


Impact Evaluation of 2013-14 Upstream HVAC Programs (HVAC1)

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1 EXECUTIVE SUMMARY

This report presents DNV GL's impact evaluation of non-residential upstream programs that are part of the California Public Utilities Commission (CPUC) 2013-14 HVAC Research Roadmap. The primary results of this evaluation are adjustments to key technical assumptions that affect the calculation of energy savings. These adjustments, when run through standard engineering models, result in estimates of ex post gross energy impacts achieved by the 2013-14 HVAC upstream programs offered by three California investor-owned electric utilities (IOUs): San Diego Gas and Electric Company (SDG&E), Southern California Edison (SCE), and Pacific Gas and Electric Company (PG&E). This report presents the evaluation results for the energy impacts achieved by the programs.

1.1 Program overview

For program year (PY) 2013 through 2014, California IOUs funded upstream HVAC rebate programs for both non-residential (commercial) and residential applications. The non-residential components of the upstream 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:

1. Encourage participating distributors to increase their stock of high-efficiency equipment so that it is readily available to customers (contractors and large businesses)
2. 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)
3. 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 commercial and residential installations. The available rebate amounts are based on equipment performance tiers.² 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 mechanical 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 by rebated upstream HVAC measures during the 2013-14 program cycle for three programs: PG&E Commercial HVAC, SCE Commercial HVAC, and SDG&E Deemed Incentives-Commercial HVAC. The three evaluated measures were chillers, unitary systems, and mini-split systems. The second critical goal was to provide information that leads to more accurate savings estimates for future program cycles.

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 type of evaluation include the uncertainty and difficulty of in-field efficiency testing and the recruitment of customers who may be unaware that the distributor of their new HVAC systems participated in an incentive program. This study was also limited by the fact that long-term metering would require much larger sample sizes and costs to meet precision targets for all building type, climate zone, and measure combinations.

To achieve evaluation goals, DNV GL used a measurement and verification (M&V) method with tracking data and on-site data collection to estimate savings for chillers and unitary systems. For mini-split systems, we evaluated the commercial market using end-user surveys. The survey investigated how mini-split systems were used, their age, what types of systems they were replacing, and if they complemented or replaced existing systems. Savings were then adjusted following the workpaper methods and applying the survey results. This task was designed to help inform the Energy Savings Performance Incentive (ESPI) requirement. ESPI was adopted by the CPUC on September 5, 2013, as a mechanism to encourage California's IOUs to maximize long-lived energy savings.

1.3 Key findings and results

1.3.1 Chillers

The overall realization rate for chiller energy (kWh) savings across all programs is 47%. Air-cooled chiller category had a very low realization rate of 18%, and this category accounted for 64% of all chiller upstream claims. For all of these upstream chiller measures, there have been no significant DEER updates since the 2013-14 ex ante values were developed; the only differences between ex ante and ex post estimates are the chiller efficiencies.

The IOU programs stipulated that chillers could meet each efficiency tier requirement by meeting the full load efficiency (kW/ton) or the integrated part load value (IPLV) criteria. The IOU air-cooled chiller workpapers acknowledge that the full load efficiency of the DEER measure is higher than the majority of high efficiency models available. After further investigation, we found that the air-cooled chiller energy savings estimates developed in workpapers were much higher than are feasible, representing approximately 85% of the cooling end use energy usage estimate from the DEER prototypes. In contrast, the ex post savings were about 10% of the cooling end use energy usage.

For water-cooled chillers, many of the units met the efficiency assumptions, and realization rates were over 100% for two of the four categories. The total realization rate for water-cooled chillers was 98%. Table 1 shows the results.

Table 1. Ex ante and ex post kWh savings and realization rates for chillers

Sample Group	Unit Size	Total Tonnage Claimed	Ex Ante Total (kWh)	Efficiency Adjusted Ex Post Total (kWh)	Efficiency Adjusted Realization Rate (kWh)	Building Type Adjusted (kWh)	Final Ex Post Savings Total (kWh)	Final Realization Rate (kWh)
Air-cooled Chillers	All	43,077	32,057,004	5,010,090	16%	115%	5,751,057	18%
Water-cooled Screw Chiller	<150 ton	463	133,531	62,580	47%	115%	71,835	54%
Water-cooled Screw Chiller	150 - 300 ton	8,992	3,416,405	2,282,340	67%	115%	2,619,887	77%
Water-cooled Screw Chiller	>300 ton	800	334,507	209,463	63%	115%	240,442	72%
Water-cooled Centrifugal Chiller	150 - 300 ton	1,132	249,859	440,809	176%	115%	506,002	203%
Water-cooled Centrifugal Chiller	>300 ton	42,497	14,250,960	12,765,019	90%	115%	14,652,901	103%
Water -cooled Total	All	53,884	18,385,262	15,760,211	86%	115%	18,091,067	98%
All Chiller Total	All	96,961	50,442,266	20,770,301	41%	115%	23,842,124	47%

In stark contrast to the energy savings, the demand (kW) reduction realization rate for all upstream chiller measures was 129% as shown in Table 2. The exact reason for the high realization rate is unknown since the ex ante models were unavailable to the evaluation team, but is likely due to differences in ex ante and ex post calculation methods.

Table 2. Ex ante and ex post kW savings and realization rates for chillers

Sample Group	Unit Size	Total Tonnage Claimed	Ex Ante Total (kW)	Efficiency Adjusted Ex Post Total (kW)	Efficiency Adjusted Realization Rate (kW)	Building Type Adjusted (kW)	Final Ex Post Savings Total (kW)	Final Realization Rate (kW)
Air-cooled Chillers	All	43,077	2,507	2,857	114%	95%	2,708	108%
Water-cooled Screw Chiller	<150 ton	463	35	39	111%	95%	37	106%
Water-cooled Screw Chiller	150 - 300 ton	8,992	928	1,369	148%	95%	1,298	140%
Water-cooled Screw Chiller	>300 ton	800	88	65	74%	95%	61	70%
Water-cooled Centrifugal Chiller	150 - 300 ton	1,132	75	213	285%	95%	202	270%
Water-cooled Centrifugal Chiller	>300 ton	42,497	3,801	5,545	146%	95%	5,256	138%
Water -cooled Total	All	53,884	4,926	7,230	147%	95%	6,853	139%
All Chiller Total	All	96,961	7,433	10,087	136%	95%	9,561	129%

1.3.2 Unitary systems

The overall realization rate for unitary systems across all programs and measures was 71.2%. 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 installation³. 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

For unitary systems less than 20 tons, 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.

Table 3 shows the results for large units. Similar to the results for air-cooled chillers, the ex ante claimed savings for the largest size, greater than 63.3 tons group appeared to be unrealistically high, representing approximately 70% of the baseline cooling consumption in the prototype models.⁴ The DEER savings are more realistic for units between 20 and 63 tons, but some of the units surveyed only met baseline efficiency levels, driving down the realization rate.

Table 3. Ex ante and ex post kWh savings and realization rates for large unitary systems

Unit Size	Ex Post Efficiency Level	Total Adjusted Tonnage	Ex Ante Total (kWh)	Final Ex Post Savings Total (kWh)	Final Realization Rate (kWh)
20 - 63.3 ton	10.5EER	4,455	1,487,279	160,547	10.8%
20 - 63.3 ton	10.8EER	39,000	13,019,415	2,139,894	16.4%
20 - 63.3 ton	11.5EER	4,370	1,458,678	396,689	27.2%
20 - 63.3 ton	12.5EER	3,770	1,258,467	513,379	40.8%
>63.3 ton	10.2EER	3,799	1,942,249	125,186	6.4%
>63.3 ton	11EER	10,701	5,471,125	787,311	14.4%
>63.3 ton	12 EER	1,284	656,535	239,754	36.5%
Large	All	67,379	25,293,748	4,362,760	17.2%

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.

⁴ The ex ante kWh savings claims were approximately 70% of the baseline cooling consumption in the baseline models generated with MAS Control. The sources are IOU workpapers which take the DEER models and estimates of runtime; a change in EER and IEER is then multiplied by these runtimes to estimate savings. Since it is not possible to obtain this level of savings through equipment efficiency alone, this suggests an error in the estimate.

The demand reduction (kW) realization rate for large unitary systems was 149.7%. The high realization rate is likely due to differences between ex ante and ex post calculation methods. Table 4 shows the results for large units.

Table 4. Ex ante and ex post kW savings and realization rates for large unitary systems

Unit Size	Ex Post Efficiency Level	Total Adjusted Tonnage	Ex Ante Total (kW)	Final Ex Post Savings Total (kW)	Final Realization Rate (kW)
20 - 63.3 ton	10.5EER	4,455	189	126	66.7%
20 - 63.3 ton	10.8EER	39,000	1,655	1,631	98.6%
20 - 63.3 ton	11.5EER	4,370	185	381	205.4%
20 - 63.3 ton	12.5EER	3,770	160	488	304.9%
>63.3 ton	10.2EER	3,799	86	112	129.9%
>63.3 ton	11EER	10,701	243	869	358.1%
>63.3 ton	12 EER	1,284	29	206	707.6%
Large	All	67,379	2,547	3,812	149.7%

Additional adjustments were made for small units 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 75% (approximately 3 out of 4 units tested had properly functioning economizers). Table 5 provides the results and applies the economizer functionality to the claimed tonnage to create the weighting of 75% 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 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 airflow and 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.

Table 5. Ex ante and ex post kWh savings and realization rates for small unitary systems

Unit Size	Ex Post Efficiency Level	Working Economizer	Total Adjusted Tonnage	Ex Ante Total (kWh)	Final Ex Post Savings Total (kWh)	Final Realization Rate (kWh)
< 5 Ton	Tier0P, 14 SEER/12 EER, 1spd	NA	2,943	767,405	910,840	118.7%
< 5 Ton	Tier1, 15 SEER /<13 EER, 1spd	NA	3,211	837,169	1,066,079	127.3%
< 5 Ton	Tier1, 15 SEER /<13 EER, 2spd	NA	7,760	2,023,158	4,684,153	231.5%
< 5 Ton	Tier2, 16 SEER/>13EER, 2spd	NA	3,478	906,933	2,191,289	241.6%
< 5 Ton	Tier3, 17 SEER/>13EER, 2spd	NA	8,830	2,302,214	6,056,715	263.1%
< 5 Ton	Tier4, 18 SEER/>13EER, 2spd	NA	535	139,528	393,691	282.2%
< 5 Ton (2013 Code)	Tier1, 15 SEER /<13 EER, 1spd	NA	763	296,132	17,216	5.8%
< 5 Ton (2013 Code)	Tier1, 15 SEER /<13 EER, 2spd	NA	1,844	715,653	542,583	75.8%
< 5 Ton (2013 Code)	Tier2, 16 SEER/>13EER, 2spd	NA	827	320,810	264,973	82.6%
< 5 Ton (2013 Code)	Tier3, 17 SEER/>13EER, 2spd	NA	2,099	814,364	790,088	97.0%
< 5 Ton (2013 Code)	Tier4, 18 SEER/>13EER, 2spd	NA	127	49,355	54,210	109.8%
5.5 - 11.5 Ton	11.5EER, 1spd	Yes	1,598	287,632	55,143	19.2%
5.5 - 11.5 Ton	11.5EER, 1spd	No	533	95,877	24,675	25.7%
5.5 - 11.5 Ton	12EER,1spd	Yes	6,660	1,198,466	443,113	37.0%
5.5 - 11.5 Ton	12EER,1spd	No	2,220	399,489	197,925	49.5%
5.5 - 11.5 Ton	12EER,2spd	Yes	4,795	862,895	2,091,481	242.4%
5.5 - 11.5 Ton	12EER,2spd	No	1,598	287,632	842,163	292.8%
5.5 - 11.5 Ton	13EER,2spd	Yes	13,587	2,444,870	6,317,564	258.4%
5.5 - 11.5 Ton	13EER,2spd	No	4,529	814,957	2,553,750	313.4%
5.5 - 11.5 Ton (2013 Code)	11.5EER, 1spd	Yes	358	79,515	(113,248)	-142.4%
5.5 - 11.5 Ton (2013 Code)	11.5EER, 1spd	No	119	26,505	(44,760)	-168.9%
5.5 - 11.5 Ton (2013 Code)	12EER,1spd	Yes	1,493	331,313	(423,770)	-127.9%
5.5 - 11.5 Ton (2013 Code)	12EER,1spd	No	498	110,438	(165,289)	-149.7%
5.5 - 11.5 Ton (2013 Code)	12EER,2spd	Yes	1,075	238,545	72,066	30.2%
5.5 - 11.5 Ton (2013 Code)	12EER,2spd	No	358	79,515	30,371	38.2%
5.5 - 11.5 Ton (2013 Code)	13EER,2spd	Yes	3,046	675,878	293,089	43.4%
5.5 - 11.5 Ton (2013 Code)	13EER,2spd	No	1,015	225,293	123,469	54.8%
11.6 - 20 Ton	Tier2, 12.0EER, 1spd	Yes	739	196,515	(214,276)	-109.0%
11.6 - 20 Ton	Tier2, 12.0EER, 1spd	No	246	65,505	(82,965)	-126.7%
11.6 - 20 Ton	Tier2, 12.0EER, 2spd	Yes	9,601	2,554,700	789,865	30.9%
11.6 - 20 Ton	Tier2, 12.0EER, 2spd	No	3,200	851,567	338,452	39.7%
11.6 - 20 Ton	Tier3, 12.5EER, 1spd	Yes	923	245,644	(237,357)	-96.6%
11.6 - 20 Ton	Tier3, 12.5EER, 1spd	No	308	81,881	(90,483)	-110.5%
11.6 - 20 Ton	Tier3, 12.5EER, 2spd	Yes	7,201	1,916,025	808,548	42.2%
11.6 - 20 Ton	Tier3, 12.5EER, 2spd	No	2,400	638,675	346,466	54.2%
Small Units	All	All	100,520	23,882,052	30,927,828	129.5%

Table 6 shows the results of peak demand reduction saving for units over 20 tons. The realization rate across all categories is 129.9%

Table 6. Ex ante and ex post kW savings and realization rates for small unitary systems

Unit Size	Ex Post Efficiency Level	Working Economizer	Total Adjusted Tonnage	Ex Ante Total (kW)	Final Ex Post Savings (kW)	Final Realization Rate (kW)
< 5 Ton	Tier0P, 14 SEER/12 EER, 1spd	NA	2,943	146.3	256.5	175.3%
< 5 Ton	Tier1, 15 SEER /<13 EER, 1spd	NA	3,211	159.6	315.5	197.7%
< 5 Ton	Tier1, 15 SEER /<13 EER, 2spd	NA	7,760	385.8	1,027.3	266.3%
< 5 Ton	Tier2, 16 SEER/>13EER, 2spd	NA	3,478	172.9	531.1	307.1%
< 5 Ton	Tier3, 17 SEER/>13EER, 2spd	NA	8,830	439.0	1,602.8	365.1%
< 5 Ton	Tier4, 18 SEER/>13EER, 2spd	NA	535	26.6	111.0	417.1%
< 5 Ton (2013 Code)	Tier1, 15 SEER /<13 EER, 1spd	NA	763	62.0	8.5	13.7%
< 5 Ton (2013 Code)	Tier1, 15 SEER /<13 EER, 2spd	NA	1,844	149.9	83.5	55.7%
< 5 Ton (2013 Code)	Tier2, 16 SEER/>13EER, 2spd	NA	827	67.2	54.2	80.7%
< 5 Ton (2013 Code)	Tier3, 17 SEER/>13EER, 2spd	NA	2,099	170.6	198.1	116.1%
< 5 Ton (2013 Code)	Tier4, 18 SEER/>13EER, 2spd	NA	127	10.3	15.3	148.0%
5.5 - 11.5 Ton	11.5EER, 1spd	Yes	1,598	145.5	40.4	27.8%
5.5 - 11.5 Ton	11.5EER, 1spd	No	533	48.5	13.7	28.2%
5.5 - 11.5 Ton	12EER,1spd	Yes	6,660	606.2	305.1	50.3%
5.5 - 11.5 Ton	12EER,1spd	No	2,220	202.1	103.5	51.2%
5.5 - 11.5 Ton	12EER,2spd	Yes	4,795	436.5	511.0	117.1%
5.5 - 11.5 Ton	12EER,2spd	No	1,598	145.5	177.2	121.8%
5.5 - 11.5 Ton	13EER,2spd	Yes	13,587	1236.6	1,719.0	139.0%
5.5 - 11.5 Ton	13EER,2spd	No	4,529	412.2	594.7	144.3%
5.5 - 11.5 Ton (2013 Code)	11.5EER, 1spd	Yes	358	35.0	(15.2)	-43.4%
5.5 - 11.5 Ton (2013 Code)	11.5EER, 1spd	No	119	11.7	(5.3)	-45.3%
5.5 - 11.5 Ton (2013 Code)	12EER,1spd	Yes	1,493	145.9	(24.0)	-16.5%
5.5 - 11.5 Ton (2013 Code)	12EER,1spd	No	498	48.6	(8.9)	-18.2%
5.5 - 11.5 Ton (2013 Code)	12EER,2spd	Yes	1,075	105.0	51.6	49.1%
5.5 - 11.5 Ton (2013 Code)	12EER,2spd	No	358	35.0	17.3	49.5%
5.5 - 11.5 Ton (2013 Code)	13EER,2spd	Yes	3,046	297.6	212.7	71.5%
5.5 - 11.5 Ton (2013 Code)	13EER,2spd	No	1,015	99.2	71.7	72.3%
11.6 - 20 Ton	Tier2, 12.0EER, 1spd	Yes	739	44.7	(3.1)	-6.8%
11.6 - 20 Ton	Tier2, 12.0EER, 1spd	No	246	14.9	(1.7)	-11.4%
11.6 - 20 Ton	Tier2, 12.0EER, 2spd	Yes	9,601	581.1	550.2	94.7%
11.6 - 20 Ton	Tier2, 12.0EER, 2spd	No	3,200	193.7	185.9	96.0%
11.6 - 20 Ton	Tier3, 12.5EER, 1spd	Yes	923	55.9	15.6	27.9%
11.6 - 20 Ton	Tier3, 12.5EER, 1spd	No	308	18.6	4.5	24.0%
11.6 - 20 Ton	Tier3, 12.5EER, 2spd	Yes	7,201	435.8	563.9	129.4%
11.6 - 20 Ton	Tier3, 12.5EER, 2spd	No	2,400	145.3	190.7	131.3%
Small Units	All	All	100,520	7291.3	9,474.5	129.9%

The energy savings results for small and large unitary systems are summarized by unit size in Table 7. Low realization rates in large systems are balanced out by high realization rates for smaller systems leading to an overall realization rate of 71.2%.

Table 7. Ex ante and ex post kWh savings and realization rates for all unitary systems

Unit Size	Total Tonnage Claimed	Ex Ante Total (kWh)	Final Ex Post Savings Total (kWh)	Final Realization Rate (kWh)
< 5 Ton	32,417	9,172,721	16,971,836	185.0%
5.5 - 11.5 Ton	43,485	8,158,817	12,297,743	150.7%
11.6 - 20 Ton	24,618	6,550,514	1,658,249	25.3%
20 - 63.3 Ton	51,595	17,223,839	3,210,509	18.6%
>63.3 Ton	15,784	8,069,909	851,418	10.6%
All	167,899	49,175,800	34,989,755	71.2%

The peak demand reduction results for small and large unitary systems are summarized by unit size as shown in Table 8. The overall realization rate across all size categories is 128.9%.

Table 8. Ex ante and ex post kW savings and realization rates for all unitary systems

Unit Size	Total Tonnage Claimed	Ex Ante Total (kW)	Final Ex Post Savings (kW)	Final Realization Rate (kW)
< 5 Ton	32,417	1,790	4,204	234.8%
5.5 - 11.5 Ton	43,485	4,011	3,765	93.9%
11.6 - 20 Ton	24,618	1,490	1,506	101.1%
20 - 63.3 Ton	51,595	2,189	2,625	119.9%
>63.3 Ton	15,784	358	583	162.7%
All	167,899	9,838	12,682	128.9%

1.4 Mini-split

In the 2013 ESPI memo, mini-split system savings were adjusted to account for what appeared to be an incorrect adjustment factor, which increased savings, by about 50%. In 2014, we have included this adjustment and determined through customer surveys that only 4% of units replaced existing ducted systems; in contrast, the workpaper assumption was 50%. Based on these findings we decided to pass through mini-split ex ante savings.


1.5 Conclusions and recommendations

Section 5 of this report provides a detailed discussion of study findings. Of these findings, the evaluation team judges the following to be particularly noteworthy.

Finding #1: Program savings were lower than expected.

This impact evaluation of the 2013-14 Upstream HVAC programs revealed lower than expected savings. The primary driver of the low realization rates was that the actual efficiencies of the installed equipment were lower than ex ante estimates assumed efficiency levels. The resulting low savings levels were most prevalent for air-cooled chillers and large unitary systems, which had gross savings realization rates of 11% and 15%, respectively. The evaluation team believes one root cause is having optional efficiency criteria for full load or partial load rather than requiring both full and partial load efficiencies meet a threshold that ensures savings are above code minimum. Consequently, we recommend the following:

For program managers and designers: Set program efficiency criteria for full-load and part-load combinations. Pre-identify units that meet the criteria such that savings claims are tied back to make and model numbers collected by participating distributors.



Another possible factor for low realization rates include using system performance maps that do not accurately represent the performance of the systems being installed through the program. To mitigate the discrepancies arising from this factor, we recommend the following:

For program managers and designers: Work with distributors to obtain extended performance maps that can be used in future simulations. DEER updates are limited by the availability of information from manufacturers, and the upstream program may be in a better position to obtain this information.

For workpaper developers and engineers: Use DEER estimates generally and focus workpaper efforts on EER and IEER combinations greater than DEER values. Detail the performance maps and additional features if any such as variable speed compressors, energy recovery ventilation, etc.

Another possible factor for low realization rates is issues with building types⁵ associated with Upstream claims. To resolve this issue, we recommend the following.

For program managers and tracking data teams: Avoid building types that do not map to ex ante values. In general, the building types in tracking such as "Multiple" and "Miscellaneous" were associated with specific building types based on site visits.

Another issue that may lead to inaccuracies in realization rates is using a deemed saving approach for large water cooled chillers. The same exact chiller could have highly varying savings dependent upon how it is being operated especially regarding chilled water temperatures and control approaches. To reduce error associated with deemed chiller savings, we recommend the following:

For program managers and designers: Implement a calculated savings approach for large water-cooled chillers. Having a few calculation inputs, such as the site-specific set points and controls, could produce much more accurate estimates without adding much more work to the process.


Finally, the realization rates were profoundly affected by ex ante estimates that did not pass basic quality control steps. For example, the air-cooled chiller savings ex ante estimates were 85% of the baseline cooling end use total usage, which is impossible. In order to eliminate errors of this type, we recommend the following:

For workpaper developers and tracking data teams: Check unit energy savings estimates relative to the baseline cooling energy consumption per ton. This will improve the ability of future workpapers to check whether adjustment factors to DEER estimates produce reasonable savings. Also, check that workpaper values agree with values in tracking data.

Finding #2: Many Upstream unitary HVAC systems have non-functional economizers.

The evaluation team found that a considerable savings potential is not being realized because many economizers for unitary systems being installed through the program are not functioning properly. Our

⁵ Building types used in this evaluation are DEER standard building types.



testing occurred within two years of installation, but 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: Develop methods to obtain evidence that the economizer is fully functional before dispersing the final incentive payment. Obtain acceptance testing data for the technician to assure a functioning economizer that includes documenting economizer functionality with video/photographic evidence.

Finding #3: Inputs for DEER estimates appear to have improved.

The field-testing of 5.5- 20 ton units showed that fan performance and part-load performance curves were similar to current DEER assumptions. The current DEER update appears to have improved the accuracy of fan performance inputs for the simulations; thus, using current DEER estimates are an improvement over the estimates available to the IOUs when the 2013-14 programs began. 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 to assure the quality of the DEER assumptions. As a result of this finding, we recommend the following:

For workpaper developers and evaluators: Use current DEER assumptions for deemed savings estimates for the 5.5-20-ton unitary system. Collect additional data on fan performance to characterize the program population.

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:

1. Look at participation records; what results did the program implementers expect?
2. Develop a field testing approach; create an M&V plan.
3. Test the M&V approach in pilot evaluation; finalize the M&V plan.
4. 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.
5. 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.
6. Analyze all collected data, and estimate load impacts and savings from the upstream program using engineering analysis and/or simulation modeling.

