MEMO

Date: June 5, 2020

To: Brian A. Smith, PG&E

From: Aimee Savage and Stephanie Bieler, Nexant, Inc.

Re: Phase One Report: Early M&V to Inform PG&E's 2019 Savings Claims for Universal Audit Tool (UAT)

Summary of Phase One

The residential Universal Audit Tool (UAT) is an online survey designed to identify no- and low-cost energy savings actions that renters and homeowners can undertake to save energy. The UAT is offered to customers of California's Investor-Owned Utilities under different brand names whereby customers log in using their utility customer credentials and are ported to the UAT. Branded to PG&E customers as the Home Energy Checkup (HEC), UAT provides residential customers with advice on energy efficiency, insight into areas of high energy use, and tips and suggestions for saving both energy and money based on responses to a series of questions regarding household appliances, occupancy, and other dwelling characteristics. It's designed dynamically in the sense that, the more information a customer provides about housing attributes and occupant behaviors, the more customized the audit recommendations become.

This memo represents the culmination of phase one of a two-phase project investigating the savings resulting from participation in the UAT. Phase one includes the following task elements:

- Prepare a "Workpaper Plan" (WPP) that summarizes the processes and methods for estimating savings resulting from the UAT and addresses the requirements in the CPUC's "Non-Standard Disposition Rejecting Southern California Gas Company's Universal Audit Tool Energy Efficiency Workpaper - WPSCGREHC180409 Rev 0" issued to the Joint IOUs on February 13, 2019. The WPP provides the methodological foundation for the Statewide UAT Workpaper. This task was completed.
- Provide technical support in the preparation of the statewide workpaper for the Universal Audit Tool. PG&E submitted Revision 1.0 of the Universal Audit Tool Workpaper SWWB002-01 on December 19, 2019.
- Produce this present memorandum that summarizes the findings of the UAT gross savings analysis. These estimates will be used as a key input to the 2019 *ex ante* savings claims for this measure.
- Submit this memo to the CPUC and its residential evaluation consultant team as a preliminary step to advance the goal of identifying a single set of comparison groups for both savings claim ("Early M&V") and impact evaluation purposes for the UAT measure moving forward. The specific method and process for collaborating on comparison group formation has not been finalized, but providing this documentation as a basis for a

review and critique of the matching methodology will serve as a key step toward achieving this goal.

Table 1 and Table 2 summarize the electric energy and natural gas savings estimates from the HEC tool for 2018, respectively. A total of 133,596 customers used the tool in 2018, leading to a total of 13,993 MWh in electric savings and 265,335 therms in natural gas savings. On average, each customer who used the tool saved 104.7 kWh annually and 2.5 therms annually, or 1.7% of their annual electric usage and 0.5% of their annual gas usage. Of the customers who used the tool, 28,381 were defined to be high engagement customers and 105,215 were low engagement customers.

High engagement customers had greater savings than low engagement customers, on average, saving 144.6 kWh and 3.4 therms annually. Low engagement customers saved an estimated 94.1 kWh and 2.2 therms annually. Natural gas savings were not statistically significant, however.

Table 1: 2018 HEC Electric Energy Savings

Engagement Level	Number of Participants	% Savings	Aggregate Annual Savings (kWh)
All Users	133,596	1.7%	13,993,012
Low Engagement	105,215	1.5%	9,902,188
High Engagement	28,381	2.2%	4,104,160

Table 2: 2018 HEC Natural Gas Savings

Engagement Level	Number of Participants	% Savings	Aggregate Annual Savings (therms)
All Users	103,940	0.5%	256,335
Low Engagement	81,349	0.5%	179,347
High Engagement	22,591	0.7%	76,820

Methodology

Nexant estimated energy savings using a matched control group and a difference-in-differences (DID) methodology, as described in the Universal Audit Tool work paper recently submitted to the Energy Division[1]. This method estimates impacts by subtracting treatment customers' loads

[1] SWWB002-01 Whole Building Universal Audit Tool

from control customers' loads in each month after the treatments are in place and subtracts from this value the difference in loads between treatment and control customers for the same period in the pretreatment period. Subtracting any difference between treatment and control customers prior to the treatment going into effect adjusts for any differences between the two groups that might occur due to inaccuracies in the matching algorithms.

