IMPACT EVALUATION REPORT

Commercial HVAC Sector – Program Year 2020

California Public Utility Commission

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1 EXECUTIVE SUMMARY

This report presents the electric and natural gas energy savings evaluation of commercial heating, ventilation, and air conditioning (HVAC) equipment in ratepayer-funded energy-efficiency programs in program year 2020 (PY2020). DNV estimated energy and demand savings for the replacement HVAC systems technology group and an estimate of program influence, called the net-to-gross ratio (NTGR) for the boiler technology groups. These technology groups are implemented across programs offered by the following program administrators (PAs): Southern California Edison (SCE), Southern California Gas Company (SCG), and Pacific Gas and Electric Company (PG&E). We conducted this evaluation as part of the California Public Utilities Commission (CPUC) Energy Division (ED) Evaluation, Measurement & Verification contract.

The primary goals of this PY2020 evaluation were to:

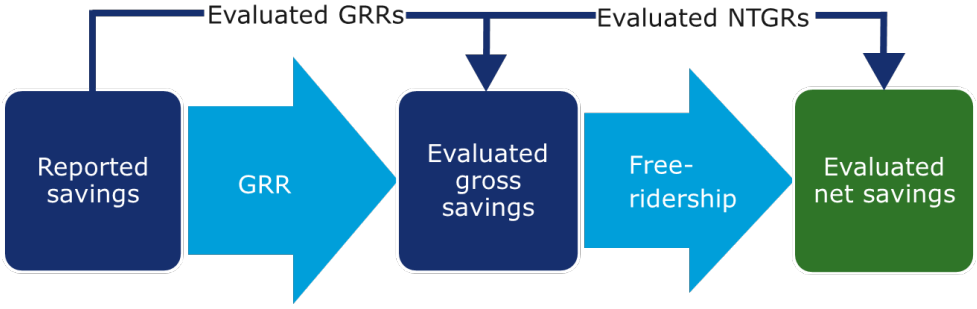
- Assess savings for electric demand in kilowatts (kW), electric consumption in kilowatt-hours (kWh), and gas consumption in therms with a focus on quantifying peak demand impacts for the replacement HVAC systems technology group.
- Determine the savings that result because of program influence with respect to end users, decision-makers, and distributors for the boiler technology groups.
- 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 savings.

For the replacement HVAC systems technology group, the first major task was estimating the gross savings. Gross savings are the changes in energy and power demand that resulted from energy efficiency program activities, regardless of what factors may have motivated program participants to take action. We developed ratios of the evaluated gross savings estimated to the PA reported gross savings values to determine how much savings were realized through the evaluation, referred to as gross realization rates (GRRs) as shown in Figure 1-1.

For the boiler technology groups we estimated the amount of savings that resulted from the program, referred to as net savings. 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.

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



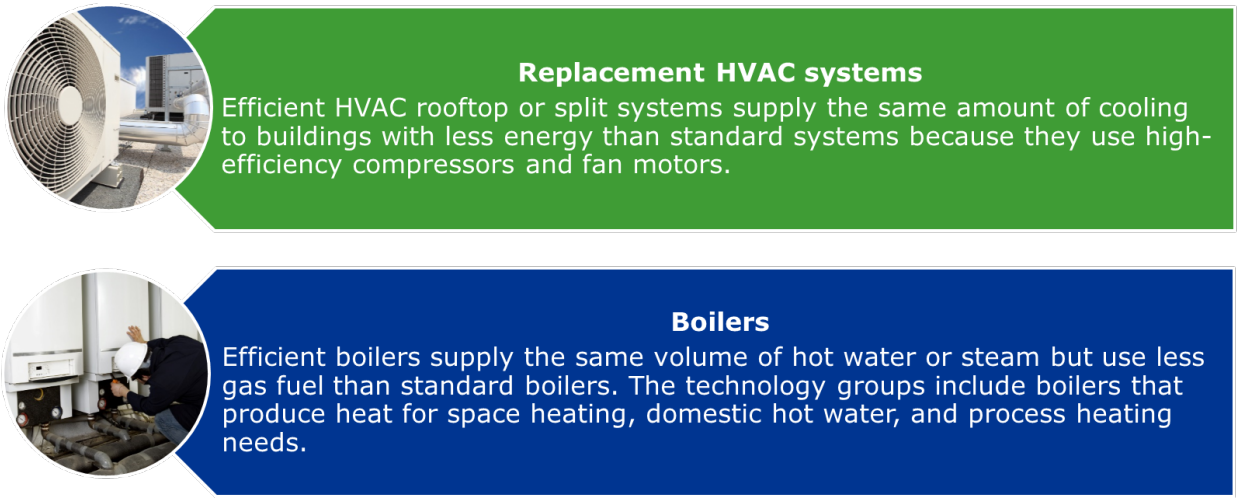
1.1 Study background and approach

The DNV evaluation team selected the HVAC technology for this PY2020 commercial sector HVAC evaluation based on the reported savings (kWh, kW, therms) and trends in savings claims. Along with the Commission ED staff, the evaluation team sought stakeholder engagement on the proposed technology group selection through the HVAC Project Coordination Group meetings and through the HVAC workplan engagement process with the PAs. The replacement HVAC systems technology group was selected for gross savings evaluation based on its ongoing high contribution to statewide energy savings and energy savings uncertainty. Starting in 2021, the replacement HVAC systems technology group changed from PA-specific program delivery mechanisms to a statewide program. Knowing this shift in delivery structure will impact the program influence and net savings, we did not perform a net savings evaluation on the PY2020 replacement HVAC systems technology group. This report utilized the PAs' reported NTGR for the replacement HVAC systems technology group.

The boiler technology groups were selected for a net savings evaluation because of the consistently large contribution to gas savings they represent and because of high NTGR uncertainty seen with HVAC boiler technologies in past evaluations. The last HVAC boiler evaluation results found more gross savings certainty (102% gross therms realization rate), so we did not evaluate the PY2020 boiler gross savings. This report utilized the PA's reported gross savings for the boiler technology groups.

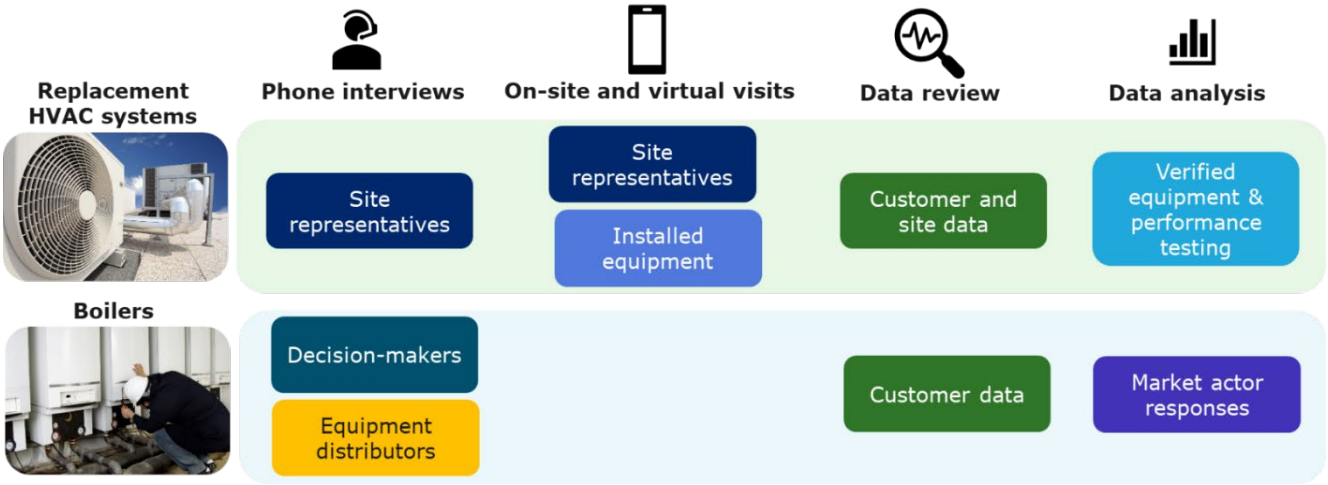
The PY2020 evaluation approaches used for the selected HVAC technologies were built on previous HVAC program evaluation methods. To estimate gross savings, we surveyed end users, collected site-specific data, performed equipment verification, and conducted performance testing on certain technologies. Net savings were estimated from surveys of end users or decision-makers and from interviews with equipment distributors. The two technology groups selected for this evaluation (PY 2020) are summarized in Figure 1-2.

Figure 1-2. Evaluated commercial HVAC technologies



It should be noted that both PY2020 and the subsequent evaluation period were subject to COVID-19 impacts. Potential pandemic-related impacts were examined during the technology selection process, development of the evaluation methodology, and during interviews with the PAs, equipment distributors, and end-user participants. The evaluation methodology focused on parameters that are unaffected by impacts stemming from the global pandemic. Neither customer billing data nor long-term equipment monitoring were collected. Figure 1-3 shows the various data collection and analysis methods to calculate the savings that were used to evaluate the two technology groups.

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 two technology groups. 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	Reported Net Savings	Evaluated Net Savings	Net Realization Rate (NRR)
Electric Consumption (kWh)			
Replacement HVAC Systems	3,987,111	4,942,329*	124%
HVAC Boilers	306,675	98,126	32%
Water Heating Boilers	-	-	-
Process Boilers	-	-	-
Peak Electric Demand (kW)			
Replacement HVAC Systems	1,664	1,946	117%
HVAC Boilers	14	4	33%
Water Heating Boilers	-	-	-
Process Boilers	-	-	-
Gas Consumption (therms)			
Replacement HVAC Systems	34,754	33,175	95%
HVAC Boilers	437,707	120,864	28%
Water Heating Boilers	350,165	64,077	18%
Process Boilers	159,863	159,863	100%

* The evaluated net savings adopted the PA's reported NTGR for the replacement HVAC systems technology group.

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

1.2.1 Replacement HVAC systems

PG&E and SCE were the two PAs to report savings for installing energy-efficient replacement HVAC systems in PY2020. An energy efficient replacement HVAC system uses less energy than a standard efficiency system while providing equivalent thermal comfort to the building occupants. The incentives for these systems were primarily issued to equipment distributors. To receive the incentives, distributors are required to document where the reported HVAC systems are installed at the site, confirm the site is within the PA's service territory, and document basic information about the installed systems that serves to validate the claims meet the incentive's efficiency requirements. The level of detail documented and submitted by distributors varies considerably, which creates a barrier to evaluators when seeking to verify systems were in fact installed and are realizing savings.

Overall, first-year GRRs for kWh, kW, and therms were 124%, 117%, and 95%, respectively (Table 1-2).

Table 1-2. Statewide first-year savings summary for replacement HVAC system

Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR*	Reported Net Savings	Evaluated Net Savings	NRR
Electric consumption (kWh)							
5,672,099	124%	7,031,000	70%	70%	3,987,111	4,942,329	124%
Peak electric demand (kW)							
2,363	117%	2,764	70%	70%	1,664	1,946	117%
Gas consumption (therms)							
51,531	95%	49,190	67%	67%	34,754	33,175	95%

* The evaluated net savings adopted the PA's reported NTGR.

The evaluated savings appear to be significantly higher than reported for electric savings and very close to reported for gas savings. Various unique factors influenced the savings to go both up and down. The most significant impacts that led to increased savings were:

- **Higher rated efficiency:** For most of the systems we observed in the field, the verified installed unit efficiency rating exceeded the reported efficiency rating. This trend was especially pronounced for the larger systems, where the evaluator determined all 59 larger systems were rated at a higher efficiency level than reported. Because the rebated systems are rated to perform more efficiently than the PAs reported, they are generating more savings than the PAs reported.
- **Undersized systems reported:** One PA reported over 440 systems with a unit capacity listed as 0.1 ton in size, but the equipment model numbers indicate the systems are all normal sized between 3-20 tons. The evaluator verified 11 of these systems in the field and confirmed all were normal sized. The PA reported savings for these systems is a fraction of what it should have been because it was based on a unit savings of 0.1. This impact increased the evaluated energy savings by approximately 4%.
- **Under reported part-load savings:** One PA reported savings for larger HVAC systems assuming full-load performance, which evaluators verified achieved high cooling efficiency in both part-load performance and full-load performance. Because these units are achieving high-efficiency performance in more cooling conditions and more hours of the year than reported, the evaluated savings increased by approximately 9%.

The following factors resulted in lower evaluated savings:

- **Outside PA territory:** Five of the forty-three sampled sites are outside the PAs' electric service territories and are served by municipal electric service providers. This impact reduced the evaluated energy savings by approximately 8%.
- **Lower rated efficiency:** The evaluators encountered three smaller size systems rated at an efficiency level two tiers below the level reported.
- **Missing units**: Across the 43 site visits evaluators performed, we found 19 of 281 systems were not present anywhere at the reported business address. This included one site where none of the six reported systems were present. The remaining missing systems were reported at sites with other verified systems installed and present. This impact reduced the evaluated energy savings by approximately 8%.

While the program savings results demonstrate the statewide replacement HVAC systems technology group is performing well, the evaluated results show considerable variation in savings. Within the program participant data delivered to the

CPUC and DNV, over half of the sites were missing valid business names, over 60% were missing valid phone numbers, and over two-thirds were missing a valid contact name for the end user. Because of these data gaps, the recruiting and data collection effort fell considerably short of the targeted 85 site sample with only 43 site visits. The evaluated results come with some uncertainty. The uncertainty is a product of both the reduced sample size and site by site variations of the evaluated savings. All the steps the evaluators took to meet the sample targets are presented in section 3.4 of the report.

1.2.2 Commercial boilers

PG&E and SCG reported savings in PY2020 under the boiler technology groups. The DNV team evaluated three statewide boiler measure packages: HVAC, water heating, and process boilers. Relative to standard boilers, these efficient boilers use incrementally less gas fuel to produce the same heat than the equivalent standard efficiency units. The evaluated NTGRs were 17% +/- 6%[1] for HVAC boilers and 11% +/- 4% for water heating boilers as shown in Table 1-3 below, along with first-year electric and gas savings. These NTGR values indicate that the commercial boiler programs had minor effect on end users' purchasing decisions. There was one end-user survey respondent for process boiler measure group, which is insufficient to calculate a statistically valid NTGR. We applied the reported net savings value for the evaluated net savings.

Table 1-3. First-year energy savings summary for commercial boilers

Boiler Technology Group	Reported Gross Savings	GRR*	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR	Reported Net Savings	Evaluated Net Savings	NRR
Electric consumption (kWh)								
HVAC	501,453	100%	501,453	61%	20%	306,675	98,126	32%
Water Heating	-	-	-	-	-	-	-	-
Process	-	-	-	-	-	-	-	-
Peak electric demand (kW)								
HVAC	23	100%	23	60%	20%	14	4	33%
Water Heating	-	-	-	-	-	-	-	-
Process	-	-	-	-	-	-	-	-
Gas consumption (therms)								
HVAC	718,377	100%	718,377	61%	17%	437,707	120,864	28%
Water Heating	591,661	100%	591,661	59%	11%	350,165	64,077	18%
Process	266,439	100%	266,439	60%	n/a	159,863	159,863	100%

* The evaluated gross savings adopted the PA's reported gross savings for the boiler technology groups.

The commercial boiler programs at PG&E and SCG were predominantly midstream programs providing incentives to influence distributors to stock, upsell, and (at the distributors' discretion) reduce the price of high-efficiency boilers. This means that to have an effect on the final decision to purchase a high-efficiency boiler, the program must first change the distributors' behaviors and then those behaviors have to make a difference to the person purchasing from the distributors. DNV surveyed both the distributors and the buyers (end users) to capture the program influence.

For the distributors, the program had little effect on their stocking or upselling behaviors. Below is a summary of distributor survey responses:

[1] Absolute precision at 90% confidence interval.

- Distributors are stocking high-efficiency models 5% more often and not upselling any more often because of the program.
- The majority (92%) of distributors did indicate that they pass a significant portion (41%) of the rebates to buyers. Note that the program does not require the distributors to pass any of the rebates to buyers.
- Distributors also reported that reducing the incremental cost between standard and high-efficiency models was the most effective way for them to sell high-efficiency options. It should be noted that DNV's conversations with program managers as part of previous program year evaluation indicated that the program logic is based on altering distributors' stocking and upselling practices, not necessarily in reducing the incremental cost of high-efficiency models.

From the buyer or end-user perspective, DNV's surveys indicate that dealer upselling had the most influence in their decision to purchase a high-efficiency boiler. End-users also indicated that it was not very important whether the dealer or contractor they purchased the boiler from had the unit immediately available. Below is a summary of buyer or end-user survey responses:

- Most (78%) end users said they were influenced by the recommendation of either the distributor or contractor to install a high-efficiency boiler.
- Contrary to the distributors' responses about lower equipment costs as an effective influence, 70% of end users indicated they would be willing to purchase high-efficiency units even if the equipment included rebate costs. For example, if the rebate was $100 and the end users paid $500, the end users indicated they would be willing to purchase the same unit for $600.
- Most (53%) end users indicated that they would have waited or gone to another supplier to ensure they got a high-efficiency model.

End-user survey responses clearly show distributor actions and recommendations do make a difference in their decision-making process; however, distributor responses indicate the boiler programs had a marginal market-effect on their recommendations to contractors and end-users. While a few distributors that represented a smaller portion of the market reported the program had some impact on their recommendations, the larger distributors reported they would make similar recommendations in the absence of the program. Also, survey findings show the distributors are already stocking and upselling high-efficiency units. The NTGRs for the commercial boiler technology groups are low because the programs did little to change distributor behaviors.

1.3 Study recommendations

In this section we provide key findings, illustrated with the key symbol, and recommendations, shown by the gear symbol. Recommendations include supporting context for energy service providers. A detailed discussion of findings, recommendations, and implications are provided in section 5 of the report.

PA tracking and participant data fails to adequately document claims. Across all evaluated technology groups, the PAs were unable to consistently provide critical pieces of data essential for third-party evaluators to validate and assess claimed savings. Overall, site contact names were missing or invalid for over two-thirds of requested sites and phone numbers were missing or invalid for over half of all requested sites. This resulted in evaluation data collection delays, reduced site and survey counts, poor certainty, and above all, questions whether all reported claims are actually installed and operating as intended.

PAs should increase efforts to provide accurate and consistent tracking documentation. The evaluator recommends the PAs and their implementers increase efforts to train participating midstream program distributors on proper documentation requirements, consistent and accurate data recording practices, as well as regular quality control reviews of the data prior to submittal. Systematically capturing a valid site contact name, phone number, email address, and business name should be incorporated into the program data requirements.

PAs claiming electric savings outside their service territory. Evaluators visited five sites where the PAs claimed both electric and gas savings for the installed systems, but the sites' electricity is provided by a municipal electric utility. The evaluated gross kWh and kW savings for claims installed at these sites were zero because the savings is occurring outside the PAs service territory. Additionally, the incentive is benefiting an electric end-use customer that is not contributing to the Public Purpose Program (PPP) Funds. This resulted in an overall decrease in electric gross savings 7% for this technology group.

PAs should not claim electric savings for installations outside their service territory. The evaluator recommends the PAs check to confirm the claimed system's installation address has a valid electric and gas account before claiming the corresponding savings. Additionally, they should make sure that the end-use customer contributes to the PPP Funds.

Poor net savings realization is driven by programs' lack of influence on distributor recommendations. Distributors reported that they would recommend program eligible high-efficiency units at the same frequency without the program. End-user surveys indicate decisions are most driven by distributor recommendations and by price to a lesser extent. The participating distributors we spoke to claim their recommendations have minimal impact on purchasing decisions, which represents a lost opportunity because end users say otherwise.

PAs and implementers should encourage distributors to upsell highest efficiency tier boilers. The evaluator recommends future programs consider offering increased incentives on the highest-efficiency tier boilers so distributors increase high-efficiency equipment recommendations. Most end-user survey respondents (70%) reported they would pay full price for high-efficiency boilers if that's what their distributor or contractor recommended. By providing an increased incentive to distributors for selling the higher-efficiency tier units they will be more likely to upsell the higher-efficiency units and achieve greater net savings. The PAs should dutifully notify distributors and other market actors of expected large program changes for boiler measures.

2 INTRODUCTION

This report presents the electric and natural gas energy savings evaluation of commercial heating, ventilation, and air conditioning (HVAC) equipment in ratepayer-funded energy-efficiency programs in program year 2020 (PY2020). DNV estimated gross energy and demand savings for the replacement HVAC systems technology group and the net-to-gross ratio (NTGR) for the boiler technology groups. The boiler technology groups include HVAC boilers, water heating boilers, and process boilers. These technology groups are implemented across programs offered by the following program administrators (PAs): Southern California Edison (SCE), Southern California Gas Company (SCG), and Pacific Gas and Electric Company (PG&E). DNV conducted this evaluation as part of the California Public Utilities Commission (CPUC) Energy Division (ED) Evaluation, Measurement & Verification Group A contract.

2.1 Evaluation objectives and researchable issues

The primary objective of this evaluation is to assess the gross and net kWh, peak kW, and therm savings achieved from the four selected technology groups across the HVAC portfolio from the 2020 programs offered by SCG, SCE, and PG&E. The evaluated measures are described in greater detail in the next section.

The evaluation objectives and researchable issues include the following:

- 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 reported 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 technology groups.
- Provide results and data that will assist with updating reported measure packages (measure packages) and the California Database for Energy Efficiency Resources (DEER) values.
- 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.
- 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 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 market actors and end-use customers.

2.2 Evaluated technology groups

The DNV team based its commercial sector evaluation on an analysis of the PY2020 HVAC technology groups' contributions to lifecycle savings (kWh, kW, therms), consideration for whether a technology group had been evaluated recently, and trends in the savings claims for each technology group. The Commission staff and the evaluation team sought stakeholder engagement on both the process and the proposed technology group selection through the HVAC Project Coordination Group meetings and the HVAC Workplan engagement process with the PAs.

The replacement HVAC technology group was selected for gross savings evaluation based on its continued high contribution to lifecycle gross kWh (72%) and kW (79%) savings within commercial HVAC and the commercial sector overall (16% for kWh, 25% for kW) and outstanding gross savings uncertainty. Primarily evaluated as the rooftop or split system technology group in the PY2018 and PY2019 evaluations, evaluated gross kWh realization rates were 55% and 49%

respectively. Starting in 2021, the replacement HVAC systems technology group changed from PA-specific program delivery mechanisms to a statewide program. Knowing this shift in delivery structure would impact the program influence and net savings attribution, DNV did not perform a net savings evaluation on the PY2020 replacement HVAC systems technology group. This evaluation of net savings adopted the PAs' reported NTGR for the replacement HVAC systems technology group.

The boiler technology groups (HVAC, water heating, and process) were selected for a net attribution evaluation because of their consistently large contribution to lifecycle therm savings claims for the overall commercial sector (18% in PY2020) and because of the high uncertainty of ex post net-to-gross ratio (NTGR) results from PY2017 and PY2018 HVAC boiler technology group studies that did not agree with ex ante NTGR values. The most recent HVAC boiler evaluation results found more gross savings certainty (102% gross therms realization rate), so we did not evaluate the PY2020 boiler gross savings. The evaluated gross savings adopted the PA's reported gross savings for the boiler technology groups.

The technology groups selected in this evaluation were offered to end users primarily through midstream channels with a small percentage being offered through downstream delivery channels. The methodologies for evaluating these technology groups were formed around how the programs influence the way the technologies are offered to end users.

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 due to the influence of the program
- Unit energy savings (UES): the savings produced per measure or unit

We addressed the parameters that feed into the evaluated gross savings estimates for the replacement HVAC systems technology group and the parameters that feed into the evaluated net savings for the boiler technology groups. The boiler technology group was not included in the PY2019 evaluation but was evaluated in the PY2018 and PY2017 evaluations. The PY2017 evaluation net survey effort had difficulties recruiting the appropriate decision-makers for the boiler claims and was unable to complete a sufficient sample of NTG surveys to revise the default NTG ratio. The PY2018 boiler evaluation chose to revisit the net impact survey effort with boiler measures claims from both PY2017 and PY2018 but applied the PY2017 102% therm gross realization rate to the combined PY2017 and PY2018 results. While difficulties contacting decision-makers for the boiler measure claims persisted, the overall evaluated therm net-to-gross ratio was 19% with an achieved relative precision of 28% at 90% confidence.

We provide details on the four evaluated technology groups and the programs that provide below.

2.2.1 Replacement HVAC systems

The replacement HVAC systems technology group consists of new, above-code efficiency air conditioning or heat pump HVAC units, either split or unitary, installed as either a normal replacement of existing equipment or in new construction applications. The base case is a new packaged or split system meeting Title-24 energy code minimum efficiency requirements. High efficiency packaged or split systems save energy by proving greater efficiency and reduce on/off cycling. These systems provide more efficient dehumidification, cooling, and heating without sacrificing occupant comfort. Other benefits of high-efficiency units are increased effectiveness and optimal operation of economizer, dampers, sensors, and controls. If the installation of the rooftop or split system achieves optimal system efficiency, power input to the unit will be reduced and the unit will achieve the operating temperature setpoint more quickly than a standard efficiency unit would require.

