

Impact Evaluation of 2015 Upstream HVAC Programs (HVAC 1)

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1 EXECUTIVE SUMMARY

This report presents DNV GL's impact evaluation of 2015 non-residential upstream HVAC incentive programs. The evaluation accomplishes part of the California Public Utilities Commission (CPUC) 2013-15 HVAC Research Roadmap. The evaluation estimated gross and net energy and demand savings for new high-efficiency HVAC equipment promoted by the upstream HVAC programs. The evaluation collected onsite data on participating units to make adjustments to key technical assumptions that affect the calculation of energy and demand savings. These adjustments, when run through standard engineering models, result in revised estimates of gross and net energy impacts achieved by the 2015 HVAC upstream programs. The three California investor-owned electric utilities (IOUs) offer the program: San Diego Gas and Electric Company (SDG&E), Southern California Edison (SCE), and Pacific Gas and Electric Company (PG&E).

1.1 Program overview

For program year (PY) 2015, California IOUs continued 2013-14 funded upstream HVAC incentive programs for both non-residential (commercial) and residential applications. The non-residential components of the upstream HVAC programs have been in continuous operation since 1998. The residential component is a recent addition with a pilot phase launched in 2014.¹

The upstream programs share three primary goals:

- Encourage participating distributors to increase their stock of high-efficiency equipment so that it is readily available to customers (contractors and large businesses)
- Encourage participating distributors to up-sell higher-efficiency equipment to customers (e.g., explaining to customers the technical and financial benefits of the more efficient options and calculating the payback or net present value when possible)
- Encourage the purchase and installation of the most efficient equipment available

To achieve these goals, the upstream HVAC programs enlist HVAC equipment distributors who are willing to participate under the programs' terms and conditions to sell high-efficiency heating and cooling equipment for use in both non-residential and residential installations. The available incentive amounts are based on equipment performance tiers.² The performance tiers vary based on equipment type, capacity, and efficiency in seasonal energy efficiency ratio (SEER), energy efficiency ratio (EER), or integrated energy efficiency ratio (IEER) ratings. Distributors' customers are typically licensed HVAC contractors (C-20) or HVAC design engineers.

1.2 Evaluation overview

The main goal of this evaluation was to determine the best estimate of actual energy and demand savings achieved through incentivized upstream HVAC measures during the 2015 program year. The evaluation included the PG&E, SCE, and SDG&E programs and focused on small unitary systems defined as units less than or equal to 20 tons cooling capacity. A secondary objective was to provide information that can be used to develop more accurate savings estimates for future program cycles. The chiller systems, large unitary systems, and other measures were thoroughly evaluated in the 2013-14 Impact Evaluation and were not prioritized this year due to budgetary constraints.

¹ More information on upstream programs is provided on Energy Solution's website: <https://energy-solution.com/project/distributor-hvac-program/>

² <https://www.cainstantrebates.com/>

Challenges to this evaluation include the uncertainty and difficulty of in-field measurement and testing, and the recruitment of customers who may be unaware that the distributor of their new HVAC systems “received an incentive through the program”. This study was also limited by a constraint to build on and refine data collected in the 2013-14 evaluation as opposed to starting a new effort.

For small unitary systems (up to 20 tons), DNV GL estimated savings using program tracking data, installation verification, and field measurements of performance. For large unitary systems (greater than 20 tons), and chiller systems, the gross savings were not updated, however, net-to-gross ratios were applied to the chiller and large unitary systems savings.

1.2.1 Unitary systems

The unitary systems installed through the IOU 2015 non-residential upstream HVAC incentive programs had an overall realization rate of 55.6% for kWh and 51% for kW. The unitary systems were classified in to two groups by unit cooling tonnage: large unitary systems greater than 20 tons small unitary systems up to 20 tons. M&V efforts focused on the small unitary system classification with field measurements of performance and installation verification. This 2015 evaluation did not update gross realization rates for the large unitary systems those greater than 20 tons and gross savings for the larger units were passed through. Table 1 and Table 2 summarize the application of gross realization rates and NTGR ratios across the unit types. We used the overall NTGR for all the program measures because there were no statistically-significant differences between the measure-level scores and the overall score.

Table 1 Claimed kWh savings with gross realization rate and NTGR applied

Measure Group	Unit Size	Claimed Gross Savings (kWh)	Gross Realization Rate	Final Evaluated Gross Savings (kWh)	Net to Gross Ratio (NTGR)	Final Net Savings (kWh)	Net Realization Rate
Large Unitary Systems	All	6,073,717	100.0%	6,073,717	64%	3,887,179	64%
Small Unitary Systems	All	10,148,944	78.9%	8,011,589	64%	5,127,417	51%
	All	16,222,661	86.8%	14,085,306	64%	9,014,596	55.6%


Table 2 Claimed kW savings with gross realization rate and NTGR applied

Measure Group	Unit Size	Claimed Gross Savings (kW)	Gross Realization Rate	Final Evaluated Gross Savings (kW)	Net to Gross Ratio (NTGR)	Final Net Savings (kW)	Net Realization Rate
Large Unitary Systems	All	3,586	100.0%	3,586	64%	2,295	64%
Small Unitary Systems	All	5,820	67.6%	3,932	64%	2,517	43%
	All	9,406	79.9%	7,518	64%	4,812	51%

The following sections describe the process for developing the gross and net savings.

1.2.1.1 Gross Savings

The overall gross realization rate for small unitary systems across all programs and measures was 67.6%. The primary reason is that the efficiencies of the units installed and units verified were lower than indicated in the program documentation. There were significant updates to the California Database for Energy Efficient Resources (DEER) in 2014 as a result of code changes that affect minimum efficiency, fan speed



requirements, and performance maps. DNV GL's 2013-14 evaluation used these updated values in the simulation models, which resulted in reduced savings when compared to the IOU claimed estimates appropriate to code requirements at the time of installation.³ In 2015, the IOU's claimed savings were lower and realization rates improved because IOUs have adopted the updated DEER estimates. The following modifications were made for the evaluation estimates based on site observations:

- Adjustments to the assigned efficiencies
- Adjustments based on economizer functionality
- Limited adjustment to fan performance

In 2015 no additional adjustment was made due to building type differences between tracking and as-found sites because the adjustment factor was initially estimated to be on the order of two percent.

The IOU programs in 2013-15 stipulated that units could meet each efficiency tier requirement by meeting the full-load efficiency (EER) or the integrated energy efficiency ratio (IEER) criteria. This led to some units complying with IEER requirements that had full load efficiencies at or close to code minimum. DEER 2016 updates have mapped IEER values to the performance curves to address this issue in the future. The tables below show the final savings for small unitary systems, and then show the step-wise adjustments to small units 20 tons and under to demonstrate the effect of each adjustment.

Adjustments were made for small unit savings estimates based on economizer functionality. Results from the functional testing of economizers on units with 20 tons of cooling capacity and lower showed an operational rate of 73% (approximately 3 out of 4 units tested had properly functioning economizers). Table 3 provides the results and applies the economizer functionality to the claimed tonnage to create the weighting of 73% working economizers in both the baseline and measure case. We used an assumption that all failed units failed with outside air dampers in the minimum position. Economizers are not required for units less than 5 ton, and adding an economizer to a unit in this size range is considered a separate measure from the efficiency upgrade.

³ Code minimum was based on the installation date for all units. Exceeding earlier code requirements led to very high realization rates for units with two speed or variable speed fans. Categories with low savings /realization rates had two key factors, equipment and workpapers. The equipment factor caused low realization rates when units just met prior code minimum efficiency requirements and/or had a single-speed fan when two-speed was minimum. The performance maps in the current DEER (updated 2015) represent the equipment installed in 2013 and 2014 better than the performance maps in DEER 2011 which best represent units from 2011-12.

Table 3. Claimed and evaluated gross kWh savings and realization rates for small unitary systems

Unit Size	Claimed Efficiency Level	Working Economizer	Total Tonnage Adjusted	Claimed Total (kWh)	Evaluated Total (kWh)	Efficiency Adjustment Realization Rate (kWh)
< 3.5 Ton	Tier0, To Code	NA	29	10,533	10,533	100.0%
< 3.5 Ton	Tier2, 16 SEER/>13EER, 2spd	NA	107	3,060	5,383	175.9%
< 3.5 Ton	Tier3, 17 SEER/>13EER, 2spd	NA	130	9,644	8,366	86.7%
< 3.5 Ton	Tier4, 18 SEER/>13EER, 2spd	NA	886	101,861	65,150	64.0%
3.5 - 4.5 Ton	Tier0, To Code	NA	1,348	544,513	544,513	100.0%
3.5 - 4.5 Ton	Tier1, 15 SEER /<13 EER, 2spd	NA	1,832	269,958	193,929	71.8%
3.5 - 4.5 Ton	Tier2, 16 SEER/>13EER, 2spd	NA	2,442	647,052	177,809	27.5%
3.5 - 4.5 Ton	Tier3, 17 SEER/>13EER, 2spd	NA	3,414	1,209,700	297,143	24.6%
3.5 - 4.5 Ton	Tier4, 18 SEER/>13EER, 2spd	NA	238	90,467	22,881	25.3%
3.5 - 4.5 Ton	Tier0, To Code	NA	2,408	1,323,852	1,323,852	100.0%
4.5 - 5.5 Ton	Tier1, 15 SEER /<13 EER, 2spd	Yes	777	52,269	82,736	158.3%
4.5 - 5.5 Ton	Tier2, 16 SEER/>13EER, 2spd	Yes	4,481	465,824	591,618	127.0%
4.5 - 5.5 Ton	Tier3, 17 SEER/>13EER, 2spd	Yes	1,702	244,610	241,088	98.6%
4.5 - 5.5 Ton	Tier4, 18 SEER/>13EER, 2spd	Yes	53	10,581	7,791	73.6%
4.5 - 5.5 Ton	Tier0, To Code	No	2,408	1,323,852	1,323,852	100.0%
4.5 - 5.5 Ton	Tier1, 15 SEER /<13 EER, 2spd	No	777	52,269	96,321	184.3%
4.5 - 5.5 Ton	Tier2, 16 SEER/>13EER, 2spd	No	4,481	465,824	802,324	172.2%
4.5 - 5.5 Ton	Tier3, 17 SEER/>13EER, 2spd	No	1,702	244,610	329,022	134.5%
4.5 - 5.5 Ton	Tier4, 18 SEER/>13EER, 2spd	No	53	10,581	10,670	100.8%
5.5 - 11.5 Ton	Tier0, To Code	Yes	1,779	762,716	762,716	100.0%
5.5 - 11.5 Ton	Tier1, 11.5 EER	Yes	4,412	326,670	128,789	39.4%
5.5 - 11.5 Ton	Tier2, 12.0 EER	Yes	10,668	712,914	601,945	84.4%
5.5 - 11.5 Ton	Tier3, 12.5 EER	Yes	2,858	251,184	231,054	92.0%
5.5 - 11.5 Ton	Tier4, 13.0 EER	Yes	1,181	114,937	122,232	106.3%
5.5 - 11.5 Ton	Tier0, To Code	No	1,779	762,716	762,716	100.0%
5.5 - 11.5 Ton	Tier1, 11.5 EER	No	4,412	326,670	173,442	53.1%
5.5 - 11.5 Ton	Tier2, 12.0 EER	No	10,668	712,914	810,699	113.7%
5.5 - 11.5 Ton	Tier3, 12.5 EER	No	2,858	251,184	311,181	123.9%
5.5 - 11.5 Ton	Tier4, 13.0 EER	No	1,181	114,937	164,630	143.2%
11.6 - 20 Ton	Tier0, To Code	Yes	921	354,819	354,819	100.0%
11.6 - 20 Ton	Tier1, 11.5 EER	Yes	857	42,211	37,240	88.2%
11.6 - 20 Ton	Tier2, 12.0 EER	Yes	4,563	470,932	324,163	68.8%
11.6 - 20 Ton	Tier3, 12.5 EER	Yes	4,701	408,821	455,982	111.5%
11.6 - 20 Ton	Tier4, 13.0 EER	Yes	1,188	280,396	143,904	51.3%
11.6 - 20 Ton	Tier0, To Code	No	921	354,819	354,819	100.0%
11.6 - 20 Ton	Tier1, 11.5 EER	No	857	42,211	50,197	118.9%
11.6 - 20 Ton	Tier2, 12.0 EER	No	4,563	470,932	436,938	92.8%
11.6 - 20 Ton	Tier3, 12.5 EER	No	4,701	408,821	614,658	150.3%
11.6 - 20 Ton	Tier4, 13.0 EER	No	1,188	280,396	193,983	69.2%

Table 4 shows the results of peak demand savings for all small unitary efficiency tiers and size bins up to 20 ton. The realization rate across all small unit categories is 67.6%. The efficiency realization rates vary by size bin and across efficiency tiers from 7% to 112%. A primary driver of the energy and demand realization rates were findings that a mix of efficiencies were found within program efficiency tier and that the tier average efficiencies were lower than the ex ante assumption in the majority of cases. There was no strong trend of realization rate by tier across size ranges.

Table 4. Claimed and evaluated gross kW savings and realization rates for small unitary systems

Unit Size	Claimed Efficiency Level	Working Economizer	Total Tonnage Adjusted	Claimed Total (kW)	Evaluated Total (kW)	Efficiency Adjustment Realization Rate (kW)
< 3.5 Ton	Tier0, To Code	NA	29	8	1	7.4%
< 3.5 Ton	Tier2, 16 SEER/>13EER, 2spd	NA	107	2	1	57.9%
< 3.5 Ton	Tier3, 17 SEER/>13EER, 2spd	NA	130	7	2	34.0%
< 3.5 Ton	Tier4, 18 SEER/>13EER, 2spd	NA	886	78	21	27.1%
3.5 - 4.5 Ton	Tier0, To Code	NA	1,348	414	414	100.0%
3.5 - 4.5 Ton	Tier1, 15 SEER /<13 EER, 2spd	NA	1,832	107	55	52.1%
3.5 - 4.5 Ton	Tier2, 16 SEER/>13EER, 2spd	NA	2,442	177	50	28.2%
3.5 - 4.5 Ton	Tier3, 17 SEER/>13EER, 2spd	NA	3,414	487	95	19.5%
3.5 - 4.5 Ton	Tier4, 18 SEER/>13EER, 2spd	NA	238	90	8	8.6%
4.5 - 5.5 Ton	Tier0, To Code	Yes	1,758	396	396	100.0%
4.5 - 5.5 Ton	Tier1, 15 SEER /<13 EER, 2spd	Yes	567	20	21	107.0%
4.5 - 5.5 Ton	Tier2, 16 SEER/>13EER, 2spd	Yes	3,271	234	242	103.1%
4.5 - 5.5 Ton	Tier3, 17 SEER/>13EER, 2spd	Yes	1,243	137	100	73.1%
4.5 - 5.5 Ton	Tier4, 18 SEER/>13EER, 2spd	Yes	39	6	3	55.7%
4.5 - 5.5 Ton	Tier0, To Code	No	650	146	146	100.0%
4.5 - 5.5 Ton	Tier1, 15 SEER /<13 EER, 2spd	No	210	7	8	111.6%
4.5 - 5.5 Ton	Tier2, 16 SEER/>13EER, 2spd	No	1,210	87	96	110.5%
4.5 - 5.5 Ton	Tier3, 17 SEER/>13EER, 2spd	No	460	51	40	78.3%
4.5 - 5.5 Ton	Tier4, 18 SEER/>13EER, 2spd	No	14	2	1	59.7%
5.5 - 11.5 Ton	Tier0, To Code	Yes	1,299	146	146	100.0%
5.5 - 11.5 Ton	Tier1, 11.5 EER	Yes	3,221	200	70	35.1%
5.5 - 11.5 Ton	Tier2, 12.0 EER	Yes	7,788	489	328	67.0%
5.5 - 11.5 Ton	Tier3, 12.5 EER	Yes	2,086	173	126	72.8%
5.5 - 11.5 Ton	Tier4, 13.0 EER	Yes	862	92	67	72.5%
5.5 - 11.5 Ton	Tier0, To Code	No	480	54	54	100.0%
5.5 - 11.5 Ton	Tier1, 11.5 EER	No	1,191	74	27	36.0%
5.5 - 11.5 Ton	Tier2, 12.0 EER	No	2,880	181	124	68.8%
5.5 - 11.5 Ton	Tier3, 12.5 EER	No	772	64	48	74.7%
5.5 - 11.5 Ton	Tier4, 13.0 EER	No	319	34	25	74.3%
11.6 - 20 Ton	Tier0, To Code	Yes	672	117	117	100.0%
11.6 - 20 Ton	Tier1, 11.5 EER	Yes	626	25	20	79.4%
11.6 - 20 Ton	Tier2, 12.0 EER	Yes	3,331	335	172	51.5%
11.6 - 20 Ton	Tier3, 12.5 EER	Yes	3,431	316	242	76.6%
11.6 - 20 Ton	Tier4, 13.0 EER	Yes	867	207	77	36.9%
11.6 - 20 Ton	Tier0, To Code	No	249	43	43	100.0%
11.6 - 20 Ton	Tier1, 11.5 EER	No	231	9	8	81.7%
11.6 - 20 Ton	Tier2, 12.0 EER	No	1,232	124	66	53.1%
11.6 - 20 Ton	Tier3, 12.5 EER	No	1,269	117	92	78.9%
11.6 - 20 Ton	Tier4, 13.0 EER	No	321	77	29	38.0%

The 2015 evaluation did not update gross realization rates for the large unitary systems greater than 20 ton and the savings for these units were passed through. The sample collected in 2013-14 would not be appropriate to apply to 2015 given the sample of units installed under 2013 code was very small and 2015 data collection focused on small units (up to 20 tons) only. Table 5 and Table 6 summarize energy and demand savings for all unitary systems.⁴

⁴ Water cooled unitary systems are not included in the evaluated savings

Table 5. Claimed and evaluated gross kWh savings and realization rates for all unitary systems

Unit Size	Claimed UES (kWh/ton)	Evaluated UES (kWh/ton)	Total Tonnage Claimed	Claimed Total (kWh)	Evaluated Total (kWh)	Final Realization Rate (kWh)
< 5.5 Ton	235.5	172.8	28,745	6,768,621	4,967,720	73.4%
5.5 - 11.5 Ton	100.8	90.6	19,287	1,944,014	1,746,618	89.8%
11.6 - 20 Ton	124.0	112.0	11,583	1,436,308	1,297,252	90.3%
20 - 63.3 Ton	167.9	167.9	28,298	4,752,250	4,752,250	100.0%
>63.3 Ton	198.7	198.7	6,650	1,321,467	1,321,467	100.0%
All	171.6	149.0	94,563	16,222,661	14,085,306	86.8%

Table 6. Claimed and evaluated gross kW savings and realization rates for all unitary systems

Unit Size	Claimed UES (kW/ton)	Evaluated UES (kW/ton)	Total Tonnage Claimed	Claimed Total (kW)	Evaluated Savings (kW)	Final Realization Rate (kW)
< 5.5 Ton	0.12	0.08	28,745	3,324	2,302	69.2%
5.5 - 11.5 Ton	0.07	0.05	19,287	1,292	870	67.3%
11.6 - 20 Ton	0.10	0.07	11,583	1,203	761	63.2%
20 - 63.3 Ton	0.11	0.11	28,298	3,010	3,010	100.0%
>63.3 Ton	0.09	0.09	6,650	576	576	100.0%
All	0.10	0.08	94,563	9,406	7,518	79.9%

1.2.1.2 Net savings

In 2016, DNV GL developed a full net-to-gross (NTG) report as a separate evaluation effort.⁵ The NTG analysis was performed for large and small unitary systems and was informed through interviews with participating distributors and ultimate equipment buyers to determine the program influence along discrete paths in which the program could influence purchases. These included stocking high efficiency units, offering reduced prices on high efficiency units, and upselling wholesale customers to higher efficiency levels. Our data collection and NTG expansion analysis resulted in an overall attribution NTGR ratio (NTGR) score of 64% ($\pm 6\%$ at the 90% Confidence Interval) for the upstream program.

1.3 Conclusions and recommendations

Section 5 of this report provides a detailed discussion of study findings. Of these findings, the evaluation team have determined the following to be particularly noteworthy. We recognize that some of the 2013-14 recommendations have been implemented in the 2016 programs. Most notably, after the last report the IOUs provided make and model of the full population to the DEER Ex Ante team making that recommendation completed. In addition, based on further data analysis, we now believe that there are very few sites where the effects can be seen at the meter. Whole building analysis may not be appropriate for Upstream as measures are rarely installed at the same site at a given site with multiple measures over a program cycle.

Finding #1: Program savings improved for units evaluated in 2015.


This impact evaluation of the 2015 Upstream HVAC programs revealed lower than expected savings for the smallest size units (under 4.5 ton) and good realization rates for units 5.5–20 ton. The primary driver of the realization rates was that, on average, the full-load efficiencies of the installed equipment were lower than claimed estimates assumed efficiency levels in some cases. While not evaluated in 2015, we did notice the measures with lower 2013-14 realization rates also had decreased unit energy savings claims in 2015. The evaluation team believes minimum primary reason for the improvements was the code update and updated version of DEER for 2015 while 2014 had to utilize different baselines within the calendar year.

We commend the IOUs and DEER team for the updates made to the latest versions of DEER based on performance data provided by the Upstream programs and PG&E in particular. The 2015 claims already showed some key improvements and the expectation is that going forward the measure efficiency should not be a major source of uncertainty.

Finding #2: Inputs for DEER estimates continue to improve.

The field-testing of 5.5-20 ton units showed that fan performance and part-load performance curves were similar to current DEER assumptions in most cases and only one size class had a measured average fan power index that was different than DEER. The characterization of fan performance and part-load performance data for smaller systems, under 5.5 ton, can still benefit from additional data collection, as the sample size for this evaluation was insufficient since there are now multiple size categories below 5.5 ton. As a result of this finding, we recommend the following:

⁵ Net-to-gross Evaluation of 2013-14 Upstream HVAC Programs (HVAC1), DNV GL, 2017, California Public Utilities Commission, San Francisco CA



For workpaper developers and evaluators: Review new data collected by this study, especially for 5.5–11.5 ton units where a change was made to the workpaper fan power index assumption. Collect additional data on fan performance, W/CFM, to characterize the program population.

Finding #3: Potential savings from non-code required economizers are not being claimed.

The smallest unitary systems, less than 4.5 tons, are not required by Title 24 to have economizers. However, many of the units incentivized by the program in this size category were found to be equipped with economizers. Although the evaluation team has not yet established any influence, it is probable that the program has influenced the economizer inclusion for a portion of units in this size category. Seeing this situation as a potential savings opportunity, we recommend the following:

For program managers and designers: Create a measure to capture economizers added to units that do not require them (less than 4.5 ton). For this study it was unknown to what degree economizer additions were influenced by the program. If the program is determined to be strong influence, there would be substantial savings to be claimed.

Finding #4: Some Upstream unitary HVAC systems have non-functional economizers.


The evaluation team found that a considerable savings potential is not being realized because many of economizers for unitary systems being installed through the program are not functioning properly. Our testing occurred within two years of installation, but just over one-quarter of the economizers were found to not be working. Some tests uncovered errors such as improperly wired sensors that indicate that the economizer was not installed correctly and has never functioned as designed. In order to realize this savings opportunity, we recommend the following:

For program managers and designers: Although this recommendation does not fit within the Upstream Program, the non-functioning economizers found by this evaluation represent an excellent savings opportunity. We recommend a separate initiative to assure proper economizer function through contractor training and incentives. The program would obtain video/photographic evidence or some other proof that the economizer is fully functional before dispersing an incentive payment. This would be separate from the Upstream program and proposed post-installation and not as a code compliance activity.

Relevant findings and recommendations from the NTG report include the following.

Finding #5: We found that the program did not have a major effect on distributors' behavior, leading only 35 percent of distributors to change their patterns for stocking equipment. During their interviews, several distributors mentioned a lack of clarity on incentive timing which impeded their ability to stock and sell the units. Another distributor commented that if he can count on an incentive's availability he will stock the high-efficiency equipment. As a result, we recommend the following:

For program managers and designers: Reducing uncertainty regarding how long the incentives will remain in place at a given level would likely increase the trust which distributors have in the program, and, in turn, increase their willingness to change their stocking practices. Program practices which would increase participant certainty about how long the incentives will remain in place would include informing the



distributors when the program is going to run out of money ahead of time, and honoring incentives for HVAC purchases that are already registered in the system.

Finding #6: Marketing tools for distributors could be improved.

During our interviews, multiple distributors asked for additional sales tools and marketing materials to help them sell high efficiency units. We believe that distributors would make good use of CPUC- and IOU-hosted training and online savings calculators. This may seem counterintuitive based on some of the evidence we provided which indicated that much upselling is already occurring, with or without the program's influence. This evidence includes the fact that only 26% of distributors said that their upselling was attributable to the program, that less than 30% of buyers stated that the distributors discussed more than one efficiency option (this suggests that the upselling was already happening for the majority of buyers presented with only one option) and that only 4% of buyers were considering other efficiency types.

However, the fact that many distributors are still seeking additional marketing assistance indicates that some need exists. We believe it is important to point out that the buyer surveys only reflected the perspective of customers who bought energy-efficient units, whether due to previous disposition or due to distributor salesmanship (whether program-influenced or not). The comments from distributors may not be focused on those buyers, but rather on the customers who did not choose the energy-efficient units. It is likely for these "lost sales" that the distributors are seeking additional program marketing tools. As a result, we have the following recommendation:

For program managers and designers: Provide distributor program training and online savings estimators that are focused on helping convert lost sales of high-efficiency equipment.


Finding #7: Many distributors sought better communications on program changes in general, in addition to their more specific demands for better information about incentive availability.

Because the sales cycle for some high efficiency units can be several months, distributors want to keep their staff and buyers informed of any changes to the incentives. To prevent sales lost to program changes, we have the following recommendation:

For program managers and designers: Communicate program changes more clearly to distributors with as much advance warning as possible. Since pass-through incentives had the highest attribution score for both distributors and buyers, clear communication on program changes can help distributors make better decisions on the incentives they pass on to buyers.

Finding #8: During their interviews distributors provided suggestions on how the upstream HVAC program could be improved. Some of their suggestions, in addition to those mentioned above, included involving small municipalities in this program, offering different incentives and technologies based on climate zones, and including new technologies in the program. Since distributors are positioned to understand their markets and sales cycles, we have the following recommendation:

For the HVAC Project Coordination Group: We recommend that the IOUs and CPUC set up a mechanism (if one does not exist) to solicit regular input from distributors on potential improvements to the program.



Finding #9: Nearly 50% of the buyer program tracking data we received was missing distributor names and buyer contact information. As a result, we could not match several completed distributor interviews to buyers, resulting in their omission from our NTG analysis. However, we believe that the data from these unmatched distributor interviews should be used for future analysis. As a result of these data quality issues, we recommend the following:

For program managers and designers: The programs should strive to collect higher quality buyer tracking data, with special emphasis on collecting information relating buyers to the distributors that sold them their units. This will help increase the number of buyers matched to distributors that evaluators can use for our NTG causal pathway analysis in future studies. For example, the program application form should have the contact information for the distributor, contractor, and buyer, as well as indicate who was present at the time of purchase.

For IOU EM&V staff: We further recommend that a process evaluation be conducted for this HVAC upstream program to further analyze the distributor interview responses (from both “matched” and “unmatched”) distributors. Our evaluation, by necessity, focused on distributor responses most relevant to program attribution, but other interview responses could also be useful for identifying interesting market trends and for providing insights on how to improve upstream HVAC program design.

2 INTRODUCTION

2.1 Study focus

For each program, the IOUs develop energy savings using the process shown in Figure 1. The savings developed by the IOUs and their implementation contractors are the ex ante savings. The IOUs either rely on pre-approved measures in the Database of Energy Efficient Resources (DEER) or develop workpapers to describe each measure and propose the savings method and deemed savings amounts. Generally, the workpapers make adjustments to DEER values or pull some assumptions from DEER and others from alternate sources. The CPUC may review and revise these workpapers; it then provides a disposition of the approved calculation for each measure. The IOU programs are based on the approved workpapers. During the program implementation, the IOUs collect and track data on each measure performed, and the associated savings.

The CPUC conducts impact evaluations to assess the achieved savings of the program activities and to conduct complementary research that can be used in future ex ante savings calculations. The impact evaluation produces ex post savings.

Figure 2 shows the process for the development of ex post savings.

To summarize, the evaluation approach involved the following steps:

- Look at participation records; what results did the program implementers expect?
- Develop a field testing approach; create an M&V plan.
- Test the M&V approach in pilot evaluation; finalize the M&V plan.
- Visit a sample of sites where participating equipment was installed and collect data to evaluate gross load impacts and other parameters that may be useful for future analyses.
- Estimate parameters needed to relate indirect field measurements to the parameters needed in the analysis; use these parameters in subsequent calculations of gross load impacts.
- Analyze all collected data, and estimate load impacts and savings from the upstream program using engineering analysis and/or simulation modeling.

The approach centers on the fact that the variation in simulation inputs collected in the field is smaller than variation in energy usage and energy savings per ton. Consistent with the ex ante values the ex post savings uses simulations to project a smaller dataset across all applicable climate zones and buildings. The building vintage weights were not modified and the current source is the 2012 Commercial Saturation Study.

