SAFER, SMARTER, GREENER

Impact Evaluation Report - Final

HVAC – Program Year 2017

EM&V Group A

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Table of contents

List of figures

List of tables

1 EXECUTIVE SUMMARY

This report presents the California Public Utility Commission (CPUC) evaluation of residential and commercial Heating Ventilation and Air Conditioning (HVAC) electric and gas energy efficiency incentive programs in 2017. We estimated energy and demand savings of selected HVAC technology groups across all HVAC programs offered by five energy efficiency program administrators (PAs) including San Diego Gas and Electric Company (SDG&E), Southern California Edison (SCE), Southern Gas Company (SCG), Pacific Gas and Electric Company (PG&E), and Marin Clean Energy (MCE).

The evaluation collected data from participating customers, contractors, and distributors to adjust key technical parameters that impact the calculation of energy and demand savings. This evaluation estimated the "gross" savings for the evaluated technologies. Gross savings represent the changes in energy and demand that resulted from energy efficiency program activities regardless of what factors may have motivated the program participants to take actions. The evaluated gross savings were then compared with the reported gross savings as a ratio called gross realization rate (GRR). The study also estimated the amount of "free ridership," that is, savings that would have occurred without the EE incentive being provided. From this, net-to-gross ratios (NTGRs) were estimated for each of the evaluated technologies. NTGRs represent the proportion of savings that occurred because of the program. A NTGR is a value between zero and one, and a value closer to one means more savings can be attributed directly to the program.

The primary goals of this 2017 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 the peak demand impacts of selected HVAC technologies.
- Determine the savings that occur as a result of the program with respect to market actors, distributors, and end-user customers.
- Provide insights into how effectively evaluated HVAC technologies are producing energy savings cost-effectively and what improvements can be made to move towards statewide strategic energy efficiency goals.

1.1 Background and approach

The evaluation approaches of the seven selected HVAC technologies were built on previous HVAC program evaluation methods. One technology, the package terminal air conditioner (PTAC)[1], is not required to be evaluated but was selected for evaluation because of its significant contributions to HVAC savings.

[1] A PTAC is a through-wall air conditioner typically used in hotels and motels

The study began in August 2018 with a publication deadline of March 1, 2019. Because of the quick turnaround our data collection and analysis options were limited. We used the following methods for this evaluation:

To Estimate Gross Savings	To Estimate Net Savings	To Estimate Gross & Net Savings
• For commercial boilers, we conducted interviews with the customers and collected site-specific data. • For PTAC controls, we interviewed hotel/motel customers.	• For residential furnaces, we completed end-user surveys. • For commercial rooftop and split systems, we interviewed distributors and surveyed end-users.	• For commercial fan controls, we conducted phone interviews with customers and surveyed contractors. • For commercial HVAC thermostat controls, we completed customer interviews and surveyed contractors. • For commercial fan VFDs, we interviewed decision-makers and surveyed customers.

1.2 Gross and net savings results

This section presents results of the gross and net savings evaluation by HVAC technology. After we present the savings, we provide a summary of key findings and recommendations. In this section we introduce a term called the "realization rate." This is simply the ratio of an evaluated savings number to the utility reported number. A realization rate of 1.0 means the evaluation determined all the utility reported savings occurred. Gross realization rates include savings from installations that happened because of the program ***and*** savings from installations that would have happened even if there were no rebates. Net realization rates remove the savings from installations that would have happened even if there were no rebates; this shows the true impact of the ratepayer-funded program. This is shown in the last column of the following tables: the closer the values are to 1.0 (or 100%) the better.

1.2.1 Rooftop and split systems

Statewide, about 30% of the savings from rooftop and split system air-conditioners occurred because of the program; in other words, the majority of customers who upgraded these air conditioners would have done so without a rebate,[2] leading to total net savings from these measures of 2,218,767 kWh, 1,730 kW, and -5,694 therms (Table 1-1). The NTGR is considered a low value for energy efficiency programs and is a result of the program having little effect on air-conditioner dealers' sales practices. Our surveys suggest dealer upselling and equipment price had a moderate influence on end-user decisions, and that distributor stocking of the equipment, which is part of the program design, had a low influence on whether or not a customer installed an efficient rooftop and split system air-conditioner.

[2] Reported NTGRs ranged from 55% to 85% for the rooftop and split systems measures.

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

Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	Net Realization Rate
Electric consumption (kWh)						
7,043,473	100%	7,043,473	32%	2,218,767	5,666,909	39%
Electric demand (kW)						
5,512	100%	5,512	31%	1,730	4,421	39%
Gas consumption (Therm)						
(15,121)	100%	(15,121)	34%	(5,694)	(13,436)	42%

1.2.2 Furnaces

Across the PAs, the NTGR revealed that a moderate-to-high level of program participants would have installed energy efficient furnaces without any program incentive. The overall, statewide NTGR ratio of therm savings was 33% for furnaces,[3] which means 67% of the savings would have happened anyway. The NTGR results for the PAs are presented in Section 4 of this report.

Seventeen percent of end-users said the program had influence in buying their furnace. When the program did influence end-users, it tended to increase the efficiency of the equipment they selected, not the timing of the purchase.

Table 1-2. Statewide first-year net gas impacts of HVAC furnace

Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	Net Realization Rate
Electric consumption (kWh)						
6,962	100%	6,962	44%	3,063	4,525	68%
Electric demand (kW)						
3	100%	3	44%	1	2	68%
Gas consumption (Therm)						
40,432	100%	40,432	33%	13,523	25,489	53%

1.2.3 HVAC supply fan controls

Overall gross realization rates for kWh and kW were 75% and 78%, respectively. These gross realization rates were higher than the 2015 program year study[4] due to the improvement in the equipment baseline conditions compared to the previous evaluation ("baseline conditions" refers to the energy that would have been consumed if the efficient equipment was not installed). Our phone verifications confirmed that a greater number of fans operated continuously before the controls were installed.

Generally, we found the HVAC supply fan control NTGRs were low. The overall NTGR was 46% for kWh, meaning over half of the savings came from customers who were planning to upgrade their supply fan controls

[3] Reported NTGRs ranged from 55% to 85% for the furnace measures.

[4] Impact Evaluation of 2015 Commercial Quality Maintenance Programs (HVAC3)

to equipment offered by the program even without the program rebate. In other words, the program did not influence a customer to be more energy efficient for 54% of the savings.[5]

Table 1-3. Statewide first-year gross and net impacts of HVAC Supply fan controls

Reported Gross Savings	GRR	Evaluated Gross Savings	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	Net Realization Rate
Electric consumption (kWh)						
3,980,416	75%	2,978,400	46%	1,373,460	3,159,524	43%
Electric demand (kW)						
(35)	78%	(27)	32%	(9)	(27)	32%
Gas consumption (Therm)						
171,663	67%	114,761	40%	46,318	135,807	34%

1.2.4 HVAC thermostat controls

PG&E is the only program administrator that implemented HVAC thermostat controls in 2017. We should note these are not the smart thermostats that adjust to your behavior, rather these are programmable thermostats that adjust temperatures during pre-set timeframes. Both the kWh and therm gross realization rate for HVAC thermostat controls were 4%, meaning 4% of the reported savings from the program actually happened. This is significantly lower than the previous study results. Our phone verification found that most of the PG&E sites did not meet the programming requirements, and in a number of cases, the thermostats were manually turned off during the unoccupied hours instead of operating in a programmed lower or higher temperature conditions.

The NTGR for this technology was 36%, nearly identical to the NTGR of the previous evaluation. Seven of the eight surveyed contractors provided responses that resulted in 0% savings credit for the program. This means their answers indicated they were already implementing the measure before participating in the program, and that the program had no effect on how many thermostats they installed.

Table 1-4. First-year gross and net impacts of HVAC thermostat controls

PA	Reported Gross Savings	GRR	Evaluated Gross Savings	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	Net Realization Rate
Electric consumption (kWh)							
PG&E	1,584,830	4%	61,894	36%	22,050	1,201,941	2%
Gas consumption (Therm)							
PG&E	230,169	4%	10,160	36%	3,620	174,504	2%

1.2.5 Packaged terminal air-conditioner (PTAC) controls

PTAC controls, which are the controls on the air-conditioners found mainly in hotels and motels, were only evaluated for gross savings.

[5] Reported NTGRs ranged from 55% to 85% for the HVAC supply fan controls measures.

The overall gross realization rate was 94%, indicating the majority of reported savings from the PTAC controls actually occurred. Program administrator specific gross realization rates and gross savings for the PTAC controls are presented in Section 4 of the main report. The primary reason behind this minor difference between reported and evaluated savings is that our evaluation found in some cases the PTAC controls were not operating as intended, which led some customers to uninstall the controls. However, in most cases this equipment was installed properly and operating.

This study collected data through phone surveys, and only evaluated if the controls were installed and operating. This means the study did not evaluate the change in savings as a result of installing the controls. As such, the unit energy savings value for this technology deserves a thorough and rigorous evaluation in the future if PA claims for this measure persist or grow in volume.

Table 1-5. Statewide first-year net impacts of HVAC PTAC controls

Reported Gross Savings	GRR	Evaluated Gross Savings	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	Net Realization Rate
Electric consumption (kWh)						
13,094,210	94%	12,261,220	60%	7,356,732	8,511,236	86%
Electric demand (kW)						
4,848	94%	4,547	60%	2,728	3,151	87%

1.2.6 HVAC boilers

SCG was the only PA that reported savings for boilers. Although there were considerable variations among site-specific reported and evaluated therm savings estimate, the overall therm gross realization rate for boilers was in line with the reported savings estimate.

Table 1-6. First-year gross impacts of HVAC boilers

PA	Reported Gross Savings	GRR	Evaluated Gross Savings	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	Net Realization Rate
Electric consumption (kWh)							
SCG	73,603	100%	73,603	59%	43,199	46,880	92%
Electric demand (kW)							
SCG	3	100%	3	63%	2	2	93%
Gas consumption (Therm)							
SCG	78,565	102%	80,485	64%	51,666	54,361	95%

1.2.7 HVAC fan Variable Frequency Drive (VFD)

Installing Variable Frequency Drive (VFD) motors increases the efficiency of the HVAC fan since the motor does not operate at full speed when it is not needed. Overall the gross realization rates were close to 100% for the installation of VFD motors across the PAs. PA specific gross savings and GRRs are presented in Section 4 of this report.

The difference between the reported and the evaluated savings for VFD motors were primarily due to the discrepancies in the number of installations counted and the installed horsepower of the fan motors. Our evaluation found differences between the quantity of VFD motors in the reported values versus how many fan VFD motors were verified to be installed based on interviews. In some cases, the total horsepower claimed in the reported savings was considerably different than the total value verified to be installed at the sites. These issues added difficulty in evaluating the VFD motors when contacting the end users and affected the evaluated gross savings estimates.

The NTGR revealed that a moderate to low level of free-ridership has persisted for this technology across the PAs. The overall NTGR was 53%, due to survey respondents' slightly higher credit to program influences, such as rebate amounts, program information, and marketing materials, as compared to non-program influences such as the age of existing equipment and vendor recommendations.

Table 1-7. Statewide first-year gross and net impacts of HVAC VFD motor

Reported Gross Savings	GRR	Evaluated Gross Savings	NTGR	Evaluated Net Savings	Reported Net Savings	Net Realization Rate
Electric consumption (kWh)						
10,437,877	102%	10,659,734	53%	5,670,819	7,091,114	80%
Electric demand (kW)						
2,120	105%	2,226	59%	1,312	1,442	91%
Gas consumption (Therm)						
(13,771)	93%	(12,753)	52%	(6,630)	(8,501)	78%

2 INTRODUCTION

The report presents DNV GL's impact evaluation of commercial and residential heating, ventilating, and air conditioning (HVAC) programs 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 evaluated gross and net energy impacts (kWh, kW, and therms) achieved by the 2017 HVAC programs offered by five California program administrators (PAs): San Diego Gas and Electric Company (SDG&E), Southern California Edison (SCE), Southern California Gas Company (SoCalGas), Pacific Gas and Electric Company (PG&E), and Marin Clean Energy (MCE).

2.1 Evaluation objectives and researchable issues

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 7 selected measure groups across the HVAC portfolio from the 2017 programs offered by SDG&E, SCG, SCE, PG&E, and MCE. The evaluated measures are described in greater detail in the next section (Section 2.2).

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 realization rates can be improved. 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 level of 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 comprised of DNV GL, Energy Resource Solutions (ERS), and Tierra Resource Consultants, LLC. The team achieved these objectives by reviewing program data, conducting phone surveys, and collecting operating parameters for the measures to support the evaluated gross savings estimates. The team estimated net savings based on the responses from the HVAC market actors and end-use customers.

2.2 Evaluated measure groups

DNV GL reviewed and selected measure groups for this evaluation from the statewide list of HVAC ESPI uncertain measures. Our selection was based primarily on each specific measure group's savings contributions to the HVAC portfolio and growing trend of the measure group in the HVAC market. We also considered whether certain measure groups will be dropped from future uncertain measure lists and so need to be addressed in this evaluation cycle.

The 7 HVAC measure groups in this evaluation were offered to customers through various program delivery mechanisms including upstream, midstream, and downstream channels. The methodologies for evaluating

these measure groups can vary by delivery mechanism. Therefore, we grouped HVAC measures into 3 subsectors based on how they are delivered to customers as described below:

- **HVAC Unitary and VRF**. The measure groups in this subsector are delivered to the customers through the upstream distributor incentive program and multiple deemed programs across the 5 PAs. Most of the measure groups in this measure category are one-to-one replacements of HVAC units. The primary goals of the upstream program are to encourage participating distributors to increase their stock of high-efficiency equipment so that it is readily available to the customers, to motivate participating distributors to upsell high efficiency equipment, and to encourage the purchase and installation of the most efficient equipment available. In PY 2017, these measure groups accounted for under 25% of statewide HVAC peak demand savings and gas energy savings as well as electric energy savings.
- **HVAC Maintenance and Controls. This subsector is delivered through midstream channels.** This measure category covers multiple measure groups related to HVAC maintenance and controls which are delivered via midstream channels. The PAs offer these measure groups via multiple programs. The primary goals of the HVAC maintenance and controls programs to address HVAC unit efficiencies via specific maintenance activities and controls optimizations. In PY 2017, the measure groups in this measure category claimed about 67% of the statewide HVAC kW, roughly 60% of the kWh, and a little less than 60% of the therm savings.
- **HVAC Central Plant.** The measure groups implemented under this subsector are mostly downstream programs. It includes the measure groups that are related to built-up central plant HVAC systems. This category includes 3 2017 ESPI measures. The measures associated with this study group are not only one-to-one replacements, but also retrofits of existing systems with energy efficient technologies such as variable frequency drives (VFDs) and controls to optimize their operation. The 4 PAs offer incentives for these measure groups via 15 different programs, which together accounted for only 23% of the statewide HVAC kWh claims, just over 10% of the kW reduction, and 9% of the gas savings in PY 2017.

Table 2-1 shows the 3 HVAC evaluation subsectors and highlights the 7 measure groups we evaluated. The items categorized as "Other" in the table are the HVAC measure groups that received no evaluation treatment and were passed through. The table also shows the reported first-year gross kW, kWh, and therm savings claimed along with the ESPI uncertain parameters for these measure groups for program year 2017.

Table 2-1. PY 2017 gross first-year savings claims for the 7 selected HVAC ESPI measure groups

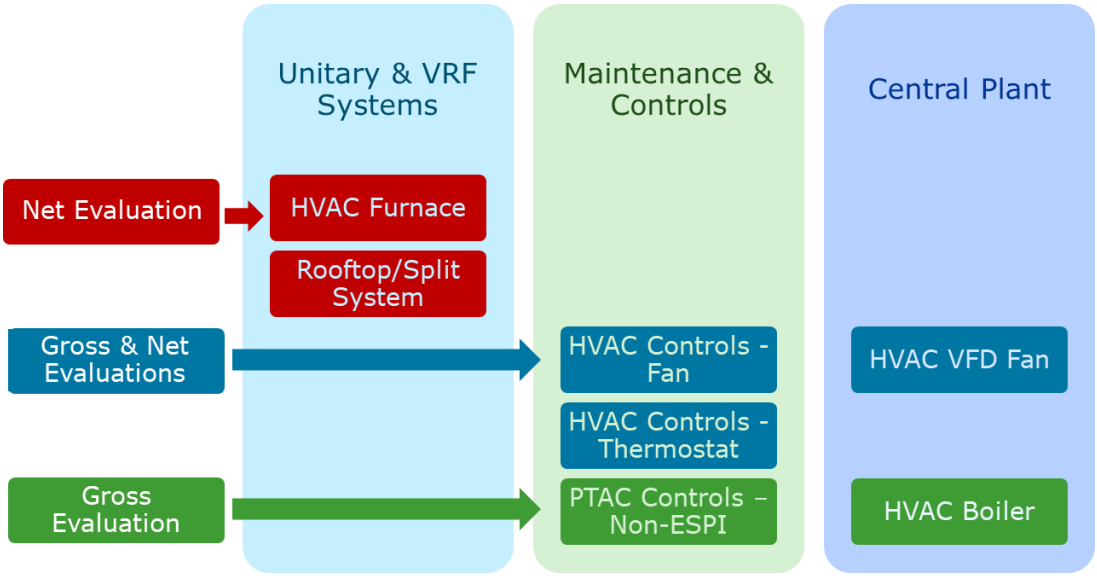
Measure Group	kW	kWh	Therms	ESPI Uncertain Parameters*	% of Total kW	% Total kWh Savings	% Total Therms Savings
Subsector: Unitary and VRF							
HVAC Rooftop or Split System	5,512	7,043,473	(15,121)	GRR, NTGR, UES	9%	4%	0%
HVAC Furnace	3	6,962	40,432	GRR, NTGR	0%	0%	1%
Other	8,186	20,706,033	1,015,591		13%	13%	31%
Subtotal	**13,701**	**27,756,468**	**1,040,902**		**22%**	**17%**	**32%**
Subsector: Maintenance & Controls							
HVAC Controls Fan	(35)	3,980,416	171,663	NTGR, UES	0%	2%	5%

Measure Group	kW	kWh	Therms	ESPI Uncertain Parameters*	% of Total kW	% Total kWh Savings	% Total Therms Savings
HVAC Controls Thermostat	0	1,584,830	230,169	IR, UES, NTGR, EUL	0%	1%	7%
PTAC Controls (Non-ESPI)	4,848	13,094,210	0		8%	8%	0%
Other	37,291	77,619,197	1,523,954		60%	48%	47%
Subtotal	**42,104**	**96,278,653**	**1,925,787**		**67%**	**60%**	**59%**
Subsector: Central Plant							
HVAC Boiler	3	73,603	78,565	GRR, UES, NTG	0%	0%	2%
VFD Fan	2,120	10,437,877	(13,771)		3%	7%	0%
Other	4,651	25,553,446	221,641	GRR, NTG	7%	16%	7%
Subtotal	**6,774**	**36,064,926**	**286,435**		**11%**	**23%**	**9%**
HVAC Sector							
Total	**62,579**	**160,100,047**	**3,253,124**		**100%**	**100%**	**100%**

*GRR is gross realization rate; NTGR is net-to-gross ratio; UES is unit energy savings; and EUL is effective useful life.

Our team addressed the parameters that feed into the evaluated gross savings estimates and quantified the net-to-gross ratio (NTGR) for the 7 measure groups. We performed both gross and net evaluations of 3 of the 7 selected measure groups, gross savings evaluations on 2 of the measure groups and net savings evaluations for the remaining 2 measure groups. Figure 2-1. shows this graphically.

Figure 2-1. PY 2017 HVAC evaluated uncertain measure groups



Background for the 7 evaluated HVAC measure groups are described in the following sections.

2.2.1 HVAC furnace

This measure saves energy by installing high-efficiency central gas furnace in place of an existing, lower efficiency gas furnace in residential homes.

The base case of this measure is a central natural gas furnace meeting minimum federal standard of 80% annual fuel utilization efficiency (AFUE).

These furnaces are typically forced air units that provide heat in the conditioned space by passing indoor air through a heat exchanger, transferring heat from the combustion gases to the indoor air. A blower motor installed in the furnace cabinet moves return air from the dwelling, passing it through an air filter and the heat exchanger, and onto the where the warmed air is distributed back into the conditioned space.

Figure 2-2. A typical high-efficiency residential furnace shows a typical high-efficiency furnace installed in a residential application.

Figure 2-2. A typical high-efficiency residential furnace

2.2.2 HVAC rooftop or split system

Figure 2-3. Packaged commercial rooftop unit (RTU)

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 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.

Figure 2-3. shows a typical packaged commercial rooftop unit (RTU) for a small office space. Packaged units are connected to duct systems that distribute the conditioned air to the indoor spaces.

2.2.3 HVAC supply fan controls

In the commercial QM programs, the only measure implemented with any significant frequency was the supply fan control measure. This measure entails adjusting the unit controls, changing the supply fan operating mode from "always on" (the base case) to "cycle on with load" or "off" during programmed unoccupied periods. The control is typically a thermostat although it could also be a building's energy management system. This measure saves energy directly by turning off the fan motor when not needed and indirectly by reducing ventilation rates of the conditioned space when the space is not occupied and thus the requirement for ventilation is removed. Figure 2-4 shows a typical RTU supply fan.

Figure 2-4. Supply fan in RTU

2.2.4 HVAC thermostat controls

Figure 2-5. A programmable thermostat

These measures involve the replacement of a non-programmable thermostat control unit with a programmable thermostat such as the one shown in Figure 2-5. They save energy by implementing setback temperature setpoints and discontinuous fan operation during unoccupied periods, whereas the baseline would be a manually operated thermostat with continuous fan operation and no programmed unoccupied setbacks. The measure criterion specifies discontinuous fan operation during unoccupied periods as well as setback temperature setpoint thresholds and occupied period temperature setpoint ranges.

This measure group was commonly installed in the commercial quality maintenance (QM) programs and was not installed in any of the residential QM programs in 2017.

2.2.5 PTAC controls (non-ESPI measure)

Packaged terminal air conditioner (PTAC) controllers are installed in guestrooms at hotels, motels, and similar lodging facilities, so each site is expected to install multiple PTAC unit controllers. These measures save energy by setting back the temperature setpoints of the HVAC units (either PTAC, or packaged terminal heat pumps, PTHP) when the systems detect the guest room are unoccupied. These measures use either a passive infrared and motion occupancy sensor or an occupant card key dock to determine when the room is unoccupied in combination with a guest-room energy management system (GREMS) that adjusts the HVAC temperature setpoints. The GREMS controller can be physically located in a separate control box, jointly with an occupancy sensor, or jointly with a thermostat depending on the vendor and existing site parameters. This measure group is commonly installed in hotel and motel rooms as part of the hospitality management program.

2.2.6 HVAC boiler

Figure 2-6. HVAC boiler

HVAC boilers are pressure vessels that transfer heat from fuels to water for use in space heating applications. Boilers heat water using a heat exchanger that works like an instantaneous water heater or by the addition of a separate tank with an internal heat exchanger that is connected to the boiler. Energy efficient units often feature high-efficiency and/or low NOx burners, and typically have features such as forced air burners, relatively large heat exchange surfaces, advanced controls, and/or utilize heat recovery from flue stack gases.

These boiler measures primarily installed for space heating applications in commercial buildings. Energy savings are realized due to the installation of a high-efficiency unit in place of a code-baseline efficiency unit. Figure 2-6 shows part of a condensing boiler, which reaches high levels of efficiency due to latent heat recovery from the boiler's exhaust flue gases.

2.2.7 HVAC fan variable frequency drives (VFDs)

Figure 2-7. Fan motor VFD control inside an RTU

Central plant systems provide conditioning (cooling or heating) to a building's interior spaces. A significant amount of the total energy used by central plant systems is consumed by fans moving air throughout the system. The fans and motors are sized to meet peak load conditions, when the equipment must operate at 100% capacity. However, most of the time the required airflow levels for cooling or heating are lower than the maximum design capacity. Standard practice has been the installation of single-speed fan motors in conjunction with damper controls, which cause the fan motors to operate at 100% speed, even when actual airflow requirement is lower. VFDs control motor speed by varying the frequency and voltage of the electricity delivered to fan motor. Fan motor speeds are modulated to meet actual airflow required for operating conditions, thus reducing fan motor energy consumption when operating conditions are below maximum design conditions. This results in significant fan energy savings throughout the year. Figure 2-7. shows a controller for a variable frequency drive installed on a supply fan motor.

The most prevalent central plant HVAC fan VFD projects that we evaluated were:

- VFDs on HVAC supply and return fans
- VFD-enhanced ventilation for packaged HVAC units with gas heating and packaged heat pumps

Both are described in the next two sections. The evaluation projects also included 2 additional measures—VFDs on cooling tower fans and VFDs on parking garage exhaust fans—though these measures only comprised 9 of the 150 projects in PY 2017 and were therefore not a focus of this study.

2.2.7.1 VFDs on HVAC supply and return fans

Energy usage in variable air volume HVAC systems can be reduced by installing VFDs on ventilation fans. VFDs offer a far more efficient method of regulating motor speed or torque than throttling valves, inlet vanes, and fan dampers. Installing a VFD on the fan motor will enable the fan to slow down more efficiently whenever the building load allows it, saving fan motor energy. VFDs typically incorporate a static pressure sensor in the supply or return air ducts to inform the conditioned space's air flow needs. Due to the fan affinity laws, a small reduction in fan speed results in significant energy savings.

2.2.7.2 VFD enhanced ventilation for packaged HVAC units with gas heating and packaged heat pumps

This measure involves adding a combination of VFDs, National Electrical Manufacturers Association (NEMA) premium motors, permanent magnet motors (PMM), and an advanced digital economizer controller to an

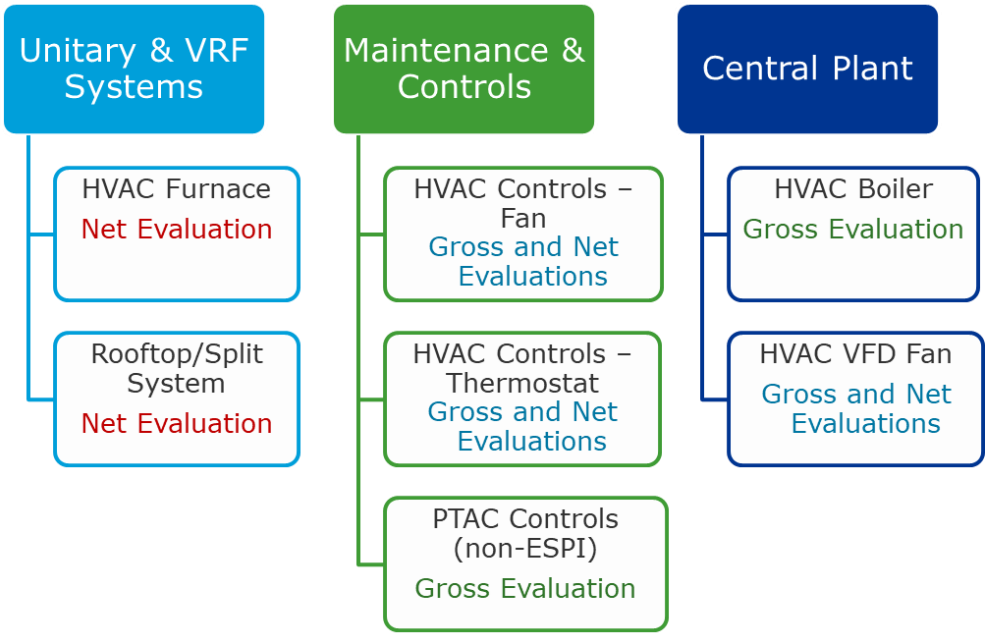
existing packaged HVAC unit with economizer capability. Energy savings are realized due to the reduction in fan speeds due to the VFD, improved operating efficiency of the fan motor compared to a baseline standard motor, and from the implementation of digital economizer controls compared to a baseline analog outdoor air economizer.

2.3 Evaluation approach

This evaluation is built on DNV GL's PY 2010-2012,[6] 2013-2014 Upstream,[7] 2013-2014 Quality Maintenance, and 2015 Quality Maintenance program[8] evaluations. Of the 7 measure groups we evaluated, all but PTAC controls are on the 2017 statewide ESPI uncertain measure list. Three of the 7 measure groups were evaluated for both gross and net estimate; of the remaining measure groups, 2 received net-only treatment and the other two received gross-only treatment.

Figure 2-8. below shows the 7 evaluated measure groups selected for gross and net evaluation across the 3 HVAC subsectors.

Figure 2-8. PY 2017 HVAC evaluated uncertain measure groups



For the 2 net-only impact evaluations, HVAC furnace and rooftop/split system measure groups in the unitary and VRF subsector, we derived a NTGR by estimating the influence various program activities had on distributor behavior, and how downstream end users may have been influenced by this program as well. By quantifying this influence, we were able to estimate what percent of the gross savings was attributable to this measure groups, and what portion was free-ridership.

[6] DNV GL, Inc. HVAC Impact Evaluation FINAL Report WO32 HVAC – Volume 1: Report. California Public Utilities Commission, 2014.

[7] DNV GL, Inc. Impact Evaluation of 2013-14 Upstream HVAC Programs (HVAC1). California Public Utilities Commission, 2016.

[8] DNV GL, Inc. Impact Evaluation of 2013-14 Commercial Quality Maintenance Programs (HVAC3) Report. California Public Utilities Commission, 2016; Impact Evaluation of 2015 Commercial Quality Maintenance Programs (HVAC3) Report. California Public Utilities Commission, 2017.

For the 3 measure groups in the maintenance and controls subsector, we conducted phone interviews, verified the installation of the measures, and collected operational parameters and conditions such as temperatures, airflows, control set points, and other relevant parameters for savings calculations. This allowed us to adjust the reported savings estimate to calculate gross savings. Depending upon the availability of collected data, in some cases we were able to true up the installation rates of the measure and in other cases we had to make some scalar adjustments to the savings estimate. For example, we were able to true up PTAC controls to installation rates, whereas for HVAC fan VFD measure group, we had to adjust savings.

Net evaluation for the HVAC fan controls and thermostat controls used phone surveys with participating contractors to estimate NTGRs based on the methodology used in the 2015 Quality Maintenance evaluation.[9] This methodology asks concrete questions to get at quantifiable, identifiable aspects of program effect.

The boiler measure group from the central plant subsector was evaluated using a billing analysis approach. The normalized billing analysis used timing of measure installation, weather data, and advanced metering infrastructure (AMI) billing data to estimate the gross impact of this measure group. Our team also conducted phone interviews with the customer to verify the installation of the measure, confirm the intended operation of the measure, verify the baseline, and understand the equipment usage patterns. No net-to-gross evaluation was performed for this measure group.

For the VFD fan measure group from the central plant subsector, we followed the deemed savings analysis methodology specified in Workpapers (see footnotes to Table 3-9), adjusting measure parameters when possible based on data collected during the phone interview. Phone verifications were utilized to verify or adjust installed VFD quantity, impacted fan motor(s) horsepower, facility HVAC system type, and minimum allowable air flow adjustments.

To calculate NTGR for the VFD fan measure group, we conducted phone surveys and confirmed with the program participant's decision-maker the measure installation and other project details that support an estimate of free-ridership. The questions asked of interviewees were designed to gather information to allow the evaluation team to estimate participant free-ridership to support the development of Net-to-Gross and net savings values for this measure group.

2.4 Structure of the report

Table 2-2 shows the overall organization of this report. Although findings and recommendations are overarching in Chapter 6, study findings and recommendations are included in Chapters 4 and 5 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 2-2. 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	**Sample Design and Data Collection**	Sampling design approaches to gross impact determination, on-site M&V activities, NTG survey

[9] Op. cit.

Section	Title	Content
4	**Gross and Net Impact Findings**	Gross impacts and realization rates, measure and program differentiation, Net of free ridership ratios and results, net realization rates and NTG result drivers
5	**Conclusion and Recommendations**	Detailed gross and net findings, recommendations to improve program impacts

3 STUDY APPROACH & METHODOLOGY

The primary evaluation task was to verify the installation of the incentivized HVAC measures 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 can be projected to all building type and CZ combinations for all of the claimed measures using building energy simulations.

To estimate net savings, we developed net-to gross ratios (NTGRs) for each measure group that we applied to the gross savings estimate previously 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 this upstream program as well. For quality maintenance programs the program influence was assessed through contractor's interviews, whereas 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 of 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 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 7 measure groups across 3 HVAC subsectors that were evaluated for PY 2017. 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 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 0.6 based on previous studies.[10] Once sample sizes were calculated, we randomly chose sample points from the population in each stratum.

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

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

[10] 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.

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 $se(b) = \frac{\sqrt{\sum_{i=1}^{n} w_i\,(w_i - 1)\,e_i^2}}{\sum_{i=1}^{n} w_i\,x_i}$
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 several of the measure groups, achieved relative precisions were worse than anticipated. Generally, the achieved precisions did not match expectations for the following 4 reasons:

1. **Completed sites/surveys less than expected** – Due to the reduced recruitment timeframe, response rates were lower than planned and additional mitigation steps were unavailable.
2. **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.
3. **Observed variation in the sample is greater than assumed** – The sample designs each used a 0.6 ER. Future studies may require a greater ER assumption to achieve the planned precision.
4. **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 reason #4, 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 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 A.

3.1.1 HVAC unitary and VRF subsector sample design

DNV GL designed the sample to achieve ±10% relative precision for each measure group at the 90% confidence level. Two measure groups were evaluated under the unitary and VRF subsector. These two measure groups were evaluated for net-only savings. In order to achieve ±10% relative precision for each measure groups at 90% confidence level, a total of 75 sample sites were planned for the HVAC furnace group and 80 sample sites were planned for HVAC rooftop/split measure group. In addition, we attempted a census of distributors of rooftop split systems as the program design has a significant upstream component.

For both the measure groups, the samples were not completed as planned. The response rates were much lower than the expected, primarily due to incorrect or incomplete contact data. For the HVAC Furnace measure group, 57 surveys were completed whereas for HVAC rooftop/split unit measure group 99 end-user surveys were completed from the 80 planned sample points. We completed seven interviews with distributors for the rooftop/split unit measure group as well. The overall achieved relative precision was 25% for the HVAC furnace measure group and a relative precision of 137% for the HVAC rooftop split measure group. The precisions did not achieve the target due to the low ratios and greater than anticipated variation in customer responses.

Table 3-1 and Table 3-2 show the planned and achieved sample sizes with their relative precisions by PA for the HVAC Furnace and HVAC Rooftop/Split measure groups respectively.

Table 3-1. Planned and achieved precision for HVAC furnace 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
PG&E	164	20	19%	18	26%
SCG	801	40	13%	24	39%
SDG&E	184	15	21%	15	51%
Total	**1,149**	**75**	**10%**	**57**	**25%**

Table 3-2. Planned and achieved precision for HVAC rooftop/split unit net sample by PA

PA	Population Size	Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
PG&E	1,411	40	14%	47	199%
SCE	839	25	17%	31	2000%
SDG&E	247	15	23%	21	225%
Total	**2,497**	**80**	**10%**	**99**	**137%**

3.1.2 HVAC maintenance and controls subsector sample design

In the maintenance and controls subsector, 3 measure groups have been selected for evaluation for PY 2017. Two of these measure groups (HVAC fan controls and HVAC thermostat controls) were part of the PY 2017 uncertain measure list; PTAC controls were not. All measure groups were planned to be evaluated to produce both gross and net savings estimates. However, due to the tight timeline and poor survey response rates, our team was only able to perform gross and net evaluations on Fan controls and Thermostat controls measure groups; the PTAC control measure group could only be evaluated for gross savings.

The gross and net data collection process resulted in completed interviews for 25 HVAC fan controls sites and 29 HVAC thermostat control sites. Gross data collection was completed for 54 PTAC control sites. For the PTAC

controls measure group we came close to the target precision. For the HVAC fan controls and thermostat measure groups we fell short of our planned sample target for a number of reasons, chiefly:

- The tracking data contained poor contact data (e.g., disconnected phone, incorrect telephone number, etc.).
- The contact information provided led to the contractor or a third-party processor who was unable or unwilling to provide contact information for their customers.
- Contacts failed to respond to multiple telephone messages requesting their participation.
- Contacts actively declined to participate.

Table 3-3 shows the total planned sample size as well as achieved sample size relative precisions by PA for the HVAC fan controls measure group. Table 3-4 shows the total planned net and gross sample size and the achieved sample size relative precisions by PA for the thermostat controls measure group and Table 3-5 shows the total planned net and gross sample size and achieved sample size with their relative precisions by PA for the PTAC controls measure group. The net evaluation for fan controls and thermostat settings attempted a census of maintenance contractors and received responses from 13 contractors who participated in the program.

Table 3-3. Planned and achieved precision of HVAC fan controls net and gross sample by PA

PA	Population Size	Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
PG&E	290	35	15%	17	38%
SCE	201	35	13%	23	11%
Total	**491**	**70**	**11%**	**40**	**21%**

Table 3-4. Planned and achieved precision of HVAC thermostat controls net and gross sample by PA

PA	Population Size	Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
PG&E	142	41	10%	17	141%
Total	**142**	**41**	**10%**	**17**	141%

Table 3-5. Planned and achieved precision of PTAC controls net and gross sample by PA

PA	Population Size	Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
MCE	1	1	0%	1	0%
PG&E	157	53	10%	43	5%
SDG&E	1	1	0%	1	0%

Total	**159**	**55**	**10%**	**45**	**5%**

3.1.3 HVAC central plant subsector sample design

In the central plant subsector only 2 measure groups were selected for evaluation: HVAC boiler and VFD fan. Both gross and net samples were planned for these two measure groups. Sixteen sample points were planned for the boiler measure group and 45 sample points were planned for VFD fan measure group to achieve ±10% relative precision for each measure group at a 90% confidence level.

For the boiler measure group, we were able to surpass the sample target and evaluate 19 sites (the sample target was 16). Although we surpassed the sample target for the boiler measure group, we fell short in achieving the planned relative precision for this measure group. The reason being the error ratio achieved (1.31) for this measure group was more than 2 times higher than the planned error ratio of 0.6. This is primarily due to the significant variations between the reported savings claim and evaluated savings estimate for the evaluated samples.

For the VFD fan measure group we were only able to complete analysis on 40 sample sites compared with the target of 45, but we achieved better relative precision than the targeted precision of 9.7%. This is because of very little variation between the reported savings claim and evaluated savings estimate for the 40 evaluated sites.

To estimate net savings for these measure groups, we had planned to assess the program influence by interviewing the decision-maker at the site. However, we were only able reach a very handful of decision-makers for the boiler measure group due old contact information and turnover of decision-makers at customer facilities. With significant attempts, we were only able to get accurate net surveys completed only for 4 of the sites. For the VFD fan measure group, DNV GL was able to complete 23 surveys compared to 45 planned in the sample design.

Table 3-6 and Table 3-7 show both planned and achieved gross sample sizes for HVAC boiler and HVAC VFD fan measure groups for PY 2017.

Table 3-6. Planned and achieved precision of HVAC boiler gross sample by PA

PA	Population Size	Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
SCG	26	16	10%	19	37%
Total	**26**	**16**	**10%**	**19**	**37%**

Table 3-7. Planned and achieved precision of HVAC VFD fan gross sample by PA

PA	Population Size	Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
PG&E	54	15	14%	13	2%

PA	Population Size	Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
SCE	98	30	13%	27	9%
Total	**152**	**45**	**10%**	**40**	**6%**

Table 3-8 shows the net planned sample size and the achieved sample size with their relative precisions for VFD fan measure group. For this measure group we fell short of the sample target as well as the planned relative precision due to the low response rates and difficulty of reaching the appropriate decision makers to conduct net-to-gross surveys.

Table 3-8. Planned and achieved precision of HVAC VFD fan net sample by PA

PA	Population Size	Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
PG&E	54	15	14%	12	4%
SCE	98	30	13%	11	47%
Total	**152**	**45**	**10%**	**23**	**32%**

For the HVAC boiler measure, evaluators collected insufficient data for NTGR update in this cycle (4 completes total). The following reasons contributed to lower-than-anticipated NTG completes:

- The participant contact data contained within PY 2017 tracking data was often unreliable. In some cases, evaluators had to make several follow-up phone calls to identify the appropriate project decision-maker for the NTG survey. Despite additional assistance from PG&E and SCG account representatives, evaluators hit dead ends for many projects in the population.
- In many cases, the project decision-maker could not be reached. For central plant projects, this individual(s) is often different from the most appropriate gross contact—typically a facilities manager or maintenance representative.
- Overall, the survey response rate for this evaluation cycle is markedly lower than prior cycles. The evaluation team has observed this among all measure groups for PY 2017.
- Finally, the PY 2017 evaluation timeframe was reduced compared to typical cycles, limiting the duration of NTG data collection.

3.2 Data collection

This section addresses the data collection plans for the 7 selected measure groups across 3 HVAC subsectors.

3.2.1 Unitary & VRF systems

We collected data for the unitary & VRF measure groups (HVAC furnaces and rooftop or split systems) to develop net energy savings estimates. Three of the PAs (SCG, SDG&E, and PG&E) reported furnace savings in PY 2017, which were claimed by a population of 1,149 participants.

Four (SCE, SCG, SDG&E and PG&E) of the 5 PAs reported rooftop or split systems savings in PY 2017, which were claimed among a population of 2,707 participants. The evaluation targeted a sample of 80 sites for net impact evaluation.

For furnaces, we interviewed residential end users using utility-provided contact and equipment information. The phone interview involved questions to determine what role, if any, PA programs played in the selection of equipment and timing of the installation. We also verified that the site met baseline conditions for the measure prior to measure installation. The evaluation targeted a sample of 75 sample sites for net impact evaluation. Overall, we attempted to contact 150 sites and from that completed 57 end-user interviews, reaching 75% of the sample target with a response rate of 37%

For rooftop or split systems, the team interviewed commercial end users using utility-provided contact and equipment information. The phone interview involved questions to determine what role, if any, PA programs played in the selection of equipment and timing of the installation and to verify the baseline case. Overall, we attempted to contact 150 sites and from that completed 31 end-user interviews, reaching 39% of the sample target with a response rate of 14%. See Section 6.10 Appendix F for the rooftop or split system and HVAC furnace interview questions.

3.2.2 Maintenance & controls

3.2.2.1 End-user data collection

We collected data for the 3 maintenance & controls measure groups (programmable thermostats, unoccupied fan controls, and package terminal air conditioner or heat pump controls) to develop both gross and net energy savings estimates. As noted elsewhere, the team limited our evaluation to commercial recipients of these 3 measure groups.

PG&E was the only PA to report programmable thermostat savings in PY 2017. The population included 142 commercial participants. We targeted a sample of 41 sites for evaluation.

For unoccupied fan controls, both PG&E and SCE reported 2017 savings. The total population was 290 commercial sites, of which we targeted 70 for evaluation.

PG&E, Marin Clean Energy, and SDG&E all claimed savings for PTAC controls in 2017. The total population comprised 159 hotels, motels, and inns. From this population we sampled 55 sites for evaluation.

For programmable thermostats and unoccupied fan controls, the team interviewed measure end users using tracking data and utility-provided equipment information to guide the interview. The end-user survey captured the weekday and weekend operating schedules and setpoints of a sample of installed programmable thermostats. We also collected the baseline and current operation (on/off/auto) of supply fans during occupied and unoccupied times. The findings from the survey were used to update installation rates and to estimate gross savings estimates for both measures.

The survey included questions aimed at determining how the HVAC maintenance programs in which the customers participated influenced setpoints and settings. The responses to these questions were used as check against the responses from the 13 contractor interviews. Overall, for the programmable thermostat measure we

attempted to contact 72 sites and completed 29 end-user interviews (71% to the sample target, 54% response rate) while for the unoccupied fan control measure, we attempted to contact 128 sites and completed 25 end-user interviews (36% of the sample target, 31% response rate). See 6.1 for the programmable thermostat and unoccupied fan control end-users' interview questions.

For PTAC controls, we interviewed the end users of participating guestroom facilities using utility-provided contact and equipment information. The phone interview included questions to establish the baseline control scheme as well as whether the new controls were still in operation. This data allowed us to update installation rates for the purpose of refining the estimate gross savings for PTAC controls. Overall, we completed 45 end user interviews, reaching 85% of the sample target response rate.

3.2.2.2 Contractor survey implementation

In addition to customers, we also interviewed contractors who participate in PA commercial maintenance programs. These contractors provided the thermostat and fan control programming services to their customers. These contractor interviews helped inform our net savings estimates for these two measure groups as described in Section 3.4.

Our trained internal staff completed surveys with these participating contractors. We attempted to complete interviews with 36 participating contractors and completed interviews with 13 during the period from January 7−January 15, 2018. Section 6.9 Appendix E contains the questions we asked them.

3.2.3 Central plant

This section summarizes evaluation team's measure-specific data collection approaches to central plant measures.

3.2.3.1 HVAC boiler

Only SCG reported savings in PY 2017, which were claimed among a population of 26 participants. The evaluation initially targeted a sample of 16 sites for gross impact evaluation, but due to attrition, the evaluation team undertook a census attempt targeting all 26 sites.

Evaluation engineers interviewed the facility representatives using utility-provided contact information. The phone interview involved a series of in-depth questions to populate a comprehensive data collection template (see Section 6.7 Appendix C for the boiler data collection form) to obtain key parameter information associated with the measure. The evaluation team received additional recruiting assistance from the SCG account representatives for some sites with facility contacts who were non-responsive during the initial contact attempts. Overall, we were able to interview 14 facility representatives, resulting in a 54% response rate.

The phone interviews covered the following:

- **Verify measure installation and continued operation.** We confirmed that the claimed quantity of incentivized equipment was installed and still in use and the make and model number of the incentivized HVAC boiler(s).
- **Verify baselines.** All applicable HVAC boiler workpapers for this measure specify replace on burnout (ROB) as the event type, with an applicable baseline of relevant Title 24 code minimum efficiency at the time of installation. We asked specific questions about the age and operability of pre-existing boiler(s) at the facility to confirm the applicable site-specific baselines.

- **Understand typical equipment usage.** Details about the heating loads served by the HVAC boiler, operating schedules, space heating temperature setpoints, return-water temperatures, observed efficiencies, seasonality in boiler operation, and staging of multiple boilers at the facility (if applicable) were confirmed during the phone interview. This information informed our desk review analysis.
- **Confirm utility meter account information.** During the interview, we confirmed the number of utility accounts and meters associated with the upgraded boiler(s). We also requested copies of monthly natural gas consumption data for the meter serving the installed boiler from the facility manager. The interview also covered questions specific to additional end-uses associated with the natural gas meter serving the boiler to help us isolate the gas consumption of the incentivized boiler(s) from the overall metered natural gas usage.

We visited 5 of the 14 interviewed sites to independently confirm installation of the described equipment, verify phone interview responses, and gather additional measure-specific data. DNV GL engineers took spot-measurements of boiler combustion efficiency and, for condensing boilers, took spot-measurements of return-water temperature to the boiler to inform site-specific evaluation gross savings calculations. We also verified that the site observations were consistent with phone interview responses.

The evaluation team also requested billing data from SCG for up to 14 months prior to the installation date. SCG provided monthly natural gas billing data for all 26 sites in the population, and daily natural gas usage data from advanced metering infrastructure (AMI) meters for 20 sites.

3.2.3.2 HVAC fan VFD

For the VFD fan measure group, we assessed each sampled project for installation/operability and eligibility through project file reviews and phone interviews with key facility contacts.

The measure groups that were prevalent among the 2017 population of central plant HVAC fan VFD projects are shown in Table 3-9.

Table 3-9. Fan VFD measure groups

PA	Measure Group	Number of Projects in Population	Number of Projects in Target Sample	Number of Projects Completed
PG&E	VFDs for HVAC Fans[11]	50	15	13
SCE	VFDs on HVAC Fan Control[12],[13]	32	11	4
	VFDs on Garage Exhaust Fan Control[14]	1	1	1
	VFDs on Cooling Tower Fan Control[15]	8	0	0
	Enhanced Ventilation[16]	59	17	22[17]
Total		**150**	**45**	**40**

[11] *Work Paper PGECOHVC106 VFDs for HVAC Fans Revision # 5, PG&E, Variable Frequency Drives (VFDs) for HVAC Fans*

[12] *Work Paper SCE13HC050 Revision #2, SCE, Variable Speed Drive on HVAC Fan Control*

[13] The 'VFD for HVAC Fans' and 'VFDs on HVAC Fan Control' offered by PG&E and SCE respectively addresses the same measure group - installing a variable frequency drive and associated controls on an existing constant speed HVAC supply or return fan

[14] *Work Paper SCE13HC038 Revision #2, SCE, VFD Demand Control System Retrofit to Parking Structure Exhaust Fan*

[15] *Work Paper SCE13HC039 Revision #2, SCE, VFD Retrofit to Central Plant Systems*

[16] Work Paper SCE13HC045 Revision #2, *SCE, VFD Enhanced Ventilation for Packaged HVAC Units with Gas Heating and Packaged Heat Pumps*

[17] Due to a high number of non-responsive participants in the initial target sample, the evaluators selected replacement sites from the backup sample based on sampling stratum and site priority list. This resulted in the selection of 5 additional enhanced ventilation sites than the initial target sample.

We developed comprehensive data collection templates (see Section 6.7 Appendix C) for the HVAC fan VFD and enhanced ventilation measure groups to obtain key parameter information associated with the equipment installation. For VFDs on garage exhaust fan and cooling tower fan control measures, we found few sites in the population and sample. Because of this we developed site-specific questions based on project tracking data obtained from PAs and in-depth reviews of relevant workpaper references for key measure parameters affecting the gross reported savings calculations.

We recruited the facility representative using utility-provided contact information. Generally, the utility-provided contact information did not include the facility representative most knowledgeable on the HVAC central plant; as a result, our evaluators typically gathered this contact information from the utility-supplied contact and made additional calls to interview the best representative. Some facility contacts were not responsive to our phone calls; each non-responsive participant received at least five calls at different times of the day and week and follow-up email prompts before the evaluators moved on to a backup site, when possible.

The data collection templates utilized by evaluators during the phone interviews focused on equipment installation and operability and measure eligibility as compared with program requirements provided in their respective workpapers. The workpapers specify the measures as a retrofit add-on event. Therefore, the evaluation engineers also attempted to collect information on preexisting conditions during the phone interview with facility representative(s) to confirm the most appropriate site-specific baseline.

Overall, the evaluation team was able to complete data collection for 40 projects in the sample as shown in Table 3-1.

3.3 Gross methodology

Section 3.3 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, on-site inspections and analysis for representative sample for 5 selected measure groups across the 3 HVAC subsectors. 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.

3.3.1 Maintenance & controls

The Maintenance and Controls subsector includes the programmable thermostat controls, supply fan controls, and guestroom PTAC controls measure groups.

3.3.1.1 Programmable thermostat and supply fan controls measures

These measure groups are closely related; they are both implemented at the thermostat or building energy management system and they are both aimed at ensuring that HVAC systems don't needlessly condition or ventilate spaces during scheduled unoccupied periods.

The gross savings estimates for these measure groups involved telephone interviews with a sample of commercial recipients of these measures. Section 3.2.2.1 details the data we collected in these interviews.

Below are excerpts from the PG&E work papers covering the measure criteria used to evaluate the installation of the programmable thermostat controls and the supply fan controls measure groups:

> The base case for the programmable thermostat controls measure is an existing non-programmable thermostat installed on split or packaged cooling systems with or without an economizer. The programmable thermostat measure calls for the replacement of these existing non-programmable thermostats. The programmable thermostat also allows the supply fan to change from continuous operation during unoccupied periods to intermittent fan operation. Additional electric and gas savings are achieved both by directly reducing equipment runtime during unoccupied hours and by reducing the amount of outside air brought into the conditioned space during those hours. To qualify, the replacement thermostat must be set during unoccupied hours to call for heating at less than 55°F and call for cooling at greater than 85°F. Occupied comfort settings must be in the range of 72°F to 75°F for cooling and 65°F to 68°F for heating. –Work Paper *PGE3PHVC153 Revision 3 – Programmable Thermostat – Nonresidential*

> The base case for the supply fan controls measures is existing HVAC equipment with the supply fan operating continuously during unoccupied periods. The supply fan control measure modifies existing thermostat settings during unoccupied periods from continuous fan operation to intermittent fan operation. Energy savings are achieved through reducing unoccupied supply fan runtime except when zone conditions call for cooling or heating. Reducing or eliminating supply fan runtime during unoccupied periods can also prevent outside air infiltration into the conditioned space through leaky economizer dampers, causing an unnecessary increase in space heating or cooling. –Work Paper *PGE3PHVC157 Revision 2 – Unoccupied Supply Fan Control*

The team completed 33 site interviews for the supply fan control measures and 17 site interviews for the programmable thermostat measures. In both cases we fell well short of our targets; we targeted 70 unoccupied fan control sites and 41 programmable thermostat sites for interviews. Several factors contributed to these low response rates:

- Tracking data contained bad contact information (disconnected phone, respondent not known at that telephone number, etc.)
- Contact information led to the contractor or a third-party processor who was unable or unwilling to provide contact information for their customers.
- Contacts failed to respond to multiple telephone messages requesting their participation.
- The contact refused to participate.