Figure 1. Ex ante savings calculation process

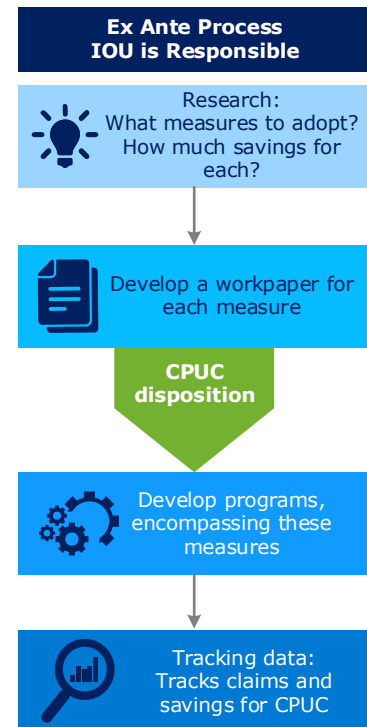
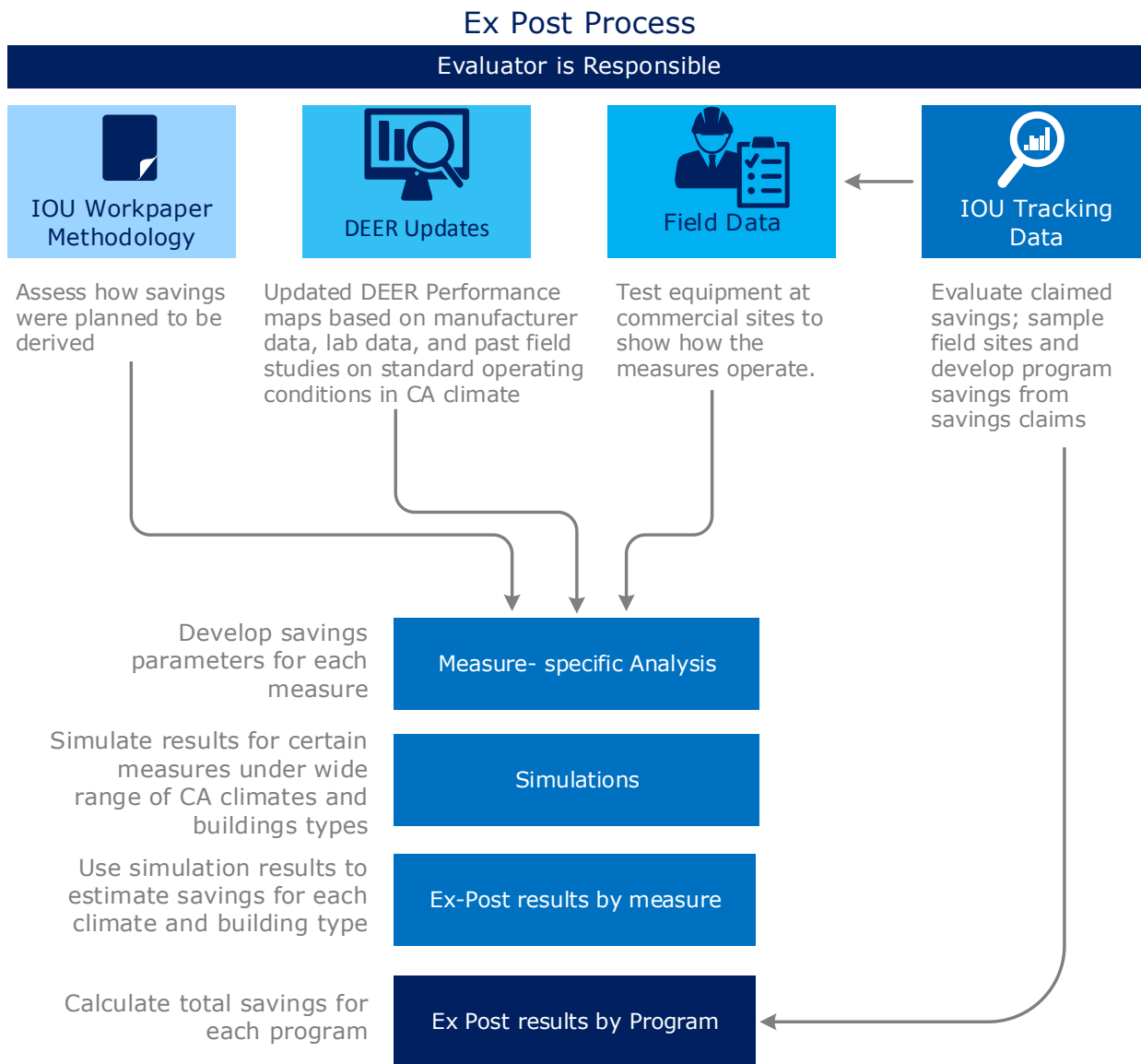


Figure 2. Development of ex post savings



2.2 Background

The upstream HVAC programs provide rebates to HVAC equipment distributors for selling high-efficiency heating and cooling equipment. Rebate amounts are based on equipment performance tiers, which vary based on equipment type, capacity, and efficiency. The underlying program theory is that the rebates 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 2013 through 2014, California IOUs funded upstream HVAC rebate programs for both non-residential (commercial) and residential applications. The non-residential components of the upstream programs have been in continuous operation since 1998. The residential component is a recent addition with a pilot phase launched in 2014.⁶

The upstream programs share three primary goals:

1. Encourage participating distributors to increase their stock of high-efficiency equipment so that it is readily available to customers (contractors and large businesses)
2. 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)
3. 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 rebate 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 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 rebated 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 rebates 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 2013–14 program cycle.

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"

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/>

in its measure description field to differentiate the claim from a downstream measure. SCE upstream claims were identified when “Up-Stream Programs-Up-Stream Incentive” was entered in its implementation description field for the measure in question.

The 2013–14 tracking data only had upstream measure claims in the non-residential sector. Each IOU had one single non-residential program where the upstream measures were administered. All of PG&E’s 2013–14 upstream measures were administered through Program 21015-Commercial HVAC. SCE’s 2013–14 upstream measures were administered through Program SCE-13-SW-002F, Non-Residential HVAC. SDG&E’s 2013–14 upstream measures were administered through Program 3224, SW-COM-Deemed Incentives-HVAC Commercial.

Table 9 shows the 2013–14 upstream HVAC aggregate electric energy and demand savings claims for identified upstream measures within each IOU non-residential program mentioned above. This represents the entire upstream population, since there are no residential claims through 2014. The entire 2013–14 portfolio savings are included in the table for comparison. The 2013–2014 upstream program claims represent 2% of the entire statewide portfolio electric energy claims, and 2% of the portfolio demand savings claims.

Table 9. 2013–14 upstream program savings by IOU

Energy Savings Claims by IOU		
IOU	Electric Energy (GWh)	Electric Demand (MW)
PG&E	41.7	6.8
SCE	76.3	13.0
SDG&E	10.2	0.1
Total	118.2	19.9
Portfolio Savings Claims		
PG&E	3297.1	568.8
SCE	3,464.8	292.7
SDG&E	688.4	111.3
Total*	7,450.3	972.8

Claimed savings from all measures related to the 2013–14 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 HVAC program (PGE 21015). Table 10 shows the measure categories, the number of claims, and aggregate kW and kWh savings found in the 2013–14 (Q1–Q8) tracking data. Unitary (packaged/split) systems had the greatest proportion of kWh/year savings. Note that mini-splits were not specifically identified in the PG&E tracking data and are classified as packaged/split/AC/HP systems in Table 10.

Table 10. PG&E non-residential HVAC upstream activity by measure category Q1-Q8

Measure Categories	2013-14 Claims	kW	First Year kWh
Packaged/Split AC/HP Systems	6,149	3,357	21,405,939
Air-Cooled Chillers	248	956	13,405,143
VRF AC/HP Systems	1,326	1,683	5,395,335
Water Source Heat Pumps	1,335	691	1,372,315
Evaporative-Cooled AC	14	145	156,792
Total	9,072	6,831	41,735,525

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 <65kBtu/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). The tracking data show upstream claims under 52 separate measure names distinguished by size and equipment efficiency tiers. Table 11 shows the savings for SCE's upstream measures aggregated by basic equipment technology category. Note that packaged/split systems had the most claims and savings. 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 just over 50% of first-year program savings.

Table 11. SCE commercial upstream program activity by measure category

Measures Category	2013-14 Claims	kW	First Year kWh
Packaged/Split AC/HP Systems	5,146	5,154	37,471,711
Air-Cooled Chillers	177	1,268	18,383,631
Water-Cooled Chillers	114	3,852	13,285,244
VRF AC/HP Systems	293	2,515	6,170,454
Ductless/Mini/Multi-split Systems	539	107	634,034
Water Source Heat Pumps	138	122	330,076
Evaporative-Cooled AC	46	52	32,701
Total	6,453	13,070	76,307,850

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
- 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 2013–14 tracking data, SDG&E claimed savings across 12 upstream measure line items. All of these measures were for the packaged-units measure category. The measures rely on scaling factors referenced in the workpaper to determine savings tier levels. Table 12 summarizes SDG&E claims.

Table 12. SDG&E commercial upstream program activity by measure category

Measures Category	2013–14 Claims	kW	First Year kWh
Packaged/Split AC Systems	146	81.0	178,155
Economizers	7	0.2	31,620
Total	153	81.2	209,775


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 Chillers

The analysis for the upstream chiller evaluation utilized a multi-phase approach to ensure that the adjustments made to ex ante savings are clear, and to clearly document the effects of each phase of the analysis. The first phase compared the program measure efficiencies for the program subpopulations, which were divided into chiller type (air-cooled, water-cooled scroll/screw, and water-cooled centrifugal), efficiency tier, and capacity for screw/scroll chiller. The 2013-14 ex ante program measure efficiencies are the average efficiencies for each efficiency tier and chiller type for the 2010-12 program cycle participants. For the first phase, we compared whether the ex ante program measure efficiencies differ from those found in the evaluation sample. DNV GL termed this phase of the savings adjustment as the efficiency adjustment realization rate because it exclusively looks at the installed efficiency compared to the assumed efficiency. The workpapers estimate deemed energy impacts based on some critical inputs and assumptions. Some

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.



inputs identify appropriate DEER deemed savings and some calculate scaling factors. To simplify the calculations, we applied some standard assumptions. These assumptions vary by IOU, and are as follows:

For the PG&E air-cooled chiller measure workpaper, critical inputs include building type, climate zone, chiller tonnage, and chiller full load efficiency. The chiller full load efficiency determines the chiller efficiency tier, impacting the deemed savings in terms of kWh/ton or kW/ton in the workpaper. A key assumption is that this is a replace on burnout (ROB) project and that the building vintage is ANY. The chiller compressor type can be either screw or scroll, but not reciprocating. The chiller efficiency and tonnage are tested in accordance with ARI 550/590 under the standard conditions of 44°F chilled water and 95°F outdoor dry-bulb temperature. Note that the savings in the workpaper do not appear in the tracking data. It appears savings more similar to SCE's workpaper applied to PG&E climate zones were used in the official tracking data.

For the SCE air-cooled chiller measure workpaper, critical inputs include building type, climate zone, chiller tonnage, and chiller full load and IPLV efficiencies. In addition, some information about the 2010-12 SCE and PG&E upstream programs was used to generate savings estimates. This information includes program average EER and IPLV for each efficiency tier, and the percentage of units qualifying under EER only, under IPLV only, or under both. The average annual cooling hours for each building type and climate zone for air-cooled screw chillers are derived from the DEER 2011 database. This workpaper also assumes that this is a ROB project and that the building vintage is ANY. The chiller compressor type can be either screw or scroll, but not reciprocating. The chiller efficiency and tonnage are tested in accordance with ARI 550/590 under the standard conditions of 44°F chilled water and 95°F outdoor dry-bulb temperature. Overall, the full load efficiencies were lower than DEER, but the annual savings were much higher based on the higher IPLV of the program tiers.

For the water-cooled screw or scroll chiller measure workpaper, critical inputs include building type, climate zone, chiller tonnage, chiller full load and IPLV efficiencies, coincident diversity factor from DEER 2011, and total run time hours from effective full-load cooling hours (EFLCHs). The EFLCHs are from the 2008 DEER v2.05 database. This workpaper also assumes that this is a ROB project and that the building vintage is ANY. The chiller compressor type can be either screw or scroll, but not reciprocating. The chiller efficiency and tonnage are tested in accordance with ARI 550/590 under the standard conditions of 44°F chilled water and 85°F condenser water entering temperature.

For the water-cooled centrifugal chiller measure workpaper, critical inputs include climate zone, chiller tonnage, and chiller full load and IPLV efficiencies. The eQUEST models used in the workpaper to determine savings for water-cooled chillers are Title 24-compliant chilled-water systems. The workpaper assumes that the project type is ROB, the building vintage is 1978-1992, and the building type is Large Office. The baseline chiller efficiency is based on Title 24 2008 minimum values and the post chiller efficiency is based on 2010-12 program average efficiency for each efficiency tier. There are two equally sized chillers serving the whole building. The two chillers operate in stages, such that the second chiller comes on only when the building load exceeds the first chiller's capacity. Custom chiller curves are created based on manufacturer data to simulate chiller performance. Variable-Speed Measure Case Chillers use the load-based condenser water relief controls in eQUEST, optimized for minimum energy use with each climate zone modeled. The workpaper combined the two size categories for each compressor type and applied the same savings for chillers in the same efficiency tier with different size categories. The chiller efficiency and tonnage are tested in accordance with ARI 550/590 under the standard conditions of 44°F chilled water and 85°F condenser water entering temperature.



2.5.2 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) are identical in measure case and baseline models. All projects are considered replace on burnout or new construction, so there is no remaining useful life (RUL) 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 DX 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 grouping, we used the observed parameters for the program subpopulation.

3 ANALYTICAL APPROACH

The main goal of this research included determining the best estimate of actual energy and demand savings achieved by rebated upstream HVAC measures during the 2013–14 program cycle. California’s 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:

1. **Assess program documentation quality:** Assess how accurately the program claims energy-saving measures and the completeness of program documentation.
2. **Assess installed measure conditions:** The primary basis for the energy savings claims is the California Database for Energy Efficient Resources (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 as-is conditions due to the uncertainty of direct measurement of in situ performance.
3. **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 using a different calculation methodology is one approach to determining realized savings. The variation in energy consumption alone requires a larger end-use measurement cost than what can be undertaken in this evaluation given the variations in building type and climate zone (CZ), as well as site-specific conditions.
4. **Program improvement recommendations:** Communicate findings and recommendations from this M&V study, literature review of variable refrigerant flow (VRF) mini-split and multi-split systems, market survey of VRF mini-split and multi-split systems, and the metering pilot study.

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 13 shows how research activities served evaluation objectives.

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

Table 13. 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 283 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 for VRF/mini-split/multi-split literature review, VRF/mini-split/multi-split market survey and metering pilot study	Communicate findings and recommendations via memoranda and report; mini-splits are on the ESPI uncertain measure list (D.13.09.023 Attachment 3)

4 METHODS

This study consisted of two major tasks:

1. **Measurement & verification (M&V):** 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 combinations¹⁰ for all of the claimed measures.
2. **Mini-split HVAC system market survey:** This survey investigated how these systems were used and what types of systems they were replacing. The survey, coupled with the literature review, was used to meet ESPI ex post evaluation requirements.

Sections 4.1, 4.2 , and 4.3 discuss the evaluation team’s methods for conducting the M&V primary task of this study. Section 4.4 presents methods for the mini-split HVAC system market survey.

4.1 M&V sample design

From the IOU tracking data, the evaluation team designed three samples covering the period of Q1 2013 to Q4 2014. 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. The planned sample sizes and populations by IOU and equipment type are shown in Table 14. Sample design details can be found in Appendix H.

Table 14. Planned sample and population totals by IOU and equipment type–sites

IOU	Sample/ Population	Chiller	Large Unitary	Small Unitary
PG&E	Sample	48	27	50
	Population	127	405	2,812
SCE	Sample	52	23	80
	Population	161	236	1,669
SDG&E	Sample	0	3	10
	Population	0	3	21
Total	Sample	100	53	140
	Population	288	644	4,502

¹⁰ Since we are considering equipment parameters, we believe it is appropriate to project to all building types. The underlying assumption is that participating equipment is consistent across climate zones and building types.

For chillers the planned samples were completed and a few additional sites were recruited to account for sample points that may fall through. The sample for PG&E came two sites short and for SCE we ended with one additional site. Table 15 shows the achieved relative precision 9% compared to the planned 8%.

Table 15. Planned and achieved precision for chillers

IOU	Planned Sample Sites	Completed Sample Sites	Planned Relative Precision at 90% Confidence	Achieved Relative Precision at 90% Confidence
PG&E	48	46	±10%	±11%
SCE	52	53	±10%	±10%
Total	100	99	±8%	±9%

For large unitary systems the planned samples were completed and a few additional sites were recruited to account for sample points that may fall through. The sample for PG&E came two sites short and for SCE we ended with one additional site. Table 16 shows the final goal of 9% relative precision overall was still achieved.¹¹

Table 16. Planned and achieved precision for large unitary systems

IOU	Planned Sample Sites	Completed Sample Sites	Planned Relative Precision at 90% Confidence	Achieved Relative Precision at 90% Confidence
PGE	27	26	±12%	±13%
SCE	23	24	±13%	±13%
SDGE	3	2	±1%	±27%
Total	53	52	±9%	±9%

For small unitary systems the planned samples were not completed as planned. There were also delays in the launch of the field testing due to methodological development that led to not being able to complete as many sites as planned. The sample for PG&E came close to goal, but the samples for SCE and SDG&E came up short due to the above challenges. Additional SCE and SDG&E samples are a priority for the next phase of this study.

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 this is replicated in the ex post analysis. The estimated precision of each simulation input is also estimated in the study results presented in Chapter 5. Table 17 shows that the overall achieved precision is approximately 14%, while the planned precision was 10%. Data collection

¹¹ For Tables 16 and 17, note that for SDG&E the population is very small so a census results in a relative precision of 0% and any response rate below 100% drastically raises the precision. While we did not achieve the goal of recruiting all sites, the relative precision will be high in cases of small populations. The savings generated from the simulation for the building types and climate zones claims likely is more accurate than the reported precision by IOU.

efforts will continue in the next program year with a focus on improving these estimates with targeted data collection to fill the incomplete sample targets.

Table 17. Planned and achieved precision for small unitary systems

IOU	Planned Sample Sites	Completed Sample Sites	Planned Relative Precision at 90% Confidence	Achieved Relative Precision at 90% Confidence
PGE	50	48	±19%	±19%
SCE	80	41	±12%	±18%
SDGE	10	2	±20%	±55%
Total	140	91	±10%	±14%

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.¹²

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.

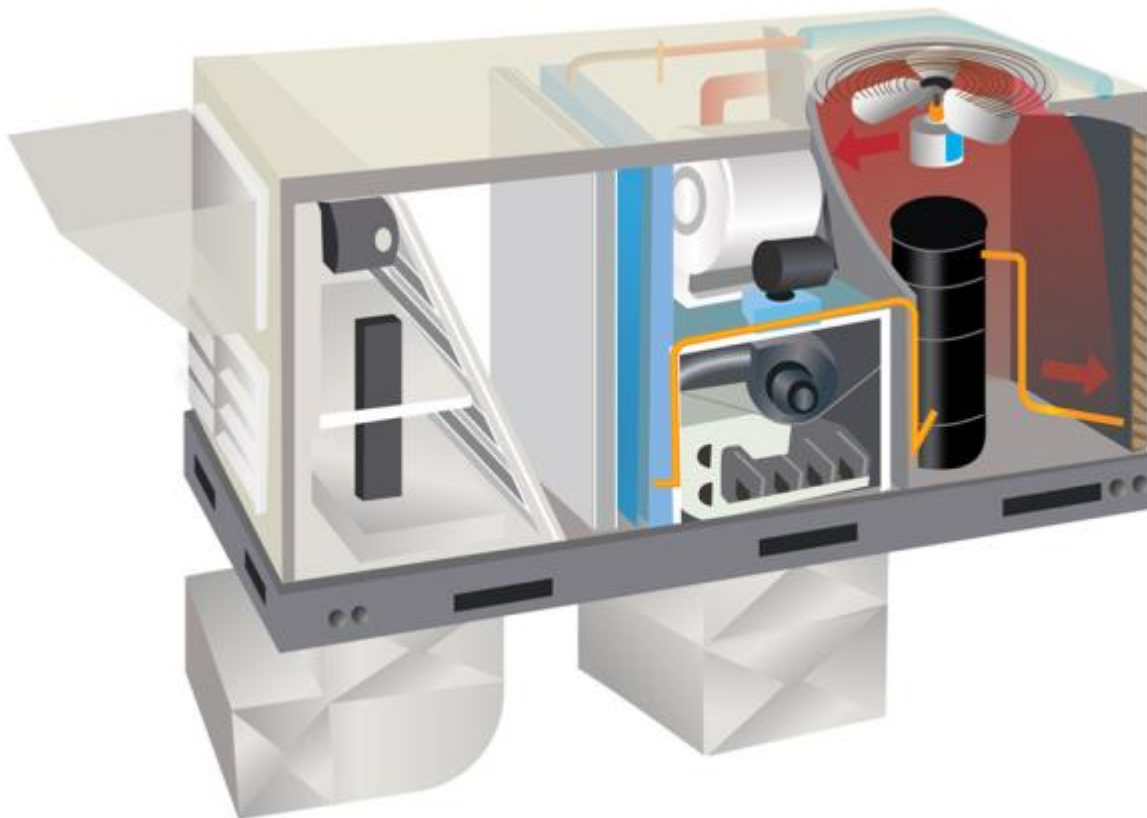
¹² Controls account for a very small amount of electricity consumption.

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; 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 air handler, where the air is cooled and dehumidified by passing through the evaporator coil (or heated by the heating coil) and supplied to the conditioned space. Compressors, condenser fans, and evaporator blower fans operate simultaneously when the cooling system is operating without the economizer.¹³

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

¹³ 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.



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 peak power include:

- The amount and quality of refrigerant in the system
- 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
- Electrical (contactors/capacitors) and control system operation and efficiency
- Furnace operation and efficiency
- Effectiveness and operation of the economizer, dampers, sensors, and controls
- Fault detection diagnostic (FDD) operation and controls
- Thermostat and/or energy management system (EMS) controls

If the installation achieves optimal system efficiency, this will reduce power input to the unit and possibly the length of time the unit operates to achieve the thermostat setpoint. The evaluation team began gross savings determinations by collecting and analyzing the data described below.

4.2.2 Data collection: Unitary systems

Unitary systems (rooftop or split systems) were evaluated at 193 sites. The sample plan selected sites that had three 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 tons and below.

Each unit was subjected to the following observations and measurements:

Installation characteristics: Inspectors recorded the building type, space type, and square footage served by each selected unit. A list of recorded items can be found in Appendix G.

Equipment nameplate: Inspectors recorded the nameplate information and photographed the nameplate. A complete list of nameplate data elements is provided in Appendix G.

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 building type and space type served by each selected unit.

Operating characteristics: Inspectors attempted to collect the operating and set-point schedules. Where possible, the schedules were obtained by direct observation of a programmable thermostat or energy management system. When the inspector could not directly observe the schedules, facility personnel were queried for the schedules. The inspector obtained the on/off time for weekdays,

weekends, and holidays and the heating and cooling set points for occupied and non-occupied periods. The site contact was also asked for the list of holidays observed at the facility.

Additional data was collected for 143 of the unitary systems. This included the following:

Spot measurements:

- Cooling-mode and fan-mode static pressure differentials across the supply fan, across unit, and between return and ambient air
- Cooling-mode and fan-only mode fan true electric power
- Cooling mode airflow

Economizer measurement

- Height and width of damper array
- Number of blades
- Configuration
- Blade angle

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

4.2.3 Data collection: Chiller (central plant) systems

Chillers were evaluated at 100 sites. No tests or measurements were performed on chiller systems, but inspection teams requested operating information. Activities included interviews and direct observation to gather the following information:

Installation characteristics: Inspectors recorded the building type, space type, and square footage served by each selected unit.

Equipment nameplate: Information from the nameplate was recorded and a photograph of the nameplate was taken.

Operating characteristics: Inspectors attempted to collect the operating and set-point schedules for each unit. The site contact was also asked for the list of holidays observed at the facility.

Equipment details:

- Chiller
 - Chiller compressor type
 - Chiller status (primary, secondary/backup)
 - Plant optimization strategy
 - Chiller sequencing
 - Control strategy
 - Condenser type
 - If a water-side economizer was present: schematic loop arrangement, control logic for economizer operation, loop temperature, and pressure-sensor data
 - kW/ton and other trend data along with basic analysis (if the site's energy management system could provide it)
- Chilled water pumps
 - Nameplate information
 - Control sequence
 - Motor type: constant-velocity or variable-frequency drive (VFD)
 - Primary or secondary/backup service
 - Temperature set points

- Flow rates, variable flow settings, and loop valve types
- Condenser water pumps
 - Nameplate information
 - Control sequence
 - Motor type: constant-velocity or VFD
 - Temperature set points
 - Flow rates, variable flow settings, and loop valve types
- Air-cooled condensers and cooling towers
 - Nameplate
 - Control sequence
 - Fan controls
 - Fan horsepower
 - Temperature set points and control strategy

Protocols for these on-site observations can be found in Appendix G.

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.

The actual ex ante models were not available; therefore we used a DOE-2 simulation generator and batch processing tool called MAS Control. 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 including the WHPA.

For analysis of the chiller measures, the only differences between the baseline and measure case models were the equipment efficiencies. The average as-found efficiency of the installed chillers was used for the measure case, while the baseline models used code minimum efficiency according to chiller type and capacity.

The DX units were evaluated in a similar fashion regarding the unit efficiencies, 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 75% working economizers and 25% with fixed outside air percentage to simulate non-functional economizers in the participant sample. An additional factor for the ex post calculations was that the SEER-rated DX units, 5.5 ton and under, were subject to a code change during this project cycle as the 2013 Title 24 came into effect on July 14, 2014. The code baseline for these units changed from 13 SEER to 14 SEER. Therefore, the baseline efficiencies for these units were adjusted depending on which code was applicable. The install date determined the applicable code year.

4.4 Mini-split HVAC system market survey and analysis

The IOU Upstream Program provides upstream rebates for commercial installation of high efficiency mini-split and VRF heating and cooling systems. DNV GL found that most existing field data regarding these systems were collected from residential units in the Pacific Northwest, and indicated mini-split systems replaced or complemented resistance heaters.

Because these existing data were collected in a different region and from residential units, they did not provide useful insight into mini-split systems installed in Californian businesses. In order to determine whether Californian businesses were installing new mini-split and VRF systems, were replacing existing mini-splits and VRF systems, or were replacing existing traditional HVAC systems (such as ducted split or packaged units), the CPUC engaged DNV GL to conduct a market survey and analysis.

The market survey targeted end users (commercial customers) of mini-split systems, and sought to answer the following research questions:

Was the mini-split a retrofit, addition to an existing system, or new installation?

What was the reason for the installation?

How did the customer learn about the technology?

What space type does the mini-split system serve?

If the mini-split was a replacement, what did it replace?

When applicable, what were the efficiency levels of installed and replaced measures?

For any additional mini-splits installed:

- What was the HVAC efficiency typically purchased (standard, above standard, high efficiency)?
- What was the manufacturer?

This report contains interview results only from mini-split system owners. Surveys of VRF system owners will be conducted at a later date, because these systems are not considered ESPI measures.¹⁴

¹⁴ ESPI was adopted by the California Public Utilities Commission (CPUC) on September 5, 2013, as the mechanism whereby they encourage California's Investor-Owned Utilities (IOUs) to maximize long-lived energy savings.

5 FINDINGS

The primary findings across all sampled measures focused on the efficiency of the installed units. In the workpapers for both chillers and 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 Chiller efficiency inputs

A direct comparison of chiller inputs showed some minor differences in the code minimum value for DEER and what was used in the workpaper or what was shown as the applicable Title 24 minimum based on installation date. Table 18 provides all of the efficiency inputs that were modified to estimate gross savings. For water-cooled centrifugal chillers, the post model coefficient of performance (COP) was consistent across all size ranges due to the small sample size that would result from estimates by size range. The inverse of the COP is the energy input ratio (EIR), which is used as the simulation input.

