SAFER, SMARTER, GREENER

Impact Evaluation Report

Commercial HVAC Sector – Program Year 2019

EM&V Group A

CALIFORNIA PUBLIC UTILITIES COMMISSION

May 14, 2021

CALMAC ID: CPU0228.01

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1 EXECUTIVE SUMMARY

This report presents the electric and natural gas energy savings evaluation of commercial heating, ventilation, and air conditioning (HVAC) equipment in ratepayer-funded energy-efficiency programs in program year (PY) 2019. DNV GL estimated energy and peak demand savings for two selected HVAC technology groups, package terminal air conditioner (PTAC) controls and rooftop/split systems, across programs. The programs are offered by the following program administrators (PAs): San Diego Gas and Electric Company (SDG&E), Southern California Edison (SCE), and Pacific Gas and Electric Company (PG&E). We conducted this evaluation as part of the California Public Utilities Commission (CPUC) Energy Division (ED) Evaluation, Measurement & Verification contract.

The primary goals of this PY2019 evaluation are to:

- Assess savings for electric demand in kilowatts (kW), electric consumption in kilowatt-hours (kWh), and gas consumption in therms with a focus on quantifying peak demand impacts of the selected HVAC technologies.
- Determine the savings that occur as a result of the program with respect to end users, decision makers, and distributors.
- Provide insights into how evaluated HVAC technologies are producing energy savings cost-effectively and what improvements can be made to move towards strategic statewide energy-efficiency goals.

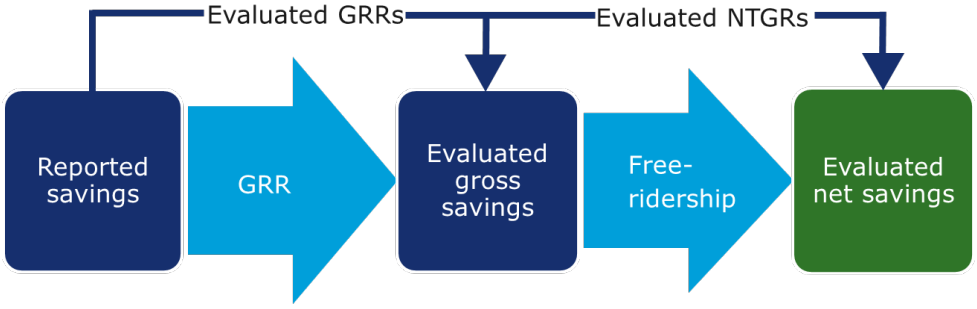
Central to this evaluation was collecting data from participating end user customers and decision makers (those who make the decision to implement an energy efficiency project) to adjust key technical parameters that affect the calculation of energy and demand savings.

The first major step was estimating the gross savings for each of the two evaluated technologies. Gross savings are the changes in energy and power demand that resulted from energy efficiency program activities, regardless of what factors may have motivated the program participants to take actions. We compared the evaluated gross savings with the gross savings reported by PAs to develop ratios of the evaluated savings estimated to the PA-reported savings values, which are referred to as gross realization rates (GRRs).

We also estimated the amount of savings that resulted from the program. This estimate is developed by first estimating the amount of "free-ridership," which represents the savings that would have occurred without the incentive being provided (e.g., because the customer indicates s/he would have purchased the equipment at full cost if the incentive had not been offered). From this, net-to-gross ratios (NTGRs) can be estimated for each of the evaluated technologies by subtracting the free-ridership savings from the gross savings and dividing by gross savings. An evaluated NTGR of 100% would indicate that the energy and gas savings were completely due to the influence of the incentive offered by the program. A score less than 100% means that other factors were responsible for the energy savings.

NTGR values are used to calculate the evaluated technologies' net savings, which tell us how much impact the program had on the evaluated technologies' electricity and gas savings. Figure 1-1 illustrates how the GRRs and NTRGs are applied.

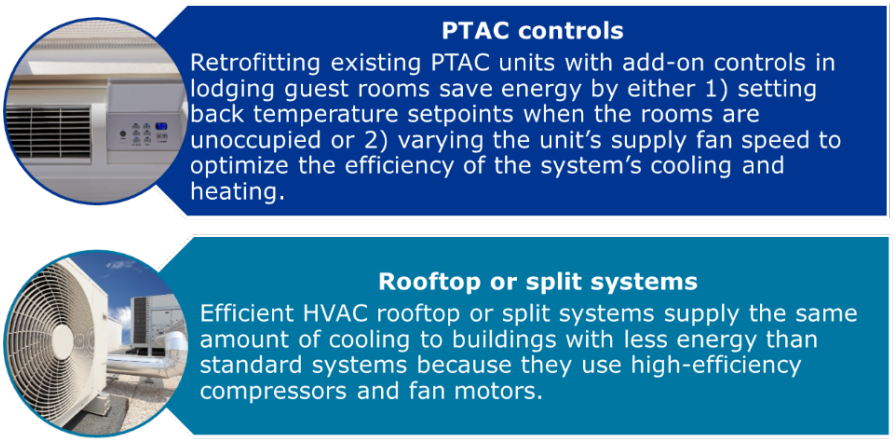
Figure 1-1. Energy savings evaluation process: getting from gross to net



1.1. Study background and approach

The evaluation approaches of the two selected HVAC technologies were built on previous HVAC program evaluation methods. The two selected HVAC technologies evaluated in PY2019 were package terminal air conditioner (PTAC) controls and rooftop/split systems, which are summarized in Figure 1-2. The PTAC controls and rooftop/spit systems technology groups are the top two contributors to the commercial HVAC savings portfolio and represent 41% and 23% of first-year kWh savings reported, respectively.

Figure 1-2. Summary of evaluated technologies

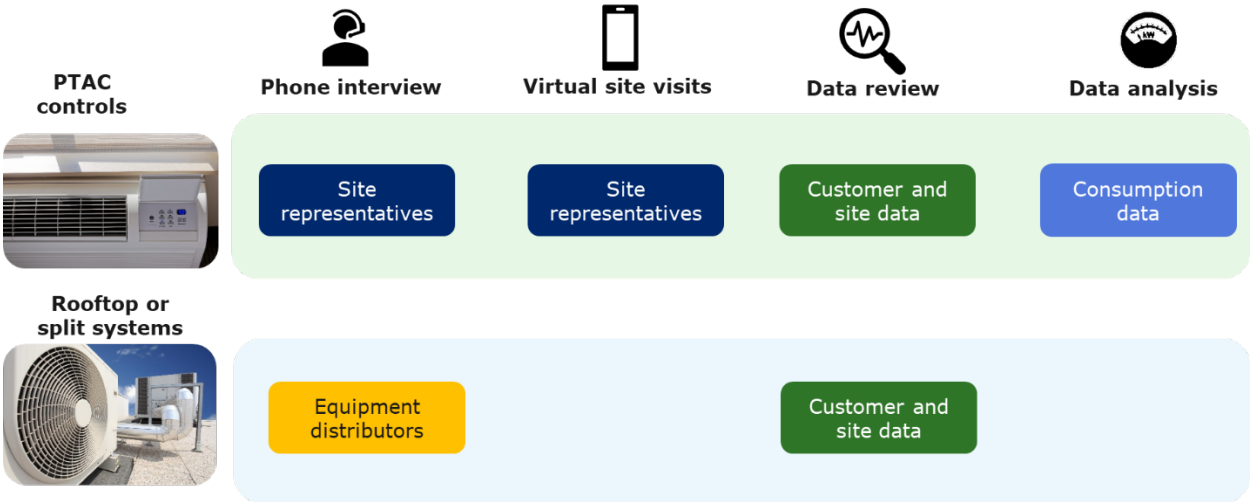


To estimate gross savings, we performed remote site visits in order to verify equipment installation and operation as well as collect site-specific data. In response to the COVID-19 pandemic, we collected data from the site representative through meetings via online platforms such as Zoom or Microsoft Teams. For PTAC controls, we completed 87 remote site visits out of a target sample of 85. We did not conduct remote site visits for the rooftop/split system technology, but we did perform a desk review of 300 sites. Physical or remote site visits are preferred as they allow the evaluator to measure critical inputs like installation and attrition rates. However, the combination of incomplete tracking data (e.g., site contact information was for participating trade ally and not recipient of installed equipment) and the COVID-19 pandemic led the evaluators to devote heavier resources toward requesting data from PAs and verifying the building type for the installation address.

Additional data sources that supported the gross savings estimates included utility meter billing data, energy management system (EMS) data, and internet-based research to verify installation locations. Net savings were estimated from phone surveys of decision makers. For PTAC controls, the evaluation team completed 87 phone surveys of decision makers out of a census attempt.

To assess gross savings for the rooftop/split systems technology group, we used existing reporting data (PY2019) and its supporting sources, PY2018-developed energy simulation outputs, and web research. We performed a thorough desk review of reported savings sources, reviewed and corrected the reported technology installation locations, assigned the appropriate building type based on the web research of the actual installation location, and then applied PY2018 developed evaluation savings estimates where appropriate. We also leveraged applicable PY2018 free-ridership estimates to determine the evaluated net savings estimates. Net attribution estimates for the rooftop/split systems technology group are built upon the 2018 survey results from 23 decision makers and eight program participating equipment distributors. A summary of key data collection sources and activities used to calculate the savings of the two HVAC technology groups are provided in 3.

Figure 1-3. Key data collection sources and activities by technology group



1.2. Evaluated savings results

Table 1-1 on the next page provides a summary of the programs' success in providing gas and electric savings through the two technologies.

The table presents evaluated net savings compared with the PA-reported net savings, and then in the last column, the net realization rate (NRR). The NRR removes the savings from installations that would have happened even if there were no rebates and is calculated as the ratio of the evaluated net savings value to the PA-reported net savings value. Thus, the NRR indicates the true impact of the ratepayer-funded program. The higher the NRR value, the greater the program's achieved savings.

Table 1-1. Statewide net electric and gas savings results by technology

Technology (Measure) Group	Evaluated Net Savings	Reported Net Savings	Net Realization Rate (NRR)
Electric Consumption (kWh)			
PTAC controls	2,450,185	11,654,377	21%
Rooftop/split systems	2,408,401	8,298,476	29%
Peak Electric Demand (kW)			
PTAC controls	462	4,084	11%
Rooftop/split systems	1,886	4,211	45%
Gas Consumption (therms)			
PTAC controls	Not applicable	Not applicable	Not applicable
Rooftop/split systems	-596	-41,223	1%

The next sections present more detailed results of the gross and net savings evaluation by HVAC technology group, followed by a summary of key findings.

1.2.1 PTAC controls technology group

This technology group uses controls on the PTAC and package terminal heat pump (PTHP) units found mainly in hotel and motel guest rooms. Two PAs filed savings claims with this technology group: PG&E and SDG&E. PG&E's measure reduces operation when installed controls sense the room is unoccupied whereas the SDG&E measure, the Adaptive Climate Controller (ACC), varies the speed of the PTAC/PTHP fan based on climate demands without respect to guest unit occupancy.

Table 1-2 presents the PY2019 statewide reported savings summary for PTAC controls. Overall, 15% of reported electric consumption (kWh) savings and 8% of the reported peak demand (kW) savings from the program are realized for the PTAC controls technology group. This is significantly lower than the previous study results of PY2017. Based on phone interviews and remote site-visits, we determined 36% of the controls installed by the programs were on newer PTACs that are required by

the California building energy code to already have occupancy-based controls with the newly installed PTAC units. Based on a review of the equipment cut sheets and interviews with the site contact, we understood that the PTAC units have controls built-in. Therefore, adding another control at the thermostat or via hotel room key controller to control the PTAC units is redundant and does not provide additional savings as compared to the existing conditions of the PTAC units. This means there are no savings for the PA to claim for these newly installed PTAC units. Additionally, on-site data obtained for the evaluation shows the technology saves 25% less energy compared to the claimed operation. A full summary of the factors contributing to the 15% evaluated gross kWh savings realization rate is found in section 4.1.1.

The results of the net savings showed a 94% ±3% overall program attribution rate. Decision makers reported the program incentive was critical in their decision to install the technology.

Table 1-2. Statewide first-year savings summary by fuel for PTAC controls

Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR[1]	Evaluated NTGR	Reported Net Savings	Evaluated Net Savings	NRR
Electric consumption (kWh)							
17,831,593	15%	2,604,375	65%	94%	11,654,377	2,450,185	21%
Peak electric demand (kW)							
6,280	8%	494	65%	94%	4,084	462	11%
Gas consumption (Therm)							
0	n/a	0	n/a	n/a	0	0	n/a

1.2.2 Rooftop/split systems technology group

PG&E, SCE, and SDG&E reported savings for installing new energy efficient rooftop and split HVAC systems. Energy efficient rooftop and split HVAC systems use less energy than standard rooftop HVAC systems while providing the same or better level of comfort to the building occupants.

Overall, GRRs for kWh, kW, and therms were 48%, 73%, and 2%, respectively (Table 1-3). The GRRs were an expected continuation of the PY2018 results for this technology group as the programs, their technology, and the market did not appreciably change between the two program years. Findings showed reduced cooling savings, no fan energy savings, and reduced savings due to the assessed building type. The analysis demonstrated lower installed efficiency levels than were reported for these technologies, resulting in reduced cooling savings. We re-assessed savings for specific building types rather than the reported savings based on an average commercial building, further reducing evaluated savings.

The evaluated therm savings were largely discounted (2% GRR) because we applied the PY2018 evaluation finding, which found no improvement in fan energy savings above the assumed baseline, thus the fan savings and associated therms penalty is not achieved. The low therms realization rate can be interpreted as incidentally beneficial for the program because reported therms savings are negative and are an energy penalty. Again, we found the PY2018 findings are validly applicable to

[1] The Reported NTGR includes the 5% market effects benefit.

PY2019 as the programs, their technology, the baseline, and the market did not appreciably change between the two program years.

We applied the PY2018 kWh NTGR of 50% to the PY2019 gross results. This is because we conducted a rigorous assessment of the programs' influences in PY2018 and found no appreciable changes in program design or execution between PY2018 and PY2019 (for more information see section 3.5.2). Therefore, the PY2018 NTGR values are applicable to PY2019.

Table 1-3. Statewide first-year savings summary by fuel for rooftop and split system

Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR[2]	Evaluated NTGR	Reported Net Savings	Evaluated Net Savings	NRR
Electric consumption (kWh)							
10,130,395	48%	4,816,802	82%	50%	8,298,476	2,408,401	29%
Peak electric demand (kW)							
5,176	73%	3,773	81%	50%	4,211	1,886	45%
Gas consumption (Therm)							
-50,372	2%	-1,193	82%	50%	-41,223	-596	1%

1.3. Study recommendations

This section provides a summary of recommendations from this study findings. A detailed discussion of findings, recommendations, and implications are provided in section 5 of the report.

- DNV GL recommends that PAs develop savings for PTAC controls and other similar HVAC controls technology groups using appropriate baselines and correct building types and vintages to reasonably capture the savings attributable to the technology improvements. Based on phone interviews and remote site visits, we determined 36% of the controls installed were on newer PTAC systems that are required by the California building energy code to come with occupancy-based controls, and consequently, there are no savings for a PA to claim. We also found nine of the 87 evaluated projects were inappropriately labeled as "hotel" when they were senior living centers, which have a completely different occupancy profile than hotel. We also observed building vintages in the workpaper assumed a greater percentage of pre-1978 building vintage and less post-2005 vintage compared with the actual building vintage in the sample, which overestimated the actual savings. These three factors combined had a significant impact on the savings for PTAC controls measure group.
- For PTAC controls and other similar HVAC controls technology groups, DNV GL suggests PAs consider collecting and archiving the technology-related performance data to ensure that the technologies are operating as intended. The collection of performance data will also assist appropriate evaluation of the HVAC controls technologies.
- For a new technology, like the Adaptive Climate Controller under the PTAC controls technology group, PAs should vet the technology by studying test results, reviewing third party measurements, and research other evaluation studies that demonstrate the efficacy of the

[2] The Reported NTGR includes the 5% market effects benefit.

technology before introducing the technology to the program. Marketing materials from the technology equipment manufacturer do not provide the same level of credibility as data-driven analyses and reports by independent third parties.

- DNV GL recommends PAs develop savings for the rooftop/split system technology group with appropriate baselines and high-efficiency characteristics including the HVAC system efficiencies, fan power, and applicable controls that better reflect the savings achieved as a result of the installed conditions and actual performance.
- For HVAC controls technologies similar to the PTAC controls technology group, PAs should incorporate the direct-install design components of the PTAC controls technology group that led to high NTGR values, which equate to high program savings attribution.

2 INTRODUCTION

The report presents DNV GL's energy savings estimates (impact evaluation) of commercial heating, ventilating, and air conditioning (HVAC) technology groups (measures) that are part of the California Public Utilities Commission (CPUC) HVAC Research Roadmap. These programs are evaluated under CPUC's Group A evaluation contract group. The primary results of this evaluation are estimated energy savings (in kWh, kW, and therms) achieved by two selected HVAC measures—package terminal air conditioner (PTAC) controls and rooftop/split systems—in program year 2019 (PY2019). The programs are offered by the following California program administrators (PAs): San Diego Gas and Electric Company (SDG&E), Southern California Edison (SCE), and Pacific Gas and Electric Company (PG&E).

2.1. Project goals and objectives

The primary objective of this evaluation is to assess the gross and net kWh, kW, and therm savings achieved from the statewide list of HVAC Efficiency Savings and Performance Incentive (ESPI) uncertain measure groups. The focus is on the two selected measure groups across the HVAC portfolio from the 2019 programs offered by SDG&E, SCE, and PG&E. The evaluated measures are described in greater detail in the next section.

The priorities of this evaluation effort and researchable issues this evaluation seeks to examine are described as follows:

1. Determine reasons for differences between evaluated (ex post) and reported (ex ante) savings, and as necessary, assess how to improve the ratio of evaluated savings to predicted savings (realization rates). Identify issues with respect to reported impact methods, inputs, procedures and make recommendations to improve savings estimates and realization rates of the evaluated measure groups.
2. Provide results and data that will assist with updating reported workpapers and the California Database for Energy Efficiency Resources (DEER) values.
3. Estimate the proportion of program-supported technology groups that would have been installed absent program support (free-ridership), determine the factors that characterize free-ridership, and as necessary, provide recommendations on how free-ridership could be reduced.
4. Provide timely feedback to the CPUC, PAs, and other stakeholders on the evaluation research study to facilitate timely program improvements and support future program design efforts and reported impact estimates.

The impact evaluation team ("the team") is made up of DNV GL, Energy Resource Solutions (ERS), and GC Green Inc. The team achieved these objectives by reviewing program data, conducting virtual site visits and phone surveys, and collecting operating parameters for the measures to support the evaluated gross savings estimates. The team estimated net savings based on survey responses from HVAC market actors and end-use customers.

2.2. Evaluated measure groups

For PY2019 we evaluated both gross and net saving impacts for one ESPI measure groups and gross impacts only for one non-ESPI measure group. The measure groups selected for this evaluation effort were chosen based on several considerations, primary among them:

- ESPI status in PY2019 and, to a lesser extent, in subsequent years
- The measure group's ranked contribution to first year and lifetime savings
- Year-over-year trends in savings contributions
- Previous evaluation activity and findings

The measure groups being evaluated for the 2021 Bus Stop are:

- **PTAC controls**. The PTAC controls measure group was included in the 2019 ESPI uncertain list and contributed 27% of the total HVAC portfolio first year electric energy savings. These ESPI measures involve retrofit add-on controls to PTAC units in lodging guest rooms. The controls either modify setpoints of the guest room PTAC unit when the room is unoccupied or adjust the supply fan speed to optimize the PTAC unit's cooling delivery.
- **Rooftop/split systems.** These non-ESPI measures, higher-efficiency package rooftop (RTUs) or split HVAC systems, are delivered primarily through upstream, distributor-focused programs and are generally a one-to-one replacement of existing HVAC units. This measure group was selected for gross savings evaluation due to its large contribution to the HVAC portfolio (16%), recent ESPI status, and previous evaluation findings.

Details on these evaluated HVAC measure groups and the programs that provide them are described next.

2.2.1 PTAC controls

These measures involve retrofit add-on controls to PTAC and package terminal heat pump (PTHP) units in lodging guest rooms. Two PAs filed savings claims under this measure group: PG&E and SDG&E. The control measures claimed by PG&E modulate temperature setpoints of the guest room PTAC unit when controls sense the room is unoccupied, whereas the SDG&E control measure, called the Adaptive Climate Controller (ACC), varies the PTAC unit's supply fan speed to optimize the efficiency of the system's cooling and heating. PG&E administered seven programs with PTAC controls measures, with most claims originating from their Hospitality program. SDG&E administered only one program with PTAC controls measures, the SW-COM-Deemed Incentives-HVAC Commercial program.

2.2.2 Rooftop/split systems

PA upstream programs focus on installing high-efficiency replacement HVAC systems serving commercial and residential buildings. The base case is an existing packaged or split system meeting energy code minimum efficiency requirements. High-efficiency packaged or split systems save energy by proving greater efficiency and reduce on/off cycling. These systems provide more efficient dehumidification, cooling, and heating without sacrificing occupant comfort.

Other benefits of high-efficiency units are increased effectiveness and optimal operation of economizer, dampers, sensors, and controls. If the installation of the rooftop or split system achieves optimal system efficiency, power input to the unit will be reduced and the unit will achieve the operating temperature setpoint more quickly than a standard efficiency unit would require.

2.3. Overview of approach

This section of the report provides high level descriptions of the evaluation approaches used to evaluate gross savings or net attribution estimates for the selected measure groups.

2.3.1 PTAC controls

For the program year 2019 PTAC controls evaluation, the evaluation team applied an enhanced rigor approach to evaluate the gross savings and a standard rigor approach to evaluate the net attribution of savings. This section describes the aspects of determining gross and net savings estimates that are specific to this measure group.

Due to the COVID-19 pandemic, conducting on-site data collection for this evaluation was not prudent. Therefore, our data collection activities consisted of remote verification of measure installation and key parameters to estimate gross savings and interviews with end-user decision makers to quantify program attribution.

We conducted in-depth phone/web-based interviews with the participant site contacts to verify the installation, collect building characteristics and equipment specific information from the affected PTAC/PTHP units, assess the baseline operation, and obtain details about pre- and post- installation occupancy rates, equipment run times and temperature set-point schedules of the guest rooms. The PAs provided the utility meter consumption information for the program populations to inform us of the pre-retrofit energy consumption. We also obtained data logged by on-site guest room energy management systems (GREMS) from the vendor for an available subset of PG&E sites in the sample.

We utilized the collected data to adjust critical measure-specific operational input parameters in baseline eQUEST DEER prototype models. The appropriate DEER prototype model based on building type, building vintage, and climate zone were selected for each project for this exercise. Baseline models were constructed that represent how the guest room energy systems were operated in the pre-installation scenario, including HVAC, lighting, and appliances. We also used the pre-installation monthly and AMI consumption data obtained for the facility to verify seasonality and daily occupancy/usage patterns of guest rooms estimated by the baseline eQUEST models.

With an appropriate baseline model developed for each project, we developed a similar site-specific as-built model in eQUEST by modifying independent variables.

Some of the independent variables we modified in the site-specific models included:

- Post-installation set-points and schedules
- Reported occupancy rates
- Fan motor operation
- Operational data found in vendor provided GREMS logs

These two models form the basis of evaluating the savings for this measure. For each sampled project, the adjusted baseline and as-built models were simulated to produce ex-post unit energy savings (UES) estimates which were then multiplied by the number of units installed (for PG&E projects) or capacity of PTAC/PTHP units affected by the measure (in tons, for SDG&E projects) to estimate the ex-post energy savings at the project level.

Net attribution estimations were based on responses from survey of the participant decision makers. The surveys asked decision makers when (timing) and how many (quantity) PTAC controls they would have purchased in absence of the program. The timing and quantity dimensions each received a free-ridership score. Then total free-ridership was calculated as the product of the timing and quantity free-ridership scores. Attribution was calculated as one minus the total free-ridership. Program and PA level NTGRs were then calculated by summing the product of attribution and tracked savings at the site-level and dividing by the sum of the site-level tracked savings:

$$NTGR = \frac{\sum Attribution * Tracked\ savings}{\sum Tracked\ savings}$$

2.3.2 Rooftop/split systems

For the gross savings evaluation of rooftop or split system measure group, we conducted a detailed desk review of claimed unit energy savings (UES) to identify specific discrepancies that led to the previous year's (PY2018) low gross realization rate. In order to categorize and develop causes for discrepancies, we utilized the PY2018 evaluation data and collected building type information for the PY2019 sample through PA data requests and web searches.

Desk review tasks included workpaper reviews, DEER measure definition review, and review and comparison of DEER eQUEST simulations to DEER measure definitions. The desk review also searched for tracking data discrepancies like misapplication of DEER or workpaper UES savings values.

Gross savings for PY2019 were estimated using building types collected through web searches and PY2018 ex-post gross measure saving results. Installation rates measured in PY2018 (83%) were not carried over for the PY2019 gross savings estimate. Instead, a 100% installation rate was assumed for PY2019. There were some limitations to how PY2018 savings were applied to PY2019 claims. The eQUEST models that were adjusted for the PY2018 ex-post savings did not include all building types, climate zones, and unit type combinations that were sampled for PY2019. For example, the PY2018 ex-post savings did not model the "less than 45 kBtuh" measure size because they were not present in the achieved PY2018 sample. As a result, some PY2019 claims did not have "ex-post" modeled savings results applied. Instead, other modifications were made to adjust the claimed savings. These modifications include:

- Using verified building type to reference a deemed DEER savings value different from the claimed DEER savings value (e.g., DEER estimates different savings values for the generic "Commercial" and the specific "Assembly" building types)
- Using verified climate zone to update the deemed DEER savings value (e.g., DEER estimates different savings values for the generic CZ = "IOU" and the specific CZ = "CZ13" climate zones)

For PY2019, the evaluation team did not conduct data collection on net attribution of the program's influence on decision makers in addition to what was collected and analyzed in PY2018. The evaluated kWh net to gross ratio (NTGR) from PY2018 was applied to the PY2019 evaluated savings to arrive at net savings for PY2019. The evaluation team believes the PY2018-evaluated kWh NTGR was the best estimate of the programs' influence. This conclusion was validated by interviews with PA program managers during workplan development that revealed that the 2019 programs for rooftop/split system measure group have not changed substantially from 2018 programs in terms of program design, delivery, marketing, and outreach.

The PY2018 NTGRs were based on causal pathway surveys. DNV GL surveyed distributors to assess how the program changed their stocking, upselling, and pricing practices. We also surveyed end users to assess how the distributors' stocking, upselling, and pricing affected their decisions. The NTGR calculation then combined the pathways to estimate how much the program affected end-user decisions indirectly through the changes in distributors' behaviors.

2.4. Organization of report

Table 2-1 shows the overall organization of this report. Although overarching findings and recommendations are provided in section 5, detailed study findings and recommendations are included in section 4 as well. Readers seeking a more comprehensive assessment of opportunities for program improvement are therefore encouraged to read these particular chapters along with the appendices.