For both measure groups we calculated gross evaluated installation rates by evaluating the measure requirements against the controls settings in place at the time of the interview and the end user reported baseline condition prior to the measure installation. If the requirements were met for a given operating period (e.g. weekday or weekend, and occupied or unoccupied), the measure was considered installed and scored a value of 1 for that period. Likewise, If the requirements were not met for a given operating period, the measure was considered not installed and scored a value of 0. The measure installation rate was calculated as the average of installation scores for each period, weighted by the number of hours of that operation of period relative to the total weekly operating hours. For sites with 1 to 3 controls measure claims, data were collected for each installed control measure. For sites with greater than 3 control measure claims, data collected for 3 representative measure installations. The site-level installation rate is calculated as the average of the unit-level installation rates for a given site.

3.3.1.2 PTAC controls measures

This section discusses the methodology used to determine evaluated gross savings results for the PTAC control measures. The base case for this measure is a guestroom with PTAC, PTHP, or split AC with no occupancy controls present. This measure involves the installation of a passive infrared occupancy sensor or an occupancy key card and occupancy setback controls. During unoccupied periods the temperature is set back by 8°F to 10°F.

The evaluated gross savings estimates for the PTAC Control measure group are calculated using site level installation rates based on telephone interviews with end users of this measure.

The team completed 45 interviews with a target of 55 interviews.

The evaluated gross installation rate for this measure is evaluated as the quotient of the number of control units installed and operational at the time of the interview divided by the number of units initially installed. The tracking data provides the tons of cooling that received this measure rather than the number of units upgraded with controls, so we were unable to verify with the end user the quantity independently, because we anticipated the end user's unfamiliarity with the cooling tons unit and with the capacity of their PTAC units receiving this controls measure. For this reason, the interview respondents were instead asked how many guestrooms received this measure, how many guestrooms had the measure removed, and how many guestrooms still have

occupancy-based controls installed and operational. The site-level installation rate is calculated as the number of unit controls still operational divided by the number of unit controls initially installed.

The evaluated savings were calculated by multiplying the reported UES savings with the evaluated installation rate.

3.3.2 Central plant

This section describes the methodology used for gross savings estimation of the HVAC central plant measures.

3.3.2.1 HVAC boiler

The overall gross savings estimation approach for the boiler measure involved analysis of normalized metered energy use to determine normalized annual heating load from their savings as the difference in gas consumption between installed and baseline efficiencies of the boiler. This section describes that approach in detail.

All relevant HVAC boiler workpapers specify ROB as the event type. Through phone interviews and some follow-up site visits, the evaluation team confirmed that the baselines were ROB for all surveyed sites. For ROB, the baseline is defined by the relevant Title 24 California building energy code minimum efficiency at the time of installation or permit application. The workpapers document these efficiencies, designated by boiler capacity. The evaluation team verified these code efficiencies before using them in site-specific analysis.

To perform our weather-normalized analysis of metered energy use, we confirmed through phone and/or site interviews that the replaced boiler represents the majority of gas use of the affected meter *or* space heating generally represents the majority of gas use and the replaced boiler provides a definable percentage of the annual space heating. Then we performed the following steps:

1. We began with correlating monthly or daily AMI gas consumption with historical monthly heating-degree days (HDD) at the nearest weather station.
2. Next, we determined the typical monthly HDD using typical meteorological year (TMY) weather data for the facility's climate zone.
3. We applied the post-project gas consumption correlations to the TMY HDD to determine normalized gas usage after the project. This normalized use reflects the present-day, typical gas consumption expected at the facility.
4. We then calculated the annual heating load served by the impacted boilers by multiplying the weather-normalized post-project gas usage and the verified installed boiler efficiency.
5. As the baseline condition reflects code requirements at the time of the project, we determined the weather-normalized baseline gas usage by dividing the annual heating load by the verified code baseline efficiency.
6. Finally, we calculated evaluated gross savings by subtracting the post-project normalized gas consumption from the baseline normalized gas consumption.

Overall, the evaluation team completed weather-normalized billing analysis for 19 sites in the population, and the site-specific results were utilized in the aggregation of overall results for HVAC boilers. Though 5 sites did not include a completed phone interview, evaluators had sufficient confidence in their available billing and tracking data to calculate gross savings results.

3.3.2.2 HVAC Fan VFD

Due to limitations on Year 1 data collection (see Section 3.2.3.2), the evaluation engineers focused the analysis on equipment installation and operability and measure eligibility as compared with program requirements. The evaluation team also considered adjusting the reported measure quantities to account for installation rates and leakage (installation of the measure outside of California).

For the VFDs on HVAC supply and return fan measures, we followed the deemed savings analysis methodology specified in Workpapers PGECOHVC106 and SCE13HC050, adjusting measure parameters when possible based on data collected during the phone interview. We verified by phone the installed VFD quantity, impacted fan motor(s) horsepower, facility HVAC system type, and minimum allowable airflow adjustments. Since the measure occurs as a retrofit add-on event, the baseline represented the same fan(s) with damper flow control. We collected information on the measure parameters provided in the workpapers that affect the gross savings estimates and generally found that phone interview responses were consistent with workpaper parameter assumptions.

For the enhanced ventilation measures, evaluators followed deemed savings analysis methodology specified in Workpaper SCE13HC045, adjusting measure parameters when possible based on data collected during the phone interview. We used phone survey responses were used to verify or adjust installed VFD quantity, impacted tonnage, pre-/post- fan motor types, pre-/post- economizer types, and pre-/post- minimum fan speeds for cooling and heating modes adjustments. We collected information on the measure parameters provided in the workpaper that affect the gross savings estimates and generally found that phone interview responses were consistent with the workpaper parameter assumptions.

For the garage exhaust fan VFD measure, the evaluation engineer followed deemed savings analysis methodology specified in Workpaper SCE13HC038. We verified the installed quantity, impacted fan motor horsepower, and the equipment operating schedules and seasonality using in-depth phone interviews with facility representatives. When we found differences in operating schedules of the garage exhaust fan compared with workpaper assumptions, we adjusted the operating hours in the workpaper deemed savings algorithm to calculate evaluated gross savings for the project.

3.4 NTGR methodology

This section contains descriptions of how the evaluation team calculated net to gross ratios (NTGRs) for the measures studied in this evaluation. In general, this evaluation used the same NTGR calculations as were used in the previous evaluation on each of the measures included this year. While each method has a similar core approach, the details vary considerably by measure category.

Table 3-10 provides a high-level summary of the methods used for each measure group. Detailed methodology used to calculate NTGRs for each is provided in the Section 0 appendices listed in the table.

Table 3-10. NTGR method summary

Measure Group	NTGR Method	Location of Detailed Methodology
Unitary VRF – Rooftop and Split Systems	• Assess program effects on distributor stocking and sales practices • Assess effects of distributor stocking and sales practices on end-user decisions • Combines program effects on distributors and distributors' effects on end users	Section 6.11 Appendix G
Unitary VRF – Furnaces	• Assess program effects on timing and efficiency level of installed furnaces	Section 6.11 Appendix G
Quality Maintenance – Controls	• Assess program effect on contractors' implementation of thermostat and fan control settings • Assess end users' likelihood of choosing the same controls settings in absence of the contractor	Section 6.12 Appendix H
Central Plant	• Asked end users to rate the level of influence of a variety of factors • Asked end users to rate the program's effect on timing, efficiency, and quantity of measures installed • Combined these two calculations • Boilers used pass-through due to low response rates	Section 6.13 Appendix I

3.5 Data sources

3.5.1 Data source descriptions

We based our savings estimates on data from several sources, summarized in Table 3-11. Section 6.15 Appendix K shows the details of these data sources including contents and types of the data and how they are used in the evaluation.

Table 3-11. Summary of data sources and applicable measure groups

Data Sources	Description	Applicable Measure Groups
Program Tracking Data	Collected by the PAs and maintained by the CPUC; includes detailed information about programs' savings claims	System HVAC boilers HVAC fan VFDS HVAC furnace HVAC rooftop or splits HVAC thermostat controls HVAC fan controls
Program Billing Data	PA billing data including kWh	HVAC boilers HVAC fan VFDS
Program AMI Data	Detailed, time-based energy consumption information	HVAC boilers HVAC fan VFDS
Project-Specific Information	Scope of work, equipment model number, serial number efficiency, test results, project cost, and so on	HVAC boilers HVAC fan VFDS
Manufacturer Data Sheet	Equipment specifications such as horsepower (HP), efficiency, capacity, and so on	HVAC boilers HVAC fan VFDS
Telephone Surveys	Surveys of involved parties	System HVAC boilers HVAC fan VFDS HVAC furnace HVAC rooftop or splits HVAC thermostat controls HVAC fan controls
Onsite Visits	Verification of measure installation; collection of measure performance parameters such as efficiency, schedules, set-points, and building characteristics	HVAC boilers HVAC fan VFDS

4 STUDY RESULTS

This section presents the results of the gross and net evaluations of the measure groups. Gross impact realization rates (GRRs), 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 AA, Appendix AB, and Appendix AC contain the IESR Standard high-level savings, standard per-unit savings, and the tabularized report recommendations. The evaluation utilized the PA reported EUL measure values to calculate lifetime savings from first year savings.

4.1 Unitary VRF

Findings for this subsector's two measure groups are presented and discussed in this section.

4.1.1 Rooftop and split systems

4.1.1.1 Gross impact findings

Gross savings for this measure group were not evaluated. Existing reported gross savings will be passed through.

4.1.1.2 Net impact findings

The NTGR method (see Section 6.11 Appendix G for the NTG methods) for rooftop and split systems generated an attribution score for three causal paths (stocking, upselling, and price) for distributors and end users (Table 4-1). Distributor attribution scores were low across the board. This indicates that the program did not have a strong effect on distributor sales practices.

In contrast, the end-user attribution scores indicate that the distributors have a moderately strong influence on end-user decisions. In this case, the price set by distributors and distributor upselling behavior are stronger influencers on end-user behaviors than the distributors' stocking practices. The stocking path has less influence on end users than the other paths because most of these end users are non-residential customers. Thus, they are more likely than residential customers to be able to wait for distributors to get precise models in stock than residential customers who have a higher likelihood of having to make an emergency purchase.

Table 4-1. Rooftop & split systems NTGRs by causal path - statewide

Causal Path	Distributor Sample Complete	Distributor Attribution	End-user Completes	End-user Attribution	Combined Attribution
Stocking	7	13%	108	28%	4%
Upselling	7	12%	108	64%	8%
Price	7	29%	108	75%	21%

These results represent lower NTGRs than the previous evaluation of these measures, although the relative strengths of each causal pathway are similar. There are several possible explanations for the change over time including:

- Distributors may already be stocking and upselling most of the time, so there is little room for the program to affect their practices. This might be due to the success of the program in changing distributor behavior long term or could be due to exogenous factors such as increased utility rates or increased concern about climate change.

- The incentive may be too low to motivate distributors.
- The evaluation only reached 7 distributors this year, versus 19 last time. Smaller samples carry greater risks of sample bias. For example, this year's evaluation might have unintentionally gathered information from an unusually unaffected portion of the distributor population.

A follow-up process evaluation could help produce evidence to support or refute these potential explanations.

After combining all the causal pathways, the final NTGR for rooftop and split systems is approximately 30%. There were slight variations in NTGRs across PAs and fuels (Table 4-2). The wide confidence intervals (low precision) are noteworthy. The estimates themselves were variable enough to cause wide confidence intervals despite the generally adequate sample sizes even when broken down by PA.

Table 4-2. Rooftop & split systems population, sample, realization rate, and relative precision

PA	Population Size	Completed Sample Size	Evaluated kWh NTGR	kWh Achieved Relative Precision[18]	Evaluated kW NTGR	kW Achieved Relative Precision[18]	Evaluated Therm NTGR	Therms Achieved Relative Precision[18]
PG&E	3,622	47	32%	178%	30%	192%	35%	228%
SCE	1,398	31	35%	217%	36%	218%	30%	179%
SDG&E	781	21	30%	183%	28%	206%	30%	184%
Total	**5,801**	**99**	**32%**	**130%**	**31%**	**140%**	**34%**	**188%**

The relative precisions for all realization rates shown in Table 4-2 are greater than 100% For this measure group, the absolute precisions are also quite wide: 32%±42%, 31%±43%, and 34%±64% for kWh, kW, and therms, respectively. These absolute precisions may be too wide to provide much guidance on program design or policy decisions.

However, if one observes the component parts of the NTGR (Table 4-1), a clearer picture emerges. The findings in Table 4-1 show that the distributors have a fairly strong effect on end-user choices, but the program is not strongly influencing the distributors. This suggests the distributors are a good market actor for the program to target, but that the specific mechanisms the program currently uses to change distributor behaviors are not very effective.

Table 4-3 shows final net savings calculations by PA and fuel. Statewide, total net savings from these measures are 2,218,767 kWh, 1,730 kW, and -5,694 therms.

[18] Relative precision at 90% confidence.

Table 4-3. First year gross and net savings summary – rooftop & split systems measure group

PA	Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings	Reported NTGR[19]	Evaluated NTGR[20]	Evaluated Net Savings	Reported Net Savings[21]	Net Realization Rate[22]
kWh								
PG&E	4,746,251	100%	4,746,251	80%	30%	1,438,961	3,778,266	38%
SCE	1,846,940	100%	1,846,940	81%	35%	646,896	1,504,707	43%
SCG	-	N/a	-	-	N/a	N/a	-	N/a
SDG&E	450,282	100%	450,282	85%	30%	132,909	383,935	35%
Total	**7,043,473**	**100%**	**7,043,473**	**80%**	**32%**	**2,218,767**	**5,666,909**	**39%**
kW								
PG&E	3,768	100%	3,768	80%	30%	1,127	3,018	37%
SCE	1,511	100%	1,511	80%	36%	537	1,206	45%
SCG	-	N/a	-	-	N/a	N/a	-	N/a
SDG&E	233	100%	233	84%	28%	65	196	33%
Total	**5,512**	**100%**	**5,512**	**80%**	**31%**	**1,730**	**4,421**	**39%**
Therm								
PG&E	(13,870)	100%	(13,870)	81%	35%	(4,859)	(11,224)	43%
SCE	(1,863)	100%	(1,863)	125%	30%	(555)	(2,323)	24%
SCG	1,539	100%	1,539	60%	34%	526	923	57%
SDG&E	(927)	100%	(927)	88%	30%	(281)	(813)	35%
Total	**(15,121)**	**100%**	**(15,121)**	**89%**	**34%**	**(5,694)**	**(13,436)**	**42%**

4.1.1.3 Other findings

The surveys asked rooftop end users what factors influenced their equipment choice. Responses are shown in Figure 4-1. The most common answer - even more common than initial price - was energy savings (or return on investment). Old equipment reaching the end of its useful life and contractor recommendations were also relatively common answers. Non-energy benefits such as decreased maintenance costs, improved safety/comfort, and improved productivity were less-common responses.

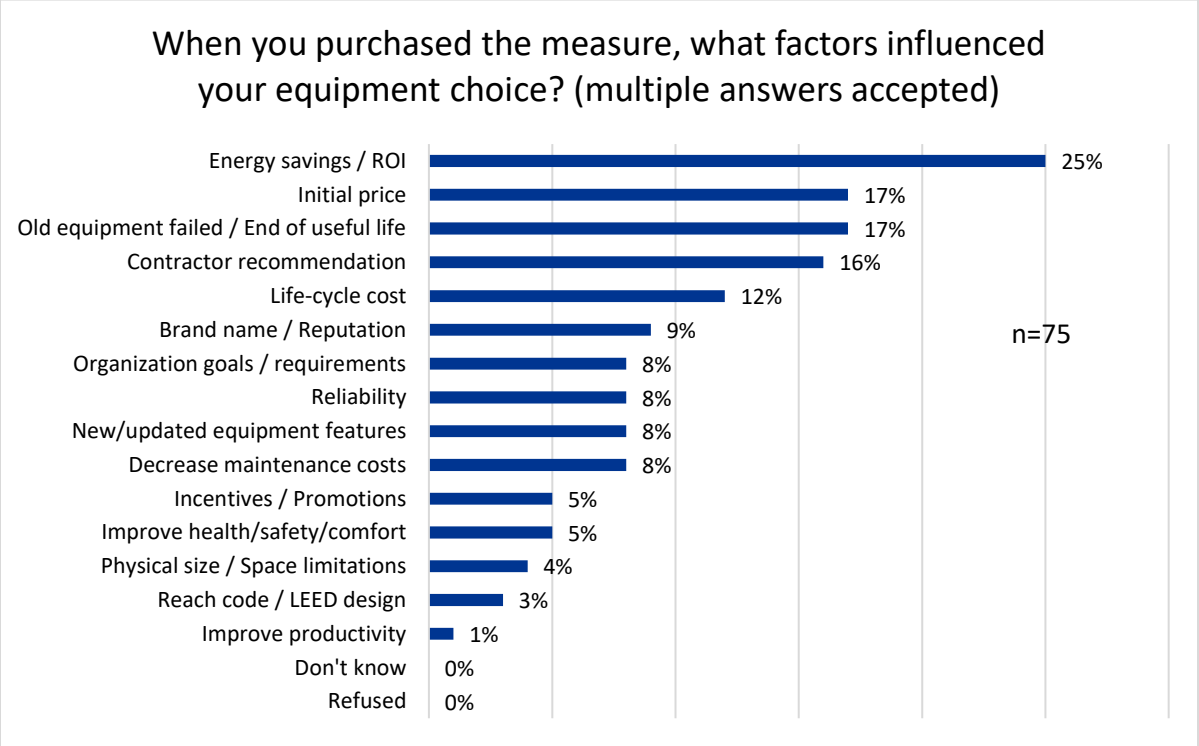
[19] Reported NTGR includes 5% market effects benefits

[20] Evaluated NTGR does not include market effects benefits

[21] Reported net savings include market effects benefits

[22] Ratio of the evaluated net savings to the reported net savings (do not include market effects benefits)

Figure 4-1. Factors influencing rooftop end user equipment choice



The surveys also asked end users what challenges they encountered when selecting the specific equipment they installed. Thirty-three respondents answered; most (55%) answered "none." The only common challenge cited by these respondents was related to physical space limitations in the building or area where the equipment would be installed. Answers in this category included the equipment's physical footprint and needing to make additional modifications such as installing duct work for the new equipment.

4.1.2 Furnaces

4.1.2.1 Gross impact findings

Gross savings for this measure group were not evaluated. Existing reported gross savings will be passed through.

4.1.2.2 Net impact findings

Table 4-4 provides the NTG results for furnaces. The statewide NTG ratio is 33%. Individual PA NTG ratios ranged from 44% for PG&E to 30% for SCG. Each of the PA's had similar NTG results: none are statistically different from the others.

Table 4-4. Furnace population, sample, realization rate, and relative precision

PA	Population Size	Completed Sample Size	Evaluated kWh & kW NTGR	kWh & kW Achieved Relative Precision[23]	Evaluated Therm NTGR	Therm Achieved Relative Precision[23]
PG&E	164	18	44%	29%	44%	29%
SCG	801	24	-	-	30%	46%
SDG&E	184	15	-	-	36%	43%
Total	**1,149**	**57**	**44%**	**29%**	**33%**	**29%**

Of the 57 respondents, 20 were full free-riders, 27 were partial free-riders and 10 were full non-free-riders. The program affected the efficiency of 34/57 respondents and had an effect on the timing of the furnace installation for 14/57 respondents. Thirty-four (60%) respondents were replace-on-failure installations. The primary source of attribution for respondents was price with 28 respondents citing the rebate as a contributing factor in their decision. Several of the respondents volunteered that they lived in mobile homes, and that the contractors' door-to-door approach was instrumental in their participation.

Table 4-5 shows final net savings calculations by PA for the furnace measure. Statewide, total net savings from these measures are 3,063 kWh, 1 kW, and 13,523 therms.

Table 4-5. First year gross and net savings summary – furnace measure group

PA	Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	Net Realization Rate
kWh								
PG&E	6,962	100%	6,962	65%	44%	3,063	4,525	68%
SCG	-	-	-	-	-	-	-	-
SDG&E	-	-	-	-	-	-	-	-
Total	**6,962**	**100%**	**6,962**	**65%**	**44%**	**3,063**	**4,525**	**68%**
kW								
PG&E	3	100%	3	65%	44%	1	2	68%
SCG	-	-	-	-	-	-	-	-
SDG&E	-	-	-	-	-	-	-	-
Total	**3**	**100%**	**3**	**65%**	**44%**	**1**	**2**	**68%**
Therm								
PG&E	8,893	100%	8,893	74%	44%	3,901	6,566	59%
SCG	27,106	100%	27,106	60%	30%	8,047	16,263	49%
SDG&E	4,433	100%	4,433	60%	36%	1,576	2,660	59%
Total	**40,432**	**100%**	**40,432**	**63%**	**33%**	**13,523**	**25,489**	**53%**

[23] Relative precision at 90% confidence

When the ratios in question are less than 50%, it is often useful to look at absolute precisions. For example, a 150% relative precision on a 4% ratio means the absolute precision is 6%. This means one can have 90% confidence that the true ratio is between -2% and 10%. That is still an actionable window when it comes to program design.

In some cases (e.g. rooftop/split systems), even the absolute error bands are quite wide. In that case, it is beyond our mandate to say what the policy should be for using or not using the evaluated NTGRs. However, these evaluation findings may still prove useful for program design purposes. In the case of rooftops/split systems specifically, our findings show that distributor behavior does have a reasonably strong effect on end-user behavior, but that the program is not having a strong effect on the distributor behavior. This suggests that the program is targeting the right market actors but is not using effective mechanisms to move those market actors.

4.2 Maintenance & controls

4.2.1 Thermostat and fan controls measure groups

4.2.1.1 Gross impact findings

We assessed gross savings by determining evaluated installation rates for the measure group. To assess installation rates, we evaluated the measure requirements against the controls settings in place at the time of the interview and the end user reported baseline condition prior to the measure installation. Evaluated installation rates were set to 1.0 when program requirements were met and 0 when requirements were not met. Qualifying sites must meet requirements for supply fan control operation for baseline and post conditions. Operators were asked to verify if supply fans were currently set to "on," "off," or "auto" for each thermostat. Fan control requirements are met when evaluated supply fan operation is set to either "off" or "auto." Baseline fan controls must be set to continuous operation to meet requirements.

Table 4-6 and Table 4-7 show the population sizes, sample sizes, realization rates, and relative precisions for the thermostat controls and supply fan controls measure groups. The completed sample size (attributable to the difficulty of contacting measure group end users) and a greater-than-anticipated error ratio of the sample resulted in achieved relative precision values of savings (i.e. low precision) that were higher than planned or expected, especially for the thermostat controls measure group. This is because we fell short of our planned sample target.

Table 4-6. Thermostat controls population, sample, realization rate, and relative precision

PA	Population Size	Completed Sample Size	kWh Gross Realization Rate	kWh Achieved Relative Precision[24]	Therm Gross Realization Rate	Therms Achieved Relative Precision[24]
PG&E	142	17	4%	141%	4%	141%
Total	**142**	**17**	**4%**	**141%**	**4%**	**141%**

[24] Relative precision at 90% confidence

Table 4-7. Fan controls population, sample, realization rate, and relative precision

PA	Population Size	Completed Sample Size	kWh Gross Realization Rate	kWh Achieved Relative Precision[24]	kW Gross Realization Rate	kW Achieved Relative Precision[24]	Therm Gross Realization Rate	Therms Achieved Relative Precision[24]
PG&E	290	10	65%	46%	80%	44%	63%	53%
SCE	201	23	93%	11%	101%	2%	94%	9%
Total	**491**	**33**	**75%**	**27%**	**78%**	**50%**	**67%**	**42%**

The HVAC fan controls and thermostat controls measure groups fell short of achieving the planned relative precision. The achieved relative precisions were worse than anticipated due to two reasons. First, the response rates for these two measure groups were much lower than the expected, primarily due to incorrect or incomplete contact data, contacts failed to respond to the multiple telephone messages and in some cases the contacts declined to participate. This resulted in samples for these two of the three measure groups not reaching the planned target. Second, the error ratio achieved (1.31) for the thermostat controls measure group was more than twice as high than the planned error ratio of 0.6. This is primarily due to the significant variations between the reported savings claim and evaluated savings estimate for the evaluated samples. In case of the thermostat controls the savings were lower than the estimated outcomes. A total of 16 out of 17 sampled sites had no evaluated savings. The poor achieved relative precision of 141% for the thermostat controls measure is primarily due to lower savings as compared to the estimated outcome.

As described in the VRF result finding section above, when the ratios in question are less than 50%, it is often useful to look at absolute precisions. For example, a 150% relative precision on a 4% ratio means the absolute precision is ±6%. This means one can have 90% confidence that the true ratio is between -2% and 10%. That is still an actionable window when it comes to program design. However, the thermostat controls measure absolute error is quite large, but the evaluation findings may still be useful for informing program design since there were consistent responses. For the thermostat controls measure, our primary finding was that the majority of the sampled sites did not meet the programing requirements of the thermostat and the thermostats were manually turned off during the unoccupied hours instead of operating in a programmed lower or higher temperature conditions. This suggest that the program might need to re-look at the measure eligibility requirements despite the precisions since they are somewhat a result of many observed cases being zero savings installations.

Table 4-8 shows the site level gross thermostat controls measure savings analysis, installation rate, and evaluated savings results. Note that all but one sampled site achieved an evaluated installation rate of 0. Sites with installation rates of 0 failed to meet the program's measure requirements for temperature setpoints or operated their thermostat schedule manually instead of relying on the schedule programming capability of the controls measure. The data on the thermostat and fan controls measure settings used to determine these installation rates are presented in Section 6.12 Appendix H.

Table 4-8. Thermostat controls measure group site-level gross impact analysis

Site ID	Reported Gross kWh	Reported Gross Therm	T-stat 1 meets criteria?	T-stat 2 meets criteria?	T-stat 3 meets criteria?	Evaluated Installation Rate	Evaluated Gross kWh	Evaluated Gross Therm
PGE.1	39,919	6,603	0	N/a	N/a	0	0	0
PGE.2	20,218	2,980	0	N/a	N/a	0	0	0
PGE.3	47,108	6,763	0	0	N/a	0	0	0
PGE.4	23,969	3,441	0	0	N/a	0	0	0
PGE.5	34,265	5,050	0	N/a	N/a	0	0	0
PGE.6	6,189	828	0	N/a	N/a	0	0	0
PGE.7	7,245	970	0	N/a	N/a	0	0	0
PGE.8	41,153	7,018	0	N/a	N/a	0	0	0
PGE.9	52,925	8,640	0	0	0	0	0	0
PGE.10	27,138	4,500	0.9	-	N/a	0.9	24,876	4,125
PGE.11	12,934	2,145	0	0	N/a	0	0	0
PGE.12	11,140	1,843	0	0	N/a	0	0	0
PGE.13	29,498	3,237	0	0	N/a	0	0	0
PGE.14	14,714	2,112	0	0	N/a	0	0	0
PGE.15	19,430	2,864	0	0	N/a	0	0	0
PGE.16	7,158	801	0	N/a	N/a	0	0	0
PGE.17	13,053	1,874	0	N/a	N/a	0	0	0

Table 4-9 shows the site level gross supply fan controls measure savings analysis, installation rate, and evaluated savings results. Most of the sampled supply fan controls sites met the requirements for the measure and were scored as fully installation (a value of 1.0). Only 5 sites were scored as not installed and this was because the site contact reported the baseline fan control condition already met the measure requirements (baseline ineligibility). This is a significant improvement from the findings of the PY 2015 HVAC3 report which found a lower installation rate for this measure group due to a high frequency of baseline ineligibility.

Table 4-9. Supply fan controls measure group site level gross impact analysis

Site ID	Reported Gross kWh	Reported Gross kW	Reported Gross Therm	Evaluated Installation Rate	Evaluated Gross kWh	Evaluated Gross kW	Evaluated Gross Therm
PGE.1	522	0	0	0	0	0	0
PGE.2	10,376	1	699	1.0	10,376	1	699
PGE.3	25,479	1	1,422	1.0	25,479	1	1,422
PGE.4	112,318	6	6,809	1.0	112,318	6	6,809
PGE.5	24,053	2	1,619	0	0	0	0
PGE.6	46,373	0	3,250	0	0	0	0
PGE.7	54,293	3	3,199	1.0	54,293	3	3,199
PGE.8	41,169	2	1,669	1.0	41,169	2	1,669
PGE.9	9,330	0	535	0	0	0	0
PGE.10	102,021	5	4,623	1.0	102,021	5	4,623
SCE.1	3,002	0	37	1.0	3,002	0	37

Site ID	Reported Gross kWh	Reported Gross kW	Reported Gross Therm	Evaluated Installation Rate	Evaluated Gross kWh	Evaluated Gross kW	Evaluated Gross Therm
SCE.2	47,092	-1	1,805	1.0	47,092	-1	1,805
SCE.3	6,511	0	183	1.0	6,511	0	183
SCE.4	11,557	0	455	1.0	11,557	0	455
SCE.5	24,585	0	472	1.0	24,585	0	472
SCE.6	9,115	0	257	1.0	9,115	0	257
SCE.7	5,117	0	167	1.0	5,117	0	167
SCE.8	2,343	0	0	1.0	2,343	0	0
SCE.9	8,265	0	223	1.0	8,265	0	223
SCE.10	1,935	0	0	1.0	1,935	0	0
SCE.11	5,800	0	190	1.0	5,800	0	190
SCE.12	7,208	0	1	1.0	7,208	0	1
SCE.13	1,302	0	37	1.0	1,302	0	37
SCE.14	33,043	0	931	1.0	33,043	0	931
SCE.15	14,958	0	598	1.0	14,958	0	598
SCE.16	13,673	0	385	1.0	13,673	0	385
SCE.17	10,064	0	329	1.0	10,064	0	329
SCE.18	5,800	0	190	1.0	5,800	0	190
SCE.19	3,412	0	112	1.0	3,412	0	112
SCE.20	5,838	0	167	1.0	5,838	0	167
SCE.21	3,186	0	34	1.0	3,186	0	34
SCE.22	1,081	0	0	1.0	1,081	0	0
SCE.23	23,470	0	490	0	0	0	0

Table 4-10 and Table 4-11 show the reported gross savings, gross realization rate, and evaluated savings for thermostat controls and fan controls. As shown in the table below, the GRR for the thermostat controls measure group was quite low. The primary reason behind these low GRRs is the measure not meeting the program requirements for thermostat programming. We found that most of the sites did not meet the program setback requirements, and in a number of cases, the thermostats were manually turned off during the unoccupied hours instead of operating in a programmed setback condition.

Table 4-10. First year gross savings summary – thermostat controls

PA	Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings
kWh			
PG&E	1,584,830	4%	61,894
Total	**1,584,830**	**4%**	**61,894**
Therm			
PG&E	230,169	4%	10,160
Total	**230,169**	**4%**	**10,160**

Table 4-11. First year gross savings summary – supply fan controls

PA	Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings
kWh			
PG&E	2,598,699	65%	1,696,740
SCE	1,381,717	93%	1,281,661
Total	**3,980,416**	**75%**	**2,978,400**
kW			
PG&E	(39)	80%	(31)
SCE	4	101%	4
Total	**(35)**	**78%**	**(27)**
Therm			
PG&E	147,998	63%	92,466
SCE	23,665	94%	22,295
Total	**171,663**	**67%**	**114,761**

4.2.1.2 Net impact findings

PG&E's Quality Maintenance contractors gave the program a NTGR of 36% for the thermostat controls adjustment measures (Table 4-12). The fan controls adjustment measure had the same NTGR for PG&E (Table 4-13). SCE does not require thermostat adjustments for its program, so their participating contractors' responses counted only towards the fan controls setting measure. For SCE, fan controls received an NTGR of 60% (Table 4-13). These results are similar to those measured in the previous evaluation of the Quality Maintenance program, although the specific measures covered differed. Low response rates to the surveys were the primary cause of the low precisions.

Table 4-12. Thermostat controls NTG survey results - contractors

PA	Population Size	Completed Sample Size	Evaluated kWh NTGR	kWh Achieved Relative Precision[25]	Evaluated Therm NTGR	Therms Achieved Relative Precision[25]
PG&E	142	8	36%	82%	36%	82%
Total	**142**	**8**	**36%**	**82%**	**36%**	**82%**

These relative precisions translate into absolute precisions of ±30%. Thus, even with only 8 respondents, these results suggest the NTGRs for thermostat controls are no higher than 66%.

[25] Relative precision at 90% confidence

Table 4-13. Fan controls NTG summary – contractors

PA	Population Size	Completed Sample Size	Evaluated kWh NTGR	kWh Achieved Relative Precision[25]	Evaluated Therm NTGR	Therms Achieved Relative Precision[25]
PG&E	290	8	36%	77%	36%	77%
SCE	201	5	60%	52%	60%	52%
Total	**491**	**13**	**46%**	**45%**	**40%**	**57%**

The end user surveys included a question about whether they would have used the same settings without the program. Only one of the 28 end users with positive evaluated gross savings indicated that the settings were different because of the program. Most end users did not know about the program or did not know that the contractors adjusted settings. Because of the low incidence of awareness, the evaluation team did not use the end user results in the NTG ratio calculations.

Combining the gross and net realization rates for thermostat controls results in a final net savings of 22,050 kWh and 3,620 Therms for PG&E (Table 4-14). The low gross realization rate had a very strong effect on these final savings.

Table 4-14. First year gross and net savings summary – thermostat controls

PA	Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings	Reported NTGR[26]	Evaluated NTGR[27]	Evaluated Net Savings	Reported Net Savings[28]	Net Realization Rate[29]
kWh								
PG&E	1,584,830	4%	61,894	76%	36%	22,050	1,201,941	2%
Total	**1,584,830**	**4%**	**61,894**	**76%**	**36%**	**22,050**	**1,201,941**	**2%**
Therm								
PG&E	230,169	4%	10,160	76%	36%	3,620	174,504	2%
Total	**230,169**	**4%**	**10,160**	**76%**	**36%**	**3,620**	**174,504**	**2%**

Combining gross and net realization rates for supply fan controls results in a total of 1,373,460 kWh, -9 kW, and 46,318 Therms net savings, statewide (Table 4-15).

[26] Reported NTGR includes 5% market effects benefits
[27] Evaluated NTGR does not include market effects benefits
[28] Reported net savings include market effects benefits
[29] Ratio of the evaluated net savings to the reported net savings (do not include market effects benefits)

Table 4-15. First year gross and net savings summary – supply fan controls

PA	Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings	Reported NTGR[30]	Evaluated NTGR[31]	Evaluated Net Savings	Reported Net Savings[32]	Net Realization Rate[33]
kWh								
PG&E	2,598,699	65%	1,696,740	78%	36%	604,463	2,039,443	30%
SCE	1,381,717	93%	1,281,661	81%	60%	768,997	1,120,081	69%
Total	**3,980,416**	**75%**	**2,978,400**	**79%**	**46%**	**1,373,460**	**3,159,524**	**43%**
kW								
PG&E	(39)	80%	(31)	77%	36%	(11)	(30)	37%
SCE	4	101%	4	78%	60%	2	3	78%
Total	**(35)**	**78%**	**(27)**	**77%**	**32%**	**(9)**	**(27)**	**32%**
Therm								
PG&E	147,998	63%	92,466	79%	36%	32,941	116,234	28%
SCE	23,665	94%	22,295	83%	60%	13,377	19,573	68%
Total	**171,663**	**67%**	**114,761**	**79%**	**40%**	**46,318**	**135,807**	**34%**

Net savings calculations were low because most contractors indicated they would offer the same amount of these measures even without the program. In particular:

- Nine out of the 13 interviewed contractors said they already offered these measures before participating in the program.
- Ten out of the 13 interviewed contractors said these measures were likely to occur without program assistance. Among the 3 contractors who said the measures were unlikely to occur, they estimated they would have installed an average of approximately 30% of the measures they did through the program.
- For controls measures generally, contractors estimated they would have installed approximately 52% of the measures they installed in 2017 without the program.

4.2.1.3 Other findings

Surveys with the Quality Maintenance contractors revealed 3 other topics of interest:

- Five of the 13 interviewed contractors indicated that the program has helped increase their sales of maintenance packages.
- Average satisfaction with the financial incentives on a 1 to 10 scale (where a 10 is "very satisfied" and 1 is "very dissatisfied") was 7.5. Only two contractors gave a rating less than 7. Those two explained that the incentives are not enough to cover the additional administrative burden (paperwork) required by the program.

[30] Reported NTGR includes 5% market effects benefits

[31] Evaluated NTGR does not include market effects benefits

[32] Reported net savings include market effects benefits

[33] Ratio of the evaluated net savings to the reported net savings (do not include market effects benefits

- Interviewed contractors found it difficult to answer about these specific components of quality maintenance offers. Future net savings evaluations should consider asking about quality maintenance practices and offers in more general terms.

4.2.2 PTAC control measures

4.2.2.1 Gross impact findings

Similar to the thermostat and supply fan controls measure groups, we assessed gross savings for the PTAC controls measure group by determining evaluated installation rates. To assess installation rates, we calculated the quotient of the number of control units installed and operational at the time of the interview divided by the number of units initially installed.

Table 4-16 shows the population sizes, sample sizes, realization rates, and relative precisions for the PTAC controls measure group. The relatively large completed sample size, relative to the population size, and a small error ratio of the sample resulted in low achieved relative precision values of savings that indicate high precision at the 90% confidence interval.

Table 4-16. PTAC controls population, sample, realization rates, and relative precisions

PA	Population Size	Completed Sample Size	kWh Gross Realization Rate	kWh Achieved Relative Precision[34]	kW Gross Realization Rate	kW Achieved Relative Precision[34]
MCE	1	1	100%	0%	100%	0%
PG&E	157	43	94%	5%	94%	4%
SDG&E	1	1	100%	0%	100%	0%
Total	**159**	**45**	**94%**	**5%**	**94%**	**4%**

Table 4-17 shows the site level gross impact analysis for the PTAC controls measure group. Overall the site level installation rates were high, with only a limited number of sites reporting some or all controls no longer still installed or operating as intended.

[34] **Relative precision at 90% confidence for the final evaluation results**

Table 4-17. PTAC controls measure group site level gross impact analysis

Site ID	Reported Gross kWh	Reported Gross kW	Evaluated Installation Rate	Evaluated Gross kWh	Evaluated Gross kW
MCE.1	26,850	10	1.0	26,850	10
PGE.1	145,068	45	1.0	145,068	45
PGE.2	68,915	26	1.0	68,915	26
PGE.3	1,790	1	1.0	1,765	1
PGE.4	25,955	10	0	0	-
PGE.5	114,296	36	1.0	114,296	36
PGE.6	179,892	88	1.0	179,892	88
PGE.7	1,875	1	1.0	1,813	1
PGE.8	132,552	65	1.0	132,552	65
PGE.9	67,868	26	1.0	67,868	26
PGE.10	192,425	74	1.0	189,765	73
PGE.11	71,440	28	0.8	60,010	23
PGE.12	40,275	15	1.0	40,275	15
PGE.13	154,240	44	1.0	154,240	44
PGE.14	261,120	99	1.0	261,120	99
PGE.15	90,472	44	1.0	88,368	43
PGE.16	134,640	51	1.0	134,640	51
PGE.17	76,798	30	1.0	74,494	29
PGE.18	51,153	33	1.0	51,153	33
PGE.19	171,110	49	1.0	171,110	49
PGE.20	20,585	8	1.0	20,585	8
PGE.21	116,090	45	1.0	116,090	45
PGE.22	33,810	19	1.0	33,810	19
PGE.23	35,000	19	0.8	26,250	14
PGE.24	234,596	115	1.0	234,596	115
PGE.25	287,448	70	1.0	287,448	70
PGE.26	33,740	10	0.5	16,870	5
PGE.27	136,276	43	1.0	136,276	43
PGE.28	136,000	52	1.0	136,000	52
PGE.29	39,618	32	0.9	36,683	30
PGE.30	176,939	55	1.0	176,939	55
PGE.31	114,296	36	1.0	114,296	36
PGE.32	228,480	87	0.2	40,320	15
PGE.33	84,160	41	1.0	84,160	41
PGE.34	125,188	61	1.0	125,188	61
PGE.35	197,820	62	1.0	197,820	62
PGE.36	58,175	22	1.0	58,175	22
PGE.37	80,550	31	1.0	80,550	31
PGE.38	122,032	60	1.0	122,032	60
PGE.39	119,928	59	1.0	119,928	59
PGE.40	19,690	8	0.8	16,581	6
PGE.41	138,474	43	1.0	138,474	43
PGE.42	151,830	43	1.0	151,830	43
PGE.43	179,545	51	1.0	178,348	51
SDGE.1	64,392	24	1.0	64,392	24

Table 4-18 shows the reported gross savings, gross realization rate, and evaluated savings for PTAC controls. Our evaluation found in most of the cases the PTAC controls measures were operating as intended. This resulted in very minor difference between reported and evaluated savings estimates.

Table 4-18. First year gross savings summary – PTAC controls

PA	Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings
kWh			
MCE	26,850	100%	26,850
PG&E	13,002,968	94%	12,169,978
SDG&E	64,392	100%	64,392
Total	**13,094,210**	**94%**	**12,261,220**
kW			
MCE	10	100%	10
PG&E	4,814	94%	4,513
SDG&E	24	100%	24
Total	**4,848**	**94%**	**4,547**

4.2.2.2 Net impact findings

The PTAC Control Measures did not have a net component to the study. In claims, each of the PAs used a 0.65 NTGR, for which we found no source. We recommend use of the 0.6 NTGR identified in the workpaper *PGE3PHVC149 Revision 2 PTAC/PTHP/Split AC Controller*. Combining gross and net realization rates for PTAC controls measure group results in a total of 8,51,236 kWh and 3,151 kW of net savings statewide (Table 4-19).

Table 4-19. First year gross and net savings summary – PTAC controls

PA	Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings	Reported NTGR[35]	Evaluated NTGR[36]	Evaluated Net Savings	Reported Net Savings[37]	Net Realization Rate[38]
kWh								
MCE	26,850	100%	26,850	65%	60%	16,110	17,453	92%
PG&E	13,002,968	94%	12,169,978	65%	60%	7,301,987	8,451,929	86%
SDG&E	64,392	100%	64,392	65%	60%	38,635	41,855	92%
Total	**13,094,210**	**94%**	**12,261,220**	**65%**	**60%**	**7,356,732**	**8,511,236**	**86%**
kW								
MCE	10	100%	10	65%	60%	6	7	89%
PG&E	4,814	94%	4,513	65%	60%	2,708	3,129	87%
SDG&E	24	100%	24	65%	60%	14	15	94%
Total	**4,848**	**94%**	**4,547**	**65%**	**60%**	**2,728**	**3,151**	**87%**

[35] Reported NTGR includes 5% market effects benefits

[36] Evaluated NTGR does not include market effects benefits. Evaluated NTG for PTAC controls was pass-through from the workpaper.

[37] Reported net savings include market effects benefits

[38] Ratio of the evaluated net savings to the reported net savings (do not include market effects benefits)

4.3 Central plant

The central plant projects were evaluated at the measure level. The evaluation results are discussed below in the context of the workpapers related to the uncertain measures studied in PY 2017: HVAC boiler and HVAC fan VFD. Each measure-specific subsection includes observations on both gross and net results.

4.3.1 Boiler measures

4.3.1.1 Gross impact findings

Table 4-20 shows the gross natural gas impact results for HVAC boiler measures. We did not have adequate site-specific data to estimate the evaluated electric energy and coincident peak demand impacts for HVAC boilers and therefore assigned a gross realization rate of 100% for kWh and kW impacts. As the table indicates, SCG was the only PA with rebated HVAC boiler projects in PY 2017.

Table 4-20. HVAC boiler population, sample, realization rates, and relative precisions

PA	Population Size	Completed Sample Size	Reported Gross Therm Savings	Evaluated Gross Therm Savings	Therm Gross Realization Rate	Therms Achieved Relative Precision[39]
SCG	26	19	78,565	80,485	102%	37%
Total	**26**	**19**	**78,565**	**80,485**	**102%**	**37%**

The evaluators determined a gross natural gas RR of 102%, at a relative precision of ±37% at the 90% confidence interval, for the HVAC boiler projects in the evaluation sample. This poor relative precision is primarily due to the significant variations between the reported savings claim and evaluated savings estimate for the evaluated samples.

Below, Figure 4-2 compares reported and evaluated gross annual natural gas savings color-coded by building type for the sample of HVAC boiler 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 4-3. is a close-up of the shaded portion of Figure 4-2.

[39] Relative precision at 90% confidence

Figure 4-2. Comparison of HVAC boiler reported and evaluated first year gross therm savings

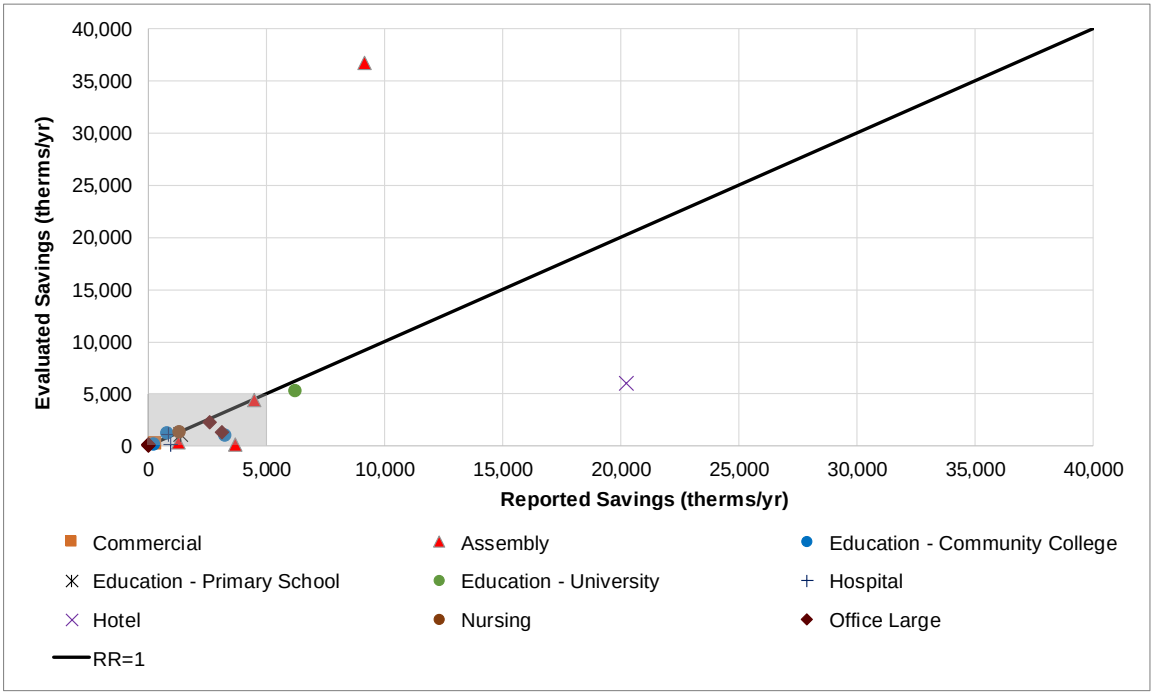


Figure 4-3. Comparison of HVAC boiler reported and evaluated first year gross therm savings – close up

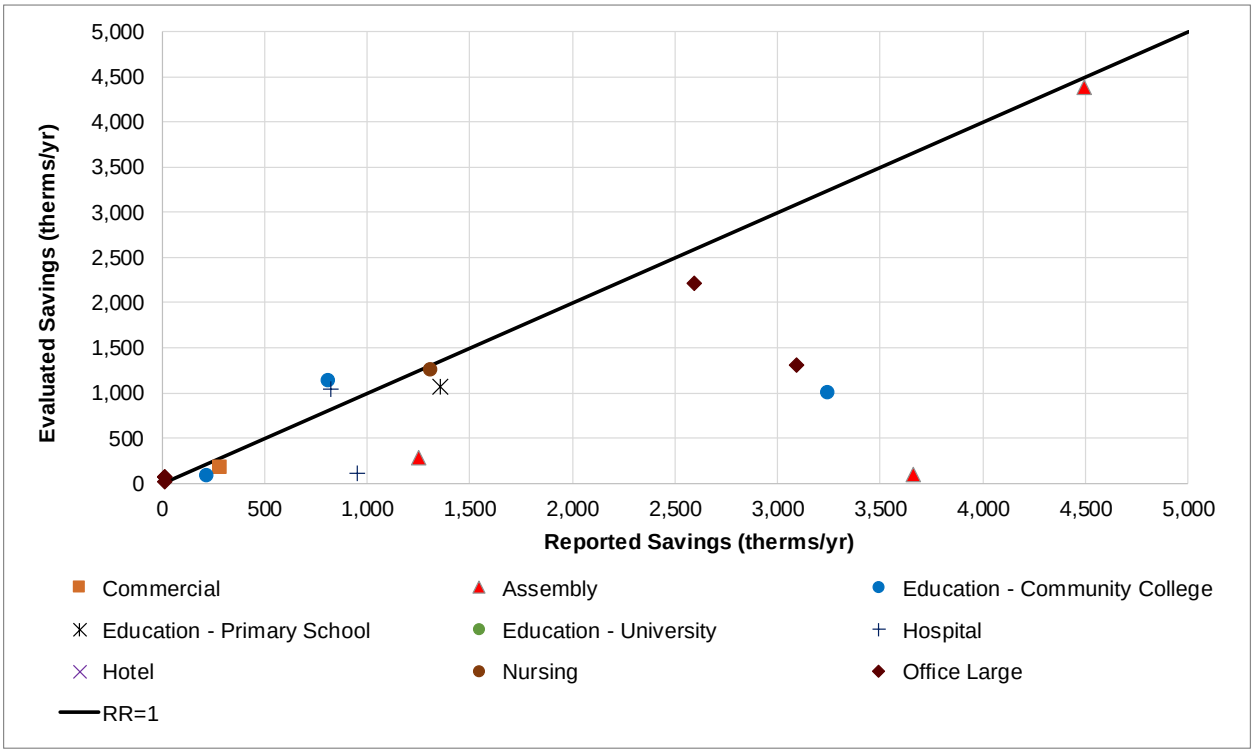


Figure 4-1 and Figure 4-3. illustrate that while most projects resulted in gross therm RRs less than one (points below the ideal line), evaluators found one project classified as "Assembly" within the SCG tracking data with significantly higher evaluated savings, leading to slightly higher evaluated gross natural gas savings than reported. Table 4-21 shows the site-specific gross impact results for the sample of HVAC boiler projects studied.

Table 4-21. HVAC boiler measure group site level first year gross impact analysis

Site ID	Building Type	Reported Annual Savings (therm)	Evaluated Annual Savings (therm)	Gross therm RR
SCG.1	Education - University	6,237	5,254	84%
SCG.2	Hotel	20,240	5,968	29%
SCG.3	Assembly	9,150	36,779	402%
SCG.4	Assembly	3,660	100	3%
SCG.5	Office - Large	11	75	700%
SCG.6	Office - Large	11	28	257%
SCG.7	Education - Community College	812	1,146	141%
SCG.8	Assembly	1,251	295	24%
SCG.9	Education - Primary School	1,355	1,074	79%
SCG.10	Education - Community College	3,247	1,009	31%
SCG.11	Assembly	4,495	4,392	98%
SCG.12	Office - Large	3,094	1,310	42%
SCG.13	Education - Community College	219	96	44%
SCG.14	Hospital	952	114	12%
SCG.15	Hospital	825	1,050	127%
SCG.16	Nursing	1,313	1,258	96%
SCG.17	Commercial	285	188	66%
SCG.18	Office - Large	11	77	696%
SCG.19	Office - Large	2,592	2,219	86%

We used a weather-normalized billing analysis method to calculate the site-specific natural gas (therm) savings. While the overall GRR indicates agreement between reported and reported gross savings, evaluators found wide variation in site-specific results among the 19 projects, as reflected in Table 4-21 above and in the poorer-than-expected relative precision. There are two main reasons for this variation:

- The evaluator-verified nameplate efficiencies of the installed boilers were different from tracking data for 8 projects in the population, resulting in reported savings inaccuracies, as the workpaper savings assumptions are a function of installed boiler efficiency.
- Evaluators determined that 4 projects in the population were inaccurately classified as "Assembly" within the SCG tracking data. Results by building category vary widely, as illustrated in Figure 4-3.. The evaluated unit energy savings for misclassified building types were higher than reported assumptions, thereby contributing to a GRR slightly higher than 100%.

Figure 4-4. is a chart that illustrates the variation in reported and evaluated unit gross energy savings (therms/yr. · kBtuh) for the sample of HVAC boiler projects studied.

The different colored bubbles represent the building types and the size of the bubbles indicate the comparative sizes of evaluated and reported gross natural gas savings.

While most projects resulted in gross unit energy savings less than reported estimates (points below the ideal line of RR=1), evaluators found one project classified as "Assembly" (gray bubble named ASM) within the SCG tracking data with significantly higher evaluated savings as seen by the size of the bubble, leading to slightly higher evaluated gross natural gas savings than reported.