Table 18. Efficiency input values used for chiller savings estimates

Chiller Type	Size Range (tons)	Case Option	DEER Prototype Model Inputs	HVAC 1 Inputs	HVAC 1 Inputs	HVAC 1 Inputs
			EIR	COP	EIR	IPLV
Air-Cooled Screw	Any	Code	0.35837	2.80	0.35714	3.48
Air-Cooled Screw	Any	Measure	0.28669	3.11	0.32137	3.86
Water-Cooled Screw	< 150	Code	0.22469	4.45	0.22472	5.65
Water-Cooled Screw	< 150	Measure	0.17975	5.26	0.19000	6.68
Water-Cooled Screw	151 - 299	Code	0.20421	4.90	0.20408	6.22
Water-Cooled Screw	152 - 299	Measure	0.16326	7.14	0.14000	9.07
Water-Cooled Screw	> 300	Code	0.18174	5.50	0.18182	6.98
Water-Cooled Screw	> 300	Measure	0.14534	6.67	0.15000	8.47
Water-Cooled Centrifugal	< 150	Code	0.19909	5.00	0.20000	5.58
Water-Cooled Centrifugal-VSD	< 150	Measure	0.15927	6.91	0.14464	11.29
Water-Cooled Centrifugal-Turbocor	< 150	Measure	0.19909	6.91	0.14464	11.29
Water-Cooled Centrifugal	151 - 299	Code	0.18032	5.55	0.18018	6.20
Water-Cooled Centrifugal-VSD	154 - 299	Measure	0.14420	6.91	0.14464	11.29
Water-Cooled Centrifugal-Turbocor	154 - 299	Measure	0.18032	6.91	0.14464	11.29
Water-Cooled Centrifugal	> 300	Code	0.16382	6.10	0.16393	6.81
Water-Cooled Centrifugal-VSD	> 300	Measure	0.13112	6.91	0.14464	11.29
Water-Cooled Centrifugal-Turbocor	> 300	Measure	0.16382	6.91	0.14464	11.29

Other important modeling inputs and considerations included:

Chillers in the base models operated at a constant speed.

All water-cooled centrifugal chiller post models adopted variable chiller curves.

All prototype models were based on built-up VAV system (SVAV).

Chiller capacities are based on the prototype INP files created with MASControl v3.00.20 and CZ2010.

The size could be different from the size in the DEER database, but all results are normalized per ton for the base and post case.

5.1.2 Unitary systems efficiency inputs

The site visit sample primarily included units installed under 2008 Title 24, with installation prior to July 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 22% of tonnage and 30% of savings claimed after the code change. Units 5.5 to 11.5 ton had 13% of tonnage and 12% of savings claimed after the code change. Table 19 shows the results by IOU.

Table 19. Distribution of claims before and after code change

Unit Size	IOU	Claimed Tonnage		Claimed Savings (kWh)	
		T2008	T2013	T2008	T2013
< 5 Ton	PGE	9,232	1,605	1,844,220	717,345
< 5 Ton	SCE	7,219	3,204	2,151,368	980,993
< 5 Ton	SDGE	152		36,408	
< 5 Ton	Total	16,603	4,810	4,031,996	1,698,338
5.5 - 11.5 Ton	PGE	12,274	3,043	2,070,122	545,334
5.5 - 11.5 Ton	SCE	23,169	2,207	5,672,513	517,967
5.5 - 11.5 Ton	SDGE	336		72,102	
5.5 - 11.5 Ton	Total	35,778	5,250	7,814,737	1,063,301

For units less than 5 tons (SEER rated units), the base case from DEER 2015 is a 14 SEER; we used a 13 SEER baseline with updated performance maps. The prototypes were also run to represent the units found to have two-speed and variable-speed fans, which are not required by code. Table 20 shows the distribution of the participant population and evaluation sample. For this size range we also indicated whether constant speed fans had electrically commutated motors (ECM) and in general these motors were more frequently part of the highest efficiency package units.

Table 20. Distribution of unit efficiency and fan type for units under 5 tons

Efficiency and Fan Type	As-Found Tons	Sampled Units	Proportion
Tier1 - 14 SEER, 12 EER	55	16	16.7%
Constant	15	5	4.6%
ECM	9	3	2.7%
Variable	31	8	9.4%
Tier2 - 15 SEER, 12.9 EER	91	21	27.7%
Constant	72	16	21.9%
ECM	5	1	1.5%
Variable	14	4	4.3%
Tier3 - 16+ SEER, 13+ EER	183	43	55.6%
Constant	50	14	15.2%
ECM	73	16	22.2%
Variable	60	13	18.2%
Total	329	80	100.0%

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

Efficiency and Fan Type	As-Found Tons	Sampled Units	Proportion
6-11.5 Ton	683	80	100.0%
Tier1 - 11.5 EER	113	13	16.5%
Constant	70	8	10.2%
Variable	44	5	6.4%
Tier2 - 12 EER	234	26	34.3%
Constant	67	9	9.8%
Variable	168	17	24.5%
Tier3 - 13 EER	336	41	49.2%
Constant	91	12	13.3%
Variable	245	29	35.9%
12-20 Ton	635	40	100.0%
Tier1 - 11.5 EER	13	1	2.0%
Constant	13	1	2.0%
Tier2 - 12 EER	382	25	60.2%
Constant	25	2	3.9%
Variable	357	23	56.3%
Tier3 - 12.5 EER	241	14	37.9%
Constant	30	2	4.7%
Variable	211	12	33.2%

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 2008 Title 24 energy code and a small number of units that were installed after the code change in July 2014. 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 to 11.5 tons.

Similar to small unitary systems we first determined the distribution of unit efficiency and applied that distribution to the building simulation results. Table 22 shows the distribution of as found efficiency level. All units were found to have variable air volume fan systems as required by code.

Table 22. Distribution of unit efficiency for unitary systems over 20 tons

Unit Size	Tier	As-Found Tons	Proportion
20 - 63.3 ton	9.8EER	324	22%
20 - 63.3 ton	10.5EER	140	10%
20 - 63.3 ton	10.8EER	619	43%
20 - 63.3 ton	11.5EER	235	16%
20 - 63.3 ton	12.5EER	128	9%
20 - 63.3 ton	Total	1,446	100%
>63.3 ton	10.2EER	355	26%
>63.3 ton	11EER	1,000	74%
>63.3 ton	Total	1,355	100%

The units over a 20-ton capacity had no change in Title 24 requirements. There was an update in DEER methodology to provide results for systems with and without zone-level controls and variable air volume air distribution. In the 2013-14 ex ante methodology, the unit type varied by building type. The evaluation used the updated methodology and simulated results using pre and post 2014 code changes so that the results could be applied to the unit types found in the field study and tracked by utility claims. All efficiency values for units over 20 tons were taken from DEER.

Comparisons were also made between the sample and the current DEER analysis of unit efficiency by size for IEER-rated units. The following four figures compare DEER values and the site visit sample.

Figure 5. IEER and EER for Units 5.5-11.5 ton with one speed fans

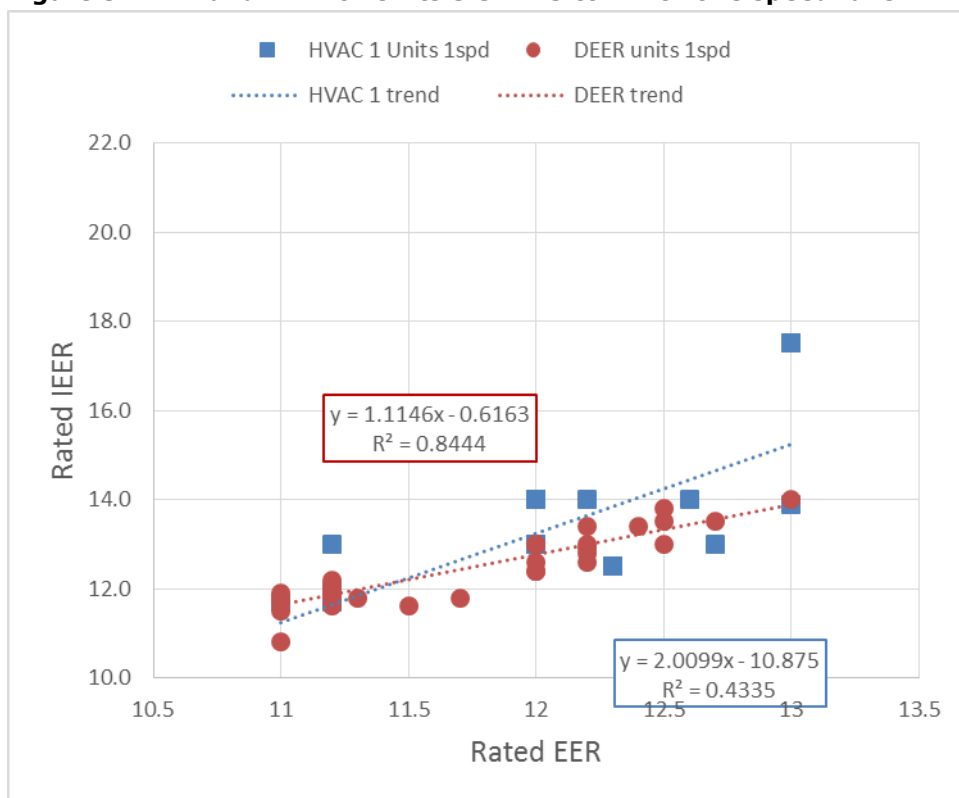


Figure 6. IEER and EER for Units 5.5-11.5 ton with two speed fans

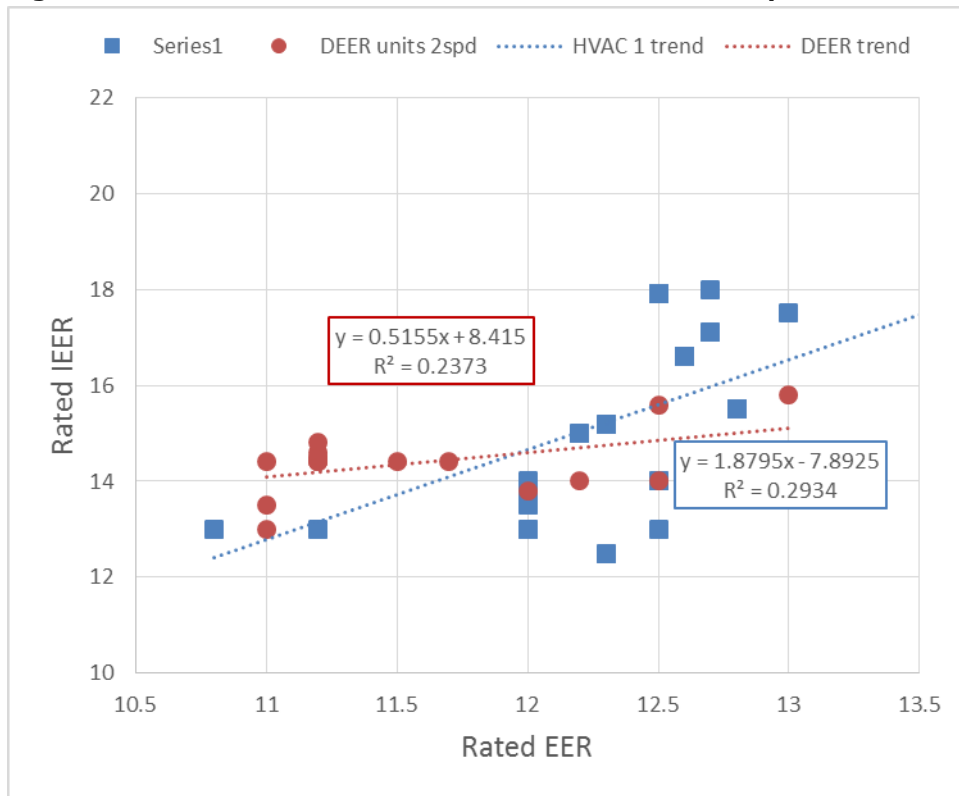


Figure 7. IEER and EER for Units 11.5-20 ton with one speed fans

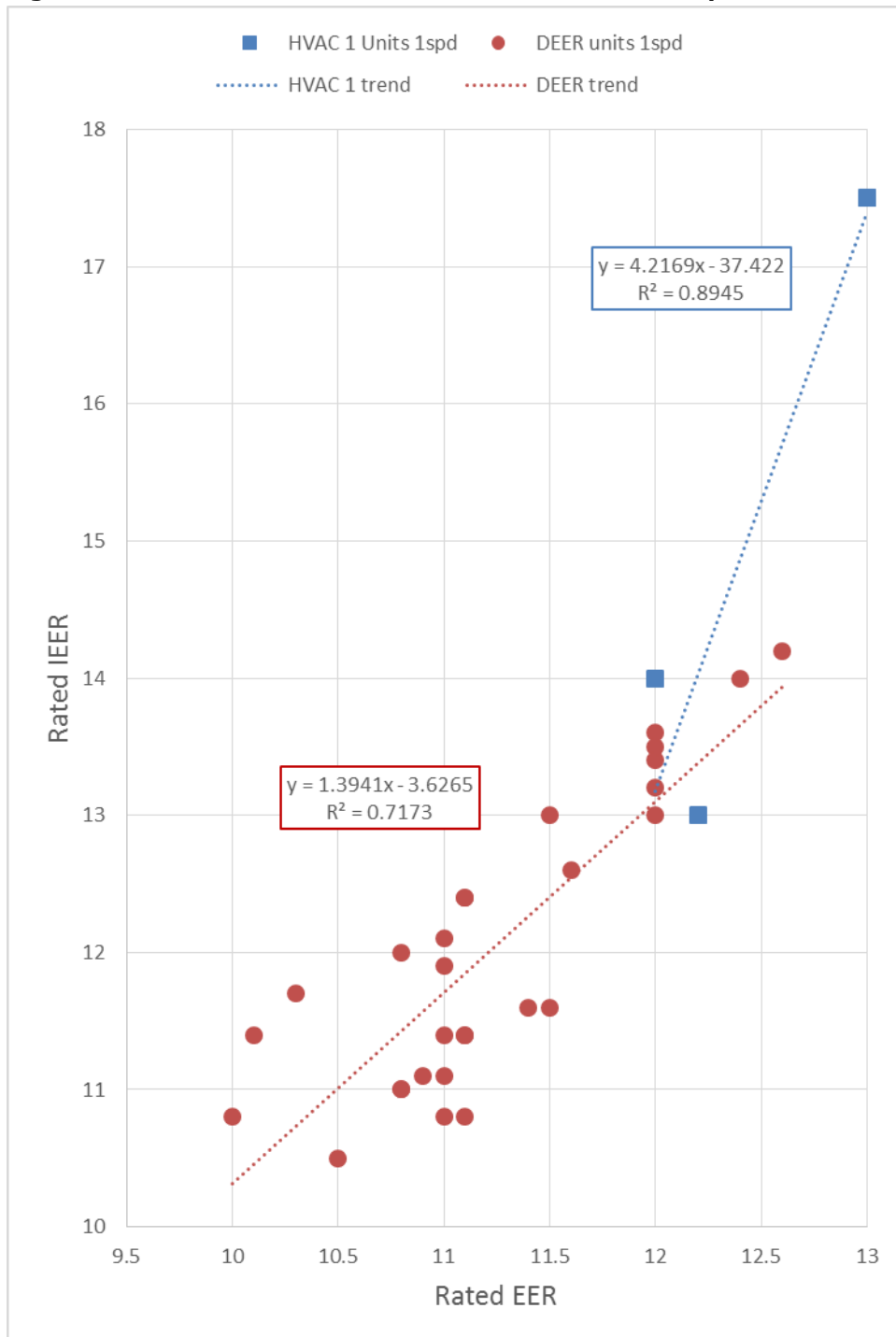
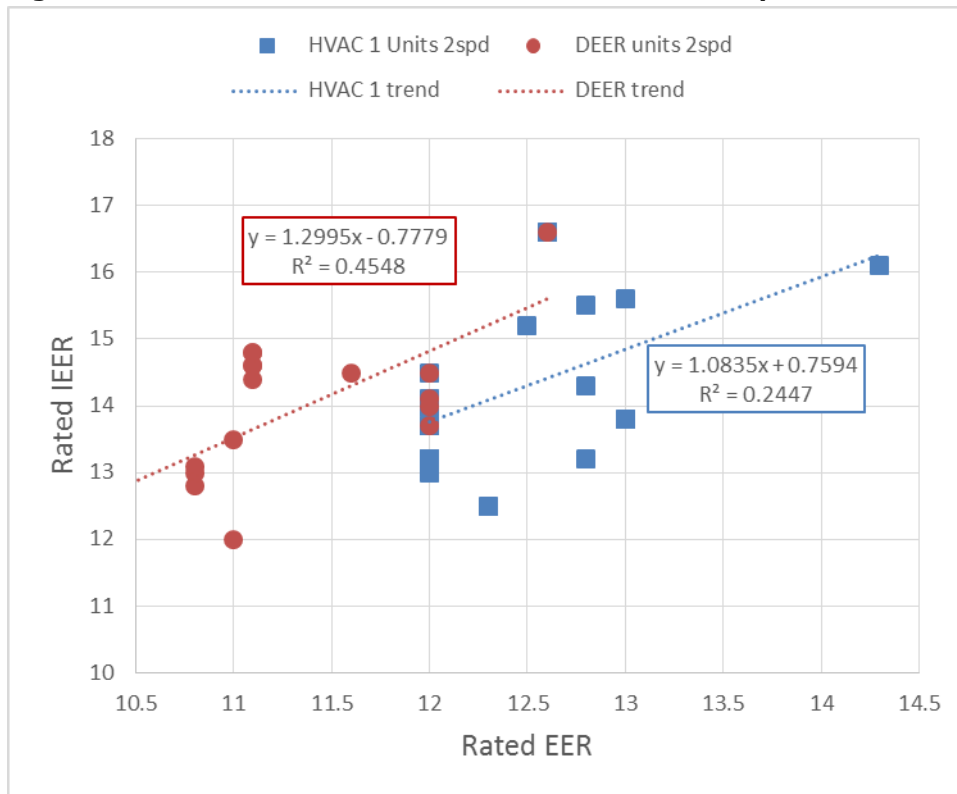


Figure 8. IEER and EER for Units 11.5-20 ton with two speed fans



Generally the values agreed between as-found and DEER assumptions. There were some values at higher EER and IEER combinations than DEER. The current savings analysis only uses DEER values and additional performance mapping and analysis is recommended for future analysis.

5.2 Test results for small unitary systems

Unitary systems with a capacity of 20 tons and less underwent additional testing beyond collection of nameplate data and rated efficiency. Limitations in testing equipment and procedures precluded detailed field testing of larger units. Units were tested for economizer functionality and fan performance. Economizers were subjected to operational tests. Fan performance was evaluated with airflow and fan power measurements. The intent was to use the economizer and fan data to update key uncertainties in the current ex ante performance maps. Table 23 shows the sample sizes and tested subsample for the small unitary sector.

Table 23. Sample sizes with additional testing

Unit Size	Total Sites	Total Units	Units with Economizer Function	Units with Airflow	Units with Fan Power
<5.5 ton	46	83	33	44	49
5.5–11.5 ton	41	82	26	41	41
11.5–20 ton	23	36	18	18	14

The results of the economizer functionality tests are summarized in Table 24. 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, 79% passed the functional test. Our field engineers determined this would be a best-case-scenario functionality rate, and if many of the no-determination units actually did not work, the rate could be as low as 51%. Since 36% of surveyed units had an outcome of no determination, engineering judgment was used to establish 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. We held economizer functionality consistent because otherwise we would simulate the addition or removal of the economizer, which has a greater impact than the efficiency upgrade.

Table 24. Economizer functionality results

Economizer Functionality	Count	Average Size Tons	Achieved Relative Precision at 90% Confidence
Pass	62	8.1	±10%
Fail	16	9.3	
No Determination	44	6.5	NA

System airflow test results with nominal system capacities were used to produce system airflow values normalized by cooling capacity in units of CFM of airflow per ton or Btu of cooling capacity. Data from two units were excluded from the analysis as the results failed reasonableness tests.

As shown in Table 25, the average cooling capacity was consistent across the unit size categories. The overall average is 355 CFM/ton. The DEER value used in prototype for most building types and climate zones is 385 CFM/ton. Given the sample size and airflow measurement uncertainty, the normalized airflow measurements did not justify any model adjustments as they support the DEER assumption within uncertainty.

Table 25. Average normalized system airflow

Unit Size	CFM/ton	CFM/Btu	Units	Achieved Relative Precision at 90% Confidence	Ex Ante (DEER) CFM/ton	Statistically Significant Ex Ante/ Ex Post Difference
<5.5 ton	347	0.029	44	±7%	333	No
5.5 11.5 ton-	369	0.031	39	±8%	333	Yes
11.5 20 ton	344	0.029	16	±12%	333	No
All	355	0.030	99	±6%	333	No

Table 26 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 23 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 speed was operating at full speed with certainty. Therefore, an unknown amount of units tested with low airflow 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 26. Normalized unit airflow distribution

CFM/Ton	Count	From DEER Data
100-200	12	5%
200-300	11	33%
300-400	49	48%
400-500	21	15%
Over 500	7	1%

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 27, units under 5.5 tons averaged 0.364 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 did not support any adjustment for these values. Larger samples could also justify making adjustments.

Table 27. Normalized fan performance

Unit Size	W/CFM	Units	Achieved Relative Precision at 90% Confidence	Ex Ante (DEER) W/CFM	Statistically Significant Ex Ante/ Ex Post Difference
< 5.5 ton	0.364	41	±13%		No
< 5.5 ton – SEER 14	0.349	6	±32%	0.294	Small Sample
5.5 ton – SEER 15	0.516	7	±28%	0.251	Small Sample
5.5 ton – SEER 16+	0.3292	28	±15%	0.251	No
5.5-11.5 ton	0.43	30	±11%	0.400	No
11.5-20 ton	0.45	14	±12%	0.410	No
All	0.41	92	±8%	NA	No

Table 28 show the distribution of system supply fan W/CFM across the tested sample. The distribution is normal with a few outliers.

Table 28. Normalized fan performance distribution

W/CFM Range	Units
0-0.1	1
0.1-0.2	9
0.2-0.3	10
0.3-0.4	24
0.4-0.5	21
0.5-0.6	13
0.6-0.7	3
0.7-0.8	3
0.8-0.9	1
Over 0.9	3

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 Chiller building types

There were 9 building types in the sample population from the tracking. These building types represent 26,209 tons of cooling and 103 units. The largest difference in the as found building types were for multiple and office. Table 29 presents the comparison of the tracking building types and the as found building types.

Table 29. Chiller system building type comparison

Tracking Building Type	As Found Building Type	Sum Cooling Cap (Tons)	# of Units
Education - Community College	Education - Community College	80	1
	Education - University	30	1
Education - Secondary School	Education - Secondary School	65	1
Education - University	Education - Secondary School	190	2
Health/Medical - Hospital	Health/Medical - Hospital	332	4
	Health/Medical - Nursing Home	140	3
	Office - Large	101	2
Lodging - Hotel	Lodging - Hotel	130	1
Manufacturing - Bio/Tech	Manufacturing - Bio/Tech	160	2
	Office - Large	140	1
	Office - Small	130	1
Multiple	Education - Secondary School	300	3
	Manufacturing - Bio/Tech	200	2
	Office - Large	858	6
	Office - Small	100	1
Office - Large	Health/Medical - Hospital	2,364	6
	Lodging - Hotel	1,526	4
	Manufacturing - Bio/Tech	200	1
	Office - Large	13,243	39
	Office - Small	290	4
Office - Small	Education - Secondary School	550	3
	Health/Medical - Hospital	200	2
	Health/Medical - Nursing Home	80	1
	Office - Large	1,800	5
	Office - Small	3,000	7
Grand Total		26,209	103

Table 30. Chiller system tonnage comparison shows the number of units and cooling tonnage by building type. There were tonnage and number of units variances for all building types in the sample population.

Table 30. Chiller system tonnage comparison

Building Type	Tracking Tons	As Found Tons	Tracking # Units	As Found # Units
Education - Community College	110	80	2	1
Education - Secondary School	65	1,105	1	9
Education - University	190	30	2	1
Health/Medical - Hospital	573	2,896	9	12
Health/Medical - Nursing Home	0	220	0	4
Lodging - Hotel	130	1,656	1	5
Manufacturing - Bio/Tech	430	560	4	5
Multiple	1,458	0	12	0
Office - Large	17,623	16,142	54	53
Office - Small	5,630	3,520	18	13
Total	26,209	26,209	103	103

Table 31 shows the comparison of energy and demand savings by building type.

Table 31. Chiller system kWh and kW comparison

Tracking Building Type	Ex Ante kWh	Ex Post kWh	Ex Ante kW	Ex Post kW
Education - Community College	9,366	7,656	3.77	3.44
Education - Secondary School	4,376	82,441	1.37	49.72
Education - University	25,175	2,577	13.72	0.52
Health/Medical - Hospital	96,599	1,441,691	33.86	258.90
Health/Medical - Nursing Home	0	28,225	0.00	15.66
Lodging - Hotel	24,283	751,727	10.42	190.13
Manufacturing - Bio/Tech	46,939	40,666	34.99	16.14
Multiple	181,699	0	90.81	0.00
Office - Large	4,635,718	3,917,741	2,123.05	1,861.72
Office - Small	932,219	564,568	541.67	308.70
Total	5,956,374	6,837,292	2,853.66	2,704.95
Savings adjustment factor		115%		95%

5.3.2 Unitary systems building types

There were 14 building types in the small unitary and 9 building types in the large unitary sample population from the tracking. These building types represent 29,377 tons of cooling and 285 units. The largest difference in the as found building types was for the tracking types miscellaneous, multiple and office. Table 32 presents the small unitary system building type comparison and Table 33 presents the large unitary system building type comparison.

Table 32. Small unitary system building type comparison

Tracking Building Type	As Found Building Type	Sum Cooling Cap (Tons)	# of Units
Education - Community College	Education - Community College	15	1
Education - Primary School	Education - Primary School	18	5
	Education - Secondary School	47	7
Education - Secondary School	Education - Secondary School	34	2
Miscellaneous	Assembly	46	4
	Education - Primary School	31	7
	Education - Secondary School	17	1
	Manufacturing - Light Industrial	38	5
	Office - Large	3	1
	Office - Small	21	2
	Restaurant - Fast Food	19	3
	Retail - Large 1 story	189	22
Multiple	Multiple	4	1
	Office - Small	3	1
Multiple - Any	Office - Large	63	8
	Retail - Large 1 story	53	3
Multiple - Commercial	Education - Primary School	23	6
	Manufacturing - Light Industrial	10	1
	Retail - Large 1 story	143	14
Office - Large	Education - Community College	5	1
	Manufacturing - Light Industrial	62	3
	Office - Large	145	14
	Retail - Large 1 story	24	4
Office - Small	Office - Small	20	2
Restaurant - Fast Food	Restaurant - Sit Down	8	1
Restaurant - Sit Down	Restaurant - Fast Food	39	4
	Restaurant - Sit Down	10	1
Retail - 3 story	Retail - Large 1 story	241	31
Retail - Large 1 story	Retail - Large 1 story	65	7
Retail - Small	Retail - Large 1 story	25	3
Grand Total		1,417	165

Table 33. Large unitary system building type comparison

Tracking Building Type	As Found Building Type	Sum Cooling Cap (Tons)	# of Units
Education - Community College	Education - Community College	80	1
	Education – University	30	1
Education - Secondary School	Education - Secondary School	65	1
Education - University	Education - Secondary School	190	2
Health/Medical - Hospital	Health/Medical – Hospital	332	4
	Multifamily	140	3
	Office – Large	101	2
Lodging - Hotel	Lodging – Hotel	130	1
Manufacturing - Bio/Tech	Manufacturing - Bio/Tech	160	2
	Office – Large	140	1
	Office – Small	130	1
Multiple	Education - Primary School	557	5
	Education - Secondary School	300	3
	Manufacturing - Bio/Tech	200	2
	Manufacturing - Light Industrial	228	3
	Multifamily	56	1
	Multiple	60	1
	Office – Large	858	6
	Office – Small	100	1
Office - Large	Education - Primary School	330	2
	Health/Medical – Hospital	2,364	6
	Lodging – Hotel	1,526	4
	Manufacturing - Bio/Tech	200	1
	Manufacturing - Light Industrial	660	3
	Office – Large	12,993	40
	Office – Small	290	4
	Retail - Large 1 story	70	1
Office - Small	Education - Secondary School	550	3
	Health/Medical – Hospital	200	2
	Health/Medical - Nursing Home	80	1
	Office – Large	1,800	5
	Office – Small	3,000	7
Grand Total		27,920	120

Error! Reference source not found. Table 34 and Table 35 represent the comparison by building type the tonnage and number of units. For both small and large unitary systems the total tonnage and number of units matches but the tonnage distribution and number of units have a wide variance across building types.