Figure 1. Ex ante savings calculation process

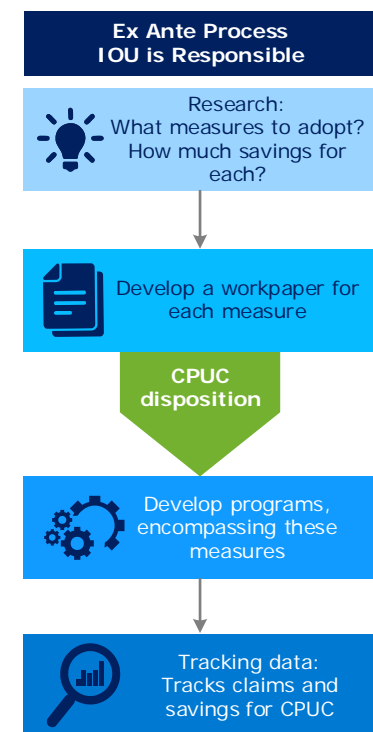
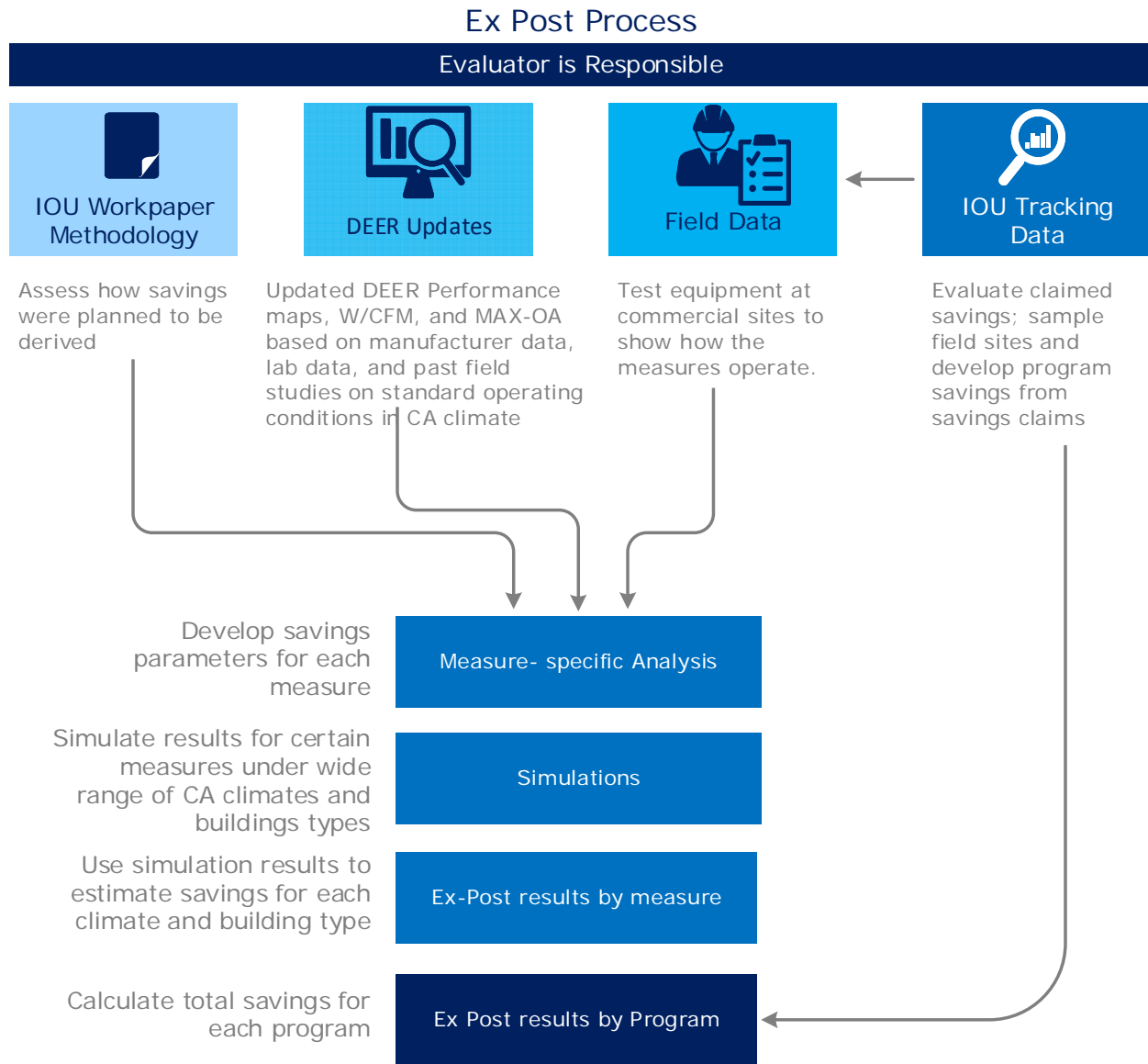


Figure 2. Development of ex post savings



2.2 Background

The upstream HVAC programs provide incentives to HVAC equipment distributors for selling high-efficiency heating and cooling equipment. Incentive amounts are based on equipment performance tiers, which vary based on equipment type, capacity, and efficiency. The underlying program theory is that the incentives encourage distributors to stock and sell higher efficiency equipment. The purpose of this evaluation is to verify gross and net savings claims for the measures associated with these upstream programs, and to provide information that will lead to more accurate savings estimates for future program cycles.

2.3 Program descriptions

For PY 2015, California IOUs funded upstream HVAC incentive programs for both non-residential (commercial) and residential applications. The non-residential components of the upstream programs have been in continuous operation since 1998⁶. There was a pilot phase for an Upstream residential component launched in 2014, but there was no expansion of this component in 2015.

The upstream programs share three primary goals:

- Encourage participating distributors to increase their stock of high-efficiency equipment so that it is readily available to customers (contractors and large businesses)
- Encourage participating distributors to up-sell equipment to customers (e.g., explaining to customers the technical and financial benefits of the efficient option and calculating the payback or net present value when possible)
- Encourage the purchase and installation of the most efficient equipment available

To achieve these goals, the upstream HVAC programs enlist HVAC equipment distributors who are willing to participate under the program's terms and conditions to sell high-efficiency heating and cooling equipment for use in both non-residential and residential installations. The available incentive amounts are based on equipment performance tiers.⁷ Tiers vary based on equipment type, capacity, and efficiency (SEER, EER, or IEER) ratings. Distributors' customers are typically licensed HVAC contractors (C-20) or mechanical design engineers.

For a distributor to receive an incentive payment, the program-eligible equipment must be installed within the sponsoring IOU's service territory and must meet program-specified efficiency requirements; distributors must provide information on the location of the installation to the program administrator. The most common incentivized equipment includes:

- Three-phase packaged and split equipment (air-cooled and water-sourced heat pumps (HP), water- and evaporative-cooled AC)
- Single-phase equipment (air cooled)
- Single-phase ductless equipment (mini- and multi-split equipment)
- Distributors are also entitled to receive incentives for these less common equipment types:
 - Three-phase air-cooled chiller equipment
 - Three-phase water-cooled chiller equipment
 - Three-phase VRF equipment (HP with and without heat recovery)

2.4 Program and measure activity

PG&E, SCE, and SDG&E programs all implemented consistent upstream measures, but each utility implemented a slightly different program structure. Southern California Gas Company did not offer any upstream measures in its energy efficiency program portfolio for the 2015 program year.

Upstream measures were identified in the tracking data differently by each IOU. PG&E used an "Upstream Flag" field that clearly indicated that the claim was an upstream measure. SDG&E put the word "upstream" in its measure description field to differentiate the claim from a downstream measure. SCE upstream claims

⁶ More information on upstream programs is provided on Energy Solution's website: <https://energy-solution.com/project/distributor-hvac-program/>

⁷ <https://www.cainstantrebates.com/>

were identified when “Up-Stream Programs-Up-Stream Incentive” was entered in its implementation description field for the measure in question.

Each IOU had one single non-residential program where the upstream measures were administered. All of PG&E’s 2015 upstream measures were administered through Program 21015-Commercial HVAC. SCE’s 2015 upstream measures were administered through Program SCE-13-SW-002F, Non-Residential HVAC. SDG&E’s 2015 upstream measures were administered through Program 3224, SW-COM-Deemed Incentives-HVAC Commercial.

Table 7 shows the 2015 upstream HVAC aggregate electric energy and demand savings claims for identified upstream measures within each IOU non-residential program mentioned above. Only the 2015 portfolio savings are included in the table for comparison. The 2015 upstream program claims represent 1% of the entire statewide portfolio electric energy claims, and 2% of the portfolio demand savings claims.

Table 7. 2015 upstream program savings by IOU

Energy Savings Claims by IOU		
IOU	Electric Energy (GWh)	Electric Demand (MW)
PG&E	9.82	5.74
SCE	9.78	5.78
SDG&E	0.47	0.17
Total	20.1	11.7

Claimed savings from all measures related to the 2015 upstream evaluation are described below. The measure names shown in the tables are the measure names given in the tracking data. In some cases, tracking data also included measure codes. A list of measure names with their respective codes can be found in the appendices. Each claim represents a line item in the tracking data, which is not necessarily at the unit level.

2.4.1 PG&E Commercial HVAC

PG&E implemented upstream measures for the non-residential sector through its core Commercial HVAC. Table 8 shows the measure categories, the number of claims, and aggregate energy and demand savings found in the 2015 tracking data. Unitary (packaged or split) systems had the greatest proportion of annual energy savings.

Table 8. PG&E non-residential HVAC upstream activity by measure group 2015

Measure Categories	2015 Claimed Tonnages	First Year kWh	First Year kW
HVAC Chiller Air Cooled	10,959	3,797,660	326
HVAC Rooftop or Split System	49,269	9,820,410	5,742
HVAC VRF/Mini-Split	3,772	118,805	30

Measure Categories	2015 Claimed Tonnages	First Year kWh	First Year kW
Total	64,000	13,736,875	6,098

The following detailed workpapers were used to determine the gross ex ante savings for non-residential upstream measures installed in PG&E's service territory.

- PGECOHC126, Unitary Air-Cooled Commercial Air Conditioners and Heat Pumps <65 kBtu/h
- PGECOHC128, Unitary Air-Cooled Commercial Air Conditioners and Heat Pumps >= 65 kBtu/h
- PGECOHC162, Unitary Water Cooled Heat Pumps
- PGECOHC142, Variable Refrigerant Flow Nonresidential Systems
- PGECOHC120, Air-Cooled Packaged Chillers

2.4.2 SCE Commercial HVAC

All of SCE's commercial upstream-related activities were administered through this broad-based core commercial HVAC program (SCE-13-SW-002F). Table 9 shows the savings for SCE's upstream measures aggregated by basic equipment technology category. Note that packaged/split systems had the most claims yet the savings was about equal to the chiller claims. There were fewer chiller claims than packaged systems, yet due to the large kWh savings per claim, water and air-cooled chiller savings in the aggregate composed under 50% of first-year program savings.

Table 9. SCE commercial upstream program activity by measure category 2015

Measures Category	2015 Claimed Tonnage	First Year kWh	First Year Kw
HVAC Chiller Air Cooled	3,020	1,309,035	213
HVAC Chiller Water Cooled	14,063	11,038,314	1,986
HVAC Rooftop or Split System	47,733	9,775,362	5,782
HVAC VRF/Mini Split	2,632	2,797,059	1,094
Total	67,448	24,919,770	9,075

SCE's upstream program workpapers are listed below. These workpapers describe the assumptions and methodologies for generating an estimate of the "typical unit" participating in the program. The savings are defined by building type using the California Energy Commission (CEC) 16 climate zones (CZ), unit cooling capacity, and unit efficiency tier. These workpapers⁸ were used to determine the gross ex ante savings for measures installed in SCE's service territory:

- SCE13HC035, Unitary Air Cooled AC Units 65 kBtu and Larger (includes larger VRF units)
- SCE13HC019, Unitary Split-System Air Cooled Heat Pumps Under 65 kBtu

⁸ To estimate ductless system savings, this workpaper used a ducted split system savings and applied a multiplier to approximate the savings for the absence of ducting.

- SCE13HC012, Packaged and Split Air Cooled Commercial Air Conditioning and Heat Pump Units, Under 65 kBtu/h
- SCE13HC032, Ductless Air Conditioners under 24 kBtu
- SCE13HC033, Ductless Mini-Split and Multi-Split Heat Pump units under 65 kBtu/h
- SCE13HC030 Air-Cooled Packaged Chiller
- SCE13HC043 Water-Cooled Chillers

2.4.3 SDG&E Deemed Incentives-Commercial HVAC

The upstream measures in the SDGE Deemed Incentives – Commercial HVAC program (3224 SW-COM) were a small part of this comprehensive commercial deemed incentive program. According to the 2015 tracking data, SDG&E claimed 3,808 tons in the small unit packaged-units measure category. The measures rely on scaling factors referenced in the workpaper to determine savings tier levels. Table 10 summarizes SDG&E claims which were only for unitary systems.

Table 10. SDG&E commercial upstream program activity by measure category 2015

Measures Category	2015 Claimed Tonnage	First Year kWh	First Year kW
Packaged/Split AC Systems	3,808	468,432	172

There are relatively few SDG&E upstream measures when compared with SCE and PG&E upstream measures in the program tracking data.

2.5 Ex ante savings approach


2.5.1 Large and small unitary HVAC

Program administrators (PAs) produced the ex-ante estimates by making assumptions about the pre- and post-treatment performance of the participating systems. DNV GL input these assumptions and measure details into eQUEST models using DEER prototype buildings for the following parameters:

- Climate zone
- Building type
- Building vintage
- Efficiency tier

In essence, there are two basic components for these savings estimates: The improvement of system efficiency above that of the Title 24 code minimum baseline, and an estimate of the annual cooling load on these units. In the ex ante models, all model inputs except for system efficiency (COOLING_EIR) and select curve fits are identical in measure case and baseline models. Appropriately for the upstream programs, all projects are considered replace on burnout or new construction, so there is no remaining useful life or dual baseline considerations in the model calculations.

The evaluation team utilized the DEER prototype models as the starting point of the ex post calculations. We used the collected data to confirm or adjust inputs in the DEER prototype models. For most of the upstream air conditioner population segments, the team used the average input value of the sample. However, when we found a sufficient sample to obtain a defensible estimate on a tier / size subgrouping, we used the observed parameters for the program subpopulation. In this evaluation, this occurred in one case where fan



performance index was adjusted because data showed a difference greater than 10% from the DEER input value.

3 ANALYTICAL APPROACH

The main goal of this research included determining the best estimate of actual energy and demand savings achieved by incentivized upstream HVAC measures during the 2015 program year. California IOUs SDG&E, SCE, and PG&E, offered these upstream programs. Providing information that leads to more accurate savings estimates for future program cycles was another critical research goal.

To achieve these goals, DNV GL conducted evaluation activities in support of four basic evaluation objectives:

- **Assess program documentation quality:** Assess how accurately the program claims energy-saving measures and the completeness of program documentation.
- **Assess installed measure conditions:** The primary basis for the energy savings claims is the DEER. DEER estimates are based on efficiencies rated by the Air-Conditioning, Heating, and Refrigeration Institute (AHRI), and use typical performance maps for the appropriate EER and SEER rating. Efficiencies are altered based on installed conditions to estimate in situ performance. A key component of the evaluation includes collecting data on installed conditions affecting efficiency, but not directly measuring efficiency due to the uncertainty of in situ efficiency measurements.
- **Assess measure claimed savings:** Determine whether claimed energy and demand savings are accurate estimates of the realized savings. Selecting a set of specific input parameters rather than an independent ex post estimate is the approach taken to determining realized savings. The variation in energy consumption requires a larger sample than can be undertaken in this evaluation given the variations in building type and climate zone (CZ), as well as site-specific conditions.
- **Program improvement recommendations:** Communicate findings and recommendations from this M&V study and net to gross survey.

3.1 Gross savings

Using data and observations from site visits,⁹ unit savings were calculated for an updated gross savings estimate. The savings were recalculated using methods consistent with DEER methodologies. Deviations between these methods and IOU workpaper assumptions and the M&V method described in Section 4.3 provides data envisioned to be most useful to both this evaluation and future DEER updates.

3.2 Evaluation activities

All of the activities undertaken by this evaluation addressed at least one of these objectives. Table 11 shows how research activities served evaluation objectives.

⁹ Details of on-site data collection activities are available in Section 4.2 and in the Research Plan.

Table 11. Evaluation objective to activity mapping

Goal	Objective	Planned Activities	Details
Estimate actual energy and demand savings achieved	Assess program documentation quality	M&V site inspection compared with claim	Measure and verify a select sample of 30 end-user installations
	Assess measure savings	Targeted input parameter data collection (e.g., static pressure conditions, installed options based on nameplate)	Compare the inputs and methods used in the ex ante calculations to the data gathered during the site inspection
	Calculate program savings	Revised DEER-like measure analysis, including building simulation of program specific inputs	Adjust ex ante savings based on findings of the documentation and savings assessments. This process may include methodological updates to DEER that were not in place when workpapers were filed, such as treatment of integrated energy efficiency ratio (IEER-rated equipment).
Provide actionable information to improve the accuracy of savings estimates for future program cycles	Provide program improvement recommendations	M&V findings and net to gross survey recommendations and findings	Communicate findings and recommendations

4 METHODS

The primary evaluation task was to verify the installation of participating installed equipment across California. Gross impacts for kW and kWh savings were determined by collecting targeted inputs to the ex ante calculations via site visits and analysis of the acquired data. The analytic approach focused on the accuracy and precision of selected simulation inputs, which vary less than energy savings across building types and climate zone (CZ). The savings resulting from the revised assumptions can be projected to all building type and CZ combinations for all of the claimed measures using building energy simulations.

Sections 4.1, 4.2, and 4.3 discuss the evaluation team's methods for conducting the M&V the primary task of this study.

4.1 M&V sample design

From the IOU tracking data, the evaluation team designed three samples in the 2013-14 evaluation. The three samples represent chillers (air- and water-cooled), large package and split systems (those exceeding 20 tons cooling capacity), and small package and split systems (20 tons or less). Ductless mini-split units are a separate category where no sites were visited. Samples were designed to provide a $\pm 10\%$ relative precision for measure group at a 90% confidence level. For small unitary systems, the planned samples were not completed as planned in 2013-14. The 2013-14 sample for PG&E came close to goal, but the samples for SCE and SDG&E came up short due to a delayed launch and other challenges. In the 2015 evaluation SCE and SDG&E small package systems (20 tons or less) were a priority and no additional samples were completed for chillers or large unitary systems. The planned sample sizes and populations by IOU and equipment type are shown in Table 12.

Table 12. Planned sample and population site totals by IOU and equipment type

IOU	Sample/ Population	Chiller 2013-14	Large Unitary 2013-14	Small Unitary 2013-14	Small Unitary 2013-2015
PG&E	Sample	48	27	50	60
	Population	127	405	2,812	7,194
SCE	Sample	52	23	80	90
	Population	161	236	1,669	3,164
SDG&E	Sample	0	3	10	2
	Population	0	3	21	21
Total	Sample	100	53	140	152
	Population	288	644	4,502	10,379

In terms of achieved precision, the study measured multiple unit-level parameters used for simulations across IOUs. The variability of ex ante and ex post site savings was essentially equal given that savings vary by building type and climate zone and the same calculation procedures were used in the ex-ante and ex-post analysis. The estimated precision of each simulation input is also estimated in the study results presented in Chapter 5. Table 13 shows that the overall achieved precision for 2013-14 was approximately 14%, while the planned precision was 10%. Data collection for the 2015 program year focused on improving these estimates with targeted data collection to fill the incomplete sample targets, especially for SCE and SDGE. The final achieved precision met the original precision goal and achieved 10% relative precision based on number of sites. Since there were insufficient data to adjust inputs by IOU, we used the data across IOUs to inform model inputs.

Table 13. Planned and achieved precision for small unitary systems

IOU	Planned Sample Sites	2013-14 Completed Sample Sites	2013-14 Achieved Relative Precision at 90% Confidence	2015 Completed Sample Sites	2013-2015 Completed Sample Sites	Achieved Relative Precision at 90% Confidence
PGE	50	48	±19%	13	61	±15%
SCE	80	41	±18%	50	91	±12%
SDGE	10	2	±55%	0	2	±55%
Total	140	91	±14%	87	153	±10%

4.2 M&V on-site data collection

This section provides a brief review of HVAC fundamentals followed by a description of the data collected via site visits from each of three samples.

4.2.1 HVAC system fundamentals

Utility upstream programs focus primarily on unitary HVAC systems serving commercial and residential buildings. These systems mostly share common attributes, although some variation exists based on a unit's size and application. Three components account for the bulk of HVAC-system electricity consumption: 1) compressors, 2) condenser fans, and 3) evaporator fans.¹⁰

Figure 3 shows how a typical packaged commercial air conditioner is installed in a small office space. The "cut-away" air conditioner on the left of the roof is shown in greater detail in Figure 4; the other three air conditioners more closely approximate what a unit looks like when installed. The packaged units are connected to duct systems that distribute the air to the office locations.

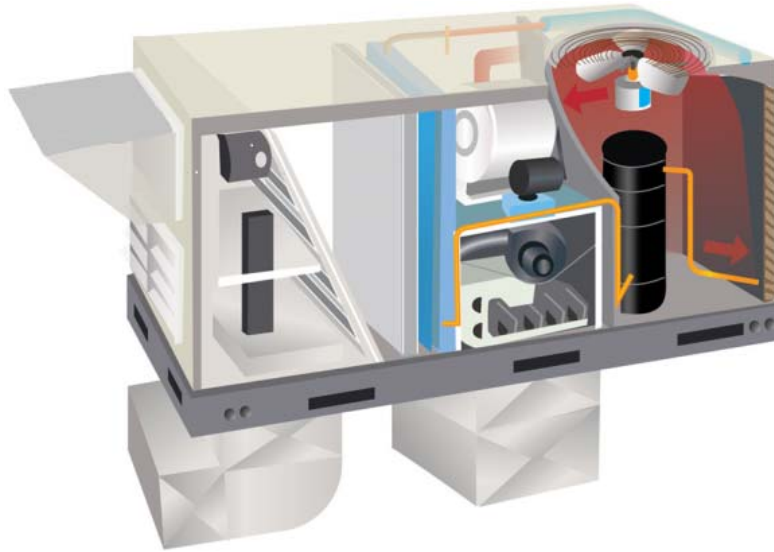
¹⁰ Controls account for a very small amount of electricity consumption.

Figure 3. Installed packaged commercial air conditioner



Figure 4 shows a cut-away view of the packaged air conditioner on the left of the roof in Figure 3. Outside air enters the unit through the vent on the left, while return air enters from the curved duct under the unit. The warm air (from the outside and the return) is sent through an air filter and pulled through the cooling coil (shown in blue). A supply fan delivers the cooled air to the building through the straight duct under the unit. The final portion of the air conditioner contains the compressor, which is the portion of the refrigeration cycle that removes and rejects the heat from the air conditioner. The fan at the top right of the unit helps keep the compressor cool.

Figure 4. Cut-away packaged air conditioner



Compressors increase refrigerant pressure and temperature, and circulate superheated vapor to the condenser. There, the vapor is condensed to a liquid and sub-cooled through the condenser heat transfer coils. The liquid then circulates through the expansion device. As the refrigerant passes across the expansion device, the pressure is reduced, which causes a further reduction of the liquid temperature. Next, the refrigerant enters the evaporator coil as cold liquid, expands into the vapor state and pulls heat from the air passing over the evaporator coil. The refrigerant exits the evaporator as a superheated vapor and then returns to the compressor to repeat the cycle.

The condenser fan moves outdoor air through the condenser coil to reject heat from the refrigeration system that has been absorbed from the building return air and outdoor air mixture. The evaporator blower fan moves mixed air—made up of return air from the conditioned space and outdoor air (required to meet ASHRAE 62.1 outdoor air ventilation requirements)—through the evaporator coil, where the air is cooled and dehumidified and supplied to the conditioned space. Compressors, condenser fans, and the evaporator fan operate simultaneously when the cooling system is operating without the economizer.¹¹

The evaporator fan operates by itself in ventilation-only mode or when the economizer is operating properly in first-stage cooling mode (using only outdoor air to cool). The compressor and condenser fan operate simultaneously with the evaporator fan in second-stage cooling (with economizer dampers closed, partially open, or fully open) to provide cooling and ventilation.

Individual unit power consumption typically peaks at the highest outdoor air temperatures. As a result, the number of individual units simultaneously operating across a region of the state also peaks. Thus, peak HVAC electric consumption has high coincidence with the electricity grid's system peak demand in California.

Factors that influence an HVAC system's energy consumption and/or peak power include:

- The amount and quality of refrigerant in the system

¹¹ Many commercial packaged units (greater than 5-ton cooling capacity) with multiple condenser fans will cycle off one or more condenser fans when compressor is operating at low outdoor air temperatures to avoid low pressure cut-out or icing of the evaporator coil.

- Effectiveness of the heat exchangers, including the evaporator coil, furnace heat exchanger, and condenser coil
- Outdoor airflow required to meet ventilation requirements
- Unintended outdoor airflow through the system (including unintended damper leakage, duct leakage, cabinet leakage, and curb leakage)
- Compressor operation, controls, and efficiency
- Indoor/outdoor fans, fan motors, controls, speed, sheaves, pulleys, belts, operation, and efficiency
- Effectiveness and operation of the economizer, dampers, sensors, and controls
- Fault detection diagnostic operation and controls
- Thermostat and/or energy management system (EMS) controls
- Duct insulation
- Duct system design

If the installation achieves optimal system efficiency, power input to the unit will be reduced and possibly the unit will need less time to achieve the thermostat setpoint. The evaluation team began gross savings determinations by collecting and analyzing the data described below. Distribution system losses and related effects were not addressed in these analyses.

4.2.2 Data collection: Small unitary systems

Unitary systems (rooftop systems) were evaluated at 30 sites for the 2015 program evaluation. The sample plan selected sites that had two or more participating units installed. At each site, the evaluation team made observations, performed functional testing, and took spot measurements on selected units with cooling capacities of 20 ton and less.

Each unit was subjected to the following observations and measurements:

- **Installation characteristics:** Inspectors recorded the building type, building vintage, and space type, served by each selected unit. A list of recorded items can be found in Appendix B
- **Equipment nameplate:** Inspectors recorded the nameplate information and photographed the nameplate. A complete list of nameplate data elements is provided in Appendix B
- **Economizer:** Inspectors recorded the presence or absence of an economizer on each selected unit and, where an economizer was present, performed economizer functionality testing on selected units with cooling capacities of 20 tons and below.
- **Application characteristics:** Inspectors recorded the duct location, unit configuration, and unit mounting
- **Performance measurements:**
 - Spot measurements:
 - Operating static pressure differentials across the unit, and between return and ambient air
 - Cooling-mode and fan-only mode fan true electric power
 - Economizer functionality
 - Economizer characteristics
 - ADEC readings (temperatures, damper position)
 - Damper test
 - Sensor test

Protocols for these on-site observations and measurements can be found in found in Appendix B

4.3 M&V gross savings analysis

The 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 upstream programs. These model runs were used to produce ex post savings estimates for each climate zone, building type, and unit type combination. The ex post gross savings were obtained by recalculating the savings for all the program populations using the revised estimates. In order to obtain combined vintage average values, the DEER weights were applied to individual vintage estimates.¹²

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

The DX units were evaluated in a similar fashion regarding the unit efficiencies¹³, but with an additional consideration of non-functional economizers. The baseline case was modeled with code minimum efficiencies and the measure case was modeled with 73% working economizers and 27% with fixed outside air percentage to simulate non-functional economizers in the participant sample.

¹² The DEER vintage weights were taken from Itron's 2012 Commercial Saturation Study

¹³ The full load EER efficiency was modified directly and we chose a DEER performance map that represented the IEER for that Tier and size range.

5 FINDINGS

The primary findings across all sampled measures focused on the efficiency of the installed units. In the workpapers for unitary systems, the IOUs scaled the available DEER values into the program-defined efficiency tiers. In the ex post evaluation, the as-found rated efficiency was determined for each sampled unit, and the tonnage-weighted average was used to re-run the DEER prototype simulations, rather than using a scaling factor, to ensure accuracy.

5.1 Average unit efficiency

The as-found unit efficiency was collected for multiple units at each site in the sample. The analysis sought to provide measure-level inputs from the site-based sample that would feed simulations consistent with the ex ante calculation process used by DEER. The simulations were run for all combinations of building types and climate zones claimed by the program. The average efficiency by size range was then turned into an energy input ratio for use in simulation models.

5.1.1 Unitary systems efficiency inputs

Earlier site visits in 2013-14 primarily included units installed under 2008 Title 24, with installation prior to July 2014. Data collection for 2015 included only units installed under 2013 Title 24, which took effect July 1, 2014. Code changes did not affect chillers but did affect the smallest two categories of unitary systems. The evaluation used DEER 2015/16 values directly to reflect the savings of installations completed after July 2014. Units less than 5 ton had over half of the claimed savings and nearly half of the claimed tonnage for small unitary systems. Table 14 shows the results for 2015 by IOU.

Table 14. Distribution of 2015 claims (2013 code only)

Unit Size	IOU	Claimed Tonnage	Claimed Savings (kWh)
< 5 Ton	PGE	15,670	3,223,706
< 5 Ton	SCE	11,203	3,241,912
< 5 Ton	SDGE	1,873	303,003
< 5 Ton	Total	28,745	6,768,621
5.5 - 11.5 Ton	PGE	7,988	525,563
5.5 - 11.5 Ton	SCE	10,633	1,340,586
5.5 - 11.5 Ton	SDGE	667	77,866
5.5 - 11.5 Ton	Total	19,287	1,944,014
11.5 - 20 Ton	PGE	5,551	517,500
11.5 - 20 Ton	SCE	5,632	883,430
11.5 - 20 Ton	SDGE	399	35,378
11.5 - 20 Ton	Total	11,583	1,436,308

For units of less than 5 tons (SEER rated units), the base case from DEER 2015 is a 14 SEER unit. Table 15 shows the distribution of the evaluation sample. The “as-found tons” refer to the actual surveyed tonnages of the sampled units as opposed to the “claimed tons” from the tracking data.

Table 15. Distribution of unit efficiency and fan type for units under 5 tons

Efficiency Tier	As-Found Ton	Sampled Units	Tonnage Proportion
Tier0 - 14 SEER, 12 EER	51	13	10%
Tier1 – 15 SEER, <13 EER	20	6	4%
Tier2 - 16 SEER, >13 EER	44	12	9%
Tier3 - 17 SEER, 13+ EER	127	30	25%
Tier4 – 18 SEER	264	63	52%
Total	506	124	100%

For units between 5.5 and 11.5 tons, Title 24 now includes requirements to install a two-speed fan similar to the units larger than 11.5 tons. Prior to the code change, many units were being installed with two-speed fans; this led to those units being higher IEER than the same unit in a single-speed configuration, as detailed in the DEER 2016 update. Roughly one-third of the claimed tonnage mapped to Tier 1 (11.5 EER) with 1-speed fan. The IEER average also agreed with DEER assumption for Tier 1. For the remaining two-thirds of the claimed tonnage the units had a 2-speed fan. This group had units at 12 EER and 12.5 EER and varying IEER.

For the cases with no code changes, there was more uniformity. For units 11.6 to 20 ton, 90% of tonnage were Tier 3 (12.5 EER) with 2-speed fan. The 10% that had 1-speed fan were scattered between 11.5 and 12 EER, but were not code compliant and therefore the simulations give negative savings since 2-speed fan is in the base case.

Table 16. Distribution of unit efficiency and fan type for units 5.5 to 20 tons

Efficiency and Fan Type	As-Found Tons	Sampled Units	Proportion
5.5-11.5 Ton	1,143	130	100%
Tier0 - To Code	120	13	11%
Tier1 - 11.5 EER	92	10	8%
Tier2 - 12 EER	680	78	59%
Tier3 - 12.5 EER	186	22	16%

Efficiency and Fan Type	As-Found Tons	Sampled Units	Proportion
Tier4 - 13 EER	65	7	6%
12-20 Ton	875	57	100%
Tier0 - To Code	70	4	8%
Tier1 - 11.5 EER	13	1	1%
Tier2 - 12 EER	355	23	41%
Tier3 - 12.5 EER	318	27	36%
Tier4 - 13 EER	99	7	14%

A direct comparison of unitary system inputs showed some minor differences in the code minimum value for DEER and what was used in the workpaper or what was shown in Title 24. Most of the savings claims were for units installed under the 2013 Title 24 energy code. For units installed under 2013 Title 24, the efficiency baseline was updated to 14 SEER for small units and two-speed supply fan operation for units 5.5–11.5 ton.