Figure 4-4. Reported and Evaluated unit energy savings by building type

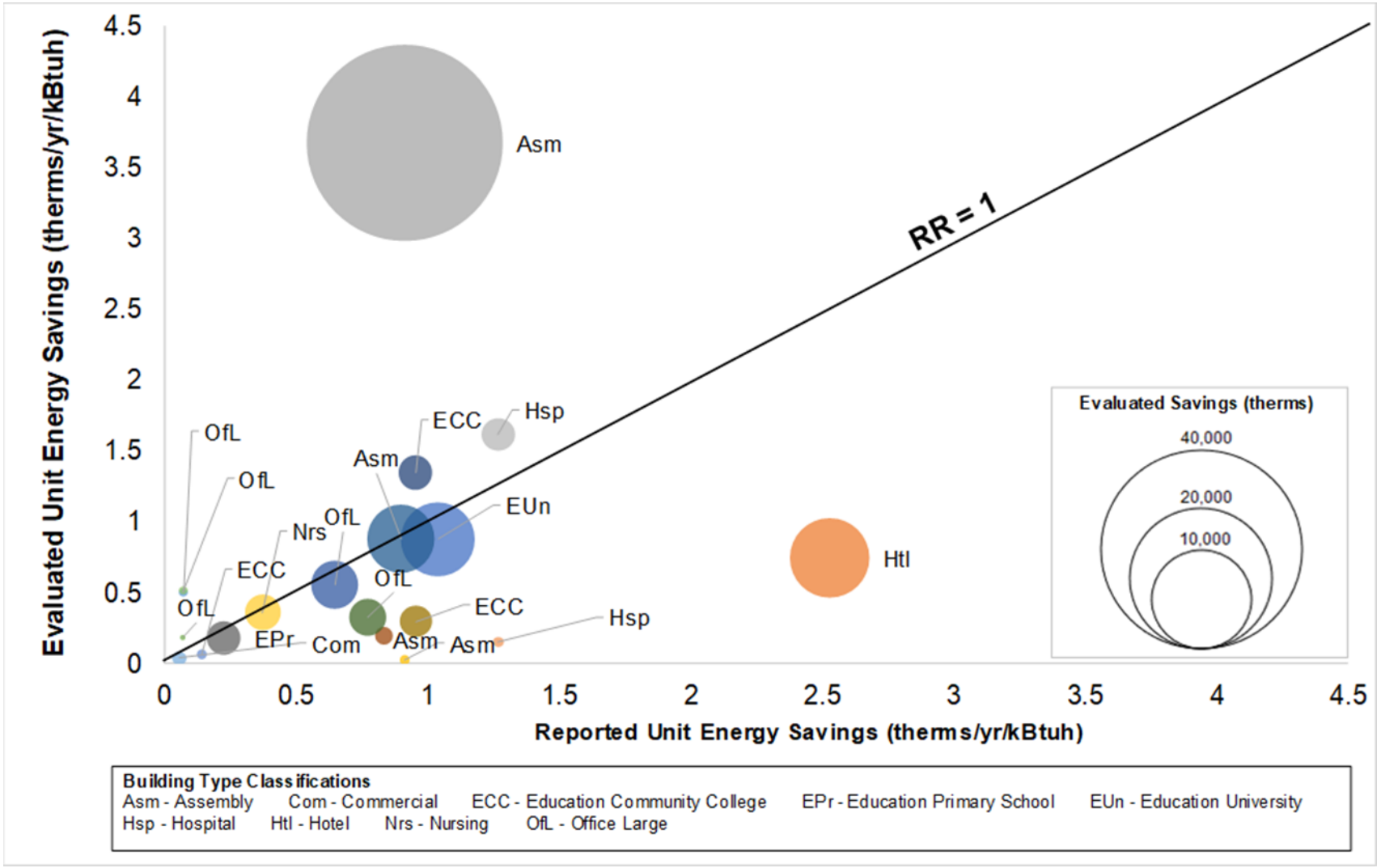


Table 4-22 shows the reported gross savings, gross realization rate, and the evaluated gross savings for HVAC boilers.

Table 4-22. First year gross savings summary – HVAC boiler

PA	Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings
kWh			
SCG	73,603	100%	73,603
Total	**73,603**	**100%**	**73,603**
kW			
SCG	3	100%	3
Total	**3**	**100%**	**3**
Therm			
SCG	78,565	102%	80,485
Total	**78,565**	**102%**	**80,485**

Though the boiler measure primarily impacts natural gas consumption, evaluators observed ancillary electric savings reported among many boiler projects in the sample. In most cases, high-efficiency boilers are equipped with variable-speed combustion fan motors which can result in electric savings due to reduced fan speeds at part-load conditions. Such electric impacts were more pronounced in building types with high, seasonally variable heating loads (e.g., hotels, hospitals). As these reported electric impacts were minimal compared with gas savings, evaluators did not assess electric impacts in this study and applied a 100% GRR to reported electric savings.

4.3.1.2 Net impact findings

The evaluation team completed NTG surveys with 4 PY 2017 customers. Due to difficulties in contacting the appropriate decision-maker for phone interview, evaluators did not complete a sufficient sample of NTG surveys to revise the default NTG ratio. Therefore, per the *WPSCGNRHC120206A Revision 4* workpaper, we applied a 0.60 NTGR to all projects at facilities not classified as K-12 education or community college. DEER 2016 recommends a 0.85 NTGR for all projects at K-12 schools and community colleges; therefore, the ex post NTGR is 0.85 for the two K-12 school and community college projects in the evaluation sample.

The evaluation team noticed discrepancies between the workpaper and DEER NTGR recommendations and the NTGRs reflected in reported savings. Upon comparing the reported gross savings to the reported net savings in SCG's HVAC Boiler tracking data, evaluators determined that the reported net savings reflected an NTGR of 0.90 for K-12 school and community college projects and 0.65 for remaining PY 2017 projects. The overall reported NTGR was 0.69, resulting in an NRR of 95% when compared with the overall ex-post NTGR of 0.64. Gross and net results for the boiler measure are summarized in Table 4-23.

Table 4-23. First year gross and net savings summary – HVAC boiler

PA	Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings	Reported NTGR[40]	Evaluated NTGR[41]	Evaluated Net Savings	Reported Net Savings[42]	Net Realization Rate[43]
kWh								
SCG	73,603	100%	73,603	64%	59%	43,199	46,880	92%
Total	**73,603**	**100%**	**73,603**	**64%**	**59%**	**43,199**	**46,880**	**92%**
kW								
SCG	3	100%	3	68%	63%	2	2	93%
Total	**3**	**100%**	**3**	**68%**	**63%**	**2**	**2**	**93%**
Therm								
SCG	78,565	102%	80,485	69%	64%	51,666	54,361	95%
Total	**78,565**	**102%**	**80,485**	**69%**	**64%**	**51,666**	**54,361**	**95%**

4.3.2 HVAC Fan VFD

4.3.2.1 Gross impact findings

Table 4-24 and Table 4-25 show the completed sample size, GRRs, and achieved precision on a PA level and site level, respectively, for fan VFD measure group.

Table 4-24. HVAC Fan VFD population, sample, realization rate, and relative precision

PA	Population Size	Completed Sample Size	kWh Gross Realization Rate	kWh Achieved Relative Precision[44]	kW Gross Realization Rate	kW Achieved Relative Precision[44]	Therm Gross Realization Rate	Therm Achieved Relative Precision[44]
PG&E	50	13	98%	2%	100%	1%	98%	4%
SCE	96	27	104%	9%	108%	8%	86%	86%
Total	**146**	**40**	**102%**	**6%**	**105%**	**6%**	**93%**	**36%**

Table 4-25. HVAC Fan VFD measure group site level first year gross impact analysis

Site ID	Reported Gross kWh Savings	Evaluated Gross kWh Savings	Gross kWh RR	Reported Gross kW Savings	Evaluated Gross kW Savings	Gross kW RR	Reported Gross Therm Savings	Evaluated Gross Therm Savings	Gross Therm RR
VFD on Supply/Return Fans									
PG&E.1	24,600	24,600	100%	3	3	100%	-15	-15	100%
PG&E.2	44,290	44,290	100%	9	9	100%	-22	-22	100%

[40] Reported NTGR includes 5% market effects benefits

[41] Evaluated NTGR does not include market effects benefits. Evaluated NTG for HVAC boilers was pass-through from the workpaper.

[42] Reported net savings include market effects benefits

[43] Ratio of the evaluated net savings to the reported net savings (do not include market effects benefits)

Site ID	Reported Gross kWh Savings	Evaluated Gross kWh Savings	Gross kWh RR	Reported Gross kW Savings	Evaluated Gross kW Savings	Gross kW RR	Reported Gross Therm Savings	Evaluated Gross Therm Savings	Gross Therm RR
PG&E.3	36,050	36,050	100%	8	8	100%	-18	-18	100%
PG&E.4	59,740	59,740	100%	13	13	100%	-29	-29	100%
PG&E.5	167,940	167,940	100%	36	36	100%	-35	-35	100%
PG&E.6	407,925	407,925	100%	67	67	100%	-746	-746	100%
PG&E.7	397,200	397,200	100%	83	83	100%	-114	-114	100%
PG&E.8	28,280	25,250	89%	3	3	89%	-97	-87	89%
PG&E.9	30,750	30,750	100%	4	4	100%	-19	-19	100%
PG&E.10	30,300	30,300	100%	3	3	100%	-104	-104	100%
PG&E.11	60,475	61,500	102%	32	32	102%	-627	-638	102%
PG&E.12	55,980	55,980	100%	12	12	100%	-12	-12	100%
PG&E.13	131,325	131,325	100%	28	28	100%	-64	-64	100%
SCE.23	260,550	453,550	174%	37	64	174%	-1,126	-1,960	174%
SCE.24	317,250	317,250	100%	67	67	100%	-204	-204	100%
SCE.25	748,800	748,800	100%	105	105	100%	-3,475	-3,475	100%
SCE.26	288,000	278,400	97%	40	39	97%	-1,337	-1,292	97%
Enhanced Ventilation Measures									
SCE.1	22,930	24,789	108%	2	3	108%	-152	-165	108%
SCE.2	39,060	6,975	18%	7	1	18%	0	0	N/A
SCE.3	22,975	21,252	93%	2	2	93%	-209	-193	93%
SCE.4	7,193	28,247	393%	2	8	393%	0	0	N/A
SCE.5	54,801	60,774	111%	17	19	111%	0	0	N/A
SCE.6	59,810	61,569	103%	15	16	103%	0	0	N/A
SCE.7	58,764	54,753	93%	11	10	93%	0	0	N/A
SCE.8	60,238	96,932	161%	15	24	161%	450	724	161%
SCE.9	68,703	52,661	77%	12	10	77%	0	0	N/A
SCE.10	93,060	106,807	115%	17	20	115%	73	84	115%
SCE.11	84,303	84,303	100%	19	19	100%	612	612	100%
SCE.12	90,277	108,795	121%	21	26	121%	377	455	121%
SCE.13	92,875	91,165	98%	17	16	98%	0	0	N/A
SCE.14	99,712	99,712	100%	18	18	100%	0	0	N/A
SCE.15	217,369	231,050	106%	42	45	106%	2,062	2,192	106%
SCE.16	117,439	111,123	95%	38	36	95%	141	133	95%
SCE.17	15,930	15,930	100%	2	2	100%	-130	-130	100%
SCE.18	17,841	19,116	107%	2	2	107%	-145	-156	107%
SCE.19	68,374	68,374	100%	12	12	100%	0	0	N/a
SCE.20	68,374	68,374	100%	12	12	100%	0	0	N/a
SCE.21	93,423	175,662	188%	17	33	188%	197	370	188%
SCE.22	77,870	75,971	98%	14	14	98%	0	0	N/a
VFD on Parking Garage Exhaust Fans									
SCE.27	397,066	131,879	33%	39	23	59%	0	0	N/a

Below, Figure 4-5. compare reported and evaluated gross annual electric energy savings color-coded by measure type for the sample of HVAC fan VFD projects studied. Figure 4-6. is a close-up of the shaded portion of Figure 4-5.

Figure 4-5. Comparison of HVAC fan VFD reported and evaluated first year gross kWh savings

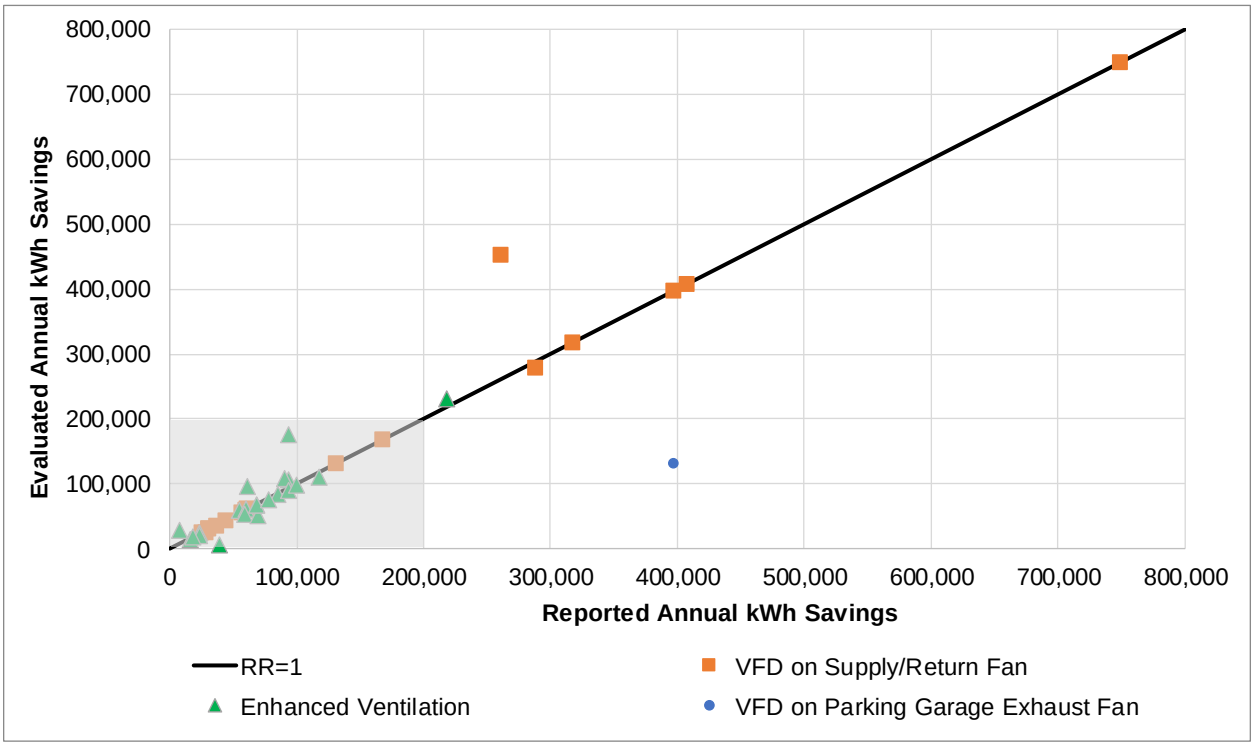
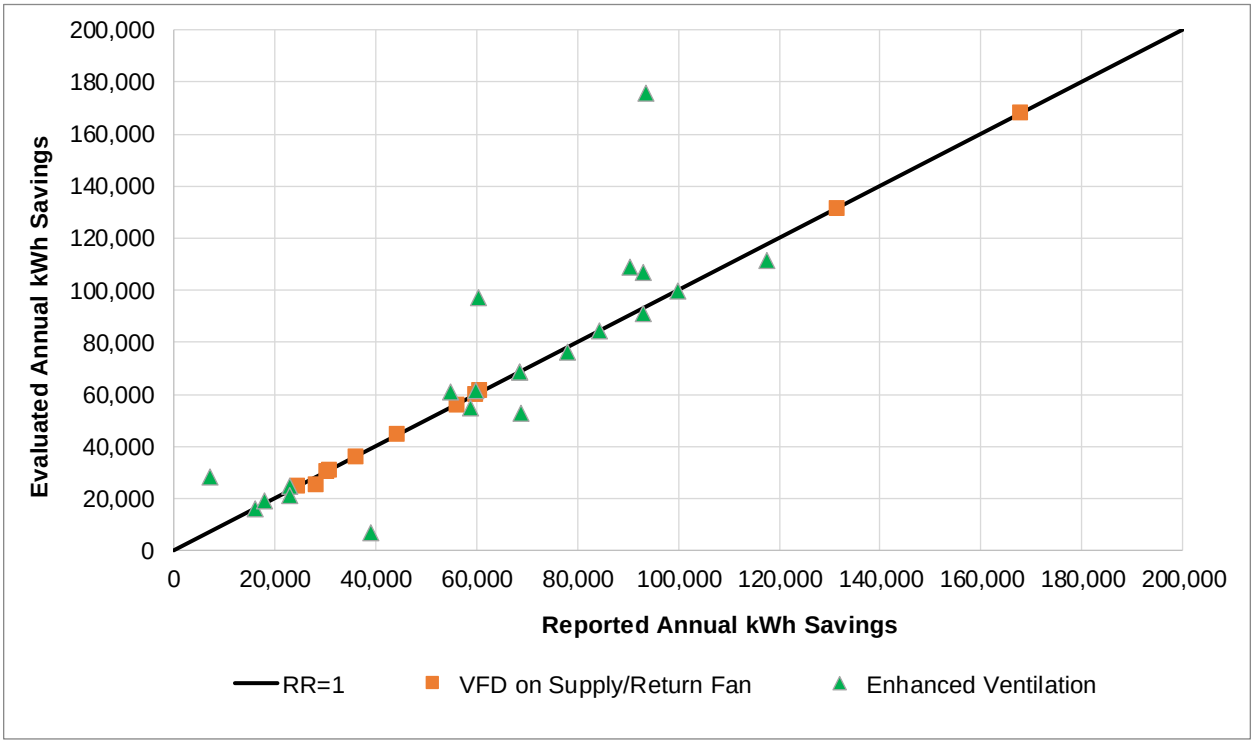


Figure 4-6. Comparison of HVAC fan VFD reported and evaluated first year gross kWh savings – close up



Below, Figure 4-7. and Figure 4-8. compare reported and evaluated first year gross electric demand savings color-coded by measure type for the sample of HVAC fan VFD projects studied. Figure 4-8. is a close-up of the shaded portion of Figure 4-7. Comparison of HVAC fan VFD reported and evaluated first year gross kW savings

Figure 4-7. Comparison of HVAC fan VFD reported and evaluated first year gross kW savings

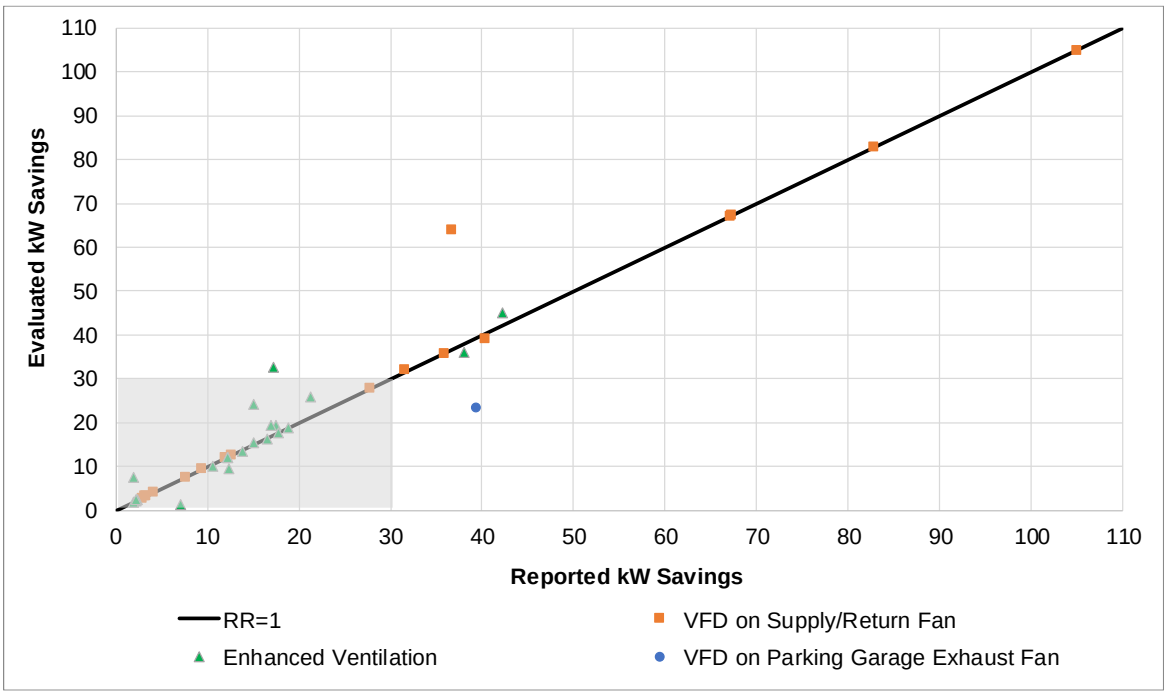


Figure 4-8. Comparison of HVAC fan VFD reported and evaluated first year gross kW savings – close up

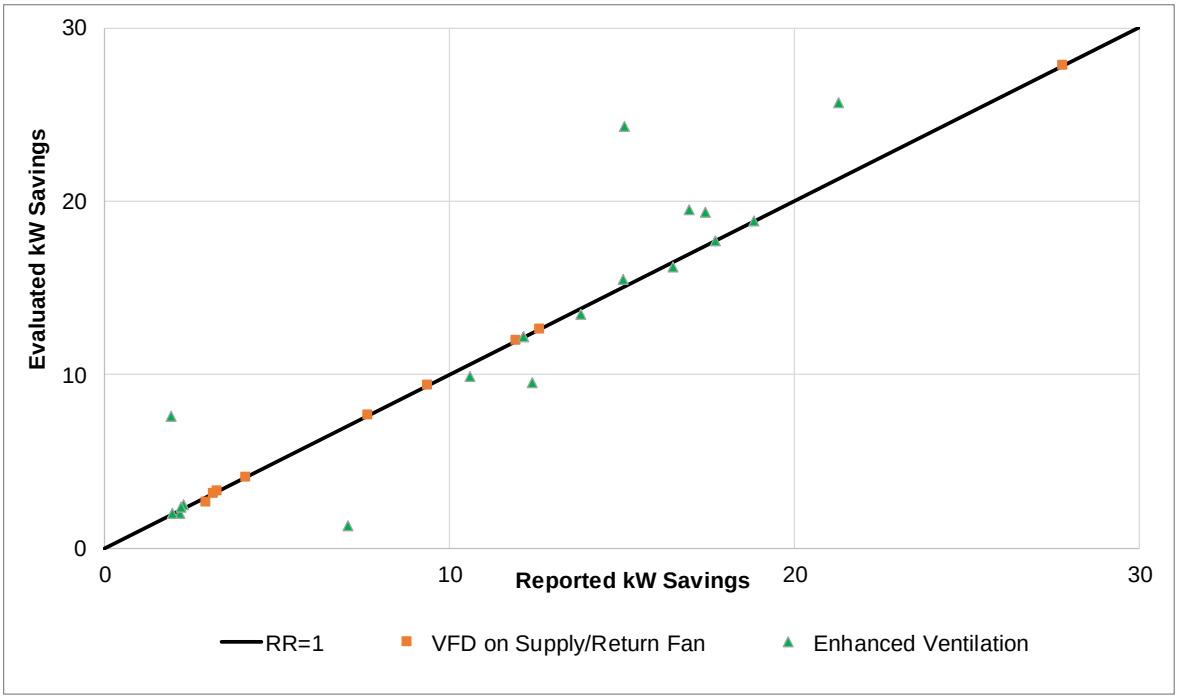


Figure 4-5. through Figure 4-8. illustrate that for this cycle of evaluation for fan VFD measures, most projects resulted in near-ideal GRRs. Evaluators also found that the parking garage exhaust fan VFD project in the sample resulted in significantly lower evaluated savings than reported.

The workpapers for the evaluated fan VFD measure group cover a range of technologies, including VFDs on supply and return fans, enhanced ventilation, cooling tower fan VFDs, and parking garage exhaust fan VFDs. DEER model simulation in eQUEST and DOE-2.2 forms the basis of the reported savings estimates developed for these workpapers. The evaluators planned to utilize the DEER eQUEST models, incorporating changes in measured unit performance into changes in energy use reflected in evaluated savings.

For the supply and return fan VFD measures, evaluators planned to update the minimum air flow in the DEER eQUEST baseline and measure models based on participant survey results. Evaluators obtained minimum air flow data for 76% of the sites sampled and determined an average minimum air flow ratio of 32%, similar to the 30% recommended in workpapers *PGECOHVC106 and SCE13HC050 Revision #2*. Evaluation engineers also collected information on the measure parameters provided in the workpaper that affect the gross savings estimates, like facility HVAC system type and baseline fan control strategies, and generally found that phone interview responses were consistent with the workpaper parameter assumptions. Therefore, evaluators did not adjust any measure parameters in the DEER eQUEST models.

The evaluators found discrepancies in quantities and impacted motor horsepower between tracking data and participant survey results, as shown in Table 4-26. Specifically, for SCE programs, evaluators found that the impacted motor horsepower in tracking data reflected the overall HP of multiple motors incentivized as part of each project and was not broken down into number of motors with horsepower values associated with each individual motor type. Evaluated energy savings were hence adjusted to account for the verified motor quantities and impacted motor horsepower.

Table 4-26. VFDs on HVAC supply and return fans – quantities and impacted motor HP

PA	Sampling Stratum	Reported Motor Quantity	Evaluated Motor Quantity	Reported Total HP	Evaluated Total Verified HP
PG&E	1	1	1	20	20
	2	1	1	28	25
	3	6	6	133	133
	4	5	11	266	268
	5	21	21	308	308
	6	23	23	768	768
SCE	5	2	16	285	380
	6	3	19	765	765
Overall		**62**	**98**	**2,572**	**2,666**

For 5 of the 17 supply/return fan projects in the sample, evaluators determined that the project scope involved conversion from a constant air volume (CAV) to a variable air volume (VAV) distribution system, in addition to the installation of VFDs on the supply/return fan motors. The conversion from CAV to VAV system type is classified as a separate measure from the fan VFD measure, with deemed measure savings reflecting *DEER energy impact ID: D03-050*, that are quite different from fan VFD deemed savings assumptions. The evaluators confirmed that tracking savings for these projects did not reflect savings resulting from CAV to VAV conversions, and that the 5 sampled customers did not file separate CAV-to-VAV claims in PY 2017. For informational purposes, we calculated the resulting impacts due to CAV-to-VAV conversions at the 5 sampled customer locations and estimated that the program could

have claimed an additional savings of 464,250 kWh, 50 kW and 47,600 therms if the CAV-to-VAV system conversion measures were claimed properly.

For the ventilation enhancement measures, evaluators planned to update the pre-/post- minimum fan speeds for cooling and heating modes adjustments based on participant survey results in the DEER eQUEST models. Evaluation engineers collected information on the measure parameters provided in workpaper *SCE13HC045 Revision #2* that affect the gross savings estimates, like pre-/post- fan motor types and pre-/post- economizer types, and generally found that phone interview responses were consistent with the workpaper parameter assumptions. Evaluators obtained pre-/post- minimum fan speeds for cooling and heating modes for 16 of the 22 sites that had participant surveys completed. However, these 16 sites represented similar buildings at different locations within the same organization, and hence were not representative of the overall population. Evaluators therefore did not adjust any measure parameters in the DEER eQUEST models.

The evaluators found discrepancies in impacted packaged unit tonnages between tracking data and participant survey results as shown in Table 4-27. Evaluated energy savings were adjusted to account for the increase in impacted tonnage as compared with tracking claims.

Table 4-27. Enhanced ventilation packaged HVAC unit tonnages

PA	Sampling Stratum	Reported Total Tonnage	Evaluated Total Verified Tonnage
SCE	1	198	167
	2	621	694
	3	557	511
	4	1,406	1,594
	5	537	542
Overall		**3,318**	**3,507**

Table 4-28 shows the reported gross savings, gross realization rate, and evaluated gross savings for the fan VFD measure group.

Table 4-28. First year gross savings summary – HVAC fan VFD

PA	Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings
kWh			
PG&E	2,920,079	99%	2,881,852
SCE	7,517,798	103%	7,777,882
Total	**10,437,877**	**102%**	**10,659,734**
kW			
PG&E	730	100%	726
SCE	1,390	108%	1,500
Total	**2,120**	**105%**	**2,226**
Therm			
PG&E	(7,589)	98%	(7,416)
SCE	(6,182)	86%	(5,337)
Total	**(13,771)**	**93%**	**(12,753)**

4.3.2.2 Net impact findings

The evaluation team noticed similar misapplication of workpaper NTGR within the fan VFD tracking data. Both active PG&E and SCE workpapers recommended an NTGR of 0.60 for the supply/return fan VFD measure and 0.70 for the enhanced ventilation measure. However, evaluators found that NTGRs of 0.65 and 0.75 were reflected within supply/return fan VFD and enhanced ventilation savings, respectively, in PY 2017.

The evaluation team completed NTG surveys with 16 unique customers representing 23 of the 146 applications in PY 2017 and approximately 14% of reported kWh savings. Table 4-29 indicate an overall NTGR of 0.53 for kWh and 0.59 for kW.

Table 4-29. HVAC Fan VFD NTGR – population, sample, realization rates, and relative precisions

PA	Population Size	Completed Sample Size	Evaluated kWh NTGR	kWh Achieved Relative Precision[45]	Evaluated kW NTGR	kW Achieved Relative Precision[45]
PG&E	50	13	62%	4%	64%	4%
SCE	96	27	50%	47%	57%	35%
Total	**146**	**40**	**53%**	**32%**	**59%**	**22%**

Based on the 23 survey responses, we make the following qualitative observations regarding customer influences:

- The customers surveyed were split evenly between replacement and add-on projects.
- Respondents attributed slightly more credit to program influences, such as rebate amounts, program information, and marketing materials, than they did to non-program influences such as the age of existing equipment and vendor recommendations.
- When asked about impacts on timing of installations, customer responses suggest that participation in the program helped accelerate installation of the VFD fans at their facilities.

There was fairly wide variability in the results, particularly among the 11 SCE projects, as indicated by the higher error ratios for both kWh and kW NTGRs. Of the 23 projects characterized by the survey, responses for 14 projects indicated that the customer would likely not have installed the measure in the absence of the program, while customers representing 5 projects indicated that they most likely would have pursued the measure regardless of program intervention.

Gross and net savings are summarized in Table 4-30 for the fan VFD measure group.

[45] Relative precision at 90% confidence for the final evaluation results

Table 4-30. First year gross and net savings summary – HVAC fan VFD

PA	Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings	Reported NTGR[46]	Evaluated NTGR[47]	Evaluated Net Savings	Reported Net Savings[48]	Net Realization Rate[49]
				kWh				
PG&E	2,920,079	99%	2,881,852	65%	62%	1,796,941	1,898,051	95%
SCE	7,517,798	103%	7,777,882	69%	50%	3,873,878	5,193,063	75%
Total	**10,437,877**	**102%**	**10,659,734**	68%	**53%**	**5,670,819**	**7,091,114**	**80%**
								kW
PG&E	730	100%	726	65%	63%	461	474	97%
SCE	1,390	108%	1,500	70%	57%	851	968	88%
Total	**2,120**	**105%**	**2,226**	68%	**59%**	**1,312**	**1,442**	**91%**
								Therm
PG&E	(7,589)	98%	(7,416)	65%	60%	(4,413)	(4,933)	89%
SCE	(6,182)	86%	(5,337)	58%	42%	2,217	(3,568)	62%
Total	**(13,771)**	**93%**	**(12,753)**	62%	**52%**	**(6,630)**	**(8,501)**	**78%**

4.4 Study results across subsectors

Figure 4-9, Figure 4-10, and Figure 4-11, display a summary of findings across measure groups for electric energy savings, demand savings, and natural gas savings. The figures show the adjustments to gross savings made through evaluation adjustments to installation rate, quantity of measures, or gross unit energy savings. Note that where evaluated NTG was lower than reported there are two downward adjustments from evaluated gross and if evaluated NTG was higher than reported there is a downward and then upward adjustment to reach final evaluated net savings.

[46] Reported NTGR includes 5% market effects benefits
[47] Evaluated NTGR does not include market effects benefits
[48] Reported net savings include market effects benefits
[49] Ratio of the evaluated net savings to the reported net savings (do not include market effects benefits)

Figure 4-9. Waterfall of kWh savings for evaluated measure groups across all subsectors

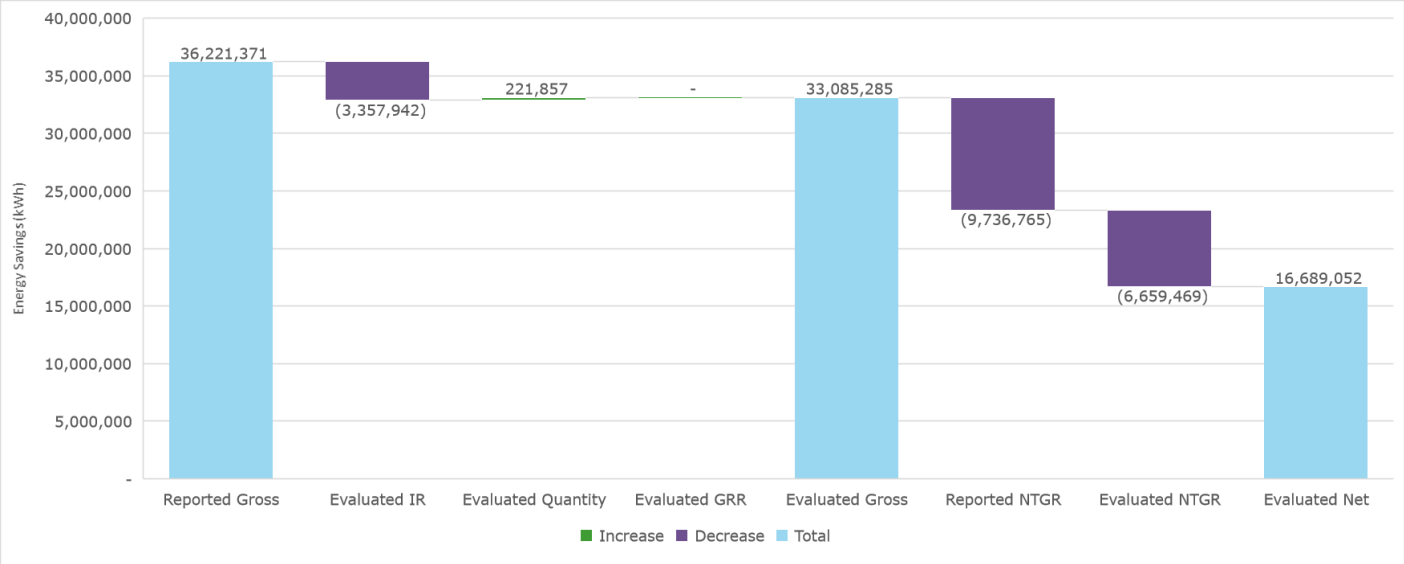


Figure 4-10. Waterfall of kW savings for evaluated measure groups across all subsectors

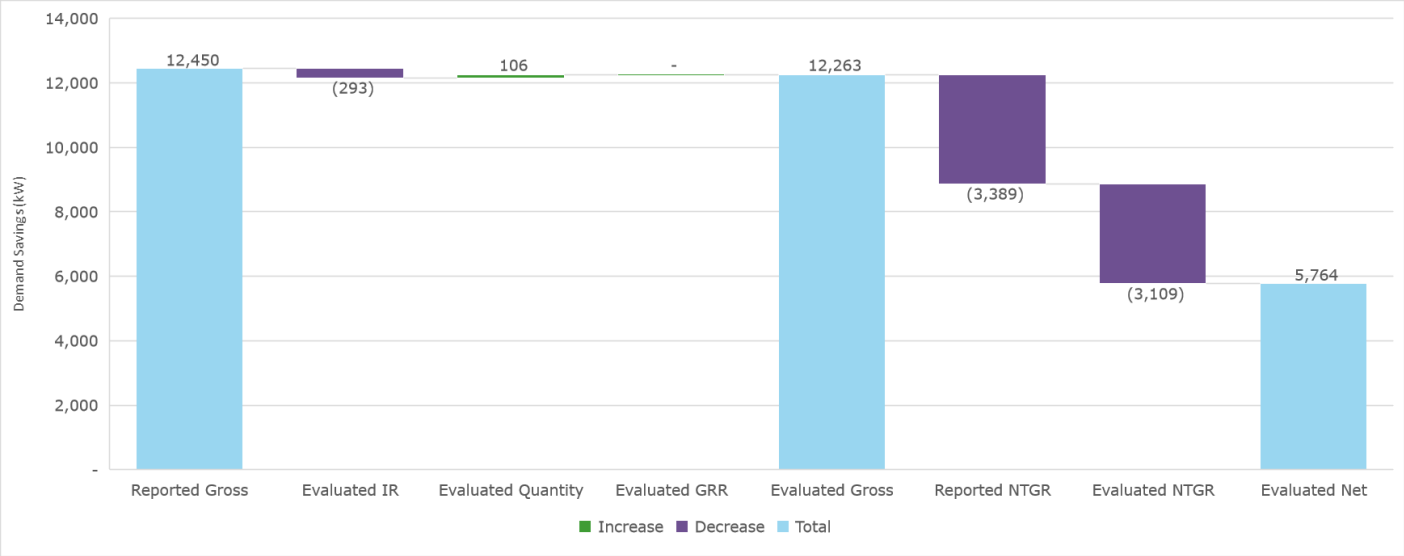
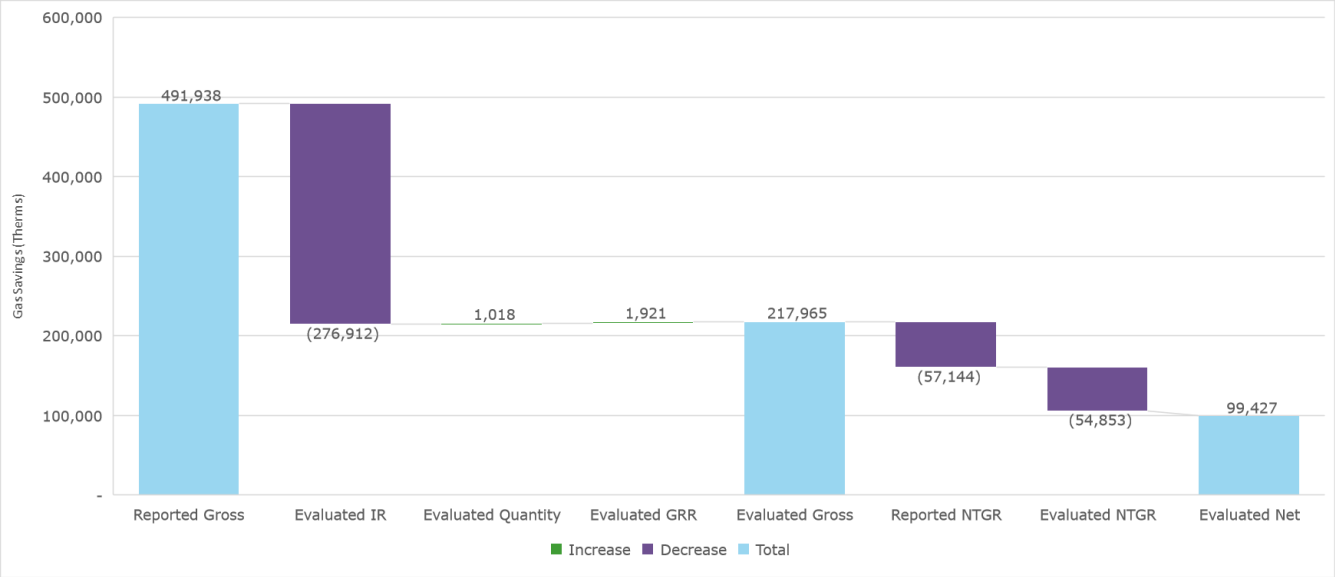


Figure 4-11. Waterfall of therm savings for evaluated measure groups across all subsectors



5 CONCLUSIONS, FINDINGS, & RECOMMENDATIONS

In this section we provide overall program conclusions followed by key findings and recommendations.

Findings are noted with a key symbol:

Overarching or universal key findings are presented first, followed by key findings by measure.

Recommendations are provided directly in response to key findings and their implications, along with more process-related recommendations.

Recommendations are noted by a gear symbol:

Recommendations include supporting context for energy service providers. A list of these recommendations is listed and described in Appendix AC per the CPUC ED Impact Evaluation Standard Reporting 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 to assessing and tracking performance. Overall, PY 2017 gross evaluation activities showed savings close to expectations with evaluated gross savings from 4% to 102% of expectations. The study results for NTGR ranged from 32% to 60% and overall were lower than claims for most of the measure groups. 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 only the contractor's contact information was available, and as a result end-user data collection was not possible. With the compressed schedule, this evaluation was unable to spend additional time 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.

For upstream and midstream programs, PAs could provide more uniformity in reporting the explicit links between distributors/contractors and end users. One way to do this is to record both the distributor and the contractor in each tracking record. The ability to link specific contractors and distributors with specific end users helps increase the precision of net savings estimates that take multiple causal pathways into account.

We also acknowledge that this evaluation was executed under a very tight timeline and that with more time we could have reached a greater number of respondents with the contact data we had. We recommend that future evaluations allow enough time during the data-collection phase to allow interviewers and surveyors to navigate the customer organization in order to reach the right person.

PA tracking data showed inconsistent measure types and quantities. Review of tracking data showed that measure quantities and measure descriptions were inconsistent. For example, we found discrepancies in motor quantities and horsepower between tracking data and participant survey results. Specifically, for SCE programs, we saw that the motor horsepower in tracking data reflected the sum of horsepower for the project rather than the horsepower values associated with each individual motor type.

PAs should verify that they all use the same rules for reporting measure parameters in claims. In general, we see good agreement in data between PAs and believe this may be an isolated case. We would still request that the PAs take time to confirm that they are consistent in reporting measure parameters, thus improving the quality of shared tracking data.

Upstream and midstream market actors, particularly Quality Maintenance contractors, were difficult to reach for surveys. This results in increased evaluation costs and/or lower precisions for metrics (e.g., NTG ratio of midstream programs) that rely on responses from these market actors.

Improve the quality of contact information in the tracking databases. Evaluators should take this increased survey difficulty into account when planning the next round of evaluations. Steps they could take to improve the number of completed surveys include increasing sample sizes, asking the PAs to reach out to

these market actors to encourage cooperation, planning for longer fielding periods, and offering incentives for participation.

Contractors and distributors were not linked to tracking data. The PAs supplied contact information (firm name, contact name, email address, and telephone number) for participating distributors and contractors, but links between the contractor/distributor data and the tracking data were not provided consistently. This limited our ability to relate contractors and distributors to the appropriate claims in tracking data.

We recommend that contractor contact information (and, for upstream program claims, distributor contact information) be part of claim-level tracking data. This will allow future evaluations to tie the results of contractor and distributor interviews specifically to their claims.

5.3 Unitary VRF

5.3.1 Rooftop and split systems

Program design for rooftop and split systems is not strongly influencing distributor behavior. The distributors do have a strong influence on end-user decisions, so they appear to be the right group to target. However, the current mechanism(s) used to motivate them are resulting in only very small changes. There are multiple reasons this could be occurring, including that the distributors are already stocking and recommending high efficiency units most of the time, the program incentives and other mechanisms simply are not motivating, and sampling bias on the part of the evaluation.

Conduct a process evaluation to better assess current distributor behavior and if there is room to change, what mechanisms would influence them.

Rooftop end-users ranked energy savings as more influential to their specific equipment decisions than non-energy benefits such as decreased maintenance costs or increased productivity. This is interesting because energy costs often represent a much smaller portion of many businesses' budgets than labor. This suggests that there might be an opportunity for program marketing to increase participation by illuminating non-energy benefits of the high efficiency equipment.

PAs should examine whether program marketing currently covers non-energy benefits. If not, consider producing and piloting some materials that do cover these benefits.

5.3.2 Furnaces

The NTGR revealed that a moderate-to-high level of free-ridership persists for this measure group across the PAs. The overall, NTGR ratio was 33% for this measure group.[50] PG&E had a higher NTGR of 44%, SCG had a NTGR of 30%, and SDG&E had a NTGR of 36%. The overall lower NTGR for this measure group is due to higher number of free-riders. The evaluation result indicated that 35% of the end-users were full free-riders, 47% of them were partial full-riders and a 17% of end-users were full non-free-riders and said the program had influence in buying their furnace. Where the program influenced end-users, it tended to increase the efficiency of the equipment they selected, but not the timing of the purchase. The majority (53%) of end-users indicated their previous furnace had failed or reached the end of its useful life.

[50] Reported NTGRs ranged from 0.55 to 0.85 for the furnace measures.

As a mid-stream program, future evaluations should consider interviews with contractors and examine multiple causal pathways similar to the methods used for the rooftop and split systems. Additionally, future evaluations should review program design and logic to confirm that the program is intended to accelerate furnace replacements and adjust NTGR methods to stay consistent with program logic.

5.4 HVAC maintenance and controls

Both gross and net realization rates for the thermostat controls measures were low. This suggests that the program (which only PG&E offers) is having little effect on implementation. Both the kWh and therm GRRs of this measure group were 4%, significantly lower than the program year 2015 HVAC3 study found for this measure. The primary reason behind these low ratios is that sites do not meet the program requirements for thermostat programming. Our telephone verification found that most of the sites did not meet the program setback requirements, and in a number of cases, the users specifically stated that their thermostats were manually turned off during the unoccupied hours instead of programmed to operate at lower or higher temperature conditions. The NTGR for this measure group was 36%. Seven of the 8 surveyed contractors provided responses that resulted in 0% savings credit for the program. This means the contractors indicated that they were already implementing the measure before participating in the program, and that the program had no effect on how many they completed for this measure group.

SCE already does not include this measure as part of its program**. PG&E could consider removing the measure as well, while continuing to offer fan controls measures.**

Unapproved workpapers were used to claim reported savings. We found claims for thermostat control measures that were sourced from the workpaper PGE3PHVC153-4, but the most recent approved version is PGE3PHVC153-3. Our team searched, and we were able to obtain the PGE3PHVC153-4 workpaper from PG&E. Apparently, the reference to version 4 was correct, but somehow the updated version of the workpaper was not in the DEER workpaper database.

To eliminate this source of confusion, PAs should take care to ensure that the source of the reported savings claims in tracking data are appropriately catalogued.

Contractors found it difficult to answer questions about specific maintenance and control measures in their quality maintenance offers.

This difficulty combined with the similar NTGRs found in this and the previous evaluation (each of which covered different specific components of the Quality Maintenance program) suggest that **future net savings evaluations should ask about maintenance offers more generally.**

PTAC unit energy savings are highly uncertain estimates. While the evaluation found that installation rates are acceptably high, considerable uncertainty still remains around the unit energy savings estimate for the PTAC controls measure.

As this measure group is included in the PY 2019 ESPI uncertain measures list, future **CPUC evaluations should consider performing enhanced rigor evaluation to accurately assess the unit energy savings of this measure.**

5.5 Central plant

5.5.1 HVAC boilers

We have identified the following findings and conclusions based on the evaluation of HVAC boiler measures.

The response rates were low at 54% (gross data collection) and 15% (net) for the census of PY 2017 boiler participants. Low response rates led to inability to quantify an evaluated net-to-gross ratio for the boiler measure. We found that tracking data did not contain relevant contact information for the most appropriate decision-making staff at many of the participating facilities. These decision-makers are the best facility representatives to answer the NTG questions for downstream projects in particular. We faced difficulties in contacting the decision-makers, leading to an inadequate number of NTG surveys completed for the boiler measure.

PA account representatives should maintain up-to-date contact information for a variety of facility staff involved with the project at participating facilities, including staff involved in financial decision-making, if possible. As changes in customer staffing occur, we recommend that the PA account representatives update their contact database accordingly.

Workpaper NTGR was not used. The reported savings did not reflect the workpaper and DEER NTGR recommendations of 0.60 and 0.85 (K-12 education and community college), respectively. Upon comparing the reported gross savings to the reported net savings in SCG's HVAC Boiler tracking data, we determined that the reported net savings reflected an NTGR of either 0.65 or 0.9 (K-12 school and community college projects). The values reported in CEDARS are reflected in all tables in this report but featured the incorrect NTGR. SCG program staff indicated that the 0.05 adder to the NTGR accounts for market effects such as spillover; however, evaluators could not find formal documentation to justify this number superseding workpaper guidance.

The programs should more carefully incorporate all active workpaper and DEER values, including NTGR, in reported savings. More careful application of NTGR would have increased the net realization rate for first-year and lifecycle savings. While we were not able to collect sufficient data to quantify an alternative NTGR for boilers, the NRR was 88.8% due primarily to the 0.05 adder to NTGR reflected in reported savings.

Incorrect DEER data were used in workpaper. The applicable SCG workpaper for space heating boilers *WPSCGNRHC120206A Revision 4* references the DEER 2014 boiler measures list and associated efficiency data for baseline boiler efficiencies. However, the tracking savings were estimated using the DEER 2016 revision, which included revisions to the boiler measures list and associated efficiency data for baseline boiler efficiencies. These updates are not currently reflected in the current SCG workpaper.

The *WPSCGNRHC120206A Revision 4* workpaper should be updated to reflect the most recent DEER 2016 boiler measures list and associated efficiency and NTGR data.

Incorrect building type was used. We determined that the building type characterization was inaccurate in tracking data for 4 out of 26 projects in the PY 2017 population. Evaluators also found imprecise building characterization for 2 sites in the population where "mixed-use" facilities were classified as "office-large" buildings. Inappropriate building classification led to reported savings inaccuracies, since the workpaper's savings assumptions are a function of the building type.

The PA account representatives should review and revise (if necessary) the facility type provided in the rebate application to ensure the most accurate reported savings claims as a function of building type.

Improper boiler efficiency values were found. The evaluator-verified nameplate efficiencies of the installed boilers were different from tracking data for 8 projects in the population, resulting in reported savings inaccuracies, as the workpaper savings assumptions are a function of installed boiler efficiency.

The PAs should consider additional research to better characterize and track the installed boiler efficiency. Ideally, field M&V should inform an efficiency adjustment factor to account for actual boiler operation. At the very least, PAs should consider creating a database of nameplate boiler efficiencies for a range of common packaged boiler models in the commercial market. This data could be used to cross-check customer application inputs for more accurate savings claims.

5.5.2 HVAC fan VFD

We have identified the following findings and conclusions based on the evaluation of HVAC fan VFD measures:

There were misapplied NTG ratios. We calculated net-to-gross ratios (NTGR) of 0.53 and 0.59 for kWh and kW savings, respectively. We observed misapplication of the SCE and PG&E workpapers' NTGRs when comparing tracked net savings with tracked gross savings.

Fan VFD workpapers should revise the recommended NTGRs to 0.53 and 0.59 for kWh and kW, respectively. As this evaluation did not focus on gas impacts for the fan VFD measures, we do not recommend application of a new therm NTGR in fan VFD workpapers. We urge any programs offering deemed fan VFD measures to adhere to the therm NTGR recommendations set forth in the active workpapers.

There were low survey response rates. The response rates were low at 61% (gross data collection) and 31% (net) for the sample of participants we contacted. We determined that the tracking data did not contain relevant contact information for the most appropriate decision-making staff at many of the participating facilities. These decision-makers are the best facility representatives to answer the NTG questions for downstream projects in particular. Because we faced difficulties in contacting the decision-makers, we had fewer completed NTG surveys than expected for the fan VFD measures.

PA account representatives should maintain up-to-date contact information for a variety of facility staff involved with the project at participating facilities, including staff involved in financial decision-making, if possible. As changes in customer staffing occur, we recommend that the PA account representatives update their contact database accordingly.

There was a high installation rate. The installation rate for HVAC fan VFD measures was 100% overall, among the 40 participants we interviewed.

We have no recommendation for this finding.

Motor horsepower was not properly reported. For the VFDs on HVAC supply and return fan measure, we found that the quantity and total impacted fan motor horsepower differed from tracking data for 5 out of 17 evaluated projects. Specifically, for SCE programs, we found that the impacted motor horsepower in tracking data reflected the total horsepower of multiple motors in each project and was not broken down into individual motors, quantities, and horsepower. This lack of tracking data granularity led to challenges with gross data collection.

The SCE application paperwork and tracking protocols should be updated for supply/return fan VFD measure groups to reflect quantities and horsepower for each individual motor in the application, to avoid potential mistakes in reported savings calculations.

Projects did not claim savings from CAV-to-VAV conversions. The team determined that, for 5 of the 17 supply/return fan projects in the sample, the project scope involved conversion from a constant air volume (CAV) to a variable air volume (VAV) distribution system in addition to the installation of VFDs on

the supply/return fan motors. The conversion from CAV to VAV system type is a separate measure from the fan VFD measure, with deemed measure savings reflecting *DEER energy impact ID: D03-050*, that are quite different from fan VFD deemed savings assumptions. We confirmed that tracking savings for these projects did not reflect savings resulting from CAV to VAV conversions, and that the 5 sampled customers did not file separate CAV-to-VAV claims in PY 2017.

The PAs should update the supply/return fan VFD application paperwork to include "Existing HVAC distribution system type" in order to better identify CAV-to-VAV conversions that might have been incorrectly submitted as fan VFD measures.

For the enhanced ventilation measures, the affected HVAC packaged unit(s) tonnage differed from tracking data for 17 out of 22 evaluated projects, resulting in differences between evaluated and reported savings.