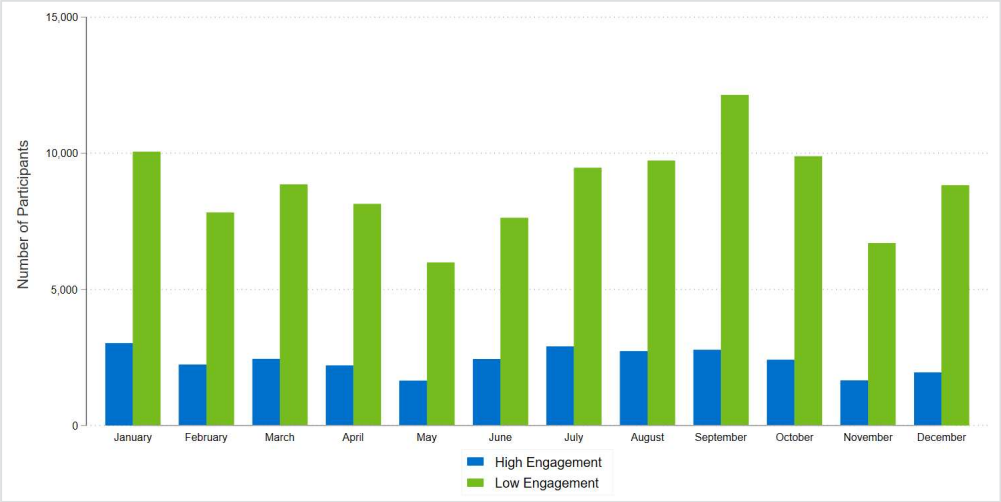
For the purposes of developing the matched control groups, HEC participants were first segmented into cohorts based on the month of their initial engagement with the audit tool in 2018. In other words, the "September 2018" cohort is the group of customers which engaged with the online audit tool for the first time in 2018 during the month of September. While a matched comparison group was developed for each cohort separately, the energy savings were assessed with a single model across all cohorts.

Finally, Nexant classified participants based on their level of engagement with the tool.[2] Customers who used the tool, but never visited the HEC Disaggregation page after completing the audit, were classified as "low engagement." Participants who visited the HEC Disaggregation page at least once after completing the audit were classified as "high engagement." High engagement and low engagement customers were not matched separately (as each customer is matched separately based on characteristics unique to that customer); however, the energy savings were assessed separately for each engagement level.

Figure 1 summarizes the number of customers in each cohort and engagement level for 2018. Each cohort was matched separately based on their 12 months of pre-HEC usage and impacts for each cohort were estimated for 12 months following their interaction with the tool. Across all cohorts, pre-treatment months included January 2017 through November 2018 and impacts were measured from January 2018 through November 2019.

[2] This participant classification method is consistent with, but not identical to, the process used in the most recent impact evaluation of the UAT. See DNV GL (2017). Universal Audit Tool Impact Evaluation – Residential. California Public Utilities Commission. CALMAC ID CPU160.01.

Figure 1: 2018 Participation by Cohort and Engagement Level



Control Group Selection & Validation

As a first step in the comparison group selection process, Nexant received customer characteristics data for the entire residential PG&E population. This data included (but was not limited to) billing data, housing type, customer rates, and customer location. Using this data, Nexant selected a very large sample of non-HEC users from the general population to serve as pool of potential control customers. To minimize self-selection, stratification was used so that matching efforts were focused within narrow geographical locations and rate classes. The control pool contained 10 non-participants for every one HEC participant. Nexant then submitted a data request to PG&E for hourly electric consumption and daily gas consumption for 2017 through 2019 for approximately 938,000 non-participants and 96,000 HEC participants.[3]

Nexant then selected matched control groups using a statistical technique called propensity score matching (PSM). Propensity scores are calculated for all HEC users using a probit statistical model. Probit models estimate probabilities—in this case, the probability that a customer would use the HEC tool. The propensity score can be thought of as a summary variable that includes all the relevant information in the observable variables about whether a customer would choose to use the HEC tool. The propensity score is our estimate of the probability that a customer would use the HEC tool. Propensity scores were estimated for all HEC users as well as for all customers in the control pool.

Each customer in the HEC population was matched with a customer in the non-HEC population that has the closest propensity score. One match was found for each HEC customer, but the same control customer could be matched to multiple HEC users, meaning that a control

[3] Participants are defined to be residential customers who used the tool in 2018

customer could be represented more than once in the control group. Matching was conducted separately to estimate natural gas savings and electric savings. For electric savings, customers were clustered based on their average annual weekday electric load shape and we enforced an exact match on that load shape as well as the customer's net-metering status. For natural gas savings, we enforced an exact match on the customer's local capacity area (LCA).

Equation 1 shows the basic form of the logit model specification used for selecting matched control groups for the HEC user population. Table 3 follows, which provides the definitions of the variables in Equation 1.

