SAFER, SMARTER, GREENER

Impact Evaluation Report

HVAC Sector – Program Year 2018

EM&V Group A

CALIFORNIA PUBLIC UTILITIES COMMISSION

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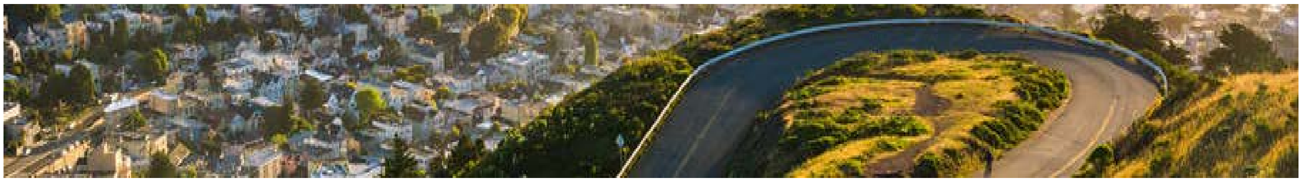
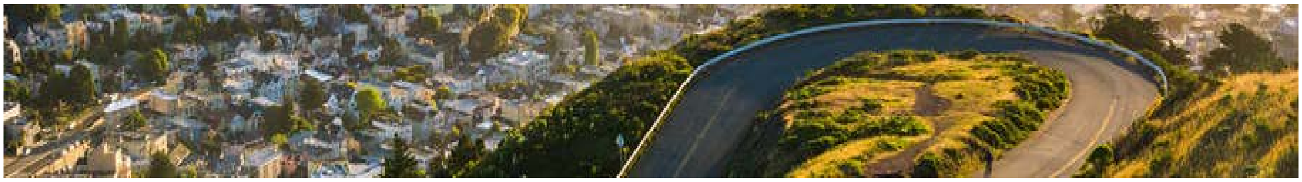
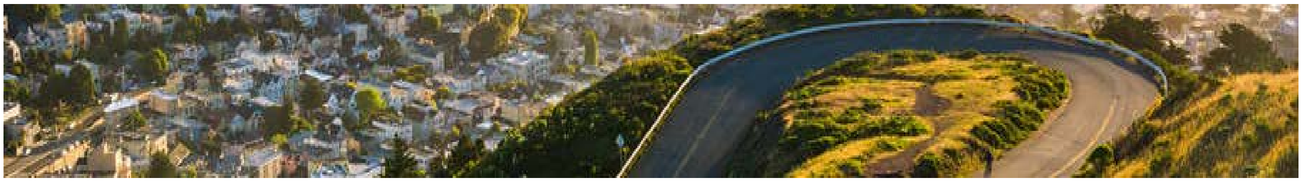


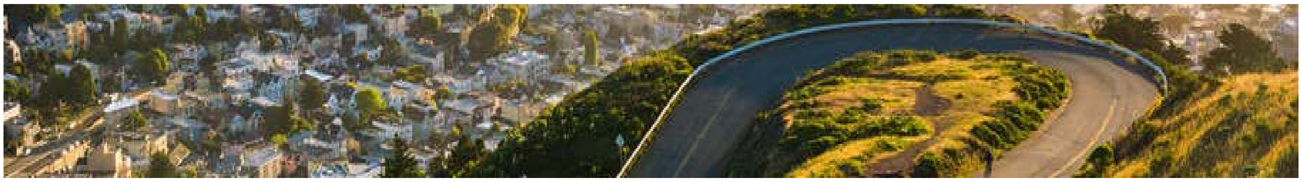
Table of contents



List of figures



List of tables



1 EXECUTIVE SUMMARY

This report presents the electric and natural gas energy savings evaluation of residential and commercial heating, ventilation, and air conditioning (HVAC) equipment in ratepayer-funded energy-efficiency programs in Program Year (PY) 2018. DNV GL estimated energy and demand savings for five selected HVAC technology groups across programs offered by the following program administrators (PAs): San Diego Gas and Electric Company (SDG&E), Southern California Edison (SCE), Southern California Gas Company (SCG), Pacific Gas and Electric Company (PG&E), and Marin Clean Energy (MCE). We conducted this evaluation as part of the California Public Utilities Commission (CPUC) Energy Division (ED) Evaluation, Measurement & Verification contract.

The primary goals of this 2018 evaluation were to:

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

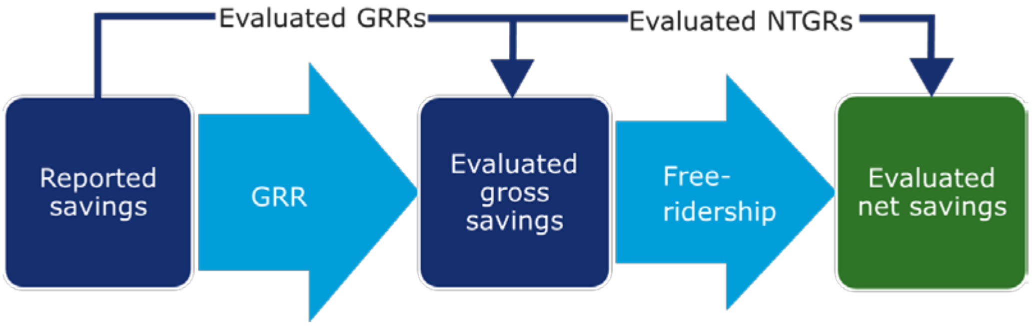
Central to this evaluation was collecting data from participating end users, decision makers (those who make the decision to implement an energy efficiency project), and distributors to adjust key technical parameters that affect the calculation of energy and demand savings.

The first major step was estimating the gross savings for each of the five evaluated technologies. Gross savings are the changes in energy and power demand that resulted from energy efficiency program activities, regardless of what factors may have motivated the program participants to take actions. We compared the evaluated gross savings with the gross savings reported by PAs to develop ratios of the evaluated savings estimated to the PA-reported savings values, which are referred to as gross realization rates (GRRs). Figure 1-1 illustrates how the GRRs are developed.

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

NTGR values are used to calculate the evaluated technologies’ net savings, which tell us how much impact the program had on the evaluated technologies’ electricity and gas savings.

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



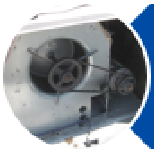
1.1 Study background and approach

The evaluation approaches of the five selected HVAC technologies were built on previous HVAC program evaluation methods. To estimate gross savings, we surveyed end users, collected site-specific data, performed equipment verification, and conducted performance testing on certain HVAC technologies. Net savings were estimated from surveys of end-users or decision makers and from interviews with equipment distributors. The five technology groups selected for this evaluation (PY 2018) are summarized below:

Figure 1-2. Summary of evaluated technologies

Rooftop and split systems for commercial customers

Efficient HVAC rooftop or split systems supply the same amount of cooling to buildings with less energy than standard rooftop or split systems because they use high-efficiency compressors and fan motors that draw less power.



Fan motor replacement for residential customers

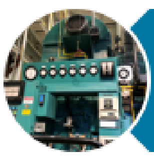
Brushless fan motors consume less electric energy compared with standard fan motors because the energy required to power them is much less than standard fan motors of the same size.

Duct testing and sealing for residential customers

Improperly sealed ducts cause conditioned air to spill out to the unconditioned surrounding space, which makes the HVAC system work inefficiently. Sealing ducts prevents the conditioned air in the ducts from escaping to the unconditioned space, which increases the HVAC system's cooling and heating efficiency.

Water-cooled chillers for commercial customers

Energy-efficient chillers use high-efficiency compressor motors that consume less energy to produce the same amount of chilled water that provides cooling to buildings than same-sized chillers with standard compressor motors.

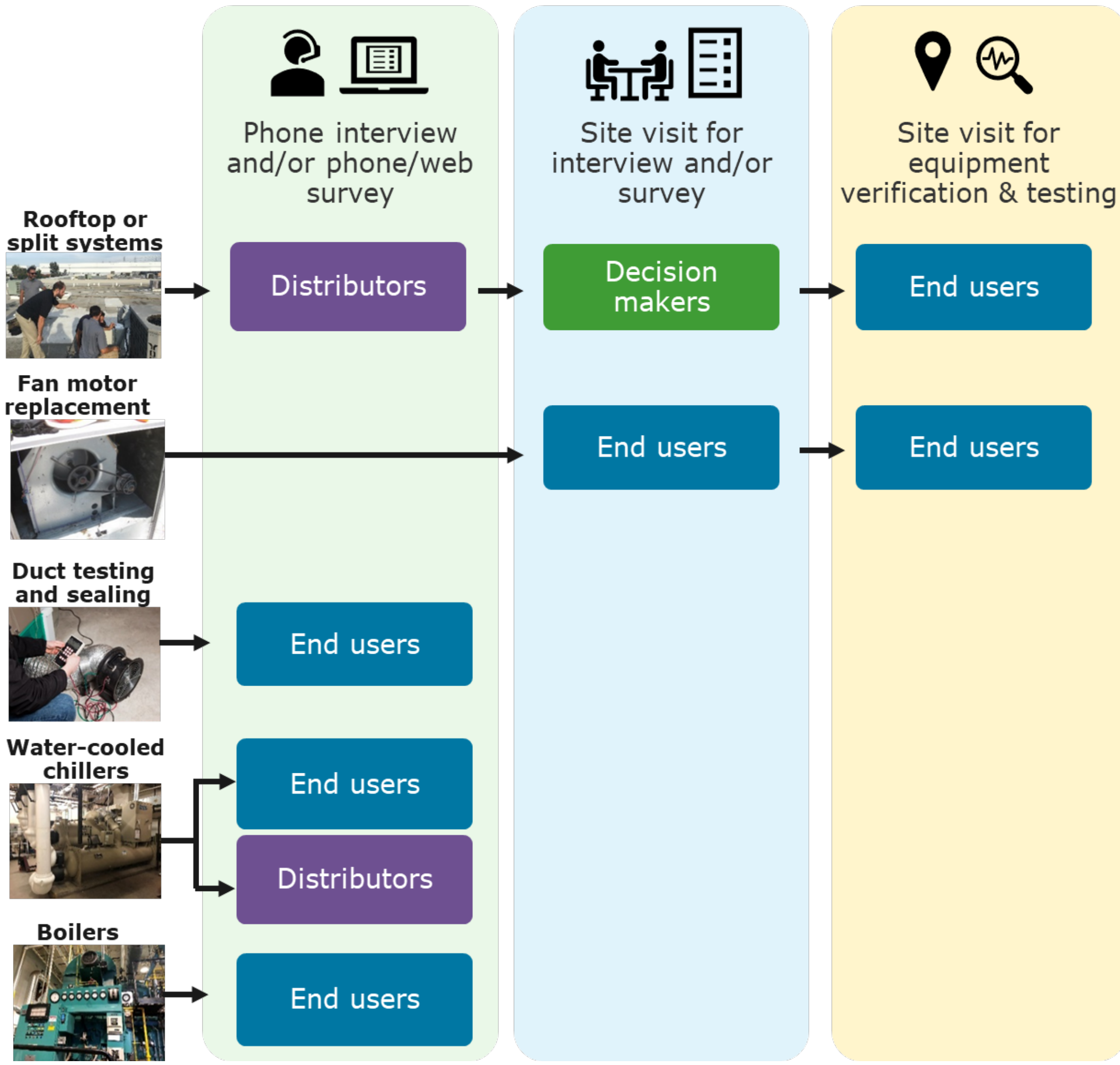


HVAC boilers for commercial customers

Boilers are pressure vessels used to heat space in commercial buildings. More efficient boilers use high-efficiency burners that consume less gas to heat the building than standard boilers.

The evaluation used various data collection and analysis methods to calculate the savings of the five selected HVAC technologies, as illustrated in Figure 1-3.

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



1.2 Evaluated savings results

Table 1-1 below provides a summary of the programs' success in providing gas and electric savings through the five technologies. The table presents evaluated net savings compared with the PA-reported net savings, and then in the last column, the net realization rate (NRR). The NRR removes the savings from installations that would have happened even if there were no rebates and is calculated as the ratio of the evaluated net savings value to the PA-reported net savings value. Thus, the NRR indicates the true impact of the ratepayer-funded program. The higher the NRR value, the greater the program's achieved savings.

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

Technology (Measure) Group	Evaluated Net Savings	Reported Net Savings	Net Realization Rate (NRR)
Electric Consumption (kWh)			
Rooftop & split systems	3,148,654	9,359,314	34%
Fan motor replacement	7,029,745	4,140,641	170%
Duct testing & sealing	1,329,974	1,216,937	109%
Water-cooled chillers	2,238,228	806,705	277%
HVAC boilers	Not applicable	Not applicable	Not applicable
Peak Electric Demand (kW)			
Rooftop & split systems	1,829	5,126	36%
Fan motor replacement	2,119	3,485	61%
Duct testing & sealing	55	1,591	3%
Water-cooled chillers	911	404	225%
HVAC boilers	Not applicable	Not applicable	Not applicable
Gas Consumption (therms)			
Rooftop & split systems	-15,165	-35,481	43%
Fan motor replacement	-84,553	-40,669	208%
Duct testing & sealing	83,057	56,720	146%
Water-cooled chillers	Not applicable	Not applicable	Not applicable
HVAC boilers	12,784	46,281	28%

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

1.2.1 Rooftop and split systems

Three of the five PAs (PG&E, SCE, and SDG&E) reported savings for installing new energy efficient rooftop and split HVAC systems. An energy efficient rooftop and split HVAC system uses less energy than a standard rooftop HVAC system while providing the same or better level of comfort to the building occupants.

Overall, GRRs for kWh, kW, and therms were 55%, 61%, and 58%, respectively (Table 1-2). This means the evaluated savings were close to half of the reported savings for all fuel types. In general, our surveys found the installed efficiencies of the rooftop and split systems to be close to the PA-reported efficiencies, but the evaluation modeling outputs produced very different result than the claimed values. The reported savings approach claimed savings equivalent to 60% of the total cooling load whereas the evaluation approach produced the savings to be approximately 10% of the total cooling load, which is in line with the efficiency improvement between the standard and high efficiency equipment. Additionally, the evaluation found a limited number of instances where the incentivized equipment was not installed as reported. These factors resulted in lower evaluated savings than the expected.

This is a midstream program designed to affect the behaviors of distributors, and the evaluation results suggest that it is successful at this, although not as successful as reported savings. Distributors indicated that about half of their decisions to stock and recommend high-efficiency equipment is due to the program rebates and activities. Furthermore, they pass on the majority of the rebates they receive from the program to their buyers to lower the incremental costs of high-efficiency equipment. The end users indicated that distributor recommendations to install high-efficiency equipment ("upselling") was the most important factor to them and price was the least important.

Table 1-2. Statewide first-year savings summary by fuel for rooftop and split system

Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR	Reported Net Savings	Evaluated Net Savings	NRR
Electric consumption (kWh)							
11,529,180	55%	6,326,438	76%	50%	9,359,314	3,148,654	34%
Peak electric demand (kW)							
6,343	61%	3,843	76%	48%	5,126	1,829	36%
Gas consumption (Therm)							
-43,402	58%	-25,281	77%	60%	-35,481	-15,165	43%

1.2.2 Fan motor replacement

The fan motor replacement technology saves energy by replacing a standard residential HVAC supply-air fan motor with a brushless fan motor. The brushless fan motor is more efficient, drawing less power than an equivalently sized standard fan motor for space cooling and heating.

The overall GRRs of kWh, kW and therms were 124%, 46%, and 148%, respectively, across the PAs as shown in Table 1-3 on the next page. The reported savings analysis assumed approximately 4,200 hours a year whereas the evaluation analysis found the annual fan operating hours to be ranging from 4,200 hours to 5,600 hours across all the residential dwelling types including single family, multifamily, and manufactured homes.

The lower peak kW savings are due to differences in thermostat settings between the evaluated and the reported values. The thermostat settings used in the reported savings model were based on older Database Energy Efficiency Resources (DEER)[1] thermostat values, whereas the evaluation savings model used 2017 DEER thermostat values that were higher and allowed the fan to operate at lower loads or not operate during the peak hours. This resulted in lower peak demand savings. The reported negative therm savings are due to the technology's reduced heat rejection to the airstream that increases gas space-heating consumption during winter. The evaluated therm savings showed even higher negative therm savings due to greater number of fan operating hours as compared to the reported values.

[1] The Database for Energy Efficient Resources (DEER) contains information on selected energy-efficient technologies and assumptions used to estimate savings for residential and non-residential applications.

Our net surveys revealed that a high number of program participants needed the program incentive to upgrade their fan motors. The overall, statewide NTGR ratio of therm savings was 85% for fan motor,[2] which means only 15% of the savings would have happened without program influences. The NTGR results for the PAs are presented in Section 4 of this report.

High attribution for this program is expected as it provides low or no cost upgrades through a direct install mechanism for a measure that is relatively unknown to typical residential end users. Our surveys showed that 78% percent of end users said the program had influence in deciding to install their fan motor because the service was free and/or they would not have known to install the efficient fan motors without program assistance.

Table 1-3. Statewide first-year savings summary by fuel for fan motor replacement

Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR	Reported Net Savings	Evaluated Net Savings	NRR
Electric consumption (kWh)							
6,667,992	124%	8,264,339	57%	85%	4,140,641	7,029,745	170%
Peak electric demand(kW)							
5,593	46%	2,581	57%	82%	3,485	2,119	61%
Gas consumption (Therm)							
-65,901	148%	-97,700	57%	87%	-40,669	-84,553	208%

1.2.3 Duct testing and sealing

All four PAs implemented HVAC system duct testing and sealing in 2018. This technology tests and seals the duct system when necessary to reduce the loss of conditioned air leaking from the air ducts into spaces outside the building's envelope. Electric consumption (kWh), peak demand (kW), and therm GRRs for this technology were 98%, 3%, and 130% respectively. For both electric and gas savings, the evaluated savings were approximately close to the reported savings, while the evaluation found little peak demand savings. The peak demand savings were lower due to the fact that the evaluated analysis used DEER peak definitions (i.e., Three consecutive hottest days in a year from 2:00 p.m.-5:00 p.m.) to calculate the peak savings, but our analysis revealed that the actual peak occurs later in the day than the DEER peak. This resulted in reduction of the peak demand savings.

Similar to the fan motor replacement technology group, high NTGR scores for duct sealing technology is expected as the programs also deliver the technology at reduced cost via a direct install approach.

Table 1-4. Statewide first-year gross and net impacts of HVAC duct seal

Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR	Reported Net Savings	Evaluated Net Savings	NRR
Electric Consumption kWh							
1,445,315	98%	1,418,599	79%	94%	1,216,937	1,329,974	109%
Peak electric demand(kW)							
1,883	3%	58	79%	95%	1,591	55	3%

[2] Reported NTGRs ranged from 82% to 87% for the fan motor measure.

Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR	Reported Net Savings	Evaluated Net Savings	NRR
Gas consumption (Therm)							
67,496	130%	87,478	79%	95%	56,720	83,057	146%

1.2.4 Water-cooled chillers

SCE is the only PA that reported savings for the water-cooled chiller technology group. Energy efficient water-cooled chillers require less energy than standard water-cooled chillers to produce the chilled water that provides cooling to buildings.

The gross realization rates for kWh and kW were 221% and 179%, respectively. This means the water-cooled chiller technology saved more than double the reported gross kWh savings. This is because the evaluation savings approach modeled different DEER building types, with various chiller annual operating hours, to calculate savings for different sample claims whereas the reported analysis used a single average "commercial" building type to estimate savings across all their claims. For most of the building types, our evaluation analysis found annual chiller operating hours to be higher than the operating hours assumed in the reported savings.

Generally, we found the water-cooled chiller NTGRs were higher than reported. The overall NTGR was 81% for kWh, meaning the program had a strong effect on high-efficiency chiller sales. The program's effect on sales is due mostly to the distributors' decisions to pass on most of the rebates they receive from the program to their buyers to lower the incremental costs of the high efficiency options. The distributors said that the ability to lower the incremental cost of high-efficiency equipment was key to making sales and their sales volume of high-efficiency models would be lower without the program. The program is also designed to increase distributors' recommendations of high-efficiency equipment, but survey responses indicate the program has minimal effect on this behavior.

Table 1-5. First-year gross and net impacts of water-cooled chiller

PA	Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR	Reported Net Savings	Evaluated Net Savings	NRR
Energy consumption(kWh)								
SCE	1,241,085	221%	2,748,426	60%	81%	806,705	2,238,228	277%
Peak demand (kW)								
SCE	622	179%	1,112	60%	82%	404	911	225%

1.2.5 HVAC boilers

SCG was the only PA that reported savings for the boiler technology group. Relative to standard boilers, the efficient boilers offered in the program use incrementally less gas fuel to heat the building. The evaluated NRR for the boiler technology group was 28%. Our surveys indicate that only 19% of the reported therm savings from boilers occurred because of the program's influence. This means the program had minimal effect on the end-users' purchasing decisions. A majority of survey respondents said they learned about the program *after* making the decision to purchase a high-efficiency boiler. Furthermore, 70% said they would have installed the same equipment even without the program incentives. Instead, respondents indicated the age of existing equipment and organizational policies as the primary factors in their decisions to upgrade to an energy efficient boiler. Note that the boiler technology was evaluated in program year 2018 for net savings only, but the evaluation team applied the program year 2017 evaluation GRR to estimate the evaluated gross savings for program year 2018.

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

PA	Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR	Reported Net Savings	Evaluated Net Savings	NRR
Gas consumption (Therm)								
SCG	66,106	102%	67,429	65%	19%	46,281	12,784	28%

1.3 Study Recommendations

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

- PAs should model the rooftop or split systems and the fan motor controls technology groups with appropriate baselines and propose conditions to reasonably capture the savings attributed to technology improvements in these two groups.
- For the water-cooled chiller technology group, PAs should take a closer look at the workpaper assumptions and review the savings model to ensure that all the building types are included in the model runs to capture the variations in chiller operating hours across the various building types.
- PAs should adopt a uniform technology description naming convention for technology groups to homogenize and therefore consolidate the descriptions under each technology group in order to move towards a statewide focused portfolio and to improve the evaluability of these technology groups across the PAs.
- For direct install programs, the PAs should consider increasing their reported NTGRs as the attribution can be expected to remain high under this program delivery mechanism due to low or no cost upgrades.
- PAs should reconsider offering boiler technology as a deemed program. This technology has previously been offered as a custom program by other PAs, an approach that enables more detailed project screening to better understand customer decision drivers and identify potential free-ridership prior to project approval.

2 INTRODUCTION

The report presents DNV GL's energy savings estimates (impact evaluation) of commercial and residential heating, ventilating, and air conditioning (HVAC) technology groups (measures) that are part of the California Public Utilities Commission (CPUC) HVAC Research Roadmap. These programs are evaluated under CPUC's Group A evaluation contract group. The primary results of this evaluation are estimated energy savings (in kWh, kW, and therms) achieved by 5 selected measures in Program Year 2018 (PY 2018) HVAC programs. The programs are offered by the following 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 5 selected measure groups across the HVAC portfolio from the 2018 programs offered by SDG&E, SCG, SCE, PG&E, and MCE. The evaluated measures are described in greater detail in the next section.

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

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

The impact evaluation team ("the team") is made up of DNV GL, Energy Resource Solutions (ERS), and 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 of measure groups was based primarily on each specific measure group's savings contributions to the HVAC portfolio in program year 2018 and growing trend of the measure group in the HVAC market. We also considered whether specific measure groups were in the 2017 ESPI uncertain measure list but not evaluated last year and so need to be addressed in this evaluation cycle.

The HVAC measure groups selected in this evaluation were offered to end users through various program delivery mechanisms including upstream, midstream, and downstream channels. The methodologies for evaluating these measure groups can vary by delivery mechanism and how these measure groups influence the programs via which they are offered to end users. The 5 measure groups chosen for this evaluation are:

- **Rooftop or split systems – commercial customers.** These measures are primarily delivered through upstream, distributor-focused programs and are generally a one-to-one replacement of HVAC units.
- **Fan motor replacement – residential customers.** These measures involve the replacement of existing permanent split-capacitor supply (i.e., furnace, indoor, or air handler unit) fan motors with high-efficiency brushless fan motors in residential applications that use central air-cooled direct expansion cooling and/or furnace HVAC equipment.
- **Duct testing and sealing – residential customers.** These measures involve testing and sealing residential ductworks to reduce leakage to specified levels.
- **Water-cooled chillers – commercial customers.** These measures involve high-capacity cooling equipment that is part of the built-up central plant HVAC systems used in larger buildings. Water-cooled chillers use evaporative cooling via cooling towers to dissipate heat from the system and in general operate at higher efficiency than their air-cooled counterparts.
- **HVAC boilers – commercial customers.** These measures involve high efficiency boilers (hot water or steam) for space heating applications. Boilers covered under this measure groups include mechanical draft boilers but exclude natural draft boiler types.

All of the measure groups listed above are from 2018 ESPI measure group except the boiler measure group. The boiler measure group was evaluated for gross savings last year as part of the 2017 ESPI measure group, so for this evaluation the evaluation team focused on calculating the net savings estimate and quantifying the net-to-gross ratio (NTGR) for this measure group.

Table 2-1 shows the 5 measure groups we evaluated for PY 2018. The items categorized as “Not Evaluated” 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 2018.

The uncertain energy-savings parameters evaluated for the measures are:

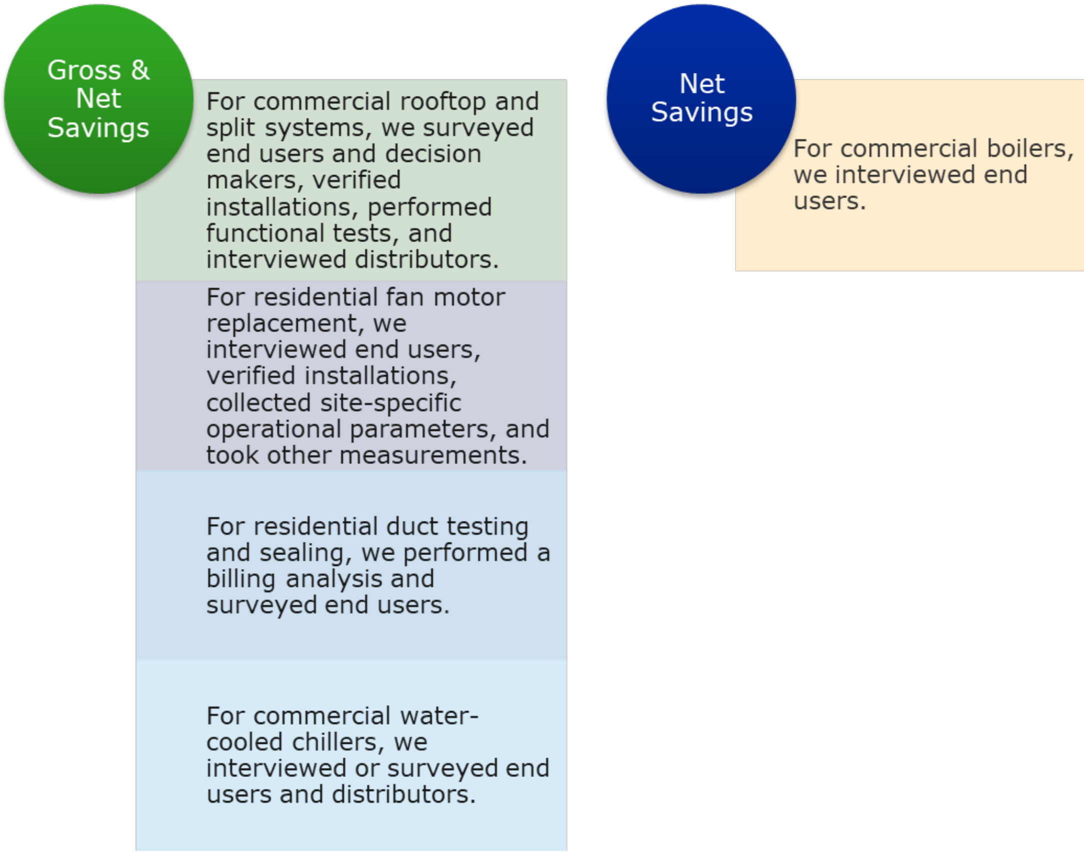
- gross realization rate (GRR): the ratio of evaluated gross savings to ex ante (reported) gross savings
- NTGR: the portion of savings that occurred because of the program
- Unit energy savings (UES): the savings produced per measure or unit

Table 2-1. PY 2018 gross first-year savings claims for the 5 selected HVAC measure groups

	Evaluation Type	Measure Group	Program Count	kWh	% kWh	kW	% kW	Therms	% Therms	ESPI Uncertain Parameters
ESPI	Gross and Net Savings	HVAC Rooftop or Split Systems	5	11,529,180	15%	6,343	16%	-43,950	-5%	GRR, NTGR, UES
		Motor Replacement	10	6,667,992	9%	5,593	14%	-65,901	-8%	GRR, NTGR, UES
		Duct Sealing	9	1,445,315	2%	1,883	6%	67,496	14%	GRR, NTGR, UES
		Water-Cooled Chiller	1	1,241,085	2%	622	2%	0	0%	GRR, NTGR, UES
		Subtotal – ESPI Evaluated	25	21,176,092	28%	14,842	36%	5,129	1%	
	Subtotal – ESPI Not Evaluated		32	8,131,044	11%	6,924	17%	39,926	5%	
	ESPI Subtotal		**57**	**29,307,136**	**38%**	**21,766**	**54%**	**45,055**	**5%**	
Non-ESPI	Net Savings	HVAC Boiler	2	-16,818	0%	1	0%	53,963	6%	
		Subtotal—Non-ESPI Evaluated	2	-16,818	0%	4,038	10%	53,963	6%	
		Subtotal Non-ESPI Not Evaluated	22	47,442,963	62%	18,915	46%	751,645	88%	
	Non-ESPI Subtotal		24	47,426,145	62%	18,915	46%	805,609	95%	
Total Deemed HVAC			**81**	**76,733,281**	**100%**	**40,681**	**100%**	**850,664**	**100%**	

We addressed the parameters that feed into the evaluated gross savings estimates and quantified the NTGR for the 5 measure groups. We performed both gross and net evaluations of 4 of the 5 selected measure groups and net savings evaluations for the remaining measure group (boilers) as shown in Figure 2-1.

Figure 2-1. PY 2018 HVAC evaluated energy savings types and activities per measure group



Details on the 5 evaluated HVAC measure groups and the programs that provide them are described next.

2.2.1 HVAC rooftop or split systems

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

Figure 2-2 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.

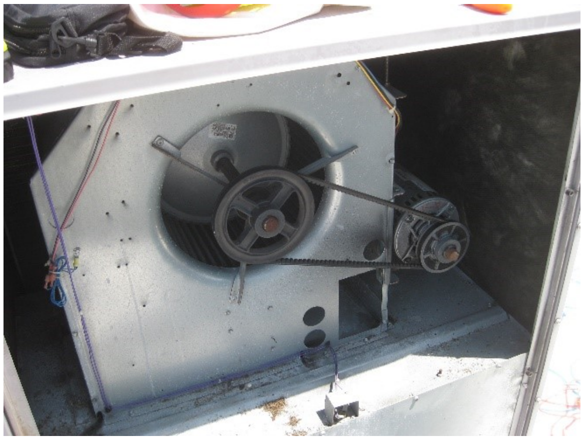
Figure 2-2. Commercial packaged RTU

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

2.2.2 Fan motor replacement

The fan motor replacement measure is offered to the residential end users through PA's direct-install delivery channels. This measure can be applied to all residential building types including single family, multi-family and mobile homes that use central air-cooled direct expansion HVAC system from cooling and heating. The fan motor measure replaces a standard permanent shaded pole (PSC) residential supply fan blower motor with a brushless fan motor.

Figure 2-3. RTU fan motor



PSC motors are typically used at two speeds but use almost the same power whether set to high speed or low. Brushless fan motors have a higher efficiency under design conditions and are much more efficient at lower speeds than the PSC motors, reducing power draw and saving energy whether heating or cooling. Blower fan motors also reject less heat to the airstream; this increases gas space heating consumption during winter but decreases cooling energy use in summer.

2.2.3 Duct testing and sealing

Duct sealing is part of the PA's direct install program and the incentives are provided to the program implementers and HVAC contractors to test and record the existing duct leakage via field testing and then perform duct sealing to achieve the leakage thresholds. The duct sealing measure is applied to any residential building that uses air cooled direct expansion cooling.

Figure 2-4. Residential air duct testing prior to sealing

Duct sealing measure can reduce both heating and cooling energy by preventing conditioned air from leaking from the ducts and cooling unconditioned spaces which waste energy. In addition, leaky return ducts can bring in air from unconditioned spaces which wastes energy by making the HVAC system work harder to cool the space. A well-sealed duct also improves indoor comfort, providing better air quality and improved safety.

2.2.4 Water-cooled chiller

SCE is the only PA to offer a water-cooled chiller measure via their upstream program. This measure provides incentives for installing variable speed water-cooled chillers in non-residential buildings, exceeding the 2016 California Title-24 minimum efficiency standard by 10% and 15% for both full load and integrated part load value (IPLV) efficiency. Variable speed chillers use less energy at part load condition than chillers that meet state building energy efficiency code (California Code of Regulations, Title 24, Part 2, Chapter 2-53 regulations) when cooling capacity can be reduced and the compressor speed can be reduced to more closely match the load.

Figure 2-5. Water-cooled chiller

It is worth noting that at lower speeds, variable speed chiller motors make less noise, which in turn possibly eliminates the cost of sound-attenuating equipment and improves building occupant comfort. Figure 2-5 shows a typical variable speed water-cooled chiller suppling chilled water to a large office building.

2.2.5 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.

Figure 2-6. HVAC boiler

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.

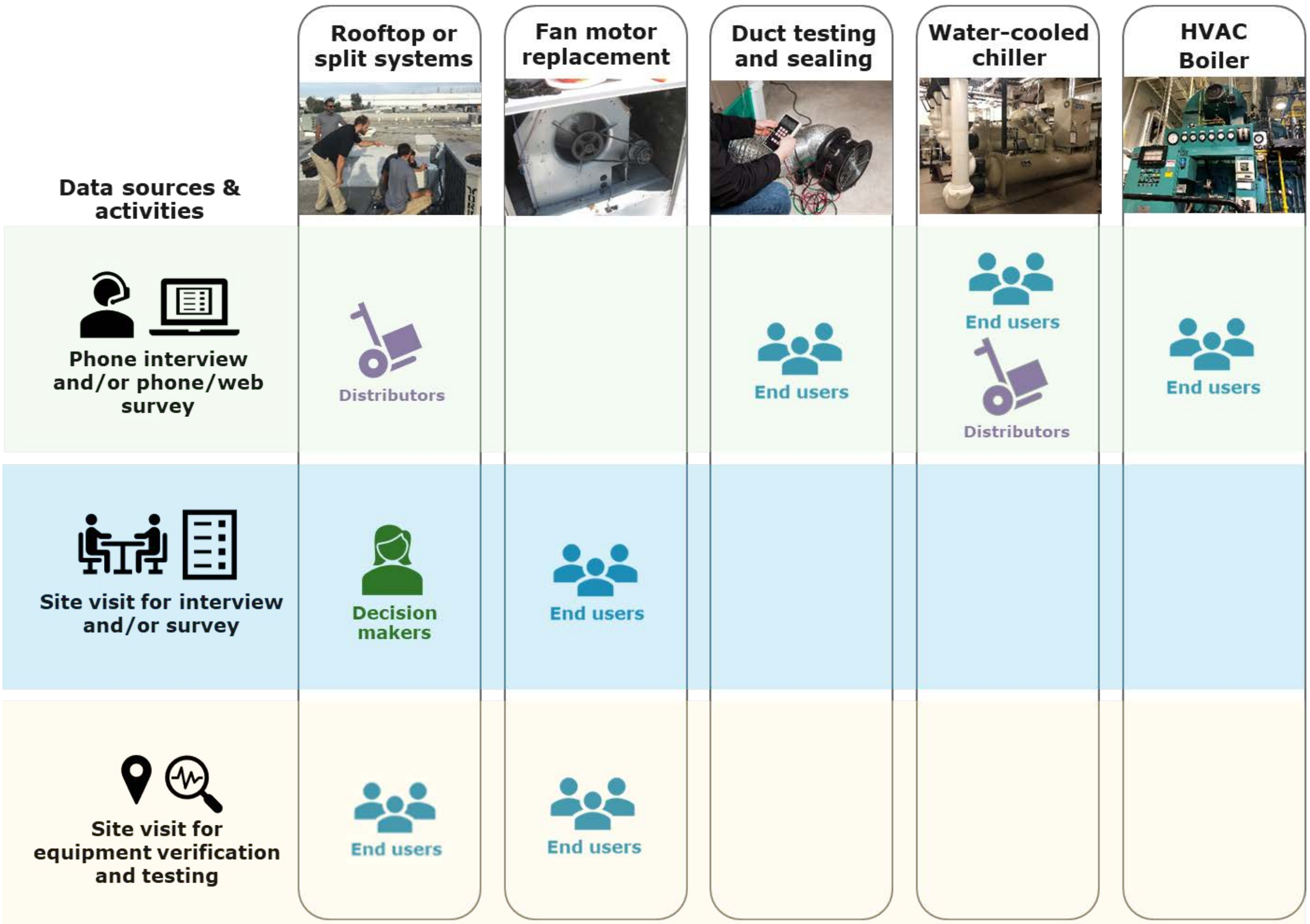
Figure 2-6 shows part of a condensing boiler, which reaches high levels of efficiency due to latent heat recovery from the boiler’s exhaust flue gases.

2.3 Overview of approach

This evaluation is built on DNV GL's PY 2010-2012,[3] 2013-2014 Upstream,[4] 2013-2014 Quality Maintenance, and 2015 Quality Maintenance program[5] evaluations. Of the 5 measure groups we evaluated, all but boilers are on the 2018 statewide ESPI uncertain measure list. Four of the 5 measure groups were evaluated for both gross and net estimates; the boiler measure group received net-only treatment.

Figure 2-7 below shows the 5 evaluated measure groups selected for gross and net evaluation for the HVAC sector along with the data sources and activities used to evaluate these selected measure groups.

Figure 2-7. PY 2018 HVAC evaluated measure groups and study data sources



For the rooftop or split system measure group, we conducted site visits to verify the installation of the new equipment, confirmed the intended operation of the installed system, completed performance measurements, and collected operational parameters for savings calculations. Some of the critical data collected are HVAC system tonnage, efficiency, compressor and fan powers, building vintage, and space

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

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

5 DNV GL, Inc. Impact Evaluation of 2015 Commercial Quality Maintenance Programs (HVAC3). California Public Utilities Commission, 2017

types served by the system. This allowed us to adjust the reported savings estimate to calculate gross savings.

Gross savings were estimated by using site-collected data to adjust critical model input parameters for the ex ante eQUEST savings models. The adjusted models were then run for every climate zone, building type, vintage, and unit type combination used across all upstream programs. These model runs were used to produce ex post (evaluated) savings estimates for each climate zone, building type, and unit type combination. The ex post gross savings were obtained by recalculating the savings for all the program populations using the revised estimates. In order to obtain combined vintage average values, the DEER weights were applied to individual vintage estimates.[6]

For net savings estimates, 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 the programs and what portion was free-ridership.

DNV GL used on-site data collection to evaluate the fan motor replacement measure group. We verified the installation of the blower motor, collect nameplate information, confirm the baseline, collect site specific operational parameters and perform spot measurements on the blower motor power draw (kW) and the system airflow in cubic feet per minute (CFM).The data collected on-site was used to calculate the fan power index (FPI) in kW/CFM of the supply fan system. We used FPI and other critical performance parameters to adjust the eQUEST model inputs to quantify the gross savings for this measure group. Net evaluation for the fan motor replacement measure group used surveys with participating end use customers to estimate NTGRs based on the participants responses on timing, efficiency and influence of financial incentive.

The duct testing and sealing measure group 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. We included non-participants as comparison group in the analysis to isolate the measure group effects. Our team also administered web-surveys with end-use customers to ask about program awareness and the decision-making process to get participants thinking about that time, then ask how much the program affected the timing, efficiency, and quantity of the installed measure to develop net-to-gross estimate.

For gross savings estimation of the water-cooled chiller measure group, we verified unit rated full-load and IPLV efficiencies of installed chillers, gathered performance data, and collected chiller installation characteristics, including seasonal operating strategies. The primary data collected were chiller capacity, rated kW/ton, flow control strategy (e.g., variable speed drive), lead/lag configuration, chilled water/condenser water supply and return temperatures, flow rates, etc. The data collected were used as inputs to the eQUEST prototype models to estimate the ex post gross savings of the measure group. To estimate NTGR, we surveyed the HVAC distributors about how the program affects the availability, pricing, and sales approaches of high efficiency water-cooled chillers on the market.

To calculate NTGR for the boiler 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.

[6] The DEER vintage weights were taken from Itron's 2012 Commercial Saturation Study.

2.4 Organization of report

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

Table 2-2. 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	**Study Methodology**	Sampling design approaches to gross impact determination, on-site measurement and verification (M&V) activities, measurement methods, analysis approach, NTG survey
4	**Detailed Results**	Gross impacts and realization rates, measure and program differentiation, Net of free ridership ratios and results, net realization rates, and NTG result drivers
5	**Conclusions**	Detailed gross and net findings, recommendations to improve program impacts

3 METHODOLOGY

The primary evaluation task was to verify the installation of the 5 selected 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 and then applied them to the gross savings estimate calculated by the evaluation team. We derived the NTGR by estimating the influence various program activities had on distributor behavior, and how downstream end-users may have been influenced by the upstream program as well. For the downstream programs, program influence was determined from end-use customer interviews. By quantifying this influence, we were able to estimate what percent of the gross savings was attributable to this upstream program and what portion was free-ridership.

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

3.1 Sample design

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

First, we defined sampling frames for each of the 5 HVAC measure groups that were evaluated for PY 2018. 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.[7] 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:

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

[7] 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 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 $se(b) = \dfrac{\sqrt{\sum_{i=1}^{n} w_i\,(w_i - 1)\,e_i^2}}{\sum_{i=1}^{n} w_i\,x_i}$
3. Calculate the relative precision $rp = \dfrac{1.645\,se(b)}{b}$ 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:

- **Completed sites/surveys less than expected** – Due to the reduced recruitment timeframe, response rates were lower than planned and additional mitigation steps were unavailable.
- **Inability to collect data from the largest sites** – Related the first reason, lower response rates meant that for some measures, the largest site(s) were unable to be completed, which can have a significant effect on the final achieved precision.
- **Observed variation in the sample is greater than assumed** – The sample designs each used a 0.6 error ratio (ER). Future studies may require a greater ER assumption to achieve the planned precision.
- **Ratio result is less than 50%** - Relative precision is calculated as a function of the ratio result (the ratio is in the denominator). Our sample designs assume a ratio of 50%. When ratios are lower than 50%, the relative precision can increase considerably, even when other statistics (such as confidence limits and standard errors) are reasonable.

We should note that especially in cases related to the fourth reason, where the achieved ratios are low, absolute precision should be considered along with relative precision. For example, a ratio of 10% with a relative precision of 150% has an absolute precision of ±15%. This would mean the PAs can be confident the true ratio is no greater than 25%. This is likely still an actionable finding when it comes to program design choices.