Table 34. Small unitary system tonnage comparison

Building Type	Tracking Tons	As Found Tons	Tracking # Units	As Found # Units
Education - Community College	15	20	1	2
Education - Primary School	65	72	12	18
Education - Secondary School	34	98	2	10
Miscellaneous	362	0	45	0
Multiple	7	4	2	1
Multiple - Any	116	0	11	0
Multiple - Commercial	176	0	21	0
Office - Large	236	211	22	23
Office - Small	20	44	2	5
Restaurant - Fast Food	8	58	1	7
Restaurant - Sit Down	49	18	5	2
Retail - 3 story	241	0	31	0
Retail - Large 1 story	65	739	7	84
Retail - Small	25	0	3	0
Manufacturing - Light Industrial	0	110	0	9
Assembly	0	46	0	4
Total	1,417	1,417	165	165

Table 35. Large unitary system tonnage comparison

Building Type	Tracking Tons	Tracking # Units	As Found Tons	As Found # Units
Education - Community College	50	1	0	0
Health/Medical - Nursing Home	60	1	0	0
Manufacturing - Light Industrial	40	1	25	1
Miscellaneous	535	10	0	0
Multiple - Any	525	9	0	0
Multiple - Commercial	50	2	0	0
Office - Large	705	12	2,068	33
Office - Small	916	13	388	8
Restaurant - Sit Down	60	3	60	3
Retail - 3 story	40	1	0	0
Education - University	0	0	50	1
Health/Medical - Hospital	0	0	290	4
Retail - Large 1 story	0	0	40	1
Retail - Small	0	0	40	1
Storage - Conditioned	0	0	20	1
Total	2,981	53	2,981	53

Table 36 represents the comparison of energy and demand impacts by building type for small unitary systems.

Table 36. Small unitary kWh and kW comparison

Tracking Building Type	Ex Ante kWh	Ex Post kWh	Ex Ante kW	Ex Post kW
Education - Community College	962	3,595	0.95	1.34
Education - Primary School	12,384	19,230	3.37	4.94
Education - Secondary School	1,451	8,142	0.07	1.68
Miscellaneous	87,011	0	29.49	0
Multiple	4,227	1,661	0.95	0.53
Multiple - Any	9,303	0	8.08	0
Multiple - Commercial	67,197	0	19.21	0
Office - Large	30,254	23,815	9.56	8.65
Office - Small	629	625	0.63	2.08
Restaurant - Fast Food	3,044	15,943	0.46	3.45
Restaurant - Sit Down	15,281	7,067	4.49	1.76
Retail - 3 story	86,969	0	27.95	0
Retail - Large 1 story	15,925	251,519	6.52	79.77
Retail - Small	11,035	0	2.9	0
Manufacturing - Light Industrial	0	2,971	0	2.61
Assembly	0	6,884	0	4.41
Total	345,673	341,451	114.62	111.21
Savings adjustment factor		99%		97%

Table 37 represents the comparison of energy and demand impacts by building type for large unitary systems.

Table 37. Large unitary kWh and kW comparison

Tracking Building Type	Ex Ante kWh	Ex Post kWh	Ex Ante kW	Ex Post kW
Education - Community College	3,885	0	2.97	0
Health/Medical - Nursing Home	5,598	0	3.10	0
Manufacturing - Light Industrial	3,011	1,882	4.00	2.50
Miscellaneous	40,313	0	37.66	0
Multiple - Any	35,886	0	34.14	0
Multiple - Commercial	3,536	0	2.90	0
Office - Large	89,485	236,618	83.67	204.89
Office - Small	88,047	23,033	83.83	19.05
Restaurant - Sit Down	7,520	7,520	5.93	5.93
Retail - 3 story	11,773	0	10.03	0
Education - University	0	4,360	0	2.73
Health/Medical - Hospital	0	27,123	0	10.89
Retail - Large 1 story	0	9,907	0	10.89
Retail - Small	0	1,236	0	2.12
Storage - Conditioned	0	1,932	0	4.06
Total	289,053	313,610	268.22	263.06
Savings Adjustment Factor		108.5%		98.1%

5.3.3 Building Type Vintages

Note that all savings assumed replace on burnout and 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%. In the site visits we did sample a chain store and two chiller sites that appeared to be new construction, 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 per ton consistent with DEER and those savings were multiplied by the claimed quantity of tons in the tracking. 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 Chillers

The overall realization rate for chiller energy (kWh) savings across all programs is 47%. Air-cooled chiller category had a very low realization rate of 18%, and this category accounted for 64% of all chiller upstream

claims. For all of these upstream chiller measures, there have been no significant DEER updates since the 2013-14 ex ante values were developed; the only differences between ex ante and ex post estimates are the chiller efficiencies.

The IOU programs stipulated that chillers could meet each efficiency tier requirement by meeting the full load efficiency (kW/ton) or the integrated part load value (IPLV) criteria. The IOU air-cooled chiller workpapers acknowledge that the full load efficiency of the DEER measure is higher than the majority of high efficiency models available. After further investigation, we found that the air-cooled chiller energy savings estimates developed in workpapers were much higher than are feasible, representing approximately 85% of the cooling end use energy usage estimate from the DEER prototypes. In contrast, the ex post savings were about 10% of the cooling end use energy usage.

For water-cooled chillers, many of the units met the efficiency assumptions, and realization rates were over 100% for two of the four categories. The total realization rate for water-cooled chillers was 98%. Table 38 shows the results.

Table 38. Ex ante and ex post kWh savings and realization rates for chillers

Sample Group	Unit Size	Ex Ante UES (kWh)	Efficiency Adjusted Ex Post UES (kWh)	Total Tonnage Claimed	Ex Ante Total (kWh)	Efficiency Adjusted Ex Post Total (kWh)	Efficiency Adjustment Realization Rate (kWh)	Building Type Adjustment (kWh)	Final Ex Post Savings Total (kWh)	Final Realization Rate (kWh)
Air-cooled Chillers	All	744	116	43,077	32,057,004	5,010,090	16%	115%	5,751,057	18%
Water-cooled Screw Chiller	<150 ton	288	135	463	133,531	62,580	47%	115%	71,835	54%
Water-cooled Screw Chiller	150 - 300 ton	380	254	8,992	3,416,405	2,282,340	67%	115%	2,619,887	77%
Water-cooled Screw Chiller	>300 ton	418	262	800	334,507	209,463	63%	115%	240,442	72%
Water-cooled Centrifugal Chiller	150 - 300 ton	221	389	1,132	249,859	440,809	176%	115%	506,002	203%
Water-cooled Centrifugal Chiller	>300 ton	335	300	42,497	14,250,960	12,765,019	90%	115%	14,652,901	103%
Water-cooled Total	All	341	292	53,884	18,385,262	15,760,211	86%	115%	18,091,067	98%
All Chiller Total	All	520	214	96,961	50,442,266	20,770,301	41%	115%	23,842,124	47%

In stark contrast to the energy savings, the demand (kW) reduction realization rate for all upstream chiller measures was 129% as shown in Table 39. The exact reason for the high realization rate is unknown since the ex ante models were unavailable to the evaluation team, but is likely due to differences in ex ante and ex post calculation methods.

Table 39. Ex ante and ex post kW savings and realization rates for chillers

Sample Group	Unit Size	Ex Ante UES (kW)	Efficiency Adjusted Ex Post UES (kW)	Total Tonnage Claimed	Ex Ante Total (kW)	Efficiency Adjusted Ex Post Total (kW)	Efficiency Adjustment Realization Rate (kW)	Building Type Adjustment (kW)	Final Ex Post Savings Total (kW)	Final Realization Rate (kW)
Air-cooled Chillers	All	0.06	0.07	43,077	2,507	2,857	114%	95%	2,708	108%
Water-cooled Screw Chiller	<150 ton	0.08	0.08	463	35	39	111%	95%	37	106%
Water-cooled Screw Chiller	150 - 300 ton	0.10	0.15	8,992	928	1,369	148%	95%	1,298	140%
Water-cooled Screw Chiller	>300 ton	0.11	0.08	800	88	65	74%	95%	61	70%
Water-cooled Centrifugal Chiller	150 - 300 ton	0.07	0.19	1,132	75	213	285%	95%	202	270%
Water-cooled Centrifugal Chiller	>300 ton	0.09	0.13	42,497	3,801	5,545	146%	95%	5,256	138%
Water -cooled Total	All	0.09	0.13	53,884	4,926	7,230	147%	95%	6,853	139%
All Chiller Total	All	0.08	0.10	96,961	7,433	10,087	136%	95%	9,561	129%

5.4.2 Unitary systems

The overall realization rate for unitary systems across all programs and measures was 71.2%. 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 installation¹⁵. 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

For unitary systems less than 20 tons, 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.

Table 40 shows the results for large units. Similar to the results for air-cooled chillers, the ex ante claimed savings for the largest size, greater than 63.3 tons group appeared to be unrealistically high, representing approximately 70% of the baseline cooling consumption in the prototype models.¹⁶ The DEER savings are

¹⁵ 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.

¹⁶ The ex ante kWh savings claims were approximately 70% of the baseline cooling consumption in the baseline models generated with MAS Control. The sources are IOU workpapers which take the DEER models and estimates of runtime; a change in EER and IEER is then multiplied by these runtimes to estimate savings. Since it is not possible to obtain this level of savings through equipment efficiency alone, this suggests an error in the estimate.

more realistic for units between 20 and 63 tons, but some of the units surveyed only met baseline efficiency levels, driving down the realization rate.

Table 40. Ex ante and ex post kWh savings and realization rates for large unitary systems

Unit Size	Ex Post Efficiency Level	Ex Ante UES (kWh/ ton)	Efficiency Adjusted Ex Post UES (kWh/ ton)	Total Adjusted Tonnage	Ex Ante Total (kWh)	Efficiency Adjusted Ex Post Total (kWh)	Efficiency Adjusted Realization Rate (kWh)	Building Type Adjusted (kWh)	Final Ex Post Savings Total (kWh)	Final Realization Rate (kWh)
20 - 63.3 ton	10.5EER	333.8	33.2	4,455	1,487,279	147,976	9.9%	108.5%	160,547	10.8%
20 - 63.3 ton	10.8EER	333.8	50.6	39,000	13,019,415	1,972,333	15.1%	108.5%	2,139,894	16.4%
20 - 63.3 ton	11.5EER	333.8	83.7	4,370	1,458,678	365,627	25.1%	108.5%	396,689	27.2%
20 - 63.3 ton	12.5EER	333.8	125.5	3,770	1,258,467	473,180	37.6%	108.5%	513,379	40.8%
>63.3 ton	10.2EER	511.3	30.4	3,799	1,942,249	115,383	5.9%	108.5%	125,186	6.4%
>63.3 ton	11EER	511.3	67.8	10,701	5,471,125	725,662	13.3%	108.5%	787,311	14.4%
>63.3 ton	12 EER	511.3	172.1	1,284	656,535	220,980	33.7%	108.5%	239,754	36.5%
Large	All	375.4	59.7	67,379	25,293,748	4,021,141	15.9%	108.5%	4,362,760	17.2%

The demand (kW) reduction realization rate for all upstream large unitary was 149.7% as shown in Table 41. The exact reason for the high realization rate is unknown since the ex ante models were unavailable to the evaluation team, but is likely due to differences in ex ante and ex post calculation methods.

Table 41. Ex ante and ex post kW savings and realization rates for large unitary systems

Unit Size	Ex Post Efficiency Level	Ex Ante UES (kW/ton)	Efficiency Adjusted Ex Post UES (kW/ton)	Total Adjusted Tonnage	Ex Ante Total (kW)	Efficiency Adjusted Ex Post Total (kW)	Efficiency Adjusted Realization Rate (kW)	Building Type Adjustment (kW)	Final Ex Post Savings Total (kW)	Final Realization Rate (kW)
20 - 63.3 ton	10.5EER	0.04	0.03	4,455	189	128	68.0%	98.1%	126	66.7%
20 - 63.3 ton	10.8EER	0.04	0.04	39,000	1,655	1,663	100.5%	98.1%	1,631	98.6%
20 - 63.3 ton	11.5EER	0.04	0.09	4,370	185	388	209.4%	98.1%	381	205.4%
20 - 63.3 ton	12.5EER	0.04	0.13	3,770	160	497	310.9%	98.1%	488	304.9%
>63.3 ton	10.2EER	0.02	0.03	3,799	86	114	132.4%	98.1%	112	129.9%
>63.3 ton	11EER	0.02	0.08	10,701	243	886	365.1%	98.1%	869	358.1%
>63.3 ton	12 EER	0.02	0.16	1,284	29	210	721.5%	98.1%	206	707.6%
Large	All	0.04	0.06	67,379	2,547	3,887	152.6%	98.1%	3,812	149.7%

Additional adjustments were made for small units 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 75% (approximately 3 out of 4 units tested had properly functioning economizers).

Table 42 provides the results and applies the economizer functionality to the claimed tonnage to create the weighting of 75% 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 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 airflow and 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.

Table 42. Ex ante and ex post kWh savings and realization rates for small unitary systems

Unit Size	Ex Post Efficiency Level	Working Economizer	Ex Ante UES (kWh/ton)	Efficiency Adjusted Ex Post UES (kWh/ton)	Total Adjusted Tonnage	Ex Ante Total (kWh)	Efficiency Adjusted Ex Post Total (kWh)	Efficiency Adjusted Realization Rate (kWh)	Final Ex Post Savings Total (kWh)	Final Realization Rate (kWh)
< 5 Ton	Tier0P, 14 SEER/12 EER, 1spd	NA	260.7	313.3	2,943	767,405	922,102	120.2%	910,840	118.7%
< 5 Ton	Tier1, 15 SEER /<13 EER, 1spd	NA	260.7	336.1	3,211	837,169	1,079,261	128.9%	1,066,079	127.3%
< 5 Ton	Tier1, 15 SEER /<13 EER, 2spd	NA	260.7	611.1	7,760	2,023,158	4,742,072	234.4%	4,684,153	231.5%
< 5 Ton	Tier2, 16 SEER/>13EER, 2spd	NA	260.7	637.8	3,478	906,933	2,218,384	244.6%	2,191,289	241.6%
< 5 Ton	Tier3, 17 SEER/>13EER, 2spd	NA	260.7	694.4	8,830	2,302,214	6,131,605	266.3%	6,056,715	263.1%
< 5 Ton	Tier4, 18 SEER/>13EER, 2spd	NA	260.7	744.8	535	139,528	398,558	285.6%	393,691	282.2%
< 5 Ton (2013 Code)	Tier1, 15 SEER /<13 EER, 1spd	NA	388.0	22.8	763	296,132	17,429	5.9%	17,216	5.8%
< 5 Ton (2013 Code)	Tier1, 15 SEER /<13 EER, 2spd	NA	388.0	297.8	1,844	715,653	549,292	76.8%	542,583	75.8%
< 5 Ton (2013 Code)	Tier2, 16 SEER/>13EER, 2spd	NA	388.0	324.5	827	320,810	268,250	83.6%	264,973	82.6%
< 5 Ton (2013 Code)	Tier3, 17 SEER/>13EER, 2spd	NA	388.0	381.1	2,099	814,364	799,857	98.2%	790,088	97.0%
< 5 Ton (2013 Code)	Tier4, 18 SEER/>13EER, 2spd	NA	388.0	431.5	127	49,355	54,881	111.2%	54,210	109.8%
5.5 - 11.5 Ton	11.5EER, 1spd	Yes	179.9	34.9	1,598	287,632	55,825	19.4%	55,143	19.2%
5.5 - 11.5 Ton	11.5EER, 1spd	No	179.9	46.9	533	95,877	24,980	26.1%	24,675	25.7%
5.5 - 11.5 Ton	12EER,1spd	Yes	179.9	67.4	6,660	1,198,466	448,592	37.4%	443,113	37.0%
5.5 - 11.5 Ton	12EER,1spd	No	179.9	90.3	2,220	399,489	200,373	50.2%	197,925	49.5%
5.5 - 11.5 Ton	12EER,2spd	Yes	179.9	441.5	4,795	862,895	2,117,342	245.4%	2,091,481	242.4%
5.5 - 11.5 Ton	12EER,2spd	No	179.9	533.4	1,598	287,632	852,576	296.4%	842,163	292.8%
5.5 - 11.5 Ton	13EER,2spd	Yes	179.9	470.7	13,587	2,444,870	6,395,680	261.6%	6,317,564	258.4%
5.5 - 11.5 Ton	13EER,2spd	No	179.9	570.8	4,529	814,957	2,585,327	317.2%	2,553,750	313.4%
5.5 - 11.5 Ton (2013 Code)	11.5EER, 1spd	Yes	221.9	-319.9	358	79,515	(114,648)	-144.2%	(113,248)	-142.4%
5.5 - 11.5 Ton (2013 Code)	11.5EER, 1spd	No	221.9	-379.4	119	26,505	(45,314)	-171.0%	(44,760)	-168.9%
5.5 - 11.5 Ton (2013 Code)	12EER,1spd	Yes	221.9	-287.3	1,493	331,313	(429,010)	-129.5%	(423,770)	-127.9%
5.5 - 11.5 Ton (2013 Code)	12EER,1spd	No	221.9	-336.2	498	110,438	(167,333)	-151.5%	(165,289)	-149.7%
5.5 - 11.5 Ton (2013 Code)	12EER,2spd	Yes	221.9	67.9	1,075	238,545	72,957	30.6%	72,066	30.2%
5.5 - 11.5 Ton (2013 Code)	12EER,2spd	No	221.9	85.8	358	79,515	30,747	38.7%	30,371	38.2%
5.5 - 11.5 Ton (2013 Code)	13EER,2spd	Yes	221.9	97.4	3,046	675,878	296,713	43.9%	293,089	43.4%
5.5 - 11.5 Ton (2013 Code)	13EER,2spd	No	221.9	123.1	1,015	225,293	124,996	55.5%	123,469	54.8%
11.6 - 20 Ton	Tier2, 12.0EER, 1spd	Yes	266.1	-293.7	739	196,515	(216,926)	-110.4%	(214,276)	-109.0%
11.6 - 20 Ton	Tier2, 12.0EER, 1spd	No	266.1	-341.2	246	65,505	(83,991)	-128.2%	(82,965)	-126.7%
11.6 - 20 Ton	Tier2, 12.0EER, 2spd	Yes	266.1	83.3	9,601	2,554,700	799,632	31.3%	789,865	30.9%
11.6 - 20 Ton	Tier2, 12.0EER, 2spd	No	266.1	107.1	3,200	851,567	342,637	40.2%	338,452	39.7%
11.6 - 20 Ton	Tier3, 12.5EER, 1spd	Yes	266.1	-260.3	923	245,644	(240,292)	-97.8%	(237,357)	-96.6%
11.6 - 20 Ton	Tier3, 12.5EER, 1spd	No	266.1	-297.7	308	81,881	(91,602)	-111.9%	(90,483)	-110.5%
11.6 - 20 Ton	Tier3, 12.5EER, 2spd	Yes	266.1	113.7	7,201	1,916,025	818,545	42.7%	808,548	42.2%
11.6 - 20 Ton	Tier3, 12.5EER, 2spd	No	266.1	146.1	2,400	638,675	350,750	54.9%	346,466	54.2%
Small Units	All	All	237.6	311.5	100,520	23,882,052	31,310,247	131.1%	30,927,828	129.5%

The demand (kW) reduction realization rate for all upstream small unitary was 129.9% as shown in Table 43Table 39. The exact reason for the high realization rate is unknown since the ex ante models were unavailable to the evaluation team, but is likely due to differences in ex ante and ex post calculation methods.

Table 43. Ex ante and ex post kW savings and realization rates for small unitary systems

Unit Size	Ex Post Efficiency Level	Working Economizer	Ex Ante UES (kW/ton)	Efficiency Adjusted Ex Post UES (kW/ton)	Total Adjusted Tonnage	Ex Ante Total (kW)	Efficiency Adjusted Ex Post Total (kW)	Efficiency Adjusted Realization Rate (kW)	Final Ex Post Savings (kW)	Final Realization Rate (kW)
< 5 Ton	Tier0P, 14 SEER/12 EER, 1spd	NA	0.05	0.09	2,943	146.3	264.3	180.6%	256.5	175.3%
< 5 Ton	Tier1, 15 SEER /<13 EER, 1spd	NA	0.05	0.10	3,211	159.6	325.2	203.7%	315.5	197.7%
< 5 Ton	Tier1, 15 SEER /<13 EER, 2spd	NA	0.05	0.14	7,760	385.8	1058.8	274.5%	1,027.3	266.3%
< 5 Ton	Tier2, 16 SEER/>13EER, 2spd	NA	0.05	0.16	3,478	172.9	547.4	316.6%	531.1	307.1%
< 5 Ton	Tier3, 17 SEER/>13EER, 2spd	NA	0.05	0.19	8,830	439.0	1652.0	376.3%	1,602.8	365.1%
< 5 Ton	Tier4, 18 SEER/>13EER, 2spd	NA	0.05	0.21	535	26.6	114.4	429.9%	111.0	417.1%
< 5 Ton (2013 Code)	Tier1, 15 SEER /<13 EER, 1spd	NA	0.08	0.01	763	62.0	8.8	14.1%	8.5	13.7%
< 5 Ton (2013 Code)	Tier1, 15 SEER /<13 EER, 2spd	NA	0.08	0.05	1,844	149.9	86.0	57.4%	83.5	55.7%
< 5 Ton (2013 Code)	Tier2, 16 SEER/>13EER, 2spd	NA	0.08	0.07	827	67.2	55.9	83.1%	54.2	80.7%
< 5 Ton (2013 Code)	Tier3, 17 SEER/>13EER, 2spd	NA	0.08	0.10	2,099	170.6	204.2	119.7%	198.1	116.1%
< 5 Ton (2013 Code)	Tier4, 18 SEER/>13EER, 2spd	NA	0.08	0.12	127	10.3	15.8	152.5%	15.3	148.0%
5.5 - 11.5 Ton	11.5EER, 1spd	Yes	0.09	0.03	1,598	145.5	41.7	28.6%	40.4	27.8%
5.5 - 11.5 Ton	11.5EER, 1spd	No	0.09	0.03	533	48.5	14.1	29.1%	13.7	28.2%
5.5 - 11.5 Ton	12EER,1spd	Yes	0.09	0.05	6,660	606.2	314.5	51.9%	305.1	50.3%
5.5 - 11.5 Ton	12EER,1spd	No	0.09	0.05	2,220	202.1	106.7	52.8%	103.5	51.2%
5.5 - 11.5 Ton	12EER,2spd	Yes	0.09	0.11	4,795	436.5	526.6	120.7%	511.0	117.1%
5.5 - 11.5 Ton	12EER,2spd	No	0.09	0.11	1,598	145.5	182.7	125.5%	177.2	121.8%
5.5 - 11.5 Ton	13EER,2spd	Yes	0.09	0.13	13,587	1236.6	1771.7	143.3%	1,719.0	139.0%
5.5 - 11.5 Ton	13EER,2spd	No	0.09	0.14	4,529	412.2	612.9	148.7%	594.7	144.3%
5.5 - 11.5 Ton (2013 Code)	11.5EER, 1spd	Yes	0.10	-0.04	358	35.0	-15.7	-44.7%	(15.2)	-43.4%
5.5 - 11.5 Ton (2013 Code)	11.5EER, 1spd	No	0.10	-0.05	119	11.7	-5.4	-46.7%	(5.3)	-45.3%
5.5 - 11.5 Ton (2013 Code)	12EER,1spd	Yes	0.10	-0.02	1,493	145.9	-24.8	-17.0%	(24.0)	-16.5%
5.5 - 11.5 Ton (2013 Code)	12EER,1spd	No	0.10	-0.02	498	48.6	-9.1	-18.8%	(8.9)	-18.2%
5.5 - 11.5 Ton (2013 Code)	12EER,2spd	Yes	0.10	0.05	1,075	105.0	53.2	50.6%	51.6	49.1%
5.5 - 11.5 Ton (2013 Code)	12EER,2spd	No	0.10	0.05	358	35.0	17.9	51.0%	17.3	49.5%
5.5 - 11.5 Ton (2013 Code)	13EER,2spd	Yes	0.10	0.07	3,046	297.6	219.2	73.7%	212.7	71.5%
5.5 - 11.5 Ton (2013 Code)	13EER,2spd	No	0.10	0.07	1,015	99.2	74.0	74.6%	71.7	72.3%
11.6 - 20 Ton	Tier2, 12.0EER, 1spd	Yes	0.06	0.00	739	44.7	-3.2	-7.0%	(3.1)	-6.8%
11.6 - 20 Ton	Tier2, 12.0EER, 1spd	No	0.06	-0.01	246	14.9	-1.8	-11.7%	(1.7)	-11.4%
11.6 - 20 Ton	Tier2, 12.0EER, 2spd	Yes	0.06	0.06	9,601	581.1	567.1	97.6%	550.2	94.7%
11.6 - 20 Ton	Tier2, 12.0EER, 2spd	No	0.06	0.06	3,200	193.7	191.6	98.9%	185.9	96.0%
11.6 - 20 Ton	Tier3, 12.5EER, 1spd	Yes	0.06	0.02	923	55.9	16.1	28.8%	15.6	27.9%
11.6 - 20 Ton	Tier3, 12.5EER, 1spd	No	0.06	0.01	308	18.6	4.6	24.8%	4.5	24.0%
11.6 - 20 Ton	Tier3, 12.5EER, 2spd	Yes	0.06	0.08	7,201	435.8	581.2	133.4%	563.9	129.4%
11.6 - 20 Ton	Tier3, 12.5EER, 2spd	No	0.06	0.08	2,400	145.3	196.6	135.3%	190.7	131.3%
Small Units	All	All	0.07	0.10	100,520	7291.3	9765.0	133.9%	9,474.5	129.9%

The energy savings results for small and large unitary systems are summarized by size in Table 44. These overall results are applicable across the measure group.