Figure 2-1. A packaged commercial rooftop unit (RTU)

Commercial replacement HVAC systems routinely account for a very high portion of statewide electric energy and peak demand savings and a small portion of the statewide therm savings for deemed measures. In PY2020, replacement HVAC systems were claimed by PG&E and SCE under the Commercial HVAC and Non-residential HVAC Programs, respectively. A total of 7,056 claims were filed that included over 104 GWh in Lifecycle Gross Electric savings under those two programs. However, 81% of those claims were supported by new statewide measure packages (formerly workpapers) and the remaining 19% of claims were supported by PA-specific measure packages that are being phased out completely. To maximize current and future value, the evaluation team focused the PY2020 evaluation efforts on Replacement HVAC System claims supported by the statewide measure packages introduced in 2020.

The measure package IDs and descriptions for the three new statewide measure packages under this technology group are as follows:

- SWHC013-01: Unitary Air-Cooled Air Conditioner, Over 65 kBtu/hr
- SWHC014-01: Unitary Air-Cooled Air Conditioner or Heat Pump, Under 65 kBtu/hr
- SWHC043-01: Multiple Capacity Unitary Air-Cooled Commercial Air Conditioners Between 65 and 240 kBtu/hr

The summary of program claims for statewide measure package replacement HVAC System measures are summarized in Table 2-1.

Table 2-1. Summary of PY2020 replacement HVAC systems

Program ID	Program Name	Measure package Description	Count of Claims	Reported Lifecycle Gross Therm	Reported Lifecycle Gross kWh	Total Gross kW
PGE21015	Commercial HVAC	Unitary Air-Cooled Air Conditioner or Heat Pump, Under 65 kBtu/hr, Commercial	3,806	584,043	27,417,864	635
		Unitary Air-Cooled Air Conditioner, Over 65 kBtu/hr, Commercial	653	-	6,435,776	274
		Multiple Capacity Unitary Air-Cooled Air Conditioners Between 65 and 240 kBtu/hr, Commercial	225	-	6,408,153	178
SCE-13-SW-002F	Non-residential HVAC Program	Unitary Air-Cooled Air Conditioner or Heat Pump, Under 65 kBtu/hr, Commercial	840	188,919	26,800,177	627
		Unitary Air-Cooled Air Conditioner, Over 65 kBtu/hr, Commercial	365	-	12,989,446	515
		Multiple Capacity Unitary Air-Cooled Air Conditioners Between 65 and 240 kBtu/hr, Commercial	54	-	5,030,062	134
Total			**5,943**	**772,962**	**85,081,479**	**2,363**

2.2.2 Commercial boilers

This technology group includes the installation of a high-efficiency space heating, domestic water heating, and process boilers that meet the program efficiency requirements in place of a less efficient boiler. This technology group includes both

condensing and non-condensing boilers and consists of claims supported by four unique statewide measure packages. For all claim categories, the measure includes high-efficiency options which qualify as new construction or normal replacement event types. A measure specific summary of the four categories includes:

Space Heating Boilers (statewide measure package ID SWHC004-01). This measure case is defined as a high-efficiency space heating boiler that can include either a hot water boiler or a steam boiler along with hot water temperature reset control based on outside air temperature (OAT). The measure case has three capacity categories for the hot-water boiler and two capacity categories for the steam boiler and includes both condensing and non-condensing types for hot water boilers. The measure case has two tiers, each with two different efficiency and hot water temperature reset range and exceeds the 2019 Title 24 code requirement. The measure qualifies for both new construction (NC) and normal replacement (NR) in residential (multi-family) and commercial sectors.[2]

Figure 2-2. An HVAC boiler

Commercial Water Heating Boilers (statewide measure package ID SWWH005-03). This measure case is defined as a more efficient instantaneous water heater or a commercial hot water boiler of similar rated capacity that can include either condensing or non-condensing boilers. The measure uses California Title 20 and Title 24 as the baseline which defines commercial domestic hot water (DHW) boilers as instantaneous water heaters with an input rating of at least 4,000 Btu/hr per gallon of stored water. The measure qualifies for either new construction (NC)/normal replacement (NR) or accelerated replacement in commercial sectors.[3]

Process Boilers (statewide measure package ID SWWH008-01). This measure case is defined as a high-efficiency process boiler, that can include either a hot water process boiler or a steam process boiler. The measure case has two efficiency tiers for the water boiler category and one tier for the steam boiler category and has a minimum qualifying combustion efficiency (CE) requirement. Both water boiler and steam boilers have input ratings of less than 200,000 kBtu/hr The baseline boiler efficiency is based on 2013 Title 24 which requires 82% CE for water boilers and 80% CE for steam boilers. The measure qualifies for normal replacement (NR) in agriculture, commercial, industrial sectors.[4]

Multifamily Boilers (statewide measure package ID SWWH010-01). This measure case is defined as the replacement of a standard efficiency boiler of a multifamily central water heating system with a high-efficiency boiler or multiple instantaneous water heaters that include either a condensing or a non-condensing boiler. The measure case has two efficiency tiers with their minimum qualifying thermal efficiency (TE) requirement. The baseline is a hot water boiler with Title 20 specified minimum TE of 80%. The measure qualifies for both normal replacement (NR) and new construction in the residential sector.[5]

The reported NTRGs for the reported boiler claims range from 55% for multifamily, 60% for commercial, and 85% for school applications. A majority of claims fall under the commercial application, and thus, the average NTGR across the technology groups and programs is at or near 60%. Table 2-2 illustrates the Boiler technology groups programs and claims characteristics.

[2] https://www.caetrm.com/measure/SWHC004/01/
[3] https://www.caetrm.com/measure/SWWH005/03/
[4] https://www.caetrm.com/measure/SWWH008/01/
[5] https://www.caetrm.com/measure/SWWH010/01/

Table 2-2. PY2020 commercial boilers programs and claims characteristics

Boiler Technology group	Program ID	Program Name	Count of Claims	Reported Lifecycle Gross Therm	Reported Lifecycle Gross kWh	Reported gross kW	Average NTGR
HVAC	PGE21012	Commercial Deemed Incentives	802	11,826,227	8,813,856	0	61%
	SCG3814	COM-Midstream Water Heating	53	2,315,158	942,514	23	60%
	SCG3711	COM-Deemed Incentives	8	196,990	220,736	0	60%
	SCG3816	PUB-Deemed Incentives	2	29,171	51,948	0	60%
Process	SCG3716	IND-Deemed Incentives	9	2,584,574	0	0	60%
	PGE21012	Commercial Deemed Incentives	15	1,941,770	0	0	60%
	SCG3711	COM-Deemed Incentives	7	802,429	0	0	60%
Commercial Water Heating	PGE21012	Commercial Deemed Incentives	544	7,823,799	0	0	60%
	SCG3816	PUB-Deemed Incentives	17	833,051	0	0	61%
	SCG3711	COM-Deemed Incentives	22	736,609	0	0	60%
Multifamily	SCG3702	RES-Residential Energy Efficiency Program	52	2,439,754	0	0	55%
Total			**1,531**	**31,529,532**	**10,029,054**	**23**	**60%**

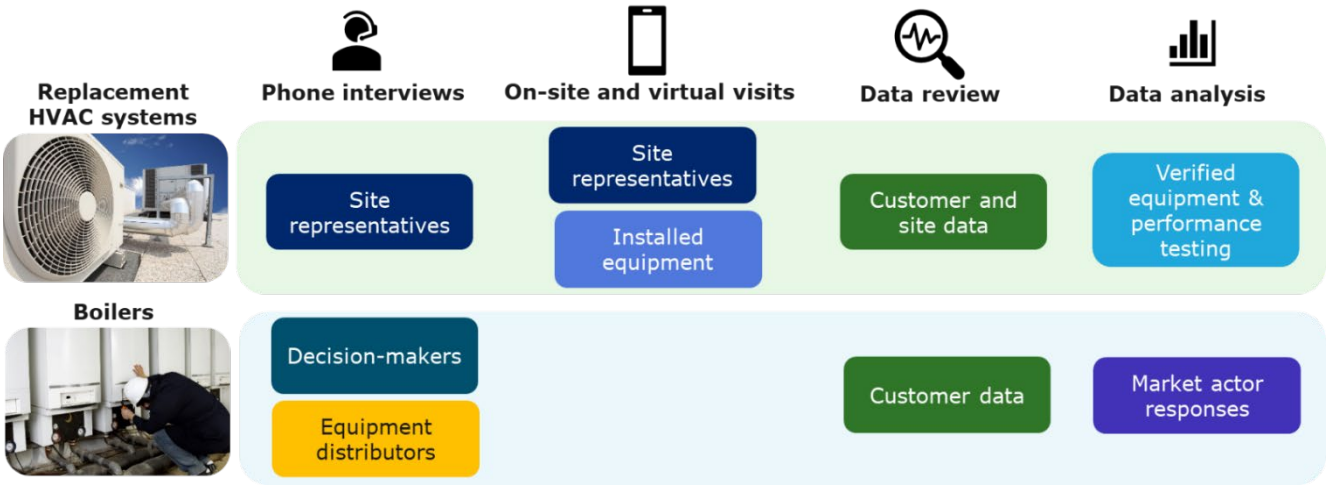
Figure 2-6 shows part of an HVAC condensing boiler, which reaches high levels of efficiency due to latent heat recovery from the boiler's exhaust flue gases.

2.3 Overview of approach

This evaluation is built on DNV's CPUC HVAC evaluation approach over the past decade and focuses on the savings parameters that have historically seen the highest levels of uncertainty. It should be noted that both PY2020 and the subsequent evaluation period were subject to COVID-19 impacts. Potential pandemic-related impacts were examined during the technology selection process, development of the evaluation methodology, and during interviews with the PAs, equipment distributors, and end-user participants. The evaluation methodology focused on parameters that are unaffected by impacts stemming from the global pandemic. Neither customer billing data nor long-term equipment monitoring were collected.

Figure 2-3 below shows the evaluated technology groups selected for gross and net evaluation for the HVAC sector along with the data sources and activities used to evaluate these selected technology groups.

Figure 2-3. PY2020 evaluated technology groups and study data sources



For the Replacement HVAC systems technology 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 capacity, efficiency, rated compressor and fan powers, building vintage, duct configuration, and space 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 savings models. The adjusted models were then run for every climate zone, building type, vintage, and unit type combination used across all Replacement HVAC 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 DEER2020 updated vintage weights[6] were applied to individual vintage estimates.

For the boiler technology groups net savings estimates, we derived a NTGR by estimating the influence that various program activities had on distributor behavior, and how midstream and 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.

To calculate the NTGR for the boiler technology 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 technology group.

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.

[6] http://www.deeresources.com/index.php/23-deer-versions/46-deer2020#BldgVint

Table 2-3. Overall organizational structure of the report

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

3 METHODOLOGY

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, 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 technology 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 HVAC technology groups that were evaluated for PY 2020. The sampling frame for each technology group is the list of records under that technology 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 technology group at the 90% confidence level using an assumed error ratio[7] (ER) of 0.6 based on previous studies. Once sample sizes were calculated, we randomly chose sample points from the population in each stratum.

Once data for the sample are collected and ex-post savings for each site are calculated, the technology group savings realization rate is calculated as:

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

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 technology group ex-post savings value is estimated as *b* times the program ex-ante savings total.

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

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

[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 evaluated values around their mean value as a fraction of that mean value. Similarly, the error ratio measures the variability (root-mean-square difference) of individual evaluated values from the ratio line Evaluated = Ratio multiplied by Reported, as a fraction of the mean evaluated value.

For both the replacement HVAC systems technology group and the commercial boiler technology groups the achieved relative precisions were worse than anticipated. The achieved precisions did not match expectations for the following reasons:

- **Completed sites/surveys less than expected** – Due to incomplete and frequently invalid participant contact information provided to the evaluators, 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 many of the largest sites were unable to be reached, which can have a significant effect on the final achieved precision.
- **Observed variation between ex-ante and ex-post values in the sample were greater than assumed** – The sample designs each used a 0.6 error ratio (ER). For the replacement HVAC technology group, the observed variation was higher than planned, with a 0.76 error ratio for the evaluated gross kWh savings.
- **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 technology groups are described in Appendix E.

3.2 Replacement HVAC systems sample design

DNV designed the sample to achieve ±10% relative precision at the 90% confidence level for each technology group. In order to achieve ±10% relative precision for each technology group at 90% confidence level, a total of 85 sample sites were planned for the Replacement HVAC systems technology group. However, the sample was not completed as planned. The recruiting effort and subsequent response rates were lower than expected, primarily due to incorrect and incomplete end user contact information. As a result, 43 sample points were evaluated as compared to the planned 85 sample points for gross savings estimate. The overall achieved relative precision was 19% for gross kWh and gross peak demand savings and 34% for gross therm savings for the replacement HVAC systems technology group. The overall archived relative precisions fell short of the target due to variations in the evaluated savings for the sampled sites and because the evaluated sample size was just over half (51%) of the targeted size. We provide a more detailed discussion of the site-by-site variations seen for the evaluated gross savings in section 4.1.

Table 3-1 shows the planned and achieved sample sizes with their relative precisions for the replacement HVAC systems technology group by PA for gross savings. The SCE achieved relative precision (29%) clearly demonstrates the impact a reduced sample size can have. Even with attempting to recruit all sampled and backup sites, the evaluation team was only able to recruit and visit 17 of the planned 46 SCE sites.

Table 3-1. Replacement HVAC systems gross sample by PA

PA	PA Site IDs	Planned Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
PGE	703	39	15.9%	26	23%
SCE	792	46	13.9%	17	29%

PA	PA Site IDs	Planned Sample Size	Planned Relative Precision at 90% Confidence	Completed Sample Size	Achieved Relative Precision at 90% Confidence
Total	**1,495**	**85**	**10.5%**	**43**	**19%**

3.3 Commercial boiler sample design

DNV designed the sample to achieve ±10% relative precision at the 90% confidence level for each measure group. In order to meet these statistical requirements, a total of 145 sample sites were required for the three boiler technology groups as shown in Table 3-2. The sample was stratified by boiler measure group and PA. The targeted relative precision of ±10% was based on a 0.6 error ratio based on our previous experience with similar studies. In addition to end-user interviews, we attempted a census of distributors of commercial boiler claims as the program design has a significant midstream component.

The evaluation team completed end user interviews for 35% (51 of the 145) of the targeted sample size and a census of interviews with distributors of the commercial boiler program. For the commercial boiler technology group, we fell short of the targeted sample size due to low response rates and low quality of contact information. More details on the contact data quality can be found in Section 3.4.2. The combination of smaller sample size, the variation between the tracking estimate of NTGR and the evaluated result, combined with the program's evaluated low NTGR values (<20%) meant that the team did not achieve ±10% relative precision at the 90% confidence level. There was one respondent for process boiler technology group which was insufficient to calculate a statistically valid NTGR. For the HVAC boiler and water heating boiler technology groups, DNV analysts achieved absolute precision of less than 10% at the 90% confidence interval with a NTGR of 17% ± 5% for HVAC boilers and a NTGR of 11% ± 4% for water heating boilers.

Table 3-2. Commercial boilers sample design

Boiler Technology Group	PA	Accounts	First Year Gross Therm Savings	First Year Net Therm Savings	Sample	Expected Relative Precision	Completed Sample Size	Achieved Relative Precision	Achieved Absolute Precision
HVAC boiler	PG&E	330	591,311	361,468	55		25	31%	6%
HVAC boiler	SCG	57	127,066	76,240	15		2	0%	0%
HVAC boiler	**Total**	**387**	**718,377**	**437,707**	**70**	**10.3%**	**27**	**29%**	**5%**
Water heating boiler	PG&E	203	391,190	235,745	40		15	79%	6%
Water heating boiler	SCG	67	200,471	114,421	20		8	30%	5%
Water heating boiler	**Total**	**270**	**591,661**	**350,165**	**60**	**10.1%**	**23**	**41%**	**4%**
Process boiler*	PG&E	7	97,089	58,253	5		-	n/a	n/a
Process boiler*	SCG	13	169,350	101,610	10		1	n/a	n/a
Process boiler*	**Total**	**20**	**266,439**	**159,863**	**15**	**8.3%**	**1**	**n/a**	**n/a**

* There was one respondent for the process boiler technology group, so a statistically valid NTGR or relative precision was not calculated.

3.4 Data collection

This section addresses the data collection plans for the technology groups selected for evaluation.

3.4.1 Replacement HVAC systems

Two PAs, PG&E and SCE, reported Replacement HVAC systems savings claims in PY 2020, which were claimed among a population of 1,495 participants. The programs and statewide measure packages supporting the PY2020 population of replacement HVAC systems claims are shown in Table 3-3.

Table 3-3. Replacement HVAC systems technology group sample

PA	Program ID	Supporting Statewide Measure Package	PA Site IDs	Target Sample Sites	Completed Sites
PG&E	PGE21015	SWHC013-01: Over 65 kBtu/hr Unitary Air Conditioners and Heat Pumps	126	7	1
PG&E	PGE21015	SWHC014-01: Under 65 kBtu/hr Unitary and Split-system Air Conditioners and Heat Pumps	524	25	19
PG&E	PGE21015	SWHC043-01: Multiple Capacity Unitary Air-Cooled Commercial Air Conditioners Between 65 and 240 kBtu/hr	53	7	6
PG&E	**Total**		**703**	**39**	**26**
SCE	SCE-13-SW-002F	SWHC013-01: Over 65 kBtu/hr Unitary Air Conditioners and Heat Pumps	230	15	4
SCE	SCE-13-SW-002F	SWHC014-01: Under 65 kBtu/hr Unitary and Split-system Air Conditioners and Heat Pumps	539	25	12
SCE	SCE-13-SW-002F	SWHC043-01: Multiple Capacity Unitary Air-Cooled Commercial Air Conditioners Between 65 and 240 kBtu/hr	23	6	1
SCE	**Total**		**792**	**46**	**17**
Overall Result			**1,495**	**85**	**43**

The evaluation targeted a sample of 85 PA sites for gross data collection. We attempted to recruit site representatives to participate in either virtual or in-person site visits. The workplan was developed during the COVID-19 pandemic and a surge in case rates coincided with the start of the data collection period. Knowing a possible pandemic surge could hamper recruiting and the ability to physically attend site visits, we developed virtual data collection instruments and protocols as an alternative to in-person site visits. Of the 43 completed site visits, 42 were completed via in-person site visits and one was completed virtually.

The data collection period spanned September to December of 2021. Initial data requests were submitted to the PAs in early September. However, the site-participant contact information the PAs provided to the evaluators was incomplete, inconsistent, and often incorrect. Evaluators submitted follow up data requests to each PA as the level of detail provided in the initial data request fell well short of what the PAs told evaluators they tracked and could provide when asked during PA program manager interviews in August of 2021. Minimal information was provided in the follow up data request responses. For many of the PA claims, the corresponding site data did not contain critical customer contact information needed to recruit sampled end-users for measurement and verification. DNV leveraged numerous data sources to supplement the missing customer contact info to use when recruiting site visits. In spite of all these efforts, over half of the sites were missing valid business names, over 60% were missing valid phone numbers, and over two-thirds were missing a valid contact name at the site.

Due to the midstream program design where the program incentive payment is issued to the equipment distributor, the end-user customers are often unaware the new HVAC unit was part of a high-efficiency PA rebate program. This lack of

familiarity with the program coupled with missing customer data resulted in a challenging recruiting effort with very poor response rates. To overcome the recruiting challenges, the evaluators expanded the replacement HVAC systems recruitment to include all sample and backup sites within the population. The expanded group only included sites for which a phone number and either a business or customer name were available, however. Overall, more than 2,200 outreach attempts were made to contact 687 sites from which gross data collection for 43 sites were completed. The gross data collection fell short of the target sample count statewide by 42 sites. Replacement HVAC systems recruitment resulted in a success rate of 6.3% due to various factors which are demonstrated in Figure 3-1.

Figure 3-1. Replacement HVAC systems recruiting disposition summary

For both the in-person and virtual site visits, 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. While onsite or with the help of a site contact, evaluators performed an in-depth unit-specific characterization for all the program participating 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 control strategies. For site visits that included HVAC systems with savings claimed under the statewide measure package, SWHC014-01: Unitary Air-Cooled Air Conditioner or Heat Pump, Under 65 kBtu/hr, evaluators conducted performance testing to measure the system fan power efficiency.

After collecting this information, the evaluators conducted a series of spot measurements on this subset of installed units that fell below 65 kBtu to be used in the gross analysis methodology. The evaluator followed an on-site sampling protocol for selecting the number of units for which to conduct fan power performance testing at each site. For sites with three or fewer units under 65 kBtu installed, one unit was selected for in-depth data collection. For sites with four to nine installed units, two were selected. For any sites with 10 or more installed units, two to three units were tested pending access time authorization from the sites. Appendix G provides more information on the on-site sampling strategy.

The first performance measurement conducted consisted of locating the installed 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 3.5.

In addition to collecting data supporting the gross impact evaluation, evaluators asked site contacts a series of questions assessing pandemic impacts and questions supporting forward looking research. In total nine questions were asked with four questions designed to assess COVID-19 impacts on HVAC and five questions supporting forward looking research. A full list of questions asked with their responses can be found in Appendix D. See Appendix G for the replacement HVAC systems data collection instrument.

3.4.2 Commercial boilers

PG&E and SCG were the two PAs who reported savings for PY2020 under the boiler technology groups which were claimed among a population of 677 participants. Based on the sample design described in Section 3.3, the target sample was 145 participants split between the three technology groups: HVAC (70 participants), water heating (60 participants), and process boilers (15 participants).

Table 3-4. Commercial boilers technology group sample

PA	Boiler Technology Group	Program ID	Statewide Supporting Measure package	Sites	Targeted Sample Sites	Completed Sites
PG&E	HVAC Boiler	PGE21012	SWHC004-01	330	55	22
PG&E	Water Heating Boiler	PGE21012	SWWH005-03	203	40	14
PG&E	Process Boiler	PGE21012	SWWH008-01	7	5	0
PG&E		**Total**		**540**	**100**	**36**
SCG	HVAC Boiler	SCG3711 SCG3814 SCG3816	SWHC004-01	57	15	3
SCG	Water Heating Boiler	SCG3702 SCG3711 SCG3816	SWWH005-03 SWWH010-01	67	20	11
SCG	Process Boiler	SCG3711 SCG3716	SWWH008-01	13	10	1
SCG		**Total**		**137**	**45**	**15**
Overall Result				**677**	**145**	**51**

The evaluation team interviewed a combination of end user decision-makers and equipment distributors using utility-provided contact data and equipment information. The end-user phone survey involved questions to determine how the program may indirectly influence the final purchase decision of buyers through the distributors' stocking, upselling or pricing. The equipment distributor phone survey involved complementary questions on how the program impacted the distributor to

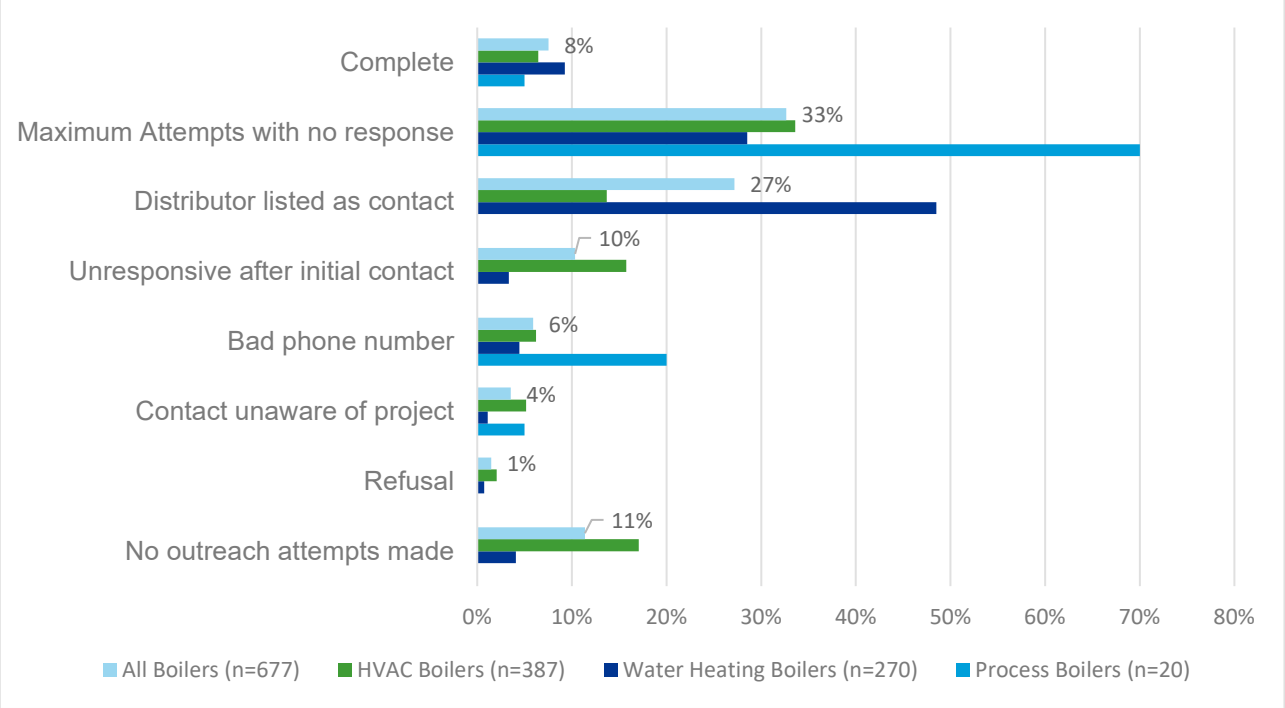
stock, upsell and price their high efficiency units. Interviewers completed a census phone survey effort of the 12 equipment distributors. For end user decision-makers, interviewers completed 35% (51 of 145 sites) of the targeted sample sites.