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

3.2 HVAC measure group sample design

DNV GL designed the sample to achieve ±10% relative precision at the 90% confidence level for each measure group. Four of the 5 selected measure groups were evaluated for both gross and net savings. In order to achieve ±10% relative precision for each measure group at 90% confidence level, a total of 85 sample sites were planned for the HVAC rooftop or split systems measure group, 131 sample sites were planned for the HVAC Motor Replacements group. For the duct sealing measure group, we performed a normalized billing analysis on the representative program participants of the measure group population. So, as a result this measure group has no sample design. Due to the smaller size of the population, all sites in water-cooled chiller and boiler measure groups were planned to be evaluated for gross and net savings respectively. In addition, we attempted a census of distributors of rooftop split systems and water-cooled chillers as the program design has a significant upstream component.

For the rooftop or split systems measure group and fan motor replacement measure group, the samples were not completed as planned. The response rates were much lower than the expected, primarily due to incorrect and incomplete end user contact information. For rooftop or split systems measure group, 59 sample points were evaluated as compared to the planned 85 sample points for gross savings estimate. We interviewed 23 end users and 8 HVAC distributors for this measure group to assess the net savings. The overall achieved relative precision was 5% for gross savings and 8% for net savings for the rooftop or split systems measure group. The overall archived relative precisions exceeded the target due to less variations between PA reported and evaluated savings. Also, the evaluation found the installed efficiencies of the rooftop or split systems to be very close to the PA-reported efficiencies.

Table 3-1 and Table 3-2 show the planned achieved sample sizes with their relative precisions for the rooftop or split systems measure group by PA for gross and net savings estimate respectively.

Table 3-1. HVAC rooftop or split system gross sample by PA

PA	Population Size	Planned Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
PGE	1,070	40	15.6%	27	9%
SCE	561	35	16.5%	23	6%
SDGE	190	10	31.0%	9	0.04%
Total	**1,738**	**85**	**10.7%**	**59**	**5%**

Table 3-2. HVAC rooftop or split system net sample by PA

PA	Population Size	Planned Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
PGE	1,070	40	15.6%	13	12%
SCE	561	35	16.5%	7	11%
SDGE	190	10	31.0%	3	18%
Total	**1,738**	**85**	**10.7%**	**23**	**8%**

For fan motor replacement measure group, we conducted on-site data collection and completed end user interviews on 117 sample points from the 131 planned sample points for both gross and net evaluations. The overall achieved relative precision was 4% for this measure group. The precisions for fan motor measure group exceeded the target due to the minimal variation between the ex ante savings estimate and ex post savings.

Table 3-3 shows the total planned sample size as well as achieved sample size relative precisions by PA for the HVAC fan motor replacements measure group.

Table 3-3. HVAC fan motor replacements gross and net sample by PA

PA	Population Size	Planned Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
PGE	17,043	69	11.9%	64	4%
SCE	2,562	45	14.7%	40	8%
SDGE	430	15	23.5%	11	15%
Total	**20,023**	**129**	**8.6%**	**115**	**4%**

Table 3-4 presents the HVAC programs that have the HVAC duct sealing measure. We included the HVAC duct sealing measures from 6 out of the 9 programs, excluding the Home Upgrade Program which is a whole house program and two small programs. HVAC Duct Sealing measure will be evaluated employing billing analysis approach in which all program participants with available billing data will be used to evaluate the savings. As a result, this measure has no sample design.

Table 3-4. HVAC programs with the HVAC duct sealing measure

Duct Testing & Sealing Evaluated?	PA	Program Name	Reported Gross Savings		
			kWh	kW	Therm
Evaluated	**PG&E**	Direct Install for Manufactured and Mobile Homes	454,897	474	36,070
	SCE	Comprehensive Manufactured Homes	720,630	988	Not applicable
	SCE	Residential Direct Install Program	218,445	325	Not applicable
	SCG	RES-Manufactured Mobile Home	Not applicable	Not applicable	18,494
	SDG&E	3P-Res-Comprehensive Manufactured-Mobile Home	35,773	67	1,777
	SDG&E	Local-CALS-Middle Income Direct Install (MIDI)	5,856	12	830
Not Evaluated	**PG&E**	Residential Energy Fitness program	1,981	2	283
	SCG	RES-Home Upgrade Program	Not applicable	Not applicable	8,928
	SDG&E	SW-CALS-MFEER	7,734	15	1,114
Overall			**1,445,315**	**1,883**	**67,496**

Table 3-5 shows the archived sample size as compared to the Census of 14 participants.

Table 3-5. HVAC water-cooled chiller, gross and net sample

PA	Population Size	Planned Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
SCE	14	14	0%	10	14%
Total	**14**	**14**	**0%**	**10**	**14%**

Net savings were not assessed for the boiler measure group in PY 2017 due to insufficient data and low response rates. However, the PY 2018 evaluation planned to perform a net evaluation on this measure group by combining the claims for both PY 2017 and PY 2018. Our team had planned to take a census approach and interview all 45 participants from PY 2017 and PY 2018. We were only able to reach 16 participants due to old contact information and turnover of decision-makers at customer facilities.

Table 3-6 shows the planned census and the archived sample size with its relative precisions for the boiler measure groups. For this measure group we fell short due to the low response rates and difficulty of reaching the appropriate decision makers to conduct net-to-gross surveys and fell to meet the relative precision target of ±10% at 90% confidence interval.

Table 3-6. HVAC boiler net sample

PA	Population[8] Size	Planned Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
SCG	45	45	0%	16	28%
Total	**45**	**45**	**0%**	**16**	**28%**

3.3 Data collection

This section addresses the data collection plans for the 5 measure groups selected for evaluation for the HVAC sector.

3.3.1 HVAC rooftop or split systems

Three (SCE, SDG&E, and PG&E) of the 5 PAs reported rooftop or split systems savings in PY 2018, which were claimed among a population of 2,033 participants. The programs that were prevalent among the 2018 population of rooftop and split system measure groups are shown in Table 3-7.

Table 3-7. Rooftop or split systems measure groups

PA	Programs	Number of Sites in Target Sample	Number of Sites Completed
PG&E	Commercial HVAC	30	18
	School Energy Efficiency	10	9
SCE	Nonresidential HVAC Program	35	23
SDG&E	3P-Res-Comprehensive Manufactured-Mobile Home	3	3
	SW-COM-Deemed Incentives-HVAC Commercial	7	6
Total		**85**	**59**

8 From the 45 sample points, 26 claims were from program year 2017 and rest of the claims are from program year 2018

The evaluation targeted a sample of 85 end-users for gross and net data collection. We attempted to recruit the facility representatives using PA-provided contact information. Due to the midstream, distributor-facing design of rooftop or split systems measures, evaluators found that the tracking data, in particular for PG&E and SCE, did not contain sufficient customer contact information to recruit sampled end-users for the evaluation study. As a result, we submitted follow-up data requests with all three PAs to attempt to fill the apparent data gaps. Overall, we estimated 74% of the PY 2018 population ultimately did not have sufficient end-user contact data for effective recruitment.

For projects with sufficient customer contact data, we found that customers were often unaware that they had participated in an efficiency program. Due to high non-response rates from the initial recruitment efforts, evaluators expanded the recruitment for the rooftop or split systems measure group to include all sample and backup sites within the population. Overall, we contacted 818 sites, from which gross data collection for 59 sites were completed. The gross data collection fell short of the target sample count statewide by 26 sites. Rooftop or split systems recruitment resulted in a success rate of 7.2% due to several factors:

- Tracking data contained inaccurate contact information: e.g., disconnected phone, respondent not known at that telephone number
- 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
- Contacts became unresponsive after multiple contact attempts
- Contacts refused to participate

Of the 59 completed site visits, five were found to be zero-savers with equipment that could not be measured, since the incented rooftop or split equipment was never installed or energized. At the remaining 54 sites, our team performed comprehensive data collection and M&V using a protocol and template provided in Appendix D.

The data collection protocol verified key measure-level parameters from the inventory of claimed equipment via PA tracking data: equipment manufacturers, model and serial numbers, quantities, and rated tonnages.

Evaluators performed in-depth unit-specific characterization for a sample of installed units at each site. Unit-level information collected included installation characteristics (building type and vintage, space type served by each selected unit), application configuration (duct location, unit configuration and mounting) and typical unit operation (weekly operating profiles, space temperature setpoints and schedules). After collecting this information, the evaluators conducted a series of spot measurements on this subset of installed units to be used in the gross analysis methodology.

The evaluator followed an on-site sampling protocol for selecting the number of units to perform in-depth data collection on at each site. For sites with 3 or fewer installed units, one unit was selected for in-depth data collection. For sites with 4-9 installed units, 2 were selected and any site with 10 or more claimed units had 3 units selected for data collection. Appendix D provides more information on the on-site sampling strategy.

The first spot measurement consisted of locating the unit's supply fan motor power source and jumping the unit into maximum cooling mode so the supply fan would operate at full speed. The evaluators measured and recorded the isolated fan motor amperage, voltage and power factor at full speed. The evaluators then used a differential pressure gauge to measure the pressure drop over the unit operating at maximum airflow. Based on the differential pressure reading and the size of the filter opening, the evaluators calculated a maximum airflow value through the unit. The fan power and airflow values recorded were then used to inform the fan power index in the gross analysis methodology discussed in detail in Section 3.4.1. See Appendix G for the rooftop and split system data collection template.

For net savings assessment, our team interviewed commercial end users and HVAC distributors using PA-provided contact and equipment information. The phone interview involved questions to determine stocking, recommendations, pricing from the distributor perspective and how the distributors' available stock, recommendations, and price affected the end users' decisions. Some of the specific efforts under this were conducting market actor interviews (participating distributors, customers, and end users) focusing on market structure for all units and participant distributor interviews to assess program influence for rooftop or split systems.

Overall, we attempted to contact 85 sites and from that completed 23 end-user interviews and 8 distributors interviews from a total of 13 distributors in the programs.

3.3.2 Fan motor replacement

As with the rooftop or split systems measure group, three (PG&E, SCE, and SDG&E) of the 5 PAs claimed savings for the fan motor replacement measure group. This measure group comprised ~10% of the Deemed HVAC kWh savings in PY 2018 and claimed savings among a population of 20,023 participants. Table 3-8 shows the number of sites targeted vs. the number of sites completed for the fan motor replacement measures across the 3 PAs.

Table 3-8. Fan motor replacement measure group

PA	Programs	Number of Projects in Population	Number of Sites in Target Sample	Number of Sites Completed
PG&E	Direct Install for Manufactured and Mobile Homes	3,177	15	8
	Enhance Time Delay Relay	6,791	22	12
	Residential Energy Fitness program	1,367	10	18
	Residential HVAC	5,708	22	26
SCE	Comprehensive Manufactured Homes	1,282	15	13
	Residential Direct Install Program	1,788	30	27
SDG&E	3P-Res-Comprehensive Manufactured-Mobile Home	329	5	4
	Local-CALS-Middle Income Direct Install (MIDI)	86	5	3
	SW-CALS-MFEER	13	5	4
Total		**20,023**	**129**	**115**

As part of gross data collection, we verified the installation of the blower motor, collected nameplate information, confirmed the baseline, collect site-specific operational parameters and perform spot measurements on the blower motor power draw and the system airflow. At each site, our field team collected the following information:

- Installed motor type, name plate information including model number, serial number, horsepower, efficiency, rated speed, etc.
- Operating characteristics such as fan schedule, cooling/heating set-points, cooling capacity of the HVAC unit
- Perform spot power measurements on the fan
- Perform airflow measurement on the unit
- Other site-specific data including Number of bedrooms/bathrooms, number of year-round occupants, dwelling type, etc.

To estimate net savings, we conducted NTG interview with the end use customers as they were the only influencers of the fan replacement measure group. The NTG data collection approach used questions that explore how rebates and program services affected the timing installed fan motors, and in the case of property managers, the quantity. Some of these questions are:

- In the absence of the services offered by the program, would you have installed the brushless motor measure at the same time, earlier, or later?

- In the absence of the services offered by the program, would you have installed the same quantity of (or size) equipment, lesser, or more?

3.3.3 Duct testing and sealing

All 4 PAs offered duct testing and sealing. As described in section 3.1, duct testing and sealing was offered through 9 different HVAC programs, however, we did not include the Home Upgrade Program in this evaluation as it is a whole house program. We estimated gross savings using billing analysis on AMI data. Through the data preparation process, we lost approximately 50% of the starting population. Table 3-9 and

Table 3-10 present the data attrition by PA. Each of the key data preparation steps corresponding with a table header are outlined below:

- *Evaluated population*: The starting population includes all the duct testing and sealing participants from 8 of the HVAC programs.

- *Requested*: We requested AMI data for this group of participants. This group includes only participants from the 6 evaluated programs. Additionally, the counts shifted due to changing from counting SA_IDs to customer (account ID for PG&E) and premise identifiers. Some participants were also not requested due to insufficient data for the first round of matching, which required twelve months of billing data prior to and after the date of installation.

- *Received*: We received at least some AMI data for these participants. For PG&E and SDG&E, we requested both gas and electric data for all tracked participants. Some of these participants likely receive only gas or only electric service from PG&E and SDG&E, resulting in higher attrition rates.

- *Sufficient*: These data had 90% or more reads in the year prior to installation and following installation, have installation dates for all measures within 30 days, and were not master metered.

Table 3-9. HVAC duct sealing gross data evaluated by electric PA

PA	Tracked	Requested	Received	Sufficient Data
PG&E	1,375	1,256	860	458
SCE	4,698	4,477	4,451	2,450
SDG&E	442	353	349	214
Overall	**6,515**	**6,086**	**5,660**	**3,122**

Table 3-10. HVAC duct sealing gross data evaluated by gas PA

PA	Population	Requested	Received	Sufficient Data
PG&E	1,375	1,261	1,245	695
SCG	2,141	1,836	1,780	984
SDG&E	442	353	341	255
Overall	**3,958**	**3,450**	**3,366**	**1,934**

We based net impacts for this measure group on NTG survey data obtained from program participants. The survey questions are similar to the fan motor replacement measure group. The battery of questions for this measure group primarily focused on the timing of the installation of the duct seal measure in residential homes.

3.3.4 Water-cooled chiller

SCE is the only PA that claimed savings for the water-cooled measure group in PY 2018. For this measure, our data collection activities included remote verification of measure installation and installation parameters (such as equipment size) along with basic program attribution. We verified unit-rated full-load and IPLV nameplate efficiencies of the installed chillers and collected data on their installation characteristics, including seasonal operating strategies (as determined through controls sequences and operator logs), as possible. We also requested data logged by on-site building automation systems. This information provided insight into in-situ operating characteristics and the input parameters collected from the sites were used to adjust the eQUEST model inputs to quantify the ex post savings. Some of the critical parameters collected from the remote verification were:

- Installed characteristics of the chiller including model number, serial number, # of chillers, capacity, flow control strategies, etc.
- Operating characteristics such as chilled water supply/return temperatures, condenser water supply/return temperatures, chiller schedules.

To support NTG assessment, we began by conducting surveys with end users. However, no end users were aware of their participation in the program. Based on further discussion with program staff, we determined that the program is a midstream program targeted at chiller distributors. Therefore, so we added in-depth interviews with the chiller distributors. The distributor’s NTG questions are very similar to the rooftop or split systems system distributor questions and queried the programs effects on upselling and prices for high efficiency equipment. Because chillers tend to be custom-built, the interviews did not focus on how the program changes stocking practices.

3.3.5 HVAC boiler

Only SCG reported savings in PY 2018, which were claimed among a population of 19 participants. The HVAC boiler measure received only a net attribution assessment in PY 2018 evaluation, as the measure underwent gross evaluation in PY 2017. The evaluation team had previously attempted net assessment in PY 2017 but completed only 4 NTG surveys due to the compressed evaluation timeframe. As a result, and because of the relatively low participant populations in PY 2017 (26) and PY 2018 (19), evaluators pooled the two program years together and attempted telephone interviews with a census of customer decision makers to gather sufficiently representative data to quantify NRR and NTG ratio.

The evaluators surveyed commercial end users using utility-provided contact data and equipment information. The end-user phone survey 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 preexisting conditions. Overall, evaluators completed 16 end-user interviews, reaching 36% of the population representing approximately 59% of the PY 2017 and PY 2018 ex-ante savings. The HVAC boiler interview guide used by evaluators is in Appendix G.

3.4 Gross methodology

This section presents the methods by which we developed our gross savings estimates. Our gross impact assessment involved standard M&V approaches to extent appropriate and practical, including desk reviews, phone data collection, on-site inspections and analysis for representative sample for 4 selected measure groups in HVAC sector. The gross impact analysis: (a) developed evaluated estimates of the energy and demand savings for each site in the sample, and (b) applied those findings back against the full measure group population to obtain population estimates of the measure group impacts. The evaluation team utilized PA and implementer-collected information, including project-implementer's submitted project files/documentation, supplemented by data collected for this evaluation.

3.4.1 HVAC rooftop or split systems

The gross savings for rooftop or split systems system measure group were estimated by using site-collected data to adjust critical model input parameters for the ex ante savings models. The adjusted models were then run for every climate zone, building type, vintage, and unit type combination used across all upstream programs. These model runs were used to produce ex post savings estimates for each climate zone, building type, and unit type combination. The ex post gross savings were obtained by recalculating the savings for all the program populations using the revised estimates. In order to obtain combined vintage average values, the DEER weights were applied to individual vintage estimates. [9]

The actual ex ante models were not available, so we used a DOE-2 simulation generator and batch processing tool called MASControl. With this tool, DEER prototype models were generated for each building zone/ climate zone combination. Building vintage bins were collapsed into a single weighted average using the DEER 2014 Energy Impact Weights Tables.

[9] The DEER vintage weights were taken from Itron's 2012 Commercial Saturation Study

3.4.3 Fan motor replacement

Fan motor replacement measure group utilized the same approach as the rooftop or split systems measure group. The critical input parameters adjusted in the eQUEST model runs are Fan Power Index (FPI) in kW/CFM, supply delta-T (temperature rise in the air stream across the supply fan), and thermostat schedules.

3.4.4 Duct testing and sealing

The duct testing and sealing measure group evaluation used a two-stage billing analysis with a matched comparison group to estimate savings. The evaluation selected the matched comparison group using advanced metering infrastructure (AMI) data to identify households with similar energy use to duct testing and sealing participants prior to program intervention. The comparison group did not install any other rebated energy efficiency measures during the matching and evaluation periods. The comparison group controls for non-program and non-weather-related changes. While most of the duct testing and sealing was done through manufactured housing programs, we could not stratify by housing type, as we could not identify which households resided in manufactured houses for the general population.

The first stage site-level model correlates daily energy consumption with heating and cooling degree days and is used to weather normalize energy consumption. The second stage uses a difference-in-difference modeling approach to estimate savings using the weather normalized energy consumption from the first stage. As households often installed additional measures at the same time as duct testing and sealing was completed[10], we estimated savings at the household level as well as at the disaggregated measure level. We estimated peak demand savings at the household level using the DEER defined peak periods and a difference-in-difference modeling approach. See Appendix D for additional details.

3.4.5 Water-cooled chiller

Water-cooled chiller measure group also used the same analysis approach as the rooftop or split systems system and fan motor replacement measure groups. For analysis of the chiller measures, the major differences between the baseline and measure case models were the equipment efficiencies. The average as-found efficiency of the installed chillers was used for the measure case, while the baseline models used code minimum efficiency according to chiller type and capacity. The other critical input parameters adjusted in the eQUEST model runs apart from the chiller efficiencies were chilled water supply air temperature, minimum chiller unloading ratio, and condenser water supply temperatures. The adjusted models were simulated for SCE’s climate zones (5-6, 8-10, and 13-16), building types, vintages and capacity type combinations. The model outputs were used to estimate ex post savings of the water-cooled chiller for each climate zone, building type and chiller capacity type combinations.

3.5 Net methodology

This section contains descriptions of how the evaluation team calculated net to gross ratios (NTGRs) for the 5 measure groups 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.

[10] We excluded duct testing and sealing participants who implemented other measures more than a month before or after duct testing and sealing. These installations occurred during the matching period, pre-period, or post-period and would prevent the accurate measurement of savings.

Table 3-11 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 sections listed in the table.

Table 3-11. NTGR method summary

Measure Group	NTGR Method	Location of Detailed Methodology
Rooftop or Split Systems	• Distributor interviews: Assess program effects on distributor stocking, upselling, and price changes • End-user surveys: Assess effects of distributor stocking and sales practices on end-user decisions • Combines program effects on distributors and distributors' effects on end users	Section 6.6.1
Fan Motor Replacement	• Assess program effects on timing and number of installed brushless fan motors • Assess the influence of incentive on end user decision	Section 6.6.2
Duct Testing and Sealing	• Assess program effects on timing of the duct seal • Assess the influence of incentive on end user decision	Section 6.6.3
Water-Cooled Chiller	• Assess program effects on distributor upselling and price changes	Section 6.6.4
HVAC Boiler	• Assess program and non-program impacts on end-user decisions • Assess program's effect on timing, efficiency, and quantity of measures installed • Assess likely end-user actions if the program had not been available	Section 6.6.5

3.6 Data sources

We based our savings estimates on data from several sources, summarized in Table 3-12. Section 6.4.4 in Appendix D provides the details of these data sources including contents and types of data and how we use them in the evaluation.

Table 3-12. Summary of data sources and applicable measure groups

Data Sources	Description	Applicable Measure Groups
Program Tracking Data	IOU Program data includes number of records, savings per record, program type, name, measure groups, measure description, incentives etc.	HVAC rooftop or split systems Fan motor replacement Duct testing and sealing Water-cooled chiller HVAC boiler
Program Billing Data	PA billing data including kWh	HVAC rooftop or split systems Fan motor replacement Duct testing and sealing Water-cooled chiller
Program AMI Data	Detailed, time-based energy consumption information	Duct testing and sealing
Project-Specific Information	Project folders include scope of work, equipment model and serial numbers, nominal efficiency, test results, project costs, etc.	HVAC rooftop or split systems Fan motor replacement Duct testing and sealing Water-cooled chiller HVAC boiler
Manufacturer Data Sheet	Data sheets Include equipment specifications such as horsepower (HP), efficiency, capacity, etc.	HVAC rooftop or split systems Fan motor replacement Water-cooled chiller
Telephone/Web Surveys	Includes surveys of customers, distributors, other market actors, and PA program staff.	HVAC rooftop or split systems Fan motor replacement Duct testing and sealing Water-cooled chiller HVAC boiler
On-Site Surveys	Includes verifying measure installation, gathering measure performance parameters such as efficiency, schedules, setpoints, building characteristics etc.	HVAC rooftop or split systems Fan motor replacement Water-cooled chiller
End-use Metering	Includes performing spot measurements, short-term metering with data loggers, performance measurements	HVAC rooftop or split systems Fan motor replacement

4 DETAILED RESULTS

This section presents the results of the gross and net evaluations of the measure groups. Gross impact realization rates (GRRs) and first-year evaluated gross and net savings are presented in this section by PA for electric energy (kWh), electric demand (kW), and gas energy (therms). Section 6.2 (Appendix B) contains the IESR Standard high-level savings and standard per-unit savings. Section 6.3 (Appendix C) contains the tabularized report recommendations. The evaluation used the PA-reported EUL measure values to calculate lifetime savings from first year savings.

4.1 HVAC rooftop or split systems

Overall, the gross and net realization rates were lower than the expected. This difference is primarily due to the overestimation of savings in the ex ante estimate. The ex ante estimate approach claimed savings equivalent to ~60% of the total cooling load whereas the evaluation approach produced the savings to be approximately 10% of the total cooling load, which is in line with the efficiency improvement between the standard and high-efficiency equipment. Overall, this measure group shows a moderate free-ridership as half of the distributor's decisions to stock and promote higher efficiency equipment is due to the program incentive and activities.

Table 4-1. Rooftop or split first-year gross and net savings summary[11]

PA	Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	NRR
Electric consumption (kWh)								
PGE	6,627,193	61%	4,070,801	75%	49%	2,009,989	5,317,389	38%
SCE	4,311,227	48%	2,066,150	77%	50%	1,039,531	3,532,576	29%
SDGE	590,759	32%	189,486	81%	52%	99,133	509,349	19%
Total	**11,529,180**	**55%**	**6,326,438**	**76%**	**50%**	3,148,654	**9,359,314**	**34%**
Peak electric demand (kW)								
PGE	3,790	57%	2,174	75%	49%	1,056	3,033	35%
SCE	2,273	64%	1,461	77%	46%	669	1,855	36%
SDGE	280	74%	208	80%	50%	104	238	43%
Total	**6,343**	**61%**	**3,843**	**76%**	**48%**	**1,829**	**5,126**	**36%**
Gas consumption (Therm)								
PGE	-25,663	58%	-14,955	75%	62%	-9,272	-20,530	45%
SCE	-16,621	58%	-9,670	79%	60%	-5,892	-13,905	42%

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

SDGE	-1,118	59%	-656	94%	0.2%	-1	-1,046	0%
Total	**-43,402**	**58%**	**-25,281**	**77%**	**60%**	**-15,165**	**-35,481**	**43%**

4.1.1 Gross impact findings

Table 4-2 presents gross results for the rooftop or split measure group. Statewide GRRs were 55% for kWh, 61% for peak demand, and 58% for therm savings. Each PA had similar gross results, and none are statistically different from each other.

Table 4-2. Rooftop or split system first-year gross savings summary

PA	Reported Gross Savings	GRR	Evaluated Gross Savings
Electric consumption (kWh)			
PGE	6,627,193	61%	4,070,801
SCE	4,311,227	48%	2,066,150
SDGE	590,759	32%	189,486
Total	**11,529,180**	**55%**	**6,326,438**
Peak electric demand (kW)			
PGE	3,790	57%	2,174
SCE	2,273	64%	1,461
SDGE	280	74%	208
Total	**6,343**	**61%**	**3,843**
Gas consumption (Therm)			
PGE	-25,663	58%	-14,955
SCE	-16,621	58%	-9,670
SDGE	-1,118	59%	-656
Total	**-43,402**	**58%**	**-25,281**

Table 4-3 shows the population sizes, sample sizes, gross realization rates and relative precisions for the rooftop or split system measure group. 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. This is because we fell short of our planned sample target.

Table 4-3. Rooftop or split system population, GRR, and relative precisions

PA	Population Size	Completed Sample Size	kWh GRR	kWh Achieved Relative Precision[12]	kW GRR	kW Achieved Relative Precision[13]	Therm GRR	Therm Achieved Relative Precision[14]
PGE	1,070	27	61%	12%	57%	21%	58%	0.9%

[12] Relative precision at 90% confidence
[13] Relative precision at 90% confidence
[14] Relative precision at 90% confidence

SCE	561	23	48%	41%	64%	29%	58%	1.2%
SDGE	107	9	32%	68%	74%	8%	59%	0.2%
Total	**1,738**	**59**	**55%**	**16%**	**61%**	**16%**	**58%**	**0.7%**

We estimated gross savings for the rooftop or split systems measure group by updating the installation rates and adjusting the energy efficiency ratio (EER) and fan power index (kW/CFM) of the systems. The adjusted models were then run for every climate zone, building type, vintage, and unit type combination used across all upstream programs. These model runs were used to produce ex post savings estimates for each climate zone, building type, and unit type combination. The ex post gross savings were obtained by recalculating the savings for all the program populations using the revised estimates. In order to obtain combined vintage average values, the DEER weights were applied to individual vintage estimates.[15]

Our field verifications did not find a significant difference between installed and reported EER values. The majority of the installed efficiencies were in line with the reported claims with a few exceptions. Therefore, the evaluated savings were expected to be closer to the reported savings estimate. However, our evaluation analysis produced savings that were significantly lower than the reported savings for this measure group. The reasons behind this lower savings are described below:

Overestimated ex ante savings model: The review of ex ante eQUEST models revealed that the savings produced in the ex ante models are significantly higher than what were expected from high-efficiency rooftop or split systems measure. The simulated savings in these models were approximately 60% of the total cooling load of the equipment. As this measure group claims savings for improved EER as compared to Title-24 baseline systems and some cases with embedded economizers, the expected savings should be within 10%-15% of the total cooling load. The evaluation model estimated savings equivalent to 10% of the total cooling load which is in line with the efficiency improvement between the Title-24 standard and high efficiency equipment. This difference had a significant impact on the ex ante savings and lowered the evaluated savings by 45% and resulted in achieving poor GRRs.

Zero savers: Evaluators observed lower than anticipated installation rate at various sites leading to zero evaluated energy savings for these sites. Of the 59 sites visited, 54 had equipment that was found to be installed and operating as intended while the remaining 5 were found to be not operational, as described:

- There were 2 instances of sites with units that were found to be installed but the facility was vacant, and the units were not operational
- One site had units that had been purchased but never got installed
- One site had no record of units ever being purchased
- One mobile home site had a unit that had been installed but the occupant (and mobile home) moved. Currently, the mobile unit and claimed HVAC unit are no longer installed or operating at the given address in tracking data

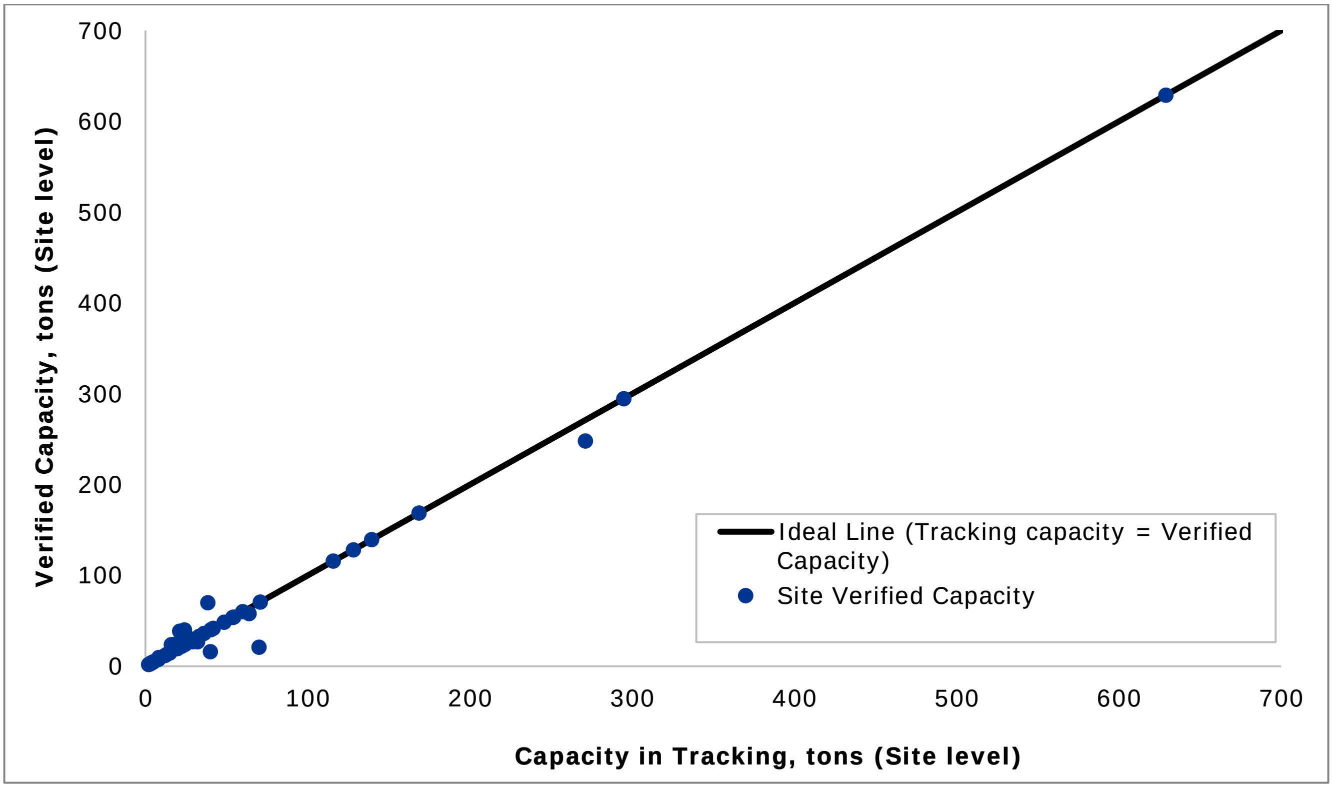
These 5 zero-saver sites contributed some reduction to the overall energy savings to this measure group which in turn affected the measure group GRRs.

Verified tonnages different compared to tracking: There were multiple instances where the capacity (tonnage) of the claimed units verified on-site were different than what was listed in the tracking data. Below, Figure 4-1 compares the measure's site-level reported capacities and verified capacities of the

[15] The DEER vintage weights were taken from Itron's 2012 Commercial Saturation Study

sampled 59 sites. Ideally, the verified capacities would always match the reported capacities and all the blue dots (that represents sites) should fall on the solid black line of the chart. The figure shows that while the verified tonnages for most sites were equal to reported tonnages, slight discrepancies were observed in verified tonnages for 16 out of 59 sites visited. This discrepancy resulted in an overall reduction of 1% in verified tonnages compared to tracking, leading to lower evaluated energy savings compared to tracking.

Figure 4-1. Site-level reported vs. verified capacities of rooftop or split systems



Building Type Discrepancies: We determined that the building type for 4 sites in the sample were broadly classified as "Commercial" within the PA's tracking data, and the evaluation team believes that more appropriate building types (mostly primary and secondary schools with at least one fast-food restaurant) should have been specified to estimate tracking savings. Results by building category vary widely, and evaluators believe this discrepancy led to an overall reduction in energy savings.

4.1.2 Net impact findings

Table 4-4 provides the NTG results for rooftop or split systems measure group. The statewide NTGRs were 50% for kWh, 48% for kW, and 60% for therms. Individual PA NTGRs ranged from 0.2% to 62%.

Table 4-4. Rooftop or split system first-year net savings summary[16]

PA	Reported NTGR	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	NRR
	Electric consumption (kWh)				
PGE	75%	49%	2,009,989	5,317,389	38%
SCE	77%	50%	1,039,531	3,532,576	29%
SDGE	81%	52%	99,133	509,349	19%
Total	**76%**	**50%**	**3,148,654**	**9,359,314**	**34%**
	Peak electric demand (kW)				
PGE	75%	49%	1,056	3,033	35%
SCE	77%	46%	669	1,855	36%
SDGE	80%	50%	104	238	43%
Total	**76%**	**48%**	**1,829**	**5,126**	**36%**
	Gas consumption (Therm)				
PGE	75%	62%	-9,272	-20,530	45%
SCE	79%	60%	-5,892	-13,905	42%
SDGE	94%	0.2%	-1	-1,046	0%
Total	**77%**	**60%**	**-15,165**	**-35,481**	**43%**

The NTGR method (see Section 6.6.2 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 4-5).

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

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

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

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

Table 4-5. Rooftop or split systems NTGRs by causal path - statewide

Causal Path	Distributor Sample Complete	Distributor Attribution	End-user Completes	End-user Attribution	Combined Attribution
Stocking	8	46%	23	41%	19%
Upselling	8	49%	23	73%	36%
Price	8	57%	23	11%	6%

These results represent higher NTGRs than the previous evaluation (PY 2017) of these measures. This year, the distributor attribution scores are substantially higher than they were for PY 2017 (when they ranged from 12% to 29%). The end-user attribution scores this year are higher for stocking and upselling, but much lower for price. There are several possible explanations for the change over time including:

- The evaluation team conducted in-depth interviews with program staff to obtain a better understanding of how the program runs. This resulted in some streamlining and modification of the surveys.
- The distributor sample received from the PAs was better for PY2018 than PY2017. In PY2018, program staff gave evaluators contact information for the distributor contacts they communicate with most often. For PY2017, the evaluation team had to rely on secondary contact information recorded in program tracking files.
- The evaluation reached only 23 end-users this year compared to over 100 for PY2017. Smaller samples make the end-user attribution scores more susceptible to sampling bias. In particular, the low-price attribution score for PY2018 could be due to an unusually large portion of this small sample saying they had to by efficient models despite the extra cost because of organizational policies.

After combining all the causal pathways, the final NTGR for rooftop and split systems is 50% for kWh, 47% for kW, and 61% for therms. There were slight variations in NTGRs across PAs and fuels (Table 4-6). The statewide confidence interval for kWh and therms is 90/10 or better; kW just missed this threshold with a 13% relative precision.

Table 4-6. Rooftop or split systems population, sample, realization rate, and relative precision[17]

PA	Population Size	Completed Sample Size	Evaluated kWh NTGR	kWh Achieved Relative Precision[18]	Evaluated kW NTGR	kW Achieved Relative Precision[19]	Evaluated Therm NTGR	Therms Achieved Relative Precision[20]
PG&E	1,282	13	49%	12%	49%	13%	62%	18%
SCE	561	7	50%	19%	46%	25%	61%	0.3%
SDG&E	190	3	52%	23%	50%	26%	-0.2%	68%
Total	**2,033**	**23**	**50%**	**10%**	**47%**	**13%**	**61%**	**7%**

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

18 Relative precision at 90% confidence

19 Relative precision at 90% confidence

20 Relative precision at 90% confidence

4.2 Fan motor replacement

The overall, gross, and net realization rates for kWh were greater than 100% across the PAs. This means both the gross and net evaluated electric savings were more than the PA reported savings. The primary reasons behind the higher gross kWh savings are differences between modeled building types and differences in associated cooling loads and fan operating hours between reported and evaluated values, which we discuss below. The higher net savings were contributed from strong program influence observed for this measure group. The evaluation resulted in lower peak kW savings for this measure group due to difference in thermostat schedules between reported and evaluated values.

Table 4-7 shows the overall gross and net results for the fan motor replacement measure group. The detailed results of gross and net savings are discussed in their respective sub-sections below.

Table 4-7. Fan motor replacement first-year gross and net savings summary[21]

PA	Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	NRR
Electricity consumption (kWh)								
PGE	5,323,161	117%	6,203,274	55%	84%	5,197,246	3,193,897	163%
SCE	1,153,227	154%	1,777,987	67%	90%	1,593,715	831,726	192%
SDGE	191,604	148%	283,079	55%	84%	238,784	115,018	208%
Total	**6,667,992**	**124%**	**8,264,339**	**57%**	**85%**	**7,029,745**	**4,140,641**	**170%**
Peak electric demand (kW)								
PGE	4,314	40%	1,705	55%	80%	1,359	2,588	52%
SCE	1,049	67%	704	67%	88%	620	759	82%
SDGE	229	75%	172	55%	81%	141	138	102%
Total	**5,593**	**46%**	**2,581**	**57%**	**82%**	**2,120**	**3,485**	**61%**
Gas consumption (Therm)								
PGE	-59,952	132%	-79,228	55%	85%	-67,384	-35,971	187%
SCE	-5,949	311%	-18,473	74%	93%	-17,169	-4,698	365%
SDGE	0	0%	0	0%	0%	0	0	0%
Total	**-65,901**	**148%**	**-97,700**	**57%**	**87%**	**-84,553**	**-40,669**	**208%**

4.2.1 Gross impact findings

The overall realization rates for the fan motor replacement measure group across the PAs are 124% for kWh, 46% for kW, and 148% for therm. The main reason behind the higher realization rate for kWh is that modeled heating and cooling loads and operating hours for 2 of the 3 residential building types were found to be greater than the single building type modeling approach used to estimate the reported savings. Differences in thermostat schedules between the assumed and evaluated settings had the effect of reducing the evaluated kW gross realization rate. The higher heating load and higher operating hours also resulted in a greater therm savings penalty; the efficient fan motor results in lower heat contributions from the supply fan itself, requiring more gas energy to meet the heating load.

Table 4-8. Fan motor replacements first-year gross savings summary

PA	Reported Gross Savings	GRR	Evaluated Gross Savings
Electricity consumption (kWh)			
PGE	5,323,161	117%	6,203,274
SCE	1,153,227	154%	1,777,987
SDGE	191,604	148%	283,079
Total	**6,667,992**	**124%**	**8,264,339**
Peak electric demand (kW)			
PGE	4,314	40%	1,705
SCE	1,049	67%	704

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

PA	Reported Gross Savings	GRR	Evaluated Gross Savings
SDGE	229	75%	172
Total	**5,592**	**46%**	**2,581**
Gas consumption (Therm)			
PGE	-59,952	132%	-79,228
SCE	-5,949	311%	-18,473
SDGE	0	0%	0
Total	**-65,901**	**148%**	**-97,700**

Table 4-9 show the population sizes, sample sizes, realization rates, and relative precisions for the measure groups. Although the completed sample size was below the target, the lower-than-anticipated error ratio of the sample resulted in achieving better relative revisions than planned for this measure group. In other words, the evaluated variability between the reported savings and the evaluated savings for the selected sample were lower than the anticipated variability between the reported and evaluated savings. The planned error ratio for the sample design was 0.6 with 131 sites whereas the evaluation resulted in achieving an error ratio of 0.25 with the completed sample of 117 sites.

Table 4-9. Fan motor replacement population, sample, realization rate, and relative precision

PA	Population Size	Completed Sample Size	kWh GRR	kWh Achieved Relative Precision[22]	kW GRR	kW Achieved Relative Precision[23]	Therm GRR	Therm Achieved Relative Precision[24]
PGE	17,031	64	117%	4%	40%	13%	132%	9%
SCE	2,562	40	154%	8%	67%	17%	311%	21%
SDGE	430	11	148%	15%	75%	22%	0%	0%
Total	**20,023**	**115**	**124%**	**4%**	**46%**	**10%**	**148%**	**8%**

We estimated gross savings for the fan motor replacement measure group by updating the installation rates and two post-retrofit operational parameters in the eQUEST mode as shown in Table 4-10. The table also compares the ex ante assumptions and ex post inputs used in the eQUEST model for quantifying savings for the measure.

Table 4-10. Fan motor replacement model inputs comparison

Parameter	Ex Ante Value	Ex Post Value
Post-retrofit Fan Watt Draw (kW/CFM)	0.000365	0.000399
Post-retrofit Supply Delta-T (°F)	1.153	1.012

[22] Relative precision at 90% confidence
[23] Relative precision at 90% confidence
[24] Relative precision at 90% confidence

The evaluated fan watt draw was higher than the expected with an anticipation of lower overall savings. However, the savings were significantly higher than the reported savings. The discrepancy in savings are due to the difference in fan operating hours between the ex ante assumptions and the ex post values. Our analysis found that the ex ante savings appear to result from applying single-family home hours of operation to mobile homes and multi-family buildings whereas the eQUEST models showed longer hours of operation for mobile homes and multi-family buildings, resulting in significantly greater evaluated savings than claimed for these building types.

Table 4-11, Table 4-12, and Table 4-13 on the following pages provide comparisons between claims and evaluated savings for kWh, kW, and therms respectively.

Negative savings for natural gas in residential buildings result from increased fan motor efficiency; efficient fans generate less heat (a lower Supply Delta-T), so more gas must be combusted to provide enough heat to the conditioned space.

Note that many occupants continue to use their thermostats – even the smart thermostats often provided in conjunction with the fan motor replacement – in a manual mode rather than programming in their setpoints and hours of operation. Many households have irregular schedules and are less inclined to program fixed operating hours, but households with a regular schedule are good candidates for a programmed operating schedule. A number of occupants mentioned to field staff that they had received no instruction in the use of their new smart thermostats beyond being shown how to turn the system on and off and setting a temperature. Training occupants in the use of their new smart thermostats could result in overall reductions in consumption.