5.2 Test results for small unitary systems

Unitary systems with a capacity of 20 tons or less underwent additional testing beyond collection of nameplate data and rated efficiency. Units were tested for economizer functionality and fan performance. Economizers were subjected to operational tests. Fan performance was evaluated with fan power measurements. The intent was to use the economizer data to establish economizer installation rates and fan data to update DOE2 fan power assumptions. Overall the 2015 evaluation over doubled the 2013-14 measurement sample for small units. The following cumulative total samples were used for the analysis. In all cases, more units were measured, but some test results did not pass quality control and validity tests.

- Assessed Economizer functionality for 172 units. Another 74 were indeterminate mostly from the 2013-14 evaluation before protocols were improved.
- Measured fan power for 157 units
- Measured airflow in full load cooling mode for 130 units

The results of the economizer functionality tests are summarized in Table 17. An economizer was considered functional if it passed both mechanical and sensor functionality tests. The economizer was considered non-functional if it failed either the mechanical or sensor test. We could not determine a pass or fail if there was mechanical ability but no incontrovertible evidence that the sensors worked or did not work. In some cases, there were central controls leading to the outcome of no determination.

For units with a determination, 73% passed the functional test across all sample points. Our field engineers improved the procedures greatly reducing the units with no determination in the 2015 sample. In the previous report, we assumed our final adjustment that 75% of economizers worked in the base and measure case and 25% of economizers did not work in the base or measure case. Given the additional data provided

a lower pass rate with more granularity we decided to use the combined pass rate of 73% in the 2015 analysis. We held economizer functionality consistent in simulation runs because otherwise we would simulate the addition or removal of the economizer, which has a greater impact than the efficiency upgrade.

Table 17. Economizer functionality results

Economizer Functionality	2013-14 Report Sample	2015 Report Sample	Total Sample	Pass rate	Achieved Relative Precision at 90% Confidence
Pass	62	63	125	73%	±8%
Fail	16	31	47		
No Determination	44	20	74		NA

2015 Sample included new protocols, separated sensor failure and mechanical failure

As The average normalized system airflows by unit size are shown in Table 18 The overall average is 357CFM/ton. The DEER value used in the prototype for most building types and climate zones is 400 or 333 CFM/ton. Given the sample size and airflow measurement uncertainty, no normalized airflow measurements were adjusted in the model.

Table 18. Average normalized system airflow

Unit Size	CFM/ton	CFM/Btu	Units	Achieved Relative Precision at 90% Confidence	Ex Ante (DEER) CFM/ton
<5.5 ton	348	0.029	54	±7%	400
5.5–11.5 ton-	360	0.030	55	±8%	333
11.5–20 ton	373	0.031	21	±12%	333
All	357	0.030	130	±6%	333

Table 19 shows the distribution of normalized unit airflow across the measured units. Most of the units are in the 300 to 500 CFM range. There were 27 systems tested at less than 300 CFM per ton, which is considered inadequate airflow under most conditions. Certainly, some of these systems may have been suffering from inadequate airflow, but many may have been tested at fan speeds below maximum. Field engineers were instructed to perform airflow tests at full speed, and most of the units were tested at full speed, but there were occasions where the field engineer could not verify if the fan was operating at full speed with certainty. Therefore, an unknown number of units with low airflow results may have been actually operating at reduced fan speeds. This also should be considered when looking into the average airflow results. The results from units that we know to be operating less than full speed were excluded from this analysis. We suspect that some of the units with low flow rates included in the table may also have been operating in ventilation modes, and may not have been in cooling mode.

Table 19. Normalized unit airflow distribution

CFM/Ton	2015 Count	2013-14 report Count
100-200	6	12
200-300	21	11
300-400	69	49
400-500	27	21
Over 500	6	7

System airflow test results were combined with fan power measurements to produce values of fan power normalized by airflow in unit of kilowatts per CFM. As seen in Table 20, units under 5.5 tons averaged 0.273 W/CFM. The DEER assumption for code-level units of this size was 0.379 W/CFM and the measure assumption was 0.294 and 0.251. Ultimately no adjustments were made as data for the baseline would likely also be higher than DEER assumptions, but analysis of other field studies was not completed as part of this evaluation. The DEER assumption for the other small DX size categories, 5.5 to 11.5 tons, was the same for both the measure and code case, 0.400 and 0.410 W/CFM. The fan performance results supported an adjustment for units 5.5 – 11.5 ton based on a statistically significant difference between the measured average and the current ex ante assumption. Larger samples could also justify making adjustments.

Table 20. Normalized fan performance

Unit Size	W/CFM	W/CFM from 2013-14	Units	Achieved Relative Precision at 90% Confidence	Ex Ante (DEER) W/CFM	Statistically Significant Ex Ante/ Ex Post Difference
< 5.5 ton	0.273	.364	65	±13%		No
< 5.5 ton – SEER 15	0.151	.516	5	±32%	0.251	Small Sample
< 5.5 ton – SEER 16	0.359	.329	13	±28%	0.271	Small Sample
< 5.5 ton – SEER 17	0.257	.329	45	±15%	0.271	No
< 5.5 ton – SEER 18	n/a		n/a	±11%	0.271	No
5.5–11.5 ton	0.303	.43	64	±12%	0.4	Yes
11.5–20 ton	0.472	.45	28	±8%	0.41	No

Table 21 show the distribution of system supply fan W/CFM across the tested sample. The distribution is normal with a few outliers.

Table 21. Normalized fan performance distribution

W/CFM Range	Units from 2015	Units from 2013-14 report
0-0.1	19	1
0.1-0.2	47	9
0.2-0.3	22	10
0.3-0.4	26	24
0.4-0.5	19	21
0.5-0.6	14	13
0.6-0.7	2	3
0.7-0.8	3	3
0.8-0.9	2	1
Over 0.9	3	3
total	157	88

5.3 Building type assignments

After reviewing all of the sampled units for efficiency and fan performance an overall adjustment was considered based on differences between the building type found through site visits and the tracked building type. In general, there were many differences, especially where the building type appeared to be unknown such as entries for “Multiple” and “Any.”

5.3.1 Unitary systems building types

There were 17 building types in the small unitary sample population from the tracking. These building types represent 3,362 ton of cooling and 525 units. The largest difference in the as found building types was for the tracking types miscellaneous and retail. Table 22 presents the small unitary system building type comparison.

Table 22. Small unitary system tonnage comparison 2015

Building Type	Tracking Tons	As Found Tons	Tracking # Units	As Found # Units	UES kWh	UES kW	Track kWh	Found kWh	Track kW	Found kW
Education - Community College	15	20	1	2	103	0	1,538	2,050	1.1	1.5
Education - Primary School	401	492	59	86	75	0	30,249	37,113	20.0	24.6
Education - Secondary School	873	937	173	181	65	0	56,959	61,135	20.3	21.8
Miscellaneous	749	0	95	0	125	0	93,571	0	67.8	0.0
Multiple	7	4	2	1	139	0	973	556	0.6	0.4
Multiple - Any	116	0	11	0	139	0	16,124	0	10.4	0.0
Multiple - Commercial	334	0	53	0	139	0	46,426	0	30.1	0.0
Office - Large	283	237	27	56	96	0	27,263	22,832	21.2	17.7
Office - Small	118	352	51	51	105	0	12,302	36,802	10.6	31.8
Restaurant - Fast Food	8	58	1	7	139	0	1,113	8,068	0.7	5.4
Restaurant - Sit Down	49	18	5	2	162	0	7,922	2,910	6.1	2.2
Retail - 3 story	241	0	31	0	136	0	32,795	0	23.8	0.0
Retail - Large 1 story	105	869	9	97	175	0	18,373	152,058	13.0	107.6
Retail - Small	25	40	3	2	135	0	3,370	5,391	3.0	4.7
Manufacturing - Light Industrial	28	182	2	21	80	0	2,247	14,606	1.0	6.7
Utility	10	0	2	0	139	0	1,390	0	0.9	0.0
Assembly	0	96	0	8	156	0	0	14,998	0.0	10.4
Total	3,362	3,305	525	514			352,615	358,519	230.7	234.8

In the 2013-14 evaluation adjustments were made for small units, large units, and chillers. In this 2015 evaluation adjustments were made for small units only and the magnitude of the adjustment to both energy and demand savings was estimated to be within 2% of the claimed savings. The final gross savings for 2015 only includes the efficiency adjustment, fan power and airflow adjustment for 5.5 to 11.5 ton units. The factor in the analysis for building type adjustment was set to 100%.

5.3.2 Building Type Vintages

Note that all savings assumed replace on burnout and after runs were completed we used the DEER weighted average vintage for existing buildings. The weights vary by IOU and climate zone based on building stock and a small percentage is assumed to be new construction, roughly 3%-4%. There were new construction projects in the sample but these were within the range of the building vintage weights so no adjustments were made related to building vintage.

5.4 Gross impacts

The evaluation developed gross savings for each measure group. The DEER prototype models were re-run using simulation inputs developed from the M&V analysis. Only the combinations of building type and climate zone claimed in the program tracking were run, as opposed to all combinations that are published in DEER. Savings were developed on a per ton basis, consistent with DEER, and those savings were multiplied by the claimed quantity of tons in the tracking. In some cases, tracking savings had claims with building types or climate zones are not in the DEER database. Where building type or climate zone were not consistent with DEER prototypes the evaluation team used the final realization rate for the known combinations and applied them.

5.4.1 Unitary systems

The unitary systems were classified in to two groups by unit cooling tonnage: large unitary systems over 20 tons and small unitary systems up to 20 tons. M&V efforts focused on the small unitary system classification with field measurements of performance and installation verification.

5.4.1.1 Small unitary systems

The overall realization rate for small unitary systems across all programs and measures was 78.9%. The primary reason for this realization rate was lower than expected unit efficiencies (EERs) than expected. A contributing factor is that there have been significant DEER updates for these measures since the 2013-14 ex ante values were developed, including code changes in 2014 to minimum efficiency, changes to fan speed requirements, and updated performance maps. These updates were incorporated into ex post simulation baseline models, which resulted in reduced savings when compared to the ex ante estimates appropriate to the fan speed and other code requirements in effect at the time of installation¹⁴. Aside from the code changes, the following modifications were made for the ex post estimates based on site observations:

- Adjustments to the building type assigned
- Adjustments to the assigned efficiency and fan control
- Adjustments based on economizer functionality
- The IOU programs stipulated that units could meet each efficiency tier requirement by meeting the full-load efficiency (EER) *or* the integrated energy efficiency ratio (IEER) criteria. This led to some units complying with IEER requirements that had full load efficiency at or close to code minimum. DEER 2016 updates have mapped IEER values to the performance curves to address this issue in the future. The tables below show the final savings for all large unitary systems, and then show the step-wise adjustments to small units 20 tons and under to demonstrate the effect of each adjustment.

Adjustments were made for small unit savings estimates based on economizer functionality. Results from the functional testing of economizers on units with 20 tons of cooling capacity and lower showed an operational rate of 73% (approximately 3 out of 4 units tested had properly functioning economizers). Table 23 provides the results and applies the economizer functionality to the claimed tonnage to create the weighting of 73% working economizers in both the baseline and measure case since program participation has no known effect on economizer functionality. We used an assumption that all failed units failed with outside air dampers in the minimum position. Economizers are not required for units less than 5 tons, and adding an economizer to a unit in this size range is considered a separate measure from the efficiency upgrade. The evaluation also measured fan power for small units, but we achieved small samples for each efficiency tier. In addition, adjustments to the baseline would also be necessary and analysis of other data sources necessary to produce baseline adjustments were not completed in time for this report.

¹⁴ Code minimum was based on the installation date for all units. Exceeding earlier code requirements led to very high realization rates for units with two speed or variable speed fans. Categories with low savings /realization rates had two key factors, equipment and workpapers. The equipment factor caused low realization rates when units just met prior code minimum efficiency requirements and/or had a single-speed fan when two-speed was minimum. The performance maps in the current DEER (updated 2015) represent the equipment installed in 2013 and 2014 better than the performance maps in DEER 2011 which best represent units from 2011-12.

Table 23. Ex ante and ex post kWh savings and gross realization rates for small unitary systems

Unit Size	Claimed Efficiency Level	Working Economizer	Ex Ante UES (kWh/ton)	Ex Post UES (kWh/ton)	Total Tonnage Adjusted	Ex Ante Total (kWh)	Ex Post Total (kWh)	Efficiency Adjustment Realization Rate (kWh)
< 3.5 Ton	Tier0, To Code	NA	364.6	364.6	29	10,533	10,533	100.0%
< 3.5 Ton	Tier2, 16 SEER />13EER, 2spd	NA	28.6	50.3	107	3,060	5,383	175.9%
< 3.5 Ton	Tier3, 17 SEER />13EER, 2spd	NA	74.4	64.5	130	9,644	8,366	86.7%
< 3.5 Ton	Tier4, 18 SEER />13EER, 2spd	NA	115.0	73.6	886	101,861	65,150	64.0%
3.5 - 4.5 Ton	Tier0, To Code	NA	404.0	404.0	1,348	544,513	544,513	100.0%
3.5 - 4.5 Ton	Tier1, 15 SEER /<13 EER, 2spd	NA	147.4	105.9	1,832	269,958	193,929	71.8%
3.5 - 4.5 Ton	Tier2, 16 SEER />13EER, 2spd	NA	264.9	72.8	2,442	647,052	177,809	27.5%
3.5 - 4.5 Ton	Tier3, 17 SEER />13EER, 2spd	NA	354.3	87.0	3,414	1,209,700	297,143	24.6%
3.5 - 4.5 Ton	Tier4, 18 SEER />13EER, 2spd	NA	379.7	96.0	238	90,467	22,881	25.3%
3.5 - 4.5 Ton	Tier0, To Code	NA	549.8	549.8	2,408	1,323,852	1,323,852	100.0%
4.5 - 5.5 Ton	Tier1, 15 SEER /<13 EER, 2spd	Yes	67.3	106.5	777	52,269	82,736	158.3%
4.5 - 5.5 Ton	Tier2, 16 SEER />13EER, 2spd	Yes	104.0	132.0	4,481	465,824	591,618	127.0%
4.5 - 5.5 Ton	Tier3, 17 SEER />13EER, 2spd	Yes	143.7	141.6	1,702	244,610	241,088	98.6%
4.5 - 5.5 Ton	Tier4, 18 SEER />13EER, 2spd	Yes	200.6	147.7	53	10,581	7,791	73.6%
4.5 - 5.5 Ton	Tier0, To Code	No	549.8	549.8	2,408	1,323,852	1,323,852	100.0%
4.5 - 5.5 Ton	Tier1, 15 SEER /<13 EER, 2spd	No	67.3	124.0	777	52,269	96,321	184.3%
4.5 - 5.5 Ton	Tier2, 16 SEER />13EER, 2spd	No	104.0	179.1	4,481	465,824	802,324	172.2%
4.5 - 5.5 Ton	Tier3, 17 SEER />13EER, 2spd	No	143.7	193.3	1,702	244,610	329,022	134.5%
4.5 - 5.5 Ton	Tier4, 18 SEER />13EER, 2spd	No	200.6	202.3	53	10,581	10,670	100.8%
5.5 - 11.5 Ton	Tier0, To Code	Yes	428.6	428.6	1,779	762,716	762,716	100.0%
5.5 - 11.5 Ton	Tier1, 11.5 EER	Yes	74.0	29.2	4,412	326,670	128,789	39.4%
5.5 - 11.5 Ton	Tier2, 12.0 EER	Yes	66.8	56.4	10,668	712,914	601,945	84.4%
5.5 - 11.5 Ton	Tier3, 12.5 EER	Yes	87.9	80.8	2,858	251,184	231,054	92.0%
5.5 - 11.5 Ton	Tier4, 13.0 EER	Yes	97.4	103.5	1,181	114,937	122,232	106.3%
5.5 - 11.5 Ton	Tier0, To Code	No	428.6	428.6	1,779	762,716	762,716	100.0%
5.5 - 11.5 Ton	Tier1, 11.5 EER	No	74.0	39.3	4,412	326,670	173,442	53.1%
5.5 - 11.5 Ton	Tier2, 12.0 EER	No	66.8	76.0	10,668	712,914	810,699	113.7%
5.5 - 11.5 Ton	Tier3, 12.5 EER	No	87.9	108.9	2,858	251,184	311,181	123.9%
5.5 - 11.5 Ton	Tier4, 13.0 EER	No	97.4	139.5	1,181	114,937	164,630	143.2%
11.6 - 20 Ton	Tier0, To Code	Yes	385.4	385.4	921	354,819	354,819	100.0%
11.6 - 20 Ton	Tier1, 11.5 EER	Yes	49.2	43.4	857	42,211	37,240	88.2%
11.6 - 20 Ton	Tier2, 12.0 EER	Yes	103.2	71.0	4,563	470,932	324,163	68.8%
11.6 - 20 Ton	Tier3, 12.5 EER	Yes	87.0	97.0	4,701	408,821	455,982	111.5%
11.6 - 20 Ton	Tier4, 13.0 EER	Yes	236.0	121.1	1,188	280,396	143,904	51.3%
11.6 - 20 Ton	Tier0, To Code	No	385.4	385.4	921	354,819	354,819	100.0%
11.6 - 20 Ton	Tier1, 11.5 EER	No	49.2	58.6	857	42,211	50,197	118.9%
11.6 - 20 Ton	Tier2, 12.0 EER	No	103.2	95.7	4,563	470,932	436,938	92.8%
11.6 - 20 Ton	Tier3, 12.5 EER	No	87.0	130.8	4,701	408,821	614,658	150.3%
11.6 - 20 Ton	Tier4, 13.0 EER	No	236.0	163.3	1,188	280,396	193,983	69.2%

Table 24. shows the results of peak demand reduction saving for all small unitary size bins and efficiency levels up to 20 ton. The realization rate across all small unit categories is 67.6%. The efficiency realization rates vary by size bin and across efficiency levels from 7% to 112%. A primary driver of the energy and demand realization rates were findings that a mix of efficiencies were found within each claimed efficiency tier. There was no strong trend of realization rate by tier across size ranges.

Table 24. Ex ante and ex post kW savings and gross realization rates for small unitary systems

Unit Size	Claimed Efficiency Level	Working Economizer	Total Tonnage Adjusted	Ex Ante UES (kW/ton)	Ex Post UES (kW/ton)	Ex Ante Total (kW)	Ex Post Total (kW)	Efficiency Adjustment Realization Rate (kW)
< 3.5 Ton	Tier0, To Code	NA	29	0.29	0.02	8	1	7.4%
< 3.5 Ton	Tier2, 16 SEER/>13EER, 2spd	NA	107	0.02	0.01	2	1	57.9%
< 3.5 Ton	Tier3, 17 SEER/>13EER, 2spd	NA	130	0.06	0.02	7	2	34.0%
< 3.5 Ton	Tier4, 18 SEER/>13EER, 2spd	NA	886	0.09	0.02	78	21	27.1%
3.5 - 4.5 Ton	Tier0, To Code	NA	1,348	0.31	0.31	414	414	100.0%
3.5 - 4.5 Ton	Tier1, 15 SEER /<13 EER, 2spd	NA	1,832	0.06	0.03	107	55	52.1%
3.5 - 4.5 Ton	Tier2, 16 SEER/>13EER, 2spd	NA	2,442	0.07	0.02	177	50	28.2%
3.5 - 4.5 Ton	Tier3, 17 SEER/>13EER, 2spd	NA	3,414	0.14	0.03	487	95	19.5%
3.5 - 4.5 Ton	Tier4, 18 SEER/>13EER, 2spd	NA	238	0.38	0.03	90	8	8.6%
3.5 - 4.5 Ton	Tier0, To Code	NA	2,408	0.23	0.23	542	542	100.0%
4.5 - 5.5 Ton	Tier1, 15 SEER /<13 EER, 2spd	Yes	777	0.03	0.04	27	29	107.0%
4.5 - 5.5 Ton	Tier2, 16 SEER/>13EER, 2spd	Yes	4,481	0.07	0.07	321	331	103.1%
4.5 - 5.5 Ton	Tier3, 17 SEER/>13EER, 2spd	Yes	1,702	0.11	0.08	188	137	73.1%
4.5 - 5.5 Ton	Tier4, 18 SEER/>13EER, 2spd	Yes	53	0.15	0.09	8	4	55.7%
4.5 - 5.5 Ton	Tier0, To Code	No	2,408	0.23	0.23	542	542	100.0%
4.5 - 5.5 Ton	Tier1, 15 SEER /<13 EER, 2spd	No	777	0.03	0.04	27	30	111.6%
4.5 - 5.5 Ton	Tier2, 16 SEER/>13EER, 2spd	No	4,481	0.07	0.08	321	355	110.5%
4.5 - 5.5 Ton	Tier3, 17 SEER/>13EER, 2spd	No	1,702	0.11	0.09	188	147	78.3%
4.5 - 5.5 Ton	Tier4, 18 SEER/>13EER, 2spd	No	53	0.15	0.09	8	5	59.7%
5.5 - 11.5 Ton	Tier0, To Code	Yes	1,779	0.11	0.11	200	200	100.0%
5.5 - 11.5 Ton	Tier1, 11.5 EER	Yes	4,412	0.06	0.02	274	96	35.1%
5.5 - 11.5 Ton	Tier2, 12.0 EER	Yes	10,668	0.06	0.04	670	449	67.0%
5.5 - 11.5 Ton	Tier3, 12.5 EER	Yes	2,858	0.08	0.06	237	173	72.8%
5.5 - 11.5 Ton	Tier4, 13.0 EER	Yes	1,181	0.11	0.08	126	91	72.5%
5.5 - 11.5 Ton	Tier0, To Code	No	1,779	0.11	0.11	200	200	100.0%
5.5 - 11.5 Ton	Tier1, 11.5 EER	No	4,412	0.06	0.02	274	99	36.0%
5.5 - 11.5 Ton	Tier2, 12.0 EER	No	10,668	0.06	0.04	670	461	68.8%
5.5 - 11.5 Ton	Tier3, 12.5 EER	No	2,858	0.08	0.06	237	177	74.7%
5.5 - 11.5 Ton	Tier4, 13.0 EER	No	1,181	0.11	0.08	126	94	74.3%
11.6 - 20 Ton	Tier0, To Code	Yes	921	0.17	0.17	160	160	100.0%
11.6 - 20 Ton	Tier1, 11.5 EER	Yes	857	0.04	0.03	34	27	79.4%
11.6 - 20 Ton	Tier2, 12.0 EER	Yes	4,563	0.10	0.05	458	236	51.5%
11.6 - 20 Ton	Tier3, 12.5 EER	Yes	4,701	0.09	0.07	433	332	76.6%
11.6 - 20 Ton	Tier4, 13.0 EER	Yes	1,188	0.24	0.09	284	105	36.9%
11.6 - 20 Ton	Tier0, To Code	No	921	0.17	0.17	160	160	100.0%
11.6 - 20 Ton	Tier1, 11.5 EER	No	857	0.04	0.03	34	28	81.7%
11.6 - 20 Ton	Tier2, 12.0 EER	No	4,563	0.10	0.05	458	243	53.1%
11.6 - 20 Ton	Tier3, 12.5 EER	No	4,701	0.09	0.07	433	342	78.9%
11.6 - 20 Ton	Tier4, 13.0 EER	No	1,188	0.24	0.09	284	108	38.0%

5.5 Net-to-gross

This section summarizes the full net-to-gross (NTG) report, available as a separate document.¹⁵

Our primary goal for this research was to produce a reliable estimate of the net energy and demand savings achieved by incentivized upstream HVAC measures during the 2013-2015 program cycle. To estimate net savings, we developed an NTG ratio that we applied to the gross savings estimates previously calculated by DNV GL. We derived the NTG ratio by estimating the influence various program activities had on distributor behavior, and how downstream buyers may have been influenced by this program as well. By quantifying this influence, we were able to estimate what percent of the gross savings was attributable to this upstream program and what portion was free-ridership.

¹⁵ Net-to-gross Evaluation of 2013-14 Upstream HVAC Programs (HVAC1), DNV GL, 2017, California Public Utilities Commission, San Francisco CA

5.5.1 NTG Evaluation

To establish program attribution, we considered the pathways distributors take when selling a high efficiency HVAC unit and the related pathways buyers take when purchasing one. Our goal was to develop an approach that considered these pathways in the context of the HVAC1 program design and real-world complexity. We created the term “causal pathway” to identify how the program may cause behavior change along these paths. 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 both the HVAC equipment distributor and buyer. We derived these assumptions from the program logic model provided from the IOUs. 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. Table 25 shows the researchable questions which represent the three causal pathways across distributors and buyers.

Table 25. Question themes across three causal pathways for distributors and buyers

Causal Pathways	Distributor Questions	Buyer Questions
Stock	1. What was the program influence on distributor stock?	1. How did the mix of equipment in stock influence the buyer?
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 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?

DNV GL used trained internal staff to complete the distributor in-depth interviews, and Pacific Market Research (PMR) to conduct buyer surveys. We completed 19 interviews with participating distributors, and PMR completed 99 surveys with buyers. The full report below provides further detail on the sample design and response rates for these interviews and surveys.

After we received the original buyer data sets from the utilities, we discovered that 48% of total program kWh savings did not have distributor information listed. Therefore, we limited our buyer sample frame to those who had distributor contact information, and purchased equipment from distributors who responded to our distributor interview.

Only eight of the 19 completed distributor interviews had completed buyer surveys for the causal pathway analysis. All eight matched distributors were from the largest strata, representing 41% of program kWh savings, or 79% of the program kWh savings from the eligible buyer sample frame. All buyer survey responses for the equipment purchases were used with these eight distributors.

After the distributor and buyer surveys were completed, we calculated the individual buyer and distributor attribution scores, mapped them together, and expanded the scores to the whole population.

5.5.2 NTG findings

Our data collection and NTG expansion analysis resulted in an overall attribution NTGR ratio (NTGR) score of 64% ($\pm 6\%$ at the 90% Confidence Interval) for the upstream program. Again, this NTGR started with

individual buyers and their related distributors, and expanded these connected NTG scores to the whole population.

We used an overall NTGR instead of the measure category NTGR for two reasons. First, our sample for VRFs was so small that the NTGR could not be considered statistically significant for that measure. Second, the scores for each measure strata were not statistically different from the overall value.

Table 26 summarizes how each survey group responded to the individual questions contributing to each causal path. Note that these attribution scores cannot be multiplied together to calculate the overall NTGR since these scores group distributors and buyers separately. The overall NTGR is based on first matching the attribution scores of distributors with those of their equipment purchasers and then expanding these, which is different from what is displayed below. We present Table 26 broken out by each causal pathway to provide additional information on the results along each pathway, and to add context to our recommendations.

Table 26. Grouped attribution scores for each causal pathway

Causal Pathway	Distributor attribution	Buyer attribution
Stocking	35%	21%
Upsell	26%	81%
Price	54%	98%
Efficiency		4%
Sales	41%	

The evaluation results indicated that 35% of distributors' high efficiency stock was due to the program, and 21% of buyers were impacted by a distributor's stock during their purchase. The results also suggest that 26% of distributor upselling of high efficiency equipment was as influenced by the program, and buyers indicated that 81% of their purchases were influenced by distributor recommendation. Finally, the distributors reported that the program influenced them to pass-through 54% of the upstream incentives, and buyers indicated price was the largest influencer of their behavior when they made this purchase.

For the consistency checks, Table 26 shows that distributors indicated that over 40% of their sales of program-qualifying high efficiency equipment could be attributable to the program. It also shows that buyers were not considering lower efficiency options than what they purchased, as indicated by the 4% attribution score. While the low-efficiency attribution may be due to buyers already intending to buy high efficiency units, it also may indicate that many distributors are upselling and only presenting one option to buyers. One piece of evidence for this is that less than 30% of buyers indicated that distributors discussed more than one HVAC option with them. Since all the buyers surveyed bought the energy-efficient model, we can assume the majority of buyers were shown only one energy-efficient option. Our buyer survey results indicated that they take the recommendations of distributors seriously (80% attribution). Therefore, if a given distributor started off by recommending only one high efficiency model, it is possible that a buyer who might have otherwise considered a wider range of unit efficiencies instead deferred to their distributor's recommendation for the more efficient model.

Our distributor interviews revealed that only 26% of distributors indicated that their upselling practices were due to the program. This low attribution score could relate to the evidence described above regarding distributors only discussing one option with buyers. This attribution score could also be due to many distributors overvaluing their salesmanship abilities and consequently undervaluing program influence. This

is akin to the “green retailer bias” –which has been recognized as a potential bias in past evaluations of California upstream lighting programs.¹⁶

After we reviewed the causal pathway findings and checked for consistency, DNV GL applied the final NTGR to the *ex post* gross energy and demand savings to arrive at *ex post* net program energy and demand savings.

5.5.3 Application to 2015 Evaluation

The NTGRs and gross realization rates are applied to the *ex ante* savings in Table 27 and Table 28. We used the overall NTGR for all the program measures because there were no statistically-significant differences between the measure-level scores and the overall score as noted above.

Table 27. Program kWh savings with gross realization rate and NTGR applied

Measure Group	Unit Size	Claimed Gross Savings (kWh)	Gross Realization Rate	Final Evaluated Gross Savings (kWh)	Net to Gross Ratio (NTGR)	Final Net Savings (kWh)	Net Realization Rate
Large Unitary Systems	All	6,073,717	100.0%	6,073,717	64%	3,887,179	64%
Small Unitary Systems	All	10,148,944	78.9%	8,011,589	64%	5,127,417	51%
	All	16,222,661	86.8%	14,085,306	64%	9,014,596	55.6%

Table 28. Program kW savings with gross realization rate and NTGR applied

Measure Group	Unit Size	Claimed Gross Savings (kW)	Gross Realization Rate	Final Evaluated Gross Savings (kW)	Net to Gross Ratio (NTGR)	Final Net Savings (kW)	Net Realization Rate
Large Unitary Systems	All	3,586	100.0%	3,586	64%	2,295	64%
Small Unitary Systems	All	5,820	67.6%	3,932	64%	2,517	43%
	All	9,406	79.9%	7,518	64%	4,812	51%

¹⁶ See “Documentation for DEER Net to Gross Update,” Prepared by DEER Consultant Team for the CPUC Energy Division, May 2, 2008. In that report the green retailer bias referred to the tendency of some retailers who participate in upstream lighting programs to overrate their ability to promote environmentally-friendly lighting products and thereby underrate the contribution of program discounts to their sales of energy-efficient lighting products. While that bias was occurring at the retail rather than the wholesale level, it is plausible that a similar bias might be present among some HVAC distributors.

6 CONCLUSIONS AND RECOMMENDATIONS

Section 5 of this report provides a detailed discussion of study findings. Of these findings, the evaluation team have determined the following to be particularly noteworthy. We recognize that some of the 2013-14 recommendations have been implemented in the 2016 programs. Most notably, after the last report the IOUs provided make and model of the full population to the DEER Ex Ante team making that recommendation completed. In addition, based on further data analysis, we now believe that there are very few sites where the effects can be seen at the meter. Whole building analysis may not be appropriate for Upstream as measures are rarely installed at the same site at a given site with multiple measures over a program cycle.

Finding #1: Program savings improved for units evaluated in 2015.