We reached out to the 145 primary samples randomly selected based on their stratum to interview. The team made the best use of the available contact information to make outreach attempts through phone calls, emails (when available), voice messages, and text messages to aid in scheduling interviews. When a primary sample reached a final disposition, the team contacted the next backup within the same stratum. A sample was considered exhausted or complete when either there was an interview completed, invalid contact information, a refusal to participate, or when a maximum five outreach attempts were made with no response.

A major challenge in reaching out to end-users was due to low quality of utility-provided contact data. The utility provided contact data for end-users had unique phone numbers for 47% of the claims and unique email addresses for 12% of the claims. The point of contact in the claim was often a distributor or installation contractor (27% of all contact information) and not the end-user. Another challenge with the low quality of the utility-provided contact data was that it often took multiple attempts to reach the decision-maker or someone knowledge about the boiler project.

Although the DNV team's target sample size was 145, the DNV team attempted a near census outreach to 600 of 677 participants (89%). DNV made more than 1,900 outreach attempts were made to reach 600 participants for which 51 interviews were completed resulting a success rate of 8.5%. The recruitment summary for boiler participants is shows in Table 3-2.

Figure 3-2. Commercial boilers recruiting disposition summary by technology group



3.5 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 the extent appropriate and practical, including desk reviews, phone data collection, on-site inspections and analysis for representative sample for the replacement HVAC systems technology groups. 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 technology group population to obtain population estimates of the technology group impacts. The evaluation team utilized PA and implementer-collected information, including the project-implementer's submitted project files/documentation, supplemented by data collected for this evaluation.

The gross savings for the replacement HVAC systems technology group were estimated by using site-collected data to adjust critical model input parameters for the ex ante savings models. The rated cooling efficiency was collected across all unit types verified as a critical input parameter, and the supply fan efficacy (watts/ CFM) was a targeted input parameter for units less than 65 kBtuh. The adjusted models were simulated for every applicable climate zone, building type, vintage, and unit type combination. 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 DEER2020 updated vintage weights were applied to individual vintage estimates.

The actual ex ante models were not available, so we used a DOE-2 simulation generator and batch processing tool called MASControl 3. 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 2020 Energy Impact Weights Tables.

3.6 Net methodology

This section contains descriptions of how the evaluation team calculated NTGRs for the boiler technology groups. In general, this evaluation used the same NTGR calculations as were used in the previous evaluation on the boiler technology groups. Table 3-5 provides a high-level summary of the methods used.

DNV developed and used one end-user survey for the mid-stream programs (HVAC boilers and Commercial Water Heating boilers) to assess distributors' impact on end-user's decision-making process. DNV also developed a complementary distributor survey for use in the same mid-stream programs to assess the program's impact on distributors' stocking, upselling and pricing behavior of high efficiency units. A separate survey was created and used for downstream program participants of process boiler programs. Detailed methodology used to calculate NTGRs for each is provided in the sections listed in Table 3-5.

Table 3-5. NTGR methods by boiler technology group

Commercial Boilers Technology Group	NTGR Method	Location of Detailed Methodology
HVAC Boiler & Water Heating Boiler	**Midstream Programs:** • Assess program's impact on distributors' stocking, upselling, and pricing of high efficiency units • Assess program's impact on distributors' sales as a consistency check • Assess how distributor's stocking, upselling and pricing of high efficiency units impacted end-users • Assess likely distributor and end-user actions without program	Appendix E: Detailed net attribution scoring methods

Commercial Boilers Technology Group	NTGR Method	Location of Detailed Methodology
Process Boiler	**Downstream Programs:** • 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	Appendix E: Detailed net attribution scoring methods

3.7 Data sources

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

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

Data Sources	Description	Applicable Technology groups
Program Tracking Data	PA program data includes number of records, savings per record, program type, name, technology groups, measure description, incentives etc.	Replacement HVAC systems HVAC Boiler Commercial Water Heating Boiler Process Boiler
Project-Specific Information	Project folders include scope of work, equipment model and serial numbers, nominal efficiency, test results, project costs, etc.	Replacement HVAC systems HVAC Boiler Commercial Water Heating Boiler Process Boiler
Telephone Surveys	Includes surveys of customers, distributors, other market actors, and PA program staff.	Replacement HVAC systems HVAC Boiler Commercial Water Heating Boiler Process Boiler
Manufacturer Data Sheet	Data sheets Include equipment specifications such as horsepower (HP), efficiency, capacity, etc.	Replacement HVAC systems
In-person & Virtual On-Site Surveys	Includes verifying measure installation, gathering measure performance parameters such as efficiency, control strategy, building characteristics etc.	Replacement HVAC systems
End-use Performance Testing	Includes performing spot power measurements and airflow performance measurements	Replacement HVAC systems

4 DETAILED RESULTS

This section presents the results of the gross and net evaluations of the technology 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 Impact Evaluation Standard Reporting (IESR) high-level savings and standard per-unit savings. Section 6.3 (Appendix C) contains the tabularized report recommendations. The evaluation used the PA-reported Effective Useful Life (EUL) measure values to calculate lifetime savings from first year savings.

4.1 Replacement HVAC systems

Overall, the gross realization rates were higher than the expected. Overall, GRRs for kWh, kW, and therms were 124%, 117%, and 95%, respectively (Table 4-1). This means the evaluated savings appear to be significantly higher than the reported electric savings and very close to the reported gas savings. Net attribution was not evaluated for the replacement HVAC system technology group, so the evaluator adopted the PA reported NTGR for the evaluated NTGR.

Table 4-1. Statewide and PA first-year savings summary for replacement HVAC system

PA	Reported Gross Savings	GRR	Evaluated Gross Savings	Reported NTGR	Evaluated NTGR*	Reported Net Savings	Evaluated Net Savings	NRR
Electric consumption (kWh)								
PGE	2,684,120	131%	3,524,504	65%	65%	1,744,678	2,290,927	131%
SCE	2,987,979	117%	3,506,496	75%	75%	2,242,433	2,631,573	117%
Total	5,672,099	124%	7,031,000	70%	70%	3,987,111	4,942,329	124%
Peak electric demand (kW)								
PGE	1,087	107%	1,165	65%	65%	707	757	107%
SCE	1,276	125%	1,599	75%	75%	957	1,200	125%
Total	2,363	117%	2,764	70%	70%	1,664	1,946	117%
Gas consumption (therms)								
PGE	38,936	85%	33,237	65%	65%	25,308	21,604	85%
SCE	12,595	127%	15,953	75%	75%	9,446	11,964	127%
Total	51,531	95%	49,190	67%	67%	34,754	33,175	95%

*The evaluated net savings adopted the PA's reported NTGR.

Table 4-2 shows the population sizes, sample sizes, gross realization rates and relative precisions for the replacement HVAC system technology group. The lower achieved sample size, attributable to the difficulty of contacting 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 worse than planned or expected.

Table 4-2. Replacement HVAC system population, GRR, and relative precision

PA	Population Size	Completed Sample Size	kWh GRR	kWh Achieved Relative Precision[8]	kW GRR	kW Achieved Relative Precision[9]	Therm GRR	Therm Achieved Relative Precision[10]
PGE	703	26	131%	23%	107%	28%	85%	38%
SCE	792	17	117%	29%	125%	25%	127%	71%
Total	1,495	43	124%	19%	117%	19%	95%	34%

We estimated gross savings for the replacement HVAC systems technology group by updating the installation rates and adjusting the energy efficiency ratio (EER) for all system types evaluated. For the replacement HVAC system claims supported by the statewide measure package SWHC014-01, we also adjusted the supply fan power efficacy (watts/CFM) of both the measure and baseline case systems to better reflect the conditions of the installed systems. The adjusted models were then run for every climate zone, building type, vintage, and unit type combination observed within the evaluated claims. 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.

An assortment of discrepancy factors impacted the evaluated savings results. As is shown by the high gross realization rates, these discrepancy factors mostly improved savings results but there were some factors that diminished the savings results as well. The factors that increased savings are presented below:

- **Higher Rated Efficiency**: For most of the systems we observed in the field, the verified installed unit efficiency rating exceeded the reported efficiency rating. This trend was especially pronounced for the larger systems, where the evaluator determined all 59 larger systems were rated at a higher efficiency level than reported. Because the rebated systems are rated to perform more efficiently than the PAs reported, they are generating additional savings than the PAs reported.
- **Undersized systems reported:** One PA reported over 440 systems with a unit capacity listed as 0.1 ton in size, but the equipment model numbers indicate the systems are all normal sized between 3-20 tons. The evaluator verified 11 of these systems in the field and confirmed all were normal sized. The PA reported savings for these systems is a fraction of what it should have been because it was based on a unit savings of 0.1. This impact increased the evaluated energy savings by approximately 4%.
- **Under reported part-load savings:** One PA reported savings for larger HVAC systems assuming full-load performance, which evaluators verified achieved high cooling efficiency in both part-load performance and full-load performance., Because these units are achieving high-efficiency performance in more cooling conditions and more hours of the year than reported, the evaluated savings increased by approximately 9%.

The following discrepancy factors resulted in lower evaluated savings:

[8] Relative precision at 90% confidence
[9] Relative precision at 90% confidence
[10] Relative precision at 90% confidence

- **Outside PA territory:** Five of the forty-three sampled sites are outside the PAs' electric service territories and are served by municipal electric service providers. This impact reduced the evaluated energy savings by approximately 8%.
- **Lower rated efficiency:** The evaluators encountered three smaller size systems rated at an efficiency level two tiers below the level reported.
- **Missing units**: Across the 43 site visits evaluators performed, we found 19 of 281 systems were not present anywhere at the reported business address. This included one site where none of the six reported systems were present. The remaining missing systems were reported at sites with other verified systems installed and present. This impact reduced the evaluated energy savings by approximately 8%.
- **Existing building vintage:** Every single PY2020 reported replacement HVAC system was claimed as an existing building installation and the sourced savings came from the DEER existing building prototypes. The existing building prototypes assume older building characteristics that result in higher heating and cooling loads when compared to the new building prototypes. This means the same HVAC system will achieve more savings when installed at an existing building than when installed at a new building. The evaluator team determined 19 of the 43 evaluated sites were newly constructed buildings. We sourced the savings for those sites' claims from the new construction modeling results and not the existing buildings which caused savings to decrease.
- **Building Type Discrepancies*:*** The PA's tracking data has a field to specify building type but in every reported PY2020 claim the reported building type is the commercial average. The evaluation team believes that more appropriate building types 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.

While the program savings results demonstrate the statewide replacement HVAC systems technology group is performing well, the evaluated results show considerable variation in savings. Within the program participant data delivered to the CPUC and DNV, over half of the sites were missing valid business names, over 60% were missing valid phone numbers, and over two-thirds were missing a valid contact name for the end user. Because of these data gaps, the recruiting and data collection effort fell considerably short of the targeted 85 site sample with only 43 site visits. The evaluated results come with some uncertainty. The uncertainty is a product of both the reduced sample size and site by site variations of the evaluated savings.

4.2 Commercial boilers

PG&E and SCG were the two PAs who reported savings for PY2020 under the boiler technology groups. DNV evaluated three boiler technology groups: HVAC, water heating, and process boilers. The evaluated NTGRs were 17% +/- 6% for HVAC boilers and 11% +/- 4% for water heating boilers. See Table 4-3 for a further breakdown by PA of the NTGRs and first-year net impacts. There was one sample point for the process boiler technology group which was insufficient to calculate a statistically valid NTGR.

Table 4-3. Statewide first-year net impacts of commercial boilers[11]

Boiler Technology group	PA	Reported Gross Savings (therms)	Reported NTGR	Evaluated NTGR	Reported Net Savings (therms)	Evaluated Net Savings (therms)	NRR
HVAC Boiler	PG&E	591,311	61%	20%	361,468	115,680	32%
	SCG	127,066	60%	4%	76,240	5,184	7%

[11] None of the values for reported or net savings reflect the 5% market effects adder.

Boiler Technology group	PA	Reported Gross Savings (therms)	Reported NTGR	Evaluated NTGR	Reported Net Savings (therms)	Evaluated Net Savings (therms)	NRR
	All	718,377	61%	17%	437,707	120,864	28%
Water Heating Boiler	PG&E	391,190	60%	8%	235,745	30,681	13%
	SCG	200,471	57%	17%	114,421	22,264	19%
	All	591,661	60%	11%	350,165	64,077	18%
Process Boiler*	PG&E	97,089	60%	n/a	58,253	58,253	100%
	SCG	169,350	60%	n/a	101,610	101,610	100%
	All	266,439	60%	n/a	159,863	159,863	100%

* There was one respondent for the process boiler technology group, so a statistically valid NTGR was not calculated.

The commercial boiler programs at PG&E and SCG were predominantly midstream programs providing incentives to influence distributors to stock, upsell, and (at the distributors discretion) reduce the price of high-efficiency boilers. This means that to have an effect on the final decision to purchase a high-efficiency boiler, the program must first change the distributors' behaviors and then those behaviors have to make a difference to the person purchasing from the distributors. The evaluation team captured this "causal chain" by surveying both the distributors and the buyers (end users) to capture the program influence. Although the majority of commercial boiler programs were midstream programs, the process boiler programs at PG&E and SCG were downstream programs where the program had a direct influence on the timing, efficiency and quantity of equipment purchased by the end-user. One respondent for the process boiler technology group indicated that without the program they would have installed the equipment at the same time, installed the required efficiency of equipment by code, and were influenced to participate from positive prior experiences with utility programs.

4.2.1 Distributors

For the distributors, the program has little effect on their stocking or upselling behaviors. Survey responses indicate that distributors are stocking high-efficiency models 5% more often and upselling no more often because of the program. The majority (92%) of distributors did indicate that they pass a significant portion (41%) of the rebates to buyers. Distributors also reported that reducing the incremental cost between standard and high-efficiency models was the most effective way for them to sell high-efficiency options. It should be noted that DNV's conversations with program managers as part of previous program year evaluations indicated that the program logic is based on altering distributors' stocking and upselling practices, not necessarily in reducing the incremental cost of high-efficiency models. In fact, the program does not require the distributors to pass any of the rebate down to buyers.

Evaluators also compared the responses of the large distributors to the responses of smaller distributors. Large distributors consist of the four distributors making up 73% of all commercial boiler claims across the two PAs. The smaller distributors are comprised of the remaining eight distributors making up the remainder of commercial boiler claims. We found that smaller distributors passed through a greater portion of the rebate (47%) to the end-users as compared to larger distributors who pass through 28% of the rebate. Half of smaller distributors indicated using the rebate to aid in sales as a statement credit or instant rebate to the end-users at the point of sale. Larger distributors indicated using the rebate to buy down the cost for the end-user, but it is unclear if the rebate was used as at the point of sale as an instant rebate or statement credit like smaller distributors. Recall that there is no program requirement to pass through rebates to the buyers and any pass-through is at the discretion of each distributed. Evaluators identified no difference between large or smaller distributors in program influence on stocking high efficiency equipment or on upselling behaviors.

Distributors were asked to estimate the percentage of their California commercial boiler sales that were high efficiency with and without the program. Large distributors indicated that the program rebate and non-rebate activities increased their proportion of high-efficiency commercial boiler sales from 50% to 94%. Smaller distributors revealed a lesser impact, with the program increasing their proportion of high-efficiency commercial boiler sales from 62% to 66%. We identified no difference between large or smaller distributors in program influence on stocking high efficiency equipment or on upselling behaviors. Although large distributors indicated low program influence on stocking and upselling behavior, the program does have a large impact on the high efficiency sales made by large distributors. On the contrary, the program has low impact on the stocking, upselling, or sales for smaller distributors.

Evaluators identified areas of potential program improvement from the perspective of distributors. Smaller distributors are claiming a lower percentage (49%) of their high-efficiency sales as compared to the large distributors (60%). Most of the smaller distributors (75%) identified not claiming rebates on their high efficiency sales as a missed opportunity. One smaller distributor indicated that they had "hard time connecting with the program and would have participated sooner" and another smaller distributor said that claiming rebates created an administrative time burden and the process was not integrated into their system. These findings suggest that there is an opportunity for improved program outreach to the smaller distributors to increase awareness of rebate opportunities and eligibility to participate in the program. From the perspective of large distributors, the primary reason they are not submitting rebates for all high efficiency equipment sales is that the installed equipment is not eligible for rebates due to the equipment being located outside of the PAs service territory. This reasoning indicates that large distributors are familiar with program requirements and eligibility.

4.2.2 End users

Evaluators interviewed end-users of the commercial boiler systems to complement distributor interviews to help identify indirect or direct program influence on the end-user's decision-making process and understand the motivations of end-users. The majority (84%) of end-users purchased a high-efficiency boiler to replace an existing boiler. Among the replacement boilers, 83% of the replacements were for existing boilers that were functioning but had significant maintenance or performance issues.

From the buyer or end user perspective, surveys indicate that dealer upselling had the most influence in their decision to purchase a high-efficiency boiler. Most (end-users 78%) said they were influenced by the recommendation of distributor or contractor to install a high-efficiency boiler. Prior to buying the boilers, a majority of end-users (73%) relied on their vendors and installation contractors for information on the equipment. Contrary to the distributors' responses about lower equipment costs as an effective influence, 70% of end-users indicated they would be willing to purchase high-efficiency units without the rebates. For example, if the rebate was $100 and the end users paid $500, the end users indicated they would be willing to purchase the same unit for $600. From the buyer perspective, immediate availability of the unit they purchased was not very important. Most (53%) end-users indicated that they would have waited or gone to another supplier to ensure they got a high-efficiency model.

The NTGRs for the commercial boiler technology groups are low because the programs did little to change distributor behaviors. End-user survey responses clearly show distributor actions and recommendations do make a difference in their decision-making process; however, distributor responses indicate the boiler programs had a marginal effect on their recommendations to contractors and end-users. Also, survey findings show the distributors are already stocking and upselling high-efficiency units. See Table 4-4 for further details on NTGR and relative precision at 90% confidence interval by boiler technology group.

Table 4-4. Commercial boilers population, sample, NTGR, and relative precision at 90% confidence interval

Boiler Technology group	PA	Population Size	Completed Sample Size	Evaluated kWh NTGR	kWh Achieved Relative Precision	Evaluated kW NTGR	kW Achieved Relative Precision	Evaluated Therm NTGR	Therm Achieved Relative Precision
HVAC Boiler	All	387	25	20%	29%	n/a	n/a	17%	29%
Water Heating Boiler	All	270	25	n/a	n/a	n/a	n/a	11%	41%
Process Boiler*	All	20	1	n/a	n/a	n/a	n/a	n/a	n/a

* There was one respondent for the process boiler technology group, so a statistically valid NTGR was not calculated.

5 CONCLUSIONS AND 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 6.1 per the CPUC ED Impact Evaluation Standard Reporting (IESR) Guidelines.

5.1 Overarching findings

PA tracking and participant data fails to adequately document claims. Across all evaluated technology groups, the PAs were unable to consistently provide critical pieces of data essential for third-party evaluators to validate and assess claimed savings. Overall, site contact names were missing or invalid for over two-thirds of requested sites and phone numbers were missing or invalid for over half of all requested sites. This resulted in evaluation data collection delays, reduced site and survey counts, poor relative precision, and above all, questions whether all of these claims are actually installed and operating as intended.

PAs should increase efforts to provide accurate and consistent tracking documentation. The evaluator recommends the PAs and their implementers increase efforts to train participating midstream program distributors on proper documentation requirements, consistent and accurate data recording, as well as regular quality control reviews of the data prior to submittal. Systematically capturing a valid site contact name, phone number, email address, and business name should all be incorporated into the program data requirements.

5.1.1 Replacement HVAC systems

PAs not reporting building types or vintages. The PAs defaulted to using the commercial average building type and existing building vintage for all reported replacement HVAC system claims. The measure package model savings estimates vary significantly by both building type and vintage of the building where installed.

PAs should track and report claim savings using accurate building vintages and types. By specifying the correct building type and vintage ex-ante savings estimates will be considerably more accurate on a claim-by-claim basis and result in more reliable cost savings estimates.

PAs claiming electric savings outside their service territory. Evaluators visited five sites where the PAs claimed both electric and gas savings for the installed units, but the sites' electricity is provided by a municipal electric utility. The evaluated gross kWh and kW savings for claims installed at these sites were zero because the savings is occurring outside the PAs service territory. Additionally, the incentive is benefiting an electric end-use customer that is not contributing to the Public Purpose Program Funds. This resulted in a decreased electric gross savings realization rate for this technology group.

PAs should not claim electric savings for installations outside their service territory. The evaluator recommends the PAs check to confirm the claimed system's installation address has a valid electric and gas account before claiming the corresponding savings. Additionally, they should make sure that the end-use customer contributes to the PPP Funds.

5.1.2 Commercial boilers

Poor net savings realization is driven by programs' lack of influence on distributor recommendations. Distributors reported that they would recommend program eligible high-efficiency units at the same frequency without the program. End-user surveys indicate decisions are most driven by distributor recommendations and by price to a lesser extent. The participating distributors we spoke with claim their recommendations have minimal impact on purchasing decisions, which represents a lost opportunity because end-users say otherwise.

PAs and implementers should encourage distributors to upsell highest efficiency tier boilers. The evaluator recommends future programs consider offering increased incentives on the highest efficiency tier boilers, so distributors increase high-efficiency equipment recommendations. Most end-user survey respondents (70%) reported they would pay full price for high-efficiency boilers if that's what their distributor or contractor recommended. By providing an increased incentive to distributors for selling the higher efficiency tier units they will be more likely to upsell the higher efficiency units and achieve greater program attribution. The PAs should dutifully notify distributors and other market actors of expected large program changes for boiler measures.