Equation 1: Propensity Score Matching

$$Propensity\ score = \phi(\alpha + \beta_1 x_1 + \cdots + \beta_p x_p)$$

Table 3: Description of Propensity Score Matching Variables

Variable	Description
$Propensity\ score$	Probability of a customer using the HEC tool
ϕ	Standard cumulative normal distribution
α	The probability of a customer using the HEC tool if all the predictors are equal to zero
β_1	Coefficient of the first variable chosen to be a predictor
x_1	The first predictor chosen to be used in the model
β_p	Coefficient of the last variable that was chosen to be a predictor
x_p	The last predictor chosen to be used in the model

The predictor variables included for each analysis are as follows:

Electric:

- Average daily consumption, consumption during the resource adequacy (RA) window as a percent of total daily consumption; monthly consumption during July, August, and December; CARE status; and customer location (Bay Area vs. non-Bay Area).

Natural gas:

- Average daily consumption; monthly consumption during January, June, and December; CARE status; and housing type.

Figure 2 and Figure 3 compare average daily energy usage during pre-treatment months for electric energy and natural gas, respectively. Note that the pre-treatment months are labeled based on where they are located in the pre-treatment period, with month 12, for example, referring to the month 12 months prior to the customer using the tool. Across all cohorts, the largest difference in pre-treatment usage was 1.4% for electric consumption and less than 0.1% for natural gas consumption. While some small differences exist, the differences between treatment and control groups for each cohort were generally found to not be statistically significant. Additionally, any differences noted below were accounted for using the difference-in-differences analysis.