This impact evaluation of the 2015 Upstream HVAC programs revealed lower than expected savings for the smallest size units (under 4.5 ton) and good realization rates for units 5.5–20 ton. The primary driver of the realization rates was that, on average, the full-load efficiencies of the installed equipment were lower than claimed estimates assumed efficiency levels in some cases. While not evaluated in 2015, we did notice the measures with lower 2013-14 realization rates also had decreased unit energy savings claims in 2015. The evaluation team believes minimum primary reason for the improvements was the code update and updated version of DEER for 2015 while 2014 had to utilize different baselines within the calendar year.

We commend the IOUs and DEER team for the updates made to the latest versions of DEER based on performance data provided by the Upstream programs and PG&E in particular. The 2015 claims already showed some key improvements and the expectation is that going forward the measure efficiency should not be a major source of uncertainty.


Finding #2: Inputs for DEER estimates continue to improve.

The field-testing of 5.5-20 ton units showed that fan performance and part-load performance curves were similar to current DEER assumptions in most cases and only one size class had a measured average fan power index that was different than DEER. The characterization of fan performance and part-load performance data for smaller systems, under 5.5 ton, can still benefit from additional data collection, as the sample size for this evaluation was insufficient since there are now multiple size categories below 5.5 ton. As a result of this finding, we recommend the following:

For workpaper developers and evaluators: Review new data collected by this study, especially for 5.5–11.5 ton units where a change was made to the workpaper fan power index assumption. Collect additional data on fan performance, W/CFM, to characterize the program population.

Finding #3: Potential savings from non-code required economizers are not being claimed.

The smallest unitary systems, less than 4.5 tons, are not required by Title 24 to have economizers. However, many of the units incentivized by the program in this size category were found to be equipped with economizers. Although the evaluation team has not yet established any influence, is probable that the program has influenced the economizer inclusion for a portion of units in this size category. Seeing this situation as a potential savings opportunity, we recommend the following:



For program managers and designers: Create a measure to capture economizers added to units that do not require them (less than 4.5 ton). For this study it was unknown to what degree economizer additions were influenced by the program. If the program is determined to have a strong influence, there would be substantial savings to be claimed.

Finding #4: Some Upstream unitary HVAC systems have non-functional economizers.

The evaluation team found that a considerable savings potential is not being realized because many of the economizers for unitary systems being installed through the program are not functioning properly. Our testing occurred within two years of installation, but just over one-quarter of the economizers were found to not be working. Some tests uncovered errors such as improperly wired sensors that indicate that the economizer was not installed correctly and has never functioned as designed. In order to realize this savings opportunity, we recommend the following:

For program managers and designers: Although this recommendation does not fit within the Upstream Program, the non-functioning economizers found by this evaluation represent an excellent savings opportunity. We recommend a separate initiative to assure proper economizer function through contractor training and incentives. The program would obtain video/photographic evidence or some other proof that the economizer is fully functional before dispersing an incentive payment. This would be separate from the Upstream program and proposed post-installation and not as a code compliance activity.


Relevant findings and recommendations from the NTG report include the following.

Finding #5: We found that the program did not have a major effect on distributors' behavior, leading only 35 percent of distributors to change their patterns for stocking equipment. During their interviews, several distributors mentioned a lack of clarity on incentive timing which impeded their ability to stock and sell the units. Another distributor commented that if he can count on an incentive's availability he will stock the high-efficiency equipment. As a result, we recommend the following:

For program managers and designers: Reducing uncertainty regarding how long the incentives will remain in place at a given level would likely increase the trust which distributors have in the program, and, in turn, increase their willingness to change their stocking practices. Program practices which would increase participant certainty about how long the incentives will remain in place would include informing the distributors when the program is going to run out of money ahead of time, and honoring incentives for HVAC purchases that are already registered in the system.

Finding #6: Marketing tools for distributors could be improved.

During our interviews, multiple distributors asked for additional sales tools and marketing materials to help them sell high efficiency units. We believe that distributors would make good use of CPUC- and IOU-hosted training and online savings calculators. This may seem counterintuitive based on some of the evidence we provided which indicated that much upselling is already occurring, with or without the program's influence. This evidence includes the fact that only 26% of distributors said that their upselling was attributable to the program, that less than 30% of buyers stated that the distributors discussed more than one efficiency option (this suggests that the upselling was already happening for the majority of buyers presented with only one option) and that only 4% of buyers were considering other efficiency types.



However, the fact that many distributors are still seeking additional marketing assistance indicates that some need exists. We believe it is important to point out that the buyer surveys only reflected the perspective of customers who bought energy-efficient units, whether due to previous disposition or due to distributor salesmanship (whether program-influenced or not). The comments from distributors may not be focused on those buyers, but rather on the customers who did not choose the energy-efficient units. It is likely for these “lost sales” that the distributors are seeking additional program marketing tools. As a result, we have the following recommendation:

For program managers and designers: Provide distributor program training and online savings estimators that are focused on helping convert lost sales of high-efficiency equipment.

Finding #7: Many distributors sought better communications on program changes in general, in addition to their more specific demands for better information about incentive availability.

Because the sales cycle for some high efficiency units can be several months, distributors want to keep their staff and buyers informed of any changes to the incentives. To prevent sales lost to program changes, we have the following recommendation:


For program managers and designers: Communicate program changes more clearly to distributors with as much advance warning as possible. Since pass-through incentives had the highest attribution score for both distributors and buyers, clear communication on program changes can help distributors make better decisions on the incentives they pass on to buyers.

Finding #8: During their interviews distributors provided suggestions on how the upstream HVAC program could be improved. Some of their suggestions, in addition to those mentioned above, included involving small municipalities in this program, offering different incentives and technologies based on climate zones, and including new technologies in the program. Since distributors are positioned to understand their markets and sales cycles, we have the following recommendation:

For the HVAC Project Coordination Group: We recommend that the IOUs and CPUC set up a mechanism (if one does not exist) to solicit regular input from distributors on potential improvements to the program.

Finding #9: Nearly 50% of the buyer program tracking data we received was missing distributor names and buyer contact information. As a result, we could not match several completed distributor interviews to buyers, resulting in their omission from our NTG analysis. However, we believe that the data from these unmatched distributor interviews should be used for future analysis. As a result of these data quality issues, we recommend the following:

For program managers and designers: The programs should strive to collect higher quality buyer tracking data, with special emphasis on collecting information relating buyers to the distributors that sold them their units. This will help increase the number of buyers matched to distributors that evaluators can use for our NTG causal pathway analysis in future studies. For example, the program



application form should have the contact information for the distributor, contractor, and buyer, as well as indicate who was present at the time of purchase.

For IOU EM&V staff: We further recommend that a process evaluation be conducted for this HVAC upstream program to further analyze the distributor interview responses (from both “matched” and “unmatched”) distributors. Our evaluation, by necessity, focused on distributor responses most relevant to program attribution, but other interview responses could also be useful for identifying interesting market trends and for providing insights on how to improve upstream HVAC program design.





Appendix A. DETAILED SIMULATION RESULTS BY BUILDING TYPE AND CLIMATE ZONE

See following pages

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	1SPD	Tier1P, 15 SEER/12 EER, 1spd	No,No	Small DX


Average Ex-post Savings kWh/ton																		
		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	
Building Type		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Average
AGOTH																		
Assembly	Asm							97	103	103	107					133		109
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	77	83	76	82	74	76	77	81	83	86	99	91	98	99		89	85
Education - Primary School	EPr						51	48	53	55	57			68	66			57
Education - Secondary School	ESe						53			59								56
Education - University	EUn			84	91		88		90	92	95		97	103				92
Grocery	Gro																	
Health/Medical - Hospital	Hsp									154	158							156
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			63										76				69
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						156		158	159	161			165	167		153	160
Office - Large	OFL	57	64	58	65	58						73	69	74			65	65
Office - Small	OFS		59	55	59		56	54	58	61	64	67	62	69		86		63
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		125	119	126			122		127		136	130	139				128
Restaurant - Sit Down	RSD						94		96	96	102			106	111			101
Retail - 3 story	RI3	83	93	86	94	86			96	96		105	97	106				94
Retail - Large 1 story	RI1						104	104	107	106	111				120	138		113
Retail - Small	RS						101	99	104	104	109							103
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															113		113
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							0.02	0.03	0.03	0.03					0.04		0.03
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.03	0.02	0.03	0.02	0.03	0.02	0.03		0.02	0.02
Education - Primary School	EPr						0.00	0.02	0.02	0.01	0.01			0.02	0.02			0.02
Education - Secondary School	ESe						0.00			0.01								0.01
Education - University	EUn			0.01	0.02		0.02		0.03	0.02	0.03		0.03	0.02				0.02
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.03	0.03							0.03
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.01										0.01				0.01
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.02		0.02	0.02	0.03			0.03	0.03		0.02	0.02
Office - Large	OfL	0.02	0.02	0.01	0.02	0.02					0.02	0.03	0.03	0.03			0.02	0.02
Office - Small	OfS		0.02	0.01	0.01		0.02	0.02	0.02	0.03	0.04	0.02	0.03	0.03		0.04		0.02
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.02	0.02	0.02			0.02		0.02		0.03	0.03	0.03				0.02
Restaurant - Sit Down	RSD						0.02		0.03	0.03	0.03			0.03	0.04			0.03
Retail - 3 story	Rt3	0.02	0.02	0.02	0.03	0.02			0.03	0.03		0.03	0.03	0.04				0.03
Retail - Large 1 story	RtL						0.02	0.02	0.03	0.03	0.03				0.04	0.04		0.03
Retail - Small	RtS						0.03	0.03	0.03	0.03	0.04							0.03
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															0.04		0.04
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	1SPD	Tier1, 15 SEER /<13 EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm							(21)	(37)	(13)	(48)					(63)		(36)
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	51	(1)	18	(3)	15	(19)	(33)	(38)	(4)	(34)	(26)	(14)	(38)	(30)		33	(8)
Education - Primary School	EPr						(4)	(4)	(0)	7	(5)			(1)	4			(0)
Education - Secondary School	ESe						9			13								11
Education - University	EUh			53	31		11		3	26	(1)		20	(4)				17
Grocery	Gro																	
Health/Medical - Hospital	Hsp									72	69							71
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			39										(33)				3
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						102		78	89	57			32	31		123	73
Office - Large	OfL	10	(7)	(9)	(13)	(13)						(16)	(17)	(26)			10	(9)
Office - Small	OfS		3	4	(2)		(17)	(27)	(19)	(8)	(18)	(8)	(5)	(16)		(46)		(13)
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		36	63	25			19		30		(14)	13	(31)				18
Restaurant - Sit Down	RSD						2		(8)	13	(13)			(37)	(25)			(11)
Retail - 3 story	RtS	74	(11)	21	(20)	21			(62)	(27)		(52)	(32)	(69)				(16)
Retail - Large 1 story	RtL						2	(8)	(12)	10	(26)				(28)	(94)		(22)
Retail - Small	RtS						(60)	(78)	(73)	(51)	(88)							(70)
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															(86)		(86)
Single Family Residential																		


Average Ex-post savings kW/ton																		
bldgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							(0.06)	(0.02)	(0.01)	(0.02)					(0.03)		(0.03)
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.00	(0.03)	0.00	(0.01)	(0.04)	(0.02)	(0.05)	(0.04)	(0.02)	(0.08)	(0.03)	(0.08)	0.01	(0.08)		(0.03)	(0.03)
Education - Primary School	EPr						0.00	(0.04)	(0.03)	0.00	(0.00)			0.00	0.00			(0.01)
Education - Secondary School	ESe						0.00			0.00								0.00
Education - University	EUn			0.00	(0.01)		(0.02)		(0.03)	(0.02)	(0.07)		(0.07)	0.00				(0.03)
Grocery	Gro																	
Health/Medical - Hospital	Hsp									(0.04)	(0.07)							(0.05)
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			(0.00)										(0.03)				(0.01)
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						(0.01)		(0.03)	(0.03)	(0.07)			(0.08)	(0.09)		(0.03)	(0.05)
Office - Large	OfL	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)						(0.03)	(0.04)	(0.04)			(0.03)	(0.02)
Office - Small	OfS		(0.02)	(0.00)	(0.01)		(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)		(0.04)		(0.02)
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		(0.02)	(0.00)	(0.05)			(0.04)		(0.03)		(0.08)	(0.07)	(0.08)				(0.05)
Restaurant - Sit Down	RSD					(0.02)		(0.01)	0.02	0.01				(0.06)	(0.03)			(0.01)
Retail - 3 story	Rt3	0.02	(0.04)	(0.02)	(0.05)	(0.05)			(0.02)	(0.01)		(0.07)	(0.08)	(0.09)				(0.04)
Retail - Large 1 story	RtL						(0.03)	(0.04)	(0.02)	(0.02)	(0.03)				(0.09)	(0.08)		(0.05)
Retail - Small	RtS						(0.05)	(0.04)	(0.05)	(0.04)	(0.07)							(0.05)
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															(0.11)		(0.11)
Single Family Residential																		



Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	1SPD	Tier2, 16 SEER/>13EER, 2spd	No,No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							(7)	17	31	28					88		31
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	39	38	34	39	34	25	12	23	45	40	55	44	47	60		49	39
Education - Primary School	EPr						20	17	28	35	35			44	52			33
Education - Secondary School	ESe						28			38								33
Education - University	EUn			90	92		72		77	88	87		97	102				88
Grocery	Gro																	
Health/Medical - Hospital	Hsp									151	168							160
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			43										43				43
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						89		87	96	90			98	117		102	97
Office - Large	OL	39	48	39	48	38						63	52	59			49	48
Office - Small	OS		48	39	49		41	34	46	54	58	63	54	60		94		53
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		71	66	70			57		76		93	79	87				75
Restaurant - Sit Down	RSD						34		41	56	57			64	77			55
Retail - 3 story	Rt3	50	44	45	46	48			24	49		63	53	53				47
Retail - Large 1 story	RtL						57	47	61	74	73			94	116			74
Retail - Small	RtS						6	(11)	9	26	20							10
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															49		49
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							(0.02)	0.00	0.02	0.02					0.03		0.01
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.01	0.00	0.01	0.00	(0.01)	(0.00)	(0.02)	(0.01)	0.01	0.01	0.01	0.01	0.02	0.01		0.02	0.00
Education - Primary School	EPr						0.00	(0.00)	0.01	0.01	0.01			0.02	0.02			0.01
Education - Secondary School	ESe						0.00			0.01								0.01
Education - University	EUn			0.01	0.01		0.00		(0.00)	0.02	0.02		0.02	0.02				0.01
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.03	0.03							0.03
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.01										0.00				0.00
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.00		0.01	0.01	0.00			0.01	0.02		0.03	0.01
Office - Large	OfL	0.01	0.01	0.01	0.01	0.00						0.02	0.03	0.03			0.02	0.02
Office - Small	OfS		0.02	0.01	0.02		0.01	0.01	0.02	0.03	0.04	0.03	0.04	0.04		0.05		0.03
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.01	0.01	0.01			(0.00)		0.02		0.02	0.02	0.03				0.01
Restaurant - Sit Down	RSD						(0.00)		0.01	0.03	0.03			0.03	0.03			0.02
Retail - 3 story	Rt3	0.01	0.00	0.00	(0.00)	(0.01)			(0.01)	0.01		0.00	0.01	(0.00)				0.00
Retail - Large 1 story	RtL						0.00	(0.00)	0.00	0.02	0.02				0.02	0.02		0.01
Retail - Small	RtS						(0.02)	(0.02)	(0.01)	(0.00)	(0.00)							(0.01)
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															0.00		0.00
Single Family Residential																		



Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	1SPD	Tier3, 17 SEER/>13EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm							5	33	46	46					121		50
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	43	49	43	52	43	39	28	40	58	56	72	58	64	78		59	52
Education - Primary School	EPr						29	26	37	44	44			54	62			42
Education - Secondary School	ESe						35			47								41
Education - University	EUn			103	108		91		97	105	107		115	123				106
Grocery	Gro																	
Health/Medical - Hospital	Hsp									180	197							188
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			48										59				54
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						99		101	108	104			114	134		109	110
Office - Large	OfL	48	61	52	63	52						80	68	77			61	63
Office - Small	OfS		60	50	62		56	50	62	69	74	79	68	77		120		69
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		83	75	85			73		92		113	94	108				90
Restaurant - Sit Down	RSD						49		59	73	77			83	100			74
Retail - 3 story	Rt3	53	59	55	62	59			49	70		83	70	75				64
Retail - Large 1 story	RtL						74	66	82	92	94				113	152		96
Retail - Small	RtS						23	10	29	44	41							29
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															69		69
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							(0.01)	0.01	0.03	0.03					0.04		0.02
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.01	0.01	0.01	0.00	0.00	0.00	(0.01)	0.00	0.02	0.02	0.01	0.02	0.02	0.03		0.02	0.01
Education - Primary School	EPr						0.00	0.01	0.02	0.01	0.01			0.02	0.03			0.02
Education - Secondary School	ESe						0.00			0.01								0.01
Education - University	EUn			0.01	0.02		0.01		0.01	0.03	0.03		0.03	0.02				0.02
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.04	0.04							0.04
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.01										0.00				0.01
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.01		0.01	0.02	0.01			0.02	0.04		0.03	0.02
Office - Large	OL	0.01	0.02	0.01	0.02	0.01						0.03	0.04	0.04			0.03	0.02
Office - Small	OS		0.02	0.01	0.02		0.02	0.02	0.03	0.04	0.05	0.04	0.05	0.05		0.06		0.03
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.01	0.01	0.01			0.01		0.03		0.03	0.03	0.04				0.02
Restaurant - Sit Down	RSD						0.00		0.02	0.04	0.04			0.04	0.05			0.03
Retail - 3 story	RS	0.01	0.01	0.01	0.01	(0.00)			0.01	0.02		0.01	0.02	0.01				0.01
Retail - Large 1 story	RL						0.01	0.01	0.02	0.03	0.03				0.04	0.03		0.02
Retail - Small	RS						(0.01)	(0.01)	(0.00)	0.01	0.01							(0.00)
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															0.02		0.02
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	1SPD	Tier4, 18 SEER/>13EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average	
Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
AGOTH																		
Assembly	Asm						13	44	55	57					142		62	
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	45	57	49	59	49	48	38	51	67	66	83	67	75	89	65	61	
Education - Primary School	EPr						35	31	43	49	50		61	69			48	
Education - Secondary School	ESe						40		52								46	
Education - University	EUn			112	119		103		110	116	119		126	137			118	
Grocery	Gro																	
Health/Medical - Hospital	Hsp								198	215							207	
Lodging - Hotel	Hl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			51									69				60	
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs					106		109	116	113			124	144		114	118	
Office - Large	OIL	54	70	60	72	60					91	79	88			69	72	
Office - Small	OIS		67	56	70		65	60	72	78	84	89	76	88		137	79	
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		91	80	94			83		103		126	104	122			100	
Restaurant - Sit Down	RSD								70	83	90		96	115			85	
Retail - 3 story	Rt3	54	69	62	73	66		65	83		97	80	90				74	
Retail - Large 1 story	RtL						85	77	95	104	107			125	175		110	
Retail - Small	RtS						35	23	42	55	54						42	
S_AGR																		
S_FST																		
Storage - Conditioned	SCn														81		81	
Single Family Residential																		

Average Ex-post savings kW/ton																		
	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16		
bldgtype	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Average	
AGOTH																		
Assembly	Asm						(0.00)	0.02	0.04	0.04					0.05		0.03	
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.01	0.01	0.01	0.01	0.00	0.01	(0.00)	0.01	0.02	0.03	0.02	0.02	0.02	0.03		0.03	0.02
Education - Primary School	EPr						0.00	0.01	0.03	0.01	0.02			0.03	0.03			0.02
Education - Secondary School	ESe						0.00			0.01								0.01
Education - University	EUn			0.01	0.02		0.01		0.02	0.03	0.04		0.04	0.03				0.02
Grocery	Gro																	
Health/Medical - Hospital	Hsp								0.04	0.05								0.05
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.01										0.01				0.01
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs					0.01		0.02	0.02	0.02			0.03	0.04			0.04	0.03
Office - Large	OIL	0.02	0.02	0.02	0.02	0.02						0.04	0.05	0.04		0.04	0.04	0.03
Office - Small	OIS		0.03	0.01	0.03		0.02	0.03	0.04	0.05	0.06	0.04	0.05	0.05		0.07		0.04
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.01	0.02	0.02			0.01		0.04		0.03	0.03	0.05				0.03
Restaurant - Sit Down	RSD					0.01		0.02	0.05	0.05			0.05	0.06				0.04
Retail - 3 story	RT3	0.01	0.01	0.01	0.02	0.00		0.02	0.03			0.02	0.02	0.02				0.02
Retail - Large 1 story	RL						0.02	0.01	0.02	0.04	0.04			0.05	0.04			0.03
Retail - Small	RIS						(0.00)	(0.01)	0.01	0.02	0.02							0.01
S_AGR																		
S_FST																		
Storage - Conditioned	SCn														0.03			0.03
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	1SPD	Tier1, 15 SEER/12 EER, 1spd	No,No	Small DX

Average Ex-post Savings kWh/ton																		
	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average	
Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
AGOTH																		
Assembly	Asm						120	127	122	127					162		132	
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	84	99	91	99	90	104	109	110	103	106	118	107	116	120		106	104
Education - Primary School	EPr						68	65	67	68	70			81	79			71
Education - Secondary School	ESe						68		71									70
Education - University	EUh				108	116			125	119	120		120	126				120
Grocery	Gro																	
Health/Medical - Hospital	Hsp								203	200								201
Lodging - Hotel	Hl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI				73									96				85
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						177		180	178	179			180	184		164	178
Office - Large	OIL	77	88	85	92	87					98	94	99				93	90
Office - Small	OIS		80	78	83		88	90	89	86	89	91	85	94		118		89
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		142	134	147				155		152		157	148	160			149
Restaurant - Sit Down	RSD						122			126	121	128		126	137			127
Retail - 3 story	Rt3	88	113	105	118	105				138	127		126	116	127			116
Retail - Large 1 story	RtL						139	143	142	134	138				137	170		143
Retail - Small	RtS						134	140	135	129	132							134
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															129		129
Single Family Residential																		

Average Ex-post savings kW/ton																		
bldgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							0.04	0.04	0.04	0.04					0.05		0.04
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.02	0.03	0.01	0.02	0.03	0.03	0.04	0.05	0.03	0.04	0.02	0.04	0.02	0.04		0.03	0.03
Education - Primary School	EPr						0.00	0.04	0.04	0.02	0.02		0.02	0.02				0.02
Education - Secondary School	ESe						0.00			0.01								0.01
Education - University	EUn			0.02	0.02		0.03		0.05	0.03	0.04		0.04	0.02				0.03
Grocery	Gro																	
Health/Medical - Hospital	Hsp								0.04	0.04								0.04
Lodging - Hotel	Hl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.01										0.02				0.01
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.03		0.03	0.03	0.03			0.03	0.04			0.03
Office - Large	OFL	0.03	0.03	0.02	0.03	0.03						0.03	0.04	0.03	0.03		0.04	0.03
Office - Small	OFS		0.03	0.02	0.02		0.03	0.04	0.04	0.04	0.04	0.03	0.04	0.03		0.04		0.03
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.03	0.02	0.03			0.04		0.04		0.04	0.03	0.04				0.03
Restaurant - Sit Down	RSD						0.04		0.04	0.04	0.04		0.05	0.06				0.04
Retail - 3 story	Rt3	0.02	0.03	0.03	0.04	0.04			0.05	0.04		0.04	0.04	0.05				0.04
Retail - Large 1 story	RtL						0.04	0.04	0.04	0.04	0.04				0.05	0.05		0.04
Retail - Small	RtS						0.05	0.05	0.05	0.05	0.05							0.05
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															0.05		0.05
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	1SPD	Tier1, 15 SEER/12 EER, 2spd	No,No	Small DX

Average Ex-post Savings kWh/ton																	
	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																	
Assembly	Asm						2	(12)	6	(28)					(35)		(13)
CNC																	
Multiple - Commercial																	
Education - Community College	ECC	59	15	33	14	31	8	(1)	(9)	17	(14)	(6)	2	(20)	(9)	50	11
Education - Primary School	EPr						13	13	14	20	7			12	16		14
Education - Secondary School	ESe						23		25								24
Education - University	EUn			77	56		48		38	53	25		43	19			45
Grocery	Gro																
Health/Medical - Hospital	Hsp								121	111							116
Lodging - Hotel	Hl																
Industrial																	
Manufacturing - Bio/Tech	MBT																
Manufacturing - Light Industrial	MLI			50									(13)				18
Lodging - Motel																	
Health/Medical - Nursing Home	Nrs					123		100	108	75			48	48		134	91
Office - Large	OL	30	17	17	14	15					9	8	(1)			38	16
Office - Small	OS		24	27	22		15	9	12	17	7	16	17	8	(14)		13
Miscellaneous																	
Res																	
Restaurant - Fast Food	RFF		53	78	46			52		55		7	31	(10)			39
Restaurant - Sit Down	RSD								22	37	13			(17)	1		14
Retail - 3 story	Rt3	79	9	40	4	39			(19)	5		(31)	(12)	(47)			7
Retail - Large 1 story	RtL						38	31	23	38	1			(11)	(61)		8
Retail - Small	RtS						(27)	(38)	(41)	(25)	(64)						(39)
S_AGR																	
S_FST																	
Storage - Conditioned	SCn														(70)		(70)
Single Family Residential																	

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							(0.04)	(0.01)	0.00	(0.01)					(0.01)		(0.02)
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.01	(0.02)	0.01	(0.01)	(0.03)	(0.01)	(0.03)	(0.02)	(0.02)	(0.07)	(0.02)	(0.07)	0.01	(0.07)		(0.02)	(0.02)
Education - Primary School	EPr						0.00	(0.02)	(0.02)	0.00	(0.00)			0.00	0.01			(0.00)
Education - Secondary School	ESe						0.00			0.00								0.00
Education - University	EUn			0.01	(0.01)		(0.01)		(0.02)	(0.01)	(0.06)		(0.07)	0.01				(0.02)
Grocery	Gro																	
Health/Medical - Hospital	Hsp									(0.02)	(0.06)							(0.04)
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.00										(0.02)				(0.01)
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						(0.00)		(0.02)	(0.02)	(0.07)			(0.08)	(0.08)		(0.02)	(0.04)
Office - Large	OfL	(0.00)	(0.01)	0.00	(0.01)	(0.01)						(0.02)	(0.03)	(0.03)			(0.01)	(0.01)
Office - Small	OfS		(0.01)	0.00	(0.00)		(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.01)	(0.02)	(0.02)		(0.03)		(0.01)
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		(0.02)	0.00	(0.04)			(0.03)		(0.02)		(0.07)	(0.07)	(0.07)				(0.04)
Restaurant - Sit Down	RSD						(0.01)		0.01	0.03	0.03			(0.05)	(0.01)			0.00
Retail - 3 story	Rt3	0.02	(0.03)	(0.01)	(0.03)	(0.04)			(0.00)	0.01		(0.06)	(0.07)	(0.08)				(0.03)
Retail - Large 1 story	RtL						(0.02)	(0.02)	(0.01)	(0.00)	(0.02)				(0.08)	(0.07)		(0.03)
Retail - Small	RtS						(0.03)	(0.03)	(0.03)	(0.03)	(0.06)							(0.03)
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															(0.10)		(0.10)
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	1SPD	Tier2, 16 SEER/>13EER, 2spd	No,No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm							16	41	50	48					117		54
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	47	54	50	57	50	52	44	52	65	60	75	61	65	81		66	59
Education - Primary School	EPr						37	34	43	48	47			56	64			47
Education - Secondary School	ESe						42			51								47
Education - University	EUn			114	117		109		112	115	113		120	126				116
Grocery	Gro																	
Health/Medical - Hospital	Hsp									200	209							205
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			54										63				59
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						110		110	116	108			113	134			115
Office - Large	OFL	59	72	66	75	67						88	77	84				74
Office - Small	OFS		70	62	73		72	69	77	80	82	87	76	85		126		80
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		87	81	91			89		101		114	96	108				96
Restaurant - Sit Down	RSD						63		71	80	83			83	104			81
Retail - 3 story	Rt3								67	81				74				70
Retail - Large 1 story	RtL	55	65	64	70	67		92	86	96	102	100			110	148		105
Retail - Small	RtS						39	30	41	51	43							41
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															65		65
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							(0.00)	0.01	0.03	0.03					0.04		0.02
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.01	0.01	0.01	0.01	0.01	0.01	(0.00)	0.01	0.02	0.02	0.01	0.01	0.02	0.02		0.02	0.01
Education - Primary School	EPr							0.00	0.01	0.02	0.01	0.01		0.02	0.03			0.02
Education - Secondary School	ESe							0.00		0.01								0.01
Education - University	EUn			0.01	0.02		0.01		0.01	0.03	0.03		0.02	0.02				0.02
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.04	0.04							0.04
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.01										0.00				0.01
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.01		0.02	0.02	0.01			0.02	0.03		0.03	0.02
Office - Large	OfL	0.02	0.02	0.02	0.02	0.02						0.03	0.04	0.04			0.04	0.03
Office - Small	OfS		0.03	0.01	0.02		0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.04		0.06		0.04
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.01	0.01	0.01			0.01		0.03		0.02	0.02	0.04				0.02
Restaurant - Sit Down	RSD						0.01		0.02	0.04	0.04			0.04	0.05			0.03
Retail - 3 story	Rt3	0.01	0.01	0.01	0.01	0.00			0.01	0.02		0.01	0.01	0.01				0.01
Retail - Large 1 story	RtL						0.02	0.01	0.02	0.03	0.03				0.03	0.03		0.03
Retail - Small	RtS						(0.00)	(0.00)	0.00	0.01	0.01							0.00
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															0.02		0.02
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	1SPD	Tier3, 17 SEER/>13EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																	
	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																	
Assembly	Asm						28	58	65	65					150		73
CNC																	
Multiple - Commercial																	
Education - Community College	ECC	51	65	58	69	59	67	60	69	79	76	92	75	82	99	76	72
Education - Primary School	EPr						46	42	51	57	57		67	75			56
Education - Secondary School	ESe						50		59								55
Education - University	EUn			127	133		128		132	133	132		138	147			134
Grocery	Gro																
Health/Medical - Hospital	Hsp								229	238							233
Lodging - Hotel	Hl																
Industrial																	
Manufacturing - Bio/Tech	MBT																
Manufacturing - Light Industrial	MLI			59									79				69
Lodging - Motel																	
Health/Medical - Nursing Home	Nrs					120		123	128	122			129	151		120	128
Office - Large	OIL	68	85	78	90	80					105	93	101			89	88
Office - Small	OIS		81	73	86		87	85	93	94	98	103	90	102	152		95
Miscellaneous																	
Res																	
Restaurant - Fast Food	RFF		100	90	105			105		117		134	112	129			112
Restaurant - Sit Down	RSD						77		89	97	103			103	127		99
Retail - 3 story	Rt3	57	80	74	86	78			92	102		104	89	97			86
Retail - Large 1 story	RtL						109	104	117	120	121			130	184		126
Retail - Small	RtS						57	50	61	69	64						60
S_AGR																	
S_FST																	
Storage - Conditioned	SCn														85		85
Single Family Residential																	