Table 2-1. Overall organizational structure of the report

Section	Title	Content
1	**Executive Summary**	Summary of results and high-level study findings
2	**Introduction**	Evaluation objectives, research issues, approach, and savings claims
3	**Study Methodology**	Sampling design approaches to gross impact determination, on-site measurement and verification (M&V) activities, measurement methods, analysis approach, NTG survey
4	**Detailed Results**	Gross impacts and realization rates, measure and program differentiation, Net of free-ridership ratios and results, net realization rates, and NTG result drivers
5	**Conclusions**	Detailed gross and net findings, recommendations to improve program impacts
6	**Appendices**	Impact Evaluation Standard Reporting, data collection forms and sampling memo, surveys, and gross impact findings tables for rooftop/split systems

3 METHODOLOGY

The primary evaluation task was to verify the installation of the two selected incentivized HVAC measure groups across California. Gross impacts of kW, kWh, and therm savings were determined by collecting targeted input parameters via file reviews and phone interviews and analysis of acquired data. The analytic approach focused on the accuracy and precision of selected simulation inputs, which vary less than energy savings across building types and climate zone (CZ). The savings resulting from the revised assumptions were projected to all building type and CZ combinations for all the claimed measures using building energy simulations.

To estimate net savings, we developed net-to-gross-ratios (NTGRs) for each measure group and then applied them to the gross savings estimate calculated by the evaluation team. We derived the NTGR by estimating the influence various program activities had on distributor behavior, and how downstream end-users may have been influenced by the upstream program as well. For the downstream programs, program influence was determined from end-use customer interviews. By quantifying this influence, we were able to estimate what percent of the gross savings was attributable to this upstream program and what portion was free-ridership.

This section discusses the evaluation team's methods of conducting the M&V for the primary tasks of this study including sample design, gross impact, net impact, data collection techniques, and data sources and constraints associated with the evaluation methodology.

3.1. Sample design

The sampling methodology employs a stratified ratio estimation model that first places participants into segments of interest (by evaluated measure group and PA) and then into strata by size, measured in kWh and therm savings. The methodology then estimates appropriate sample sizes based on an assumed error ratio.

First, we defined sampling frames for each of the two HVAC measure groups that were evaluated for PY2019. The sampling frame for each measure group is the list of records under that measure group from which the sampling units are selected. Once sampling frames were defined, we stratified the population on the claimed energy savings (kWh or therms). Then we determined the target precisions and designed the sample to achieve ±10% relative precision for each measure group at the 90% confidence level using an assumed error ratio (ER) of 0.8 based on previous experience with similar studies.[3] Once sample sizes were calculated, we randomly chose sample points from the population in each stratum.

Once data for the sample had been collected and ex-post savings for each site have been calculated, the measure group savings realization rate was calculated as:

[3] The error ratio is the ratio-based equivalent of a coefficient of variation (CV). The CV measures the variability (standard deviation or root-mean-square difference) of individual evaluated values around their mean value, as a fraction of that mean value. Similarly, the error ratio measures the variability (root-mean-square difference) of individual evaluated values from the ratio line Evaluated = Ratio multiplied by Reported, as a fraction of the mean evaluated value.

$$b = \frac{\sum_{i=1}^{n} w_i \, y_i}{\sum_{i=1}^{n} w_i \, x_i}$$

Where b is combined ratio estimator, w_i is the stratum case weight, y_i is the ex-post savings estimate, and x_i is the ex-ante savings estimate. The measure group ex-post savings value is estimated as b times the program ex-ante savings total.

The relative precision at 90% confidence is calculated for b in three steps:

1. Calculate the sample residual $e_i = y_i - b\,x_i$ for each unit in the sample
2. Calculate the standard error $se(b) = \frac{\sqrt{\sum_{i=1}^{n} w_i \left(w_i - 1\right) e_i^2}}{\sum_{i=1}^{n} w_i \, x_i}$
3. Calculate the relative precision $rp = \frac{1.645 \; se(b)}{b}$ where 1.645 is the z-coefficient for the 90% confidence interval

For the PTAC controls measure group, achieved relative precisions were worse than anticipated. Generally, the achieved precisions did not match expectations for the following four reasons:

- **Completed sites/surveys less than expected** – Due to the reduced recruitment timeframe,[4] response rates were lower than planned and additional mitigation steps were unavailable.
- **Inability to collect data from the largest sites** – Related the first reason, lower response rates meant that for some measures, the largest site(s) were unable to be completed, which can have a significant effect on the final achieved precision.
- **Observed variation in the sample is greater than assumed** – The sample designs each used a 0.8 error ratio (ER). Future studies may require a greater ER assumption to achieve the planned precision.
- **Ratio result is less than 50%** - Relative precision is calculated as a function of the ratio result (the ratio is in the denominator). Our sample designs assume a ratio of 50%. When ratios are lower than 50%, the relative precision can increase considerably, even when other statistics (such as confidence limits and standard errors) are reasonable.

We should note that especially in cases related to the fourth reason, where the achieved ratios are low, absolute precision should be considered along with relative precision. For example, a ratio of 10% with a relative precision of 150% has an absolute precision of ±15%. This would mean the PAs can be

[4] Caused by delayed execution of recruiting due to wildfire and PSPS events.

confident the true ratio is no greater than 25%. This is likely still an actionable finding when it comes to program design choices.

The detailed sample design methodologies for the evaluated measure groups are described in Appendix D.

3.2. Commercial HVAC measure group sample design

DNV GL designed the sample to achieve ±10% relative precision at the 90% confidence level for each measure group. The gross sampling methodology for PTAC controls and rooftop/split systems measure groups employed a stratified ratio estimation model that places participants into strata by kWh savings. The methodology then estimated appropriate sample sizes based on an assumed error ratio. The assumed error ratio used was 0.8 based on our previous experience with similar impact studies.

The determination of the net program attribution for the commercial HVAC PTAC controls measure group used a census approach targeting the utility customers who are the decision makers being influenced by the programs.

In order to achieve ±10% relative precision at 90% confidence level, a total of 85 site-level sample points were targeted for the PTAC controls measure group gross sample, and 300 site sample points were targeted for the rooftop/split systems measure group gross sample. A census sample was attempted for the PTAC controls measure group net assessment. No net assessment of for the rooftop/split stems measure group was conducted for PY2019.

For the PTAC controls measure group, gross and net data collection began in August of 2020 for both the SDG&E and PG&E programs. While the total number of completed site assessments exceeded the target total, we were unable to achieve the target counts in every stratum due to isolated instances of customer refusal or non-response. In an effort to fulfill the targets by stratum, we attempted to contact every customer in each program with the exception of the lowest-saving projects in the PG&E Hospitality program. Details of the programs for which savings were claimed in this measure group are shown in Table 3-1.

Table 3-1. PTAC controls measure group target and achieved sample by program

PA	Program Name	Count of Sites in Target Gross Sample	Count of Gross Completes	Count of Net Completes[5]
PGE	Association of Monterey Bay Area Governments	3	4	3
	Hospitality Program	51	55	67
	Local Government Energy Action Resources	3	2	2
	San Francisco	10	9	6
	Silicon Valley	3	4	2

[5] While the number of gross and net completes is the same, the completed sites did not fully overlap with one another due to mixed availability of decision makers and support staff at every site to participate in both surveys.

PA	Program Name	Count of Sites in Target Gross Sample	Count of Gross Completes	Count of Net Completes[5]
SDGE	SW-COM-Deemed Incentives-HVAC Commercial	15	13	7
Total		**85**	**87**	**87**

Table 3-2 and Table 3-3 show the planned and achieved sample sizes with their relative precisions for the PTAC controls measure group by PA for the gross and net savings estimates, respectively.

Table 3-2. PTAC controls gross sample by PA

PA	Population Size	Planned Sample Size[6]	Planned Relative Precision at 90% Confidence[7]	Completed Sample Size	Achieved Relative Precision at 90% Confidence
PGE	162	70	11.3%	74	15.4%
SDGE	30	15	19.0%	13	2.5%
Total	**1,738**	**85**	**10.6%**	**87**	**14.6%**

Table 3-3. PTAC controls net sample by PA

PA	Population Size	Planned Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
PGE	162	-	-	80	3.1%
SDGE	30	-	-	7	0.2%
Total	**1,738**	**-**	**-**	**87**	**2.9%**

For the rooftop/split systems measure group, all planned sample points were achieved as planned because no direct participant surveys or data collection requiring study participant recruitment was conducted. Instead, a detailed desk review was performed using available tracking data and supplemented with equipment installation addresses collected after an additional PA data request. We were able to complete all 300 sample points by using the PY2018 ex-post eQUEST modeling results combined with other discrepancy analysis methods described in 3.5.2.[8] The achieved relative precision is better than the target due to overall less variation between the evaluated savings and PA-reported savings for the 300 sample sites.

Table 3-4 shows the planned and achieved sample sizes with their relative precisions for the rooftop/split systems measure group by PA for the gross savings estimate.

[6] No sample size was planned as census was attempted for quantifying net impacts.

[7] No planned precision as no sample design was planned for net assessment.

[8] Note that sample size refers to sites (site ID). There are frequently multiple claims (claim ID) associated with a site ID. There were a total of 2,188 claim IDs included under the 300 sampled sites

Table 3-4. Rooftop/split system gross sample by PA

PA	Population Size	Planned Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
PGE	1,140	120	11.1%	120	13.2%
SCE	786	120	9.8%	120	9.7%
SDGE	153	60	9.4%	60	12.3%
Total	**2,079**	**300**	**9.6%**	**300**	**7.7%**

3.3. Data collection

This section addresses the data collection plans for the two measure groups selected for evaluation for the HVAC sector.

3.3.1 PTAC controls

This section addresses the data collection plans for the PTAC / PTHP controls measure groups selected for evaluation for the HVAC sector. We contacted end-users via PA-provided contact information to interview staff with knowledge of the project (for gross data collection) along with decision makers who chose to finance the projects with support from utility rebates (for net). The next sections provide details of gross and net data collection activities for the PTAC controls measure group.

3.3.1.1 Gross Data Collection

For each of the 87 completes in Table 3-1, we performed comprehensive gross data collection and "virtual M&V" through a combination of videoconferences, telephone calls, emails, and photograph exchanges. Virtual M&V allowed remote verification of measure installation and data collection on the impacted equipment and facility, despite the ongoing COVID-19 pandemic.

An assigned engineer conducted a virtual audit with knowledgeable facility staff by first confirming key project tracking details through a battery of questions. Appendix E contains the gross data collection instruments (PG&E and SDG&E) for the PTAC controls measure group. We then performed a remote inspection of the installed controls and affected PTACs or PTHPs within a selection of guest rooms. When possible, evaluation engineers remotely inspected systems via live video feed (e.g., FaceTime, Zoom), but if facility staff were unable to accommodate video, we conducted a phone call during which facility staff answered questions about the controls and impacted equipment while physically inspecting the affected equipment. For all methods of virtual M&V conducted, we requested photographs of the impacted PTAC and PTHP unit nameplate for verification and incorporation in the model. We visually confirmed nameplate data through photos and videos for 40 out of 87 sampled sites (46%) that we completed data collection for. We also collected nameplate data for 53 out of 87 sampled sites (61%). For projects where we lacked nameplate data, we utilized the weighted average efficiencies (EER, COP) in the building simulation models from units for which we had nameplate data (53 sites with data).

Following the inspection, we asked the facility representative a battery of questions to collect information about both the installed and pre-existing guest room HVAC controls along with details about the facility and its general operation. The survey battery included the topics listed below and can be found in full in Appendix E.

- Make and model of installed controls,
- Make and model number of all impacted PTAC, PTHP, or Split A/C units,
- Pre-existing control types, setpoints, and usage patterns,
- Post-project control schemes including typical occupied and unoccupied setpoints, and override patterns
- Pre- and post-project occupancy along with any notable changes to the facility's operations or energy consumption, including seasonality
- Facility details including building square footage, number of floors, and total number of guest rooms,
- Common area information including HVAC and lighting inventories along with other energy-intensive end-uses (e.g., elevators, swimming pools, fitness centers, etc.)

The virtual M&V process also included our request and collection of cloud-based, temperature and occupancy trend data directly from the controls manufacturer affiliated with PG&E's programs. This pre- and post-project trend data covered as many pre-pandemic months in 2019 and 2020 as were available among 50 participating facilities. While site-specific data was not available for all 87 sample points, we processed and parsed the available data by key segments (e.g., hotel/motel, assisted living) to be as representative of PY2019 participants as possible. This trended data provided evaluation-grade performance data as robust as would have been obtained if field M&V were possible.

Additionally, we requested and received monthly billing and AMI data from the PAs for all sampled facilities. This facility-level data allowed us to compare modeled and actual building-level energy consumption and hourly usage patterns, as further detailed in section 3.5.1.1.

3.3.1.2 Net Data Collection

For net savings assessment, our team interviewed end-user decision-makers using PA-provided contact information. In several cases, the most knowledgeable facility contact for gross interview was not the project decision-maker; rather, the assigned engineers obtained the contact information for the project decision-maker. We pursued these decision-makers to ensure the most appropriate net-to-gross survey responses possible.

The net attribution interview included questions to determine the decision makers' awareness of the program; their motivation for pursuing equipment upgrades; and the influence of PA programs, rebates, and trade allies in the selection of equipment and the timing of installation. Overall, we attempted to contact all 192 sites in the population and completed 87 end-user interviews. Appendix E includes a copy of the PTAC controls net data collection instrument.

3.3.2 Rooftop/split systems

For the rooftop/split systems measure group, DNV GL requested additional tracking data for the 1,152 PGE21015 program claims within the evaluation sample of 300 sites containing 2,188 claims.[9] The data request filled the installation address gap—there were many claims where customer information

[9] We also attempted to request additional data for the SCE-13-SW-002F program; however, installation addresses were not available for the claims.

(customer name, customer address, customer email, customer phone number, etc.) was not accurate. In most cases distributor and contractor information were provided instead of customer contact information and location. For example, 791 claims within the sampled 1,152 PGE21015 claims had the same customer contact information – a participating HVAC distributor.

This additional data request provided correct equipment installation site addresses. We performed web searches to determine the building types of the installation addresses. The discovered building types were used to assign DEER-specific building types to the 1,563 claims that reported a "Com" building type.[10] The installation addresses were also used to assign a specific climate zone for the 118 sampled claims that reported an "IOU" climate zone. A breakdown of the building types assigned by evaluators is listed in Table 6-4 (Appendix F).

3.4. Gross methodology

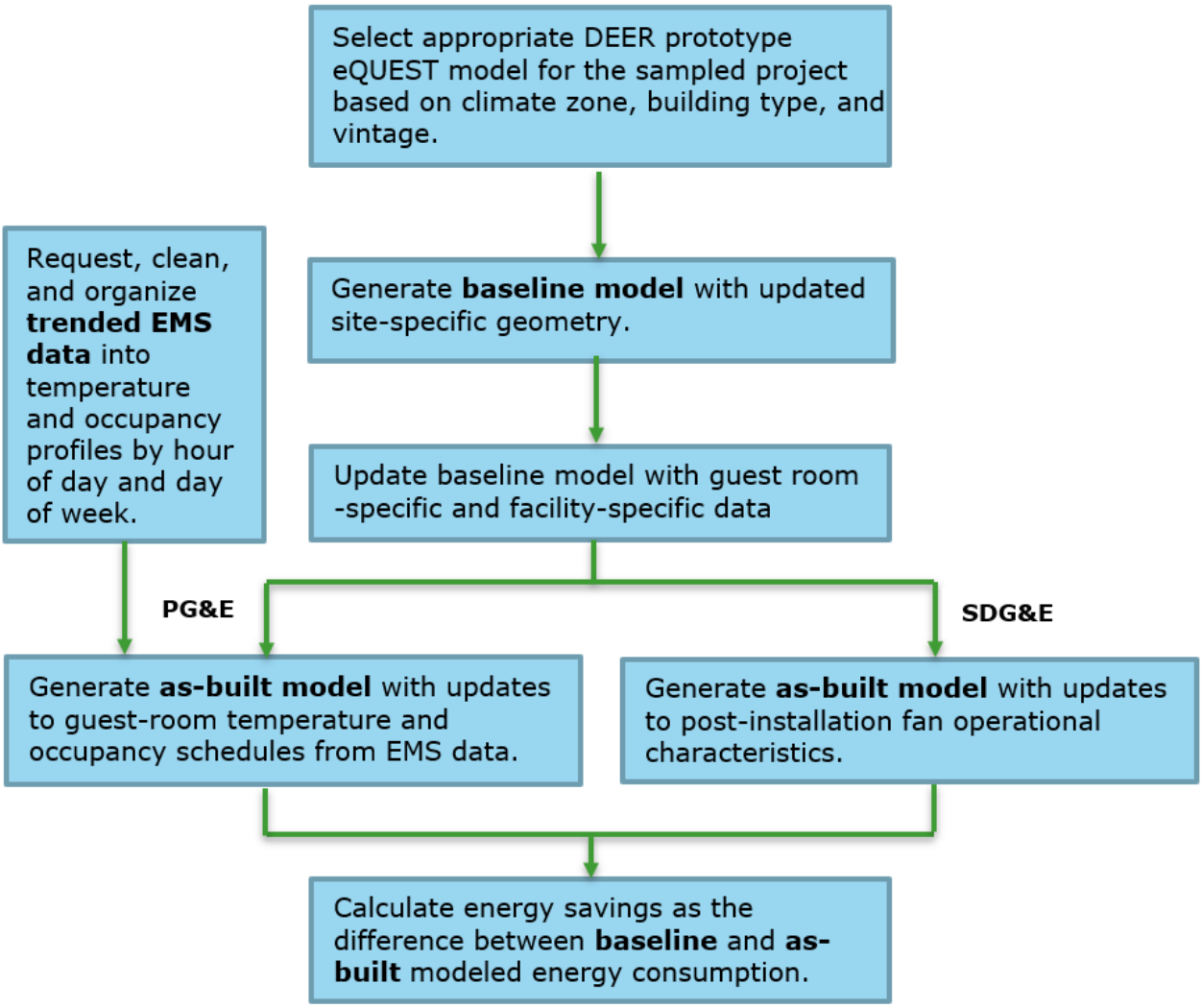
This section presents the methods by which we developed our gross savings estimates. Our gross impact assessment involved standard M&V approaches to extent appropriate and practical, including desk reviews, phone data collection, virtual-site inspections, analysis and building simulation for representative sample for two (2) selected measure groups in HVAC sector. The gross impact analysis: (a) developed evaluated estimates of the energy and demand savings for each site in the sample, and (b) applied those findings back against the full measure group population to obtain population estimates of the measure group impacts. The evaluation team utilized PA and implementer-collected information, including project-implementer's submitted project files/documentation, supplemented by data collected for this evaluation.

3.4.1 PTAC controls

For the PY2019 evaluation, ERS used an enhanced rigor approach to evaluate the savings of the PTAC controls measure group. Instead of creating site-specific building simulation models from scratch, we used a "semi-custom" modeling approach as depicted in the figure below.

[10] Not all claims with an installation site address could be assigned a DEER-specific building type. Of the 1,563 claims with a reported "Com" building type, 78 claims retained the "Com" building type. For most of these claims, a DEER-specific building type was not assigned because we could not confidently determine which building type to apply. For those cases, the "Com" building type was considered to be appropriate to use.

Figure 3-1. PTAC controls measure group analysis process flow



The next sections describe the baseline and as-built modeling processes.

3.4.1.1 Developing the baseline model

Based on our data collection efforts for this measure group, we determined that PTAC controls measures were implemented in hotels, motels, and senior living facilities in 2019. We selected the most appropriate DEER prototype building model[11] for each of those classifications; in the case of senior living facilities, we determined the nursing home prototype to be most appropriate.

Evaluation engineers next updated the DEER prototype model's library files to reflect real-world data collected during virtual M&V. We revised building geometries to reflect actual facility area (in square

[11] The CPUC and California Energy Commission (CEC) developed DEER prototype building models to allow comprehensive assessment of building energy performance for 23 building types assumed to be representative of California's non-residential building stock. The prototype building models encompass six vintage tiers and 16 California climate zones. The DEER prototype models are in eQUEST format, as defined in the footnote below. The PTAC controls measure workpapers for both PG&E and SDG&E reference ex-ante unit energy savings as estimated from DEER prototype models.

feet) and percentage area contributions from each space type (e.g., guest rooms vs. common areas). Then, we generated the appropriate baseline model for each sampled project based on building type, building vintage, and climate zone using simulation generator software called MASControl3.[12] In the created baseline eQUEST[13] model, we adjusted critical input parameters that represent how the guest room's energy-consuming systems operated in the pre-installation scenario, including HVAC, lighting, and plug loads. We also updated the baseline model's guest room cooling setpoints and schedules, heating setpoints and schedules, and occupancy schedules as determined from trend data provided directly by the controls manufacturer (see below subsection).

As a final step in baseline model development, we compared the baseline model to the weather-normalized, pre-installation monthly electric billing data as provided by the PAs. This comparison with billed electric consumption data generally instilled confidence in baseline model accuracy and, in some cases, led us to refine inputs to reflect real-world operating conditions more appropriately (e.g., common area plug loads and senior living patient room equipment power densities).

3.4.1.2 Manufacturer EMS data processing

We requested hourly data for cooling temperature setpoints, heating temperature setpoints, and occupancy rates from the controls manufacturer for all 162 projects incented by the PG&E programs offering the PTAC controls measure in PY2019. The controls manufacturer provided cloud-based data trends for 50 PY2019 projects spanning 35 of the 74 achieved sample of PG&E projects. Each project's data included hourly average readings of temperature setpoints, and the occupancy status for individual guest rooms, and covered approximately 10 months in the post-installation period on average.

We reviewed the data trends in depth to parse out any erroneous values prior to utilizing them in the analysis. We cleaned, processed, and filtered the dataset to include only periods that were not affected by COVID-19 (prior to March 2020). Next, we aggregated the data at the project level to estimate daily profiles for cooling temperature setpoints, heating temperature setpoints, and occupancy rates for both rented and non-rented rooms. For sampled projects for which data was not provided by the controls manufacturer, we aggregated and averaged the data from similar projects with available data to estimate daily profiles for use in the analysis. Since the trended data represented only the post-installation period, we assumed the pre-installation cooling and heating setpoints to be equal to the average post-installation setpoints during occupied periods.

3.4.1.3 Developing the as-built model – PG&E measure group

Once an appropriate baseline model was developed for each sampled project, we developed a similar site-specific, post-installation (i.e., "as-built") model using the 'parametric runs' feature in eQUEST. This was done by modifying independent variables such as post-installation guest room cooling, and heating set point schedules, and occupancy schedules based on the trend data described previously.

[12] MASControl is CPUC's model-based measure analysis software, created to generate DEER prototypical buildings and to estimate impacts from pre-developed DEER measures. The software application allows the use of existing prototypes to address non-DEER measures.

[13] eQUEST is building energy simulation software that estimates building energy performance as a function of numerous, interdependent internal and external factors, such as material selection, mechanical and electrical systems, solar orientation, climate, and occupant usage.

3.4.1.4 Developing the as-built model – SDG&E measure group

Using the 'parametric runs' feature of eQUEST, we updated the post-installation PTAC/PTHP supply fan operational characteristics based on the control module's operation as described by the manufacturer. We modified the model to reflect 'continuous' fan operation instead of 'intermittent' in the baseline model, resulting in fan savings intended from the measure.[14]

3.4.1.5 Evaluated savings calculation

The baseline and as-built models form the basis of the evaluated savings for the PTAC controls measure. For each project in the sample, we ran the models through the eQUEST simulation to produce annual energy consumption totals and peak demand estimates[15] for baseline and as-built conditions. The differences in energy consumption and peak demand between the two models defines the modeled evaluated savings. We next calculated the evaluated unit energy savings (UES) as the quotient of modeled evaluated savings and the number of modeled guest rooms. Finally, to account for any discrepancies in installation rate (e.g., equipment removal or override), we multiplied the number of eligible guest rooms with the evaluated UES values to determine the final evaluated energy and peak demand savings.

The analysis results and reasons for differences between reported and evaluated energy savings for this measure group are detailed in Section 4.1.

3.4.2 Rooftop/split systems

The PY2019 evaluation focus for the rooftop/split systems measure group centered on determining reasons for discrepancy between ex-ante savings, for which this measure group predominantly uses unmodified DEER measures, and the PY2018 savings methodology. In effect, the PY2019 and PY2018 savings methodologies are equivalent.

To assess gross savings for the rooftop/split systems technology group, we used existing reporting data (PY2019) and its supporting sources, PY2018-developed energy simulation outputs, and web research. We performed a thorough desk review of reported savings sources, reviewed and corrected the reported technology installation locations, assigned the appropriate building type based on the web research of the actual installation location, and then applied PY2018 developed evaluation savings estimates where appropriate. As the rooftop/split measure group technology, the baseline, and the market did not appreciably change from PY2018 to PY2019, the evaluation team expects the PY2018 evaluated gross UES values are the best estimates of gross impacts available to apply to PY2019.

For PY2018, the gross savings methodology estimated savings by using site-collected data to adjust critical model input parameters for the ex-ante savings models. The adjusted models were then run for every climate zone, building type, vintage, and unit type combination used across all upstream programs. These model runs were used to produce ex-post savings estimates for each climate zone, building type, and unit type combination. The ex-post gross savings were obtained by recalculating

[14] Evaluators received limited information on the SDG&E PTAC controls technology. We worked directly with the controls manufacturer to request all available information on supporting pilot M&V, lab tests, or other independent, evaluation-style assessments of technology performance. The manufacturer ultimately provided a single redacted study that involved M&V on five controls installations on PTACs within multifamily dwelling units. The M&V study demonstrated that the controls directly impacted the fan motor speed and energy consumption but had only minimal impact on the PTAC compressor. Based on this available literature and our understanding of the technology, we modeled the SDG&E controls measure to impact the simulated fan mode and speed.

[15] We used the peak period definitions by climate zone per their corresponding DEER peak hours using the DEER2014 weather data (Title 24 2013).

the savings for all the program populations using the revised estimates. In order to obtain combined vintage average values, the DEER weights were applied to individual vintage estimates.

The discrepancy methodology approach was broken in to five steps, with each step quantifying its portion of the difference between ex-ante and ex-post savings. All five discrepancy steps summed together equals the difference between ex-ante and ex-post savings. The discrepancy steps are as follows, starting from the tracking (ex-ante) savings:

1. Apply workpaper savings using tracking building type and climate zone:

This discrepancy targets the impact of claims that reported using an implementation ID and measure code (from a workpaper or workpaper savings table) but the reported UES is different from the measure code UES.

2. Apply DEER database (READI) UES using tracking building type and climate zone:

This discrepancy step measures impacts from claims whose referenced workpaper measure code UES do not agree with the corresponding DEER UES. We used the program claims' workpapers DEER version and measure references to cross check with the savings values reported in the DEER database (via the READI program).[16] There were program claims whose workpapers referenced DEER measure savings; however, the claimed savings did not match the DEER savings when cross checked.

3. Apply DEER UES with new building type:

Using the new customer installation addresses obtained during data collection, we assigned DEER-specific building types to program claims that used the weighted "Com" building type.

4. Apply DEER UES with new building type and climate zone:

Like step three, the installation addresses allowed us to assign a specific climate zone to program claims that used the weighted "IOU" climate zone.