Table 44. Ex ante and ex post kWh savings and realization rates for all unitary systems

Unit Size	Ex Ante UES (kWh/ ton)	Ex Post UES (kWh/ ton)	Total Tonnage Claimed	Ex Ante Total (kWh)	Ex Post Total (kWh)	Efficiency Adjusted Realization Rate (kWh)	Building Type Adjustment (kWh)	Final Ex Post Savings Total (kWh)	Final Realization Rate (kWh)
< 5 Ton	265.9	530.0	32,417	9,172,721	17,181,691	187.3%	98.8%	16,971,836	185.0%
5.5 - 11.5 Ton	187.6	286.3	43,485	8,158,817	12,449,803	152.6%	98.8%	12,297,743	150.7%
11.6 - 20 Ton	266.1	68.2	24,618	6,550,514	1,678,753	25.6%	98.8%	1,658,249	25.3%
20 - 63.3 Ton	333.8	57.4	51,595	17,223,839	2,959,115	17.2%	108.5%	3,210,509	18.6%
>63.3 Ton	511.3	49.7	15,784	8,069,909	784,749	9.7%	108.5%	851,418	10.6%
All	292.9	208.8	167,899	49,175,800	35,054,112	71.3%	99.8%	34,989,755	71.2%

The demand savings results for small and large unitary systems are summarized by size in Table 45. These overall results are applicable across the measure group.

Table 45. Ex ante and ex post kW savings and realization rates for all unitary systems

Unit Size	Ex Ante UES (kW/ton)	Ex Post UES (kW/ton)	Total Tonnage Claimed	Ex Ante Total (kW)	Efficiency Adjusted Ex Post Total (kW)	Efficiency Adjustment Realization Rate (kW)	Building Type Adjustment (kW)	Final Ex Post Savings (kW)	Final Realization Rate (kW)
< 5 Ton	0.06	0.13	32,417	1,790	4,333	242.0%	97.0%	4,204	234.8%
5.5 - 11.5 Ton	0.09	0.09	43,485	4,011	3,880	96.7%	97.0%	3,765	93.9%
11.6 - 20 Ton	0.06	0.06	24,618	1,490	1,552	104.2%	97.0%	1,506	101.1%
20 - 63.3 Ton	0.04	0.05	51,595	2,189	2,677	122.3%	98.1%	2,625	119.9%
>63.3 Ton	0.02	0.04	15,784	358	594	165.9%	98.1%	583	162.7%
All	0.06	0.08	167,899	9,838	13,036	132.5%	97.3%	12,682	128.9%

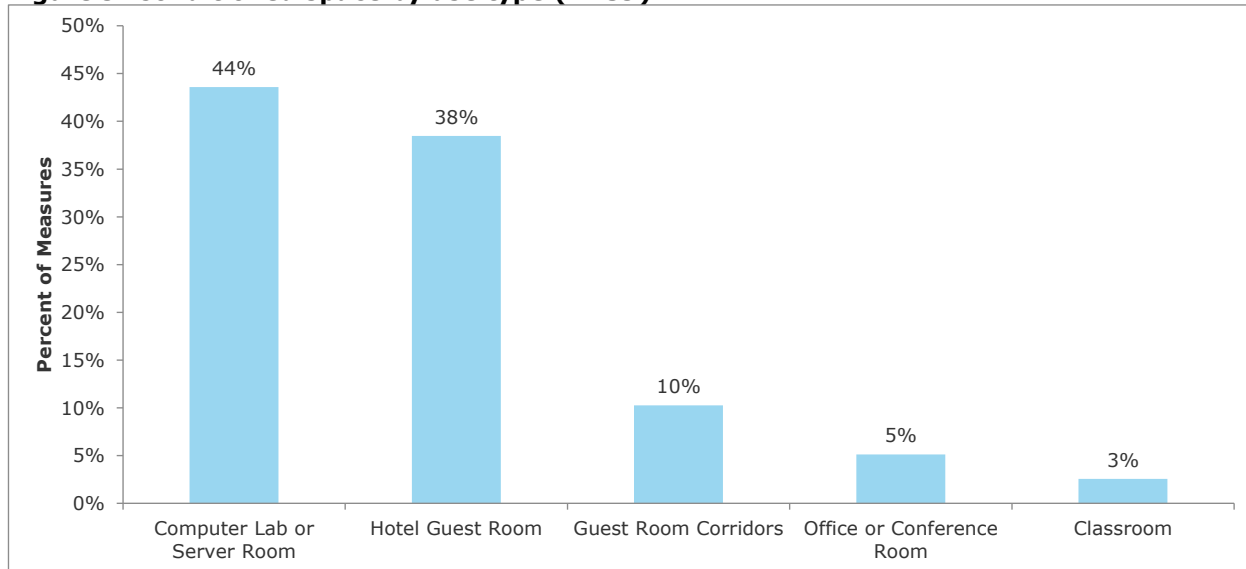
5.5 Mini-split

This section contains interview results from mini-split system owners only.

5.5.1 Findings below report responses per measure

In some cases, as mentioned previously, customers had multiple measures. Interviewers collected data on each measure installed for a total of 39 individual measures applications. The mini-split systems were used in a variety of different spaces. The most commonly mentioned categories of use types were computer labs or server rooms (44%) and hotel guest rooms (38%). The remaining spaces mentioned included guest room corridors (10%), offices or conference rooms (5%), and classroom (3%). Figure 4 shows the use types for the spaces served by the installed mini-split system. The size of the conditioned spaces ranged in square footage, with most ranging between 100-500 sq. ft. (51%), followed by less than 100 sq. ft. (31%). Some computer or server rooms were quite small (<100 sq. ft.), while the majority of office spaces and hotel rooms were between 101-500 sq. ft. Other larger areas served community areas (guest room corridors) and a conference area over 2,000 sq. ft.

Figure 9. Conditioned space by use type (n=39)



5.5.2 Previous equipment characteristics

Among 39 total responses, slightly over half (54%) completely replaced the previous system. About one-fifth (21%) of measures were added to spaces that had no previous heating or cooling capacity, and roughly one-fourth (26%) stated that they added the new installation to a pre-existing system.

Customers also provided their primary reason for installing a new system. More than one-third (41%) reported that the previous system was at the end of its life cycle. Roughly one-fourth each mentioned their company either added additional capacity to an existing system (26%) or that the space was a new construction (21%). The remaining customers (13%) stated that the installation was an early replacement (defined as replacement of the previous equipment when its remaining useful life was five years or greater).

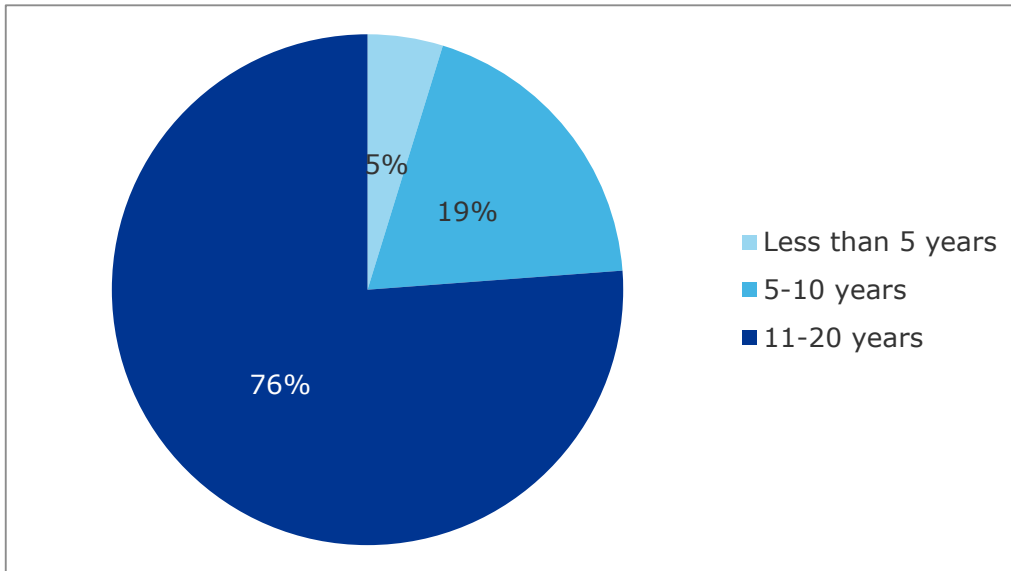
DNV GL surveyors asked customers who replaced a previous system (54% of total respondents) what type of equipment the ductless mini-split system replaced. Nearly three-fourths (71%) of respondents indicated that the previous equipment was a mini-split system. One-fourth acknowledged that they did not know the type of system that was replaced. One respondent (5%) indicated replacing a packaged DX rooftop air conditioner with a natural gas furnace and stated it was a constant (not variable) system.


Table 46. Prior systems that were replaced with rebated mini-split systems (n=21)

Measure Type	Total
Packaged DX Rooftop with Natural Gas Furnace	1
Mini-Split System	15
Don't Know	5
Total	21

Roughly three-fourths (76%) of the systems that customers replaced ranged between 11 and 20 years old. Another one-fifth (19%) were between 5 and 10 years old. The remaining 5% were less than five years old. Figure 10 displays the age of the replaced systems.

Figure 10. Age of previous system (n=21)





None knew the previous heating capacity of the replaced system. However, three-fourths of respondents (75%) knew the previous cooling capacity, and cited it as 9 kBtu/hr cooling.

Interviewers asked about the efficiency of the previous equipment. Nearly one-fourth (24%) did not know the efficiency of the previous equipment. Among those who did know the efficiency, nearly all cited 10-SEER (15 of 16 responses), with one respondent citing 8-SEER.

5.5.3 Added to pre-existing system

Interviewers asked customers who added to their pre-existing system (26% of total respondents) why they did so. More than three-fourths (80%) stated the reason being the cooling load was not being met. One respondent indicated that heating capacity was the issue (10%) and one respondent didn't know (10%). A large majority (80%) of these pre-existing systems were between 11 and 15 years old while 10% were between 5 and 10 years old. One respondent (10%) was unsure of the previous system's age.

Ninety percent recalled the pre-existing system type, and all of them mentioned it was a ducted split system air conditioner with natural gas furnace. Ten percent didn't recall the pre-existing system type. While none knew the heating capacity, a large majority (80%) of respondents cited the pre-existing system's cooling capacity as 60 kBTU. A similar percentage (80%) reported the pre-existing system efficiency at 10-SEER and the remaining (20%) stated they didn't know.

5.5.4 Results

DNV GL consultants found that, as expected, the impact of the Upstream Program was difficult to measure at the customer level. It was challenging to find a contact that was aware of the mini-split installation, and those who were aware of the installation often had limited knowledge regarding the details of the current or previous measures. Timing may also affect responses, as installations occurred up to three years ago. If customer surveys remain a priority for the Upstream Program, we recommend scheduling data collection to occur at the same time or immediately after the manufacturer records a sale.

Despite challenges to data collection, the mini-split survey was able to provide an initial description of the market. Single zone mini-split air conditioners (natural gas heating) and heat pumps comprised the sample. Fujitsu and Mitsubishi were the most common manufacturers of the rebated technology and Samsung was the third most common. About half of the responses reported that the mini-split was installed to replace existing capacity (mostly equipment that is approaching the end of its useful life) with more efficient systems. The other half added load: roughly half of these by supplementing existing systems that lacked sufficient cooling capacity, and the other half by adding new systems to new or previously unconditioned space.

In the 2013 ESPI memo savings were adjusted to account for what appeared to be an incorrect adjustment factor. In 2014, we have included this adjustment and determined that only 4% of units replaced existing ducted systems while the workpaper assumption was 50%.

6 CONCLUSIONS AND RECOMMENDATIONS

Section 5 of this report provides a detailed discussion of study findings. Of these findings, the evaluation team judges the following particularly noteworthy.

Finding #1: Program savings were lower than expected.

This impact evaluation of the 2013-14 Upstream HVAC programs revealed lower than expected savings. The primary driver of the low realization rates was that the actual efficiencies of the installed equipment was lower than ex ante estimates assumed efficiency levels. The resulting low savings levels were most prevalent for air-cooled chillers and large unitary systems, which had gross savings realization rates of 11% and 15%, respectively. The evaluation team believes one root cause is having optional efficiency criteria for full load or partial load rather than requiring both full and partial load efficiencies meet a threshold that ensures savings are above code minimum. Consequently, we recommend the following:

For program managers and designers: Set program efficiency criteria for full-load and part-load combinations. Pre-identify units that meet the criteria such that savings claims are tied back to make and model numbers collected by participating distributors.

Another possible factor for low realization rates include using system performance maps that do not accurately represent the performance of the systems being installed through the program. To mitigate the discrepancies arising from this factor, we recommend the following:


For program managers and designers: Work with distributors to obtain extended performance maps that can be used in future simulations. DEER updates are limited by the availability of information from manufacturers, and the upstream program may be in a better position to obtain this information.
For workpaper developers and engineers: Use DEER estimates generally and focus workpaper efforts on EER and IEER combinations greater than DEER values. Detail the performance maps and additional features if any such as variable speed compressors, energy recovery ventilation, etc.

Another possible factor for low realization rates is issues with building types¹⁷ associated with Upstream claims. To resolve this issue, we recommend the following.

For program managers and tracking data teams: Avoid building types that do not map to ex ante values. In general, the building types in tracking such as "Multiple" and "Miscellaneous" were associated with specific building types based on site visits.

Another issue that may lead to inaccuracies in realization rates is using a deemed saving approach for large water cooled chillers. The same exact chiller could have highly varying savings dependent upon how it is being operated especially regarding chilled water temperatures and control approaches. To reduce error associated with deemed chiller savings, we recommend the following:

¹⁷ Building types used in this evaluation are DEER standard building types.



For program managers and designers: Implement a calculated savings approach for large water-cooled chillers. Having a few calculation inputs, such as the site-specific set points and controls, could produce much more accurate estimates without adding much more work to the process.

Finally, the realization rates were profoundly affected by ex ante estimates that did not pass basic quality control steps. For example, the air-cooled chiller savings ex ante estimates were 85% of the baseline cooling end use total usage, which is impossible. In order to eliminate errors of this type, we recommend the following:

For workpaper developers and tracking data teams: Check unit energy savings estimates relative to the baseline cooling energy consumption per ton. This will improve the ability of future workpapers to check whether adjustment factors to DEER estimates produce reasonable savings. Also check that workpaper values agree with values in tracking data.

Finding #2: Many Upstream unitary HVAC systems have non-functional economizers.

The evaluation team found that a considerable savings potential is not being realized because many economizers for unitary systems being installed through the program are not functioning properly. Our testing occurred within two years of installation, but 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 wasn't installed correctly and has never functioned as designed. In order to realize this savings opportunity, we recommend the following:

For program managers and designers: Develop methods to obtain evidence that the economizer is fully functional before dispersing the final incentive payment. Obtain acceptance testing data for the technician to assure a functioning economizer that includes documenting economizer functionality with video/photographic evidence.

Finding #3: Inputs for DEER estimates appear to have improved.

The field-testing of 5.5- 20 ton units showed that fan performance and part-load performance curves were similar to current DEER assumptions. The current DEER update appears to have improved the accuracy of fan performance inputs for the simulations; thus, using current DEER estimates are an improvement over the estimates available to the IOUs when the 2013-14 programs began. 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 to assure the quality of the DEER assumptions. As a result of this finding, we recommend the following:

For workpaper developers and evaluators: Use current DEER assumptions for deemed savings estimates for the 5.5-20-ton unitary system. Collect additional data on fan performance to accurately characterize the program population.



6.1 Next steps and recommendations for future study

As next steps for this evaluation, DNV GL will complete net to gross interviews and surveys, and will collect additional field data to increase sample sizes where current estimates remain uncertain.

The evaluation of program year 2015 claims may also enable:

- Additional analysis of population-level data (such as make and model data) that are currently not part of tracking claims

- Analysis of whole building consumption to determine if the estimates from the prototype simulations are in line with effects seen at the meter, especially for sites where all unitary systems or chillers were replaced

These analyses may lead to additional savings adjustments.



Appendix AA. IESR APPENDICES

Appendix AA: Standardized High Level Savings¹⁸

Appendix AB: Standardized Per Unit Savings

Appendix AC: Recommendations

¹⁸ 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.



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

See following pages

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	1SPD	Tier0P, 14 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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		232	216	233	214	237		253		250	278	252	271		337		252
Education - Primary School	EPr		147	134	150		152		157	162	165	187	166	189	189	243		170
Education - Secondary School	ESe						155	155	164	168	175			211	207		163	175
Education - University	EUn						288		295	288								290
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		454	457	472	454	495		505	497	492	491	472	495	504	577		490
Health/Medical - Nursing Home	Nrs						400		410	411	414			420	427	493		425
Industrial																		
Lodging - Hotel	Htl		551	492		493	605		649	647						956		628
Manufacturing - Bio/Tech	MBT			239	244			261					251					249
Manufacturing - Light Industrial	MLI						182	181	195	191	195				203			191
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	191	216	209	222	212	228	233	231	224	232	239	230	238	236	290	213	228
Office - Small	OfS						215	220	220	215	223			229	233	279	198	226
Res																		
Restaurant - Fast Food	RFF	280	328	311	338	312	346		361	356		372	345	371				338
Restaurant - Sit Down	RSD						268		281	280	292			287	314	348	242	289
Retail - 3 story	Rt3	200	259	241	268	243	289		305	292	295	288	269	289	300			272
Retail - Large 1 story	RtL						303	305	311	307	315			315	311	389	262	313
Retail - Small	RtS						271		280	275	278					344		290
Single Family Residential																		
Storage - Conditioned	SCn		193	178	196	176						222	207	225				200
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.06	0.02	0.04	0.07	0.05		0.09		0.09	0.05	0.08	0.06		0.08		0.06
Education - Primary School	EPr		0.00		0.01		0.01		0.08	0.04	0.04	0.05	0.04	0.06	0.06	0.06		0.04
Education - Secondary School	ESe						0.01	0.08	0.08	0.04	0.04			0.06	0.06		0.02	0.05
Education - University	EUn						0.06		0.09	0.07								0.08
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.07	0.06	0.08	0.07	0.08		0.09	0.09	0.09	0.08	0.08	0.09	0.11	0.10		0.08
Health/Medical - Nursing Home	Nrs						0.06		0.07	0.07	0.08			0.08	0.09	0.09		0.08
Industrial																		
Lodging - Hotel	Htl		0.13	0.11		0.12	0.15		0.20	0.22						0.25		0.17
Manufacturing - Bio/Tech	MBT			0.03	0.03			0.09					0.10					0.06
Manufacturing - Light Industrial	MLI						0.05	0.08	0.09	0.06	0.10				0.08			0.08
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.07	0.08	0.05	0.07	0.07	0.08	0.08	0.09	0.08	0.09	0.07	0.10	0.08	0.10	0.10	0.09	0.08
Office - Small	OfS						0.07	0.08	0.09	0.09	0.09			0.08	0.11	0.10	0.09	0.09
Res																		
Restaurant - Fast Food	RFF	0.04	0.06	0.05	0.07	0.06	0.08		0.09	0.08		0.08	0.08	0.10				0.07
Restaurant - Sit Down	RSD						0.08		0.09	0.09	0.10			0.10	0.13	0.10	0.10	0.10
Retail - 3 story	Rt3	0.04	0.07	0.06	0.08	0.07	0.08		0.09	0.10	0.10	0.09	0.08	0.09	0.12			0.08
Retail - Large 1 story	RtL						0.08	0.08	0.09	0.09	0.09			0.10	0.11	0.11	0.09	0.09
Retail - Small	RtS						0.08		0.09	0.10	0.10					0.11		0.10
Single Family Residential																		
Storage - Conditioned	SCn		0.05	0.04	0.06	0.04						0.07	0.07	0.08				0.06
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		232	216	233	214	237		253		250	278	252	271		337		252
Education - Primary School	EPr		147	134	150		152		157	162	165	187	166	189	189	243		170
Education - Secondary School	ESe						155	155	164	168	175			211	207		163	175
Education - University	EUn						288		295	288								290
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		454	457	472	454	495		505	497	492	491	472	495	504	577		490
Health/Medical - Nursing Home	Nrs						400		410	411	414			420	427	493		425
Industrial																		
Lodging - Hotel	Htl		551	492		493	605		649	647						956		628
Manufacturing - Bio/Tech	MBT			239	244			261					251					249
Manufacturing - Light Industrial	MLI						182	181	195	191	195				203			191
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	191	216	209	222	212	228	233	231	224	232	239	230	238	236	290	213	228
Office - Small	OfS						215	220	220	215	223			229	233	279	198	226
Res																		
Restaurant - Fast Food	RFF	280	328	311	338	312	346		361	356		372	345	371				338
Restaurant - Sit Down	RSD						268		281	280	292			287	314	348	242	289
Retail - 3 story	Rt3	200	259	241	268	243	289		305	292	295	288	269	289	300			272
Retail - Large 1 story	RtL						303	305	311	307	315			315	311	389	262	313
Retail - Small	RtS						271		280	275	278					344		290
Single Family Residential																		
Storage - Conditioned	SCn		193	178	196	176						222	207	225				200
Utilities																		

Average Ex-post savings kW/ton																		
		w0 1	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
bldgtype		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.06	0.02	0.04	0.07	0.05		0.09		0.09	0.05	0.08	0.06		0.08		0.06
Education - Primary School	EPr		0.00		0.01		0.01		0.08	0.04	0.04	0.05	0.04	0.06	0.06	0.06		0.04
Education - Secondary School	ESe						0.01	0.08	0.08	0.04	0.04			0.06	0.06		0.02	0.05
Education - University	EUn						0.06		0.09	0.07								0.08
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.07	0.06	0.08	0.07	0.08		0.09	0.09	0.09	0.08	0.08	0.09	0.11	0.10		0.08
Health/Medical - Nursing Home	Nrs						0.06		0.07	0.07	0.08			0.08	0.09	0.09		0.08
Industrial																		
Lodging - Hotel	Htl		0.13	0.11		0.12	0.15		0.20	0.22						0.25		0.17
Manufacturing - Bio/Tech	MBT			0.03	0.03			0.09					0.10					0.06
Manufacturing - Light Industrial	MLI						0.05	0.08	0.09	0.06	0.10				0.08			0.08
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.07	0.08	0.05	0.07	0.07	0.08	0.08	0.09	0.08	0.09	0.07	0.10	0.08	0.10	0.10	0.09	0.08
Office - Small	OfS						0.07	0.08	0.09	0.09	0.09			0.08	0.11	0.10	0.09	0.09
Res																		
Restaurant - Fast Food	RFF	0.04	0.06	0.05	0.07	0.06	0.08		0.09	0.08		0.08	0.08	0.10				0.07
Restaurant - Sit Down	RS D						0.08		0.09	0.09	0.10			0.10	0.13	0.10	0.10	0.10
Retail - 3 story	Rt3	0.04	0.07	0.06	0.08	0.07	0.08		0.09	0.10	0.10	0.09	0.08	0.09	0.12			0.08
Retail - Large 1 story	RtL						0.08	0.08	0.09	0.09	0.09			0.10	0.11	0.11	0.09	0.09
Retail - Small	RtS						0.08		0.09	0.10	0.10					0.11		0.10
Single Family Residential																		
Storage - Conditioned	SCn		0.05	0.04	0.06	0.04					0.07	0.07	0.08					0.06
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
< 5 Ton	1SPD	Tier1, 15 SEER /<13 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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		248	228	250	227	254		275		272	298	271	295		367		271
Education - Primary School	EPr		155	141	160		163		168	173	178	197	177	202	198	259		181
Education - Secondary School	ESe						164	165	176	179	187			225	217		166	185
Education - University	EUn						311		320	309								313
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		478	482	500	478	528		542	528	528	520	500	532	530	625		521
Health/Medical - Nursing Home	Nrs						411		425	425	432			441	444	527		444
Industrial																		
Lodging - Hotel	Htl		606	536		538	669		724	716						1,076		695
Manufacturing - Bio/Tech	MBT			262	268			289					276					274
Manufacturing - Light Industrial	MLI						192	190	210	204	211				218			204
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	203	233	224	238	227	247	252	251	241	254	257	249	259	250	314	222	245
Office - Small	OfS						230	236	237	230	242			246	245	301	206	241
Res																		
Restaurant - Fast Food	RFF	285	346	324	360	326	364		386	377		397	368	402				358
Restaurant - Sit Down	RSD						285		304	301	319			314	334	381	252	311
Retail - 3 story	Rt3	203	280	255	292	258	313		337	318	328	314	294	322	324			295
Retail - Large 1 story	RtL						324	326	337	330	345			347	332	429	274	338
Retail - Small	RtS						294		309	300	309					384		319
Single Family Residential																		
Storage - Conditioned	SCn		196	178	199	176						231	214	237				204
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.07	0.03	0.04	0.08	0.06		0.10		0.10	0.06	0.10	0.06		0.09		0.07
Education - Primary School	EPr		0.00		0.01		0.01		0.09	0.05	0.05	0.05	0.04	0.06	0.06	0.07		0.05
Education - Secondary School	ESe						0.01	0.09	0.10	0.04	0.04			0.06	0.06		0.02	0.05
Education - University	EUn						0.07		0.11	0.08								0.09
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.08	0.07	0.09	0.08	0.09		0.10	0.10	0.11	0.09	0.10	0.10	0.12	0.11		0.09
Health/Medical - Nursing Home	Nrs						0.07		0.08	0.08	0.09			0.09	0.10	0.10		0.09
Industrial																		
Lodging - Hotel	Htl		0.16	0.13		0.15	0.19		0.25	0.26						0.30		0.20
Manufacturing - Bio/Tech	MBT			0.03	0.03			0.10					0.12					0.07
Manufacturing - Light Industrial	MLI						0.06	0.09	0.11	0.07	0.11				0.09			0.09
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.07	0.09	0.06	0.07	0.08	0.09	0.09	0.10	0.10	0.11	0.08	0.11	0.09	0.11	0.11	0.10	0.09
Office - Small	OfS						0.08	0.10	0.10	0.10	0.12			0.09	0.12	0.12	0.10	0.10
Res																		
Restaurant - Fast Food	RFF	0.05	0.07	0.06	0.09	0.07	0.08		0.10	0.10		0.10	0.09	0.11				0.08
Restaurant - Sit Down	RSD						0.09		0.10	0.11	0.12			0.11	0.14	0.11	0.11	0.11
Retail - 3 story	Rt3	0.04	0.08	0.07	0.10	0.08	0.09		0.11	0.11	0.12	0.11	0.10	0.11	0.13			0.10
Retail - Large 1 story	RtL						0.09	0.09	0.10	0.10	0.11			0.11	0.12	0.12	0.10	0.10
Retail - Small	RtS						0.09		0.11	0.11	0.12					0.13		0.11
Single Family Residential																		
Storage - Conditioned	SCn		0.05	0.04	0.07	0.04						0.08	0.08	0.09				0.06
Utilities																		