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							0.00	0.02	0.04	0.04					0.05		0.03
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.02	0.02	0.02	0.04		0.03	0.02
Education - Primary School	EPr								0.02	0.03	0.02	0.02		0.03	0.03			0.02
Education - Secondary School	ESe									0.01								0.01
Education - University	EUn			0.02	0.02		0.02		0.03	0.04	0.04		0.03	0.03				0.03
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.05	0.05							0.05
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.01										0.01				0.01
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs																	
Office - Large	OfL	0.02	0.03	0.02	0.03	0.02	0.02		0.02	0.03	0.02	0.04	0.05	0.03	0.04		0.04	0.03
Office - Small	OfS		0.04	0.02	0.03		0.03	0.04	0.05	0.05	0.05	0.05	0.06	0.05		0.07		0.04
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.02	0.02	0.02			0.02		0.04		0.03	0.03	0.05				0.03
Restaurant - Sit Down	RSD						0.02		0.03	0.05	0.06			0.06	0.07			0.05
Retail - 3 story	Rt3	0.01	0.02	0.02	0.02	0.01			0.02	0.04		0.02	0.02	0.02				0.02
Retail - Large 1 story	RtL							0.03	0.02	0.03	0.05				0.05	0.04		0.04
Retail - Small	RtS						0.01	0.01	0.02	0.02	0.02							0.02
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															0.03		0.03
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	1SPD	Tier4, 18 SEER/>13EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm							36	68	74	76					171		85
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	53	73	64	77	65	75	70	80	88	86	103	84	93	110		82	80
Education - Primary School	EPr						52	48	57	62	63			73	81			62
Education - Secondary School	ESe						55			65								60
Education - University	EUn			136	144		140		144	144	144		149	160				145
Grocery	Gro																	
Health/Medical - Hospital	Hsp									247	256							252
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			62										89				76
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						127		131	136	131		139	162			125	136
Office - Large	OFL	74	94	87	99	89						116	104	113			97	97
Office - Small	OFS		89	79	94		97	95	103	104	109	113	99	113		168		105
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		108	95	115			115		128		147	122	143				122
Restaurant - Sit Down	RSD						86		100	108	116			115	141			111
Retail - 3 story	Rt3								108	115				111				96
Retail - Large 1 story	RtL	59	89	80	97	84		120	116	130	131	134			142	207		140
Retail - Small	RtS						68	63	73	81	77							73
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															98		98
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							0.01	0.03	0.04	0.05					0.06		0.04
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.02	0.03	0.03	0.04		0.03	0.02
Education - Primary School	EPr						0.00	0.03	0.04	0.02	0.02			0.03	0.03			0.02
Education - Secondary School	ESe						0.00			0.01								0.01
Education - University	EUn			0.02	0.03		0.03		0.04	0.04	0.05		0.04	0.03				0.03
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.06	0.06							0.06
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.01										0.01				0.01
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.02		0.03	0.03	0.03			0.03	0.05		0.04	0.03
Office - Large	OfL	0.03	0.04	0.02	0.03	0.03						0.04	0.06	0.05			0.05	0.04
Office - Small	OfS		0.04	0.02	0.03		0.04	0.04	0.05	0.06	0.06	0.05	0.06	0.06		0.08		0.05
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.02	0.02	0.03			0.03		0.05		0.04	0.04	0.06				0.04
Restaurant - Sit Down	RSD						0.03		0.04	0.06	0.06			0.07	0.08			0.06
Retail - 3 story	Rt3	0.01	0.02	0.02	0.03	0.02			0.03	0.05		0.03	0.03	0.03				0.03
Retail - Large 1 story	RtL						0.03	0.03	0.04	0.05	0.05				0.05	0.05		0.05
Retail - Small	RtS						0.02	0.01	0.02	0.03	0.03							0.02
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															0.04		0.04
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	2SPD	Tier1, 15 SEER/12 EER, 2spd	Yes, Yes	Small DX

Average Ex-post Savings kWh/ton																		
		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
Building Type		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							117	129	124	134					183		137
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	77	102	86	100	86	98	101	111	105	112	129	113	128	131		106	106
Education - Primary School	EPr						66	61	68	71	75			88	87			74
Education - Secondary School	ESe						65			74								70
Education - University	EUn			98	116		118		126	122	129		127	141				122
Grocery	Gro																	
Health/Medical - Hospital	Hsp									208	211							210
Lodging - Hotel	Hl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			66										100				83
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						165		176	179	184			194	198		161	179
Office - Large	OIL	61	86	75	89	78						104	97	106			86	87
Office - Small	OIS		80	70	82		86	83	91	90	95	98	89	102		135		92
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		147	128	151			144		157		175	158	178				155
Restaurant - Sit Down	RSD						123		134	132	142			144	153			138
Retail - 3 story	Rt3	84	119	101	123	104			142	133		142	128	146				122
Retail - Large 1 story	RtL						132	132	143	139	149				152	198		149
Retail - Small	RtS						119	121	128	126	135							126
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															143		143
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							0.04	0.05	0.04	0.05					0.06		0.05
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.02	0.04	0.01	0.02	0.04	0.03	0.05	0.05	0.04	0.05	0.03	0.05	0.03	0.05		0.03	0.03
Education - Primary School	EPr						0.01	0.04	0.04	0.02	0.02			0.03	0.03			0.03
Education - Secondary School	ESe						0.00			0.02								0.01
Education - University	EUn			0.01	0.03		0.03		0.05	0.04	0.06		0.05	0.03				0.04
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.05	0.06							0.06
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.01										0.02				0.01
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.03		0.04	0.04	0.05			0.05	0.06		0.04	0.04
Office - Large	OfL	0.02	0.04	0.02	0.03	0.03						0.04	0.05	0.04			0.05	0.04
Office - Small	OfS		0.04	0.01	0.03		0.04	0.04	0.05	0.05	0.06	0.04	0.05	0.05		0.06		0.04
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.03	0.02	0.04			0.04		0.05		0.05	0.05	0.05				0.04
Restaurant - Sit Down	RSD						0.04		0.05	0.05	0.05			0.05	0.07			0.05
Retail - 3 story	Rt3	0.02	0.04	0.03	0.05	0.04			0.05	0.05		0.05	0.05	0.06				0.04
Retail - Large 1 story	RtL						0.04	0.05	0.05	0.05	0.05				0.06	0.06		0.05
Retail - Small	RtS						0.05	0.05	0.05	0.05	0.06							0.05
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															0.06		0.06
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	2SPD	Tier2, 16 SEER/>13EER, 2spd	Yes, Yes	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm							107	166	156	198					325		190
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	43	117	69	115	70	107	101	137	130	161	189	149	192	203		103	126
Education - Primary School	EPPr						70	58	81	86	103			123	126			92
Education - Secondary School	ESe						68			87								77
Education - University	EUn			82	137		129		156	152	185		173	219				154
Grocery	Gro																	
Health/Medical - Hospital	Hsp									233	258							246
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			50										157				103
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						126		161	169	198		242	268			119	183
Office - Large	OFL	34	103	67	109	74						157	133	163			91	103
Office - Small	OFS		96	62	101		105	90	121	123	142	150	123	158		256		127
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		158	94	167			133		181		266	204	277				185
Restaurant - Sit Down	RSD						134		164	161	198			234	248			190
Retail - 3 story	Rt3								189	183								160
Retail - Large 1 story	RtL	48	152	89	162	94		150	138	184	182	226			263	392		219
Retail - Small	RtS						146	131	176	179	219							170
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															275		275
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							0.08	0.07	0.07	0.10					0.11		0.09
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.01	0.06	0.00	0.03	0.05	0.05	0.08	0.08	0.07	0.14	0.06	0.14	0.04	0.14		0.08	0.07
Education - Primary School	EPr						0.01	0.07	0.09	0.03	0.04			0.05	0.05			0.05
Education - Secondary School	ESe						0.00			0.03								0.01
Education - University	EUn			0.01	0.05		0.06		0.08	0.08	0.15		0.14	0.04				0.08
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.11	0.16							0.14
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.00										0.05				0.02
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.05		0.08	0.08	0.12			0.14	0.17		0.09	0.11
Office - Large	OfL	0.01	0.07	0.01	0.06	0.05						0.09	0.12	0.11			0.10	0.07
Office - Small	OfS		0.08	0.01	0.06		0.07	0.08	0.09	0.10	0.12	0.09	0.12	0.11		0.15		0.09
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.06	0.02	0.09			0.08		0.09		0.14	0.14	0.16				0.10
Restaurant - Sit Down	RSD						0.06		0.06	0.05	0.07			0.14	0.13			0.09
Retail - 3 story	Rt3	0.01	0.08	0.03	0.09	0.07			0.07	0.07		0.12	0.13	0.14				0.08
Retail - Large 1 story	RtL						0.08	0.08	0.08	0.09	0.11				0.18	0.16		0.11
Retail - Small	RtS						0.07	0.07	0.08	0.09	0.13							0.09
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															0.17		0.17
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	2SPD	Tier3, 17 SEER/>13EER, 2spd	Yes, Yes	Small DX

Average Ex-post Savings kWh/ton																		
	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average	
Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
AGOTH																		
Assembly	Asm						117	180	169	214					357		207	
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	43	125	72	123	74	115	110	149	139	173	203	159	206	218		109	135
Education - Primary School	EPr						76	62	87	93	110			131	135			99
Education - Secondary School	ESe						72			93								83
Education - University	EUn			87	148		140		169	164	199		186	236				166
Grocery	Gro																	
Health/Medical - Hospital	Hsp								252	278								265
Lodging - Hotel	Hl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			51										170				111
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						132		170	178	209			255	282		123	193
Office - Large	OIL	35	111	72	117	80					170	144	176				98	111
Office - Small	OIS		104	66	109		114	98	132	133	154	162	133	172		278		138
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		167	97	178			141		194		283	216	295				196
Restaurant - Sit Down	RSD								179	176	217			252	270			206
Retail - 3 story	Rt3	49	163	94	174	100			208	200		262	208	271				173
Retail - Large 1 story	RtL						162	149	200	197	244			281	426			237
Retail - Small	RtS						158	144	191	193	236							184
S_AGR																		
S_FST																		
Storage - Conditioned	SCn														295			295
Single Family Residential																		

Ex post Savings, kWh																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	9999
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
AGOTH																		
Assembly	Asm						2.9	7.1	1.7	3.2	3.0					2.4		
CNC							1.7	4.7	2.9	1.6					1.3			
Multiple - Commercial				26.1	0.4		1.7	2.7				9.6	7.8	0.5				
Education - Community College	ECC	0.0	4.6	1.2	8.1	3.5	0.5	57.3	37.9	73.6	30.5	5.8	23.8	25.1	42.8		22.3	
Education - Primary School	EPr						0.2	42.5	44.2	5.6	37.6			3.2	32.4			
Education - Secondary School	ESe						0.0			1.6								
Education - University	EUn			0.0	0.8		0.6		1.6	0.4	1.6		2.2	1.1				
Grocery	Gro		1.1	0.9								2.2	4.6	4.7	0.3			
Health/Medical - Hospital	Hsp									5.5	1.3							
Lodging - Hotel	Htl																	
Industrial			1.5	0.4	4.1		0.4	3.8										1.8
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.2										0.4				
Lodging - Motel							17.6	0.6	8.5	5.9	5.3							
Health/Medical - Nursing Home	Nrs						22.5		83.9	33.3	113.1			3.7	19.7			3.9
Office - Large	OfL	0.5	14.0	23.8	141.1	8.2						73.3	188.1	81.4				0.2
Office - Small	OfS		8.2	24.6	36.4		10.1	1.6	7.3	3.6	17.9	11.0	92.0	14.0			5.1	
Miscellaneous							26.7	2.7	22.0	33.2	5.0				1.3	6.6	4.0	
Res												47.7	8.6				0.3	
Restaurant - Fast Food	RFF		0.7	0.6	3.2			1.2		0.5		1.4	0.7	4.5				
Restaurant - Sit Down	RSD						0.3		1.7	1.3	1.8			0.5	0.7			
Retail - 3 story	Rt3	0.0	4.8	3.8	14.6	0.2			6.7	0.2		4.9	24.1	23.4				
Retail - Large 1 story	RtL						8.3	6.3	9.5	7.6	7.4				2.7	7.6		
Retail - Small	RtS						9.2	1.9	1.2	0.5	3.2							
S_AGR																		
S_FST							0.5											
Storage - Conditioned	SCn																227.0	
Single Family Residential				4.7	8.9								1.7	6.2				

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	2SPD	Tier4, 18 SEER/>13EER, 2spd	Yes, Yes	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm							123	189	177	224					376		218
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	44	130	75	128	76	120	116	156	145	180	212	166	215	227		113	140
Education - Primary School	EPPr						80	65	90	97	115			137	141			104
Education - Secondary School	ESe						75			97								86
Education - University	EUn			91	154		147		178	172	208		194	247				174
Grocery	Gro																	
Health/Medical - Hospital	Hsp									264	291							277
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			53										179				116
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						135		175	184	216			263	291			125
Office - Large	OFL	36	116	75	123	84						178	151	185				117
Office - Small	OFS		108	68	114		120	103	139	139	161	170	139	180		293		145
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		173	99	184			146		201		294	224	307				203
Restaurant - Sit Down	RSD						152		188	185	228			264	283			217
Retail - 3 story	Rt3								220	210				284				181
Retail - Large 1 story	RtL	49	170	97	182	104		169	157	210	206	255			292	448		248
Retail - Small	RtS						165	152	201	202	247							193
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															307		307
Single Family Residential																		

Average Ex-post savings kW/ton																		
		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							0.09	0.09	0.09	0.12					0.13		0.10
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.01	0.07	0.00	0.04	0.06	0.06	0.10	0.10	0.08	0.16	0.07	0.15	0.04	0.16		0.09	0.08
Education - Primary School	EPr						0.01	0.09	0.10	0.03	0.04			0.05	0.06			0.05
Education - Secondary School	ESe						0.00			0.03								0.02
Education - University	EUn			0.01	0.06		0.07		0.11	0.09	0.17		0.16	0.05				0.09
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.13	0.18							0.16
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.00										0.05				0.03
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.06		0.09	0.09	0.14			0.16	0.19		0.10	0.12
Office - Large	OfL	0.01	0.09	0.01	0.07	0.06						0.10	0.14	0.13			0.11	0.08
Office - Small	OfS		0.09	0.01	0.06		0.08	0.09	0.11	0.11	0.14	0.10	0.14	0.12		0.17		0.10
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.07	0.02	0.11			0.10		0.11		0.16	0.15	0.18				0.11
Restaurant - Sit Down	RSD						0.08		0.08	0.07	0.09			0.16	0.16			0.11
Retail - 3 story	R3	0.01	0.09	0.04	0.11	0.08			0.09	0.09		0.14	0.15	0.17				0.10
Retail - Large 1 story	RL						0.09	0.10	0.10	0.10	0.13				0.20	0.18		0.13
Retail - Small	RS						0.09	0.09	0.10	0.11	0.15							0.11
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															0.19		0.19
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	2SPD	Tier1, 15 SEER/12 EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm							126	138	133	141					189		145
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	92	116	106	117	105	120	125	131	123	129	141	128	141	142		117	122
Education - Primary School	EPr						76	74	78	80	83			94	92			83
Education - Secondary School	ESe						76			83								79
Education - University	EUn			129	140		146		152	144	150		146	158				146
Grocery	Gro																	
Health/Medical - Hospital	Hsp									249	250							250
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			78										109				94
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						191		199	197	202		208	211			174	197
Office - Large	OFL	92	107	103	111	106						120	115	122			106	109
Office - Small	OFS		97	93	100		106	109	110	106	111	111	103	114		147		109
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		162	150	169			174		175		187	173	191				173
Restaurant - Sit Down	RSD						135		145	141	151			150	157			146
Retail - 3 story	Rt3									162	151			155				136
Retail - Large 1 story	RtL	92	132	120	139	121		153	157	162	154	163			159	208		165
Retail - Small	RtS						141	148	147	141	149							145
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															145		145
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							0.04	0.05	0.04	0.05					0.06		0.05
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.03	0.04	0.01	0.02	0.04	0.03	0.05	0.05	0.04	0.05	0.03	0.05	0.03	0.05		0.03	0.04
Education - Primary School	EPr						0.01	0.04	0.04	0.02	0.02			0.03	0.03			0.03
Education - Secondary School	ESe						0.00			0.02								0.01
Education - University	EUn			0.02	0.03		0.03		0.05	0.04	0.06		0.05	0.03				0.04
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.05	0.06							0.06
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.01										0.02				0.02
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.03		0.04	0.04	0.05			0.05	0.05			0.04
Office - Large	OfL	0.03	0.04	0.03	0.03	0.04						0.04	0.05	0.04				0.04
Office - Small	OfS		0.04	0.02	0.03		0.04	0.04	0.05	0.05	0.06	0.04	0.05	0.05		0.06		0.04
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.04	0.03	0.04			0.04		0.05		0.05	0.05	0.05				0.04
Restaurant - Sit Down	RSD						0.04		0.05	0.05	0.05			0.05	0.07			0.05
Retail - 3 story	Rt3	0.02	0.04	0.04	0.05	0.04			0.05	0.05		0.05	0.05	0.06				0.04
Retail - Large 1 story	RtL						0.04	0.05	0.05	0.05	0.05				0.06	0.06		0.05
Retail - Small	RtS						0.05	0.05	0.05	0.05	0.06							0.05
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															0.06		0.06
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	2SPD	Tier2, 16 SEER/>13EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm							140	192	176	217					340		213
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	80	155	122	160	124	164	171	191	172	203	222	186	226	232		134	169
Education - Primary School	EPPr						101	95	107	108	123			139	140			116
Education - Secondary School	ESe						95			108								101
Education - University	EUn			166	201		208		225	207	238		223	264				216
Grocery	Gro																	
Health/Medical - Hospital	Hsp									329	349							339
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			81										186				134
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						178		209	205	235			273	296			221
Office - Large	OFL	121	162	152	172	157						200	184	206			144	166
Office - Small	OFS		142	128	151		163	170	175	169	187	182	162	191		287		176
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		196	153	214			212		221		294	238	308				230
Restaurant - Sit Down	RSD						168		194	184	221			250	260			213
Retail - 3 story	Rt3								248	227				276				199
Retail - Large 1 story	RtL	69	188	144	204	149		208	211	235	218	262			280	417		262
Retail - Small	RtS						206	215	229	217	257							225
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															280		280
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							0.08	0.07	0.07	0.10					0.11		0.09
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.03	0.07	0.01	0.04	0.07	0.05	0.08	0.08	0.07	0.14	0.06	0.14	0.04	0.14		0.08	0.07
Education - Primary School	EPr						0.01	0.07	0.09	0.03	0.04			0.05	0.05			0.05
Education - Secondary School	ESe						0.00			0.03								0.01
Education - University	EUn			0.03	0.06		0.06		0.08	0.08	0.15		0.14	0.04				0.08
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.11	0.16							0.14
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.02										0.05				0.03
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.05	0.08	0.08	0.13				0.14	0.17		0.09	0.11
Office - Large	OfL	0.06	0.08	0.04	0.06	0.06					0.09	0.12	0.11				0.10	0.08
Office - Small	OfS		0.08	0.03	0.06		0.07	0.08	0.09	0.10	0.12	0.09	0.12	0.11		0.15		0.09
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.07	0.04	0.10			0.08		0.09		0.14	0.14	0.16				0.10
Restaurant - Sit Down	RSD						0.06		0.06	0.05	0.07			0.14	0.13			0.09
Retail - 3 story	R3	0.01	0.08	0.06	0.09	0.09			0.07	0.07		0.12	0.13	0.14				0.09
Retail - Large 1 story	RL						0.08	0.08	0.08	0.09	0.11				0.18	0.16		0.11
Retail - Small	RS						0.07	0.07	0.08	0.09	0.13							0.09
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															0.17		0.17
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	2SPD	Tier3, 17 SEER/>13EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																	
	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																	
Assembly	Asm						152	208	191	234					373		232
CNC																	
Multiple - Commercial																	
Education - Community College	ECC	84	167	131	172	133	178	208	185	219	239	200	243	250		144	183
Education - Primary School	EPr						110	103	116	117	133		149	150			125
Education - Secondary School	ESe						103		116								109
Education - University	EUh			179	217		227	245	224	257		241	285				234
Grocery	Gro																
Health/Medical - Hospital	Hsp								357	377							367
Lodging - Hotel	Hl																
Industrial																	
Manufacturing - Bio/Tech	MBT																
Manufacturing - Light Industrial	MLI			86									202				144
Lodging - Motel																	
Health/Medical - Nursing Home	Nrs					188		222	217	249			289	313		161	234
Office - Large	OIL	130	175	164	187	171					217	200	224			157	181
Office - Small	OIS		154	138	164		178	186	191	183	203	198	176	207		312	191
Miscellaneous																	
Res																	
Restaurant - Fast Food	RFF		209	162	229			228		237		314	253	330			245
Restaurant - Sit Down	RSD								212	201	241			270	283		231
Retail - 3 story	Rt3	71	203	154	221	160			273	247		285	241	299			215
Retail - Large 1 story	RtL						225	230	256	236	283			299	454		283
Retail - Small	RtS						224	236	249	235	277						244
S_AGR																	
S_FST																	
Storage - Conditioned	SCn														300		300
Single Family Residential																	

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							0.09	0.08	0.08	0.11					0.12		0.10
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.03	0.07	0.01	0.04	0.08	0.05	0.09	0.09	0.08	0.15	0.07	0.15	0.04	0.15		0.09	0.08
Education - Primary School	EPr						0.01	0.08	0.09	0.03	0.04			0.05	0.06			0.05
Education - Secondary School	ESe						0.00			0.03								0.02
Education - University	EUn			0.03	0.06		0.06		0.10	0.09	0.16		0.15	0.05				0.09
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.13	0.17							0.15
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.02										0.05				0.04
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.06		0.09	0.09	0.14			0.15	0.18		0.10	0.11
Office - Large	OfL	0.06	0.08	0.04	0.07	0.07						0.10	0.13	0.12			0.11	0.09
Office - Small	OfS		0.08	0.04	0.06		0.08	0.09	0.10	0.11	0.13	0.10	0.13	0.12		0.16		0.10
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.07	0.05	0.10			0.09		0.10		0.15	0.15	0.17				0.11
Restaurant - Sit Down	RSD						0.07		0.07	0.07	0.08			0.16	0.15			0.10
Retail - 3 story	R3	0.01	0.09	0.07	0.10	0.09			0.08	0.08		0.13	0.14	0.16				0.10
Retail - Large 1 story	RL						0.09	0.09	0.09	0.10	0.12				0.19	0.17		0.12
Retail - Small	RIS						0.08	0.08	0.10	0.10	0.14							0.10
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															0.18		0.18
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	2SPD	Tier4, 18 SEER/>13EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm							160	219	200	245					394		244
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	87	174	137	180	139	187	196	219	194	229	250	209	254	261		150	191
Education - Primary School	EPPr						115	108	121	122	139			156	157			131
Education - Secondary School	ESe						107			122								114
Education - University	EUn			187	228		239		258	235	269		253	298				246
Grocery	Gro																	
Health/Medical - Hospital	Hsp									375	396							386
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			90										212				151
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						195		230	225	258			299	324		165	242
Office - Large	OfL	136	184	173	196	179						228	210	235			165	190
Office - Small	OfS		161	145	172		188	196	201	192	213	208	185	218		329		201
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		217	167	238			238		248		327	263	344				255
Restaurant - Sit Down	RSD						191			223	211	254		282	297			243
Retail - 3 story	Rt3									289	261			313				226
Retail - Large 1 story	RtL	73	212	160	232	166		236	242	269	247	297			312	477		297
Retail - Small	RtS							236	249	262	247	290						257
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															312		312
Single Family Residential																		

Average Ex-post savings kW/ton																		
		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm							0.09	0.09	0.09	0.12					0.13		0.10
CNC																		
Multiple - Commercial																		
Education - Community College	ECC	0.04	0.08	0.01	0.04	0.08	0.06	0.10	0.10	0.08	0.16	0.07	0.16	0.04	0.16		0.09	0.08
Education - Primary School	EPr						0.01	0.09	0.10	0.03	0.04			0.05	0.06			0.05
Education - Secondary School	ESe						0.00			0.03								0.02
Education - University	EUn			0.03	0.07		0.07		0.11	0.09	0.17		0.16	0.05				0.09
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.13	0.18							0.16
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT																	
Manufacturing - Light Industrial	MLI			0.02										0.05				0.04
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.06		0.09	0.10	0.14			0.16	0.19		0.10	0.12
Office - Large	OfL	0.06	0.09	0.05	0.07	0.07						0.10	0.14	0.13			0.11	0.09
Office - Small	OfS		0.09	0.04	0.07		0.08	0.09	0.11	0.11	0.14	0.10	0.14	0.12		0.17		0.11
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.07	0.05	0.11			0.10		0.11		0.16	0.15	0.18				0.12
Restaurant - Sit Down	RSD						0.08		0.08	0.07	0.09			0.16	0.16			0.11
Retail - 3 story	R3	0.01	0.09	0.07	0.11	0.10			0.09	0.09		0.14	0.15	0.17				0.10
Retail - Large 1 story	RL						0.09	0.10	0.10	0.10	0.13				0.20	0.18		0.13
Retail - Small	RS						0.09	0.09	0.10	0.11	0.15							0.11
S_AGR																		
S_FST																		
Storage - Conditioned	SCn															0.19		0.19
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	2SPD	Tier1, 11.5EER, 2spd	Yes, Yes	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm						34	42	45	35	44							40
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		22	12	22	13	25		34	26	32	38	28	37	40		19	27
Education - Primary School	EPr							15	17	18	20			23	24			20
Education - Secondary School	ESe								14	17	17							16
Education - University	EUn			16	28		32		37	32	38	44	34	44				34
Grocery	Gro																	
Health/Medical - Hospital	Hsp									50								50
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT										42							42
Manufacturing - Light Industrial	MLI			6				15						34				18
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						14		23	25	28			33	37	68	10	30
Office - Large	OfL		22	15	25	17						34	30	36			19	25
Office - Small	OfS		20	13	22		26	25	30	28	32	33	26	36		60	19	28
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		24	10	28						42	46	33	50				33
Restaurant - Sit Down	RSD						37	36	45	41	51			49	57			45
Retail - 3 story	Rt3	7	32	17	35	22			56	45		50	37	54				35
Retail - Large 1 story	RtL						34	37	44	39	47					90		48
Retail - Small	RtS						35	40	42	39	46							40
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm						0.02	0.02	0.03	0.03	0.04							0.03
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		0.01	0.00	0.01	0.02	0.01		0.03	0.02	0.03	0.01	0.03	0.01	0.03		0.02	0.02
Education - Primary School	EPr							0.02	0.03	0.01	0.01			0.01	0.01			0.01
Education - Secondary School	ESe						0.00		0.03	0.00								0.01
Education - University	EUn			0.00	0.01		0.02		0.04	0.02	0.03	0.02	0.03	0.01				0.02
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.03								0.03
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									0.02								0.02
Manufacturing - Light Industrial	MLI			0.00				0.02						0.01				0.01
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.01		0.02	0.02	0.03			0.02	0.03	0.03	0.02	0.02
Office - Large	OfL		0.02	0.00	0.02	0.01						0.02	0.03	0.02				0.02
Office - Small	OfS		0.02	0.00	0.01		0.02	0.02	0.03	0.03	0.03	0.02	0.03	0.02		0.03	0.03	0.02
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.01	0.01	0.03						0.04	0.03	0.03	0.03				0.02
Restaurant - Sit Down	RSD						0.03	0.03	0.03	0.03	0.04			0.03	0.04			0.03
Retail - 3 story	R3	0.00	0.02	0.01	0.03	0.02			0.04	0.04		0.03	0.03	0.04				0.02
Retail - Large 1 story	RL						0.03	0.03	0.03	0.03	0.04					0.04		0.03
Retail - Small	RS						0.03	0.03	0.03	0.03	0.04							0.03
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	2SPD	Tier2, 12.0EER, 2spd	Yes, Yes	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm						66	82	87	68	85							78
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		43	23	42	26	47		66	51	62	73	54	72	77		37	52
Education - Primary School	EPPr							30	32	35	39			45	46			38
Education - Secondary School	ESe						27		34	33								32
Education - University	EUn			32	55		62		72	62	73	85	67	85				66
Grocery	Gro																	
Health/Medical - Hospital	Hsp									97								97
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT										80							80
Manufacturing - Light Industrial	MLI			11				29						66				35
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						28		45	48	53			65	71	132	20	58
Office - Large	OFL		42	28	48	33						65	58	69			37	48
Office - Small	OFS		38	24	42		50	48	57	53	62	64	51	70		116	37	55
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		47	19	53						81	89	63	96				64
Restaurant - Sit Down	RSD						71	70	87	79	98			94	110			87
Retail - 3 story	Rt3	13	61	33	68	42			108	88		96	72	104				68
Retail - Large 1 story	RtL						66	71	84	76	91					174		94
Retail - Small	RtS						67	76	81	75	89							78
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm						0.04	0.05	0.06	0.06	0.07							0.06
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		0.03	0.00	0.02	0.03	0.03		0.07	0.04	0.06	0.03	0.06	0.01	0.06		0.03	0.04
Education - Primary School	EPr							0.05	0.05	0.01	0.01			0.02	0.02			0.03
Education - Secondary School	ESe						0.00		0.06	0.01								0.02
Education - University	EUn			0.00	0.03		0.04		0.07	0.04	0.07	0.04	0.06	0.02				0.04
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.06								0.06
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									0.05								0.05
Manufacturing - Light Industrial	MLI			0.00				0.05						0.02				0.02
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.03		0.04	0.04	0.05			0.04	0.06	0.05	0.03	0.04
Office - Large	OfL		0.04	0.01	0.03	0.03						0.04	0.06	0.05			0.05	0.04
Office - Small	OfS		0.04	0.00	0.03		0.04	0.05	0.05	0.05	0.06	0.04	0.06	0.05		0.07	0.05	0.04
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.03	0.01	0.05						0.07	0.05	0.05	0.06				0.04
Restaurant - Sit Down	RSD						0.05	0.05	0.06	0.07	0.08			0.07	0.09			0.07
Retail - 3 story	R3	0.00	0.03	0.02	0.05	0.04			0.07	0.07		0.06	0.06	0.07				0.05
Retail - Large 1 story	RL						0.05	0.05	0.06	0.06	0.07					0.08		0.06
Retail - Small	RIS						0.05	0.06	0.06	0.07	0.08							0.06
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	2SPD	Tier3, 12.5EER, 2spd	Yes, Yes	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm						94	117	125	98	122							111
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		62	33	60	37	68		94	73	88	105	77	104	110		53	74
Education - Primary School	EPr							42	46	50	56			65	65			54
Education - Secondary School	ESe						39		48	48								45
Education - University	EUn			46	79		89		104	89	104	122	96	122				94
Grocery	Gro																	
Health/Medical - Hospital	Hsp									140								140
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT										115							115
Manufacturing - Light Industrial	MLI			16				42						94				51
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						40		64	68	76			92	102	189	29	82
Office - Large	OFL		60	41	68	47						94	83	99			53	68
Office - Small	OFS		54	35	60		72	68	82	76	88	92	73	101		166	53	79
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		67	28	77							116	127	90	137			92
Restaurant - Sit Down	RSD						102	100	124	113	140			135	157			125
Retail - 3 story	Rt3	18	88	48	97	61			154	126		138	104	148				98
Retail - Large 1 story	RtL						95	101	121	109	131					249		134
Retail - Small	RtS						96	110	116	107	127							111
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm						0.06	0.07	0.08	0.08	0.10							0.08
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		0.04	0.00	0.02	0.05	0.04		0.09	0.06	0.09	0.04	0.08	0.02	0.09		0.05	0.05
Education - Primary School	EPr							0.07	0.07	0.02	0.02			0.02	0.03			0.04
Education - Secondary School	ESe						0.00		0.08	0.01								0.03
Education - University	EUn			0.01	0.04		0.05		0.10	0.06	0.10	0.05	0.09	0.02				0.06
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.08								0.08
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									0.07								0.07
Manufacturing - Light Industrial	MLI			0.00				0.07						0.03				0.03
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.04		0.06	0.06	0.07			0.06	0.08	0.07	0.04	0.06
Office - Large	OfL		0.05	0.01	0.04	0.04						0.06	0.09	0.06			0.07	0.05
Office - Small	OfS		0.05	0.01	0.04		0.06	0.07	0.08	0.07	0.09	0.06	0.08	0.07		0.10	0.07	0.06
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.04	0.01	0.06						0.10	0.08	0.07	0.09				0.06
Restaurant - Sit Down	RSD						0.07	0.07	0.09	0.10	0.11			0.09	0.12			0.09
Retail - 3 story	Rt3	0.00	0.05	0.03	0.08	0.06			0.10	0.10		0.09	0.08	0.10				0.07
Retail - Large 1 story	RtL						0.07	0.07	0.09	0.09	0.10					0.11		0.09
Retail - Small	RtS						0.08	0.09	0.09	0.10	0.11							0.09
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	2SPD	Tier4, 13.0EER, 2spd	Yes, Yes	Small DX