Figure 2: Comparison of Electric Energy Usage during Pre-Treatment Months

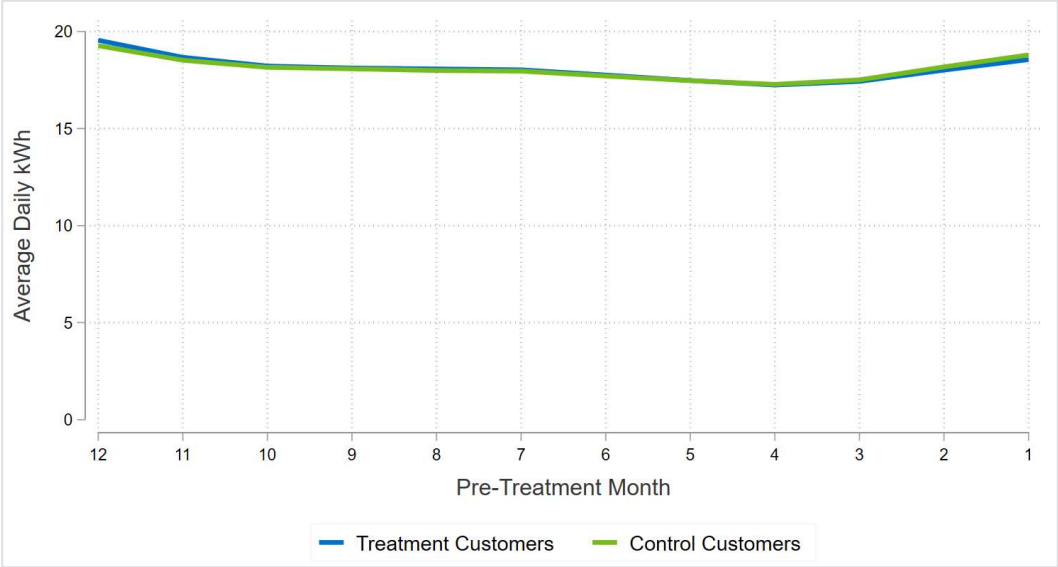


Figure 3: Comparison of Natural Gas Usage during Pre-Treatment Months

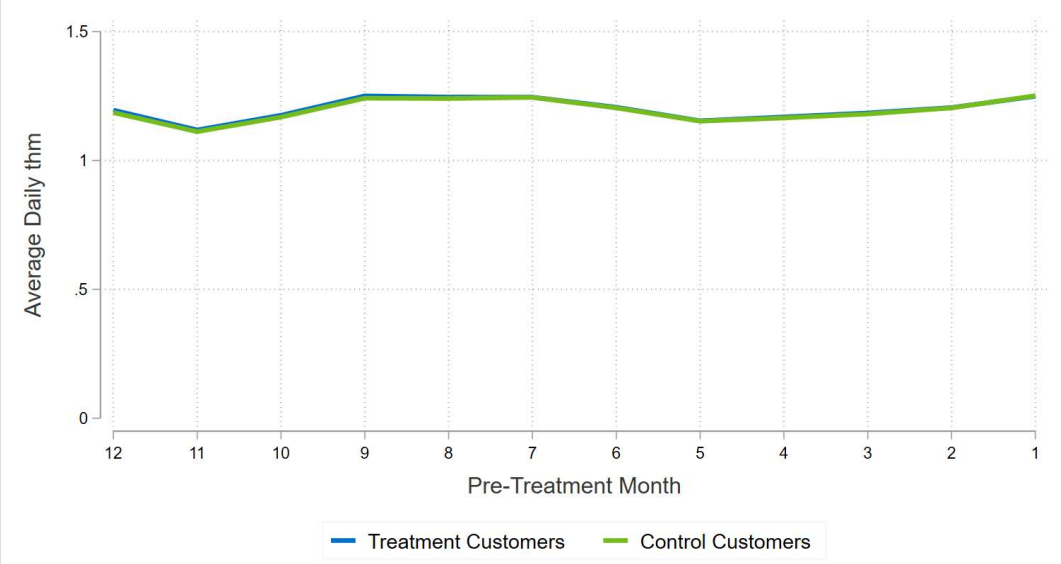


Figure 4 and Figure 5 compare the overall distribution of pre-treatment annual electric and natural gas consumption, respectively, for the HEC users and the control groups. For electric energy, the average control customer's annual consumption is 0.3% higher than the average HEC user's annual consumption. For natural gas, the average control customer's annual consumption is 0.7% higher than the average HEC user's annual consumption. While some small differences exist, the differences between treatment and control groups for each cohort were generally found to not be statistically significant.

Figure 4: Comparison of Distribution of Annual Electric Energy Consumption

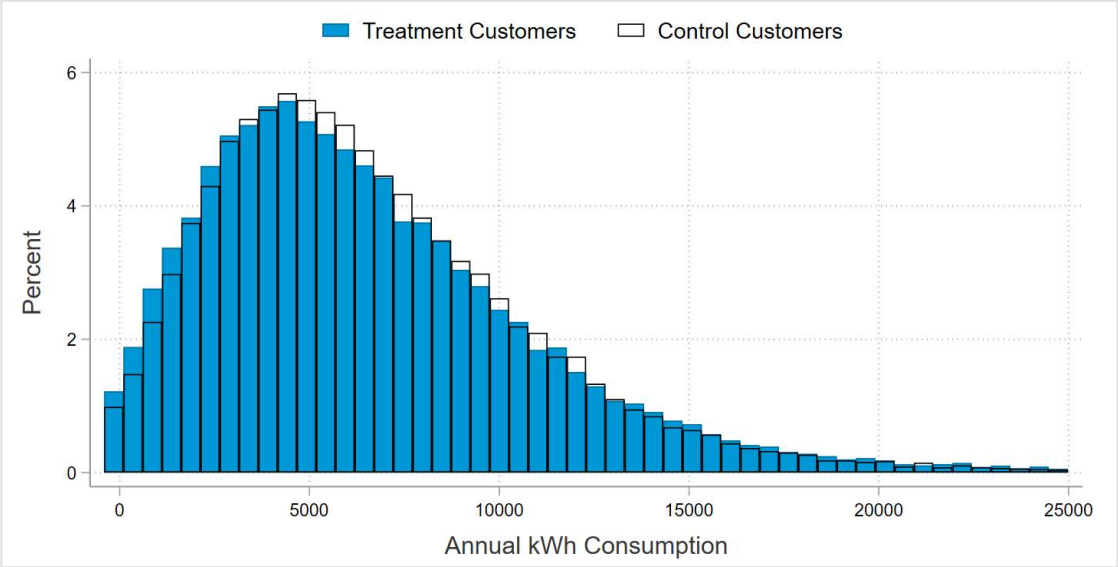
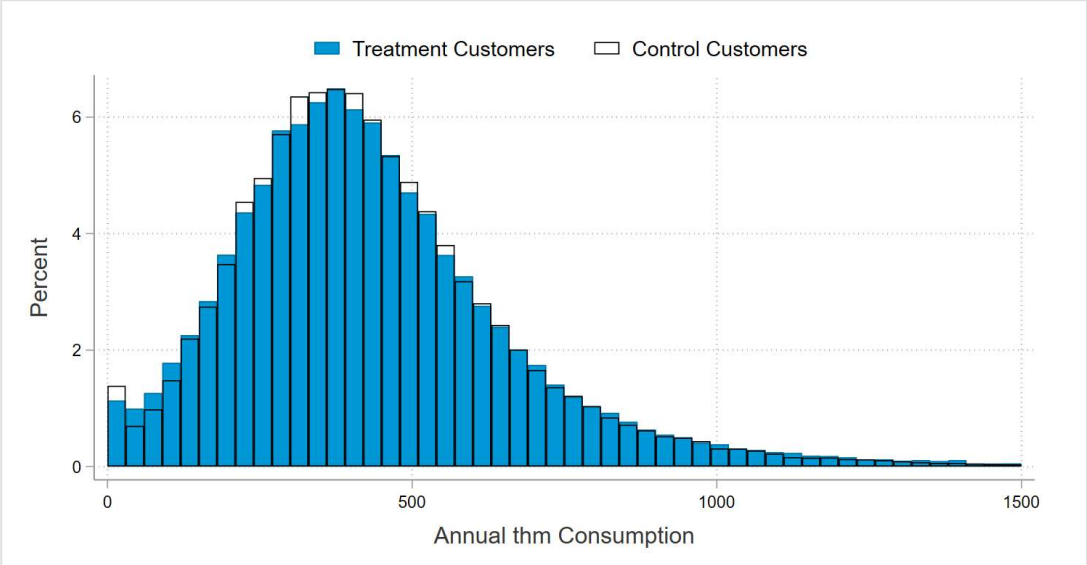