5. Apply PY2018 ex-post modeled results with new building type and climate zone.

The PY2018 savings methodology was used to assign ex-post savings to program claims, where applicable.

3.5. Net methodology

This section provides an overview of the net savings methodology used to calculate the net to gross ratios (NTGRs) for two evaluated commercial HVAC measure groups.

3.5.1 PTAC controls

Information that informed our determination of net program attribution came from enhanced participant self-report surveys. We designed phone surveys to:

1. Carefully screen respondents in a way that ensured they understood the program and measures we were calling about.

16 Using the READI program available from http://deeresources.com/

2. Gather data on free-ridership to allow us to calculate NTGRs. The surveys included two free-ridership questions, one on quantity and one on timing. We did not include a question for intermediate efficiency because we determined these measures have only two levels of efficiency: standard or program-level.
3. Gather open-ended data to confirm the free-ridership scoring.
4. Gather additional information about program awareness and contractor communication.

3.5.1.1 Timing Free-ridership

Timing free-ridership was assessed with question NTG_T1. Question wording, answers, and scoring are shown in Table 3-5.

Table 3-5. Timing free-ridership scoring

NTG_T1. If you had not received these energy management systems through the program in 2019, when would you have purchased them in the absence of the program?	Timing Free-ridership score
At the same time or sooner	$FR_t = 1$
1 to 24 months later	$FR_t = 0.67$
25 to 48 months later	$FR_t = 0.33$
More than 48 months later	$FR_t = 0$
Never	$FR_t = 0$
Don't know	FR_t = average of non-DK or R responses

The survey additionally asked respondents an open-ended question to confirm why they selected their answer to question NTG_T1. These questions were reviewed and found to be consistent with the answers given on NTG_T1. There was one case where DNV GL adjusted the NTG_T1 based on the open-ended question. The participant answered "don't know" to NTG_T1 and said "Within a year if they were aware of the technology" to the open-ended question. DNV GL scored this participant as 1 to 24 months later for NTG_T1.

3.5.1.2 Quantity free-ridership

Quantity free-ridership was assessed with question NTG_Q1:

> NTG_Q1. If you had not received these energy management systems through the program, how many would you have purchased and installed, at an equipment cost of approximately $250-300/ unit?

The free-ridership score was calculated as:

$$FR_q = \text{Answer to NTG\_Q1} \div \text{Total number of measures installed}$$

The survey additionally asked respondents an open-ended question to confirm why they selected their answer to question NTG_Q1. These questions were reviewed and found to be consistent with the answers given on NTG_Q1.

3.5.1.3 Total attribution

The first step to calculate total attribution was to calculate combined free-ridership. We combine the individual free-ridership components before converting to attribution to maintain fairness. Multiplying

fractions together always results in a lower product than the inputs, and a 0 free-ridership on any dimension translates to a total free-ridership of 0.

$$FR_{total} = FR_t * FR_q$$

Total attribution was then calculated as $1\text{-}FR_{total}$. We calculated total attribution for all respondents. To calculate total NTGR, we averaged the attribution scores across the respondents, weighted by the number of PTAC units claimed for each participant.

3.5.2 Rooftop/split systems

For PY2019, the evaluation team did not conduct net-to-gross surveys to determine the net savings for the rooftop/split system measure group. Instead the evaluated net to gross ratios (NTGR) from PY2018 were applied to the PY2019 evaluated savings to arrive at net savings for PY2019 because the program design and delivery for the rooftop/split measure group did not changed from PY2018 to PY2019, and because the technology, baseline, and market did not appreciably change between the two program years. This conclusion was validated by the PA program managers while interviewing them during the development of workplan of the study. Therefore, the evaluation team expects the PY2018 evaluated NTGRs are the best estimate of program's influence in the state they existed in during PY2018 and PY2019.

To establish program attribution for PY2018, we considered the pathways distributors take when selling a high efficiency HVAC unit, and the related pathways buyers take when purchasing one. Our goal was to develop an approach that considered these pathways in the context of the HVAC1 program design and real-world complexity. We created the term "causal pathway" to represent how the program may indirectly influence the final purchase decisions of buyers. We then used this approach to integrate NTG survey responses between buyers and the distributors into an overall NTG score.

Our methodology assumed that there were three main causal pathways of influence which impacted the HVAC equipment distributor, installation contractors, and end users. We derived these assumptions from the program logic model provided from the IOUs and conversations with program implementers. Distributors and buyers are both important when evaluating program attribution of this nature, and both were taken into consideration to formulate an overarching attribution score.

For PY2018, DNV GL surveyed distributors to assess how the program changed their stocking, upselling, and pricing practices. DNV GL also surveyed the end-users to assess how the distributors' stocking, upselling, and pricing affected their decisions. The NTGR calculation then combined the pathways to estimate how much the program affected end-user decisions indirectly through the changes to the distributors' behaviors.

3.6. Data sources

We based our savings estimates on data from several sources, summarized in Table 3-6. Appendix D provides the details of these data sources including contents and types of data and how we use them in the evaluation.

Table 3-6. Summary of data sources and applicable measure groups

Data Sources	Description	Applicable Measure Groups
Program tracking data	PA program data includes number of records, savings per record, program type, name, measure groups, measure description, incentives etc.	HVAC rooftop or split systems PTAC controls
Program equipment installation addresses	Requested equipment installation addresses not available in tracking data	HVAC rooftop or split systems
Program billing data	PA billing data including kWh	HVAC rooftop or split systems PTAC controls
Project-specific information	Project folders include scope of work, equipment model and serial numbers, nominal efficiency, test results, project costs, etc.	PTAC controls
Manufacturer data sheet	Data sheets include equipment specifications such as horsepower (HP), efficiency, capacity, etc.	PTAC controls
Telephone/web surveys	Includes surveys of customers, distributors, other market actors, and PA program staff.	PTAC controls
Manufacturer EMS data	Includes aggregated occupancy rates, thermostat set points, etc. for installation sites	PTAC controls
Web searches for building type	Performed web searches to determine DEER-specific building types for equipment installation addresses	HVAC rooftop or split systems PTAC controls

4 DETAILED RESULTS

This section presents the results of the gross and net evaluations of the measure groups. Gross impact realization rates (GRRs) and first-year evaluated gross and net savings are presented in this section by PA for electric energy (kWh), electric demand (kW), and gas energy (therms). Appendix B contains the Impact Evaluation Standard Reporting (IESR) high-level savings and standard per-unit savings. Appendix C contains the tabularized report recommendations. The evaluation used the PA-reported EUL measure values to calculate lifetime savings from first year savings.

4.1. PTAC controls

The PTAC controls measure group's GRRs and net realization rates (NRRs) for kWh and kW fell significantly short of 100% for both PAs, as summarized in Table 4-1. The sections following the table provide more detail on the results and key contributors to the GRRs. We did not observe any evaluated natural gas energy savings (therms) for this measure group, consistent with the PG&E and SDG&E workpaper assumptions for savings claims.

Table 4-1. First year gross and net savings summary - PTAC controls

PA	Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR[17]	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	NRR
Electricity consumption (kWh)								
PGE	16,680,578	15%	2,575,811	65%	94%	2,421,654	10,901,422	22%
SDGE	1,151,015	2%	28,564	65%	100%	28,532	752,955	4%
Total	**17,831,593**	**15%**	**2,604,375**	**65%**	**94%**	**2,450,185**	**11,654,377**	**21%**
Peak electric demand (kW)								
PGE	5,860.3	8%	481	65%	93%	450	3,809	12%
SDGE	420.2	3%	12	65%	100%	12	275	4%
Total	**6,280**	**8%**	**494**	**65%**	**94%**	**462**	**4,084**	**11%**

4.1.1 Gross impact findings

Table 4-2 presents gross results for the PTAC controls measure group. Statewide GRRs were 15% for kWh, and 8% for peak demand savings. Both PAs had similarly low gross results because of a variety of factors, including inaccurate workpaper savings, baseline ineligibility, and removal or overriding of the controls.

[17] The Reported NTGR includes the 5% market effects benefit.

Table 4-2. PTAC controls first-year gross savings summary

PA	Reported Gross Savings	GRR	Evaluated Gross Savings
Electric consumption (kWh)			
PGE	16,680,578	15%	2,575,811
SDGE	1,151,015	2%	28,564
Total	**17,831,593**	**15%**	**2,604,375**
Peak electric demand (kW)			
PGE	5,860.3	8%	481.6
SDGE	420.2	3%	12.1
Total	**6,280**	**8%**	**494**

Table 4-3 shows the population sizes, sample sizes, gross realization rates and relative precisions for the PTAC controls measure group. A greater-than-anticipated error ratio, which quantifies the variation in results among all sampled projects, resulted in achieved relative precisions that were slightly poorer than the ±10% relative precision (at the 90% confidence interval) that was targeted in the evaluation sample design.

Table 4-3. PTAC controls population, gross realization rate, and relative precisions

PA	Population Size	Completed Sample Size	Sampled Share of Gross kWh Savings	kWh Gross Realization Rate	kWh Achieved Relative Precision	kW Gross Realization Rate	kW Achieved Relative Precision
PGE	162	74	51%	15%	16%	8%	15%
SDGE	30	13	39%	2%	14%	3%	19%
Total	**192**	**87**	**50%**	**15%**	**16%**	**8%**	**15%**

The achieved relative precisions fell short of the target 10% at the 90% confidence interval. Gross relative precision is inversely proportional to GRR, and the low GRRs were therefore a notable contributor to the poorer-than-expected RPs.

Figure 4-1 compares the reported and evaluated annual kWh savings for the sample of PTAC controls projects studied. Ideally, the evaluated savings would always match the reported savings; this ideal is shown as a solid black line on the chart. However, the figure shows that all sampled projects fell below the ideal line and achieved significantly lower savings than anticipated.

Figure 4-1. Comparison of reported and evaluated electric energy savings

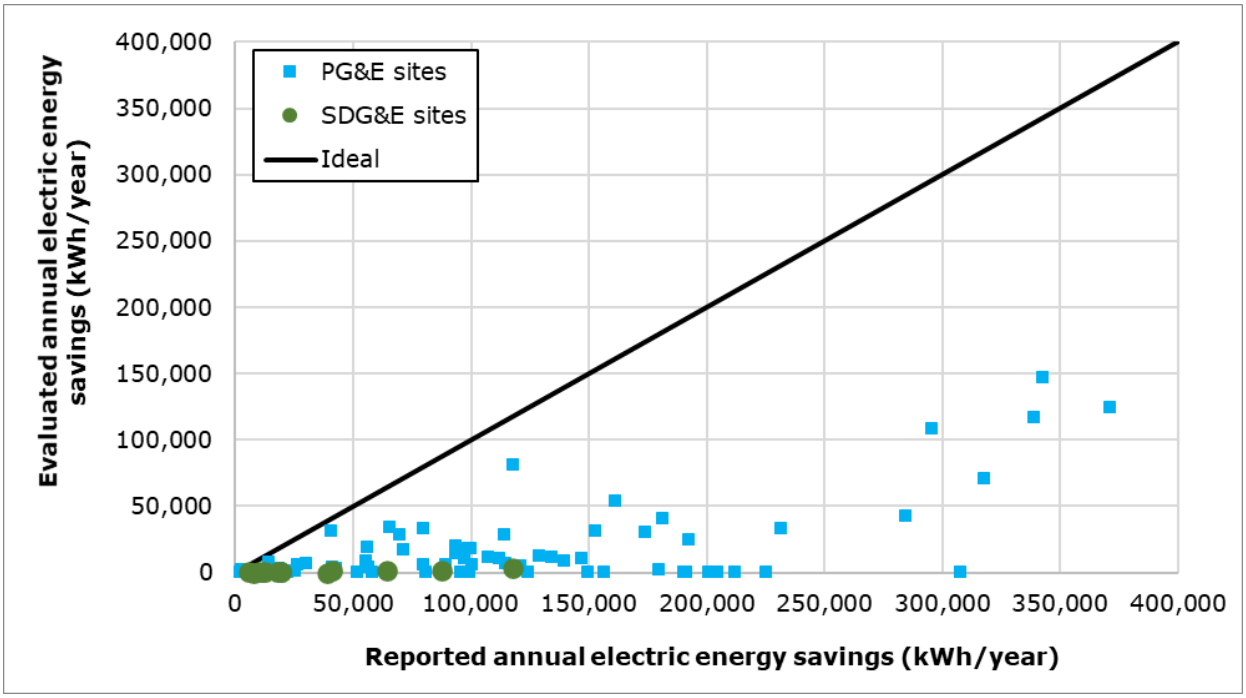
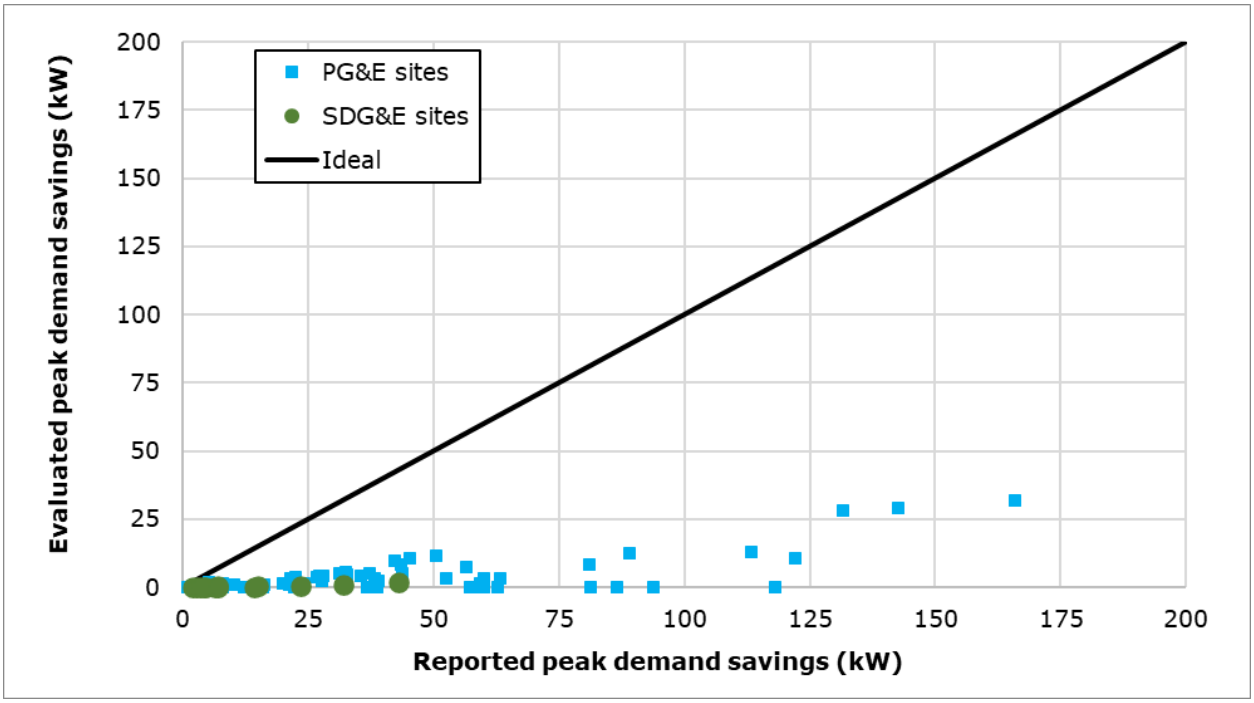


Figure 4-2 compares the reported and evaluated peak demand savings for the sample of PTAC controls projects studied. Ideally, the evaluated savings would always match the reported savings; this ideal is shown as a solid black line on the chart. Figure 4-2 shows that all sampled projects fell below the ideal line and achieved significantly lower peak demand savings than anticipated. To calculate the reported peak demand savings per unit, the PG&E workpaper multiplied the assumed base case duty cycle at peak load conditions, assumed runtime reduction, and assumed operating power, whereas the SDG&E workpaper multiplied the annual energy savings by a constant conversion factor of 0.0003848. To estimate the evaluated peak demand savings, we applied the difference between simulated baseline and as-built models during the peak hours from DEER2014 peak period definitions. The DEER2014 peak periods are defined by climate zone per their corresponding DEER peak hours using the DEER2014 weather data (Title 24 2013).

Figure 4-2. Comparison of reported and evaluated peak demand savings



The significant difference between reported and evaluated peak demand savings stem from two primary factors. First, there are discrepancies between assumed calculation parameters in the workpapers and actual site-specific PTAC/PTHP operational characteristics. Second, there are discrepancies in peak demand savings calculation methodologies between workpaper and evaluation (one-line calculation vs. simulated results).

4.1.1.1 Savings Discrepancy Analysis

As part of the site-specific, "semi-custom" modeling approach detailed in Section 3.5.1, we quantified the key contributors to kWh GRR among ten discrepancy categories. These site-specific analyses allowed evaluators to quantify the overall discrepancies that led to a 15% kWh GRR and an 8% peak kW GRR for the PTAC controls measure group. The frequency and GRR magnitudes (both positive and negative) of each discrepancy category are illustrated in Table 4-4.

Table 4-4. Key drivers behind PTAC controls gross energy realization rate

Discrepancy Category	PG&E	SDG&E	# Instances	Negative Impact on RR	Positive Impact on RR	Overall Impact on RR
Occupancy controls required by Title 24 2013 code	✓		31	-28%	0%	-28%
Guest room schedules and measure updates	✓	✓	61	-25%	0%	-25%
Site-specific updates to baseline model	✓	✓	52	-13%	2%	-11%
Inaccurate workpaper savings estimation	✓	✓	41	-10%	0%	-10%
Differences in building vintage classification	✓		41	-6%	2%	-4%
Removal/override of rebated controls	✓	✓	12	-2%	0%	-2%
Occupancy-based controls in baseline	✓		1	-2%	0%	-2%
Project occurred at a senior living facility	✓		9	-1%	0%	-1%
Controls installed in common areas	✓		10	-1%	0%	-1%
Differences in installation rate	✓	✓	11	-1%	0%	-1%
Total			**269**	**-90%**	**4%**	**-85%**

The discrepancy categories are described in more detail below:

- **Occupancy controls required by Title 24 code.** California Title 24 2013, which went into effect on July 1, 2014, requires that PTACs within hotel/motel guest rooms "shall have captive card key controls, occupancy sensing controls, or automatic controls built-in such that, no longer than 30 minutes after the guest room has been vacated, setpoints are setup at least +5°F (+3°C) in heating mode."[18] During virtual inspections, we found that 31 facilities were either constructed, majorly renovated, or had all guest room HVAC systems replaced after July 2014, invoking Title 24 2013 and invalidating the claimed measure savings for those incented units. Our engineers verified project ineligibility by collecting photos of PTAC/PTHP unit nameplates to confirm the date of manufacture to corroborate the facility managers' accounts of project timelines and other supporting documentation. Based on a review of the equipment cut sheets and interviews with the facility manager's, we understood that the PTAC units have controls built-in. Therefore, adding another control at the thermostat or via hotel room key controller to control the PTAC units is redundant and does not provide additional savings as compared to the existing conditions of the PTAC units. This means there are no savings for the PA to claim for these newly installed PTAC units. This discrepancy resulted in zero evaluated savings for 18 sampled projects and partial reductions in evaluated savings for 13 projects, leading to a 28% overall reduction in evaluated kWh savings for the measure group.
- **Guest room schedules and measure updates.** The PG&E workpaper recommends UES values based on an assumed 45% reduction[19] to the total baseline consumption of the PTAC/PTHP units as modeled in eQUEST prototype models. For each project sampled for evaluation, we quantified savings by adjusting model inputs in the baseline eQUEST models such as actual, post-installation guest room cooling and heating temperature setpoint schedules and occupancy schedules based on the trend data provided by the controls manufacturer. This discrepancy represents the differences between the actual site-specific set-points and occupancy schedules and the fixed runtime reduction assumed in the PG&E workpaper.

  Similarly, the SDG&E workpaper recommends UES values based on an assumed 30% reduction[20] to the total modeled baseline consumption of the PTAC/PTHP units. As detailed in Section 3.5.1, we modeled the measure savings by updating the post-installation PTAC/PTHP supply fan operational characteristics based on the control module's operation as described by the manufacturer. This discrepancy led to a 25% reduction in evaluated kWh savings for the measure group.
- **Site-specific updates to baseline model.** As described in Section 3.5.1, we made a number of site-specific updates to DEER prototype models, including building geometries, square footages by space type, guest room HVAC characteristics and usage patterns, and lighting and plug load power densities, to estimate site-specific evaluated savings. Customization of DEER prototype models to reflect the sampled facilities led to an 11% reduction in evaluated kWh savings. In one case, we

[18] California Title 24 Code, 2013 (Section 120.2 (e) (4))

[19] The 45% savings assumption is based on studies performed for the Honeywell Cool Control Plus program in California.

[20] The source of the 30% savings assumption is unclear but appears to be based on tests conducted by the manufacturer.

determined **occupancy-based controls were already installed in the baseline case** for the affected PTACs, thereby resulting in a 2% reduction in overall evaluated kWh savings.

- **Inaccurate workpaper savings methodology.** We found that the PG&E workpaper based the UES on the facility's total HVAC energy consumption, including common areas, instead of the guest room HVAC consumption only. The workpaper itself recommended decreasing the total hotel/motel HVAC consumption by 20% to isolate only guest room usage; however, our review of the DEER prototype models and the workpaper UES showed that this recommendation was not reflected in the UES values themselves. Since the PTAC controls measure is eligible for PTAC/PTHPs serving guest rooms only, the ex ante savings were over-estimated because they include savings in common areas and other ineligible spaces. This discrepancy led to a 10% reduction in evaluated kWh savings.
- **Differences in building vintage classification.** The PG&E workpaper UES reflects PTAC controls savings for a hotel/motel of average vintage that inflated the baseline energy consumption while we used site-specific vintage data in our modeling analysis. This discrepancy led to a 4% reduction in evaluated kWh savings. Table 4-5 shows the comparison between weighted average of building vintages assumed in the PG&E workpaper and what we observed from the site-specific data from the sample.

Table 4-5. PTAC controls population weighted average building vintages

Vintage Classification	< 1978	1978-1992	1993-2001	2002-2005	> 2005
PG&E Workpaper	32%	34%	22%	7%	6%
Evaluation Sample	12%	34%	28%	6%	20%

- **Removal/override of rebated controls.** In 12 of 87 sampled projects, we determined that the rebated controls were partially or completely removed or overridden within their first year of installation. Site representatives indicate this was largely due to compatibility issues with the impacted PTAC/PTHP units, which is detailed in Table 4-6 for each of the 12 projects. Relatedly, we found **differences in installation rate** between tracked values and virtual audit findings, resulting in a 1% reduction to evaluated kWh savings.

Table 4-6. PTAC controls removal/override by customers and justification

Site	Action	Reason	Controls Removed/ Overridden	Total Claimed Quantity of Controls
PGE01	Removed	Customer unhappy as they had to constantly reprogram thermostats to operate correctly.	4	39
PGE02	Removed	Controls not working as demonstrated by vendor. Customer has removed and returned thermostats due to compatibility issues with existing equipment.	50	68
PGE03	Overridden	Customer disabled all controls after recurring functionality issues with PTAC operation.	165	165
PGE04	Overridden	Thermostats overridden due to functionality issues.	4	24
PGE05	Removed	Customer indicated that thermostats were removed due to functionality issues and guest complaints.	12	122
PGE06	Removed	All installed thermostats removed & returned to vendor.	66	66
PGE07	Removed	Thermostats removed due to functionality issues and regular customer complaints.	3	95
SDGE01	Removed	Power to all units was cut at time of installation causing inoperability.	63	63
SDGE02	Removed	Controls removed due to operability issues. Customer believed it to be an isolated incident.	1	21
SDGE03	Removed	All controls removed due to several issues that caused PTACs to freeze up and stop working.	20	20
SDGE04	Removed	Half of installed controls were removed after rendering PTAC units inoperable.	56	112
SDGE05	Overridden	Controls were overridden due to functionality issues	15	81

- **Project occurred at a senior living facility.** The PG&E workpaper specifies that hotels and motels are eligible for the PTAC controls measure; however, we found that 9 out of 87 evaluated projects occurred at senior living centers. The tracking data characterized the senior living centers as "hotels," and the reported savings were based on workpaper UES for hotels. To accurately model the energy savings from senior living centers in eQUEST, we modified the DEER prototype model for nursing homes instead of hotels. The efficacy of the PTAC controls measure in senior living facilities is unclear due to the overlapping discrepancies summarized in this section. Our review of the trended temperature setpoint data for senior living facilities showed minimal setbacks during both heating and cooling modes.
- **Controls installed in common areas.** The PG&E workpaper indicates that the installed controls must be connected to a guest room PTAC, PTHP, or Split AC unit as the savings are achieved through temperature setbacks in unoccupied guest rooms. We identified 10 projects in which at least one rebated controls device was installed in hotel/motel common areas, thereby eliminating those devices' savings due to ineligibility. This discrepancy resulted in zero evaluated savings for

seven projects and partial reduction in evaluated savings for three projects in the sample, leading to a 1% reduction in evaluated kWh savings.

4.1.2 Net impact findings

Table 4-5 below provides the net-to-gross results for the PTAC controls measure group. The statewide evaluated Net-to-gross ratios for PTAC controls measure group are 94% for both kWh and kW savings. The PG&E NTGR is 94% for kWh and 93% for kW, whereas SDG&E NTGRs are 100% for both kWh and kW. The evaluated NTGRs are considerably higher than the values reported by the PAs.

Table 4-5. First year net savings summary - PTAC controls

PA	Reported NTGR	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	NRR
Electricity consumption (kWh)					
PGE	60%	94%	2,421,654	10,901,422	22%
SDGE	60%	100%	28,532	752,955	4%
Total	**60%**	**94%**	**2,450,185**	**11,654,377**	**21%**
Peak electric demand (kW)					
PGE	60%	93%	450	3,809.2	12%
SDGE	60%	100%	12	274.9	4%
Total	**60%**	**94%**	**462**	**4,084**	**11%**

The drivers of these high NTGRs for PTAC controls are primarily attributable to two main factors: lack of end-user awareness of the rebated controls technology and the direct-install program design that reduced the application burden on the end-user. The incentives and the costs to do the improvements on their own were the most common reason (69%) that participants gave for participating in the program. No other reason was chosen by more than 10% of the participants.

Table 4-6 below shows the completed net sample sizes, evaluated NTGRs, and achieved relative precision values. The achieved relative precision values are well below the targeted 10% precision.

Table 4-6. PTAC controls population, net sample, realization rate, and relative precision[21]

PA	Population Size	Completed Sample Size	Evaluated kWh NTGR	kWh Achieved Relative Precision*	Evaluated kW NTGR	kW Achieved Relative Precision
PGE	162	80	94%	3.1%	93%	3.4%
SDGE	30	7	100%	0.2%	100%	0.2%
Total	**192**	**87**	**94%**	**2.9%**	**94%**	**3.2%**

*Relative precision at 90% confidence.