Average Ex-post Savings kWh/ton																	
	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																	
Assembly	Asm					120	150	160	125	156							142
CNC																	
Multiple - Commercial																	
Education - Community College	ECC	79	42	77	47	87		121	93	113	135	98	133	141		68	95
Education - Primary School	EPr						54	59	64	72			83	84			69
Education - Secondary School	ESe					50		62	61								58
Education - University	EUn			58	101	114		133	114	133	157	122	157				121
Grocery	Gro																
Health/Medical - Hospital	Hsp								179								179
Lodging - Hotel	Hl																
Industrial																	
Manufacturing - Bio/Tech	MBT								147								147
Manufacturing - Light Industrial	MLI			20			53						121				65
Lodging - Motel																	
Health/Medical - Nursing Home	Nrs					51		82	88	98			118	130	242	37	106
Office - Large	OIL	77	52	87	60						120	107	127			68	87
Office - Small	OIS	69	45	77		92	87	105	98	113	118	94	129		212	67	101
Miscellaneous																	
Res																	
Restaurant - Fast Food	RFF		86	35	98					148	163	115	175				117
Restaurant - Sit Down	RSD																
Retail - 3 story	Rt3	24	112	61	124	78		131	128	159	145	180		173	202		159
Retail - Large 1 story	RtL							121	130	155	140	168				319	172
Retail - Small	RtS							124	140	149	138	163					143
S_AGR																	
S_FST																	
Storage - Conditioned	SCn																
Single Family Residential																	

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm						0.08	0.08	0.11	0.11	0.13							0.10
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		0.05	0.00	0.03	0.06	0.05		0.12	0.07	0.12	0.05	0.10	0.02	0.11		0.06	0.07
Education - Primary School	EPr							0.09	0.10	0.02	0.02			0.03	0.03			0.05
Education - Secondary School	ESe						0.00		0.11	0.02								0.04
Education - University	EUn			0.01	0.05		0.07		0.13	0.08	0.12	0.07	0.11	0.03				0.07
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.11								0.11
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									0.09								0.09
Manufacturing - Light Industrial	MLI							0.09						0.04				0.04
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.05		0.07	0.08	0.09			0.08	0.10	0.10	0.06	0.08
Office - Large	OfL		0.07	0.01	0.06	0.05						0.07	0.11	0.08			0.08	0.07
Office - Small	OfS		0.07	0.01	0.05		0.07	0.09	0.10	0.09	0.12	0.07	0.11	0.09		0.12	0.09	0.08
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.05	0.01	0.08						0.12	0.10	0.09	0.11				0.08
Restaurant - Sit Down	RSD						0.09	0.09	0.12	0.12	0.15			0.12	0.16			0.12
Retail - 3 story	R3	0.01	0.06	0.04	0.10	0.07			0.13	0.13		0.12	0.10	0.13				0.09
Retail - Large 1 story	RL						0.09	0.10	0.11	0.11	0.13					0.14		0.11
Retail - Small	RS						0.10	0.11	0.12	0.12	0.14							0.12
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	2SPD	Tier1, 11.5EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm						38	45	48	40	47							43
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		31	24	32	25	38		46	36	41	45	36	45	46		26	36
Education - Primary School	EPr							22	23	23	25			27	26			24
Education - Secondary School	ESe						20		23	22								22
Education - University	EUn			34	42		50		53	45	49	54	46	54				47
Grocery	Gro																	
Health/Medical - Hospital	Hsp									75								75
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									60								60
Manufacturing - Light Industrial	MLI			12				26						40				26
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						27		34	33	36			40	43	75	18	38
Office - Large	OfL		36	34	39	36						44	42	46			34	39
Office - Small	OfS		31	28	34		40	43	42	39	43	41	36	44		68	31	40
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		33	24	39						52	53	41	57				43
Restaurant - Sit Down	RSD						44	43	51	46	55			52	59			50
Retail - 3 story	Rt3	10	39	27	43	30			66	55		54	44	58				43
Retail - Large 1 story	RtL						46	49	54	48	55					95		58
Retail - Small	RtS						48	55	54	48	54							52
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm						0.02	0.02	0.03	0.03	0.04							0.03
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		0.01	0.00	0.01	0.02	0.01		0.03	0.02	0.03	0.01	0.03	0.01	0.03		0.02	0.02
Education - Primary School	EPr							0.02	0.03	0.01	0.01			0.01	0.01			0.01
Education - Secondary School	ESe						0.00		0.03	0.00								0.01
Education - University	EUn			0.01	0.01		0.02		0.04	0.02	0.03	0.02	0.03	0.01				0.02
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.03								0.03
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									0.02								0.02
Manufacturing - Light Industrial	MLI							0.02						0.01				0.01
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.01		0.02	0.02	0.03			0.02	0.03	0.03	0.02	0.02
Office - Large	OfL		0.02	0.01	0.02	0.02						0.02	0.03	0.02				0.02
Office - Small	OfS		0.02	0.01	0.01		0.02	0.02	0.03	0.03	0.03	0.02	0.03	0.02		0.03	0.02	0.02
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.01	0.01	0.02						0.04	0.03	0.03	0.03				0.02
Restaurant - Sit Down	RSD						0.03	0.03	0.03	0.03	0.04			0.03	0.04			0.03
Retail - 3 story	R3	0.00	0.02	0.01	0.03	0.02			0.04	0.04		0.03	0.03	0.04				0.03
Retail - Large 1 story	RL						0.03	0.03	0.03	0.03	0.04					0.04		0.03
Retail - Small	RS						0.03	0.03	0.03	0.03	0.04							0.03
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	2SPD	Tier2, 12.0EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm						73	87	93	77	91							84
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		59	46	61	48	74		90	70	80	87	70	86	89		50	70
Education - Primary School	EPr							43	44	45	48			52	51			47
Education - Secondary School	ESe						39		45	43								42
Education - University	EUn			66	81		96		102	87	95	104	88	104				91
Grocery	Gro																	
Health/Medical - Hospital	Hsp									145								145
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT										117							117
Manufacturing - Light Industrial	MLI			24				50						77				50
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						52		66	63	69			77	83	144	34	73
Office - Large	OFL		69	65	76	69						85	81	89			65	75
Office - Small	OFS		60	55	65		76	83	82	75	82	80	70	86		131	59	77
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		65	46	75						101	102	79	110				82
Restaurant - Sit Down	RSD						85	84	99	89	107			101	115			97
Retail - 3 story	Rt3	20	75	51	83	58			128	107		104	85	113				82
Retail - Large 1 story	RtL						89	95	105	92	106					184		112
Retail - Small	RtS						93	106	104	92	105							100
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm						0.04	0.05	0.06	0.06	0.07							0.06
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		0.03	0.00	0.02	0.03	0.03		0.07	0.04	0.06	0.03	0.06	0.01	0.06		0.03	0.04
Education - Primary School	EPr							0.05	0.05	0.01	0.01			0.02	0.02			0.03
Education - Secondary School	ESe						0.00		0.06	0.01								0.02
Education - University	EUn			0.01	0.03		0.04		0.07	0.04	0.07	0.04	0.06	0.02				0.04
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.06								0.06
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									0.05								0.05
Manufacturing - Light Industrial	MLI			0.01				0.05						0.02				0.03
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.03		0.04	0.04	0.05			0.04	0.06	0.05	0.03	0.04
Office - Large	OfL		0.04	0.02	0.03	0.03						0.04	0.06	0.05			0.05	0.04
Office - Small	OfS		0.03	0.02	0.03		0.04	0.05	0.05	0.05	0.06	0.04	0.06	0.05		0.07	0.05	0.05
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.03	0.02	0.04						0.07	0.05	0.05	0.06				0.05
Restaurant - Sit Down	RSD						0.05	0.05	0.06	0.07	0.08			0.07	0.09			0.07
Retail - 3 story	R3	0.00	0.03	0.03	0.05	0.04			0.07	0.07		0.06	0.06	0.07				0.05
Retail - Large 1 story	RL						0.05	0.05	0.06	0.06	0.07					0.08		0.06
Retail - Small	RS						0.06	0.06	0.06	0.07	0.08							0.06
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	2SPD	Tier3, 12.5EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm						104	125	133	110	131							120
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		85	65	88	68	106		129	100	115	124	100	124	128		71	100
Education - Primary School	EPPr							62	63	64	69			74	73			67
Education - Secondary School	ESe						56		65	61								61
Education - University	EUn			95	117		137		146	124	137	149	126	149				131
Grocery	Gro																	
Health/Medical - Hospital	Hsp									208								208
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT										167							167
Manufacturing - Light Industrial	MLI			34				71						110				72
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						75		95	90	99			111	118	206	49	105
Office - Large	OFL		99	94	108	99						122	116	128			94	108
Office - Small	OFS		86	79	94		110	119	117	107	118	115	100	123		187	85	111
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		93	66	107							144	147	113	158			118
Restaurant - Sit Down	RSD						121	120	142	128	154			145	165			139
Retail - 3 story	Rt3	28	107	74	119	82			183	153		149	121	162				118
Retail - Large 1 story	RtL						128	137	150	132	152					264		160
Retail - Small	RtS						133	152	148	132	150							143
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm						0.06	0.07	0.08	0.08	0.10							0.08
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		0.04	0.01	0.02	0.05	0.04		0.09	0.06	0.09	0.04	0.08	0.02	0.09		0.04	0.05
Education - Primary School	EPr							0.07	0.07	0.02	0.02			0.02	0.03			0.04
Education - Secondary School	ESe						0.00		0.08	0.01								0.03
Education - University	EUn			0.02	0.04		0.05		0.10	0.06	0.10	0.05	0.09	0.02				0.06
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.08								0.08
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									0.07								0.07
Manufacturing - Light Industrial	MLI			0.01				0.07						0.03				0.04
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.04		0.06	0.06	0.07			0.06	0.08	0.07	0.04	0.06
Office - Large	OfL		0.05	0.03	0.04	0.05						0.06	0.09	0.06				0.07
Office - Small	OfS		0.05	0.02	0.04		0.06	0.07	0.08	0.07	0.09	0.06	0.08	0.07		0.10	0.07	0.07
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.04	0.03	0.06						0.10	0.08	0.07	0.09				0.07
Restaurant - Sit Down	RSD						0.07	0.07	0.09	0.10	0.11			0.09	0.12			0.09
Retail - 3 story	Rt3	0.00	0.05	0.04	0.08	0.06			0.10	0.10		0.09	0.08	0.10				0.07
Retail - Large 1 story	RtL						0.07	0.07	0.09	0.09	0.10						0.11	0.09
Retail - Small	RtS						0.08	0.09	0.09	0.10	0.11							0.09
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	2SPD	Tier4, 13.0EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH																		
Assembly	Asm						134	160	170	140	168							154
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		109	84	112	87	136		165	128	147	159	128	158	164		91	128
Education - Primary School	EPPr							79	81	82	88			95	94			86
Education - Secondary School	ESe						72		83	79								78
Education - University	EUn			122	149		176		187	159	175	191	162	191				168
Grocery	Gro																	
Health/Medical - Hospital	Hsp									266								266
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT										214							214
Manufacturing - Light Industrial	MLI			44				91						140				92
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						96		121	116	126		142	152	264	63		135
Office - Large	OFL		127	120	139	127						157	149	164			120	138
Office - Small	OFS		110	101	120		140	153	150	137	151	147	128	158		240	109	142
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		119	84	138						185	188	145	202				151
Restaurant - Sit Down	RSD						156	154	181	164	197			185	211			178
Retail - 3 story	Rt3	36	137	94	152	106			235	196		191	156	207				151
Retail - Large 1 story	RtL						164	175	192	169	195					338		205
Retail - Small	RtS						170	195	190	169	192							183
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																		
bidgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm						0.08	0.08	0.11	0.11	0.13							0.10
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		0.05	0.01	0.03	0.06	0.05		0.12	0.07	0.12	0.05	0.10	0.02	0.11		0.06	0.07
Education - Primary School	EPr							0.09	0.10	0.02	0.02			0.03	0.03			0.05
Education - Secondary School	ESe						0.00		0.11	0.02								0.04
Education - University	EUn			0.02	0.05		0.07		0.13	0.08	0.12	0.07	0.11	0.03				0.07
Grocery	Gro																	
Health/Medical - Hospital	Hsp									0.11								0.11
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									0.09								0.09
Manufacturing - Light Industrial	MLI			0.01				0.09						0.04				0.05
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						0.05		0.07	0.08	0.09			0.08	0.10	0.10	0.06	0.08
Office - Large	OfL		0.07	0.03	0.06	0.06						0.07	0.11	0.08			0.08	0.07
Office - Small	OfS		0.06	0.03	0.05		0.07	0.09	0.10	0.10	0.12	0.07	0.11	0.09		0.12	0.09	0.08
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF		0.05	0.03	0.08						0.12	0.10	0.09	0.11				0.08
Restaurant - Sit Down	RSD						0.09	0.09	0.12	0.12	0.15			0.12	0.16			0.12
Retail - 3 story	R3	0.01	0.06	0.05	0.10	0.08			0.13	0.13		0.12	0.10	0.13				0.09
Retail - Large 1 story	RL						0.09	0.10	0.11	0.11	0.13					0.14		0.11
Retail - Small	RS						0.10	0.11	0.12	0.12	0.14							0.12
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
11.6 - 20 Ton	2SPD	Tier1, 11.5EER, 2spd	Yes, Yes	Small DX

Average Ex-post Savings kWh/ton																		
		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	
Building Type		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Average
AGOTH																		
Assembly	Asm						49	62	66		64					123		73
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		33	18	32		36	43	50	38	47	55	41	54	58		28	41
Education - Primary School	EPr								25	27	30			35				29
Education - Secondary School	ESe						21				30							25
Education - University	EUn								55				50	64				56
Grocery	Gro																	
Health/Medical - Hospital	Hsp																	
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									60								60
Manufacturing - Light Industrial	MLI																	
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						21		34	37	41				55		16	34
Office - Large	OIL		32		36							50	44	53				39
Office - Small	OIS			19	32	20	38		44	41	47		39				28	34
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF			15	40							67		72				49
Restaurant - Sit Down	RSD							52	65	59								66
Retail - 3 story	Rt3		46	26	51				80	66		72	54	77		82		59
Retail - Large 1 story	RtL						50		63	57	69				66			61
Retail - Small	RtS						50	57			66							58
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																	
bldgtype	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																	
Assembly	Asm					0.03	0.03	0.04		0.05					0.06		0.04
CNC																	
Multiple - Commercial																	
Education - Community College	ECC	0.02	0.00	0.01		0.02	0.04	0.05	0.03	0.05	0.02	0.04	0.01	0.04		0.02	0.03
Education - Primary School	EPr							0.04	0.01	0.01				0.01			0.02
Education - Secondary School	ESe					0.00				0.01							0.00
Education - University	EUn							0.05				0.04	0.01				0.04
Grocery	Gro																
Health/Medical - Hospital	Hsp																
Lodging - Hotel	HI																
Industrial																	
Manufacturing - Bio/Tech	MBT								0.03								0.03
Manufacturing - Light Industrial	MLI																
Lodging - Motel																	
Health/Medical - Nursing Home	Nrs					0.02		0.03	0.03	0.04				0.04		0.02	0.03
Office - Large	OL	0.03	0.00	0.02							0.03	0.05	0.03				0.03
Office - Small	OS		0.00	0.02	0.02	0.03		0.04	0.04	0.05		0.04				0.04	0.03
Miscellaneous																	
Res																	
Restaurant - Fast Food	RFF		0.01	0.03							0.04		0.04				0.03
Restaurant - Sit Down	RSD						0.04	0.05	0.05	0.06				0.06			0.05
Retail - 3 story	Rt3	0.03	0.02	0.04				0.05	0.05		0.05	0.04	0.05				0.04
Retail - Large 1 story	RtL					0.04		0.04	0.05	0.05				0.05			0.05
Retail - Small	RtS					0.04	0.04			0.05							0.05
S_AGR																	
S_FST																	
Storage - Conditioned	SCn																
Single Family Residential																	

Unit Size	Base	Scenario	Working Economizer	Sample Group
11.6 - 20 Ton	2SPD	Tier2, 12.0EER, 2spd	Yes, Yes	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm						81	101	107		105					201		119
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		53	29	52		59	71	81	63	76	90	66	89	95		46	67
Education - Primary School	EPr								40	43	48			57				47
Education - Secondary School	ESe						34				49							41
Education - University	EUn								90				82	105				92
Grocery	Gro																	
Health/Medical - Hospital	Hsp																	
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									99								99
Manufacturing - Light Industrial	MLI																	
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						35		56	60	67				89		26	56
Office - Large	OL		53	35	59							81	72	86				64
Office - Small	OS			31	53	33	62		71	66	76		64				46	56
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF			24	66							109		117				79
Restaurant - Sit Down	RSD							85	106	97	120				134			109
Retail - 3 story	R3		75	42	83							117	89	126				96
Retail - Large 1 story	RL						81		131	107					108			100
Retail - Small	RS						82	93	104	94	112							95
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																	
bldgtype	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																	
Assembly	Asm					0.05	0.06	0.07		0.09					0.09		0.07
CNC																	
Multiple - Commercial																	
Education - Community College	ECC	0.03	0.00	0.02		0.03	0.07	0.08	0.05	0.08	0.03	0.07	0.02	0.07		0.04	0.04
Education - Primary School	EPr							0.06	0.01	0.01				0.02			0.03
Education - Secondary School	ESe					0.00				0.01							0.01
Education - University	EUn							0.08				0.07	0.02				0.06
Grocery	Gro																
Health/Medical - Hospital	Hsp																
Lodging - Hotel	HI																
Industrial																	
Manufacturing - Bio/Tech	MBT								0.06								0.06
Manufacturing - Light Industrial	MLI																
Lodging - Motel																	
Health/Medical - Nursing Home	Nrs					0.04		0.05	0.05	0.06				0.07		0.04	0.05
Office - Large	OL	0.05	0.01	0.04							0.05	0.07	0.06				0.05
Office - Small	OS		0.01	0.03	0.03	0.05		0.07	0.06	0.08		0.07				0.06	0.05
Miscellaneous																	
Res																	
Restaurant - Fast Food	RFF		0.01	0.06							0.06		0.07				0.05
Restaurant - Sit Down	RSD						0.06	0.08	0.08	0.10				0.10			0.08
Retail - 3 story	Rt3	0.04	0.03	0.07				0.08	0.08		0.08	0.07	0.08				0.07
Retail - Large 1 story	RtL					0.06		0.07	0.07	0.09				0.08			0.08
Retail - Small	RtS					0.07	0.07			0.09							0.08
S_AGR																	
S_FST																	
Storage - Conditioned	SCn																
Single Family Residential																	

Unit Size	Base	Scenario	Working Economizer	Sample Group
11.6 - 20 Ton	2SPD	Tier3, 12.5EER, 2spd	Yes, Yes	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Assembly	Asm						110	137	147		143					275		162
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		73	39	72		80	96	111	86	104	123	91	121	129		63	91
Education - Primary School	EPPr								55	59	66			78				64
Education - Secondary School	ESe						47				67							57
Education - University	EUn								122				112	143				126
Grocery	Gro																	
Health/Medical - Hospital	Hsp																	
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									135								135
Manufacturing - Light Industrial	MLI																	
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						48		77	82	91				122		36	76
Office - Large	OL		72	48	81							111	98	117				88
Office - Small	OS			42	72	45	85		97	91	104		87				62	76
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF			33	90							149		160				108
Restaurant - Sit Down	RSD							116	145	132	164				183			148
Retail - 3 story	RI3		103	57	114				179	146		160	122	172				132
Retail - Large 1 story	RI1						111		141	128	153			147				136
Retail - Small	RI2						112	127			148							129
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																	
bldgtype	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																	
Assembly	Asm					0.07	0.08	0.10		0.12					0.12		0.10
CNC																	
Multiple - Commercial																	
Education - Community College	ECC	0.05	0.00	0.03		0.05	0.09	0.11	0.06	0.10	0.05	0.09	0.02	0.10		0.05	0.06
Education - Primary School	EPr							0.09	0.02	0.02				0.03			0.04
Education - Secondary School	ESe					0.00				0.02							0.01
Education - University	EUn							0.11				0.10	0.03				0.08
Grocery	Gro																
Health/Medical - Hospital	Hsp																
Lodging - Hotel	HI																
Industrial																	
Manufacturing - Bio/Tech	MBT								0.08								0.08
Manufacturing - Light Industrial	MLI																
Lodging - Motel																	
Health/Medical - Nursing Home	Nrs					0.05		0.07	0.07	0.08				0.09		0.05	0.07
Office - Large	OL	0.06	0.01	0.05							0.07	0.10	0.08				0.06
Office - Small	OS		0.01	0.04	0.05	0.07		0.09	0.09	0.10		0.10				0.08	0.07
Miscellaneous																	
Res																	
Restaurant - Fast Food	RFF		0.02	0.07							0.09		0.10				0.07
Restaurant - Sit Down	RSD						0.08	0.11	0.11	0.13				0.14			0.11
Retail - 3 story	Rt3	0.06	0.04	0.09				0.11	0.11		0.10	0.09	0.11				0.09
Retail - Large 1 story	RtL					0.08		0.10	0.10	0.12				0.11			0.10
Retail - Small	RtS					0.09	0.10			0.12							0.10
S_AGR																	
S_FST																	
Storage - Conditioned	SCn																
Single Family Residential																	

Unit Size	Base	Scenario	Working Economizer	Sample Group
11.6 - 20 Ton	2SPD	Tier4, 13.0EER, 2spd	Yes, Yes	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Assembly	Asm						138	172	183		179					343		203
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		91	49	89		100	120	138	107	130	154	113	152	162		79	114
Education - Primary School	EPr								69	74	83			97				81
Education - Secondary School	ESe						58				83							71
Education - University	EUn								153				140	179				157
Grocery	Gro																	
Health/Medical - Hospital	Hsp																	
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									168								168
Manufacturing - Light Industrial	MLI																	
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						60		96	102	114				152		44	95
Office - Large	OL		90	60	101							138	123	146				110
Office - Small	OS			52	89	57	106		122	113	130		109				78	95
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF			42	113							187		200				135
Restaurant - Sit Down	RSD							145	181	165	205				229			185
Retail - 3 story	R3		128	72	142							200	152	214				164
Retail - Large 1 story	RL						139		177	160	191				184			170
Retail - Small	RS						140	159			185							161
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																	
bldgtype	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																	
Assembly	Asm					0.09	0.10	0.12		0.15					0.16		0.12
CNC																	
Multiple - Commercial																	
Education - Community College	ECC	0.06	0.00	0.03		0.06	0.12	0.13	0.08	0.13	0.06	0.11	0.03	0.12		0.07	0.08
Education - Primary School	EPr							0.11	0.02	0.02				0.04			0.05
Education - Secondary School	ESe					0.00				0.02							0.01
Education - University	EUn							0.14				0.12	0.04				0.10
Grocery	Gro																
Health/Medical - Hospital	Hsp																
Lodging - Hotel	HI																
Industrial																	
Manufacturing - Bio/Tech	MBT								0.10								0.10
Manufacturing - Light Industrial	MLI																
Lodging - Motel																	
Health/Medical - Nursing Home	Nrs					0.06		0.08	0.09	0.10				0.12		0.07	0.09
Office - Large	OL	0.08	0.01	0.06							0.08	0.13	0.09				0.08
Office - Small	OS		0.01	0.06	0.06	0.08		0.11	0.11	0.13		0.12				0.10	0.09
Miscellaneous																	
Res																	
Restaurant - Fast Food	RFF		0.02	0.10							0.11		0.12				0.09
Restaurant - Sit Down	RSD						0.10	0.13	0.14	0.16				0.18			0.14
Retail - 3 story	Rt3	0.07	0.04	0.11				0.14	0.14		0.13	0.12	0.14				0.11
Retail - Large 1 story	RtL					0.10		0.12	0.13	0.15				0.14			0.13
Retail - Small	RtS					0.11	0.12			0.15							0.13
S_AGR																	
S_FST																	
Storage - Conditioned	SCn																
Single Family Residential																	

Unit Size	Base	Scenario	Working Economizer	Sample Group
11.6 - 20 Ton	2SPD	Tier1, 11.5EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm						55	65	70		69					127		77
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		45	35	47		56	64	67	53	61	65	53	65	67		38	55
Education - Primary School	EPPr								33	34	36			39				36
Education - Secondary School	ESe						30				36							33
Education - University	EUn								77				67	78				74
Grocery	Gro																	
Health/Medical - Hospital	Hsp																	
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									87								87
Manufacturing - Light Industrial	MLI																	
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						41		51	49	53				64		27	47
Office - Large	OL		52	49	57							65	61	68				59
Office - Small	OS			42	50	44	58		62	57	62		53				45	52
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF			35	57							77		83				63
Restaurant - Sit Down	RSD								63	74	67	81			86			74
Retail - 3 story	RI3		56	39	63					95	80		78	64	84			70
Retail - Large 1 story	RI1						67		79	70	80				71			73
Retail - Small	RI5						69	79			78							76
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																	
bidgtype	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																	
Assembly	Asm					0.03	0.03	0.04		0.05					0.06		0.04
CNC																	
Multiple - Commercial																	
Education - Community College	ECC	0.02	0.00	0.01		0.02	0.04	0.05	0.03	0.05	0.02	0.04	0.01	0.04		0.02	0.03
Education - Primary School	EPr							0.04	0.01	0.01				0.01			0.02
Education - Secondary School	ESe					0.00				0.01							0.00
Education - University	EUn							0.05				0.04	0.01				0.04
Grocery	Gro																
Health/Medical - Hospital	Hsp																
Lodging - Hotel	HI																
Industrial																	
Manufacturing - Bio/Tech	MBT								0.03								0.03
Manufacturing - Light Industrial	MLI																
Lodging - Motel																	
Health/Medical - Nursing Home	Nrs					0.02		0.03	0.03	0.04				0.04		0.02	0.03
Office - Large	OL	0.03	0.01	0.02							0.03	0.05	0.03				0.03
Office - Small	OS		0.01	0.02	0.02	0.03		0.04	0.04	0.05		0.04				0.04	0.03
Miscellaneous																	
Res																	
Restaurant - Fast Food	RFF		0.01	0.03							0.04		0.04				0.03
Restaurant - Sit Down	RSD						0.04	0.05	0.05	0.06				0.06			0.05
Retail - 3 story	Rt3	0.03	0.02	0.04				0.05	0.05		0.05	0.04	0.05				0.04
Retail - Large 1 story	RtL					0.04		0.04	0.05	0.05				0.05			0.05
Retail - Small	RtS					0.04	0.04			0.05							0.05
S_AGR																	
S_FST																	
Storage - Conditioned	SCn																
Single Family Residential																	

Unit Size	Base	Scenario	Working Economizer	Sample Group
11.6 - 20 Ton	2SPD	Tier2, 12.0EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Assembly	Asm						90	107	114		113					208		126
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		74	57	76		91	105	110	87	99	107	86	106	110		62	90
Education - Primary School	EPPr								55	56	59			64				58
Education - Secondary School	ESe						48				59							54
Education - University	EUn								126				109	128				121
Grocery	Gro																	
Health/Medical - Hospital	Hsp																	
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									142								142
Manufacturing - Light Industrial	MLI																	
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						66		84	80	87				104			78
Office - Large	OL		86	81	94							106	100	110				96
Office - Small	OS			68	81	71	94		101	93	102		86				73	86
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF			58	94							127		136				103
Restaurant - Sit Down	RSD							103	121	110	132				140			121
Retail - 3 story	RI3		92	64	102				156	131		127	104	137				114
Retail - Large 1 story	RI1						110		129	114	131				116			120
Retail - Small	RI2						113	129			128							124
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																	
bldgtype	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																	
Assembly	Asm					0.05	0.06	0.07		0.09					0.09		0.07
CNC																	
Multiple - Commercial																	
Education - Community College	ECC	0.04	0.01	0.02		0.03	0.07	0.08	0.05	0.08	0.03	0.07	0.02	0.07		0.04	0.05
Education - Primary School	EPr							0.06	0.01	0.01				0.02			0.03
Education - Secondary School	ESe					0.00				0.01							0.01
Education - University	EUn							0.08				0.07	0.02				0.06
Grocery	Gro																
Health/Medical - Hospital	Hsp																
Lodging - Hotel	HI																
Industrial																	
Manufacturing - Bio/Tech	MBT								0.06								0.06
Manufacturing - Light Industrial	MLI																
Lodging - Motel																	
Health/Medical - Nursing Home	Nrs					0.04		0.05	0.05	0.06				0.07		0.04	0.05
Office - Large	OL	0.05	0.02	0.04							0.05	0.07	0.05				0.05
Office - Small	OS		0.02	0.03	0.04	0.05		0.07	0.06	0.08		0.07				0.06	0.05
Miscellaneous																	
Res																	
Restaurant - Fast Food	RFF		0.02	0.06							0.06		0.07				0.05
Restaurant - Sit Down	RSD						0.06	0.08	0.08	0.10				0.10			0.08
Retail - 3 story	Rt3	0.04	0.03	0.07				0.08	0.08		0.08	0.07	0.08				0.07
Retail - Large 1 story	RtL					0.06		0.07	0.07	0.09				0.08			0.08
Retail - Small	RtS					0.07	0.07			0.09							0.08
S_AGR																	
S_FST																	
Storage - Conditioned	SCn																
Single Family Residential																	