Table 4-11 and Table 4-12 aggregated gross results for kWh and kW respectively by climate zone and residential dwelling types. For kWh savings, overall ex post savings were higher than the ex ante savings claims for almost across the three building types and climates zones except a few. The sites in climate zone 11 and 12 showed lower savings than the ex ante estimate across the building types. Additionally, most of the manufacture homes higher savings than the reported due to greater fan operating hours as compared to single family dwellings. All most all multi-family and single family showed lower peak demand savings, but the manufacture homes saved more peak demand than the expected across the climate zone.

However, overall the peak demand saving was lower than the reported. The lower peak kW savings are due to differences in the modeled thermostat settings between the evaluated and the reported values. The thermostat settings used in the reported savings model was based on older DEER[25] thermostat values and the CPUC issued disposition titled "Workpaper Disposition for Residential HVAC Quality Maintenance" which modified the calculation of savings for residential fan motor replacement through PY2019, whereas the evaluation savings model used 2017 DEER thermostat values that were higher and allowed the fan to operate at lower loads or not operate during the peak hours. This resulted in lower peak demand savings.

Table 4-13 shows aggregated gross results for the therm savings. Overall the evaluated therm savings more negative than the ex post estimate which expected due to greater number of fan operating hours as compared to the reported values.

[25] The Database for Energy Efficient Resources (DEER) contains information on selected energy-efficient technologies and assumptions used to estimate savings for residential and non-residential applications.

Table 4-11. Fan motor aggregated gross evaluation results by building type and CZ, kWh

Building Type	Climate Zone	Ex Ante Gross Savings, kWh	Avg Ex Post UES, kWh	Tracked Tonnage	Installation Rate	Ex Post Gross Savings, kWh	GRR, kWh
Mobile Homes	CZ04	228.9	109.8	4	100%	439.1	192%
	CZ08	277.3	120.7	7	100%	844.8	305%
	CZ09	463.9	140.7	8	100%	1,125.5	243%
	CZ10	4,453.3	153.0	59	87%	7,962.9	179%
	CZ11	1,362.3	183.3	6	130%	1,375.1	101%
	CZ13	2,237.8	187.1	12.5	118%	2,619.9	117%
	CZ15	2,038.0	295.6	9	100%	2,660.6	131%
Multi-family Buildings	CZ10	21,122.6	100.7	283	100%	28,510.5	135%
	CZ11	1,481.2	116.9	12	100%	1,402.6	95%
	CZ13	1,727.1	154.0	12.5	100%	1,925.5	111%
Single Family Homes	CZ08	194.4	86.9	4	100%	347.6	179%
	CZ10	6,265.8	117.3	84.5	96%	9,280.0	148%
	CZ11	5,821.2	141.7	42	121%	7,225.8	124%
	CZ12	4,278.5	100.6	43	98%	4,225.3	99%
	CZ13	6,154.3	159.0	51.5	96%	7,869.1	128%
	CZ14	2,397.0	169.5	23.5	96%	3,813.2	159%
	CZ15	4,053.0	174.9	21	84%	2,972.6	73%
	CZ16	519.4	125.7	7	100%	880.1	169%

Table 4-12. Fan motor aggregated evaluation results by building type and CZ, kW

Building Type	Climate Zone	Ex Ante Gross Peak Savings, kW	Avg Ex Post UES, kW	Tracked Tonnage	Installation Rate	Ex Post Gross Peak Savings, kW	GRR, kW
Mobile Homes	CZ04	0.2	0.1	4	100%	0.3	131%
	CZ08	0.4	0.1	7	100%	0.6	150%
	CZ09	0.7	0.1	8	100%	0.8	121%
	CZ10	5.5	0.1	59	87%	6.1	113%
	CZ11	1.2	0.1	6	130%	0.7	56%
	CZ13	2.1	0.1	12.5	118%	1.8	85%
	CZ15	0.8	0.1	9	100%	1.3	172%
Multi-family Buildings	CZ10	25.5	0.1	283	100%	18.0	71%
	CZ11	0.9	0.0	12	100%	0.5	55%
	CZ13	1.0	0.1	12.5	100%	0.9	91%
Single Family Homes	CZ08	0.2	0.0	4	100%	0.1	50%
	CZ10	8.3	0.0	84.5	96%	2.7	33%
	CZ11	5.2	0.0	42	121%	1.2	23%
	CZ12	4.2	0.0	43	98%	1.0	23%
	CZ13	5.1	0.0	51.5	96%	1.9	37%
	CZ14	2.0	0.1	23.5	96%	1.1	57%
	CZ15	2.3	0.0	21	84%	0.6	27%
	CZ16	0.4	0.0	7	100%	0.2	55%

Table 4-13. Fan motor aggregated evaluation results by building type and CZ, Therms

Building Type	Climate Zone	Ex Ante Gross Savings, Therms	Avg Ex Post UES, Therms	Tracked Tonnage	Installation Rate	Ex Post Gross Savings, Therms	GRR, Therms
Mobile Homes	CZ04	-2.74	-2.15	4	100%	-8.62	315%
	CZ08	0.00	-1.30	7	100%	-9.10	0%
	CZ09	0.00	-1.76	8	100%	-14.08	0%
	CZ10	-6.14	-2.12	59	87%	-110.34	1798%
	CZ11	-6.88	-2.67	6	130%	-20.04	291%
	CZ13	-6.82	-2.72	12.5	118%	-38.14	559%
	CZ15	0.00	-1.04	9	100%	-9.37	0%
Multi-family Buildings	CZ10	0.00	-0.78	283	100%	-221.01	0%
	CZ11	-19.35	-1.55	12	100%	-18.62	96%
	CZ13	-12.73	-1.33	12.5	100%	-16.64	131%
Single Family Homes	CZ08	-2.97	-1.15	4	100%	-4.62	156%
	CZ10	-52.17	-1.63	84.5	96%	-129.32	248%
	CZ11	-88.20	-1.82	42	121%	-92.91	105%
	CZ12	-92.45	-2.17	43	98%	-91.19	99%
	CZ13	-58.20	-2.17	51.5	96%	-107.49	185%
	CZ14	-23.22	-1.83	23.5	96%	-41.11	177%
	CZ15	-3.17	-0.54	21	84%	-9.24	291%
	CZ16	-15.33	-4.61	7	100%	-32.29	211%

4.2.2 Net impact findings

The final NTGR for fan motor replacement kWh is 85% (Table 4-14). KW and therms NTGRs are similar at 82% and 87%, respectively. There were slight variations in NTGRs across PAs and fuels. Table 4-14 shows the overall net savings results for both PAs and statewide including reported NTGR, evaluated NTGR, reported net savings, evaluated net savings and finally the net realization rates. Table 4-15 presents the completed sample size and achieved relative precisions for the net savings assessments for the fan motor replacement measure group.

Table 4-14. First-year net savings summary-fan motor replacements[26]

PA	Reported NTGR	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	NRR
	Electricity consumption (kWh)				
PGE	55%	84%	5,197,246	3,193,897	163%
SCE	67%	90%	1,593,715	831,726	192%
SDGE	55%	84%	238,784	115,018	208%
Total	**57%**	**85%**	**7,029,745**	**4,140,641**	**170%**
	Peak electric demand (kW)				
PGE	55%	80%	1,359	2,588	52%
SCE	67%	88%	620	759	82%
SDGE	55%	81%	141	138	102%
Total	**57%**	**82%**	**2,120**	**3,485**	**61%**
	Gas consumption (Therm)				
PGE	55%	85%	-67,384	-35,971	187%
SCE	74%	93%	-17,169	-4,698	365%
SDGE	0%	0%	0	0	0%
Total	**57%**	**87%**	**-84,553**	**-40,669**	**208%**

Table 4-15. Fan motor replacement population, sample, realization rate, and relative precision

PA	Population Size	Completed Sample Size	Evaluated kWh NTGR	kWh Achieved Relative Precision[27]	Evaluated kW NTGR	kW Achieved Relative Precision[28]	Evaluated Therm NTGR	Therms Achieved Relative Precision[29]
PG&E	17,031	72	84%	9%	80%	14%	85%	9%
SCE	2,562	32	90%	9%	88%	12%	93%	7%
SDG&E	430	10	84%	23%	81%	29%	0%	0%

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

27 Relative precision at 90% confidence

28 Relative precision at 90% confidence

29 Relative precision at 90% confidence

Total	**20,023**	**114**	**85%**	**7%**	**82%**	**10%**	**87%**	**7%**

The high attribution scores for this program were expected. The program offers free upgrades via a direct install approach for a measure few people are aware of. Open-ended, qualitative answers are consistent with and validate the attribution scores. Respondents who agreed to the service for reasons other than the incentive had lower attribution scores.

- Most (78%) respondents indicated they would not have known to do the service and/or cited the free service as their reason for participating. These respondents received attribution scores of 100%.
- A total of 7% of respondents cited their equipment was at or near the end of life, so it needed to be replaced anyway. These respondents had an average attribution of 41%.
- A total of 7% of respondents cited an interest in saving energy. These respondents had an average attribution of 24%.

4.3 Duct testing and sealing

4.3.1 Gross impact findings

First-year gross and net savings are summarized in Table 4-16. The duct testing and sealing measure is generally installed along with multiple other measures. Using billing analysis, we first estimated the average household-level savings which are presented in Table 4-17. These estimates represent the savings "budget" that can be disaggregated to measure-level savings. The evaluation found positive and statistically significant electric household savings for PG&E, SCE, and statewide. The electric estimate for SDG&E is negative but not statistically significant. The electric household level-realization rates are relatively low, meaning that the combinations of measures installed achieved substantially less savings together than expected.

For peak demand savings estimates, we used the DEER heatwave definition and the peak period for each of the state's 16 Title 24 climate zones (CZs) using the most current TMY (typical meteorological year) datasets so that average demand impact is estimated under conditions that represent grid peak.[30] Using this definition, we found negative savings for PG&E, positive but not statistically significant savings for SCE, positive and statistically significant savings for SDG&E, and positive but not statistically significant savings overall.[31]

For gas, we found positive and statistically significant gas household savings for SCG and a high household level-realization rate. The gas estimates for PG&E and SDG&E are negative but not statistically significant. The statewide gas estimate was zero. Relative precisions are large due to small estimates and large variation.

[30] DEER2008 version 2.05, adopted by CPUC Decision 09-09-047,3

[31] The peak period for duct testing and sealing participants tended to be later than the DEER defined period of 2 p.m. to 5 p.m. It is possible that participants achieved savings during their peak period or would achieve savings under the 2020 DEER definition, but our evaluation did not include these alternative analyses.

Table 4-16. Duct testing and sealing first-year gross and net savings summary[32]

PA	Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	Net Realization Rate[33]
Electric consumption(kWh)								
PGE	456,878	104.0%	475,153	78%	94%	446,056	379,209	118%
SCE	939,075	94%	882,730	80%	94%	826,290	796,739	104%
SDGE	49,362	123%	60,716	78%	95%	57,629	40,989	141%
SCG				85%			333,144	
Total	**1,445,315**	**98%**	**1,418,599**	**79%**	**94%**	**1,329,974**	**1,216,937**	**109%**
Peak demand (kW)								
PGE	476	0%	0	78%	0%	0	395	0%
SCE	1,313	0%	0	80%	0%	0	1,118	0%
SDGE	94	62%	58	78%	95%	55	78	71%
SCG	543			80%			464	0%
Total	**1,883**	**3%**	**58**	**79%**	**95%**	**55**	**1,591**	**3%**
Gas consumption (Therm)								
PGE	36,353	0%	-	78%	0%	0	30,173	0%
SCE	54,387			80%			46,204	0%
SDGE	3,721	0%	-	78%	0%	0	3,089	0%
SCG	27,423	319%	87,478	81%	95%	83,057	23,458	354%
Total	**67,496**	**130%**	**87,478**	**79%**	**95%**	**83,057**	**56,720**	**146%**

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

33 Ratio of the evaluated net savings to the reported net savings (does not include market effects benefits)

Table 4-17. Duct testing and sealing participant household-level savings estimates by PA

PA	Evaluated Households	Reported Gross Savings per Household	Evaluated Gross Savings per Household	p-value	Relative Precision[34]	GRR
Electricity consumption(kWh)						
PG&E	458	751	259	0.003	54%	35%
SCE	2,450	835	244	0.000	26%	29%
SDG&E	214	554	-74	0.637	349%	-13%
Overall	**3,122**	**803**	**224**	**0.000**	**25%**	**28%**
Peak electric demand (kW)						
PG&E	455	0.5	-0.1	0.357	178%	-14%
SCE	2,446	0.6	0.0	0.427	207%	6%
SDG&E	213	0.4	0.3	0.038	79%	62%
Overall	**3,114**	**0.6**	**0.0**	**0.338**	**172%**	**6%**
Gas consumption (Therm)						
PG&E	695	16	-13	0.311	162%	-83%
SCG	749	12	13	0.007	61%	111%
SDG&E	255	16	-3	0.669	384%	-22%
Overall	**1,699**	**14**	**-0.3**	**0.955**	**2,886%**	**-2%**

Table 4-18 and Table 4-19 present the overlap between duct testing and sealing and other measure groups. The greater the overlap between measure groups the harder it is to disaggregate the savings using billing analysis. For the electric PAs, SCE and SDG&E both have substantial overlap between duct testing and sealing and other measure groups. For the gas PAs, there is less measure overlap, but it is still substantial. PG&E also had substantial numbers of gas participants with measure groups expected to reduce savings: HVAC motor replacement and LED A-lamps.

Table 4-18. Percent of electric duct testing and sealing participants installing other measure groups

Measure Group	PG&E	SCE	SDG&E	Overall
HVAC RCA	28%	85%	79%	76%
HVAC Controls Thermostat	47%	77%	75%	73%
HVAC Controls Fan	38%	73%	68%	68%
HVAC Coil Cleaning	0%	82%	0%	64%
HVAC Motor Replacement	45%	25%	38%	29%
Lighting Indoor LED A-lamp	26%	0%	0%	4%
Water Heating Faucet Aerator	0%	0%	20%	1%
Water Heating Showerhead	0%	0%	31%	2%
Other	0%	1%	0%	1%

34 Relative precision at 90% confidence.

Table 4-19. Duct testing and sealing gas measure group overlap

Measure Group	PG&E	SCG	SDG&E	Overall
HVAC Controls Fan	32%	54%	75%	48%
Water Heating Showerhead	29%	28%	30%	29%
Water Heating Faucet Aerator	8%	31%	18%	20%
HVAC RCA	4%	0%	79%	14%
HVAC Motor Replacement	30%	0%	0%	12%
Lighting Indoor LED A-lamp	17%	0%	0%	7%

Table 4-20 presents the measure-level electric and gas savings estimates for PAs with positive household-level savings. The iterative modeling process kept only measures with positive estimated savings effectively fixing savings at zero. Table 4-20 presents only the savings estimates for duct testing and sealing. The other measure-level savings estimates can be found in Appendix E. The electric duct testing and sealing estimates are relatively close to the claimed savings, with realization rates near 100% for PG&E, SCE, and statewide. For SCG, only the measure-level estimate for duct testing and sealing was positive, resulting in a very high realization rate.

Table 4-20. Duct testing and sealing measure-level savings estimates

PA	Evaluated Households	Reported Gross Savings per Household	Evaluated Gross Savings per Household	p-Value	Relative Precision[35]	GRR
kWh						
PG&E	458	182	190	0.072	91%	104%
SCE	2,450	133	126	0.038	79%	94%
Overall[36]	**3,122**	**134**	**165**	**0.001**	**48%**	**123%**
Therm						
SCG	749	4	13	0.011	65%	319%

As the household-level demand savings were not statistically significantly different from zero for PG&E and SCE, we assume the duct testing and sealing demand savings is zero. For SDG&E, the household-level savings were too small to disaggregate using a billing analysis approach. We estimated the measure's proportion of household-level demand savings by using the proportion of claimed measure savings relative to claimed household savings as presented in Table 4-21.

35 Relative precision at 90% confidence.

36 The overall results include PG&E, SCE, and SDG&E.

Table 4-21. Duct testing and sealing measure-level demand savings estimate

PA	Household Savings Estimate	Average kW claimed		Measure Percent of Claimed	Measure Evaluated Gross Savings per Household	Measure Realization Rate
		Whole House	From Duct Testing and Sealing Measure			
SDG&E	0.28	0.45	0.08	17%	0.05	62%

4.3.2 Net impact findings

The overall NTGR for duct sealing is 94% for kWh and 95% for therms (Table 4-22). Confidence intervals are within 90/10 precisions.

Table 4-22. Duct test and sealing population, sample, realization rate, and relative precision[37]

PA	Population Size	Completed Sample Size	Evaluated kWh NTGR	kWh Achieved Relative Precision[38]	Evaluated kW NTGR[39]	kW Achieved Relative Precision[40]	Evaluated Therm NTGR	Therms Achieved Relative Precision[41]
PG&E	3,118	81	94%	3%	0%	0%	93%	4%
SCE	4,702	338	94%	2%	0%	0%		
SCG	7941	75					95%	1%
SDGE	749	21	95%	1%	95%	1%	95%	1%
Total	**16,510**	**515**	**94%**	**1%**	**95%**	**1%**	**94%**	**1%**

High attribution scores for this program were expected. The program offers free upgrades via a direct install approach for a measure few people are aware of. Verbatim answers of the single-family homeowners reveal some motivational factors. The patterns of these different subsets of respondents helps validate the attribution scores. Respondents who opted into the service for reasons other than the incentives had lower attribution scores:

- More than half (60%) of single-family homeowners did not provide any additional verbatim information about their scores. These respondents had an average attribution score of 92%.
- A little more than one quarter (27%) of SF owners cited the free service or part of a package deal. These respondents received attribution scores of 100%.
- A total of 8% of SF owners cited general maintenance needs, concerns, or poorly functioning HVAC systems. These respondents had an average attribution score of 84%.

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

38 Relative precision at 90% confidence.

39 Evaluated kW NTGR and the precision for kW NTGR are 0 for PG&E and SCE because gross savings were 0 for both of those PAs.

40 Relative precision at 90% confidence.

41 Relative precision at 90% confidence.

- A total of 4% of SF owners cited energy conservation or management. These respondents had an average attribution score of 77%.
- A total of 1.5% of single-family homeowners cited word of mouth or recommendations from friends, neighbors, or co-workers. These respondents had an average attribution score of 83%.

The multifamily property manager surveys did not collect verbatim answers to provide additional qualitative insight into decisions, in part because many of these interviews covered multiple properties. Five of the 53 interviewed property managers did indicate the free service in one of the close-ended questions. These property managers received attribution scores of 100%. These sites made little difference in the final score. With these respondents included, the average (unweighted) attributions score was 97.4%; it was 97.2% without them.

4.5 Water-cooled chiller

SCE is the only PA that reported savings for the water-cooled chiller measure group. The overall realization rates for gross and net savings are higher than 100%. The large discrepancy in gross realization rates are primarily due to the difference in the reported operating hours the evaluated operating hours of the water-cooled chillers. The higher net realization rate also showed the program had a strong influence on high efficiency chiller sales. Table 4-23 shows the overall evaluation results for the water-cooled chiller measure group. The following two subsections goes over the detailed gross and net results.

Table 4-23. First-year gross and net savings summary - water-cooled chiller[42]

PA	Reported Gross Savings	Gross Realization Rate	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	NRR
Electric consumption (kWh)								
SCE	1,241,085	221%	2,748,426	65%	81%	2,238,228	806,705	277%
Total	**1,241,085**	**221%**	**2,748,426**	**65%**	**81%**	**2,238,228**	**806,705**	**277%**
Peak electric demand (kW)								
SCE	622	179%	1,112	65%	82%	911	404	225%
Total	**622**	**179%**	**1,112**	**65%**	**82%**	**911**	**404**	**225%**

4.5.1 Gross impact findings

Table 4-24 shows reported gross savings and evaluated gross savings for the water-cooled chiller measure group. The total ex ante (reported) savings claimed for the chiller measure group was 1,242,085 kWh, and 622 kW. The total ex post (evaluated) savings were 2,748,426 kWh and 1,112 kW. The overall GRRs were 221% for electric energy (kWh) and 179% for electric demand (kW).

Table 4-24. First-year gross savings summary - water-cooled chiller

PA	Reported Gross Savings	GRR	Evaluated Gross Savings
Electric consumption (kWh)			
SCE	1,241,085	221%	2,748,426
Total	**1,241,085**	**221%**	**2,748,426**
Peak electric demand (kW)			
SCE	621	179%	1,112
Total	**622**	**179%**	**1,112**

Table 4-25 provides the results for the 10 completed sample points. The table also shows each sample point's unique site ID. The majority of the sites (7 out of 10) has higher GRR than 100%, 2 of the sites has

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

GRR of less than 100% and the last site was a “0” saver. Basically, no chiller got installed at this site, so no savings were credited to this site.

Table 4-25. Water-cooled chiller measure group site-level gross analysis

Site ID	Building Type	Climate Zone	Installation rate	Reported Gross kWh	Evaluated Gross kWh	Unweighted Gross kWh Realization Rate[43]	Reported Gross kW	Evaluated Gross kW	Unweighted Gross kW Realization Rate[44]
SCE.1	Office – Large	9	138%	55,051	39,575	72%	29	19	66%
SCE.2	Office – Large	8	88%	60,000	63,701	106%	31	32	104%
SCE.3	Office – Large	6	100%	82,390	250,741	304%	36	125	350%
SCE.4	Manufacturing – Biotech	8	100%	150,000	230,534	154%	78	128	165%
SCE.5	Education – University	8	123%	182,250	386,333	212%	95	200	212%
SCE.6	Hospital	8	100%	187,500	739,768	395%	97	182	187%
SCE.7	Hotel	6	100%	32,520	239,328	736%	14	46	326%
SCE.8	Assembly	8	0%	247,500	-	0%	128	0.0	0%
SCE.9	Office – Large	8	103%	12,920	8,749	68%	7	4	63%
SCE.10	Education – University	8	90%	82,500	128,778	156%	43	67	156%
Total			**94%**	**1,092,631**	**2,087,508**	**191%**	**558**	**803**	**144%**

43 The un-weighted gross realization rate is the average realization rate across the evaluated sites and is for informational purposes only.

44 The un-weighted gross realization rate is the average realization rate across the evaluated sites and is for informational purposes only.

Of the 10 completed sample points, 4 of the sample points were large office buildings, 2 were university buildings, 1 was a hospital building, 1 was a hotel, 1 was an assembly building, and 1 was a manufacturing facility. Overall, the large discrepancy between the reported savings and the evaluated savings were due to the following reasons:

- **More efficient chillers.** Our gross collection revealed that most of the installed water-cooled chillers have higher efficiency (kW/Ton) than the efficiency reported in the tracking data. Higher efficient chiller uses less electricity to deliver same amount of cooling. Therefore, the efficiency difference between the reported and the evaluated value was one of the contributors for this savings discrepancy.
- **Higher chiller annual operating hours.** The evaluation team believes that the major discrepancy in savings was due to the difference in chiller operating hours between PA's assumption and evaluator's modeled chiller annual operating hours in eQUEST model. The ex ante model used a single average "commercial" building type to estimate savings across all their claims and that mostly adhere to the commercial building's chiller operating schedule. However, the evaluation modeled different DEER building types, with various chiller annual operating hours, to calculate savings for different sample claims. For most building types, our analysis found the annual chiller operating hours to be higher than the operating hours assumed in the reported savings. For example: A hospital's chiller operating schedule could be 24/7 whereas a commercial office mostly operates their HVAC equipment 8 hours a day and 5 days a week. This difference in operating hours could have a significant impact on the savings of the chiller. Some of the building types in the sample were hotels, hospitals, light manufacturing and university buildings that have higher chiller operating hours than an office building.

4.5.2 Net impact findings

Table 4-26 presents the net results for the water-cooled chiller measure group. Overall, the evaluated NTGR was higher than the reported NTGR which shows the program has strong influence high efficiency chiller sales. Our evaluation found the program incentives offered to the end users for the chillers via distributors had a great influence in improving the sale of high efficiency chillers as the incentives helped the end users to offset some of the incremental cost.

Table 4-26. First-year net savings - water-cooled chiller[45]

PA	Reported NTGR	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	NRR
Energy consumption(kWh)					
SCE	60%	81%	2,238,228	806,705	277%
Peak demand (kW)					
SCE	60%	82%	911	404	225%

The chiller distributor net impact findings also used attribution scores similar causal paths (upselling and price) as rooftop and split systems. Unlike for rooftop and split systems, the stocking causal path was

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

removed because chiller equipment is usually custom ordered rather than warehoused. Also, the chiller attributions did not include a component for end-users. DNV GL attempted to survey end-users, but none of them were aware of their participation in the program or installation of high efficiency (rather than standard efficiency) chiller equipment.

The distributors we spoke to split into two camps: some always recommend high-efficiency equipment, others provide a set of options that includes a high-efficiency choice. Only one of the distributors indicated that the program affects their recommendations. Two distributors said that the program does not affect their recommendations, but it does increase the volume of sales of high-efficiency equipment. Overall this resulted in a low attribution score for upselling (10%; Table 4-27). On average (unweighted), the distributors reported passing through 93% of the rebates to their customers. They cited that this ability to lower the cost of high-efficiency equipment was a key factor to being able to make those sales.

Table 4-27. Chillers NTGRs by causal path - statewide[46]

Causal Path	Distributor Sample Complete	Distributor Attribution
Upselling	5	10%
Price	5	93%

After weighting based on ex ante kWh claims, the final NTGR for chillers is 81% for kWh and 82% for kW (Table 4-28). The confidence interval is within 90/10 precisions.

Table 4-28. Chiller systems population, sample, realization rate, and relative precision

PA	Population Size	Completed Sample Size	Evaluated kWh NTGR[44]	kWh Achieved Relative Precision[47]	Evaluated kW NTGR[44]	kW Achieved Relative Precision[48]
SCE	14	9	81%	6%	82%	6%
Total	**14**	**9**	**81%**	**6%**	**82%**	**6%**

A notable limitation of this methodology is that we only talked to distributors and it relies on those distributors being able to make accurate reports of the decision making of their buyers. A preferable method would include firsthand self-reports of those end user decisions. However, this methodology is acceptable in this case because the program is a midstream program aimed at distributors, and the evaluation did survey end users. Those end users surveyed had no awareness of the program or high efficiency equipment decisions.

4.6 HVAC boiler

SCG is the only PA that reported savings for the boiler. In PY 2018, gross savings assessments were not performed for the boiler measure group. We evaluated this measure group for net savings only. However, as

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

47 Relative precision at 90% confidence.

48 Relative precision at 90% confidence.

boiler was evaluated in PY 2017, the evaluation team used the PY 2017 GRR (102%) of this measure group along with PY 2018 reported savings to calculate the PY 2018 ex post gross savings. Then, the revised PY 2018 ex post gross savings and NTGR were utilized to estimate the net savings and determine the NRR. Table 4-29 shows the summary of gross and net savings results for the boiler measure group.

Our NTG surveys indicated high free ridership and only 19% of the reported therm savings from the boiler occurred because of the program's influence. This means the program had minimal impact on the end users' high efficiency boiler purchasing decisions. A majority of survey respondents said they learned about the program *after* making the decision to purchase a high efficiency boiler.

Table 4-29. First-year gross and net savings summary-boiler[49]

PA	Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR	Evaluated Net Savings	Reported Net Savings	NRR
Gas consumption (Therm)								
SCG	66,106	102%	67,723	65%	19%	12,784	46,281	28%

4.6.1 Net impact findings

The evaluation team completed NTG surveys with 16 customer decision-makers out of a total 45 applications from PY 2017 and PY 2018. Table 4-30 shows the evaluated NTGRs and relative precisions. These relative precisions are outside the 90/10 level primarily because of the low NGTRs. Absolute precisions are less than 10% for each ratio.

Table 4-30. Boiler systems population, sample, realization rate, and relative precision[47]

PA	Population Size	Completed Sample Size	Evaluated kWh NTGR	kWh Achieved Relative Precision[50]	Evaluated kW NTGR	kW Achieved Relative Precision[51]	Evaluated Therm	Therm Achieved Relative Precision[52]
SCG	45	16	8%	109%	22%	32%	19%	28%
Total	**45**	**16**	**8%**	**109%**	**22%**	**32%**	**19%**	**28%**

Based on these completed surveys, we make the following qualitative observations regarding customer influences:

- 69% of decision-makers surveyed identified that they had made the decision to upgrade their boilers, including selecting efficient equipment, prior to learning about the rebates available from SCG.
- 70% of customers revealed that they would have installed the same equipment regardless of the availability of a program rebate.

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

50 Relative precision at 90% confidence.

51 Relative precision at 90% confidence.

52 Relative precision at 90% confidence.

- Respondents attributed more credit to non-program influences, such as age of existing equipment and company policies, than they did to program influences such as rebate amounts and program information/marketing materials.
- When asked about the timing of installations, some customers noted that the program and rebate helped accelerate the timing of boiler replacement.
- The poorer-than-expected relative precision is driven by two main contributors: 1) NTG results showed high variation among respondents; and 2) NTGR is inversely proportional to relative precision, and low NTGR results in a wider precision value.

5 CONCLUSIONS, FINDINGS, & RECOMMENDATIONS

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

Recommendations include supporting context for energy service providers. A list of these recommendations is listed and described in Appendix C, Section 6.2 per the CPUC ED Impact Evaluation Standard Reporting (IESR) Guidelines.

5.1 Conclusions

The implementation and evaluation of HVAC measures have evolved over the last decade. The changes to programs, measures, and the evaluation of impacts present challenges to assessing and tracking performance. Overall, PY 2018 gross evaluation activities showed savings close to, or higher than, expectations with evaluated gross savings from 46% to 221% of expectations. The study results for NTGR ranged from 19% to 95% and overall were higher 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 no end user contact information was available, and as a result end-user data collection was not possible. Therefore, the evaluation was unable to spend additional 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.

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.

Program design elements that were not communicated to evaluators required changes in approach and led to consequent delays. When we published our workplan and sampling memo we specified which market actors we would need to reach for program evaluation. It wasn't until we received responses to multiple data requests and completed one set of planned surveys that we learned that some programs do not collect data necessary to evaluators.

We recommend PA program and EM&V staff be more involved in critical workplan review. We would also invite PA staff to host webinars where they discuss program aims, targets, and methods. If Informational sessions took place shortly after we publish the list of measures and programs to be evaluated, we could work with the PAs to make sure that our evaluation design and data requirements are consistent with program operations.

5.2.1 Rooftop or split systems

The ex post savings were lower than the ex ante estimate. The overall GRRs are 55% for kWh, 61% for peak kW and 58% for the therm. This difference is primarily due to the overestimation of savings in the ex ante estimate. The ex ante estimate approach claimed savings equivalent to 60% of the total cooling load whereas the evaluation approach produced the savings to be approximately 10% of the total cooling load, which is in line with the efficiency improvement between the standard and high efficiency equipment.

The evaluation team recommends that the PAs should model this measure group with appropriate baseline and proposed conditions including the HVAC system efficiencies, fan power index and applicable economizer controls. In that way, the simulation results will reasonably capture the savings attributed only to the efficiency improvement between the Title -24 standard and high efficiency equipment along with other efficiency upgrades.

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

For any measures delivered midstream through distributor rebates, such as the rooftop and split system measure group, PAs must require participating distributors and partnering contractors to collaboratively collect and submit basic information for each customer that ultimately receives the rebated equipment. Such information should include: facility name; facility classification; facility address; facility account number(s); name(s), phone number(s), and email address(es) of customer representative(s) familiar with the project; distributor name, phone number, and email address; and contractor name, phone number, and email address. Information for customer representatives should include equipment operators (e.g., facility maintenance) for gross data collection as well as project decision-makers (e.g., CFO) for net data collection. This basic information is critical for the utilities, the CPUC, and its contractors to verify installations and maintain the integrity of ratepayer incentive dollars.

Six of the 59 evaluated projects were determined to result in zero electricity savings due to non-install or ineligibility. For 5 projects, evaluators determined that the incented rooftop or split systems equipment was never installed or energized. For one project, we found that the facility receives electricity from a municipal utility and is therefore ineligible for a PA savings claim. Data collection, transmission, and screening complications, as a result of the rooftop or split systems measure group's midstream design, are the likely culprits for zero savings from these issues. Ineligibility and non-install reduced the RR of rooftop or split systems measures by 7% and were particularly prevalent for programs administered by PG&E and SCE.

The evaluation team recommends PAs make sure that the incented equipment are installed at the appropriate location. PAs should also perform post inspections on the installed equipment to ensure they are properly installed and operating as intended.

A total of 36% of evaluated projects revealed measure-specific inconsistencies between tracking data and field-verified nameplate data. In all, 27% of evaluated projects showed differences in equipment quantity, manufacturer, size, or efficiency rating between PA implementation data and field-verified characteristics. 32% of evaluated projects showed differences in equipment model or serial number. Again, data collection and transmission complications due to the RTU/split measures' midstream design have prevented the programs from accurately tracking basic installation information for rebated equipment.

For midstream measures, the programs should require that distributors and contractors submit more comprehensive installation documentation (e.g., invoices, commissioning reports) and photographs to prove quantity, size, make/model, and efficiency. Such documentation would allow the PAs and/or evaluators to conduct internal audits of a selection of tracked installations to confirm installation and tracking data accuracy.

The rooftop/split system measure group consisted of more than 100 unique measure descriptions for PY2018. For many of these, the PAs are claiming the same measure but the measure descriptions are not consistent across the PAs. This makes the task of grouping the same measures across the PAs more difficult and introduces unnecessary complication and uncertainty.

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

5.2.2 Fan motor replacement

The evaluated savings for kWh was higher than the reported savings whereas the peak kW savings were lower than the expected. These differences in savings are due to the difference in fan operating hours between the ex ante assumptions and the ex post values. Our analysis found that the ex ante savings appear to result from applying single-family hours of operation to mobile homes and multi-family buildings whereas the eQUEST models showed longer hours of operation for mobile homes and multi-family buildings, resulting in significantly greater evaluated savings than claimed for these building types. The lower peak kW savings are due to differences in thermostat settings between the evaluated and the reported values. The thermostat settings used in the reported savings model was based on older Database Energy Efficiency Resources (DEER) thermostat values, whereas the evaluation savings model used 2017 DEER thermostat values that were higher and allowed the fan to operate at lower loads or not operate during peak hours.

The evaluation team recommends that the PAs model this measure group with the 3 residential dwelling types (single family, multi-family, and manufactured home) and most up-to-date DEER thermostats schedule to capture the variations in fan operating hours and accurately calculate the kWh and peak kW savings.

Attribution was very high. This was expected considering the program design and the measure involved. The program is delivered via direct install methods, which had relatively high attribution rates across the board (including the residential evaluation) for PY 2018. Furthermore, this program provides a free upgrade to a measure that few people think about.

If the program delivery mechanism remains primarily direct install, consider increasing ex ante NTGRs from 57% to 85%. Under this program delivery mechanism, attribution can be expected to remain high.

5.2.3 Duct testing and sealing

Attribution was very high, which makes sense considering the program is delivered via direct install methods, which had relatively high attribution rates across the board (including the residential evaluation) for PY 2018. Furthermore, this program provides a free upgrade to a measure that few people think about.

If program delivery mechanism remains primarily direct install, consider increasing ex ante NTGRs from 79% to 95%. Under this program delivery mechanism, attribution can be expected to remain high.

5.2.4 Water-cooled chiller

Both the kWh and kW GRRs for the water-cooled chiller measure group were higher than the reported. Our evaluation determined the GRRs to be 221% and 179% for the kWh and kW respectively. This means the evaluated kWh savings were more than double the reported kWh savings and the evaluated kW is 79% higher than the reported kW. The primary reason for this large discrepancy is due to the difference in the chiller annual operating hours between the reported assumption and evaluated findings. The PA eQUEST model used a single average "commercial" building type to estimate savings across all their claims that did not capture the variations in chiller operating hours across the various building types.

Take a closer look at the workpaper assumptions and review the eQUEST model and ensure all the building types are included in the model runs to capture the variations in chiller operating hours across the various building type. Alternatively, we suggest this measure group to use custom calculation approach where the savings should be calculated using site-specific information rather than using a deemed approach via workpaper to claim savings.

Distributors reported upselling or at least offering high efficiency options as a standard practice. However, they pass almost all of the rebate through to their buyers and they said that the rebate is necessary to get paybacks low enough to make the sales possible. They attribute greater sales volume of high-efficiency equipment to the program.

Record installation contractor contact information in the tracking data. Many distributors sell to contractors, who in turn sell to end users. Ideally, the evaluation would complete surveys or interviews with each step of the supply chain. However, the tracking data did not contain contact information for installation contractors, so evaluators could not collect data on the influence of the program those market actors' actions.

5.2.5 HVAC boiler

Low NTGR revealed a high level of free-ridership for this measure group. We determined an NTGR of 19% for this measure group, due to a high number of free-riders as evidenced from interviews with customer decision-makers. About 70% of end-users surveyed had already made the decision to upgrade their boiler, in many cases selecting their energy efficient equipment, prior to learning about rebates available. Their selection of energy efficient boilers was driven more by company policies dictating that they select efficient options when replacing old equipment than by program-provided rebates and information. When the program influenced end users, it tended to accelerate the timing of boiler installation, but not increase the efficiency of the equipment they selected.

PAs should reconsider including boilers as a deemed measure in this program. This measure has previously been offered under the custom program by other PAs, which enables more detailed project screening to better understand customer decision drivers and identify potential free-ridership prior to project approval. As a deemed measure, PAs have limited insight into customer decision-making factors and methods.

Consider reducing the ex ante NTGR for therms from 65% to 20%. Program free-ridership survey questions indicate that most participants learned about the program after making a decision to install high-efficiency measures. Therefore, the program could not have had a strong effect on those decisions.