6 APPENDICES

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

Gross Lifecycle Savings (MWh)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	BOILERS	8,814	8,814	1.00	100.0%	
PGE	PROCESS BOILER	0	0			
PGE	REPLACEMENT_HVAC_SYS	40,262	52,868	1.31	0.0%	1.31
PGE	WATER HEATING BOILER	0	0			
PGE	**Total**	**49,076**	**61,681**	**1.26**	**18.0%**	**1.31**
SCE	REPLACEMENT_HVAC_SYS	44,820	52,597	1.17	0.0%	1.17
SCE	**Total**	**44,820**	**52,597**	**1.17**	**0.0%**	**1.17**
SCG	BOILERS	1,215	1,215	1.00	100.0%	
SCG	PROCESS BOILER	0	0			
SCG	WATER HEATING BOILER	0	0			
SCG	**Total**	**1,215**	**1,215**	**1.00**	**100.0%**	
	Statewide	***95,111***	***115,494***	***1.21***	***10.5%***	***1.24***

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	BOILERS	5,845	2,354	0.40	0.0%	0.66	0.27	0.66	0.27
PGE	PROCESS BOILER	0	0						
PGE	REPLACEMENT_HVAC_SYS	28,183	37,007	1.31	100.0%	0.70	0.70		
PGE	WATER HEATING BOILER	0	0						
PGE	**Total**	**34,028**	**39,361**	**1.16**	**82.8%**	**0.69**	**0.64**	**0.66**	**0.27**
SCE	REPLACEMENT_HVAC_SYS	35,877	42,103	1.17	100.0%	0.80	0.80		
SCE	**Total**	**35,877**	**42,103**	**1.17**	**100.0%**	**0.80**	**0.80**		
SCG	BOILERS	790	110	0.14	0.0%	0.65	0.09	0.65	0.09
SCG	PROCESS BOILER	0	0						
SCG	WATER HEATING BOILER	0	0						
SCG	**Total**	**790**	**110**	**0.14**	**0.0%**	**0.65**	**0.09**	**0.65**	**0.09**
	Statewide	***70,696***	***81,575***	***1.15***	***90.6%***	***0.74***	***0.71***	***0.66***	***0.25***

Gross Lifecycle Savings (MW)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	BOILERS	0.0	0.0			
PGE	PROCESS BOILER	0.0	0.0			
PGE	REPLACEMENT_HVAC_SYS	16.3	17.5	1.07	0.0%	1.07
PGE	WATER HEATING BOILER	0.0	0.0			
PGE	**Total**	**16.3**	**17.5**	**1.07**	**0.0%**	**1.07**
SCE	REPLACEMENT_HVAC_SYS	19.1	24.0	1.25	0.0%	1.25
SCE	**Total**	**19.1**	**24.0**	**1.25**	**0.0%**	**1.25**
SCG	BOILERS	0.5	0.5	1.00	100.0%	
SCG	PROCESS BOILER	0.0	0.0			
SCG	WATER HEATING BOILER	0.0	0.0			
SCG	**Total**	**0.5**	**0.5**	**1.00**	**100.0%**	
	Statewide	***35.9***	***41.9***	***1.17***	***1.3%***	***1.17***

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	BOILERS	0.0	0.0						
PGE	PROCESS BOILER	0.0	0.0						
PGE	REPLACEMENT_HVAC_SYS	11.4	12.2	1.07	100.0%	0.70	0.70		
PGE	WATER HEATING BOILER	0.0	0.0						
PGE	**Total**	**11.4**	**12.2**	**1.07**	**100.0%**	**0.70**	**0.70**		
SCE	REPLACEMENT_HVAC_SYS	15.3	19.2	1.25	100.0%	0.80	0.80		
SCE	**Total**	**15.3**	**19.2**	**1.25**	**100.0%**	**0.80**	**0.80**		
SCG	BOILERS	0.3	0.3	1.00	0.0%	0.65	0.65	0.65	0.65
SCG	PROCESS BOILER	0.0	0.0						
SCG	WATER HEATING BOILER	0.0	0.0						
SCG	**Total**	**0.3**	**0.3**	**1.00**	**0.0%**	**0.65**	**0.65**	**0.65**	**0.65**
	Statewide	***27.0***	***31.7***	***1.17***	***98.9%***	***0.75***	***0.76***	***0.65***	***0.65***

Gross Lifecycle Savings (MTherms)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	BOILERS	11,826	11,826	1.00	100.0%	
PGE	PROCESS BOILER	1,942	1,942	1.00	100.0%	
PGE	REPLACEMENT_HVAC_SYS	584	499	0.85	0.0%	0.85
PGE	WATER HEATING BOILER	7,824	7,824	1.00	100.0%	
PGE	**Total**	**22,176**	**22,090**	**1.00**	**97.4%**	**0.85**
SCE	REPLACEMENT_HVAC_SYS	189	239	1.27	0.0%	1.27
SCE	**Total**	**189**	**239**	**1.27**	**0.0%**	**1.27**
SCG	BOILERS	2,541	2,541	1.00	100.0%	
SCG	PROCESS BOILER	3,387	3,387	1.00	100.0%	
SCG	WATER HEATING BOILER	4,009	4,009	1.00	100.0%	
SCG	**Total**	**9,938**	**9,938**	**1.00**	**100.0%**	
	Statewide	***32,302***	***32,267***	***1.00***	***97.6%***	***0.95***

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	BOILERS	7,821	2,905	0.37	0.0%	0.66	0.25	0.66	0.25
PGE	PROCESS BOILER	1,262	1,262	1.00	100.0%	0.65	0.65		
PGE	REPLACEMENT_HVAC_SYS	409	349	0.85	100.0%	0.70	0.70		
PGE	WATER HEATING BOILER	5,106	1,005	0.20	0.0%	0.65	0.13	0.65	0.13
PGE	**Total**	**14,598**	**5,521**	**0.38**	**11.4%**	**0.66**	**0.25**	**0.66**	**0.20**
SCE	REPLACEMENT_HVAC_SYS	151	191	1.27	100.0%	0.80	0.80		
SCE	**Total**	**151**	**191**	**1.27**	**100.0%**	**0.80**	**0.80**		
SCG	BOILERS	1,652	231	0.14	0.0%	0.65	0.09	0.65	0.09
SCG	PROCESS BOILER	2,202	2,202	1.00	100.0%	0.65	0.65		
SCG	WATER HEATING BOILER	2,489	868	0.35	0.0%	0.62	0.22	0.62	0.22
SCG	**Total**	**6,342**	**3,301**	**0.52**	**34.7%**	**0.64**	**0.33**	**0.63**	**0.17**
	Statewide	***21,091***	***9,013***	***0.43***	***19.1%***	***0.65***	***0.28***	***0.65***	***0.19***

Gross First Year Savings (MWh)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	BOILERS	441	441	1.00	100.0%	
PGE	PROCESS BOILER	0	0			
PGE	REPLACEMENT_HVAC_SYS	2,684	3,525	1.31	0.0%	1.31
PGE	WATER HEATING BOILER	0	0			
PGE	**Total**	**3,125**	**3,965**	**1.27**	**14.1%**	**1.31**
SCE	REPLACEMENT_HVAC_SYS	2,988	3,506	1.17	0.0%	1.17
SCE	**Total**	**2,988**	**3,506**	**1.17**	**0.0%**	**1.17**
SCG	BOILERS	61	61	1.00	100.0%	
SCG	PROCESS BOILER	0	0			
SCG	WATER HEATING BOILER	0	0			
SCG	**Total**	**61**	**61**	**1.00**	**100.0%**	
	Statewide	***6,174***	***7,532***	***1.22***	***8.1%***	***1.24***

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	BOILERS	292	118	0.40	0.0%	0.66	0.27	0.66	0.27
PGE	PROCESS BOILER	0	0						
PGE	REPLACEMENT_HVAC_SYS	1,879	2,467	1.31	100.0%	0.70	0.70		
PGE	WATER HEATING BOILER	0	0						
PGE	**Total**	**2,171**	**2,585**	**1.19**	**86.5%**	**0.69**	**0.65**	**0.66**	**0.27**
SCE	REPLACEMENT_HVAC_SYS	2,392	2,807	1.17	100.0%	0.80	0.80		
SCE	**Total**	**2,392**	**2,807**	**1.17**	**100.0%**	**0.80**	**0.80**		
SCG	BOILERS	39	6	0.14	0.0%	0.65	0.09	0.65	0.09
SCG	PROCESS BOILER	0	0						
SCG	WATER HEATING BOILER	0	0						
SCG	**Total**	**39**	**6**	**0.14**	**0.0%**	**0.65**	**0.09**	**0.65**	**0.09**
	Statewide	***4,602***	***5,397***	***1.17***	***92.8%***	***0.75***	***0.72***	***0.66***	***0.25***

Gross First Year Savings (MW)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	BOILERS	0.0	0.0			
PGE	PROCESS BOILER	0.0	0.0			
PGE	REPLACEMENT_HVAC_SYS	1.1	1.2	1.07	0.0%	1.07
PGE	WATER HEATING BOILER	0.0	0.0			
PGE	**Total**	**1.1**	**1.2**	**1.07**	**0.0%**	**1.07**
SCE	REPLACEMENT_HVAC_SYS	1.3	1.6	1.25	0.0%	1.25
SCE	**Total**	**1.3**	**1.6**	**1.25**	**0.0%**	**1.25**
SCG	BOILERS	0.0	0.0	1.00	100.0%	
SCG	PROCESS BOILER	0.0	0.0			
SCG	WATER HEATING BOILER	0.0	0.0			
SCG	**Total**	**0.0**	**0.0**	**1.00**	**100.0%**	
	Statewide	***2.4***	***2.8***	***1.17***	***0.9%***	***1.17***

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	BOILERS	0.0	0.0						
PGE	PROCESS BOILER	0.0	0.0						
PGE	REPLACEMENT_HVAC_SYS	0.8	0.8	1.07	100.0%	0.70	0.70		
PGE	WATER HEATING BOILER	0.0	0.0						
PGE	**Total**	**0.8**	**0.8**	**1.07**	**100.0%**	**0.70**	**0.70**		
SCE	REPLACEMENT_HVAC_SYS	1.0	1.3	1.25	100.0%	0.80	0.80		
SCE	**Total**	**1.0**	**1.3**	**1.25**	**100.0%**	**0.80**	**0.80**		
SCG	BOILERS	0.0	0.0	1.00	0.0%	0.65	0.65	0.65	0.65
SCG	PROCESS BOILER	0.0	0.0						
SCG	WATER HEATING BOILER	0.0	0.0						
SCG	**Total**	**0.0**	**0.0**	**1.00**	**0.0%**	**0.65**	**0.65**	**0.65**	**0.65**
	Statewide	***1.8***	***2.1***	***1.17***	***99.2%***	***0.75***	***0.76***	***0.65***	***0.65***

Gross First Year Savings (MTherms)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	BOILERS	591	591	1.00	100.0%	
PGE	PROCESS BOILER	97	97	1.00	100.0%	
PGE	REPLACEMENT_HVAC_SYS	39	33	0.85	0.0%	0.85
PGE	WATER HEATING BOILER	391	391	1.00	100.0%	
PGE	**Total**	**1,119**	**1,113**	**0.99**	**96.5%**	**0.85**
SCE	REPLACEMENT_HVAC_SYS	13	16	1.27	0.0%	1.27
SCE	**Total**	**13**	**16**	**1.27**	**0.0%**	**1.27**
SCG	BOILERS	127	127	1.00	100.0%	
SCG	PROCESS BOILER	169	169	1.00	100.0%	
SCG	WATER HEATING BOILER	200	200	1.00	100.0%	
SCG	**Total**	**497**	**497**	**1.00**	**100.0%**	
	Statewide	***1,628***	***1,626***	***1.00***	***96.8%***	***0.95***

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	BOILERS	391	145	0.37	0.0%	0.66	0.25	0.66	0.25
PGE	PROCESS BOILER	63	63	1.00	100.0%	0.65	0.65		
PGE	REPLACEMENT_HVAC_SYS	27	23	0.85	100.0%	0.70	0.70		
PGE	WATER HEATING BOILER	255	50	0.20	0.0%	0.65	0.13	0.65	0.13
PGE	**Total**	**737**	**282**	**0.38**	**12.3%**	**0.66**	**0.25**	**0.66**	**0.20**
SCE	REPLACEMENT_HVAC_SYS	10	13	1.27	100.0%	0.80	0.80		
SCE	**Total**	**10**	**13**	**1.27**	**100.0%**	**0.80**	**0.80**		
SCG	BOILERS	83	12	0.14	0.0%	0.65	0.09	0.65	0.09
SCG	PROCESS BOILER	110	110	1.00	100.0%	0.65	0.65		
SCG	WATER HEATING BOILER	124	43	0.35	0.0%	0.62	0.22	0.62	0.22
SCG	**Total**	**317**	**165**	**0.52**	**34.7%**	**0.64**	**0.33**	**0.63**	**0.17**
	Statewide	***1,064***	***460***	***0.43***	***19.8%***	***0.65***	***0.28***	***0.65***	***0.19***

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	REPLACEMENT_HVAC_SYS	0	0.0%	0.0%	15.0	3,376.7	225.1	225.1
PGE	BOILERS	1	0.0%		20.0	10.8	0.5	0.5
PGE	PROCESS BOILER	1	0.0%		20.0	0.0	0.0	0.0
PGE	WATER HEATING BOILER	1	0.0%		20.0	0.0	0.0	0.0
SCE	REPLACEMENT_HVAC_SYS	0	0.0%	0.0%	15.0	2,696.0	179.7	179.7
SCG	BOILERS	1	0.0%		20.0	12.2	0.6	0.6
SCG	PROCESS BOILER	1	0.0%		20.0	0.0	0.0	0.0
SCG	WATER HEATING BOILER	1	0.0%		20.0	0.0	0.0	0.0

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	REPLACEMENT_HVAC_SYS	0	0.0%	0.0%	15.0	31.8	2.1	2.1
PGE	BOILERS	1	0.0%		20.0	14.4	0.7	0.7
PGE	PROCESS BOILER	1	0.0%		20.0	34.7	1.7	1.7
PGE	WATER HEATING BOILER	1	0.0%		20.0	39.7	2.0	2.0
SCE	REPLACEMENT_HVAC_SYS	0	0.0%	0.0%	15.0	12.3	0.8	0.8
SCG	BOILERS	1	0.0%		20.0	25.5	1.3	1.3
SCG	PROCESS BOILER	1	0.0%		20.0	38.2	1.9	1.9
SCG	WATER HEATING BOILER	1	0.0%		20.0	36.3	1.8	1.8

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	BOILERS	0	0.0%	0.0%	20.0	2.9	0.1	0.1
PGE	WATER HEATING BOILER	0	0.0%	0.0%	20.0	0.0	0.0	0.0
PGE	PROCESS BOILER	1	0.0%		20.0	0.0	0.0	0.0
PGE	REPLACEMENT_HVAC_SYS	1	0.0%		15.0	2,363.7	157.6	157.6
SCE	REPLACEMENT_HVAC_SYS	1	0.0%		15.0	2,158.1	143.9	143.9
SCG	BOILERS	0	0.0%	0.0%	20.0	1.1	0.1	0.1
SCG	WATER HEATING BOILER	0	0.0%	0.0%	20.0	0.0	0.0	0.0
SCG	PROCESS BOILER	1	0.0%		20.0	0.0	0.0	0.0

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	BOILERS	0	0.0%	0.0%	20.0	3.5	0.2	0.2
PGE	WATER HEATING BOILER	0	0.0%	0.0%	20.0	5.1	0.3	0.3
PGE	PROCESS BOILER	1	0.0%		20.0	22.6	1.1	1.1
PGE	REPLACEMENT_HVAC_SYS	1	0.0%		15.0	22.3	1.5	1.5
SCE	REPLACEMENT_HVAC_SYS	1	0.0%		15.0	9.8	0.7	0.7
SCG	BOILERS	0	0.0%	0.0%	20.0	2.3	0.1	0.1
SCG	WATER HEATING BOILER	0	0.0%	0.0%	20.0	7.9	0.4	0.4
SCG	PROCESS BOILER	1	0.0%		20.0	24.8	1.2	1.2

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

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice/Recommendations	Recipient	Affected Measure Package or DEER
1	All Programs	PA tracking and participant data fails to adequately document claims	Across all evaluated technology groups, the PAs were unable to consistently provide critical pieces of data essential for third-party evaluators to validate and assess claimed savings. Overall, site contact names were missing or invalid for over two-thirds of requested sites and phone numbers were missing or invalid for over half of all requested sites. This resulted in evaluation data collection delays, reduced site and survey counts, poor relative precision, and above all, questions whether all of these claims are actually installed and operating as intended.	**PAs should increase efforts to provide accurate and consistent tracking documentation**. The evaluator recommends the PAs and their implementers increase efforts to train participating midstream program distributors on proper documentation requirements, consistent and accurate data recording, as well as regular quality control reviews of the data prior to submittal. Systematically capturing a valid site contact name, phone number, email address, and business name should all be incorporated into the program data requirements.	All PAs	SWHC013-01, SWHC014-01, SWHC043-01, SWHC004-01, SWWH005-03, SWWH008-01, SWWH010-01
2	Replacement HVAC systems	PAs not reporting building types or vintages.	The PAs defaulted to using the commercial average building type and existing building vintage for all reported replacement HVAC system claims. The measure package model savings estimates vary significantly by both building type and vintage of the building where installed.	**PAs should track and report claim savings using accurate building vintages and types.** By specifying the correct building type and vintage ex-ante savings estimates will be considerably more accurate on a claim-by-claim basis and result in more reliable cost savings estimates	All PAs	SWHC013-01, SWHC014-01, SWHC043-01

Rec #	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice/Recommendations	Recipient	Affected Measure Package or DEER
3	Replacement HVAC systems	PAs claiming electric savings outside their service territory	Evaluators visited five sites where the PAs claimed both electric and gas savings for the installed units, but the sites' electricity is provided by a municipal electric utility. The evaluated gross kWh and kW savings for claims installed at these sites were zero because the savings is occurring outside the PAs service territory. Additionally, the incentive is benefiting an electric end-use customer that is not contributing to the Public Purpose Program Funds. This resulted in a decreased electric gross savings realization rate for this technology group.	**PAs should not claim electric savings for installations outside their service territory.** The evaluator recommends the PAs check to confirm the claimed system's installation address has a valid electric and gas account before claiming the corresponding savings. Additionally, they should make sure that the end-use customer contributes to the PPP Funds.	All PAs	SWHC013-01, SWHC014-01, SWHC043-01
4	Commercial boilers	Poor net savings realization is driven by programs' lack of influence on distributor actions	Distributors reported that they would recommend program eligible high-efficiency units at the same frequency without the program. End-user surveys indicate decisions are most driven by distributor recommendations and by price to a lesser extent. The participating distributors we spoke with claim their recommendations have minimal impact on purchasing decisions, which represents a lost opportunity because end-users say otherwise.	**PAs and implementers should encourage distributors to upsell highest efficiency tier boilers.** The evaluator recommends future programs consider offering increased incentives on the highest-efficiency tier boilers, so distributors increase high-efficiency equipment recommendations. Most end-user survey respondents (70%) reported they would pay full price for high-efficiency boilers if that's what their distributor or contractor recommended. By providing an increased incentive to distributors for selling the higher efficiency tier units they will be more likely to upsell the higher efficiency units and achieve greater program attribution. The PAs should dutifully notify distributors and other market actors of expected large program changes for boiler measures.	All PAs	SWHC004-01, SWWH005-03, SWWH008-01, SWWH010-01

6.4 Appendix D: Forward-looking replacement HVAC systems question responses

Q1: Did you consider or did the contractor present a Heat Pump Unit as an option? If yes which?	Qty of Sites
Don't know	15
No	27
Yes - Both	1
Grand Total	43

Q2: Has COVID-19 changed your HVAC operation? If yes, did the change increase or decrease your HVAC usage?	Qty of Sites
Don't know	5
No	30
Yes - decreased	6
Yes - increased	2
Grand Total	43

Q3: Did you increase your ventilation in any way as a response to COVID-19?	Qty of Sites
Don't know	8
No	30
Yes	5
Grand Total	43

Q4: Did you adjust your outside air intake at all because of COVID-19?	Qty of Sites
Don't know	9
No	30
Yes	4
Grand Total	43

Q5: Is your organization considering making any changes that would impact HVAC operation because of COVID-19?	Qty of Sites
Don't know	6
No	33
Yes	4
Grand Total	43

Q6: Have you made any changes to your HVAC operation or maintenance because of increased wildfire smoke?	Qty of Sites
Don't know	6
No	31
Yes	6
Grand Total	43

Q7: Does your company have a policy regarding energy efficiency or climate change?	Qty of Sites
Don't know	11
No	18
Yes	14
Grand Total	43

Q8: Do greenhouse gas impacts of leaked refrigerants impact your decision making?	Qty of Sites
Don't know	10
No	33
Grand Total	43

Q9: Is there any other feedback you would like to share with the CPUC and or the California Investor Owned Utilities?	Qty of Sites
Customer does not like heat pumps since they found them to be ineffective during winter months. They prefer gas packs.	1
If they have gas why get rid of it?	1
No	41
Grand Total	43

6.5 Appendix E: Detailed net attribution scoring methods

1 PY2020 BOILER ATTRIBUTION SCORING METHODS

1.1 Midstream programs

The midstream attribution scoring method is based on the 'causal pathways' method of measuring attribution that DNV developed for use with California midstream and upstream programs. The program logic for mid- and up-stream programs is that the programs interact with the manufacturers (upstream) or distributors (midstream) to influence their marketing practices. In the case of the midstream programs specifically, the program attempts to increase how often distributors upsell to higher efficiency models and how often the distributors stock higher efficiency models. The program does not attempt to directly influence prices distributors charge, but it does offer an incentive and potentially changes the revenue calculus for dealers in a way that allows them to offer lower prices for high efficiency models than they would without the program. The program logic holds that these changes to distributor behaviors will influence buyers to purchase higher efficiency models more often than they would without the program.

The attribution measures follow the program logic. First, they attempt to estimate the degree to which the program has changed distributor upselling, stocking, and pricing behaviors. It then attempts to estimate how much dealer upselling, stocking, and pricing affects the buyer's decision. The program can only influence the final decision when both elements exist: first it has to change distributor behavior, *and* that distributor behavior has to influence buyer decisions.

The instruments and scoring methods described here were based on the 2018 Midstream Rooftop Unit methods. We have adapted the instruments for boiler measures and streamlined in a few places to shorten them.

1.1.1 Identifying causal pathways of influence

To establish program attribution, we considered the pathways distributors take when selling a high efficiency boiler 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 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 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 1-1 shows the researchable questions themes that represent the three causal pathways across distributors and buyers.

Table 1-1. 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.

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 Sales Attribution scores were calculated for the distributors.

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

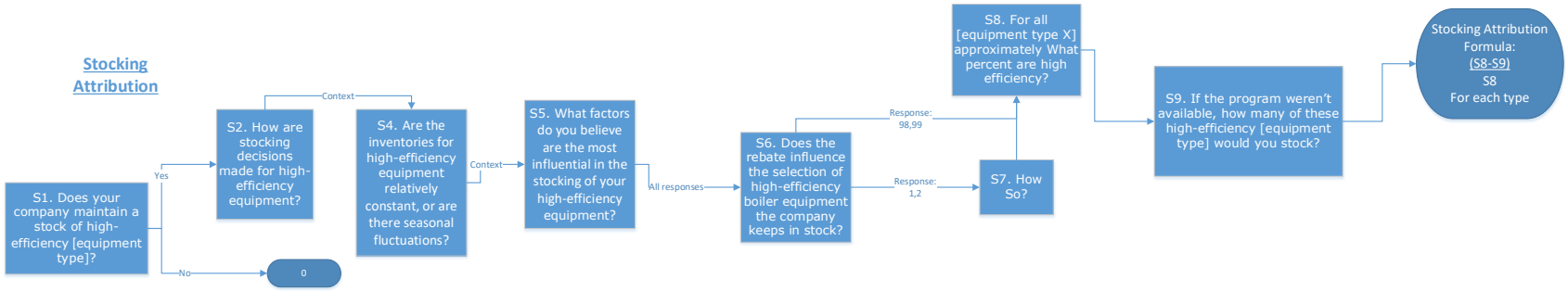


Figure 1-2. Detailed distributor causal pathway scoring: upselling

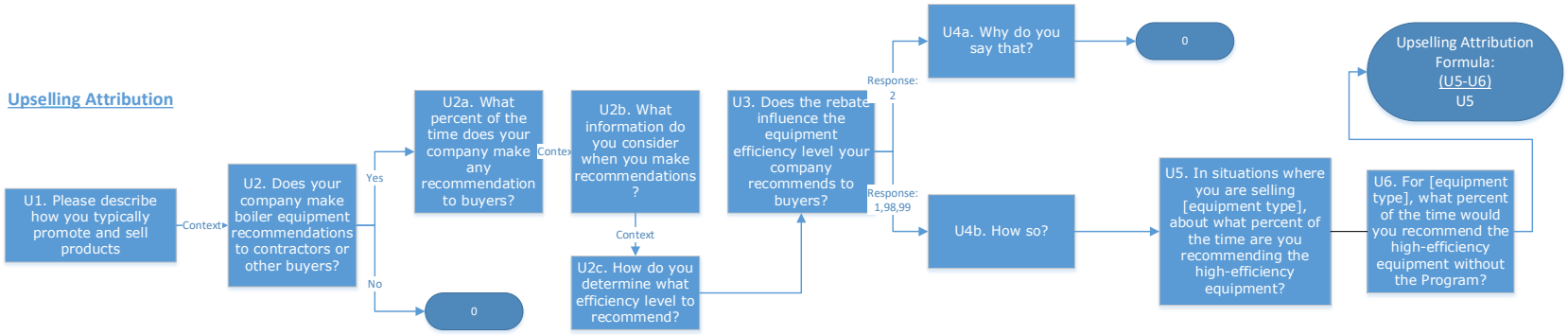


Figure 1-3. Detailed distributor causal pathway scoring: price

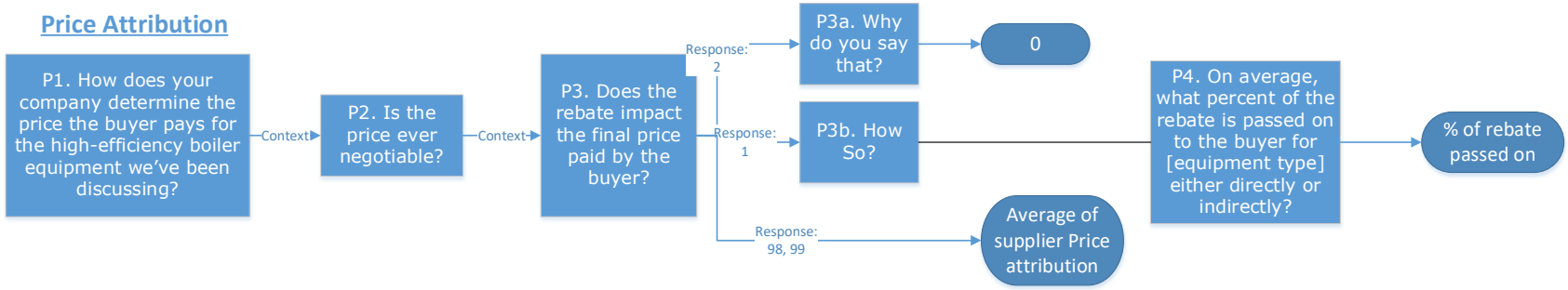
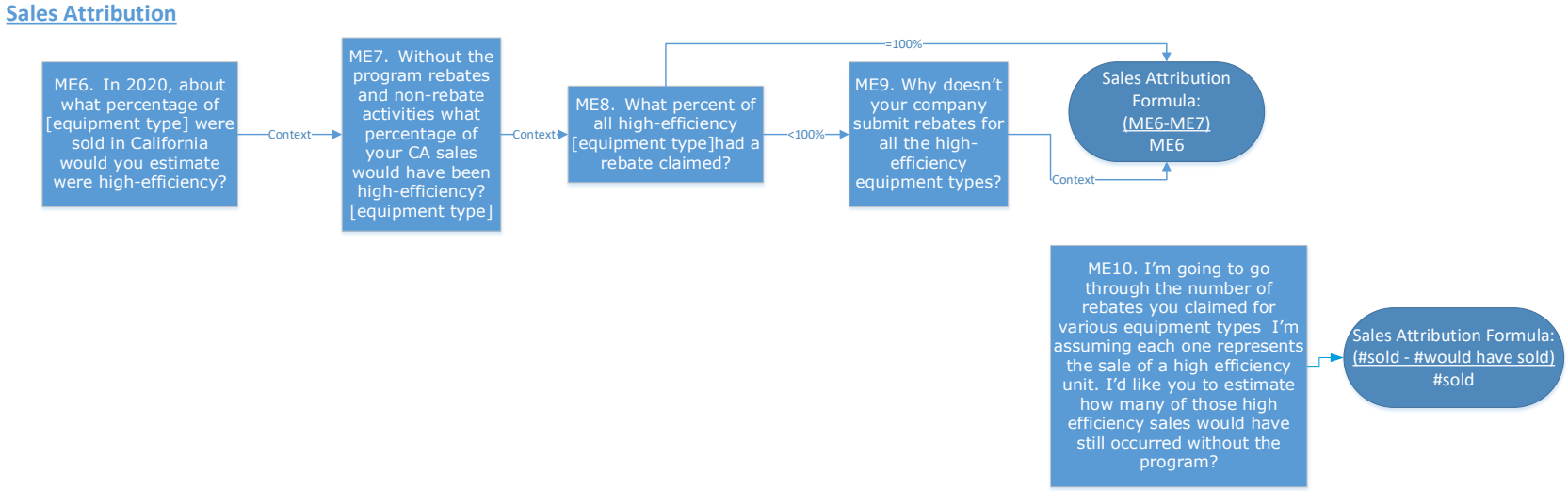