PAs should urge project implementers to submit accurate information, particularly the capacity of affected equipment.

Results showed lower exhaust fan operating hours than provided in the workpaper assumptions. For the garage exhaust fan VFD measure, Workpaper *SCE13HC038 Revision 2* assumes a base case of an existing parking structure allowed to run 24 hours per day, 7 days a week. Our site interviews revealed that parking garage occupancies have declined in the past 3 years due to app-based ride-share programs, resulting in lower exhaust fan operating hours than provided in the workpaper assumptions. While our sample did not feature a prevalence of these projects, we note this finding for informational purposes.

PAs may want to update the workpaper assumptions for baseline parking garage exhaust fan operation to reflect the most appropriate operating hours. Our limited research in this study indicated a trend of reduced garage operation due to the emergence of ride-share services.

6 APPENDICES

6.1 Appendix AA: Standard high-level savings

The standard high-level savings are provided on the next page.

6.2 Appendix AB: Standard per-unit savings

The standard per-unit savings are provided on the next page.

6.3 Appendix AC: Recommendations

The following table presents findings and recommendations in the format from CPUC ED Impact Evaluation Standard Reporting Guidelines November 2015 memo.[51]

Study ID	Study Type	Study Title	Study Manager
	Impact Evaluation	Impact Evaluation Report – HVAC – Program Year 2017	CPUC

Recommendation Number	Program or Database	Summary of Findings	Additional Supporting Info	Best Practice/Recommendation	Recommendation Recipient	Affected Workpaper or DEER
1a	All Programs	PA tracking data contained incorrect contact information.		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.	All PAs	
1b	All Upstream & Midstream Programs	PA tracking data contained incorrect contact information.		For upstream and midstream programs, provide more uniformity in reporting the explicit links between distributors/contractors and end users.	All PAs	
2	All Programs	PA tracking data showed inconsistent measure types and quantities.		PAs should verify that they all use the same rules for reporting measure parameters in claims.	All PAs	

[51] https://pda.energydataweb.com/api/downloads/1399/IESR_Guidelines_Memo_FINAL_11_30_2015.pdf

Recommendation Number	Program or Database	Summary of Findings	Additional Supporting Info	Best Practice/Recommendation	Recommendation Recipient	Affected Workpaper or DEER
3	All Upstream & Mid-Stream Programs	Upstream and midstream market actors, particularly Quality Maintenance contractors, were difficult to reach for surveys.		Improve the quality of contact information in the tracking databases. Steps to improve the number of completed surveys include increasing sample sizes, asking the PAs to reach out to these market actors to encourage cooperation, planning for longer fielding periods, and offering incentives for participation.	All Evaluators	
4	All Programs	Contractors and distributors were not linked to tracking data.		Make contractor contact information (and, for upstream program claims, distributor contact information) part of claim-level tracking data.	All PAs	
5	Upstream HVAC Programs with Rooftop & Split System Measures	Program design for rooftop and split systems is not strongly influencing distributor behavior.		Conduct a process evaluation to better assess current distributor behavior and if there is room to change, what mechanisms would influence them.	CPUC-ED	

Recommendation Number	Program or Database	Summary of Findings	Additional Supporting Info	Best Practice/Recommendation	Recommendation Recipient	Affected Workpaper or DEER
6	All HVAC Programs with Rooftop & Split System Measures	Rooftop end-users ranked energy savings as more influential to their specific equipment decisions than non-energy benefits such as decreased maintenance costs or increased productivity.		Examine whether program marketing currently covers non-energy benefits. If not, consider producing and piloting some materials that do cover these benefits.	All PAs	
7	All Mid-Stream HVAC Programs with Furnace Measures	The NTGR revealed that a moderate-to-high level of free-ridership persists for this measure group across the PAs.		• Consider interviews with contractors and examine multiple causal pathways similar to the methods used for the rooftop and split systems. • Review program design and logic to confirm that the program is intended to accelerate furnace replacements and adjust NTGR methods to stay consistent with program logic.	CPUC-ED and all PAs	
8	All HVAC Programs with Maintenance & Controls Measures	Both gross and net realization rates for the thermostat controls measures were low.		PG&E could consider removing the measure while continuing to offer fan controls measures.	PG&E	

Recommendation Number	Program or Database	Summary of Findings	Additional Supporting Info	Best Practice/Recommendation	Recommendation Recipient	Affected Workpaper or DEER
9	All HVAC Programs with Maintenance & Controls Measures	Unapproved workpapers were used to claim reported savings.		Ensure that the source of the reported savings claims in tracking data are appropriately catalogued.	All PAs	
10	All HVAC Programs with Maintenance & Controls Measures	Contractors found it difficult to answer questions about maintenance & controls measures in their quality maintenance offers.		Ask about maintenance & controls offers more generally in future net savings evaluations.	CPUC-ED	
11	All HVAC Programs with PTAC Measures	PTAC unit energy savings are highly uncertain estimates.		Consider performing an enhanced rigor evaluation to accurately assess the unit energy savings of this measure.	CPUC-ED	
12	All HVAC Programs with Boiler Measures	The response rates were low at 54% (gross data collection) and 15% (net) for the census of PY 2017 boiler participants.		Maintain up-to-date contact information for a variety of facility staff involved with the project at participating facilities, including staff involved in financial decision-making, if possible.	All PAs	

Recommendation Number	Program or Database	Summary of Findings	Additional Supporting Info	Best Practice/Recommendation	Recommendation Recipient	Affected Workpaper or DEER
13	All HVAC Programs with Boiler Measures	Workpaper NTGR was not used.		Carefully incorporate all active workpaper values, including NTGR, in reported savings.	All PAs	WPSCGNRHC120206A Revision 4
14	All HVAC Programs with Boiler Measures	Incorrect DEER data were used in workpaper.		Update the WPSCGNRHC120206A Revision 4 workpaper to reflect the most recent DEER 2016 boiler measures list and associated efficiency data.	SCG	WPSCGNRHC120206A Revision 4
15	All HVAC Programs with Boiler Measures	Incorrect building type was used.		Review and revise (if necessary) the facility type provided in the rebate application to ensure the most accurate reported savings claims as a function of building type.	All PAs	WPSCGNRHC120206A Revision 4
16	All HVAC Programs with Boiler Measures	Improper boiler efficiency values were found.		Consider additional research to better characterize and track the installed boiler efficiency.	CPUC-ED and all PAs	
17	All HVAC Programs with Fan VFD Measures	There were misapplied NTGRs.		Update fan VFPD workpapers recommended NTGRs to 0.53 and 0.59 for kWh and kW, respectively.	All PAs	PGECOHVC106 Revision 5 SCE13HC050 Revision #2
18	All HVAC Programs with Fan VFD Measures	There were low survey response rates.		Maintain up-to-date contact information for a variety of facility staff involved with the project at participating facilities, including staff involved in financial decision-making, if possible.	All PAs	

Recommendation Number	Program or Database	Summary of Findings	Additional Supporting Info	Best Practice/Recommendation	Recommendation Recipient	Affected Workpaper or DEER
19	All HVAC Programs with Fan VFD Measures	There was a high installation rate.		DNV GL has no recommendations at this time.		
20	All HVAC Programs with Fan VFD Measures	Motor horsepower was not properly reported.		Update application paperwork and tracking protocols for supply/return fan VFD measure groups to reflect quantities and horsepower for each individual motor in the applications.	SCE	
21	All HVAC Programs with Fan VFD Measures	Projects did not claim savings from CAV-to-VAV conversions.		Update the supply/return fan VFD application paperwork to include "Existing HVAC distribution system type" in order to better identify CAV-to-VAV conversions that might have been incorrectly submitted as fan VFD measures.	All PAs	
22	All HVAC Programs with Fan VFD Enhanced-Ventilation Measures	For enhanced ventilation measures, the affected HVAC packaged unit tonnage differed from tracking data for 17 out of 22 evaluated projects, resulting in differences between evaluated and reported savings.		Urge project implementers to submit accurate information, particularly the capacity of affected equipment.	All PAs	

Recommendation Number	Program or Database	Summary of Findings	Additional Supporting Info	Best Practice/Recommendation	Recommendation Recipient	Affected Workpaper or DEER
23		Site interviews revealed lower exhaust fan operating hours than provided in the workpaper assumptions.		Update workpaper assumptions for baseline parking garage exhaust fan operation to reflect the most appropriate operating hours.	All PAs	SCE13HC038 Revision 2

6.4 Appendix AD: Waterfalls by subsectors

Figure 6-1. Unitary VRF: rooftop and split systems kWh savings

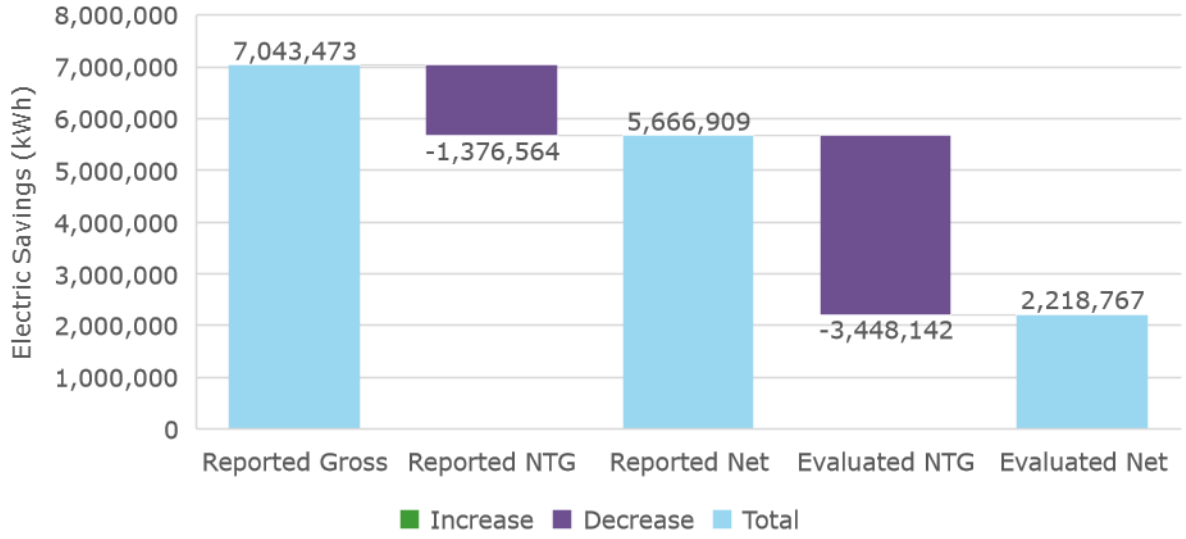


Figure 6-2. Unitary VRF: rooftop and split systems kW savings

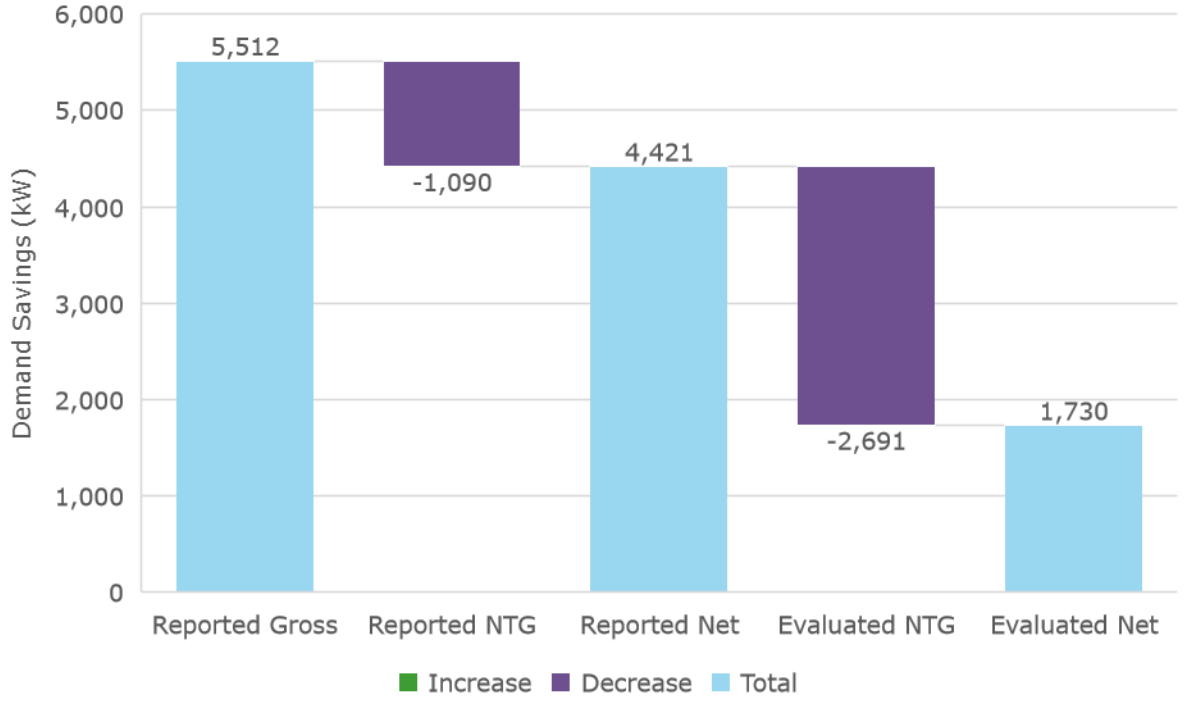


Figure 6-3. Unitary VRF: rooftop and split systems therm savings

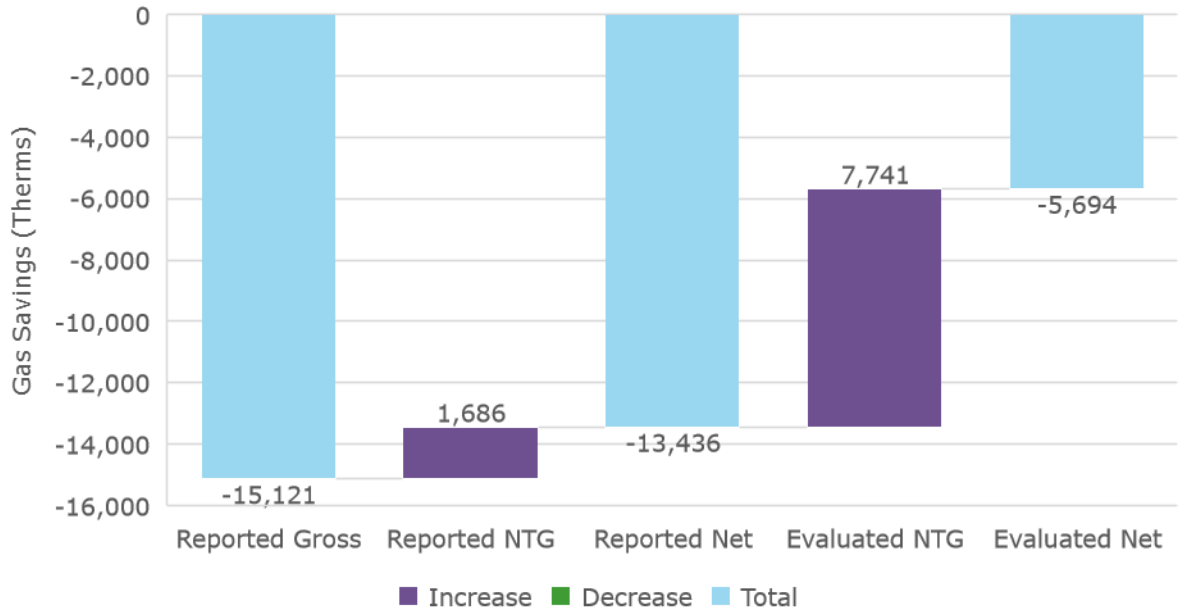


Figure 6-4. Unitary VRF: furnace kWh savings

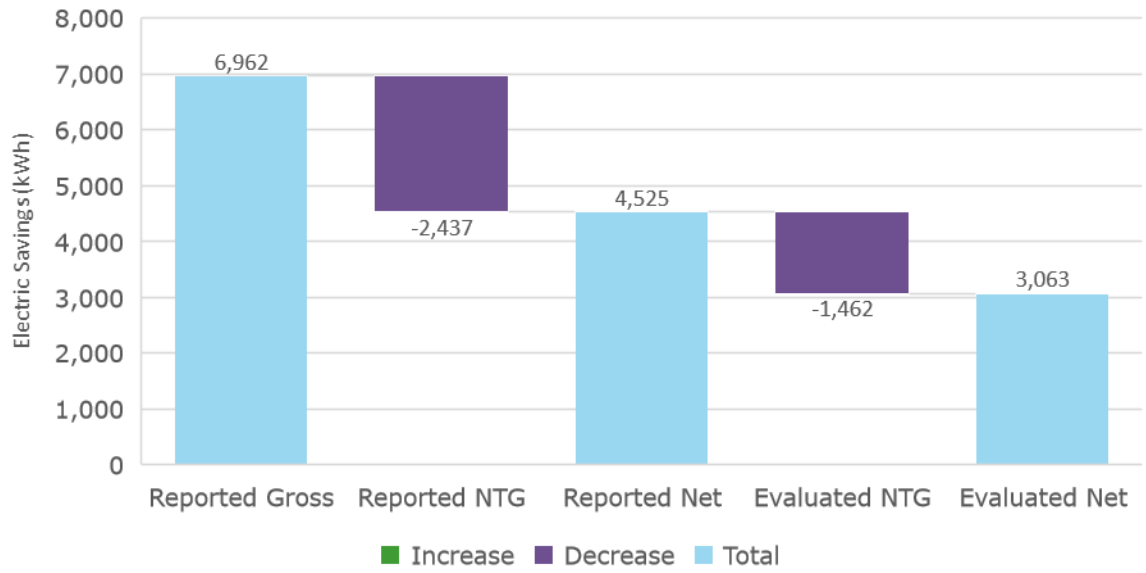


Figure 6-5. Unitary VRF: furnace kW savings

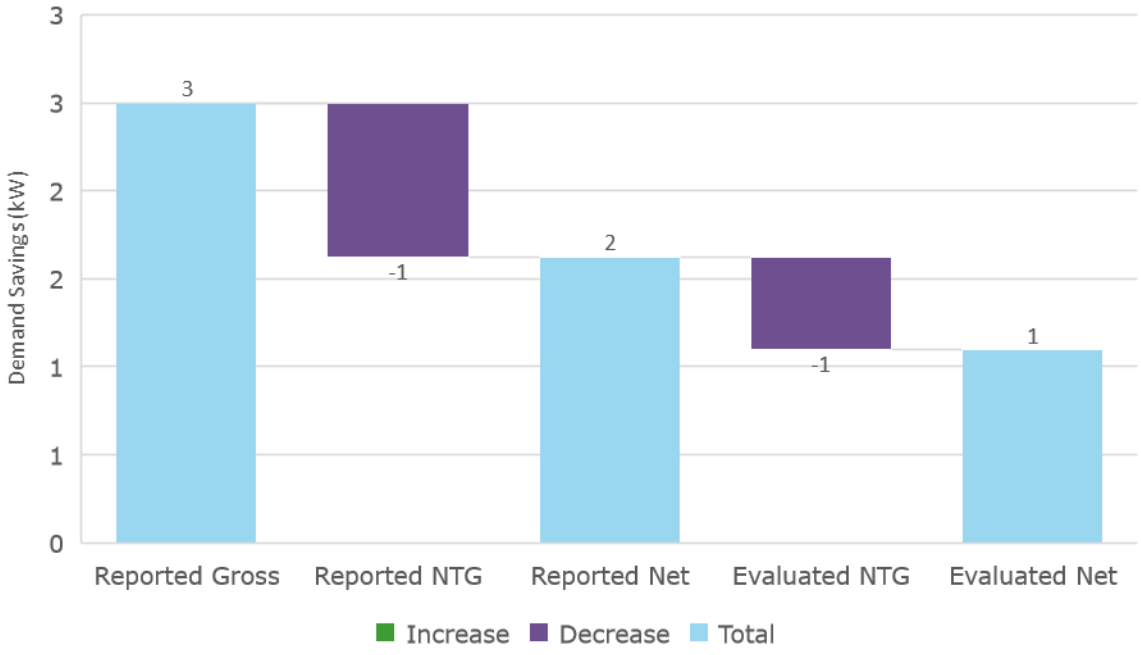


Figure 6-6. Unitary VRF: furnace therm savings

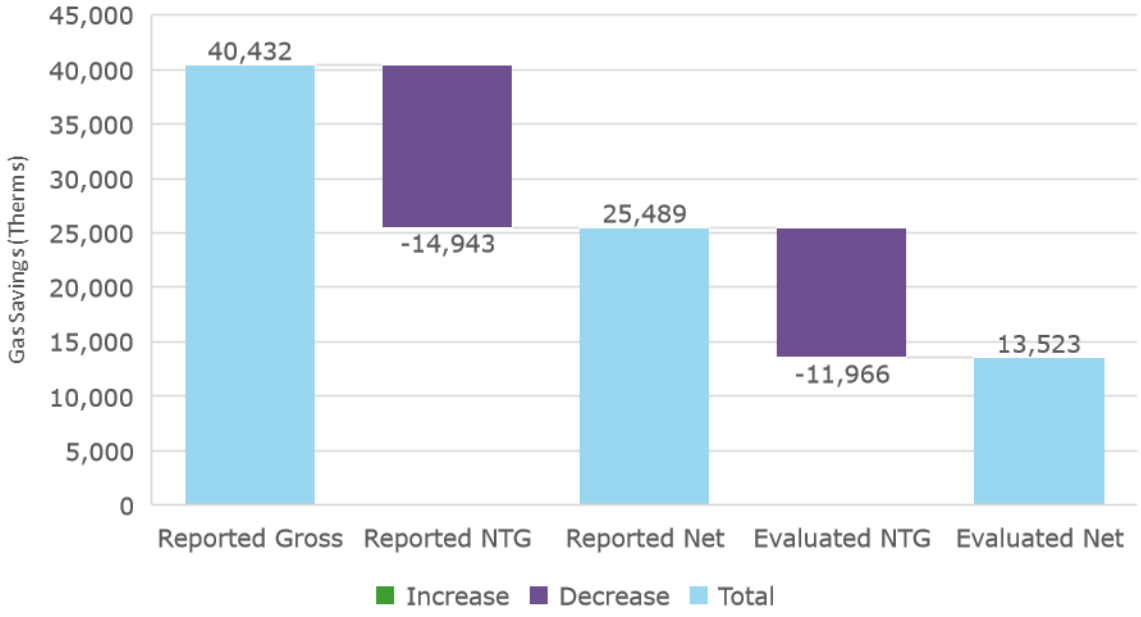


Figure 6-7. Maintenance & controls: thermostat control kWh savings

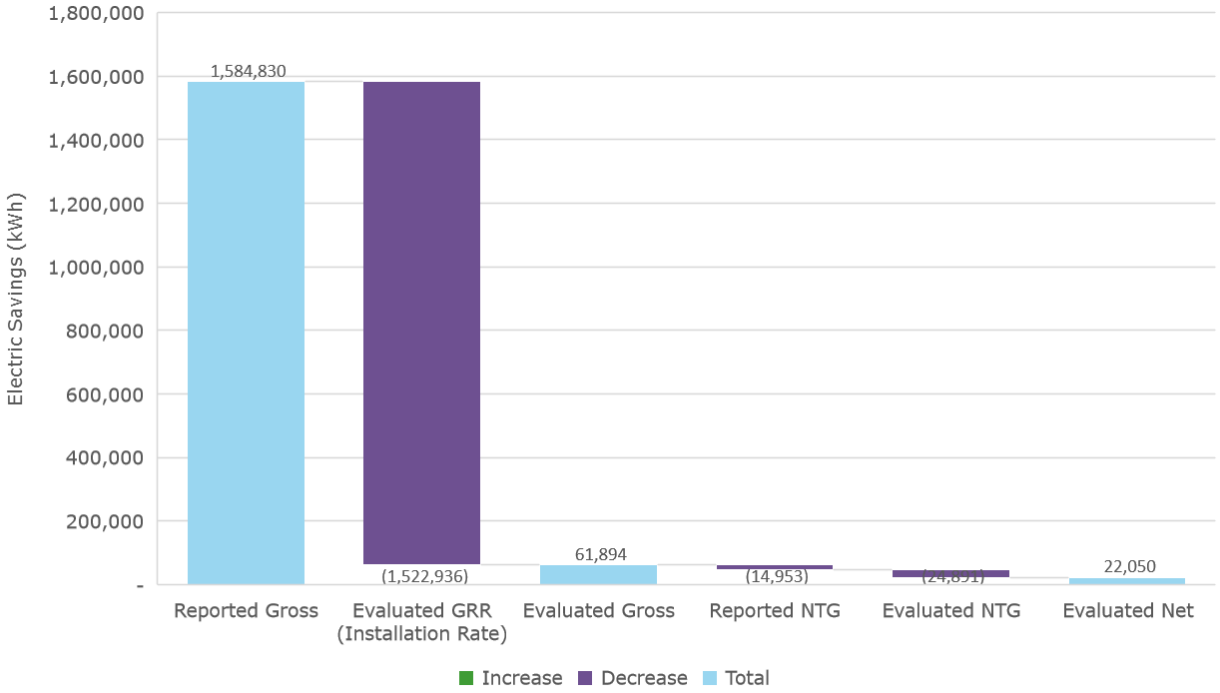


Figure 6-8. Maintenance & controls: thermostat therm savings

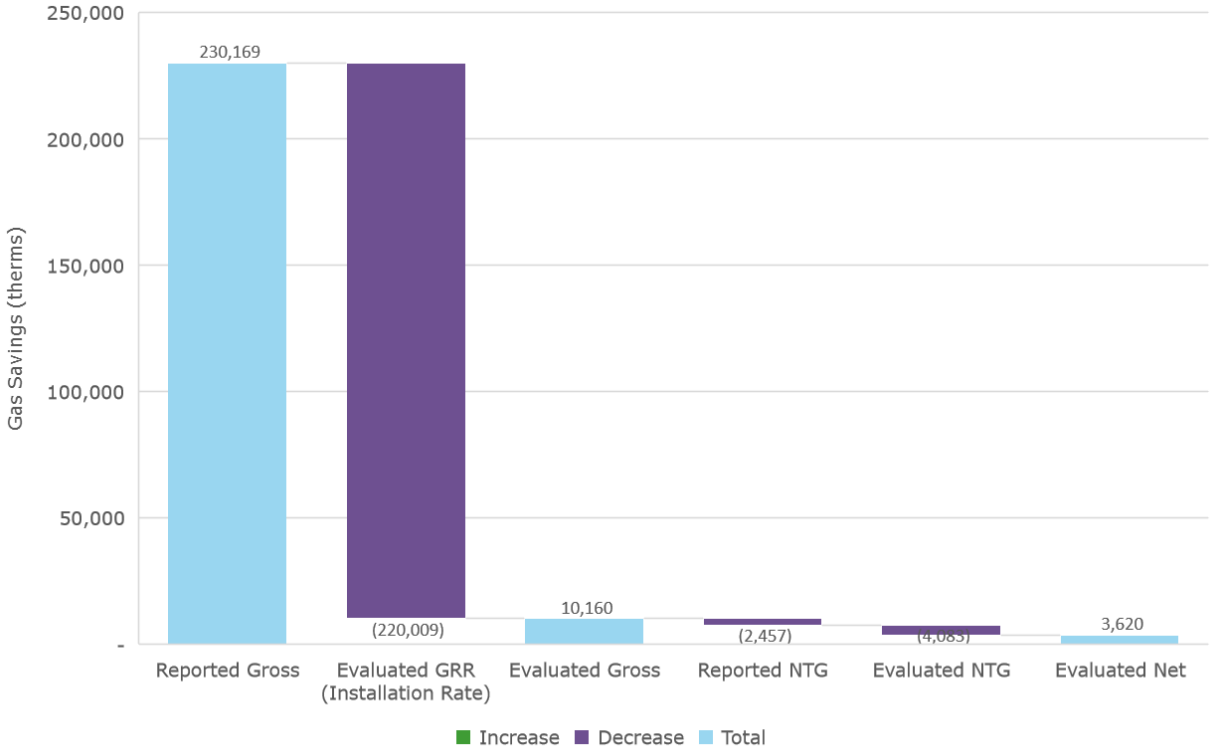


Figure 6-9. Maintenance & controls: fan control kWh savings

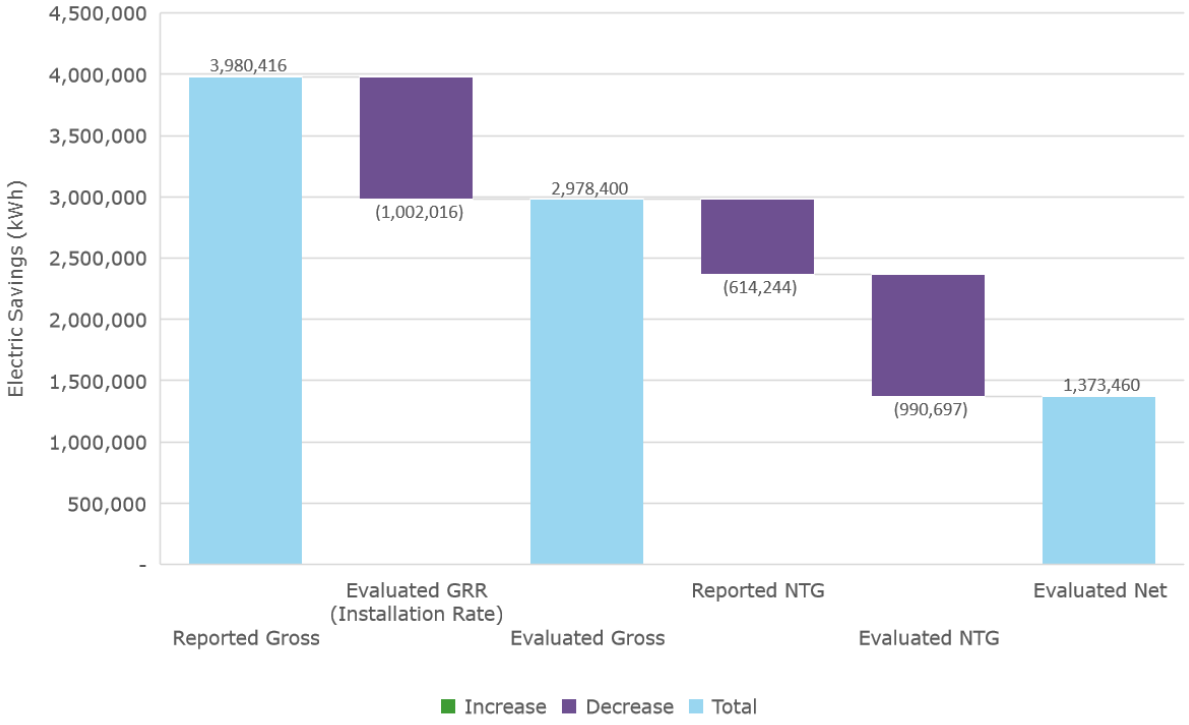


Figure 6-10. Maintenance & controls: fan control kW savings

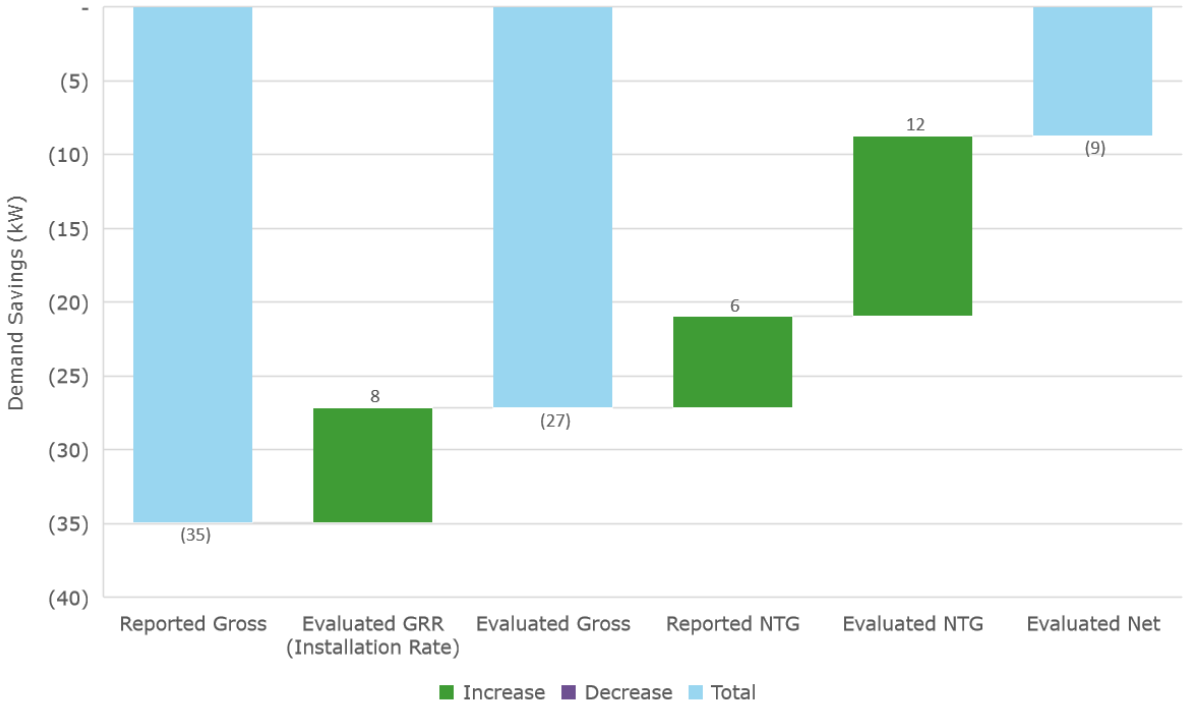


Figure 6-11. Maintenance & controls: fan control therm savings

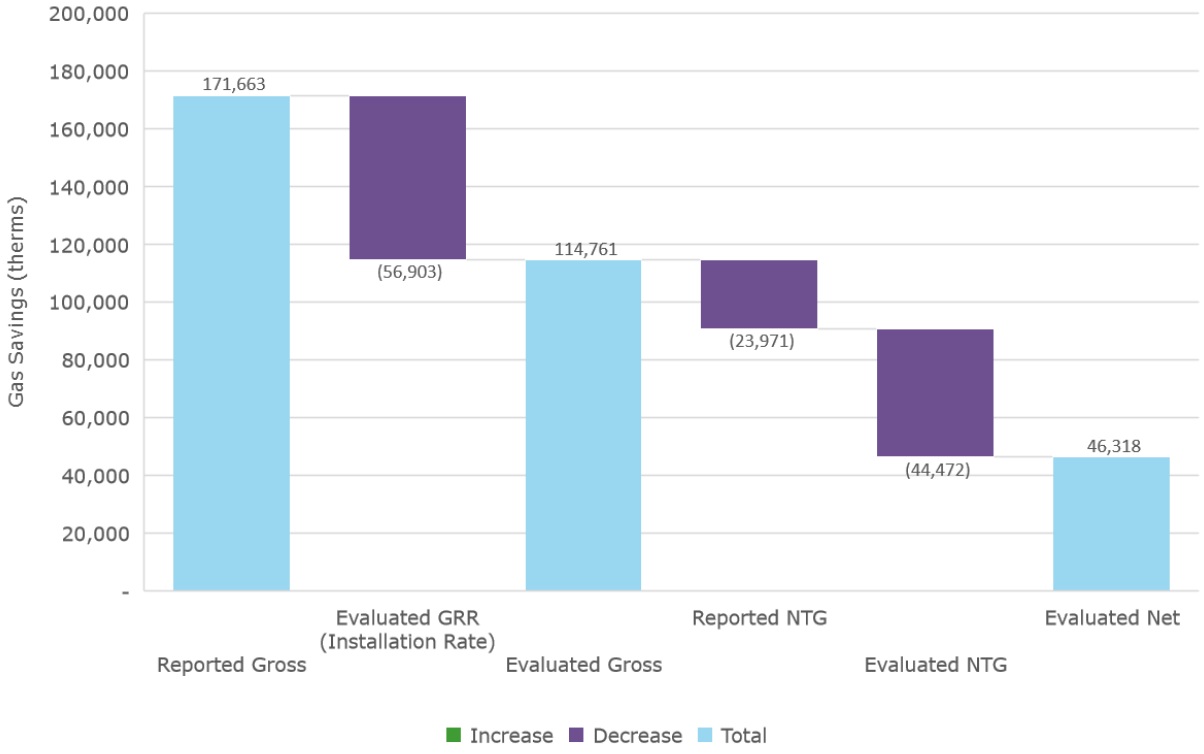


Figure 6-12. Maintenance & controls: PTAC control kWh savings

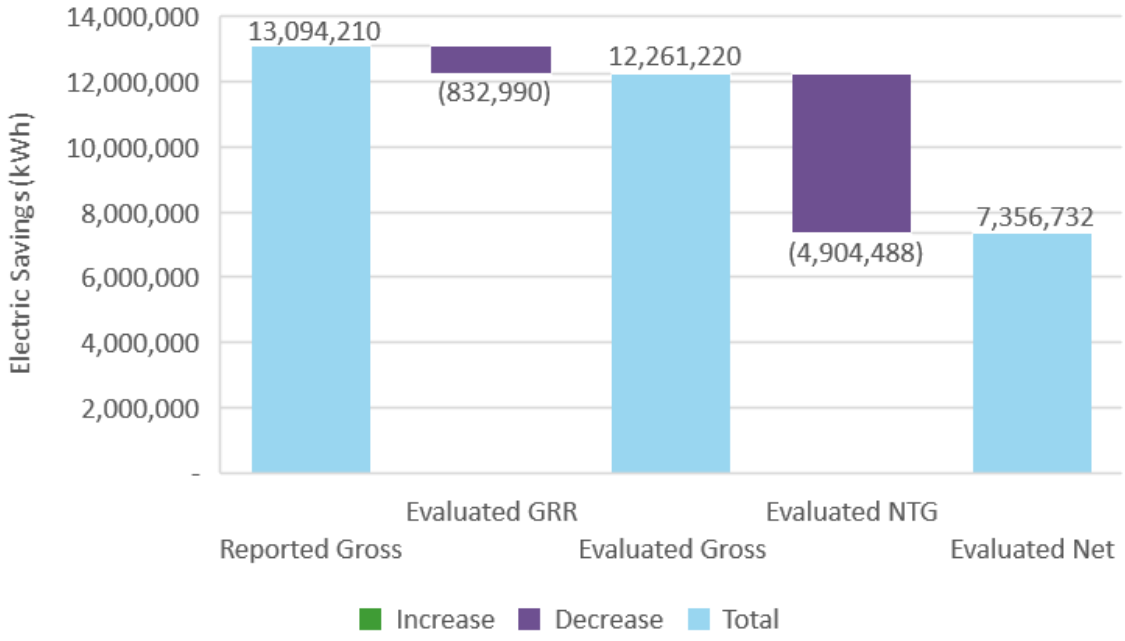


Figure 6-13. Maintenance & controls: PTAC control therm savings

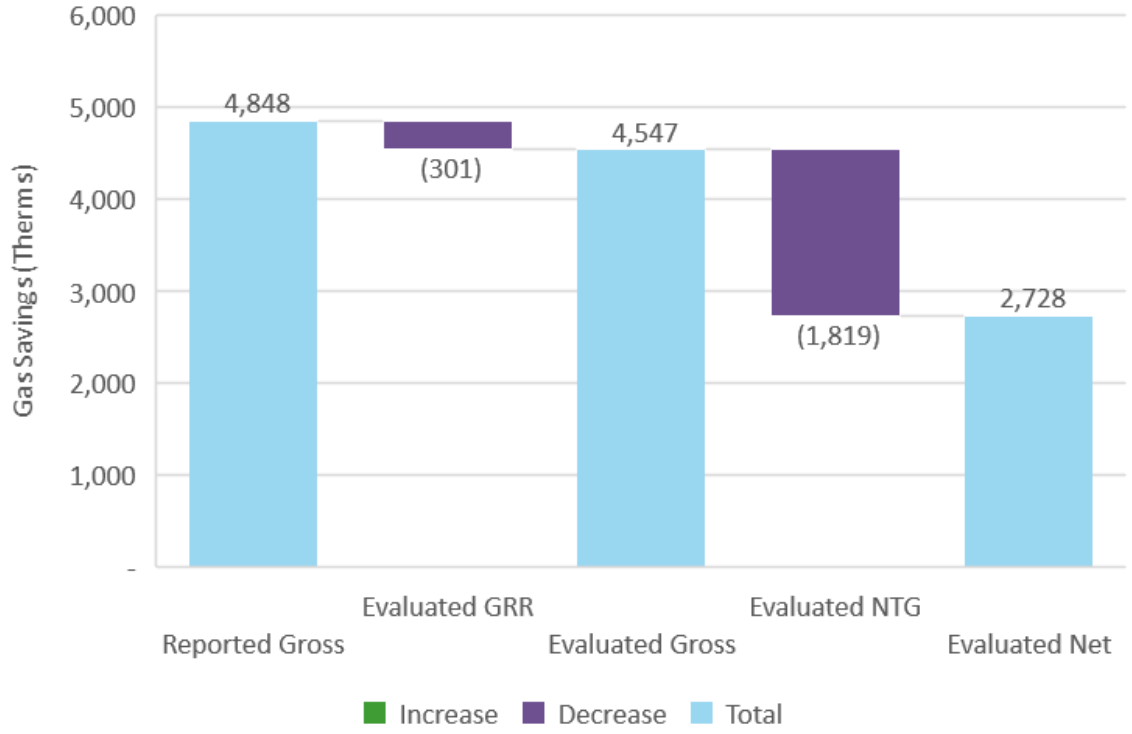


Figure 6-14. Central plant: boiler kWh savings

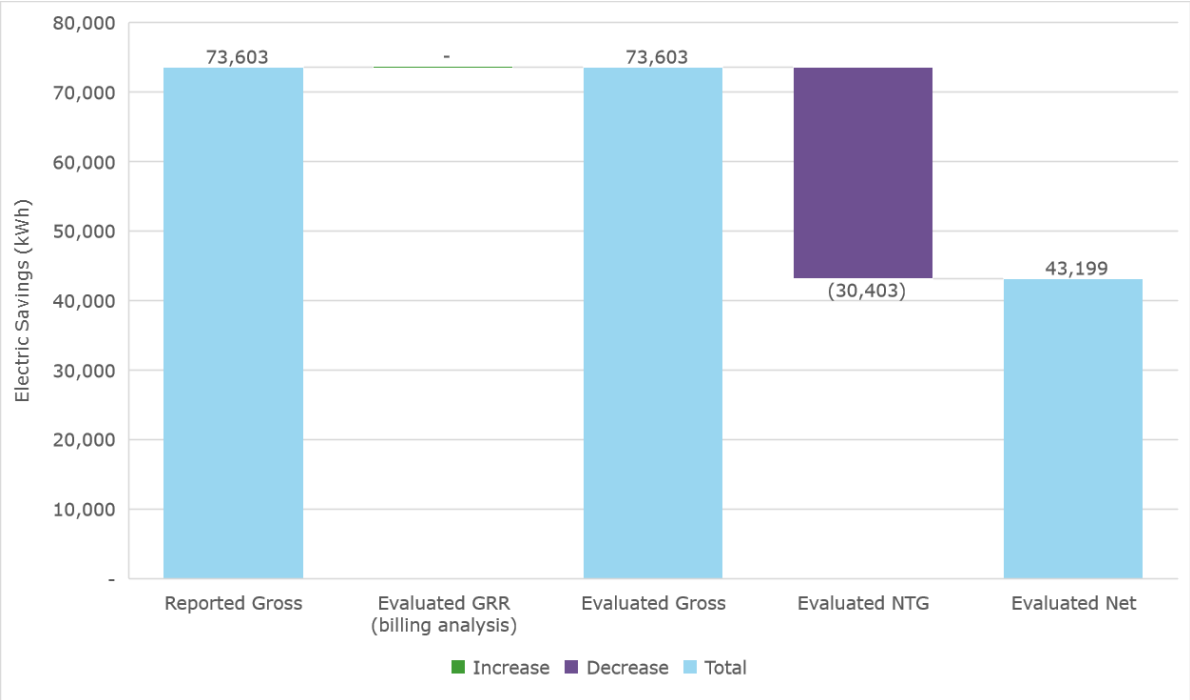


Figure 6-15. Central plant: boiler kW savings

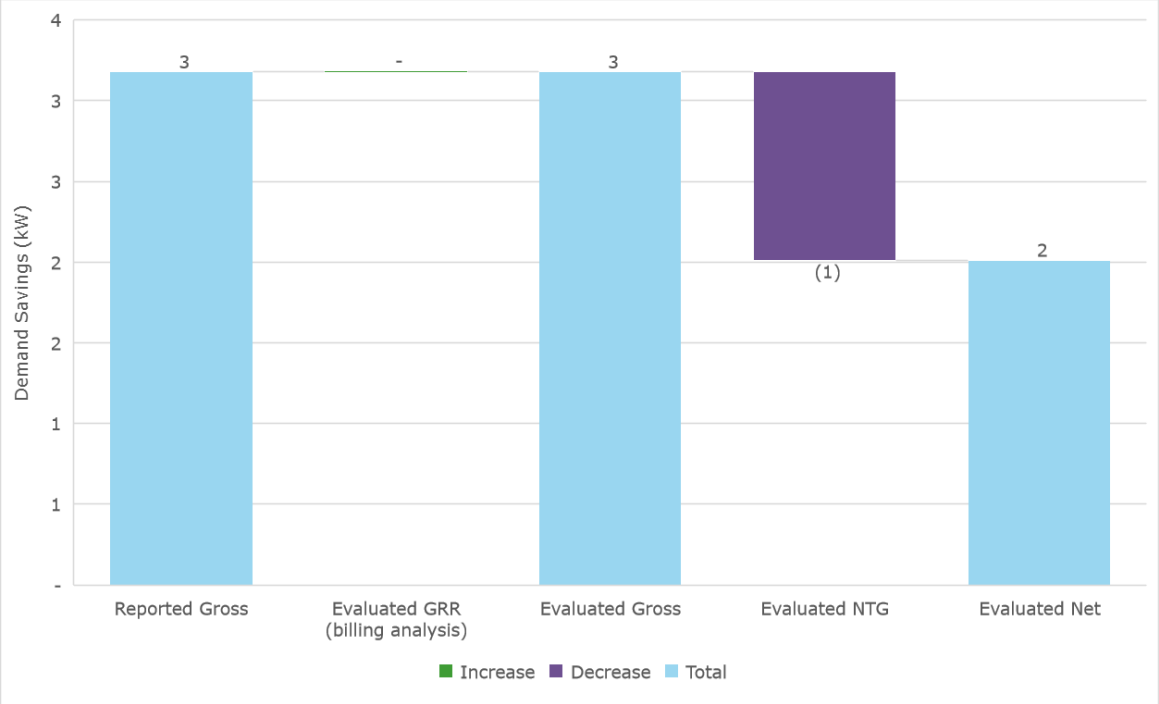


Figure 6-16. Central plant: boiler therm savings

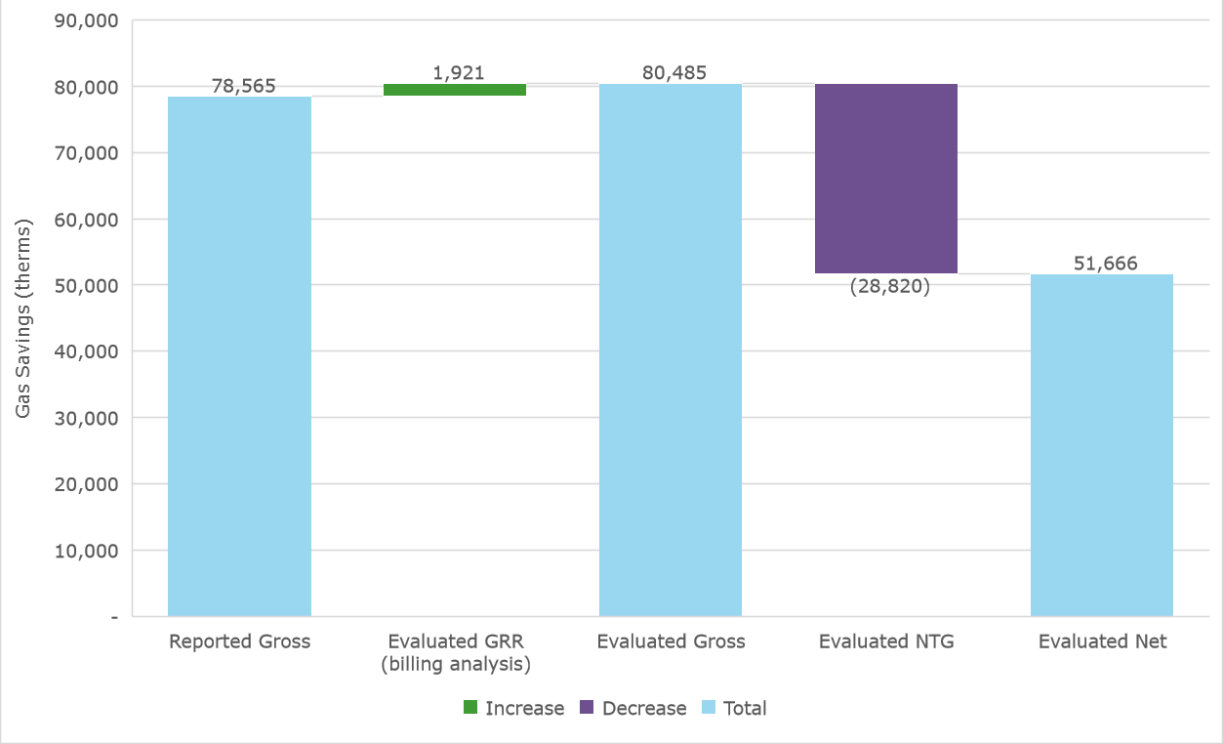


Figure 6-17. Central plant: fan VFD kWh savings

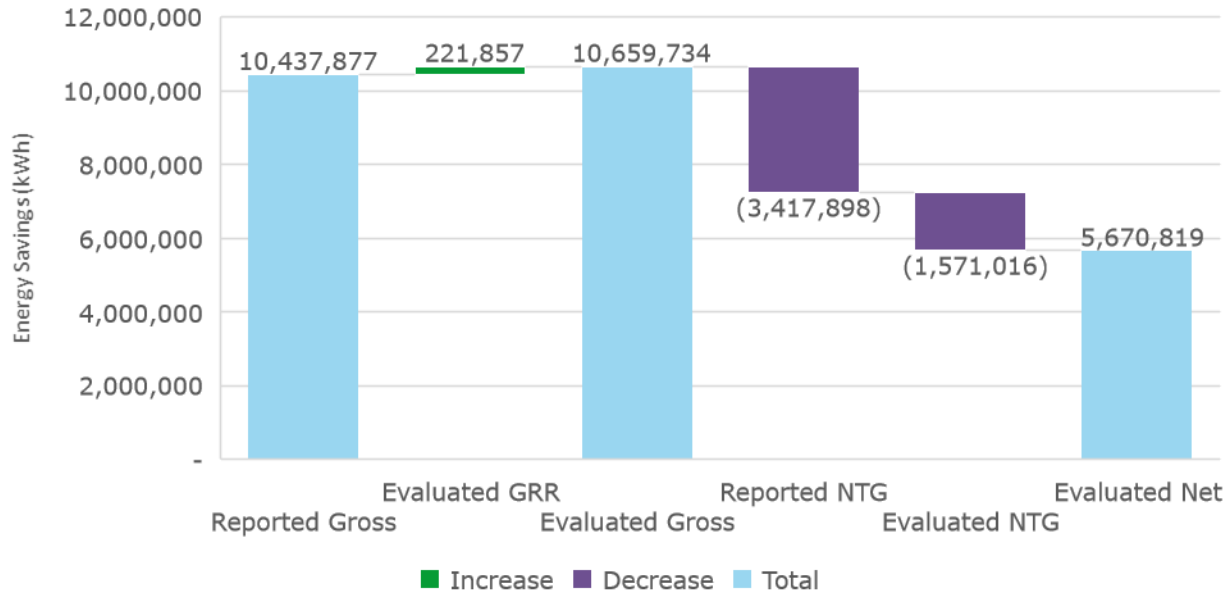


Figure 6-18. Central plant: fan VFD kW savings

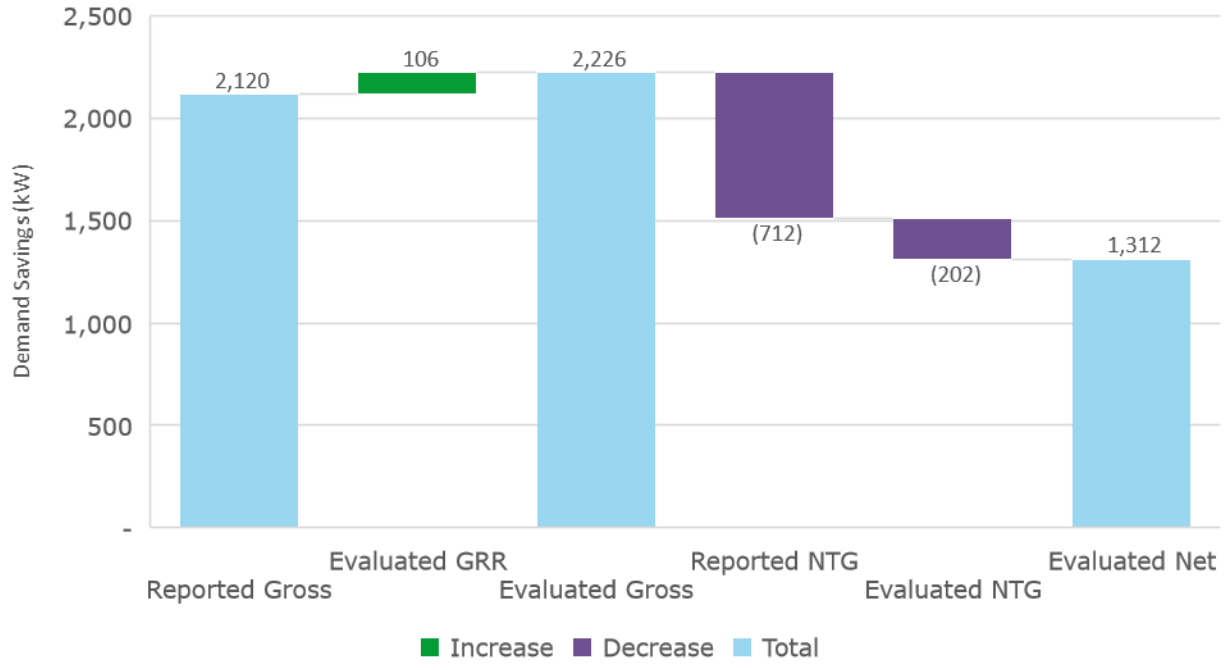
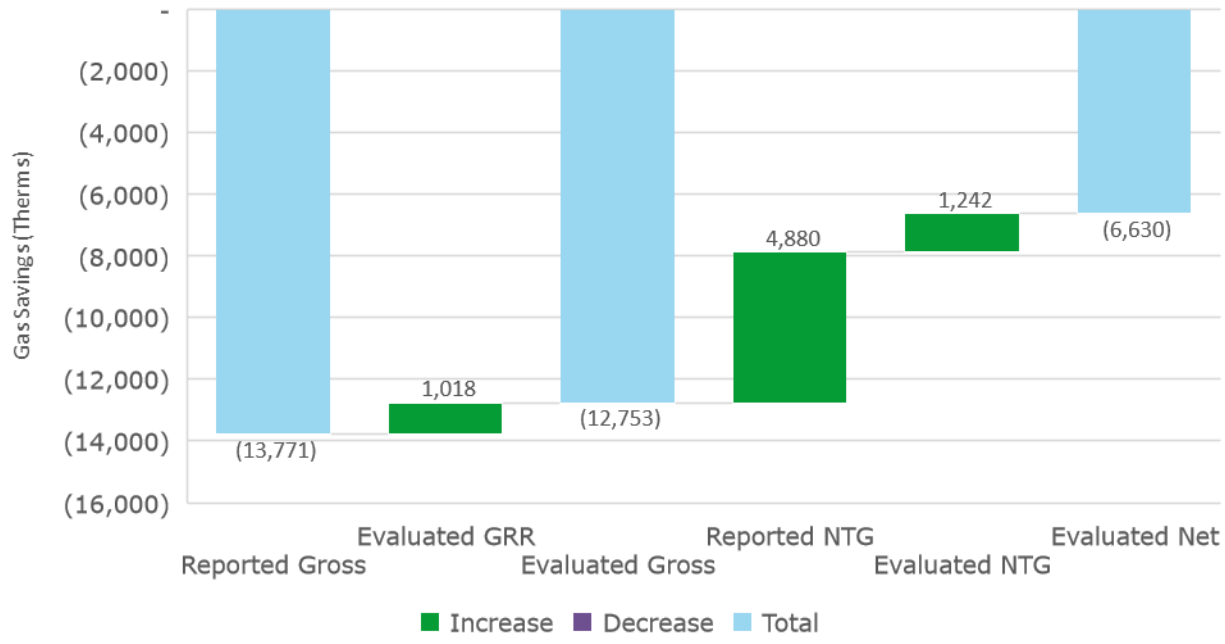


Figure 6-19. Central plant: fan VFD therm savings



6.5 Appendix A: Data collection and sampling memo

The memo is providing starting on the next page.