Figure 5: Comparison of Distribution of Annual Natural Gas Consumption



Energy Savings Estimation

Energy savings were estimated for natural gas and electric energy, both on a per-customer and aggregate basis. As discussed earlier, comparison groups were selected separately for each HEC cohort based on when each customer used the tool (defined by month in 2018). However, Nexant estimated a single savings model across all 12 cohorts for each month. The analysis dataset included 12 months of pre-HEC data and 12 months of post-HEC data for each

participant (and their matched control customer). Therefore, a customer who used the tool in January 2018 was not included in the March 2019 savings estimate.

Equation 2 shows the model specification used for estimating impacts for each month for each post treatment month. Table 4 follows, which provides the definitions of the variables in Equation 2.

Equation 2: Impact Estimation

$$kW_{i,t} = \alpha_i + \gamma \text{post}_t + \beta(\text{treatpost})_{i,t} + v_i + \varepsilon_{i,t}$$

Table 4: Description of Impact Estimation Variables

Variable	Description
$kW_{i,t}$	Electric energy usage during the period of interest for each customer
α_i	Mean usage for each customer for the relevant time period
γpost_{t_1}	Treatment variable, equal to 1 for days after a customer has completed the online survey a value of 0 for days during the pretreatment period
$\beta(\text{treatpost})_{i,t}$	Difference-in-differences estimator of the treatment effect that makes use of the pretreatment data
v_i	Customer fixed effects variable that controls for unobserved factors that are time-invariant and unique to each customer
$\varepsilon_{i,t}$	Error term

Energy Savings

Figure 6, Figure 7, and Figure 8 summarize the average monthly electric savings for each month for all customers, low engagement customers, and high engagement customers respectively. Generally, we do not see program savings appear until the summer of 2018, with savings then remaining relatively constant for the remainder of the period until they declined at the end of 2019. The decline at the end of 2019 appears to be due to the fact that customers that used the HEC tool at the end of 2018 (November and December cohorts) had lower savings relative to the early cohorts, and were the only users included in the savings at the end of 2019. Generally speaking, electric energy savings were not statisically significant at the monthly level, with a few exceptions.