6 APPENDICES

6.1 Appendix A: Impact evaluation standard reporting (IESR) required reporting—first year and lifecycle savings

Appendices A through C are included in accordance with the CPUC Energy Division Impact Evaluation Standard Reporting Guidelines (November 2015, https://pda.energydataweb.com/api/view/1399/IESR_Guidelines_Memo_FINAL_11_30_2015.pdf)

Gross Lifecycle Savings (MWh)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC Duct Sealing	1,378	1,433	1.04	0.0%	1.04
PGE	HVAC Motor Replacement	16,083	18,742	1.17	0.0%	1.17
PGE	HVAC Rooftop or Split System	99,408	61,062	0.61	0.0%	0.61
PGE	**Total**	**116,869**	**81,237**	**0.70**	**0.0%**	**0.70**
SCE	HVAC Chiller Water Cooled	24,822	54,969	2.21	0.0%	2.21
SCE	HVAC Duct Sealing	939	883	0.94	0.0%	0.94
SCE	HVAC Motor Replacement	5,721	8,890	1.55	0.0%	1.55
SCE	HVAC Rooftop or Split System	61,097	29,281	0.48	0.0%	0.48
SCE	**Total**	**92,579**	**94,022**	**1.02**	**0.0%**	**1.02**
SCG	HVAC Boiler	-363	0	0.00	0.0%	0.00
SCG	HVAC Duct Sealing	3,349	3,349	1.00	0.0%	1.00
SCG	**Total**	**2,986**	**3,349**	**1.12**	**0.0%**	**1.12**
SDGE	HVAC Duct Sealing	163	200	1.23	0.0%	1.23
SDGE	HVAC Motor Replacement	2,874	4,246	1.48	0.0%	1.48
SDGE	HVAC Rooftop or Split System	8,861	2,842	0.32	0.0%	0.32
SDGE	**Total**	**11,898**	**7,289**	**0.61**	**0.0%**	**0.61**
	Statewide	***224,333***	***185,897***	***0.83***	***0.0%***	***0.83***

Net Lifecycle Savings (MWh)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC Duct Sealing	1,144	1,417	1.24	0.0%	0.83	0.99	0.83	0.99
PGE	HVAC Motor Replacement	9,650	16,640	1.72	0.0%	0.60	0.89	0.60	0.89
PGE	HVAC Rooftop or Split System	79,761	33,203	0.42	0.0%	0.80	0.54	0.80	0.54
PGE	**Total**	**90,554**	**51,259**	**0.57**	**0.0%**	**0.77**	**0.63**	**0.77**	**0.63**
SCE	HVAC Chiller Water Cooled	16,134	47,513	2.94	0.0%	0.65	0.86	0.65	0.86
SCE	HVAC Duct Sealing	797	870	1.09	0.0%	0.85	0.99	0.85	0.99
SCE	HVAC Motor Replacement	4,132	8,413	2.04	0.0%	0.72	0.95	0.72	0.95
SCE	HVAC Rooftop or Split System	49,944	16,196	0.32	0.0%	0.82	0.55	0.82	0.55
SCE	**Total**	**71,007**	**72,992**	**1.03**	**0.0%**	**0.77**	**0.78**	**0.77**	**0.78**
SCG	HVAC Boiler	-237	0	0.00	0.0%	0.65		0.65	
SCG	HVAC Duct Sealing	2,846	2,846	1.00	0.0%	0.85	0.85	0.85	0.85
SCG	**Total**	**2,609**	**2,846**	**1.09**	**0.0%**	**0.87**	**0.85**	**0.87**	**0.85**
SDGE	HVAC Duct Sealing	135	200	1.48	0.0%	0.83	1.00	0.83	1.00
SDGE	HVAC Motor Replacement	1,725	3,794	2.20	0.0%	0.60	0.89	0.60	0.89
SDGE	HVAC Rooftop or Split System	7,640	1,629	0.21	0.0%	0.86	0.57	0.86	0.57
SDGE	**Total**	**9,501**	**5,623**	**0.59**	**0.0%**	**0.80**	**0.77**	**0.80**	**0.77**
	Statewide	***173,671***	***132,721***	***0.76***	***0.0%***	***0.77***	***0.71***	***0.77***	***0.71***

Gross Lifecycle Savings (MW)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC Duct Sealing	1.4	0.0	0.00	0.0%	0.00
PGE	HVAC Motor Replacement	13.1	5.2	0.40	0.0%	0.40
PGE	HVAC Rooftop or Split System	56.8	32.6	0.57	0.0%	0.57
PGE	**Total**	**71.3**	**37.8**	**0.53**	**0.0%**	**0.53**
SCE	HVAC Chiller Water Cooled	12.4	22.2	1.79	0.0%	1.79
SCE	HVAC Duct Sealing	1.3	0.0	0.00	0.0%	0.00
SCE	HVAC Motor Replacement	5.2	3.5	0.68	0.0%	0.68
SCE	HVAC Rooftop or Split System	33.0	21.2	0.64	0.0%	0.64
SCE	**Total**	**52.0**	**47.0**	**0.90**	**0.0%**	**0.90**
SCG	HVAC Boiler	0.0	0.0	0.00	0.0%	0.00
SCG	HVAC Duct Sealing	4.7	4.7	1.00	0.0%	1.00
SCG	**Total**	**4.8**	**4.7**	**1.00**	**0.0%**	**1.00**
SDGE	HVAC Duct Sealing	0.3	0.2	0.62	0.0%	0.62
SDGE	HVAC Motor Replacement	3.4	2.6	0.75	0.0%	0.75
SDGE	HVAC Rooftop or Split System	4.2	3.1	0.74	0.0%	0.74
SDGE	**Total**	**8.0**	**5.9**	**0.74**	**0.0%**	**0.74**
	Statewide	***136.0***	***95.4***	***0.70***	***0.0%***	***0.70***

Net Lifecycle Savings (MW)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC Duct Sealing	1.2	0.0	0.00	0.0%	0.83		0.83	
PGE	HVAC Motor Replacement	7.8	4.4	0.56	0.0%	0.60	0.85	0.60	0.85
PGE	HVAC Rooftop or Split System	45.5	17.5	0.38	0.0%	0.80	0.54	0.80	0.54
PGE	**Total**	**54.5**	**21.8**	**0.40**	**0.0%**	**0.76**	**0.58**	**0.76**	**0.58**
SCE	HVAC Chiller Water Cooled	8.1	19.3	2.39	0.0%	0.65	0.87	0.65	0.87
SCE	HVAC Duct Sealing	1.1	0.0	0.00	0.0%	0.85		0.85	
SCE	HVAC Motor Replacement	3.8	3.3	0.87	0.0%	0.72	0.93	0.72	0.93
SCE	HVAC Rooftop or Split System	26.9	10.8	0.40	0.0%	0.82	0.51	0.82	0.51
SCE	**Total**	**39.9**	**33.4**	**0.84**	**0.0%**	**0.77**	**0.71**	**0.77**	**0.71**
SCG	HVAC Boiler	0.0	0.0	0.00	0.0%	0.83		0.83	
SCG	HVAC Duct Sealing	4.0	4.0	1.00	0.0%	0.85	0.85	0.85	0.85
SCG	**Total**	**4.1**	**4.0**	**1.00**	**0.0%**	**0.85**	**0.85**	**0.85**	**0.85**
SDGE	HVAC Duct Sealing	0.3	0.2	0.75	0.0%	0.83	1.00	0.83	1.00
SDGE	HVAC Motor Replacement	2.1	2.2	1.08	0.0%	0.60	0.86	0.60	0.86
SDGE	HVAC Rooftop or Split System	3.6	1.7	0.48	0.0%	0.85	0.55	0.85	0.55
SDGE	**Total**	**5.9**	**4.1**	**0.70**	**0.0%**	**0.74**	**0.70**	**0.74**	**0.70**
	Statewide	***104.4***	***63.4***	***0.61***	***0.0%***	***0.77***	***0.66***	***0.77***	***0.66***

Gross Lifecycle Savings (MTherms)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC Duct Sealing	109	0	0.00	0.0%	0.00
PGE	HVAC Motor Replacement	-181	-240	1.32	0.0%	1.32
PGE	HVAC Rooftop or Split System	-385	-224	0.58	0.0%	0.58
PGE	**Total**	**-457**	**-464**	**1.02**	**0.0%**	**1.02**
SCE	HVAC Chiller Water Cooled	0	0			
SCE	HVAC Duct Sealing	54	54	1.00	0.0%	1.00
SCE	HVAC Motor Replacement	-30	-92	3.11	0.0%	3.11
SCE	HVAC Rooftop or Split System	-229	-133	0.58	0.0%	0.58
SCE	**Total**	**-205**	**-171**	**0.84**	**0.0%**	**0.84**
SCG	HVAC Boiler	1,322	1,354	1.02	0.0%	1.02
SCG	HVAC Duct Sealing	272	867	3.19	0.0%	3.19
SCG	**Total**	**1,594**	**2,221**	**1.39**	**0.0%**	**1.39**
SDGE	HVAC Duct Sealing	12	0	0.00	0.0%	0.00
SDGE	HVAC Motor Replacement	0	0			
SDGE	HVAC Rooftop or Split System	-17	-10	0.59	0.0%	0.59
SDGE	**Total**	**-4**	**-10**	**2.19**	**0.0%**	**2.19**
	Statewide	***928***	***1,576***	***1.70***	***0.0%***	***1.70***

Net Lifecycle Savings (MTherms)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC Duct Sealing	91	0	0.00	0.0%	0.83		0.83	
PGE	HVAC Motor Replacement	-109	-216	1.98	0.0%	0.60	0.90	0.60	0.90
PGE	HVAC Rooftop or Split System	-308	-150	0.49	0.0%	0.80	0.67	0.80	0.67
PGE	**Total**	**-326**	**-366**	**1.12**	**0.0%**	**0.71**	**0.79**	**0.71**	**0.79**
SCE	HVAC Chiller Water Cooled	0	0						
SCE	HVAC Duct Sealing	46	46	1.00	0.0%	0.85	0.85	0.85	0.85
SCE	HVAC Motor Replacement	-23	-90	3.85	0.0%	0.79	0.98	0.79	0.98
SCE	HVAC Rooftop or Split System	-191	-88	0.46	0.0%	0.83	0.66	0.83	0.66
SCE	**Total**	**-169**	**-132**	**0.78**	**0.0%**	**0.82**	**0.77**	**0.82**	**0.77**
SCG	HVAC Boiler	926	323	0.35	0.0%	0.70	0.24	0.70	0.24
SCG	HVAC Duct Sealing	231	866	3.75	0.0%	0.85	1.00	0.85	1.00
SCG	**Total**	**1,157**	**1,190**	**1.03**	**0.0%**	**0.73**	**0.54**	**0.73**	**0.54**
SDGE	HVAC Duct Sealing	10	0	0.00	0.0%	0.83		0.83	
SDGE	HVAC Motor Replacement	0	0						
SDGE	HVAC Rooftop or Split System	-16	-1	0.03	0.0%	0.94	0.05	0.94	0.05
SDGE	**Total**	**-5**	**-1**	**0.09**	**0.0%**	**1.22**	**0.05**	**1.22**	**0.05**
	Statewide	***656***	***691***	***1.05***	***0.0%***	***0.71***	***0.44***	***0.71***	***0.44***

Gross First Year Savings (MWh)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC Duct Sealing	457	475	1.04	0.0%	1.04
PGE	HVAC Motor Replacement	5,323	6,203	1.17	0.0%	1.17
PGE	HVAC Rooftop or Split System	6,627	4,071	0.61	0.0%	0.61
PGE	**Total**	**12,407**	**10,749**	**0.87**	**0.0%**	**0.87**
SCE	HVAC Chiller Water Cooled	1,241	2,748	2.21	0.0%	2.21
SCE	HVAC Duct Sealing	939	883	0.94	0.0%	0.94
SCE	HVAC Motor Replacement	1,153	1,778	1.54	0.0%	1.54
SCE	HVAC Rooftop or Split System	4,311	2,066	0.48	0.0%	0.48
SCE	**Total**	**7,645**	**7,475**	**0.98**	**0.0%**	**0.98**
SCG	HVAC Boiler	-18	0	0.00	0.0%	0.00
SCG	HVAC Duct Sealing	390	390	1.00	0.0%	1.00
SCG	**Total**	**372**	**390**	**1.05**	**0.0%**	**1.05**
SDGE	HVAC Duct Sealing	49	61	1.23	0.0%	1.23
SDGE	HVAC Motor Replacement	192	283	1.48	0.0%	1.48
SDGE	HVAC Rooftop or Split System	591	189	0.32	0.0%	0.32
SDGE	**Total**	**832**	**533**	**0.64**	**0.0%**	**0.64**
	Statewide	***21,256***	***19,148***	***0.90***	***0.0%***	***0.90***

Net First Year Savings (MWh)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC Duct Sealing	379	470	1.24	0.0%	0.83	0.99	0.83	0.99
PGE	HVAC Motor Replacement	3,194	5,507	1.72	0.0%	0.60	0.89	0.60	0.89
PGE	HVAC Rooftop or Split System	5,317	2,214	0.42	0.0%	0.80	0.54	0.80	0.54
PGE	**Total**	**8,890**	**8,191**	**0.92**	**0.0%**	**0.72**	**0.76**	**0.72**	**0.76**
SCE	HVAC Chiller Water Cooled	807	2,376	2.94	0.0%	0.65	0.86	0.65	0.86
SCE	HVAC Duct Sealing	797	870	1.09	0.0%	0.85	0.99	0.85	0.99
SCE	HVAC Motor Replacement	832	1,683	2.02	0.0%	0.72	0.95	0.72	0.95
SCE	HVAC Rooftop or Split System	3,533	1,143	0.32	0.0%	0.82	0.55	0.82	0.55
SCE	**Total**	**5,968**	**6,072**	**1.02**	**0.0%**	**0.78**	**0.81**	**0.78**	**0.81**
SCG	HVAC Boiler	-12	0	0.00	0.0%	0.65		0.65	
SCG	HVAC Duct Sealing	333	333	1.00	0.0%	0.85	0.85	0.85	0.85
SCG	**Total**	**321**	**333**	**1.04**	**0.0%**	**0.86**	**0.85**	**0.86**	**0.85**
SDGE	HVAC Duct Sealing	41	61	1.48	0.0%	0.83	1.00	0.83	1.00
SDGE	HVAC Motor Replacement	115	253	2.20	0.0%	0.60	0.89	0.60	0.89
SDGE	HVAC Rooftop or Split System	509	109	0.21	0.0%	0.86	0.57	0.86	0.57
SDGE	**Total**	**665**	**422**	**0.63**	**0.0%**	**0.80**	**0.79**	**0.80**	**0.79**
	Statewide	***15,845***	***15,018***	***0.95***	***0.0%***	***0.75***	***0.78***	***0.75***	***0.78***

Gross First Year Savings (MW)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC Duct Sealing	0.5	0.0	0.00	0.0%	0.00
PGE	HVAC Motor Replacement	4.3	1.7	0.40	0.0%	0.40
PGE	HVAC Rooftop or Split System	3.8	2.2	0.57	0.0%	0.57
PGE	**Total**	**8.6**	**3.9**	**0.45**	**0.0%**	**0.45**
SCE	HVAC Chiller Water Cooled	0.6	1.1	1.79	0.0%	1.79
SCE	HVAC Duct Sealing	1.3	0.0	0.00	0.0%	0.00
SCE	HVAC Motor Replacement	1.0	0.7	0.67	0.0%	0.67
SCE	HVAC Rooftop or Split System	2.3	1.5	0.64	0.0%	0.64
SCE	**Total**	**5.3**	**3.3**	**0.62**	**0.0%**	**0.62**
SCG	HVAC Boiler	0.0	0.0	0.00	0.0%	0.00
SCG	HVAC Duct Sealing	0.5	0.5	1.00	0.0%	1.00
SCG	**Total**	**0.5**	**0.5**	**1.00**	**0.0%**	**1.00**
SDGE	HVAC Duct Sealing	0.1	0.1	0.62	0.0%	0.62
SDGE	HVAC Motor Replacement	0.2	0.2	0.75	0.0%	0.75
SDGE	HVAC Rooftop or Split System	0.3	0.2	0.74	0.0%	0.74
SDGE	**Total**	**0.6**	**0.4**	**0.73**	**0.0%**	**0.73**
	Statewide	***15.0***	***8.1***	***0.54***	***0.0%***	***0.54***

Net First Year Savings (MW)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC Duct Sealing	0.4	0.0	0.00	0.0%	0.83		0.83	
PGE	HVAC Motor Replacement	2.6	1.4	0.56	0.0%	0.60	0.85	0.60	0.85
PGE	HVAC Rooftop or Split System	3.0	1.2	0.38	0.0%	0.80	0.54	0.80	0.54
PGE	**Total**	**6.0**	**2.6**	**0.43**	**0.0%**	**0.70**	**0.67**	**0.70**	**0.67**
SCE	HVAC Chiller Water Cooled	0.4	1.0	2.39	0.0%	0.65	0.87	0.65	0.87
SCE	HVAC Duct Sealing	1.1	0.0	0.00	0.0%	0.85		0.85	
SCE	HVAC Motor Replacement	0.8	0.7	0.86	0.0%	0.72	0.93	0.72	0.93
SCE	HVAC Rooftop or Split System	1.9	0.7	0.40	0.0%	0.82	0.51	0.82	0.51
SCE	**Total**	**4.1**	**2.4**	**0.57**	**0.0%**	**0.79**	**0.72**	**0.79**	**0.72**
SCG	HVAC Boiler	0.0	0.0	0.00	0.0%	0.83		0.83	
SCG	HVAC Duct Sealing	0.5	0.5	1.00	0.0%	0.85	0.85	0.85	0.85
SCG	**Total**	**0.5**	**0.5**	**1.00**	**0.0%**	**0.85**	**0.85**	**0.85**	**0.85**
SDGE	HVAC Duct Sealing	0.1	0.1	0.75	0.0%	0.83	1.00	0.83	1.00
SDGE	HVAC Motor Replacement	0.1	0.1	1.08	0.0%	0.60	0.86	0.60	0.86
SDGE	HVAC Rooftop or Split System	0.2	0.1	0.48	0.0%	0.85	0.55	0.85	0.55
SDGE	**Total**	**0.5**	**0.3**	**0.71**	**0.0%**	**0.75**	**0.73**	**0.75**	**0.73**
	Statewide	***11.1***	***5.8***	***0.52***	***0.0%***	***0.74***	***0.71***	***0.74***	***0.71***

Gross First Year Savings (MTherms)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC Duct Sealing	36	0	0.00	0.0%	0.00
PGE	HVAC Motor Replacement	-60	-79	1.32	0.0%	1.32
PGE	HVAC Rooftop or Split System	-26	-15	0.58	0.0%	0.58
PGE	**Total**	**-49**	**-94**	**1.91**	**0.0%**	**1.91**
SCE	HVAC Chiller Water Cooled	0	0			
SCE	HVAC Duct Sealing	54	54	1.00	0.0%	1.00
SCE	HVAC Motor Replacement	-6	-18	3.11	0.0%	3.11
SCE	HVAC Rooftop or Split System	-17	-10	0.58	0.0%	0.58
SCE	**Total**	**32**	**26**	**0.82**	**0.0%**	**0.82**
SCG	HVAC Boiler	66	68	1.02	0.0%	1.02
SCG	HVAC Duct Sealing	27	87	3.19	0.0%	3.19
SCG	**Total**	**94**	**155**	**1.66**	**0.0%**	**1.66**
SDGE	HVAC Duct Sealing	4	0	0.00	0.0%	0.00
SDGE	HVAC Motor Replacement	0	0			
SDGE	HVAC Rooftop or Split System	-1	-1	0.59	0.0%	0.59
SDGE	**Total**	**3**	**-1**	**-0.25**	**0.0%**	**-0.25**
	Statewide	***79***	***87***	***1.10***	***0.0%***	***1.10***

Net First Year Savings (MTherms)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC Duct Sealing	30	0	0.00	0.0%	0.83		0.83	
PGE	HVAC Motor Replacement	-36	-71	1.98	0.0%	0.60	0.90	0.60	0.90
PGE	HVAC Rooftop or Split System	-21	-10	0.49	0.0%	0.80	0.67	0.80	0.67
PGE	**Total**	**-26**	**-81**	**3.09**	**0.0%**	**0.53**	**0.86**	**0.53**	**0.86**
SCE	HVAC Chiller Water Cooled	0	0						
SCE	HVAC Duct Sealing	46	46	1.00	0.0%	0.85	0.85	0.85	0.85
SCE	HVAC Motor Replacement	-5	-18	3.85	0.0%	0.79	0.98	0.79	0.98
SCE	HVAC Rooftop or Split System	-14	-6	0.46	0.0%	0.84	0.66	0.84	0.66
SCE	**Total**	**28**	**22**	**0.79**	**0.0%**	**0.87**	**0.83**	**0.87**	**0.83**
SCG	HVAC Boiler	46	16	0.35	0.0%	0.70	0.24	0.70	0.24
SCG	HVAC Duct Sealing	23	87	3.73	0.0%	0.86	1.00	0.86	1.00
SCG	**Total**	**70**	**104**	**1.49**	**0.0%**	**0.75**	**0.67**	**0.75**	**0.67**
SDGE	HVAC Duct Sealing	3	0	0.00	0.0%	0.83		0.83	
SDGE	HVAC Motor Replacement	0	0						
SDGE	HVAC Rooftop or Split System	-1	0	0.03	0.0%	0.94	0.05	0.94	0.05
SDGE	**Total**	**2**	**0**	**-0.02**	**0.0%**	**0.78**	**0.05**	**0.78**	**0.05**
	Statewide	***73***	***44***	***0.60***	***0.0%***	***0.93***	***0.51***	***0.93***	***0.51***

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

Per Unit (Quantity) Gross Energy Savings (kWh)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HVAC Duct Sealing	0	0.0%	0.0%	3.0	451.6	149.7	149.7
PGE	HVAC Motor Replacement	0	0.0%	0.0%	3.0	419.7	138.9	138.9
PGE	HVAC Rooftop or Split System	0	0.0%	0.0%	15.0	1,360.4	90.7	90.7
SCE	HVAC Chiller Water Cooled	0	0.0%	0.0%	20.0	3,394.8	169.7	169.7
SCE	HVAC Duct Sealing	0	0.0%	0.0%	1.0	36.5	36.5	36.5
SCE	HVAC Motor Replacement	0	4.9%	0.0%	5.0	783.8	156.8	156.8
SCE	HVAC Rooftop or Split System	0	0.0%	0.0%	14.5	1,141.2	80.5	80.5
SCG	HVAC Boiler	0	0.0%	0.0%	20.0	0.0	0.0	0.0
SCG	HVAC Duct Sealing	0	0.0%	0.0%	10.5	402.1	46.8	46.8
SDGE	HVAC Duct Sealing	0	0.0%	0.0%	3.3	34.4	10.4	10.4
SDGE	HVAC Motor Replacement	0	0.0%	0.0%	15.0	1,636.9	109.1	109.1
SDGE	HVAC Rooftop or Split System	0	0.0%	0.0%	15.0	753.3	50.2	50.2

Per Unit (Quantity) Gross Energy Savings (Therms)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HVAC Duct Sealing	0	0.0%	0.0%	3.0	0.0	0.0	0.0
PGE	HVAC Motor Replacement	0	0.0%	0.0%	3.0	-5.4	-1.8	-1.8
PGE	HVAC Rooftop or Split System	0	0.0%	0.0%	15.0	-5.0	-0.3	-0.3
SCE	HVAC Chiller Water Cooled	0	0.0%	0.0%	20.0	0.0	0.0	0.0
SCE	HVAC Duct Sealing	0	0.0%	0.0%	1.0	2.2	2.2	2.2
SCE	HVAC Motor Replacement	0	4.9%	0.0%	5.0	-8.1	-1.6	-1.6
SCE	HVAC Rooftop or Split System	0	0.0%	0.0%	14.5	-5.2	-0.4	-0.4
SCG	HVAC Boiler	0	0.0%	0.0%	20.0	16.9	0.8	0.8
SCG	HVAC Duct Sealing	0	0.0%	0.0%	10.5	104.1	10.5	10.5
SDGE	HVAC Duct Sealing	0	0.0%	0.0%	3.3	0.0	0.0	0.0
SDGE	HVAC Motor Replacement	0	0.0%	0.0%	15.0	0.0	0.0	0.0
SDGE	HVAC Rooftop or Split System	0	0.0%	0.0%	15.0	-2.6	-0.2	-0.2

Per Unit (Quantity) Net Energy Savings (kWh)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HVAC Duct Sealing	0	0.0%	0.0%	3.0	446.5	148.1	148.1
PGE	HVAC Motor Replacement	0	0.0%	0.0%	3.0	372.6	123.3	123.3
PGE	HVAC Rooftop or Split System	0	0.0%	0.0%	15.0	739.7	49.3	49.3
SCE	HVAC Chiller Water Cooled	0	0.0%	0.0%	20.0	2,934.3	146.7	146.7
SCE	HVAC Duct Sealing	0	0.0%	0.0%	1.0	36.0	36.0	36.0
SCE	HVAC Motor Replacement	0	4.9%	0.0%	5.0	741.8	148.4	148.4
SCE	HVAC Rooftop or Split System	0	0.0%	0.0%	14.5	631.2	44.5	44.5
SCG	HVAC Boiler	0	0.0%	0.0%	20.0	0.0	0.0	0.0
SCG	HVAC Duct Sealing	0	0.0%	0.0%	10.5	341.7	40.0	40.0
SDGE	HVAC Duct Sealing	0	0.0%	0.0%	3.3	34.4	10.4	10.4
SDGE	HVAC Motor Replacement	0	0.0%	0.0%	15.0	1,462.6	97.5	97.5
SDGE	HVAC Rooftop or Split System	0	0.0%	0.0%	15.0	431.8	28.8	28.8

Per Unit (Quantity) Net Energy Savings (Therms)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HVAC Duct Sealing	0	0.0%	0.0%	3.0	0.0	0.0	0.0
PGE	HVAC Motor Replacement	0	0.0%	0.0%	3.0	-4.8	-1.6	-1.6
PGE	HVAC Rooftop or Split System	0	0.0%	0.0%	15.0	-3.3	-0.2	-0.2
SCE	HVAC Chiller Water Cooled	0	0.0%	0.0%	20.0	0.0	0.0	0.0
SCE	HVAC Duct Sealing	0	0.0%	0.0%	1.0	1.9	1.9	1.9
SCE	HVAC Motor Replacement	0	4.9%	0.0%	5.0	-8.0	-1.6	-1.6
SCE	HVAC Rooftop or Split System	0	0.0%	0.0%	14.5	-3.4	-0.2	-0.2
SCG	HVAC Boiler	0	0.0%	0.0%	20.0	4.0	0.2	0.2
SCG	HVAC Duct Sealing	0	0.0%	0.0%	10.5	104.0	10.5	10.5
SDGE	HVAC Duct Sealing	0	0.0%	0.0%	3.3	0.0	0.0	0.0
SDGE	HVAC Motor Replacement	0	0.0%	0.0%	15.0	0.0	0.0	0.0
SDGE	HVAC Rooftop or Split System	0	0.0%	0.0%	15.0	-0.1	0.0	0.0

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

Study ID	Study Type	Study Title	CPUC Study Manager
Group A HVAC Sector	Impact Evaluation	Impact Evaluation Report – HVAC – Program Year 2018	CPUC

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
1	All Programs	PA tracking data contained incorrect contact information.	there were a large number of cases where no end user contact information was available, and as a result end-user data collection was not possible. Therefore, the evaluation was unable to spend additional 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. Implementers should also take measures to ensure that project data includes contact information for both the equipment buyer (for evaluating purchasing decisions) and the equipment operator (for obtaining installation characteristics such as schedules, setpoints, installed quantities, and so on). We believe accurate contact information will improve the response rates in at least two ways: • Evaluators will be able to establish their bona fides early through introductory letters or emails, giving later attempts to reach site contacts a better chance of success than cold calls. • Evaluators will be more likely to reach the best respondent at each site on their first attempt.	All PAs	

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
2	All Programs	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.	All PAs	
3	All Programs	Program design elements that were not communicated to evaluators required changes in approach and led to consequent delays.	When we published our workplan and sampling memo we specified which market actors we would need to reach for program evaluation. It wasn't until we received responses to multiple data requests and completed one set of planned surveys that we learned that some programs do not collect data necessary to evaluators.	We recommend PA program and EM&V staff be more involved in critical workplan review. We would also invite PA staff to host webinars where they discuss program aims, targets, and methods. If Informational sessions took place shortly after we publish the list of measures and programs to be evaluated, we could work with the PAs to make sure that our evaluation design and data requirements are consistent with program operations.	All PAs	

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
4	All Upstream & Midstream Programs	The midstream, distributor-facing design of the rooftop unit/split system measure group results in inconsistent or incomplete tracking data for all PAs.	Rooftop or split systems measure rebates are paid to distributors, who in turn work with contractors to install high-efficiency systems among commercial customers. For approximately 74% of projects in the PY2018 population, the evaluation team did not have sufficient customer contact data to verify equipment installation or quantify evaluated savings. For the 26% of projects with sufficient customer contact data, recruitment for evaluation was challenging, as the customers were often unaware that they had participated in an efficiency program. The measure's midstream design and subsequent data gaps caused the evaluators to fall short of the target evaluation sample count of 85 projects. Data gaps were most prominent for programs administered by PG&E and SCE.	For any measures delivered midstream through distributor rebates, such as the rooftop and split system measure group, PAs must require participating distributors and partnering contractors to collaboratively collect and submit basic information for each customer that ultimately receives the rebated equipment.	All PAs	

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
5	All Upstream & Midstream Programs	Six of the 59 evaluated projects were determined to result in zero electricity savings due to non-install or ineligibility.	For 5 projects, evaluators determined that the incented rooftop or split systems equipment was never installed or energized. For one project, we found that the facility receives electricity from a municipal utility and is therefore ineligible for PA savings claim. Data collection, transmission, and screening complications, as a result of the rooftop or split systems measure group's midstream design, are the likely culprits for zero savings from these issues. Ineligibility and non-install reduced the RR of rooftop or split systems measures by 7% and were particularly prevalent for programs administered by PG&E and SCE.	The evaluation team recommends PAs to make sure that the incented equipment is installed at the appropriate location. PAs should also perform post inspections on the installed equipment to ensure they are properly installed and operating as intended.	All PAs	
6	All Upstream & Midstream Programs	A total of 36% of evaluated projects revealed measure-specific inconsistencies between tracking data and field-verified nameplate data.	In all, 27% of evaluated projects showed differences in equipment quantity, manufacturer, size, or efficiency rating between PA implementation data and field-verified characteristics. 32% of evaluated projects showed differences in equipment model or serial number. Again, data collection and transmission complications due to the RTU/split measures' midstream design have prevented the programs from accurately tracking basic installation information for rebated equipment.	For midstream measures, the programs should require that distributors and contractors submit more comprehensive installation documentation (e.g., invoices, commissioning reports) and photographs to prove quantity, size, make/model, and efficiency. Such documentation would allow the PAs and/or evaluators to conduct internal audits of a selection of tracked installations to confirm installation and tracking data accuracy.	All PAs	

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
7	Rooftop Package and Split Systems Programs: PGE210112, School Energy Efficiency; PGE21015, Commercial HVAC; SCE-13-SW-002F, Nonresidential HVAC Program; SDGE3224, SW-COM-Deemed Incentives-HVAC Commercial; SDGE3279, 3P-Res-Comprehensive Manufactured-Mobile Home; SDGE3302, SW-CALS - Residential HVAC Upstream	The ex post savings were lower than the ex ante estimate.	The overall GRRs are 55% for kWh, 61% for peak kW and 58% for the therm. This difference is primarily due to the overestimation of savings in the ex ante estimate. The ex ante estimate approach claimed savings equivalent to 60% of the total cooling load whereas the evaluation approach produced the savings to be approximately 10% of the total cooling load, which is in line with the efficiency improvement between the standard and high efficiency equipment	The evaluation team recommends that the PAs model this measure group with appropriate baseline and proposed conditions including the HVAC system efficiencies, fan power index and applicable economizer controls. In that way, the simulation results will reasonably capture the savings attributed only to the efficiency improvement between the Title -24 standard and high efficiency equipment	All PAs	PGECOHVC172-1 PGECOHVC126-7 PGECOHVC128-9 PGECOHVC161-2 PGECOHVC162-3 SCE17HC012.1 SCE17HC035.1 WPSDGENRHC0023-2 WPSDGENRHC0025-0

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
8	Rooftop Package and Split Systems Programs: PGE210112, School Energy Efficiency; PGE21015, Commercial HVAC; SCE-13-SW-002F, Nonresidential HVAC Program; SDGE3224, SW-COM-Deemed Incentives-HVAC Commercial; SDGE3279, 3P-Res-Comprehensive Manufactured-Mobile Home; SDGE3302, SW-CALS - Residential HVAC Upstream	The rooftop/split system measure group consisted of more than 100 unique measure descriptions for PY2018.	For many of these, the PAs are claiming the same measure, but the measure descriptions are not consistent across the PAs. This makes the task of grouping the same measures across the PAs more difficult and introduces unnecessary complication and uncertainty.	The evaluation team recommends that the PAs adopt a uniform measure description naming convention to homogenize and therefore consolidate the descriptions under this measure group in order to move towards a statewide focused portfolio and to improve the evaluability of these measures across the PAs.	All PAs	PGECOHVC172-1 PGECOHVC126-7 PGECOHVC128-9 PGECOHVC161-2 PGECOHVC162-3 SCE17HC012.1 SCE17HC035.1 WPSDGENRHC0023-2 WPSDGENRHC0025-0

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
9	Fan motor programs: PGE210011, Residential Energy Fitness program; PGE21006, Residential HVAC; PGE21008, Enhance Time Delay Relay; PGE21009, Direct Install for Manufactured and Mobile Homes; SCE-13-SW-001B, Plug Load and Appliances Program; SCE-13-SW-001G, Residential Direct Install Program; SCE-13-TP-001, Comprehensive Manufactured Homes; SDGE3207, SW-CALS-MFEER; SDGE3211, Local-CALS-Middle Income Direct Install (MIDI); SDGE3279, 3P-Res-Comprehensive Manufactured-Mobile Home	The evaluated savings for kWh was higher than the reported savings whereas the peak kW savings were lower than the expected.	These differences in savings are due to the difference in fan operating hours between the ex ante assumptions and the ex post values. Our analysis found that the ex ante savings appear to result from applying single-family hours of operation to mobile homes and multi-family buildings whereas the eQUEST models showed longer hours of operation for mobile homes and multi-family buildings, resulting in significantly greater evaluated savings than claimed for these building types. The lower peak kW savings are due to differences in thermostat settings between the evaluated and the reported values. The thermostat settings used in the reported savings model was based on older Database Energy Efficiency Resources (DEER) thermostat values, whereas the evaluation savings model used 2017 DEER thermostat values that were higher and allowed the fan to operate at lower loads or not operate during peak hours.	The evaluation team recommends that the PAs should model this measure group with the 3 residential dwelling types (single family, multi-family, and manufactured home) and most up-to-date DEER thermostats schedule to capture the variations in fan operating hours and accurately calculate the kWh and peak kW savings.	All PAs	PGECOHVC139-6, SCE17HC005.0, SCE13HC028.4, SCE17HC028.1, WPSDGEREHC1065-4

10	Fan motor programs: PGE210011, Residential Energy Fitness program; PGE21006, Residential HVAC; PGE21008, Enhance Time Delay Relay; PGE21009, Direct Install for Manufactured and Mobile Homes; SCE-13-SW-001B, Plug Load and Appliances Program; SCE-13-SW-001G, Residential Direct Install Program; SCE-13-TP-001, Comprehensive Manufactured Homes; SDGE3205, RES-Home Upgrade Program; SDGE3207, SW-CALS-MFEER; SDGE3211, Local-CALS-Middle Income Direct Install (MIDI); SDGE3279, 3P-Res-Comprehensive Manufactured-Mobile Home	Attribution was very high.	This was expected considering the program design and the measure involved. The program is delivered via direct install methods, which had relatively high attribution rates across the board (including the residential evaluation) for PY 2018. Furthermore, this program provides a free upgrade to a measure that few people think about.	If program delivery mechanism remains primarily direct install, consider increasing ex ante NTGRs from 57% to 85%. Under this program delivery mechanism, attribution can be expected to remain high.	PG&E, SCE, SDG&E	PGECOHVC139-6, SCE17HC029.2, WPSDGEREHC1067-1

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
11	Duct testing and sealing programs: PGE210011, Residential Energy Fitness program; SCE-13-SW-001G, Residential Direct Install Program; SCE-13-TP-001, Comprehensive Manufactured Homes; SDGE3211, Local-CALS-Middle Income Direct Install (MIDI); SDGE3279, 3P-Res-Comprehensive Manufactured-Mobile Home	Attribution was very high, which makes sense considering the program is delivered via direct install methods, which had relatively high attribution rates across the board (including the residential evaluation) for PY 2018.	Furthermore, this program provides a free upgrade to a measure that few people think about.	If program delivery mechanism remains primarily direct install, consider increasing ex ante NTGRs from 79% to 95%. Under this program delivery mechanism, attribution can be expected to remain high.	PG&E, SCE, SDG&E	PGE3PHVC159-6, SCE17HC029.2, WPSDGEREHC1067-1

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
12	Water-cooled Chiller program: SCE-13-SW-002F, Nonresidential HVAC Program	Both the kWh and kW GRRs for the water-cooled chiller measure group were higher than the reported.	Our evaluation determined the GRRs to be 221% and 179% for the kWh and kW respectively. This means the evaluated kWh savings were more than double the reported kWh savings and the evaluated kW is 79% higher than the reported kW. The primary reason for this large discrepancy is due to the difference in the chiller annual operating hours between the reported assumption and evaluated findings. The PA eQUEST model used a single average “commercial” building type to estimate savings across all their claims that did not capture the variations in chiller operating hours across the various building types.	Take a closer look at the workpaper assumptions and review the eQUEST model and ensure all the building types are included in the model runs to capture the variations in chiller operating hours across the various building type. Alternatively, we suggest this measure group to use custom calculation approach where the savings should be calculated using site-specific information rather than using a deemed approach via workpaper to claim savings.	SCE	SCE17HC043.0
13	Water-cooled Chiller program: SCE-13-SW-002F, Nonresidential HVAC Program	Both the kWh and kW GRRs for the water-cooled chiller measure group were higher than the reported.	Our evaluation determined the GRRs to be 221% and 179% for the kWh and kW respectively. This means the evaluated kWh savings were more than double the reported kWh savings and the evaluated kW is 79% higher than the reported kW. The primary reason for this large discrepancy is due to the difference in the chiller annual operating hours between the reported assumption and evaluated findings. The PA eQUEST model used a single average “commercial” building type to estimate savings across all their claims that did not capture the variations in chiller operating hours across the various building types.	Take a closer look at the workpaper assumptions and review the eQUEST model and ensure all the building types are included in the model runs to capture the variations in chiller operating hours across the various building type. Alternatively, we suggest this measure group to use custom calculation approach where the savings should be calculated using site-specific information rather than using a deemed approach via workpaper to claim savings.	SCE	SCE17HC043.0

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
14	Boiler programs: SCG3711, COM-DEEMED INCENTIVES; SCG3758, PUB-K-12 PERFORMANCE PROGRAM	Low NTGR revealed a high level of free-ridership for this measure group.	We determined an NTGR of 19% for this measure group, due to a high number of free-riders as evidenced from interviews with customer decision-makers. About 70% of end-users surveyed had already made the decision to upgrade their boiler, in many cases selecting their energy efficient equipment, prior to learning about rebates available. Their selection of energy efficient boilers was driven more by company policies dictating that they select efficient options when replacing old equipment than by program-provided rebates and information. When the program influenced end-users, it tended to accelerate the timing of boiler installation, but not increase the efficiency of the equipment they selected.	PAs should reconsider including boilers as a deemed measure in this program. This measure has previously been offered under the custom program by other PAs, which enables more detailed project screening to better understand customer decision drivers and identify potential free-ridership prior to project approval. As a deemed measure, PAs have limited insight into customer decision-making factors and methods.	SoCalGas	WPSCGNRHC120206A Revision 4

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
15	Boiler programs: SCG3711, COM-DEEMED INCENTIVES; SCG3758, PUB-K-12 PERFORMANCE PROGRAM	Low NTGR revealed a high level of free-ridership for this measure group.	We determined an NTGR of 19% for this measure group, due to a high number of free-riders as evidenced from interviews with customer decision-makers. About 70% of end-users surveyed had already made the decision to upgrade their boiler, in many cases selecting their energy efficient equipment, prior to learning about rebates available. Their selection of energy efficient boilers was driven more by company policies dictating that they select efficient options when replacing old equipment than by program-provided rebates and information. When the program influenced end-users, it tended to accelerate the timing of boiler installation, but not increase the efficiency of the equipment they selected.	Consider reducing the ex ante NTGR for therms from 65% to 20%. Program free-ridership survey questions indicate that most participants learned about the program after making a decision to install high-efficiency measures. Therefore, the program could not have had a strong effect on those decisions.	SoCalGas	WPSCGNRHC120206A Revision 4

6.4 Appendix D: Data collection and sampling memo

This document outlines the sampling and data collection plan for the Heating Ventilating Air Conditioning (HVAC) sector for Program Year (PY 2018).

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

Our approach to sample development is described in **Section 6.4.1**, where we also summarize the sample. **Section 0** covers data collection for both gross and net savings estimates. Finally, the data collection instruments we will use to gather data for quantifying our gross and net savings are included in Appendix G.

6.4.1 Sampling approach

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

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

In practice, error ratios cannot be determined until after the data are collected and savings are evaluated, and therefore need to be estimated. The sample design and projected precision are therefore based on assumed error ratios from experience with similar work. We assumed an error ratio of 0.6 based on previous experience with similar studies. A study looking to measure annual or peak consumption would have a higher estimated error ratio based on past metering studies, somewhere between 0.7 and 1.0 depending on buildings and climates covered.[53] A simple verification study may use an error ratio of 0.5. This evaluation will measure a set of conditions and compare them to current simulation model assumptions. The team chose to assume an error ratio of 0.6 by Program Administrator (PA). Analysis by some building types will be possible across PAs but building types and Climate Zones (CZs) with small population savings will have small or no samples.

6.4.1.1 Participant data and aggregation

The tracking data file contains 52,466 sites that claimed savings during PY 2018 for measures associated with the HVAC sector. About 54% of the sites (26,660 records) were from Pacific Gas and Electric(PG&E) programs, 22% (10,968 records) from Southern California Edition(SCE) SCE, 7% of sites (3,523 records) were from San Diego Gas and Electric (SDG&E), and 17% of sites (8,355 records) were from Southern California Gas (SCG).

6.4.1.2 Measure group selection process

Working with Commission staff, the evaluation team determined which measure groups to evaluate for PY 2018 based on the following selection process. First, the deemed HVAC savings claims were grouped by PY 2018 ESPI (Efficiency Savings and Performance Incentive) and Non-ESPI measure groups. Next, each measure group's contribution to savings (kWh, kW, therms) was ranked and these individual rankings combined to quantify an overall HVAC sector savings contribution ranking. The selection process then took into consideration whether a measure group had been evaluated recently and looked at trends in the savings claims for that measure group. The Commission staff and the evaluation team sought Stakeholder engagement on both the process and the proposed measure

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

groups selection through the HVAC Project Coordination Group meetings and the HVAC Workplan engagement process with the PAs.

The measure groups selected for this evaluation are primarily from the statewide list of HVAC ESPI uncertain measures. For the PY 2018 evaluation, we have selected six measure groups across the HVAC sector—four are ESPI measure groups and two are non-ESPI. The four ESPI measure groups are water-cooled chillers, duct testing and sealing, fan motor replacement, and rooftop or split systems; the two non-ESPI measure groups are packaged terminal air conditioner (PTAC) controls and boilers.

Because PG&E's Residential Upstream program is being discontinued following PY 2018 and SDG&E is considering the same following PY 2019, the rooftop or split systems measure group will be limited to commercial upstream programs. Similarly, the Motor Replacement measure group sample is limited to the fan motor replacement measure only, meaning the whole house fan measure is excluded from the evaluation scope. This is done because the whole house fan measure is only offered by one PA (SCE), and the technology is distinct from the other fan motor replacement measures and therefore would require an entirely different savings approach. Additionally, this measure's future savings potential is limited due to significantly lower prevalence of whole house fans compared to forced-air central HVAC systems.

Our evaluation team will perform both gross savings and net attribution assessments on the four selected ESPI measure groups, while the two non-ESPI measure groups will receive only an assessment of net program attribution. Table 6-1 shows a complete list of ESPI measure groups from 2017-2019 and specifies the measure groups that are selected for evaluation of gross savings and/or net program attribution for PY 2018.

Table 6-1. PY 2018 HVAC sector measure groups for evaluation

HVAC Measure Groups	ESPI Years	Gross Savings Evaluation	Net Attribution Evaluation
Chiller-Water Cooled	2017—2018	✓	✓
Duct Testing or Sealing	2018—2019	✓	✓
Furnace	2017—2018	-	-
Maintenance	2016—2019	-	-
Motor Replacement	2017—2019	✓	✓
Pump VFD	2017—2018	-	-
RCA	2017—2019	-	-
Rooftop or Split Systems	2017—2018	✓	✓
VRF/ Mini Split	2018	-	-
HVAC Boiler	2017	-	✓
PTAC Controls	2016, 2019	-	✓

Table 6-2 shows the counts of programs and savings claims for the PY 2018 HVAC Sector ESPI and non-ESPI measure groups selected for evaluation as well as the combined savings claims grouped by evaluation measure treatment.

Table 6-2. PY 2018 first-year gross savings claims for deemed HVAC ESPI and non-ESPI measure groups

ESPI	Treatment	Measure Group	Program Count	kWh	% kWh	kW	% kW	Therms	% Therms
ESPI	Gross and Net Savings	ROOFTOP OR SPLIT SYSTEM	8	11,567,191	15%	6,367	16%	-44,662	-5%
		MOTOR REPLACEMENT	11	7,816,095	10%	7,027	18%	-71,450	-8%
		DUCT SEALING	9	1,737,836	2%	2,285	6%	114,980	14%
		CHILLER WATER COOLED	1	1,241,085	2%	622	2%	0	0%
		Subtotal – ESPI Evaluated	**29**	**22,362,206**	**29%**	**16,301**	**41%**	**-1,133**	**0%**
	Subtotal –ESPI Not Evaluated		**21**	**6,555,015**	**9%**	**4,924**	**12%**	**46,774**	**5%**
	ESPI Subtotal		**50**	**28,917,222**	**38%**	**21,225**	**53%**	**45,641**	**5%**
Non-ESPI	Net Savings	CONTROLS PTAC	8	11,153,164	15%	4,038	10%	0	0%
		BOILER	2	-16,818	0%	1	0%	53,963	6%
		Subtotal—Non-ESPI Evaluated	**10**	**11,136,346**	**15%**	**4,038**	**10%**	**53,963**	**6%**
	Not Evaluated	**Subtotal Non-ESPI Not Evaluated**	**21**	**36,289,799**	**48%**	**14,877**	**37%**	**751,645**	**88%**
	Non-ESPI Subtotal		**31**	**47,426,145**	**62%**	**18,915**	**47%**	**805,609**	**95%**
Total Deemed HVAC			**81**	**76,343,367**	**100%**	**40,140**	**100%**	**851,250**	**100%**

6.4.2 Measure group sampling overview

From the six selected PY 2018 measure groups, duct seal, boiler, and chiller measure groups will utilize a census approach, where the entire population in the measure groups will be evaluated, whereas the remaining measure groups will use stratified ratio estimation approach for sample design.

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

The sampling methodology for fan motor replacement and rooftop or split systems measure groups employ 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.

For the Water-Cooled Chiller and Boiler measure groups the population sizes are small enough to warrant a census approach, so we will attempt to evaluate all project sites ("census") in the population.

Gross savings for the duct sealing measure group will be evaluated using a billing analysis where all sites in the population will be evaluated.[54]

The net attribution evaluation of the PTAC controls measure group will target the implementers (contractors/installers) serving the program year population if the number of implementers is 30 or less. If there are more than 30 implementers, DNV GL will survey those implementers with the most savings claims associated in order to represent the majority of program tracking savings for the measure group.

6.4.2.1 HVAC measure groups sample design

DNV GL designed the sample to achieve ±10% relative precision at the 90% confidence level for each measure group. In order to achieve ±10% relative precision for each measure group at 90% confidence level, a total of 125 sample sites are required for the HVAC fan motor replacement measure as shown in Table 6-4 and 95 sample sites are required for HVAC rooftop or split systems measure group as shown in Table 6-5. As mentioned earlier, all Water-Cooled Chillers sites will be evaluated as shown in Table 6-3.

Table 6-3. Water-cooled chiller gross and 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
SCE	14	14	0%	10	14%
Total	14	14	0%	10	**14%**

Net savings were not assessed for the boiler measure group in PY 2017 due to insufficient data and low response rates. However, the PY 2018 evaluation planned to perform a net evaluation on this measure group by combining the claims for both PY 2017 and PY 2018. Our team had planned to take a census approach and interview all 45 participants from PY 2017 and PY 2018. We were only able to reach 16 participants due to old contact information and turnover of decision-makers at customer facilities.

