey Sample and Response Rate – Summer 2016

Treatment	Test Group		
	Number of Contacted	Number of Completes	Response Rate
TOU1	65	13	20%
TOU2	242	57	24%
TOU3	100	32	32%
PTR1	96	24	25%
PTR2	335	59	18%
PTR3	95	14	15%
TOU1xPTR2	88	19	22%
TOU2xPTR2	243	68	28%
TOU3xPTR2	93	18	19%
TOU2xBDR	110	15	14%
PTR2-OO	218	11	5%
BDR-OO	3,333	108	3%
Total	**5,018**	**438**	**9%**

Table 27. Experience Survey Sample and Response Rate – Winter 2016/2017

Treatment	Test Group			Control Group		
	Number of Contacted	Number of Completes	Response Rate	Number of Contacted	Number of Completes	Response Rate
TOU1	110	18	16%	–	–	–
TOU2	402	66	16%	–	–	–
TOU3	115	19	17%	–	–	–
PTR1	103	24	23%	–	–	–
PTR2	206	61	30%	–	–	–
PTR3	157	40	25%	–	–	–
TOU1xPTR2	94	17	18%	–	–	–
TOU2xPTR2	203	39	19%	–	–	–
TOU3xPTR2	110	26	24%	–	–	–
TOU2xBDR	159	18	11%	–	–	–
PTR2-OO	346	28	8%	396	42	11%
BDR-OO	3,333	132	4%	3,333	303	9%
Total	**5,338**	**488**	**9%**	**3,729**	**345**	**9%**

Table 28. Experience Survey Sample and Response Rate – Summer 2017

Treatment	Test Group		
	Number of Contacted	Number of Completes	Response Rate
TOU1	342	70	20%
TOU2	781	146	19%
TOU3	365	72	20%
PTR1	306	81	26%
PTR2	188	26	14%
PTR3	358	98	27%
TOU1xPTR2	285	67	24%
TOU2xPTR2	177	44	25%
TOU3xPTR2	260	58	22%
TOU2xBDR	766	155	20%
PTR2-OO	562	45	8%
BDR-OO	3,333	157	5%
Total	**7,723**	**1,019**	**13%**

Table 29. Experience Survey Sample and Response Rate – Winter 2017/2018

Treatment	Test Group			Control Group		
	Number of Contacted	Number of Completes	Response Rate	Number of Contacted	Number of Completes	Response Rate
TOU1	318	74	23%	389	83	21%
TOU2	746	133	18%	388	79	20%
TOU3	338	71	21%	389	88	23%
PTR1	289	88	30%	295	77	26%
PTR2	181	47	26%	169	43	25%
PTR3	339	104	31%	351	83	24%
TOU1xPTR2	275	71	26%	265	53	20%
TOU2xPTR2	172	45	26%	153	41	27%
TOU3xPTR2	251	57	23%	248	52	21%
TOU2xBDR	726	143	20%	–	–	–
PTR2-OO	507	57	11%	593	53	9%
BDR-OO	3,333	220	7%	3,333	309	9%
Total	**7,475**	**1,110**	**15%**	**6,573**	**961**	**15%**

Appendix F. Additional Survey Results

Table 30, Table 31, Table 32, Table 33, Table 34, Table 35, Table 36, Table 37, Table 38, Table 39, and Table 40 provide additional survey results, which the report's main body does not include.

Table 30. Percentage of Correct Rate Schedule Identification – Winter 2016/2017

Treatment	% Who Correctly Identified Their Rate Schedule	n
TOU-Only	**63%**	**103**
TOU1	78%	18
TOU2	58%	66
TOU3	53%	19
Hybrids	**65%**	**100**
TOU1xPTR2	76%	17
TOU2xPTR2	79%	39
TOU3xPTR2	50%	26
TOU2xBDR	56%	18
All	**64%**	**203**

Survey Question: Which image describes the rates you pay for electricity on the Flex Program?

Table 31. Flex Event Energy Conservation Participation Rates – Winter 2016/2017

Treatment	% Who Responded "Yes" to Conserving During Events	n
PTR-Only	**79%**	**125**
PTR1	79%	24
PTR2	75%	61
PTR3	85%	40
Hybrids	**81%**	**100**
TOU1xPTR2	94%	17
TOU2xPTR2	82%	39
TOU3xPTR2	92%	26
TOU2xBDR	50%	18
Opt-Outs	**64%**	**160**
BDR-OO	64%	132
PTR2-OO	61%	28
All	**73%**	**385**

Survey Question: Did you and your household do anything to conserve energy during "Flex Time" events?