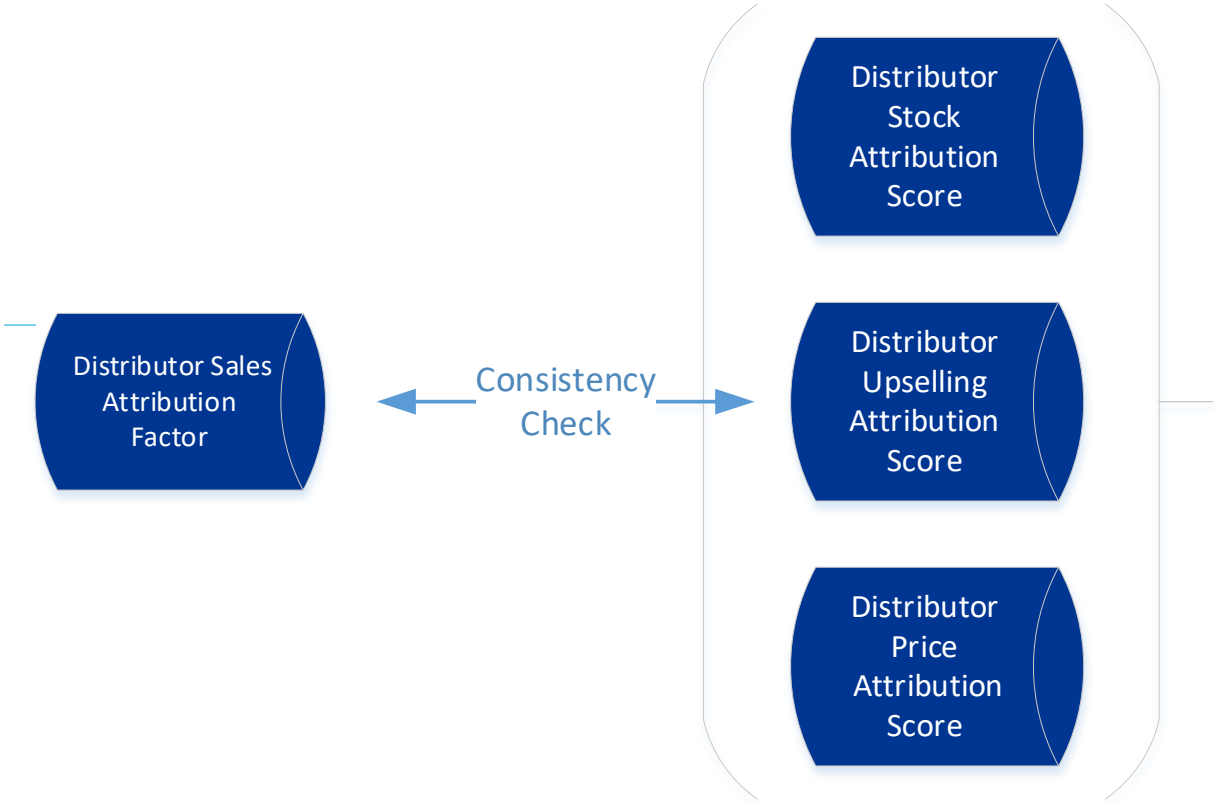
Figure 1-4. Detailed distributor causal pathway scoring: sales



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 1-5. shows how we calculated sales attribution, and used the result to check consistency across the other attribution scores.

Figure 1-5. Distributor attribution consistency check



1.1.2 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 1-1. Finally, we asked them about the minimum energy efficiency they were considering before buying their 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 1-6. Detailed buyer causal pathway scoring: stocking

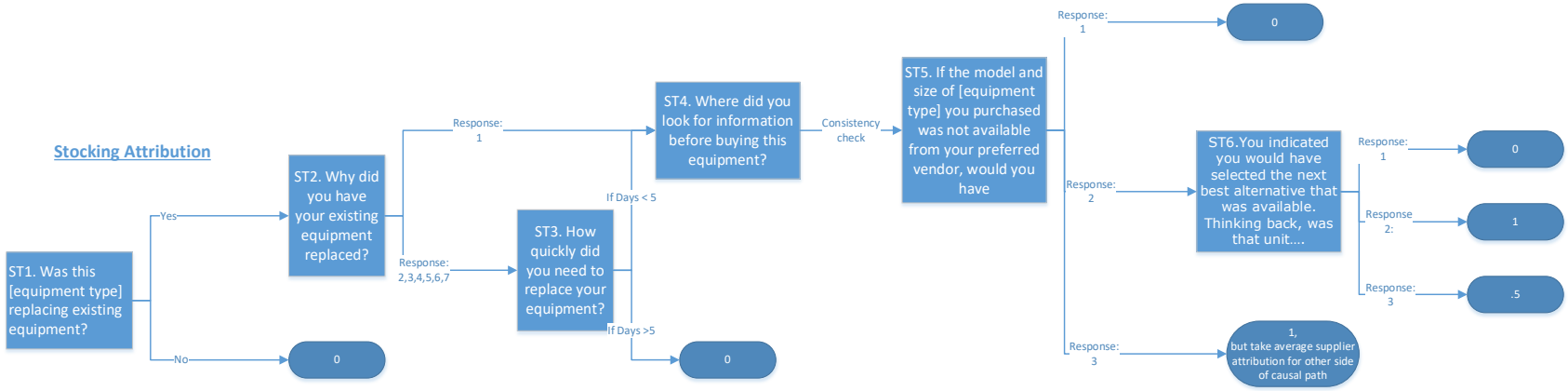


Figure 1-7. Detailed buyer causal pathway scoring: upselling

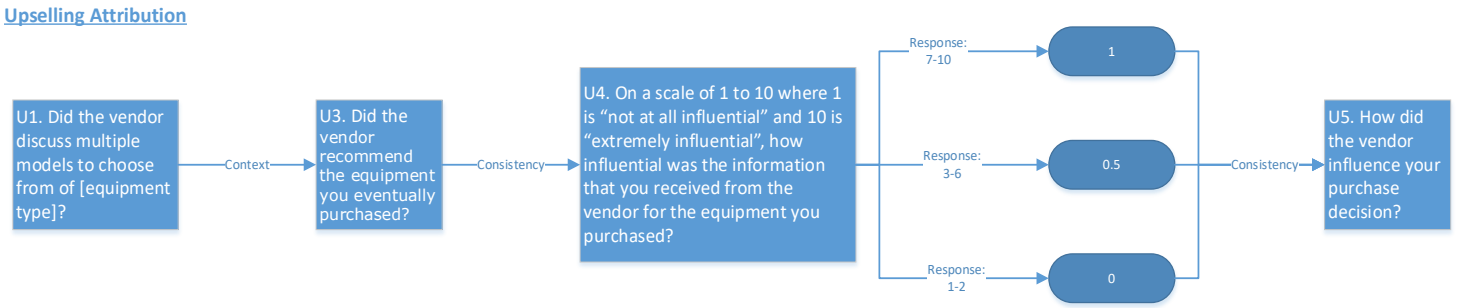


Figure 1-8. Detailed buyer causal pathway scoring: price

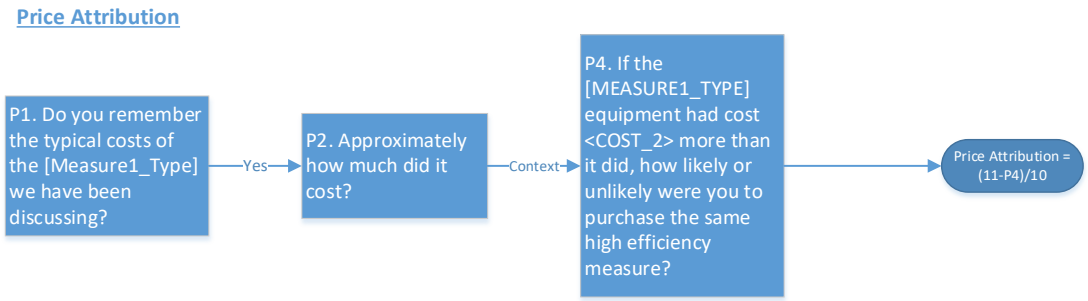
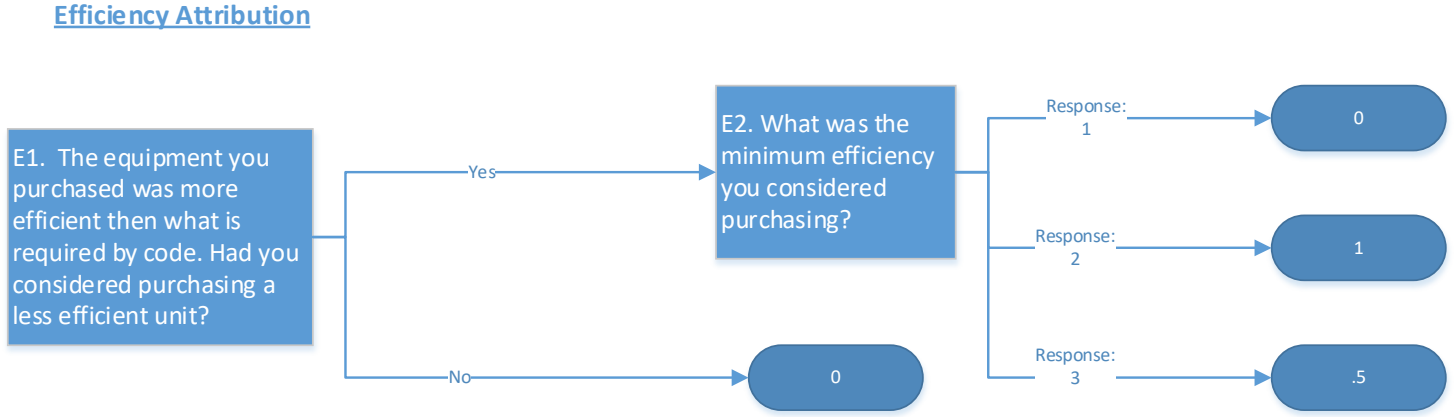


Figure 1-9. Detailed buyer causal pathway scoring: efficiency



Consistency Check

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

1.1.3 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.

$$\text{Combined Attribution}_{\text{Stock}} = \text{Distributor\_Attribution}_{\text{Stock}} \times \text{Enduser}_y\text{Attribution}_{\text{Stock}}$$

$$\text{Combined Attribution}_{\text{Upsell}} = \text{Distributor\_Attribution}_{\text{Upsell}} \times \text{Enduser}_y\text{Attribution}_{\text{Upsell}}$$

$$\text{Combined Attribution}_{\text{Price}} = \text{Distributor\_Attribution}_{\text{Price}} \times \text{Buyer}_y\text{Attribution}_{\text{Price}}$$

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

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

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.

1.2 Downstream programs

The NTGR methods for the downstream boiler programs are identical to those used for PY2017 and PY2018.

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):[1]

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

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

— 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

 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:

1. 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.

6.6 Appendix F: Stakeholder comments and evaluator responses

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
1	Effect of building vintage and type on accuracy of savings calc	Southern California Edison Company	N/A	N/A	"The PAs defaulted to using the commercial average building type and existing building vintage for all reported replacement HVAC system claims. The measure package model savings estimates vary significantly by both building type and vintage of the building where installed. PAs should track and report claim savings using accurate building vintages and types. By specifying the correct building type and vintage ex-ante savings estimates will be considerably more accurate on a claim-by-claim basis and result in more reliable cost savings estimates." SCE believes that DEER PY 2023 will rectify this problem going forward. E5152 also directs the PAs on the proper collection of data for mid/upstream programs.	Thank you for the comment.
2	Table 2-1 Summary of replacement HVAC systems	Southern California Edison Company	N/A	N/A	on Table 2-1 there appears to be a mismatch between claims and kWh/kW for SCE and PG&E	We checked the numbers presented in Table 2-1 and those counts are consistent with the final PY2020 tracking data we received. It should be noted that SCE bundled multiple systems within a single claim ID where PG&E created a new claim ID for each system installed. The ratio of number of claims to annual savings will be different because of the way individual systems were claimed by the two PAs.
3	Response to Recommend ations	Southern California Edison Company	N/A	N/A	SCE will respond to the recommendations upon the finalization of the report via the authorized Response to Recommendations process.	Understood, thanks

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
4	Finding and recommendation conflict: High efficiency boiler pricing	San Diego Gas & Electric Company	N/A	7	A key finding from the evaluation is "distributor responses indicate the boiler programs had a marginal market-effect on their recommendations to contractors and end-users." However, the evaluation also recommends that "PAs and implementers should encourage distributors to upsell higher efficiency boilers." The finding and recommendation seem to conflict since larger distributors are already upselling higher efficiency boilers in the absence of the program. Additionally, would the evaluators recommend passing more of the rebate to the distributor instead of the customer to drive distributor change.	The study did not produce evidence to support or undermine the idea that moving (more of) the rebate to distributors would increase the frequency they recommended high efficiency. The survey asked distributors what they would do in *absence* of the program. Also please see response to comment 17.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
5	Tracking of savings documentation	Southern California Gas Company	N/A	N/A	Study recommendation 1.3, PA tracking and participant data fails to adequately document claims and it is recommended that PAs increase efforts to provide accurate and consistent tracking documentation. "SoCalGas believes that at a midstream level, the focus of the evaluation should remain on the midstream participant data i.e., distributor data and not downstream customer data. SoCalGas does collect customer information from participating distributors, but the program management and delivery are focused on distributor activity. Furthermore, SoCalGas continues to recommend that evaluation data and findings be divided by program delivery channel, i.e., downstream vs midstream, to better distinguish the difference between data collected and validated."	The full recommendation in the report reads: "The evaluator recommends the PAs and their implementers increase efforts to train participating midstream program distributors on proper documentation requirements, consistent and accurate data recording, as well as regular quality control reviews of the data prior to submittal. Systematically capturing a valid site contact name, phone number, email address, and business name should all be incorporated into the program data requirements." As third-party evaluators tasked with performing measurement and verification of the replacement HVAC systems and commercial boiler claims, this data is essential to at a minimum validate the claims are installed and operating, and to measure the performance of their respective energy savings. The achieved sample did not support reporting by both the boiler technology groups and the respective program delivery channels. The process boiler technology group claims were all delivered via a downstream delivery channel, yet the quality of tracking data received and subsequent recruiting success for those claims was no better than the midstream claims. Future evaluation efforts will look to incorporate delivery type as a sampling criterion where feasible.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
6	Issue with selection of target group. Low sample size	Southern California Gas Company	3.4.2	N/A	Section 3.4.2, table 3-4 shows low sample size, report refers to the reason as “end-user contact data was not correct (usually the contact information was the distributor or installation contractors (27%))” "SoCalGas believes that the purpose of midstream energy efficiency programs is to stock and upsell high efficiency equipment at the midstream level. The program data should be to target those interveners (distributors and contractors), not end-use gas customers. Targeting the end user instead of the midstream intervenor does not appropriately evaluate the program or its intent. The characterization of the data being incorrect is not accurate, as the contact data for midstream programs, correctly, is the distributor or installation contractor."	The purpose of the program is to deliver energy savings and other benefits to the PAs' customers who pay into the PPP. Stocking and upselling high efficiency equipment through a mid-stream program is a method of program design for achieving that purpose but not the sole intent. A formal data request was submitted to SoCalGas requesting the end-user customer name and phone number. A distributor name and contact number was provided in this field 27% of the time at a statewide level and the distributor’s name listed offered no assistance in contacting the end-user. The end-user decision making process when purchasing a boiler or any EE measure is critical when assessing the net attribution of a program.
7	Issue with selection of target group	Southern California Gas Company	3.6	N/A	Net Assessment Methodology section 3.6.SoCalGas disagrees with the evaluation done here, as the contractor is the end-use customer of the program. The survey tool was inappropriately targeting the wrong participant group.	The evaluator disagrees with the statement the contractor is the end-use customer of the program. The PAs' customers are the program end-users and the beneficiary of the program. The evaluation used the end-user contact information provided by the utilities via the formal data request. The program data did not distinguish end-user contact information as contractor or site owner.
8	Error discussion	Southern California Gas Company	3.6	N/A	Net methodology section 3.6. Table 3.5 includes error for “location of detailed methodology”.	The detailed methods were included in Appendix D as an embedded PDF but others have commented that it was difficult to find. Users not viewing the report in recent versions of Adobe may have issues opening the embedded links in the draft report. The evaluator and the CPUC does not intend to limit any reader’s ability to view the entire report so in the final report, all appendices are now expanded and available in one single document. Appendix E contains the detailed net attribution scoring methods.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
9	Concern over sample size in NTG Analysis for Commercial boiler savings	Southern California Gas Company	4.2	N/A	Section 4.2 Commercial boilers, table 4.3. Please explain what the driver is for 4% evaluated NTGR for HVAC boilers, since Tier 1 (83-90% Thermal Efficiency) were dropped off the rebate app starting 2023 due to becoming ISP. Same question for water heating boilers evaluated NTGR. SoCalGas comment is that the completed sample size being 2 out of 57 accounts is the basis for 4% NTGR (table 3-2), this is not an acceptable sample size to draw any meaningful conclusion.	The study covered program year 2020. A low NTGR in 2020 is consistent with the conclusion that this level of efficiency has become ISP by PY2023.
10	Need copy of distributor responses for program improvement	Southern California Gas Company	4.2.1	N/A	Distributor influence section 4.2.1: Survey responses indicate that distributors are stocking high-efficiency models 5% more often and upselling no more often because of the program. SoCalGas would like to receive a copy of responses, if possible, for participating distributors in SoCalGas' program. This will help program improvement efforts.	DNV cannot share individual distributor responses because we promise anonymity when we conduct surveys to help produce the most honest answers. DNV can confirm that SCG's distributors did not all report 100% pass through of 100% of rebates on the surveys. SCG may wish to follow up with its distributors as part of standard program QA/QC processes.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
11	Requesting a copy of the survey tool, the survey participants, which service territories they represent and which, if any, of distributors operating in SoCalGas service territory claimed that they passed anything less than the full incentive levels to their participating customers	Southern California Gas Company	4.2.1	N/A	Distributor influence section 4.2.1: The majority (92%) of distributors did indicate that they pass a significant portion (41%) of the rebates to buyers. SoCalGas participating distributors pass 100% of the incentive to customers. For example, when distributors submit monthly invoices for repayment, SoCalGas requires that the distributor provide paid customer receipts demonstrating that the incentive has been applied to the customer, via their invoice. This ensures that the prearranged incentive value has been applied, as a point-of-sale discount, to the customer. The distributor is incapable of altering the incentive value and, in-turn, must apply the full value of the incentive directly to the customer. SoCalGas would like to request a copy of the survey tool, the survey participants, which service territories they represent and which, if any, of distributors operating in SoCalGas service territory claimed that they passed anything less than the full incentive levels to their participating customers.	DNV cannot share individual distributor responses because we promise anonymity when we conduct surveys to help produce the most honest answers. DNV can confirm that SCG's distributors did not all report 100% pass through of 100% of rebates on the surveys. SCG may wish to follow up with its distributors as part of standard program QA/QC processes
12	General comment on price disparity between standard and high efficiency models.	Southern California Gas Company	4.2.1	N/A	Distributors also reported that reducing the incremental cost between standard and high-efficiency models was the most effective way for them to sell high-efficiency options. This statement demonstrates that the Incremental Measure Cost (IMC) for these measures is too far spread if the only alternative solution to selling high EE equipment is to either reduce the cost of EE equipment or increase the cost of standard equipment. This demonstrates a need for increased incentives, however the TRC would be negatively impacted.	In response to this comment, the evaluator's recommendation is to focus incentives on the highest tier efficiency boiler options. End-user and distributor responses indicate this would have the greatest impact on increasing the program attribution. Passing all of the incentive on to the end-user would also help reduce the IMC burden on the PA customer/end-user.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
13	Concern over discrepancy between invoice and survey answers	Southern California Gas Company	N/A	N/A	Smaller distributors passed through a greater portion of the rebate (47%) to the end-users. This statement is not reflective of SoCalGas. All SoCalGas incentives are passed directly to participants through a point-of-sale discount. This is proven via the invoice, which leads SoCalGas to believe that the evaluation effort either did not distinguish findings across IOUs, or the evaluation team did not consider verifying this information and only relied on survey answers. SoCalGas requests that the evaluation team verify survey participant claims prior to submittal of the final evaluation.	DNV does not have invoice data to corroborate survey responses against. The reference 47% smaller distributor rebate pass-through isn't reflective of one program or PA but rather on a statewide level. Net-to-gross results by PA are presented in Table 4 3. Statewide first-year net impacts of commercial boilers. DNV cannot share individual distributor responses because we promise anonymity when we conduct surveys to help produce the most honest answers. DNV can confirm that SCG's distributors did not all report 100% pass through of 100% of rebates on the surveys. SCG may wish to follow up with its distributors as part of standard program QA/QC processes.
14	Discrepancy between distributor and end-use perspective on program influence on inventory stocking	Southern California Gas Company	4.4.2	N/A	End Users 4.4.2. According to this report about the surveys, the distributors are saying that the program had zero impact on stocking practices and zero impact on participation, but end use customers are saying that the distributor and contractor are directly influencing the sales of the high efficient equipment. SoCalGas is not clear which one of these statements are true, it appears that these two are conflicting and it raises the concern that evaluation report doesn't clearly state who the end-user was. SoCalGas recommends the evaluation team explain the discrepancy in these two perspectives.	Both are true. The distinction is explained in the causal pathway methodology. For the program to have an effect on the purchaser's decision, it must 1) change the distributors' behavior, and 2) the distributors' behavior must matter to the purchaser. #1 is assessed through distributor surveys, and the evaluation found that it did not occur. #2 is assessed independently and simultaneously through the contractor and end-user surveys, and those surveys found that the distributors' behaviors do matter to the purchasers. For the current evaluation, the lack of an effect for #1 means the answer to #2 does not matter. However, that #2 is true suggests that if the program could change distributors' behaviors, purchasers are likely to respond.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
15	Possible Contradiction	Southern California Gas Company	N/A	N/A	70% of end-users indicated they would be willing to purchase high-efficiency units without the rebates. SoCalGas believes that this contradicts the statement that was discussed in the report earlier: "Most (end-users 78%) said they were influenced by the recommendation of distributor or contractor to install a high-efficiency boiler. "	These factors are measured independently. It is theoretically possible that someone could both be willing to pay full price for a high efficiency unit and be influenced by distributors to install one.
16	Concern over effect of low sample size on low NTGR	Southern California Gas Company	N/A	N/A	Table 4-4, HVAC boiler, Water heating evaluated therm NTGR. 83% and 89% free ridership, given the cost of new boilers, it doesn't seem appropriate that the NTGR is so low. End-users consider numerous inputs to their purchase decision, and it's hard to believe high efficiency and lower incremental cost due to the rebate buy-down does not tip the scale toward the high-efficiency mode. The low sample size likely contributes to this low NTGR, but SoCalGas is very concerned that the evaluated results are not accurate, and the impact of the evaluation results on the program going forward will be devastating for the market for efficient boilers.	The combination of responses from distributors suggested that the reduced cost was the only factor substantially affected by the program, despite distributor reports that reduction in incremental costs was an important factor, Contrary to the distributors' responses about lower equipment costs as an effective influence, 70% of end-users indicated they would be willing to purchase high-efficiency units without the rebates (as reported in section 4.2.2) A sample size of 25 is not ideal, but it is also not so low as to invalidate the evaluation. The relative confidence intervals of 29% and 41% mean that the upper bounds on NTGRs are 23% for HVAC boilers and 15% for water heating boilers. So regardless of the low sample size, NTGRs are very likely still low. The commercial boiler evaluation performed in PY2018 found similarly low NTG ratios.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
17	Concern over possible contradictory statement	Southern California Gas Company	5	N/A	Section 5, Conclusion and Recommendations: "…Poor net savings realization is driven by lack of distributor actions. End-user surveys indicate decisions are most driven by distributor recommendations and by price to a lesser extent. The participating distributors we spoke with claim their recommendations have minimal impact on purchasing decisions, which represents a lost opportunity because end-users say otherwise…" This statement is contradictory, SoCalGas would like to know whether the incentive is influencing any of the distributor actions considering that the customer is receiving a discounted price and the distributor is receiving an incentive for the sale of the equipment.	In an effort to best articulate this finding we've revised the finding to say: "Poor net savings realization is driven by programs' lack of influence on distributor recommendations. Distributors reported that they would recommend program eligible high efficiency units at the same frequency without the program. End-user surveys indicate decisions are most driven by distributor recommendations and by price to a lesser extent. The participating distributors we spoke to claim their recommendations have minimal impact on purchasing decisions, which represents a lost opportunity because end users say otherwise." The corresponding recommendation was modified to stress increasing incentives on the highest efficiency tier boilers and to notify market actors of large program changes. "The evaluator recommends future programs consider offering increased incentives on the highest efficiency tier boilers, so distributors increase high-efficiency equipment recommendations. Most end-user survey respondents (70%) reported they would pay full price for high-efficiency boilers if that's what their distributor or contractor recommended. By providing an increased incentive to distributors for selling the higher efficiency tier units they will be more likely to upsell the higher efficiency units and achieve greater program attribution. The PAs should dutifully notify distributors and other market actors of expected large program changes for boiler measures."