[54] *DNV GL will attempt to evaluate all sites in the "HVAC DUCT SEALING" measure group. Due to the availability and quality of the billing data, it is possible not all sites will be evaluated in the billing analysis.*

Table 3-6 shows the planned census and the archived sample size with its relative precisions for the boiler measure groups. For this measure group we fell short due to the low response rates and difficulty of reaching the appropriate decision makers to conduct net-to-gross surveys and fell to meet the relative precision target of ±10% at 90% confidence interval.

Also as mentioned previously, the HVAC Duct Sealing measure will be evaluated by a billing analysis in which all available billing data for program participants will be used to evaluate the savings. As a result, this measure has no sample design. A summary of the program is shown in **Table 6-6**.

Table 6-4. HVAC fan motor replacements gross and net sample by PA

PA	Sample Size	Population Size	Relative Precision at 90% Confidence	Program Savings (kWh)	Percent Program Savings (kWh)
PGE	70	17,031	11.9%	5,323,161	68%
SCE	45	2,993	20.9%	2,303,621	29%
SDGE	10	430	33.9%	191,604	2%
Total	**125**	**20,454**	**10.2%**	**7,818,386**	**100%**

Table 6-5. HVAC rooftop or split system gross and net sample by PA

PA	Sample Size	Population Size	Relative Precision at 90% Confidence	Program Savings (kWh)	Percent Program Savings (kWh)
PGE	50	1,282	13.5%	6,657,654	58%
SCE	35	561	16.1%	4,311,227	37%
SDGE	10	190	31.0%	598,057	5%
Total	**95**	**2,033**	**9.9%**	**11,566,938**	**100%**

Table 6-6. Water-cooled chiller census summary by PA

PA	Sample Size	Population Size	Relative Precision at 90% Confidence	Program Savings (kWh)	Percent Program Savings (kWh)
SCE	14	14	0%	1,241,085	100%
Total	**14**	**14**	**0%**	**1,241,085**	**100%**

Table 6-7. Duct testing and sealing program summary by PA

PA	Sample Size	Population Size	Program Savings (kWh)	Percent Program Savings (kWh)
PGE	3,118	3,118	456,878	25%
SCE	4,702	4,702	939,075	51%
SCG	7,941	7,941	390,168	21%
SDGE	749	749	49,362	3%
Total	**16,510**	**16,510**	**1,835,483**	**100%**

Table 6-7 shows the stratification for the HVAC fan motor replacement sample design.

Table 6-8. Fan motor replacement stratification

PA	Stratum	Maximum	Accounts	Program Savings (kWh)	Sample	Inclusion Probability
PG&E	1	276	7,322	1,655,003	24	0.00
PG&E	2	359	5,537	1,764,782	23	0.00
PG&E	3	3,151	4,172	1,903,376	23	0.01
SCE	1	360	1,570	428,427	14	0.01
SCE	2	612	1,064	471,425	14	0.01
SCE	3	94,554	356	783,741	14	0.04
SCE	4	230,796	3	620,028	3	1.00
SDG&E	1	224	231	45,286	4	0.02
SDG&E	2	373	183	47,806	3	0.02
SDG&E	3	18,249	16	98,513	3	0.19

Table 6-8 shows the stratification for the HVAC rooftop or split systems measure stratification. The sample was designed with multiple strata for each PA based on first-year kWh savings.

Table 6-9. HVAC rooftop or split systems unit stratification

PA	Stratum	Maximum	Accounts	Program Savings (kWh)	Sample	Inclusion Probability
PG&E	1	2,968	836	809,229	12	0.01
PG&E	2	7,189	225	1,045,822	12	0.05
PG&E	3	15,753	120	1,219,622	12	0.10
PG&E	4	33,742	63	1,427,219	12	0.19
PG&E	5	159,377	30	1,769,425	11	0.37
PG&E	6	386,337	1	386,337	1	1.00
SCE	1	3,973	331	575,304	7	0.02
SCE	2	9,355	117	715,674	7	0.06
SCE	3	18,823	63	841,883	7	0.11
SCE	4	40,907	33	974,750	7	0.21
SCE	5	190,944	17	1,203,615	7	0.41
SDG&E	1	5,513	161	137,786	4	0.02
SDG&E	2	18,998	21	186,694	3	0.14
SDG&E	3	68,549	8	273,577	3	0.38

Table 6-10 shows the total sample size for the HVAC water-cooled chiller measure group.

Table 6-10. Water-cooled chiller gross and net census

PA	Stratum	Maximum	Accounts	Program Savings (kWh)	Sample	Inclusion Probability
SCE	1	247,500	14	1,241,085	14	1.00

6.4.3 Data collection

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

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

The details of developing this data collection framework are described in Appendix B of the PY 2018 workplan.

6.4.3.1 Data collection instruments

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

6.4.3.2 Rooftop or split systems

In the 2015 upstream HVAC evaluations, our evaluation team verified measure installation, performed functional tests, and took spot measurements. On-site verification included capturing the building type and vintage, the space type, and equipment nameplate information as well as documenting economizer operation. The evaluation recorded duct location, unit configuration, and unit mounting. In some cases, we also took performance measurements such as static pressure differentials across HVAC units, fan power, damper positions, and more. To establish program attribution, we performed in-depth interviews of the HVAC distributors and end-users that we used to inform the NTG estimate.

The HVAC 4 uncertainty study conducted for program years 2013-2015 found that discrepancies in cooling sizing ratio, cooling setpoint, and fan power index (watts/CFM) were the primary drivers for savings uncertainty for HVAC Unitary systems. One other uncertain factor that affected savings estimates was the misalignment of building types in the tracking data, but since this discrepancy impacted savings estimates by only 5 to 10%, it was not a major driver of savings uncertainty.

To address these major uncertainties and improve ex post savings estimates for rooftop and split systems for the program year 2018 evaluation, we will collect thermostat settings and take measurements to determine the fan power index of the sampled unit in addition to collecting nameplate and installation characteristics. As part of the data collection effort for program year 2018, along with on-site data collection we will attempt to collect whole-premises meter data in order to calibrate the models of rooftop and split systems by CZ and building types.

Because PG&E's Residential Upstream program is being discontinued following PY 2018 and SDG&E is considering the same following PY 2019, this measure group will be limited to non-residential upstream participants.

At each site, the evaluation team will make observations and take the following measurements:

- **Installation Characteristics**: Inspectors will record the building type served by each selected unit. A list of additional items to be recorded can be found in 6.7.1.
- **Equipment Nameplate**: A photograph of the nameplate of each unit will be taken. The inspector will also make a written record of the nameplate information.
- **Operating Characteristics**: Inspectors will attempt to collect the operating and set-point schedules. If possible, the schedules will be obtained by direct observation of a programmable thermostat or energy management system. If the inspector cannot directly observe the schedules, then facility personnel will be queried for the schedules. The inspector will obtain the on/off time for weekdays, weekends and holidays as well as the heating and cooling set points for occupied and non-occupied periods. The site contact will also be asked for the list of holidays observed at the facility.
- **Additional data** will be collected on unitary systems and will include the spot measurements necessary to determine the fan power index:
  - Cooling-mode fan true electric power
  - Cooling mode airflow

6.4.3.3 Blower motor

As part of gross data collection, we will verify the installation of the blower motor, collect nameplate information, confirm the baseline, collect site-specific operational parameters and perform spot measurements on the blower motor power draw and the system airflow.

6.4.3.4 Duct sealing

We propose a normalized annual consumption (NAC) pre-post billing analysis based on participant billing data received from the PAs (including data from at least one year prior to measure installation to one year after) to estimate gross savings for this measure. To improve the accuracy of our results, we will limit the population to residential sites with no other EE claims in PY2018. We plan to include non-participants in the NAC billing analysis as well. We will base net impacts for this subsector on NTG survey data obtained from program participants and contractors.

6.4.3.5 Water-cooled chiller

The water-cooled HVAC chiller measure is on the 2018 ESPI list and is targeted for evaluation of the installation rate, unit energy savings, and NTGR. For this measure, our data collection activities will include remote and on-site verification of measure installation and installation parameters (such as equipment size) along with basic program attribution. The 2013-2014 evaluation included HVAC chiller water cooled measures; these measures performed well in that evaluation.

We will verify unit-rated full-load and IPLV nameplate efficiencies of the installed chillers and will collect as much data on their installation characteristics, including seasonal operating strategies (as determined through controls sequences and operator logs), as possible. We will also request data logged by on-site building automation systems. This information will provide insight into in-situ operating characteristics from which we will develop regression-based performance curves used in modeling savings for these measures.

6.4.3.6 Net attribution data collection

We will perform both gross and net evaluations for the above four measure groups. In addition, we will be performing net-only assessments for PTAC controls and HVAC boiler measure groups for PY 2018.

To support our net savings estimates for the six measure groups, we propose to interview combinations of customers, contractors, and HVAC distributors. Some of the specific efforts under this plan are:

- Review secondary sources for market share information pertaining to the upstream program
- Conduct market actor interviews (participating distributors, contractors, customers, and end users) focused on market structure for all units and participant distributor interviews to assess program influence for Rooftop and Split
- Review the program PIP and conduct interviews with program managers to discuss program theory on influencing alternate equipment types (e.g., mini-split, VRF Multi-Split)
- Conduct end-user interviews to assess free ridership for the downstream programs

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

A major area for collaboration among stakeholders is standardizing implementer data typically requested by EM&V. For example, to verify installation of unitary equipment, evaluators need manufacturers' names, model numbers, and serial numbers of existing and new equipment. Evaluators also need clear links to measure names and efficiency tiers used in workpapers and DEER. DNV GL's team will work with the Data Management and Reporting PCG to determine if an HVAC table could be developed providing basic equipment information. This effort will grow in importance as third-party programs increase. We will pay special attention to the ability to link upstream equipment upgrades to specific PA meters for future NMEC approaches.

6.4.4 Data sources

Table 6-11 shows the data sources and data collection activities across the measure groups for this sector. Data will be used to provide a robust, accurate, and defensible ex post estimate of measure impacts. On-site data collection efforts will focus on verifying the simulation model inputs and short-term monitoring of critical equipment. We provide additional detail below the table.

Table 6-11. Summary of Data Sources and Applicable Measure Groups

Data Sources	Description	Applicable Measure Group(s)
Program Tracking Data	IOU Program data includes number of records, savings per record, program type, name, measure groups, measure description, incentives etc.	HVAC ROOFTOP OR SPLIT SYSTEM HVAC WATER-COOLED CHILLER HVAC MOTOR REPLACEMENT HVAC DUCT SEAL HVAC PTAC CONTROLS HVAC BOILER
Program Billing Data	PA billing data including kWh	HVAC ROOFTOP OR SPLIT SYSTEM HVAC WATER-COOLED CHILLER HVAC MOTOR REPLACEMENT HVAC DUCT SEAL
Program AMI Data	Detailed, time-based energy consumption information	HVAC ROOFTOP OR SPLIT SYSTEM HVAC DUCT SEAL
Project Specific Information	Project folders include scope of work, equipment model and serial numbers, nominal efficiency, test results, project costs, etc.	HVAC ROOFTOP OR SPLIT SYSTEM HVAC WATER-COOLED CHILLER HVAC MOTOR REPLACEMENT HVAC DUCT SEAL
Manufacturer Data Sheet	Data sheets Include equipment specifications such as horsepower (HP), efficiency, capacity, etc.	HVAC ROOFTOP OR SPLIT SYSTEM HVAC WATER-COOLED CHILLER HVAC MOTOR REPLACEMENT
Telephone/ web surveys	Includes surveys of customers, distributors, other market actors, and PA program staff.	HVAC ROOFTOP OR SPLIT SYSTEM HVAC WATER-COOLED CHILLER HVAC MOTOR REPLACEMENT HVAC DUCT SEAL HVAC PTAC CONTROLS HVAC BOILER
On-site Surveys	Includes verifying measure installation, gathering measure performance parameters such as efficiency, schedules, set-points, building characteristics etc.	HVAC ROOFTOP OR SPLIT SYSTEM HVAC WATER-COOLED CHILLER HVAC MOTOR REPLACEMENT
End-use metering	Includes performing spot measurements, short-term metering with data loggers, performance measurements	HVAC ROOFTOP OR SPLIT SYSTEM HVAC WATER-COOLED CHILLER HVAC MOTOR REPLACEMENT

- **Program tracking data.** Each of the 4 PAs will provide and upload program tracking data onto a centralized server. We will then analyze, clean, re-categorize, and reformat these datasets, if necessary. For programs and measures, the impact evaluation team will review PA monthly reports and actual program tracking data to reconcile actual versus reported claims, thereby validating PA tracking data uploads.
- **Project-specific information.** The PAs maintain 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. As part of the file review process, we will thoroughly review these documents to assess their reasonableness.

- **Data sheets from equipment manufacturers.** As part of the gross data collection, we will request technical specifications of the evaluated equipment from manufacturers and equipment vendors. These data sheets typically include performance parameters of the equipment such as horsepower, efficiency, capacity, energy efficiency ratio (EER).
- **Telephone / web surveys of participating customers and distributors.** Both gross and net deliverables will require telephone/web surveys. We will perform surveys with customers, distributors, other market actors, and PAs.
- **On-site surveys.** DNV GL's team will complete on-site surveys for some of the sample points. During the on-site visits, we will collect the data identified and measurements specified in each site-specific data collection instrument. These data may include: site monitoring records; instantaneous spot power measurements; temperatures; energy management system (EMS) trend data; equipment nameplate data; system operating schedules; and detailed descriptions of the installed equipment, systems, and conditions. We will train and instruct evaluation engineers in data collection procedures and appropriate use of documentation prior to scheduling site visits.
- **End-use metering.** Aside from spot measurements, DNV GL does not expect to need end-use metering. It may become necessary in instances where no other method provides the data we need. If so, we will install equipment for spot measurements, short-term measurements, and long-term measurements, as necessary, to carry out the evaluation plan. Metering may capture hours of operation, amps, kW, fluid flow rates, temperatures, and other operating parameters.

6.5 Appendix E: Detailed gross methodology

6.5.1 Duct testing and sealing

6.5.1.1 Matching

The goal of energy efficiency evaluation is to estimate change in energy use due to an intervention, while accounting for the effect of other changes in consumption, such as weather, income, and household characteristics. Weather normalization accounts for the effect weather has on consumption changes. After weather normalizing consumption, there remain two other possible explanations for pre-post differences: program-related savings and exogenous consumption changes (non-program, non-weather related changes in consumption). Exogenous changes may be driven by economic or other factors but, importantly, they occur across all customers, not just program participants. If, for instance, customers are coming out of a period of economic recession, an average two to three percent increase in consumption may occur across all customers. If this increase is not addressed, it will directly undermine true savings. DNV GL controlled for the effect of these types of exogenous changes by using a comparison group.

DNV GL conducted two rounds of matching to select the comparison group. The first round used propensity score matching to select 10 potential comparators for every duct testing and sealing participant. We then requested AMI data for this group which we used to conduct the second round of matching using Mahalanobis minimum distance matching. Propensity score matching uses propensity scores to summarize several dimensions of household characteristics, such as consumption levels and patterns, into single values that can be used to match program participants with similar non-participant households. Mahalanobis distance matching selects the best matches by minimizing the distance between the treatment and comparison matching variables.

The first round of matching, using the propensity score matching approach, involved the following general steps:

- Select household characteristics that are unrelated to program participation. We used pre-program consumption.
- Examine the distribution of these characteristics and exclude observations of the comparison group that do not overlap with those of participants’ as a first round of identifying common support for matching. We did not stratify by housing type, as the variable was not readily available in the billing data customer tables.
- Fit a logistic regression using these variables to estimate the probability of program participation.
- Conduct a second round of trimming or common support identification based on propensity scores.
- Select a matching method, the number of comparators in the many-to-one matching, and whether to match with or without replacement; match participant households’ scores to comparison households based on these selections. We selected 10 comparators for every participant without replacement.
- Conduct diagnostic checks to see if selected matches are well-balanced.

The second round of matching, using the Mahalanobis distance matching process, involved the following general steps:

- Check AMI data completeness. We restricted the treatment data to records with at least 90% of reads in the year prior to treatment and the year following treatment. Restrict potential comparator data to records with 90% of all requested reads.
- Select household characteristics that are unrelated to program participation. We stratified by climate zone and used annual consumption and the ratio of average summer daily consumption to average winter daily consumption prior to participation.
- Examine the distribution of these characteristics and exclude observations of the comparison group that do not overlap with those of participants' as a first round of identifying common support for matching.
- Select a matching method, the number of comparators in the many-to-one matching, and whether to match with or without replacement; match participant households to comparison households based on these selections. We selected one comparator for every treatment household and matched with replacement for SCG and without replacement for the other PAs.
- Conduct diagnostic checks to see if selected matches are well-balanced

6.5.1.2 Site-level modeling

The first stage site-level model correlates daily energy consumption with heating and cooling degree days. Based on PRISM,[55] this model is used to estimate each household's response to (1) outdoor temperatures, (2) the temperature points (base or balance points) that trigger cooling and heating, and (2) weather-adjusted consumption that reflects typical weather for each site. The outcome of this process is weather normalized energy consumption.

The site-level model is given by:

$$E_{im} = \mu_i + \beta_H H_{im}(\tau_H) + \beta_C C_{im}(\tau_C) + \varepsilon_{im}$$

Where:

E_{im}	Average electric (or gas) consumption per day for participant i during period m
μ_i	Base load usage (intercept) for participant i
$H_{im}(\tau_H)$	Heating degree-days (HDD) at the heating base temperature τ_H
$C_{im}(\tau_C)$	Cooling degree-days (CDD) at the cooling base temperature $\boldsymbol{\tau_C}$ (not included in gas models)
β_H	Heating coefficient determined by the regression
β_C	Cooling coefficient determined by the regression (not included in gas models)
τ_H	Heating base temperatures, determined by choice of the optimal regression model
τ_C	Cooling base temperatures, determined by choice of the optimal regression model
ε_{im}	Regression residual

Consumption is estimated over a range of 64F° to 80F° for cooling and 50F° to 70F° for heating to identify the temperature base points for each site (household); statistical tests identify the optimal set of base points. The outcome of the site-level model is parameters that indicate the level of baseload (consumption

[55] Princeton Scorekeeping Method (PRISM™). F. Fels, Margaret. (1986). PRISM: An introduction. Energy and Buildings - ENERG BLDG. 9. 5-18.

not correlated with either HDD or CDD) and the relationship between heating and cooling consumption and HDD and CDD, respectively.

Model parameter estimates for each site allow the prediction of consumption under any weather conditions. For evaluation purposes, all consumption is put on a typical weather basis called normalized annual consumption (NAC). NAC for the pre- and post-installation periods are calculated for each site and analysis time frame by combining the estimated coefficients $\hat{\beta}_H$ and $\hat{\beta}_C$ with the annual typical meteorological year (TMY) degree days H_0 and C_0 calculated at the site-specific degree-day base(s), $\hat{\tau}_H$ and $\hat{\tau}_C$. Normalized annual consumption is given by:

$$NAC_i = (365 \times \hat{\mu}_i) + \hat{\beta}_H H_0 + \hat{\beta}_C C_0$$

6.5.1.3 Household difference-in-difference model

Normalized annual consumption from site-level models form the basis for the second stage of the analysis. A model based on the pre- and post-difference in NAC for participant households and a matched comparison group is estimated using a difference-in-difference modelling approach. This model is given by:

$$\Delta \mathrm{NAC}_i = \alpha + \beta T_i + \varepsilon_i$$

In this model, α is the intercept, which represents the change in consumption between the pre and post period driven by factors other than program participation or weather. i subscripts a household and T is a treatment indicator that is 1 for duct testing and sealing and 0 for matched comparison homes. The effect of participation is captured by the coefficient estimate of the term associated with the treatment indicator, $\hat{\beta}$.

Pre- and post-program periods are based on a definition of a blackout period for each participant. Based on the CalTrack recommendation and the CPUC tracking data, DNV GL defined a three-month black out period to include the installation month and two months prior to installation for all projects. According to CalTrack, an intervention period is a "time between the end of the baseline period and the beginning of the reporting period in which a project is being installed. It advises the use of "the earliest intervention date as project start date and the latest date as the project completion date."[56] Typically, the tracking data indicates a single installation date, though some sites have multiple installation dates indicated.

Table 6-11 and Table 6-12 present the parameters from the difference-in-difference models. The intercept captures the exogenous change between the pre and post periods. The treatment parameter is the amount of savings due to program intervention. A positive value indicates positive savings.

[56] http://docs.caltrack.org/en/latest/methods.html#section-2-data-management

Table 6-12. Electric duct testing and sealing household-level difference-in-difference parameters

PA	Parameters	Evaluated Households	Estimates	Standard Error	t-stat	p-value
PG&E	Intercept	458	-34	60.5	-0.6	0.570
	Treatment		259	85.5	3.0	0.003
SCE	Intercept	2,450	-109	27.5	-4.0	0.000
	Treatment		244	38.9	6.3	0.000
SDG&E	Intercept	214	92	110.8	0.8	0.405
	Treatment		-74	156.7	-0.5	0.637
Overall	Intercept	3,122	-84	24.6	-3.4	0.001
	Treatment		224	34.7	6.5	0.000

Table 6-13. Gas duct testing and sealing household-level difference-in-difference parameters

PA	Parameters	Evaluated Households	Estimates	Standard Error	t-stat	p-value
PG&E	Intercept	695	-9	9.3	-0.9	0.349
	Treatment		-13	13.1	-1.0	0.311
SCG	Intercept	749	-12	3.4	-3.4	0.001
	Treatment		13	4.8	2.7	0.007
SDG&E	Intercept	255	-17	5.8	-3.0	0.003
	Treatment		-3	8.2	-0.4	0.669
Overall	Intercept	1,699	-11	4.2	-2.7	0.007
	Treatment		0	5.9	-0.1	0.955

6.5.1.4 Measure-level difference-in-difference model

Duct testing and sealing households tended to install at least one other measure at the same time. This means that the household-level savings estimate represents the savings for the bundle of measures installed rather than for duct testing and sealing alone. We used a difference-in-difference modeling approach using both measure-level dummy variables and claimed savings to disaggregate the savings by measure group using the following model specification:

$$\Delta NAC_i = \alpha + \beta_{t,m}\mathrm{T}_{\mathrm{i,m}} + \beta_{s,m}S_{\mathrm{i,m}} + \varepsilon_i$$

Where:

ΔNAC_i = Change in NAC for customer i

$\mathrm{T}_{\mathrm{i,m}}$ = An indicator variable that is 1 if participant i installed measure m, 0 otherwise

$S_{\mathrm{i,m}}$ = Total savings if participant i installed measure m, 0 otherwise

ε_i = Model error term

We then estimated the measure-level savings using the parameters for the dummy and savings variable in the following way:

$$E_m = \beta_{t,m} + \beta_{s,m} A_m$$

Where:

E_m = Estimated savings for measure m

$\beta_{t,m}$ = Parameter estimate for the measure m indicator variable

A_m = Average claimed savings for measure m

We initially ran the model with variables for all of the measures claimed by duct testing and sealing participants; however, some of these measures had negative estimates. This resulted in the inflation of the duct testing and sealing estimates. As we had no reason to expect these measures to result in negative savings, we dropped them from the model, effectively setting their savings to zero. Table 6-14 presents the parameters from the final measure-level difference-in-difference models. Table 6-15 presents the savings estimates for each of the measures with positive savings.

Table 6-14. Duct testing and sealing measure-level difference-in-difference parameters

PA	Parameter Type	Parameter Measure	Evaluated Households	Estimates	Standard Error	t-stat	p-value
Overall	Intercept	Intercept	3,122	-84.4	24.1	-3.5	0.0
	Dummy Parameters	HVAC Controls Fan		46.7	90.4	0.5	0.6
		HVAC Duct Testing and Sealing		127.4	64.3	2.0	0.0
		HVAC Motor Replacement		-55.8	126.0	-0.4	0.7
		Lighting Indoor LED A-lamp		-70.0	237.5	-0.3	0.8
	Savings Parameters	HVAC Controls Fan		0.0	0.2	-0.2	0.8
		HVAC Duct Testing and Sealing		0.3	0.3	1.1	0.3
		HVAC Motor Replacement		0.5	0.3	1.6	0.1
		Lighting Indoor LED A-lamp		3.9	5.1	0.8	0.4
PG&E	Intercept	Intercept	458	-34.3	61.3	-0.6	0.6
	Dummy Parameters	HVAC Controls Fan		99.4	209.4	0.5	0.6
		HVAC Duct Testing and Sealing		66.3	173.8	0.4	0.7
		Lighting Indoor LED A-lamp		-62.3	237.1	-0.3	0.8
	Savings Parameters	HVAC Controls Fan		0.2	0.8	0.3	0.8
		HVAC Duct Testing and Sealing		0.7	0.8	0.8	0.4
		Lighting Indoor LED A-lamp		2.7	5.0	0.5	0.6
SCE	Intercept	Intercept	2,450	-109.2	26.8	-4.1	0.0
	Dummy Parameters	HVAC Controls Thermostat		226.7	98.7	2.3	0.0
		HVAC Duct Testing and Sealing		64.0	82.8	0.8	0.4
		HVAC Motor Replacement		-176.7	156.1	-1.1	0.3
	Savings Parameters	HVAC Controls Thermostat		-0.4	0.2	-1.8	0.1
		HVAC Duct Testing and Sealing		0.5	0.4	1.3	0.2
		HVAC Motor Replacement		1.0	0.4	2.2	0.0
SCG	Intercept	Intercept	749	-11.5	3.9	-2.9	0.0
	Dummy Parameter	HVAC Duct Testing and Sealing		7.9	7.3	1.1	0.3
	Savings Parameter	HVAC Duct Testing and Sealing		1.2	1.5	0.8	0.4

Table 6-15. Duct testing and sealing measure-level savings estimates

PA	Measure Group	Households with Measure	Reported Gross Savings per Household	Evaluated Gross Savings per Household	p-Value	Relative Precision at 90% Confidence	Realization Rate
kWh							
PG&E	HVAC Controls Fan	173	277	164	0.170	120%	59%
	HVAC Duct Sealing	458	182	190	0.072	91%	104%
	LED A-Lamp	119	33	28	0.827	754%	85%
SCE	HVAC Controls Thermostat	1,890	281	106	0.098	99%	38%
	HVAC Duct Sealing	2,450	133	126	0.038	79%	94%
	HVAC Motor Replacement	620	335	143	0.041	80%	43%
Overall	HVAC Controls Fan	2,117	362	30	0.576	294%	8%
	HVAC Duct Sealing	3,122	134	165	0.001	48%	123%
	HVAC Motor Replacement	905	357	127	0.033	77%	35%
	LED A-Lamp	119	33	60	0.612	324%	178%
Therm							
SCG	HVAC Duct Sealing	749	4	13	0.011	65%	319%

6.5.1.5 Peak demand savings

Peak demand savings estimates from this model are based on DEER defined heat wave period cooling degree days.[57] According to the DEER (2008) definition, a peak period is 3 consecutive non-holiday weekdays between June 1 and September 30 with the hottest temperatures within the 9-hour window of 2 p.m. to 5 p.m. This definition considers the average temperature, average afternoon temperature (12 p.m.–6 p.m.), and maximum temperature over the course of 3-day heatwave candidates.

For this analysis, we used the peak period for each of the state's 16 Title 24 climate zones (CZs) using the most current TMY (typical meteorological year) datasets so average demand impact is estimated under conditions that represent grid peak. The following table provides a definition of the peak period (heat wave) applicable to each climate zone based on this definition.

[57] DEER2008 version 2.05, adopted by CPUC Decision 09-09-047,3

Table 6-16. Typical meteorological year -based heat wave definitions by climate zone

Climate Zone	CZ2010 (2013 Title-24) Weather Files			
	Start Date	Weekday	Peak T	Ave T
CZ01	16-Sep	Wed	81	59.8
CZ02	8-Jul	Wed	103	75.9
CZ03	8-Jul	Wed	91	69.2
CZ04	1-Sep	Tue	99	77.5
CZ05	8-Sep	Tue	87	64.8
CZ06	1-Sep	Tue	102	77.1
CZ07	1-Sep	Tue	90	73.9
CZ08	1-Sep	Tue	105	79.8
CZ09	1-Sep	Tue	107	86.6
CZ10	1-Sep	Tue	109	86.3
CZ11	8-Jul	Wed	113	88.3
CZ12	8-Jul	Wed	109	82.4
CZ13	8-Jul	Wed	108	86.7
CZ14	26-Aug	Wed	105	86.8
CZ15	25-Aug	Tue	112	97.5
CZ16	8-Jul	Wed	90	78.8

Source: http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2013-July2013-Workshop.ppt

As the basis for the following regression model, DNV GL uses the 15- and 60-minute interval data from 2 p.m. to 5 p.m. during the DEER defined heatwaves. The model produces estimates of peak demand savings due to program intervention:

We used hourly interval data from 2 p.m. to 5 p.m. during the identified peak periods to estimate the peak demand using the following model:

$$\Delta\overline{kW}_i = \alpha + \beta T_i + \varepsilon_i$$

Where:

$\Delta\overline{kW}_i$ =Average difference in demand for household $i$between the pre- and post-program periods during the DEER-defined peak period

T_i = An indicator variable that is 1 for duct testing and sealing participants, 0 otherwise

α, β = Model coefficients – β represents the average peak demand reduction due to duct testing and sealing

ε_i = Model error term

Table 6-16 presents the parameters from the demand models.

Table 6-17. Demand duct testing and sealing household-level difference-in-difference parameters

PA	Parameters	Evaluated Households	Estimates	Standard Error	t-stat	p-value
PG&E	Intercept	455	0.8	0.1	15.5	0.000
	Treatment		-0.1	0.1	-0.9	0.357
SCE	Intercept	2,446	0.7	0.0	23.9	0.000
	Treatment		0.0	0.0	0.8	0.427
SDG&E	Intercept	213	1.3	0.1	13.5	0.000
	Treatment		0.3	0.1	2.1	0.038
Overall	Intercept	3,114	0.8	0.0	29.8	0.000
	Treatment		0.0	0.0	1.0	0.338

6.6 Appendix F: Detailed NTG methodology

6.6.1 HVAC rooftop or split systems

6.6.1.1 PY2018 Update

The PY2018 Rooftop NTG evaluation is based on the method used in PY2017. Major changes include:

- Added a contractor layer to the conceptual framework. Now we assess program influence on distributors, distributor influence on installation contractors, and contractor influence on end users. Installation contractors and end users are collectively referred to as “buyers”.
- Added more specific measure categories for the distributors
- Updated the price attribution sequence

6.6.1.2 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 buyers take when purchasing one. Our goal was to develop an approach that considered these pathways in the context of the HVAC1 program design and real-world complexity. We created the term “causal pathway” to represent how the program may indirectly influence the final purchase decisions of buyers. We then used this approach to integrate NTG survey responses between buyers and the distributors into an overall NTG score.

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

The three main causal pathways of program influence included:

1. The program influenced distributors to **stock** high efficiency units, and what was in stock influenced what buyers purchased when their unit failed. This causal pathway was driven by the assumption that

when buyers replace existing equipment in an urgent situation (replace on failure in five days or less), the stocking habits of distributors would be most influential.

2. The program encouraged distributors to **upsell or promote** high efficiency units, and buyers were influenced by the upselling and promotional efforts to purchase high efficiency units rather than standard efficiency models. Note, there is a circular relationship between upselling and stocking. Based on our conversations with program staff, distributors stock what sells and sell what is in stock. Therefore, program effects on stocking can have an indirect effect on upselling. We attempt to address this indirect effect through framing questions, but ultimately only capture a singular program influence on upselling that includes indirect effects through stocking, coaching, the rebates, and other program activities.

3. The program offers distributors a rebate on high efficiency units but does not encourage nor require distributors to reduce the **price** of high efficiency units or pass along the rebate to buyers. The rebate is intended to compensate the distributors for indirect costs to maintaining high efficiency stock and upselling high efficiency units. Some distributors might pass rebates through to buyers, and in those cases, buyers might be influenced by the lower prices of these high efficiency units.

Thus, the primary attribution pathway for the program is through increasing upselling and promotion of high efficiency units. The program's intended effects on stock and price are captured within the upselling and promotion pathway. However, there are additional ways that stocking and price could affect final buyer decisions, so the surveys attempt to capture those influences as well. Table 6-17 shows the researchable questions themes that represent the three causal pathways across distributors and buyers.

Table 6-18. Question themes across causal pathways for distributors and buyers

Causal Pathways	Distributor Question Theme	End user Question Theme
Stock	1. Did the program influence distributor to carry more high efficiency (HE) stock?	1. Did immediately available HE stock affect purchase?
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 buyer'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 buyer's decision?

Each of the three 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. The evaluation measured each causal path independently. For each causal path, the approach assumed 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 buyers 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 three 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 buyer surveys were completed, we calculated the individual buyer and distributor attribution scores, mapped them together, and expanded to the whole population. Whenever possible, we attempted to connect specific distributors, contractors, and end users. When specific connections could not be made, we substituted average distributor and contractor values. This section will review the process of calculating the attribution scores individually, and then expanding them to the population.

6.6.1.2.1 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. Updates from the interview guide used for PY2017 included adding some questions about specific program activities we learned of during the interview with program managers (e.g. regular meetings between program managers and distributors to coach on upselling). We also used a more specific matrix of technologies and sizes for the key attribution questions.

The following flowcharts diagram how the Stocking Attribution, Upselling Attribution, Price Attribution, and S

ales Attribution scores were calculated for the distributors.

Figure 6-1. Detailed distributor causal pathway scoring: stocking

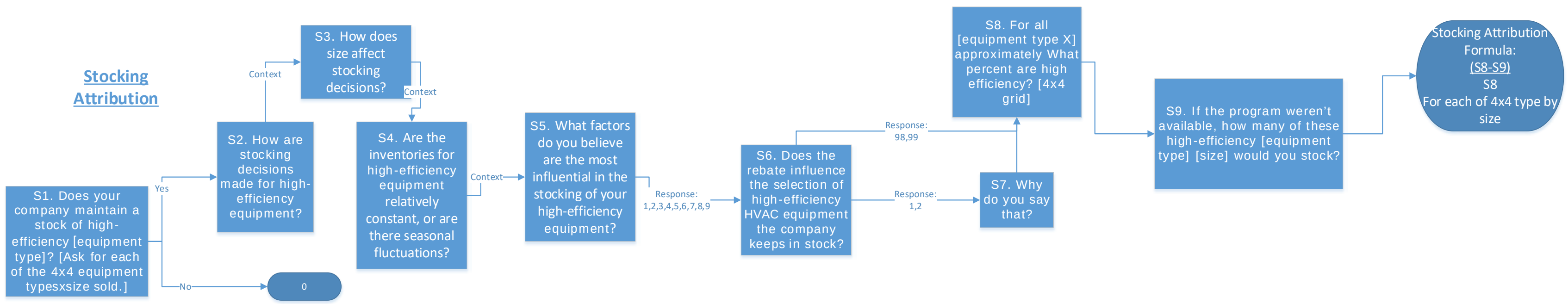


Figure 6-2. Detailed distributor causal pathway scoring: upselling

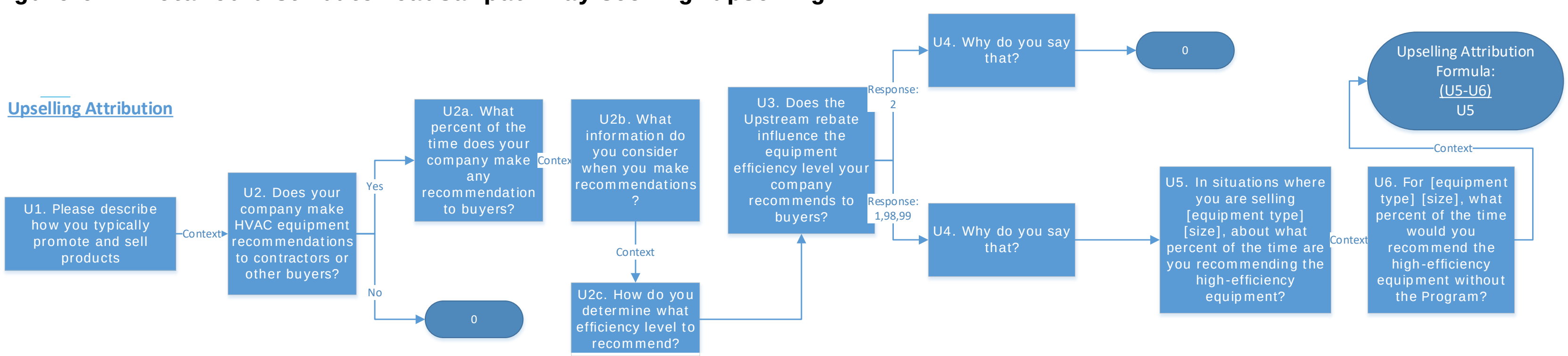


Figure 6-3. Detailed distributor causal pathway scoring: price

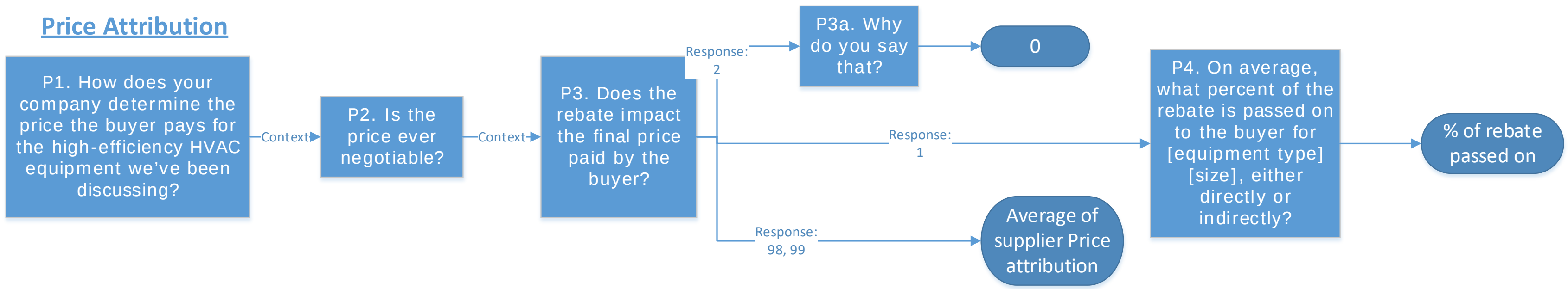
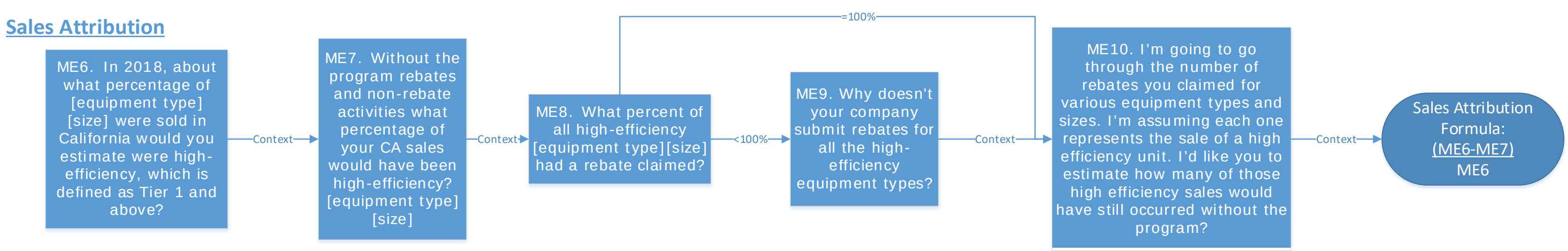


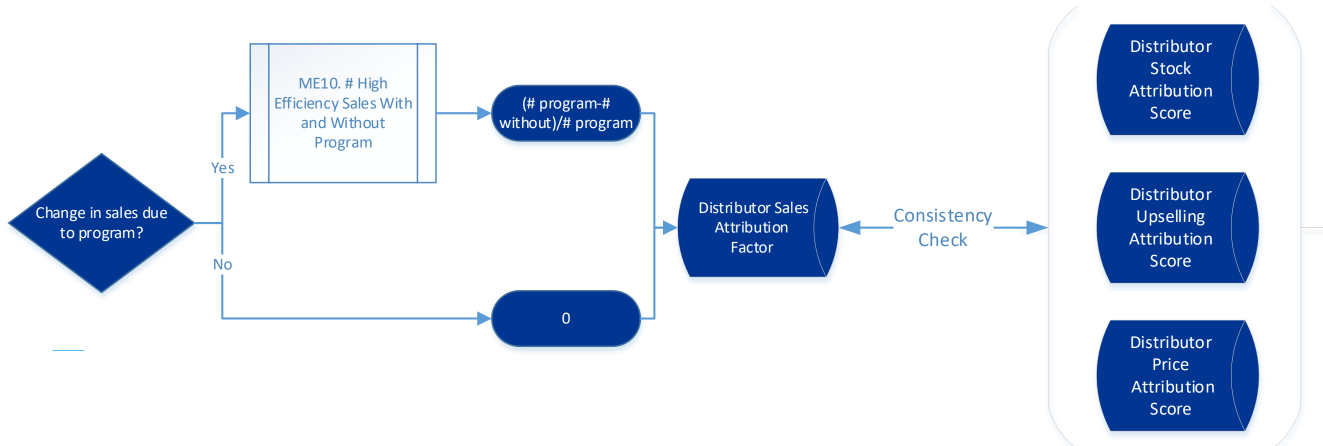
Figure 6-4. Detailed distributor causal pathway scoring: sales



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



6.6.1.3 End user attribution calculation

For the buyer survey, we first asked buyers 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 Table 6-17. 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 Buyers.