6.6 Appendix B: Maintenance & controls data collection forms

6.6.1 Thermostat and fan gross data collection form

Thermostat/Supply Fan Control Verification Survey

Background. The primary objective of the programmable thermostat and supply fan portion of the HVAC evaluation is to verify the PA's energy savings claims for these measures. The largest uncertainties affecting the reported energy savings estimates of the programmable thermostat measure are:

- Whether or not participants are even using the programmable thermostat
- Whether or not thermostat set-points adhere to the program requirements for periods when the building is unoccupied
- The baseline set-points during unoccupied periods
- And the hours that the building is occupied.

The baseline set-points are very hard to collect reliably and we don't attempt to collect them in this survey. However, DNV GL will attempt to characterize baseline operation (i.e. whether or not the thermostat was set back) during unoccupied hours in this survey. Evaluation efforts for 2013-14 were limited to field-collected data at 11 sites and only verified whether or not the thermostats observed at those sites met the conditions outlined in PA workpapers for unoccupied periods. The results from that evaluation exhibited a high degree of uncertainty but indicated that only 30 percent of the verified thermostats meet the program's specifications.

The largest uncertainty affecting the reported energy savings estimates of the supply fan control measure is the baseline operation of the supply fan, especially for periods when the building is unoccupied. The previous evaluation had difficulty verifying the baseline condition and also had a large degree of uncertainty due to a small sample size (14 sites).

Survey Goals. The goal of the T-STAT and Supply Fan Verification Survey is to determine operating characteristics of rebated programmable thermostat and supply fan controls. The survey will attempt to document the schedule and set-points of a sample of installed programmable thermostats as well as the baseline and current operation (on/off/auto) of supply fans during occupied and unoccupied times. The findings from the survey will be used to verify program tracking savings claims and ultimately update gross savings estimates for both measures.

Key Research Questions. The T-STAT and Supply Fan Verification Survey will address the following key research questions in support of updating gross savings estimates:

- Are participants using their programmable thermostat?
- What is the average thermostat set-point during unoccupied hours (across all building types)?

- What was the baseline operation of the supply fan during unoccupied hours (across all building types)?

Survey Scope. DNV GL will collect thermostat and supply fan data through a phone survey; participants will be selected from the sample as described in the 2017 CPUC HVAC Roadmap Data Collection and Sampling Plan. The sample of participants will be stratified by PA, building type, and size (i.e. quantity of rebated measures or energy savings).

Survey Introduction

Database Variables

Variable	Description
<CONTACT NAME>	Program participant's full name
<ADDRESS>	Program participant address
<COMPANY NAME>	Program participant's company name
<DATE>	Month and year tstat and/or supply fan control was installed
<PHONE>	Telephone number
<PROGRAM NAME>	Multiple program names depending on the PA
<MEASURE QTY>	# of installed t-stats and/or supply fan control(s)

Introduction/Screener

I0 Hello, my name is _____, and I'm calling on behalf of the California Public Utilities Commission. May I speak with <**CONTACT NAME**>?

[IF NECESSARY:
We are conducting a survey on behalf of the Commission to better understand how your business is using its programmable thermostats (and/or supply fan). The utility will use your input to improve the programs they offer to commercial and industrial customers. This is NOT a sales call and the information that you provide will be kept strictly confidential. The survey should only take 10-15 minutes.

You may validate the legitimacy of this study by contacting Justin Hagler of the CPUC via phone at 415-703-5355.

I1. Are you familiar with how **<COMPANY NAME>** controls their heating and cooling?

1	Yes	I2.
2	No	Find other contact/ Reschedule/TT
98	DON'T KNOW	Find other contact/ Reschedule/TT
99	REFUSED	Find other contact/ Reschedule/TT

I2. Is the heating and cooling controlled by thermostats or by an energy management system (EMS)?

1	Thermostats	I3
2	EMS	I3
98	DON'T KNOW	Find other contact/ Reschedule/TT
99	REFUSED	Find other contact/ Reschedule/TT

I3. Are you responsible for setting or adjusting your company's programmable thermostats (or EMS or supply fan controls as appropriate)?

1	Yes (tstats only)	I4. Ask tstat battery.
2	Yes (supply fans only)	I4. Ask supply fan battery.
3	Yes (both)	I4. Ask about both
4	Yes (EMS)	I4. Ask about both
5	No	Find other contact/ Reschedule/TT
98	DON'T KNOW	Find other contact/ Reschedule/TT
99	REFUSED	Find other contact/ Reschedule/TT

I4. Which of the following building type best describes your company's facility? **RECORD ANSWER.**

1	Assembly	12	Manufacturing - Bio/ Tech
2	Education- Primary School	13	Manufacturing - Light Industrial
3	Education- Secondary School	14	Office - Large
4	Education- Community College	15	Office - Small
5	Education- University	16	Restaurant - Sit-Down
6	Education - Re locatable Classroom	17	Restaurant - Fast-Food
7	Grocery	18	Retail - 3-Story Large
8	Health/Medical - Hospital	19	Retail - Single-Story Large
9	Health/ Nursing Home	20	Retail - Small
10	Lodging - Hotel	21	Storage - Conditioned
11	Lodging - Motel	22	Storage - Refrigerated Warehouse
98	Don't Know	99	Refused

I5. What's the total area of the facility? (please estimate in sq. feet, if multiple buildings, combine area). RECORD ANSWER.

I6. What percent of the building(s) area was retrofitted with programmable thermostats? RECORD ANSWER.

Operating/Occupied Hours.

Now I'd like to ask you a few questions about the regular hours of occupancy at **<COMPANY NAME>.**This info will allow us to compare the operating/occupied hours in program-provided data with the data collected off the thermostats.

OH1. During the week, Monday through Friday, what hours are <COMPANY NAME> occupied by employees? (Note: these may be different than the actual business hours if employees typically come in early or stay late) **RECORD ANSWER.**

OH2. During the weekend, Saturday and Sunday, what hours are <COMPANY NAME> occupied by employees? (Note: these may be different than the actual business hours if employees typically come in early or stay late) **RECORD ANSWER, then proceed to TB intro.**

T-stat Baseline.

[READ INTRO then proceed to TB1] Now I'd like to ask you a question about the old thermostats that were installed at your company <COMPANY NAME> prior to participating in the <PROGRAM NAME> and installing (or reprogramming) programmable thermostat.

TB1. What type of thermostat was installed prior to participating in the <PROGRAM NAME>? (Read list if necessary)

1	Programmable t-stat	TB2
2	Manual t-stat	TB2
3	Switch (on/off)	TB2
4	EMS	TB2
5	No t-stat	TB2
6	Other	Record answer, TB2
98	DON'T KNOW	TB2
99	REFUSED	TB2

TB2. Prior to participating in the <PROGRAM NAME>, did your company <COMPANY NAME> change the thermostat settings during unoccupied periods?

1	Yes	TB3
2	No	TV intro
98	DON'T KNOW	TV intro
99	REFUSED	TV intro

TB3. How frequently did you adjust the thermostat?

1	Frequently	TV intro
2	One-time adjustment	TV intro
3	Seasonal adjustments	TV intro
4	On-going/as needed adjustments	TV intro
5	Occupant controlled	TV intro
98	DON'T KNOW	TV intro
99	REFUSED	TV intro

T-stat Verification. [READ INTRO then proceed to TV1]

Now I'd like to ask you a few questions about the programmable thermostats currently installed at your company. As a reminder, the <PROGRAM NAME> provides contractors with incentives and guidelines for replacing or reprogramming thermostats and supply fans. According to our records, your company <COMPANY NAME> at <ADDRESS> received a rebate for installing or reprogramming <MEASURE QTY> programmable thermostats (and <MEASURE QTY> supply fan controls if necessary) on <DATE>. In order to collect the necessary information about these programmable thermostats I'd like to ask you to read the programmed schedule and set-points on 1-3 thermostats (depending on the <MEASURE QTY>).

NOTE: If more than 1 thermostat, mention that "the thermostats should be in non-adjacent areas. Ask questions about the different types of spaces at the business (i.e. offices, class rooms, storage rooms, workshops, kitchen, etc.) and if each space has different levels/times of occupancy. Push for different space/occupancy types depending on the information provided.

TV1. Are you able to walk around to <MEASURE QTY> thermostats and provide this information at this time?

1	Yes	TV2
2	No, not right now	Schedule follow-up

TV2. Where is the first thermostat located? **RECORD ANSWER. Proceed to TV3**

TV3. Please read me the complete schedule of the (occupied and unoccupied) thermostat including applicable days, time ranges, cooling set points, heating set points, operational mode

(heating/cooling/auto (both)/off), and supply fan setting (on/off/auto). **Record answers below.** Probe if schedule/data is incomplete.

TV4. [If applicable] Where is the second thermostat located? **RECORD ANSWER. Repeat TV3.**

TV5. [If applicable] Where is the third thermostat located? **RECORD ANSWER. Repeat TV3.**

Thermostat schedule and set-points. (Add rows if necessary)
Note: we need set-points for 4 time periods weekday occupied/unoccupied (2) and weekend occupied/unoccupied

Period	Name	Applicable Days and Times	Cooling SP	Heating SP	Operational mode (heating/ cooling/ auto/ off)	Supply Fan (on/off/auto)
1	**TSTAT 1**	MF Occ.				
2		MF Unocc.				
3		SS Occ.				
4		SS Unocc.				
5						
6	**TSTAT2**					
7						
8						
9						
10						
11	**TSTAT3**					
12						
13						
14						
15						
16						

TV6. Since the initial programming by the HVAC contractor has your company <COMPANY NAME> change the thermostat settings during unoccupied periods?

1	Yes	TV7
2	No	TV intro
98	DON'T KNOW	TV intro
99	REFUSED	TV intro

TV7. Please describe the changes you made to the thermostat setting during unoccupied periods since the measure was installed and programmed by the HVAC contractor?

1	Frequent adjustments	TV intro
2	One-time adjustment	TV intro
3	Seasonal adjustments	TV intro
4	On-going/as needed adjustments	TV intro
5	Occupant controlled	TV intro
98	DON'T KNOW	TV intro
99	REFUSED	TV intro

SF Intro.

Supply Fan Controls Verification As I previously mentioned, according to our records <**COMPANY NAME**> implemented controls on their <**MEASURE QTY**> supply fans.

SF1. [If applicable] Are able to answer a couple of questions about how you were using the supply fans before the control measure was implemented?

1	Yes	SF2
2	No, not right now	TT

Ask these 2 questions of all customers that had supply fans controls installed or reprogrammed.

SF2. Prior to implementing controls, what was the setting on the company's supply fans when the building was occupied?

1	On (all the time)	SF3
2	Auto (intermittent)	SF3
3	Off	SF3
99	Don't know	C1

SF3. (This is the really important one!) Prior to implementing controls, what was the setting on the company's supply fans when the building was unoccupied?

1	On (all the time)	C1
2	Auto (intermittent)	C1
3	Off	C1
99	Don't know	C1

Contextual Information I have just one final question about your HVAC maintenance practices prior to participating in <**PROGRAM NAME**> to provide context for this study.

C1. Prior to participating in the <**PROGRAM NAME**> did you regularly perform proactive preventative maintenance on your HVAC systems? **Y/N**

1	Yes	C2
2	No	TT
98	DON'T KNOW	TT
99	REFUSED	TT

C2. If yes, please describe the type of maintenance. Read list. RECORD ANSWER.

1	Clean condenser coil	
2	Clean evaporator coil	

3	Check refrigerant charge	
4	Tighten/replace fan belt	
5	Check economizer operation	
6	Check/replace thermostat	
7	Verify minimum ventilation fan setting	
8	ACCA 180 checklist	
98	Other	Record Verbatim
99	Don't know	

Those are all of our questions. Thank you so much for your time. ☺

6.6.2 PTAC/HP controls data collection form

CA HVAC Group A PTAC Survey

Introduction

Intro1. Hello, my name is _____, and I'm calling on behalf of the **<program>** offered by **<utility>**. I'm calling to discuss the installation of packaged terminal air conditioning equipment at your business in 2017. I'm not selling anything; I'd just like to ask your opinions. Your responses will be kept confidential and your individual responses will not be revealed to anyone.

[IF THEY WANT TO VERIFY THE SURVEY, THEY CAN CONTACT Justin Hagler, HVAC Study Manager at the California Public Utilities Commission, AT (415) 703-5355]

Intro2. Our records show that your business had <measure> installed in 2017 through this 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?

Awareness

A1. Next, I'd like to start by asking you about your awareness of the program.

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]
[<DI Vendor> called]
[<DI Vendor>emailed]
[<DI Vendor>dropped in/came into office]
[<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]

A3. On a scale from 1 to 5 where 1 is not at all concerned and 5 is very concerned, how concerned would you say your organization is about energy cost?

Energy Inspection

M1. Our records show that your business had a Guest Room Energy Management System installed through this program. Does that sound correct? **[IF YES, SKIP TO M4]**

M2. How many **rooms** had the new controls installed?

M4. Are all **Guest Room Energy Management Systems** still installed? **[IF YES, SKIP TO M7]**

M5. How many are still installed?

M6. Why are a different number still installed?

M7. Are all **those still installed** operational? **[IF YES, SKIP TO I1]**

M8. How many are still operational?

M9. Why are a different number still operational?

I1. Our records show the installations took place in 2017. Was that the first time you had participated in this type of program?

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

[Contractor recommendation]
[Rebates]
[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 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 _____]
[Don’t know]
[Refused]

Firmographic Information

Thank you for your patience. We’re almost finished. These final questions are about your company.
F1. Does your company have more than one location?

F2. Do you work out of the main office or is this a satellite or local branch?

F3. About how many full time employees work at this location? **[IF THEIR COMPANY HAS MORE THAN ONE LOCATION, ADDITIONALLY ASK ABOUT HOW MANY EMPLOYEES AT ALL LOCATIONS]**

Thanks & Terminate

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

6.7 Appendix C: Central plant gross data collection forms

6.7.1 Boiler data collection form

Q	Survey Script	Response	Additional Notes
1	What type of loads does the installed boiler(s) serve; space heating, process or both?		
2	Does the installed boiler(s) supply steam or hot water? [If hot water, ask if atmospheric or condensing]		
3	What are the typical facility operating hours?		
4	During which seasons/months of the year does the installed boiler(s) operate?		
5	Does the installed boiler(s) operation vary by season of the year?		
6	Does the installed boiler(s) use any fuel other than natural gas for its operation?		
7	Approximately how old was the boiler(s) that was removed and replaced?		
8	What is the operation type of the installed boiler(s)? - (On/off, modulating etc.)		
9	How would you describe the removed equipment's condition?		
10	Our records indicate that your installed [Boiler Make & Model Number]. Is that correct? [If not, request the make and model number of the installed boiler(s)]		
11	Can you provide the make and model number of the boiler(s) that was removed and replaced? [If not, request the request the size/input capacity of the removed boiler(s)]		
12	Can you estimate the efficiency at which the installed boiler(s) is operating?		
13	Do you have boiler efficiency test reports performed on the installed boiler(s)? [If yes, request]		

Q	Survey Script	Response	Additional Notes
14	[For condensing boilers] Do you have recent logs on return water temperature for the installed boiler(s)? [If yes, request]		
15	[For condensing boilers in pre-existing case] Do you have logs on return water temperature for the pre-existing boiler(s), or can you estimate the return water temperature at which the pre-existing boiler(s) were operating? [If yes, request]		
16	As a standard practice for all projects, we are requesting monthly natural gas usage data for the meter serving the installed boiler(s). Is the installed boiler(s) on a dedicated natural gas meter?		
	[If yes] Ask the following		
	i. Any changes in the way facility equipment was operated since project was installed?		
	ii. Any changes in business hours since project was installed?		
	iii. Any changes in occupancy since project was installed?		
	iv. Any changes in heating temperature set points since project was installed?		
	v. Heating system start month?		
	vi. Heating system end month?		
	vii. Heating space temperature set point for:		
	1. Daytime		
	2. Nights		
	3. Weekends		
	viii. Heating system control type (OA-based, schedule based etc.)?		
	ix. Heating system is enabled if OAT goes below __ °F		
	[If no] Ask the following		
	i. What other end uses are associated with the gas meter (cooking, DHW etc.)? Can you provide information on quantities, capacities and operating schedules of these end uses at the facility?		
	ii. Any changes in the way facility equipment was operated since project was installed?		
	iii. Any changes in business hours since project was installed?		
	iv. Any changes in occupancy since project was installed?		
	v. Any changes in heating temperature set points since project was installed?		
	vi. Heating system start month?		
	vii. Heating system end month?		
	viii. Heating space temperature set point for:		

Q	Survey Script	Response	Additional Notes
	1. Daytime		
	2. Nights		
	3. Weekends		
	ix. Heating system control type (OA-based, schedule based etc.)?		
	x. Heating system is enabled if OAT goes below __ °F		
17	Can you send me copies of monthly natural gas bills from the meter serving the installed boiler(s) for the past 36 months?		
18	Do you have a BMS (Building Management System) system at the facility with trending capabilities on the installed boiler(s)? [If yes, probe further to obtain what parameters are trended and request trend data for analysis]		
19	I have one last request. This evaluation involves a site visit to your facility to confirm that the boiler(s) was installed. We hope to schedule this visit at your convenience. Is there a specific date or time that works for you over the next few [weeks/days]? [Obtain a set of dates that would work for the site personnel]		

6.7.2 Fan VFD data collection forms

6.7.2.1 Fan VFD

Fan VFD Phone Survey Data Collection Worksheet One worksheet can be used for up to 3 impacted fan motor types	Site ID	
	Surveyor	
	Date	

Category	Question/Parameter		Motor 1	Motor 2	Motor 3
Eligibility	According to our records, the project occurred at <Site Address>. Is this correct?	*for Climate Zone*			
	Our records also indicate that VFDs were installed on <quantity> HVAC fan motors, Is this correct?	*Record quantity for each fan motor type*			
	Motor Horsepower	*HP*			
	Application Type	*Supply/return fan/other*			

	Building Type	*e.g., Assembly, Hospital/Clinic etc.*			
	Building Vintage	*e.g., Before 1978, 1978-1992 etc.*			
	Facility HVAC Distribution Type	*e.g., CAV, VAV etc.*			
	Was the fan's airflow controlled prior to the project?	*Yes/No*			
	[If yes] How was the fan's airflow controlled before the VFD installation?	*e.g., Inlet guide vanes, bypass dampers, discharge dampers, VFDs etc.*			
	[If no/don't know] Our records indicate that the fan's airflow was previously controlled by discharge dampers. Is this correct?	*Yes/No*			
	VFDs typically operate safely above a minimum speed setting. Do you know what the minimum allowable fan speed or air flow is for the installed VFD?	*%*			
	Do you know what the minimum allowable air flow was before the VFD was installed?	*%*			
	Did the fan itself change as a result of the VFD installation?	*Yes/No*			
	[If no] Which of the following best describe the type of fan that received the VFD? - Forward curved - Backward inclined - Radial blade	*Forward curved/backward inclined/radial blade etc.*			

	[If yes] Which of the following best describe the type of fan before the VFD installation? - Forward curved - Backward incline - Radial blade	*Forward curved/backward inclined/radial blade etc.*			
	[If yes] Which of the following best describe the type of fan after the VFD installation? - Forward curved - Backward incline - Radial blade	*Forward curved/backward inclined/radial blade etc.*			
	Pre-project fan motor age (years)				
	Pre-project fan controls age (years)				
	Pre-project fan motor condition	*e.g., Working, End-of-life, Failed*			
	Pre-project fan controls condition	*e.g., Working, End-of-life, Failed*			
Next, I'd like to ask about your fan operating schedules that influences the energy savings from this project.					
Fan Operation	Fan Operating Hours (Weekdays)				
	Fan Operating Hours (Weekends)				
	Fan Operating Hours (Holidays)				
	Does the installed fan VFD affect cooling or heating system, or both?				
	Cooling System Months of Operation				
	Heating System Months of Operation				
Next, I'd like to ask about your facility operating patterns that might influence the energy savings from this project.					
Facility Operation	Hours of Operation (Weekdays)				

	Hours of Operation (Weekends)	
	Hours of Operation (Holidays)	
	Holidays Observed	

6.7.2.2 Enhanced ventilation phone interview data collection template

Enhanced Ventilation Phone Survey Data Collection Worksheet One worksheet can be used for upto 3 impacted packaged HVAC units	Site ID	
	Surveyor	
	Date	

Category	Question/Parameter		Unit 1	Unit 2	Unit 3
Eligibility	According to our records, the project occurred at <Site Address>. Is this correct?	*for Climate Zone*			
	Our records also indicate that VFD and NEMA Motor for Gas Pack with ADEC Control were implemented on <quantity> Packaged HVAC units, Is this correct?	*Record quantity for each packaged HVAC type*			
	Building Type	*e.g., Assembly, Hospital/Clinic etc.*			
	Building Vintage	*e.g., Before 1978, 1978-1992 etc.*			
	Space type(s) served by Packaged unit	*e.g., Cafeteria, kitchen etc.*			
	Total capacity of the cooling system affected by the project, in tons:	*tons*			
	Total capacity of the heating system affected by the project, in Btu/h (if applicable)	*Btuh*			

	Which of the following best describes the fan motor type after the ventilation enhancements were made? - Standard motor - NEMA premium efficiency motor - Permanent magnet motor (PMM)	*Standard motor/ NEMA premium efficiency motor/ Permanent Magnet Motor (PMM)*			
	Which of the following best describes the fan motor type prior to the project? - Standard motor - NEMA premium efficiency motor - Permanent magnet motor (PMM)	*Standard motor/ NEMA premium efficiency motor/ Permanent Magnet Motor (PMM)*			
	Was the fan's airflow controlled prior to the project?	*Yes/No*			
	[If yes] How was the fan's airflow controlled before the VFD installation?	*e.g., Inlet guide vanes, bypass dampers, discharge dampers, no controls, VFD etc.*			
	[If yes] Do you know what the minimum allowable air flow was before the VFD?	*%*			
	What is the minimum VFD speed in cooling mode?	*%*			
	What is the minimum VFD speed in heating mode?	*%*			
	What is the minimum air flow ratio of the system (supply fan mode only for occupied times when heating or cooling is not required)?	*%*			
	Are Advanced Digital Economizer Controllers (ADEC) installed on the packaged unit?	*Yes/No*			

	[If yes] Which of the following best describe the economizer control type? - Fixed dry bulb - Differential dry bulb - Fixed enthalpy + Fixed dry bulb	*Fixed dry bulb/ Differential dry bulb/ Fixed enthalpy + Fixed dry bulb*			
	[If fixed dry bulb] Do you know the OA dry bulb temperature at which the economizer would shut off?	*°F*			
	[If differential dry bulb] Do you know the differential temperature set point between OA dry bulb and return air temperature at which the economizer would shut off?	*°F*			
	[If fixed enthalpy + fixed dry bulb] Do you know the OA dry bulb temperature or OA enthalpy at which the economizer would shut off?	*Btu/lb or °F*			
	Was outside air economizing implemented prior to the project?	*Yes/No*			
	[If yes] Was Advanced Digital Economizer Controller (ADEC) installed prior to the project?	*Yes/No*			
	[If yes] Which of the following best describe the economizer control type prior to the project? - Fixed dry bulb - Differential dry bulb - Fixed enthalpy + Fixed dry bulb	*Fixed dry bulb/ Differential dry bulb/ Fixed enthalpy + Fixed dry bulb*			
	[If fixed dry bulb] Do you know the OA dry bulb temperature at which the economizer would shut off?	*°F*			
	[If differential dry bulb] Do you know the differential temperature set point between OA dry bulb and return air temperature at which the economizer would shut off?	*°F*			
	[If fixed enthalpy + fixed dry bulb] Do you know the OA dry bulb temperature or OA enthalpy at which the economizer would shut off?	*Btu/lb or °F*			

	Do you know what the minimum outside air fraction was prior to the project?	*%*			
	Do you know what the maximum outside air fraction was prior to the project?	*%*			
	Pre-project packaged unit age (years)				
	Pre-project packaged unit condition	*e.g., Working, End-of-life, Failed*			
Next, I'd like to ask about your HVAC unit's operating schedules that influences the energy savings from this project.					
HVAC Unit Operation	Packaged Unit Operating Hours (Weekdays)				
	Packaged Unit Operating Hours (Weekends)				
	Packaged Unit Operating Hours (Holidays)				
Next, I'd like to ask about your facility operating patterns that might influence the energy savings from this project.					
Facility Operation	Hours of Operation of Space type served by Packaged unit (Weekdays)				
	Hours of Operation of Space type served by Packaged unit (Weekends)				
	Hours of Operation of Space type served by Packaged unit (Holidays)				
	Holidays Observed				

6.8 Appendix D: Distributor (upstream) NTG interview guide

Introduction

Hello <Distributor Name>, this is <Interviewer name> the reason for my call is that I'm conducting a state-wide evaluation of the utility-sponsored Commercial Upstream Distributor Rebate Program. I'd like to ask you about your companies past experience with this program. This call is sponsored by the CA Public Utilities Commission performed here at DNV GL. (PAUSE). I'd like to assure you that I'm not selling anything and the information you provide is treated confidentially.

[AGREES TO PARTICIPATE]	1	Intro4
[DOES NOT AGREE TO PARTICIPATE]	2	Thank & Terminate

[REPEAT IF NEEDED] All survey information collected including the results to this survey will be treated confidentially and reported in aggregate form.

[IF ASKED] If you would like to verify the legitimacy of this research our CPUC manager is Justin Hagler at xxx-xxx-xxxx. If you have questions about this or the follow up survey you can reach our study manager by calling xxxxx at xxx-xxx-xxxx.

Screener Questions

SC1. The California Investor Owned Utilities, PG&E, SCE and SDG&E deliver incentives through a commercial Upstream HVAC Equipment Incentive Program that buys down the cost of high-efficiency HVAC equipment. The incentive records show your company received rebates. Are you familiar with your company's participation in this program?

Yes	1	G1
No	2	Terminate
Don't know	98	
Refused	99	

S1a. Who at your company could I speak with that would be familiar with this program?

Record and ask to speak with them.	1	G1
No one	2	Terminate
Don't know	98	
Refused	99	

General Distributor Information

Next, I'm going to ask a few general questions about your company.

G1. Which of the following distribution business models best describes your company's practice? Is this company a [Read list]

An Independent HVAC equipment distributor	1	G2
A manufacturer-owned or franchise distributor	2	
An Independent manufacturers' representative	3	
[Combination (list which ones)]	4/Record	
[Other (Self-report]	50/Record	

G2. Does the company also offer HVAC installations?

Yes	1	G3
No	2	D1
Don't know	98	
Refused	99	

G3. Would you say the company is more of a distributor, installer or manufacturer?

Distributor	1	D1
Installer	2	
Manufacturer	3	
Don't know	98	
Refused	99	

G4. How many full time employees work at your company?

Record #	1	D1
Don't know	98	
Refused	99	

Distribution Area

D1. Which regions in California do you distribute your HVAC equipment? Do you sell in northern, central or southern California?

[Northern]	1	D1a
[Central]	2	D1a
[Southern]	3	D1a
[All of the Above]	4	D1a
[Don't know]	98	D1b
[Refused]	99	D1b

D1a. Which of those regions do you have personal knowledge of when it comes to sales and sales practices?

[Northern]	1	D1b
[Central]	2	D1b

[Southern]	3	D1b
[All of the Above]	4	D1b
[Don't know]	98	D1b
[Refused]	99	D1b

D1b. Is there anyone else at <company> who I could talk to that is knowledgeable about sales and sales practices in regions that you're not familiar with?

[Record verbatim] *[If "Yes", ask for contact info at the end of the interview]*		D2
Don't know	98	
Refused	99	

D2. Do you distribute anywhere else besides the state of California?

Yes	1	D2a.
No	2	D4
Don't know	98	
Refused	99	

D2a. Where else do you distribute? [record states or major metropolitan areas]

[Record verbatim]		D3
Don't know	98	D4
Refused	99	

D3. Do sales and/or stocking practices differ significantly in regions outside of California?

Yes	1	D3a
No	2	D4
Don't know	98	
Refused	99	

D3a. Why do you say that? [Probe: How are these markets different? How are they similar?]

[Record verbatim]		D3b
Don't know	98	
Refused	99	

D3b. Is there anyone else we should speak to at the company in those states?

[Record verbatim] *[If "Yes", ask for contact info at the end of the interview]*		D4
Don't know	98	

Refused	99	

Equipment type and sizes distributed

Next, I'd like to ask about a few equipment types distributed in California.

D4. Do you sell or distribute Unitary Air-Cooled or Water-Cooled Equipment (a.k.a. Air Conditioners, Heat Pumps, Rooftop Units, Package Units)?

Yes	1	D5
No	2	D6
Don't know	98	
Refused	99	

D5. Do you sell the following sizes?

D5	Unitary Air-Cooled or Water Cooled Equipment Size Category	Response Code		Skip Logic
		Yes	1	
		No	2	
		Don't know	98	
		Refused	99	
D5a	≤ 20 ton			D6
D5b	>20 ton			

D6. Do you sell or distribute Chiller Systems?

Yes	1	D7
No	2	D8
Don't know	98	
Refused	99	

D7. Do you sell the following types and sizes?

D7	Size Category	Response Code		Skip logic
		Yes	1	
		No	2	
		Don't know	98	
		Refused	99	
D7a	Air-Cooled			D8
D7b	Water Cooled ≤300 ton			

D7c	Water Cooled >300 ton	

D8. Do you sell or distribute Variable Refrigerant Flow (VRF) Systems?

Yes	1	ME1
No	2	
Don't know	98	
Refused	99	

Market effects

A.1 Sales

[Repeat for each equipment type and size that the respondent indicates their company sells]

ME1. In the past year, about what percentage of [equipment type] [size] that were sold in California would you estimate were high-efficiency, which is defined as Tier 1 and above?

ME1	Unitary Air-Cooled or Water Cooled Equipment Size Category	Response Code: [Record % in table]	Response Code	Skip Logic
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
ME1a	≤ 20 ton			ME2
ME1b	>20 ton			

ME1	Chillers Size Category	Response Code: [Record % in table]	Response Code	Skip logic
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
ME1c	Air-Cooled			ME2
ME1d	Water Cooled ≤300 ton			
ME1e	Water Cooled >300 ton			

M12	Variable Refrigerant Flow (VRF) Systems	Response Code: [Record % in table]	Response Code	Skip Logic
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
ME1f	VRF			ME2

ME2. What percent of all the high-efficiency [equipment type] [size] had a rebate claimed?

ME2	Unitary Air-Cooled or Water Cooled Equipment Size Category	Response Code: [Record % in table]	Response Code	Skip Logic
		Don't know	98	
		Refused	99	
		Not Applicable	NA	

ME2	Chillers Size Category	Response Code: [Record % in table]	Response Code	Skip logic
		Don't know	98	
		Refused	99	
		Not Applicable	NA	

ME2a	≤ 20 ton		ME2 <100%, then to go ME3, otherwise skip to ME4
ME2b	>20 ton		

ME2c	Air-Cooled		ME2 <100% then to go ME3, otherwise ski to ME4
ME2d	Water Cooled ≤300 ton		
ME2e	Water Cooled >300 ton		

ME2	Variable Refrigerant Flow (VRF) Systems	Response Code		Skip Logic
		[Record % in table]		
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
ME2f	VRF			ME2 <100%, then to go ME3, otherwise skip to ME4

ME3. Why doesn't your company submit rebates for all the high-efficiency equipment types? [Reflect all that apply]

Not qualified	1	ME4
Missed opportunity	2	
Paid through down/mid-stream rebate	3	
Not in PA service territory	4	
Other reason	50	
Don't know	98	
Refused	99	

ME4. What factors do you believe are the most influential in the sale of your company's high-efficiency equipment? [PROMPT AS NEEDED, RECORD ALL THAT APPLY]

Market demand or turns rate	1	ME5
Utility rebates	2	
Competitive comparisons/market competition	3	
Manufacturer rebates	4	
Energy costs	5	
Sales marketing/education	6	
Vendor promotions	7	
New product line offering	8	
Other (Record)	50	
Don't know	98	
Refused	99	

A.2 Stocking

Next, I would like to ask about stocking.

ME5. Does your company maintain a stock of high-efficiency [equipment type]? [Ask for each of the 3 equipment types sold.]

Yes	1	ME6
No	2	U1
Don't know	98	
Refused	99	

ME6. How are stocking decisions made for high-efficiency equipment?

[Record verbatim]		ME6b
Don't know	98	ME7
Refused	99	U1

ME6b. How, if at all, do factors like equipment size and type affect your stocking decisions?

[Record verbatim]		ME7
Don't know	98	ME7
Refused	99	U1

ME7. Are the inventories for high-efficiency equipment relatively constant, or are there seasonal fluctuations? [Reflect all that apply]

Constant	1	ME8
Seasonal variation	2	
[Varies by equipment type (record)]	3	
[Made to order]	4	
[Don't know]	98	
[Refused]	99	

ME8. What factors do you believe are the most influential in the stocking of your high-efficiency equipment? [PROMPT AS NEEDED, RECORD ALL THAT APPLY]

Utility rebates	1	ME11
Market demand or turns rate	2	ME9
Competitive comparisons/market competition	3	
Manufacturer rebates	4	
Energy costs	5	
Sales marketing/education	6	

Vendor promotions	7	
New product line offering	8	
Warehouse size limitations	9	
Other	50	
Don't know	98	
Refused	99	

ME9. Does the rebate influence the selection of high-efficiency HVAC equipment the company keeps in stock?

Yes	1	ME10
No	2	ME10
Don't know	98	ME11
Refused	99	ME11

ME10. Why do you say that?

[Record verbatim]		ME11
Don't know	98	
Refused	99	

*[**Question related to NTG calculations***

Repeat for each equipment type and size confirmed as sold in questions D4-D7]

ME11. For all [equipment type X] approximately how many [equipment type] [size] to do you normally keep available in stock? *[Probe: this includes regular and high-efficiency equipment? Emphasize a "soft estimate" is fine, and we're looking specifically at the CA market]*

ME11	Unitary Air-Cooled or Water Cooled Equipment Size Category	Response Code		Skip Logic
		[Record # in table]		
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
ME11a	≤ 20 ton			ME12
ME11b	>20 ton			

ME11	Chillers Size Category	Response Code		Skip logic
		[Record # in table]		
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
ME11c	Air-Cooled			ME12
ME11d	Water Cooled ≤300 ton			
ME11e	Water Cooled >300 ton			

ME11	Variable Refrigerant Flow (VRF) Systems	Response Code		Skip Logic
		[Record % in table]		
		Don't know	98	
		Refused	99	

		Not Applicable	NA	
ME11f	VRF			ME12

*[**Question related to NTG calculations***

Repeat for each equipment type and size confirmed as sold in questions D4-D7]

ME12. Of those, how many are high-efficiency?

ME12	Unitary Air-Cooled or Water Cooled Equipment Size Category	Response Code		Skip Logic
		[Record # in table]		
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
ME12a	≤ 20 ton			ME13
ME12b	>20 ton			

ME12	Chillers Size Category	Response Code				Skip logic
		[Record # in table]				
		Don't know	98			
		Refused	99			
		Not Applicable	NA			
ME12c	Air-Cooled					ME13
ME12d	Water Cooled ≤300 ton					
ME12e	Water Cooled >300 ton					

ME12	Variable Refrigerant Flow (VRF) Systems	Response Code		Skip Logic
		[Record % in table]		
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
ME12f	VRF			ME13

*[**Question related to NTG calculations***

Repeat for each equipment type and size confirmed as sold in questions D4-D7]

ME13. If the program weren't available, how many of these high-efficiency [equipment type] [size] would you stock?

ME13	Unitary Air-Cooled or Water Cooled Equipment Size Category	Response Code		Skip Logic
		[Record # in table]		
		No change	97	
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
ME13a	≤ 20 ton			ME14
ME13b	>20 ton			

ME13	Chillers Size Category	Response Code				Skip logic
		[Record # in table]				
		No change	97			
		Don't know	98			
		Refused	99			
		Not Applicable	NA			
ME13c	Air-Cooled					ME14
ME13d	Water Cooled ≤300 ton					
ME13e	Water Cooled >300 ton					

ME13	Variable Refrigerant Flow (VRF) Systems	Response Code		Skip Logic
		[Record % in table]		
		No Change	97	
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
ME13f	VRF			ME14

[We are summing the values for ME12 for the ME15 QC question]

ME14. From your previous responses [in ME12] it appears that you have a total of [equipment type] in stock, across all sizes. Does that sound correct?

ME14	Unitary Air-Cooled or Water Cooled Equipment Size Category	Response Code		Skip Logic
		Yes	1	
		No	2	
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
ME14a	Total			U1

ME14	Chillers Size Category	Response Code		Skip logic
		Yes	1	
		No	2	
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
ME14b	Total			U1

ME14	Variable Refrigerant Flow (VRF) Systems	Response Code		Skip Logic
		Yes	1	
		No	2	
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
ME14c	VRF			U1

Upselling

U1. Can you describe what your company's marketing practices are? *[Probe: By marketing, we mean any actions your company takes to promote and sell their products]*

[Record verbatim]		U2
Don't know	98	
Refused	99	

U2. Does your company make HVAC equipment recommendations to contractors or other buyers?

Yes	1	U2a
No	2	P1
Don't know	98	
Refused	99	

U2a. What percent of the time does your company make any recommendation to buyers?

[Record %]		
Don't know	98	U3
Refused	99	

U2b. What information do you consider when you make recommendations?

[Record verbatim]		U2c
Don't know	98	U3
Refused	99	U3

U2c. How do you determine what efficiency level to recommend?

[Record verbatim]		U3
Don't know	98	U3
Refused	99	U3

U3. Does the Upstream rebate influence the equipment efficiency level your company recommends to buyers?

Yes	1	U4
No	2	U3a
Don't know	98	U4
Refused	99	U4

U3a. Why do you say that? *[Probes "why does it [rebate] influence/why is it not influential?"]*

[Record verbatim]		
Don't know	98	P1
Refused	99	

[Question related to NTG calculations

Repeat for each equipment type and size confirmed as sold in questions D4-D7]

U4. In situations where you are selling [equipment type] [size], about what percent of the time are you recommending the high-efficiency equipment?

U4	Unitary Air-Cooled or Water Cooled	Response Code [Record % in table]		Skip Logic

U4	Chillers Size Category	Response Code [Record % in table]		Skip logic

	Equipment Size Category	Don't know	998	
		Refused	999	
		Not Applicable	NNA	
U4a	≤ 20 ton			U5
U4b	>20 ton			

		Don't know	98	
		Refused	99	
		Not Applicable	NA	
U4c	Air-Cooled			U5
U4d	Water Cooled ≤300 ton			
U4e	Water Cooled >300 ton			

U4	Variable Refrigerant Flow (VRF) Systems	Response Code [Record % in table]		Skip Logic
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
U4f	VRF			U5

*[**Question related to NTG calculations***

Repeat for each equipment type and size confirmed as sold in questions D4-D7]

U5. For [equipment type] [size], what percent of the time would you recommend the high-efficiency equipment without the Program? *[Probe: and what we mean by "without the program" is supposing the program ran out of funding next month]*

U5	Unitary Air-Cooled or Water Cooled Equipment Size Category	Response Code [Record % in table]		Skip Logic
		Don't know	998	
		Refused	999	
		Not Applicable	NNA	
U5a	≤ 20 ton			P1
U5b	>20 ton			

U5	Chillers Size Category	Response Code [Record % in table]		Skip logic
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
U5c	Air-Cooled			P1
U5d	Water Cooled ≤300 ton			
U5e	Water Cooled >300 ton			

U5	Variable Refrigerant Flow (VRF) Systems	Response Code [Record % in table]		Skip Logic
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
U5f	VRF			P1

Trickle down incentives

P1. How does your company determine the price the buyer pays for the high-efficiency HVAC equipment we've been discussing?

[Record verbatim]		P2
Don't know	98	
Refused	99	

P2. Is the price ever negotiable?

Yes	1	P3
No	2	
Don't know	98	
Refused	99	

P3. Does the rebate impact the final price paid by the buyer?

Yes	1	P4
No	2	P3a
Don't know	98	S1
Refused	99	S1

P3a. Why do you say that?

[Record verbatim]		S1
Don't know	98	
Refused	99	

*[**Question related to NTG calculations***

Repeat for each equipment type and size confirmed as sold in questions D4-D7]

P4. On average, what percent of the rebate is passed on to the buyer for [equipment type] [size], either directly or indirectly?

P4	Unitary Air-Cooled or Water Cooled Equipment Size Category	Response Code		Skip Logic
		[Record % in table]		
		Don't know	998	
		Refused	999	
		Not Applicable	NA	
P4a	≤ 20 ton			S1
P4b	>20 ton			

P4	Chillers Size Category	Response Code		Skip log
		[Record % in table]		
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
P4c	Air-Cooled			
P4d	Water Cooled ≤300 ton			S1
P4e	Water Cooled >300 ton			

P4	Variable Refrigerant Flow	Response Code		Skip Logic
		[Record % in table]		

	(VRF) Systems	Don't know	98
		Refused	99
		Not Applicable	NA
P4f	VRF		S1

Program influence on sales

[You will be using previous response from ME1 Table for question S1]

*[**Question related to NTG calculations***
Repeat for each equipment type and size confirmed as sold in questions D4-D7]

S1. Earlier you described the percent of high-efficiency sales across the different equipment types in California [Question ME1]. Had there been no Upstream rebates 2015, what percent of high-efficiency sales do you think these [equipment type] [size] sales would be?

S1	Unitary Air-Cooled or Water Cooled Equipment Size Category	Response Code		Skip Logic
		[Record % in table]		
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
S1a	≤ 20 ton			PE1
S1b	>20 ton			

S1	Chillers Size Category	Response Code		Skip logic
		[Record % in table]		
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
S1c	Air-Cooled			PE11
S1d	Water Cooled ≤300 ton			
S1e	Water Cooled >300 ton			

S1	Variable Refrigerant Flow (VRF) Systems	Response Code		Skip Logic
		[Record % in table]		
		Don't know	98	
		Refused	99	
		Not Applicable	NA	
S1f	VRF			PE11

Process questions

[Go through this section if you have time, and participant doesn't seem anxious to get off the phone. These questions are "nice to haves", not "must haves".]

PE1. Do you have any suggestions on how the program can be improved?

[Record verbatim]		PE2
Don't know	98	
Refused	99	

PE2. Is there anything else you would like to tell us regarding your experience with this program?

[Record verbatim]		End

Don’t know	98	
Refused	99	

End. Those are all the questions I have for you today. Unless you have any questions for me, we are finished. Thank you for your time and cooperation.

6.9 Appendix E: Contractor (midstream) interview guide

CPUC HVAC# Contractor NTG Survey	
Introduction	
	Name
Intro4	Position
Intro5	Years in position
Framing	
	What are <program> basics
Frame1	When did you start with the <program>?
Services	
Frame2	Offered through program
Frame3	Offered before program
Frame4,5	Offered outside program
Frame6	Changes to…
Frame7	If program ended, would you change…
Sales Practices	
Frame8	Offered through program
Frame9	Offered before program
Frame10	Offered outside program
Frame11	Changes to…
Frame12	If program ended, would you change…
Impression of Customers	
Frame13	Customers informed about QM/TU
Frame14	Importance of QM/YU
Satisfaction with	
Frame15	Training
Frame16	Leads
Frame17	Incentives
Frame18	Marketing
Attribution	
Frame3	QM/TU offered before the program
Frame3a	If so, were services different and how
Attr1	Any participating customers received services prior to program
Attr1a	If so, what %
Attr2	[ASSESSMENT ATTRIBUTION QUESTION]
Spillover	
Spill1	Program used outside of incentive jobs
Spill2	What %

Note: This document is currently designed for trained DNV GL staff to execute surveys.

Introduction

Hello, my name is ___ and I'm calling from DNV GL on behalf of the <program> that is sponsored by <PA>. We are calling for research for the California Public Utilities Commission about the <program> that your company participates in, not for any sales purposes. Is <contact> available?
Intro:
According to records from <PA>, your company participated in the <program. <PA> wants to ask your company a few questions that will allow them to improve their program.

[IF NECESSARY, ADD: "We're not selling anything, this is purely for research purposes to help <PA> improve this <program>"]

[IF NECESSARY, ADD: "All your responses will be kept confidential."]

Intro1. Are you familiar with the <program> program?

1	Yes	Go to Intro4.
2	No	Intro1a
98	Don't know	
99	Refused	

a) Is there somebody else with your company who might be familiar with this program?

1	Yes	Go to Intro2
2	No	Thank and terminate
98	Don't Know	Thank and terminate
99	Refused	Thank and terminate

Intro2. What is the name and contact information of the person you suggest?

a) Name
b) Title
c) Phone
d) Call back date
e) Call back time

Intro3. And can you give me your name, so I can mention it when I call?

a) Name
b) Title

Thank and terminate.
[Keep following up until the right person is on the phone, then start at beginning]

Intro4. Could you please tell me what your position is at <company>?

Intro5. And how long have you been working in this position at <company>?

Intro6. Which of the following are you familiar with? [CHECK ONE]

1	The sales practices for your whole location	GOTO FRAMING
2	<company>'s sales practices across the entire state of California	GOTO FRAMING
3	Only your own personal sales	
98	Don't Know	
99	Refused	GOTO FRAMING

Intro7. Can you give me the contact information for a person who might be familiar with <company>'s sales practices for your whole location and/or the entire state?

a) Name
b) Title
c) Phone
d) Call back date
e) Call back time

Framing

A.1 Services

Frame1. Approximately how many years ago did your company first begin participating in the <program>?

1	Record # Years	Frame2
98	Don't know	
99	Refused	

Frame2. What services do you offer to customers through the <program>?

[If necessary: we are asking about any and all potential services that you offer to customers through <program>.]

(Select *all* that are mentioned. If they say that they offer a package of maintenance services, record and ask them to specify which services this package includes.)

1	A package of maintenance services	Frame3
2	Coil cleaning – condenser	
3	Coil cleaning – evaporator	
4	Refrigerant charge adjustment RCA	
5	Economizer repair	
6	Thermostat adjustment	
7	Fan Control adjustment	
77	Other: (Record)	
98	Don't Know	Intro1a
99	Refused	

Frame3. Did you offer any of those services to customers before working with the <program> in <Q7 response>?

1	Yes	Frame3a
2	No	Frame4
98	Don't Know	
99	Refused	

a) Which of these services did you offer before participating in the program?

(Select *all* that are mentioned. If they say that they offered a package of maintenance services before program involvement, ask them to specify which services this package included.)

1	Coil cleaning – condenser	Frame4
2	Coil cleaning – evaporator	
3	RCA	
4	Economizer	
5	Thermostat	
6	Fan Control	
77	Other: (Record)	
98	Don't Know	
99	Refused	

Frame4. Do you currently offer any HVAC maintenance or tune-up services to customers that are not participating in the <program>?

1	Yes	Frame5
2	No	Frame6
98	Don't Know	
99	Refused	

Frame5. What types of HVAC maintenance or tune-up services do you offer these non-program customers?

(Select all that are mentioned. If they say that they offer a package of maintenance services, ask them to specify which services this package includes.)

1	Coil cleaning – condenser	Frame6
2	Coil cleaning – evaporator	
3	RCA	
4	Economizer	
5	Thermostat	
6	Fan Control	
77	Other: (Record)	
98	Don't Know	
99	Refused	

Frame6. Has the <program> caused you to change your HVAC maintenance or tune-up service offerings?

1	Yes	go to Frame6b
2	No	If Frame3≠1, goo Frame6a, else go to Frame7
98	Don't Know	Frame7
99	Refused	

a) Can you please clarify? You previously said that prior to participating in the program, you did not offer <maintenance/tune-up services mentioned Frame4>.

(Change responses to appropriate questions, OR Record explanation)

(This is a consistency check – be sure to be polite and to not "badger the witness")

1	Record explanation:	Frame7
98	Don't Know	
99	Refused	

b) How has the program caused you to change your HVAC maintenance and tune-up service offerings?

1	Record:	Frame7
98	Don't Know	
99	Refused	

Frame7. If the program were to end tomorrow, would you continue to offer all of the same HVAC maintenance and tune-up services that you are currently offering?

1	Yes	Frame8
2	No	Frame7a
98	Don't Know	Frame8
99	Refused	

a) Which HVAC maintenance or tune-up services would you stop offering if the program went away?

(Select *all* that are mentioned)

1	Coil cleaning – condenser	Frame7b
2	Coil cleaning – evaporator	
3	RCA	
4	Economizer	

5	Thermostat	
6	Fan Control	
77	Other: (Record)	
98	Don't Know	Frame8
99	Refused	

b) Why would you stop offering these maintenance or tune-up services if the program went away?

1	Lack of customer interest	Frame8
2	Unavailability of rebates	
77	Other: Record	
98	Don't Know	
99	Refused	

A.2 Sales practices

Frame8. I would like to ask about your sales practices. How do you sell <program> services to customers?

Probe for:

- How new customers are identified
- Sales pitch
- Feature energy efficiency
- Feature QM or TU branding?
- Mention programs specifically by name?