Unit Size	Base	Scenario	Working Economizer	Sample Group
11.6 - 20 Ton	2SPD	Tier3, 12.5EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
Building Type		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																		
Assembly	Asm						123	146	156		154					284		173
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		101	78	104		124	143	151	119	135	146	118	145	150		85	123
Education - Primary School	EPr								75	76	81			87				80
Education - Secondary School	ESe						66				81							74
Education - University	EUn								172				149	175				165
Grocery	Gro																	
Health/Medical - Hospital	Hsp																	
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									194								194
Manufacturing - Light Industrial	MLI																	
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						91		114	109	119				142		60	106
Office - Large	OL		117	110	128							144	137	151				131
Office - Small	OS			93	111	97	129		138	127	139		118				100	117
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF			79	128							173		185				141
Restaurant - Sit Down	RSD							141	166	151	180				192			166
Retail - 3 story	R3		126	87	140							174	143	187				156
Retail - Large 1 story	RL						150		213	179					159			164
Retail - Small	RS						155	176			175							169
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																	
bldgtype	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																	
Assembly	Asm					0.07	0.08	0.10		0.12					0.12		0.10
CNC																	
Multiple - Commercial																	
Education - Community College	ECC	0.05	0.01	0.03		0.05	0.09	0.11	0.06	0.10	0.05	0.09	0.02	0.10		0.05	0.06
Education - Primary School	EPr							0.09	0.02	0.02				0.03			0.04
Education - Secondary School	ESe					0.00				0.02							0.01
Education - University	EUn							0.11				0.10	0.03				0.08
Grocery	Gro																
Health/Medical - Hospital	Hsp																
Lodging - Hotel	HI																
Industrial																	
Manufacturing - Bio/Tech	MBT								0.08								0.08
Manufacturing - Light Industrial	MLI																
Lodging - Motel																	
Health/Medical - Nursing Home	Nrs					0.05		0.07	0.07	0.08				0.09		0.05	0.07
Office - Large	OL	0.06	0.03	0.05							0.07	0.10	0.08				0.06
Office - Small	OS		0.03	0.04	0.05	0.07		0.09	0.09	0.10		0.10				0.08	0.07
Miscellaneous																	
Res																	
Restaurant - Fast Food	RFF		0.03	0.07							0.09		0.10				0.07
Restaurant - Sit Down	RSD						0.08	0.11	0.11	0.13				0.14			0.11
Retail - 3 story	Rt3	0.06	0.05	0.09				0.11	0.11		0.10	0.09	0.11				0.09
Retail - Large 1 story	RtL					0.08		0.10	0.10	0.12				0.11			0.10
Retail - Small	RtS					0.09	0.10			0.12							0.10
S_AGR																	
S_FST																	
Storage - Conditioned	SCn																
Single Family Residential																	

Unit Size	Base	Scenario	Working Economizer	Sample Group
11.6 - 20 Ton	2SPD	Tier4, 13.0EER, 2spd	No, No	Small DX

Average Ex-post Savings kWh/ton																		
Building Type		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
AGOTH		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Assembly	Asm						154	182	195		192					354		215
CNC																		
Multiple - Commercial																		
Education - Community College	ECC		126	97	130		155	179	188	149	169	182	147	181	188		106	154
Education - Primary School	EPPr								93	95	101			108				99
Education - Secondary School	ESe						83				101							92
Education - University	EUn								214				186	218				206
Grocery	Gro																	
Health/Medical - Hospital	Hsp																	
Lodging - Hotel	Htl																	
Industrial																		
Manufacturing - Bio/Tech	MBT									243								243
Manufacturing - Light Industrial	MLI																	
Lodging - Motel																		
Health/Medical - Nursing Home	Nrs						113		143	136	149				178		75	132
Office - Large	OL		146	137	160							180	171	188				164
Office - Small	OS			116	138	122	161		172	159	174		147				125	146
Miscellaneous																		
Res																		
Restaurant - Fast Food	RFF			99	160							216		231				176
Restaurant - Sit Down	RSD							176	207	188	225				240			207
Retail - 3 story	RI3		157	109	174				266	223		217	178	234				195
Retail - Large 1 story	RI1						187		220	195	223				199			205
Retail - Small	RI2						193	220			219							211
S_AGR																		
S_FST																		
Storage - Conditioned	SCn																	
Single Family Residential																		

Average Ex-post savings kW/ton																	
bidgtype	w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
AGOTH																	
Assembly	Asm					0.09	0.09	0.12		0.15					0.16		0.12
CNC																	
Multiple - Commercial																	
Education - Community College	ECC	0.06	0.01	0.03		0.06	0.11	0.13	0.08	0.13	0.06	0.11	0.03	0.12		0.07	0.08
Education - Primary School	EPr							0.11	0.02	0.02				0.04			0.05
Education - Secondary School	ESe					0.00				0.02							0.01
Education - University	EUn							0.14				0.13	0.04				0.10
Grocery	Gro																
Health/Medical - Hospital	Hsp																
Lodging - Hotel	HI																
Industrial																	
Manufacturing - Bio/Tech	MBT								0.10								0.10
Manufacturing - Light Industrial	MLI																
Lodging - Motel																	
Health/Medical - Nursing Home	Nrs					0.06		0.08	0.09	0.10				0.12		0.07	0.09
Office - Large	OL	0.08	0.04	0.06							0.08	0.13	0.09				0.08
Office - Small	OS		0.03	0.05	0.07	0.08		0.11	0.11	0.13		0.12				0.10	0.09
Miscellaneous																	
Res																	
Restaurant - Fast Food	RFF		0.04	0.10							0.11		0.12				0.09
Restaurant - Sit Down	RSD						0.10	0.13	0.14	0.17				0.18			0.14
Retail - 3 story	Rt3	0.07	0.06	0.11				0.14	0.14		0.13	0.12	0.14				0.11
Retail - Large 1 story	RtL					0.10		0.13	0.13	0.15				0.14			0.13
Retail - Small	RtS					0.11	0.12			0.15							0.13
S_AGR																	
S_FST																	
Storage - Conditioned	SCn																
Single Family Residential																	



Appendix B. DATA COLLECTION FIELD PROTOCOLS AND PROCEDURES

Introduction

This document provides field data collection protocols and procedures for the small package HVAC (≤ 20 Tons Cooling Capacity) element for Phase III of the Upstream HVAC data collection component. Its purpose is to ensure rigorous onsite data collection, allowing analysts to achieve the objectives of this study. Section 2 allows evaluation of fan power draw, Section 3 allows evaluation of unit economizer presence and functionality both in simulated weather conditions and basic operational functionality. This document covers all onsite activities conducted during the initial and any subsequent site visits. Refer to the M&V plan for details related to the instrumentation discussed in this document.


Unit Verification and General Site Data

Upon arriving to the scheduled sites meet with the designated site contact and discuss the schedule of activities and needs of the on-site visit. Confirm there are no unique hazards or safety concerns that need to be considered. Also ask the building vintage and confirm the DEER-defined building type on the site sheet matches the areas served by the units to be tested, and take notes of any disparities. Find out how the HVAC systems are controlled. If possible ask to see the thermostats for the units to be tested. Determine the safest and least invasive access point to the HVAC equipment and transport the equipment and yourself to the roof outside area following the DNV GL Job Safety Analysis prescribed methods.

Upon arrival to the roof or area outside the building with the package HVAC equipment examine the units to identify the tracking data units by looking at unit nameplates for manufacturer, model number and serial numbers. Confirm the presence of all units listed in the tracking data. Additionally, record the nominal cooling capacity of all units serving the conditioned floor area of the premise. Do not include any mini-split units that are dedicated server room units. Select two units from the list of upstream program units to test. Depending on how many qualifying units are present the selection process will vary. If two or fewer units are present then the procedure is to test all units. If greater than two units are present attempt to test at least two units that will represent the highest percentage of qualifying units present at the site. For example if a site has (9) identical five-ton units and one seven-ton unit it would be better to select two of the five-ton units than it would to select one five and one seven-ton unit. If there is a more even distribution of unit types and sizes attempt to diversify the unit selection so multiple types are included in the test procedure. Please test as many units as possible, do not stop at two units if there is sufficient time.

Here is a summary of the data to be collected:

- **Installation characteristics:** Record the building type, space type, and square footage served by each selected unit.
- **Equipment nameplate:** Record the nameplate information and photographed the nameplate.
- **Economizer:** Record the presence or absence of an economizer on each selected unit and, where an economizer was present, perform economizer functionality testing on selected units with cooling capacities of 20 tons and below.

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- **Application characteristics:** Record the building type and space type served by each selected unit.
 - **Operating characteristics:** Attempt to collect the operating and set-point schedules. Where possible, obtain the schedules by direct observation of a programmable thermostat or energy management system. When you can not directly observe the schedules, ask facility personnel for the schedules. Record the on/off time for weekdays, weekends, and holidays and the heating and cooling set points for occupied and non-occupied periods.

HVAC Unit and Fan Power Testing

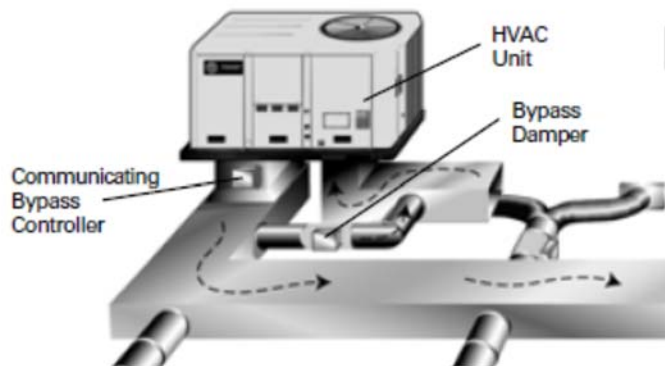
HVAC Unit Information

Once the units have been selected, record the corresponding measure number from the first page of the DNV GL site form and the unit identifier on the side of the unit (designated by the facility) on the HVAC info page, the Fan power page, and the Economizer Test page. Take a picture of the HVAC unit and its surroundings, take a picture of the nameplate and record all of the following pieces of information from the nameplate: manufacturer, model number, serial number, and manufacture date (if listed).

Based on the presence or absence of a gas line going into the units, the term “heat pump” listed on the nameplate or the first few characters of the model number determine the unit type. Record the type of unit on the site form (Package AC only, Package AC w/Furnace, Package Heat Pump). Observe the location of the ducts and indicate if they are in conditioned space, on the roof, or some other location. The duct location will be obvious if on roof, if not on roof look for ducts inside conditioned space, if above drop down ceilings or other ceiling types attempt to determine the location of the roof insulation. Look to see if the insulation is at the roof or resting on top of the drop ceiling. If insulation is just under the roof or above the roof deck but below the roof membrane and ducts go straight down to the conditioned space then ducts are in conditioned space. If the ducts are between the insulation and the ceiling please describe in notes and provide photos. Also note whether or not there is insulation on the plenum walls in these cases.

The Duct Configuration refers to the duct runs after the initial plenum or chase run from the roof. Most office buildings or areas with drop down ceilings have horizontal ducts running above the ceiling tiles. Large box stores or warehouse stores have down flow ducts that lead directly to supply and return vents with little or no horizontal air movement. Indicate which type is present in the Duct Configuration field.

Check for the presence of “runaround” bypass ducts. Bypass ducts are a way of complying with the Title 24 code requirement for variable volume with a single speed fan. Bypass ducts are ducts that brings cold supply air back into the mixed air chamber. Bypass ducts are easily identified when on the roof, but could be difficult to discern when located in the plenum. Look for a duct that runs from the supply back to the return or mixed air chamber. There may also be a bypass damper actuator visible.



If a Variable Speed Drive or Variable Frequency Drive (VSD) is installed it will likely be inside the unit with a digital display. Make a note of its presence and take a photograph of it if present. If not, indicate "No" in the VSD present field.

Fan Power Measurements

Prior to performing the fan spot power measurements attempt trace the load wires leading to the evaporator or supply fan of the unit. If able to identify these wires attempt to trace them to a location where they can be accessed with a clamp-on true power meter outside of the air chambers so that all air-handler cabinet doors are closed and normal air-flow is not being altered because of testing conditions. If able to isolate the evaporator fan lines, jump the HVAC unit into max cooling mode so that all compressors are running.

If unable to determine the which contactors feed the supply fan, then take the unit power in fan-only mode and then the unit level power in standby mode. The fan power is then calculated by subtracting standby power from the unit-level fan only mode power, so both measurements are necessary.

The fan should be at full flow for the measurements. Verify that the fan is in full flow and note how you determined this on the site form. If you are unable to determine if the fan is at full flow or are unable to get the unit into full fan flow, call field support with the make and model number and they can access the manual to aid in the determination and manipulation of the controls.

1. Suit up. Make sure you properly use all appropriate Personal Protective Equipment (PPE) and follow all DNV GL safety procedures.
2. Take phase-to-ground spot power measurements on the fan using the power meter. Record volts, amps, power, power factor (pf), and time. If the fan can't be isolated, spot measurements should be taken on the line side of the disconnect are preferable.



3. Wait a minute and take another set of spot power measurements. If using a single-phase meter, move the amp clamp and voltage tap over to the next leg and record two more sets of measurements, then repeat for the 3rd leg if equipped.
4. Run the unit to ensure proper operation.

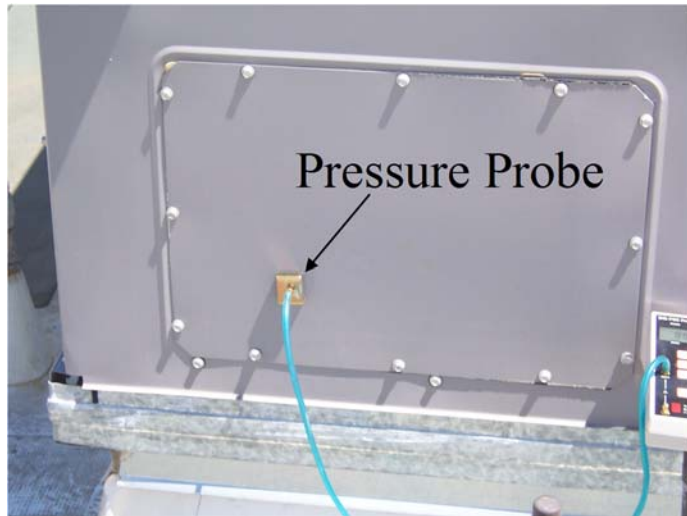
Pressure Testing Protocol

Static Pressure Testing

Manufacturers typically provide tables in their service manuals listing fan flow as a function of external static pressure (ESP) and fan revolutions per minute (RPM). Unfortunately, manufacturers are not consistent in their definition of ESP; some manufacturers use ESP to refer to the pressure change across the supply fan alone, while other use ESP to refer to the pressure change across the whole unit (inclusive of filters & cooling coil). Tests will be conducted to account for both possibilities.

Perform the test according to the following procedure:


1. Turn the unit off. Lockout and tag out. If there is no local disconnect, consult the site contact and call the field manager as needed before attempting to disable power.
2. Examine the unit's return and supply plenum to identify the presence of previously-made static pressure holes. If present, use the existing static pressure holes. If no holes are found drill ¼" static pressure tap holes in the unit. Drill holes on the outlet side of the fan (supply plenum) and the inlet to the unit (return air plenum). When installing the probes, attempt to insert them in a "dead corner" with little to no flow.
3. Take photos of the return and supply plenum probes after completing installation.



4. After inserting the probes turn the unit back on. If necessary, jump the unit into maximum Cooling to activate the fan. Check to see that the evaporative coil is moist, if not wait 5-10 minutes or until the coil becomes moist. Attach the return plenum outlet probe to the "input" port of a DG700 gauge and leave the "reference" port of the gauge open to ambient air pressure. With the DG 700 gauge in PR/PR (Pressure/Pressure) Mode rotate the probe until the pressure reading is minimized, indicating that the probe is no longer picking up velocity pressure. Set the reading to record a 5 second average reading. Record the second reading in the "static pressure return to ambient" field.
5. Switch the return air probe tube from the "input" to the "reference" port on the DG 700 gauge. Attach the supply air probe tube to the "input" port. Rotate the probe until the pressure reading is minimized, indicating that the probe is no longer picking up velocity pressure. Set the reading to record a 5 second average reading. Record the second reading in the "static pressure across unit" field.
6. Remove the return plenum probe from the plenum and the DG 700 gauge leaving the reference port open and the supply plenum probe in place and connected to the "input" port A of the DG 700 gauge.
7. Plug and seal the return plenum hole with permanent hole plugs.

Economizer Verification and Testing

Inspect the economizer controller and record the model number. Determine whether the sensors are enthalpy (temp/RH) or dry-bulb sensors and if the economizer type is a setpoint single sensor, or a differential set-up. Jade controllers have a MAT sensor. If an OAT sensor is connected, indicates single point temperature control. If S-Bus sensors connected, indicates enthalpy control. S-bus sensor in



the return indicates dual enthalpy. OA S-bus sensor only indicates single point enthalpy. Record any sensor model numbers and sensor set points (some sensors have dip switches for adjusting the sensor set points).

Actuator Test – The actuator test is conducted by using the test function of the economizer controller to open and/or close the economizer dampers. If the dampers can be moved into the desired position via the controller, this is considered a passing test. A passing actuator test assures that the damper motor, linkage and actuator for the economizer is working properly.

Sensor Test – The sensor test is conducted by fooling the temperature sensor such that the economizer either opens or closes the outside air damper. If the temperature is warm and the outside air damper is closed, then the outside air sensor will be fooled using cold spray or a cold pack on the outside air temperature or enthalpy sensor. The outside air temperature display on the unit controller is monitored during the test and cold spray or the cold pack is applied until the changeover set point is reached. If the unit is equipped with an enthalpy sensor, the sensor is placed in plastic bag before the cold spray or pack is applied to protect the sensor from any moisture. If the set point is unknown, a 65F setpoint is assumed and the test is considered valid (for a dry-bulb sensors) if the sensor readout is 65 or below. If the outside air is cool and the outside air dampers are open, the sensor will be fooled through direct contact with the field technicians hand or other methods of causing the perceived outside air temperature to rise above the changeover set point. The sensor test is considered passing if the manipulation of the outside air temperature sensor causes the outside air dampers to move.

Economizer Integration – If an economizer is not integrated, the outside air dampers will not ever be open while the compressor is running. If the economizer is integrated, then the outside air dampers will be open when the compressor is running if the outside air conditions are suitable for economizing. If the compressor is running and the outside air dampers are closed, determine if the outside air conditions are within the suitable economizing range. A non-functional economizer that has failed in the minimum OA position would also appear to be a non-integrated economizer. Likewise, a non-functional economizer with the OA damper failed in the fully open position (though rare), would look appear to be an integrated economizer. Therefore, it is critical to know if the economizer is functional because if it is not functional one can't determine with certainty if the economizer is integrated.


Economizer set points

Honeywell analog economizer have A, B, C, D and sometimes E setpoints. Note if the dial is in between the letters if that is the case.

For an ADEC-equipped unit, scroll through and select the setpoint menu. The setpoints that show up in the menu are a function of how the economizer is set up. Record all of the setpoints that are displayed on the set point menu.

Cleanup and Teardown Checklist


Make sure HVAC system is operating properly and thermostat is controlling the unit as-found (e.g. cooling on, scheduled program being followed). If you installed jumpers at any point, make sure you've removed them. Return economizer controller to the run mode if setup mode was used to determine setpoints. Confirm all panels have been replaced and secured.



Confirm all equipment and supplies used for testing have been removed from the premises.

Tool Checklist

- CPUC Project Validation Letter
- Pre-populated site instrument
- Clipboard and Pen
- DG-700 Manometer (Pressure Gauge)
- True Power meter, +/- 2% of reading for true RMS power, (Fluke 49 or equivalent)
- QEW PPE
- Frozen Water Bottles, Ice Pack, soft cooler
- Jumper Wires
- 50' rope with carabineer for lifting equipment
- Cell phone
- Camera
- Mini-first-aid kit
- 6-1 tool
- Small screwdriver
- Pliers
- Power Drill
- 1/4" Drill Bit
- 5/16" Hex Bit
- Shade Structure
- Snacks
- Portable tri-pod stool

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- Drinking water



Appendix C. IESR APPENDICES

Appendix AA: Standardized High Level Savings¹⁷

Appendix AB: Standardized Per Unit Savings

Appendix AC: Recommendations

¹⁷ The tables in Appendix AA summarizing natural gas savings make use of the unit MTherms – 1,000 Therms – rather than MMTherms – 1,000,000 Therms – for formatting purposes.

Gross Lifecycle Savings (MWh)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC Rooftop Or Split System	90,215	72,082	0.80	0.0%	0.80
PGE	Passthru: HVAC Chiller Air Cooled	61,391	61,391	1.00	100.0%	
PGE	Passthru: HVAC Rooftop Or Split System	57,091	57,091	1.00	100.0%	
PGE	Passthru: HVAC VRF/Mini Split	1,782	1,782	1.00	100.0%	
PGE	Total	210,479	192,346	0.91	57.1%	0.80
SCE	HVAC Rooftop Or Split System	91,242	72,903	0.80	0.0%	0.80
SCE	Passthru: HVAC Chiller Air Cooled	26,181	26,181	1.00	100.0%	
SCE	Passthru: HVAC Chiller Water Cooled	220,766	220,766	1.00	100.0%	
SCE	Passthru: HVAC Rooftop Or Split System	335	335	1.00	100.0%	
SCE	Passthru: HVAC VRF/Mini Split	41,956	41,956	1.00	100.0%	
SCE	Total	380,480	362,141	0.95	76.0%	0.80
SDGE	HVAC Rooftop Or Split System	6,861	5,482	0.80	0.0%	0.80
SDGE	Passthru: HVAC Rooftop Or Split System	166	166	1.00	100.0%	
SDGE	Total	7,026	5,647	0.80	2.4%	0.80
Statewide		597,986	560,134	0.94	68.5%	0.80

Net Lifecycle Savings (MWh)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC Rooftop Or Split System	76,683	61,269	0.80	100.0%	0.85	0.85		
PGE	Passthru: HVAC Chiller Air Cooled	37,476	37,476	1.00	100.0%	0.61	0.61		
PGE	Passthru: HVAC Rooftop Or Split System	48,528	48,528	1.00	100.0%	0.85	0.85		
PGE	Passthru: HVAC VRF/Mini Split	1,515	1,515	1.00	100.0%	0.85	0.85		
PGE	Total	164,201	148,787	0.91	100.0%	0.78	0.77		
SCE	HVAC Rooftop Or Split System	77,543	61,957	0.80	100.0%	0.85	0.85		
SCE	Passthru: HVAC Chiller Air Cooled	16,167	16,167	1.00	100.0%	0.62	0.62		
SCE	Passthru: HVAC Chiller Water Cooled	152,732	152,732	1.00	100.0%	0.69	0.69		
SCE	Passthru: HVAC Rooftop Or Split System	285	285	1.00	100.0%	0.85	0.85		
SCE	Passthru: HVAC VRF/Mini Split	35,663	35,663	1.00	100.0%	0.85	0.85		
SCE	Total	282,390	266,804	0.94	100.0%	0.74	0.74		
SDGE	HVAC Rooftop Or Split System	5,636	4,504	0.80	100.0%	0.82	0.82		
SDGE	Passthru: HVAC Rooftop Or Split System	99	99	1.00	100.0%	0.60	0.60		
SDGE	Total	5,736	4,603	0.80	100.0%	0.82	0.82		
	Statewide	452,326	420,194	0.93	100.0%	0.76	0.75		

Gross Lifecycle Savings (MW)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC Rooftop Or Split System	52.0	35.2	0.68	0.0%	0.68
PGE	Passthru: HVAC Chiller Air Cooled	5.0	5.0	1.00	100.0%	
PGE	Passthru: HVAC Rooftop Or Split System	34.1	34.1	1.00	100.0%	
PGE	Passthru: HVAC VRF/Mini Split	0.5	0.5	1.00	100.0%	
PGE	Total	91.5	74.7	0.82	43.2%	0.68
SCE	HVAC Rooftop Or Split System	63.6	43.0	0.68	0.0%	0.68
SCE	Passthru: HVAC Chiller Air Cooled	4.3	4.3	1.00	100.0%	
SCE	Passthru: HVAC Chiller Water Cooled	39.7	39.7	1.00	100.0%	
SCE	Passthru: HVAC Rooftop Or Split System	0.1	0.1	1.00	100.0%	
SCE	Passthru: HVAC VRF/Mini Split	16.4	16.4	1.00	100.0%	
SCE	Total	124.1	103.5	0.83	48.8%	0.68
SDGE	HVAC Rooftop Or Split System	2.5	1.7	0.68	0.0%	0.68
SDGE	Passthru: HVAC Rooftop Or Split System	0.1	0.1	1.00	100.0%	
SDGE	Total	2.6	1.8	0.69	3.5%	0.68
Statewide		218.3	180.0	0.82	45.9%	0.68

Net Lifecycle Savings (MW)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC Rooftop Or Split System	44.2	29.9	0.68	100.0%	0.85	0.85		
PGE	Passthru: HVAC Chiller Air Cooled	3.0	3.0	1.00	100.0%	0.61	0.61		
PGE	Passthru: HVAC Rooftop Or Split System	29.0	29.0	1.00	100.0%	0.85	0.85		
PGE	Passthru: HVAC VRF/Mini Split	0.4	0.4	1.00	100.0%	0.85	0.85		
PGE	Total	76.6	62.3	0.81	100.0%	0.84	0.83		
SCE	HVAC Rooftop Or Split System	54.1	36.5	0.68	100.0%	0.85	0.85		
SCE	Passthru: HVAC Chiller Air Cooled	2.7	2.7	1.00	100.0%	0.63	0.63		
SCE	Passthru: HVAC Chiller Water Cooled	27.4	27.4	1.00	100.0%	0.69	0.69		
SCE	Passthru: HVAC Rooftop Or Split System	0.1	0.1	1.00	100.0%	0.85	0.85		
SCE	Passthru: HVAC VRF/Mini Split	13.9	13.9	1.00	100.0%	0.85	0.85		
SCE	Total	98.2	80.7	0.82	100.0%	0.79	0.78		
SDGE	HVAC Rooftop Or Split System	2.0	1.4	0.68	100.0%	0.82	0.82		
SDGE	Passthru: HVAC Rooftop Or Split System	0.1	0.1	1.00	100.0%	0.60	0.60		
SDGE	Total	2.1	1.4	0.68	100.0%	0.81	0.80		
Statewide		176.9	144.4	0.82	100.0%	0.81	0.80		

Gross Lifecycle Savings (MTherms)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC Rooftop Or Split System	-154	-154	1.00	0.0%	1.00
PGE	Passthru: HVAC Chiller Air Cooled	0	0			
PGE	Passthru: HVAC Rooftop Or Split System	-190	-190	1.00	100.0%	
PGE	Passthru: HVAC VRF/Mini Split	3	3	1.00	100.0%	
PGE	Total	-341	-341	1.00	54.8%	1.00
SCE	HVAC Rooftop Or Split System	-112	-112	1.00	0.0%	1.00
SCE	Passthru: HVAC Chiller Air Cooled	0	0			
SCE	Passthru: HVAC Chiller Water Cooled	0	0			
SCE	Passthru: HVAC Rooftop Or Split System	0	0	1.00	100.0%	
SCE	Passthru: HVAC VRF/Mini Split	0	0	1.00	100.0%	
SCE	Total	-112	-112	1.00	0.4%	1.00
SDGE	HVAC Rooftop Or Split System	-34	-34	1.00	0.0%	1.00
SDGE	Passthru: HVAC Rooftop Or Split System	0	0			
SDGE	Total	-34	-34	1.00	0.0%	1.00
	<i>Statewide</i>	<i>-487</i>	<i>-487</i>	<i>1.00</i>	<i>38.5%</i>	<i>1.00</i>

Net Lifecycle Savings (MTherms)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC Rooftop Or Split System	-131	-131	1.00	100.0%	0.85	0.85		
PGE	Passthru: HVAC Chiller Air Cooled	0	0						
PGE	Passthru: HVAC Rooftop Or Split System	-161	-161	1.00	100.0%	0.85	0.85		
PGE	Passthru: HVAC VRF/Mini Split	2	2	1.00	100.0%	0.85	0.85		
PGE	Total	-290	-290	1.00	100.0%	0.85	0.85		
SCE	HVAC Rooftop Or Split System	-95	-95	1.00	100.0%	0.85	0.85		
SCE	Passthru: HVAC Chiller Air Cooled	0	0						
SCE	Passthru: HVAC Chiller Water Cooled	0	0						
SCE	Passthru: HVAC Rooftop Or Split System	0	0	1.00	100.0%	0.85	0.85		
SCE	Passthru: HVAC VRF/Mini Split	0	0	1.00	100.0%	0.85	0.85		
SCE	Total	-95	-95	1.00	100.0%	0.85	0.85		
SDGE	HVAC Rooftop Or Split System	-28	-28	1.00	100.0%	0.84	0.84		
SDGE	Passthru: HVAC Rooftop Or Split System	0	0						
SDGE	Total	-28	-28	1.00	100.0%	0.84	0.84		
	Statewide	-414	-414	1.00	100.0%	0.85	0.85		

Gross First Year Savings (MWh)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC Rooftop Or Split System	6,014	4,805	0.80	0.0%	0.80
PGE	Passthru: HVAC Chiller Air Cooled	3,798	3,798	1.00	100.0%	
PGE	Passthru: HVAC Rooftop Or Split System	3,806	3,806	1.00	100.0%	
PGE	Passthru: HVAC VRF/Mini Split	119	119	1.00	100.0%	
PGE	Total	13,737	12,528	0.91	56.2%	0.80
SCE	HVAC Rooftop Or Split System	9,751	7,791	0.80	0.0%	0.80
SCE	Passthru: HVAC Chiller Air Cooled	1,309	1,309	1.00	100.0%	
SCE	Passthru: HVAC Chiller Water Cooled	11,038	11,038	1.00	100.0%	
SCE	Passthru: HVAC Rooftop Or Split System	24	24	1.00	100.0%	
SCE	Passthru: HVAC VRF/Mini Split	2,797	2,797	1.00	100.0%	
SCE	Total	24,920	22,960	0.92	60.9%	0.80
SDGE	HVAC Rooftop Or Split System	457	365	0.80	0.0%	0.80
SDGE	Passthru: HVAC Rooftop Or Split System	11	11	1.00	100.0%	
SDGE	Total	468	376	0.80	2.4%	0.80
	Statewide	39,125	35,864	0.92	58.5%	0.80