Figure 6-6. Detailed buyer causal pathway scoring: stocking

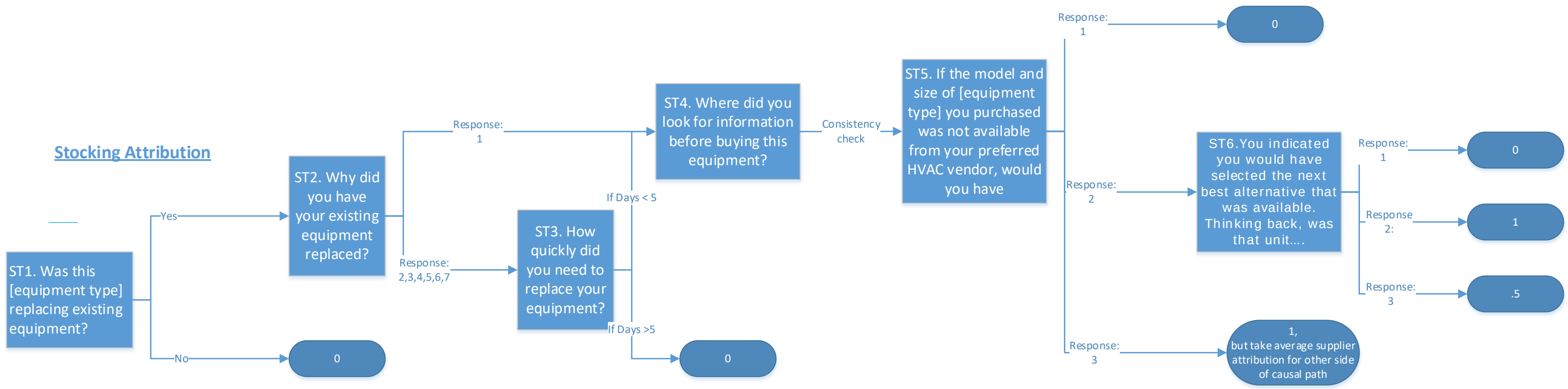


Figure 6-7. Detailed buyer causal pathway scoring: upselling

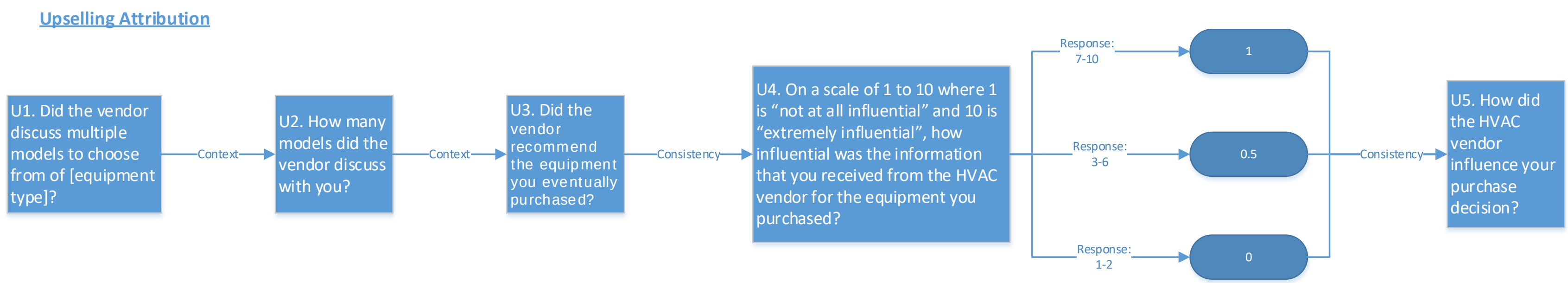


Figure 6-8. Detailed buyer causal pathway scoring: price

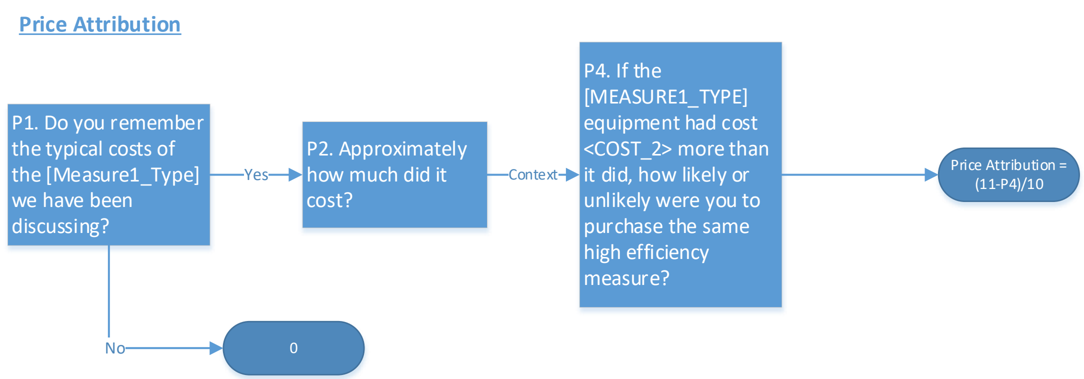
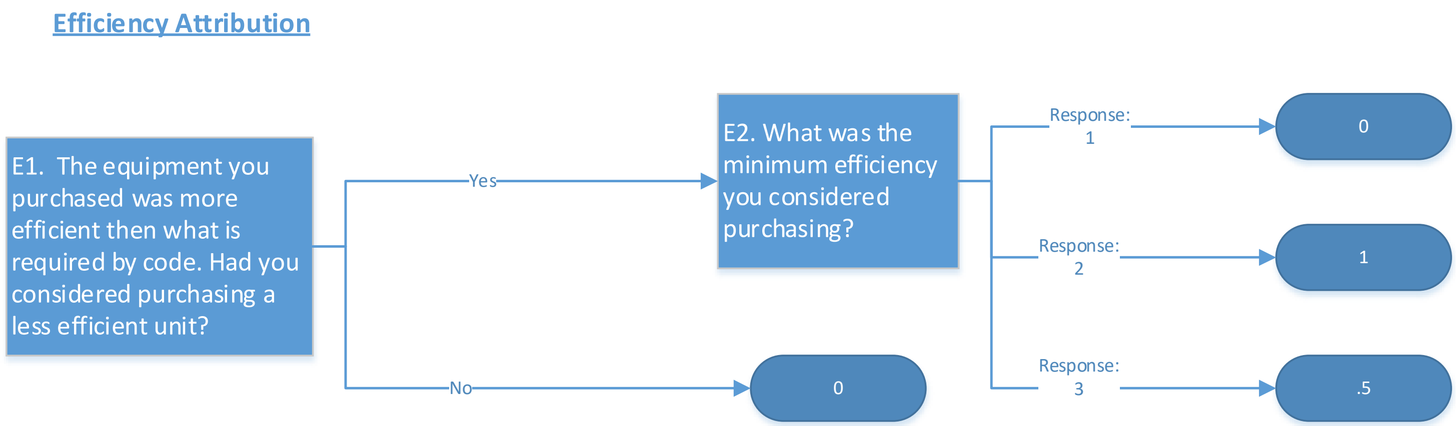


Figure 6-9. Detailed buyer causal pathway scoring: efficiency



Consistency Check

Use answers to G3c, P3, and P5 to check consistency of end user attribution scores.

6.6.1.3.1 Combining attribution scores

We calculate the overall attribution scores for each end user survey completed. The basic approach is to multiply the individual distributor, contractor, and end user component scores to get an overall component score. Then we combine the overall component scores into a total attribution score.

The scores as calculated from the flowcharts above are attribution. We first combine the attributions across the three market levels: distributors, contractors, and end users by multiplying them. This method of combination takes into account the multiple indirect steps the program influence has to go through to eventually affect the end-user decision. If the program fails to influence any of the three market actors, then it would not influence the final decision for that particular causal pathway.

We then compute the overall attribution for each of the three causal pathways to free-ridership by subtracting from 1. We multiply the three-component free-ridership scores together to get overall free-ridership. Then we subtract that from 1 to get overall attribution. We chose this approach because we wanted to give the program the maximum opportunity for attribution, and believe this provides the following benefits:

1. Ensures that attribution is capped at 100%
2. If multiple paths of partial attribution exist, they are fairly represented in the equation
3. If one of three paths is 100% attribution (0% free-ridership), then the total program score gets 100% attribution
4. If one of three paths is 100% free-ridership (0% attribution), 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 buyer attribution scores from survey responses related to an individual purchase, and the distributor attribution scores based on the equipment type the buyer purchased.

Calculation steps:

1. The program tracking data did not allow us to make specific connections from distributors to end users, so we combined the weighted (based on ex ante kWh claims) average distributor score with all end-user scores for each causal pathway.

$$\text{Combined Attribution}_{\text{Stock}} = \text{Distributor}_{.}\text{Attribution}_{\text{Stock}} \times \text{Enduser}_{y}\text{Attribution}_{\text{Stock}}$$

$$\text{Combined Attribution}_{\text{Upsell}} = \text{Distributor}_{.}\text{Attribution}_{\text{Upsell}} \times \text{Enduser}_{y}\text{Attribution}_{\text{Upsell}}$$

$$\text{Combined Attribution}_{\text{Price}} = \text{Distributor}_{.}\text{Attribution}_{\text{Price}} \times \text{Buyer}_{y}\text{Attribution}_{\text{Price}}$$

2. Convert attribution scores to free-ridership

$$\text{Freeridership}_{\text{Stock}} = 1 - \text{Combined Attribution}_{\text{Stock}}$$

$$\text{Freeridership}_{\text{Upsell}} = 1 - \text{Combined Attribution}_{\text{Upsell}}$$

$$\text{Freeridership}_{\text{Price}} = 1 - \text{Combined Attribution}_{\text{Price}}$$

3. Combine free-riderships into overall attribution

$$\text{Combined Program Attribution} = 1 - \left((\text{Freeridership}_{\text{Stock}}) * (\text{Freeridership}_{\text{Upsell}}) * (\text{Freeridership}_{\text{Price}})\right)$$

After we calculated this combined distributor/buyer attribution score for every single buyer, we expanded these estimates to the population. The next section describes how we reviewed all of the buyers for each distributor, as well as equipment type, to create a weighted overall attribution score for the program.

6.6.2 Fan motor replacement

DNV GL used an approach for the fan motor replacement NTG methods similar to the methods used for many residential measures. This approach focuses on assessing three dimensions of free-ridership: timing, quantity, and efficiency. Taken together, these dimensions allow one to estimate the net energy (kWh) attributable by the program, because that energy is a factor of the number of measures installed (quantity), the efficiency of the measures (efficiency), and the duration that the measures are installed (timing).

Fan motors require a modification to the methodology. Fan motors do not have an equipment option with efficiency levels between baseline and program sponsored levels. Therefore, the efficiency dimension does not make sense, and we eliminated the questions from the survey. Similarly, for single-family residential locations, we assumed quantity is also not applicable – HVAC units usually have a single fan motor. It should be noted that in the multi-family context, where we spoke to property managers, quantity is applicable because it represents the number of HVAC units upgraded through the program. This leaves timing, which is still applicable in both the single family and multi-family contexts. Table 19 shows the free-ridership scoring for timing and quantity.

Table 19: Free-ridership elements

Free Ridership Dimension	Question Wording	Answer	Freeridership Score
Timing (Single-Family)	If the program-provided financial incentive had not been offered in 2018, do you think you would have had new fan motors installed sooner, at the same time, later, or never?	At the same time or sooner	100%
		1 to 24 months later	(24 - # of months)/24
		More than 24 months later	0
		Never	0
		Don't know	Average of non-Don't know answers
Timing (Multi-family)	If the program-provided financial incentive had not been offered in 2018, do you think you would have had new fan motors installed sooner, at the same time, later, or never?	At the same time or sooner	100%
		1 to 48 months later	(48 - # of months)/48
		More than 24 months later	0
		Never	0
		Don't know	Average of non-Don't know answers
Quantity (Multi-family)	Program records show that you had new fan motors installed in **[NUMBER]** units. Without the program assistance, would you have installed new fan motors in more units, the same amount, fewer units, or none?	The same number or more	100%
		Fewer	(#installed - #fewer)/(#installed)
		None	0
		Don't know	Average of non-Don't know answers

Using these metrics in combination allows us to more fully assess the amount of savings that could be attributed to fixtures that participants would have installed absent program support. We assigned each respondent a score for each free-ridership metric based on their survey responses and combined those scores into an overall free-ridership score using the algorithm in Equation 1.

Equation 2: Free-ridership Scoring Algorithm

Free Ridership=FRq* FRt* FRe

The surveys included a likelihood question that we used to verify the free-ridership score:

G4. **[UTILITY]**provided financial assistance to have the new fan motors installed in your HVAC systems. Without this program assistance, how likely would you have been to have new fan motors installed in your air conditioning systems at a full price of $300 to $600per unit? Would you say…

	Very unlikely		
	Somewhat unlikely		
	Somewhat likely		
	Very likely		
	Don't know		
	Refused		

Very unlikely received a score of 0, somewhat unlikely 0.33, somewhat likely 0.67, and very likely 1.

Each of the timing and quantity questions was followed up with a verbatim "Why do you say that?" Two experienced NTG researchers inspected these answers and confirmed their consistency with the free-ridership score as calculated in Equation 2. In cases where the verbatim and the calculated score were inconsistent, the researchers overrode the free-ridership score to match what was indicated by the verbatim. In almost all cases, this resulted in an attribution score of 1 because the respondent mentioned the program was free of charge or they couldn't otherwise afford the upgrade without the program.

6.6.3 Duct testing and sealing

The duct sealing measure used the same NTG methodology as the Fan Motors measure.

6.6.4 Water-cooled chiller

The chiller NTG method followed the same approach as the rooftop/ split systems with two exceptions:

1. End-user surveys were not used. Only the distributor causal pathway applies.
2. Stocking attribution was not used.

These changes mean that chiller attribution was based on changes to distributors' upselling practices and how much of the rebate they pass through to their buyers. We also used the market changes questions as a confirmation and crosscheck to the scores resulting from the answers to the causal pathway questions.

6.6.5 HVAC boiler

The NTGR for boiler 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 1 (PAI-1) score that captures what action the respondent would have taken if the program had not been available. This is an enhancement from the prior PAI-1 score due to several issues with the prior PAI-1 identified by the evaluation team.

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 3 (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.

PAI-1 Score

The evaluation team examined several alternative specifications to replace the PAI_1 score and then calculated the resulting NTGR using each alternative by averaging it with the PAI_2 and PAI_3 scores. The Evaluation team's preferred alternative approach uses the participant phone survey question N6 value and assigns a PAI score based on the following responses to this question. Note that this approach is also referred to as PAI-1 alternative 3 = Assign value based on No Program actions (survey question N6):[58]

Question N6 - Now I would like you to think one last time about what action you would have taken if the program had not been available. Which of the following alternatives would you have been most likely to do?

☐ If N6 = 2,4 then NTGR = 1

— 2 Install standard efficiency equipment or whatever required by code

— 4 Done nothing (keep existing equipment as is)

☐ If N6=5 then NTGR = 0

— 5 Done the same thing I would have done as I did through the program

[58] The numbers immediately below each bullet point indicate specific response categories to question N6.

☐ If N6=1, then NTGR = 1.00 minus the % share they would have installed

— 1 Install/Delamped fewer units

☐ If N6=3, then NTGR =0.75

— 3 Installed equipment more efficient than code but less efficient than what you installed through the program

☐ IF N6=6, NTGR=missing (This is a repair and the efficiency of the action ultimately taken is unknown, therefore this response is excluded from the analysis.)

— 6 Repair/rewind or overhaul the existing equipment

☐ If N6=77, the response is reviewed and a judgment made regarding the likely NTGR level, frequently a 0 or 1

— 77 Something else (specify what _____________)

PAI–2 score

The questions that feed into the PAI-2 score are:

5. Did you learn about PROGRAM BEFORE or AFTER you decided to implement the specific MEASURE that was eventually adopted or installed?

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.

PAI–3 score

The questions that feed into the PAI-3 score are:

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

Core NTGR scores

The self-reported core NTGR is the average of the PAI-2 and PAI-3 scores, divided by 10.

6.7 Appendix G: Data collection forms

6.7.1 HVAC rooftop or split systems gross data collection site form

On-Site Data Collection Form - CPUC Group A HVAC Rooftop and Split Systems					
Site ID:		Primary Contact:		Visit Date:	
Location/Business:		Primary Contact Off#:		Visit Time:	
Address 1:		Primary Contact Cell:		Surveyors:	
City:		Email:		Climate Zone:	
Zip:		Alt Contact:		DEER Bldg Type:	
Program Year:		Alt Phone:		DEER Bldg Vintage:	
Facility Operation (include seasonality)					

DNV MEASURE	Data Source	Manufacturer	Model Number	Serial Number	Quantity	Tonnage	Verified On-site?	Tested? (if yes indicate name on Unit)
Claim ID 1	Tracked							
	Evaluated							
Claim ID 2	Tracked							
	Evaluated							
Claim ID 3	Tracked							
	Evaluated							
Claim ID 4	Tracked							
	Evaluated							
Claim ID 5	Tracked							
	Evaluated							
Claim ID 6	Tracked							
	Evaluated							
Claim ID 7	Tracked							
	Evaluated							
Claim ID 8	Tracked							
	Evaluated							
Claim ID 9	Tracked							
	Evaluated							
Claim ID 10	Tracked							
	Evaluated							
Claim ID 11	Tracked							
	Evaluated							
Claim ID 12	Tracked							
	Evaluated							

Site Notes:

General Information		System Information		
Site ID:	0		Is the system **VAV** or **Constant Volume?**	
Measure Number:		>>>>>>> For VAV Only >>>>>>>	Bypass ducts on roof?	YES or NO
Name on Unit:			Bypass ducts in plenum?	YES or NO
Zone Type (normally same as the building's DEER type unless HVAC Unit Zone is significantly different)			Does unit feed into individually-controlled VAV boxes?	YES or NO

Unit Notes:

System Notes:

HVAC Unit Information

Equipment	Package / Split / AC Only / AC w Furnace / Heat Pump				
Duct Location	Roof (external) / Plenum (inside envelope) / Plenum (outside envelope) / Exposed in cond zone				
Fan Control	VFD / Two-speed / One-speed		☐ Fan Control Photo		**Nominal Supply Fan Motor Power:** If HP is available multiply Supply or Evaporator Fan Motor HP by 746 Watts to get Nominal Motor Power. If HP not available take Supply or Evaporator Fan FLA and Rated Voltage and use the following formula: **Nominal Power = FLA * Voltage * 1.72 (Root3)** After taking fan power measurements check measured fan power over Nominal fan power. It should be between .5 and .9, if outside that range please call Nathan to make sure results are reliable.
Manufacturer		Supply/Evap Fan Details	amps	volts	HP
Mfg Year					
MODEL NUMBER (CRITICAL)		Nominal CFM	cfm	☐ Unit Photo	
Serial #		Nominal EER/IEER		☐ Nameplate Photo	
HVAC Unit is properly mounted to curb/roof? Look for signs of air leakage between unit and air plennums, take photo's of any irregularities observed.		☐ Yes	☐ No (Document with Photos!)		

Unit in Fan Only Mode (wet coils)

Moist Fan Coil Observed? YES or NO

Motor Speed (if variable attempt to measure at full flow)		**Full Power (circle)**	**_______% speed**	**_______ hz**
Reading (if coils are dry, run compressor for at least 15 minutes to wet coils, then place unit in desired mode)		ISOLATED FAN Power Draw (*PREFERRED*- can be taken in full cooling mode as long as fan power is isolated)	*Taken when fan power draw cannot be isolated: * Fan Only Power at the Unit Level	*Standby Mode (FAN OFF)
Amps1	A1			
Volts1 Ph-Gnd	V1			
Power Factor1	PF1			
Power 1	W1			
Amps2	A2			
Volts2 Ph-Gnd	V2			
Power Factor2	PF2			
Power 2	W2			
Amps3	A3			
Volts3 Ph-Gnd	V3			
Power Factor3	PF3			
Power 3	W3			
	Total Power			

External Static Pressure

Static Pressure Across Unit (Supply to Return or MA Chamber)		**NSOP - Static Pressure - Return to Ambient (outside air)**	
Test #	☐ **Picture?**	**Test #**	☐ **Picture?**
1	Pa	**1**	Pa
2	Pa	**2**	Pa

Thermostat Information								
Thermostat type (circle)	EMS	-	Mechanical	-	Digital (Non Programmable)	-	Programmable	
Cycling or continuous indoor fan operation?			Cycling	or	Continuous Operation			
Day Grouping	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Holiday
Full operation:	◯	◯	◯	◯	◯	◯	◯	◯
Light operation:	◯	◯	◯	◯	◯	◯	◯	◯
Closed:	◯	◯	◯	◯	◯	◯	◯	◯
Other:	◯	◯	◯	◯	◯	◯	◯	◯

Cooling Setpoint Schedule							
	Temp 1 (F)	Start/End Times	Night setback (F)	Temp 2 (F)	Start/End Times	Temp 3 (F)	Start/End Times
Full Operation							
Light Operation							
Closed							
Other							

TrueFlow Test

As-Found Cooling Stage[1] (circle one)	Low	Low-Med	Med	Med-Hi	Hi

NSOP		Remote return	YES or NO	No. of Returns	

	Grid 1 size: 14 or 20				Grid 2 size: 14 or 20			
	Filter Size:				Filter Size:			
Test #	TFSOP	Flow	Plate Pressure	Time	TFSOP	Flow	Plate Pressure	Time
1								
2								
3								

	Grid 3 size: 14 or 20				Grid 4 size: 14 or 20			
	Filter Size:				Filter Size:			
Test #	TFSOP	Flow	Plate Pressure	Time	TFSOP	Flow	Plate Pressure	Time
1								
2								
3								

	Grid 5 size: 14 or 20				Grid 6 size: 14 or 20			
	Filter Size:				Filter Size:			
Test #	TFSOP	Flow	Plate Pressure	Time	TFSOP	Flow	Plate Pressure	Time
1								
2								
3								

	Grid 7 size: 14 or 20				Grid 8 size: 14 or 20			
	Filter Size:				Filter Size:			
Test #	TFSOP	Flow	Plate Pressure	Time	TFSOP	Flow	Plate Pressure	Time
1								
2								
3								

Equipment
Cardboard
Utility knife
Scissors
Canned air
hot pack
(2) Gel cold packs
Tape measure
Protractor
Rulers
Multimeter
(6) to (8) True Flow kits
DG 700
6-in-1
insulated tools
QEW PPE
Camera
Jumpers
Rope
2' to 3' dowel
snacks
2-3 liters of water/person
Cooler
Frozen water bottles

DEER Building Type	
Description	Code
Manufactured Home	DMO
Muilti-Family	MFM
Single Family	SFM
Assembly	Asm
Education - Community College	ECC
Education - Primary School	EPr
Education - Relocateable Classroom	ERC
Education - Secondary School	ESe
Education – University	EUn
Grocery Store	Gro
Hospital	Hsp
Nursing Home	Nrs
Hotel	Htl
Motel	Mtl
Office – Small	OfS
Office – Large	OfL
Restaurant - Fast Food	RFF
Restaurant - Sit Down	RSD
Retail - Three Story	Rt3
Retail - One Story Large	RtL
Retail – Small	RtS
Storage – Conditioned	SCn
Storage – Unconditioned	SUn
Warehouse – Refrigerated	WRf
Manufacturing - Light Industrial	MLI
Manufacturing – Biotech	MBT

DEER Nres HVAC System Types	
Description	Code
NRes GasPAC	hDXGF
NRes Pkg HP	hPKHP
NRes WLHP	hWLHP
NRes AC w/Elec Heat	hPSZE
NRes Elec Heat Only	hEHNC
NRes Gas Heat Only	hGFNC
NRes PVAV w/HW Reheat	hPVAV
NRes VAV w/HW Reheat	hSVAV
NRes PVAV w/Elec Reheat	hPVVE
NRes VAV w/Elec Reheat	hSVVE

DEER Building Vintage	
Description	Code
Before 1978	v75
1978-1992	v85
1993-2001	v96
2002-2005	v03
2006-2009	v07
2010-2013	v11
After 2013	v14
Built to 2008 Title 24	vN8
Built to 2013 Title 24	vN13
Mobile home before 1976	vM72
Mobile home 1976-1994	vM85
Mobile home 1995-2005	vM00
Mobile home after 2005	vM06

CA Climate Zones	CAZ
1 - Eureka	1
2 - Napa	2
3 - San Francisco	3
4 - San Jose	4
5 - Santa Maria	5
6 - L.A. (LAX/Coastal)	6
7 - San Diego	7
8 - Long Beach	8
9 - L.A. (Civic Center/Inland)	9
10 - Riverside	10
11 - Red Bluff	11
12 - Stockton	12
13 - Fresno	13
14 - Barstow	14
15 - Brawley	15
16 - Bishop	16

Day Types
Full Operation
Light Operation
Closed
Other

6.7.2 HVAC rooftop or split systems net contractor survey

Introduction

Hello, my name is [Interviewer_name] and my company ,______, 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 in [Year]. We are conducting research to learn more about the high efficiency AC market and how certain factors affect installation decisions. Is there someone there available that I could talk to about that?

[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]

[IF NECESSARY, ADD]: "We're not selling anything, this is purely for research purposes to help increase high efficiency purchases in California"

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

[IF ASKED] **If you would like to verify the legitimacy of this research our CPUC manager Jeorge Tagnipes at 415.703.2451. If you have questions about this or the follow up survey, you can reach our study manager by calling Cameron Tuttle at (510) 891-0461 x44271.**

[ITERATE UNTIL YOU FIND SOMEONE KNOWLEDGABLE ABOUT HIGH EFFICIENCY SALES]

Equipment types installed

I want to start by asking about the types of equipment your company installs.

D4. Which of the following types of equipment do you install? [READ EACH EQUIPMENT TYPE. ONLY ASK ABOUT SIZE BINS IF THEY INSTALL THAT EQUIPMENT TYPE. CHECK ALL THAT APPLY]

Equipment Type/Size	<5.5 tons	5.5 to 9.9 tons	10 to 19.9 tons	>20 tons	Skip instructions
Packaged DX units (rooftops)					D5
Split DX units					
Air-source heat pumps					
Water-source heat pumps					
Don't know	98				D6
Refused	99				

D5. What percent of your sales of each type and size would you say are Tier 1 efficiency or better? [READ CHOICES CORRESPNDING TO CHECKS IN D4. FILL IN %s]

Equipment Type/Size	<5.5 tons	5.5 to 9.9 tons	10 to 19.9 tons	>20 tons	Skip instructions
Packaged DX units (rooftops)	%	%	%	%	D7
Split DX units	%	%	%	%	
Air-source heat pumps	%	%	%	%	
Water-source heat pumps	%	%	%	%	
Don't know	998				D6
Refused	999				

D6. Is there someone else at your company I could speak to who might be more knowledgeable about your sales of unitary air-cooled or water-cooled HVAC equipment?

Record name and contact details and ask to speak with them.	1	Thank and terminate with initial respondent. Resume survey at D7 with new respondent.
No one	2	
Don't know	98	Terminate
Refused	99	

Equipment Choices

D7. When you are installing unitary air-cooled or water-cooled HVAC equipment, about what percent of the time is the type of equipment already pre-specified either by the customer, the general contractor, or by someone else outside your firm?

___%			**D8 IF % < 100% ELSE D12**
Don't know	998	D8	
Refused	999	D8	

D8. For projects where there are options as to the types of unitary air-cooled or water-cooled HVAC equipment to be installed, what role does *equipment availability* play in the choices you offer to the customer?

[SPECIFY] ___________________________________		D9
Don't know	998	D9
Refused	999	D9

D9. For projects where there are options as to the types of equipment to be installed, what role does *equipment price* play in the choices you offer to the customer?

[SPECIFY] ___________________________________		D10
Don't know	998	D10
Refused	999	D10

D10. For projects where there are options as to the types of equipment to be installed, what role does *customer type or preference* play in the choices you offer to the customer?

[SPECIFY] ___________________________________		D11
Don't know	998	D11
Refused	999	D11

D11. For projects where there are options for the types of unitary air-cooled or water-cooled HVAC equipment to be installed, about what % of the time … [INSURE FIRST THREE OPTIONS ADD UP TO 100%]

Are you the most significant influence in what equipment type is eventually chosen? _[SPECIFY %__]	D12

Is the customer or general contractor the most significant influence in what equipment type is eventually chosen? [SPECIFY__%]		D12
You and the customer have about equal influence as to what equipment type is eventually chosen? [SPECIFY__%]		D12
[Other scenarios] [PLEASE SPECIFY]		D12
Don't know	998	D12
Refused	999	D12

Stocking

D12. Do you keep any unitary air-cooled or water-cooled HVAC equipment in stock, either in your primary location or at a nearby warehouse?

Yes	1	D12a
No	2	D15
Don't know	998	D15
Refused	999	D15

D12a. Would you say most of your sales are out of your own inventory or out of a distributor's inventory?

Own inventory	1	D13
Distributor inventory	2	D15
Don't know	998	D15
Refused	999	D15

D13. What factors or considerations determine what types of equipment you keep in stock?

[SPECIFY] ____________________________________		D13A
Don't know	998	D14
Refused	999	D14

D13A. [IF NOT ALREADY MENTIONED] How does what your distributors stock impact what you stock?

[SPECIFY] ____________________________________		D14
Don't know	998	D14

Refused	999	D14

D14. How does the equipment you have in stock influence what equipment you recommend to customers?

[SPECIFY] ______________________________ ________		D15
Don't know	998	D15
Refused	999	D15

Distribution Chain

D15. About how many different distributors do you use to get the unitary air-cooled or water-cooled HVAC equipment you install?

[SPECIFY #] ______________________________ ________		D16
Don't know	998	D16
Refused	999	D16

D16. [D15>1] What factors determine when you get your equipment from one distributor vs. another?

[SPECIFY] ______________________________ ________		D17
Don't know	998	D17
Refused	999	D17

D17. How does the equipment your dealer has in stock influence what equipment you recommend to customers?

[SPECIFY] ______________________________ ________		ST4
Don't know	998	ST4
Refused	999	ST4

Stocking Attribution

[IF D12=YES and D12a = OWN INVENTORY → They keep own inventory and that's primarily what they sell out of → Ask ST4 and ST5.
ELSE, they sell primarily out of distributor inventory → Ask ST6 and ST7]

ST4. **For sales of Tier 1 or higher efficiency equipment, what do you do if you do not have the preferred model and size equipment available in your inventory? What percent of the time do you…**
[READ ALL ANSWER OPTIONS; ST4a+ST4b+ST4c should sum to 100%]

ST4a	Delay the project until the preferred model and size is available?	Record %	ST5
ST4b	Select the next best available alternative that is in stock?	Record %	ST5
ST4c	Do Something else (record)	Record %	ST5
	[Don't know]	998	NEXT SECTION
	[Refused]	999	NEXT SECTION

ST5. **When you would install an alternative model and/or size, how often would the alternative be…**
[READ ALL ANSWER OPTIONS; ST5a+ST5b+ST5c+ST5d should sum to 100%]

ST5a	Tier 3 efficiency or better	Record %	NEXT SECTION
ST5b	Tier 2 efficiency	Record %	NEXT SECTION
ST5c	Tier 1 efficiency	Record %	
ST5d	Standard market efficiency	Record %	
	Don't know	998	
	Refused	999	

ST6. **For sales of Tier 1 or higher efficiency equipment, what do you do if your distributor does not have the preferred model and size equipment available in inventory? What percent of the time do you…**
[READ ALL ANSWER OPTIONS; ST6a+ST6b+ST6c+ST6d should sum to 100%]

ST6a	Delay the project until the preferred model and size is available?	Record %	ST7
ST6b	Select the next best available alternative that is in stock at the distributor?	Record %	ST7
ST6c	Attempt to find comparable equipment from a different distributor?	Record %	ST7
ST6d	Do Something else (record)	Record %	ST7
	[Don't know]	998	NEXT SECTION
	[Refused]	999	NEXT SECTION

ST7. **When you would install an alternative model and/or size, how often would the alternative be…**
[READ ALL ANSWER OPTIONS; ST7a+ST7b+ST7c+ST7d should sum to 100%]

ST7a	Tier 3 efficiency or better	Record %	NEXT SECTION
ST7b	Tier 2 efficiency	Record %	NEXT SECTION

ST7c	Tier 1 efficiency	Record %
ST7d	Standard market efficiency	Record %
	Don't know	998
	Refused	999

Upselling

U1. When you make equipment recommendations, how do you determine what to recommend? [PROBE SPECIFICALLY FOR HOW THEY DETERMINE WHAT EFFICIENCY TO RECOMMEND]

[SPECIFY] ___________________________________		U2
Don't know	998	U4
Refused	999	U4

U2. [IF NOT ALREADY COVERED ABOVE] How, if at all, do you factor in input or recommendations from distributors when it comes to recommending specific equipment types and efficiencies?

[SPECIFY] ___________________________________		U3
Don't know	998	U4
Refused	999	U4

U3. [IF NOT ALREADY COVERED ABOVE] How does your or distributor's available stock affect your recommendations?

[SPECIFY] ___________________________________		U4
Don't know	998	U4
Refused	999	U4

U4. On a scale of 1 to 10 where 1 is "not at all influential" and 10 is "extremely influential", how influential are the equipment recommendations made by HVAC distributors on the decision of what ultimately gets installed?

Record Level of Influence (1-10)		PRICE SETTING
Don't know	98	
Refused	99	

Price setting

P1. Remembering that everything you say is confidential - generally speaking, how do you determine the prices you charge to your customers?

[SPECIFY] ___________________________________		U4
Don't know	998	U4

Refused	999	U4

P2. How does the price for Tier 1 or higher efficiency equipment compare to lower efficiency equipment?

[SPECIFY] ____________________________________		U4
Don't know	998	U4
Refused	999	U4

P3. What causes those differences in cost to your customer?

[SPECIFY] ____________________________________		U4
Don't know	998	U4
Refused	999	U4

P4. To what extent does the price you pay to distributors affect what you charge enduser?

[SPECIFY] ____________________________________		U4
Don't know	998	U4
Refused	999	U4

I'd like to explore how a change in price that your distributors charge for equipment would affect what you charge YOUR customers. How, if at all, would the costs to your customers change in the following scenarios?
[COUNTERBALANCE / RANDOMIZE ORDER OF P5 AND P6: HALF SEE "INCREASE" FIRST, HALF SEE "DECREASE" FIRST]

P5a. If your distributor(s) INCREASED PER TON equipment costs by <COST_1>…

No change to the cost charged to their customers	1	P5c
Increase costs by equal amount	2	P5c
Increase costs by equal amount PLUS markup	3	P5b
Decrease costs by equal amount	4	P5c
Decrease costs by more than equal amount	5	P5b
Other [RECORD]	6	P5b
[Don't know]	98	P6a
[Refused]	99	P6a

P5b. How much [MORE/LESS] beyond that per ton difference would you charge customers?

Record Verbatim		P5c
Don't know	98	
Refused	99	

P5c. If your distributor(s) INCREASED PER TON equipment costs by <COST_2>…

No change to the cost charged to their customers	1	P6a
Increase costs by equal amount	2	P6a
Increase costs by equal amount PLUS markup	3	P5d
Decrease costs by equal amount	4	P6a
Decrease costs by more than equal amount	5	P5d
Other [RECORD]	6	P5d
[Don't know]	98	F3
[Refused]	99	F3

P5d. How much [MORE/LESS] beyond that per ton difference would you charge customers?

Record Verbatim		P6a
Don't know	98	
Refused	99	

P6a. If your distributor(s) DECREASED PER TON equipment costs by <COST_1>…

No change to the cost charged to their customers	1	P6c
Increase costs by equal amount	2	P6c
Increase costs by equal amount PLUS markup	3	P6b
Decrease costs by equal amount	4	P6c
Decrease costs by more than equal amount	5	P6b
Other [RECORD]	6	P6b
[Don't know]	98	F3
[Refused]	99	F3

P6b. How much [MORE/LESS] beyond that per ton difference would you charge customers?

Record Verbatim		P6c
Don't know	98	
Refused	99	

P6c. If your distributors(s) DECREASED PER TON equipment costs by <COST_2>…

No change to the cost charged to their customers	1	F3
Increase costs by equal amount	2	F3
Increase costs by equal amount PLUS markup	3	P6d
Decrease costs by equal amount	4	F3

Decrease costs by more than equal amount	5	P6d
Other [RECORD]	6	P6d
[Don't know]	98	F3
[Refused]	99	F3

P6d. How much [MORE/LESS] beyond that per ton difference would you charge customers?

Record Verbatim	
Don't know	98
Refused	99

Firmographics

F3. **About how many full-time employees work for your company?**

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.

6.7.3 HVAC rooftop or split systems net buyer survey

Introduction

Hello, my name is [Interviewer_name] and my company,______, is calling on behalf of the California Public Utilities Commission and utility service provider, [Utility].

Our records show that your company installed high efficiency air conditioning equipment around {ClaimYearQuarter]. 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]

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 study manager is Jeorge Tagnipes at 415.703.2451. If you have questions about this or the follow up survey you can reach our study manager by calling Cameron Tuttle at (510) 891-0461 x44271.

Screener questions

S1. Are you familiar with the company's decision to install rooftop or split HVAC systems sometime around [ClaimYearQuarter]?

[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 to G1
[Don't know]	98	

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 PROGRAMMER: START LOOPING HERE

G1. Our records show that around [ClaimYearQuarter], your company installed [Measure1_Type] that were installed at [Measure1_SiteAddress1], [Measure1_SiteCity1].

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

[Verbatim]	1
[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

[Verbatim]	1
[No]	2
[Don't know]	98
[Refused]	99

G3a. When did you first start considering installing high efficiency rooftop or split HVAC equipment?

[Month]		G3b
[Year]		G3b
[Don't know]	98	G3c
[Refused]	99	G3c

G3b. What caused you to start thinking of high efficiency rooftop or split HVAC equipment at that time?

[PROBE: Was there any particular event or situation that made you realize it was time to look for high efficiency rooftop or split HVAC equipment?]

[Verbatim]	
[Don't know]	98
[Refused]	99

G3c. When you purchased the rooftop or split HVAC equipment, 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 G5
[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]		Go to G5
[Don't know]	98	
[Refused]	99	

G5. What challenges did you encounter when selecting the specific rooftop or split HVAC equipment that you decided to install?

[Verbatim]		Go to G6
[Don't know]	98	Go to G7
[Refused]	99	

G6. What, if anything, helped you overcome those challenges?

[Verbatim]		Go to G7
[Don't know]	98	
[Refused]	99	

For these next set of questions, I would like you to think specifically about the [Measure1_Type] that was/were installed at around [ClaimYearQuarter].

G7. Did you purchase this measure directly from an equipment distributor or through an installation contractor?

[Purchased directly from distributor]	1	G8
[Through installation contractor]	2	
[Don't know]	98	
[Refused]	99	

G8. Why did you choose this vendor? [CHECK ALL THAT APPLY]

[Recommendation of Utility or utility representative]	1	ST1
[Worked with them before]	2	
[Wanted High efficiency and we know they do that]	3	
[Internet search]	4	
[Word of mouth]	5	
[Other (Record)]	6	
[Don't know]	98	
[Refused]	99	

Influence of stock

ST1. Did all of the [Measure1_Type] replace 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 replace your existing equipment 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 the existing equipment?

[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 >1 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].

U1. Did the vendor discuss multiple models of [Measure1_Type] to choose from at your sites?

[Yes]	1	U2
[At some of these sites]	2	U1.1
[No]	3	U3
[Don't know]	98	
[Refused]	99	

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	P4

[COUNTERBALANCE/ RANDOMIZE ORDER OF P3 AND P5 SO HALF SEE LOWER PRICE FIRST AND HALF SEE HIGHER PRICE FIRST. THE SCORE WE REALLY CARE ABOUT IS P4, WHICH IS ALWAYS AS CLOSE TO THE ACTUAL REBATE AS POSSIBLE.]

I'm going to ask you some questions about what you would have purchased under a few different price scenarios. For each of these, I'd like you to answer with a 1 to 10 scale where 1 means "definitely would NOT have purchased the same high efficiency measure" and 10 means "definitely WOULD have purchased the same high efficiency measure."

P3. If the [MEASURE1_TYPE] equipment had cost <COST_1> more than it did, how likely or unlikely were you to purchase the same high efficiency measure?

[1 Definitely would NOT have purchased the same high efficiency measure]	1	P4
[2]	2	P4
[3]	3	P4
[4]	4	P4
[5]	5	P4
[6]	6	P4
[7]	7	P4
[8]	8	P4
[9]	9	P4
[10 Definitely WOULD have purchased the same high efficiency measure]	10	P4
[Don't know]	98	E1
[Refused]	99	E1

P4. If the [MEASURE1_TYPE] equipment had cost <COST_2> more than it did, how likely or unlikely were you to purchase the same high efficiency measure?

[1 Definitely would NOT have purchased the same high efficiency measure]	1	P5
[2]	2	P5
[3]	3	P5
[4]	4	P5
[5]	5	P5
[6]	6	P5
[7]	7	P5
[8]	8	P5
[9]	9	P5

[10 Definitely WOULD have purchased the same high efficiency measure]	10	P5
[Don't know]	98	E1
[Refused]	99	E1

P5. If the [MEASURE1_TYPE] equipment had cost <COST_3> more than it did, how likely or unlikely were you to purchase the same high efficiency measure?

[1 Definitely would NOT have purchased the same high efficiency measure]	1	P6
[2]	2	P6
[3]	3	P6
[4]	4	P6
[5]	5	P6
[6]	6	P6
[7]	7	P6
[8]	8	P6
[9]	9	P6
[10 Definitely WOULD have purchased the same high efficiency measure]	10	P6
[Don't know]	98	E1
[Refused]	99	E1

P6. **Why did you make the choices you did?**

[Record Verbatim]		E1
[Don't know]	98	
[Refused]	99	

Influence of efficiency

E1. The [Measure1_Type] you purchased at these sites were more efficient then what is required by the building energy 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	
[Refused]	99	

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? [READ OPTIONS]

The same efficiency as what you purchased	1	E3
Standard efficiency on the market at time	2	
Between standard efficiency and what you purchased	3	
[Don't know]	98	F1
[Refused]	99	

E3. Why is that the minimum efficiency you would have considered purchasing?

[Record verbatim]		F1
[Don't know]	98	
[Refused]	99	

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.

6.7.4 HVAC rooftop or split systems net distributor survey

Hello <Distributor Name>, this is <Interviewer name>. The reason for my call is I'm conducting a state-wide evaluation of the utility-sponsored Commercial Upstream Distributor Rebate Program. I'd like to ask you about your company's past experience with this program. This call is sponsored by the CA Public Utilities Commission and 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 PARTCIPATE]	1	SC1
[DOES NOT AGREE TO PARTCIPATE]	2	Thank & Terminate

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

[IF ASKED] If you would like to verify the legitimacy of this research our CPUC manager Jeorge Tagnipes at 415.703.2451. If you have questions about this or the follow up survey, you can reach our study manager by calling Cameron Tuttle at (415) 706 - 4580.

Screener questions

SC1. The California Investor Owned Utilities PG&E, SCE, SCG, 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	
Don't know	98	S1a
Refused	99	

SC1a. Who at your company could I speak with that would be familiar with this program?

Record name and contact details and ask to speak with them.	1	G1
No one	2	
Don't know	98	Terminate
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 business model? Is your company a… [READ LIST; CHOOSE ALL THAT APPLY]

An Independent HVAC equipment distributor	1	G2
A manufacturer-owned or franchise distributor	2	
An Independent manufacturers' representative	3	

[Other (Self-report]	50/Record	

G2. Does the company also offer HVAC installations?

Yes	1	G3
No	2	G4
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	

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

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

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

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]*		D4
Don't know	98	
Refused	99	

Equipment types distributed

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

D4. Which of the following types of equipment do you sell? [READ CHOICES. CHECK ALL THAT APPLY]

Packaged DX units (rooftops)	1	D5a
Split DX units	2	
Air-source heat pumps	3	
Water-source heat pumps	4	
Don't know	98	D5b
Refused	99	

D5a. What percentage of those equipment types do you sell to installation contractors, and what percentage do you sell directly to endusers? Your best guess is fine.

Technology	% to contractors	% to end users	
Packaged DX units (rooftops)			D6
Split DX units			
Air-source heat pumps			
Water-source heat pumps			
Don't know	998	998	D6
Refused	999	999	

D5b. Is there someone else at your company I could speak to who might be more knowledgeable about your sales of unitary air-cooled or water-cooled HVAC equipment?