[21] For all analyses DNV GL realization rates do not include the 5% market effects adder. NTGR values are calculated expanding DNV GL calculated ex-post gross to DNV GL calculated ex-post net values which do not include the 5% market effects adder. The only values that include the market effects 5% adder are the reported NTGR values in the tracking data; the tracking gross/net savings estimates themselves do not include the 5%. In order to address this in the reporting tables, the values for the "Reported NTGR" (which comes from the tracking data) have all been reduced by the 5% market effects adder so that the overall NRR are an equivalent comparison and thus not artificially deflating the results.

4.2. Rooftop/split

Table 4-7 below summarizes the evaluation results for the rooftop/split system measure group. The overall gross kWh, kW and therms realization rates are 48%, 73%, and 2% respectively. The evaluated NTGR values are 50% across kWh, kW, and therms savings. The gross and net realization rates were in line with PY2018 results, with the exception of the therms GRR, where the evaluation found a reduced therm penalty for the rooftop/split system measure group.

Table 4-7. Rooftop/split systems first-year gross and net savings summary[22]

PA	Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR[23]	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	NRR
Electric consumption (kWh)								
PGE	4,994,986	48%	2,388,312	80%	50%	1,194,156	4,002,614	30%
SCE	4,100,117	47%	1,930,250	83%	50%	965,125	3,419,895	28%
SDGE	1,035,291	48%	498,240	85%	50%	249,120	875,967	28%
Total	**10,130,395**	**48%**	**4,816,802**	82%	**50%**	**2,408,401**	**8,298,476**	**29%**
Peak electric demand (kW)								
PGE	2,605.4	70%	1,812.4	80%	50%	906	2,085.0	43%
SCE	2,069.8	72%	1,497.7	83%	50%	749	1,711.0	44%
SDGE	501.2	92%	462.7	83%	50%	231	415.4	56%
Total	**5,176**	**73%**	**3,773**	81%	**50%**	**1,886**	**4,211**	**45%**
Gas consumption (Therm)								
PGE	-32,170	2%	-485	80%	50%	-242	-25,736	1%
SCE	-16,583	4%	-681	85%	50%	-340	-14,059	2%
SDGE	-1,619	2%	-28	88%	50%	-14	-1,427	1%
Total	**-50,372**	**2%**	**-1,193**	82%	**50%**	**-596**	**-41,223**	**1%**

Our analysis showed reduced cooling savings, no fan energy savings, and reduced savings due to the assessed building type. The analysis demonstrated lower installed efficiency levels than were reported

[22] For all analyses DNV GL realization rates do not include the 5% market effects adder. DNV GL NTGR values are calculated expanding DNV GL calculated ex-post gross to DNV GL calculated ex-post net values which do not include the 5% market effects adder. The only values that include the market effects 5% adder are the reported NTGR values in the tracking data; the tracking gross/net savings estimates themselves do not include the 5%. In order to address this in the reporting tables, the values for the "Reported NTGR" (which comes from the tracking data) have all been reduced by the 5% market effects adder so that the overall NRR are an equivalent comparison and thus not artificially deflating the results.

[23] The Reported NTGR includes the 5% market effects benefit.

for these technologies, resulting in reduced cooling savings. The discrepancy steps described in 3.5.2 broke down attributions to the total difference, but the primary reason is due to the overestimation of savings in the ex ante estimate. The ex ante estimate approach claimed savings equivalent to ~60% of the total cooling load whereas the evaluation approach produced the savings to be approximately 10% of the total cooling load, which is in line with the efficiency improvement between the standard and high-efficiency equipment.

The ex-ante savings estimate assumed an improvement in fan efficacy (W/cfm) between standard and efficient equipment. The (PY2018) evaluation found that the measured fan efficacy in participating (efficient) equipment was less efficient than the fan efficacy assumed in the standard equipment. The ex post eQUEST models used the measured fan efficacy for both standard and efficient cases, effectively removing ex-ante savings from improved fan efficacy.

Overall, this measure group shows a moderate free-ridership as half of the distributor's decisions to stock and promote higher efficiency equipment is due to the program incentive and activities.

4.2.1 Gross impact findings

Table 4-8 presents gross results for the rooftop or split measure group. Statewide GRRs were 48% for kWh, 73% for peak demand, and 2% for therm savings. Each PA had similar gross results, and none are statistically different from each other.

Table 4-8. Rooftop or split system first-year gross savings summary

PA	Reported Gross Savings	GRR	Evaluated Gross Savings
Electric consumption (kWh)			
PGE	4,994,986	48%	2,388,312
SCE	4,100,117	47%	1,930,250
SDGE	1,035,291	48%	498,240
Total	**10,130,395**	**48%**	**4,816,802**
Peak electric demand (kW)			
PGE	2,605.4	70%	1,812.4
SCE	2,069.8	72%	1,497.7
SDGE	501.2	92%	462.7
Total	**5,176**	**73%**	**3,773**
Gas consumption (Therm)			
PGE	-32,170	2%	-485
SCE	-16,583	4%	-681
SDGE	-1,619	2%	-28
Total	**-50,372**	**2%**	**-1,193**

The PY2019 statewide kWh and kW GRRs are similar to PY2018 results (55%, 61%, and 58% for kWh, kW, and therms GRR). The therms GRR changed significantly for PY2019 because it incorporated the PY2018 ex-post results' impact on the gas savings penalty.

The ex-ante measures estimate a gas savings penalty because the standard equipment is assumed to have a higher fan power index (W/cfm) than the efficient equipment. A portion of fan power is added to the equipment's air stream as heat; therefore, the efficient equipment requires more mechanical

heating to serve the same heating load as the standard equipment. The PY2018 evaluation determined that the participating (efficient) equipment fan power index was less efficient than the assumed standard equipment fan power index. The evaluation team controlled for this finding by setting equivalent the fan power index of both standard and efficient eQUEST models. This adjustment removes savings impacts due to fan efficacy with the sole source of savings deriving from improvements to cooling efficiency.

Table 4-9 shows the population sizes, completed sample sizes, gross realization rates and relative precisions for the rooftop/split system measure group. The completed sample size was achieved because of the nature of the desk review evaluation for PY2019. The achieved relative precision for therms is high because the ex-post results removed fan efficacy improvements thereby removing therms penalties. With such a small therms impact and GRR, the relative precision is consequentially high.

Table 4-9. Rooftop or split system population, GRR, and relative precisions

PA	Population Size	Completed Sample Size (sites)	kWh GRR	kWh Achieved Relative Precision[24]	kW GRR	kW Achieved Relative Precision[25]	Therm GRR	Therm Achieved Relative Precision[26]
PGE	1,140	120	48%	13%	70%	9%	2%	148%
SCE	786	120	47%	10%	72%	6%	4%	72%
SDGE	153	60	48%	12%	92%	6%	2%	138%
Total	**2,079**	**300**	**48%**	**8%**	**73%**	**5%**	**2%**	**73%**

Some of the specific findings of the five discrepancy steps described in section 3.5.2 are listed below.

- Step 1. Tracking building type, climate zone, and savings combination did exist in workpaper – 725 of the 2,188 (33%) sampled claims did not have matching workpaper UES values because the (1) workpapers did not have the building type and climate zone combination in their savings tables. This occurred exclusively for PGE21015 when the tracking building type and climate zone combination was "Com" and "IOU", respectively; (2) workpapers did not contain savings tables for its measure codes. This occurred exclusively for SDGE3224 where the tracking data refers to existing workpapers and measure codes; however, the workpapers do not have supplemental savings tables that define UES for its measure codes. This discrepancy does not attribute a difference in savings from what was reported because the workpapers did not provide a UES value (i.e., N/A). This discrepancy highlights administrative shortcomings in tracking data and the potential difficulty cross-checking tracking savings to workpaper measure codes and savings.
- Step 2. Tracking building type, climate zone, and savings combination did not match corresponding DEER UES – 669 of the 2,188 (31%) sampled claims had building type, climate zone and UES value combinations that did not match the corresponding DEER UES values. The majority of claims reference workpapers that use unaltered DEER UES values to define the

[24] Relative precision at 90% confidence
[25] Relative precision at 90% confidence
[26] Relative precision at 90% confidence

measure code savings values referenced in tracking. In theory, since the workpapers do not alter the DEER methodology and UES, the tracking building type, climate zone, and measure code combination should look up the corresponding DEER UES and that DEER UES should match the tracking UES. The SDG&E program (SDGE3224) claims were the greatest offender, where 551 claims recorded a building type and climate zone in the tracking data that were different from the building type and climate zone used to look up the DEER UES. In almost all the 551 cases, the tracking UES value was derived from the building type and climate zone combination of "Com" and "IOU", respectively. However, the tracking data for those claims reported different building types and climate zones other than "Com" and "IOU." In these cases, the tracking UES value should have been derived from the building type and climate zone that the claim recorded in tracking (e.g., the claim recorded building type "Primary School" in climate zone 7 but used the DEER UES value for building type "Com" and climate zone "IOU"). This discrepancy had an average difference from ex-ante of -17%, 4%, and 23% on kWh, kW, and therms, respectively

- Step 3. Tracking building type did not match building type found through web searches – the reported (ex-ante) savings overwhelmingly use building type "Com" to estimate savings. The "Com" building type represents a weighted average of existing building stock in a given climate zone. The measure savings (which use DEER eQUEST building types) vary widely depending on building type because of differences in occupancy types, schedules, and internal loads, among many other factors. We replaced the "Com" building type with DEER-specific building types after conducting web searches on the equipment installation addresses. This adjustment had an overall impact of -11%, -7%, and -11% on kWh, kW, and therms, respectively, relative to the step 2 discrepancy.
- Step 4. Tracking climate zone did not match climate zone found through web searches – a subset of claims that used building type "Com" also used climate zone "IOU." Like the "Com" weighted average, the "IOU" climate zone is a weighted average of building stock within PA-specific climate zones. Measure savings also vary widely with climate zone because of differences in building cooling/heating loads. We replaced the "IOU" climate zone with the climate zone corresponding to the zip code of the installation address. This adjustment had an overall impact of -2%, -2%, and -13% on kWh, kW, and therms, respectively, relative to the step 3 discrepancy.
- Step 5. Apply PY2018 ex-post results with known building type and climate zone – the final discrepancy step is equivalent to the PY2019 ex-post results. This step applies to step 4 the gross savings methodology described in the PY2018 report and in section 3.5.2. This adjustment had an overall impact of -29%, -23%, and -69% on kWh, kW, and therms, respectively, relative to the step 4 discrepancy.

Detailed gross impact findings that show the range of discrepancy step kWh impacts and the average sampled GRR for kWh are provided in Appendix F.

4.2.2 Net impact findings

Table 4-10 provides the NTG results for rooftop or split systems measure group. The statewide NTGRs were 50% for kWh, kW, and therms. No NTG survey was conducted for this measure group in PY2019 evaluation. The evaluated kWh NTGR from PY2018 were applied to the PY2019 evaluated savings to arrive at net savings for PY2019. The evaluation team believes the PY2018 evaluated NTGRs are the best estimate of program's influence in the state they existed in during PY2018 and PY2019.

Table 4-10. Rooftop or split system first-year net savings summary[27]

PA	Reported NTGR[28]	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	NRR
	Electric consumption (kWh)				
PGE	80%	50%	1,194,156	4,002,614	30%
SCE	83%	50%	965,125	3,419,895	28%
SDGE	85%	50%	249,120	875,967	28%
Total	82%	**50%**	**2,408,401**	**8,298,476**	**29%**
	Peak electric demand (kW)				
PGE	80%	50%	906	2,085.0	43%
SCE	83%	50%	749	1,711.0	44%
SDGE	83%	50%	231	415.4	56%
Total	81%	**50%**	**1,886**	**4,211**	**45%**
	Gas consumption (Therm)				
PGE	80%	50%	-242	-25,736	1%
SCE	85%	50%	-340	-14,059	2%
SDGE	88%	50%	-14	-1,427	1%
Total	82%	**50%**	**-596**	**-41,223**	**1%**

The NTGR method for rooftop and split systems in PY2018 evaluation generated an attribution score for three causal paths (stocking, upselling, and price) for distributors and end users.

Each of the three causal pathways had average distributor attributions of approximately 50%. Considering the many market factors affecting distributor behaviors, this is a strong effect for the program. Several open-ended answers by the distributors provide more detail about what influences their behaviors:

- Many of the distributors mentioned that it is necessary to get paybacks down to 3 or 4 years to sell a high efficiency model.
- All of the distributors said they stock based on what sells.
- Approximately half of the distributors mentioned that recent program changes make fewer types of equipment eligible and this makes it harder to sell high efficiency systems.
- Most also mentioned that the program sometimes runs out of funds before the end of the year, and that makes it hard to do business because they might promise a reduced price to a customer that they then can't follow through on if the program funding is gone.

Attributions for the causal pathways for end-users varied more than for distributors. The end-user scores indicate that distributor upselling is the most important factor when it comes to the sale of high efficiency equipment.

[27] For all analyses DNV GL realization rates do not include the 5% market effects adder. DNV GL NTGR values are calculated expanding DNV GL calculated ex-post gross to DNV GL calculated ex-post net values which do not include the 5% market effects adder. The only values that include the market effects 5% adder are the reported NTGR values in the tracking data; the tracking gross/net savings estimates themselves do not include the 5%. In order to address this in the reporting tables, the values for the "Reported NTGR" (which comes from the tracking data) have all been reduced by the 5% market effects adder so that the overall NRR are an equivalent comparison and thus not artificially deflating the results.

[28] The Reported NTGR includes the 5% market effects benefit.

5 CONCLUSIONS, FINDINGS, & RECOMMENDATIONS

In this section we provide overall program conclusions followed by each measure's key findings, illustrated with the key symbol, and recommendations, shown by the gear symbol.

Recommendations include supporting context for energy service providers. A list of these recommendations is listed and described in Appendix C per the CPUC ED Impact Evaluation Standard Reporting (IESR) Guidelines.

5.1. Conclusions

The implementation and evaluation of HVAC measures have evolved over the last decade. The changes to programs, measures, and the evaluation of impacts present challenges in assessing and tracking performance. Overall, PY 2019 gross evaluation activities showed savings lower than, expectations for both the selected measure groups with evaluated gross savings of 15% for the PTAC controls measure group and 48% for the Rooftop/Split measure group of expectations. The study results showed mixed NTGR scores for the selected measure groups with 94% NTGR for the PTAC controls measure group which is higher than the reported for this measure group whereas the Rooftop/Split measure group received a NTGR of 50% which is lower than the reported. The findings

and recommendations include those discovered during the evaluation process such as PA data quality, as well as those targeted for program or savings estimation improvement.

5.2. Overarching findings

PA tracking data contained incorrect contact information. We came across many cases where the contacts listed in the tracking and implementation data were unknown at the telephone numbers provided. In other cases, the telephone number had been disconnected. These types of issues are in some cases unavoidable. However, there were a large number of cases where no end user contact information was available, and as a result end-user data collection was not possible. Therefore, the evaluation was unable to spend additional resources trying to reach the right contact at each site when the PA provided contact proved incorrect.

PAs should continue to work to ensure that the contact information in the tracking data includes the correct and complete name, phone number, and e-mail address of the end-user's primary contact. We would also ask that implementers take measures to ensure that project data includes contact information for both the equipment buyer (for evaluating purchasing decisions) and the equipment operator (for obtaining installation characteristics such as schedules, setpoints, installed quantities, and so on).

We believe accurate contact information will improve the response rates in at least two ways:

- Evaluators will be able to establish their bona fides early through introductory letters or emails, giving later attempts to reach site contacts a better chance of success than cold calls.
- Evaluators will be more likely to reach the best respondent at each site on their first attempt.

5.2.1 PTAC controls

Findings and recommendations are grouped below as those applicable to both PG&E and SDG&E programs, those applicable to PG&E only, and those applicable to SDG&E.

PTAC controls realized 15% and 8% of statewide reported electric energy (kWh) and peak demand (kW) savings, respectively, in 2019. SDG&E programs realized 2% and 3% of reported electric energy and peak demand savings, respectively.

DNV GL recommends that PAs develop savings for PTAC controls and other similar HVAC controls technology groups with appropriate baseline, proper building types and vintage to reasonably capture the savings attributed to the technology improvements in these technology groups. For PTAC controls and other similar HVAC controls technology groups, DNV GL suggests PAs consider collecting and archiving the technology related performance data to ensure that the technologies are operating as intended. The collection of performance data will also assist appropriate evaluation of the HVAC controls technologies

Achieved GRRs are lower than 100% due in part to a reduction in installation rate from controls removal or override, as determined through our virtual audits. The SDG&E program in particular exhibited a 22% reduction in claimed kWh savings due to 5 of

13 sampled projects that had at least one instance of measure removal or override as a result of guest complaints. We determined that the PG&E and SDG&E programs, which are administered by third parties, did not incorporate independent QA/QC or field verification on a subset of tracked claims.

Administrators of programs involving similar HVAC controls measures should perform quality verification of installations to mitigate the risk of removal or bypassing of the controls. Hotel/motel guest comfort can be wide-ranging and subjective, potentially resulting in gradual controls equipment override or removal. One defensible method for quantifying the in-service rate involves field verification on a subset of tracked claims after an agreed-upon period of time. For programs that outsource administration and implementation responsibilities to third parties, we have found that withholding a share of the performance payment can be an effective motivator to perform field QA/QC and incorporate its findings in the final savings claims.

We continuously encountered gaps in tracking data for basic information that could have been collected by direct-installers throughout the PTAC controls evaluation. Such information that would have lessened the evaluation burden included: make/model and vintage of affected PTACs and PTHPs, average square footage of affected guest rooms, and year of hotel/motel construction or renovation.

Future programs offering similar nonresidential HVAC controls measures should require implementers and measure installers to collect, aggregate, and archive facility- and measure-level data relevant to independent savings assessment.

Despite the lower-than-expected GRRs, we found that the PTAC controls measure group exhibited relatively high net-to-gross ratios (NTGRs): 94% for both electric energy and peak demand savings. The high NTGRs are attributable to two main factors: lack of end-user awareness of the rebated controls technology and the direct-install program design that reduced the application burden on the end-user.

Future programs offering similar nonresidential HVAC controls measures should incorporate the successful direct-install design components that led to high NTGR values for the PTAC controls measure group in PY2018-19.

5.2.1.1 PG&E

The evaluation team identified three main deviations between PG&E savings claims and workpaper guidance applicable to PY2019 projects (PGE3PHVC149 Revision 2).

- **Title 24 code requirements** – The PG&E workpaper specifies that newly constructed facilities or end-of-life PTAC/PTHP installations must abide by the energy code in effect at the time of project application. In the case of PY2019 PTAC controls, the applicable code was California Title 24 2013, which requires that new PTACs or PTHPs installed in hotel or motel guest rooms to already have occupancy-sensing devices or equivalent controls built-in that set back the temperature set-point during periods of guest room vacancy.[29]

[29] "Hotel and motel guest rooms shall have captive card key controls, occupancy sensing controls, or automatic controls such that, no longer than 30 minutes after the guest room has been vacated, setpoints are setup at least +5°F (+3°C) in cooling mode and set-down at least -5°F (-3°C) in heating mode." California Title 24 2013, Section 120.2 (e) 4.

This code requirement thereby eliminates the controls savings for PTACs or PTHPs installed after the code's effective date of July 1, 2014.

- **Building classification** – The PG&E workpaper specifies that hotel/motel facility types are eligible for the PTAC controls measure. However, evaluators identified 9 projects within the sample of 74 PG&E projects that occurred at senior care facilities distinctly different from hotels or motels. Evaluators nonetheless quantified the savings for such installations (using the nursing home prototype DEER model as explained in Section 4.1), as they may present a viable market opportunity for other IOU programs moving forward.
- **Installations in common areas** – The PG&E workpaper specifies that PTAC controls measures are eligible only for PTAC, PTHP, or Split AC systems serving hotel/motel guest rooms. We found that 10 of the 74 sampled PG&E projects included at least one PTAC controls measure instance on HVAC systems serving hotel/motel common areas only. We therefore did not quantify the savings for such ineligible measure installations.

PAs should ensure that ex ante savings claims comply with the applicable workpaper(s). While the PTAC controls hotel/motel guest room measure has since been discontinued by PG&E, we have identified some best practices should a similar nonresidential HVAC controls measure be introduced in the future. Such measures should ensure that ex ante savings claims comply with the applicable workpaper(s), specifically in three areas: 1) code requirements for controls on newly installed HVAC systems, 2) eligibility by facility type for measures targeting specific nonresidential facility types, and 3) eligibility by space type for measures available to only discrete spaces within those facility types.

The PG&E workpaper overestimated the unit energy savings for the PTAC controls measure by treating the total, modeled, facility-wide HVAC electric energy consumption as the basis for savings. Since the PTAC controls measure only impacts the HVAC consumption in guest rooms—hotel/motel common areas are unaffected— the workpaper's inaccuracy led to the overestimation savings claims for PG&E programs in 2019.

Workpapers for similar HVAC controls measures should treat the modeled or measured HVAC energy consumption *only for affected spaces* as the basis for controls savings.

5.2.1.2 SDG&E

The ACC controls only marginally reduced the PTACs' fan energy consumption and did not produce savings at the magnitude claimed by the SDG&E workpaper. To inform the development of evaluated savings models, we requested from the adaptive climate controls (ACC) manufacturer any information supporting the SDG&E workpaper's savings claim of 30% reduction in PTAC/PTHP energy consumption (WPSDGENRHC1051). Such supporting information could include bench tests, pilot measurement and verification, or evaluation studies of the technology in other jurisdictions. Ultimately, the manufacturer produced only a single redacted study that involved pilot M&V on control boxes installed in five dwelling unit PTACs within a multifamily building. The study showed that the ACC controls only marginally reduced the PTACs' fan energy consumption and did not produce savings at the magnitude claimed by the SDG&E workpaper.

PAs should vet measures that include proprietary and/or innovative technologies through M&V or pilot test results. When designing programs that involve proprietary and/or innovative technologies, SDG&E and other California IOUs should vet such measures by requesting and reviewing third-party M&V data, pilot or bench test results, or other evaluation studies that demonstrate the efficacy of the proposed technology. Marketing materials from the manufacturer do not provide the same level of credibility as data-driven analyses and reports by independent third parties.

5.2.2 Rooftop/split systems

The ex-post savings were lower than the ex-ante estimate. The overall GRRs are 48% for kWh, 73% for peak kW and 2% for the therm. This difference is primarily due to the overestimation of savings in the ex-ante estimate, particularly due to the fan power index (W/cfm) assumption. But significant difference also materialized from the misapplication of building type, where the majority of sampled claims were assigned the weighted "Com" building type to estimate UES. The ex-ante estimate approach claimed savings equivalent to 60% of the total cooling load whereas the evaluation approach produced the savings to be approximately 10% of the total cooling load, which is in line with the efficiency improvement between the standard and high efficiency equipment.

The evaluation team recommends that the PAs model this measure group with appropriate baseline and proposed conditions including the HVAC system efficiencies, fan power index and applicable economizer controls. In that way, the simulation results will reasonably capture the savings attributed only to the efficiency improvement between the Title-24 standard and high efficiency equipment along with other efficiency upgrades. **We also recommend that appropriate building type and climate zone selections are made to assign UES whenever possible.** The simulation results will more accurately capture the building and weather loads represented by the DEER-specific building type and CA climate zone weather.

The midstream, distributor-facing design of the rooftop unit/split system measure group results in inconsistent or incomplete tracking data for all PAs. Rooftop or split systems measure rebates are paid to distributors, who in turn work with contractors to install high-efficiency systems among commercial customers. While the PY2019 evaluation did not contact customers for this measure group, we did identify many cases in the sampled tracking data where the customer contact information was the HVAC distributor or contractor. For approximately 74% of projects in the PY2018 population, the evaluation team did not have sufficient customer contact data to verify equipment installation or quantify evaluated savings. For the 26% of projects with sufficient customer contact data, recruitment for evaluation was challenging, as the customers were often unaware that they had participated in an efficiency program. The measure's midstream design and subsequent data gaps caused the evaluators to fall short of the target evaluation sample count of 85 projects. Data gaps were most prominent for programs administered by PG&E and SCE.

For any measures delivered midstream through distributor rebates, such as the rooftop and split system measure group, PAs must require participating distributors and partnering contractors to collaboratively collect and submit basic information for each customer that ultimately receives the rebated equipment. Such information

should include: facility name; facility classification; facility address; facility account number(s); name(s), phone number(s), and email address(es) of customer representative(s) familiar with the project; distributor name, phone number, and email address; and contractor name, phone number, and email address. Information for customer representatives should include equipment operators (e.g., facility maintenance) for gross data collection as well as project decision-makers (e.g., CFO) for net data collection. This basic information is critical for the utilities, the CPUC, and its contractors to verify installations and maintain the integrity of ratepayer incentive dollars.

The rooftop/split system measure group consisted of more than 100 unique measure descriptions for PY2019. For many of these, the PAs are claiming the same (DEER) measure but the measure descriptions are not consistent across the PAs. This makes the task of grouping the same measures across the PAs more difficult and introduces unnecessary complication and uncertainty.

The evaluation team recommends that PAs adopt a uniform technology description naming convention for technology groups to homogenize and therefore consolidate the descriptions under each technology group in order to move towards a statewide focused portfolio and to improve the evaluability of these technology groups across the PAs.