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																		
		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	
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		475	457	479	450	451		464		490	543	513	536		614		498
Education - Primary School	EPr		305	284	305		285		309	322	326	374	332	376	372	461		338
Education - Secondary School	ESe						313	297	329	345	352			427	410		335	351
Education - University	EUn						556		572	585								571
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		1,011	1,012	1,031	1,003	1,033		1,042	1,047	1,045	1,057	1,037	1,057	1,062	1,145		1,045
Health/Medical - Nursing Home	Nrs						928		933	941	937			941	950	1,034		952
Industrial																		
Lodging - Hotel	Htl		961	910		910	1,020		1,053	1,066						1,358		1,039
Manufacturing - Bio/Tech	MBT			404	425			350					419					399
Manufacturing - Light Industrial	MLI						385	388	391	398	398			401				394
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	403	425	417	434	414	417	409	427	440	441	453	434	446	459	521	399	434
Office - Small	OfS						408	399	415	422	424			415	428	471	368	417
Res																		
Restaurant - Fast Food	RFF	498	590	571	612	564	615		630	643		640	618	639				602
Restaurant - Sit Down	RSD						453		491	511	514			512	524	607	400	501
Retail - 3 story	Rt3	470	535	531	548	539	545		548	568	568	562	548	558	562			545
Retail - Large 1 story	RtL						575	573	588	595	599			596	601	682	537	594
Retail - Small	RtS						486		493	508	508					568		513
Single Family Residential																		
Storage - Conditioned	SCn		456	436	463	435						475	465	471				457
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.11	0.05	0.07	0.10	0.08		0.09		0.12	0.09	0.12	0.12		0.11		0.10
Education - Primary School	EPr		0.01	0.00	0.03		0.02		0.12	0.09	0.09	0.11	0.08	0.12	0.13	0.13		0.08
Education - Secondary School	ESe						0.01	0.10	0.12	0.08	0.08			0.12	0.12		0.05	0.08
Education - University	EUn						0.09		0.10	0.12								0.10
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.13	0.12	0.14	0.12	0.12		0.13	0.14	0.13	0.14	0.14	0.14	0.16	0.15		0.14
Health/Medical - Nursing Home	Nrs						0.12		0.12	0.12	0.11			0.12	0.14	0.13		0.12
Industrial																		
Lodging - Hotel	Htl		0.17	0.14		0.14	0.15		0.18	0.21						0.23		0.17
Manufacturing - Bio/Tech	MBT			0.04	0.04			0.08					0.11					0.06
Manufacturing - Light Industrial	MLI						0.08	0.12	0.10	0.09	0.13				0.07			0.10
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.13	0.13	0.10	0.11	0.11	0.11	0.11	0.12	0.14	0.13	0.12	0.13	0.13	0.15	0.15	0.14	0.13
Office - Small	OfS						0.12	0.12	0.13	0.15	0.14			0.13	0.15	0.15	0.15	0.14
Res																		
Restaurant - Fast Food	RFF	0.07	0.10	0.10	0.10	0.09	0.10		0.11	0.12		0.11	0.11	0.12				0.10
Restaurant - Sit Down	RSD						0.09		0.11	0.15	0.16			0.14	0.12	0.14	0.17	0.14
Retail - 3 story	Rt3	0.10	0.12	0.12	0.11	0.10	0.10		0.10	0.13	0.14	0.12	0.12	0.12	0.13			0.12
Retail - Large 1 story	RtL						0.10	0.10	0.11	0.13	0.14			0.12	0.14	0.13	0.15	0.13
Retail - Small	RtS						0.08		0.09	0.11	0.12					0.12		0.10
Single Family Residential																		
Storage - Conditioned	SCn		0.12	0.10	0.12	0.10						0.10	0.11	0.11				0.11
Utilities																		

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																		
		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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		487	462	492	456	469		489		511	567	529	560		662		517
Education - Primary School	EPr		308	284	312		296		318	332	337	384	340	387	384	487		347
Education - Secondary School	ESe						319	305	339	353	363			439	423		331	359
Education - University	EUn						584		602	608								598
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		1,022	1,025	1,052	1,015	1,065		1,081	1,078	1,077	1,085	1,056	1,091	1,097	1,218		1,074
Health/Medical - Nursing Home	Nrs						915		927	934	934			944	954	1,068		954
Industrial																		
Lodging - Hotel	Htl		1,059	974		975	1,136		1,195	1,205						1,658		1,172
Manufacturing - Bio/Tech	MBT			442	466			403					464					443
Manufacturing - Light Industrial	MLI						394	395	408	411	415				422			407
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	414	449	437	459	435	447	442	459	466	474	484	464	480	488	571	418	462
Office - Small	OfS						435	429	445	447	456			448	460	524	385	448
Res																		
Restaurant - Fast Food	RFF	468	585	556	612	550	614		640	647		655	621	657				601
Restaurant - Sit Down	RSD						465		511	528	540			537	558	655	400	524
Retail - 3 story	Rt3	457	553	537	571	545	575		591	601	606	596	572	597	602			569
Retail - Large 1 story	RtL						593	592	612	615	628			629	624	748	538	620
Retail - Small	RtS						513		529	539	543					636		552
Single Family Residential																		
Storage - Conditioned	SCn		444	421	452	420						477	460	476				450
Utilities																		

Average Ex-post savings kW/ton																		
		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
bldgtype		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.12	0.05	0.07	0.11	0.09		0.12		0.15	0.10	0.14	0.13		0.13		0.11
Education - Primary School	EPr		0.01	0.00	0.03		0.02		0.14	0.09	0.09	0.11	0.08	0.12	0.13	0.13		0.08
Education - Secondary School	ESe						0.01	0.12	0.14	0.08	0.08			0.12	0.13		0.05	0.09
Education - University	EUn						0.10		0.13	0.13								0.12
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.14	0.13	0.15	0.14	0.13		0.15	0.16	0.16	0.16	0.17	0.17	0.19	0.17		0.16
Health/Medical - Nursing Home	Nrs						0.12		0.13	0.14	0.13			0.14	0.17	0.15		0.14
Industrial																		
Lodging - Hotel	Htl		0.22	0.17		0.18	0.21		0.27	0.31						0.35		0.25
Manufacturing - Bio/Tech	MBT			0.04	0.05			0.10					0.14					0.08
Manufacturing - Light Industrial	MLI						0.09	0.14	0.13	0.10	0.16				0.10			0.12
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.14	0.14	0.11	0.13	0.13	0.13	0.13	0.15	0.16	0.16	0.14	0.16	0.15	0.18	0.18	0.16	0.15
Office - Small	OfS						0.14	0.14	0.16	0.17	0.17			0.15	0.18	0.19	0.16	0.16
Res																		
Restaurant - Fast Food	RFF	0.07	0.11	0.10	0.12	0.09	0.11		0.13	0.14		0.13	0.13	0.15				0.11
Restaurant - Sit Down	RSD						0.11		0.14	0.17	0.19			0.17	0.16	0.17	0.19	0.16
Retail - 3 story	Rt3	0.09	0.13	0.13	0.14	0.12	0.12		0.13	0.16	0.17	0.15	0.15	0.15	0.17			0.14
Retail - Large 1 story	RtL						0.12	0.12	0.14	0.16	0.17			0.15	0.17	0.17	0.17	0.15
Retail - Small	RtS						0.10		0.12	0.14	0.15					0.16		0.13
Single Family Residential																		
Storage - Conditioned	SCn		0.12	0.09	0.13	0.09						0.12	0.12	0.13				0.11
Utilities																		

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	
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		521	487	527	482	510		539		556	617	569	609		741		560
Education - Primary School	EPr		326	298	333		321		343	357	364	412	366	417	413	536		374
Education - Secondary School	ESe						341	329	365	377	390			470	455		343	384
Education - University	EUn						637		660	657								651
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		1,073	1,077	1,114	1,067	1,141		1,165	1,153	1,152	1,157	1,117	1,170	1,176	1,343		1,147
Health/Medical - Nursing Home	Nrs						937		957	963	967			983	996	1,144		993
Industrial																		
Lodging - Hotel	Htl		1,212	1,086		1,087	1,312		1,402	1,407						2,055		1,366
Manufacturing - Bio/Tech	MBT			504	530			484					533					513
Manufacturing - Light Industrial	MLI						418	417	443	441	449				462			439
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	443	493	475	504	476	499	497	512	513	528	537	516	536	537	648	457	511
Office - Small	OfS						481	478	494	491	508			503	513	604	421	499
Res																		
Restaurant - Fast Food	RFF	476	621	581	654	576	655		694	693		716	666	721				641
Restaurant - Sit Down	RSD						507		562	576	600			595	627	740	430	580
Retail - 3 story	Rt3	462	595	564	618	572	631		662	660	672	657	621	662	670			619
Retail - Large 1 story	RtL						641	640	668	665	689			694	679	852	567	677
Retail - Small	RtS						567		591	594	605					737		619
Single Family Residential																		
Storage - Conditioned	SCn		450	421	458	420						499	473	502				460
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.14	0.06	0.08	0.13	0.10		0.16		0.18	0.11	0.17	0.13		0.16		0.13
Education - Primary School	EPr		0.01	0.00	0.03		0.02		0.17	0.10	0.10	0.11	0.09	0.13	0.14	0.14		0.09
Education - Secondary School	ESe						0.01	0.15	0.17	0.08	0.09			0.13	0.14		0.05	0.10
Education - University	EUn						0.12		0.17	0.15								0.15
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.16	0.15	0.18	0.15	0.16		0.18	0.19	0.20	0.19	0.19	0.20	0.23	0.21		0.18
Health/Medical - Nursing Home	Nrs						0.14		0.15	0.16	0.16			0.16	0.20	0.18		0.16
Industrial																		
Lodging - Hotel	Htl		0.29	0.22		0.25	0.30		0.39	0.44						0.50		0.34
Manufacturing - Bio/Tech	MBT			0.05	0.06			0.14					0.19					0.11
Manufacturing - Light Industrial	MLI						0.11	0.16	0.17	0.13	0.20				0.14			0.15
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.15	0.17	0.12	0.14	0.15	0.15	0.16	0.18	0.19	0.20	0.16	0.20	0.18	0.22	0.22	0.19	0.17
Office - Small	OfS						0.16	0.17	0.19	0.20	0.21			0.18	0.22	0.23	0.20	0.19
Res																		
Restaurant - Fast Food	RFF	0.07	0.12	0.11	0.14	0.11	0.13		0.16	0.17		0.16	0.16	0.19				0.14
Restaurant - Sit Down	RSD						0.14		0.17	0.21	0.23			0.21	0.21	0.21	0.22	0.20
Retail - 3 story	Rt3	0.09	0.15	0.14	0.17	0.14	0.15		0.17	0.20	0.21	0.19	0.18	0.19	0.22			0.17
Retail - Large 1 story	RtL						0.15	0.15	0.17	0.19	0.21			0.19	0.21	0.21	0.19	0.19
Retail - Small	RtS						0.13		0.16	0.18	0.20					0.21		0.17
Single Family Residential																		
Storage - Conditioned	SCn		0.12	0.09	0.14	0.09						0.14	0.14	0.16				0.13
Utilities																		

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	
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		551	510	558	505	546		583		596	661	604	653		812		598
Education - Primary School	EPr		342	310	352		344		365	379	388	437	388	444	440	579		397
Education - Secondary School	ESe						360	350	387	399	415			499	483		354	406
Education - University	EUn						685		711	700								699
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		1,119	1,124	1,169	1,113	1,208		1,240	1,220	1,220	1,221	1,171	1,240	1,246	1,454		1,211
Health/Medical - Nursing Home	Nrs						956		983	988	997			1,018	1,034	1,213		1,027
Industrial																		
Lodging - Hotel	Htl		1,347	1,186		1,188	1,468		1,586	1,587						2,408		1,539
Manufacturing - Bio/Tech	MB T			559	587			557					595					574
Manufacturing - Light Industrial	MLI						440	437	474	468	480				498			466
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	468	532	510	544	512	545	546	560	554	577	585	562	586	581	717	491	554
Office - Small	OfS						522	523	538	530	554			552	560	674	453	545
Res																		
Restaurant - Fast Food	RFF	484	653	603	691	599	691		741	735		770	706	778				678
Restaurant - Sit Down	RSD						544		608	619	653			646	689	815	457	629
Retail - 3 story	Rt3	466	633	588	660	597	681		726	712	730	711	664	721	729			663
Retail - Large 1 story	RtL						684	684	717	710	743			752	728	944	592	728
Retail - Small	RtS						614		646	644	659					826		678
Single Family Residential																		
Storage - Conditioned	SCn		454	421	464	420						519	484	525				470
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.16	0.06	0.09	0.15	0.12		0.19		0.21	0.13	0.20	0.14		0.19		0.15
Education - Primary School	EPr		0.01	0.00	0.03		0.03		0.19	0.10	0.10	0.12	0.09	0.14	0.15	0.15		0.09
Education - Secondary School	ESe						0.01	0.17	0.20	0.09	0.10			0.14	0.15		0.06	0.11
Education - University	EUn						0.14		0.20	0.18								0.17
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.18	0.16	0.20	0.17	0.18		0.21	0.22	0.23	0.21	0.22	0.23	0.26	0.25		0.21
Health/Medical - Nursing Home	Nrs						0.15		0.17	0.18	0.18			0.19	0.23	0.20		0.18
Industrial																		
Lodging - Hotel	Htl		0.35	0.27		0.30	0.37		0.50	0.55						0.63		0.42
Manufacturing - Bio/Tech	MBT			0.06	0.07			0.17					0.23					0.13
Manufacturing - Light Industrial	MLI						0.12	0.19	0.20	0.15	0.24				0.17			0.18
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.17	0.19	0.13	0.16	0.16	0.17	0.18	0.21	0.21	0.24	0.19	0.24	0.20	0.25	0.25	0.21	0.20
Office - Small	OfS						0.18	0.20	0.22	0.23	0.24			0.20	0.26	0.26	0.22	0.22
Res																		
Restaurant - Fast Food	RFF	0.07	0.13	0.12	0.17	0.12	0.15		0.18	0.19		0.19	0.18	0.21				0.16
Restaurant - Sit Down	RSD						0.16		0.20	0.24	0.27			0.24	0.26	0.24	0.25	0.23
Retail - 3 story	Rt3	0.09	0.17	0.16	0.20	0.17	0.18		0.20	0.24	0.25	0.22	0.21	0.23	0.26			0.20
Retail - Large 1 story	RtL						0.17	0.17	0.20	0.22	0.25			0.23	0.25	0.25	0.22	0.22
Retail - Small	RtS						0.16		0.19	0.22	0.23					0.25		0.21
Single Family Residential																		
Storage - Conditioned	SCn		0.12	0.09	0.15	0.09						0.16	0.16	0.18				0.14
Utilities																		

Unit Size	Base	Scenario			Working Economizer								Sample Group					
5.5 - 11.5 Ton	1SPD	Tier1, 11.5EER, 1spd			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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		21	9	21	10	22		31		31	38	27	37		66		28
Education - Primary School	EPr		13	6	15		15		16	18	20	23	19	24	25	43		20
Education - Secondary School	ESe						13	12	17	18	21			26	27		9	18
Education - University	EUn						29		35	32								32
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		28	16	33	17	37		46	47	48	51	38	56	58	101		44
Health/Medical - Nursing Home	Nrs						14		22	24	28			34	37	69		33
Industrial																		
Lodging - Hotel	Htl		120	74		77	132		161	164						341		153
Manufacturing - Bio/Tech	MBT			18	31			40					37					31
Manufacturing - Light Industrial	MLI						16	12	24	22	26				33			22
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	2	23	13	25	15	29	25	32	29	34	36	32	38	34	61	21	28
Office - Small	OfS						27	22	31	26	33			38	40	62	20	33
Res																		
Restaurant - Fast Food	RFF		24	12	28	14	23		32	36		48	33	52				30
Restaurant - Sit Down	RSD						29		39	39	50			49	62	75	24	46
Retail - 3 story	Rt3	1	31	13	34	15	36		51	44	50	50	38	53	56			36
Retail - Large 1 story	RtL						31	27	39	39	48			54	46	90	22	44
Retail - Small	RtS						34		43	41	46					84		50
Single Family Residential																		
Storage - Conditioned	SCn		6	1	7							20	13	23				12
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.01	0.00	0.01	0.01	0.01		0.03		0.03	0.01	0.03	0.01		0.03		0.02
Education - Primary School	EPr				0.00				0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01		0.01
Education - Secondary School	ESe						0.00	0.03	0.03	0.01	0.01			0.01	0.01		0.00	0.01
Education - University	EUn						0.02		0.03	0.02								0.02
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.02	0.01	0.02	0.01	0.02		0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03		0.02
Health/Medical - Nursing Home	Nrs						0.01		0.02	0.02	0.02			0.02	0.03	0.03		0.02
Industrial																		
Lodging - Hotel	Htl		0.06	0.04		0.04	0.07		0.10	0.11						0.12		0.08
Manufacturing - Bio/Tech	MBT			0.00	0.01			0.03					0.04					0.02
Manufacturing - Light Industrial	MLI						0.02	0.02	0.03	0.02	0.04				0.03			0.03
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL		0.02	0.00	0.02	0.01	0.02	0.03	0.03	0.03	0.03	0.02	0.04	0.02	0.03	0.03	0.03	0.02
Office - Small	OfS						0.03		0.03	0.03	0.03			0.03	0.03	0.03		0.03
Res																		
Restaurant - Fast Food	RFF				0.05		0.05			0.03		0.04		0.04				0.04
Restaurant - Sit Down	RSD						0.03		0.05	0.04	0.02			0.03	0.05	0.04	0.03	0.04
Retail - 3 story	Rt3		0.02	0.01	0.03	0.02	0.02		0.04	0.03	0.04	0.03	0.03	0.04	0.04			0.03
Retail - Large 1 story	RtL						0.03	0.03	0.03	0.03	0.04			0.03	0.04	0.04	0.03	0.03
Retail - Small	RtS						0.03		0.04	0.03	0.04					0.04		0.04
Single Family Residential																		
Storage - Conditioned	SCn		0.00		0.01							0.02	0.02	0.02				0.01
Utilities																		

Unit Size	Base	Scenario					Working Economizer						Sample Group					
5.5 - 11.5 Ton	1SPD	Tier1, 11.5EER, 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	Average
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		31	24	33	25	38		46		42	46	37	45		72		40
Education - Primary School	EPr		17	13	20		24		24	24	26	27	24	28	28	47		25
Education - Secondary School	ESe						21	22	24	23	26			30	30		12	24
Education - University	EUn						51		54	47								51
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		52	54	62	53	75		81	74	73	70	60	75	75	116		71
Health/Medical - Nursing Home	Nrs						25		32	31	34			39	41	74		39
Industrial																		
Lodging - Hotel	Htl		139	105		106	164		190	187						352		178
Manufacturing - Bio/Tech	MBT			56	58			72					63					62
Manufacturing - Light Industrial	MLI						24	23	33	30	32				37			30
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	29	41	37	43	39	48	51	49	44	50	49	48	51	46	71	37	46
Office - Small	OfS						43	47	47	42	49			51	50	73	37	49
Res																		
Restaurant - Fast Food	RFF	8	33	25	42	20	36		50	46		52	44	56				38
Restaurant - Sit Down	RSD						37		47	47	54		53	64	79	24		51
Retail - 3 story	Rt3	6	39	26	44	28	53		66	55	60	55	45	59	60			46
Retail - Large 1 story	RtL						46	47	53	49	57			59	50	96	27	54
Retail - Small	RtS						50		57	51	56					90		61
Single Family Residential																		
Storage - Conditioned	SCn		6	0	7							21	13	24				12
Utilities																		