Record name and contact details and ask to speak with them.	1	Thank and terminate
No one	2	
Don't know	98	Terminate
Refused	99	

Market effects

Sales

ME1. What are the strongest drivers for high-efficiency sales?
[PROMPT AS NEEDED, RECORD ALL THAT APPLY]

Sales engineers upselling practices	1	ME2
Available stock / delivery time	2	
ROI or payback calculations	3	
Engineer / Architect preferences	4	
Manufacturer rebates / promotions	5	

Utility rebates	6	
Non-rebate program activities (e.g. quarterly sales meeting, letter of commitment, market reports)	7	
Other (Record)	50	
Don't know	98	
Refused	99	

ME2. What are the biggest barriers when it comes to selling high-efficiency equipment? [PROMPT AS NEEDED, RECORD ALL THAT APPLY]

Increased cost of HE models	1	ME3
Increased size/weight of HE models	2	
Increased delivery time of HE models	3	
Market demand or turnover rate	4	
Sales marketing / educating buyers	5	
Ability to keep repairing old equipment	6	
Other (Record)	50	
Don't know	98	
Refused	99	

ME3. Which of the following non-rebate program activities has your company participated in or received from the program?
[PROMPT AS NEEDED, RECORD ALL THAT APPLY]

Letter of commitment to sell high efficiency equipment	1	ME3a
Regular meetings with program staff and your sales engineers	2	ME3a
Quarterly program market share report	3	ME3a
Other [SPECIFY]	4	ME3a
Don't know	98	ME3a
Refused	99	ME3a

ME3a. How, if at all, do the program rebates and non-rebate activities help you overcome the barriers to selling efficient models?

[Record verbatim]		ME4
Don't know	98	ME4
Refused	99	ME4

ME4. What effects, if any, do the <PROGRAM> rebates and non-rebate activities have on your company's *policies* regarding stocking of high efficiency equipment?

[Record verbatim]		ME5
Don't know	98	ME5
Refused	99	ME5

ME5. What effects, if any, do the <PROGRAM> rebates and non-rebate activities have on your company's *policies* regarding upselling of high efficiency equipment?

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

Stocking

Next, I would like to ask about your organization's stocking practices.

S1. Does your company maintain a stock of high-efficiency [equipment type]?
[ASK FOR EACH OF THE TYPES INDICATED IN D4.
RECORD 1 FOR YES, 2 FOR NO, 98 FOR DK, 99 FOR REFUSED]

Equipment Type/Size	<5.5 tons	5.5 to 9.9 tons	10 to 19.9 tons	>20 tons
Packaged DX units (rooftops)				
Split DX units				
Air-source heat pumps				
Water-source heat pumps				
Don't know	98			
Refused	99			

[IF ALL ANSWERS = NO, SKIP TO U1]

S2. How are stocking decisions made for high-efficiency equipment?

[Record verbatim]		S3
Don't know	98	S3
Refused	99	U1

S3. How, if at all, do factors like equipment size and type affect your stocking decisions?

[Record verbatim]		S4
Don't know	98	
Refused	99	U1

S4. Are the inventories for high-efficiency equipment relatively constant, or are there seasonal fluctuations? [SELECT ALL THAT APPLY]

Constant	1	S5
Seasonal variation	2	
[Varies by equipment type (record)]	3	
[Made to order]	4	
[Don’t know]	98	
[Refused]	99	

S5. 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	S6
Market demand or turns rate	2	S6
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	

S6. Does the utility rebate influence the selection of high-efficiency HVAC equipment the company keeps in stock?

Yes	1	S7
No	2	
Don’t know	98	S8
Refused	99	

S7. Why do you say that?

[Record verbatim]		S8
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]

S8. For all [equipment type X] that you keep in stock, approximately what percent are high efficiency? [REPEAT FOR EACH [EQUIPMENT TYPE] [SIZE] PAIR]

[IF NECESSARY: High-efficiency is defined as Tier 1 and above.]

Equipment Type/Size	<5.5 tons	5.5 to 9.9 tons	10 to 19.9 tons	>20 tons	S9
Packaged DX units (rooftops)					
Split DX units					
Air-source heat pumps					
Water-source heat pumps					
Don't know	98				
Refused	99				

[IF ALL 0%, DK/R, SKIP TO U1]

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

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

S9. If the program weren't available what percent of high efficiency [equipment type] [size] would you stock?

Equipment Type/Size	<5.5 tons	5.5 to 9.9 tons	10 to 19.9 tons	>20 tons	U1
Packaged DX units (rooftops)					
Split DX units					
Air-source heat pumps					
Water-source heat pumps					
Don't know	98				
Refused	99				

Upselling

Now I want to talk about upselling.

U1. Please describe how you typically promote and sell 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 %]		U3
Don't know	98	
Refused	99	

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

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

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

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

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

Yes	1	U4
No	2	U4
Don't know	98	U5
Refused	99	

U4. Why do you say that?

[Record verbatim]		U5
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]

U5. In situations where you are selling [equipment type] [size], about what percent of the time do you recommend the high-efficiency equipment?

[IF NECESSARY: High-efficiency is defined as Tier 1 and above.]

Equipment Type/Size	<5.5 tons	5.5 to 9.9 tons	10 to 19.9 tons	>20 tons	U6
Packaged DX units (rooftops)					
Split DX units					
Air-source heat pumps					
Water-source heat pumps					
Don't know	98				
Refused	99				

[IF ALL 0%, DK/R, SKIP TO P1]

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

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

U6. For [equipment type] [size], what percent of the time would you recommend the high-efficiency equipment if [Program] did not exist? *[Probe: and what we mean by "without the program" is supposing the program ran out of funding next month]*

[IF NECESSARY: High-efficiency is defined as Tier 1 and above.]

Equipment Type/Size	<5.5 tons	5.5 to 9.9 tons	10 to 19.9 tons	>20 tons	P1
Packaged DX units (rooftops)					
Split DX units					
Air-source heat pumps					
Water-source heat pumps					
Don't know	98				

Refused	99				

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	P3a
No	2	P3a
Don't know	98	Next Section
Refused	99	

P3a. Why do you say that?

[Record verbatim]		P4
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?

Equipment Type/Size	<5.5 tons	5.5 to 9.9 tons	10 to 19.9 tons	>20 tons	Next Section
Packaged DX units (rooftops)					
Split DX units					

Air-source heat pumps					
Water-source heat pumps					
Don't know	98				
Refused	99				

Program influence on sales

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

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

[IF WE HAVE TOTAL REBATES CLAIMED BY DISTRIBUTOR FROM TRACKING DATA, SKIP TO ME10]

ME6. In 2018, about what percentage of [equipment type] [size] that you sold in California would you estimate were high-efficiency, which is defined as Tier 1 and above? [Repeat for all combinations in the table below they have indicated they offer.]

Equipment Type/Size	<5.5 tons	5.5 to 11.2 tons	11.2 to 20 tons	>20 tons	ME7
Packaged DX units (rooftops)					
Split DX units					
Air-source heat pumps					
Water-source heat pumps					
Don't know	98				
Refused	99				

[IF ALL 0 or DK/R, SKIP TO STOCKING]

ME7. Without the program rebates and non-rebate activities, what percentage of your California sales would have been high-efficiency?

[Repeat for all combinations in the table below they have indicated they offer.]

[IF NECESSARY: High efficiency means tier 1 or above]

Equipment Type/Size	<5.5 tons	5.5 to 9.9 tons	10 to 19.9 tons	>20 tons	

					ME8
Packaged DX units (rooftops)					
Split DX units					
Air-source heat pumps					
Water-source heat pumps					
Don't know	98				
Refused	99				

ME8. What percent of all the high-efficiency [equipment type] [size] had a rebate claimed? **[Repeat for all combinations in the table below they have indicated they offer.]**

Equipment Type/Size	<5.5 tons	5.5 to 9.9 tons	10 to 19.9 tons	>20 tons	ME9
Packaged DX units (rooftops)					
Split DX units					
Air-source heat pumps					
Water-source heat pumps					
Don't know	98				
Refused	99				

ME9. [IF ANY ME6-ME8 >0] Why doesn't your company submit rebates for all the high-efficiency equipment types? [Reflect all that apply]

Not qualified	1	STOCKING
Missed opportunity	2	
Paid through down/mid-stream rebate	3	
Not in IOU service territory	4	
Other reason [Record Verbatim]	50	

Don’t know	98	
Refused	99	

[IF WE HAVE TOTAL REBATES CLAIMED BY DISTRIBUTOR FROM TRACKING DATA, WE WILL ASK ME10 INSTEAD OF ME6 TO ME9]

ME10. I’m going to go through the number of rebates you claimed for various equipment types and sizes. I’m assuming each one represents the sale of a high efficiency unit. I’d like you to estimate how many of those high efficiency sales would have still occurred without the program?

[IF NECESSARY: High efficiency means tier 1 and above]

# SOLD **Equipment Type/Size**	<5.5 tons	5.5 to 9.9 tons	10 to 19.9 tons	>20 tons
Packaged DX units (rooftops)	PIPE IN	PIPE IN	PIPE IN	PIPE IN
Split DX units	PIPE IN	PIPE IN	PIPE IN	PIPE IN
Air-source heat pumps	PIPE IN	PIPE IN	PIPE IN	PIPE IN
Water-source heat pumps	PIPE IN	PIPE IN	PIPE IN	PIPE IN

# WOULD HAVE BEEN SOLD **Equipment Type/Size**	<5.5 tons	5.5 to 9.9 tons	10 to 19.9 tons	>20 tons	STOCKING
Packaged DX units (rooftops)					
Split DX units					
Air-source heat pumps					
Water-source heat pumps					
Don’t know	98				
Refused	99				

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.

6.7.5 Fan motor replacement gross data collection site form

Site ID:	
Occupant Name	
Address 1:	
Address 2:	
City & Zip:	
Occupant Phone:	
Mo/Yr of Fan Motor Replacement Completion:	
Any maintenance or service calls since installation? If yes, describe problem and solution. Use back if necessary.	
On-site equipment	**Furnace only** **AC only** **Both**
Number of Bedrooms/Bathrooms:	
Number of Year Round Occupants:	
Is Home All-Electric?	
Inspector(s):	
Site Visit Date & Time:	
Dwelling Type:	
Year Built:	
Fan and System Replaced Together?	
Condition of Old Fan? (Describe)	
Stories:	

Project scope and site notes:

SITE CHECKLIST

Photos		
Furnace nameplate	☐	
Evaporative coil nameplate	☐	
Condensing unit nameplate	☐	
Fan motor nameplate	☐	
TrueFlow grid(s) and pitot placement	☐	
Unusual observations, situations, etc.	☐	
Thermostat	☐	
Thermostat nameplate, if possible	☐	
Scope described	☐	
Incentive (if issued)		
Incentive paid	☐	
IVF signed	☐	
Gift card photographed	☐	
Test Results		
Airflow	☐	
Fan Spot Power	☐	
AHU Watt meter retrieved (if installed)	☐	
Thermostat reset to as-found state	☐	
System operational on departure	☐	

THERMOSTAT INFO		
T-STAT TYPE	Smart Programmable Mechanical	
If not smart or programmable, was a smart or programmable t-stat replaced?	Yes No	
Thermostat Mfg/Model		
Current Cooling Setpoint, °F (record before changing)		
Current Heating Setpoint, °F (record before changing)		
Weekday Program		
Occ Hours of Operation, e.g. "0800-1800"		
Occupied Heating, °F		
Occupied Cooling, °F		
Unocc Hours of Operation, e.g. "1800-0800"		
Unoccupied Heating, °F		
Unoccupied Cooling, °F		
Weekend Program		
Occ Hours of Operation, e.g. "0800-1800"		
Occupied Heating, °F		
Occupied Cooling, °F		
Unocc Hours of Operation, e.g. "1800-0800"		
Unoccupied Heating, °F		
Unoccupied Cooling, °F		
System Nameplate Info		
Location of furnace/fan coil	Attic Garage Cond. Space Other (describe)	
Type of unit	Package Split Package Heat Pump Split Heat Pump w/Elec supp Other (describe)	
Supply fan type	Single-speed two-speed variable-speed	
System cooling capacity		tons kBtuh
System heating capacity		kBtuh
Heating fuel type	Gas Propane Electric Other	
Condenser (outdoor) mfg/model (take nameplate photo)		
Condenser serial #		
Condenser mfg date		
Heating system mfg/model (take nameplate photo)		
Heating serial number		
Heating mfg date		
Fan motor mfg/model (take nameplate photo)		
Fan motor serial number		
Fan motor mfg date		
Evaporative coil mfg/model (take nameplate photo)		
Evap coil serial #		
Evap coil mfg date		

TrueFlow Test

As-Found Cooling Stage[1] (circle one) Low Low-Med Med Med-Hi Hi									
		Grid 1 size: 14 20				Grid 2 size: 14 20			
		Filter Size:				Filter Size:			
NSOP	Test #	TFSOP	Flow	Plate Pressure	Time	TFSOP	Flow	Plate Pressure	Time
	1								
	2								
	3								
Remote return		YES / NO		No. of Returns					

[1]For single-speed systems, circle "low"

Static Pressure Test (Cooling Mode)

Static Pressure Across Unit (Supply Plenum to Return Plenum)				Static Pressure Across Fan (if taps available)		
Test #	ESP (Pa)	Time		Test #	ESP (Pa)	Time
1				1		
2				2		

Furnace/AHU[1] Spot Power Measurements

Unit in Cooling Mode (wet coil)		Value	Time	Device (circle one)
Fan Speed as-found	Unit Power			Amprobe WattsUp
	Unit Power Factor			
	Fan Power[2]			
	Fan Power Factor			

[1]If AHU power is hard-wired, use Amprobe across fan. If AHU is plugged into an outlet, use WattsUp.

[2]If possible, also measure power across fan only

6.7.6 Fan motor replacement/duct testing and sealing net resident survey

CPUC HVAC Fan Motor End User Survey (with possible duct sealing)

ID #	
Name	

Address	
Phone #	

We are conducting research to learn more about your household's decision have a new fan motor installed in your air conditioning system, possibly with a package of other HVAC improvements, in 2018. This installation was done with help from a **[UTILITY]** energy efficiency program.
[IF NEEDED] All survey information collected will be treated confidentially.
S1.1 Do you own or lease your home?

	Own	1	S2
	Rent/lease	2	S1.2
	Don't know	98	**THANK AND TERMINATE**
	Refused	99	

S1.2 Does your property manager or landlord make the decisions about modifying heating and cooling equipment?

	Yes	1	S1.3
	No, I make those decisions	2	S2
	Don't know	98	**THANK AND TERMINATE**
	Refused	99	

S1.3 Record name and phone number of property manager or landlord, then terminate:
S2. Are you familiar with your household's decision to purchase and have a new fan motor installed in your HVAC system in 2018? Again, it may have been installed along with a package of other energy efficiency improvements.

	Yes	1	G3
	No	2	**S3, THEN END SURVEY**
	Don't know	98	
	Refused	99	

S3. Who do you suggest I speak with that would be familiar with this purchase decision?
TERMINATE SURVEY

G3. Why did you decide to have the fan motor installed when you did?

G4. **[UTILITY]** provided financial assistance to have the new fan motor installed in your HVAC system. Without this program assistance, how likely would you have been to have a new fan motor installed in your air conditioning system at a full price of $300 to $600? Would you say…

	Very unlikely	1	G4.3
	Somewhat unlikely	2	
	Somewhat likely	3	
	Very likely	4	
	Don't know	98	G5
	Refused	99	

G4.3 Why do you say that?

G5. If the program-provided financial incentive had not been offered in 2018, do you think you would have had a new fan motor installed sooner, at the same time, later, or never?

	Sooner	1	G5.1
	At the same time	2	G5.3
	Later	3	G5.1
	Never	4	G5.3
	Don't know	98	G6
	Refused	99	

G5.1 How much [SOONER/LATER]? **GO TO Q5.3**

G5.3 Why do you say that?

G6. Is there anything else you would like to share regarding your experience with this program?

IF RESPONDENT COMPLETED DUCT SEALING IN 2018, PROCEED TO NEXT PAGE. IF NOT, 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.

CPUC HVAC Duct Sealing End User Survey

ID #	
Name	
Address	
Phone #	

We are conducting research to learn more about your household's decision have duct sealing performed, possibly with a package of other HVAC improvements, in 2018. This was done with help from a **[UTILITY]** energy efficiency program.

[IF NEEDED] All survey information collected will be treated confidentially.

S1.1 Do you own or lease your home?

	Own	1	S2
	Rent/lease	2	S1.2
	Don't know	98	**THANK AND TERMINATE**
	Refused	99	

S1.2 Does your property manager or landlord make the decisions about modifying heating and cooling equipment, or the ventilation of your home?

	Yes	1	S1.3
	No, I make those decisions	2	S2
	Don't know	98	**THANK AND TERMINATE**

	Refused	99	

S1.3 Record name and phone number of property manager or landlord, then terminate:

S2. Are you familiar with your household's decision to have duct sealing performed in your home in 2018? Again, it may have been performed along with a package of other energy efficiency improvements.

	Yes	1	G3
	No	2	**S3, THEN END SURVEY**
	Don't know	98	
	Refused	99	

S3. Who do you suggest I speak with that would be familiar with this purchase decision?
TERMINATE SURVEY

G3. Why did you decide to have the duct sealing performed when you did?

G4. **[UTILITY]** provided financial incentives to have the duct sealing performed in your home in 2018. Without this program assistance, how likely would you have been to have duct sealing performed in your home at a full price of around $___? Would you say…

	Very unlikely	1	G4.3
	Somewhat unlikely	2	
	Somewhat likely	3	
	Very likely	4	
	Don't know	98	G5
	Refused	99	

G4.3 Why do you say that?

G5. If the program-provided financial incentive had not been offered in 2018, do you think you would have done the duct sealing sooner, at the same time, later, or never?

	Sooner	1	G5.1
	At the same time	2	G5.3
	Later	3	G5.1
	Never	4	G5.3
	Don't know	98	G6
	Refused	99	

G5.1 How much [SOONER/LATER]? **GO TO Q5.3**

G5.3 Why do you say that?

G6. Is there anything else you would like to share regarding your experience with this program?

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.

6.7.7 Fan motor replacement net property manager survey

ID #	
Name	
Address	
Phone #	

We are conducting research to learn more about your decision have new fan motors installed, possibly with a package of other HVAC improvements, in the air conditioning systems of **[NUMBER]** units you manage in 2018. These installations were done with help from a **[UTILITY]** energy efficiency program.

[IF NEEDED] All survey information collected will be treated confidentially.

S2. Are you familiar with your decision to purchase and have a new fan motors installed in the HVAC system of **[NUMBER]** of your units in 2018? Again, it they may have been installed along with a package of other energy efficiency improvements.

	Yes	1	G3
	No	2	**S3, THEN END SURVEY**
	Don't know	98	
	Refused	99	

S3. Who do you suggest I speak with that would be familiar with this purchase decision?
TERMINATE SURVEY

G3. Why did you decide to have the fan motors installed when you did?

G4. **[UTILITY]** provided financial assistance to have the new fan motors installed in your HVAC systems. Without this program assistance, how likely would you have been to have new fan motors installed in your air conditioning systems at a full price of $300 to $600 per unit? Would you say…

	Very unlikely	1	G4.3
	Somewhat unlikely	2	
	Somewhat likely	3	
	Very likely	4	
	Don't know	98	G5
	Refused	99	

G4.1. Program records show that you had new fan motors installed in **[NUMBER]** units. Without the program assistance, would you have installed new fan motors in more units, the same amount, fewer units, or none?

	More	1	G4.2
	The same amount	2	G4.3
	Fewer	3	G4.2
	None	4	G4.3
	Don't know	98	G5
	Refused	99	

G4.2 In how many units would you have installed fan motors if the cost to have them replaced was the full price?

G4.3 Why do you say that?

G5. If the program-provided financial incentive had not been offered in 2018, do you think you would have had new fan motors installed sooner, at the same time, later, or never?

	Sooner	1	G5.1
	At the same time	2	G5.3
	Later	3	G5.1
	Never	4	G5.3
	Don't know	98	G6
	Refused	99	

G5.1 How much [SOONER/LATER]? **GO TO Q5.3**

G5.3 Why do you say that?

G6. Is there anything else you would like to share regarding your experience with this program?

IF RESPONDENT COMPLETED DUCT SEALING IN 2018, PROCEED TO NEXT PAGE. IF NOT, 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.

6.7.8 Duct testing and sealing net property manager survey

ID #	
Name	
Address	
Phone #	

We are conducting research to learn more about your decision have duct sealing performed, possibly with a package of other HVAC improvements, in **[NUMBER]** of units in 2018. This was done with help from a **[UTILITY]** energy efficiency program.

[IF NEEDED] All survey information collected will be treated confidentially.

S2. Are you familiar with your decision to have duct sealing improvements performed in **[NUMBER]** of your units in 2018? Again, it may have been performed along with a package of other energy efficiency improvements.

	Yes	1	G3
	No	2	**S3, THEN END SURVEY**

	Don't know	98	
	Refused	99	

S3. Who do you suggest I speak with that would be familiar with this purchase decision?
TERMINATE SURVEY

G3. Why did you decide to have the duct sealing performed at this time?

G4. **[UTILITY]** provided financial incentives to have the duct sealing performed in the units you own or manage in 2018. Without this program assistance, how likely would you have been to have this duct sealing performed at a full price of around $___?[HS1] Would you say…

	Very unlikely	1	G4.3
	Somewhat unlikely	2	
	Somewhat likely	3	
	Very likely	4	
	Don't know	98	G5
	Refused	99	

G4.1. Program records show that you had duct sealing performed in **[NUMBER]** units. Without the program assistance, would you have had duct sealing performed in more units, the same number, fewer, or none?

	More	1	G4.2
	Same number	2	G4.3
	Fewer	3	G4.2
	None	4	G4.3
	Don't know	98	G5
	Refused	99	

G4.2 How many units would you have done if the cost to complete the work was the full price?

G4.3 Why do you say that?

G5. If the program-provided financial incentive had not been offered in 2018, do you think you would have done the duct sealing sooner, at the same time, later, or never?

	Sooner	1	G5.1
	At the same time	2	G5.3
	Later	3	G5.1
	Never	4	G5.3
	Don't know	98	G6
	Refused	99	

G5.1 How much [SOONER/LATER]? **GO TO Q5.3**

G5.3 Why do you say that?

G6. Is there anything else you would like to share regarding your experience with this program?

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.

6.7.9 Water-cooled chiller gross data collection site form

General Information	Chiller #1	Chiller #2	Chiller #3	Chiller #4
Site ID				
Claim ID				
Measure Code				
Project Name				
Location Business Name				
Location Address				
Location City, State, Zip				
Interview Date				
Interview Time				
Interviewer				
Primary Contact Name				
Primary Contact Role/Title				
Primary Contact Email				
Primary Contact Phone #1				
Primary Contact Phone #2				
Building Type				
Square Footage Served By CP				
Industry				
No. Buildings On Premises				
No. of Conditioned Floors Served by CP				
Project baseline				

Installed Chiller Data	Chiller #1	Chiller #2	Chiller #3	Chiller #4
Chiller Mfg				
Chiller Model #				
Chiller Serial #				
Number of chillers in the CHW (Chilled Water) loop				
Chiller staging sequence				
Design chilled water supply temp. (°F)				
Chiller Compressor type				
Number of compressors				
Chiller Cooling Type				
Water-side economizer type				
Constant speed/variable speed				
Minimum chiller unloading ratio				
Chiller rated capacity (ton)				
Chiller rated power input (kW)				
CHW supply temperature reset implemented? (Y/N)				
CHW default supply temp. (°F)				
Outside Air Temp, dry bulb (OATDB) for CHW default temp				
CHW low supply temp. (°F)				
OATDB for CHW low supply temp				
CHW return temp. (°F)				
CHW Flow Rate (GPM)				
Condenser Water (CW) supply temperature reset implemented? (Y/N)				
CW default supply temp. (°F)				
Outside Air Temp, wet bulb (OATWB) for default CW supply temp. (°F)				
CW low supply temp. (°F)				
OATWB for low CW supply temp. (°F)				
CW return temp. (°F)				
CW Flow Rate (GPM)				

EMS Trends To Request	Chiller #1	Chiller #1	Chiller #3	Chiller #4
Chiller power (kW)				
Chiller load (ton)				
CHW supply temp.				
CW supply temp.				
Outside air temp, record dry bulb, wet bulb, or both (°F)				

6.7.10 Water-cooled chillers net distributor interview guide

Introduction

Hello <Distributor Name>, this is <Interviewer name>. The reason for my call is I'm conducting a state-wide evaluation of the utility-sponsored Commercial Upstream Distributor Rebate Program. I'd like to ask you about your company's past experience with this program. This call is sponsored by the CA Public Utilities Commission and 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 PARTCIPATE]	1	SC1
[DOES NOT AGREE TO PARTCIPATE]	2	Thank & Terminate

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

[IF ASKED] If you would like to verify the legitimacy of this research our CPUC manager Jeorge Tagnipes at 415.703.2451. If you have questions about this or the follow up survey, you can reach our study manager by calling Cameron Tuttle at (510) 891-0461 x44271.

Screener questions

SC1. Southern California Edison (SCE) provides incentives to distributors through the Nonresidential HVAC Program that buys down the cost of high-efficiency water-cooled chillers. The incentive records show your company received incentives from this program in 2018. Are you familiar with your company's participation in this program?

Yes	1	G1
No	2	S1a
Don't know	98	
Refused	99	

SC1a. Who at your company could I speak with that would be familiar with this program?

Record name and contact details 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? Is your company a… [READ LIST; CHOOSE ALL THAT APPLY]**

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

G2. **Who do you sell water-cooled chillers to?**

Installation contractors only	1	G3
End-users only	2	G3
Installation contractors and end users	3	
Don't know	98	
Refused	99	

G3. **Who designs the water-cooled chillers you sell? [SELECT ALL THAT APPLY]**

3rd party Architects/Design engineers	1	ME1
You	2	ME1
Installation contractors	3	
End users	4	
Don't know	98	
Refused	99	

Market effects

Sales

ME1. **What are the strongest drivers for your sales of high-efficiency chillers? [PROMPT AS NEEDED, RECORD ALL THAT APPLY]**

Sales engineers upselling practices	1	ME2
Available stock / delivery time	2	
ROI or payback calculations	3	
Design Engineer / Consulting preferences	4	
Manufacturer rebates / promotions	5	
Utility rebates	6	
Non-rebate program activities (e.g. quarterly sales meeting, letter of commitment, market reports)	7	
Other (Record)	50	
Don't know	98	
Refused	99	

ME2. **What are your biggest barriers to being able to sell high-efficiency chillers?**
[PROMPT AS NEEDED, RECORD ALL THAT APPLY]

Increased cost of HE models	1	ME3
Increased size/weight of HE models	2	
Increased delivery time of HE models	3	
Market demand or turnover rate	4	
Sales marketing / educating buyers	5	
Ability to keep repairing old equipment	6	
Other (Record)	50	
Don't know	98	
Refused	99	

ME3. **Which of the following non-rebate program activities has your company participated in or received from the program?**
[PROMPT AS NEEDED, RECORD ALL THAT APPLY]

Letter of commitment to sell high efficiency equipment	1	ME3a
Regular meetings with program staff and your sales engineers	2	ME3a
Quarterly program market share report	3	ME3a
Other [SPECIFY]	4	ME3a
Don't know	98	ME3a
Refused	99	ME3a

ME3a. **How, if at all, do the program rebates and non-rebate activities help you overcome the barriers to selling efficient models?**

[Record verbatim]		ME5
Don't know	98	ME5
Refused	99	ME5

ME4. **[ME4 deleted because it is about stocking]**

ME5. **What effects, if any, do the <PROGRAM> rebates and non-rebate activities have on your company's policies regarding upselling of high efficiency equipment?**

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

Upselling

Now I want to talk about upselling.

U1. Please describe how you typically promote and sell products.

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

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

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

U2a. For what percent of chiller projects does your company make recommendations 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	

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

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

U3. Do the program rebates and other activities influence the equipment efficiency level your company recommends to buyers?

Yes	1	U4
No	2	U4
Don't know	98	U5
Refused	99	

U4. Why do you say that?

[Record verbatim]		
Don't know	98	U5
Refused	99	

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

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

U5. In situations where you are selling [equipment type] [size], about what percent of the time do you recommend the high-efficiency equipment?

[IF NECESSARY: High efficiency is defined as Tier 1 and above.]

Equipment Type/Size	<75 tons	75-149 tons	150-299 tons	300-599 tons	>= 600 tons	
Screw-based						U6
Centrifugal						
Don't know	98					
Refused	99					

[IF ALL 0%, DK/R, SKIP TO P1]

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

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

U6. For [equipment type] [size], what percent of the time *would* you recommend the high-efficiency equipment if [Program] did not exist? *[Probe: and what we mean by "without the program" is supposing the program ran out of funding next month and ceased giving rebates and conducting the other non-rebate activities]*

[IF NECESSARY: High efficiency is defined as Tier 1 and above.]

Equipment Type/Size	<75 tons	75-149 tons	150-299 tons	300-599 tons	>= 600 tons	
Screw-based						P1
Centrifugal						
Don't know	98					
Refused	99					

Trickle down incentives

P1. How does your company determine the price the buyer pays for the high-efficiency water-cooled chillers we've been discussing?
[BUYER means who the distributor sells to, whether that's a middle-man contractor or the end user]

[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	P3a
No	2	P3a
Don't know	98	Next Section
Refused	99	

P3a. Why do you say that?

[Record verbatim]		P4
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?

Equipment Type/Size	<75 tons	75-149 tons	150-299 tons	300-599 tons	>= 600 tons	ME6
Screw-based						
Centrifugal						
Don't know	98					
Refused	99					

Program influence on sales

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

[IF WE HAVE TOTAL REBATES CLAIMED BY DISTRIBUTOR FROM TRACKING DATA, SKIP TO ME10]

ME6. In 2018, about what percentage of water-cooled chillers that you sold in SCE territory would you estimate were high efficiency, which is defined as Tier 1 and above? [Repeat for all combinations in the table below they have indicated they offer.]

Equipment Type/Size	<75 tons	75-149 tons	150-299 tons	300-599 tons	>= 600 tons	ME7
Screw-based						
Centrifugal						
Don't know	98					
Refused	99					

[IF ALL 0 or DK/R, SKIP TO STOCKING]

ME7. Without the program rebates and non-rebate activities, what percentage of your SCE-territory sales *would have been* high-efficiency?
[IF NECESSARY: You can ask them if they had sales outside of SCE-territory and use those numbers here]
[Repeat for all combinations in the table below they have indicated they offer.]
[IF NECESSARY: High efficiency means tier 1 or above]

Equipment Type/Size	<75 tons	75-149 tons	150-299 tons	300-599 tons	>= 600 tons	ME8
Screw-based						
Centrifugal						
Don't know	98					
Refused	99					

ME8. What percent of all the high-efficiency water-cooled chiller sales in SCE-territory had a rebate claimed? [Repeat for all combinations in the table below they have indicated they offer.]

Equipment Type/Size	<75 tons	75-149 tons	150-299 tons	300-599 tons	>= 600 tons	ME9
Screw-based						
Centrifugal						
Don't know	98					
Refused	99					

ME9. [IF ANY (ME6-ME8) >0] Why doesn't your company submit rebates for all the high-efficiency water-cooled chiller sales? [Reflect all that apply]

Not qualified	1	STOCKING

Missed opportunity	2	
Paid through down/mid-stream rebate	3	
Not in IOU service territory	4	
Other reason [Record Verbatim]	50	
Don’t know	98	
Refused	99	

[IF WE HAVE TOTAL REBATES CLAIMED BY DISTRIBUTOR FROM TRACKING DATA, WE WILL ASK ME10 INSTEAD OF ME6 TO ME9]

ME10. I'm going to go through the number of rebates you claimed for various water-cooled chillers. I'm assuming each one represents the sale of a high efficiency unit. I'd like you to estimate how many of those high efficiency sales would have still occurred without the program?
[IF NECESSARY: High efficiency means tier 1 and above]

Equipment Type/Size **# SOLD**	<75 tons	75-149 tons	150-299 tons	300-599 tons	>= 600 tons	
Screw-based	PIPE	PIPE	PIPE	PIPE	PIPE	
Centrifugal	PIPE	PIPE	PIPE	PIPE	PIPE	
Don't know	98					
Refused	99					

Equipment Type/Size	<75 tons	75-149 tons	150-299 tons	300-599 tons	>= 600 tons	PROCESS
Screw-based						
Centrifugal						
Don't know	98					
Refused	99					

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.

6.7.11 Boilers net buyers interview guide

(Note: This was a comprehensive survey used for boilers in the PY2017 evaluation. We are using it without modification in order to allow us to combine the results from PY2017 and PY2018.)

Net-to-Gross Short Survey for Completion of HVAC Boiler Surveys

Interview Details	a.	Interview Date		Be sure to capture who we're speaking with and when.
	b.	Interviewer		
	c.	Interviewee		
	d.	Site Name		
	e	Site Address		
	f	ERSID		

Introduction	Hello, my name is ____________%n____________ and I am calling on behalf of the California Public Utilities Commission from ERS. [THIS IS NOT A SALES CALL.] We are interested in speaking with the person most knowledgeable about your organization's participation in Southern California Gas Boiler program during [2017] 2018. Today we're conducting a very important study on the energy needs and perceptions of organizations like yours. We are interested in how organizations like yours think about and manage their energy consumption. Your input will allow the California Public Utilities Commission to build and maintain better energy savings programs for customers like you. And we would like to remind you, your responses will not be connected with your organization in any way. This survey should take approximately 10-15 minutes. Notes for interviewers: The sites are not familiar with the term "net-to-gross" and this term should not be used. Our focus from the customer perspective is on improving the program and the customer experience. Also, please read these questions verbatim. We should not be asking any leading questions. Awkward pauses while they think are good here.

Decision-maker Intro Q	Just to confirm, were you the primary decision-maker for your organization's decision to pursue this boiler upgrade?			
	a.	Response	yes	*Note: We need to speak with the decision-maker for this interview.*

FOR SITES INSTALLING MULTIPLE PROJECTS:					
	Our records show that your organization installed more than one boiler through the SoCalGas Boiler Program during 2018[7]. Specifically, our records show that you installed [X QTY] Boilers [MAYBE ACROSS MULTIPLE LOCATIONS?].				
Multiple	Was the decision-making process to do these conversions consistent across the various projects, or were there separate decisions for each conversion?				
	a.	Single decision-making process		*[check appropriate box]*	
	b.	Separate decision-making process for each project		*[check appropriate box]*	NOTE: If there is separate decision-making processes, we need to ask the below questions for each project, as their NTG will likely be different.
	c.	Don't Know		*[check appropriate box]*	

HVAC BOILERS

BH99	Our records indicate that your organization installed (HVAC_BOILER EQUIPMENT) through the program. It is described as a (BOILER MEASURE). Is this correct?			
	a. Yes		[check appropriate box]	NOTE: If this person is not familiar with the boiler installed, ask If there is someone we can speak to that is familiar with the measure, otherwise we cannot continue.
	b. No		[check appropriate box]	
	c. Refused		[check appropriate box]	
	d. Don't know		[check appropriate box]	

BH100	Is the boiler measure a new installation, or did it replace an existing boiler?		
	a. New installation		[check appropriate box]
	b. Replaced existing equipment		[check appropriate box]
	c. Refused		[check appropriate box]
	d. Don't know		[check appropriate box]

BH101A	Approximately how old was the boiler measure that was removed and replaced? Would you say...		
	a. Less than 5 years old		[check appropriate box]
	b. Between 5 and 10 years old		[check appropriate box]
	c. Between 10 and 15 years old		[check appropriate box]
	d. More than 15 years old		[check appropriate box]
	e. Refused		[check appropriate box]
	f. Don't know		[check appropriate box]

BH101B	How would you describe the removed equipment's condition? Would you say it was in...		
	a. Poor condition		[check appropriate box]
	b. Fair condition		[check appropriate box]
	c. Good condition		[check appropriate box]
	d. Refused		[check appropriate box]
	e. Don't know		[check appropriate box]

OPERATING SCHEDULES FOR BOILERS

BHOP3	Does the boiler operation vary by season of the year?		
	a. Yes		[check appropriate box]
	b. No		[check appropriate box]
	c. Refused		[check appropriate box]
	d. Don't know		[check appropriate box]

BHOP3a	Which seasons does the boiler operate during?		
	a. Winter		[check appropriate box]
	b. Fall		[check appropriate box]
	c. Spring		[check appropriate box]
	d. Summer		[check appropriate box]
	e. Other		[check appropriate box]
	f. Refused		[check appropriate box]
	g. Don't know		[check appropriate box]

BHOP3b	What percentage of the time does the boiler operate during those seasons?		
	a. Winter percentage of time		[Enter percentage]
	b. Fall percentage of time		[Enter percentage]
	c. Spring percentage of time		[Enter percentage]
	d. Summer percentage of time		[Enter percentage]
	e. Other percentage of time		[Enter percentage]
	f. Refused		
	g. Don't know		

BHOP4	Is the boiler measure used rarely, moderately, most of the time, or always during your facility's operating hours?		
	a. Rarely		[check appropriate box]
	b. Moderately		[check appropriate box]
	c. Most of the time		[check appropriate box]
	d. All of the time		[check appropriate box]
	e. Other		[check appropriate box]
	f. Refused		[check appropriate box]
	g. Don't know		[check appropriate box]

ASK FOR ALL PROJECTS:

N1		There are usually a number of reasons why an organization like yours decides to participate in energy efficiency programs like this one. In your own words, can you tell me why you decided to participate in this program?		
	a.	*Record response verbatim:*		

N2		Did your organization make the decision to install this new equipment before, after, or at the same time as you became aware that rebates were available through the PROGRAM?		
	A.	Before		[check appropriate box]
	B.	After		[check appropriate box]
	C.	Same Time		[check appropriate box]

N3 — I'm now going to ask you to please rate the importance of several factors that might have influenced your decision to install this equipment through the program. For the following factors, using a scale of 0 to 10 where 0 means not at all important and 10 means extremely important, how would you rate the importance of:

	Influencing Factor:	Response		
A.	The age or condition of the old equipment?		[Enter 0 to 10]	(NP)
B.	Recommendation from an equipment vendor that sold you the equipment and/or installed it for you?		[Enter 0 to 10]	(NP)
C.	Availability of program rebate?		[Enter 0 to 10]	(P)
D.	Your previous experience with similar types of energy efficiency projects?		[Enter 0 to 10]	(NP)
E.	Your previous experience with SoCalGas' Boiler program or a similar utility program ?		[Enter 0 to 10]	(P)
F.	Information from the program, utility, or training course?		[Enter 0 to 10]	(P)
G.	Marketing materials provided by the program, utility, or program administrator?		[Enter 0 to 10]	(P)
H.	Standard practices in your industry?		[Enter 0 to 10]	(NP)
I.	Endorsement or recommendation by your account rep?		[Enter 0 to 10]	(P)
J.	Corporate policy or guidelines?		[Enter 0 to 10]	(NP)
K.	Payback or return on investment of installing this equipment?		[Enter 0 to 10]	(NP)
L.	Improved product quality?		[Enter 0 to 10]	(NP)
M.	Compliance with state or federal regulations such as Title 24, air quality, OSHA or FDA		[Enter 0 to 10]	(NP)
N.	Compliance with your organization's normal remodeling or equipment replacement practices?		[Enter 0 to 10]	(NP)
O.	Were there any other factors we haven't discussed that were influential in your decision to replace your boiler(s)?		[Enter 0 to 10]	
	[RECORD OTHER VERBATIM]			

N4 — Some of these influencing factors we just asked about are related to the PROGRAM (such as rebates, ...[LIST ALL P FACTORS ANSWERED IN N3]...) and some are NON-PROGRAM factors (such as equipment age, ...[LIST ALL NP FACTORS ANSWERED IN N3). I would like you to rate the importance of program factors vs. non-program factors that may have influenced your decision. If you were given 10 points to divide between the two, how many points would you give to the importance of the program factors, and how many points would you give to other non-program factors?

a.	Program Factors		[Enter 0 to 10]
b.	Non-Program Factors		[Enter 0 to 10]
c.	Total	0	MUST EQUAL 10!!

N5 — On a scale of 0 to 10, where 0 is not at all likely and 10 is extremely likely, if the rebate program had NOT been available, what is the likelihood that you would have installed exactly the same energy efficient equipment that you did regardless of when you would have installed it?

a.	Response		[Enter 0 to 10]
b.	Why do you say that?		

N6 — Now I would like you to think one last time about what action you would have taken if the program had not been available. Which of the following alternatives would you have been MOST likely to do?

a.	Upgrade fewer high efficiency boilers		[check appropriate box AND ASK QUESTION N7!]
b.	Install standard efficiency equipment or whatever required by code		[check appropriate box AND ASK QUESTION N7!]
c.	Do nothing (keep existing equipment as-is)		[check appropriate box]
d.	Install the same thing you did through the program		[check appropriate box AND ASK QUESTION N7!]
e.	Repair or overhaul the existing equipment		[check appropriate box]
f.	Something else_____ *[record this at right]*		[check appropriate box]
g.	Don't know		[check appropriate box]

Something Else:

N7 — *ASK Only if N6 = a,b,c, or e.*

Would you have [FILL IN RESPONSE TO N6 for N6 = a,b, or d] at the same time as you did under the program, within one year, or at a later time?

a.	Same time		[check appropriate box]
b.	Within one year		[check appropriate box]
c.	At a later time (ask how many yrs)		[check appropriate box]

About how many years later?

Closing	**Thanks again for your time today. Your responses will help us improve this program for you and other customers in the future.**

6.8 Appendix H: Rooftop or split system results

The following three tables include kWh, kW, and therm results at the building type and climate zone for each PA.