6 APPENDICES

6.1. Appendix A: Impact Evaluation Standard Reporting (IESR) required reporting−First year and lifecycle savings

Gross Lifecycle Savings (MWh)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC CONTROLS PTAC	83,403	12,879	0.15	0.0%	0.15
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	74,925	35,825	0.48	0.0%	0.48
PGE	**Total**	**158,328**	**48,704**	**0.31**	**0.0%**	**0.31**
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	61,502	28,954	0.47	0.0%	0.47
SCE	**Total**	**61,502**	**28,954**	**0.47**	**0.0%**	**0.47**
SDGE	HVAC CONTROLS PTAC	5,755	143	0.02	0.0%	0.02
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	15,529	7,474	0.48	0.0%	0.48
SDGE	**Total**	**21,284**	**7,616**	**0.36**	**0.0%**	**0.36**
	Statewide	***241,114***	***85,274***	***0.35***	***0.0%***	***0.35***

Net Lifecycle Savings (MWh)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC CONTROLS PTAC	54,507	12,752	0.23	0.0%	0.65	0.99	0.65	0.99
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	60,039	19,704	0.33	0.0%	0.80	0.55	0.80	0.55
PGE	**Total**	**114,546**	**32,456**	**0.28**	**0.0%**	**0.72**	**0.67**	**0.72**	**0.67**
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	51,298	15,925	0.31	0.0%	0.83	0.55	0.83	0.55
SCE	**Total**	**51,298**	**15,925**	**0.31**	**0.0%**	**0.83**	**0.55**	**0.83**	**0.55**
SDGE	HVAC CONTROLS PTAC	3,765	150	0.04	0.0%	0.65	1.05	0.65	1.05
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	13,140	4,110	0.31	0.0%	0.85	0.55	0.85	0.55
SDGE	**Total**	**16,904**	**4,260**	**0.25**	**0.0%**	**0.79**	**0.56**	**0.79**	**0.56**
	Statewide	***182,749***	***52,641***	***0.29***	***0.0%***	***0.76***	***0.62***	***0.76***	***0.62***

Gross Lifecycle Savings (MW)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC CONTROLS PTAC	29.3	2.4	0.08	0.0%	0.08
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	39.1	27.2	0.70	0.0%	0.70
PGE	**Total**	**68.4**	**29.6**	**0.43**	**0.0%**	**0.43**
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	31.0	22.5	0.72	0.0%	0.72
SCE	**Total**	**31.0**	**22.5**	**0.72**	**0.0%**	**0.72**
SDGE	HVAC CONTROLS PTAC	2.1	0.1	0.03	0.0%	0.03
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	7.5	6.9	0.92	0.0%	0.92
SDGE	**Total**	**9.6**	**7.0**	**0.73**	**0.0%**	**0.73**
	Statewide	***109.0***	***59.1***	***0.54***	***0.0%***	***0.54***

Net Lifecycle Savings (MW)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC CONTROLS PTAC	19.0	2.4	0.12	0.0%	0.65	0.98	0.65	0.98
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	31.3	15.0	0.48	0.0%	0.80	0.55	0.80	0.55
PGE	**Total**	**50.3**	**17.3**	**0.34**	**0.0%**	**0.74**	**0.59**	**0.74**	**0.59**
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	25.7	12.4	0.48	0.0%	0.83	0.55	0.83	0.55
SCE	**Total**	**25.7**	**12.4**	**0.48**	**0.0%**	**0.83**	**0.55**	**0.83**	**0.55**
SDGE	HVAC CONTROLS PTAC	1.4	0.1	0.05	0.0%	0.65	1.05	0.65	1.05
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	6.2	3.8	0.61	0.0%	0.83	0.55	0.83	0.55
SDGE	**Total**	**7.6**	**3.9**	**0.51**	**0.0%**	**0.79**	**0.55**	**0.79**	**0.55**
	Statewide	***83.6***	***33.6***	***0.40***	***0.0%***	***0.77***	***0.57***	***0.77***	***0.57***

Gross Lifecycle Savings (MTherms)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC CONTROLS PTAC	0	0			
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	-483	-7	0.02	0.0%	0.02
PGE	**Total**	**-483**	**-7**	**0.02**	**0.0%**	**0.02**
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	-249	-10	0.04	0.0%	0.04
SCE	**Total**	**-249**	**-10**	**0.04**	**0.0%**	**0.04**
SDGE	HVAC CONTROLS PTAC	0	0			
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	-24	0	0.02	0.0%	0.02
SDGE	**Total**	**-24**	**0**	**0.02**	**0.0%**	**0.02**
	Statewide	***-756***	***-18***	***0.02***	***0.0%***	***0.02***

Net Lifecycle Savings (MTherms)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC CONTROLS PTAC	0	0						
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	-386	-4	0.01	0.0%	0.80	0.55	0.80	0.55
PGE	**Total**	**-386**	**-4**	**0.01**	**0.0%**	**0.80**	**0.55**	**0.80**	**0.55**
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	-211	-6	0.03	0.0%	0.85	0.55	0.85	0.55
SCE	**Total**	**-211**	**-6**	**0.03**	**0.0%**	**0.85**	**0.55**	**0.85**	**0.55**
SDGE	HVAC CONTROLS PTAC	0	0						
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	-21	0	0.01	0.0%	0.88	0.55	0.88	0.55
SDGE	**Total**	**-21**	**0**	**0.01**	**0.0%**	**0.88**	**0.55**	**0.88**	**0.55**
	Statewide	***-618***	***-10***	***0.02***	***0.0%***	***0.82***	***0.55***	***0.82***	***0.55***

Gross First Year Savings (MWh)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC CONTROLS PTAC	16,681	2,576	0.15	0.0%	0.15
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	4,995	2,388	0.48	0.0%	0.48
PGE	**Total**	**21,676**	**4,964**	**0.23**	**0.0%**	**0.23**
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	4,100	1,930	0.47	0.0%	0.47
SCE	**Total**	**4,100**	**1,930**	**0.47**	**0.0%**	**0.47**
SDGE	HVAC CONTROLS PTAC	1,151	29	0.02	0.0%	0.02
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	1,035	498	0.48	0.0%	0.48
SDGE	**Total**	**2,186**	**527**	**0.24**	**0.0%**	**0.24**
	Statewide	***27,962***	***7,421***	***0.27***	***0.0%***	***0.27***

Net First Year Savings (MWh)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC CONTROLS PTAC	10,901	2,550	0.23	0.0%	0.65	0.99	0.65	0.99
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	4,003	1,314	0.33	0.0%	0.80	0.55	0.80	0.55
PGE	**Total**	**14,904**	**3,864**	**0.26**	**0.0%**	**0.69**	**0.78**	**0.69**	**0.78**
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	3,420	1,062	0.31	0.0%	0.83	0.55	0.83	0.55
SCE	**Total**	**3,420**	**1,062**	**0.31**	**0.0%**	**0.83**	**0.55**	**0.83**	**0.55**
SDGE	HVAC CONTROLS PTAC	753	30	0.04	0.0%	0.65	1.05	0.65	1.05
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	876	274	0.31	0.0%	0.85	0.55	0.85	0.55
SDGE	**Total**	**1,629**	**304**	**0.19**	**0.0%**	**0.75**	**0.58**	**0.75**	**0.58**
	Statewide	***19,953***	***5,230***	***0.26***	***0.0%***	***0.71***	***0.70***	***0.71***	***0.70***

Gross First Year Savings (MW)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC CONTROLS PTAC	5.9	0.5	0.08	0.0%	0.08
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	2.6	1.8	0.70	0.0%	0.70
PGE	**Total**	**8.5**	**2.3**	**0.27**	**0.0%**	**0.27**
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	2.1	1.5	0.72	0.0%	0.72
SCE	**Total**	**2.1**	**1.5**	**0.72**	**0.0%**	**0.72**
SDGE	HVAC CONTROLS PTAC	0.4	0.0	0.03	0.0%	0.03
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	0.5	0.5	0.92	0.0%	0.92
SDGE	**Total**	**0.9**	**0.5**	**0.52**	**0.0%**	**0.52**
	Statewide	***11.5***	***4.3***	***0.37***	***0.0%***	***0.37***

Net First Year Savings (MW)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC CONTROLS PTAC	3.8	0.5	0.12	0.0%	0.65	0.98	0.65	0.98
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	2.1	1.0	0.48	0.0%	0.80	0.55	0.80	0.55
PGE	**Total**	**5.9**	**1.5**	**0.25**	**0.0%**	**0.70**	**0.64**	**0.70**	**0.64**
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	1.7	0.8	0.48	0.0%	0.83	0.55	0.83	0.55
SCE	**Total**	**1.7**	**0.8**	**0.48**	**0.0%**	**0.83**	**0.55**	**0.83**	**0.55**
SDGE	HVAC CONTROLS PTAC	0.3	0.0	0.05	0.0%	0.65	1.05	0.65	1.05
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	0.4	0.3	0.61	0.0%	0.83	0.55	0.83	0.55
SDGE	**Total**	**0.7**	**0.3**	**0.39**	**0.0%**	**0.75**	**0.56**	**0.75**	**0.56**
	Statewide	***8.3***	***2.6***	***0.31***	***0.0%***	***0.72***	***0.60***	***0.72***	***0.60***

Gross First Year Savings (MTherms)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC CONTROLS PTAC	0	0			
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	-32	0	0.02	0.0%	0.02
PGE	**Total**	**-32**	**0**	**0.02**	**0.0%**	**0.02**
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	-17	-1	0.04	0.0%	0.04
SCE	**Total**	**-17**	**-1**	**0.04**	**0.0%**	**0.04**
SDGE	HVAC CONTROLS PTAC	0	0			
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	-2	0	0.02	0.0%	0.02
SDGE	**Total**	**-2**	**0**	**0.02**	**0.0%**	**0.02**
	Statewide	***-50***	***-1***	***0.02***	***0.0%***	***0.02***

Net First Year Savings (MTherms)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC CONTROLS PTAC	0	0						
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	-26	0	0.01	0.0%	0.80	0.55	0.80	0.55
PGE	**Total**	**-26**	**0**	**0.01**	**0.0%**	**0.80**	**0.55**	**0.80**	**0.55**
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	-14	0	0.03	0.0%	0.85	0.55	0.85	0.55
SCE	**Total**	**-14**	**0**	**0.03**	**0.0%**	**0.85**	**0.55**	**0.85**	**0.55**
SDGE	HVAC CONTROLS PTAC	0	0						
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	-1	0	0.01	0.0%	0.88	0.55	0.88	0.55
SDGE	**Total**	**-1**	**0**	**0.01**	**0.0%**	**0.88**	**0.55**	**0.88**	**0.55**
	Statewide	***-41***	***-1***	***0.02***	***0.0%***	***0.82***	***0.55***	***0.82***	***0.55***

6.2. Appendix B: IESR−Measure groups or passed through measures with early retirement

Per Unit (Quantity) Gross Energy Savings (kWh)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HVAC CONTROLS PTAC	0	0.0%	0.0%	5.0	805.1	161.0	161.0
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	0	0.0%	0.0%	15.0	953.5	63.6	63.6
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	0	0.0%	0.0%	15.0	1,117.3	74.5	74.5
SDGE	HVAC CONTROLS PTAC	0	0.0%	0.0%	5.0	84.0	16.8	16.8
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	0	0.0%	0.0%	15.0	1,180.1	78.7	78.7

Per Unit (Quantity) Gross Energy Savings (Therms)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HVAC CONTROLS PTAC	0	0.0%	0.0%	5.0	0.0	0.0	0.0
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	0	0.0%	0.0%	15.0	-0.2	0.0	0.0
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	0	0.0%	0.0%	15.0	-0.4	0.0	0.0
SDGE	HVAC CONTROLS PTAC	0	0.0%	0.0%	5.0	0.0	0.0	0.0
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	0	0.0%	0.0%	15.0	-0.1	0.0	0.0

Per Unit (Quantity) Net Energy Savings (kWh)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HVAC CONTROLS PTAC	0	0.0%	0.0%	5.0	797.2	159.4	159.4
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	0	0.0%	0.0%	15.0	524.4	35.0	35.0
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	0	0.0%	0.0%	15.0	614.5	41.0	41.0
SDGE	HVAC CONTROLS PTAC	0	0.0%	0.0%	5.0	88.1	17.6	17.6
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	0	0.0%	0.0%	15.0	649.1	43.3	43.3

Per Unit (Quantity) Net Energy Savings (Therms)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HVAC CONTROLS PTAC	0	0.0%	0.0%	5.0	0.0	0.0	0.0
PGE	HVAC ROOFTOP OR SPLIT SYSTEM	0	0.0%	0.0%	15.0	-0.1	0.0	0.0
SCE	HVAC ROOFTOP OR SPLIT SYSTEM	0	0.0%	0.0%	15.0	-0.2	0.0	0.0
SDGE	HVAC CONTROLS PTAC	0	0.0%	0.0%	5.0	0.0	0.0	0.0
SDGE	HVAC ROOFTOP OR SPLIT SYSTEM	0	0.0%	0.0%	15.0	0.0	0.0	0.0

6.3. Appendix C: IESR–Recommendations resulting from the evaluation research

Study ID	Study Type	Study Title	CPUC Study Manager
Group A HVAC Sector	Impact Evaluation	Impact Evaluation Report – Final Commercial HVAC Sector – Program Year 2019	Peng Gong, CPUC

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice/Recommendations	Recipient	Affected Workpaper or DEER
1	All Programs	PA Tracking data contained incorrect contact information	We came across many cases where the contacts listed in the tracking and implementation data were unknown at the telephone numbers provided. In other cases, the telephone number had been disconnected. These types of issues are in some cases unavoidable. However, there were a large number of cases where no end user contact information was available, and as a result end-user data collection was not possible. Therefore, the evaluation was unable to spend additional resources trying to reach the right contact at each site when the PA provided contact proved incorrect.	PAs should continue to work to ensure that the contact information in the tracking data includes the correct and complete name, phone number, and e-mail address of the end-user's primary contact. We would also ask that implementers take measures to ensure that project data includes contact information for both the equipment buyer (for evaluating purchasing decisions) and the equipment operator (for obtaining installation characteristics such as schedules, setpoints, installed quantities, and so on). We believe accurate contact information will improve the response rates in at least two ways: • Evaluators will be able to establish their bona fides early through introductory letters or emails, giving later attempts to reach site contacts a better chance of success than cold calls. • Evaluators will be more likely to reach the best respondent at each site on their first attempt.	All PAs	

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice/Recommendations	Recipient	Affected Workpaper or DEER
2	Association of Monterey Bay Area Governments (AMBAG), Hospitality Program, Local Government Energy Actions Resources (LGEAR), San Francisco, Silicon Valley, SW-COM-Deemed Incentives-HVAC Commercial	PTAC controls realized 15% and 8% of statewide reported electric energy (kWh) and peak demand (kW) savings, respectively, in 2019.	SDG&E programs realized 2% and 3% of reported electric energy and peak demand savings, respectively.	DNV GL recommends that PAs develop savings for PTAC controls and other similar HVAC controls technology groups with appropriate baseline, proper building types and vintage to reasonably capture the savings attributed to the technology improvements in these technology groups. For PTAC controls and other similar HVAC controls technology groups, DNV GL suggests PAs consider collecting and archiving the technology related performance data to ensure that the technologies are operating as intended. The collection of performance data will also assist appropriate evaluation of the HVAC controls technologies.	PG&E, SDG&E	PGE3PHVC149-2, WPSDGENRHC1051-1
3	Association of Monterey Bay Area Governments (AMBAG), Hospitality Program, Local Government Energy Actions Resources (LGEAR), San Francisco, Silicon Valley, SW-COM-Deemed Incentives-HVAC Commercial	Achieved GRRs are lower than 100% due in part to a reduction in installation rate from controls removal or override, as determined through our virtual audits.	The SDG&E program in particular exhibited a 22% reduction in claimed kWh savings due to 5 of 13 sampled projects that had at least one instance of measure removal or override as a result of guest complaints. We determined that the PG&E and SDG&E programs, which are administered by third parties, did not incorporate independent QA/QC or field verification on a subset of tracked claims.	Administrators of programs involving similar HVAC controls measures should perform quality verification of installations to mitigate the risk of removal or bypassing of the controls. Hotel/motel guest comfort can be wide-ranging and subjective, potentially resulting in gradual controls equipment override or removal. One defensible method for quantifying the in-service rate involves field verification on a subset of tracked claims after an agreed-upon period of time. For programs that outsource administration and implementation responsibilities to third parties, we have found that withholding a share of the performance payment can be an effective motivator to perform field QA/QC and incorporate its findings in the final savings claims.	PG&E, SDG&E	PGE3PHVC149-2, WPSDGENRHC1051-1

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice/Recommendations	Recipient	Affected Workpaper or DEER
4	Association of Monterey Bay Area Governments (AMBAG), Hospitality Program, Local Government Energy Actions Resources (LGEAR), San Francisco, Silicon Valley, SW-COM-Deemed Incentives-HVAC Commercial	We continuously encountered gaps in tracking data for basic information that could have been collected by direct-installers throughout the PTAC controls evaluation.	Such information that would have lessened the evaluation burden included: make/model and vintage of affected PTACs and PTHPs, average square footage of affected guest rooms, and year of hotel/motel construction or renovation.	Future programs offering similar nonresidential HVAC controls measures should require implementers and measure installers to collect, aggregate, and archive facility- and measure-level data relevant to independent savings assessment	PG&E, SDG&E	PGE3PHVC149-2, WPSDGENRHC1051-1
5	Association of Monterey Bay Area Governments (AMBAG), Hospitality Program, Local Government Energy Actions Resources (LGEAR), San Francisco, Silicon Valley, SW-COM-Deemed Incentives-HVAC Commercial	Despite the lower-than-expected GRRs, we found that the PTAC controls measure group exhibited relatively high net-to-gross ratios (NTGRs): 94% for both electric energy and peak demand savings.	The high NTGRs are attributable to two main factors: lack of end-user awareness of the rebated controls technology and the direct-install program design that reduced the application burden on the end-user.	Future programs offering similar nonresidential HVAC controls measures should incorporate the successful direct-install design components that led to high NTGR values for the PTAC controls measure group in PY2018-19.	PG&E, SDG&E	PGE3PHVC149-2, WPSDGENRHC1051-1

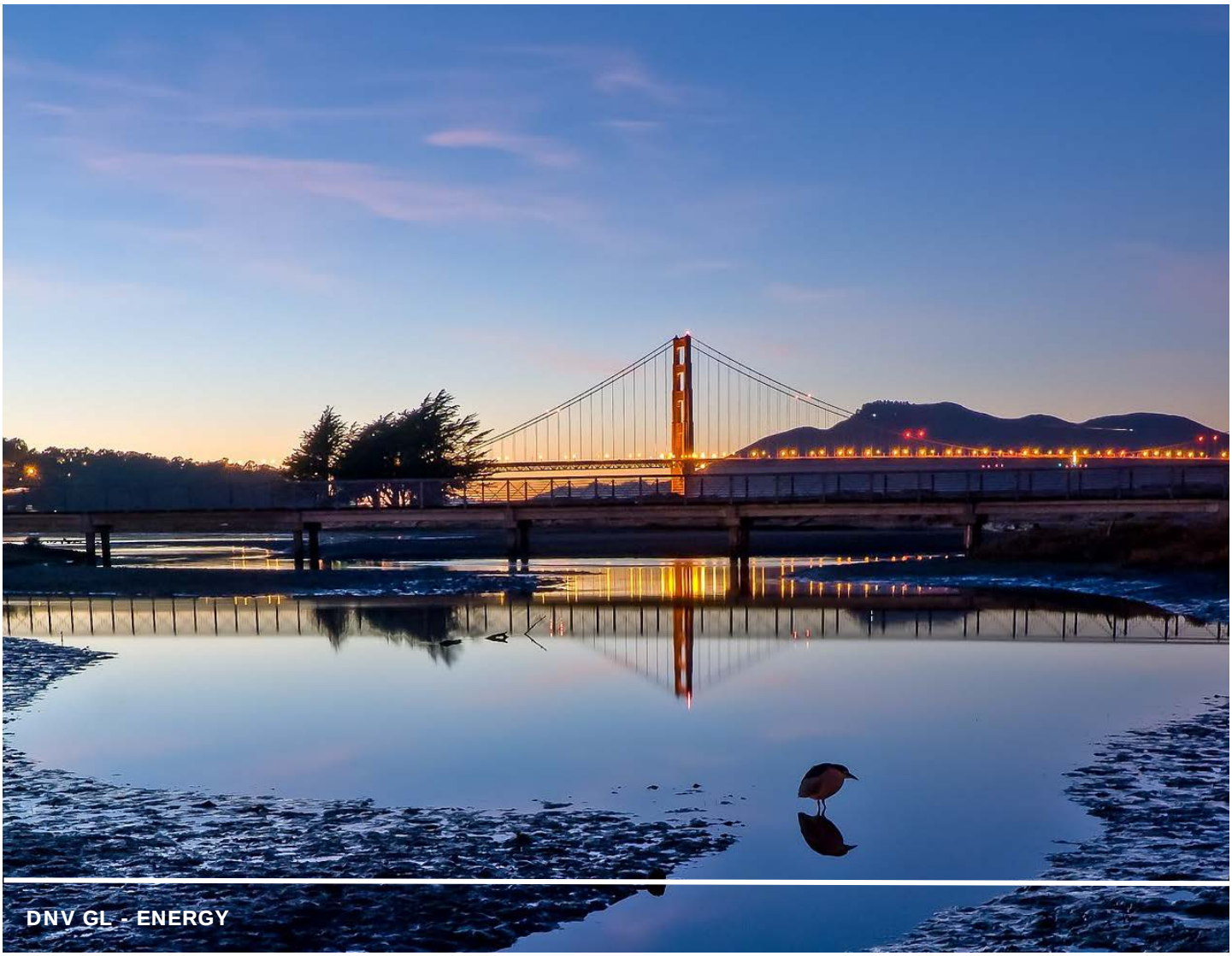
Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice/Recommendations	Recipient	Affected Workpaper or DEER
6	Association of Monterey Bay Area Governments (AMBAG), Hospitality Program, Local Government Energy Actions Resources (LGEAR), San Francisco, Silicon Valley	The evaluation team identified three main deviations between PG&E savings claims and workpaper guidance applicable to PY2019 projects	• Title 24 code requirements – The PG&E workpaper specifies that newly constructed facilities or end-of-life PTAC/PTHP installations must abide by the energy code in effect at the time of project application. In the case of PY2019 PTAC controls, the applicable code was California Title 24 2013, which requires that new PTACs or PTHPs installed in hotel or motel guest rooms to already have occupancy-sensing devices or equivalent controls built-in that set back the temperature set-point during periods of guest room vacancy. This code requirement thereby eliminates the controls savings for PTACs or PTHPs installed after the code's effective date of July 1, 2014. • Building classification – The PG&E workpaper specifies that hotel/motel facility types are eligible for the PTAC controls measure. However, evaluators identified 9 projects within the sample of 74 PG&E projects that occurred at senior care facilities distinctly different from hotels or motels. Evaluators nonetheless quantified the savings for such installations (using the nursing home prototype DEER model as explained in Section 4.1), as they may present a viable market opportunity for other IOU programs moving forward. • Installations in common areas – The PG&E workpaper specifies that PTAC controls measures are eligible only for PTAC, PTHP, or Split AC systems serving hotel/motel guest rooms. We found that 10 of the 74 sampled PG&E projects included at least one PTAC controls measure instance on HVAC systems serving hotel/motel common areas only. We therefore did not quantify the savings for such ineligible measure installations.	PAs should ensure that ex ante savings claims comply with the applicable workpaper(s). While the PTAC controls hotel/motel guest room measure has since been discontinued by PG&E, we have identified some best practices should a similar nonresidential HVAC controls measure be introduced in the future. Such measures should ensure that ex ante savings claims comply with the applicable workpaper(s), specifically in three areas: 1) code requirements for controls on newly installed HVAC systems, 2) eligibility by facility type for measures targeting specific nonresidential facility types, and 3) eligibility by space type for measures available to only discrete spaces within those facility types.	PG&E	PGE3PHVC149-2

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice/Recommendations	Recipient	Affected Workpaper or DEER
7	Association of Monterey Bay Area Governments (AMBAG), Hospitality Program, Local Government Energy Actions Resources (LGEAR), San Francisco, Silicon Valley	The PG&E workpaper overestimated the unit energy savings for the PTAC controls measure by treating the total, modeled, facility-wide HVAC electric energy consumption as the basis for savings	Since the PTAC controls measure only impacts the HVAC consumption in guest rooms—hotel/motel common areas are unaffected— the workpaper's inaccuracy led to the overestimation savings claims for PG&E programs in 2019.	Workpapers for similar HVAC controls measures should treat the modeled or measured HVAC energy consumption only for affected spaces as the basis for controls savings.	PG&E	PGE3PHVC149-2
8	SW-COM-Deemed Incentives-HVAC Commercial	The ACC controls only marginally reduced the PTACs' fan energy consumption and did not produce savings at the magnitude claimed by the SDG&E workpaper	To inform the development of evaluated savings models, we requested from the adaptive climate controls (ACC) manufacturer any information supporting the SDG&E workpaper's savings claim of 30% reduction in PTAC/PTHP energy consumption (WPSDGENRHC1051). Such supporting information could include bench tests, pilot measurement and verification, or evaluation studies of the technology in other jurisdictions. Ultimately, the manufacturer produced only a single redacted study that involved pilot M&V on control boxes installed in five dwelling unit PTACs within a multifamily building. The study showed that the ACC controls only marginally reduced the PTACs' fan energy consumption and did not produce savings at the magnitude claimed by the SDG&E workpaper.	PAs should vet measures that include proprietary and/or innovative technologies through M&V or pilot test results. When designing programs that involve proprietary and/or innovative technologies, SDG&E and other California IOUs should vet such measures by requesting and reviewing third-party M&V data, pilot or bench test results, or other evaluation studies that demonstrate the efficacy of the proposed technology. Marketing materials from the manufacturer do not provide the same level of credibility as data-driven analyses and reports by independent third parties.	SDG&E	WPSDGENRHC1051-1

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice/Recommendations	Recipient	Affected Workpaper or DEER
9	Commercial HVAC, Nonresidential HVAC Program, School Energy Efficiency, SW-COM-Deemed Incentives-HVAC Commercial	The ex-post savings were lower than the ex-ante estimate.	The overall GRRs are 48% for kWh, 73% for peak kW and 2% for the therm. This difference is primarily due to the overestimation of savings in the ex-ante estimate, particularly due to the fan power index (W/cfm) assumption. But significant difference also materialized from the misapplication of building type, where the majority of sampled claims were assigned the weighted "Com" building type to estimate UES. The ex-ante estimate approach claimed savings equivalent to 60% of the total cooling load whereas the evaluation approach produced the savings to be approximately 10% of the total cooling load, which is in line with the efficiency improvement between the standard and high efficiency equipment.	The evaluation team recommends that the PAs model this measure group with appropriate baseline and proposed conditions including the HVAC system efficiencies, fan power index and applicable economizer controls. In that way, the simulation results will reasonably capture the savings attributed only to the efficiency improvement between the Title-24 standard and high efficiency equipment along with other efficiency upgrades. We also recommend that appropriate building type and climate zone selections are made to assign UES whenever possible. The simulation results will more accurately capture the building and weather loads represented by the DEER-specific building type and CA climate zone weather.	PG&E, SCE, SDG&E	PGECOHVC126-7, PGECOHVC128-9, PGECOHVC172-0, PGECOHVC172-1, SCE17HC012.1, SCE17HC035.1, WPSDGENRHC0023-2, WPSDGENRHC0025-0

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice/Recommendations	Recipient	Affected Workpaper or DEER
10	Commercial HVAC, Nonresidential HVAC Program, School Energy Efficiency, SW-COM-Deemed Incentives-HVAC Commercial	The midstream, distributor-facing design of the rooftop unit/split system measure group results in inconsistent or incomplete tracking data for all PAs.	Rooftop or split systems measure rebates are paid to distributors, who in turn work with contractors to install high-efficiency systems among commercial customers. While the PY2019 evaluation did not contact customers for this measure group, we did identify many cases in the sampled tracking data where the customer contact information was the HVAC distributor or contractor. For approximately 74% of projects in the PY2018 population, the evaluation team did not have sufficient customer contact data to verify equipment installation or quantify evaluated savings. For the 26% of projects with sufficient customer contact data, recruitment for evaluation was challenging, as the customers were often unaware that they had participated in an efficiency program. The measure's midstream design and subsequent data gaps caused the evaluators to fall short of the target evaluation sample count of 85 projects. Data gaps were most prominent for programs administered by PG&E and SCE.	For any measures delivered midstream through distributor rebates, such as the rooftop and split system measure group, PAs must require participating distributors and partnering contractors to collaboratively collect and submit basic information for each customer that ultimately receives the rebated equipment. Such information should include: facility name; facility classification; facility address; facility account number(s); name(s), phone number(s), and email address(es) of customer representative(s) familiar with the project; distributor name, phone number, and email address; and contractor name, phone number, and email address. Information for customer representatives should include equipment operators (e.g., facility maintenance) for gross data collection as well as project decision-makers (e.g., CFO) for net data collection. This basic information is critical for the utilities, the CPUC, and its contractors to verify installations and maintain the integrity of ratepayer incentive dollars.	PG&E, SCE, SDG&E	PGECOHVC126-7, PGECOHVC128-9, PGECOHVC172-0, PGECOHVC172-1, SCE17HC012.1, SCE17HC035.1, WPSDGENRHC0023-2, WPSDGENRHC0025-0
11	Commercial HVAC, Nonresidential HVAC Program, School Energy Efficiency, SW-COM-Deemed Incentives-HVAC Commercial	The rooftop/split system measure group consisted of more than 100 unique measure descriptions for PY2019.	For many of these, the PAs are claiming the same (DEER) measure but the measure descriptions are not consistent across the PAs. This makes the task of grouping the same measures across the PAs more difficult and introduces unnecessary complication and uncertainty.	The evaluation team recommends that PAs adopt a uniform technology description naming convention for technology groups to homogenize and therefore consolidate the descriptions under each technology group in order to move towards a statewide focused portfolio and to improve the evaluability of these technology groups across the PAs.	PG&E, SCE, SDG&E	PGECOHVC126-7, PGECOHVC128-9, PGECOHVC172-0, PGECOHVC172-1, SCE17HC012.1, SCE17HC035.1, WPSDGENRHC0023-2, WPSDGENRHC0025-0

6.4. Appendix D: Data collection and sampling memo



SAFER, SMARTER, GREENER

Sampling and Data Collection Memo

HVAC Sector – Program Year 2019

CALIFORNIA PUBLIC UTILITIES COMMISSION

EM&V Group A

August 27, 2020

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1 OVERVIEW

This document outlines the sampling and data collection plan for the Heating, Ventilating, and Air Conditioning (HVAC) sector for the Program Year (PY 2019) impact evaluation of deemed savings under the Group A contract with the California Public Utilities Commission (CPUC).