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

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	1SPD	Tier2, 12.0EER, 1spd	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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		41	18	41	19	42		59		60	73	53	71		128		55
Education - Primary School	EPr		24	12	28		30		31	35	40	44	37	47	48	84		38
Education - Secondary School	ESe						25	23	33	34	41			51	52		17	35
Education - University	EUn						56		69	63								63
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		53	31	64	32	71		90	90	94	99	74	108	112	195		86
Health/Medical - Nursing Home	Nrs						28		42	47	54			66	72	133		63
Industrial																		
Lodging - Hotel	Htl		234	143		148	256		312	317						659		296
Manufacturing - Bio/Tech	MBT			35	59			77					72					61
Manufacturing - Light Industrial	MLI						32	23	47	43	49				64			43
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	4	45	24	48	29	55	49	62	55	67	70	62	74	66	119	41	54
Office - Small	OfS						50	43	60	53	67			77	74	121	41	65
Res																		
Restaurant - Fast Food	RFF		48	18	56	20	45		69	66		96	66	100				59
Restaurant - Sit Down	RSD						59		78	77	97			95	116	147	44	89
Retail - 3 story	Rt3	2	60	25	66	29	69		98	85	97	97	73	103	109			70
Retail - Large 1 story	RtL						60	52	76	75	92			104	90	174	43	85
Retail - Small	RtS						66		83	80	90					163		97
Single Family Residential																		
Storage - Conditioned	SCn		11	1	13	0						39	25	45				19
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.03	0.00	0.02	0.02	0.03		0.06		0.06	0.03	0.05	0.01		0.05		0.03
Education - Primary School	EPr				0.00		0.00		0.05	0.01	0.01	0.02	0.01	0.02	0.02	0.02		0.02
Education - Secondary School	ESe						0.00	0.05	0.05	0.01	0.01			0.02	0.02		0.01	0.02
Education - University	EUn						0.03		0.07	0.04								0.05
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.03	0.01	0.04	0.02	0.04		0.05	0.05	0.06	0.04	0.05	0.05	0.07	0.06		0.05
Health/Medical - Nursing Home	Nrs						0.02		0.03	0.04	0.04			0.04	0.05	0.05		0.04
Industrial																		
Lodging - Hotel	Htl		0.11	0.07		0.09	0.15		0.20	0.21						0.24		0.15
Manufacturing - Bio/Tech	MBT			0.01	0.02			0.06					0.07					0.04
Manufacturing - Light Industrial	MLI						0.03	0.04	0.06	0.04	0.07				0.06			0.05
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL		0.04	0.00	0.03	0.02	0.04	0.05	0.06	0.05	0.07	0.04	0.07	0.05	0.06	0.06	0.05	0.05
Office - Small	OfS						0.03	0.04	0.03	0.05	0.06			0.03	0.09	0.08	0.04	0.05
Res																		
Restaurant - Fast Food	RFF		0.05		0.05		0.05		0.05	0.03		0.07	0.04	0.04				0.05
Restaurant - Sit Down	RSD						0.05		0.07	0.06	0.06			0.07	0.09	0.06	0.07	0.07
Retail - 3 story	Rt3		0.03	0.01	0.06	0.03	0.05		0.07	0.06	0.07	0.06	0.05	0.07	0.08			0.05
Retail - Large 1 story	RtL						0.05	0.05	0.06	0.06	0.07			0.06	0.07	0.07	0.05	0.06
Retail - Small	RtS						0.06		0.07	0.07	0.07					0.08		0.07
Single Family Residential																		
Storage - Conditioned	SCn		0.01		0.02							0.04	0.03	0.05				0.03
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	1SPD	Tier2, 12.0EER, 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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		60	47	63	48	74		88		81	88	71	87		140		77
Education - Primary School	EPr		33	26	38		47		46	47	50	51	45	54	55	90		49
Education - Secondary School	ESe						41	43	47	45	50			58	59		23	46
Education - University	EUn						99		105	91								98
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		100	104	119	102	144		157	143	142	135	117	145	146	224		137
Health/Medical - Nursing Home	Nrs						49		61	60	66			75	79	142		76
Industrial																		
Lodging - Hotel	Htl		270	203		205	318		367	362						681		344
Manufacturing - Bio/Tech	MBT			109	113			139					121					121
Manufacturing - Light Industrial	MLI						47	44	64	57	63				71			58
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	55	80	72	83	76	93	99	96	85	97	96	92	100	90	137	72	89
Office - Small	OfS						83	90	88	82	94			96	96	140	65	93
Res																		
Restaurant - Fast Food	RFF	17	67	49	75	48	77		96	86		104	81	112				74
Restaurant - Sit Down	RSD						75		91	88	106			102	121	153	48	98
Retail - 3 story	Rt3	11	76	52	85	53	103		127	107	117	107	87	114	117			89
Retail - Large 1 story	RtL						90	91	102	95	111			115	98	186	53	104
Retail - Small	RtS						96		110	100	109					174		118
Single Family Residential																		
Storage - Conditioned	SCn		11	1	13	0					40	25	47					20
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.03	0.01	0.02	0.03	0.03		0.06		0.06	0.03	0.05	0.02		0.05		0.03
Education - Primary School	EPr				0.00		0.00		0.05	0.01	0.01	0.02	0.01	0.02	0.02	0.02		0.02
Education - Secondary School	ESe						0.00	0.05	0.06	0.01	0.01			0.02	0.02		0.01	0.02
Education - University	EUn						0.03		0.07	0.04								0.05
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.03	0.03	0.04	0.03	0.04		0.05	0.05	0.06	0.04	0.05	0.05	0.07	0.06		0.05
Health/Medical - Nursing Home	Nrs						0.02		0.03	0.04	0.04			0.04	0.05	0.05		0.04
Industrial																		
Lodging - Hotel	Htl		0.11	0.09		0.10	0.15		0.20	0.21						0.24		0.16
Manufacturing - Bio/Tech	MBT			0.01	0.02			0.06					0.07					0.04
Manufacturing - Light Industrial	MLI						0.03	0.04	0.06	0.04	0.07				0.06			0.05
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.03	0.04	0.02	0.03	0.04	0.04	0.05	0.06	0.05	0.07	0.04	0.07	0.05	0.06	0.06	0.05	0.05
Office - Small	OfS						0.03	0.04	0.03	0.05	0.06			0.03	0.09	0.08	0.04	0.05
Res																		
Restaurant - Fast Food	RFF		0.05		0.05		0.05		0.05	0.03		0.07	0.04	0.04				0.05
Restaurant - Sit Down	RSD						0.05		0.07	0.06	0.06			0.07	0.09	0.06	0.07	0.07
Retail - 3 story	Rt3		0.03	0.03	0.06	0.04	0.05		0.07	0.06	0.07	0.06	0.05	0.07	0.08			0.06
Retail - Large 1 story	RtL						0.05	0.05	0.05	0.06	0.07			0.06	0.07	0.07	0.05	0.06
Retail - Small	RtS						0.06		0.07	0.07	0.07					0.08		0.07
Single Family Residential																		
Storage - Conditioned	SCn		0.01		0.02							0.04	0.03	0.05				0.03
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	1SPD	Tier2, 12.0EER, 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	
Building Type		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Average
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		404	343	399	331	344		358		421	479	448	471		562		414
Education - Primary School	EPr		255	211	249		206		242	265	273	325	281	329	324	417		281
Education - Secondary School	ESe						240	200	259	290	301			379	362		273	288
Education - University	EUn						420		456	498								458
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		852	786	853	776	814		841	890	892	923	884	921	935	1,035		877
Health/Medical - Nursing Home	Nrs						845		859	880	877			888	903	983		891
Industrial																		
Lodging - Hotel	Htl		894	749		753	908		981	1,019						1,407		959
Manufacturing - Bio/Tech	MBT			211	279			161					301					238
Manufacturing - Light Industrial	MLI						341	320	338	362	363				370			349
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	261	316	251	316	248	282	235	306	341	339	366	333	361	383	448	307	318
Office - Small	OfS						286	232	299	326	326			339	354	399	286	316
Res																		
Restaurant - Fast Food	RFF	340	455	400	480	381	464		485	522		519	495	521				460
Restaurant - Sit Down	RSD						355		392	429	428			447	454	530	328	421
Retail - 3 story	Rt3	389	455	379	454	368	396		403	472	476	510	488	500	520			447
Retail - Large 1 story	RtL						413	357	446	485	485			510	533	576	424	470
Retail - Small	RtS						399		423	467	469					545		460
Single Family Residential																		
Storage - Conditioned	SCn		443	416	453	415						474	461	475				448
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.13	0.04	0.07	0.06	0.09		0.10		0.11	0.08	0.12	0.13		0.11		0.09
Education - Primary School	EPr		0.01		0.03		0.02		0.11	0.09	0.09	0.10	0.08	0.11	0.12	0.12		0.08
Education - Secondary School	ESe						0.01	0.10	0.11	0.08	0.08			0.11	0.12		0.05	0.08
Education - University	EUn						0.10		0.11	0.12								0.11
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.14	0.09	0.14	0.07	0.14		0.14	0.14	0.14	0.14	0.14	0.15	0.17	0.15		0.13
Health/Medical - Nursing Home	Nrs						0.12		0.12	0.12	0.11			0.13	0.16	0.13		0.13
Industrial																		
Lodging - Hotel	Htl		0.22	0.12		0.13	0.22		0.26	0.28						0.31		0.22
Manufacturing - Bio/Tech	MBT			0.00	0.04			0.10					0.11					0.06
Manufacturing - Light Industrial	MLI						0.08	0.13	0.11	0.08	0.12				0.08			0.10
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.05	0.13	0.04	0.12	0.06	0.12	0.11	0.12	0.13	0.13	0.12	0.13	0.12	0.15	0.14	0.13	0.11
Office - Small	OfS						0.13	0.11	0.09	0.13	0.12			0.13	0.16	0.13	0.12	0.13
Res																		
Restaurant - Fast Food	RFF	0.08	0.10	0.06	0.09	0.07	0.09		0.09	0.10		0.11	0.07	0.11				0.09
Restaurant - Sit Down	RSD						0.11		0.10	0.11	0.09			0.14	0.11	0.13	0.17	0.12
Retail - 3 story	Rt3	0.09	0.13	0.06	0.12	0.06	0.10		0.10	0.11	0.11	0.12	0.13	0.12	0.13			0.11
Retail - Large 1 story	RtL						0.10	0.09	0.10	0.12	0.11			0.12	0.14	0.12	0.13	0.12
Retail - Small	RtS						0.10		0.11	0.11	0.11					0.12		0.11
Single Family Residential																		
Storage - Conditioned	SCn		0.13	0.09	0.13	0.09						0.13	0.13	0.14				0.12
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	1SPD	Tier2, 12.0EER, 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	
Building Type		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Average
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		468	454	478	446	466		477		490	536	507	531		612		497
Education - Primary School	EPr		294	276	299		289		308	316	318	360	322	365	357	447		329
Education - Secondary School	ESe						316	302	330	339	345			416	394		304	343
Education - University	EUn						581		591	593								588
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		1,015	1,025	1,042	1,013	1,072		1,079	1,070	1,062	1,056	1,041	1,063	1,061	1,148		1,057
Health/Medical - Nursing Home	Nrs						925		931	933	929			930	934	1,023		944
Industrial																		
Lodging - Hotel	Htl		1,031	972		973	1,140		1,183	1,173						1,499		1,139
Manufacturing - Bio/Tech	MBT			414	433			389					428					416
Manufacturing - Light Industrial	MLI						404	409	411	410	410				398			407
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	402	428	422	438	417	436	430	441	447	446	451	436	446	456	515	394	438
Office - Small	OfS						422	420	424	423	423			410	419	463	364	419
Res																		
Restaurant - Fast Food	RFF	373	498	480	532	463	545		563	568		545	528	550				513
Restaurant - Sit Down	RSD						430		464	468	466			466	475	552	335	457
Retail - 3 story	Rt3	450	538	538	560	544	579		575	579	572	560	553	558	562			551
Retail - Large 1 story	RtL						578	581	582	577	577			568	576	639	496	575
Retail - Small	RtS						548		551	552	549					601		560
Single Family Residential																		
Storage - Conditioned	SCn		443	416	454	415						480	463	482				450
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.12	0.05	0.07	0.11	0.09		0.10		0.11	0.08	0.12	0.12		0.11		0.10
Education - Primary School	EPr		0.01		0.03		0.02		0.11	0.09	0.09	0.10	0.08	0.11	0.12	0.12		0.08
Education - Secondary School	ESe						0.01	0.10	0.11	0.08	0.08			0.11	0.12		0.05	0.08
Education - University	EUn						0.10		0.11	0.12								0.11
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.14	0.13	0.14	0.14	0.14		0.14	0.14	0.14	0.14	0.14	0.15	0.17	0.15		0.14
Health/Medical - Nursing Home	Nrs						0.12		0.12	0.12	0.11			0.13	0.16	0.13		0.13
Industrial																		
Lodging - Hotel	Htl		0.21	0.18		0.19	0.22		0.26	0.28						0.31		0.24
Manufacturing - Bio/Tech	MBT			0.04	0.04			0.10					0.11					0.07
Manufacturing - Light Industrial	MLI						0.08	0.13	0.11	0.08	0.12				0.08			0.10
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.13	0.13	0.10	0.12	0.12	0.12	0.11	0.12	0.13	0.13	0.12	0.13	0.12	0.15	0.14	0.13	0.13
Office - Small	OfS						0.13	0.11	0.09	0.13	0.12			0.13	0.16	0.13	0.12	0.13
Res																		
Restaurant - Fast Food	RFF	0.08	0.10	0.06	0.09	0.07	0.09		0.09	0.10		0.11	0.07	0.11				0.09
Restaurant - Sit Down	RSD						0.11		0.10	0.11	0.09			0.14	0.11	0.13	0.17	0.12
Retail - 3 story	Rt3	0.09	0.13	0.13	0.12	0.11	0.10		0.10	0.11	0.11	0.12	0.13	0.12	0.13			0.12
Retail - Large 1 story	RtL						0.10	0.09	0.10	0.12	0.11			0.12	0.14	0.12	0.13	0.12
Retail - Small	RtS						0.10		0.11	0.11	0.11					0.12		0.11
Single Family Residential																		
Storage - Conditioned	SCn		0.13	0.09	0.13	0.09						0.13	0.13	0.14				0.12
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	1SPD	Tier3, 12.5EER, 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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		422	352	416	340	363		385		447	510	470	502		616		438
Education - Primary School	EPr		266	217	261		220		255	279	290	344	297	349	344	452		298
Education - Secondary School	ESe						251	211	274	305	319			400	384		281	303
Education - University	EUn						445		486	524								485
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		875	799	880	790	845		880	927	932	964	915	966	982	1,117		913
Health/Medical - Nursing Home	Nrs						855		876	899	899			915	932	1,039		916
Industrial																		
Lodging - Hotel	Htl		995	812		819	1,019		1,116	1,155						1,691		1,087
Manufacturing - Bio/Tech	MBT			230	307			200					334					268
Manufacturing - Light Industrial	MLI						354	330	358	380	384				396			367
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	264	336	264	337	263	307	260	334	365	368	396	360	394	411	499	325	343
Office - Small	OfS						306	253	327	350	353			371	385	450	307	345
Res																		
Restaurant - Fast Food	RFF	340	478	406	504	388	482		517	552		560	524	565				483
Restaurant - Sit Down	RSD						382		427	463	471			488	505	593	349	460
Retail - 3 story	Rt3	390	481	392	483	383	428		448	510	520	552	519	545	567			478
Retail - Large 1 story	RtL						440	382	480	517	525			555	571	651	442	507
Retail - Small	RtS						428		460	501	508					615		503
Single Family Residential																		
Storage - Conditioned	SCn		447	416	458	415						490	471	494				456
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.14	0.04	0.08	0.07	0.10		0.13		0.14	0.09	0.14	0.13		0.14		0.11
Education - Primary School	EPr		0.01		0.03		0.02		0.13	0.09	0.09	0.11	0.08	0.12	0.12	0.13		0.09
Education - Secondary School	ESe						0.01	0.12	0.14	0.08	0.09			0.12	0.12		0.05	0.09
Education - University	EUn						0.12		0.14	0.14								0.13
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.15	0.09	0.16	0.08	0.15		0.16	0.17	0.17	0.16	0.17	0.17	0.20	0.18		0.15
Health/Medical - Nursing Home	Nrs						0.14		0.14	0.14	0.13			0.15	0.18	0.15		0.15
Industrial																		
Lodging - Hotel	Htl		0.27	0.15		0.18	0.29		0.35	0.37						0.41		0.29
Manufacturing - Bio/Tech	MBT			0.01	0.05			0.12					0.15					0.08
Manufacturing - Light Industrial	MLI						0.10	0.15	0.14	0.10	0.15				0.11			0.13
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.05	0.15	0.05	0.13	0.08	0.14	0.14	0.15	0.16	0.15	0.14	0.15	0.14	0.18	0.17	0.16	0.13
Office - Small	OfS						0.17	0.14	0.13	0.16	0.15			0.13	0.19	0.16	0.12	0.15
Res																		
Restaurant - Fast Food	RFF	0.08	0.10	0.06	0.14	0.07	0.14		0.09	0.13		0.15	0.11	0.15				0.11
Restaurant - Sit Down	RSD						0.11		0.12	0.13	0.13			0.17	0.16	0.17	0.17	0.14
Retail - 3 story	Rt3	0.09	0.14	0.07	0.14	0.07	0.13		0.13	0.14	0.14	0.14	0.15	0.15	0.17			0.13
Retail - Large 1 story	RtL						0.12	0.12	0.13	0.14	0.14			0.15	0.18	0.16	0.15	0.14
Retail - Small	RtS						0.13		0.13	0.13	0.14					0.16		0.14
Single Family Residential																		
Storage - Conditioned	SCn		0.13	0.09	0.14	0.09						0.14	0.14	0.16				0.13
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	1SPD	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	
Building Type		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Average
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		493	473	504	465	497		514		524	573	537	568		671		529
Education - Primary School	EPr		308	286	315		309		327	335	339	381	341	387	380	485		349
Education - Secondary School	ESe						332	320	350	357	366			439	418		313	362
Education - University	EUn						622		635	630								629
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		1,054	1,064	1,089	1,053	1,129		1,142	1,126	1,118	1,110	1,086	1,121	1,120	1,240		1,112
Health/Medical - Nursing Home	Nrs						942		954	956	954			960	966	1,081		973
Industrial																		
Lodging - Hotel	Htl		1,145	1,057		1,059	1,274		1,339	1,327						1,792		1,285
Manufacturing - Bio/Tech	MBT			460	480			449					479					467
Manufacturing - Light Industrial	MLI						422	426	437	434	436				428			430
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	424	461	451	472	448	474	471	480	482	487	490	475	488	493	572	424	475
Office - Small	OfS						455	456	459	458	463			451	459	520	389	457
Res																		
Restaurant - Fast Food	RFF	382	526	498	565	484	577		604	604		590	565	599				545
Restaurant - Sit Down	RSD						462		503	508	512			510	528	617	359	500
Retail - 3 story	Rt3	454	570	559	595	565	622		629	625	622	605	589	607	611			589
Retail - Large 1 story	RtL						614	618	624	616	623			617	616	717	517	618
Retail - Small	RtS						588		598	595	595					675		610
Single Family Residential																		
Storage - Conditioned	SCn		447	416	459	415						497	473	502				458
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.13	0.06	0.07	0.13	0.10		0.13		0.14	0.09	0.14	0.13		0.14		0.11
Education - Primary School	EPr		0.01		0.03		0.02		0.13	0.09	0.09	0.11	0.08	0.12	0.12	0.13		0.09
Education - Secondary School	ESe						0.01	0.12	0.14	0.08	0.09			0.12	0.12		0.05	0.09
Education - University	EUn						0.12		0.14	0.13								0.13
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.15	0.14	0.16	0.15	0.15		0.16	0.17	0.16	0.16	0.16	0.17	0.19	0.18		0.16
Health/Medical - Nursing Home	Nrs						0.13		0.14	0.14	0.13			0.15	0.18	0.15		0.14
Industrial																		
Lodging - Hotel	Htl		0.26	0.22		0.24	0.29		0.35	0.37						0.41		0.30
Manufacturing - Bio/Tech	MBT			0.04	0.05			0.12					0.15					0.09
Manufacturing - Light Industrial	MLI						0.10	0.15	0.14	0.10	0.15				0.11			0.13
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.14	0.15	0.11	0.13	0.14	0.14	0.14	0.15	0.16	0.15	0.14	0.15	0.14	0.18	0.17	0.16	0.15
Office - Small	OfS						0.17	0.14	0.13	0.16	0.15			0.13	0.19	0.16	0.12	0.15
Res																		
Restaurant - Fast Food	RFF	0.08	0.10	0.06	0.14	0.07	0.14		0.09	0.13		0.15	0.11	0.15				0.11
Restaurant - Sit Down	RSD						0.11		0.12	0.13	0.13			0.17	0.16	0.17	0.17	0.14
Retail - 3 story	Rt3	0.09	0.14	0.14	0.14	0.13	0.13		0.13	0.14	0.14	0.14	0.15	0.15	0.17			0.14
Retail - Large 1 story	RtL						0.12	0.12	0.13	0.14	0.14			0.15	0.18	0.16	0.15	0.14
Retail - Small	RtS						0.13		0.13	0.13	0.14					0.16		0.14
Single Family Residential																		
Storage - Conditioned	SCn		0.13	0.09	0.14	0.09						0.14	0.14	0.16				0.13
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	2SPD	Tier1, 11.5EER, 1spd	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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(341)	(314)	(337)	(300)	(278)		(266)		(330)	(369)	(368)	(363)		(370)		(331)
Education - Primary School	EPr		(219)	(192)	(207)		(159)		(194)	(212)	(214)	(259)	(225)	(259)	(253)	(294)		(224)
Education - Secondary School	ESe						(201)	(161)	(210)	(239)	(241)			(304)	(285)		(247)	(236)
Education - University	EUn						(333)		(352)	(405)								(364)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(773)	(738)	(758)	(728)	(707)		(706)	(756)	(753)	(777)	(776)	(761)	(770)	(746)		(750)
Health/Medical - Nursing Home	Nrs						(806)		(798)	(813)	(799)			(792)	(800)	(787)		(799)
Industrial																		
Lodging - Hotel	Htl		(542)	(530)		(527)	(520)		(507)	(540)						(413)		(511)
Manufacturing - Bio/Tech	MBT			(150)	(186)			(30)					(189)					(139)
Manufacturing - Light Industrial	MLI						(294)	(286)	(268)	(299)	(289)				(274)			(285)
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(252)	(248)	(210)	(242)	(200)	(194)	(154)	(210)	(258)	(237)	(260)	(239)	(249)	(284)	(271)	(244)	(234)
Office - Small	OfS						(206)	(163)	(208)	(247)	(225)			(227)	(242)	(215)	(225)	(218)
Res																		
Restaurant - Fast Food	RFF	(340)	(383)	(363)	(395)	(341)	(392)		(384)	(419)		(374)	(396)	(368)				(378)
Restaurant - Sit Down	RSD						(261)		(272)	(311)	(281)			(303)	(279)	(310)	(256)	(284)
Retail - 3 story	Rt3	(383)	(363)	(337)	(353)	(320)	(288)		(249)	(342)	(328)	(363)	(377)	(343)	(356)			(339)
Retail - Large 1 story	RtL						(321)	(274)	(330)	(372)	(345)			(353)	(400)	(314)	(360)	(341)
Retail - Small	RtS						(297)		(295)	(345)	(332)					(300)		(314)
Single Family Residential																		
Storage - Conditioned	SCn		(428)	(415)	(435)	(415)						(417)	(425)	(408)				(420)
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(0.09)	(0.04)	(0.05)	(0.02)	(0.05)		(0.00)		(0.02)	(0.04)	(0.04)	(0.11)		(0.03)		(0.04)
Education - Primary School	EPr		(0.01)		(0.02)		(0.02)		(0.04)	(0.07)	(0.07)	(0.08)	(0.06)	(0.09)	(0.09)	(0.10)		(0.06)
Education - Secondary School	ESe						(0.01)	(0.03)	(0.03)	(0.06)	(0.06)			(0.09)	(0.09)		(0.04)	(0.05)
Education - University	EUn						(0.05)		(0.01)	(0.06)								(0.04)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(0.09)	(0.07)	(0.08)	(0.04)	(0.07)		(0.06)	(0.06)	(0.05)	(0.08)	(0.07)	(0.07)	(0.07)	(0.06)		(0.07)
Health/Medical - Nursing Home	Nrs						(0.09)		(0.07)	(0.07)	(0.05)			(0.07)	(0.08)	(0.05)		(0.07)
Industrial																		
Lodging - Hotel	Htl		(0.04)	(0.01)		0.01			0.04	0.04						0.06		0.02
Manufacturing - Bio/Tech	MBT			0.01	(0.01)								(0.00)					(0.00)
Manufacturing - Light Industrial	MLI						(0.04)	(0.06)	(0.02)	(0.02)	(0.01)				0.01			(0.02)
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(0.05)	(0.07)	(0.04)	(0.07)	(0.03)	(0.06)	(0.04)	(0.04)	(0.06)	(0.03)	(0.05)	(0.02)	(0.05)	(0.06)	(0.04)	(0.06)	(0.05)
Office - Small	OfS						(0.07)	(0.07)	(0.03)	(0.05)				(0.03)	(0.06)	(0.05)	(0.08)	(0.06)
Res																		
Restaurant - Fast Food	RFF	(0.08)	(0.10)	(0.06)									(0.04)					(0.07)
Restaurant - Sit Down	RSD						(0.03)							(0.05)	0.02	(0.03)	(0.07)	(0.03)
Retail - 3 story	Rt3	(0.09)	(0.08)	(0.04)	(0.04)		(0.02)		0.01	(0.01)	0.00	(0.02)	(0.04)	(0.01)	(0.00)			(0.03)
Retail - Large 1 story	RtL						(0.03)	(0.02)	(0.02)	(0.02)				(0.02)	(0.04)	(0.01)	(0.05)	(0.03)
Retail - Small	RtS						(0.03)											(0.03)
Single Family Residential																		
Storage - Conditioned	SCn		(0.12)	(0.09)	(0.10)	(0.09)						(0.07)	(0.07)	(0.07)				(0.09)
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	2SPD	Tier1, 11.5EER, 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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(379)	(387)	(386)	(376)	(357)		(345)		(371)	(405)	(403)	(402)		(404)		(383)
Education - Primary School	EPr		(246)	(239)	(243)		(220)		(241)	(247)	(245)	(284)	(255)	(285)	(278)	(316)		(258)
Education - Secondary School	ESe						(257)	(238)	(261)	(273)	(271)			(330)	(309)		(269)	(276)
Education - University	EUn						(437)		(438)	(460)								(445)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(875)	(880)	(874)	(870)	(865)		(853)	(865)	(858)	(864)	(876)	(855)	(852)	(821)		(862)
Health/Medical - Nursing Home	Nrs						(859)		(845)	(850)	(836)			(823)	(822)	(816)		(836)
Industrial																		
Lodging - Hotel	Htl		(629)	(671)		(669)	(666)		(634)	(633)						(475)		(625)
Manufacturing - Bio/Tech	MBT			(252)	(266)			(180)					(248)					(236)
Manufacturing - Light Industrial	MLI						(337)	(347)	(318)	(328)	(318)				(294)			(324)
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(323)	(312)	(318)	(318)	(307)	(298)	(285)	(300)	(322)	(303)	(311)	(300)	(300)	(326)	(313)	(290)	(308)
Office - Small	OfS						(299)	(286)	(292)	(305)	(286)			(266)	(279)	(256)	(262)	(281)
Res																		
Restaurant - Fast Food	RFF	(349)	(402)	(406)	(414)	(395)	(433)		(416)	(436)		(386)	(407)	(383)				(402)
Restaurant - Sit Down	RSD						(318)		(326)	(335)	(307)			(315)	(295)	(323)	(260)	(310)
Retail - 3 story	Rt3	(435)	(427)	(465)	(435)	(469)	(428)		(385)	(420)	(398)	(401)	(425)	(387)	(389)			(420)
Retail - Large 1 story	RtL						(446)	(447)	(432)	(439)	(413)			(398)	(433)	(362)	(419)	(421)
Retail - Small	RtS						(406)		(388)	(405)	(387)					(340)		(385)
Single Family Residential																		
Storage - Conditioned	SCn		(428)	(415)	(436)	(415)						(422)	(427)	(414)				(422)
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(0.08)	(0.05)	(0.04)	(0.06)	(0.05)		(0.00)		(0.02)	(0.04)	(0.04)	(0.10)		(0.03)		(0.05)
Education - Primary School	EPr		(0.01)		(0.02)		(0.02)		(0.04)	(0.07)	(0.07)	(0.08)	(0.06)	(0.09)	(0.09)	(0.10)		(0.06)
Education - Secondary School	ESe						(0.01)	(0.03)	(0.03)	(0.06)	(0.06)			(0.09)	(0.09)		(0.04)	(0.05)
Education - University	EUn						(0.05)		(0.01)	(0.05)								(0.04)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(0.09)	(0.10)	(0.08)	(0.09)	(0.07)		(0.06)	(0.06)	(0.05)	(0.08)	(0.07)	(0.07)	(0.07)	(0.06)		(0.07)
Health/Medical - Nursing Home	Nrs						(0.08)		(0.07)	(0.06)	(0.05)			(0.07)	(0.07)	(0.05)		(0.07)
Industrial																		
Lodging - Hotel	Htl		(0.04)	(0.05)		(0.04)			0.04	0.05						0.06		0.00
Manufacturing - Bio/Tech	MBT			(0.02)	(0.01)								(0.00)					(0.01)
Manufacturing - Light Industrial	MLI						(0.04)	(0.06)	(0.02)	(0.02)	(0.01)				0.01			(0.02)
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(0.09)	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)	(0.04)	(0.04)	(0.06)	(0.03)	(0.06)	(0.03)	(0.06)	(0.06)	(0.04)	(0.06)	(0.06)
Office - Small	OfS						(0.07)	(0.07)	(0.03)	(0.05)				(0.03)	(0.06)	(0.05)	(0.08)	(0.06)
Res																		
Restaurant - Fast Food	RFF	(0.08)	(0.05)	(0.06)		(0.07)							(0.04)					(0.06)
Restaurant - Sit Down	RSD						(0.03)							(0.05)	0.02	(0.03)	(0.07)	(0.03)
Retail - 3 story	Rt3	(0.09)	(0.08)	(0.10)	(0.04)	(0.05)	(0.03)			(0.01)	0.00	(0.02)	(0.04)	(0.01)	(0.00)			(0.04)
Retail - Large 1 story	RtL						(0.03)	(0.02)	(0.02)	(0.02)				(0.02)	(0.04)	(0.01)	(0.05)	(0.03)
Retail - Small	RtS						(0.03)											(0.03)
Single Family Residential																		
Storage - Conditioned	SCn		(0.12)	(0.09)	(0.10)	(0.09)						(0.07)	(0.07)	(0.07)				(0.09)
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	2SPD	Tier2, 12.0EER, 1spd	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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(321)	(306)	(317)	(290)	(257)		(237)		(300)	(334)	(343)	(329)		(308)		(304)
Education - Primary School	EPr		(207)	(186)	(194)		(144)		(179)	(195)	(195)	(238)	(207)	(237)	(230)	(254)		(205)
Education - Secondary School	ESe						(189)	(150)	(194)	(223)	(221)			(280)	(260)		(238)	(219)
Education - University	EUn						(306)		(319)	(375)								(333)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(748)	(723)	(727)	(712)	(673)		(663)	(713)	(708)	(730)	(740)	(709)	(716)	(652)		(709)
Health/Medical - Nursing Home	Nrs						(793)		(777)	(790)	(773)			(760)	(765)	(722)		(769)
Industrial																		
Lodging - Hotel	Htl		(429)	(461)		(455)	(396)		(356)	(387)						(95)		(368)
Manufacturing - Bio/Tech	MBT			(133)	(157)			7					(154)					(110)
Manufacturing - Light Industrial	MLI						(278)	(275)	(245)	(278)	(265)				(243)			(264)
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(250)	(226)	(198)	(219)	(185)	(167)	(130)	(180)	(231)	(205)	(226)	(209)	(214)	(252)	(214)	(225)	(208)
Office - Small	OfS						(183)	(141)	(179)	(221)	(192)			(189)	(208)	(156)	(205)	(186)
Res																		
Restaurant - Fast Food	RFF	(340)	(359)	(357)	(367)	(334)	(370)		(348)	(390)		(326)	(363)	(320)				(352)
Restaurant - Sit Down	RSD						(232)		(233)	(274)	(233)			(257)	(224)	(238)	(236)	(241)
Retail - 3 story	Rt3	(382)	(334)	(325)	(321)	(307)	(254)		(202)	(301)	(280)	(316)	(342)	(293)	(304)			(305)
Retail - Large 1 story	RtL						(292)	(249)	(293)	(336)	(301)			(303)	(356)	(230)	(339)	(300)
Retail - Small	RtS						(265)		(254)	(306)	(287)					(221)		(267)
Single Family Residential																		
Storage - Conditioned	SCn		(422)	(414)	(428)	(414)						(398)	(413)	(387)				(411)
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(0.07)	(0.04)	(0.04)	(0.01)	(0.03)		0.03		0.01	(0.03)	(0.02)	(0.10)		(0.01)		(0.03)
Education - Primary School	EPr		(0.01)		(0.02)		(0.02)		(0.01)	(0.07)	(0.06)	(0.08)	(0.06)	(0.08)	(0.08)	(0.09)		(0.05)
Education - Secondary School	ESe						(0.01)	(0.00)	(0.00)	(0.06)	(0.06)			(0.08)	(0.08)		(0.03)	(0.04)
Education - University	EUn						(0.04)		0.02	(0.04)								(0.02)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(0.08)	(0.06)	(0.06)	(0.03)	(0.05)		(0.03)	(0.03)	(0.02)	(0.05)	(0.05)	(0.04)	(0.03)	(0.03)		(0.04)
Health/Medical - Nursing Home	Nrs						(0.08)		(0.05)	(0.05)	(0.03)			(0.05)	(0.05)	(0.03)		(0.05)
Industrial																		
Lodging - Hotel	Htl		0.01	0.03		0.05	0.07		0.13	0.15						0.17		0.09
Manufacturing - Bio/Tech	MBT			0.01	(0.00)			0.03					0.03					0.02
Manufacturing - Light Industrial	MLI						(0.02)	(0.05)	0.02		0.02				0.04			0.00
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(0.05)	(0.05)	(0.03)	(0.05)	(0.01)	(0.04)	(0.02)	(0.01)	(0.03)	0.01	(0.04)	0.01	(0.03)	(0.03)	(0.01)	(0.03)	(0.03)
Office - Small	OfS						(0.07)	(0.04)	(0.03)	(0.03)	0.03			(0.03)			(0.04)	(0.03)
Res																		
Restaurant - Fast Food	RFF	(0.08)	(0.05)	(0.06)					0.05			0.04						(0.02)
Restaurant - Sit Down	RSD								0.02	0.02	0.04			(0.02)	0.07		(0.03)	0.02
Retail - 3 story	Rt3	(0.09)	(0.07)	(0.03)	(0.01)	0.01			0.04	0.02	0.04	0.01	(0.01)	0.02	0.04			(0.00)
Retail - Large 1 story	RtL						(0.01)		0.01	0.01	0.03			0.01	(0.01)	0.02	(0.03)	0.01
Retail - Small	RtS								0.03	0.03	0.04					0.04		0.03
Single Family Residential																		
Storage - Conditioned	SCn		(0.12)	(0.09)	(0.09)	(0.09)						(0.05)	(0.06)	(0.05)				(0.08)
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
5.5 - 11.5 Ton	2SPD	Tier2, 12.0EER, 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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(350)	(364)	(355)	(353)	(322)		(303)		(332)	(363)	(369)	(360)		(336)		(346)
Education - Primary School	EPr		(231)	(227)	(224)		(197)		(219)	(225)	(221)	(260)	(233)	(259)	(251)	(272)		(235)
Education - Secondary School	ESe						(237)	(218)	(238)	(251)	(247)			(302)	(281)		(258)	(254)
Education - University	EUn						(389)		(387)	(416)								(397)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(826)	(830)	(816)	(821)	(795)		(778)	(796)	(790)	(799)	(819)	(784)	(781)	(713)		(796)
Health/Medical - Nursing Home	Nrs						(835)		(816)	(821)	(804)			(787)	(783)	(747)		(799)
Industrial																		
Lodging - Hotel	Htl		(498)	(573)		(569)	(512)		(456)	(459)						(146)		(459)
Manufacturing - Bio/Tech	MBT			(200)	(211)			(112)					(190)					(178)
Manufacturing - Light Industrial	MLI						(314)	(326)	(286)	(301)	(287)				(260)			(296)
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(297)	(274)	(283)	(278)	(270)	(253)	(237)	(253)	(281)	(256)	(264)	(256)	(252)	(282)	(247)	(255)	(265)
Office - Small	OfS						(259)	(242)	(252)	(266)	(241)			(221)	(233)	(188)	(233)	(237)
Res																		
Restaurant - Fast Food	RFF	(340)	(368)	(381)	(381)	(368)	(392)		(370)	(396)		(334)	(370)	(327)				(366)
Restaurant - Sit Down	RSD						(280)		(282)	(294)	(255)			(265)	(238)	(249)	(236)	(262)
Retail - 3 story	Rt3	(429)	(390)	(439)	(393)	(444)	(378)		(324)	(368)	(341)	(350)	(383)	(332)	(333)			(377)
Retail - Large 1 story	RtL						(402)	(404)	(383)	(393)	(360)			(342)	(385)	(272)	(394)	(371)
Retail - Small	RtS						(360)		(334)	(356)	(334)					(256)		(328)
Single Family Residential																		
Storage - Conditioned	SCn		(423)	(414)	(429)	(414)						(402)	(414)	(391)				(413)
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(0.06)	(0.04)	(0.04)	(0.05)	(0.03)		0.03		0.01	(0.03)	(0.01)	(0.09)		(0.01)		(0.03)
Education - Primary School	EPr		(0.01)		(0.02)		(0.02)		(0.01)	(0.06)	(0.06)	(0.08)	(0.06)	(0.08)	(0.08)	(0.09)		(0.05)
Education - Secondary School	ESe						(0.01)	(0.00)	0.00	(0.06)	(0.06)			(0.08)	(0.08)		(0.03)	(0.04)
Education - University	EUn						(0.03)		0.02	(0.03)								(0.01)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(0.08)	(0.08)	(0.06)	(0.07)	(0.05)		(0.03)	(0.03)	(0.02)	(0.05)	(0.05)	(0.04)	(0.03)	(0.03)		(0.05)
Health/Medical - Nursing Home	Nrs						(0.07)		(0.05)	(0.05)	(0.03)			(0.05)	(0.05)	(0.03)		(0.05)
Industrial																		
Lodging - Hotel	Htl		0.02	(0.01)		0.01	0.07		0.14	0.15						0.17		0.08
Manufacturing - Bio/Tech	MBT			(0.01)	(0.00)			0.03					0.03					0.01
Manufacturing - Light Industrial	MLI						(0.02)	(0.04)	0.02		0.02				0.04			0.00
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(0.08)	(0.05)	(0.07)	(0.06)	(0.06)	(0.04)	(0.02)	(0.01)	(0.03)	0.01	(0.04)	0.01	(0.03)	(0.03)	(0.01)	(0.03)	(0.03)
Office - Small	OfS						(0.07)	(0.04)	(0.03)	(0.03)	0.03			(0.03)			(0.04)	(0.03)
Res																		
Restaurant - Fast Food	RFF	(0.08)	(0.05)	(0.06)		(0.07)			0.05			0.04						(0.03)
Restaurant - Sit Down	RSD								0.02	0.02	0.04			(0.02)	0.07		(0.03)	0.02
Retail - 3 story	Rt3	(0.09)	(0.07)	(0.08)	(0.01)	(0.03)	(0.00)		0.04	0.02	0.04	0.01	(0.01)	0.02	0.04			(0.01)
Retail - Large 1 story	RtL						(0.01)		0.01	0.01	0.03			0.01	(0.01)	0.02	(0.03)	0.00
Retail - Small	RtS								0.03	0.03	0.04					0.04		0.03
Single Family Residential																		
Storage - Conditioned	SCn		(0.12)	(0.09)	(0.09)	(0.09)						(0.05)	(0.06)	(0.05)				(0.08)
Utilities																		