Table 6-19. Rooftop package/split systems kWh results by building type and climate zone

PA	Building Type	Climate Zone	Site Count	Ex Ante Tons	Installation Rate	Ex Ante Gross kWh	UES RR kWh	Ex Post Gross kWh
PGE	COM	13	3	149.42	4%	55,778	59%	1,292
	EPR	12	1	29.12	100%	12,609	11%	1,438
	EPR	13	3	81.71	100%	24,985	24%	4,781
	ERC	11	4	584	100%	178,704	70%	125,093
	ERC	12	5	1624.5	100%	521,465	70%	365,025
	Ese	13	3	189.16	101%	26,926	48%	12,565
	Htl	13	2	169.59	100%	10,803	65%	6,973
	Mli	13	2	19.84	100%	2,724	77%	1,447
	Ofl	13	1	2.83	100%	648	45%	292
	RFF	13	1	19.66	100%	767	85%	655
	Rt3	13	1	271.17	100%	26,679	106%	20,955
	WRf	13	1	23.5	100%	1,422	100%	1,422
SCE	Asm	8	1	48.43	100%	3,476	127%	4,107
	COM	6	1	25.63	0%	5,935	59%	0
	COM	9	1	4.08	100%	1,779	59%	1,042
	EPR	6	1	8.25	100%	484	63%	304
	EPR	8	2	17.6	50%	6,045	26%	95
	EPR	10	3	119.04	88%	19,407	37%	6,432
	ESe	8	1	70.74	100%	28,397	12%	3,364
	ESe	9	3	176.38	100%	26,657	63%	9,782
	ESe	10	1	128.11	100%	34,033	41%	5,781
	Mli	8	1	40.33	100%	9,683	48%	2,658
	Mli	10	1	60	100%	4,836	100%	4,836
	OfS	6	1	4.88	0%	1,303	19%	0
	OfS	8	2	12.08	100%	4,943	23%	1,127
	OfS	10	1	628.91	100%	42,487	95%	41,937
	OfS	15	1	27.72	100%	9,730	53%	3,801
	RSD	8	1	28.66	100%	2,238	100%	2,238
	RtL	6	1	294.72	100%	27,220	96%	21,678
SDGE	DMo	10	3	12	67%	102	59%	40
	EPr	7	1	28	100%	3,646	21%	566
	ESe	7	1	36	100%	9,764	22%	1,484
	OfS	7	1	7.5	100%	463	79%	367
	RSD	7	1	13.5	100%	833	98%	816
	RtS	7	1	12	100%	1,356	91%	1,232
	RtS	10	1	24	100%	1,881	95%	1,935

Table 6-20. Rooftop package/split systems kW results by building type and climate zone

PA	Building Type	Climate Zone	Site Count	Ex Ante Tons	Installation Rate	Ex Ante Gross kW	UES RR kW	Ex Post Gross kW
PGE	COM	13	3	149.42	4%	29.8	59%	2.0
	EPR	12	1	29.12	100%	3.8	10%	0.4
	EPR	13	3	81.71	100%	6.7	24%	1.6
	ERC	11	4	584	100%	18.7	70%	13.1
	ERC	12	5	1624.5	100%	47.1	70%	33.0
	Ese	13	3	189.16	101%	12.3	38%	4.9
	Htl	13	2	169.59	100%	10.5	64%	7.2
	Mli	13	2	19.84	100%	2.1	25%	0.5
	Ofl	13	1	2.83	100%	0.3	44%	0.1
	RFF	13	1	19.66	100%	0.7	57%	0.4
	Rt3	13	1	271.17	100%	23.0	89%	21.4
	WRf	13	1	23.5	100%	1.8	100%	1.8
SCE	Asm	8	1	48.43	100%	3.4	102%	3.5
	COM	6	1	25.63	0%	2.4	58%	0.0
	COM	9	1	4.08	100%	0.6	58%	0.3
	EPR	6	1	8.25	100%	0.5	5%	0.0
	EPR	8	2	17.6	50%	1.4	83%	0.1
	EPR	10	3	119.04	88%	16.2	15%	1.8
	ESe	8	1	70.74	100%	8.8	47%	4.1
	ESe	9	3	176.38	100%	15.8	43%	8.4
	ESe	10	1	128.11	100%	11.2	14%	1.6
	Mli	8	1	40.33	100%	3.4	90%	2.9
	Mli	10	1	60	100%	5.7	100%	5.7
	OfS	6	1	4.88	0%	0.4	55%	0.0
	OfS	8	2	12.08	100%	1.3	59%	0.7
	OfS	10	1	628.91	100%	35.7	96%	34.8
	OfS	15	1	27.72	100%	2.8	84%	2.1
	RSD	8	1	28.66	100%	2.2	100%	2.2
	RtL	6	1	294.72	100%	18.3	81%	15.6
SDGE	DMo	10	3	12	67%	-0.1	58%	-0.04
	EPr	7	1	28	100%	1.2	57%	0.7
	ESe	7	1	36	100%	2.5	74%	1.9
	OfS	7	1	7.5	100%	0.5	81%	0.4
	RSD	7	1	13.5	100%	0.8	83%	0.7
	RtS	7	1	12	100%	1.368	76%	1.0

PA	Building Type	Climate Zone	Site Count	Ex Ante Tons	Installation Rate	Ex Ante Gross kW	UES RR kW	Ex Post Gross kW
	RtS	10	1	24	100%	1.91	76%	1.6

Table 6-21. Rooftop package/split systems therm results by building type and climate zone

PA	Building Type	Climate Zone	Site Count	Ex Ante Tons	Installation Rate	Ex Ante Gross Therm	UES RR Therms	Ex Post Gross Therm
PGE	COM	13	3	149.42	4%	-7.8	56%	0.0
	EPR	12	1	29.12	100%	-126.7	0%	-74.2
	EPR	13	3	81.71	100%	-90.2	0%	-52.8
	ERC	11	4	584	100%	0.0	0%	0.0
	ERC	12	5	1624.5	100%	0.0	0%	0.0
	Ese	13	3	189.16	101%	-195.3	0%	-114.4
	Htl	13	2	169.59	100%	-40.7	6%	-23.9
	Mli	13	2	19.84	100%	-14.4	0%	-8.4
	Ofl	13	1	2.83	100%	-0.2	0%	-0.1
	RFF	13	1	19.66	100%	0.0	0%	0.0
	Rt3	13	1	271.17	100%	-115.2	0%	-67.5
	WRf	13	1	23.5	100%	0.0	0%	0.0
SCE	Asm	8	1	48.43	100%	0.0	0%	0.0
	COM	6	1	25.63	0%	-0.1	39%	0.0
	COM	9	1	4.08	100%	-10.5	59%	-6.2
	EPR	6	1	8.25	100%	0.0	0%	0.0
	EPR	8	2	17.6	50%	-1.3	0%	-0.7
	EPR	10	3	119.04	88%	-64.3	0%	-34.7
	ESe	8	1	70.74	100%	-152.6	0%	-89.4
	ESe	9	3	176.38	100%	-13.7	0%	-8.1
	ESe	10	1	128.11	100%	-262.1	0%	-153.6
	Mli	8	1	40.33	100%	-49.7	0%	-29.1
	Mli	10	1	60	100%	0.0	0%	0.0
	OfS	6	1	4.88	0%	0.0	0%	0.0
	OfS	8	2	12.08	100%	-18.7	0%	-11.0
	OfS	10	1	628.91	100%	-5.3	0%	-3.1
	OfS	15	1	27.72	100%	-22.4	0%	-13.1
	RSD	8	1	28.66	100%	0.0	0%	0.0
	RtL	6	1	294.72	100%	-82.0	0%	-48.1

PA	Building Type	Climate Zone	Site Count	Ex Ante Tons	Installation Rate	Ex Ante Gross Therm	UES RR Therms	Ex Post Gross Therm
SDGE	DMo	10	3	12	67%	1.5	59%	0.6
	EPr	7	1	28	100%	-11.4	0%	-6.7
	ESe	7	1	36	100%	-34.3	0%	-20.1
	OfS	7	1	7.5	100%	0.0	0%	0.0
	RSD	7	1	13.5	100%	0.0	0%	0.0
	RtS	7	1	12	100%	0.0	0%	0.0
	RtS	10	1	24	100%	0.0	0%	0.0

6.10 Appendix I: Fan motor replacement UES tables

This section contains eQUEST-generated savings tables for fan motor replacement measures by building type and climate zone. These tables were used to generate site-level gross savings estimates.

Table 6-22. Fan motor replacement UES values (kWh/ton)

Bldg Type	Climate Zone	PGE	SCE	SCG	SDG
		kWh/ton	kWh/ton	kWh/ton	kWh/ton
SFm	CZ01	63.6			
SFm	CZ02	73.6			
SFm	CZ03	58.2			
SFm	CZ04	93.3			
SFm	CZ05	64.2	61.7		
SFm	CZ06		70.4		68.2
SFm	CZ07				94.3
SFm	CZ08		86.9		103.0
SFm	CZ09		106.5		
SFm	CZ10		117.8		114.9
SFm	CZ11	141.7			
SFm	CZ12	100.6			
SFm	CZ13	159.0	162.5		
SFm	CZ14		169.5		159.0
SFm	CZ15		174.9		116.4
SFm	CZ16	124.3	125.7		
Mfm	CZ01	58.3			
Mfm	CZ02	62.9			
Mfm	CZ03	41.3			
Mfm	CZ04	44.6			
Mfm	CZ05	37.2	37.8		
Mfm	CZ06		58.1		54.1
Mfm	CZ07				41.1
Mfm	CZ08		64.5		5.9
Mfm	CZ09		108.7		
Mfm	CZ10		104.6		100.7
Mfm	CZ11	116.9			
Mfm	CZ12	80.7			
Mfm	CZ13	154.0	156.7		
Mfm	CZ14		174.2		177.6
Mfm	CZ15		239.0		244.1
Mfm	CZ16	120.5	116.3		
Dmo	CZ01	44.1			

Bldg Type	Climate Zone	PGE	SCE	SCG	SDG
		kWh/ton	kWh/ton	kWh/ton	kWh/ton
Dmo	CZ02	102.8			
Dmo	CZ03	69.2			
Dmo	CZ04	109.8			
Dmo	CZ05	74.0			
Dmo	CZ06		103.5		
Dmo	CZ07				98.4
Dmo	CZ08		120.7		100.3
Dmo	CZ09		140.7		
Dmo	CZ10		153.6		151.6
Dmo	CZ11	183.3			
Dmo	CZ12	138.2			
Dmo	CZ13	187.1	187.0		
Dmo	CZ14		242.0		238.9
Dmo	CZ15		295.6		
Dmo	CZ16	142.3	143.1		

Table 6-23. Fan motor replacement UES values (kW/ton)

Bldg Type	Climate Zone	PGE	SCE	SCG	SDG
		kW/ton	kW/ton	kW/ton	kW/ton
SFm	CZ01	0.0			
SFm	CZ02	0.00			
SFm	CZ03	0.00			
SFm	CZ04	0.01			
SFm	CZ05	0.00	0.00		
SFm	CZ06		0.01		0.01
SFm	CZ07				0.02
SFm	CZ08		0.02		0.03
SFm	CZ09		0.03		
SFm	CZ10		0.03		0.03
SFm	CZ11	0.02			
SFm	CZ12	0.02			
SFm	CZ13	0.04	0.04		
SFm	CZ14		0.05		0.05
SFm	CZ15		0.04		0.03
SFm	CZ16	0.03	0.03		
Mfm	CZ01	0.00			
Mfm	CZ02	0.00			
Mfm	CZ03	0.00			
Mfm	CZ04	0.00			

Bldg Type	Climate Zone	PGE	SCE	SCG	SDG
		kW/ton	kW/ton	kW/ton	kW/ton
Mfm	CZ05	0.00	0.00		
Mfm	CZ06		0.02		0.01
Mfm	CZ07				0.01
Mfm	CZ08		0.03		0.02
Mfm	CZ09		0.06		
Mfm	CZ10		0.07		0.06
Mfm	CZ11	0.04			
Mfm	CZ12	0.03			
Mfm	CZ13	0.07	0.07		
Mfm	CZ14		0.11		0.11
Mfm	CZ15		0.08		0.09
Mfm	CZ16	0.08	0.08		
Dmo	CZ01	0.00			
Dmo	CZ02	0.02			
Dmo	CZ03	0.01			
Dmo	CZ04	0.07			
Dmo	CZ05	0.02			
Dmo	CZ06		0.06		
Dmo	CZ07				0.07
Dmo	CZ08		0.09		0.08
Dmo	CZ09		0.10		
Dmo	CZ10		0.12		0.12
Dmo	CZ11	0.09			
Dmo	CZ12	0.10			
Dmo	CZ13	0.13	0.13		
Dmo	CZ14		0.16		0.17
Dmo	CZ15		0.14		
Dmo	CZ16	0.09	0.09		

Table 6-24. Fan motor replacement UES values (therms/ton)

Bldg Type	Climate Zone	PGE	SCE	SCG	SDG
		therms/ton	therms/ton	therms/ton	therms/ton
SFm	CZ01	-4.0			
SFm	CZ02	-2.9			
SFm	CZ03	-2.9			
SFm	CZ04	-2.3		-2.3	
SFm	CZ05	-3.7	-3.6	-3.7	

Bldg Type	Climate Zone	PGE	SCE	SCG	SDG
		therms/ton	therms/ton	therms/ton	therms/ton
SFm	CZ06		-1.7	-1.8	-2.0
SFm	CZ07			-2.1	-2.0
SFm	CZ08		-1.2	-1.2	-1.2
SFm	CZ09		-1.5	-1.5	
SFm	CZ10		-1.6	-1.7	-1.6
SFm	CZ11	-1.8			
SFm	CZ12	-2.2			
SFm	CZ13	-2.2	-2.2	-2.2	
SFm	CZ14		-1.8	-1.9	-1.7
SFm	CZ15		-0.5	-0.5	-0.4
SFm	CZ16	-4.6	-4.6	-4.8	
Mfm	CZ01	-6.0			
Mfm	CZ02	-4.2			
Mfm	CZ03	-1.6			
Mfm	CZ04	-1.8		-1.3	
Mfm	CZ05	-1.9	-2.0	-1.9	
Mfm	CZ06		-0.7	-0.5	-0.6
Mfm	CZ07			-0.5	-0.2
Mfm	CZ08		-1.2	-1.2	-2.4
Mfm	CZ09		-0.7	-0.9	
Mfm	CZ10		-1.0	-1.0	-0.8
Mfm	CZ11	-1.6			
Mfm	CZ12	-1.3			
Mfm	CZ13	-1.3	-1.2	-1.3	
Mfm	CZ14		-1.4	-1.4	-1.5
Mfm	CZ15		-0.3	-0.3	-0.3
Mfm	CZ16	-3.0	-3.0	-3.0	
Dmo	CZ01	-2.8			
Dmo	CZ02	-3.4			
Dmo	CZ03	-2.7			
Dmo	CZ04	-2.2		-3.3	
Dmo	CZ05	-3.7		-3.6	
Dmo	CZ06		-1.9	-1.8	
Dmo	CZ07				-1.4
Dmo	CZ08		-1.3	-1.4	-1.1
Dmo	CZ09		-1.8	-1.8	
Dmo	CZ10		-2.1	-2.2	-2.0
Dmo	CZ11	-2.7			
Dmo	CZ12	-2.7			

Bldg Type	Climate Zone	PGE	SCE	SCG	SDG
		therms/ton	therms/ton	therms/ton	therms/ton
Dmo	CZ13	-2.7	-2.8	-2.8	
Dmo	CZ14		-3.2	-3.8	-3.1
Dmo	CZ15		-1.0	-1.2	
Dmo	CZ16	-5.6	-5.7	-2.8	

6.12 Appendix J: Fan motor replacement site-level results

The following three tables include kWh, kW, and therm results for each site.

Table 6-25. Fan motor replacement site-level results (kWh)

Site ID	Building Type	Climate Zone	Tons Tracked	IR	Ex Ante Gross kWh	Ex Post UES kWh	Ex Post Gross kWh
PGE.1	DMo	CZ04	2	100%	114.5	109.8	219.6
PGE.2	DMo	CZ04	2	100%	114.5	109.8	219.6
PGE.3	DMo	CZ11	2.5	160%	567.6	183.3	733.4
PGE.4	DMo	CZ11	3.5	100%	794.7	183.3	641.7
PGE.5	DMo	CZ13	4	100%	716.1	187.1	748.6
PGE.6	DMo	CZ13	4	100%	716.1	187.1	748.6
PGE.7	DMo	CZ13	2	150%	358.0	187.1	561.4
PGE.8	DMo	CZ13	2.5	120%	447.6	187.1	561.4
PGE.9	MFM	CZ11	2	100%	246.9	116.9	233.8
PGE.10	MFM	CZ11	2	100%	246.9	116.9	233.8
PGE.11	MFM	CZ11	2	100%	246.9	116.9	233.8
PGE.12	MFM	CZ11	2	100%	246.9	116.9	233.8
PGE.13	MFM	CZ11	2	100%	246.9	116.9	233.8
PGE.14	MFM	CZ11	2	100%	246.9	116.9	233.8
PGE.15	MFM	CZ13	2.5	100%	345.4	154.0	385.1
PGE.16	MFM	CZ13	2	100%	276.3	154.0	308.1
PGE.17	MFM	CZ13	2	100%	276.3	154.0	308.1
PGE.18	MFM	CZ13	2	100%	276.3	154.0	308.1
PGE.19	MFM	CZ13	2	100%	276.3	154.0	308.1
PGE.20	MFM	CZ13	2	100%	276.3	154.0	308.1
PGE.21	SFM	CZ11	3	67%	415.8	141.7	283.4
PGE.22	SFM	CZ11	3	117%	415.8	141.7	495.9
PGE.23	SFM	CZ11	3	167%	415.8	141.7	708.4
PGE.24	SFM	CZ11	6	133%	831.6	141.7	1133.5
PGE.25	SFM	CZ11	3	100%	415.8	141.7	425.0
PGE.26	SFM	CZ11	3	167%	415.8	141.7	708.4
PGE.27	SFM	CZ11	3	117%	415.8	141.7	495.9
PGE.28	SFM	CZ11	3	117%	415.8	141.7	495.9
PGE.29	SFM	CZ11	3	117%	415.8	141.7	495.9
PGE.30	SFM	CZ11	3	133%	415.8	141.7	566.7
PGE.31	SFM	CZ11	3	100%	415.8	141.7	425.0
PGE.32	SFM	CZ11	3	100%	415.8	141.7	425.0
PGE.33	SFM	CZ11	3	133%	415.8	141.7	566.7
PGE.34	SFM	CZ12	2.5	100%	248.8	100.6	251.5

Site ID	Building Type	Climate Zone	Tons Tracked	IR	Ex Ante Gross kWh	Ex Post UES kWh	Ex Post Gross kWh
PGE.35	SFM	CZ12	4	100%	398.0	100.6	402.4
PGE.36	SFM	CZ12	3	83%	298.5	100.6	251.5
PGE.37	SFM	CZ12	3	117%	298.5	100.6	352.1
PGE.38	SFM	CZ12	3	100%	298.5	100.6	301.8
PGE.39	SFM	CZ12	2	125%	199.0	100.6	251.5
PGE.40	SFM	CZ12	2	100%	199.0	100.6	201.2
PGE.41	SFM	CZ12	3	100%	298.5	100.6	301.8
PGE.42	SFM	CZ12	2.5	80%	248.8	100.6	201.2
PGE.43	SFM	CZ12	3.5	100%	348.3	100.6	352.1
PGE.44	SFM	CZ12	3	100%	298.5	100.6	301.8
PGE.45	SFM	CZ12	3	100%	298.5	100.6	301.8
PGE.46	SFM	CZ12	3	100%	298.5	100.6	301.8
PGE.47	SFM	CZ12	2.5	100%	248.8	100.6	251.5
PGE.48	SFM	CZ12	3	67%	298.5	100.6	201.2
PGE.49	SFM	CZ13	5	100%	597.5	159.0	794.9
PGE.50	SFM	CZ13	3	67%	358.5	159.0	317.9
PGE.51	SFM	CZ13	3	83%	358.5	159.0	397.4
PGE.52	SFM	CZ13	4	100%	478.0	159.0	635.9
PGE.53	SFM	CZ13	3	100%	358.5	159.0	476.9
PGE.54	SFM	CZ13	3	100%	358.5	159.0	476.9
PGE.55	SFM	CZ13	3	100%	358.5	159.0	476.9
PGE.56	SFM	CZ13	3	100%	358.5	159.0	476.9
PGE.57	SFM	CZ13	3	100%	358.5	159.0	476.9
PGE.58	SFM	CZ13	3	117%	358.5	159.0	556.4
PGE.59	SFM	CZ13	3	83%	358.5	159.0	397.4
PGE.60	SFM	CZ13	3.5	71%	418.3	159.0	397.4
PGE.61	SFM	CZ13	3.5	100%	418.3	159.0	556.4
PGE.62	SFM	CZ13	2.5	120%	298.8	159.0	476.9
PGE.63	SFM	CZ13	3	100%	358.5	159.0	476.9
PGE.64	SFM	CZ13	3	100%	358.5	159.0	476.9
SCE.1	DMo	CZ08	7	100%	277.3	120.7	844.8
SCE.2	DMo	CZ09	4	100%	231.9	140.7	562.8
SCE.3	DMo	CZ09	4	100%	231.9	140.7	562.8
SCE.4	DMo	CZ10	6	83%	447.8	153.6	767.9
SCE.5	DMo	CZ10	12	100%	895.7	153.6	1842.9
SCE.6	DMo	CZ10	6	50%	444.6	153.6	460.7
SCE.7	DMo	CZ10	6.5	100%	539.6	153.6	998.2
SCE.8	DMo	CZ10	4	100%	298.6	153.6	614.3

Site ID	Building Type	Climate Zone	Tons Tracked	IR	Ex Ante Gross kWh	Ex Post UES kWh	Ex Post Gross kWh
SCE.9	DMo	CZ10	4	100%	298.6	153.6	614.3
SCE.10	DMo	CZ10	3	100%	223.9	153.6	460.7
SCE.11	DMo	CZ10	3	100%	222.3	153.6	460.7
SCE.12	DMo	CZ15	4	100%	905.8	295.6	1182.5
SCE.13	DMo	CZ15	5	100%	1132.2	295.6	1478.1
SCE.14	SFM	CZ08	4	100%	194.4	86.9	347.6
SCE.15	SFM	CZ10	4	100%	296.4	117.8	471.0
SCE.16	SFM	CZ10	6	100%	444.6	117.8	706.5
SCE.17	SFM	CZ10	7	114%	518.7	117.8	942.0
SCE.18	SFM	CZ10	5	100%	370.5	117.8	588.8
SCE.19	SFM	CZ10	3	100%	222.3	117.8	353.3
SCE.20	SFM	CZ10	5	100%	370.5	117.8	588.8
SCE.21	SFM	CZ10	3	100%	222.3	117.8	353.3
SCE.22	SFM	CZ10	3	100%	222.3	117.8	353.3
SCE.23	SFM	CZ10	3	100%	222.3	117.8	353.3
SCE.24	SFM	CZ10	7	50%	518.7	117.8	412.1
SCE.25	SFM	CZ10	7.5	100%	555.8	117.8	883.2
SCE.26	SFM	CZ10	3.5	100%	259.4	117.8	412.1
SCE.27	SFM	CZ10	7.5	107%	555.8	117.8	942.0
SCE.28	SFM	CZ10	7	50%	518.7	117.8	412.1
SCE.29	SFM	CZ10	5	100%	370.5	117.8	588.8
SCE.30	SFM	CZ14	7	93%	714.0	169.5	1101.6
SCE.31	SFM	CZ14	4	100%	408.0	169.5	677.9
SCE.32	SFM	CZ14	5	100%	510.0	169.5	847.4
SCE.33	SFM	CZ14	4.5	89%	459.0	169.5	677.9
SCE.34	SFM	CZ14	3	100%	306.0	169.5	508.4
SCE.35	SFM	CZ15	3.5	100%	675.5	174.9	612.0
SCE.36	SFM	CZ15	4	100%	772.0	174.9	699.4
SCE.37	SFM	CZ15	5	60%	965.0	174.9	524.6
SCE.38	SFM	CZ15	3.5	100%	675.5	174.9	612.0
SCE.39	SFM	CZ15	5	60%	965.0	174.9	524.6
SCE.40	SFM	CZ16	3	100%	222.6	125.7	377.2
SCE.41	SFM	CZ16	4	100%	296.8	125.7	502.9
SDGE.1	DMo	CZ10	2.5	100%	186.6	151.6	378.9
SDGE.2	DMo	CZ10	4	100%	298.6	151.6	606.3
SDGE.3	DMo	CZ10	3	0%	223.9	151.6	0.0
SDGE.4	DMo	CZ10	2.5	100%	186.6	151.6	378.9
SDGE.5	DMo	CZ10	2.5	100%	186.6	151.6	378.9

Site ID	Building Type	Climate Zone	Tons Tracked	IR	Ex Ante Gross kWh	Ex Post UES kWh	Ex Post Gross kWh
SDGE.6	MFM	CZ10	36	100%	2687.0	100.7	3626.8
SDGE.7	MFM	CZ10	12	100%	895.7	100.7	1208.9
SDGE.8	MFM	CZ10	155	100%	11568.9	100.7	15615.3
SDGE.9	MFM	CZ10	80	100%	5971.0	100.7	8059.5
SDGE.10	SFM	CZ10	3	100%	223.9	114.9	344.8
SDGE.11	SFM	CZ10	3	100%	223.9	114.9	344.8
SDGE.12	SFM	CZ10	2	100%	149.3	114.9	229.9

Table 6-26. Fan motor replacement site-level results (kW)

Site ID	Building Type	Climate Zone	Tons Tracked	IR	Ex Ante Gross kW	Ex Post UES kW	Ex Post Gross kW
PGE.1	DMo	CZ04	2	100%	0.10	0.07	0.134
PGE.2	DMo	CZ04	2	100%	0.103	0.07	0.134
PGE.3	DMo	CZ11	2.5	160%	0.516	0.09	0.368
PGE.4	DMo	CZ11	3.5	100%	0.722	0.09	0.322
PGE.5	DMo	CZ13	4	100%	0.670	0.13	0.511
PGE.6	DMo	CZ13	4	100%	0.670	0.13	0.511
PGE.7	DMo	CZ13	2	150%	0.335	0.13	0.383
PGE.8	DMo	CZ13	2.5	120%	0.419	0.13	0.383
PGE.9	MFM	CZ11	2	100%	0.150	0.04	0.083
PGE.10	MFM	CZ11	2	100%	0.150	0.04	0.083
PGE.11	MFM	CZ11	2	100%	0.150	0.04	0.083
PGE.12	MFM	CZ11	2	100%	0.150	0.04	0.083
PGE.13	MFM	CZ11	2	100%	0.150	0.04	0.083
PGE.14	MFM	CZ11	2	100%	0.150	0.04	0.083
PGE.15	MFM	CZ13	2.5	100%	0.192	0.07	0.175
PGE.16	MFM	CZ13	2	100%	0.154	0.07	0.140
PGE.17	MFM	CZ13	2	100%	0.154	0.07	0.140
PGE.18	MFM	CZ13	2	100%	0.154	0.07	0.140
PGE.19	MFM	CZ13	2	100%	0.154	0.07	0.140
PGE.20	MFM	CZ13	2	100%	0.154	0.07	0.140
PGE.21	SFM	CZ11	3	67%	0.374	0.02	0.047
PGE.22	SFM	CZ11	3	117%	0.374	0.02	0.083
PGE.23	SFM	CZ11	3	167%	0.374	0.02	0.118
PGE.24	SFM	CZ11	6	133%	0.747	0.02	0.189

Site ID	Building Type	Climate Zone	Tons Tracked	IR	Ex Ante Gross kW	Ex Post UES kW	Ex Post Gross kW
PGE.25	SFM	CZ11	3	100%	0.374	0.02	0.071
PGE.26	SFM	CZ11	3	167%	0.374	0.02	0.118
PGE.27	SFM	CZ11	3	117%	0.374	0.02	0.083
PGE.28	SFM	CZ11	3	117%	0.374	0.02	0.083
PGE.29	SFM	CZ11	3	117%	0.374	0.02	0.083
PGE.30	SFM	CZ11	3	133%	0.374	0.02	0.094
PGE.31	SFM	CZ11	3	100%	0.374	0.02	0.071
PGE.32	SFM	CZ11	3	100%	0.374	0.02	0.071
PGE.33	SFM	CZ11	3	133%	0.374	0.02	0.094
PGE.34	SFM	CZ12	2.5	100%	0.245	0.02	0.058
PGE.35	SFM	CZ12	4	100%	0.391	0.02	0.092
PGE.36	SFM	CZ12	3	83%	0.293	0.02	0.058
PGE.37	SFM	CZ12	3	117%	0.293	0.02	0.081
PGE.38	SFM	CZ12	3	100%	0.293	0.02	0.069
PGE.39	SFM	CZ12	2	125%	0.196	0.02	0.058
PGE.40	SFM	CZ12	2	100%	0.196	0.02	0.046
PGE.41	SFM	CZ12	3	100%	0.293	0.02	0.069
PGE.42	SFM	CZ12	2.5	80%	0.245	0.02	0.046
PGE.43	SFM	CZ12	3.5	100%	0.342	0.02	0.081
PGE.44	SFM	CZ12	3	100%	0.293	0.02	0.069
PGE.45	SFM	CZ12	3	100%	0.293	0.02	0.069
PGE.46	SFM	CZ12	3	100%	0.293	0.02	0.069
PGE.47	SFM	CZ12	2.5	100%	0.245	0.02	0.058
PGE.48	SFM	CZ12	3	67%	0.293	0.02	0.046
PGE.49	SFM	CZ13	5	100%	0.492	0.04	0.187
PGE.50	SFM	CZ13	3	67%	0.295	0.04	0.075
PGE.51	SFM	CZ13	3	83%	0.295	0.04	0.094
PGE.52	SFM	CZ13	4	100%	0.393	0.04	0.150
PGE.53	SFM	CZ13	3	100%	0.295	0.04	0.112
PGE.54	SFM	CZ13	3	100%	0.295	0.04	0.112
PGE.55	SFM	CZ13	3	100%	0.295	0.04	0.112
PGE.56	SFM	CZ13	3	100%	0.295	0.04	0.112
PGE.57	SFM	CZ13	3	100%	0.295	0.04	0.112
PGE.58	SFM	CZ13	3	117%	0.295	0.04	0.131
PGE.59	SFM	CZ13	3	83%	0.295	0.04	0.094
PGE.60	SFM	CZ13	3.5	71%	0.344	0.04	0.094
PGE.61	SFM	CZ13	3.5	100%	0.344	0.04	0.131
PGE.62	SFM	CZ13	2.5	120%	0.246	0.04	0.112

Site ID	Building Type	Climate Zone	Tons Tracked	IR	Ex Ante Gross kW	Ex Post UES kW	Ex Post Gross kW
PGE.63	SFM	CZ13	3	100%	0.295	0.04	0.112
PGE.64	SFM	CZ13	3	100%	0.295	0.04	0.112
SCE.1	DMo	CZ08	7	100%	0.422	0.09	0.632
SCE.2	DMo	CZ09	4	100%	0.342	0.10	0.413
SCE.3	DMo	CZ09	4	100%	0.342	0.10	0.413
SCE.4	DMo	CZ10	6	83%	0.540	0.12	0.594
SCE.5	DMo	CZ10	12	100%	1.079	0.12	1.426
SCE.6	DMo	CZ10	6	50%	0.593	0.12	0.356
SCE.7	DMo	CZ10	6.5	100%	0.649	0.12	0.772
SCE.8	DMo	CZ10	4	100%	0.360	0.12	0.475
SCE.9	DMo	CZ10	4	100%	0.360	0.12	0.475
SCE.10	DMo	CZ10	3	100%	0.270	0.12	0.356
SCE.11	DMo	CZ10	3	100%	0.296	0.12	0.356
SCE.12	DMo	CZ15	4	100%	0.335	0.14	0.577
SCE.13	DMo	CZ15	5	100%	0.419	0.14	0.721
SCE.14	SFM	CZ08	4	100%	0.179	0.02	0.089
SCE.15	SFM	CZ10	4	100%	0.395	0.03	0.137
SCE.16	SFM	CZ10	6	100%	0.593	0.03	0.206
SCE.17	SFM	CZ10	7	114%	0.692	0.03	0.274
SCE.18	SFM	CZ10	5	100%	0.494	0.03	0.171
SCE.19	SFM	CZ10	3	100%	0.296	0.03	0.103
SCE.20	SFM	CZ10	5	100%	0.494	0.03	0.171
SCE.21	SFM	CZ10	3	100%	0.296	0.03	0.103
SCE.22	SFM	CZ10	3	100%	0.296	0.03	0.103
SCE.23	SFM	CZ10	3	100%	0.296	0.03	0.103
SCE.24	SFM	CZ10	7	50%	0.692	0.03	0.120
SCE.25	SFM	CZ10	7.5	100%	0.741	0.03	0.257
SCE.26	SFM	CZ10	3.5	100%	0.346	0.03	0.120
SCE.27	SFM	CZ10	7.5	107%	0.741	0.03	0.274
SCE.28	SFM	CZ10	7	50%	0.692	0.03	0.120
SCE.29	SFM	CZ10	5	100%	0.494	0.03	0.171
SCE.30	SFM	CZ14	7	93%	0.595	0.05	0.327
SCE.31	SFM	CZ14	4	100%	0.340	0.05	0.201
SCE.32	SFM	CZ14	5	100%	0.425	0.05	0.252
SCE.33	SFM	CZ14	4.5	89%	0.383	0.05	0.201
SCE.34	SFM	CZ14	3	100%	0.255	0.05	0.151
SCE.35	SFM	CZ15	3.5	100%	0.378	0.04	0.126
SCE.36	SFM	CZ15	4	100%	0.432	0.04	0.143

Site ID	Building Type	Climate Zone	Tons Tracked	IR	Ex Ante Gross kW	Ex Post UES kW	Ex Post Gross kW
SCE.37	SFM	CZ15	5	60%	0.540	0.04	0.108
SCE.38	SFM	CZ15	3.5	100%	0.378	0.04	0.126
SCE.39	SFM	CZ15	5	60%	0.540	0.04	0.108
SCE.40	SFM	CZ16	3	100%	0.175	0.03	0.095
SCE.41	SFM	CZ16	4	100%	0.233	0.03	0.127
SDGE.1	DMo	CZ10	2.5	100%	0.225	0.12	0.288
SDGE.2	DMo	CZ10	4	100%	0.360	0.12	0.462
SDGE.3	DMo	CZ10	3	0%	0.270	0.12	0.000
SDGE.4	DMo	CZ10	2.5	100%	0.225	0.12	0.288
SDGE.5	DMo	CZ10	2.5	100%	0.225	0.12	0.288
SDGE.6	MFM	CZ10	36	100%	3.238	0.06	2.286
SDGE.7	MFM	CZ10	12	100%	1.079	0.06	0.762
SDGE.8	MFM	CZ10	155	100%	13.941	0.06	9.841
SDGE.9	MFM	CZ10	80	100%	7.195	0.06	5.079
SDGE.10	SFM	CZ10	3	100%	0.270	0.03	0.102
SDGE.11	SFM	CZ10	3	100%	0.270	0.03	0.102
SDGE.12	SFM	CZ10	2	100%	0.180	0.03	0.068

Table 6-27. Fan motor replacement site-level results (therms)

Site ID	Building Type	Climate Zone	Tons Tracked	IR	Ex Ante Gross Therm	Ex Post UES Therm	Ex Post Gross Therm
PGE.1	DMo	CZ04	2	100%	-1.37	-2.15	-4.310
PGE.2	DMo	CZ04	2	100%	-1.370	-2.15	-4.310
PGE.3	DMo	CZ11	2.5	160%	-2.868	-2.67	-10.689
PGE.4	DMo	CZ11	3.5	100%	-4.015	-2.67	-9.353
PGE.5	DMo	CZ13	4	100%	-2.182	-2.72	-10.897
PGE.6	DMo	CZ13	4	100%	-2.182	-2.72	-10.897
PGE.7	DMo	CZ13	2	150%	-1.091	-2.72	-8.173
PGE.8	DMo	CZ13	2.5	120%	-1.364	-2.72	-8.173
PGE.9	MFM	CZ11	2	100%	-3.226	-1.55	-3.104
PGE.10	MFM	CZ11	2	100%	-3.226	-1.55	-3.104
PGE.11	MFM	CZ11	2	100%	-3.226	-1.55	-3.104
PGE.12	MFM	CZ11	2	100%	-3.226	-1.55	-3.104
PGE.13	MFM	CZ11	2	100%	-3.226	-1.55	-3.104
PGE.14	MFM	CZ11	2	100%	-3.226	-1.55	-3.104
PGE.15	MFM	CZ13	2.5	100%	-2.545	-1.33	-3.327
PGE.16	MFM	CZ13	2	100%	-2.036	-1.33	-2.662
PGE.17	MFM	CZ13	2	100%	-2.036	-1.33	-2.662
PGE.18	MFM	CZ13	2	100%	-2.036	-1.33	-2.662
PGE.19	MFM	CZ13	2	100%	-2.036	-1.33	-2.662
PGE.20	MFM	CZ13	2	100%	-2.036	-1.33	-2.662
PGE.21	SFM	CZ11	3	67%	-6.300	-1.82	-3.643
PGE.22	SFM	CZ11	3	117%	-6.300	-1.82	-6.376
PGE.23	SFM	CZ11	3	167%	-6.300	-1.82	-9.109
PGE.24	SFM	CZ11	6	133%	-12.600	-1.82	-14.574
PGE.25	SFM	CZ11	3	100%	-6.300	-1.82	-5.465
PGE.26	SFM	CZ11	3	167%	-6.300	-1.82	-9.109
PGE.27	SFM	CZ11	3	117%	-6.300	-1.82	-6.376
PGE.28	SFM	CZ11	3	117%	-6.300	-1.82	-6.376
PGE.29	SFM	CZ11	3	117%	-6.300	-1.82	-6.376
PGE.30	SFM	CZ11	3	133%	-6.300	-1.82	-7.287
PGE.31	SFM	CZ11	3	100%	-6.300	-1.82	-5.465
PGE.32	SFM	CZ11	3	100%	-6.300	-1.82	-5.465
PGE.33	SFM	CZ11	3	133%	-6.300	-1.82	-7.287
PGE.34	SFM	CZ12	2.5	100%	-5.375	-2.17	-5.428
PGE.35	SFM	CZ12	4	100%	-8.600	-2.17	-8.685
PGE.36	SFM	CZ12	3	83%	-6.450	-2.17	-5.428
PGE.37	SFM	CZ12	3	117%	-6.450	-2.17	-7.599

Site ID	Building Type	Climate Zone	Tons Tracked	IR	Ex Ante Gross Therm	Ex Post UES Therm	Ex Post Gross Therm
PGE.38	SFM	CZ12	3	100%	-6.450	-2.17	-6.513
PGE.39	SFM	CZ12	2	125%	-4.300	-2.17	-5.428
PGE.40	SFM	CZ12	2	100%	-4.300	-2.17	-4.342
PGE.41	SFM	CZ12	3	100%	-6.450	-2.17	-6.513
PGE.42	SFM	CZ12	2.5	80%	-5.375	-2.17	-4.342
PGE.43	SFM	CZ12	3.5	100%	-7.525	-2.17	-7.599
PGE.44	SFM	CZ12	3	100%	-6.450	-2.17	-6.513
PGE.45	SFM	CZ12	3	100%	-6.450	-2.17	-6.513
PGE.46	SFM	CZ12	3	100%	-6.450	-2.17	-6.513
PGE.47	SFM	CZ12	2.5	100%	-5.375	-2.17	-5.428
PGE.48	SFM	CZ12	3	67%	-6.450	-2.17	-4.342
PGE.49	SFM	CZ13	5	100%	-5.650	-2.17	-10.858
PGE.50	SFM	CZ13	3	67%	-3.390	-2.17	-4.343
PGE.51	SFM	CZ13	3	83%	-3.390	-2.17	-5.429
PGE.52	SFM	CZ13	4	100%	-4.520	-2.17	-8.686
PGE.53	SFM	CZ13	3	100%	-3.390	-2.17	-6.515
PGE.54	SFM	CZ13	3	100%	-3.390	-2.17	-6.515
PGE.55	SFM	CZ13	3	100%	-3.390	-2.17	-6.515
PGE.56	SFM	CZ13	3	100%	-3.390	-2.17	-6.515
PGE.57	SFM	CZ13	3	100%	-3.390	-2.17	-6.515
PGE.58	SFM	CZ13	3	117%	-3.390	-2.17	-7.600
PGE.59	SFM	CZ13	3	83%	-3.390	-2.17	-5.429
PGE.60	SFM	CZ13	3.5	71%	-3.955	-2.17	-5.429
PGE.61	SFM	CZ13	3.5	100%	-3.955	-2.17	-7.600
PGE.62	SFM	CZ13	2.5	120%	-2.825	-2.17	-6.515
PGE.63	SFM	CZ13	3	100%	-3.390	-2.17	-6.515
PGE.64	SFM	CZ13	3	100%	-3.390	-2.17	-6.515
SCE.1	DMo	CZ08	7	100%	0.000	-1.30	-9.098
SCE.2	DMo	CZ09	4	100%	0.000	-1.76	-7.040
SCE.3	DMo	CZ09	4	100%	0.000	-1.76	-7.040
SCE.4	DMo	CZ10	6	83%	0.000	-2.15	-10.744
SCE.5	DMo	CZ10	12	100%	0.000	-2.15	-25.784
SCE.6	DMo	CZ10	6	50%	-4.092	-2.15	-6.446
SCE.7	DMo	CZ10	6.5	100%	0.000	-2.15	-13.967
SCE.8	DMo	CZ10	4	100%	0.000	-2.15	-8.595
SCE.9	DMo	CZ10	4	100%	0.000	-2.15	-8.595
SCE.10	DMo	CZ10	3	100%	0.000	-2.15	-6.446
SCE.11	DMo	CZ10	3	100%	-2.046	-2.15	-6.446

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SCE.12	DMo	CZ15	4	100%	0.000	-1.04	-4.166
SCE.13	DMo	CZ15	5	100%	0.000	-1.04	-5.207
SCE.14	SFM	CZ08	4	100%	-2.968	-1.15	-4.616
SCE.15	SFM	CZ10	4	100%	-2.728	-1.64	-6.580
SCE.16	SFM	CZ10	6	100%	-4.092	-1.64	-9.869
SCE.17	SFM	CZ10	7	114%	-4.774	-1.64	-13.159
SCE.18	SFM	CZ10	5	100%	-3.410	-1.64	-8.225
SCE.19	SFM	CZ10	3	100%	-2.046	-1.64	-4.935
SCE.20	SFM	CZ10	5	100%	-3.410	-1.64	-8.225
SCE.21	SFM	CZ10	3	100%	-2.046	-1.64	-4.935
SCE.22	SFM	CZ10	3	100%	-2.046	-1.64	-4.935
SCE.23	SFM	CZ10	3	100%	-2.046	-1.64	-4.935
SCE.24	SFM	CZ10	7	50%	-4.774	-1.64	-5.757
SCE.25	SFM	CZ10	7.5	100%	-5.115	-1.64	-12.337
SCE.26	SFM	CZ10	3.5	100%	-2.387	-1.64	-5.757
SCE.27	SFM	CZ10	7.5	107%	-5.115	-1.64	-13.159
SCE.28	SFM	CZ10	7	50%	-4.774	-1.64	-5.757
SCE.29	SFM	CZ10	5	100%	-3.410	-1.64	-8.225
SCE.30	SFM	CZ14	7	93%	-6.916	-1.83	-11.877
SCE.31	SFM	CZ14	4	100%	-3.952	-1.83	-7.309
SCE.32	SFM	CZ14	5	100%	-4.940	-1.83	-9.136
SCE.33	SFM	CZ14	4.5	89%	-4.446	-1.83	-7.309
SCE.34	SFM	CZ14	3	100%	-2.964	-1.83	-5.481
SCE.35	SFM	CZ15	3.5	100%	-0.529	-0.54	-1.902
SCE.36	SFM	CZ15	4	100%	-0.604	-0.54	-2.174
SCE.37	SFM	CZ15	5	60%	-0.755	-0.54	-1.631
SCE.38	SFM	CZ15	3.5	100%	-0.529	-0.54	-1.902
SCE.39	SFM	CZ15	5	60%	-0.755	-0.54	-1.631
SCE.40	SFM	CZ16	3	100%	-6.570	-4.61	-13.838
SCE.41	SFM	CZ16	4	100%	-8.760	-4.61	-18.451
SDGE.1	DMo	CZ10	2.5	100%	0.000	-2.03	-5.069
SDGE.2	DMo	CZ10	4	100%	0.000	-2.03	-8.110
SDGE.3	DMo	CZ10	3	0%	0.000	-2.03	0.000
SDGE.4	DMo	CZ10	2.5	100%	0.000	-2.03	-5.069
SDGE.5	DMo	CZ10	2.5	100%	0.000	-2.03	-5.069
SDGE.6	MFM	CZ10	36	100%	0.000	-0.78	-28.114
SDGE.7	MFM	CZ10	12	100%	0.000	-0.78	-9.371
SDGE.8	MFM	CZ10	155	100%	0.000	-0.78	-121.047

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SDGE.9	MFM	CZ10	80	100%	0.000	-0.78	-62.476
SDGE.10	SFM	CZ10	3	100%	0.000	-1.57	-4.698
SDGE.11	SFM	CZ10	3	100%	0.000	-1.57	-4.698
SDGE.12	SFM	CZ10	2	100%	0.000	-1.57	-3.132