Frame9. [Ask if Frame4 =1, else go to Frame11]

You indicated earlier that you also offer HVAC maintenance or tune-up services to customers who are not in this program. How do you sell non-program maintenance or tune-up services to customers?

[If it is a different sales method than the program sales method (see response to Frame8), probe for reasons for these differences]

1	Record:	Frame10
98	Don't Know	
99	Refused	

Frame10. [Ask if Frame3 =1, else go to Frame11]

You indicated earlier that you offered HVAC maintenance or tune-up services to customers *before* you joined the program? What were your sales practices for these HVAC maintenance or tune-up services before participating in the program?

[If it is a different sales method than the program sales method (see response to Frame8), probe for reasons for these differences]

1	Record:	Frame11
98	Don't Know	
99	Refused	

Frame11. Has the program caused you to change your sales practices for HVAC maintenance or tune-up services?

1	Yes	go to Frame11c
2	No	If sales practices in response to Frame8 (with program) are different

		than those for Frame 10 (before program), then Go to Frame11a, else go to Frame11b
98	Don't Know	Frame 12
99	Refused	

a) Could you please clarify? You previously said that prior to participating in the program, you did not you did not offer <maintenance/tune-up services mentioned Frame4>, but your sales practices have not changed. How is it that you are offering more services, but your sales practices are unchanged?

(Change responses to appropriate questions, OR Record explanation)
(This is a consistency check – be sure to be polite and to not "badger the witness")

1	Record explanation:	Frame12
98	Don't Know	
99	Refused	

b) Why haven't your sales practices for HVAC maintenance or tune-up services changed as a result of your participation in the program? [PROBE FOR DETAILS]

1	Record:	Frame12
98	Don't Know	
99	Refused	

c) How has the program caused you to change your sales practices for HVAC maintenance or tune-up services? [PROBE FOR DETAILS]

1	Record:	Frame12
98	Don't Know	
99	Refused	

Frame12. [Ask if IF Frame7=1 (THEY WILL CONTINUE TO OFFER HVAC MAINTENANCE/TUNE-UP SERVICES IF THE PROGRAM WENT AWAY) else skip to Frame13]
If the program were to end tomorrow, would you continue to use the same sales practices for your maintenance and tune-up services that you are currently using?

1	Yes	Frame12a
2	No	Frame13
98	Don't Know	
99	Refused	

a) If yes, how?

1	Record:	Frame13
98	Don't Know	
99	Refused	

A.3 Impressions of customers

I would now like to your thoughts about how your customers are reacting to this program.
Frame13. In your opinion, how informed are your customers about the HVAC maintenance/tune-up services which the program supports? On a scale of 1 to 10, where 10 is 'completely informed' and 1 is 'not informed at all,' how informed are your customers about these services?

1	Record Score:	If <8, Frame13a Else Frame14
98	Don't Know	
99	Refused	

a) If <8: What do you think could be done to increase customer awareness of program services?

1	Record:	Frame 14
98	Don't Know	
99	Refused	

Frame14. In your opinion, how much do you think your customers value these HVAC maintenance or tune-up services which the program supports?? Please use a scale of 1 to 10 where 10 is "extremely valuable" and 1 is "not valuable at all".

1	Record Score:	If <8, Frame14a Else Frame15
98	Don't Know	
99	Refused	

a) If <8: What do you think could be done to make customers value these services more?

1	Record:	Frame 15
98	Don't Know	
99	Refused	

A.4 Satisfaction & program impressions

The program offers various services designed to help contractors sell HVAC maintenance or tune-up services. I'm going to mention four of these. For each one I mention please let me know: a) if you have received that program service 2) And, if yes, how satisfied you have been with it. For your satisfaction, we're going to use a 10-point scale where a 10 is "very satisfied" and 1 is "very dissatisfied"

		a. Have you received this program service?	b. How satisfied were you with it? (Use 10-point satisfaction scale)	c. Why do you say that? (If satisfaction <8)
Frame15.	Maintenance Training (provide brief description of service)	If Yes, go to 15b. All other responses go to Frame16		
Frame16.	Sales Leads provide brief description of service)	If Yes, go to 16b. All other responses go to Frame17		
Frame17.	Financial Incentives (Rebates) provide brief description of service)	If Yes, go to 17b. All other responses go to Frame18		
Frame18.	Program Marketing Materials and Advertisement provide brief description of service)	If Yes, go to 18b. All other responses go to Attr1		

Attribution

Attr1. [Ask IF Frame3=1, else go to Attr2]

You indicated earlier that you had offered HVAC maintenance or tune-up services before joining this program. Of the customers you have offered program services to, did any of them receive your maintenance/tune-up services prior to program participation?

1	Yes	Attr1a
2	No	Attr2
98	Don't Know	
99	Refused	

a) Approximately what % of your customers that have participated in the program also received your maintenance/tune-up services prior to program participation?

1	Record %	Attr2
98	Don't Know	
99	Refused	

Attr2. In [YEAR] you implemented [#] maintenance/tune-up measures through [PROGRAM NAMES] including [LIST OF QUANTITIES OF TOP 5 MEASURES]. If these program trainings, customer leads, program endorsements, program market materials and program incentives had not been

available, approximately what % of maintenance/tune-up services would you still have provided in [YEAR]?

1	Record %	Attr2a
98	Don't Know	Attr3
99	Refused	

a) Why do you say that?

1	Record:	Attr3
98	Don't Know	
99	Refused	

Attr3. Are there any particular maintenance/tune-up measures that stand out to you as not likely to occur without the assistance of the program?

1	Yes	Attr3a
2	No	Spill1
98	Don't Know	
99	Refused	

a) Which maintenance/tune-up measures, in particular, do you think would ***not*** likely to occur without the assistance of the program? [Record all identified]

1	Coil cleaning – condenser	Attr3b
2	Coil cleaning – evaporator	
3	RCA	
4	Economizer	
5	Thermostat	
6	Fan Control	
98	Don't Know	Spill1
99	Refused	

b) [IF THEY NAMED SPECIFIC MEASURES] You just said that if these program trainings, customer leads, program endorsements and program incentives had not been available, you **still** would have provided approximately [X%] of maintenance/tune-up services that you provided in [YEAR]? What % of [MEASURE X] would you have provided in the absence of the program?

[Note to reviewers: Data collection instrument will include note to ensure interviewers understand to look for contradictions between responses to A and B

Also, collection instrument will automatically fill responses from previous questions in here.]

1	Coil cleaning – condenser	Spill1
2	Coil cleaning – evaporator	
3	RCA	
4	Economizer	
5	Thermostat	
6	Fan Control	
77	Other: (Record)	
98	Don't Know	
99	Refused	

[NOTE TO INTERVIEWERS: IF THE RESPONDENT UNDERSTOOD THE QUESTION, THE MEASURE-SPECIFIC % (b) SHOULD BE LOWER THAN THE PROGRAM-SPECIFIC QUESTION. IF THIS IS NOT THE CASE, PLEASE CLARIFY THE QUESTION AND RESPONSE WITH THE RESPONDENT

IF THE RESPONDENT MENTIONS MULTIPLE MEASURES WITH DIFFERENTIAL EFFECTS, LIMIT THE MEASURE-SPECIFIC QUESTIONS ONLY TO THREE MEASURES [TO BE DETERMINED BY EVALUATION TEAM BASED ON GROSS SAVING IMPACTS]

Spillover

Spill1. Do you also use QM or tune-up program training, checklists, tools, and/or protocols for HVAC maintenance jobs that do not receive a QM or tune-up program incentive, but are eligible for the QM or tune-up program?

1	Yes	Spill2
2	No	F1
98	Don't Know	
99	Refused	

Spill2. What percent of HVAC maintenance jobs that you perform with these receive methods and/or tools receive incentives through the QM or tune-up programs?

1	Record %	F1
98	Don't Know	
99	Refused	

Firmographics

F1. Does your company have more than one location?

1	Yes	F2
2	No	F3
98	Don't Know	
99	Refused	

F2. Do you work out of the main office or is this a satellite or local branch?

1	Main office	F3
2	Satellite office/ Local branch	
3	Other: Specify	

98	Don't Know	
99	Refused	

F3. About how many full-time employees work at this location?

[IF THEIR COMPANY HAS MORE THAN ONE LOCATION, ADDITIONALLY ASK ABOUT HOW MANY EMPLOYEES AT ALL LOCATIONS]

1	Record # at location	F4
2	Record at all locations (if applicable)	
98	Don't Know	
99	Refused	

F4. Approximately what percentage of your HVAC and water heating equipment sales occurred in the residential versus commercial markets? [%s SHOULD ADD UP TO 100%]

1	Residential %	F5
2	Commercial %	
3	Other	
98	Don't Know	
99	Refused	

F5. I'm going to read a short list of services. Please tell me if your company performs the service for residential customers.

a. Repairs

b. Replacements

c. New Installations

F6. Do you offer these same services to your commercial customers?

1	Yes	End
2	No	go to F7
98	Don't Know	End
99	Refused	End

F7. How are your commercial offerings different?

1	Record # at location	End
98	Don't Know	
99	Refused	

End: Thank and terminate

6.10 Appendix F: Unitary VRF interview guides

6.10.1 Rooftop or split systems (downstream) interview guide

Introduction

Hello, my name is [Interviewer_name] and my company, Pacific Market Research, is calling on behalf of the California Public Utilities Commission and electric utility, [Utility]. Our records show that your company installed high efficiency air conditioning equipment around [Months] in [Year]. The reason for my call is we are conducting research to learn more about the decision to purchase this equipment. Is the person most familiar with this purchase available?

[DO NOT READ. ADDITIONAL INFORMATION AS NEEDED]

[Measure1_Type] at [Measure1_SiteAddress1], [Measure1_SiteAddress2] , [Measure1_SiteAddress3] , [Measure1_SiteAddress4] , [Measure1_SiteAddress5]

[Measure2_Type] at [Measure2_SiteAddress1], [Measure2_SiteAddress2] , [Measure2_SiteAddress3] , [Measure2_SiteAddress4] , [Measure2_SiteAddress5]

[Measure3_Type] at [Measure3_SiteAddress1], [Measure3_SiteAddress2] , [Measure3_SiteAddress3] , [Measure3_SiteAddress4] , [Measure3_SiteAddress5]

Business name: [ContactName_string] IF INCORRECT BUSINESS NAME, ASK IF FAMILIAR WITH ADDRESSES, IF YES CONTINUE – IF NO TERMINATE – NOT FAMILIAR WITH ADDRESSES

[AGREES TO PARTCIPATE]	1	S1
[DOES NOT AGREE TO PARTCIPATE]	2	Thank & Terminate
[DOES NOT KNOW WHO MADE PURCHASE]	3	S1.1

S1.1. Do you own or lease your business space?

Own	1	Thank & Terminate
Rent/lease	2	S1.2
Don't know/Refused	2	Thank & Terminate

S1.2. Do you have a name and phone number for your property manager you can share with me for HVAC installation purchase decisions?

Yes - Record Name and Contact Info	1	Call and go back to Intro
No	2	Thank & Terminate
Don't know	98	
Refused	99	

[REPEAT IF NEEDED] All survey information collected including the results to this survey will be treated confidentially and reported in aggregate form.

I'd like to assure you that I'm not selling anything and the information you provide is treated confidentially.

[IF ASKED] If you would like to verify the legitimacy of this research our CPUC manager is Lola Odunlami at (415) 703-1893. If you have questions about this or the follow up survey you can reach our study manager by calling Jason Meyer at (707) 266-8332

Screener questions

S1. Are you familiar with the company's decision to install [MeasureGroup_string] sometime around [Month] in [Year]?

Yes	1	G1
No	2	S2
Don't know	98	
Refused	99	

S2. Who do you suggest I speak with that would be familiar with this purchase decision?

Record Name and Contact Info		S3
No	2	Terminate
Don't know	98	
Refused	99	

S3. Is this person an HVAC contractor?

Yes	1	Terminate
No	2	Continue
Don't know	98	

Thank you for your time.

General buyer information

I have a few general questions about your company's purchase decisions for newly installed HVAC equipment.

[DO NOT READ: The intent of G1 is to confirm purchase of program equipment]

INSTRUCTIONS TO PMR: START LOOPING HERE

G1. Our records show that around [Month] of [Year], your company installed [Measure1_Type] that was/were installed at sites, such as [Measure1_SiteAddress1], [Measure1_SiteAddress2] , [Measure1_SiteAddress3] , [Measure1_SiteAddress4] , [Measure1_SiteAddress5] .

. Does that sound correct?

Yes	1	G3
No, the equipment type is wrong	2	G2.1
No, the site addresses are wrong	3	G2.2
No, both the equipment type and site addresses are wrong	4	G2.1 then G2.2
No equipment was installed at these sites	5	Next Loop or F1
Don't know	98	
Refused	99	

G2.1 Can you describe the correct equipment type that was installed at these sites?

[Measure1_TypeUpdate]		If G2=4 go to G2.2 otherwise G3a
[Measure2_TypeUpdate]		
[Measure3_TypeUpdate]		
Verbatim		
No	2	
Don't know	98	
Refused	99	

G2.2 Can you describe the correct addresses where this equipment type was installed?

[Measure1_SiteAddress1]		G3s
[Measure1_SiteAddress2]		
[Measure1_SiteAddress3]		
[Measure1_SiteAddress4]		
[Measure1_SiteAddress5]		
Verbatim		
No	2	
Don't know	98	
Refused	99	

G3a. When did you first start considering installing high efficiency [MeasureGroup_String] equipment?

Month		G3b
Year		G3b
Don't know	98	G3c
Refused	99	G3c

G3b. What caused you to start thinking of high efficiency [MeasureGroup_String] equipment at that time? [PROBE: Was there any particular event or situation that made you realize it was time to look for high efficiency [MeasureGroup_String] equipment?]

Verbatim	
Don't know	98
Refused	99

G3c. When you purchased the [MeasureGroup_string], what factors influenced your equipment choice? *[DO NOT READ LIST. MARK ALL THAT APPLY]*

Energy savings/ROI	1	IF THEY NAME MORE THAN ONE REASON, GO TO G4, OTHERWISE SKIP TO G65
Lifecycle cost	2	
Equipment price	3	
Organization goals/requirements	4	
Physical size/space limitations	5	
Reach code/LEED design	6	
Incentives/promotions	7	
Brand name/reputation	8	
Reliability	9	
Contractor recommendation	10	
New/updated equipment features	11	
Decrease maintenance costs	12	
Improve health/safety/comfort	13	
Improve productivity	14	
Old equipment failed / end of useful life	15	
Other reasons (describe)	50	
Don't Know	98	
Refused	99	

G4. You cited multiple factors which influenced your decision to purchase this equipment. These included [response to G3c]. Which of these reasons would be your most important?

Verbatim		
Don't know	98	
Refused	99	Go to G5

G5. What challenges did you encounter when selecting the specific [MeasureGroup_string] equipment that you decided to install?

Verbatim		Go to G6

Don’t know	98	Go to ST1
Refused	99	Go to ST1

G5. What, if anything, helped you overcome those challenges?

Verbatim		
Don’t know	98	
Refused	99	Go to ST1

For these next set of questions, I would like you to think specifically about the [Measure1_Type] that was/were installed at around [Month] of [Year].

Influence of stock

ST1. Were all these [Measure1_Type] replacing existing equipment at the sites we just mentioned?

Yes	1	ST2
At some of these sites	2	ST1.1
No	3	ST4
Don’t know	98	ST4
Refused	99	ST4

ST1.1. Which specific sites from those we just mentioned had at least one existing equipment replaced with these [Measure1_Type] [READ and MARK ALL THAT APPLY]

[Measure1_SiteAddress1]	1	ST2
[Measure1_SiteAddress2]	2	
[Measure1_SiteAddress3]	3	
[Measure1_SiteAddress4]	4	
[Measure1_SiteAddress5]	5	
Don’t know	98	ST3
Refused	99	ST3

ST2. Why did you have your existing equipment replaced at these sites? [DONT READ RESPONSES BUT ALLOW MULTIPLE REASONS]

It was not functioning at all	1	ST4
It was still functioning but with significant performance or maintenance problems	2	ST3

It was too expensive to operate/Not energy efficient	3	
Our HVAC contractor/plumber recommended it	4	
We were doing a major renovation in our house	5	
Older unit was undersized	6	
Older unit was oversized	7	
Other RECORD RESPONSE	50	
Don't know	98	
Refused	99	

ST3. How quickly did you need to replace your existing equipment? (How many days did you wait?)

Record # of days		ST4
Don't know	98	
Refused	99	

ST4. Where did you look for information before buying these [Measure1_Type] (PROBE: this includes internet research, going to more than one vendor, or calling multiple vendors)

Record Verbatim		ST5
Don't know	98	
Refused	99	

ST5. If the model and size of [Measure1_Type] you purchased was not available from your preferred HVAC vendor, would you have… [READ ALL ANSWER OPTIONS]

Waited until the unit was in-stock	1	U1	
Selected the next best available alternative	2	ST6	
Contacted an alternate vendor to get the same equipment you wanted	3	U1	
[Something else (record)]	50		
[Don't know]	98		
[Refused]	99		

ST6. You indicated you would have selected the next best alternative that was available. Thinking back, would that unit have been… [READ ALL ANSWER OPTIONS]

The same efficiency as what you purchased	1	U1
Standard efficiency on the market at the time	2	

Between standard efficiency and what you purchased	3	
Don't know	98	
Refused	99	

Influence of upselling

For these next couple questions, I would like to know more about your interaction with the HVAC vendor when you purchased the [Measure1_Type] for sites, such as [Measure1_SiteAddress1], [Measure1_SiteAddress2] , [Measure1_SiteAddress3] , [Measure1_SiteAddress4] , [Measure1_SiteAddress5] .

U1. Did the vendor discuss multiple models of [Measure1_Type] to choose from at these sites?

Yes	1	U2
At some of these sites	2	U1.1
No	3	U3
Don't know	98	U3
Refused	99	U3

U1.1. Which specific sites from those we just mentioned did the vendor discuss multiple models of [Measure1_Type]? [READ and MARK ALL THAT APPLY]

[Measure1_SiteAddress1]	1	UT2
[Measure1_SiteAddress2]	2	
[Measure1_SiteAddress3]	3	
[Measure1_SiteAddress4]	4	
[Measure1_SiteAddress5]	5	
Don't know	98	U3
Refused	99	U3

U2. How many models did the vendor discuss with you for these sites?

Record #		U3
Don't know	98	
Refused	99	

U3. Did the vendor recommend the equipment you eventually purchased?

Yes	1	U4
No	2	
Don't know	98	
Refused	99	

U4. On a scale of 1 to 10 where 1 is “not at all influential” and 10 is “extremely influential”, how influential was the information that you received from the HVAC vendor for the [Measure1_Type] you purchased?

Record Level of Influence (1-10)		U5
Don’t know	98	
Refused	99	

U5. How did the HVAC vendor influence your purchase decision?

Record Verbatim		P1
Don’t know	98	
Refused	99	

Influence of price

P1. Do you remember the typical costs of the [Measure1_Type] we have been discussing*?*

Yes	1	P2
No	3	P3
Don’t know	98	P3
Refused	99	P3

P2. Approximately how much did it cost? [IF NECESSARY: After all rebates and incentives]

Record cost ($)		P3
Don’t know	98	P4
Refused	99	

P3. Which of the following best describes what percent more you would have been willing to spend on the {Q2.A1} you purchased? [IF APPLICABLE: "for each address?"]

1 to 10% more	1	E1
11 to 20% more	2	E1
21 to 40% more	3	E1
41 to 80% more	4	E1
Higher than 80% more	5	E1
Would not have been willing to pay more	6	E1
Don’t know	98	E1
Refused	99	E1

Influence of efficiency

E1. The [Measure1_Type] you purchased at these sites were more efficient then what is required by building code. Had you considered purchasing a less efficient unit at any of these sites?

Yes	1	E2
At some of these sites	2	E1.1
No	3	F1
Don't know	98	F1
Refused	99	F1

E1.1. Which of these sites that we've been discussing had you considered purchasing a less efficient [Measure1_Type]? [READ and MARK ALL THAT APPLY]

[Measure1_SiteAddress1]	1	E2
[Measure1_SiteAddress2]	2	
[Measure1_SiteAddress3]	3	
[Measure1_SiteAddress4]	4	
[Measure1_SiteAddress5]	5	
Don't know	98	
Refused	99	

E2. What was the minimum efficiency you considered purchasing at these sites?

The same efficiency as what you purchased	1	F1
Standard efficiency on the market at time	2	
Between standard efficiency and what you purchased	3	
[Don't know]	98	
[Refused]	99	

(If [Measure2_SiteCount] or [Measure3_SiteCount] is greater than 0, loop for that Measure)

Firmographic Information

Thank you for your patience. We're almost finished. These final questions are about your company.

F1. Does your company have more than one location?

Yes	1	F2
No	2	F3
Don't know	98	
Refused	99	

F2. Do you work out of the main office or is this a satellite or local branch?

Main office	1	F3
Satellite	2	
Local branch	3	
Don't know	98	
Refused	99	

F3. About how many full-time employees work at this location? [IF THEIR COMPANY HAS MORE THAN ONE LOCATION, ADDITIONALLY ASK ABOUT HOW MANY EMPLOYEES AT ALL LOCATIONS]

Record Employee #		End
Don't know	98	
Refused	99	

End. This concludes all the questions I have for you today. Unless you have any questions for me, the survey is complete. Thank you for your time.

6.10.2 Residential furnace buyer (downstream) interview guide

CA HVAC Group A Impact Evaluation
PTAC Installation and NTG Survey
Created October 2018

Survey House Instructions

1. Text in **bold** should be read.
2. Text in brackets [ ] are instructions for interviewer, minor programming such as skips, or answer choices and should NOT be read.
3. Text in carrots < > are database variables that should be filled in on a case-by-case basis.
4. Text in double-carrots << >> are larger blocks of text that will change on a case-by-case basis depending on database variables.
5. Text in gray boxes is major programming instruction.
6. Unless specifically noted, do NOT read answer choices. [Don't know] and [Refused] should NEVER be read.

Database Variables

Variable	Definition
<program>	Name of the program
<utility>	Who respondent purchases electricity from
<mqty>	Number of <equipment_string> installed
<equipment_string>	Equipment installed
<date>	Month/year installation took place according to records
<DIVendor>	Who installed equipment for respondent

INTRODUCTION

Intro1. Hello, my name is _____, and I'm calling on behalf of the <program> offered by <utility>. I'm calling to discuss the installation of packaged terminal air conditioning equipment at your business in 2017. I'm not selling anything; I'd just like to ask your opinions. Your responses will be kept confidential and your individual responses will not be revealed to anyone.

[IF THEY WANT TO VERIFY SURVEY, THEY CAN CONTACT <name> AT **<organization>** at <phone>

1	[AGREES TO PARTCIPATE]	Intro2
2	[DOES NOT AGREE TO PARTCIPATE]	TERMINATE

Intro2. Our records show that your business had <equipment_string> installed in 2017 through this program. Are you familiar with the installation of equipment?

1	[Yes]	Intro6
2	[No]	Intro3
97	[Don't know]	Intro3
98	[Refused]	Intro3

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

1	[RECORD FIRST and LAST NAME]	Intro4
98	[Refused]	
97	[Don't know]	

Intro4. Could I speak with <<Intro3>> now?

1	[Yes]	Intro1
2	[No]	Intro5
97	[Don't know]	
98	[Refused]	

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

1	[RECORD DAY and TIME]	Call back later
98	[Refused]	
97	[Don't know]	

Intro6. What is your name?

1	[RECORD FIRST and LAST NAME]	A1
98	[Refused]	
97	[Don't know]	

Awareness

A1. I'd like to start by asking you about your awareness of the program.

A2. How did you first hear about the program?
[ACCEPT MULTIPLE RESPONSES. DO NOT READ RESPONSES]

0	[Not aware/have not heard of it]	A3
1	[<DI Vendor> called]	
2	[<DI Vendor>emailed]	
3	[<DI Vendor>dropped in/came into office]	
4	[<utility> website]	
5	[<utility> representative>]	
6	[colleagues within organization]	
7	[people outside organization]	
8	[unknown person called]	
9	[unknown person emailed]	
10	[unknown person dropped in]	
77	[Other, specify_____]	
97	[Don't know]	
98	[Refused]	

A3. On a scale from 1 to 5 where 1 is not at all concerned and 5 is very concerned, how concerned would you say your organization is about energy cost?

1	[Not at all concerned]	I1
2		
3		
4		
5	[Very concerned]	
97	[Don't know]	
98	[Refused]	

Energy Inspection

M1. Our records show that your business had <mqty> <equipment_string> installed through this program. Does that sound correct?

1	[Yes]	M4; set <confirmed qty> = <mqty>
2	[No]	M2
97	[Don't know]	I1
98	[Refused]	I1

M2. How many <equipment_string> were installed?

1	[RECORD NUMBER]	M3; set <confirmed qty> = answer
98	[Refused]	I1
97	[Don't know]	I1

M3. Why was the quantity different?

1	[RECORD VERBATIM]	M4
98	[Refused]	
97	[Don't know]	

M4. Are all <confirmed qty> <equipment_string> still installed?

1	[Yes]	M7 Set <still installed> = <confirmed qty>
2	[No]	M5
97	[Don't know]	I1
98	[Refused]	I1

M5. How many <equipment_string> are still installed?

1	[RECORD NUMBER]	M6; set <still installed> = answer
98	[Refused]	I1
97	[Don't know]	I1

M6. Why are a different number still installed?

1	[RECORD VERBATIM]	M4
98	[Refused]	
97	[Don't know]	

M7. Are all <still installed> <equipment_string> operational?

1	[Yes]	I1
2	[No]	M8
97	[Don't know]	I1
98	[Refused]	I1

M8. How many <equipment_string> are still operational?

1	[RECORD NUMBER]	M9
98	[Refused]	I1
97	[Don't know]	I1

M9. Why are a different number still operational?

1	[RECORD VERBATIM]	I1
98	[Refused]	
97	[Don't know]	

I1. Our records show the installations took place in 2017. Was that the first time you had participated in this type of program?

1	[Yes]	I2
2	[No]	
97	[Don't know]	
98	[Refused]	

I2. Why did you decide to install this equipment? [ACCEPT MULTIPLE RESPONSES]

1	[Contractor recommendation]	I3
2	[Rebates]	I4
3	[Improve customer comfort]	I4
4	[Save on energy bills]	I4
5	[Payback calculations]	I4
6	[Marketing tool]	I4
77	[Other: record _____]	I4
97	[Don't know]	I4
98	[Refused]	I4

I3. What benefits did the contractor discuss with you? [ACCEPT MULTIPLE RESPONSES]

1	[Improve customer comfort]	
2	[Save on energy bills]	I4
3	[Payback calculations]	I4
4	[Marketing tool]	I4
77	[Other: record _____]	I4
97	[Don't know]	I4
98	[Refused]	I4

NTG1. Without the program, what was the likelihood of you installing these <measure string>?

1	Very unlikely	NTG2
2	Somewhat unlikely	NTG2
3	Somewhat likely	NTG2
4	Very likely	NTG2
97	[Don't know]	F1
98	[Refused]	F1

NTG2. Without the program, when would you have installed <measure string>?

1	At the same time or sooner	NTG3
2	1 to 24 months later (record specific)	NTG3
3	More than 24 months later (record specific)	NTG3
4	Never	NTG3
97	[Don't know]	F1
98	[Refused]	F1

NTG3. You said you installed <confirmed qty> <measure string>. Without the program, how many would you have installed?

1	The same number	NTG4
2	Fewer [RECORD NUMBER]	NTG4
3	More [RECORD NUMBER]	NTG4
4	None	NTG4
97	[Don't know]	F1
98	[Refused]	F1

NTG4. Without the program, would you have installed <measure string> at a level of efficiency that was…?

1	Same or higher efficiency than program requirements ()	NTG5
2	Lower than program efficiency requirements but higher than state legal minimum (	NTG5
3	Legal minimum efficiency ()	NTG5
4	[Would not have installed <measure string>]	F1
97	[Don't know]	F1
98	[Refused]	F1

NTG5. In your own words, can you explain how the program affected the timing, number, and efficiency level of the <measure string> you installed?

1	[RECORD VERBATIM]	F1
97	[Don't know]	F1
98	[Refused]	

End. This concludes all the questions I have for you today. Unless you have any questions for me, the survey is complete. Thank you for your time.

6.11 Appendix G: Unitary VRF NTGR calculations

6.11.1 Rooftop and split systems NTGR calculations

6.11.1.1 Identifying causal pathways of influence

To establish program attribution, we considered the pathways distributors take when selling a high-efficiency HVAC unit, and the related pathways end-users take when purchasing one. Our goal was to develop an approach that considered these pathways in the context of the 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 end-users. We then used this approach to integrate NTG survey responses between end-users and the distributors into an overall NTG score.

Our methodology assumed that there were 3 main causal pathways of influence which impacted both the HVAC equipment distributor and end-user. We derived these assumptions from the program logic model provided from the PAs. Distributors and end-users are both important when evaluating program attribution of this nature, and both were taken into consideration to formulate an overarching attribution score.

The three main causal pathways of program influence included:

- The program influenced distributors to **stock** high-efficiency units, and what was in stock influenced what end-users purchased when their unit failed. This causal pathway was driven by the assumption that when end-users replace existing equipment in an urgent situation (replace on failure in five days or less), the stocking habits of distributors would be most influential.
- The program encouraged distributors to **upsell or promote** high efficiency units, and end-users were influenced by the upselling and promotional efforts to purchase high efficiency units rather than standard efficiency models.
- The program encouraged distributors to reduce the **price** of high efficiency units or pass along the rebate to end-users, and end-users were influenced by the lower prices of these high efficiency units.

Table 6-1 Table 6-1. Question themes across shows the researchable question themes that represent the three causal pathways across distributors and end-users.

Table 6-1. Question themes across 3 causal pathways for distributors and end-users

Causal Pathways	Distributor Question Theme	End-user Question Theme
Stock	1. What was the program influence on distributor stock?	1. How did the mix of equipment in stock influence the end-user?
Promotion/Upsell	2. What was the program influence on encouraging the distributor to promote or upsell the units?	2. What was the influence that distributor/contractor upselling had on the end-user's decision?
Price of Units	3. Did the distributor pass on some or all of the incentive to buyers?	3. What was the influence the price had on the end-user's decision?

Each of the causal pathways was contingent on the distributor changing their behavior in response to the program, and this change in behavior influencing the behavior of their buyers. We measured each causal

path independently based on the assumption that if the program failed to show attribution through the distributors or buyers, then the program did not affect the equipment sale on that particular causal path. This did not mean that the program had no influence on the sale, only that any influence it had was not through this path. If another causal path did show program influence, then we determined the sale to be at least partially program-attributable.

We evaluated each causal path at the level of the individual end-user and their associated distributor for attribution. We then subtracted from 1 to get a free-ridership score on that pathway. To calculate the total program attribution score, we multiplied these 3 free-ridership scores together. We explore this calculation further below, but the overall approach captures multiple paths of attribution, as well as partial attribution when it exists.

After the distributor and end-user surveys were completed, we calculated the individual end-user and distributor attribution scores, mapped them together, and expanded to the whole population. This section will review the process of calculating the attribution scores individually, and then expanding them to the population.

6.11.1.2 Distributor attribution calculation

We began by asking distributors an open-ended question about how they think the program has impacted their business, and then asked questions related to the three causal pathways. Last, we asked distributors questions about how the program influenced their sales of high efficiency units. We used screening questions at the beginning of the survey to ensure that the respondent was the best person to speak to about program influence across all of these areas. For all these questions, we asked follow-up questions clarifying why the respondent gave certain answers. This allowed us to make sure that the respondent understood the question, and to collect additional information on how the program might have influenced their business practices. The following flowcharts diagram how the stocking attribution, upselling attribution, price attribution, and sales attribution scores were calculated for the distributors.

Figure 6-1. Detailed distributor causal pathway scoring: stocking

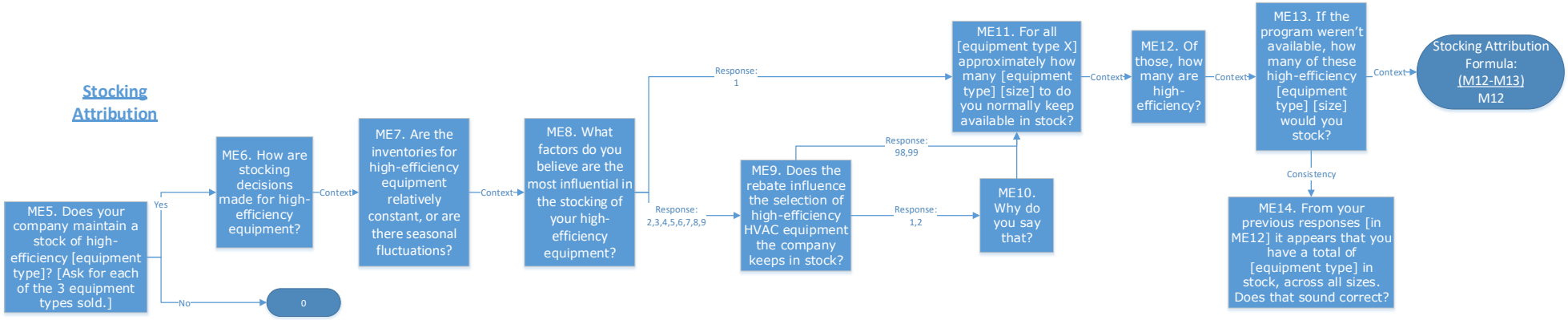


Figure 6-2. Detailed Distributor causal pathway scoring: upselling

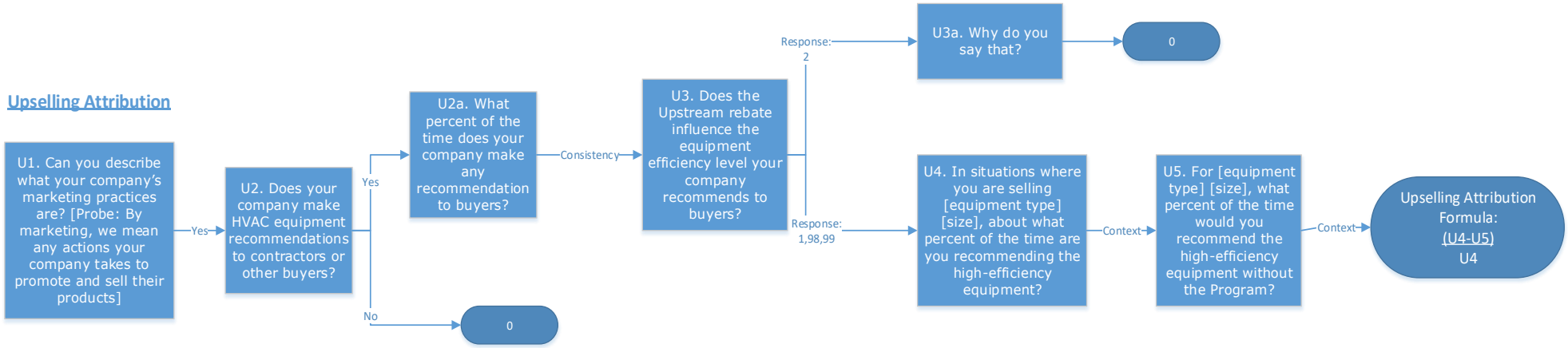


Figure 6-3. Detailed distributor causal pathway scoring: price

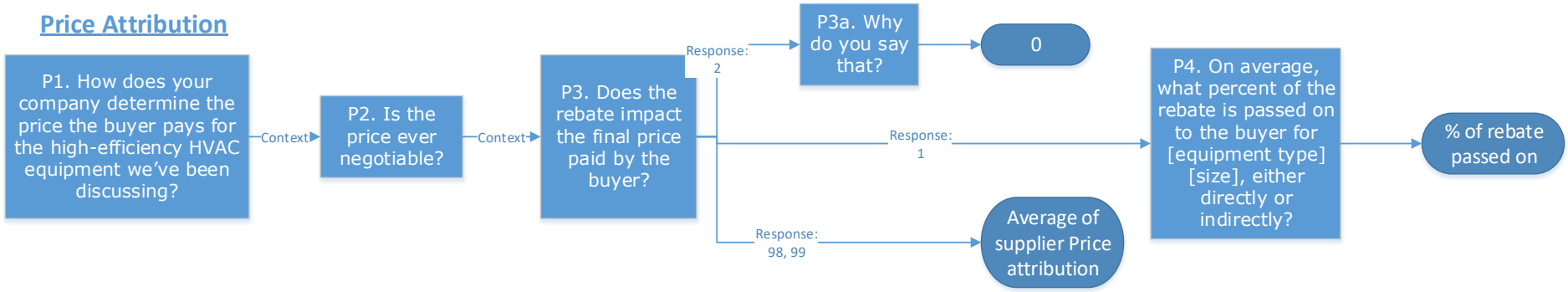
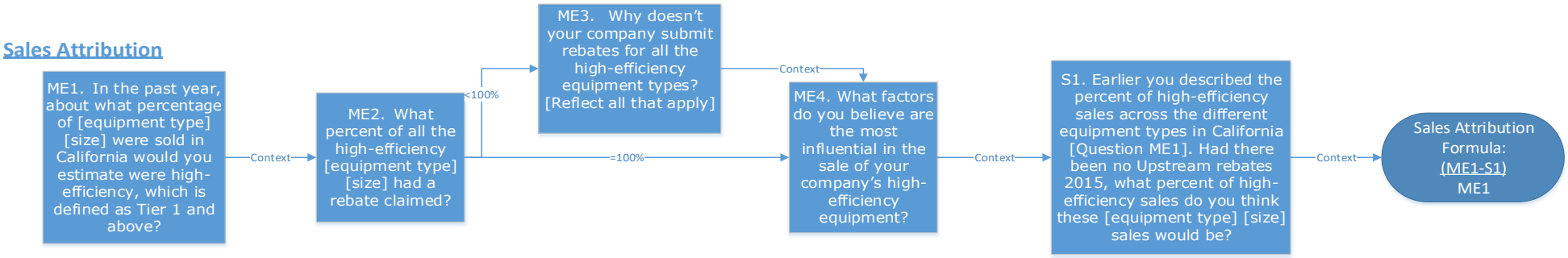


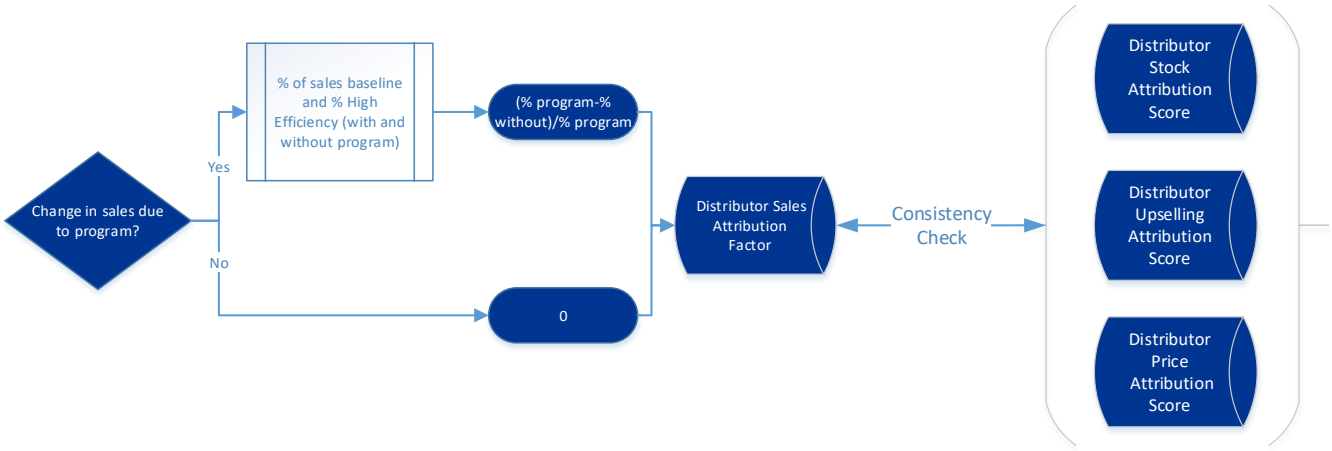
Figure 6-4. Detailed distributor causal pathway scoring: sales



Consistency Check

To check if sales were influenced by the program, we asked the distributors to describe the current percent of their sales for baseline units, and percent of their sales that are for high efficiency units, across different unit types and sizes. We then asked the distributors to estimate what baseline and high efficiency sales would have been without the upstream program. We used the change in these numbers to calculate a measurable impact the program had on distributors' sales. Figure 6-5 shows how we calculated sales attribution and used the result to check consistency across the other attribution scores.

Figure 6-5. Distributor attribution consistency check



6.11.1.3 End-user attribution calculation

For the end-user survey, we first asked end-user to list all of the factors that influenced their decision to purchase the unit. Then we asked them questions about the three causal pathways shown in Figure 6-6, Figure 6-7, and Figure 6-8. Finally, we asked them about the minimum energy efficiency they were considering before buying their HVAC equipment. Once again, for all these questions, we asked follow-up questions that allowed us to confirm the respondent's understanding of the question, and to collect additional information on how the program might have influenced the equipment purchase.

The following flowcharts diagram how the Stocking Attribution, Upselling Attribution, Price Attribution, and Efficiency Attribution scores were calculated for the end-users.

Figure 6-6. Detailed end-user causal pathway scoring: stocking

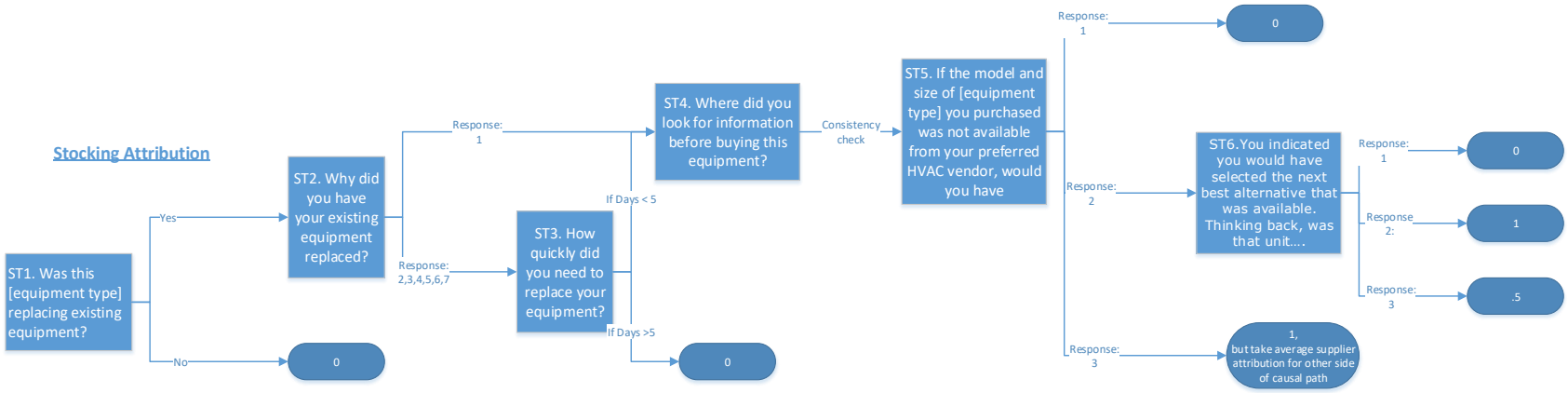


Figure 6-7. Detailed end-user causal pathway scoring: upselling

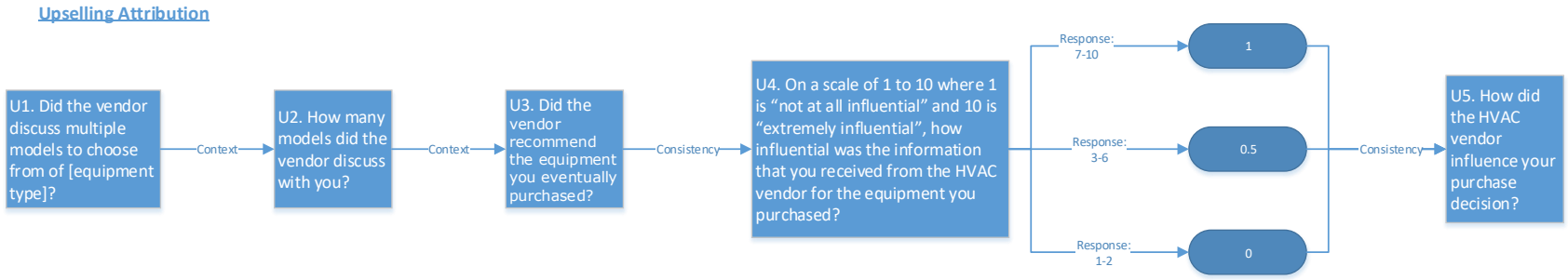


Figure 6-8. Detailed end-user causal pathway scoring: price

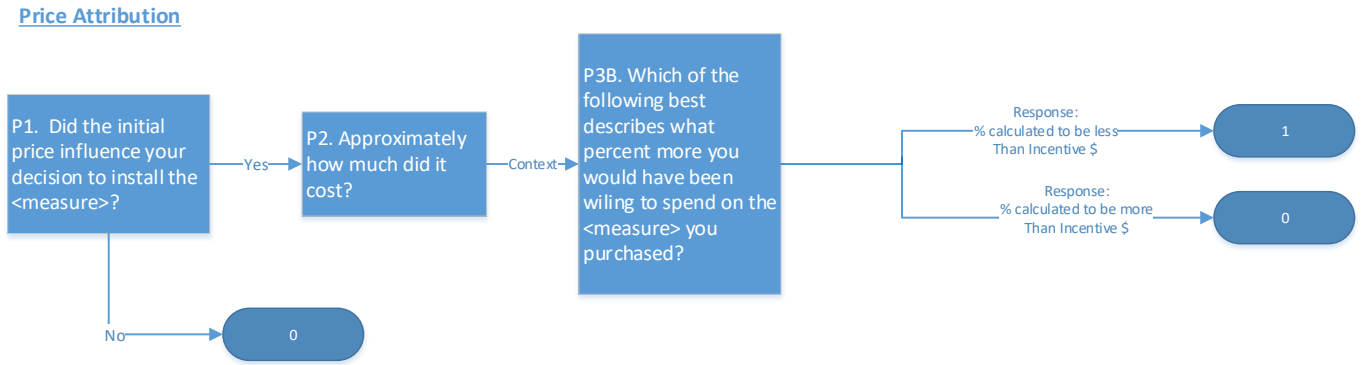
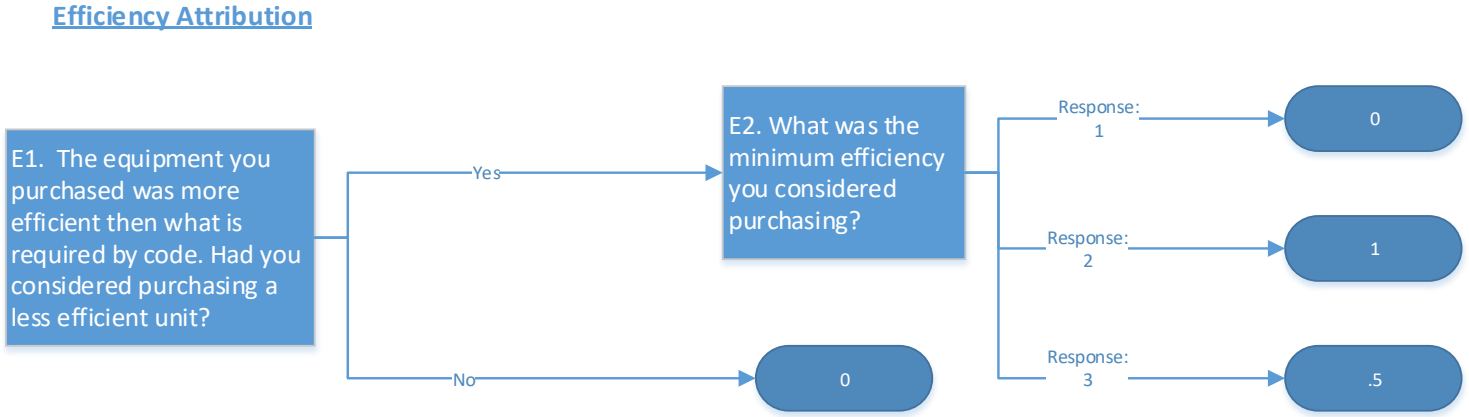


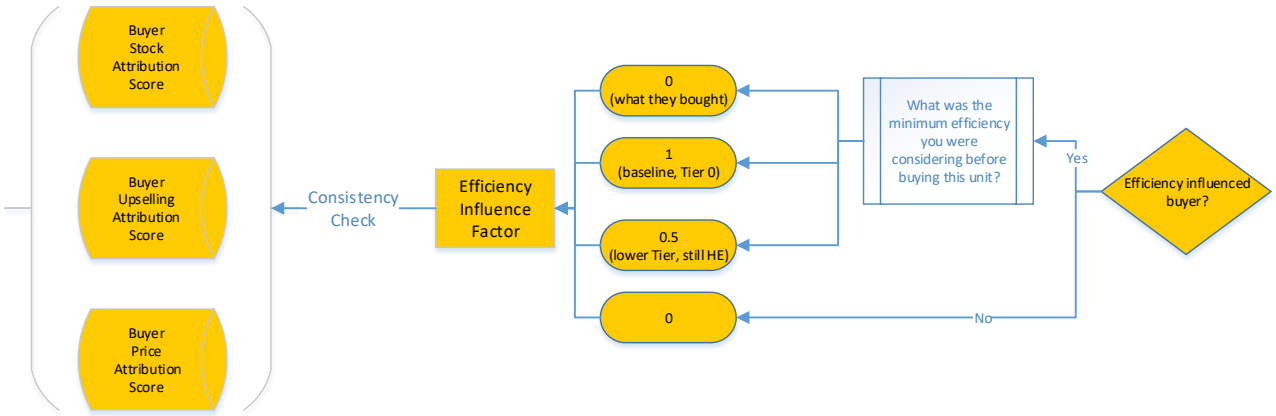
Figure 6-9. Detailed end-user causal pathway scoring: efficiency



Consistency Check

The end-user survey included a question that asked what minimum efficiency level they considered before purchasing the program-sponsored unit. Figure 6-10shows how the efficiency influence factor was calculated and used as a consistency check on the end-user stock attribution, end-user upselling attribution, and end-user price attribution scores.

Figure 6-10. End-user attribution consistency check



6.11.1.4 Combining end-user and distributor attribution scores

We calculated the overall attribution scores at the end-user level, multiplying the end-user and the mean distributor survey attribution scores on each causal path.[52] We subtracted these scores from 1 to calculate a free-ridership rate on each path. Next, we multiplied all three free-ridership scores together, and subtracted the result from 1 to get the overall program attribution score at the end-user level.

We chose this approach because we wanted to give the program the maximum opportunity for attribution, and believe this provides the following benefits:

- Ensures that attribution is capped at 100%
- If multiple paths of partial attribution exist, they are fairly represented in the equation
- If one of three paths is 100% attribution (0% free-ridership), then the total program score gets 100% attribution
- If one of three paths is 0% attribution (100% free-ridership), then the path has no impact on the total score by turning into a 1, and it does not reduce the scores produced by the other two paths.