Net First Year Savings (MWh)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC Rooftop Or Split System	5,112	4,085	0.80	100.0%	0.85	0.85		
PGE	Passthru: HVAC Chiller Air Cooled	2,354	2,354	1.00	100.0%	0.62	0.62		
PGE	Passthru: HVAC Rooftop Or Split System	3,235	3,235	1.00	100.0%	0.85	0.85		
PGE	Passthru: HVAC VRF/Mini Split	101	101	1.00	100.0%	0.85	0.85		
PGE	Total	10,802	9,774	0.90	100.0%	0.79	0.78		
SCE	HVAC Rooftop Or Split System	8,287	6,622	0.80	100.0%	0.85	0.85		
SCE	Passthru: HVAC Chiller Air Cooled	808	808	1.00	100.0%	0.62	0.62		
SCE	Passthru: HVAC Chiller Water Cooled	7,637	7,637	1.00	100.0%	0.69	0.69		
SCE	Passthru: HVAC Rooftop Or Split System	21	21	1.00	100.0%	0.85	0.85		
SCE	Passthru: HVAC VRF/Mini Split	2,378	2,378	1.00	100.0%	0.85	0.85		
SCE	Total	19,131	17,465	0.91	100.0%	0.77	0.76		
SDGE	HVAC Rooftop Or Split System	376	300	0.80	100.0%	0.82	0.82		
SDGE	Passthru: HVAC Rooftop Or Split System	7	7	1.00	100.0%	0.60	0.60		
SDGE	Total	382	307	0.80	100.0%	0.82	0.82		
Statewide		30,315	27,546	0.91	100.0%	0.77	0.77		

Gross First Year Savings (MW)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC Rooftop Or Split System	3.5	2.3	0.68	0.0%	0.68
PGE	Passthru: HVAC Chiller Air Cooled	0.3	0.3	1.00	100.0%	
PGE	Passthru: HVAC Rooftop Or Split System	2.3	2.3	1.00	100.0%	
PGE	Passthru: HVAC VRF/Mini Split	0.0	0.0	1.00	100.0%	
PGE	Total	6.1	5.0	0.82	43.1%	0.68
SCE	HVAC Rooftop Or Split System	5.8	3.9	0.68	0.0%	0.68
SCE	Passthru: HVAC Chiller Air Cooled	0.2	0.2	1.00	100.0%	
SCE	Passthru: HVAC Chiller Water Cooled	2.0	2.0	1.00	100.0%	
SCE	Passthru: HVAC Rooftop Or Split System	0.0	0.0	1.00	100.0%	
SCE	Passthru: HVAC VRF/Mini Split	1.1	1.1	1.00	100.0%	
SCE	Total	9.1	7.2	0.79	36.4%	0.68
SDGE	HVAC Rooftop Or Split System	0.2	0.1	0.68	0.0%	0.68
SDGE	Passthru: HVAC Rooftop Or Split System	0.0	0.0	1.00	100.0%	
SDGE	Total	0.2	0.1	0.69	3.5%	0.68
<i>Statewide</i>		<i>15.3</i>	<i>12.3</i>	<i>0.80</i>	<i>38.7%</i>	<i>0.68</i>

Net First Year Savings (MW)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC Rooftop Or Split System	2.9	2.0	0.68	100.0%	0.85	0.85		
PGE	Passthru: HVAC Chiller Air Cooled	0.2	0.2	1.00	100.0%	0.62	0.62		
PGE	Passthru: HVAC Rooftop Or Split System	1.9	1.9	1.00	100.0%	0.85	0.85		
PGE	Passthru: HVAC VRF/Mini Split	0.0	0.0	1.00	100.0%	0.85	0.85		
PGE	Total	5.1	4.2	0.81	100.0%	0.84	0.83		
SCE	HVAC Rooftop Or Split System	4.9	3.3	0.68	100.0%	0.85	0.85		
SCE	Passthru: HVAC Chiller Air Cooled	0.1	0.1	1.00	100.0%	0.63	0.63		
SCE	Passthru: HVAC Chiller Water Cooled	1.4	1.4	1.00	100.0%	0.69	0.69		
SCE	Passthru: HVAC Rooftop Or Split System	0.0	0.0	1.00	100.0%	0.85	0.85		
SCE	Passthru: HVAC VRF/Mini Split	0.9	0.9	1.00	100.0%	0.85	0.85		
SCE	Total	7.3	5.8	0.78	100.0%	0.81	0.80		
SDGE	HVAC Rooftop Or Split System	0.1	0.1	0.68	100.0%	0.82	0.82		
SDGE	Passthru: HVAC Rooftop Or Split System	0.0	0.0	1.00	100.0%	0.60	0.60		
SDGE	Total	0.1	0.1	0.68	100.0%	0.81	0.80		
Statewide		12.6	10.0	0.79	100.0%	0.82	0.81		

Gross First Year Savings (MTherms)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HVAC Rooftop Or Split System	-10	-10	1.00	0.0%	1.00
PGE	Passthru: HVAC Chiller Air Cooled	0	0			
PGE	Passthru: HVAC Rooftop Or Split System	-13	-13	1.00	100.0%	
PGE	Passthru: HVAC VRF/Mini Split	0	0	1.00	100.0%	
PGE	Total	-23	-23	1.00	54.8%	1.00
SCE	HVAC Rooftop Or Split System	-19	-19	1.00	0.0%	1.00
SCE	Passthru: HVAC Chiller Air Cooled	0	0			
SCE	Passthru: HVAC Chiller Water Cooled	0	0			
SCE	Passthru: HVAC Rooftop Or Split System	0	0	1.00	100.0%	
SCE	Passthru: HVAC VRF/Mini Split	0	0	1.00	100.0%	
SCE	Total	-19	-19	1.00	0.2%	1.00
SDGE	HVAC Rooftop Or Split System	-2	-2	1.00	0.0%	1.00
SDGE	Passthru: HVAC Rooftop Or Split System	0	0			
SDGE	Total	-2	-2	1.00	0.0%	1.00
	Statewide	-44	-44	1.00	28.1%	1.00

Net First Year Savings (MTherms)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HVAC Rooftop Or Split System	-9	-9	1.00	100.0%	0.85	0.85		
PGE	Passthru: HVAC Chiller Air Cooled	0	0						
PGE	Passthru: HVAC Rooftop Or Split System	-11	-11	1.00	100.0%	0.85	0.85		
PGE	Passthru: HVAC VRF/Mini Split	0	0	1.00	100.0%	0.85	0.85		
PGE	Total	-19	-19	1.00	100.0%	0.85	0.85		
SCE	HVAC Rooftop Or Split System	-17	-17	1.00	100.0%	0.85	0.85		
SCE	Passthru: HVAC Chiller Air Cooled	0	0						
SCE	Passthru: HVAC Chiller Water Cooled	0	0						
SCE	Passthru: HVAC Rooftop Or Split System	0	0	1.00	100.0%	0.85	0.85		
SCE	Passthru: HVAC VRF/Mini Split	0	0	1.00	100.0%	0.85	0.85		
SCE	Total	-17	-17	1.00	100.0%	0.85	0.85		
SDGE	HVAC Rooftop Or Split System	-2	-2	1.00	100.0%	0.84	0.84		
SDGE	Passthru: HVAC Rooftop Or Split System	0	0						
SDGE	Total	-2	-2	1.00	100.0%	0.84	0.84		
	<i>Statewide</i>	<i>-38</i>	<i>-38</i>	<i>1.00</i>	<i>100.0%</i>	<i>0.85</i>	<i>0.85</i>		

Per Unit (Quantity) Gross Energy Savings (kWh)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HVAC Rooftop Or Split System	0	0.0%	0.0%	15.0	1,666.0	111.1	111.1
PGE	Passthru: HVAC Chiller Air Cooled	1	0.0%		11.0	5,602.0	346.5	346.5
PGE	Passthru: HVAC Rooftop Or Split System	1	0.0%		15.0	9,510.1	634.0	634.0
PGE	Passthru: HVAC VRF/Mini Split	1	0.0%		15.0	472.4	31.5	31.5
SCE	HVAC Rooftop Or Split System	0	24.7%	24.7%	15.0	1,531.3	163.6	102.1
SCE	Passthru: HVAC Chiller Air Cooled	1	0.0%		20.0	8,668.0	433.4	433.4
SCE	Passthru: HVAC Chiller Water Cooled	1	0.0%		20.0	15,698.4	784.9	784.9
SCE	Passthru: HVAC Rooftop Or Split System	1	4.0%		15.0	2,689.8	196.0	179.3
SCE	Passthru: HVAC VRF/Mini Split	1	0.0%		15.0	15,942.8	1,062.9	1,062.9
SDGE	HVAC Rooftop Or Split System	0	0.0%	0.0%	15.0	1,486.4	99.1	99.1
SDGE	Passthru: HVAC Rooftop Or Split System	1	0.0%		15.0	1,380.0	92.0	92.0

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	HVAC Rooftop Or Split System	0	0.0%	0.0%	15.0	-3.6	-0.2	-0.2
PGE	Passthru: HVAC Chiller Air Cooled	1	0.0%		11.0	0.0	0.0	0.0
PGE	Passthru: HVAC Rooftop Or Split System	1	0.0%		15.0	-31.6	-2.1	-2.1
PGE	Passthru: HVAC VRF/Mini Split	1	0.0%		15.0	0.7	0.0	0.0
SCE	HVAC Rooftop Or Split System	0	24.7%	24.7%	15.0	-2.3	-0.4	-0.2
SCE	Passthru: HVAC Chiller Air Cooled	1	0.0%		20.0	0.0	0.0	0.0
SCE	Passthru: HVAC Chiller Water Cooled	1	0.0%		20.0	0.0	0.0	0.0
SCE	Passthru: HVAC Rooftop Or Split System	1	4.0%		15.0	-0.1	0.0	0.0
SCE	Passthru: HVAC VRF/Mini Split	1	0.0%		15.0	-0.2	0.0	0.0
SDGE	HVAC Rooftop Or Split System	0	0.0%	0.0%	15.0	-9.1	-0.6	-0.6
SDGE	Passthru: HVAC Rooftop Or Split System	1	0.0%		15.0	0.0	0.0	0.0

Per Unit (Quantity) Net Energy Savings (kWh)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HVAC Rooftop Or Split System	1	0.0%		15.0	1,416.1	94.4	94.4
PGE	Passthru: HVAC Chiller Air Cooled	1	0.0%		11.0	3,419.7	214.8	214.8
PGE	Passthru: HVAC Rooftop Or Split System	1	0.0%		15.0	8,083.6	538.9	538.9
PGE	Passthru: HVAC VRF/Mini Split	1	0.0%		15.0	401.6	26.8	26.8
SCE	HVAC Rooftop Or Split System	1	24.7%		15.0	1,301.4	139.1	86.8
SCE	Passthru: HVAC Chiller Air Cooled	1	0.0%		20.0	5,352.5	267.6	267.6
SCE	Passthru: HVAC Chiller Water Cooled	1	0.0%		20.0	10,860.6	543.0	543.0
SCE	Passthru: HVAC Rooftop Or Split System	1	4.0%		15.0	2,286.3	166.6	152.4
SCE	Passthru: HVAC VRF/Mini Split	1	0.0%		15.0	13,551.4	903.4	903.4
SDGE	HVAC Rooftop Or Split System	1	0.0%		15.0	1,221.1	81.4	81.4
SDGE	Passthru: HVAC Rooftop Or Split System	1	0.0%		15.0	828.0	55.2	55.2

Per Unit (Quantity) Net Energy Savings (Therms)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HVAC Rooftop Or Split System	1	0.0%		15.0	-3.0	-0.2	-0.2
PGE	Passthru: HVAC Chiller Air Cooled	1	0.0%		11.0	0.0	0.0	0.0
PGE	Passthru: HVAC Rooftop Or Split System	1	0.0%		15.0	-26.9	-1.8	-1.8
PGE	Passthru: HVAC VRF/Mini Split	1	0.0%		15.0	0.6	0.0	0.0
SCE	HVAC Rooftop Or Split System	1	24.7%		15.0	-2.0	-0.3	-0.1
SCE	Passthru: HVAC Chiller Air Cooled	1	0.0%		20.0	0.0	0.0	0.0
SCE	Passthru: HVAC Chiller Water Cooled	1	0.0%		20.0	0.0	0.0	0.0
SCE	Passthru: HVAC Rooftop Or Split System	1	4.0%		15.0	-0.1	0.0	0.0
SCE	Passthru: HVAC VRF/Mini Split	1	0.0%		15.0	-0.1	0.0	0.0
SDGE	HVAC Rooftop Or Split System	1	0.0%		15.0	-7.7	-0.5	-0.5
SDGE	Passthru: HVAC Rooftop Or Split System	1	0.0%		15.0	0.0	0.0	0.0

Impact Evaluation of 2015 Upstream HVAC Programs

Study ID	Study Type	Study Title	Study Manager			
100	Impact Evaluation	Impact Evaluation of 2015 Upstream HVAC Programs (HVAC1)	CPUC			
Item	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recommendation Recipient	Affected Workpaper or DEER
1	Upstream HVAC - Unitary Systems	<p>This impact evaluation of the 2015 Upstream HVAC programs revealed lower than expected savings for the smallest size units (under 4.5 ton) and good realization rates for units 5.5–20 ton. The primary driver of the realization rates was that, on average, the full-load efficiencies of the installed equipment were lower than claimed estimates assumed efficiency levels in some cases. While not evaluated in 2015, we did notice the measures with lower 2013-14 realization rates also had decreased unit energy savings claims in 2015. The evaluation team believes minimum primary reason for the improvements was the code update and updated version of DEER for 2015 while 2014 had to utilize different baselines within the calendar year. For the smallest units where realization rates could improve further.</p>	<p>IOU and measure specific details can be found in section 5</p>	<p>We recommend the IOUs and DEER team for the updates made to the latest versions of DEER based on performance data provided by the Upstream programs and PG&E in particular. The 2015 claims already showed some key improvements and the expectation is that going forward the measure efficiency should not be a major source of uncertainty.</p>	<p>All IOUs</p>	<p>DEER, PGECOHC126, PGECOHC128, PGECOHC162, PGECOHC142, PGECOHC120, SCE13HC035, SCE13HC019, SCE13HC012, SCE13HC032, SCE13HC033, SCE13HC030, SCE13HC043</p>

Impact Evaluation of 2015 Upstream HVAC Programs

Item	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recommendation Recipient	Affected Workpaper or DEER
2	Upstream HVAC - Unitary Systems	The field-testing of 5.5-20 ton units showed that fan performance and part-load performance curves were similar to current DEER assumptions in most cases and only one size class had a measured average fan power index that was different than DEER. The characterization of fan performance and part-load performance data for smaller systems, under 5.5 ton, can still benefit from additional data collection, as the sample size for this evaluation was insufficient since there are now multiple size categories below 5.5 ton.	IOU and measure specific details can be found in section 5	For workpaper developers and evaluators: Review new data collected by this study, especially for 5.5–11.5 ton units where a change was made to the workpaper fan power index assumption. Collect additional data on fan performance, W/CFM to characterize the program population.	All IOUs	DEER, PGECOHC126, PGECOHC128, PGECOHC162, PGECOHC142, PGECOHC120, SCE13HC035, SCE13HC019, SCE13HC012, SCE13HC032, SCE13HC033, SCE13HC030, SCE13HC043
3	Upstream HVAC - Unitary Systems	The smallest unitary system, less than 4.5 tons, are not required by Title 24 to have economizers. However, many of the units incentivized by the program in this size category were found to be equipped with economizers. Although the evaluation team has not yet established any influence, is probable that the program has influenced the economizer inclusion for a portion of units in this size category. Seeing this situation as a potential savings opportunity	IOU and measure specific details can be found in section 5	For program managers and designers: Create a measure to capture economizers added to units that do not require them (less than 4.5 ton). For this study it was unknown to what degree economizer additions were influenced by the program. If the program is determined to be strong influence, there would be substantial savings to be claimed.	All IOUs	DEER, PGECOHC126, PGECOHC128, PGECOHC162, PGECOHC142, PGECOHC120, SCE13HC035, SCE13HC019, SCE13HC012, SCE13HC032, SCE13HC033, SCE13HC030, SCE13HC043

Impact Evaluation of 2015 Upstream HVAC Programs

Item	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recommendation Recipient	Affected Workpaper or DEER
4	Upstream HVAC - Unitary Systems	The evaluation team found that a considerable savings potential is not being realized because many of economizers for unitary systems being installed through the program are not functioning properly. Our testing occurred within two years of installation, but just over one-quarter of the economizers were found to not be working. Some tests uncovered errors such as improperly wired sensors that indicate that the economizer was not installed correctly and has never functioned as designed.	IOU and measure specific details can be found in section 5	For program managers and designers: Although this recommendation does not fit within the Upstream Program, the non-functioning economizers found by this evaluation represent an excellent savings opportunity. We recommend a separate initiative to assure proper economizer function through contractor training and incentives. The program would obtain video/photographic evidence or some other proof that the economizer is fully functional before dispersing an incentive payment . This would be separate from the Upstream program and proposed post-installation and not as a code compliance activity.	All IOUs	DEER, PGECOHVC126, PGECOHVC128, PGECOHVC162, PGECOHVC142, PGECOHVC120, SCE13HC035, SCE13HC019, SCE13HC012, SCE13HC032, SCE13HC033, SCE13HC030, SCE13HC043

Impact Evaluation of 2015 Upstream HVAC Programs

Item	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recommendation Recipient	Affected Workpaper or DEER
5	Upstream HVAC - All Programs	We found that the program did not have a major effect on distributors' behavior, leading only 35 percent of distributors to change their patterns for stocking equipment. During their interviews, several distributors mentioned a lack of clarity on incentive timing which impeded their ability to stock and sell the units. Another distributor commented that if he can count on an incentive's availability he will stock the high-efficiency equipment.	Net-to-gross Evaluation of 2013-14 Upstream HVAC Programs Report	For program managers and designers: Reducing uncertainty regarding how long the incentives will remain in place at a given level would likely increase the trust which distributors have in the program, and, in turn, increase their willingness to change their stocking practices. Program practices which would increase participant certainty about how long the incentives will remain in place would include informing the distributors when the program is going to run out of money ahead of time, and honoring incentives for HVAC purchases that are already registered in the system.	All IOUs	DEER, PGECOHC126, PGECOHC128, PGECOHC162, PGECOHC142, PGECOHC120, SCE13HC035, SCE13HC019, SCE13HC012, SCE13HC032, SCE13HC033, SCE13HC030, SCE13HC043
6	Upstream HVAC - All Programs	Marketing tools for distributors could be improved: During our interviews, multiple distributors asked for additional sales tools and marketing materials to help them sell high efficiency units. We believe that distributors would make good use of CPUC- and IOU-hosted training and online savings calculators.	Net-to-gross Evaluation of 2013-14 Upstream HVAC Programs Report	For program managers and designers: Provide distributor program training and online savings estimators that are focused on helping convert lost sales of high-efficiency equipment.	All IOUs	DEER, PGECOHC126, PGECOHC128, PGECOHC162, PGECOHC142, PGECOHC120, SCE13HC035, SCE13HC019, SCE13HC012, SCE13HC032, SCE13HC033, SCE13HC030, SCE13HC043

Impact Evaluation of 2015 Upstream HVAC Programs

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7	Upstream HVAC - All Programs	Many distributors sought better communications on program changes in general, in addition to their more specific demands for better information about incentive availability. Because the sales cycle for some high efficiency units can be several months, distributors want to keep their staff and buyers informed of any changes to the incentives.	Net-to-gross Evaluation of 2013-14 Upstream HVAC Programs Report	For program managers and designers: Communicate program changes more clearly to distributors with as much advance warning as possible. Since pass-through incentives had the highest attribution score for both distributors and buyers, clear communication on program changes can help distributors make better decisions on the incentives they pass on to buyers.	All IOUs	DEER, PGECOHC126, PGECOHC128, PGECOHC162, PGECOHC142, PGECOHC120, SCE13HC035, SCE13HC019, SCE13HC012, SCE13HC032, SCE13HC033, SCE13HC030, SCE13HC043
8	Upstream HVAC - All Programs	During their interviews distributors provided suggestions on how the upstream HVAC program could be improved. Some of their suggestions, in addition to those mentioned above, included involving small municipalities in this program, offering different incentives and technologies based on climate zones, and including new technologies in the program.	Net-to-gross Evaluation of 2013-14 Upstream HVAC Programs Report	For the HVAC Project Coordination Group: We recommend that the IOUs and CPUC set up a mechanism (if one does not exist) to solicit regular input from distributors on potential improvements to the program.	All IOUs	DEER, PGECOHC126, PGECOHC128, PGECOHC162, PGECOHC142, PGECOHC120, SCE13HC035, SCE13HC019, SCE13HC012, SCE13HC032, SCE13HC033, SCE13HC030, SCE13HC043

Impact Evaluation of 2015 Upstream HVAC Programs

Item	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recommendation Recipient	Affected Workpaper or DEER
9	Upstream HVAC - All Programs	<p>Nearly 50% of the buyer program tracking data we received was missing distributor names and buyer contact information. As a result, we could not match several completed distributor interviews to buyers, resulting in their omission from our NTG analysis. However, we believe that the data from these unmatched distributor interviews should be used for future analysis.</p>	<p>Net-to-gross Evaluation of 2013-14 Upstream HVAC Programs Report</p>	<p>For program managers and designers: The programs should strive to collect higher quality buyer tracking data, with special emphasis on collecting information relating buyers to the distributors that sold them their units. This will help increase the number of buyers matched to distributors that evaluators can use for our NTG causal pathway analysis in future studies. For example, the program application form should have the contact information for the distributor, contractor, and buyer, as well as indicate who was present at the time of purchase. For IOU EM&V staff: We further recommend that a process evaluation be conducted for this HVAC upstream program to further analyze the distributor interview responses (from both “matched” and “unmatched”) distributors. Our evaluation, by necessity, focused on distributor responses most relevant to program attribution, but other interview responses could also be useful for identifying interesting market trends and for providing insights on how to improve upstream HVAC program design.</p>	<p>All IOUs</p>	<p>DEER, PGECOHC126, PGECOHC128, PGECOHC162, PGECOHC142, PGECOHC120, SCE13HC035, SCE13HC019, SCE13HC012, SCE13HC032, SCE13HC033, SCE13HC030, SCE13HC043</p>



ABOUT DNV GL

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

No.	Subject:	Commenter	Section	Page	Type (Question or Comment)	QUESTION or COMMENT	Response
1	"The primary reason realization rates were lower than expected unit efficiencies (EERS) than the claimed values".	SCE	1.2.1.1	2	Question	During webinar on 3/8, DNV-GL explained that models number document in the field, resulted in lower EERS than reported. DNV-GL explained that the number of digits report by the Utilities were fewer than found in the field. All digits are reported for models in the AHRI data base. For models not in AHRI data base, manufactures cut sheets are used to determine efficiencies (i.e. EERs and IEERs). Did DNV-GL compare model numbers in the field with model numbers on submitted manufactures' cut sheets? The Program can provide manufactures' cut sheet to verify claimed efficiencies.	There maybe some misscommunication or mis interpretation. DNV GL does not claim the number of digits found in the field did not match the tracking as an explanation for lower as found efficiencies. DNV GL compared the as found model number to the claimed model number to verify the unit installation. We then verified the installed unit efficiency using manufacturers data and the AHRI database as the primary source to derive the as found efficiency values. In some instances we found the efficiency values were lower than the claimed efficiency values. DNV GL would welcome having unit specific documentation to aid in unit verification efforts
2	GRR cited in text	PG&E	1.2.1.1, 5.4.1.1	2, 32	Comment	The first sentence in the first paragraph of section 1.2.1.1 and 5.4.1.1 appears to incorrectly state GRR. Tables 5 and 27 state that GRR is equal to 78.9 percent, and this value seems accurate when compared to the ex ante and ex post gross savings in the table. Should the text be corrected, or the tables?	Report has been revised. Table 5 and 27 have been removed and replaced with more comprehensive tables (1&2).The GRR is 78.9%
3	Clarification of whether all units complied with EER/IEER requirements	PG&E	1.2.1.1, 5.4.1.1	2, 32	Question	The report states twice: "This led to some units complying with IEER requirements that had full load efficiency at or close to code minimum." Does this imply that other units did not meet IEER requirements, or that all units met either IEER or EER criteria? If the former, how many units did not meet criteria?	Our analysis used the average efficiency found in each size range and Tier. In the Appendix we can provide the EER and IEER data by sample point, but our analysis did not look at the frequency of units that met each criteria and which met both criteria.
4	Data Discrepancy of Claimed and Evaluated Gross kW and kWh savings and Realization Rates	SCE	1.2.1.1	2-5	Question	The Total Claimed kWh and Evaluated Total kWh in Table 1 does not match the total claimed and evaluated kWh for units <20 Tons in Table 3. Table 1 shows 29,268 tons, 7,081,411 kWh claimed, and 6,134,691 kWh evaluated for units <5.5 tons, which provides a realization rate of 87%, but Table 3 shows 28,745 Tons, 6,768,621 kWh Claimed, and 4,967,720 Evaluated for a realization rate of 73.4%. These discrepancies exist for each size category and in Table 2 and Table 4 (kW Realization rate). What are the reasons for the differences? Note: Tables 1 and 2 are replicated in Tables 23 and 24 and Table 3 and 4 are summarized in Tables 27 and 28.	We will add clarifying details for the difference in the report. Table 1 & 2 represent the savings at each tier 4.5 to 20 tons for both a functioning and non functioning economizers(note: Table 1 and 2 are now table 3 & 4). Table 3 & 4 presents the evaluated savings that only includes the as found functionality as a yes or no, but not both (note: Table 3 & 4 are now table 5 & 6)
5	Tables 5-6 and 27-28	PG&E	1.2.1.2, 5.5.3	6, 37	Comment	The header of column 6 reads "Net Realization Rate," but the value shown is the Net to Gross Ratio (per discussion in the text, verification against values shown in other columns, and discussion in the HVAC impact evaluation public webinar). Please correct this column header.	corrected in the report
6	Sample size	PG&E	4.1	20	Question	In Table 13, for 2013-15, the completed sample size for PG&E is given as 61 units. As defined for the report, small unitary systems is a large category; that sample of 61 appears to span 4 EE tiers, two equipment size ranges, 9 CZ's and several different building types. While we recognize that budget constrains sample size, it seems like it would have been difficult to ensure the sample adequately represents all relevant cells. Could the report be revised to include a discussion of measures it took to address this challenge (for example, by considering ways to sample different climate zones, equipment size ranges, etc. across IOUs, if this was done), as well as the risks and threats to validity posed by the size of the sample?	This is number of sample sites not units; we do span BType and CZ in the sample, but those are not the drivers of equipment efficiency which should agree with the tracking in all cases and there is no known reason why there may be more discrepancies in certain building types or climate zones .

7	M&V Gross Savings Analysis	PG&E	4.3	24	Comment	This section states that the report used "DEER prototype models" to estimate ex post gross savings. We believe that heavy reliance on DEER inputs and models (or similar models) to determine ex post savings has led to questionable results throughout the evaluation. Using the same models for ex post and ex ante estimates seems counter intuitive to the concept of independent evaluation. PG&E made similar comments on the Impact Evaluation of 2013-14 Upstream HVAC Programs (2013-14 HVAC1 impact evaluation). While DEER may provide a good basis for savings calculations, evaluators must perform due diligence into where models and parameters are not appropriate for program realities. For example: DEER does not use representative performance maps at the higher efficiency tiers. In addition, DEER models the energy efficiency of the tier based on the lowest EER & IEER ratings for the tier, meaning that it does not accurately capture savings from higher EER/IEER units. In comments on the 2013-14 HVAC1 impact evaluation, PG&E, SCE, and Clean Energy Horizons offered several other examples of challenges presented by this approach. In future evaluations, we urge the CPUC and its evaluators to develop independent models against which to check ex ante estimates.	With limited additional resources assigned in the research roadmap for 2015, there was no ability to develop an alternative analysis plan and vet it and then complete new samples that would be representative. We chose to build on the 2013-14 approach for 2015 which was a continuation. We welcome alternative approaches for future studies. Methods such as the DOE UMP are options, but they will not directly inform ex ante updates which was the decision made for the 2013-15 activities.
8	NTG applicability to large unitary systems	PG&E	5.5.1	36	Question	Influence on distributor stock is a factor in the NTG calculation. However, our understanding is that distributors typically do not stock equipment larger than approximately 10 tons, rather, those units are built to order. It therefore seems inappropriate to apply an NTG ratio that includes a stocking factor to larger units (as shown in table 27 and 28). In the NTG battery, was a distinction made between smaller and larger units to account for these different selling practices? If not, is there a way to account for this difference in the report?	Comments on the NTG report were responded to in November 2016 and we are unable to revise the analysis. We decided to apply the values to 2015 claims given the similarities in program delivery from 2013-14 to 2015. We believe the comments should be considered when developing future NTG or when deciding whether to apply the NTG results to programs that have changed in 2016 and into the future.
9	Attribution: stocking	PG&E	5.5.1	36	Comment	We appreciate the last paragraph on p. 36, which addresses low distributor attribution for upselling. Could this discussion be expanded to include other factors as well? For example, the NTG evaluation found that only 35% of high-efficiency stocking was reported due to the program. However, this contradicts anecdotal feedback PG&E has received from some distributors who report adding high-efficiency equipment lines specifically because of the incentive program.	Comments on the NTG report were responded to in November 2016 and we are unable to revise the analysis. We decided to apply the values to 2015 claims given the similarities in program delivery from 2013-14 to 2015. We believe the comments should be considered when developing future NTG or when deciding whether to apply the NTG results to programs that have changed in 2016 and into the future.
10	Impact of DEER updates	PG&E	5.5.1	2, 32	Comment	The report notes that a contributing factor to the GRR for small unitary systems is that "there have been significant DEER updates for these measures since the 2013-14 ex ante values were developed, including code changes in 2014 to minimum efficiency, changes to fan speed requirements, and updated performance maps. These updates were incorporated into ex post simulation baseline models, which resulted in reduced savings when compared to the ex ante estimates appropriate to the fan speed and other code requirements in effect at the time of installation." Data used in the study were collected in 2013-14 and 2015. Could the report please be edited to clarify the effect of these updates (if any) on 2015 data?	This text appears to reference back to 2013-14 and it has been revised
11	Field testing/inputs for DEER estimates	PG&E	6	40	Comment	Finding 3 states that: "Field testing of 5.5-20 ton units showed that fan performance and part-load performance curves were similar to current DEER assumptions in most cases". However, DEER does not model multi- and variable speed equipment, so it is striking that part-load performance curves were measured as being close to field tests for higher-efficiency tiers of this equipment. Could a discussions of the possible reasons for this similarity be added to the report?	We clarified some text. We selected performance curves from the DEER library to match our as found IEER and SEER. So rather than use the single curve fit selected in the DEER measure we did modify the selected curve where we saw significant differences between the equipment found in the field and the claimed units.
12	Research plan	PG&E	N/A	N/A	Comment	A research plan for this study does not seem to have been posted for public comment on the PDA. Is there a reason this process was skipped?	The 2015 activities were added to the same study for 2013-14 since we did not fully complete the previous sample design. We did not change methods and did expand the sample beyond the original design with the additional funds. The research roadmap was posted to the PDA and indicated the plan not to produce a new plan in order to get into the field in summer 2016. The activities were discussed on a monthly basis with the IOUs at the HVAC PCG.