Our sampling and data collection efforts under Deliverable 7 (Data Collection and Sampling Approach) are designed to meet the needs of Deliverable 1 (Research and Evaluation Workplans), Deliverable 8 (Program Analysis and Recommendations), Deliverable 9 (Gross Savings Estimates) and Deliverable 10 (Net Savings Estimates). As part of Deliverable 7, we have developed a sampling and data collection strategy to serve the needs of these deliverables at the required rigor levels.

Our approach to measure group selection is described in Section 2, while Section 3 contains the sampling approach and sample summary. Section 4 covers data collection for both gross and net savings estimates. Finally, the Appendices include the data collection instruments we will use to gather data for quantifying our gross and net savings.

2 MEASURE GROUP SELECTION

Working with Commission staff, the evaluation team determined which measure groups to evaluate for PY 2019 based on the following selection process. First, the deemed HVAC annual savings claims[1] were grouped by PY 2019 ESPI (Efficiency Savings and Performance Incentive) and Non-ESPI measure groups. Next, each measure group's contribution to savings (kWh, kW, therms) was ranked and these individual rankings were combined to create an overall HVAC sector savings contribution ranking. The selection process then took into consideration whether a measure group had been evaluated recently and looked at year-over-year trends in the savings claims for that measure group. The Commission staff and the evaluation team sought Stakeholder engagement on both the process and the proposed measure groups selection through the HVAC Project Coordination Group meetings and the HVAC Workplan engagement process with the Program Administrators (PAs).

2.1 Measure groups selected for evaluation

The measure groups selected for this evaluation are primarily from the statewide list of HVAC ESPI uncertain measures. For the PY 2019 evaluation, we have selected nine measure groups across the HVAC sector—five are ESPI measure groups and four are non-ESPI. The four ESPI measure groups, and their market sectors, are:

- HVAC PTAC[2] Controls (Commercial)
- HVAC Motor Replacement (Residential)
- HVAC Duct Sealing (Residential)
- HVAC Maintenance (Residential)
- HVAC Refrigerant Charge Adjustment, or RCA (Residential)

The non-ESPI measure groups selected for evaluation are:

- HVAC Rooftop/Split Systems (Commercial)
- HVAC Controls Fan (Residential)
- HVAC Coil Cleaning (Residential)
- HVAC Furnace (Residential)

Our evaluation team will perform both gross savings and net attribution assessments on eight of the nine measure groups; one measure group (the Rooftop/Split System, a non-ESPI measure group) will receive gross-only assessment.

Table 1 shows a complete list of the selected measure groups for 2019 and specifies the measure groups that are selected for evaluation of gross savings estimates and/or net program attribution for PY 2019 along with their ESPI status.

[1] The evaluation team ranked measure groups by first-year gross savings and lifetime net savings and found the rankings had no substantial differences.

[2] PTAC and PTHP are acronyms for the packaged terminal air conditioning/heat pump systems frequently found serving lodging guest rooms.

Table 1. PY 2019 HVAC sector measure groups for evaluation

Measure Group	Sector	2019 ESPI	Gross Savings Evaluation	Net Savings Evaluation
HVAC PTAC Controls	Commercial	Yes	Yes	Yes
HVAC Rooftop/Split System	Commercial	No	Yes	No
HVAC Motor Replacement	Residential	Yes	Yes	Yes
HVAC Duct Sealing	Residential	Yes	Yes	Yes
HVAC Refrigerant Charge Adjustment (RCA)	Residential	Yes	Yes	Yes
HVAC Maintenance	Residential	Yes	Yes	Yes
HVAC Controls Fan	Residential	No	Yes	Yes
HVAC Coil Cleaning	Residential	No	Yes	Yes
HVAC Furnace	Residential	No	Yes	Yes

Table 2 shows the savings claims for the PY 2019 HVAC Sector ESPI and non-ESPI measure groups selected for evaluation, as well as a line item grouping all other deemed HVAC measure group claims that are not under evaluation.

Table 2. PY 2019 first year gross savings tracking data claims for deemed HVAC ESPI and Non-ESPI evaluation measure groups

ESPI Uncertain Measure List	Measure Groups	kW	% kW	kWh	% kWh	Therms	% Therms
ESPI	HVAC Controls PTAC	6,280	20%	17,831,593	27%	0	0%
	HVAC Duct Sealing	2,898	9%	2,180,142	3%	150,712	15%
	HVAC Maintenance	0	0%	0	0%	0	0%
	HVAC Motor Replacement	6,331	20%	7,985,195	12%	-37,043	-4%
	HVAC RCA	2,756	9%	2,657,242	4%	-126	0%
Non-ESPI	HVAC Coil Cleaning	651	2%	662,781	1%	-59	0%
	HVAC Controls Fan	3,997	13%	14,428,949	22%	285,954	28%
	HVAC Furnace	0	0%	0	0%	316,441	31%
	HVAC Rooftop/Split Systems	5,305	17%	10,285,837	16%	-57,133	-6%
	HVAC measure groups not evaluated	3,035	10%	9,870,631	15%	349,873	35%
Total Deemed HVAC		**31,253**	**100%**	**65,902,370**	**100%**	**1,008,619**	**100%**

3 SAMPLING

Section 3 describes the applied sampling approach and sample summary.

3.1 Sampling approach

Depending on the measure group being evaluated, the sampling methodology employs either a census approach or a stratified ratio estimation model. A census approach will study every unit in a population whereas a stratified ratio estimation approach will study a subset of units in a population. The stratified ratio approach first places participants into segments of interest (in this case, by evaluated measure group) and then into strata by size, measured in kWh and therm savings. The methodology then estimates appropriate sample sizes based on an assumed error ratio.

The error ratio is the ratio-based equivalent of a coefficient of variation (CV). The CV measures the variability (standard deviation or root-mean-square difference) of individual evaluated values around their mean value, as a fraction of that mean value. Similarly, the error ratio measures the variability (root-mean-square difference) of individual evaluated values from the ratio: Evaluated = Ratio* Reported, as a fraction of the mean evaluated value. Thus, to estimate the precision that can be achieved by the planned sample sizes, or conversely the sample sizes necessary to achieve a given precision level, it is necessary to develop a preliminary estimate of the error ratio for the sample components.

In practice, error ratios cannot be determined until after the data are collected and savings are evaluated, and therefore need to be estimated. The sample design and projected precision are therefore based on assumed error ratios from experience with similar work. A simple verification study may use an error ratio of 0.50. A study looking to measure annual or peak consumption would have a higher estimated error ratio based on past metering studies, somewhere between 0.7 and 1.0 depending on buildings and climates covered.[3] For the PTAC measure group, the only group receiving a stratified ratio sampling approach, we assume an overall error ratio of 0.8 for each Program Administrator (PA) based on previous experience with similar studies. This evaluation will measure a set of conditions and compare them to current simulation model assumptions. Analysis will be possible across PAs but Climate Zones (CZs) with small population savings will have small or no samples.

For the stratified ratio estimation sample design, first we defined sampling frames for each of the sampled measure groups being evaluated. The sampling frame for each measure group is the list of savings claims records under that measure group from which the sampling units are selected. Once sampling frames are defined, we stratified the population on the claimed savings (kWh or therms). Then we determined the target precisions and designed the sample to achieve ±10% relative precision for each measure group at the 90% confidence level assuming an error ratio of 0.8. Once sample size was calculated, we randomly chose primary sample points from the population in each stratum. We have selected a sample large enough to achieve the targeted number of completed cases, after the response rates are considered. We have also selected a backup sample in case we need to replace any sample points. This most often happens with sites that can't be visited or evaluated for some reason.

3.2 Measure group sampling overview

From the nine selected PY 2019 measure groups, only the commercial HVAC PTAC Controls measure group gross impact effort will use a stratified ratio estimation approach for sample design. As described just above, the sampling methodology for HVAC PTAC Controls measure group will employ a stratified ratio estimation model that places participants into strata by kWh savings. The methodology then estimates appropriate sample sizes based on an assumed error ratio.

The determination of the net program attribution for the commercial HVAC PTAC Controls measure group will use a census approach targeting the utility customers who are the decision makers being influenced by the programs.

The commercial HVAC Rooftop/Split Systems measure group will not involve primary data collection from PY 2019 participants and is not subject to a sampling treatment. For the Rooftop/Split System measure group, the evaluation team will perform a discrepancy analysis between PY 2018 ex-post results and claimed PY 2018 ex-ante savings and true-up the unit energy savings (UES) values as appropriate for measures within this group.

The gross and net impacts of all the residentially-focused HVAC measure groups (Duct Sealing, Maintenance, Motor Replacement, RCA, Coil Cleaning, Controls Fan, and Furnace) will use the census approach where the entire program population will be evaluated via the AMI data analysis/simulation modeling and remote data collection methods described in detail in the PY 2019 workplan and

[3] *California Commercial End-Use Survey,* Itron, Inc.; JJ Hirsh and Associates; KEMA Inc.; *ADM* 2006, CALMAC ID CEC 0023.01

summarized here. The gross AMI meter data analysis approach will use 12 months of pre- and post-retrofit kW and therms to estimate the household level savings. This analysis will also be supported by bottom-up International Performance Measurement and Verification Protocol (IPMVP) Option-D simulation approach; our team will use eQUEST simulation modeling of the DEER residential prototypes to generate measure savings estimates that will inform the disaggregation of meter-level savings to measure-group-level savings. To determine net program attribution of programs offering the HVAC residential measure groups, we will take a census approach to conduct either market actor (i.e. equipment distributors) or end-user surveys, depending on the programs' intervention point in the market.

3.3 PTAC Controls measure groups sample design

The PTAC controls measure group contains 192 sites that claimed savings during PY 2019. About 84% of the sites (162 sites) participated in Pacific Gas and Electric (PG&E) programs and 16% (30 sites) took part in the program from San Diego Gas and Electric (SDG&E). Southern California Edison (SCE) and Southern California Gas (SCG) had no PTAC Controls measures in the 2019 program year.

For gross savings of the PTAC controls measure group, DNV GL's team will design the sample to achieve +/-10% relative precision at the 90% confidence level. In order to achieve this relative precision at the 90% confidence level with an assumed error ratio of 0.80, a total of 85 sample sites are required. Table 3 shows the PY 2019 PTAC controls measure group populations and the sample sizes for each program by PA.

Table 3. PTAC Controls gross sample by PA and program

PA	Program	Sample Size	Population Size	Relative Precision[4]	Program Savings (kWh)	Error Ratio
PG&E	Hospitality Program	53	126	12.7%	14,473,895	0.80
	Local Government Energy Action Resources (LGEAR)	3	5	44.7%	217,216	0.80
	Association of Monterey Bay Area Governments (AMBAG)	3	8	74.2%	293,185	0.80
	Silicon Valley	3	4	26.5%	212,107	0.80
	San Francisco	8	19	21.7%	1,484,175	0.80
	PG&E Total	**70**	**162**	**11.3%**	**16,680,578**	**0.80**
SDG&E	SW-COM-Deemed Incentives-HVAC Commercial	15	30	19.0%	1,151,015	0.80
	SDG&E Total	**15**	**30**	**19.0%**	**1,151,015**	**0.80**
Statewide Total		**85**	**192**	**10.6%**	**17,831,593**	**0.80**

In order to be able to produce meaningful results for each program a minimum sample size was established. Due to the small population sizes of some of the PGE programs (N<10) a minimum

[4] Anticipated relative precision at 90% confidence

sample size of 3 was selected. For all programs with larger populations and savings of at least 10% of the PA program, the sample was allocated to maximize the overall relative precision of the sample design.

Table 4 shows the stratification and inclusion probability for the PTAC controls sample design.

Table 4. PTAC Controls measure group stratification

PA	Program	Stratum	Maximum	Population Size	Program Savings (kWh)	Sample Size	Inclusion Probability[5]
PG&E	Hospitality Program	1	88,605	49	2,119,164	10	0.204
		2	114,475	25	2,498,762	10	0.400
		3	152,150	20	2,661,129	10	0.500
		4	192,425	16	2,792,092	10	0.625
		5	311,017	12	2,992,619	9	0.750
		6	371,425	4	1,410,129	4	1.000
	LGEAR	1	65,025	4	118,406	2	0.500
		2	98,810	1	98,810	1	1.000
	AMBAG	1	99,345	8	293,185	3	0.375
	Silicon Valley	1	51,653	3	72,534	2	0.667
		2	139,573	1	139,573	1	1.000
	San Francisco	1	20,625	7	98,125	2	0.286
		2	30,000	5	123,125	1	0.200
		3	80,000	3	153,125	1	0.333
		4	354,420	4	1,109,800	4	1.000
SDG&E	SW-COM-Deemed Incentives-HVAC Commercial	1	18,496	9	101,444	3	0.333
		2	23,291	6	125,117	2	0.333
		3	32,196	5	141,308	2	0.400
		4	46,581	3	126,729	2	0.667
		5	4,392	3	180,327	2	0.667
		6	38,374	4	476,090	4	1.000

[5] Inclusion probability is the chance that the population element becomes part of a sample.

4 DATA COLLECTION

As part of this task the evaluation team is developing a data collection framework to improve consistency, facilitate comparison of results across data collection efforts, reduce the time for survey development, minimize review time, and facilitate quality assurance and quality control. The framework includes:

- Guidance and templates for instrument development
- Standard question modules for common survey batteries
- Recommendations on QA/QC procedures
- Guidance on data collection management
- Guidance on sample management

The details of developing this data collection framework are described in Appendix B of the Workplan document.

4.1 Data collection instruments

Where appropriate, we will base data collection on our existing Commission-approved data collection instruments. We have worked with Commission staff and other stakeholders to assess, revise, and approve these data collection instruments prior to collecting any data.

4.1.1 Commercial measure groups

4.1.1.1 HVAC PTAC Controls

For the PY 2019 evaluation of PTAC Controls measures, we will conduct interviews with end users at participating facilities (primarily over the phone, supplemented with web-based interviews if required) using utility-provided contact and equipment information. The phone interview will include questions to verify measure installation and persistence and to establish the equipment's baseline control scheme. The information collected will be used to update installation rates and refine gross savings estimates for PTAC Controls measures.

At the time of this writing, the evaluators assume that on-site visits will not be feasible for PY 2019 data collection, due to the ongoing COVID-19 pandemic. As a result, the phone interview with contacts at participating end user facilities will be the primary data collection mechanism. The data collection plan for PTAC control measures will include:

- **Installation Characteristics**: The most critical characteristics evaluators will inquire about include the facility type, building vintage, and installed unit quantity per site. A list of additional items to be recorded are included in the appendices.
- **Equipment Nameplate**: Evaluators will confirm the characteristics of the installed PTAC controllers as well as the PTAC units being controlled. Evaluators will request the contact to provide photographs of the equipment and nameplates and/or submit documentation to objectively verify installation and characteristics.
- **Operating Characteristics**: Evaluators will ask the facility contact about typical room operation and set-point schedules. Trended operating data will be requested to be shared directly from the site or through the installation vendor. The evaluator will obtain the heating and cooling

temperature set-point schedules for weekdays, weekends and holidays as well as temperature set-points for occupied and non-occupied periods. The evaluator will ask for a list of holidays observed at the facility (if applicable) as well as typical occupancy patterns and any notable changes in operation from before and after the project took place (for instance, changes due to the COVID-19 pandemic.)

- **Additional data:** These include any documentation confirming measure installation or providing additional insight into how the units are controlled before and after the project took place.

  The gross data collection instruments are in Appendix D (PG&E) and Appendix E (SDG&E.) The net data collection instrument for end users is in Appendix C**.**

4.1.1.2 Rooftop/Split Systems

No onsite data collection is proposed for Rooftop/Split System measure group. The evaluation team will address the discrepancy between the ex-ante and ex-post savings estimate via simulation and eventually propose to true up the UES of this measure group based on the simulation results. The evaluation team will use the best available models including DEER resources, the California electronic Technical Reference Manual (eTRM) [6], and other data sources (including existing EM&V data) to develop robust independent savings impact estimates.

4.1.2 Residential HVAC measure groups

4.1.2.1 Coil Cleaning, Controls Fan, Furnaces, Maintenance, Fan Motor Replacement, RCA, & Duct Sealing

For PY 2019 we will use energy consumption analysis for estimating gross energy savings for these measure groups. Gross savings estimates will be based on metered consumption data and will not require data collection instruments. See Section 3.2 for a discussion of our methodology for producing gross savings estimates.

We will complete the gross savings estimates deliverable by January 2021 and incorporate the results into the evaluation report. We will submit the draft gross savings deliverable to Commission staff prior to finalization.

4.1.2.2 Net attribution data collection

We will perform net evaluations for all residential HVAC measure groups under evaluation for PY 2019.

To support our net savings estimates we plan to interview end-user utility customers or property managers for direct install programs and HVAC equipment distributors for upstream programs. Some of the specific efforts under this plan are:

- Reviewing the program PIP and conduct interviews with program managers to discuss program theory on influencing alternate equipment types where applicable
- Conducting end-user interviews to assess free ridership for the downstream programs
- Conducting market actor interviews with participating distributors to assess program influence

[6] https://www.caetrm.com/

DNV GL's team has demonstrated effective stakeholder management in previous evaluation cycles by including a review process for all data collection instruments—not only with the Energy Division Program Manager, but also with PA program evaluation staff and other stakeholders. This process is particularly beneficial for evaluations of newer programs or programs where there have been significant changes that necessitate input from PA staff to refine and improve instruments. We have posted data collection instruments to Basecamp or other CPUC collaboration site.

The net data collection instruments are in Appendix A (furnace distributors for upstream programs) and Appendix B (residential customers for Direct Install and downstream programs.)

4.1.2.3 Data sources

Data sources and applicable measure groups are summarized in Table 5 below. This table shows some of the data sources and data collection activities across the measure groups for this sector. Data will be used to provide a robust, accurate, and defensible ex-post estimate of measure impacts. Remote data collection efforts will focus on verifying the simulation model inputs. We provide additional details in Table 5.

Table 5. Summary of data sources and applicable measure groups

Data Sources	Description	Applicable Measure Group(s)
Program Tracking Data	PA program data includes number of records, savings per record, program type, name, measure groups, measure description, incentives etc.	• PTAC Controls • Rooftop/Split System • Fan Motor Replacement • Duct Sealing • RCA • Maintenance • Controls Fan • Coil Cleaning • Furnace
Program Monthly Billing Data	PA billing data including kWh and therms	• PTAC Controls • Fan Motor Replacement • Duct Sealing • RCA • Maintenance • Controls Fan • Coil Cleaning • Furnace
Program Advanced Metering Infrastructure (AMI) Data	Detailed, time-based energy consumption information	• PTAC Controls • Fan Motor Replacement • Duct Sealing • RCA • Maintenance • Controls Fan • Coil Cleaning • Furnace
Project-Specific Information	Project folders include scope of work, energy audit reports, equipment model and serial numbers, nominal efficiency, test results, project costs, etc.	• PTAC Controls • Rooftop/Split System
Manufacturer Data Sheet	Data sheets Include equipment specifications such as horsepower (HP), efficiency, capacity, etc.	• PTAC Controls • Rooftop/Split System

Data Sources	Description	Applicable Measure Group(s)
Telephone/Web Surveys	Includes surveys of customers, distributors, other market actors, and PA program staff.	• PTAC Controls • Fan Motor Replacement • Duct Sealing • RCA • Maintenance • Controls Fan • Coil Cleaning • Furnace
On-site Surveys	Includes verifying measure installation, gathering measure performance parameters such as efficiency, schedules, setpoints, building characteristics etc.	• N/A
End-use metering	Includes performing spot measurements, short-term metering with data loggers, performance measurements	• N/A

The following list defines the data sources identified above in **Table 5**:

- **Program tracking data.** Each of the Program Administrators (PAs) will provide and upload program tracking data onto a centralized server. We will then analyze, clean, re-categorize, and reformat these datasets, if necessary. For programs and measures, the impact evaluation team will review PA monthly reports and actual program tracking data to reconcile actual versus reported claims, thereby validating PA tracking data uploads.
- **Project-specific information.** The PAs maintain paper and/or electronic files for each application or project in their energy efficiency programs. These can contain various pieces of information such as email correspondence written by the utility's customer representatives documenting various aspects of a given project such as the measure effective useful life (EUL), incremental cost, measure payback with and without the rebate. As part of the file review process, we will thoroughly review these documents to assess their reasonableness.
- **Data sheets from equipment manufacturers.** As part of the gross data collection, we will request technical specifications of the evaluated equipment from manufacturers and equipment vendors. These data sheets typically include performance parameters of the equipment such as horsepower, efficiency, capacity, energy efficiency ratio (EER).
- **Telephone / web surveys of participating customers and distributors.** Both gross and net deliverables will require telephone/web surveys. We will perform surveys with customers, distributors, other market actors, and PAs.
- **On-site surveys.** Because of the COVID-19 pandemic, DNV GL is not planning any on-site visits during this evaluation period.
- **End-use metering.** Because of the COVID-19 pandemic, DNV GL is not planning end-use metering during this evaluation period.

Appendix A HVAC RESIDENTIAL FURNACE DISTRIBUTOR NET DATA COLLECTION FORM

CPUC HVAC 2019
NTG Res Furnace Di:

Appendix B HVAC RESIDENTIAL MEASURE GROUP DATA COLLECTION FORM

CPUC PY2019
RES_HVAC NTG Surv

Appendix C HVAC COMMERCIAL PTAC CONTROLS NET DATA COLLECTION FORM

CPUC GROUP A
PTAC Net Data Colle

Appendix D HVAC COMMERCIAL PTAC CONTROLS GROSS DATA COLLECTION FORM PG&E

CPUC A PTAC Controls_Data Colle

Appendix E HVAC COMMERCIAL PTAC CONTROLS GROSS DATA COLLECTION FORM SDG&E

CPUC A PTAC Controls_Data Colle

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter, and greener.

6.5. Appendix E: PTAC controls data collection forms

6.5.1 PG&E program participant DCF

PTAC/PTHP/Split AC Controls Phone Interview Data Collection Worksheet - PG&E	Site ID	
	Surveyor	
	Date	

Hello, my name is _____ and I'm calling from ERS on behalf of PG&E.
My company has been contracted by the California Public Utilities Commission to analyze the energy savings associated with projects funded by PG&E's PTAC/PTHP/Split AC control programs. The [Project Name] project for [Owner/Facility Name] is one of the projects that has been selected for this evaluation and we would greatly appreciate your participation in this important study.
Our records indicate that your organization installed controls on PTAC/PTHP/Split AC units in the guest room through the program on [Install Date]. Does this sound familiar?
[If no] Is there someone I can talk to who might be more familiar with this particular project? [Record contact information and retry.]
[If yes, record name and title of respondent and proceed]
Our original plan for the evaluation was to conduct a site visit to the facility to confirm measure installation and install data logging equipment to estimate PTAC/PTHP/Split AC operational hours reduction due to the measure installation. However, to avoid any risks associated with exposure to the COVID-19 virus, we are conducting virtual assessments in place of site visits to gather data for our evaluation analysis. I would like to ask you a few questions about the project, the building characteristics, and the measure's operation prior to the COVID-19 pandemic to gather data for the evaluation. It would take approximately 30 minutes for this assessment. Would now be a good time for you to talk? [If not, obtain the time that would work best for site contact]
[If yes] Ok great. First, I'd like to get a few basic details about the project.