The equations below show the flow of these calculations. We calculated the end-user attribution scores from survey responses related to an individual purchase, and the distributor attribution scores based on the equipment type the end-user purchased. Note that the combined attribution scores come from an individual distributor (x) and an individual purchase from an end-user (y):

$$\text{Combined Attribution}_{\text{Stock}} = \text{Distributor}_{x}\text{Attribution}_{\text{Stock}} \times \text{End} - \text{user}_{Y}\text{Attribution}_{\text{Stock}}$$

$$\text{Combined Attribution}_{\text{Upsell}} = \text{Distributor}_{x}\text{Attribution}_{\text{Upsell}} \times \text{End} - \text{user}_{Y}\text{Attribution}_{\text{Upsell}}$$

[52] The previous evaluation of this program linked specific distributors to specific end users and combined the specific scores. This time, the PAs did not provide sufficient data to identify specific connections, so the evaluation calculated the mean score across all distributors for each of the causal pathways, and combined that with the individual buyer scores.

$$\text{Combined Attribution}_{\text{Price}} = \text{Distributor Attribution}_{\text{Price}} \times \text{End} - \text{user}_{Y}\text{Attribution}_{\text{Price}}$$

$$\text{Free} - \text{ridership}_{\text{Stock}} = 1 - \text{Combined Attribution}_{\text{Stock}}$$

$$\text{Free} - \text{ridership}_{\text{Upsell}} = 1 - \text{Combined Attribution}_{\text{Upsell}}$$

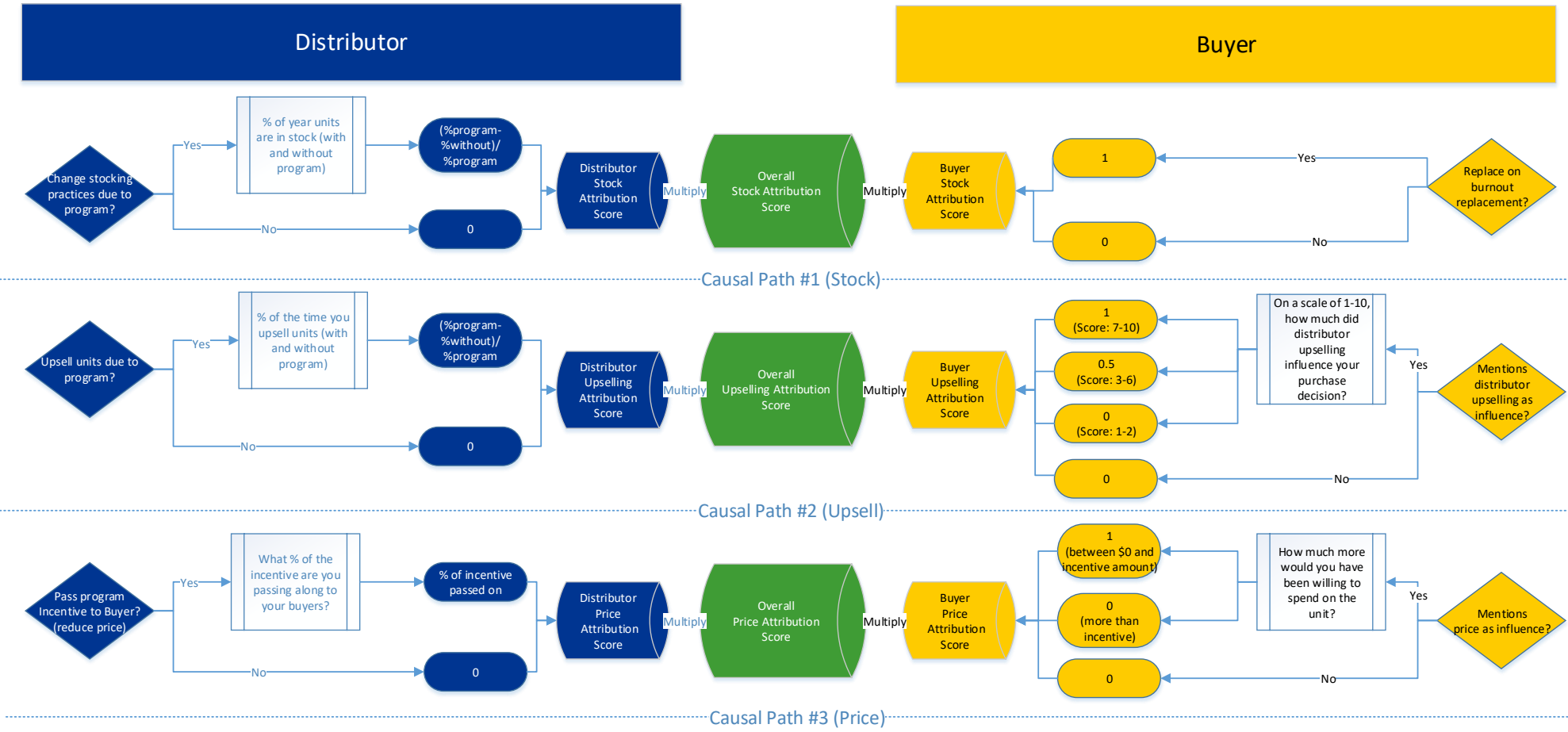
$$\text{Free} - \text{ridership}_{\text{Price}} = 1 - \text{Combined Attribution}_{\text{Price}}$$

$$\text{Combined Program Attribution} = 1 - \left((\text{Free} - \text{ridership}_{\text{Stock}}) * \left(\text{Free} - \text{ridership}_{\text{Upsell}}\right) * (\text{Free} - \text{ridership}_{\text{Price}})\right)$$

The following flowchart diagrams the attribution combination process.

After we calculated this combined distributor/end-user attribution score for every single end-user, we needed to expand these estimates to the population. The causal pathway for scoring is illustrated in the figure below

Figure 6-11. Causal pathways scoring for distributors and end-users



6.11.1.5 Site-level scores

Table 6-2 contains the scores for each of the attribution components for each of the end user survey respondents. Table 6-3 contains the scores for each of the attribution components for the distributors.

Table 6-2. Rooftop end-user individual attribution scores

Site_ID	End-user Stocking Attr	End-user Upsell Attr	End-user Price Attr	Distributor Sales Attr	Distributor Stocking Attr	Distributor Upsell Attr	Distributor Price Attr	Combined Stocking Attr	Combined Upsell Attr	Combined Price Attr	Final Attribution Score
PGE1	1.0000	1.0000	0.7500	0.4025	0.1343	0.1225	0.2857	0.1343	0.1225	0.2143	0.4031
PGE2	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE3a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE3b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE3c	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE4a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE4b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE5	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE6	0.0000	1.0000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0000	0.1225	0.2143	0.3105
PGE7a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE7b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE8	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE9	0.0000	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0000	0.0785	0.2143	0.2759

Site_ID	End-user Stocking Attr	End-user Upsell Attr	End-user Price Attr	Distributor Sales Attr	Distributor Stocking Attr	Distributor Upsell Attr	Distributor Price Attr	Combined Stocking Attr	Combined Upsell Attr	Combined Price Attr	Final Attribution Score
PGE10a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE10b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE10c	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE11	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE12	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE13	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE14	0.0000	1.0000	0.0000	0.4025	0.1343	0.1225	0.2857	0.0000	0.1225	0.0000	0.1225
PGE15	0.0000	1.0000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0000	0.1225	0.2143	0.3105
PGE16	1.0000	0.0000	1.0000	0.4025	0.1343	0.1225	0.2857	0.1343	0.0000	0.2857	0.3816
PGE17	0.0000	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0000	0.0785	0.2143	0.2759
PGE18a	0.0000	0.0000	0.0000	0.4025	0.1343	0.1225	0.2857	0.0000	0.0000	0.0000	0.0000
PGE18b	0.0000	0.0000	1.0000	0.4025	0.1343	0.1225	0.2857	0.0000	0.0000	0.2857	0.2857
PGE18c	0.0000	0.0000	1.0000	0.4025	0.1343	0.1225	0.2857	0.0000	0.0000	0.2857	0.2857
PGE19a	0.0000	0.0000	0.0000	0.4025	0.1343	0.1225	0.2857	0.0000	0.0000	0.0000	0.0000
PGE19b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE20	0.0000	0.5000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0000	0.0613	0.2143	0.2624

Site_ID	End-user Stocking Attr	End-user Upsell Attr	End-user Price Attr	Distributor Sales Attr	Distributor Stocking Attr	Distributor Upsell Attr	Distributor Price Attr	Combined Stocking Attr	Combined Upsell Attr	Combined Price Attr	Final Attribution Score
PGE21a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE21b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE22a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE22b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE23	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE24	0.5000	1.0000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0671	0.1225	0.2143	0.3568
PGE25	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE26	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE27a	0.5000	1.0000	1.0000	0.4025	0.1343	0.1225	0.2857	0.0671	0.1225	0.2857	0.4153
PGE27b	0.5000	1.0000	1.0000	0.4025	0.1343	0.1225	0.2857	0.0671	0.1225	0.2857	0.4153
PGE27c	0.5000	1.0000	1.0000	0.4025	0.1343	0.1225	0.2857	0.0671	0.1225	0.2857	0.4153
PGE28a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE28b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE28c	0.0000	1.0000	1.0000	0.4025	0.1343	0.1225	0.2857	0.0000	0.1225	0.2857	0.3732
PGE29a	1.0000	1.0000	0.0000	0.4025	0.1343	0.1225	0.2857	0.1343	0.1225	0.0000	0.2403
PGE29b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031

Site_ID	End-user Stocking Attr	End-user Upsell Attr	End-user Price Attr	Distributor Sales Attr	Distributor Stocking Attr	Distributor Upsell Attr	Distributor Price Attr	Combined Stocking Attr	Combined Upsell Attr	Combined Price Attr	Final Attribution Score
PGE30a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE30b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
PGE30c	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE1a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE1b	0.0000	0.0000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0000	0.0000	0.2143	0.2143
SCE2	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE3a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE3b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE4	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE5	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE6	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE7	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE8	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE9a	0.0000	1.0000	1.0000	0.4025	0.1343	0.1225	0.2857	0.0000	0.1225	0.2857	0.3732
SCE9b	0.0000	1.0000	1.0000	0.4025	0.1343	0.1225	0.2857	0.0000	0.1225	0.2857	0.3732
SCE10	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031

Site_ID	End-user Stocking Attr	End-user Upsell Attr	End-user Price Attr	Distributor Sales Attr	Distributor Stocking Attr	Distributor Upsell Attr	Distributor Price Attr	Combined Stocking Attr	Combined Upsell Attr	Combined Price Attr	Final Attribution Score
SCE11	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE12	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE13	1.0000	0.5000	1.0000	0.4025	0.1343	0.1225	0.2857	0.1343	0.0613	0.2857	0.4195
SCE14	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE15	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE16a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE16b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE17a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE17b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE17c	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE18a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE18b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE18c	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE19a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE19b	1.0000	0.5000	1.0000	0.4025	0.1343	0.1225	0.2857	0.1343	0.0613	0.2857	0.4195
SCE20a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031

Site_ID	End-user Stocking Attr	End-user Upsell Attr	End-user Price Attr	Distributor Sales Attr	Distributor Stocking Attr	Distributor Upsell Attr	Distributor Price Attr	Combined Stocking Attr	Combined Upsell Attr	Combined Price Attr	Final Attribution Score
SCE20b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE20c	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE21	0.5000	1.0000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0671	0.1225	0.2143	0.3568
SCE22	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE23	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SCE24a	0.0000	1.0000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0000	0.1225	0.2143	0.3105
SCE24b	0.0000	1.0000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0000	0.1225	0.2143	0.3105
SCE24c	0.0000	1.0000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0000	0.1225	0.2143	0.3105
SDGE1a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SDGE1b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SDGE2a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SDGE2b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SDGE2c	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SDGE3	1.0000	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.1343	0.0785	0.2143	0.3732
SDGE4a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SDGE4b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031

Site_ID	End-user Stocking Attr	End-user Upsell Attr	End-user Price Attr	Distributor Sales Attr	Distributor Stocking Attr	Distributor Upsell Attr	Distributor Price Attr	Combined Stocking Attr	Combined Upsell Attr	Combined Price Attr	Final Attribution Score
SDGE4c	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SDGE5a	0.0000	0.0000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0000	0.0000	0.2143	0.2143
SDGE5b	0.0000	0.0000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0000	0.0000	0.2143	0.2143
SDGE5c	0.0000	0.0000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0000	0.0000	0.2143	0.2143
SDGE6	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SDGE7a	0.0000	0.5000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0000	0.0613	0.2143	0.2624
SDGE7b	0.0000	0.5000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0000	0.0613	0.2143	0.2624
SDGE8a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SDGE8b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SDGE9a	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SDGE9b	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SDGE9c	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SDGE10	1.0000	1.0000	1.0000	0.4025	0.1343	0.1225	0.2857	0.1343	0.1225	0.2857	0.4574
SDGE11	0.2794	0.6406	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.0785	0.2143	0.3031
SDGE12	0.2794	1.0000	0.7500	0.4025	0.1343	0.1225	0.2857	0.0375	0.1225	0.2143	0.3364

Table 6-3. Rooftop distributor individual attribution scores

Site_ID	Price Attr	Stocking Attr	Upsell Attr
Dist1	0	0	0.7
Dist2	0	0	0.1575
Dist3	0	0	0
Dist4	0	0	0
Dist5	0.44	0.44	0
Dist6	0	0	0
Dist7	0.5	0.5	0

6.11.2 Furnaces NTGR calculations

Net-to-gross (NTG) calculations for furnaces were based on surveys with the furnace end-users. The overall strategy to calculate NTG for furnace end-users was to assess the programs' effect on the timing of the purchase and the efficiency of the purchased equipment. The majority of furnace purchasers were residential customers, so the evaluation team assumed that quantity (BTU output in the case of furnaces) was determined by contractors.

Free-ridership for efficiency (FR_e) and timing (FR_t) were calculated directly from the survey. Total free-ridership was calculated as the product of FR_e and FR_t. Combining free-ridership scores using multiplication creates a situation where zero free-ridership (full attribution) overrides any partial free-ridership (partial attribution) attained along another dimension. The survey included several additional questions to set the context and serve as consistency checks. The relevant questions and their impact on the NTG calculation are summarized in Table 6-4.

Table 6-4. Furnace End-user Survey Questions and NTG Calculations

Survey Question	Impact on NTG Calculation
A02. Before today, had you ever heard of the <program> program, which is sponsored by <utility>?	Yes: No effect No: FR=1 (If they are not aware of the program, how could it have affected their decision?)
A06. **[ONLY ASK IF A02 = YES]** Did you hear about the program or rebate before or after you purchased the <Measure_1>?	Before: No effect Same time: No effect After: FR = 1 (they made the purchase without the rebate, so they would have done it anyway)
PP1. Was there any specific event that triggered your decision to undertake this home upgrade? **[PROBE FOR DETAILS]**	Context-setting and consistency check.
A08. Why did you decide to install a high efficiency <measure>?	Context setting and consistency check

[ENTER 1 FOR ALL THAT APPLY. DO NOT READ RESPONSES] a. [Contractor recommendation] b. [Reduce my energy consumption / bills] c. [Wanted to get rebate while it was available] d. [Was going to buy the equipment anyway] e. [It was a good deal] f. [Help the environment / Global warming] g. [Improve home comfort] h. [Improve home air quality] i. [Other, specify] j. [Don't know] k. [Refused]	Attribution should be >0 Attribution should be >0 FR should be close to 1	
PP2. **[ONLY ASK IF AO8 RESPONSE INCLUDES a) Contractor recommendation]** Which of the following did your contractor bring up when discussing this home upgrade? **[READ ALL RESPONSES. ENTER 1 FOR ALL THAT APPLY]** a. Energy savings on your monthly bill b. Rebates on equipment purchases and contractor services c. Improved comfort in your home d. Improved air quality in your home e. Improved safety of heating and cooling equipment f. Improved moisture and mold control g. Something else (Record verbatim) h. [Don't know] i. [Refused]	Context setting and consistency check Attribution should be >0	
PP3. What, if anything, prevented you from improving the energy efficiency of your home's heating system before you participated in this program?	Context setting and consistency check	
HVAC System Upgrade - Furnace		
FU1. Without the program, what was the likelihood of your getting this furnace installed?	Consistency check	
	Very unlikely	$FR_{check} = 0$
	Somewhat unlikely	$FR_{check} = 0.33$
	Somewhat likely	$FR_{check} = 0.67$
	Very likely	$FR_{check} = 1$

	DK/R	FR_{check} = average of FU1 scores
FU2. Without the program, when would you have got this furnace installed?	Same time or sooner	$FR_t = 1$
	Up to 24 months later	$FR_t = 1 – (FU2a/24)$
	Over 24 months later	$FR_t = 0$
	Never	$FR_t = 0$
	DK/R	FR_t = average of FR_t
FU2a. **[RECORD SPECIFIC # OF MONTHS IF 1-24 MONTHS LATER]**		
FU3. Without the program, would you have installed a furnace at a level of efficiency that was…? **[READ UNBRACKETED OPTIONS]**	Same or higher than program req. (92%)	$FR_e = 1$
	Lower than required by program but higher than legal minimum (86 to 91%)	$FR_e = 0.5$
	Legal minimum (85%)	$FR_e = 0$
	Would not have installed furnace	$FR_e = 0$
	DK/R	FR_e = average of FR_e
FU4. To review, you said: - You were **<<FU1>>** to install the furnace without the program - You would have installed it **<<FU2>>** - And you would have installed the **<<FU3>>** Can you explain in your own words why this would have been the case without the program?	Consistency check	

6.11.2.1 NTGR Calculation steps:

The NTG ratio (NTGR) calculation used the following steps:

1. Calculate FR_t and FR_e according to table above.
2. $FR_{total} = FR_e * FR_t$
3. Adjust FR_{total} based on a senior consultant's review of questions AO2, AO6, AO8, PP2, PP3, FU4 to adjust FU2, FU2a, and FU3. Table 6-5 shows the few cases where and why adjustments were made.

Table 6-5. Free-ridership Score Adjustments Based on Open-ended Questions

Respondent	Question	Answer	FR_{total} adjustment
F	PP1	When refinanced the home on reverse mortgage. Had money to invest in my home. Upgraded furnace and AC and put in solar panels.	Computed FR_{total} = 0 Answers to PP1, AO8, and FU4 suggested a partial free-rider. FR_{total} adjusted to match score from FU1 = 0.67
	AO8	B. Reduce energy consumption/bills F. Help environment / global warming I. Other: I wanted to get the best I could	
	FU1	Somewhat likely	
	FU4	Only did it for the upgrade at the same time as the AC unit. Wanted to be environmentally friendly.	
R	PP1	Just our house had an inefficient furnace and the company that was servicing it recommended we do the upgrade and we put in AC at the same time.	Computed FR_{total} = 1 Answer to PP1 indicated some attribution due to contractor recommendation. FR_{total} adjusted to = 0.5
U	FU4	I always want to get the best and most energy efficient equipment I can, and since we wanted to upgrade the AC and we could get a rebate and it was a good deal for both, we decided to go with the best one. The rebate made it so we could get the best one.	Computed FR_{total} = 1 Answer to FU4 that rebated made it possible to get best model indicates some attribution to program. FR_{total} adjusted to = 0.5

4. Compare FR_{total} to score from FU1. If significantly different, review case again
5. NTGR = 1- $FR_{total\_adjusted}$

6.11.2.2 Site level NTGR variables

Table 6-6 provides the individual site-level survey results that factored in to the NTGR calculations for the furnace end-users.

Table 6-6. Site level NTGR variables – furnace end-users

SiteID	FU1_Score	FR_t	FR_e	FR_total	Override	NTGR
PGE1	1.0	1.0	0.6	0.6	0.0	0.4
PGE2	0.7	1.0	0.5	0.5	0.0	0.5
PGE3	0.7	0.9	0.0	0.0	0.0	1.0
PGE4	1.0	1.0	1.0	0.5	1.0	0.5
PGE5	1.0	1.0	1.0	1.0	0.0	0.0
PGE6	1.0	1.0	1.0	0.5	1.0	0.5
PGE7	0.7	0.0	0.5	0.0	0.0	1.0
PGE8	0.7	1.0	0.5	0.5	0.0	0.5
PGE9	1.0	1.0	0.5	0.5	0.0	0.5
PGE10	1.0	1.0	1.0	1.0	0.0	0.0
PGE11	0.7	1.0	0.5	0.5	0.0	0.5
PGE12	0.7	1.0	0.5	0.5	0.0	0.5
PGE13	0.3	0.9	0.0	0.0	0.0	1.0
PGE14	1.0	1.0	1.0	1.0	0.0	0.0
PGE15	1.0	1.0	1.0	1.0	0.0	0.0
PGE16	0.0	0.9	0.0	0.0	0.0	1.0
PGE17	0.0	0.0	0.0	0.0	0.0	1.0
PGE18	0.7	0.9	0.6	0.6	0.0	0.4
PGE19	1.0	1.0	1.0	1.0	0.0	0.0
PGE20	0.7	1.0	0.5	0.5	0.0	0.5
PGE21	1.0	1.0	1.0	1.0	0.0	0.0
PGE22	0.7	1.0	1.0	1.0	0.0	0.0

SiteID	FU1_Score	FR_t	FR_e	FR_total	Override	NTGR
PGE23	0.7	1.0	1.0	1.0	0.0	0.0
PGE24	0.3	1.0	0.5	0.5	0.0	0.5
PGE25	1.0	1.0	1.0	1.0	0.0	0.0
PGE26	0.3	1.0	0.0	0.0	0.0	1.0
PGE27	0.3	1.0	0.5	0.5	0.0	0.5
PGE28	0.3	1.0	0.5	0.5	0.0	0.5
PGE29	0.3	1.0	0.5	0.5	0.0	0.5
PGE30	0.3	1.0	0.5	0.5	0.0	0.5
SCG1	0.7	1.0	0.5	0.5	0.0	0.5
SCG2	0.3	0.9	0.5	0.5	0.0	0.5
SCG3	0.3	1.0	0.5	0.5	0.0	0.5
SCG4	0.7	1.0	0.0	0.7	1.0	0.3
SCG5	1.0	1.0	1.0	1.0	0.0	0.0
SCG6	1.0	1.0	1.0	1.0	0.0	0.0
SCG7	1.0	1.0	1.0	1.0	0.0	0.0
SCG8	1.0	1.0	1.0	1.0	0.0	0.0
SCG9	0.7	0.0	0.5	0.0	1.0	1.0
SCG10	0.7	1.0	0.5	0.5	0.0	0.5
SCG11	0.0	0.0	0.0	0.0	0.0	1.0
SCG12	0.7	1.0	0.5	0.5	0.0	0.5
SCG13	1.0	1.0	1.0	1.0	0.0	0.0
SCG14	1.0	1.0	1.0	1.0	0.0	0.0
SCG15	0.7	1.0	1.0	1.0	0.0	0.0
SCG16	0.3	1.0	0.5	0.5	0.0	0.5
SCG17	0.3	1.0	0.5	0.5	0.0	0.5
SDGE1	0.7	1.0	1.0	1.0	1.0	0.0

SiteID	FU1_Score	FR_t	FR_e	FR_total	Override	NTGR
SDGE2	1.0	1.0	1.0	1.0	0.0	0.0
SDGE3	0.7	0.5	0.5	0.3	0.0	0.8
SDGE4	0.0	0.9	0.0	0.0	0.0	1.0
SDGE5	-99.0	1.0	1.0	1.0	0.0	0.0
SDGE6	1.0	1.0	1.0	1.0	0.0	0.0
SDGE7	0.7	0.9	1.0	0.9	0.0	0.1
SDGE8	0.7	0.9	0.5	0.5	0.0	0.5
SDGE9	0.7	1.0	0.5	0.5	0.0	0.5
SDGE10	0.7	0.9	0.0	0.0	1.0	1.0

6.12 Appendix H: Maintenance & controls NTGR calculations

6.12.1 Thermostat control measures

The NTGR is the estimated proportion of gross savings that can be attributed to a program. This study used a phone survey with participating contractors to estimate NTGRs for the evaluated programs based on a methodology that we described in a memorandum submitted March 15, 2016. This methodology asks concrete questions to get at quantifiable, identifiable aspects of program effect on each of the steps necessary to get energy savings from HVAC QM and tune-up programs. The NTG evaluation method was designed to be consistent with the gross methodology, where savings were broken down to a measure level, and the baseline was assumed to be no measure installed. This is also consistent with the reported gross savings calculations.

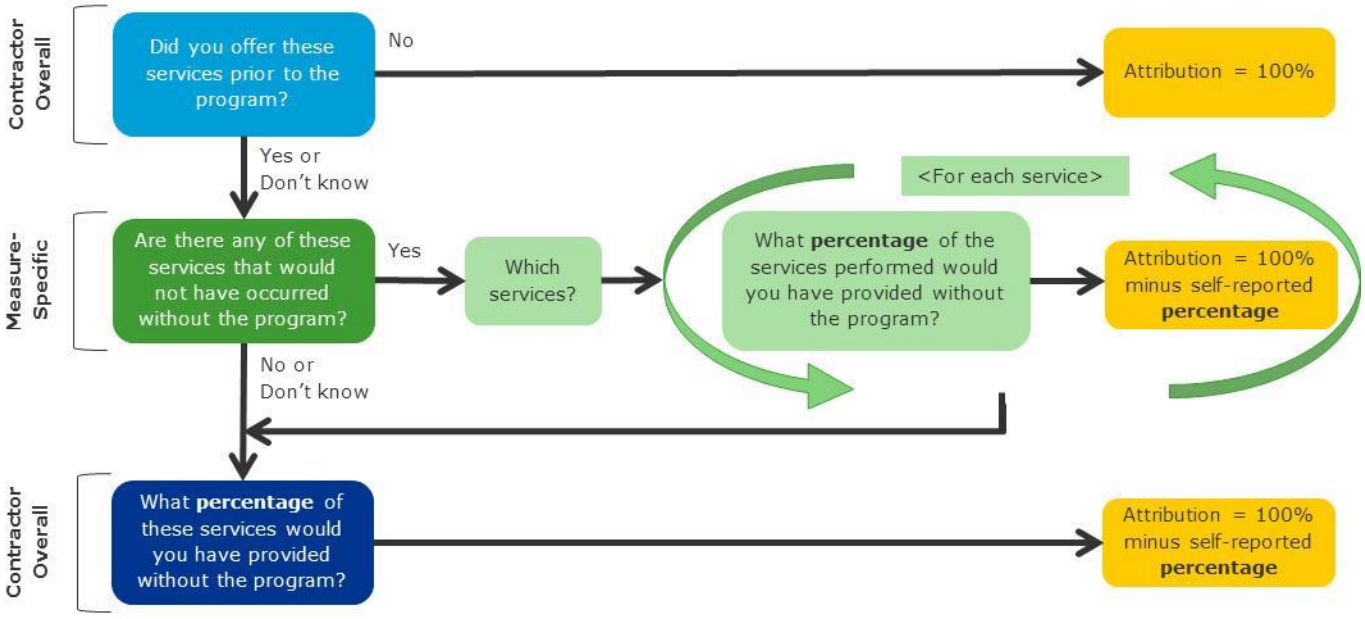
6.12.1.1 NTG analysis - Contractors

The participating contractor survey instrument had a series of NTG-related questions designed to assess program influence and attribution. Our approach addressed program attribution by asking about two key program objectives:

1. Getting contractors to offer new services/measures through program incentives
2. Increasing customer uptake of contractor offered services/measures

This question battery consisted of three primary questions listed below in Figure , which also shows the analysis flow.

Figure 6-12. NTG attribution-analysis flow



DNV GL assigned a score for program attribution to each respondent that ranged from 0%-100% depending on responses to the NTG questions outlined above. The specific questions are discussed in further detail

below. The first question used in attribution scoring, Frame3, addresses overall changes in the contractor's offerings. If the contractor had not offered any of the program incented services/measures prior to the program, the program received full attribution for all of the measures installed by that contractor. If the contractor had offered at least some of the same services/measures prior to participating in the program, they were asked which services/measures they had previously offered (Frame3a). If a specific service/measure had not been offered prior to the program, it was assigned full attribution.

For measures that had been offered prior to the program, the attribution methodology used the response to Attr3, which asks which specific measures would not have occurred without the program. If the contractor said that none of a specific measure would have occurred without the program, that measure received full attribution.

However, if the contractor said that at least some of a specific measure would have been done without the program, then the percentage that would not have been done without the program, Attr2, was used to assign attribution.

The respondent scores (for each measure) were expanded to the population using the statistical technique of ratio estimation by domains. This provided program-level NTG ratios that take into account the strata weights and savings of the individual respondents.

6.12.1.2 Question Frame3

One way to measure the program impacts on the maintenance practices of HVAC contractors is to ask them whether they offered any of these maintenance services before becoming involved with the programs. DNV GL designated survey questions Frame3 and Frame3a as the initial NTG questions for assigning program attribution.

- **Frame3.** Did you offer any of these measures to customers before working with the <program> in <Q7 response>?
  - **Frame3a.** Which of these measures did you offer before participating in the program?

We assigned an attribution rating of 100% to responses of "No" to Frame3. If respondents said "Yes" to Frame3, we asked them the follow-up question Frame3a to find out which maintenance services they had offered prior to program participation. We then assigned an attribution rating of 0% to any previously-offered services. Table 6-7Table 6-7. and Table 6-8 show the attribution assignments for contractor responses to questions Frame3 and Frame3a.

Table 6-7. NTG assignment decision based on response to Frame3 question

Response to Frame3	NTG assignment
Yes	Proceed to Frame3a
No	100% Program Attribution
Don't know	No attribution assignment
Refused	No attribution assignment

Table 6-8. NTG assignment decision based on response to Frame3a question

Response to Frame3a	NTG assignment
Thermostat (hardware)	Identified as previously-offered = 0% Measure Attribution, Not identified as previously offered = 100% Measure Attribution
Fan control (hardware)	
Don't know	No attribution assignment
Refused	No attribution assignment

6.12.1.3 Question Attr3

Another way to measure the program impacts on the maintenance practices of HVAC contractors is to ask whether there were any particular maintenance/tune-up measures which they thought would not have occurred without the assistance of the programs. Survey questions Attr3, Attr3a, and Attr3b explored this issue.

- **Attr3.** Are there any particular controls measures that stand out to you as not likely to occur without the assistance of the program?
  - **Attr3a.** Which controls measures, in particular, do you think would be ***not*** likely to occur without the assistance of the program?
  - **Attr3b[53].** [IF THEY NAMED SPECIFIC MEASURES] OK, without the program training, customer leads, program endorsements, and incentives you said that you would not have performed any [list measures mentioned in Attr3a]. Of the remaining measures [list remaining services performed by this contractor], what percent would you have provided in absence of the program?

    [Probe for each measure]

Table 6-9 shows that if the contractors responded 'No' to question Attr3, meaning that no maintenance/tune-up measures came to mind which would not have occurred without the program, DNV GL scored the attribution as 0%.

Table 6-9. NTG assignment decision based on response to Attr3 question

Response to Attr3	NTG assignment
Yes	Proceed to Attr3a
No	0% attribution
Don't Know	No attribution assignment
Refused	No attribution assignment

If the response to Attr3 was 'Yes', meaning there were some measures that might not occur without the program, DNV GL then asked respondents question Attr3a which probed for which measures they believed

[53] Original wording of Attr3b proved too confusing for respondents and was reworked by the survey team. Question wording originally read: You just said that if these program trainings, customer leads, program endorsements and program incentives had not been available, you *still* would have provided approximately [X%] of maintenance/tune-up services that you provided in [YEAR]. What % of [MEASURE X] would you have provided in the absence of the program?

would not occur without the program. If a measure was specifically mentioned, then DNV GL would ask them question Attr3b, which asked the respondent to estimate what proportion of those maintenance/tune-up measures they still would have offered in the absence of the program. Table 6-10 and Table 6-11 show how we calculated program attribution depending on the responses to questions Attra3 and Attr3b.

Table 6-10. NTG assignment decision based on response to Attr3a question

Response to Attr3a	NTG assignment
Thermostat (hardware)	If measure mentioned, proceed to Attr3b. If not, Attr2 score.
Fan control (hardware)	
Don't know	No attribution assignment
Refused	No attribution assignment

Table 6-11. NTG assignment decision based on response to Attr3b question

Response to Attr3b	NTG assignment
Thermostat (hardware)	Measure Attribution = 100% - percentage
Fan control (hardware)	
Don't know	No attribution assignment
Refused	No attribution assignment

6.12.1.4 Question Attr2

In developing our NTG methodology, we assumed that many respondents might not be able to provide measure-specific estimates of program attribution. Therefore, we included survey question Attr2 which asked respondents to estimate the percentage of their program-eligible maintenance/tune-up services which they would have still offered absent the program.

- **Attr2.** In [YEAR] you installed [#] controls measures through [PROGRAM NAMES] including [LIST OF QUANTITIES OF TOP 5 MEASURES]. If these program trainings, customer leads, program endorsements, program market materials and program incentives had not been available, approximately what % of those installs would you still have provided in [YEAR]?

Table 6-12 shows how DNV GL calculated program attribution for responses to question Attr2. We applied the percentage estimate uniformly to all maintenance/tune-up services they offered through the program.

Table 6-12. NTG assignment decision based on response to Attr2 question

Response to Attr2	NTG assignment
Percentage	Attribution = 100% - percentage
Don't Know	No attribution assignment
Refused	No attribution assignment

6.12.1.5 NTG analysis – End users

This evaluation cycle, DNV GL added two questions to the end-user surveys that were fielded primarily to collect information for gross savings calculations. The net-savings related questions asked whether the

respondents would have made similar settings to their thermostats or fans without the involvement of the Quality Maintenance contractors. In the case of end users whose contractors installed programmable thermostats as part of the program offering, the surveys also asked how likely they were to have installed those without the involvement of the contractor.

The two questions are shown below.

> NTG1. If the contractor had not set the thermostats like they did, how likely were you to set them the same way? Would you say…
>
> Very unlikely
>
> Somewhat unlikely
>
> Somewhat likely
>
> Very likely?
>
> NTG4. Without your contractor's involvement, how likely were you to install any programmable thermostats? Would you say…
>
> Very unlikely
>
> Somewhat unlikely
>
> Somewhat likely
>
> Very likely?

Initial scoring for both questions was the same and shown in Table 6-13.

Table 6-13. Quality Maintenance End User NTG Question Scoring

Response	Free-ridership score
Very unlikely	0
Somewhat unlikely	0.33
Somewhat likely	0.67
Very likely	1

Total free-ridership was calculated as the product of both scores if the respondent answered both. If the respondent answered only one, it was used as the total free-ridership score. Attribution was calculated by subtracting the total free-ridership score from 1.

6.12.2 Supply fan control measures

The supply fan control measures used the same NTGR methods as the thermostat control methods. The surveys applied to and asked questions regarding both measures.

6.12.3 PTAC control measures

- Direct Install Measure = Pass-through

6.13 Appendix I: Central plant NTGR calculations

The NTGR for fan VFD measures was calculated as an average of three scores.

Each of these scores represents the highest response or the average of several responses given to one or more questions about the decision to install a program measure.

- **Program attribution index 2 (PAI–2) score** that captures the perceived importance of the program (whether rebate, recommendation, training, or other program intervention) relative to non-program factors in the decision to implement the specific measure that was eventually adopted or installed. This score is determined by asking respondents to assign importance values to both the program and most important non-program influences so that the two total 10. The program influence score is adjusted (i.e., divided by 2) if respondents say they had already made their decision to install the specific program qualifying measure before they learned about the program.
- **Program attribution index 2 (PAI–3) score** that captures the likelihood of various actions the customer might have taken at this time and in the future if the program had not been available (the counterfactual).

When there are multiple questions that feed into the scoring algorithm, the maximum score is always used. The rationale for using the maximum value is to capture the most important element in the participant's decision making. Thus, each score is always based on the strongest influence indicated by the respondent. However, high scores that are inconsistent with other previous responses trigger consistency checks and can lead to follow-up questions to clarify and resolve the discrepancy.

The calculation of each of the above scores is discussed below. For each score, the associated questions are presented and the computation of each score is described.

6.13.1 PAI–2 score

The questions that feed into the PAI-2 score are:

7. Did you learn about PROGRAM BEFORE or AFTER you decided to implement the specific MEASURE that was eventually adopted or installed?
8. Now I'd like to ask you a last question about the importance of the program to your decision as opposed to other factors that may have influenced your decision. Again, using the 0 to 10 rating scale we used earlier, where 0 means "Not at all important" and 10 means "Very important," please rate the overall importance of PROGRAM versus the most important of the other factors we just discussed in your decision to implement the specific MEASURE that was adopted or installed. This time I would like to ask you to have the two importance ratings -- the program importance and the non-program importance -- total 10.

The PAI–2 score is calculated as:

- The importance of the program, on the 0 to 10 scale, from question 2.
- This score is reduced by half if the respondent learned about the program after the decision had been made.

6.13.2 PAI–3 score

The questions that feed into the PAI-3 score are:

9. Now I would like you to think about the action you would have taken with regard to the installation of this equipment if the PROGRAM had not been available. Using a likelihood scale from 0 to 10, where 0 is "Not at all likely" and 10 is "Extremely likely", if PROGRAM had not been available, what is the likelihood that you would have installed exactly the same program-qualifying efficiency equipment that you did in this project?

The PAI-3 score is calculated as:

- 10 minus the likelihood of installing the same equipment

6.13.3 Core NTGR scores

The self-reported core NTGR is the average of the PAI-2 and PAI-3 scores, divided by 10.

6.13.4 Accounting for partial free-ridership

Partial free ridership was assessed using the following questions asked as part of the decision maker NTGR survey.

10. Now I would like you to think one last time about what action you would have taken if the program had not been available. Supposing that you had not installed the program qualifying equipment, which of the following alternatives would you have been MOST likely to do?

    Install fewer units
    Install standard efficiency equipment or whatever required by code
    Install equipment more efficient than code but less efficient than what you installed through the program
    repair/rewind or overhaul the existing equipment
    do nothing (keep the existing equipment as is)
    something else (specify what__)

11. (IF FEWER UNITS) How many fewer units would you have installed? (It is okay to take an answer such as ...HALF...or 10 percent fewer ... etc.)
12. (IF MORE EFFICIENT THAN CODE) Can you tell me what model or efficiency level you were considering as an alternative? (It is okay to take an answer such as … 10 percent more efficient than code or 10 percent less efficient than the program equipment)
13. (IF REPAIR/REWIND/OVERHAUL) How long do you think the repaired/rewound/refurbished equipment would have lasted before requiring replacement?

In cases where partial free ridership was found and determined (Question 4) that the adjustment should be made to the net-to-gross ratio, the following procedure was used:

On the net side, the adjustment is based on the intermediate baseline indicated by the decision maker for the time period in which the intermediate equipment would have been installed (question 6). The calculation of energy saved under this intermediate baseline is done, and then divided by the savings calculated under the in-situ baseline. The resulting ratio is then multiplied by the initial NTGR which was previously calculated using only the 'core' scoring inputs. The effect of this adjustment is to reduce the NTGR further to reflect the effects of the revealed partial free ridership.

6.14 Appendix J: Site level gross survey responses and savings results

6.14.1 Maintenance & controls measures

6.14.1.1 Thermostat controls

Table 6-14. Thermostat 1 weekday schedule survey responses

SiteID	Weekday Occ. Hrs./ week	Weekday Occ. Adj. Cooling Set Point	Weekday Occ. Heating Set Point	Weekday Unocc. Hrs./ week	Weekday Unocc. Cooling Set Point	Weekday Unocc. Heating Set Point	Weekday Operational mode (heating/cooling/auto/off)
PGE.1	50	70	68	70	75	60	Auto
PGE.2	45	70	68	75	75	60	Auto
PGE.3	64	73	69	56	73	69	Auto
PGE.4	64	73	69	56	73	69	Auto
PGE.5	45	70	75	75	75	60	Auto
PGE.6	-	70	65	-	70	65	Off
PGE.7	60	75	70	60	75	70	Auto
PGE.8	60	75	70	60	75	70	Auto
PGE.9	-	74	68	-	Off	Off	off
PGE.10	65	69	66	55	Off	Off	Off
PGE.11	45	72	72	75	Off	Off	Off
PGE.12	45	72	72	75	Off	Off	Off
PGE.13	45	72	72	75	Off	Off	Off
PGE.14	45	72	72	75	Off	Off	Off
PGE.15	45	72	72	75	Off	Off	Off
PGE.16	-	75	70	-	85	60	Off
PGE.17	-	85	55	120	85	55	Auto

Table 6-15. Thermostat 1 weekend schedule survey responses

SiteID	Weekend Occ. Hrs./ week	Weekend Occ. Adj. Cooling Set Point	Weekend Occ. Heating Set Point	Weekend Unocc. Hrs./ week	Weekend Unocc. Cooling Set Point	Weekend Unocc. Heating Set Point	Weekend Operational mode (heating/cooling/auto/off)
PGE.1	-	70	68	48	75	60	Auto
PGE.2	20	70	68	28	75	60	Auto
PGE.3	-	73	69	48	73	69	Auto
PGE.4	-	73	69	48	73	69	Auto
PGE.5	-	75	60	48	75	60	Auto
PGE.6	-	70	65	-	70	65	Off
PGE.7	-	Off	Off	48	Off	Off	Off
PGE.8	-	Off	Off	48	Off	Off	Off
PGE.9	-	Off	Off	-	Off	Off	Off
PGE.10	26	69	66	22	Off	Off	Off
PGE.11	-	Off	Off	48	Off	Off	Off
PGE.12	-	Off	Off	48	Off	Off	Off
PGE.13	-	Off	Off	48	Off	Off	Off
PGE.14	-	Off	Off	48	Off	Off	Off
PGE.15	-	Off	Off	48	Off	Off	Off
PGE.16	-	75	70	-	85	60	Off
PGE.17	14	72	72	34	85	55	Auto

Table 6-16. Thermostat 2 weekday schedule survey responses

SiteID	Weekday Occ. Hrs./ week	Weekday Occ. Adj. Cooling Set Point	Weekday Occ. Heating Set Point	Weekday Unocc. Hrs./ week	Weekday Unocc. Cooling Set Point	Weekday Unocc. Heating Set Point	Weekday Operational mode (heating/cooling/auto/off)
PGE.3	64	73	69	56	73	69	Auto
PGE.4	64	73	69	56	73	69	Auto
PGE.9	-	Off	Off	-	Off	Off	Off
PGE.10	65	69	66	55	Off	Off	Off
PGE.11	45	72	72	75	Off	Off	Off
PGE.12	45	72	72	75	Off	Off	Off
PGE.13	45	72	72	75	Off	Off	Off
PGE.14	45	72	72	75	Off	Off	Off
PGE.15	45	72	72	75	Off	Off	Off

Table 6-17. Thermostat 2 weekend schedule survey responses

SiteID	Weekend Occ. Hrs./ week	Weekend Occ. Adj. Cooling Set Point	Weekend Occ. Heating Set Point	Weekend Unocc. Hrs./ week	Weekend Unocc. Cooling Set Point	Weekend Unocc. Heating Set Point	Weekend Operational mode (heating/cooling/auto/off)
PGE.3	-	-	None	48	None	None	None
PGE.4	-	-	None	48	None	None	None
PGE.9	-	Off	68	-	Off	Off	Off
PGE.10	26	69	66	22	Off	Off	Off
PGE.11	-	Off	Off	48	Off	Off	Off
PGE.12	-	Off	Off	48	Off	Off	Off
PGE.13	-	Off	Off	48	Off	Off	Off
PGE.14	-	Off	Off	48	Off	Off	Off
PGE.15	-	Off	Off	48	Off	Off	Off
PGE.16	-	75	no entry	-	no entry	no entry	no entry

Table 6-18. Thermostat 3 weekday schedule survey responses

SiteID	Weekday Occ. Hrs./ week	Weekday Occ. Adj. Cooling Set Point	Weekday Occ. Heating Set Point	Weekday Unocc. Hrs./ week	Weekday Unocc. Cooling Set Point	Weekday Unocc. Heating Set Point	Weekday Operational mode (heating/cooling/auto/off)
PGE.9	-	74	68	-	Off	Off	Off

Table 6-19. Thermostat 3 weekend schedule survey responses

SiteID	Weekend Occ. Hrs./ week	Weekend Occ. Adj. Cooling Set Point	Weekend Occ. Heating Set Point	Weekend Unocc. Hrs./ week	Weekend Unocc. Cooling Set Point	Weekend Unocc. Heating Set Point	Weekend Operational mode (heating/cooling/auto/off)
PGE.9	-	-	Off	-	Off	Off	Off

Table 6-20. Thermostat controls measure group site level gross impact analysis

PA	Reported Gross kWh	Reported Gross Therm	Thermostat 1 meets criteria? 0-1	Thermostat 2 meets criteria? 0-1	Thermostat 3 meets criteria? 0-1	Evaluated Installation Rate	Evaluated Gross kWh	Evaluated Gross Therm
PGE.1	39,919	6,603	-	-	-	_	-	-
PGE.2	20,218	2,980	-	-	-	_	-	-
PGE.3	47,108	6,763	-	-	-	_	-	-
PGE.4	23,969	3,441	-	-	-	_	-	-
PGE.5	34,265	5,050	-	-	-	_	-	-
PGE.6	6,189	828	-	-	-	_	-	-
PGE.7	7,245	970	-	-	-	_	-	-
PGE.8	41,153	7,018	-	-	-	_	-	-
PGE.9	52,925	8,640	-	-	-	_	-	-
PGE.10	27,138	4,500	0.9	-	-	0.9	24,876	4,125
PGE.11	12,934	2,145	-	-	-	_	-	-
PGE.12	11,140	1,843	-	-	-	_	-	-
PGE.13	29,498	3,237	-	-	-	_	-	-
PGE.14	14,714	2,112	-	-	-	_	-	-
PGE.15	19,430	2,864	-	-	-	_	-	-
PGE.16	7,158	801	-	-	-	_	-	-
PGE.17	13,053	1,874	-	-	-	_	-	-
Total	**408,056**	**61,669**	-	**-**	**-**	**-**	**24,876**	**4,125**

6.14.1.2 Supply fan controls

Table 6-21. Supply Fan 1 schedule survey responses

SiteID	Thermostat 1		
	Weekday Supply Fan (on/off/auto)	Weekend Supply Fan (on/off/auto)	Thermostat 1 meets fan ctrl criteria? 0-1
PGE.1	Auto	Auto	1
PGE.2	Auto	Auto	1
PGE.3	Auto	Auto	1
PGE.4	Auto	Auto	1
PGE.5	Auto	Auto	1
PGE.6	Auto	Auto	1
PGE.7	Auto	Off	1
PGE.8	Auto	Off	1
PGE.9	Off	Off	1
PGE.10	Off	Off	1
PGE.11	Off	Off	1
PGE.12	Off	Off	1
PGE.13	Off	Off	1
PGE.14	Off	Off	1
PGE.15	Off	Off	1
PGE.16	Off	Off	1
PGE.17	Auto	Auto	1

Table 6-22. Supply Fan 2 schedule survey responses

SiteID	Thermostat 2		
	Weekday Supply Fan (on/off/auto)	Weekend Supply Fan (on/off/auto)	Thermostat 2 meets fan ctrl criteria? 0-1
PGE.1	no entry	no entry	-
PGE.2	no entry	no entry	-
PGE.3	Auto	Auto	1
PGE.4	Auto	Auto	1
PGE.9	Off	Off	1
PGE.10	Off	Off	1
PGE.11	Off	Off	1
PGE.12	Off	Off	1
PGE.13	Off	Off	1
PGE.14	Off	Off	1
PGE.15	Off	Off	1

Table 6-23. Supply Fan 3 schedule survey responses

SiteID	Thermostat 3		
	Weekday Supply Fan (on/off/auto)	Weekend Supply Fan (on/off/auto)	Thermostat meets fan ctrl criteria? 0-1
PGE.9	Off	Off	1

Table 6-24. Supply fan measure group baseline setting survey responses

SiteID	Fan Count	Prior to installing/re-programming the controls, what was the setting on the company's supply fans when the building was unoccupied?	Supply Fan meets fan ctrl baseline criteria? [off or auto= 0, else 1]	IR Supply Fan Ctrl.
PGE.1	1	Don't know	1	1
PGE.2	1	Don't know	1	1
PGE.3	2	Don't know	1	1
PGE.4	2	Don't know	1	1
PGE.5	1	Don't know	1	1
PGE.6	1	Don't know	1	1
PGE.7	1	Don't know	1	1
PGE.8	1	Don't know	1	1
PGE.9	3	Don't know	1	1
PGE.10	2	Don't know	1	1
PGE.11	2	Off	-	-
PGE.12	2	Off	-	-
PGE.13	2	Off	-	-
PGE.14	2	Off	-	-
PGE.15	2	Off	-	-
PGE.16	1	Auto	-	-
PGE.17	1	Don't know	1	1

6.14.1.3 PTAC control

Table 6-25. PTAC measure group reported and evaluated gross analysis results

PA	Reported Gross kWh	Reported Gross kW	Evaluated Installation Rate	Evaluated Gross kWh	Evaluated Gross kW
MCE.1	26,850	10	1.0	26,850	10
PGE.1	145,068	45	1.0	145,068	45
PGE.2	68,915	26	1.0	68,915	26
PGE.3	1,790	1	1.0	1,765	1
PGE.4	25,955	10	-	-	-
PGE.5	114,296	36	1.0	114,296	36
PGE.6	179,892	88	1.0	179,892	88
PGE.7	1,875	1	1.0	1,813	1
PGE.8	132,552	65	1.0	132,552	65
PGE.9	67,868	26	1.0	67,868	26
PGE.10	192,425	74	1.0	189,765	73
PGE.11	71,440	28	0.8	60,010	23
PGE.12	40,275	15	1.0	40,275	15
PGE.13	154,240	44	1.0	154,240	44
PGE.14	261,120	99	1.0	261,120	99
PGE.15	90,472	44	1.0	88,368	43
PGE.16	134,640	51	1.0	134,640	51
PGE.17	76,798	30	1.0	74,494	29
PGE.18	51,153	3	1.0	51,153	33
PGE.19	171,110	49	1.0	171,110	49
PGE.20	20,585	8	1.0	20,585	8
PGE.21	116,090	45	1.0	116,090	45
PGE.22	33,810	19	1.0	33,810	19
PGE.23	35,000	19	0.8	26,250	14
PGE.24	234,596	115	1.0	234,596	115
PGE.25	287,448	70	1.0	287,448	70
PGE.26	33,740	10	0.5	16,870	5
PGE.27	136,276	43	1.0	136,276	43
PGE.28	136,000	52	1.0	136,000	52
PGE.29	39,618	32	0.9	36,683	30
PGE.30	176,939	55	1.0	176,939	55
PGE.31	114,296	36	1.0	114,296	36
PGE.32	228,480	87	0.2	40,320	15
PGE.33	84,160	41	1.0	84,160	41
PGE.34	125,188	61	1.0	125,188	61
PGE.35	197,820	62	1.0	197,820	62
PGE.36	58,175	22	1.0	58,175	22
PGE.37	80,550	31	1.0	80,550	31
PGE.38	122,032	60	1.0	122,032	60
PGE.39	119,928	59	1.0	119,928	59
PGE.40	19,690	8	0.8	16,581	6
PGE.41	138,474	43	1.0	138,474	43
PGE.42	151,830	43	1.0	151,830	43
PGE.43	179,545	51	1.0	178,348	51
SDGE.1	64,392	24	1.0	64,392	24
Total	**4,943,396**	**1,871**	**-**	**4,677,835**	**1,767**

6.14.2 Central plant measures

6.14.2.1 Boiler

Table 6-26. Boiler measure group reported and evaluated gross analysis results

PA	Reported Gross Therm	Therm GRR	Evaluated Gross Therm
SCG.1	6,237	84%	5,254
SCG.2	3,094	42%	1,310
SCG.3	1,355	79%	1,074
SCG.4	4,495	98%	4,392
SCG.5	285	66%	188
SCG.6	20,240	29%	5,968
SCG.7	2,592	86%	2,219
SCG.8	1,313	96%	1,258
SCG.9	3,247	31%	1,009
SCG.10	219	44%	96
SCG.11	952	12%	114
SCG.12	825	127%	1,050
SCG.13	9,150	402%	36,779
SCG.14	3,660	3%	100
SCG.15	11	696%	77
SCG.16	11	700%	75
SCG.17	11	257%	28
SCG.18	1,251	24%	295
SCG.19	812	141%	1,146
Total	**59,760**	-	**62,431**

6.14.2.2 Fan VFD

Table 6-27. Fan VFD measure group reported and evaluated gross analysis results

PA	Total Reported HP	Total Evaluated HP	Total Reported Tonnage	Total Evaluated Tonnage	Evaluated Installation Rate
PGE.1	180	180	0	0	1.0
PGE.2	35	35	0	0	1.0
PGE.3	20	20	0	0	1.0
PGE.4	25	25	0	0	1.0
PGE.5	128	128	0	0	1.0
PGE.6	58	58	0	0	1.0
PGE.7	148	150	0	0	1.0
PGE.8	60	60	0	0	1.0
PGE.9	368	368	0	0	1.0
PGE.10	28	25	0	0	0.9
PGE.11	30	30	0	0	1.0

PA	Total Reported HP	Total Evaluated HP	Total Reported Tonnage	Total Evaluated Tonnage	Evaluated Installation Rate
PGE.12	400	400	0	0	1.0
PGE.13	43	43	0	0	1.0
SCE.1	0	0	142	267	1.9
SCE.2	0	0	286	304	1.1
SCE.3	0	0	19	20	1.1
SCE.4	0	0	251	238	0.9
SCE.5	0	0	13	13	1.0
SCE.6	375	375	0	0	1.0
SCE.7	0	0	21	81	3.9
SCE.8	0	0	14	15	1.1
SCE.9	0	0	20	19	0.9
SCE.10	135	235	0	0	1.7
SCE.11[54]	0	0	0	0	0.3
SCE.12	0	0	99	159	1.6
SCE.13	0	0	145	240	1.0
SCE.14	0	0	263	263	1.0
SCE.15	0	0	137	137	1.0
SCE.16	0	0	112	20	0.2
SCE.17	0	0	197	151	0.8
SCE.18	0	0	205	200	1.0
SCE.19	0	0	180	180	1.0
SCE.20	0	0	170	175	1.0
SCE.21	0	0	169	157	0.9
SCE.22	0	0	180	180	1.0
SCE.23	0	0	195	235	1.2
SCE.24	0	0	220	253	1.1
SCE.25	0	0	184	204	1.1
SCE.26	150	145	0	0	1.0
SCE.27	390	390	0	0	1.0
Total	**2,572**	**2,666**	**3,318**	**3,507**	**N/A**

[54] SCE.11 represents the singular garage exhaust fan VFD measure that was sampled. Analysis of this measure did not rely on the HP and tonnage fields used to evaluate the other measures in this group.