Figure 6: Monthly Electric Savings per Household - All Customers

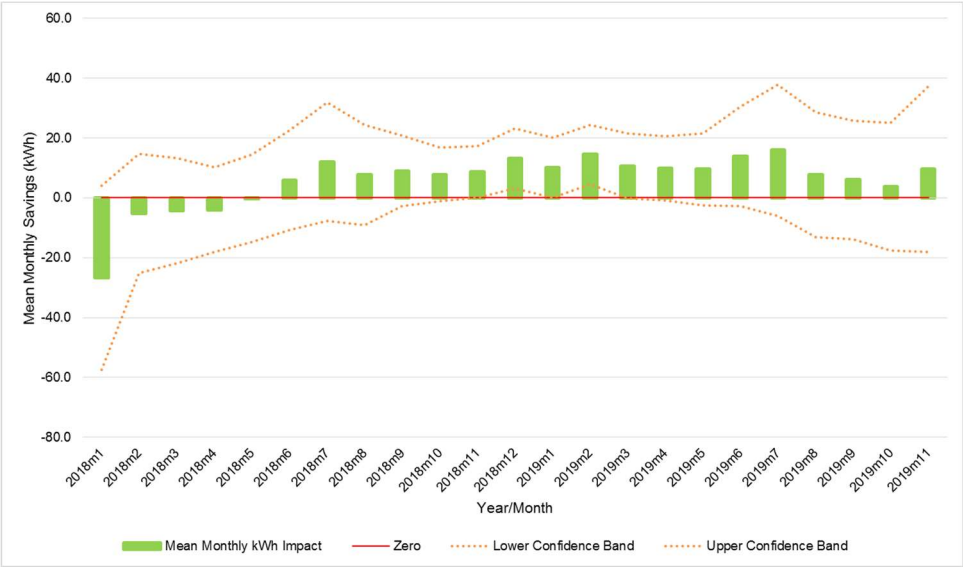


Figure 7: Monthly Electric Savings per Household - Low Engagement Customers

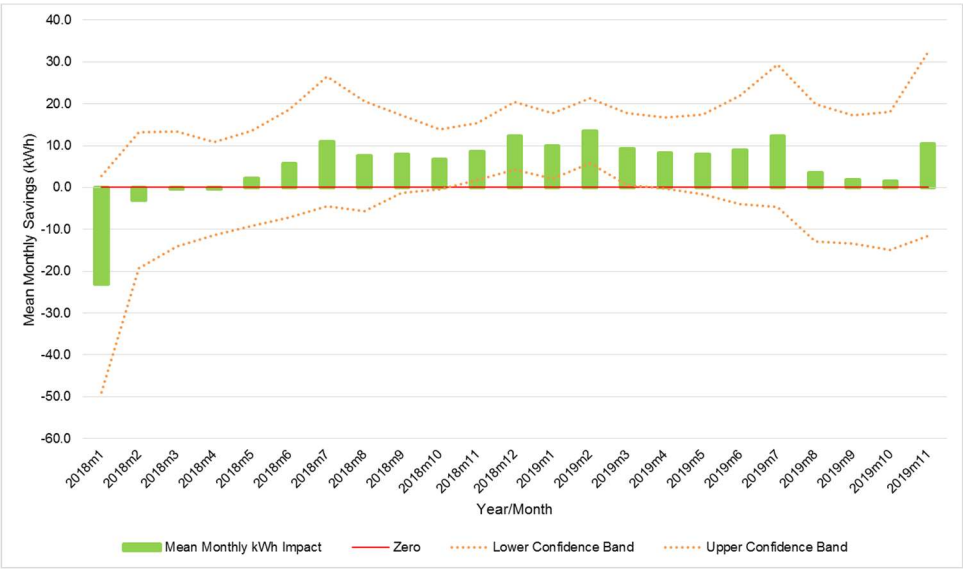


Figure 8: Monthly Electric Savings per Household - High Engagement Customers

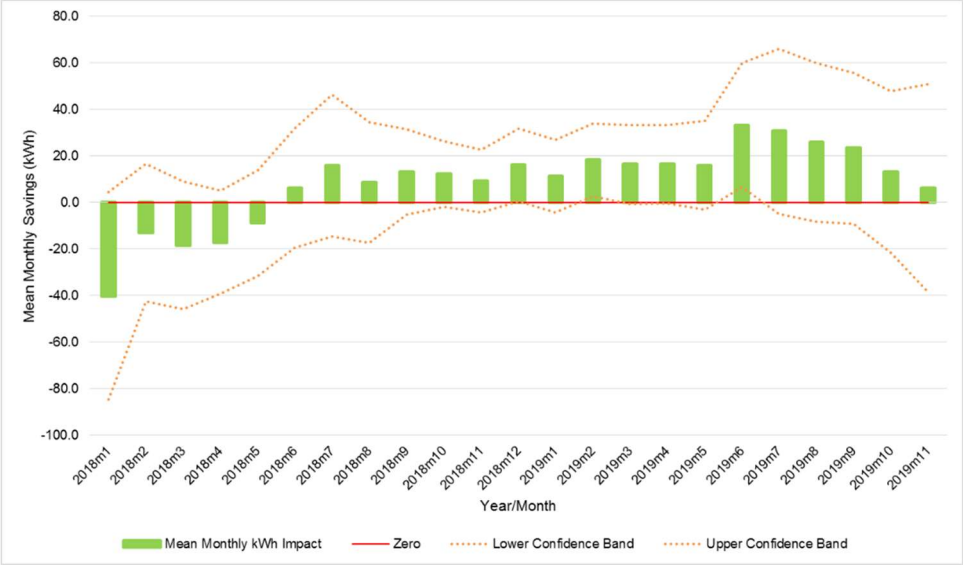


Figure 9, Figure 10, and Figure 11 summarize the average monthly natural gas savings for each month for all customers, low engagement customers, and high engagement customers respectively. Unlike the electric energy savings, gas savings are more seasonal, with higher savings in the winter relative to other months. However, natural gas energy savings were not statistically significant in most months for both levels of engagement (separately and combined).