Question/Parameter		Response
According to our records, the project occurred at [Site Address], Is this correct?	*for Climate Zone*	
Our records also indicate that controls were installed on [Quantity] guest room PTAC/PTHP/Split AC units in the facility. Is this correct?	*Record quantity for each type of unit (PTAC/PTHP/Split AC)*	
We see from our records that the controls were installed in [Month/Year]. Is this correct?	*Month/Year*	
About when was the hotel constructed or majorly renovated?	*e.g., 2003, 1998 etc.*	
Would you classify the building as a hotel or motel?	*Hotel/Motel*	
What is the overall building area (in ft^2)?		
Number of floors in the building?		
Were there any changes to hotel operations in 2019 compared to prior years?		
Is there any seasonality associated with hotel occupancy rates or other operations that could have an impact on the energy bills?		
[If yes, probe further to obtain seasonality]		
Can you recall any energy or non-energy related events that occurred at the hotel in the past 2 years which could have an impact on the energy bills? For example, an elevator out of commission for a	*Yes/No*	

PTAC/PTHP/Split AC Controls Phone Interview Data Collection Worksheet - PG&E		Site ID	
		Surveyor	
		Date	
month would impact the bills for that particular month.			
[If yes, probe further to obtain details]			
Can you provide the contact information of the HVAC vendor who assisted you with the project installation?			
How many total guest rooms are in the facility?			
Did all guest rooms have this measure installed?	*Yes/No*		
[If no, investigate the number of guest rooms with PTACs and the number affected by the project]			
What is the average guest room size? Or total area covered by the guest rooms?			
What type of controls were installed to modify the operation of the guest room PTAC/PTHP/Split AC units? (e.g., Passive IR occupancy sensors, key card controls)	*e.g., Passive IR occupancy sensors, key card controls*		
Can you provide us the make and model number of the guest room PTAC/PTHP/Split AC units?			
Would you be able to take pictures of the equipment nameplate and send us?			
We are hoping to confirm that the controls measure is still installed and in operation. Would you be able to take pictures of the installed controls and send us?			
Do you recall if any PTAC controls have been temporarily or permanently overridden or removed?			
[If yes, ask for reasons why the controls were removed or overridden]			
Can you briefly explain how the operation of the PTAC/PTHP/Split AC unit is modified based on occupancy? Does the unit turn off/modify temperature setpoints or both? More specifically, we are looking to understand how the units were controlled after the measure installation but **prior to the COVID-19 pandemic.**			
Was the operation of the PTAC/PTHP/Split AC units automatically controlled prior to the project?	*Yes/No*		
[If yes] What type of controls were present? E.g. ON/OFF, Occupancy based, manual setpoint, programmable thermostats etc.			
Do you have records of monthly facility guest room occupancy rates for the past 24 months? Importantly, we are looking to gather this data for **pre-COVID-19 time period**. March 2018 - February 2020	*Yes/No*		
[If yes] Can you send us that information?			
[If no] Can you estimate the percentage of facility guest rooms occupied for the year prior to installation of the project? Can you also explain any seasonality associated with these occupancy rates?			
As part of our energy modeling process, we are hoping to gather information about the building, its systems, and the PTAC controls themselves. You might have some of this data already in your archives. I'll first ask about the availability of some of this information, and if anything is unavailable, I'll ask some follow-up questions to fill in the gaps.			
D1. Do you have an inventory of HVAC systems throughout the			

PTAC/PTHP/Split AC Controls Phone Interview Data Collection Worksheet - PG&E		Site ID	
		Surveyor	
		Date	
[hotel/motel] including the affected PTACs in guest rooms?			
D2. Do you have an inventory of lighting fixtures and bulbs throughout the hotel, including the guest rooms?			
D3. Do you have a detailed breakdown of area or percentage of building footprint covered by each common space type in the building?			
D4. PTAC controls such as these are often paired with an Energy Management System that monitors and tracks system performance. Are you aware of such an Energy Management System for your facility's guest room PTACs?			
[If yes] Do you know if the system has trending and archiving capability?			
[If yes] Would it be possible to receive a copy of the EMS's trend logs? [probe the data points being monitored and request 2 years' worth of data from the EMS (Pre-COVID)]			
D5. Were there any energy related studies, such as energy audits, performed at your facility over the last 5 years?			
[If yes] Would it be possible to receive a copy of that energy study report? It likely includes much of the information we are seeking on HVAC and lighting systems in the building.			
[Provide details for file sharing if any/all of the data requests above (D1-D5) can be completed by the site contact]			
[If D1 = No] Can you describe the types and sizes of the HVAC systems serving the non-guest room spaces?			
[If D2 = No]			
Can you identify the lamp types, total number of lamps, and the lamp wattages in the guest rooms?			
[If no] Would you be able to take pictures of the lighting fixtures in the guest room and send to us over a secure platform?			
How are lights in the guest room controlled?	*Manual on/off, Occupancy sensor, Key card controls*		
What is the most prominent lighting fixture types in non-guest room spaces?- LEDs- Fluorescents- Halogens- Other			
[If D3 = No]			
We see that your facility includes the following common area spaces: [kitchen, restaurant, bar, lobby, laundry, 2 meeting rooms, vending, storage, mechanical closets, fitness center, sauna, pool]. Are there any that we missed?			
About how much square footage or % of building footprint is covered by the [restaurant]? [Continue similar questioning pattern for other major common space types, and fill the table below]			

PTAC/PTHP/Split AC Controls Phone Interview Data Collection Worksheet - PG&E	Site ID	
	Activity Type (ex: Kitchen, lobby, dining etc.)	Floor Square Footage or % of Building Area (ft^2 or %)
From a basic search online, we were able to understand that you have the following room types in your hotel: [Room Type 1] [Room Type 2] [Room Type 3] .. Can you provide an approximate count of each of these room types in the hotel?		
We were also able to find that you have the following appliances in your guest rooms: [TV] [Refrigerator] [Hair dryers] [Coffee makers] [Irons] [Alarm clocks] Is there something that I missed? Are there any other, abnormal energy-using equipment in guest rooms?		
Prior to the project, did the housekeepers have a checklist for guestroom lighting, HVAC and other devices, when the rooms are unoccupied? For example - turning all lights and appliances off, HVAC system set to auto at 73°F, etc?		
[If yes, probe further about default setpoint details, both for cooling and heating seasons]		
[If no] Can you estimate the default cooling and heating temperature setpoints in unoccupied guest rooms prior to the project installation?		
After the project was installed, and prior to the COVID-19 pandemic, did the housekeepers have a checklist for guestroom lighting, HVAC and other devices, when the rooms are unoccupied?		
[If yes, probe further about default setpoint details, both for cooling and heating seasons]		
[If no] Can you estimate the default cooling and heating temperature setpoints in unoccupied guest rooms after the project was installed, and prior to the COVID-19 pandemic?		
Thank you so much for your time answering these questions today. We might need to call you at a later time if we are missing something for our evaluation. Hope that works at your end. Again, thank you and I appreciate you taking time to answer my questions.		

Reference Information if Needed

"This evaluation and the results of our measurement and verification will have no impact on the incentive you have already received, or your eligibility for future projects."
"Your responses will not affect your ability to participate in the program in the future. All information obtained in this evaluation will be strictly confidential."
"I am not selling anything. I simply want to estimate the impacts from the energy efficiency measure that was installed with assistance from this program."

6.5.2 SDG&E program participant DCF

PTAC/PTHP/Split AC Controls Phone Interview Data Collection Worksheet - SDG&E	Site ID	
	Surveyor	
	Date	

Hello, my name is _____ and I'm calling from ERS on behalf of SDG&E.
My company has been contracted by the California Public Utilities Commission to analyze the energy savings associated with projects funded by SDG&E's PTAC/PTHP/Split AC Adaptive Climate Control programs. The [Project Name] project for [Owner/Facility Name] is one of the projects that has been selected for this evaluation and we would greatly appreciate your participation in this important study.
Our records indicate that your organization installed controls on PTAC/PTHP/Split AC units in the guest room through the program on [Install Date]. Does this sound familiar?
[If no] Is there someone I can talk to who might be more familiar with this particular project? [Record contact information and retry.]
[If yes, record name and title of respondent and proceed]
Our original plan for the evaluation was to conduct a site visit to the facility to confirm measure installation and install data logging equipment to estimate PTAC/PTHP/Split AC operational hours reduction due to the measure installation. However, to avoid any risks associated with exposure to the COVID-19 virus, we are conducting virtual assessments in place of site visits to gather data for our evaluation analysis. I would like to ask you a few questions about the project, the building characteristics, and the measure's operation prior to the COVID-19 pandemic to gather data for the evaluation. It would take approximately 30 minutes for this assessment. Would now be a good time for you to talk? [If not, obtain the time that would work best for site contact]
[If yes] Ok great. First, I'd like to get a few basic details about the project.

Question/Parameter		Response
According to our records, the project occurred at [Site Address], Is this correct?	*for Climate Zone*	
Our records also indicate that controls were installed on [Quantity] guest room PTAC/PTHP/Split AC units in the facility. Is this correct?	*Record quantity for each type of unit (PTAC/PTHP/Split AC)*	
We see from our records that the controls were installed in [Month/Year]. Is this correct?	*Month/Year*	
About when was the hotel constructed or majorly renovated?	*e.g., 2003, 1998 etc.*	
Would you classify the building as a hotel or motel?	*Hotel/Motel*	
What is the overall building area (in ft^2)?		
Number of floors in the building?		
Were there any changes to hotel operations in 2019 compared to prior years?		
Is there any seasonality associated with hotel occupancy rates or other operations that could have an impact on the energy bills?		
[If yes, probe further to obtain seasonality]		
Can you recall any energy or non-energy related events that occurred at the hotel in the past 2 years which could have an impact on the energy bills? For example, an elevator out of commission for a month would impact the bills for that particular month.	*Yes/No*	

PTAC/PTHP/Split AC Controls Phone Interview Data Collection Worksheet - SDG&E		Site ID	
		Surveyor	
		Date	
[If yes, probe further to obtain details]			
Can you provide the contact information of the HVAC vendor who assisted you with the project installation?			
How many total guest rooms are in the facility?			
Were all guest rooms have the measure installed?	*Yes/No*		
[If no, investigate the number of guest rooms with PTACs and the number affected by the project]			
What is the average guest room size? Or total area covered by the guest rooms?			
What type of controls were installed to modify the operation of the guest room PTAC/PTHP/Split AC units?			
Can you provide us the make and model number of the guest room PTAC/PTHP/Split AC units?			
Would you be able to take pictures of the equipment nameplate and send us?			
We are hoping to confirm that the controls measure is still installed and in operation. Would you be able to take pictures of the installed controls and send us?			
Do you recall if any PTAC controls have been temporarily or permanently overridden or removed?			
[If yes, ask for reasons why the controls were removed or overridden]			
Can you briefly explain how the operation of the PTAC/PTHP/Split AC unit is modified ? More specifically, we are looking to understand how the units were controlled after the measure installation but **prior to the COVID-19 pandemic.**			
Was the operation of the PTAC/PTHP/Split AC units automatically controlled prior to the project?	*Yes/No*		
[If yes] What type of controls were present? E.g. ON/OFF, Occupancy based, manual setpoint, programmable thermostats etc.			
Do you have records of monthly facility guest room occupancy rates for the past 24 months? Importantly, we are looking to gather this data for **pre-COVID-19 time period**. March 2018-February 2020	*Yes/No*		
[If yes] Can you send us that information?			
[If no] Can you estimate the percentage of facility guest rooms occupied for the year prior to installation of the project? Can you also explain any seasonality associated with these occupancy rates?			
As part of our energy modeling process, we are hoping to gather information about the building, its systems, and the PTAC controls themselves. You might have some of this data already in your archives. I'll first ask about the availability of some of this information, and if anything is unavailable, I'll ask some follow-up questions to fill in the gaps.			
D1. Do you have an inventory of HVAC systems throughout the			

PTAC/PTHP/Split AC Controls Phone Interview Data Collection Worksheet - SDG&E		Site ID	
		Surveyor	
		Date	
[hotel/motel] including the affected PTACs in guest rooms?			
D2. Do you have an inventory of lighting fixtures and bulbs throughout the hotel, including the guest rooms?			
D3. Do you have a detailed breakdown of area or percentage of building footprint covered by each common space type in the building?			
D4. PTAC controls such as these are often paired with an Energy Management System that monitors and tracks system performance. Are you aware of such an Energy Management System for your facility's guest room PTACs?			
[If yes] Do you know if the system has trending and archiving capability?			
[If yes] Would it be possible to receive a copy of the EMS's trend logs? [probe the data points being monitored and request 2 years' worth of data from the EMS (Pre-COVID)]			
D5. Were there any energy related studies, such as energy audits, performed at your facility over the last 5 years?			
[If yes] Would it be possible to receive a copy of that energy study report? It likely includes much of the information we are seeking on HVAC and lighting systems in the building.			
[Provide details for file sharing if any/all of the data requests above (D1-D5) can be completed by the site contact]			
[If D1 = No] Can you elaborate briefly about the types and sizes of the HVAC systems serving the non-guest room spaces?			
[If D2 = No]			
Can you identify the lamp types, total number of lamps, and the lamp wattages in the guest rooms?			
[If no] Would you be able to take pictures of the lighting fixtures in the guest room and send to us over a secure platform?			
How are lights in the guest room controlled?	*Manual on/off, Occupancy sensor, Key card controls*		
What is the most prominent lighting fixture types in non-guest room spaces? - LEDs - Fluorescents - Halogens - Other			
[If D3 = No]			
We see that your facility includes the following common area spaces: [kitchen, restaurant, bar, lobby, laundry, 2 meeting rooms, vending, storage, mechanical closets, fitness center, sauna, pool]. Are there any that we missed?			

PTAC/PTHP/Split AC Controls Phone Interview Data Collection Worksheet - SDG&E	Site ID	
	Surveyor	
	Date	

About how much square footage or % of building footprint is covered by the [restaurant]? [Continue similar questioning pattern for other major common space types, and fill the table below]	**Activity Type (ex: Kitchen, lobby, dining etc.)**	**Floor Square Footage or % of Building Area (ft^2 or %)**
From a basic search online, we were able to understand that you have the following room types in your hotel: [Room Type 1] [Room Type 2] [Room Type 3] ..... Can you provide an approximate count of each of these room types in the hotel?		
We were also able to find that you have the following appliances in your guest rooms: [TV] [Refrigerator] [Hair dryers] [Coffee makers] [Irons] [Alarm clocks] Is there something that I missed? Are there any other, abnormal energy-using equipment in guest rooms?		
Prior to the project, did the housekeepers have a checklist for guestroom lighting, HVAC and other devices, when the rooms are unoccupied? For example - turning all lights and appliances off, HVAC system set to auto at 73°F, etc?		
[If yes, probe further about default setpoint details, both for cooling and heating seasons]		
[If no] Can you estimate the default cooling and heating temperature setpoints in unoccupied guest rooms prior to the project installation?		
After the project was installed, and prior to the COVID-19 pandemic, did the housekeepers have a checklist for guestroom lighting, HVAC and other devices, when the rooms are unoccupied?		
[If yes, probe further about default setpoint details, both for cooling and heating seasons]		
[If no] Can you estimate the default cooling and heating temperature setpoints in unoccupied guest rooms after the project was installed, and prior to the COVID-19 pandemic?		
Thank you so much for your time answering these questions today. We might need to call you at a later time if we are missing something for our evaluation. Hope that works at your end. Again, thank you and I appreciate you taking time to answer my questions.		

Reference Information if Needed

"This evaluation and the results of our measurement and verification will have no impact on the incentive you

PTAC/PTHP/Split AC Controls Phone Interview Data Collection Worksheet - SDG&E	Site ID	
	Surveyor	
	Date	
have already received, or your eligibility for future projects."		
"Your responses will not affect your ability to participate in the program in the future. All information obtained in this evaluation will be strictly confidential."		
"I am not selling anything. I simply want to estimate the impacts from the energy efficiency measure that was installed with assistance from this program."		

6.5.3 PTAC controls net survey DCF

2019 CPUC_CA HVAC Group A PTAC Net Survey

Survey Length (min)

Interviewer

Contact phone number **[select from drop down - info below will autopopulate]**

- Contact Name
- Contact email
- Utility
- Program Name
- Measure Description
- Address
- Install date
- No of Installed Controls
- Installed Cost

Introduction

Intro1. Hello, my name is _____, and I'm calling on behalf SDG&E and the California Public Utilities Commission concerning an evaluation of the SDG&E Premium Efficiency Cooling program here at [company name]. SDG&E records show last year the guest rooms PTAC units air conditioning units upgraded with a fan speed controls. I'd like to speak with either the owner or someone in building management that is familiar with this installation. I'm not selling anything I just have a few questions.

Intro1. Hello, my name is _____, and I'm calling on behalf PG&E and the California Public Utilities Commission concerning an evaluation of the PG&E Hospitality program. PG&E records show last year the guest rooms had a Verdant thermostat control and sensors installed on the guest room PTAC units. I'd like to speak with either the owner or someone that is familiar with this installation. I'm not selling anything I just have a few questions.

For reference: Program Name: [PG&E: Hospitality Program, SDG&E: "Premium Efficiency Cooling"] program; Company named they may have interacted with [PG&E: Ecology Action, SDG&E: CLEAResult]; Technology name: Verdant

Intro2. Our records show that your hotel/motel had these controls installed in 2019 through [utility]'s program. Are you familiar with the installation of equipment? **[IF YES, SKIP TO Intro6]**

Intro3. Who could I speak to that would be familiar with those installations?

Intro4. Could I speak with **<<Intro3>>** now? **[IF YES, RESTART SURVEY WITH NEW RESPONDENT]**

Intro5. When is a good time I could call back to reach **<<Intro3>>**?

Intro6. What is your name & title?

Awareness

VERIFICATION

V1. Our records show that your business had a [NUMBER INSTALLED] thermostat controls /guest room energy management system installed through this program. Does that sound correct? [IF confirmed NO and None installed, make 100% sure nothing was done and if so, OK to TERMINATE]

Yes -->

No -->

[If no] How many were installed?

[Record]

V2. How many of the room thermostat/sensors are still installed and operational?

[Record]

V3. Have you made any changes to the system since you installed it?

[Record]

A2. How did you first hear about the program?
[SELECT 1 FOR ALL THAT ARE MENTIONED. DO NOT READ RESPONSES]

[Not aware/have not heard of it]

[Prior participation/previous installation at a same or different location]

[Ecology Action/ClearResult contacted them, e.g. email, phone, in-person solicitation]

[<utility> website]

[<utility> representative>]

[colleagues within organization]

[people outside organization]

[unknown person called]

[unknown person emailed]

[unknown person dropped in]

[Other, specify_____]

[Don't know]

[Refused]

FREE RIDERHSIP

In these next set of questions, we would like to know about the importance of the program in your decision to have the equipment installed. The program provided a total of $[X] dollars in incentives to buy down the cost of the equipment and installation.

NTG_L1. If you had not participated in the program in 2019, how likely would you have been to purchase these thermostat controls on your own?

1. Very unlikely
2. Somewhat unlikely
3. A 50/50 chance
4. Somewhat likely
5. Very likely

Don't know

Refused

FR_Likely

NTG_Q1. If you had not received these [QTY] PTAC thermostat controls/energy management systems through the program, how many would you have purchased and installed, on your own, at an equipment cost of approximately $250 unit?

[Fill in quantity of 0 to answer to M2; "DK" for don't know and "R" for Refused --> NTG_T1]

NTG_Q2. Why do you say that?

FR_Q

NTG_T1. If you had not received these energy management systems through the program in 2019, when would you have purchased them in the absence of the program?

At the same time or sooner --> NTG_T2

1 to 24 months later --> NTG_T2

25 to 48 months later --> NTG_T2

More than 48 months later --> NTG_T2

Never --> NTG_T2

Don't know -->I2

NTG_T2. Why do you say that?

FR_T

I2. Why did you decide to install this equipment? **[SELECT 1 FOR ALL THAT ARE MENTIONED. DO NOT READ RESPONSES]**

[Rebates/Free]

[PROGRAM (SDG&E/PG&E) Contractor recommendation]

[previous participation]

[Improve customer comfort]

[Save on energy bills]

[Payback calculations]

[Marketing tool]

[Other: record _____]

[Don’t know]

[Refused]

I3. **[ASK IF I2 = "Contractor recommendation"]** What benefits did the program contractor discuss with you?

[SELECT 1 FOR ALL THAT ARE MENTIONED. DO NOT READ RESPONSES]

[Improve customer comfort]

[Save on energy bills]

[Payback calculations]

[Marketing tool]

[Other: record _____]

POSTCODE: Rebates

[Don’t know]

[Refused]

[If i3= payback calculations] I4. What ROI requirement were you looking for

Months:

I4. Are you satisfied with the equipment installed?

Yes/No

If no, why not?

I5. Thank you for your feedback. Do you have any other feedback regarding your experience with this program that you would like to share before we close?

[Record]

Thanks & Terminate

Those are all the questions we have for you today. Thank you for your participation in our survey.

Unweighted FR_Total

Unweighted Attribution

Weighted Attribution

6.6. Appendix F: Gross impact findings tables for rooftop/split systems

Table 6-1. Rooftop or split system kWh discrepancy impacts by step, PG&E

EnergyImpactID	Count	% impact on ex-ante kWh					Average kWh GRR
		Step 1	Step 2	Step 3	Step 4	Step 5	
NE-HVAC-airHP-Pkg-lt55kBtuh-16p0seer-8p5hspf	44	0%	0%	-39%	0%	-49%	12%
NE-HVAC-airHP-Pkg-55to65kBtuh-16p0seer-8p5hspf	3	0%	5%	-18%	-8%	-67%	12%
NE-HVAC-airAC-Pkg-55to65kBtuh-16p0seer	189	0%	0%	-28%	0%	-58%	13%
NE-HVAC-airAC-Pkg-55to65kBtuh-17p0seer	69	0%	4%	-24%	-3%	-62%	14%
NE-HVAC-airAC-Pkg-lt55kBtuh-17p0seer	181	0%	2%	-26%	-2%	-60%	14%
NE-HVAC-airAC-Pkg-lt55kBtuh-16p0seer	347	0%	0%	-29%	0%	-56%	15%
NE-HVAC-airAC-SpltPkg-65to109kBtuh-11p5eer-wPreEcono	8	0%	26%	-16%	-30%	-31%	49%
NE-HVAC-airAC-Pkg-lt55kBtuh-15p0seer	50	0%	0%	-28%	0%	-21%	50%
NE-HVAC-airAC-Pkg-55to65kBtuh-15p0seer	14	0%	1%	-16%	-1%	-25%	59%
NE-HVAC-airAC-SpltPkg-65to109kBtuh-13p0eer-wPreEcono	31	0%	18%	-24%	-13%	-19%	62%
NE-HVAC-airAC-SpltPkg-135to239kBtuh-12p5eer	1	0%	0%	-34%	0%	0%	66%
NE-HVAC-airAC-SpltPkg-65to135kBtuh-12p5eer-wPreEcono	19	0%	44%	18%	-59%	-31%	72%
NE-HVAC-airAC-SpltPkg-gte760kBtuh-11p0eer	2	0%	14%	-23%	-15%	0%	76%
NE-HVAC-airHP-Pkg-lt55kBtuh-15p0seer-8p2hspf	14	0%	2%	-39%	-2%	17%	78%
NE-HVAC-airAC-Pkg-55to65kBtuh-18p0seer	4	N/A	24%	-21%	-25%	0%	79%
NE-HVAC-airAC-SpltPkg-135to239kBtuh-11p5eer	4	0%	0%	-21%	0%	0%	79%
NE-HVAC-airAC-SpltPkg-gte760kBtuh-10p2eer	51	0%	4%	-11%	-5%	0%	89%
PGE210112 measures	18	0%	N/A	N/A	N/A	N/A	100%
NE-HVAC-airAC-Pkg-lt55kBtuh-18p0seer	1	0%	0%	18%	0%	-18%	100%
NE-HVAC-airAC-SpltPkg-135to239kBtuh-12p0eer	30	0%	5%	10%	-4%	0%	111%
NE-HVAC-airAC-SpltPkg-65to109kBtuh-12p0eer-wPreEcono	69	0%	6%	8%	-9%	8%	114%
NE-HVAC-airAC-SpltPkg-240to759kBtuh-10p8eer	18	0%	12%	29%	-8%	0%	133%

EnergyImpactID	Count	% impact on ex-ante kWh					Average kWh GRR
		Step 1	Step 2	Step 3	Step 4	Step 5	
NE-HVAC-airHP-Pkg-55to65kBtuh-15p0seer-8p2hspf	3	0%	0%	31%	0%	46%	177%
Total (straight average)	**1,170**	**0%**	**3%**	**22%**	**-3%**	**43%**	**35%**

Table 6-2. Rooftop or split system kWh discrepancy impacts by step, SCE

EnergyImpactID	Count	% impact on ex-ante kWh					Average kWh GRR
		Step 1	Step 2	Step 3	Step 4	Step 5	
NE-HVAC-airAC-Pkg-lt55kBtuh-16p0seer	45	0%	0%	-12%	0%	-68%	19%
NE-HVAC-airAC-Pkg-55to65kBtuh-17p0seer	18	0%	0%	-2%	0%	-78%	20%
NE-HVAC-airAC-Pkg-55to65kBtuh-16p0seer	54	0%	0%	2%	0%	-82%	20%
NE-HVAC-airAC-Pkg-lt55kBtuh-17p0seer	42	0%	0%	-1%	0%	-78%	21%
NE-HVAC-airHP-Pkg-55to65kBtuh-16p0seer-8p5hspf	15	0%	0%	-8%	0%	-69%	23%
NE-HVAC-airHP-Pkg-lt55kBtuh-16p0seer-8p5hspf	29	0%	0%	-11%	0%	-66%	24%
NE-HVAC-airHP-Pkg-lt55kBtuh-17p0seer-9p0hspf	1	0%	0%	8%	0%	-82%	26%
NE-HVAC-airHP-Split-lt55kBtuh-16p0seer-9p0hspf	6	0%	0%	102%	0%	-161%	41%
NE-HVAC-airAC-Pkg-55to65kBtuh-15p0seer	10	0%	0%	-19%	0%	-30%	51%
NE-HVAC-airAC-Pkg-lt55kBtuh-15p0seer	26	0%	0%	-21%	0%	-20%	59%
NE-HVAC-airAC-Split-55to65kBtuh-15p0seer	1	0%	0%	-33%	0%	-6%	61%
NE-HVAC-airAC-Split-lt45kBtuh-15p0seer	11	0%	0%	-37%	0%	0%	63%
NE-HVAC-airHP-Split-lt55kBtuh-15p0seer-8p7hspf	14	0%	0%	16%	0%	-39%	77%
NE-HVAC-airAC-SpltPkg-65to135kBtuh-12p5eer-wPreEcono	10	0%	0%	-1%	0%	-20%	79%
NE-HVAC-airAC-SpltPkg-gte760kBtuh-10p2eer	1	0%	0%	-21%	0%	0%	79%
NE-HVAC-airAC-SpltPkg-gte760kBtuh-11p0eer	1	0%	0%	-21%	0%	0%	79%
NE-HVAC-airAC-SpltPkg-65to109kBtuh-13p0eer-wPreEcono	18	0%	0%	-1%	0%	-20%	80%

EnergyImpactID	Count	% impact on ex-ante kWh					Average kWh GRR
		Step 1	Step 2	Step 3	Step 4	Step 5	
NE-HVAC-airHP-Split-55to65kBtuh-15p0seer-8p7hspf	3	0%	0%	58%	0%	-70%	88%
NE-HVAC-airAC-SpltPkg-135to239kBtuh-12p5eer	4	0%	0%	9%	0%	0%	109%
NE-HVAC-airAC-SpltPkg-65to109kBtuh-12p0eer-wPreEcono	47	0%	0%	0%	0%	14%	113%
NE-HVAC-airAC-SpltPkg-135to239kBtuh-12p0eer	38	0%	0%	19%	0%	0%	119%
NE-HVAC-airAC-SpltPkg-240to759kBtuh-10p8eer	6	0%	0%	39%	0%	0%	139%
NE-HVAC-airHP-Pkg-55to65kBtuh-15p0seer-8p2hspf	5	0%	0%	5%	0%	42%	147%
NE-HVAC-airHP-Pkg-lt55kBtuh-15p0seer-8p2hspf	6	0%	0%	12%	0%	46%	157%
Total (straight average)	**411**	**0%**	**0%**	**0%**	**0%**	**42%**	**58%**

Table 6-3. Rooftop or split system kWh discrepancy impacts by step, SDG&E

EnergyImpactID	Count	% impact on ex-ante kWh					Average kWh GRR
		Step 1	Step 2	Step 3	Step 4	Step 5	
NE-HVAC-airAC-Pkg-55to65kBtuh-17p0seer-wPreEcono	41	N/A	-48%	1%	0%	-43%	10%
NE-HVAC-airAC-Pkg-55to65kBtuh-17p0seer	14	N/A	-37%	0%	0%	-52%	11%
NE-HVAC-airAC-Pkg-55to65kBtuh-16p0seer-wPreEcono	7	N/A	-39%	0%	0%	-47%	13%
NE-HVAC-airAC-Pkg-lt55kBtuh-17p0seer	80	N/A	-25%	-12%	0%	-50%	14%
NE-HVAC-airHP-Pkg-55to65kBtuh-17p0seer-9p0hspf	1	N/A	-39%	3%	0%	-50%	14%
NE-HVAC-airHP-Pkg-55to65kBtuh-16p0seer-8p5hspf	8	N/A	-38%	13%	0%	-60%	16%
NE-HVAC-airAC-Pkg-lt55kBtuh-16p0seer	110	N/A	-30%	4%	0%	-55%	18%
NE-HVAC-airHP-Pkg-lt55kBtuh-16p0seer-8p5hspf	60	N/A	-30%	4%	0%	-52%	22%
NE-HVAC-airAC-SpltPkg-65to109kBtuh-11p5eer-wPreEcono	2	N/A	-53%	37%	0%	-36%	48%
NE-HVAC-airAC-SpltPkg-65to135kBtuh-12p5eer-wPreEcono	44	N/A	-4%	-20%	0%	-23%	53%