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
18	Entire report	Pacific Gas & Electric Company	Table 1-2, Table 3-5	23	Is this draft complete? Does it contain final evaluated gross and net savings? It appears NTG for replacement HVAC systems was not evaluated. Why? Table 1-2 shows that ex-ante NTG values were passed through so that GRR and NRRs are the same. Section 3.6, Net Methodology, suggests there was a methodology to determine independent ex post NTGs, however the location of the detailed methodology says "Reference not found." Furthermore, Appendices A, B, D, and E appear to be blank. NTG and NRR estimates, detailed methodology, and IESR appendices and other appendices are key elements of an impact evaluation.	The first paragraph in section 1.1 states: "The replacement HVAC systems technology group was selected for gross savings evaluation based on its ongoing high contribution to statewide energy savings and energy savings uncertainty. Starting in 2021, the replacement HVAC systems technology group changed from PA-specific program delivery mechanisms to a statewide program. Knowing this shift in delivery structure will impact the program influence and net savings, we did not perform a net savings evaluation on the PY2020 replacement HVAC systems technology group. This report utilized the PAs' reported NTGR for the replacement HVAC systems technology group. The boiler technology groups were selected for a net savings evaluation because of the consistently large contribution to gas savings they represent and because of high NTGR uncertainty seen with HVAC boiler technologies in past evaluations. The last HVAC boiler evaluation results found more gross savings certainty (102% gross therms realization rate), so we did not evaluate the PY2020 boiler gross savings. This report utilized the PA's reported gross savings for the boiler technology groups." The detailed methods were included in Appendix D as an embedded PDF but others have commented that it was difficult to find. Users not viewing the report in recent versions of Adobe may have issues opening the embedded links in the draft report. The evaluator and the CPUC does not intend to limit any reader's ability to view the entire report so in the final report, all appendices are now expanded and available in one single document. Appendix E contains the detailed net attribution scoring methods.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
19	Focus of evaluation	Pacific Gas & Electric Company	1.1	1	The evaluation report states, "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." In what ways did the evaluation "focus on... peak demand?"	The focus of the evaluation is to evaluate claims of coincident peak kW demand, electric kWh energy, and gas Therm energy savings. The goal referenced by the commenter was written to distinguish a focus on peak coincident demand savings, as opposed to demand savings in general or across the year, and not intended to convey to the reader the entire focus of the replacement HVAC measure or evaluation is on peak demand impacts. The evaluation assessed peak coincident electric demand savings for the replacement HVAC measures.
20	Boiler NTG methods	Pacific Gas & Electric Company	1.1	1-2	The report states, "Net savings were estimated from surveys of end users or decision-makers and from interviews with equipment distributors." However, the net savings refer to boilers which were handled through a midstream program. What surveys were used to interview distributors and end-users? How were the survey results processed to develop NTG estimates? In PG&E's experience, since end-users are not program participants, they are often unaware of the program, how it influences distributor stocking practices, pricing, marketing, recommendations, and other subtle elements that may lead to final end-custom equipment decisions. To what extent do the evaluators believe end-user survey responses are useful in estimating midstream program NTG? Have the evaluators considered looking at high efficiency equipment sales quantities pre program and post program to obtain a top down estimate of market influence?	The detailed methods were included in Appendix D as an embedded PDF but others have commented that it was difficult to find. Users not viewing the report in recent versions of Adobe may have issues opening the embedded links in the draft report. The evaluator and the CPUC does not intend to limit any reader's ability to view the entire report so in the final report, all appendices are now expanded and available in one single document. Appendix E contains the detailed net attribution scoring methods. Only the distributor survey references the program. The end-user surveys ask how the distributors' behaviors affected their decisions, without reference to the program. In our experience market actors are reluctant and most often unwilling to provide data on sales or quantities.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
21	Missing units	Pacific Gas & Electric Company	1.2.1	5	PG&E would like to investigate the statement "We found 19 of 281 systems were not present anywhere at the reported business address." Could you please provide claims and project numbers related to PG&E's missing installations so that we can investigate and determine if program changes are appropriate?	Part of the evaluation outreach and recruiting includes a commitment to study participants that the site level information we collect will not be linked to specific sites but will be used in aggregate for evaluation purposes. Following the requests made on the quarterly stakeholder presentation to share the details of these missing units, DNV reached out to the individual PA customers for authorization to share the requested information about their sites. Only one of the systems for which we did not issue savings as a result of missing units was in PG&E territory. The PG&E customer did not respond to DNV's requests to share this information with PG&E. DNV did observe 17 out of 18 reported systems were present at this site however. Information regarding the missing units at SCE sites that authorized DNV to share this information was sent to SCE for their investigation purposes.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
22	Missing Units	Pacific Gas & Electric Company	1.2.1	5	The report states, "Missing units: Across the 43 site visits evaluators performed, we found 19 of 281 systems were not present anywhere at the reported business address. This included one site where none of the six reported systems were present. The remaining missing systems were observed at sites with other verified systems installed and present. This impact reduced the evaluated energy savings by approximately 8%." Please clarify what you mean by "The remaining missing systems were observed at sites with other verified systems installed and present." Were the "missing systems" installed and operating? Was this just a case of distributors not tracking the correct address of where they were installed? If the systems were installed at other locations within the PA territories, please clarify why the evaluators removed all savings from these systems.	Thanks for bringing this to our attention. We reworded the sentence, "The remaining missing systems were observed at sites with other verified systems installed and present." It now reads, "The remaining missing systems were claimed at sites with other verified systems installed and present." There were 19 missing HVAC systems in total. Six of the 19 missing systems were reported to be installed at one site where the evaluator did not find any. The remaining 13 missing systems were scattered across six different sites where the evaluator did observe other claimed units present. The evaluator checked every single HVAC units' nameplate at these sites and these reported systems were not present. The reported address locations for these systems were all confirmed by the site contacts to have received new systems in 2020. The evaluator has no way of knowing if the units were installed at other locations within the PA territory but recommends the PAs work with the distributors to ensure tracking data is correct.
23	Missing Recommendation	Pacific Gas & Electric Company	1.3	7-8	The Executive Summary, Study Recommendations (p7) has 3 recommendations listed but the Conclusions and Recommendations (p31 & 32) and Appendix C have 4 recommendations listed. The Executive Summary seems to be missing "PAs should track and report claim savings using accurate building vintages and types."	Our first recommendation focuses on tracking data quality, inclusive of building vintages and types. The executive summary is an abbreviated version of the main report and a detailed discussion about building type and vintage impacts were not included in the executive summary. For the executive summary we did not feel it would be warranted to include a recommendation that was not previously discussed.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
24	PAs claiming electric savings outside their service territory.	Pacific Gas & Electric Company	1.3 & 5.1.1	8	PG&E has multiple checks in place through an incentive processing department to ensure all applications and rebate requests are for customers served within the PA's service territory. Could you inform PG&E's program staff how many of these out-of-service-territory program applications occurred for PG&E's claims? Please include specific claim IDs and project numbers.	The evaluator can share that four of the five sites where this situation occurred were claimed by PG&E. Two of the four were Redding Electric customers, one was a Roseville Electric customer, and one was a SMUD customer. The one site claimed by SCE was a Moreno Valley Utility customer.
25	Poor net savings realization is driven by lack of distributor actions.	Pacific Gas & Electric Company	1.3	8	The report states, "Poor net savings realization is driven by lack of distributor actions. End-user surveys indicate decisions are most driven by distributor recommendations and by price to a lesser extent. The participating distributors we spoke to claim their recommendations have minimal impact on purchasing decisions, which represents a lost opportunity because end users say otherwise."	Agreed, this is what the draft report read. Others have commented on this finding and recommendation and the evaluator modified both the finding and recommendation slightly to better articulate our results.
26	Summary of HVAC system	Pacific Gas & Electric Company	2.2.1	11	Table 2-1. The number of claims in the PG&E program are much higher than SCE program, while the total kWh and kW are very similar or even smaller. Can the report provide some explanation for this discrepancy?	SCE bundled multiple systems within a single claim ID where PG&E created a new claim ID for each system installed. The evaluator encountered single SCE claims that included over 20 HVAC systems while all PG&E claims were for one single system. This accounts for the difference in savings per claim.
27	Incorrect reference	Pacific Gas & Electric Company	3.4.1, 3.6	21	There appears to be an incorrect reference, first line p21, "... inform the fan power index in the gross analysis methodology discussed in detail in Section 3.4.1." It looks like this should say section 3.5.	Thank you for catching that. This was corrected in the revised report.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
28	Sample number	Pacific Gas & Electric Company	3.4.1, 3.4.2	21	For both HVAC replacement and boiler replacement measure, the report mentioned the number of completed sample sites is much smaller than the number of targeted sample sites. Can the evaluator please suggest how this might impact the results of the evaluation? For example, how this might have impacted NTGR estimation for the boiler measure?	The primary purpose of the targeted sample sizes was to produce NTGR estimates that had 10% relative precision at the 90% confidence level. With fewer completed surveys than targeted, the precision of the NTGR estimates could not reach the preferred level. Despite a having a worse relative precision than preferred, the precision estimates still indicate that the NTGRs for these measures are low. In absolute terms, the upper bounds of the NTGR estimates for therms are 23% for HVAC boilers, and 15% for water heating boilers, and 26% for kWh for HVAC boilers. These ratios are all statistically significantly lower than the 57 to 61% ex ante NTGRs for these measures. In other words, despite lower than desired precision, the evaluation can still be interpreted to indicate lower NTGRs than the ex ante values, with a very high degree of confidence.
29	Gross methodology	Pacific Gas & Electric Company	3.5	23	The Gross Methodology section is only half a page. Can the evaluation team please include details on how gross savings were estimated ex post for both HVAC replacements and boilers? What onsite measurements were made; how were these accomplished during the Covid pandemic? How were savings estimated and with what input parameters? Other than rated cooling efficiency and supply fan efficacy (watts/CFM), what other input parameters were collected and which were considered critical? There is no mention of boilers in the methodology section. To what extent did methods differ for HVAC replacements vs. boilers? The section mention desk reviews and phone data collection, but it is unclear how all these elements were combined. Separate sections would be appropriate for HVAC and boiler gross savings methodologies.	Gross savings was not evaluated for commercial boilers. The evaluator adopted the PAs reported gross savings for commercial boilers. For replacement HVAC systems the evaluator conducted virtual and in-person site visits to determine site specific parameters critical to model inputs. Those included the observed rated cooling efficiency, cooling capacity, building type, building vintage, climate zone, and supply fan efficacy (tested watts per cfm).

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
30	Miscategorized systems reported	Pacific Gas & Electric Company	4.1	26	The report states, "Miscategorized systems reported: One PA reported savings for larger HVAC systems assuming full-load performance, which evaluators verified achieved high cooling efficiency in both part-load performance and full-load performance. Because these units are achieving high-efficiency performance in more cooling conditions and more hours of the year than reported, the evaluated savings increased by approximately 9%." Can this be re-written for clarity? What are "miscategorized systems?" Section 3.4, Data Collection, does not mention part-load cooling performance testing or data collection; can you explain what was collected and how savings were estimated?	We have revised this section to characterize these instances as under-reported part-load savings. The full and part load rated performance of these systems was collected and modeled in aggregate to reflect the high full-load cooling performance potential of the units meeting the SWHC013 workpaper requirement and the high part-load performance potential of the units meeting the SWHC043 workpaper requirements. The performance curves developed for assessing SWHC043 measure savings were modeled in conjunction with the higher rated full-load cooling found of these systems.
31	Existing building vintage	Pacific Gas & Electric Company	4.1	27	The draft report states that the fraction of buildings determined to be new construction was 44% (19 of 43), this appears to be much higher than would be expected based on discussions with distributors and manufacturers. Experience shows that the rate of new construction for commercial unitary HVAC equipment is much closer to 20% of overall equipment sales. Replacements account for approximately 80% of unitary sales, suggesting the sample is not representative. Can the evaluation team find additional data to support an accurate NR and NC fractions?	The evaluator found the data provided by distributors did not include a specification of measure application type, i.e. normal replacement vs new construction. The evaluation team requested PG&E provide additional data regarding the sampled and backup claims which it sought to evaluate but did not receive any further information. Without knowing the application type, the evaluation is unable to include it as a sampling criterion to potentially mitigate the commenters suggestion of a response bias. The evaluator recommends these numbers be documented and included in the tracking data. That would be the best source of additional data the commenter is seeking.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
32	NTGR	Pacific Gas & Electric Company	4.2	28	The evaluation found low NTGs since the program had little impact on distributors stocking high efficiency boiler and upselling that equipment to end-users. The report cited some survey responses to justify the statement. However, there is little information on how the evaluation used the survey results to estimate NTG values. Can the report include an explanation of how NTGs were estimated based on survey result?	The detailed methods were included in Appendix D as an embedded PDF but others have commented that it was difficult to find. Users not reading the report in recent versions of Adobe may have issues opening the embedded links in the draft report. The evaluator and the CPUC does not intend to limit any reader's ability to view the entire report so in the final report, all appendices are now expanded and available in one single document. Appendix E contains the detailed net attribution scoring methods.
33	NTGR	Pacific Gas & Electric Company	4.2.1	28	The report states, "Survey responses indicate that distributors are stocking high-efficiency models 5% more often and upselling no more often because of the program." Could the evaluators provide more information on how the percentage increase was calculated based on the survey?	The detailed net attribution scoring methods are found in Appendix E.

34	NTGR	Pacific Gas & Electric Company	4.2	28	The report assigned low NTGs to boilers because it was found the program had little impact on distributors stocking high efficiency boilers and upselling that equipment to end-users and "did little to change distributor behaviors." However, the report found that 92% of distributors passed on a significant portion of the rebate to buyers. That is a significant change in distributor behavior, which would not have occurred absent the program. The report states "DNV's conversations with program managers as part of previous program year evaluation indicated that the program logic is based on altering distributors' stocking and upselling practices, not necessarily in reducing the incremental cost of high-efficiency models." (p7) And, end-users reported they would have purchased the same equipment without the rebate costs. However: - The report also states, "Distributors also reported that reducing the incremental cost between standard and high-efficiency models was the most effective way for them to sell high-efficiency options." (p7) - Net savings are an estimate of the savings that occurred due to the program. Net savings must be estimated based on what's actually occurring in the market, irrespective of the mechanism, and if original program logic differs. - Note that the PY2020 Nonres Lighting Impact report DID include distributors' reduction to prices as an influencing behavior (see pdf p. 1-5 and 6-7 of that report). Based on the evaluation's findings, w**e believe the NTG for boilers is underestimated because it did not include distributors' price reductions as an "influencing behavior."** While there's a disconnect between what end-users reported and distributors in terms of the influence of price, DNV weighted the distributor responses more heavily than end-users (customers) elsewhere in the report (see p1-6).	The NTGR method takes into account both the program's influence on distributors' behaviors and then how much the distributors' behaviors matter to the end-users' purchase decisions. The methods addressed all three: stocking, upselling, and rebate passthrough. The distributors indicated that the program did little to change their stocking and upselling behaviors. Thus, the program would not get attribution for these mechanisms regardless of how important these are to end-users (and end-user surveys suggested that upselling is important to them) . The methods also assessed rebate passthrough at both the distributor and end-user level. The first paragraph in section 4.2.1 details that the majority of distributors pass through a substantial portion of the rebates to end-users. However, as reported in section 4.2.2, 70% of end-users said they would have still purchased the high-efficiency unit without the price reduction provided by the rebate. Thus, the program did affect distributors' behaviors here, but those behaviors were only moderately important to the end-users. The statement about program logic was to point out that program logic appears to no longer be true, but it did not change the NTGR computation. The statement about what distributors reported about the importance of incremental cost is included for additional detail - the distributors seem to think something about their buyers that the buyers do not confirm. This represents a cautionary note for utilities who design programs with distributor input - the

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
						distributors may or may not have accurate impressions of their end-users decision making priorities.
35	ROB treatment	Pacific Gas & Electric Company	4.2.2	29	The program treated all boilers in this program as Replace on Burnout (ROB). The evaluator found that, "Among the replacement boilers, 83% of the replacements were for existing boilers that were functioning but had significant maintenance or performance issues." DEER assumes an EUL of 20 years for boilers, even though a study found that the majority of boilers are over 20 years old: https://www.aceee.org/files/proceedings/2016/data/papers/2_105.pdf. These findings indicate many boilers may be Accelerated Replacement (AR), not Replace on Burnout (ROB). While an AR project could use the custom program, that is much more burdensome. Could the CPUC or evaluators describe how projects in the future could claim AR under a midstream model? What documentation would be needed?	Deemed measure savings rationale and methods are documented in the workpapers in this case in eTRM. The eTRM for a measure establishes the existing and high efficiency baselines, the EUL and RUL of the measure, and preponderance of evidence requirements for accelerated replacement. In general, deemed characteristics are used to calculated savings for the deemed measures that cannot be site-specific specifically for high volume mid-stream program delivery. As mentioned in the comment, the use of site-specific equipment information in determining savings implies the measure is custom or calculated. Therefore, the application of existing condition as baseline for deemed measure (such as the boiler) must involve an approved workpaper that is established on reliable aggregate data to support the existing conditions and circumstances such as buildings, customer, climate zone, equipment operating condition where the measure is applied. Existing conditions are much more variable than code conditions. This fact exacerbates the potential for error in determining reasonably assured deemed savings values for existing conditions baseline. All these efforts could be substantially resource intensive and could produce less accurate savings estimates. Therefore, we recommend using the custom program to claim AR for boiler measures as it will be less burdensome and more accurate than claiming AR via deemed program.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
36	Poor net savings realization is driven by lack of distributor actions.	Pacific Gas & Electric Company	5.1.2	32	This PA has found that the very nature of the distributor participation in these programs would have included 'upselling' more efficient units. From all interactions with distributors, this action of 'upselling' the higher efficiency units did take place.	Thank you for the comment. When evaluators asked distributors, they indicated they recommended high efficiency units approximately 90% of the time. Furthermore, and most important for NTGRs, they also indicated that they would recommend high efficiency units at the same rate without the program. Thus, the evaluation concluded that the program did not result in a net increase in the frequency of high efficiency recommendations.
37	Data collection	Pacific Gas & Electric Company	3.4.1	19 & 13	The report mentioned a couple times that COVID impacts were evaluated, and virtual data collection method was used. Can the report please provide findings related to COVID impact? For example, did it impact the savings estimate? In addition, the report states on p13, "The evaluation methodology focused on parameters that are unaffected by impacts stemming from the global pandemic." Can the report list what those parameters are? Given operating hours are likely affected by COVID, how were operating hours handled for both energy and demand calculations?	For the replacement HVAC systems site visits (both virtual and in-person) pandemic related impacts were discussed and the responses are captured in Appendix D, Forward-looking replacement HVAC systems question responses, but they did not impact the evaluated savings. The evaluated savings for replacement HVAC systems was based on site observed parameter updates to simulation models. These parameters did not include operational changes related to the pandemic but included building vintage, business type, equipment efficiency, and equipment size. Operating hours are likely affected by the pandemic but how long those impacts will last and with what permanence is still not clear. For this reason, the evaluator did not incorporate pandemic impacts with the evaluated savings results.

#	Subject	Stakeholder	Section	Page	Question or Comment	Evaluator Response
38	Missing Appendix	Pacific Gas & Electric Company	Appendix	41	Appendix A, B, D, E are missing	Those appendices were included as an embedded PDF, but others commented they had trouble opening. Users not viewing the report in recent versions of Adobe may have issues opening the embedded links in the draft report. The evaluator and the CPUC do not intend to limit any reader's ability to view the entire report. In the final report, all appendices are now expanded and available in one single document.

6.7 Appendix G: Data collection and sampling memo

GROUP A

Commercial HVAC Data Collection and Sampling Memo Program Year 2020

California Public Utilities Commission

Date: September 16, 2021

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1 OVERVIEW

This document outlines the sampling and data collection plan for the Commercial Heating Ventilating Air Conditioning (HVAC) sector for Program Year 2020 (PY2020).

Our sampling and data collection efforts under Deliverable 7 (data collection and sampling approach) are designed to meet the needs of Deliverable 1 (research and evaluation workplans), Deliverable 8 (program analysis and recommendations), Deliverable 9 (gross savings estimates), and Deliverable 10 (Net savings estimates). As part of Deliverable 7, we have developed a sampling and data collection strategy to serve the needs of these other deliverables at the required rigor levels.

Our approach to sample development is described in Section 2, where we summarize the sample. Section 3 covers data collection for both gross and net savings estimates. Finally, the Appendices include the data collection instruments we will use to gather data for quantifying our estimates of gross and net savings.

2 SAMPLING

This section describes the applied sampling approach and sample summary.

2.1 Sampling Approach

For this task there are four measure groups being evaluated:

- Replacement HVAC systems
- HVAC boilers
- Process boilers
- Hot water boilers

For all measure groups the sampling methodology employs a stratified ratio estimation technique. This stratified ratio estimation approach will study a subset of units, i.e., sample, drawn from the full population. The sample design approach first places participants into groups of interest and then place them into strata by size, measured in terms of kWh and Therm savings. The methodology then estimates appropriate sample sizes to achieve the targeted relative precision (±10%) at a desired level of confidence (90%) based on an assumed error ratio.

The error ratio is the ratio-based equivalent of a coefficient of variation (CV) measuring the variability (standard deviation or root-mean-square difference) of individual evaluated values around their mean value, as a percentage of that mean value. Therefore, 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. This preliminary estimate can be based on historical analysis of similar program offerings.

In practice, the actual 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. For this sample design, we have assumed an error ratio of 0.6 for the four measure groups based on the prior evaluation cycles of the same programs. If the study were looking to measure annual or peak consumption, then we would select a higher error ratio based on past metering studies. These were found to be somewhere between 0.7 and 1.0 depending on buildings and climates covered. A simpler verification study may use a slightly lower error ratio of 0.5.

2.2 Measure Group Selection Process

Working with Commission staff, the evaluation team determined which measure groups to evaluate for PY2020 based on each measure group's contribution to lifecycle savings (kWh, kW, therms) and consideration for 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 group selection through the HVAC Project Coordination Group meetings and the HVAC Workplan engagement process with the Program Administrators (PAs). The replacement HVAC measure group was selected based on its continued high contribution to lifecycle gross kWh (72%) and kW (79%) savings within commercial HVAC and the commercial sector overall (16% for kWh, 25% for kW) and outstanding fan energy savings uncertainty. The boiler measure groups (HVAC, Water Heating, and Process) were selected because of their consistently large contribution to lifecycle therm savings claims for the overall commercial sector (18% in PY2020) and in some part because of the high uncertainty of ex post net-to-gross ratio (NTGR) results from PY2017 and PY2018 HVAC boiler measure group studies that did not agree with ex ante NTGR values.

2.3 Measure Group Sampling

2.3.1 Overview

For the sample design, first we defined the populations (i.e., the sampling frames) for each of the 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 the sampling frames were defined, we stratified the population based on the claimed savings (kWh or therms). Next, we determined the target precisions, i.e., ±10% relative precision for each measure group, and the level of confidence require, i.e., 90% confidence level. Using the error ratio assumption discussed above, the precision and confidence targets, we developed estimates of the required sample size. Once the sample size was calculated, we randomly chose primary sample points from the population based on the stratification plan. We have selected a sufficient sample to achieve the targeted number of completed cases, after considering the likely response rates. In addition, we selected a backup sample in case any sample points need to be replaced. Replacement happens with sites that cannot be contacted, visited, or evaluated for some reason.

2.3.2 HVAC Replacement Assumptions

HVAC replacement involved customers of PG&E and SCE. The sampling methodology for the HVAC replacement measure group employed a stratified ratio estimation model that used three dimensions, program administrator, delivery program, estimates savings measured in kWh and Therm savings. The methodology then estimated appropriate sample sizes based on an assumed error ratio to achieve the desired ±10 relative precision at 90% confidence by program administrator.

2.3.3 Boilers Assumptions

The sampling methodology for the net attribution evaluation of the boilers measure groups employed a stratified ratio estimation model placing participants into segments of interest by boiler type (HVAC, process, or water heating) and PA (PG&E and SCG). Next the sites were placed into strata by size, measured in therms. The methodology then estimated appropriate sample sizes based on an assumed error ratio to achieve the desired ±10 relative precision at 90% confidence by boiler type. Please note, the desired precision for the boiler analysis were targeted by boiler type and not by program administrator. This was done in an effort to control the sample size by reducing the number of strata and the anticipated error ratio by grouping like participants across service territories. The lower error ratio is based on the assumption that participants net survey responses will be more similar based on the type of boiler installed rather than on actions by the program administrator.