Figure 9: Monthly Gas Savings per Household – All Customers

Figure 10: Monthly Gas Savings per Household – Low Engagement Customers

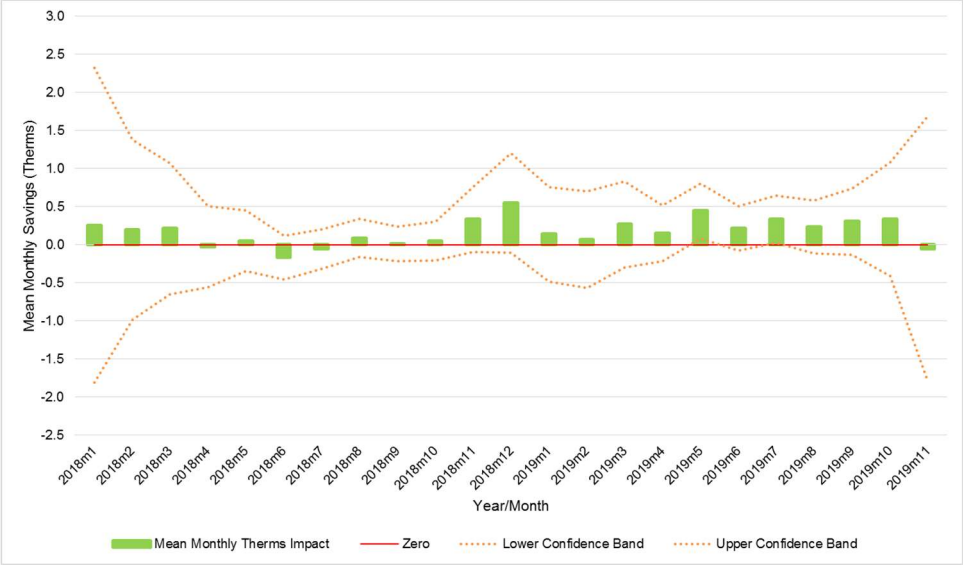


Figure 11: Monthly Gas Savings per Household – High Engagement Customers

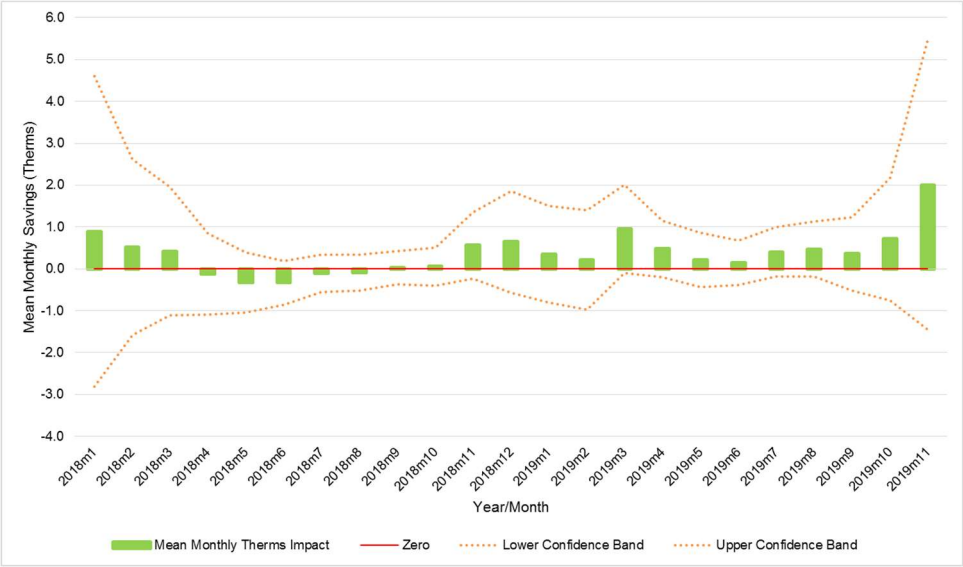


Table 5 and Table 6 summarize the average annual electric and natural gas energy savings for for all customers, low engagement customers, and high engagement customers. We see that while savings were not necessarily statistically significant at the monthly level, the electric annual savings are statistically siginficant for both engagement levels. Annual natural gas savings are not statistically significant for any of the customer groups.

Table 5: Annual Electric Savings

Engagement Level	Number of Participants	Average Annual Baseline (kWh)	Average Annual Savings (kWh)	90% Confidence Interval		% Savings	Aggregate Annual Savings (kWh)
All Users	133,596	6,221	104.7	22.3	187.2	1.7%	13,993,012
Low Engagement	105,215	6,166	94.1	28.7	159.5	1.5%	9,902,188
High Engagement	28,381	6,429	144.6	15.5	273.7	2.2%	4,104,160

Table 6: Annual Natural Gas Savings

Engagement Level	Number of Participants	Average Annual Baseline (therms)	Average Annual Savings (therms)	90% Confidence Interval		% Savings	Aggregate Annual Savings (therms)
All Users	103,940	455	2.5	-2.0	7.0	0.5%	256,335
Low Engagement	81,349	454	2.2	-1.4	5.8	0.5%	179,347
High Engagement	22,591	458	3.4	-3.3	10.2	0.7%	76,820