Table 32. How Participants Conserved During Flex Events – Winter 2016/2017

Action Taken	% (n=313)
Shifted cooking, washing, or other chores to off-peak times	77%
Turned off lights or reduced use of lights	70%
Adjusted the heating thermostat settings by lowering the temperature	53%
Put on more layers of clothes or blankets	43%
Left the house	28%
Unplugged appliances or electronics not in use	25%
Used non-electric heating source such as wood, gas, and pellets	17%
Turned off the electric heater	15%
Lowered the water heating temperature	7%
Took some other action	7%

Survey Question: How did you and your household conserve energy during "Flex Time" events? (Select all that apply)

Table 33. Overall Satisfaction with Flex – Summer 2016

Treatment	Test Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**7.0**	**31%**	**68%**	**97**
TOU1	5.4	17%	38%	24
TOU2	7.3	34%	76%	59
TOU3	8.1	43%	86%	14
PTR-Only	**7.5**	**41%**	**78%**	**102**
PTR1	7.5	46%	85%	13
PTR2	7.0	33%	72%	57
PTR3	8.3	53%	88%	32
Hybrids	**7.1**	**32%**	**73%**	**120**
TOU1xPTR2	6.3	32%	63%	19
TOU2xPTR2	7.5	38%	79%	68
TOU3xPTR2	6.6	17%	56%	18
TOU2xBDR	6.7	20%	73%	15
Opt-Outs	**6.4**	**18%**	**53%**	**119**
BDR-OO	6.4	17%	54%	108
PTR2-OO	6.4	27%	45%	11
All	**7.0**	**30%**	**68%**	**438**

Survey Question: Please rate your overall satisfaction with the Flex Program using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Table 34. Overall Satisfaction with Flex – Winter 2016/2017

Treatment	Test Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**4.4**	**17%**	**33%**	**103**
TOU1	2.8	6%	28%	18
TOU2	4.4	15%	27%	66
TOU3	6.0	32%	58%	19
PTR-Only	**7.3**	**41%**	**78%**	**125**
PTR1	5.8	17%	63%	24
PTR2	7.3	36%	77%	61
PTR3	8.3	63%	90%	40
Hybrids	**5.9**	**20%**	**58%**	**100**
TOU1xPTR2	6.5	24%	71%	17
TOU2xPTR2	5.7	13%	54%	39
TOU3xPTR2	7.0	38%	69%	26
TOU2xBDR	4.3	6%	39%	18
Opt-Outs	**6.4**	**26%**	**63%**	**160**
BDR-OO	6.3	22%	64%	132
PTR2-OO	6.7	43%	57%	28
All	**6.1**	**26%**	**59%**	**488**

Survey Question: Please rate your overall satisfaction with the Flex Program using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Table 35. Overall Satisfaction with Flex – Summer 2017

Treatment	Test Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**7.4**	**39%**	**76%**	**288**
TOU1	6.5	23%	57%	70
TOU2	7.7	45%	82%	146
TOU3	7.8	42%	82%	72
PTR-Only	**8.1**	**48%**	**83%**	**205**
PTR1	7.9	46%	79%	81
PTR2	8.0	42%	92%	26
PTR3	8.2	52%	84%	98
Hybrids	**7.5**	**37%**	**79%**	**324**
TOU1xPTR2	7.2	34%	72%	67
TOU2xPTR2	6.9	27%	70%	44
TOU3xPTR2	8.0	50%	88%	58
TOU2xBDR	7.6	37%	81%	155
Opt-Outs	**6.4**	**27%**	**56%**	**202**
BDR-OO	6.1	23%	51%	157
PTR2-OO	7.8	40%	73%	45
All	**7.4**	**38%**	**74%**	**1,019**

Survey Question: Please rate your overall satisfaction with the Flex Program using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Table 36. Overall Satisfaction with Flex – Winter 2017/2018

Treatment	Test Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**6.3**	**23%**	**61%**	**278**
TOU1	5.9	23%	54%	74
TOU2	6.5	23%	62%	133
TOU3	6.2	23%	68%	71
PTR-Only	**8.1**	**52%**	**86%**	**239**
PTR1	7.7	44%	80%	88
PTR2	8.2	55%	89%	47
PTR3	8.3	58%	89%	104
Hybrids	**6.9**	**35%**	**71%**	**316**
TOU1xPTR2	6.9	38%	69%	71
TOU2xPTR2	6.7	18%	73%	45
TOU3xPTR2	7.1	46%	72%	57
TOU2xBDR	7.0	36%	71%	143
Opt-Outs	**6.4**	**27%**	**61%**	**277**
BDR-OO	6.2	25%	57%	220
PTR2-OO	7.3	35%	79%	57
All	**6.9**	**34%**	**69%**	**1,110**

Survey Question: Please rate your overall satisfaction with the Flex Program using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Table 37. Overall Satisfaction with PGE – Summer 2016