2.4 Replacement HVAC Sample Design

DNV designed the sample to achieve ±10% relative precision at the 90% confidence level for this measure group across both PAs. In order to meet our statistical targets, a total of 85 sample sites are required for the replacement HVAC measure

group as shown in Table 1. Table 2 shows the stratification cut-points, number of accounts in the population and sample, and the inclusion probability for the replacement HVAC measure-group sample design.

Table 1. Replacement HVAC Gross Sample by PA

PA	Program ID	Statewide Supporting Workpaper	Accounts	First Year Gross Savings (kWh)	Error Ratio	Sample	Expected Relative Precision
PG&E	PGE21015	HC013-01	126	429,052	0.6	7	41.5%
PG&E	PGE21015	HC014-01	524	1,827,858	0.6	25	19.3%
PG&E	PGE21015	HC043-01	53	427,210	0.6	7	37.9%
PG&E	**Total**		**703**	**2,684,120**	**0.6**	**39**	**15.9%**
SCE	SCE-13-SW-002F	HC013-01	230	865,963	0.6	15	24.0%
SCE	SCE-13-SW-002F	HC014-01	539	1,786,678	0.6	25	19.0%
SCE	SCE-13-SW-002F	HC043-01	23	335,337	0.6	6	37.1%
SCE	**Total**		**792**	**2,987,979**	**0.6**	**46**	**13.9%**
Overall Result			**1,495**	**5,672,099**	**0.60**	**85**	**10.5%**

Table 2. Replacement HVAC – Sample Design Stratification

PA	Program ID	Statewide Supporting Workpaper	Stratum	Accounts	First Year Gross Savings (kWh)	Sample
PG&E	PGE21015	HC013-01	1	104	175,703	4
PG&E	PGE21015	HC013-01	2	22	253,348	3
PG&E	PGE21015	HC014-01	1	320	240,259	5
PG&E	PGE21015	HC014-01	2	107	299,100	5
PG&E	PGE21015	HC014-01	3	56	343,431	5
PG&E	PGE21015	HC014-01	4	28	419,640	5
PG&E	PGE21015	HC014-01	5	13	525,428	5
PG&E	PGE21015	HC043-01	1	41	176,457	4
PG&E	PGE21015	HC043-01	2	12	250,754	3
SCE	SCE-13-SW-002F	HC013-01	1	167	170,957	5
SCE	SCE-13-SW-002F	HC013-01	2	52	233,313	5
SCE	SCE-13-SW-002F	HC013-01	3	10	356,656	4
SCE	SCE-13-SW-002F	HC013-01	4	1	105,037	1
SCE	SCE-13-SW-002F	HC014-01	1	327	227,664	5
SCE	SCE-13-SW-002F	HC014-01	2	116	288,565	5
SCE	SCE-13-SW-002F	HC014-01	3	55	344,178	5
SCE	SCE-13-SW-002F	HC014-01	4	28	406,324	5
SCE	SCE-13-SW-002F	HC014-01	5	13	519,947	5
SCE	SCE-13-SW-002F	HC043-01	1	19	119,994	3
SCE	SCE-13-SW-002F	HC043-01	2	4	215,344	3

2.5 Commercial Boilers Sample Design

DNV designed the sample to achieve ±10% relative precision at the 90% confidence level for each measure group. In order to meet these statistical requirements, a total of 145 sample sites are required for the HVAC Commercial Boilers measure group as shown in Table 3. We stratified by boiler measure group and PAs. The targeted relative precision of ±10% is based on a 0.6 error ratio based on our previous experience with similar studies. Table 4 shows the stratification cut-points, number of accounts in the population and sample for the commercial boiler measure-group net survey sample design stratification.

Table 3. Commercial Boilers Net Sample by Boiler Type

Measure Group	PA	Accounts	First Year Gross Therm Savings	First Year Net Therm Savings	Sample	Expected Relative Precision
HVAC boiler	PG&E	330	591,311	361,468	55	11.6%
HVAC boiler	SCG	57	127,066	76,240	15	21.8%
HVAC boiler	Total	387	718,377	437,707	70	10.3%
Process boiler	PG&E	7	97,089	58,253	5	18.9%
Process boiler	SCG	13	169,350	101,610	10	7.4%
Process boiler	Total	20	266,439	159,863	15	8.3%
Water heating boiler	PG&E	203	391,190	235,745	40	12.9%
Water heating boiler	SCG	67	200,471	114,421	20	16.2%
Water heating boiler	**Total**	**270**	**591,661**	**350,165**	**60**	**10.1%**

Table 4. Commercial Boilers Net Sample Design Stratification

Measure Group	PA	Stratum	Accounts	Gross Program Savings (Therm)	Net Program Savings (Therm)	Sample
HVAC boiler	PGE	1	139	85,079	51,931	11
HVAC boiler	PGE	2	74	97,851	61,055	11
HVAC boiler	PGE	3	51	107,968	65,796	10
HVAC boiler	PGE	4	39	117,091	72,693	10
HVAC boiler	PGE	5	24	132,322	79,393	10
HVAC boiler	PGE	6	3	51,000	30,600	3
HVAC boiler	SCG	1	25	36,566	21,940	5
HVAC boiler	SCG	2	19	43,320	25,992	5
HVAC boiler	SCG	3	13	47,180	28,308	5
Process boiler	PGE	1	3	22,633	13,580	2
Process boiler	PGE	2	3	34,033	20,420	2
Process boiler	PGE	3	1	40,423	24,254	1
Process boiler	SCG	1	4	12,197	7,318	2
Process boiler	SCG	2	3	17,177	10,306	2
Process boiler	SCG	3	2	24,994	14,997	2
Process boiler	SCG	4	4	114,982	68,989	4
Water heating boiler	PGE	1	88	53,751	32,395	8
Water heating boiler	PGE	2	51	62,667	38,487	8
Water heating boiler	PGE	3	27	71,720	43,032	8

Measure Group	PA	Stratum	Accounts	Gross Program Savings (Therm)	Net Program Savings (Therm)	Sample
Water heating boiler	PGE	4	21	77,618	46,571	7
Water heating boiler	PGE	5	14	87,775	52,665	7
Water heating boiler	PGE	6	2	37,658	22,595	2
Water heating boiler	SCG	1	29	31,811	18,187	5
Water heating boiler	SCG	2	17	34,897	19,193	5
Water heating boiler	SCG	3	12	37,836	21,775	4
Water heating boiler	SCG	4	7	52,422	30,586	4
Water heating boiler	SCG	5	2	43,505	24,680	2

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 Group A PY2020 Workplan.

3.1 Data Collection Instruments

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

3.1.1 Replacement HVAC

For the PY2020 gross savings evaluation of Replacement HVAC measures, we will conduct virtual interviews with end users at participating facilities using utility-provided contact and equipment information. The virtual interview will include questions to verify measure installation, capture equipment nameplate data, and determine an array of building and installed measure characteristics. Additionally, at a sub-sample of up to fifty sites, on-site visits will be conducted. Along with gathering all the data points included with the virtual site visits, fan power and air-flow testing will be performed at the on-site visits. The information collected will be used to update installation rates and refine gross savings estimates for replacement HVAC measures.

3.1.1.1 Virtual Site Visits

All sample sites will at a minimum will receive a virtual site visit. These will be conducted with a site contact that is both familiar with the claimed equipment installation and is able to physically observe the equipment while on a virtual call with the DNV inspectors. During each virtual site visit, a member of the evaluation team directing the visit will make observations and collect the following parameters:

- **Equipment Verification:** Inspectors will ask the site contact to both confirm the claimed equipment was installed, the baseline conditions meet claim specifications, and to show them the claimed equipment installed and operating at the business location.
- **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.
- **Installation Characteristics**: Inspectors will record the building type served and other sites-specific characteristics pertaining to the sampled claims.

A list of additional items to be recorded on the virtual site visits can be found in Appendix A**.**

3.1.1.2 On-site Visits

In addition to collecting all the parameters found in the virtual site visit, the on-site visits will capture information on the HVAC blower motor and will include the following two test procedures necessary to determine the fan power index (FPI):

- Cooling-mode fan true electric power
- Cooling mode airflow

A list of parameters to be recorded during the on-site visits can be found in Appendix B and Appendix C.

3.1.2 Commercial Boilers

We will perform net evaluations for the statewide commercial boiler measure groups. To support our net savings estimates, we propose to interview combinations of customers and boiler equipment distributors. We will interview end-user decision makers for sampled claims delivered through down-stream program delivery. For claims delivered through a mid-stream programs we will interview a combination end-user decision makers and equipment distributors. We will attempt to perform a census survey effort on the equipment distributors. Some of the specific efforts under this plan include:

- Review secondary sources for market share information pertaining to the upstream program
- Conduct market actor interviews (participating distributors, customers, and possibly contractors) focused on market structure for all units and participant distributor interviews to assess program influence for the commercial boiler measure groups.

The net survey instruments can be found in Appendices D-G below.

4 APPENDICES

4.1 Appendix A: Virtual Visit Data Collection Instrument

6.7.1 Appendix A to Appendix G

DATA COLLECTION INSTRUMENT - Replacement HVAC Virtual Site Visit

Site ID:			**Primary Contact:**				
Location/Business:			**Primary Contact Off#:**				
Address 1:			**Primary Contact Cell:**				
City:		**Zip:**		**Email:**			
Visit Date		**Visit Time:**		**Alt Contact:**			
Surveyor(s)		**Program Year:**		**Alt Phone:**			
DEER Bld Type: (dropdown)		**Total floor area (ft^2)**		**Building Vintage** (dropdown)			
Number of buildings		**No. of Cond. Floors**					

Q1: Did you consider or did the contractor present a Heat Pump Unit as an option? If yes which?	
Q2: Has COVID-19 changed your HVAC operation? If yes, did the change increase or decrease your HVAC usag	
Q3: Did you increase your ventillation in any way as a response to COVID-19?	
Q4: Did you adjust your outside air intake at all because of COVID-19?	
Q5: Is your organization considering making any changes that would impact HVAC operation because of COVI	
Q6: Have you made any changes to your HVAC operation or maintenance because of increased wildfire smoke	
Q7: Does your company have a policy regarding energy efficiency or climate change?	
Q8: Do greenhouse gas impacts of leaked refrigerants impact your decsion making?	
Q9: Is there any other feedback you would like to share with the CPUC and or the California Investor Owned Utilities?	

Measure ID 1	**Manufacturer**	**Model Number**	**Serial Number**	**Duct Location** (dropdown)	**Duct Configuration** (dropdown)	**Refrigerant Type**	**Refrigerant Charge**
Measure ID 1 Cont.	**Equip Type** (dropdown)	**Cooling Capacity (tons)**	**EER**	**SEER/IEER**	**Heating Input**	**Heating Output**	**Unit Notes**
Measure ID 1 Cont.	**Supply Fan QTY**	**Supply Fan 1 HP**	**Supply Fan 1 FLA**	**Supply Fan 2 HP**	**Supply Fan 2 FLA**	**T-Stat Type**	**Refrigerant Charge**
Measure ID 2	**Manufacturer**	**Model Number**	**Serial Number**	**Duct Location** (dropdown)	**Duct Configuration** (dropdown)	**Refrigerant Type**	**Refrigerant Charge**
Measure ID 2 Cont.	**Equip Type** (dropdown)	**Cooling Capacity (tons)**	**EER**	**SEER/IEER**	**Heating Input**	**Heating Output**	**Unit Notes**
Measure ID 2 Cont.	**Supply Fan QTY**	**Supply Fan 1 HP**	**Supply Fan 1 FLA**	**Supply Fan 2 HP**	**Supply Fan 2 FLA**	**T-Stat Type**	**Refrigerant Charge**
Measure ID 3	**Manufacturer**	**Model Number**	**Serial Number**	**Duct Location** (dropdown)	**Duct Configuration** (dropdown)	**Refrigerant Type**	**Refrigerant Charge**
Measure ID 3 Cont.	**Equip Type** (dropdown)	**Cooling Capacity (tons)**	**EER**	**SEER/IEER**	**Heating Input**	**Heating Output**	**Unit Notes**
Measure ID 3 Cont.	**Supply Fan QTY**	**Supply Fan 1 HP**	**Supply Fan 1 FLA**	**Supply Fan 2 HP**	**Supply Fan 2 FLA**	**T-Stat Type**	**Refrigerant Charge**

Climate Zone:		**Repeat the above measure level questions for additional measures at site**

Site Notes:

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 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

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

Equipment
Cardboard
Multimeter
(6) to (8) True Flow kits
DG 700
6-in-1
insulated tools
QEW PPE
Face Masks
Jumpers
Rope
Hand Sanitizer
snacks
2-3 liters of water/person
Cooler

Thermostat Type
MECHANICAL
DIGITAL (NON/PROGRAMMABLE)
PROGRAMMABLE
EMS
Other

6.7.2 Appendix B to Appendix G

Fan Power On-site Test					
Site ID				**ZONE TYPE (normally same as the building's DEER type unless HVAC Unit Zone is significantly different)**	
MEASURE NUMBER		**Name on Unit:**			
Supply Fan Data					
Fan Make		**Part/Model Number**		**Notes:**	
Fan Amps		**Fan Phase:**			
Fan HP		**Fan RPM**			
Fan Volts		**Avg F.L. Eff:**			
Nominal Eff.		**Nom PF:**			
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 (Ducument with Photos!)			
Supply Fan Photo Taken	☐ Yes!	Nameplate Photo Taken?	☐ Yes!		
CONTROLS ON UNIT					
Cycling or continuous indoor fan operation?	**Cycling or Continuous Operation**				
Unit in Fan Only Mode (wet coils)				Moist Fan Coil Observed?	☐ Yes ☐ No
Motor Speed (if variable attempt to measure at full load)	***Full Power (circle)*** _____***% speed*** _____ ***hz***				

Reading (if compressor not running run compressor for at least 5 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**	
			***Unit Level Fan Power**	***Standby Mode (FAN OFF)**
Amps1	A1			
Volts1 Ph-Gnd	V1			
Power 1	W1			
Power Factor1	PF1			
Amps2	A2			
Volts2 Ph-Gnd	V2			
Power 2	W2			
Power Factor2	PF2			
Amps3	A3			
Volts3 Ph-Gnd	V3			
Power 3	W3			
Power Factor3	PF3			
	Total Power			

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 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

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

Equipment
Cardboard
Multimeter
(6) to (8) True Flow kits
DG 700
6-in-1
insulated tools
QEW PPE
Face Masks
Jumpers
Rope
Hand Sanitizer
snacks
2-3 liters of water/person
Cooler

Thermostat Type
MECHANICAL
DIGITAL (NON/PROGRAMMABLE)
PROGRAMMABLE
EMS
Other

6.7.3 Appendix C to Appendix G

Air-Flow On-site Test

Site ID		Measure Number:		Name on Unit	
COOLING STAGE (MAX AVAILABLE):		The highest stage (jump Y2 if installed, Y1 if not)			

Static Pressure Across Unit (Supply to Return)	
Test #	□Picture?
1	Pa
2	Pa

Notes:

TRUE FLOW TEST

Two Grids Used:	Grid 1	Grid 2

Four Grids Used:		
Grid 1	Grid 2	
Grid 3	Grid 4	

Six Grids Used			
Grid 1	Grid 2	Grid 3	
Grid 4	Grid 5	Grid 6	

Eight Grids Used				
Grid 1	Grid 2	Grid 3	Grid 4	
Grid 5	Grid 6	Grid 7	Grid 8	

Test #		1	2	Test #		1	2
NSOP				NSOP			
Grid 1	TFSOP			Grid 5	TFSOP		
	Flow				Flow		
	Time				Time		
	PP				PP		
Grid 2	TFSOP			Grid 6	TFSOP		
	Flow				Flow		
	Time				Time		
	PP				PP		
Grid 3	TFSOP			Grid 7	TFSOP		
	Flow				Flow		
	Time				Time		
	PP				PP		
Grid 4	TFSOP			Grid 8	TFSOP		
	Flow				Flow		
	Time				Time		
	PP				PP		

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 Building Vintage	
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Mobile home 1995-2005	vM00
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DEER Nres HVAC System Types	
Description	Code
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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

Equipment
Cardboard
Multimeter
(6) to (8) True Flow kits
DG 700
6-in-1
insulated tools
QEW PPE
Face Masks
Jumpers
Rope
Hand Sanitizer
snacks
2-3 liters of water/person
Cooler

Thermostat Type
MECHANICAL
DIGITAL (NON/PROGRAMMABLE)
PROGRAMMABLE
EMS
Other

6.7.4 Appendix D to Appendix G

PY2020 COMMERCIAL BOILERS DOWNSTREAM BUYERS ATTRIBUTION INTERVIEW GUIDE

Net-to-Gross Short Survey for Completion of Commercial Boiler/Water Heater Measure Surveys

Interview Details

[Be sure to capture who we're speaking with and when.]

a) Interview Date []
b) Interviewer []
c) Interviewee []
d) DNV-ID []

Introduction / Screening

Hello, my name is _____ and I am calling on behalf of the California Public Utilities Commission from DNV. **[THIS IS NOT A SALES CALL.]** This call is in regards to your facility's installation of one or more **[BOILER/WATERHEATER EQUIPMENT NAME]** on **[INSTALL DATE]** at **[ADDRESS].** We are interested in speaking with the person most knowledgeable about your organization's participation in the [UTILITY's] program to install this equipment at your facility during 2020. Gather Name

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: For many sites, we do not have individual contact information, only the name and number of the organization. We've tried to setup the initial call script to identify the person most knowledgeable. We need to speak with the decision-maker or someone knowledgeable about the decision-making process. Additionally, the customers 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. Please read these questions verbatim.]

Decision-maker Intro Q

S1. Just to confirm, were you the primary decision-maker for your organization's decision to pursue this Boiler/Water Heater upgrade? [Select one]

[Note: We need to speak with the decision-maker for this interview. Gather alternate contact as needed and restart survey with new contact.]

a. Yes

b. No

FOR SITES INSTALLING MULTIPLE PROJECTS [Multisite? = Yes]:

S2. Our records show that your organization installed **[COUNT MEASURES]** of **[BOILER/WATERHEATER EQUIPMENT NAME(s)]** through the **[UTILITY]** Tankless Water Heater Program during 2020.

Was the decision-making process consistent across the full capacity of these measures installed, or were there separate decisions within the different installations? [Select one]

[NOTE for Interviewers: Total the Count of Measures across each MultiSite=Yes contact. If there is separate decision-making processes, we need to ask the below questions for up to 3 records, as their decision-making could be different.]

a. Single decision-making process
b. Separate decision-making process for each project
c. Don't know

Boilers/Water Heaters

BH99. Our records indicate that your organization installed **[BOILER EQUIPMENT NAME]** through the program. It is described as a **[BOILER MEASURE].** Is this correct? [Select one]

[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.]

a. Yes
b. No
c. Refused
d. Don't know

BH100. Is the boiler measure a new installation, or did it replace an existing boiler? [Select one]

a. New installation
b. Replace existing equipment
c. Refused
d. Don't know

BH101A. Approximately how old was the boiler measure that was removed and replaced? Would you say… [Select one]

a. Less than 5 years old
b. Between 5 and 10 years old
c. Between 10 and 15 years old
d. More than 15 years old
e. Refused
f. Don't know

BH101B. How would you describe the removed equipment's conditions? Would you say it was in… [Select one]

a. Poor condition
b. Fair condition
c. Good condition
d. Refused
e. Don't know

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? [Open-ended response]

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? [Select one]

a. Before
b. After
c. Same Time
d. Don't know

N3. I'm now going to ask you to please rate the importance of several factors that might have influenced your decision to install the 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: [Enter 0 to 10 per factor] [NP = Non-Program Factor, P = Program Factor]

[READ OPTIONS, BUT NOT THE P OR NP PART]

a. *[NP]* The age or condition of the old equipment
b. *[NP]* Recommendation from an equipment vendor that sold you the equipment and/or installed it for you
c. *[P]* Availability of program rebate
d. *[NP]* Your previous experience with similar types of energy efficiency projects
e. *[P]* Your previous experience with similar utility programs
f. *[P]* Information from the program, utility or training course
g. *[P]* Marketing materials provided by the program, utility or program administrator
h. *[NP]* Standard practices in your industry
i. *[P]* Endorsement or recommendation by your account representative
j. *[NP]* Corporate policy or guidelines
k. *[NP]* Payback or return on investment of installing this equipment
l. *[NP]* Improved product quality
m. *[NP]* Compliance with state or federal regulations such as Title 24, air quality, OSHA or FDA

n. *[NP]* Compliance with your organization's normal remodeling or equipment replacement practices?
o. Were there any other factors we haven't discussed that were influential in your decision to replace your boiler(s)? [Open-ended response]
    a. [Ask for 0 to 10 rating]

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? [Enter 0 to 10] [Total must add to 10]

a. Program Factors [Enter 0 to 10]
b. Non-Program Factors [Enter 0 to 10]
c. Total [Sum of a + b 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]
    - Why do you say that? [Open-ended response]

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? [Select One]

a. Upgrade fewer high efficiency boilers
b. Install standard efficiency equipment or whatever required by code
c. Do nothing (keep existing equipment as-is)
d. Install the same thing you did through the program
e. Repair or overhaul the existing equipment
f. Something else
    - [Open-ended response]
g. Don't know

[ASK ONLY IF N6 = A, B, D, OR E]

N7. Would you have **[FILL IN REPONSE FROM N6 FOR N6 = a,b, d, or e]** at the same time as you did under the program, within one year, or at a later time? [Select one]

a. Same time
b. Within one year

c. At a later time
    - About how many years later? [Open ended response]

[IF MULTISITE, RETURN TO BH99]

Closing

Thanks again for your time today. Your responses will help us improve this program for you and other customers in the future

6.7.5 Appendix E to Appendix G

1 PY2020 BOILER MIDSTREAM BUYER ATTRIBUTION SURVEY

Introduction

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

Our records show that your company installed high efficiency boiler 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 decision 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 boiler 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 Peng Gong at (916) 894-5636. If you have questions about this or the follow up survey you can reach our study manager by calling Brad Hoover at (510) 229-9312.

Screener questions

S1. Are you familiar with the company's decision to install a boiler system 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 a boiler installation 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 boiler 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

G3. 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	

Influence of stock (scored section)

ST1. Did the [Measure1_Type] replace existing equipment at the sites we just mentioned?

[Yes]	1	ST2
[No]	2	ST4
[Don't know]	98	ST4
[Refused]	99	ST4

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 contractor/plumber recommended it]	4	
[We were doing a major renovation in our building]	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 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 (scored section)

For these next couple questions, I would like to know more about your interaction with the 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	U3
[No]	2	U3
[Don't know]	98	
[Refused]	99	

U2 DELETED TO SHORTEN

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 vendor for the [Measure1_Type] you purchased?

[Record Level of Influence (1-10)		U5
[Don't know]	98	
[Refused]	99	

U5. How did the vendor influence your purchase decision?

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

Influence of price (scored section)

P1. Do you remember the typical costs of the [Measure1_Type] we have been discussing?

[Yes]	1	P2
[No]	2	P3
[Don't know]	98	P3
[Refused]	99	P3

P2. Approximately how much did it cost, 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 boiler" and 10 means "definitely WOULD have purchased the same high efficiency boiler."

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 boiler?

[1 Definitely would NOT have purchased the same high efficiency boiler]	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 boiler]	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 boiler?

[1 Definitely would NOT have purchased the same high efficiency boiler]	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 boiler]	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 boiler?

[1 Definitely would NOT have purchased the same high efficiency boiler]	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 boiler]	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 (consistency check)

E1. The [Measure1_Type] you purchased was more efficient than what is required by the building energy code. Had you considered purchasing a less efficient unit at any of these sites?

[Yes]	1	E2
[No]	2	F1
[Don't know]	98	
[Refused]	99	

E2. What was the minimum efficiency you considered purchasing? [READ OPTIONS]

The same efficiency as what you purchased	1	LOOP1 or END
Standard efficiency on the market at time	2	LOOP1 or END
Between standard efficiency and what you purchased	3	LOOP1 or END
[Don't know]	98	LOOP1 or END
[Refused]	99	LOOP1 or END

[IF RESPONDENT HAS MORE THAN ONE MEASURE]

LOOP1. I see you have additional boiler measures that you purchased through the program. Are your answers for those boilers the same as we just covered, or do you think you would have different answers?

[IF NECESSARY, REMIND THEM OF THE OTHER BOILERS]
<measure 2> <location 2>
…
<measure n> <location n>

Answers would be same	1	END
Answers would differ	2	LOOP BACK TO G1

[PROGRAMMER, IF MORE THAN ONE MEASURE, LOOP BACK;
ELSE, PROCEED TO END TEXT]

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.

6.7.6 Appendix F to Appendix G

1 HVAC BOILER 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 <MIDSTREAM BOILER> 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. (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 Peng Gong at 916-894-5636. If you have questions about this or the follow up survey, you can reach our study manager by calling Brad Hoover at (510) 229 - 9312.