EnergyImpactID	Count	% impact on ex-ante kWh					Average kWh GRR
		Step 1	Step 2	Step 3	Step 4	Step 5	
NE-HVAC-airAC-SpltPkg-65to109kBtuh-13p0eer-wPreEcono	47	N/A	-31%	1%	0%	-8%	62%
NE-HVAC-airAC-SpltPkg-240to759kBtuh-12p5eer	6	N/A	-22%	0%	0%	0%	78%
NE-HVAC-airAC-SpltPkg-240to759kBtuh-11p5eer	10	N/A	-19%	-2%	0%	0%	79%
NE-HVAC-airAC-SpltPkg-240to759kBtuh-10p8eer	59	N/A	-8%	-3%	0%	0%	89%
NE-HVAC-airAC-Pkg-lt55kBtuh-18p0seer	1	N/A	16%	0%	0%	-16%	100%
NE-HVAC-airHP-Split-lt55kBtuh-18p0seer-9p7hspf	16	N/A	0%	39%	0%	-39%	100%
NE-HVAC-airAC-SpltPkg-65to109kBtuh-12p0eer-wPreEcono	96	N/A	-28%	21%	0%	8%	101%
NE-HVAC-airAC-SpltPkg-135to239kBtuh-12p5eer	2	N/A	21%	10%	0%	0%	131%
NE-HVAC-airHP-Pkg-55to65kBtuh-16p0seer-8p5hspf-wPreEcono	3	N/A	61%	85%	0%	-16%	230%
Total (straight average)	**607**	**N/A**	**25%**	**3%**	**0%**	**29%**	**48%**

Table 6-4. Rooftop or split-system breakdown of evaluator-assigned building types

Old (tracking) building type	New (evaluator assigned) building type																			Grand Total
	Asm	Com	ECC	EPr	ERC	ESe	Gro	Hsp	Htl	MLI	Nrs	OfL	OfS	RFF	RSD	Rt3	RtL	RtS	SCn	WRf	
Asm						4			8						2		8				22
COM	13	78		561	1	326	2	37	4	30	7	27	245	18	5	8	70	103	14	14	1563
EPr				250																	250
ERC		1		14		3															18
ESe			27	5		102						29									163
Htl									2												2
MBT													5								5
MLI													7	13							20
Nrs								8				13									21
OfL										2		10	20					1			33
OfS										2											2
RFF														3							3
RtL													12		1		34	39			86
Grand Total	13	79	27	830	1	435	2	45	14	34	7	79	289	34	8	8	112	143	14	14	2188

6.7. Appendix G: Stakeholder comments and evaluator responses

Table 6-5. Stakeholder comments on study and evaluator responses

Comment #	Entity	Section	Topic	Page	QUESTION or COMMENT	Evaluator Response
SDG&E-1	SDG&E			31	The title for table 4-5 seems to be incorrect. It's showing the weighted average of building vintages instead of gross realization rates and relative precisions.	Thanks for catching that oversight, the title now reads: PTAC controls population weighted average building vintages
SDG&E-2	SDG&E			63-34	Appendix C is missing recommendations from resulting evaluation. Appendix D is missing the attachment of data collection and the sampling memo.	Appendix C will be populated with the evaluation recommendations in the final report report document. We will include the data collection and sampling memo in the final report document.
Unknown -1	Unknown		2019 Programs not evaluated		It is stated that due to limited changes from 2018 to 2019 for rooftop/split system programs, that 2018 would best represent 2019. in 2019, SDG&E increased funding in program 2019 which is believed to have had a measurable positive impact on program participation. This should be taken into consideration when evaluating 2019.	SDG&E might have increased funding to this program that could have increased participation. However, in our conversations with SDG&E and other PAs about the rooftop/split measure group in 2020, the programs that offered this measure did not report significant changes to program design and delivery. This was specifically validated by the PA EM&V staff during workplan discussions. Increased funding from SDG&E to the program may have improved participation but that does not inherently change the level of influence with the participants.

Comment #	Entity	Section	Topic	Page	QUESTION or COMMENT	Evaluator Response
Unknown -2	Unknown	5.2.2	Midstream measure data collection	43	Re: 5.2.2. Rooftop/split systems. Pg. 43 While robust data is highly valued, there is often a delicate balance to be achieved for PA's, Implementers, and Trade Allies when it comes to individual program impact and cost effectiveness. Consideration should be given when it comes to overall program success, and impact relative to data collection for the sake of evaluation, alone.	Consideration for overall program success is a very important aspect of the evaluation. Integrity of ratepayer funding is a critical component of program success. That is why we value a minimum effort for collection of basic information like installation address, especially when it pertains to high impact meaure equipment that trade allies have a relatively close connection with through final installation.
PG&E-1	PG&E	Overarching	Reported Net Savings in all tables	-	In all tables where reported net savings are shown (for example Table 4-1), the Reported Net Savings are not equal to the Reported Gross Savings times the Reported NTGR. Do these values contain the market effects adder? We recommend that they should not be included because it makes it difficult to compare evaluated versus ex ante results and gives NRRs that differ from those provided in the IESR tables. This would be consistent with the approach taken by the Residential HVAC Impact Evaluation. We also recommend that all tables specify where market effects adders are included for clarity.	Thank you for bringing this to our attention. To be consistent with the residential report we are including the market effects benefit in the Reported NTGR.

Comment #	Entity	Section	Topic	Page	QUESTION or COMMENT	Evaluator Response
PG&E-2	PG&E	1.1 Study background and approach	Site visits	7	Can the evaluators note in the report any possible limitations of using a desk-only approach to verification of rooftop/split systems?	Added language in section 1.1: "Physical or remote site visits are preferred as they allow the evaluator to measure critical inputs like installation and attrition rates. However, the combination of incomplete tracking data (e.g., site contact information was for participating trade ally and not recipient of installed equipment) and the COVID-19 pandemic led the evaluators to devote heavier resources toward requesting data from PAs and verifying the building type for the installation address. "
PG&E-3	PG&E	1.1 Study background and approach	Rooftop/ split systems surveys	7	The report states: "Net attribution estimates for the rooftop/split systems technology group are built upon survey results from 23 decision makers and eight program participating equipment distributors." In this statement it is unclear whether this is in reference to new surveys that were conducted or surveys completed as a part of the PY2018 evaluation. Can this be clarified in the report?	These refer to the 2018 study. Clarification added.
PG&E-4	PG&E	1.2.1 PTAC controls technology group	PTAC controls gross savings	8	The report states that "it is presumed that the PTAC units have controls built-in". The use of the word "presumed" here seems to imply that that it is not empirically known whether this is the case. Did the evaluation verify that these PTAC units did have controllers installed? If so, can the evaluator please update this language in the report to reflect that? If not, is it reasonable to reduce gross savings based on a presumption?	We agree. We verified that the units have controllers installed based on equipment cut sheets and site contact interviews. We have updated the language in the report accordingly.

Comment #	Entity	Section	Topic	Page	QUESTION or COMMENT	Evaluator Response
PG&E-5	PG&E	1.2.2 Rooftop/split systems technology group	Therm GRR	9	Can the evaluator add a note that the low realization rate for therms is actually good, because therms is a negative savings (energy penalty)?	Added sentence in 1.2.2 to mention that "The low therms realization rate can be interpreted as incidentally beneficial for the program because negative therms savings are an energy penalty."
PG&E-6	PG&E	2.2 Evaluated measure groups	Rooftop/ split systems	12	The evaluation report states for the rooftop/split system measure, "This measure group was selected for gross savings evaluation due to its large contribution to the HVAC portfolio, recent ESPI status, and previous evaluation findings." Can the evaluators please note what fraction of the savings this technology comprised, similar to how they show 19% for PTAC controls?	Rooftop/Splits contributed 16%. This has been added to the report.
PG&E-7	PG&E	2.2.1 PTAC controls	PTAC controls programs	12	The report states: "PG&E administered seven programs with PTAC controls measures, with most claims originating from their Hospitality and Commercial HVAC programs." There may be an error here because no claims came from a PG&E program called Commercial HVAC. Should this state "with most claims originating from their Hospitality program"?	The term Commercial HVAC programs is referring to the various regional programs that also administered PTAC control measures. We understand this to be misleading and modified the sentence to read: "PG&E administered seven programs with PTAC controls measures, with most claims originating from their Hospitality program."

Comment #	Entity	Section	Topic	Page	QUESTION or COMMENT	Evaluator Response
PG&E-8	PG&E	2.3.2 Rooftop/split systems	Rooftop/ split systems gross evaluation	14	The report says that the PY2019 gross evaluation of rooftop/split systems was conducted to identify the discrepancies that led to low GRRs in the PY2018 evaluation. Why Can the report provide additional detail as to why was the PY2018 gross savings analysis was unable to explain its own the discrepancies between ex ante and ex post gross savings? This logic seems somewhat circular because it seems to imply implies that the PY2018 analysis was incomplete in some way, yet it is now being applied to PY2019 claims as a way to explain the results of the previous evaluation. Including additional details about this in the report would be helpful.	The published PY18 results were executed in a complete manner. The tracking data deficiencies identified in PY2018 caused a significant delay in executing field data collection and the subsequent analysis. This negatively impacted the evaluation teams ability to conduct and report an optional discrepancy analysis of the PY2018 results under the Bus Stop delivery timeline. The evaluation team validly applied these findings to PY19 claims as the PAs reported during the PY19 planning phase that the programs and measures had not changed appreciably from PY18 to PY19. The evaluation team took the opportunity to conduct the discrepancy analysis in PY2019 as a benefit to the stakeholders for them to understand the various sources of savings reductions.
PG&E-9	PG&E	3.1 Sample design	Survey response rates	17	The report states that response rates were lower "due to reduced recruitment timeframe." Can the report please describe why the timeframe was reduced?	Footnote added. The onset of recruitment was delayed due to wildfire and PSPS events.

Comment #	Entity	Section	Topic	Page	QUESTION or COMMENT	Evaluator Response
PG&E-10	PG&E	3.3.1.1 Gross data collection	PTAC controls gross data collection	20	Did all evaluated projects have confirmed photographs or videos of the equipment? If not, can you the evaluators specify in the report the share of evaluated sites that had photographs or videos?	We visually confirmed nameplate data through photos and videos for 40 of 87 sampled projects (46%). We collected nameplate data (e.g., specification sheets) for 53 of 87 sampled projects (61%). For projects where we lacked nameplate data, we utilized the weighted average efficiencies (EER, COP) in the building simulation models from units for which we had nameplate data (53 sites with data). We have added this information in the report.
PG&E-11	PG&E	3.3.1.1 Gross data collection	PTAC controls gross data collection	20	The report notes that the survey to facility representatives included questions about, "Pre- and post-project occupancy along with any notable changes to the facility's operations or energy consumption, including seasonality". For the post-project occupancy questions, did the evaluators phrase those questions as post-project, but pre-COVID? How did they handle hospitality projects where most of their business is in the summer, but measure was installed in 2nd half of 2019 (so the first post-project busy season would be during COVID)?	Yes, all of our questions for the post-installation case specified post-project, pre-COVID. Not all projects were installed in the second half of 2019. Additionally, many projects had busy periods during the winter of 2019. We asked customers to provide representative information on annual average occupancy (pre-COVID) to feed in to the energy models so that the annual performance of the HVAC units could be simulated appropriately without taking COVID into consideration.
PG&E-12	PG&E	3.3.2 Rooftop/split systems	Rooftop/ split systems data collection	21	The evaluators identified more specific building types for sites where rooftop/split systems were installed. What other building types were identified? Can you show a breakdown in the report of the sample by new building type?	A table was added under Appendix F that shows the breakdown of building types assigned to sampled claims by PAs (collected via tracking) and building types assigned by evaluator. Assignment was performed after PA data request to collect actual installation addresses and web search.

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PG&E-13	PG&E	3.4.1.1 Developing the baseline model	DEER model selection	23	The evaluators used the nursing home prototype model for senior living facilities, but senior living facilities can be significantly different from nursing homes in their occupancy patterns. For example, a senior living facility can be essentially a communal living environment where tenants are free to come and go from their rooms as desired, whereas tenants of nursing homes may be less mobile and will spend more time in their rooms. Can the report discuss why this model was determined to be the most appropriate prototype for these sites?	The nursing home prototype is the closest proxy from the 27 DEER building prototypes available (including Residential) for the senior living facilities based on common area load characteristics and HVAC systems serving the facility. Since we had information from the EMS data about occupancy, we were able to make site-specific updates to guest room operating characteristics. These adjustments reduced uncertainty in occupancy patterns between the nursing home prototype and the actual sampled senior living facilities.
PG&E-14	PG&E	3.4.1.1 Developing the baseline model	Baseline model	23	The report states that EMS data from the PTAC controllers were used to inform the baseline model. This is confusing. Can the report explain how the data collected by the measure was used to inform the model prior to the measure's installation?	To estimate the temperature setpoints (cooling and heating) during unoccupied hours in the baseline model, we utilized the average guest room temperature setpoints during occupied hours from the EMS data, as these temperatures are presumably what the HVAC units would have been operating to without the PTAC controls.
PG&E-15	PG&E	3.4.1.2 Manufacturer EMS data processing	Installation period	23	The report states that each project's data covered 10 months of post-installation period on average. Can the report clarify whether this 10 months of data overlaps with the initial onset of shelter-in-place orders from the COVID-19 pandemic? What are the limitations, if any, to not having a full 12 months of data? Was seasonality accounted for?	These 10 months of data do not overlap with the early March onset of lockdowns due to COVID-19. The result of not having 12 months worth of data is extrapolating the available data to cover the 2 additional months. However, this limitation does not affect the rigor or accuracy of our results as the available 10 months of data covered a representative range of weather conditions and hotel operating patterns, as confirmed through interviews with the site contacts.

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PG&E-16	PG&E	4.1.1 Gross impact findings	Table 4-3	30	The table shows the number of participants that were included in the sample. Can the report also show the share of measure savings that were covered by the sample?	Added column, "Sampled share of Gross kWh Savings." PG&E= 51%, SDG&E= 39%, Total= 50%
PG&E-17	PG&E	4.1.1.1 Savings Discrepancy Analysis	Title 24 code	32	There are two main concerns regarding the evaluator's assumption that if the PTAC was installed after July 2014, then it already had the measure controls. The first is that a permit may have been pulled prior to July 2014. Many projects pull a permit much earlier than construction start (sometimes 1 or 2 years before), and these would be subject to Title24-2010. The second concern is that the design may not have complied with code, either because designers were not aware of the code requirement or because this section of the code was not enforced. A study by PNNL (https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-26348.pdf) gave a "capability compliance score" of 9.6 out of 10 and a "configuration compliance score" of 6.9 for high-impact HVAC controls. The PNNL study results indicate that oftentimes HVAC equipment has the capability to meet the code requirement, but that the controls do not get configured properly during installation or commissioning. In the webinar, the evaluator stated	Regarding the permitting date issue - we appreciate this concern, but for these specific sites we do not feel this should have been an issue with units installed years after code effective date. Regarding compliance - we appreciate this concern, but compliance is assumed in several cases including the workpaper measure savings. The evaluation design did not collect additional information that could assess compliance (no pre-measure installation observations). Reviewing the referenced study could be considered for workpaper adjustments for this or other HVAC controls, but our review did not see applicability to this measure and use case. Compared to all other HVAC controls, the PTAC occupancy control is relatively simple to install and commission - compared to rooftop ADEC, DCV, and built up system controls reviewed in the PNNL study. Clarification added to what the evaluation team reviewed.

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					that they reviewed equipment specification sheets to confirm that the installed equipment did have the required controls. Can the evaluator please include more detail on this in the report?	
PG&E-18	PG&E	4.1.1.1 Savings Discrepancy Analysis	Title 24 code	32	The adjustments for Title 24 code resulted in partial reductions for 13 projects. Can the report please describe what circumstances existed in sites that received partial reductions instead of zero savings?	Regarding partial reductions, we meant that a share of PTAC/PTHP units in the facility was replaced recently, but not all units. Recently replaced PTAC/PTHP units are affected by Title 24 code and therefore realize zero savings, but the other, older units achieved savings, resulting in "partial savings reductions" when considering facility-level savings.
PG&E-19	PG&E	4.1.1.1 Savings Discrepancy Analysis	Removal/ override of rebated controls	33	The report notes, "In 12 of 87 sampled projects, we determined that the rebated controls were partially or completely removed or overridden within their first year of installation. Site representatives indicate this was largely due to compatibility issues with the impacted PTAC/PTHP units." This is very important feedback. Can the evaluators provide more detail on these compatibility issues (perhaps in an appendix) to inform future program design?	Details of compatibility were fairly scant as respondents were unable to elaborate on issues beyond explaining that the controls didn't work as they had originally expected with the existing equipment or received complaints from guests that the thermostats were not working properly. In most cases this issue was limited to a fraction of the units in a given facility where controls were installed. In the instances where the problem was more widespread, the customer attempted to work with the vendor to resolve the issue. We have added a table under the discrepancy category explanation to provide more detail about these compatibility issues.

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PG&E-20	PG&E	4.2.1 Gross impact findings	Sampled claims	37	There seems to be a discrepancy between what is written in the text and displayed in Table 4-9. The table says that the completed sample size was 300, but the text says "725 of 2,188 (33%) sampled claims did not have matching workpaper UES values…" Can the report please clarify how many claims were sampled?	Sample size was 300 sites (site ID). Each site ID frequently had multiple claim IDs associated with it. There were a total of 2,188 claims (claim IDs) sampled under the 300 sites. We have added a footnote clarification under Section 3.2.
SCE-1	SCE	5.2.2	Tracking Data Recommendations	45	SCE offered incentives of rooftop/split systems through the Commercial Upstream subprogram which focused on the sales delivery channels of manufacturers and distributors. Incentives were paid to manufacturers and distributors for qualifying equipment sold for installation in SCE service territory. The program collected end-user service account information to verify service customer, however, did not collect equipment buyer nor equipment operator name(s), phone number(s), and email address(es). The SCE Commercial Upstream subprogram has closed as of 3/31/2021 and transitioned to the Statewide Upstream model, Comfortably California, implemented by a third party and lead by SDG&E as of March 2021. We shall seek guidance from the third-party implementer and lead PA to meet data collection and reporting requirements.	Thank you for the update. We implore SCE and the lead PA to implement the applicable recommendations from this and previous CPUC HVAC Impact Evaluation reports when designing and implementing data collection and reporting for the new Statewide Upstream Comfortably Calfiornia program.

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SCE-2	SCE	5.2.2	Baseline Recommendations	45	Measure evaluation procedures on "Rooftop & split systems" and all EE (deemed) offerings are done using CPUC approved procedures and methods including the proper baselines and building energy (DEER) prototypes. Dynamic economizer control strategies cannot be adequately modeled in current approved building energy simulation tools. DEER prototypes for both base case and measure case are informed by latest saturation studies and impact evaluation assuming findings are statistically significant.	Several deemed rooftop and split system measures use non-DEER approaches which must be approved by the CPUC. Additionally, PY2018 ex post findings may warrant that CPUC-approved base case and measure case inputs be revisited to incorporate proxies for actual performance e.g., system efficiency, fan efficacy, and economizer functionality.
SCE-3	SCE	5.2.2	Building Type Recommendations	Year 2 HVAC Report	Measure evaluation procedures are done using latest CPUC approved procedures and methods including the proper residential building (DEER) prototypes and thermostat schedules. Thermostat schedules are informed by latest Residential Saturation studies. As part of the final measure savings evaluation, these are weighted per corresponding building type and climate zone. Building energy modeling is done in full compliance with CPUC latest approved procedures and methods. Impact evaluation findings (if statistically significant) shall be leveraged for updating and/or expanding saturation studies informing DEER updates.	It appears this comment is in response to a recommendation found in the Year 2 (PY2018) CPUC HVAC Impact Evaluation Report.

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SCE-4	SCE	5.2.2	Naming Convention Recom-mendations	46	The SCE Commercial Upstream subprogram has closed as of 3/31/2021 and transitioned to the Statewide Upstream model, Comfortably California, implemented by a third party and lead by SDG&E as of March 2021. We shall seek guidance from the third-party implementer and lead PA for uniformity in reporting.	Thank you for the update. We implore SCE and the lead PA to implement the applicable recommendations from this and previous CPUC HVAC Impact Evaluation reports when designing and implementing data collection and reporting for the new Statewide Upstream Comfortably Calfiornia program.
SCE-5	SCE	5.2.2	Program Require-ments for Distributors and Contractors	45	SCE offered incentives of rooftop/split systems through the Commercial Upstream subprogram which focused on the sales delivery channels of manufacturers and distributors. Incentives were paid to manufacturers and distributors for qualifying equipment sold for installation in SCE service territory. The program collected end-user service account information to verify service customer, however did not collect customer representative name(s), phone number(s), and email address(es). The SCE Commercial Upstream subprogram has closed as of 3/31/2021 and transitioned to the Statewide Upstream model, Comfortably California, implemented by a third party and lead by SDG&E as of March 2021. We shall seek guidance from the third-party implementer and lead PA to meet data collection and reporting requirements.	Thank you for the update. We implore SCE and the lead PA to implement the applicable recommendations from this and previous CPUC HVAC Impact Evaluation reports when designing and implementing data collection and reporting for the new Statewide Upstream Comfortably Calfiornia program.

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SCE-6	SCE	2.3.2	Rooftop/ split systems - Building Type Determine-ation	13	Determination of building type via web search may not the most reliable and accurate approach given that some customers may have the equipment installed at an address different than that reported with the distributor, e.g., address may refer to a general administration/management office but not the actual site (schools districts, etc.).	The web search building type identification process was iterative so that if the tracking provided service location showed any ambiguity about the likely DEER building type during the first review, it would be flagged for committee review. Of the 300 building types classified, less than 20 fell into this category and most were easy to classify using google satellite, street view, and considering the nuanced parameters of each DEER building type. All classification designations given by the team were given a QA/QC review by a Senior Engineer.
SCE-7	SCE	4.2.2	Net Impact Findings	40	Price attribution has been significantly higher in past years, making this price attribution number very suspect. In 2018, price attribution was 11%, 2017-75%, 2015-98%, 2013/14-98%. The average from 2013-2017 was 90%. No other causal pathway has changed by more than 17 percentage points in any given year. The 11% attribution (a change of 64 percentage points) combined with the lowest number of surveys (13 in PG&E and 23 Statewide) seems to indicate sample bias in results. The Program sets out to improve distributor attribution, while customer attribution is more an indicator of the market forces, and would not be expected to change dramatically year over year. Using a weighted average of all attributions over the past years would reduce population bias from the low number of	The evaluated net to gross ratios (NTGR) from PY2018 were applied to the PY2019 evaluated savings to arrive at net savings for PY2019 because the program design and delivery for the rooftop/split measure group did not changed from PY2018 to PY2019, and because the technology, baseline, and market did not appreciably change between the two program years. This conclusion was validated by the PA program managers while interviewing them during the development of workplan of the study. An identical comment was made to the PY2018 report. Our response was: "The price attribution question was changed this year to be asked in a way that allowed for a range of answers that didn't occur in past years because of the way the question was asked. Previously the question asked how much more

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					samples collected this year. We recommend that future studies conduct a significantly larger sample of surveys or use a weighted average of all attribution results from past years that allows for a larger sample of customers.	respondents were willing to pay for the unit, to which almost everyone provided an answer of 0. This year [PY2018], we changed the question to ask them how likely they would have been to purchase the unit if the price were higher by the amount of the rebate provided to the distributors. We believe the new method of asking the question is likely to provide a more accurate representation of the effect of price on the buyers' decision and the very high attributions of the previous evaluations were artificially high because of the way the question was asked." It should further be noted that the rebates are generally only cover a portion of the incremental cost and are small compared to the overall project costs, so the effect of the rebate on decision making would be expected to be relatively low. We have sought to improve the causal pathway attribution sequences during this contract cycle. In 2018, in addition to refining the end-user price attribution questions, we also updated the distributor questions based on program feedback and additional in-depth interviews with distributors. These refinements resulted in higher attribution scores from distributors in the PY2018 surveys than in the PY2017 surveys. The combined effects of the changes resulted in slightly higher overall attribution scores for PY2018 than PY2017.

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SCE-8	SCE	5.2.2	Rooftop/ split systems	45	The evaluation's conclusions state: **a**) 74% of projects did not have customer contact data, and **b**) 26% of the projects with contact information...recruitment for evaluation was challenging, as the customers were OFTEN UNAWARE that they had participated in an efficiency program (pg. 49). Distributors do not have access to or collect customer information for Upstream HVAC program. For Upstream HVAC, the evaluators had to research customer phone numbers (presumably from billing data), then cold call the customer, be transferred to multiple departments, searching for the decision maker involved with the project (installed in 2018). For medium and large customers this process appears unworkable with unreliable results. This customer contact information unavailable to distributors and unreliable as there are multiple market actors involved in the specification, purchase, and installation of equipment (that may cover multiple market actors). evaluation as they are knowledgeable of program design, workpapers, HVAC technology, and market actor interaction. Finally, with broader participation in the workplan review we could improve response rates and accuracy by contacting the correct decision maker. This is especially true	This text is taken from a finding that states that the program has incomplete tracking data. The recommendation for that key finding states: "For any measures delivered midstream through distributor rebates, such as the rooftop and split system measure group, PAs must require participating distributors and partnering contractors to collaboratively collect and submit basic information for each customer that ultimately receives the rebated equipment." The evaluation team's recommendation is that the program design provide a streamlined process for tracking the contact information and installation addresses for the participating ratepayers who are benefiting from the program's activities.

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					for projects installed a few years ago.	
SCE-9	SCE	4.2.2	Net Impact findings	n/a	Can you clarify if the realization rates include the 5% market effects adder? It appears that the NTGR values are calculated expanding DNV GL calculated ex-post gross to DNV GL calculated ex-post net values which do not include the 5% market effects adder. It also appears that the only values that include the market effects 5% adder are the reported NTGR values in the tracking data; the tracking gross/net savings estimates themselves do not include the 5%. In order to address this in the reporting tables, the values for the "Reported NTGR" (which comes from the tracking data) have all been reduced by the 5% market effects adder so that the overall NRR are an equivalent comparison and thus not artificially deflating the results.	Thank you for bringing this to our attention. You are correct that previously we did not include the 5% market effects benefit in the Reported NTGR. After consideration and we've modified the tables so that we are now including the market effects benefit in all instances where we present the Reported NTGR.