Treatment	Test Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**8.2**	**43%**	**93%**	**97**
TOU1	8.2	33%	92%	24
TOU2	8.2	44%	93%	59
TOU3	8.6	57%	93%	14
PTR-Only	**8.1**	**44%**	**89%**	**102**
PTR1	8.4	46%	92%	13
PTR2	7.8	37%	88%	57
PTR3	8.5	56%	91%	32
Hybrids	**7.9**	**40%**	**88%**	**120**
TOU1xPTR2	7.9	47%	84%	19
TOU2xPTR2	8.1	43%	88%	68
TOU3xPTR2	7.5	39%	89%	18
TOU2xBDR	7.6	20%	93%	15
Opt-Outs	**7.6**	**45%**	**80%**	**119**
BDR-OO	7.6	45%	80%	108
PTR2-OO	7.5	36%	82%	11
All	**7.9**	**43%**	**87%**	**438**

Survey Question: Please rate your overall satisfaction with PGE using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Table 38. Overall Satisfaction with PGE – Winter 2016/2017

Treatment	Test Group				Control Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**7.1**	**28%**	**78%**	**103**	**–**	**–**	**–**	**–**
TOU1	6.4	17%	72%	18	–	–	–	–
TOU2	7.3	30%	79%	66	–	–	–	–
TOU3	7.4	32%	79%	19	–	–	–	–
PTR-Only	**8.0**	**46%**	**87%**	**125**	**–**	**–**	**–**	**–**
PTR1	7.8	42%	88%	24	–	–	–	–
PTR2	7.9	46%	85%	61	–	–	–	–
PTR3	8.3	50%	90%	40	–	–	–	–
Hybrids	**7.5**	**35%**	**82%**	**100**	**–**	**–**	**–**	**–**
TOU1xPTR2	7.7	47%	88%	17	–	–	–	–
TOU2xPTR2	7.2	28%	79%	39	–	–	–	–
TOU3xPTR2	8.2	50%	88%	26	–	–	–	–
TOU2xBDR	6.8	17%	72%	18	–	–	–	–
Opt-Outs	**7.6**	**39%**	**83%**	**160**	**8.2**	**47%**	**90%**	**345**
BDR-OO	7.7	39%	83%	132	8.2	46%	91%	303
PTR2-OO	7.4	39%	79%	28	8.1	55%	88%	42
All	**7.6**	**38%**	**83%**	**488**	**8.2**	**47%**	**90%**	**345**

Survey Question: Please rate your overall satisfaction with PGE using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Table 39. Overall Satisfaction with PGE – Summer 2017

Treatment	Test Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**8.4**	**56%**	**91%**	**288**
TOU1	8.0	41%	91%	70
TOU2	8.5	62%	92%	146
TOU3	8.5	56%	90%	72
PTR-Only	**8.7**	**63%**	**93%**	**205**
PTR1	8.5	59%	94%	81
PTR2	8.7	65%	92%	26
PTR3	8.8	66%	93%	98
Hybrids	**8.3**	**54%**	**88%**	**324**
TOU1xPTR2	8.6	55%	91%	67
TOU2xPTR2	7.4	36%	77%	44
TOU3xPTR2	8.3	60%	86%	58
TOU2xBDR	8.5	57%	90%	155
Opt-Outs	**8.1**	**50%**	**85%**	**202**
BDR-OO	8.0	48%	83%	157
PTR2-OO	8.3	53%	91%	45
All	**8.4**	**56%**	**89%**	**1,019**

Survey Question: Please rate your overall satisfaction with PGE using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Table 40. Overall Satisfaction with PGE – Winter 2017/2018

Treatment	Test Group				Control Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**7.7**	**42%**	**79%**	**278**	**8.4**	**55%**	**90%**	**250**
TOU1	7.3	36%	78%	74	8.2	52%	87%	83
TOU2	7.8	47%	77%	133	8.8	65%	96%	79
TOU3	7.8	38%	86%	71	8.2	50%	86%	88
PTR-Only	**8.5**	**54%**	**91%**	**239**	**8.4**	**53%**	**91%**	**203**
PTR1	8.4	51%	88%	88	8.3	47%	91%	77
PTR2	8.3	51%	91%	47	8.2	49%	88%	43
PTR3	8.7	59%	93%	104	8.5	61%	93%	83
Hybrids	**7.9**	**47%**	**84%**	**316**	**8.2**	**51%**	**91%**	**146**
TOU1xPTR2	8.2	54%	86%	71	7.9	51%	89%	53
TOU2xPTR2	7.7	40%	84%	45	8.4	54%	95%	41
TOU3xPTR2	7.7	44%	79%	57	8.4	50%	90%	52
TOU2xBDR	7.9	46%	85%	143	–	–	–	–
Opt-Outs	**7.8**	**42%**	**84%**	**277**	**8.2**	**49%**	**88%**	**362**
BDR-OO	7.7	40%	81%	220	8.2	50%	89%	309
PTR2-OO	8.3	49%	95%	57	7.7	42%	81%	53
All	**8.0**	**46%**	**84%**	**1,110**	**8.3**	**52%**	**89%**	**961**

Survey Question: Please rate your overall satisfaction with PGE using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."