6.15 Appendix K: Data sources

- **Program tracking data.** Program tracking data includes the number of claims, gross and net savings per claim, program type and name, measure groups, measure description, installation address and contact information. Each of the 4 PAs submit program tracking data to the CPUC. We obtained the HVAC-related tracking datasets and cleaned and re-categorized them to meet the team's needs. This data provided the framework for our evaluation, with other data sources supplementing it as needed.
- **Billing and AMI data.** Billing data shows the amount of electricity and gas used during the billing period. When measure savings are a large enough fraction of overall energy use, billing data can establish consumption levels before and after measure installation and allow estimates of measure savings. AMI connects customers' smart meters to the PAs, allowing two-way communications between PA and customer. For boiler sites we requested all billing and AMI data from a period beginning 14 months prior to the installation date and continuing through the date of our request.
- **Project-specific information.** The PAs maintain a 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 EULs, incremental cost, measure payback with and without the rebate. We requested project-specific information to guide our interviews. Section 6.15.1 details the project-specific information we requested.
- **Data sheets from equipment manufacturers.** As part of the gross data collection, we requested technical specifications of the evaluated boiler and VFD 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 surveys of participating customers and distributors.** Using scripts, we interviewed customers, HVAC equipment distributors, and HVAC contractors. Customer interviews gleaned information about their purchasing decision to inform our net savings estimates and about their operation of the equipment to inform gross savings estimates. Distributor and contractor interviews dealt with the interactions between those market actors and the programs in which they participate (upstream equipment programs for distributors and midstream service programs for contractors). The interview scripts can be found in the appendices.
- **Onsite visits.** The team completed onsite surveys for 5 of the sampled boiler sites. During the onsite visits we took spot measurements of the equipment and we confirmed that our site observations were consistent with the telephone interviews we conducted with those sites.

6.15.1 Contents of data requests

For implementer data, we prepared and issued Data Requests to the PAs through ED. We requested these items:

- Claim ID
- Site ID
- Contact Name (end users and contractors)

- Phone # (end users and contractors)
- Email address (end users and contractors)
- Measure type
- Measure quantity or measure size
- Verbose measure description
- Tracked savings
- Install date (or application date or rebate mailed date)
- Address where measure installed
- Detailed implementer data for installed measures

In addition to implementer data, we requested natural gas AMI billing data covering up to 2 years before and 2 years after project installation date for gas boiler sites.

We also asked the PAs for contact information for all participating contractors and distributors for the upstream and midstream programs we evaluated.

Finally, we requested PA Account Representative contact information (name, telephone number, and email address) for accounts large enough for a dedicated Account Representative.

6.15.2 Applicability and usefulness of requested data

6.15.2.1 Tracking data

Tracking data contains up to 3 contact names, addresses, and telephone numbers for each claim. Contact information can be for any combination of customers, account owners, incentive applicants, third-party incentive processers, implementers, contractors, and distributors. Because all of our measure group evaluations relied on telephone interviews, having valid contact information was an essential first step. As we mentioned earlier, several issues arose which prevented us from using tracking data to reach interviewees at a number of sites.

- **Tracking data contained incorrect contact information.** Our interviewers came across many cases where the contacts listed in tracking data were unknown at the telephone numbers provided. In other cases, the telephone number had been disconnected. And there were cases where the company name in the tracking data was entirely unknown to the person we talked to.
- **Contact information led to the contractor or a third-party processor who was unable or unwilling to provide contact information for their customers.** These parties didn't have immediate access to the claim ID contained in tracking data and so were consistently unable to correlate our data with their installation records. A number of them said that, due to privacy concerns, they'd be reluctant to provide contact information for their customers even if they could.
- **Contacts failed to respond to multiple telephone messages requesting their participation.** Our protocol included making at least 4 attempts to contact a site. At each attempt we left a scripted voicemail message. These messages rarely resulted in a callback from the interviewee.
- **The contact actively declined to participate.** This issue mostly involved residential sites. The Furnace measure group, composed largely of residential furnace replacements, had a number of outright refusals

to take part. We anticipated this possibility and we took steps upfront to minimize refusals,[55] but the publicity around telephone-based fraud schemes has made people leery of giving any personal information to unknown callers.

Where we had implementer data, we searched it for additional site contact information. In some cases, the implementer data provided additional contact information that allowed us to reach a knowledgeable site contact. In general, though, the implementer data provided the same contact information already found in tracking data.

6.15.2.2 Billing and AMI data

AMI and monthly billing data were requested for all 26 boiler sites. SCG, the sole PA submitting boiler claims, provided billing data for all 26 and AMI data for 20. This data met the team's needs, allowing them to estimate pre-project and post-project energy consumption and arrive at gross savings estimates by project.

6.15.2.3 Contractor and distributor contact data

The PAs supplied contact information for participating distributors and contractors. Contact information included contractor or distributor firm name, contact name, email address, and telephone number. Links between the contractor/distributor data and the tracking data were not provided consistently, limiting our ability to reach these contacts.

6.15.2.4 Program Administrator Account Representative contact data

Once the team began contacting sites for interviews, we realized that reaching the right person could be difficult, particularly in large facilities such as boiler sites. Since many of these sites are large enough for a dedicated account representative, we requested contact information for the account representatives assigned to these large accounts. The PAs were quick to provide this information and the team was able to work with the account representatives to put us in touch with the right site contact and to encourage the site contact to take part in our interviews. Smaller sites – those with rooftop or split system replacements for instance, or fan and thermostat control measures – typically do not have a dedicated account representative and so this resource was not an option for Unitary & VRF or Maintenance and Controls subsectors.

[55] We offered a letter of introduction on Commission letterhead explaining the purpose of our call and we emphasized to potential interviewees that we were researching energy efficiency on behalf of the Commission and were not selling any products or services.

6.16 Appendix L: Evaluated programs and measures

Table 6-28. Evaluated HVAC programs and measures by PA

Measure Group	PA	Program Name	Measure Code	Measure Description
HVAC FURNACE	PGE	REDWOOD COAST	SA17	Central Natural Gas Furnace - 95-96.9% AFUE Without VSM
	PGE	REDWOOD COAST	SA18	Central Natural Gas Furnace - >=97% AFUE with VSM
	PGE	RESIDENTIAL HVAC	S8812	Efficient Residential Gas Furnace - AFUE 96
	PGE	RESIDENTIAL HVAC	S8813	Efficient Residential Gas Furnace - AFUE 97
	PGE	SCHOOL ENERGY EFFICIENCY	SA16	Central Natural Gas Furnace - 95-96.9% AFUE with VSM
	PGE	SCHOOL ENERGY EFFICIENCY	SA18	Central Natural Gas Furnace - >=97% AFUE with VSM
	SCG	RES-MFEER	540358	Central Gas Furnace 95% AFUE
	SCG	RES-PLUG LOAD AND APPLIANCES	540357	Central Gas Furnace 92% AFUE
	SCG	RES-PLUG LOAD AND APPLIANCES	540358	Central Gas Furnace 95% AFUE
	SCG	RES-RESIDENTIAL HVAC	530641	Central Gas Furnace 96% AFUE
	SCG	RES-RESIDENTIAL HVAC	530642	Central Gas Furnace 97% AFUE
	SDGE	3P-RES-COMPREHENSIVE MANUFACTURED-MOBILE HOME	462510	Furnace - Energy Star Central Gas (AFUE=92%)
	SDGE	3P-RES-COMPREHENSIVE MANUFACTURED-MOBILE HOME	462514	Furnace - Energy Star Central Gas (AFUE=96%)
	SDGE	SW-CALS - RESIDENTIAL HVAC UPSTREAM	462765	Furnace 97% AFUE Furnace
	SDGE	SW-CALS - RESIDENTIAL HVAC UPSTREAM	462819	Furnace 96% AFUE Furnace
HVAC ROOFTOP OR SPLIT SYSTEM	PGE	COMMERCIAL DEEMED INCENTIVES	SA10	HVAC Enhanced Vent Heat Pump
	PGE	COMMERCIAL HVAC	HA22	135-239kBtu/h 12.0 EER or 13.0 IEER
	PGE	COMMERCIAL HVAC	HA23	135-239kBtu/h 12.5 EER or 13.6 IEER
	PGE	COMMERCIAL HVAC	HA26	240-759kBtu/h 10.8 EER or 12.0 IEER
	PGE	COMMERCIAL HVAC	HA27	240-759kBtu/h 11.1 EER or 13.1 IEER
	PGE	COMMERCIAL HVAC	HA35	65-134kBtu/h 12.0 EER or 13.8 IEER
	PGE	COMMERCIAL HVAC	HA36	65-134kBtu/h 12.5 EER or 14.8 IEER
	PGE	COMMERCIAL HVAC	HA37	65-134kBtu/h 13.0 EER or 17.0 IEER

Measure Group	PA	Program Name	Measure Code	Measure Description
	PGE	COMMERCIAL HVAC	HA40	760kBtu/h 10.2 EER or 12.8 IEER
	PGE	COMMERCIAL HVAC	HA41	760kBtu/h 10.4 EER or 14.0 IEER
	PGE	COMMERCIAL HVAC	HB4	Water-Source Heat Pump <65kBtu/hr. 14.0 EER
	PGE	COMMERCIAL HVAC	HB5	Water-Source Heat Pump <65kBtu/hr. 15.0 EER
	PGE	COMMERCIAL HVAC	HB6	Water-Source Heat Pump <65kBtu/hr. 16.0 EER
	PGE	COMMERCIAL HVAC	HB7	Water-Source Heat Pump 65-135 kBtu/hr. 14.0 EER
	PGE	COMMERCIAL HVAC	HV043	15.0 IEER (11.6 EER) 240-759 kBtu/hr. Three Phase Unitary Air Cooled
	PGE	COMMERCIAL HVAC	HV044	17.0 IEER (12.0 EER) 240-759 kBtu/hr. Three Phase Unitary Air Cooled
	PGE	COMMERCIAL HVAC	HV045	16.0 IEER (10.7 EER) gt760 kBtu/hr. Three Phase Unitary Air Cooled
	PGE	COMMERCIAL HVAC	HV233	Water-Source Heat Pump <65kBtu/hr. 17.0 EER
	PGE	COMMERCIAL HVAC	HV234	Water-Source Heat Pump <65kBtu/hr. 18.0 EER
	PGE	COMMERCIAL HVAC	HV235	Water-Source Heat Pump 65-135 kBtu/hr. 15.0 EER
	PGE	COMMERCIAL HVAC	HV241	Packaged Air Conditioner <55kBtuh 15 SEER (12 EER)
	PGE	COMMERCIAL HVAC	HV242	Packaged Air Conditioner <55kBtuh 16 SEER (12.4 EER)
	PGE	COMMERCIAL HVAC	HV243	Packaged Air Conditioner <55kBtuh 17 SEER (13 EER)
	PGE	COMMERCIAL HVAC	HV244	Packaged Air Conditioner <55kBtuh 18 SEER (14 EER)
	PGE	COMMERCIAL HVAC	HV245	Packaged Air Conditioner 55to65kBtuh 15 SEER (12 EER)
	PGE	COMMERCIAL HVAC	HV246	Packaged Air Conditioner 55to65kBtuh 16 SEER (12.4 EER)
	PGE	COMMERCIAL HVAC	HV247	Packaged Air Conditioner 55to65kBtuh 17 SEER (13 EER)
	PGE	COMMERCIAL HVAC	HV248	Packaged Air Conditioner 55to65kBtuh 18 SEER (14 EER)
	PGE	COMMERCIAL HVAC	HV262	Packaged Heat Pump <55kBtuh 16 SEER (12.4 EER)
	PGE	COMMERCIAL HVAC	HV340	135 - 240 kBtu/hr., EER = 11.5 And Min IEER = 13
	PGE	COMMERCIAL HVAC	HV341	135 - 240 kBtu/hr., EER = 12 And Min IEER = 13.5
	PGE	COMMERCIAL HVAC	HV343	240 - 760 kBtu/hr., EER = 10.8 And Min IEER = 12.2
	PGE	COMMERCIAL HVAC	HV346	65 - 134 kBtu/hr., EER = 11.5 And Min IEER = 13
	PGE	COMMERCIAL HVAC	HV347	65 - 134 kBtu/hr., EER = 12 And Min IEER = 13.5
	PGE	COMMERCIAL HVAC	HV348	65 - 134 kBtu/hr., EER = 12.5 And Min IEER = 14

Measure Group	PA	Program Name	Measure Code	Measure Description
	PGE	COMMERCIAL HVAC	HV349	65 - 134 kBtu/hr., EER = 13 And Min IEER = 15
	PGE	COMMERCIAL HVAC	HV350	760 - kBtu/hr., EER = 10.2 And Min IEER = 11.6
	PGE	COMMERCIAL HVAC	HV351	760 - kBtu/hr., EER = 11 And Min IEER = 12.3
	PGE	ENERGYSMART GROCER	SA10	HVAC Enhanced Vent Heat Pump
	PGE	RESIDENTIAL HVAC	S8808	16 SEER (12.5 EER) Split-System Air Conditioner
	PGE	RESIDENTIAL HVAC	S8809	17 SEER (13.3 EER) Split-System Air Conditioner
	PGE	RESIDENTIAL HVAC	S8811	18 SEER (14 EER) Split-System Air Conditioner
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-18658	65 - 134 kBtu/hr. EER = 12 And Min IEER = 13.5
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-18658	65 - 134 kBtu/hr. EER = 12 AND MIN IEER = 13.5 EER-rated packaged Air Conditioner DX Equipment
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-18659	65 - 134 kBtu/hr. EER = 12.5 AND MIN IEER = 14 EER-rated packaged Air Conditioner DX Equipment
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-18660	65 - 134 kBtu/hr. EER = 13 And Min IEER = 15
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-18660	65 - 134 kBtu/hr. EER = 13 AND MIN IEER = 15 EER-rated packaged Air Conditioner DX Equipment
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-18664	135 - 240 kBtu/hr. EER = 12.5 AND MIN IEER = 14 EER-rated packaged Air Conditioner DX Equipment
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-18666	240 - 760 kBtu/hr. EER = 10.8 And Min IEER = 12.2
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-18666	240 - 760 kBtu/hr. EER = 10.8 AND MIN IEER = 12.2 EER-rated packaged Air Conditioner DX Equipment
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-18667	240 - 760 kBtu/hr. EER = 11.5 AND MIN IEER = 12.7 EER-rated packaged Air Conditioner DX Equipment
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-18671	760 - kBtu/hr. EER = 10.2 AND MIN IEER = 11.6 EER-rated packaged Air Conditioner DX Equipment
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-18672	760 - kBtu/hr. EER = 11 AND MIN IEER = 12.3 EER-rated packaged Air Conditioner DX Equipment
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-18689	135 - 240 kBtu/hr. EER = 12 AND MIN IEER = 13.5 EER-rated packaged Air Conditioner DX Equipment
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-22408	55to65 kBtu/hr. 17 SEER (13 EER) Package System Air Conditioner DX Equipment
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-37735	<55k Btu/hr. 17 SEER (13 EER) Package System Air Conditioner DX Equipment

Measure Group	PA	Program Name	Measure Code	Measure Description
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-50375	<55kBtu/hr. 15 SEER (12 EER) Package System Air Conditioner DX Equipment
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-50375	Commercial SEER-rated Packaged Air Conditioners Size Range: 18 - 55 kBtu/hr. SEER = 15 (EER = 12.9) EIR = 0.234 Fan W/CFM = 0.25 one-speed fan without Econo
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-77878	55to65 kBtu/hr. 16 SEER (12.4 EER) Package System Air Conditioner DX Equipment
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-81566	<55k Btu/hr. 16 SEER (12.4 EER) Package System Air Conditioner DX Equipment
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-81566	Commercial SEER-rated Packaged Air Conditioners Size Range: 18 - 55 kBtu/hr. SEER = 16 (EER = 12.5) EIR = 0.238 Fan W/CFM = 0.27 two-speed fan without Econo
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-87532	55to65 kBtu/hr. 15 SEER (12 EER) Package System Air Conditioner DX Equipment
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-87532	Commercial SEER-rated Packaged Air Conditioners Size Range: 55 - 65 kBtu/hr. SEER = 15 (EER = 12.6) EIR = 0.236 Fan W/CFM = 0.25 two-speed fan with Econo
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-97980	<55kBtu/hr. 15 SEER (12 EER) Package System Heat Pump
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-99784	55to65kBtu/hr. 15 SEER (12 EER) Package System Heat Pump
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-99784	Commercial SEER-rated Packaged Heat Pumps Size Range: 55 - 65 kBtu/hr. SEER = 15 (HSPF = 8.2) EIR = 0.256 Fan W/CFM = 0.25 two-speed fan with Econo
	SCE	RESIDENTIAL HVAC PROGRAM	AC-19538	QI and Efficiency Upgrade for Split Air Conditioner SEER 15 AC Only Units replacing Split Air Conditioner SEER 14
	SCE	RESIDENTIAL HVAC PROGRAM	AC-19540	QI and Efficiency Upgrade for Split Air Conditioner SEER 17 AC Only Units replacing Split Air Conditioner SEER 14
	SDGE	3P-RES-COMPREHENSIVE MANUFACTURED-MOBILE HOME	463813	Residential SEER-rated split Air Conditioners, Size Range: 18 - 45 kBtu/hr., SEER = 16 (EER = 12.5), EIR = 0.238, Fan W/CFM = 0.27, two-speed fan
	SDGE	SW-CALS - RESIDENTIAL HVAC UPSTREAM	463620	A/C Split System 17 SEER (13.3 EER)45-65kBTU
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463624	Pkg AC 55k to 65k SEER = 15.0-UP Stream
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463625	Pkg AC 55k to 65k SEER = 15.0, wPreEcono - Upstream
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463627	Pkg AC 55k to 65k SEER = 16.0, wPreEcono - Upstream

Measure Group	PA	Program Name	Measure Code	Measure Description
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463632	Pkg AC <55k SEER = 15.0-UP Stream
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463633	Pkg AC <55k SEER = 16.0-UP Stream
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463648	Split AC < 45k SEER = 15.0 - Upstream
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463649	Split AC < 45k SEER = 16.0 - Upstream
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463663	Pkg HP 55k to 65k SEER = 15.0-UP Stream
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463664	Pkg HP 55k to 65k SEER = 15.0, wPreEcono - Upstream
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463669	Pkg HP <55k SEER = 15.0-UP Stream
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463697	Pkg AC <55k SEER = 16.0-Rebate
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463707	Split AC 55k to 65k SEER = 16.0, wPreEcono
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463717	All AC 135k to 239k EER = 12.5
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463734	Pkg HP <55k SEER = 16.0-Rebate
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463745	Split HP < 55k SEER = 16.0
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463746	Split HP < 55k SEER = 17.0
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463749	All HP 110k to 134k EER = 12.0
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	463754	All HP 65k to 109k EER = 12.0
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	464032	All AC 65k to 134 kBtu/hr. EER = 12.0, wPreEcono - Upstream
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	464033	All AC 65k to 134 kBtu/hr. EER = 12.5, wPreEcono - Upstream
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	464034	All AC 65k to 134 kBtu/hr. EER = 13.0, wPreEcono - Upstream
	PGE	COMMERCIAL HVAC	HV326	Unoccupied Fan Control on AC Unit with Gas Heat
	PGE	COMMERCIAL HVAC	HV327	Unoccupied Fan Control on AC Only Unit

Measure Group	PA	Program Name	Measure Code	Measure Description
HVAC CONTROLS FAN	PGE	COMMERCIAL HVAC	HV328	Unoccupied Fan Control on Heat Pump
	PGE	COMMERCIAL HVAC	HV329	Unoccupied Fan Control on Variable Volume AC Unit with Gas Heat
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-11566	Unoccupied Fan Control AC Only Units
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-11568	Unoccupied Fan Control AC Unit with Gas Heat
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-11568	Unoccupied Fan Control on AC Unit with Gas Heat
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-11570	Unoccupied Fan Control Heat Pump
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-11570	Unoccupied Fan Control on Heat Pump
HVAC CONTROLS THERMOSTAT	PGE	COMMERCIAL HVAC	T314	Programmable Thermostat
HVAC CONTROLS PTAC	MCE	SMALL COMMERCIAL	HA82	PTAC/PTHP Controller
	PGE	ASSOCIATION OF MONTEREY BAY AREA GOVERNMENTS (AMBAG)	HA82	PTAC/PTHP Controller
	PGE	HOSPITALITY PROGRAM	HA82	PTAC/PTHP Controller
	PGE	NORTHERN SAN JOAQUIN VALLEY	HA82	PTAC/PTHP Controller
	PGE	SAN FRANCISCO	HA82	PTAC/PTHP Controller
	PGE	SAN MATEO COUNTY	HA82	PTAC/PTHP Controller
	PGE	SILICON VALLEY	HA82	PTAC/PTHP Controller
	SDGE	SW-COM-DEEMED INCENTIVES-HVAC COMMERCIAL	416361	PTAC/PTHP Controllers ACC-DI
HVAC BOILER	SCG	3P-PREPPS	530016	SpaceHeatingBoilers-Water-MediumLarge-Tier2(>=90%CE)
	SCG	3P-PREPPS	530017	SpaceHeatingBoilers-Water-Medium-Tier1(>=85%CE)
	SCG	COM-DEEMED INCENTIVES	530013	SpaceHeatingBoilers-Steam-Small-(>=82%AFUE)
	SCG	COM-DEEMED INCENTIVES	530015	SpaceHeatingBoilers-Water-Large-Tier1(>=85%CE)
	SCG	COM-DEEMED INCENTIVES	530016	SpaceHeatingBoilers-Water-MediumLarge-Tier2(>=90%CE)
	SCG	COM-DEEMED INCENTIVES	530017	SpaceHeatingBoilers-Water-Medium-Tier1(>=85%CE)
	SCG	COM-DEEMED INCENTIVES	530018	SpaceHeatingBoilers-Water-Small-Tier1(>=84%AFUE)

Measure Group	PA	Program Name	Measure Code	Measure Description
	SCG	COM-DEEMED INCENTIVES	530020	SpaceHeatingBoilers-Water-Small-Tier2(>=90%AFUE)
HVAC FAN VFD	PGE	COMMERCIAL DEEMED INCENTIVES	H148	VFDs for HVAC Fans
	PGE	ENERGYSMART GROCER	H148	VFDs for HVAC Fans
	PGE	INDUSTRIAL DEEMED INCENTIVES	H148	VFDs for HVAC Fans
	PGE	SAN FRANCISCO	H148	VFDs for HVAC Fans
	SCE	COMMERCIAL DEEMED INCENTIVES PROGRAM	AC-14365	Variable Speed Drive on Cooling Tower Fan Control
	SCE	COMMERCIAL DEEMED INCENTIVES PROGRAM	AC-29603	<10 HP Variable Speed Drive on Garage Exhaust Fan Control
	SCE	COMMERCIAL DEEMED INCENTIVES PROGRAM	AC-97352	Variable Speed Drive on HVAC Fan Control
	SCE	DATA CENTER ENERGY EFFICIENCY	AC-97352	Variable Speed Drive on HVAC Fan Control
	SCE	LODGING EE PROGRAM	AC-97352	Variable Speed Drive on HVAC Fan Control
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-18726	VFD for Packaged Heat Pump with ADEC Control
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-36894	VFD and NEMA Motor for Packaged Heat Pump with ADEC Control
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-72014	VFD for Gas Pack with ADEC Control
	SCE	NONRESIDENTIAL HVAC PROGRAM	AC-97565	VFD and NEMA Motor for Gas Pack with ADEC Control

6.17 Appendix M: Stakeholder comments and evaluator responses

Comment #:	Subject:	Entity:	Date:	Section:	Page #	QUESTION or COMMENT:	Evaluator Response:
1	Recommendations	IESR	3/1/2019	Appendix		Would it be possible for the evaluation team to include an appendix with recommendations presented using the table from the CPUC Energy Division Impact Evaluation Standard Reporting Guidelines? Thank you! <https://pda.energydataweb.com/api/downloads/1399/IESR_Guidelines_Memo_FINAL_11_30_2015.pdf>	We have added findings and recommendations into Appendix AC
2	Savings uncertainty	Open EE	3/15/2019			The impact evaluation report does not include any discussion of savings uncertainty for the measures. Sample uncertainty only reveals confidence in the sample based results but does not indicate if "we" should have greater confidence in these results than in the ex-ante savings claims. Please consider re-running the P4 Uncertainty analysis on each of the measures to include in the report, to see if uncertainty has been reduced for the investment in this analysis. Overall, uncertainty metrics should be part of the savings claim for these programs if they migrate to meter-based quantification approaches which are embedded in programs and can be used as the criteria for being included on the uncertain measure list. The HVAC programs are currently analyzed on a measure by measure (and decomposed parameters); which makes for difficulty in understanding the more holistic impacts of these program interventions. It would be helpful to conduct whole building analysis for the programs along-side the measure specific analysis, to inform future program designs in this space that would be oriented to NMEC. CPUC should be given more flexibility in their evaluation contracts to be able to adapt methods and deliverables to address contemporary research needs rather than only focus on ESPI-based outputs. While this is a necessary priority in the current context, it is lost opportunity to plan for a future that comports with AB802, SB350 and SB100 obligations for energy efficiency and understanding normalized metered energy consumption, and performance, based programs.	These savings results and uncertainties will be re-run with P4 in October 2019 to update the uncertain measure list. The scope of this impact evaluation report did not include this analysis. We agree savings claims should move toward reporting uncertainty metrics, however this was not set up for program year 2017. The current evaluations address the ESPI measures and uncertain parameters. The HVAC sector evaluation team also agrees with planning whole building analyses as part of proposer-defined activities to be conducted in parallel to program year 2018 evaluations of ESPI measures.
3	Review	PG&E	3/15/2019	Executive Summary		The draft report does not include an Executive Summary, which is a critical part of the report. When will stakeholders be provided a complete draft for review, including executive summary, before the final report is published?	Yes, the executive summary is included in the final report.
4	Review	PG&E	3/15/2019	IESR Tables		Energy Division staff (Jeorge Tagnipes) confirmed at the December 11, 2018 Quarterly Stakeholder meeting that all energy efficiency impact evaluations will contain IESR tables, i.e. tables in accordance with the CPUC Energy Division Impact Evaluation	Thank you for the comment. IESR Tables have been added to the Appendix of the report

Comment #:	Subject:	Entity:	Date:	Section:	Page #	QUESTION or COMMENT:	Evaluator Response:
						Standard Reporting Guidelines (November 2015, https://pda.energydataweb.com/api/view/1399/IESR_Guidelines_Memo_FINAL_11_30_2015.pdf). However, the draft report does not contain any IESR tables. The IESR tables are critical for stakeholder review since they ensure: 1. Comprehensive evaluation results are documented, 2. Ex Ante vs. Ex Post savings are comparable, 3. Readers can easily access and identify important results, and 4. Results from different impact evaluations are comparable. Most of this information does not appear in the draft report. When will stakeholders be provided a complete draft, including IESR tables, for review before the final report is published?	
5	Number Formats	PG&E	3/15/2019	Overarching		The report uses different number formats which makes reading some of the tables difficult. For example, table 4-9 contains zero values "0", and "-" values. Sometimes both are in the same row and it's unclear if these are both zero values or not. Can the report use consistent number formats? We request that zero values should be shown as "0", and missing values should be blank or "N/A." If blanks are used, the report should state how to interpret these.	We have edited the tables so the formatting is uniform
6	Measure Codes	PG&E	3/15/2019	Overarching		HVAC measures can be installed through a variety of different programs. Noting specifically which programs were evaluated allows the reader to draw connections between evaluation results and actual programs. Can measure codes and programs be provided for each of the measure groups?	We have added Table 6.28 in Appendix K showing measure codes and programs for each measure group.
7	EULs and Lifecycle Savings	PG&E	3/15/2019	Overarching		There is no discussion or evaluation of the EULs or lifecycle savings for the evaluated measure groups. Are the EULs as reported by the IOUs being passed through? If not, how will the evaluation team be evaluating EULs for the purpose of calculating lifecycle savings.	Program year 2017 evaluation didn't look into EULs, and IOU-reported EULs have been passed through for this cycle to calculate lifetime savings of the measure groups. The lifetime savings are shown in the IESR tables within Appendix A of the report.
8	Clarify Labeling	PG&E	3/15/2019		3-4	Are the savings listed in Table 2-1 gross savings? Please clarify in the report.	Yes, the savings in Table 2-1 are gross savings. We have clarified that in the report.
9	Clarify Evaluated Savings	PG&E	3/15/2019		3-4	Table 2-1 lists the statewide savings claims for each HVAC measure group. Can the evaluator confirm which line items were evaluated as well as that savings listed in 'other' were passed through for both gross and net savings?	Yes, we have highlighted the 7 measure groups in the Table 2-1 that were evaluated as part of the PY 2017 evaluation. The items categorized as "Other" in the table are the HVAC measure groups that didn't receive any evaluation treatments and were passed through. The evaluation team has

Comment #:	Subject:	Entity:	Date:	Section:	Page #	QUESTION or COMMENT:	Evaluator Response:
							added text around the table to clarify this.
10	Clarify Evaluated Savings	PG&E	3/15/2019		4	In Table 2-1, the 'other' line listed under the central plant measure group includes ESPI uncertain parameters of GRR and NTG. Were these values evaluated as part of this impact evaluation?	Not all the ESPI uncertain parameters were evaluated for the selected measure groups due to the compressed timeline, but some critical parameters were reviewed and evaluated. This is clearly stated in the PY 2017 HVAC workplan which was posted in PDA in September 2018
11	Clarify Savings	PG&E	3/15/2019	Overarching		Are all the reported and evaluated savings in the report first year savings? If so, please clarify throughout the report.	Yes, all reported and evaluated savings are first-year savings. We have clarified this in the report.
12	Clarify NTGR Labeling	PG&E	3/15/2019	Overarching		We appreciate that most tables throughout the report clearly identify reported vs. evaluated quantities. One exception to this is NTGs. Can the evaluation team clarify throughout the report where NTG is reported vs. evaluated? Or even better, show both values?	We have added the reported NTGR values into the tables.
13	Survey Response Influence	PG&E	3/15/2019	Overarching		Throughout the presentation, the evaluation team made comments about survey responses from participants that could show the reader why evaluation results deviated so much from the expected savings. Can the evaluator include discussions as such to provide additional color around survey results that influenced the evaluation outcome?	We added some additional detail about survey results for the fan and thermostat controls net savings calculations. All other measures already had explanations about why results turned out like they did.
14	Relative Precision	PG&E	3/15/2019		11	Please provide the formula used to calculate achieved relative precision in the final report.	The formula has been added to the report.
15	Relative Precision	PG&E	3/15/2019		12-15	The tables included in section 3.1 (planned sample, planned precision, achieved precision, etc.) provide valuable information to the reader regarding the difference between the evaluator's planned precision and the actual outcome. This is best practice and we thank the evaluators for including this information. However, it is difficult to understand to which values the relative precision applies. Can the evaluator clarify this in the final report?	The relative precision applies to the estimated savings value (Ex-Post Gross Savings for example). The relative precision is multiplied by the savings estimate to come up with the error bounds, which are the +- uncertainty interval around the estimate. For example, a program savings 100 MWh with an 13% relative precision means that the true savings values is 100 MWh +- 13 MWh.
16	Relative Precision	PG&E	3/15/2019		11	Section 3.1 has a good discussion about why achieved RP was often less than planned RP. Can the report include additional discussion that describes how the results should be interpreted and used, or not, given that achieved RPs often did not meet planned RP, especially in cases when RP is > 100%? Remember	Additional discussion on achieved relative precision is now provided in the report.

Comment #:	Subject:	Entity:	Date:	Section:	Page #	QUESTION or COMMENT:	Evaluator Response:
						that impact evaluation results are used for many things like determining goal attainment, calculating measure/program/portfolio cost effectiveness, calculating ESPI, revising ex ante DEER/workpaper values, and sometimes to inform decision making to expand or discontinue measures and programs.	
17	Limitations	PG&E	3/15/2019	Overarching		Discussing limitations help provide context, interpret the validity of work, and shape future research. Can the evaluator please include a discussion of limitations of this study?	We added additional discussions and recommendations around how the results should be interpreted and used.
18	Sample Design	PG&E	3/15/2019	Overarching		Please include a discussion of the structure of the samples. Are they simple samples? Stratified? If so, on what?	A stratified sampling approach was used for this evaluation. The sample design memo goes over all the details of the sample design; it will be attached as an appendix to the final report. We have added text in the sample design section of the report clarifying that it was a stratified sampling approach.
19	Results Presentation	PG&E	3/15/2019		26-51	The presentation of results makes it difficult to link key results together and there are an excessive number of tables. For example, tables 4-2 and 4-3 should be combined. If we're interpreting correctly, the evaluated gross savings and their achieved relative precision are displayed in two separate tables. These two quantities naturally go together. It's X savings, +/- Y% (at 90% confidence). Can the evaluator please include summary tables that bring together the different elements from each of the tables throughout the report?	The first-year savings table is already the width of the page and based on another comment, we have added the reported NTGR value. We feel the first-year table is already wide and will not be further adding the RP into the first-year table as the two tables are in close proximity.
20	Distributor Sample	PG&E	3/15/2019		27	The top 4 distributors for PG&E's program account for the majority of participation (in incentive dollars), thus, weighting responses based on distributor's contribution to the measure may provide a more representative attribution result. Additionally, such a small sample size that may not be representative of the distributors that have the most impact or even of the IOU territories introduces sample bias that may have skewed attribution results. Can the evaluator please provide a breakout of how many distributors they surveyed for midstream rooftop and split system attribution segmented by IOU territory and participation size (by incentive dollars) as well as the targeted sample size?	We are unable to provide information at this level as the PA did not provide links between distributors and claims.
21	Causal Pathways	PG&E	3/15/2019		121	The logic model for PG&E's rooftop/split system upstream program does not provide any indication that there should be buyer influence. PG&E did not provide a logic model to the evaluation team, nor were we asked to. For these reasons, we believe that buyer attribution should be eliminated from the attribution calculation. Can the evaluator please explain in the	The attribution methodology followed the same method as was used in the previous evaluation, which included both distributor and buyer influential pathways. The buyer questions assessed how the

Comment #:	Subject:	Entity:	Date:	Section:	Page #	QUESTION or COMMENT:	Evaluator Response:
						final report what logic model they used to make these assumptions and how they were concluded?	distributor behaviors affected their decisions, which is a critical form of influence to assess to determine the program's total indirect effect on purchase decisions. Buyers are always involved in decisions about equipment installations at their facilities, so for the program to affect them via the distributor behavior, the distributor behavior also has to matter to the buyers.
22	Causal Pathways	PG&E	3/15/2019		121	Some units (>12.5 tons) are not stocked by distributors as they are custom ordered, however, these orders are still upsold. Was this taken into consideration when determining stocking and upselling attribution for each distributor? If not, this misunderstanding could lead to lower attribution scores since there is no intended stocking attribution on these larger units per the design of the program.	The methodology measured attribution separately for units <=20 tons and >20 tons, then averaged those scores together.
23	Specify Date Request	PG&E	3/15/2019	Section 6.6.1.4		Footnote 14 states that "the PAs did not provide sufficient data to identify specific connections, so the evaluation calculated the mean score across all distributors for each of the causal pathways and combined that with the individual buyer scores." This was never requested in the data request, stated as a method in the research plan, or mentioned by the evaluation team during the numerous communications pertaining to the data request or during PCG calls. In future data requests, please specify that these connections are needed so that the PAs have the chance to provide them. If the PAs provide data that is insufficient in such an impactful way, please communicate this and provide the opportunity to respond with additional data to improve the quality of the impact evaluation. Can the final report reflect this clarification?	In the PY2017 data requests, evaluators asked for "the full databases of PY2017 records…", which should have included a link between the distributor and the claim - even without explicitly specifying that link in the request. By the time we realized there was no distributor-claim link, there was no time before the bus stop to request and fulfill a supplemental data request. For the next evaluation, the team will ensure that data requests are explicit about links to distributor and contractor data.
24	Survey Results	PG&E	3/15/2019	Overarching		Can the evaluator please provide the verbatim results of surveys as appendices to the final report?	No, it is not a typical practice to provide results at this level in the impact report.
25	NTG Surveys	PG&E	3/15/2019	Overarching		Can the evaluator please provide an explanation of how open-ended responses to NTG survey questions are interpreted and used to calculate final attribution?	An evaluator experienced with scoring these NTG sequences reviews each open-ended response and makes adjustments to relevant NTG component scores where suggested by the open-ended response. These decisions were reviewed by a second evaluator before being made final. A detailed

Comment #:	Subject:	Entity:	Date:	Section:	Page #	QUESTION or COMMENT:	Evaluator Response:
							example of these decisions is provided for the furnace evaluation in Table 6-5.
26	NTG Surveys	PG&E	3/15/2019	Overarching		What are the evaluator's thoughts concerning survey fatigue and how it may affect the accuracy of responses to NTG surveys? Does the evaluator believe that improvements and/or simplifications (clear and consistent terminology, etc.) to the NTG battery are possible to improve self-report reliability? If so, would they support a reconvening of the NTG Working Group?	Our plan has been to review and revise the NTG methodology with an eye towards standardization and contemporary survey response rate challenges following the PY2017 evaluations. The details of the revision process are still to be determined.
27	Thermostat Survey Responses	PG&E	3/15/2019	Tables 6-14 to 6-19		Several of the sites surveyed to verify installation of thermostat measures have no hours logged for one or more of the weekday/weekends occupied/unoccupied responses. How should this be interpreted? It seems unlikely that a customer would have 0 weekday occupied hours and 0 weekday unoccupied hours. If the customer is unsure of their weekday/weekend occupied/unoccupied hours of operation, it is unlikely that they could respond with accurate thermostat settings related to those hours of operation.	During the interview, the sites with no hours indicated that they have disabled the programming and they operate the HVAC system manually only as needed. They were confident in the temperature setpoints; they just didn't operate the equipment in the manner described by the measure workpaper.
28	Thermostat Survey Responses	PG&E	3/15/2019	Tables 6-14 to 6-19		Many thermostats have set points noted as 'Off'. Does this mean that during these times the heating and/or cooling is turned off completely? If so, wouldn't this result in higher savings than setting the thermostat to the required levels of the program? This would imply that instead of turning on when the set point is reached, the heating and/or cooling would never turn on during those hours, regardless of the temperature in the room. PG&E believes that in this case, the savings for the measure should be counted. This scenario would reverse the zeroing out of at least one site.	Turning off the thermostat means the site is not meeting the workpaper requirements: "**The replacement thermostat must be set during unoccupied hours to call for heating at < 55 degrees Fahrenheit and call for cooling at > 85 degrees Fahrenheit. Occupied comfort settings must be in the range of 72 to 75 degrees Fahrenheit for cooling and 65 to 68 degrees Fahrenheit for heating.**" Turning systems off may result in savings (or may not due to recovery penalties), but the evaluation team believes that those savings don't result from installation of the measure.
29	Thermostat Installation Rate Calculation	PG&E	3/15/2019	Tables 6-14 to 6-19		Can the evaluator please explain why thermostat measures did not receive partial credit for meeting some of the program settings? The function of the impact evaluation is to estimate the savings in the real world. Just because the customer may have changed the savings from what was originally set, doesn't mean there were no savings. Out of the 17 sites, 12 meet the occupied	Partial credit was given for time periods that met all of the workpaper setpoint requirements, but not if the time period failed to meet any setpoint or operating condition. Per the workpaper, "The

Comment #:	Subject:	Entity:	Date:	Section:	Page #	QUESTION or COMMENT:	Evaluator Response:
						weekday cooling set point requirements which is where most of the savings are at.	replacement thermostat must be set during unoccupied hours to call for heating at < 55 degrees Fahrenheit and call for cooling at > 85 degrees Fahrenheit. Occupied comfort settings must be in the range of 72 to 75 degrees Fahrenheit for cooling and 65 to 68 degrees Fahrenheit for heating." Turning systems off may result in savings (or may not due to recovery penalties), but the evaluation team believes that those savings don't result from installation of the measure.
30	Results	PG&E	3/15/2019		26-52	It does not appear any ex-post savings adjustments were made to account for the delay between measure installation and ex post evaluation. Since customer contact for ex post evaluation occurred 13-24 months after measure installation natural measure failures (broken, changed settings, etc.) are expected due to EUL. This effect is particularly large for short-EUL measures. Without adjustment, this significantly underestimates both first year and lifecycle savings. Can the evaluators adjust savings accordingly? At a minimum, the evaluation must state that savings estimates do not make the adjustment and therefore underestimate savings.	Evaluation results are, and have traditionally been, based on observations made at the time of the evaluation.
31	Thermostat Survey Results	PG&E	3/15/2019	Table 6-14		The only site that the evaluators determined met the thermostat measure criteria is site PGE.10. However, upon further review, survey responses reported in Table 6-14 do not indicate that the site met the measure criteria. This is contrary to what is reported elsewhere in the report. Can the evaluator please review all survey results for thermostat measures to ensure accurate result reporting in the final report?	PGE.10 received partial credit for meeting the criteria during unoccupied periods but none for the occupied periods during which the thermostat operations failed to meet the measure criteria.
32	Thermostat Findings	PG&E	3/15/2019		30-35	Based on the previous six comments, we find the 4% GRR for PG&E's thermostat measures un-credible and ask the evaluators to adjust savings or opine on the 4% rigor/reliability.	See responses above related to thermostat comments (#27-31).
33	Clarify Language	PG&E	3/15/2019	Overarching		Throughout the report, dealer and distributor are used interchangeably, as well as upstream and midstream. These terms have different meanings to different stakeholders. Can the final report make a distinction between the two and use consistent terms?	Dealer was changed to distributor throughout. Upstream and midstream seemed to be used correctly.
34	Graphic Representation	PG&E	3/15/2019		42	The graphic in figure 4-4 is a great visual representation of the data collected. However, it would be better to have a key to indicate the meaning of the bubble sizes.	In the narrative prior to the chart, we have added further explanation of the bubble size meaning and will also augment the figure with a reference scale.

Comment #:	Subject:	Entity:	Date:	Section:	Page #	QUESTION or COMMENT:	Evaluator Response:
35	Recommendations	PG&E	3/15/2019		52-58	What is the difference between statements following a key graphic and those following a gear graphic?	The key icon represents a key finding, while the gear icon represents the recommendation.
36	Page Numbers	PG&E	3/15/2019	Overarching		After page 125 there are no longer page numbers, making it difficult to reference. Could the final report please include page numbers throughout the appendices?	We have addressed the page numbering to be continuous throughout the report.
37		SCE	3/15/2019	Overarching		Since portfolio allocation decisions logically flow from these impact evaluations, it would be helpful to get some indications of the overall performance of the HVAC sector for PY 2017 for section 5. The webinar indicated that overall trends are in line with these 2017 results on net and gross savings so such a reproduction is probably not too burdensome. Perhaps this could be included in the pending executive summary.	A waterfall graphic has been added to show the impact of the savings on HVAC portfolio.
38		SCE	3/15/2019	Overarching		For the 2018 evaluation, SCE recommends that the evaluators consider a joint 2017 2018 evaluation to improve precision and accuracy and allow weighting of attribution by distributor size as there will be greater size variations.	The evaluation team will consider adding 2018 sample points to 2017 similar to 2014 and 2015 HVAC evaluations. This will an option for the measure groups that are in both 2017 and 2018 ESPI list.
39		SCE	3/15/2019	Section 4.1.1.2	27	"The evaluation only reached 7 dealers this year, versus 19 last time. Smaller samples carry greater risks of sample bias. For example, this year's evaluation might have unintentionally gathered information from an unusually unaffected portion of the distributor population."	This comment did not contain a question or action request.
40		SCE	3/15/2019	Section 3.1	11	In section 3.1 on page 11 the evaluation states the desired sampling frames and + or – 10% relative precision at 90% confidence level and goes on to explain: "After combining all the causal pathways, the final NTGR for rooftop and split systems is approximately 30%. Can the final report specify how accuracy levels in Table 4-2 were calculated to achieve precision at 90% confidence when each IOU sample size contains a portion of 7 total distributors contacted? Can you provide individual relative precision calculations?	The intent of sampling was to achieve 90/10 precisions at the measure group level. This is in line with the vetted workplan which was posted to the PDA in September of 2018. The actual achieved precisions depend on survey response rates, the actual variability of the relevant variables, and the point value of each particular ratio. In this case, we completed surveys with as many distributors as possible. Table 4-2 already shows the achieved relative precisions broken out for each IOU for kWh, kW, and therms separately.
41		SCE	3/15/2019			Sampling bias on the part of the evaluation may have skewed distributor's attribution results since it was not weighted based on distributor's contribution to the measure. SCE had 10 distributors that participated to deliver HVAC rooftop/split system measures.	We agree with the spirit of this comment, however the information necessary to weight the distributor responses was not provided or

Comment #:	Subject:	Entity:	Date:	Section:	Page #	QUESTION or COMMENT:	Evaluator Response:
						Of the 10 distributors, 2 are high volume distributors which delivered 80% of the projects (site). Weighing distributor responses based on distributor's contribution to the measure may provide better clarity on their practice of stocking, upselling, and price.	available. Also, see response to comment #20.
42		SCE	3/15/2019			It is not clear if distributor attribution was weighted by the distributor's contribution to gross savings. Past EM&V studies (e.g. HVAC1) categorize distributors into Distributor Stata based on their total incentives received. Without strata it's difficult to tell if the distributors interviewed were major contributors to the program. Distributors that make up a larger portion of the program sales should be weighted more heavily than distributors that do not contribute to program sales, since they contribute to a larger portion of the gross savings.	See comment responses #20 & 41.
43		SCE	3/15/2019			If weighting was not done, it may be that distributors that have little participation are those that are generally disengaged with the program and would have the lowest scores for upselling, stocking and pricing, and therefore the contribute to a low NTG score	We agree with this speculation, but there is no way to determine the relative level of engagement of the interviewed distributors. The general possibility is covered already in the bullet that says that we might have happened to interview distributors who were uncharacteristically unaffected by the program.
44		SCE	3/15/2019	Section 5.2		Section 5.2 Overarching findings (page 53): "We also acknowledge that this evaluation was executed under a very tight timeline and that with more time we could have reached a greater number of respondents with the contact data we had." SCE also hopes that PY 2018 research timeframes allow interviewers and surveyors to get the best respondents for NTG surveys.	Thank you for your comment. The evaluation team agrees that PY 2018 evaluation will give adequate time to effectively reach out the survey respondents.
45		SCE	3/15/2019			SCE recommends that for future impact evaluation studies we include and assess Upstream chiller equipment including size categories indicated in table below. If including evaluation of "custom" projects, it would be valuable to understand custom offerings on "Path B" chillers current not supported in deemed.	Water-cooled chiller is on the ESPI Uncertain measure list of program year 2018 and most likely will be evaluated as part of the PY 2018 impact evaluation that will be reported in March 2020. This comment should also be raised for the soon-to-be-released DEER scoping memo and statewide workpaper submission. Contract group D will have to look at Path B submissions as custom projects in program year 2017-2019.
46		SCG	3/15/2019		Various	Access to the formulas and calculation methodologies used in the evaluation. SCG would like to see the formulas/methodology used for calculating relative precision for the different measure groups	We have provided the formula for calculating relative precision in the sample design section of the report.

Comment #:	Subject:	Entity:	Date:	Section:	Page #	QUESTION or COMMENT:	Evaluator Response:
						and include all the required data values in the appendices so PA can verify values	
47		SCG	3/15/2019		Various	More clarification on table headers needed. Table headers should describe whether the values for NTG and Net Realization Rates are based on evaluations or derived from other sources.	We have added clarification as to the sources of the values.
48		SCG	3/15/2019		p.9	Boiler savings use a billing analysis approach normalized on weather. Can you provide more details to validate this approach, including percent of total energy saved, percent of total heating use compared to total meter use (which includes domestic hot water and ancillary uses), and normalization methods?	Our initially proposed approach involved comparison of weather-normalized pre- and post-project utility bills to determine project impacts. However, since the boiler measure invokes a baseline reflecting Title 24 boiler efficiency, and due to insufficient pre-project billing data for several projects, we used the post-install natural gas consumption data to estimate each facility's space heating load. Isolating space heating load from other gas uses required detailed telephone interviews and some follow-up on-site visits. The phone interviews ensured that other facility changes (e.g., new or removed equipment) were not inappropriately reflected within the calculated gas savings. By comparing heating load with installed boiler size, we calculated equivalent full load heating hours (EFLH) and verified that the calculated EFLHs reflect the expected range of values for the participating facility types. The evaluated gas savings calculation involved a subtraction of weather-normalized post-project gas consumption from the baseline gas consumption that reflects the space heating load and a Title 24 boiler efficiency. Our analysis resulted in the following:

Comment #:	Subject:	Entity:	Date:	Section:	Page #	QUESTION or COMMENT:	Evaluator Response:
							Weighted average percentage of gas savings as compared to total gas usage: 9% Weighted average percentage of space heating gas usage as compared to total gas use (including domestic hot water and ancillary uses): 69% space heating vs. 31% ancillary/DHW
49		SCG	3/15/2019		p.40	Four mis-classified facilities.: On page 40 the draft report, it notes, "evaluators found one project classified as "Assembly" within the SCG tracking data with significantly higher evaluated savings, leading to slightly higher evaluated gross natural gas savings than reported." To understand the discrepancies in the datasets, SCG would like to see the underlining data and associated calculations for figures 4-2 and 4-4. By comparing the calculation methodology used to calculate the net and gross savings in the evaluation with the methods that are used at SCG, we may be able to resolve some of the discrepancies in the evaluation related to Figure 4-2 and 4-4 and more importantly, reduce the relative precision.	The underlying data is the site-specific natural gas consumption provided by SCG as well as the SCG-provided tracking data on installed boiler quantity, size, and efficiency. The associated calculations follow the site-specific billing analysis methodology described in the report and in the response to comment #49.
50		SCG	3/15/2019		p. 56	Boiler workpaper NTGR was not used (Section 5.5.1): SCG's net savings claims incorporate a positive 0.05 adjustment to account for market effects as well as other measure-specific adjustments. As an example, for DEER Measure_Technology_building_Sector, "All K12 Community College Projects" (see DNVGLID numbers DNVGL_17014 and DNVGL_17003), the baseline NTGR used within our claim data is 0.85. The combined effect of those two adjustments result in a NTGR of 0.9 for All K12 Community College Projects. Could the evaluation team confirm that the ex post savings calculations include these adjustments for the Central Plant HVAC Boilers?	We have revised the NTG calculation to include the 0.85 value claimed in DEER for "All K12 Community College Projects." The additional 0.05 MEB adjustments are included in the ATR calculation but excluded in the ex post impact results.
51		SCG	3/15/2019			Difficulty trying to contact customers: Evaluators noted that it is becoming increasingly difficult to contact enough customers for the measure groups to have a valid sample from which they can draw conclusions about the population of participants. One of the recommendations is that PA spend additional time additional time maintaining current contact information for participants (buyers/decision makers, equipment operators, and other customer personnel) so that the follow-up EM&V studies can be performed. This may be an unrealistic expectation for the following reasons: a. Long Project Lead Times: Energy Efficiency projects, especially those that involve high capital expenditures and long construction periods, can take as long as two years to complete. During that	We appreciate the difficulty in acquiring and maintaining customer contact information, however in many cases, there was no contact information at all. At a minimum, the PAs to ensure there is a contact listed for every record, even if those contacts cannot be kept current. That survey response rates are down across the board only underscores the importance that the PAs do everything they can to maintain current contact

Comment #:	Subject:	Entity:	Date:	Section:	Page #	QUESTION or COMMENT:	Evaluator Response:
						time, many company personnel can be involved, and after the project is complete move on to other projects/jobs/employment. b. PAs are typically not notified about employee turnover (transfers, departures, promotions). Unless the customer is large enough to warrant an assigned Account Manager, the PA will not know when decision makers or equipment operators leave their positions. c. Even if EM&V personnel can reach the correct contact person, it is likely the case that they will decline to participate. This is not a phenomenon unique to EM&V. In an article published by the Pew Research Center, they report that they have seen declines in the response rate within their own phone surveys, and they note that one of the reasons for the decline in survey response rates could be the surge in automated telemarketing calls, particularly to cell phones.	information, even if that is challenging.
52		SCG	3/15/2019		Appendix page 150 per PDF	The Furnace NTG values seem inconsistent with the approach used for other measures. While this may be informative, it may be best to use the standard NTG default for an overall consistent approach.	We suggested in the report that future evaluations of the furnace program should update the NTG methods, including speaking with upstream market actors.
53		SDG&E	3/1/2019	Overarching		The terms "distributor" and "dealer" appear to be used interchangeably throughout the report although these represent distinctly different roles. Additionally, use of the term "buyer" is unclear as this may represent an end-use customer or a contractor/installer. The lack of clarity around the use of these terms in interviews may unintentionally skew results from the responses. For instance, on page 26, the possible explanation of "The incentive may be too low to motivate dealers" has significantly different meanings depending on which role is being discussed as not all program designs include passing incentives to dealers (contractors, installers, etc.). SDG&E recommends using the following terms for consistency and clarity: • Distributor: Midstream entity that sells HVAC equipment to contractors/installers and does not interface directly with end-use customers. • Contractor/Installer: Purchases HVAC equipment from a "distributor" and interfaces directly with end-use customers associated with the installation of HVAC equipment. • End-use Customer: Purchases HVAC equipment directly from a contractor/installer, but does not directly interface with midstream distributors.	The surveys reached distributors and in almost all cases, end-users (rather than the more general "buyers"). We have updated the verbiage throughout the report.