Screener questions

SC1. The California Investor Owned Utilities PG&E and SoCalGas deliver incentives through a commercial midstream incentive programs that buy down the cost of high-efficiency boiler 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	

An Independent boiler 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 boiler 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	

Equipment types distributed

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

There are three types of boilers we're considering:

Space Heating Boilers These are high-efficiency space heating (HVAC) boilers, including hot water boiler and steam boilers. The measure qualifies for both new construction (NC) and normal replacement (NR) in residential (multi-family) and commercial sectors. [Statewide Workpaper ID SWHC004-01]

Process Boilers These are high-efficiency process boilers, including either a hot water process boiler or a steam process boiler. [Statewide Workpaper ID SWWH008-01]

Commercial Water Heating Boilers These are more efficient instantaneous water heaters or a commercial hot water boiler of similar rated capacity that can include either condensing or non-condensing boilers. The measure serves Domestic Hot Water end-uses and can be installed in the non-residential sector as well as the multi-family residential sector. [Statewide Workpaper ID SWWH005-03 and Statewide Workpaper ID SWWH010-01]

D4. Which of those types of boilers do you sell? [READ CHOICES. CHECK ALL THAT APPLY]

Space heating	1	D5a
Process	2	
Commercial water heating	3	
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*	
Space heating			D6
Process			
Commercial water heating			
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 boilers and water heaters?

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 boiler 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	

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 boilers?

[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 boilers?

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

Stocking (Scored)

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	*1 yes 2 no 98 dk 99 refused*
Space heating	
Process	
Commercial water heating	
Don't know	98
Refused	99

[IF ALL ANSWERS = NO, SKIP TO U1]

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

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

[S3 deleted to reduce survey length]

S4. Are the inventories for high-efficiency boilers 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 boiler equipment the company keeps in stock?

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

S7. How so?

[Record verbatim]		S8
Don't know	98	
Refused	99	

S8. For all [equipment type X] that you keep in stock, approximately what percent are high efficiency?
[GET ANSWER FOR EACH EQUIPMENT TYPE THAT DISTRIBUTOR STOCKS ACCORDING TO S1]
[IF NECESSARY: High-efficiency is defined as Tier 1 and above.]

Equipment Type	*% of stock that is high efficiency*	
Space heating		S9
Process		S9
Commercial water heating		S9
Don't know	98	S9
Refused	99	S9

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

S9. If the program weren't available what percent of high efficiency [equipment type] would you stock?
[GET ANSWER FOR EACH EQUIPMENT TYPE THAT DISTRIBUTOR STOCKS ACCORDING TO S1]

Equipment Type	*% of stock that WOULD BE high efficiency*	
Space heating		U1
Process		U1
Commercial water heating		U1
Don't know	98	U1
Refused	99	U1

Upselling (scored)

Now I want to talk about upselling.

U1. Please describe how you typically promote and sell boilers.

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

U2. Does your company make boiler 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 rebate influence the equipment efficiency level your company recommends to buyers?

Yes	1	U4b
No	2	U4a
Don't know	98	U5
Refused	99	

U4a. Why do you say that?

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

U4b. How so?

[Record verbatim]		U5
Don't know	98	
Refused	99	

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

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

[GET ANSWER FOR EACH EQUIPMENT TYPE THAT DISTRIBUTOR STOCKS ACCORDING TO S1]

Equipment Type	*% of time equipment is recommended*	
Space heating		U6
Process		U6
Commercial water heating		U6
Don't know	98	P1
Refused	99	P1

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

[Repeat for each equipment type confirmed as sold in questions D4-D7]
U6. For [equipment type], 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	*% of time equipment recommended*	
Space heating		P1
Process		P1
Commercial water heating		P1
Don't know	98	P1
Refused	99	P1

Pricing (scored)

P1. How does your company determine the price the buyer pays for the high-efficiency boiler 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	P3b
No	2	P3a
Don't know	98	Next Section
Refused	99	

P3a. Why do you say that?

[Record verbatim]		Next section
Don't know	98	
Refused	99	

P3b. How so?

[Record verbatim]		P4
Don't know	98	
Refused	99	

[REPEAT FOR EACH EQUIPMENT TYPE CONFIRMED AS SOLD IN QUESTIONS D4]
P4. On average, what percent of the rebate is passed on to the buyer for [equipment type], either directly or indirectly?

Equipment Type	*% of rebate passed on to buyer*	
Space heating		Next Section
Process		Next Section
Commercial water heating		Next Section
Don't know	98	Next Section
Refused	99	Next Section

Program influence on sales

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

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

ME6. In 2020, about what percentage of [equipment type], that you sold in California would you estimate were high-efficiency, which is defined as Tier 1 and above?
[REPEAT FOR EACH EQUIPMENT TYPE CONFIRMED AS SOLD IN QUESTIONS D4]

Equipment Type	*% of high-efficiency equipment sold in California in 2020*	
Space heating		ME7
Process		ME7
Commercial water heating		ME7
Don't know	98	
Refused	99	

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

ME7. Without the program rebates and non-rebate activities, what percentage of your California sales would have been high-efficiency?
[REPEAT FOR EACH EQUIPMENT TYPE CONFIRMED AS SOLD IN QUESTIONS D4]
[IF NECESSARY: High efficiency means tier 1 or above]

Equipment Type	*% of high-efficiency equipment that would have been sold in California without rebates*	
Space heating		ME8
Process		ME8
Commercial water heating		ME8
Don't know	98	ME8
Refused	99	ME8

ME8. What percent of all the high-efficiency [equipment type], had a rebate claimed?
[REPEAT FOR EACH EQUIPMENT TYPE CONFIRMED AS SOLD IN QUESTIONS D4]

Equipment Type	*% of high-efficiency equipment with claimed rebate*	
Space heating		ME9
Process		ME9
Commercial water heating		ME9
Don't know	98	ME9
Refused	99	ME9

ME9. [IF ANY ME6-ME8 >0] Why doesn't your company submit rebates for all the high-efficiency equipment types?
[REFLECT ALL THAT APPLY]

Reason		Space heating	Process	Commercial Water Heating	
Not qualified	1				END
Missed opportunity	2				END
Paid through down/mid-stream rebate	3				END
Not in IOU service territory	4				END

Other reason [Record Verbatim]	50	END
Don't know	98	END
Refused	99	END

[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. 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*	*# of high efficiency sales*	*# of high efficiency sales without program*
Space heating	<pipe in value from tracking>	
Process	<pipe in value from tracking>	
Commercial water heating	<pipe in value from tracking>	
Don't know	98	98
Refused	99	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.

6.7.7 Appendix G to Appendix G

1 PY2020 BOILER ATTRIBUTION SCORING METHODS

1.1 Midstream programs

The midstream attribution scoring method is based on the 'causal pathways' method of measuring attribution that DNV developed for use with California midstream and upstream programs. The program logic for mid- and up-stream programs is that the programs interact with the manufacturers (upstream) or distributors (midstream) to influence their marketing practices. In the case of the midstream programs specifically, the program attempts to increase how often distributors upsell to higher efficiency models and how often the distributors stock higher efficiency models. The program does not attempt to directly influence prices distributors charge, but it does offer an incentive and potentially changes the revenue calculus for dealers in a way that allows them to offer lower prices for high efficiency models than they would without the program. The program logic holds that these changes to distributor behaviors will influence buyers to purchase higher efficiency models more often than they would without the program.

The attribution measures follow the program logic. First, they attempt to estimate the degree to which the program has changed distributor upselling, stocking, and pricing behaviors. It then attempts to estimate how much dealer upselling, stocking, and pricing affects the buyer's decision. The program can only influence the final decision when both elements exist: first it has to change distributor behavior, *and* that distributor behavior has to influence buyer decisions.

The instruments and scoring methods described here were based on the 2018 Midstream Rooftop Unit methods. We have adapted the instruments for boiler measures and streamlined in a few places to shorten them.

1.1.1 Identifying causal pathways of influence

To establish program attribution, we considered the pathways distributors take when selling a high efficiency boiler 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 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 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 1-1 shows the researchable questions themes that represent the three causal pathways across distributors and buyers.

Table 1-1. 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.

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 Sales Attribution scores were calculated for the distributors.

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

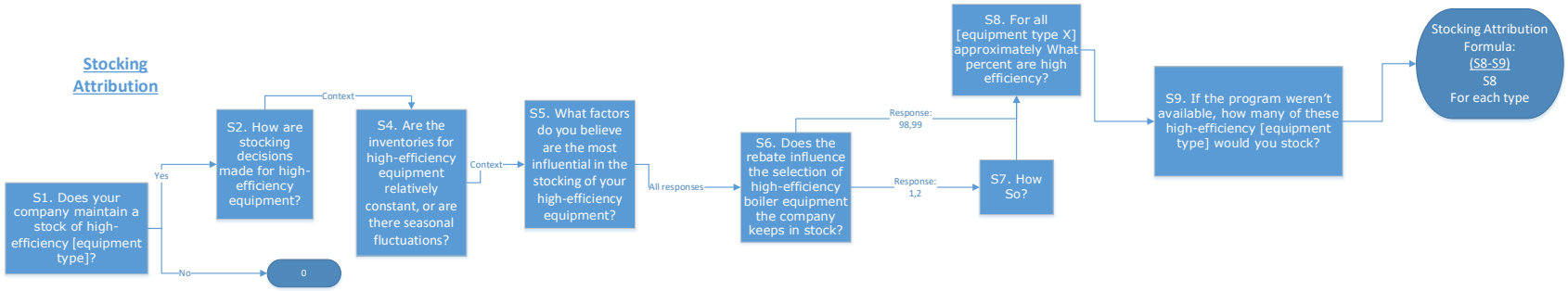


Figure 1-2. Detailed distributor causal pathway scoring: upselling

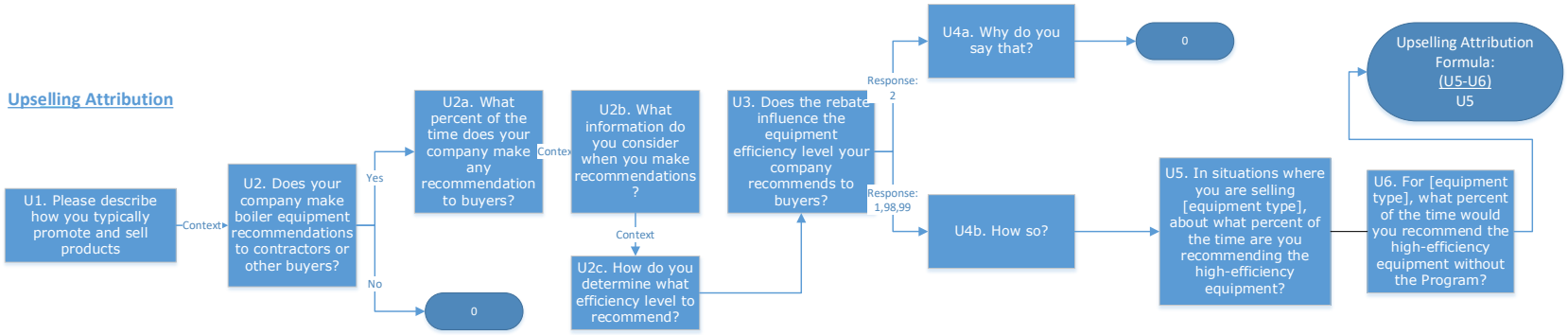


Figure 1-3. Detailed distributor causal pathway scoring: price

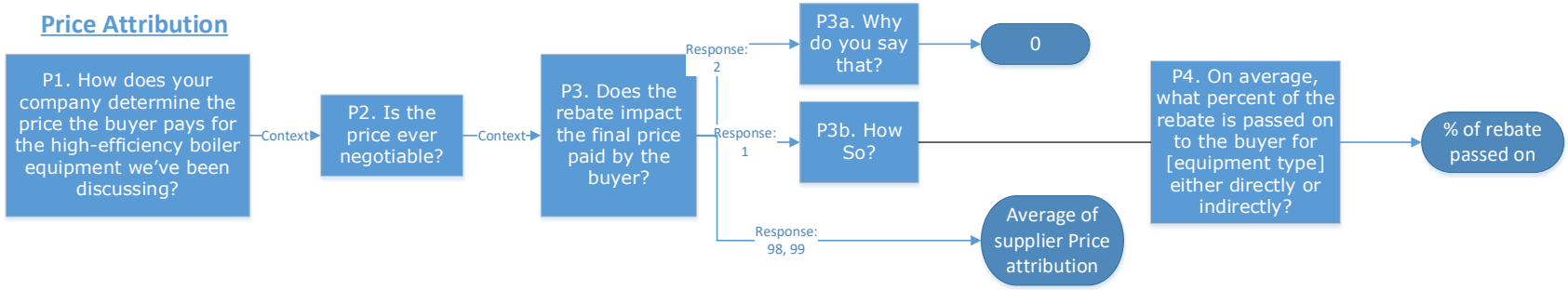
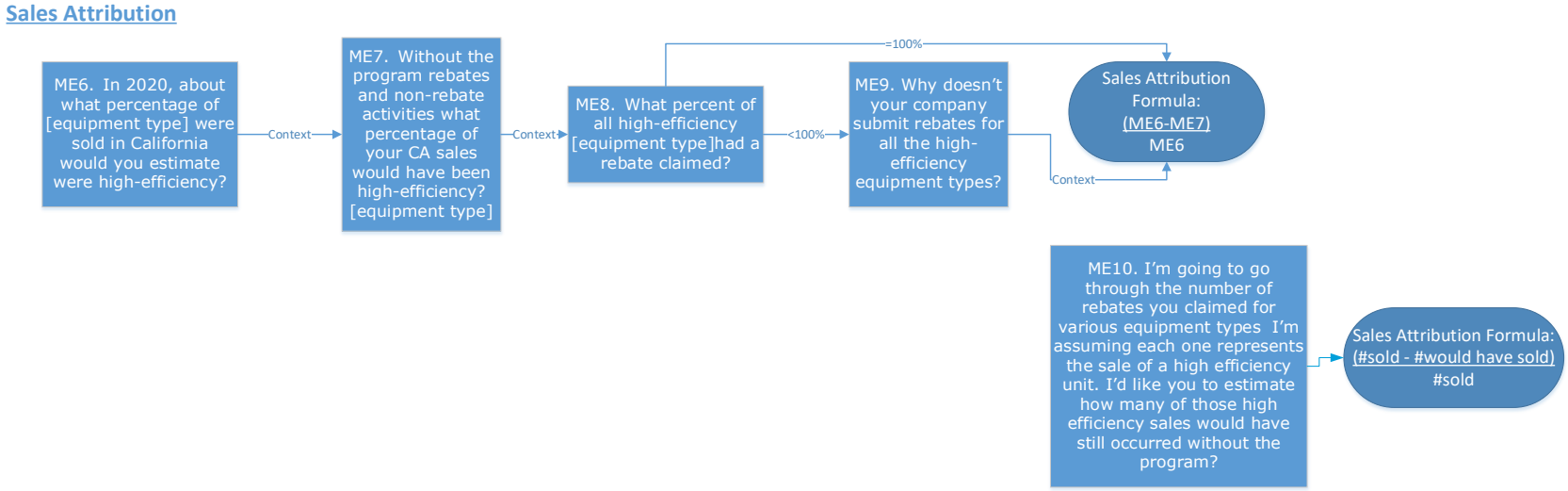


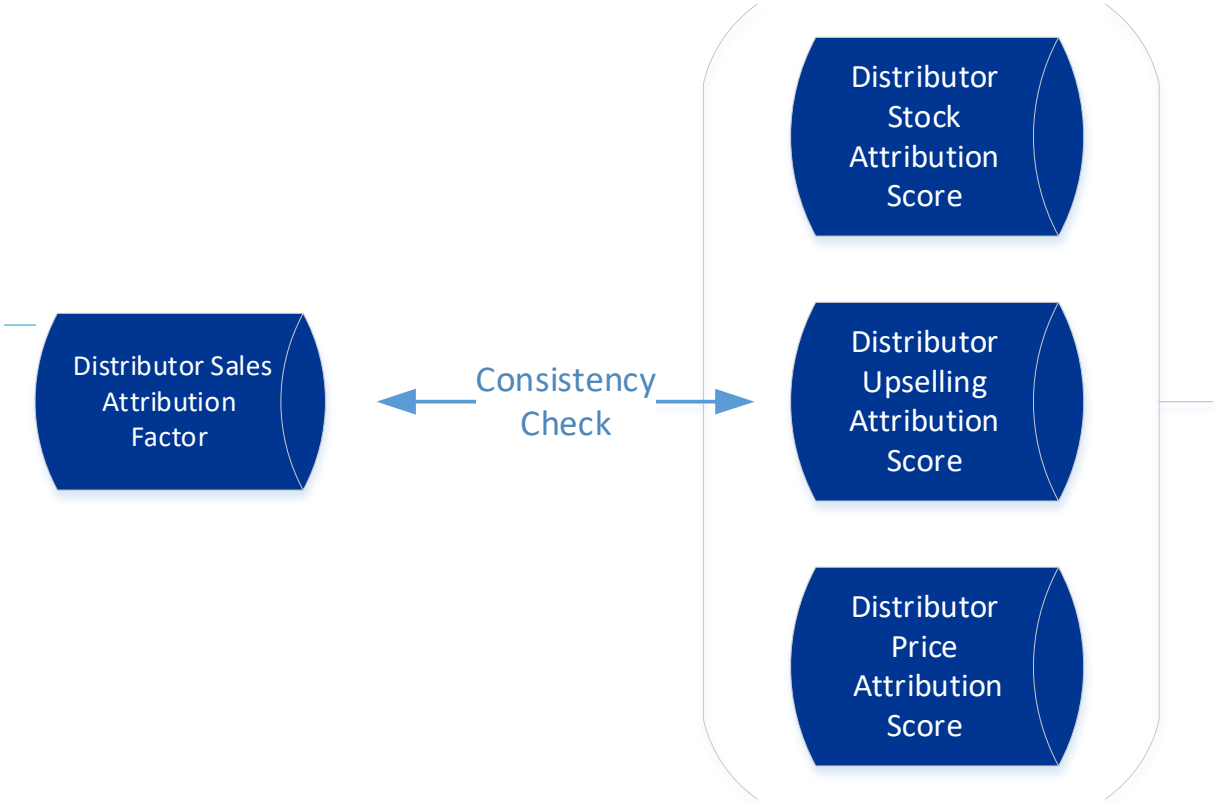
Figure 1-4. Detailed distributor causal pathway scoring: sales



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 1-5. shows how we calculated sales attribution, and used the result to check consistency across the other attribution scores.

Figure 1-5. Distributor attribution consistency check



1.1.2 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 1-1. Finally, we asked them about the minimum energy efficiency they were considering before buying their 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 1-6. Detailed buyer causal pathway scoring: stocking

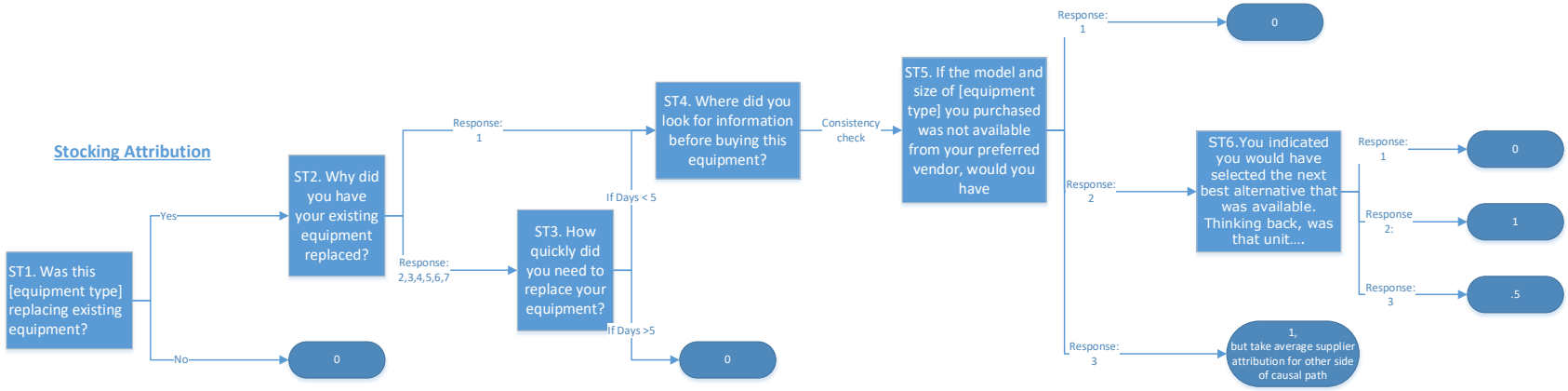


Figure 1-7. Detailed buyer causal pathway scoring: upselling

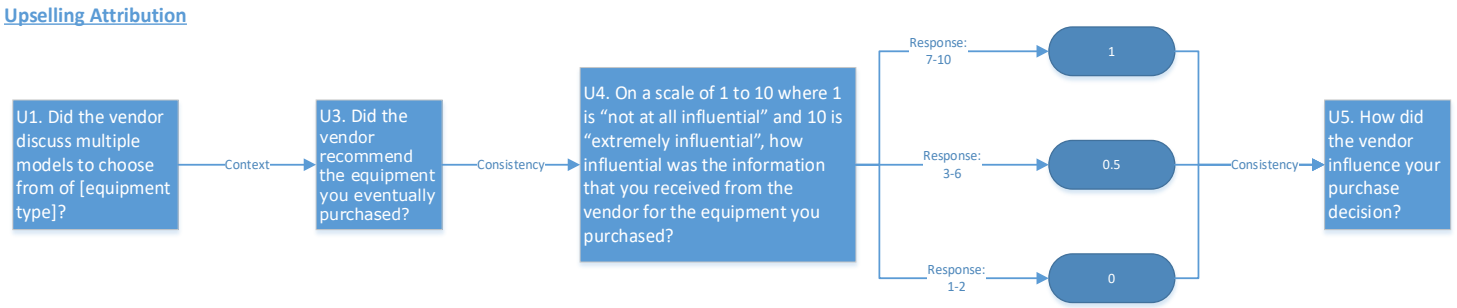


Figure 1-8. Detailed buyer causal pathway scoring: price

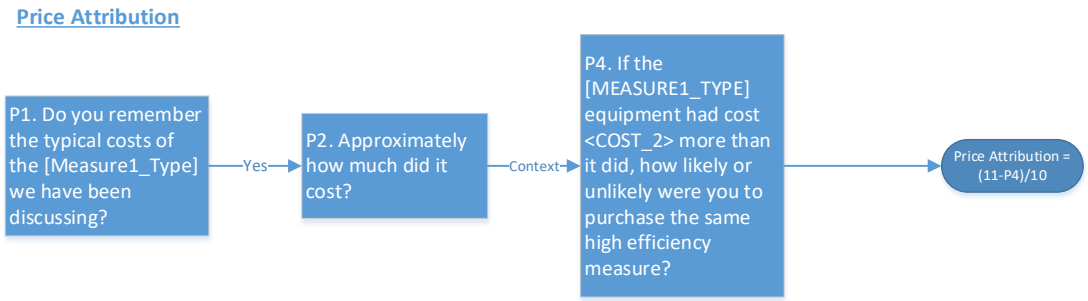
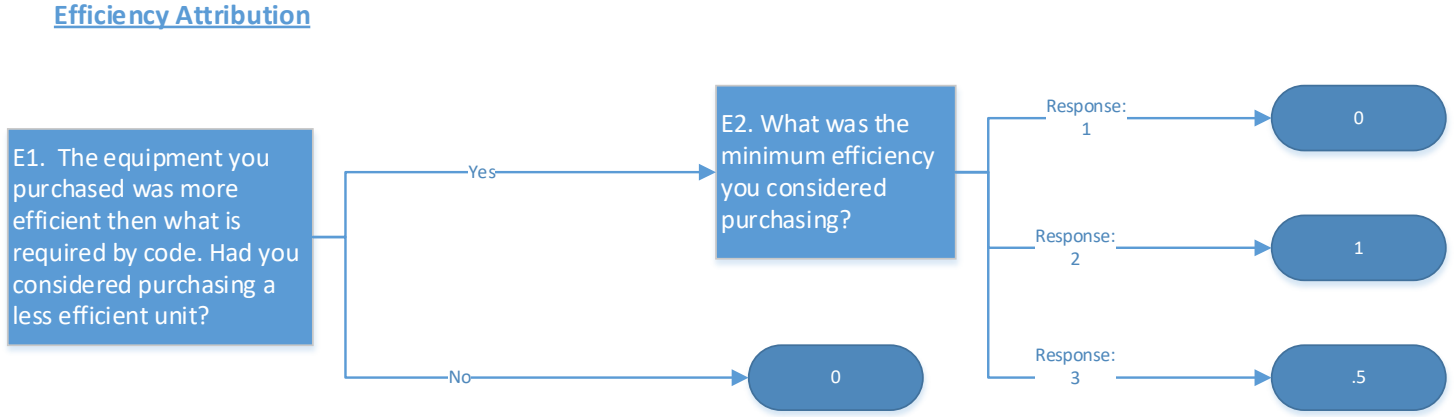


Figure 1-9. Detailed buyer causal pathway scoring: efficiency



Consistency Check

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

1.1.3 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.

$$\text{Combined Attribution}_{\text{Stock}} = \text{Distributor\_Attribution}_{\text{Stock}} \times \text{Enduser}_y\text{Attribution}_{\text{Stock}}$$

$$\text{Combined Attribution}_{\text{Upsell}} = \text{Distributor\_Attribution}_{\text{Upsell}} \times \text{Enduser}_y\text{Attribution}_{\text{Upsell}}$$

$$\text{Combined Attribution}_{\text{Price}} = \text{Distributor\_Attribution}_{\text{Price}} \times \text{Buyer}_y\text{Attribution}_{\text{Price}}$$

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

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

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.

1.2 Downstream programs

The NTGR methods for the downstream boiler programs are identical to those used for PY2017 and PY2018.

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):[1]

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

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

— 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

 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:

1. 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.

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