Joint Savings with Home Energy Report Program

The possibility of joint savings between PG&E's Home Energy Report (HER) program and HEC is a significant area of interest. Because HERs promote the HEC, it has been hypothesized that customers in HER treatment conditions are more likely than customers in control conditions to engage with the tool. Cross-participation in both HER and HEC can lead to a conflation of the impact of the two programs. Prior research on the potential overlap in savings has not found evidence of joint savings,[4] however, the percent of customers in HER treatment and control conditions who engaged with the tool in 2018 was estimated as part of Phase One. The difference in participation rates between treatment and control, summarized in Table 7, was statistically significant in seven out of sixteen HER experimental waves.

[4] See section 3.4.9: UAT HER Overlap. DNV GL (2017). Universal Audit Tool Impact Evaluation – Residential. California Public Utilities Commission. CALMAC ID CPU0160.01

Table 7: HEC Participation Rates among HER Treatment and Control Customers[5]

HER Experimental Wave	% of HER Customers that Used HEC in 2018		P-Value
	Treatment	Control	
Beta	3.1%	2.8%	0.05
Gamma Standard	2.3%	2.1%	0.25
Gamma Reduced	2.3%	2.1%	0.12
Gamma All Electric	1.8%	1.9%	0.23
Gamma Gas Only	4.6%	3.5%	0.55
Wave 1	2.4%	2.3%	0.03
Wave 1 All Electric	2.2%	2.0%	0.54
Wave 2 Area 7	2.3%	2.0%	0.00
Wave 2 Not Area 7	2.3%	2.3%	0.96
Wave 3	2.5%	2.5%	0.57
Wave 4	2.5%	2.3%	0.07
Wave 5	2.9%	2.7%	0.03
Wave 6	2.8%	2.5%	0.01
Wave 7	2.7%	2.7%	0.93
Wave 8	1.6%	1.6%	0.91
Wave 9	4.0%	3.7%	0.07

Joint savings is estimated as a function of the uplift in HEC participation among customers in HER treatment conditions and the estimated annual HEC savings, shown in Equation 3.

Equation 3: Impact Estimation

$$\begin{aligned} Joint\ Savings \\ &= \%\ Uplift\ in\ HEC\ Participation \\ &\times\ Number\ of\ HER\ Treatment\ Customers \\ &\times\ HEC\ savings\ per\ participant \end{aligned}$$

Table 8 presents the joint savings estimate between the two programs for 2018. The total electric joint savings is estimated to be 205,658 kWh, which represents 0.2% of Nexant's 2018 HER kWh savings estimate. The estimated natural gas savings overlap is 4,853 therms, or 0.1% of the 2018 HER savings estimate.

[5] This table only includes experimental waves that were in field in 2018

Table 8: HER and HEC Joint Savings

Wave	% Uplift in HEC Participation	Number of HER Treatment Customers (2018 Average)	HEC Savings per Participant (kWh)	Joint Savings (kWh)	HEC Savings per Participant (therms)	Joint Savings (therms)
Beta	0.2%	36,512	104.7	9,373	2.5	221
Gamma Standard	0.1%	41,935		5,229		123
Gamma Reduced	0.2%	41,969		7,078		167
Gamma All Electric	-0.2%	19,883		-3,459		NA
Wave 1	0.2%	219,642		36,958		870
Wave 1 All Electric	0.1%	19,898		3,008		NA
Wave 2 Area 7	0.3%	51,463		18,350		432
Wave 2 Not Area 7	0.0%	198,819		-1,045		-25
Wave 3	0.0%	132,881		-6,846		-161
Wave 4	0.2%	110,372		19,334		455
Wave 5	0.2%	130,449		32,027		754
Wave 6	0.3%	191,137		54,710		1,288
Wave 7	0.0%	123,720		1,243		29
Wave 8	0.0%	127,996		-1,499		-35
Wave 9	0.3%	96,929		31,197		735
2018 Total	**0.1%**	**1,543,602**		**205,658**		**4,853**

As indicated in the workpaper submitted to ED, joint savings between the two programs shall result in a downward adjustment to the HER savings claim. This is similar to the proceedure for estimating joint savings between the HER program and rebate measures. As the tables above indicate, this adjustment would be very small (less than 1%).

Conclusions

In 2018, the HEC produced small, but statistically significant electric energy savings for high engagement and low engagement customers. However, savings were generally not statistically significant at the individual monthly level. Annual percent savings were similar to those produced by PG&E's HER program. Gas savings attributable to the HEC were not statistically significant for either level of engagement (or the two combined). Finally, joint savings between the HER program and the HEC program were found to be quite small relative to the total savings from each program.