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																		
		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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		41	20	41	21	44		62		60	72	52	71		125		55
Education - Primary School	EPr		24	13	28		32		32	34	39	43	37	45	46	80		38
Education - Secondary School	ESe						26	27	33	33	40			49	50		17	34
Education - University	EUn						57		69	61								62
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		51	31	62	32	70		88	87	91	95	71	104	107	188		83
Health/Medical - Nursing Home	Nrs						24		40	43	50			62	67	128		59
Industrial																		
Lodging - Hotel	Htl		231	145		150	256		312	315						653		295
Manufacturing - Bio/Tech	MBT			43	63			91					75					68
Manufacturing - Light Industrial	MLI						31	22	46	41	49				62			42
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	6	46	29	49	34	59	56	64	55	68	70	63	74	64	116	41	56
Office - Small	OfS						53	47	60	53	67			74	71	121	41	65
Res																		
Restaurant - Fast Food	RFF		48	25	56	27	50		69	66		96	66	100				60
Restaurant - Sit Down	RSD						64		81	79	97			95	114	145	48	90
Retail - 3 story	Rt3	5	60	29	67	32	73		103	86	99	97	73	104	107			72
Retail - Large 1 story	RtL						61	56	77	74	92			103	87	172	42	85
Retail - Small	RtS						67		85	81	91					161		97
Single Family Residential																		
Storage - Conditioned	SCn		9	1	11						37	23	43					21
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.03	0.00	0.01	0.03	0.03		0.06		0.06	0.03	0.05	0.01		0.05		0.03
Education - Primary School	EPr						0.00		0.05	0.01	0.01	0.01	0.01	0.02	0.01	0.02		0.02
Education - Secondary School	ESe						0.00	0.05	0.06	0.01	0.01			0.02	0.02		0.01	0.02
Education - University	EUn						0.03		0.07	0.04								0.05
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.03	0.01	0.04	0.02	0.04		0.05	0.05	0.06	0.04	0.05	0.05	0.07	0.06		0.04
Health/Medical - Nursing Home	Nrs						0.02		0.04	0.04	0.04			0.04	0.05	0.05		0.04
Industrial																		
Lodging - Hotel	Htl		0.11	0.08		0.10	0.15		0.20	0.21						0.24		0.15
Manufacturing - Bio/Tech	MBT			0.01	0.02			0.06					0.07					0.04
Manufacturing - Light Industrial	MLI						0.03	0.04	0.06	0.04	0.07				0.06			0.05
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.00	0.04	0.01	0.03	0.03	0.04	0.05	0.06	0.05	0.07	0.04	0.07	0.05	0.06	0.06	0.05	0.04
Office - Small	OfS						0.03	0.04	0.03	0.05	0.09			0.06	0.06	0.05	0.04	0.05
Res																		
Restaurant - Fast Food	RFF				0.05	0.07	0.05		0.09	0.07		0.07	0.04	0.07				0.06
Restaurant - Sit Down	RSD						0.05		0.05	0.07	0.06			0.05	0.09	0.06	0.07	0.06
Retail - 3 story	Rt3		0.03	0.02	0.05	0.04	0.05		0.07	0.07	0.07	0.06	0.06	0.07	0.08			0.06
Retail - Large 1 story	RtL						0.05	0.05	0.06	0.06	0.07			0.07	0.07	0.08	0.05	0.06
Retail - Small	RtS						0.04		0.07	0.08	0.07					0.09		0.07
Single Family Residential																		
Storage - Conditioned	SCn		0.00		0.02							0.04	0.04	0.05				0.03
Utilities																		

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																		
		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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		58	43	60	45	71		86		78	85	68	84		136		74
Education - Primary School	EPr		31	23	36		45		44	44	47	48	43	52	51	85		46
Education - Secondary School	ESe						38	41	45	42	48			55	55		22	43
Education - University	EUn						93		100	85								93
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		88	91	107	90	132		145	130	130	122	104	133	134	211		125
Health/Medical - Nursing Home	Nrs						40		54	52	59		68	72	134			68
Industrial																		
Lodging - Hotel	Htl		263	195		198	309		359	353						672		336
Manufacturing - Bio/Tech	MBT			105	109			138					117					117
Manufacturing - Light Industrial	MLI						43	39	60	53	60				67			54
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	50	75	67	78	71	89	94	91	81	93	91	88	95	84	131	67	84
Office - Small	OfS						80	87	85	76	88			93	90	135	65	89
Res																		
Restaurant - Fast Food	RFF	17	62	49	75	48	77		96	86		108	77	112				73
Restaurant - Sit Down	RSD						75		91	86	106			99	116	150	51	97
Retail - 3 story	Rt3	9	73	47	81	47	98		124	104	114	103	84	112	113			85
Retail - Large 1 story	RtL						85	86	97	90	106			111	93	181	49	100
Retail - Small	RtS						92		106	97	106					171		114
Single Family Residential																		
Storage - Conditioned	SCn		9	1	11							38	23	45				21
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.03	0.00	0.01	0.03	0.03		0.06		0.06	0.03	0.05	0.01		0.05		0.03
Education - Primary School	EPr						0.00		0.05	0.01	0.01	0.01	0.01	0.02	0.01	0.02		0.02
Education - Secondary School	ESe						0.00	0.05	0.06	0.01	0.01			0.02	0.02		0.01	0.02
Education - University	EUn						0.03		0.07	0.04								0.05
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.03	0.02	0.04	0.03	0.04		0.05	0.05	0.06	0.04	0.05	0.05	0.07	0.06		0.05
Health/Medical - Nursing Home	Nrs						0.02		0.03	0.04	0.04			0.04	0.05	0.05		0.04
Industrial																		
Lodging - Hotel	Htl		0.11	0.09		0.10	0.15		0.20	0.21						0.24		0.16
Manufacturing - Bio/Tech	MBT			0.01	0.02			0.06					0.07					0.04
Manufacturing - Light Industrial	MLI						0.03	0.05	0.06	0.04	0.07				0.06			0.05
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.02	0.04	0.02	0.03	0.03	0.04	0.05	0.06	0.05	0.07	0.04	0.07	0.05	0.06	0.06	0.05	0.05
Office - Small	OfS						0.03	0.04	0.03	0.05	0.09			0.06	0.06	0.05	0.04	0.05
Res																		
Restaurant - Fast Food	RFF				0.05		0.05		0.09	0.07		0.07	0.04	0.07				0.06
Restaurant - Sit Down	RSD						0.05		0.05	0.07	0.06			0.05	0.09	0.06	0.07	0.06
Retail - 3 story	Rt3		0.03	0.02	0.05	0.04	0.05		0.07	0.07	0.07	0.06	0.06	0.07	0.08			0.06
Retail - Large 1 story	RtL						0.05	0.05	0.06	0.06	0.07			0.07	0.07	0.08	0.05	0.06
Retail - Small	RtS						0.04		0.07	0.08	0.07					0.09		0.07
Single Family Residential																		
Storage - Conditioned	SCn		0.00		0.02							0.04	0.04	0.05				0.03
Utilities																		

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																		
		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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		59	28	58	30	63		88		86	103	75	102		180		79
Education - Primary School	EPr		34	18	40		46		45	49	56	61	52	65	66	115		54
Education - Secondary School	ESe						37	38	47	48	57			70	72		25	49
Education - University	EUn						83		99	87								89
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		74	45	89	46	101		127	124	131	136	101	149	154	270		119
Health/Medical - Nursing Home	Nrs						35		57	61	72			89	96	184		85
Industrial																		
Lodging - Hotel	Htl		332	209		216	367		447	451						937		423
Manufacturing - Bio/Tech	MBT			62	91			130					108					98
Manufacturing - Light Industrial	MLI						44	31	66	59	70				89			60
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	9	66	41	70	49	85	80	93	79	97	100	90	106	93	166	59	80
Office - Small	OfS						73	69	88	76	94			106	102	172	61	94
Res																		
Restaurant - Fast Food	RFF		72	31	80	34	68		101	96		137	95	145				86
Restaurant - Sit Down	RSD						91		115	112	140			136	164	208	68	129
Retail - 3 story	Rt3	6	86	41	97	47	105		147	124	142	139	105	149	154			103
Retail - Large 1 story	RtL						88	81	110	107	133			148	125	247	61	122
Retail - Small	RtS						96		123	116	131					231		139
Single Family Residential																		
Storage - Conditioned	SCn		13	1	16							53	33	62				30
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.04	0.00	0.02	0.04	0.04		0.09		0.09	0.04	0.08	0.02		0.08		0.05
Education - Primary School	EPr				0.00		0.00		0.07	0.01	0.02	0.02	0.02	0.02	0.02	0.02		0.02
Education - Secondary School	ESe						0.00	0.07	0.08	0.01	0.01			0.02	0.02		0.01	0.03
Education - University	EUn						0.05		0.10	0.06								0.07
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.04	0.02	0.06	0.03	0.06		0.08	0.08	0.09	0.06	0.07	0.07	0.09	0.09		0.06
Health/Medical - Nursing Home	Nrs						0.03		0.05	0.05	0.06			0.06	0.07	0.07		0.06
Industrial																		
Lodging - Hotel	Htl		0.16	0.11		0.14	0.21		0.28	0.30						0.34		0.22
Manufacturing - Bio/Tech	MBT			0.01	0.03			0.09					0.10					0.06
Manufacturing - Light Industrial	MLI						0.05	0.06	0.09	0.06	0.10				0.09			0.08
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.01	0.06	0.01	0.04	0.04	0.06	0.07	0.08	0.07	0.09	0.06	0.09	0.07	0.09	0.09	0.07	0.06
Office - Small	OfS						0.07	0.07	0.06	0.08	0.12			0.06	0.09	0.08	0.04	0.08
Res																		
Restaurant - Fast Food	RFF				0.09	0.07	0.09		0.09	0.10		0.11	0.07	0.11				0.09
Restaurant - Sit Down	RSD						0.05		0.07	0.09	0.11			0.09	0.14	0.10	0.07	0.09
Retail - 3 story	Rt3		0.05	0.02	0.07	0.05	0.08		0.10	0.10	0.11	0.09	0.08	0.10	0.12			0.08
Retail - Large 1 story	RtL						0.07	0.07	0.08	0.08	0.10			0.10	0.10	0.11	0.07	0.09
Retail - Small	RtS						0.07		0.09	0.10	0.11					0.12		0.10
Single Family Residential																		
Storage - Conditioned	SCn		0.00		0.02							0.05	0.05	0.07				0.04
Utilities																		

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																		
		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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		83	62	86	64	102		124		112	122	98	121		195		106
Education - Primary School	EPr		45	33	52		64		63	63	68	69	62	74	74	122		66
Education - Secondary School	ESe						55	59	64	61	69			79	79		32	62
Education - University	EUn						134		143	122								133
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		127	131	153	130	189		208	187	187	176	150	191	192	303		179
Health/Medical - Nursing Home	Nrs						58		77	75	85			98	103	192		98
Industrial																		
Lodging - Hotel	Htl		377	280		284	444		516	506						965		482
Manufacturing - Bio/Tech	MBT			151	156			198					168					168
Manufacturing - Light Industrial	MLI						61	57	87	76	85				97			77
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	72	108	96	112	102	128	135	131	116	134	130	126	137	121	189	97	121
Office - Small	OfS						113	123	119	110	128			134	130	191	90	127
Res																		
Restaurant - Fast Food	RFF	25	91	68	108	68	108		137	122		152	114	160				105
Restaurant - Sit Down	RSD						107		130	126	151			143	169	215	75	139
Retail - 3 story	Rt3	13	104	67	116	68	141		177	149	164	148	120	161	162			122
Retail - Large 1 story	RtL						122	123	139	129	153			160	133	259	70	143
Retail - Small	RtS						132		153	139	152					245		164
Single Family Residential																		
Storage - Conditioned	SCn		13	1	16							54	33	64				30
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.04	0.01	0.02	0.05	0.04		0.09		0.09	0.04	0.08	0.02		0.08		0.05
Education - Primary School	EPr				0.00		0.00		0.07	0.02	0.01	0.02	0.02	0.02	0.02	0.02		0.02
Education - Secondary School	ESe						0.00	0.07	0.08	0.01	0.01			0.02	0.02		0.01	0.03
Education - University	EUn						0.05		0.10	0.06								0.07
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.04	0.03	0.06	0.04	0.06		0.08	0.08	0.09	0.06	0.07	0.07	0.09	0.09		0.07
Health/Medical - Nursing Home	Nrs						0.04		0.05	0.05	0.06			0.06	0.07	0.07		0.06
Industrial																		
Lodging - Hotel	Htl		0.16	0.12		0.15	0.21		0.29	0.30						0.34		0.23
Manufacturing - Bio/Tech	MBT			0.02	0.03			0.09					0.10					0.06
Manufacturing - Light Industrial	MLI						0.05	0.07	0.09	0.06	0.10				0.09			0.08
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.04	0.06	0.03	0.04	0.05	0.06	0.07	0.08	0.07	0.09	0.06	0.09	0.07	0.09	0.09	0.07	0.07
Office - Small	OfS						0.07	0.07	0.06	0.08	0.12			0.06	0.09	0.08	0.04	0.08
Res																		
Restaurant - Fast Food	RFF				0.09		0.09		0.09	0.10		0.11	0.07	0.11				0.10
Restaurant - Sit Down	RSD						0.05		0.07	0.09	0.11			0.09	0.14	0.10	0.07	0.09
Retail - 3 story	Rt3		0.05	0.03	0.07	0.06	0.07		0.10	0.10	0.11	0.09	0.08	0.10	0.12			0.08
Retail - Large 1 story	RtL						0.07	0.07	0.08	0.08	0.10			0.10	0.10	0.11	0.07	0.09
Retail - Small	RtS						0.07		0.09	0.10	0.11					0.12		0.10
Single Family Residential																		
Storage - Conditioned	SCn		0.00		0.02							0.05	0.05	0.07				0.04
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
11.6 - 20 Ton	2SPD	Tier1, 11.5EER, 1spd	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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(336)	(316)	(332)	(300)	(276)		(258)		(322)	(357)	(362)	(352)		(349)		(324)
Education - Primary School	EPr		(217)	(193)	(204)		(156)		(191)	(209)	(209)	(253)	(221)	(253)	(247)	(281)		(220)
Education - Secondary School	ESe						(201)	(160)	(207)	(237)	(236)			(299)	(279)		(248)	(233)
Education - University	EUn						(329)		(343)	(399)								(357)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(777)	(748)	(758)	(737)	(708)		(701)	(752)	(745)	(767)	(772)	(746)	(756)	(709)		(744)
Health/Medical - Nursing Home	Nrs						(822)		(809)	(825)	(806)			(794)	(802)	(779)		(805)
Industrial																		
Lodging - Hotel	Htl		(498)	(510)		(506)	(477)		(448)	(481)						(272)		(456)
Manufacturing - Bio/Tech	MBT			(143)	(170)			(16)					(169)					(125)
Manufacturing - Light Industrial	MLI						(294)	(289)	(263)	(296)	(283)				(258)			(281)
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(257)	(237)	(208)	(232)	(195)	(185)	(147)	(196)	(247)	(221)	(242)	(222)	(229)	(269)	(241)	(240)	(223)
Office - Small	OfS						(199)	(155)	(196)	(234)	(207)			(202)	(222)	(180)	(220)	(202)
Res																		
Restaurant - Fast Food	RFF	(349)	(379)	(370)	(389)	(346)	(395)		(377)	(419)		(361)	(390)	(355)				(375)
Restaurant - Sit Down	RSD						(258)		(264)	(305)	(266)			(289)	(258)	(292)	(250)	(273)
Retail - 3 story	Rt3	(391)	(355)	(337)	(342)	(319)	(283)		(234)	(332)	(313)	(344)	(365)	(322)	(332)			(328)
Retail - Large 1 story	RtL						(317)	(273)	(321)	(365)	(331)			(334)	(383)	(283)	(356)	(329)
Retail - Small	RtS						(291)		(281)	(333)	(317)					(267)		(298)
Single Family Residential																		
Storage - Conditioned	SCn		(437)	(425)	(444)	(425)						(419)	(431)	(410)				(427)
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(0.08)	(0.04)	(0.05)	(0.01)	(0.05)		0.01		(0.01)	(0.04)	(0.03)	(0.11)		(0.03)		(0.04)
Education - Primary School	EPr		(0.01)	(0.00)	(0.02)		(0.02)		(0.03)	(0.07)	(0.07)	(0.08)	(0.06)	(0.09)	(0.09)	(0.10)		(0.05)
Education - Secondary School	ESe						(0.01)	(0.02)	(0.02)	(0.06)	(0.06)			(0.09)	(0.09)		(0.04)	(0.05)
Education - University	EUn						(0.05)		0.00	(0.05)								(0.03)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(0.08)	(0.07)	(0.07)	(0.03)	(0.07)		(0.05)	(0.05)	(0.03)	(0.06)	(0.05)	(0.05)	(0.05)	(0.04)		(0.05)
Health/Medical - Nursing Home	Nrs						(0.09)		(0.07)	(0.06)	(0.04)			(0.07)	(0.07)	(0.05)		(0.06)
Industrial																		
Lodging - Hotel	Htl		(0.01)	0.01		0.03	0.03		0.08	0.09						0.11		0.05
Manufacturing - Bio/Tech	MBT			0.01	(0.01)			0.01					0.02					0.01
Manufacturing - Light Industrial	MLI						(0.03)	(0.06)	(0.00)	(0.01)	0.00				0.02			(0.01)
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(0.05)	(0.05)	(0.04)	(0.06)	(0.02)	(0.05)	(0.03)	(0.02)	(0.04)	(0.00)	(0.04)	(0.00)	(0.04)	(0.04)	(0.02)	(0.04)	(0.03)
Office - Small	OfS						(0.06)	(0.03)	(0.01)	(0.04)				(0.03)	(0.01)	(0.00)	(0.04)	(0.03)
Res																		
Restaurant - Fast Food	RFF	(0.06)	(0.05)	(0.05)	(0.02)	(0.01)	(0.04)			(0.01)		(0.01)	(0.01)	(0.02)				(0.03)
Restaurant - Sit Down	RSD						(0.03)		0.01	0.00	0.04			(0.03)	0.04	(0.02)	(0.05)	(0.00)
Retail - 3 story	Rt3	(0.09)	(0.07)	(0.04)	(0.03)	0.00	(0.02)		0.01	(0.00)	0.02	(0.01)	(0.03)	(0.00)	0.02			(0.02)
Retail - Large 1 story	RtL						(0.03)	(0.01)	(0.01)	(0.01)	0.01			(0.01)	(0.02)	0.00	(0.04)	(0.01)
Retail - Small	RtS						(0.01)		0.01	0.01	0.02					0.01		0.01
Single Family Residential																		
Storage - Conditioned	SCn		(0.12)	(0.09)	(0.10)	(0.09)						(0.06)	(0.07)	(0.07)				(0.09)
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
11.6 - 20 Ton	2SPD	Tier1, 11.5EER, 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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(369)	(381)	(377)	(370)	(350)		(331)		(359)	(390)	(392)	(388)		(381)		(372)
Education - Primary School	EPr		(243)	(237)	(239)		(215)		(235)	(243)	(239)	(278)	(249)	(278)	(270)	(302)		(252)
Education - Secondary School	ESe						(254)	(234)	(256)	(269)	(265)			(324)	(301)		(270)	(272)
Education - University	EUn						(425)		(421)	(450)								(432)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(869)	(875)	(866)	(866)	(855)		(834)	(853)	(840)	(850)	(865)	(833)	(833)	(782)		(848)
Health/Medical - Nursing Home	Nrs						(874)		(855)	(861)	(842)			(824)	(823)	(808)		(841)
Industrial																		
Lodging - Hotel	Htl		(578)	(638)		(635)	(613)		(563)	(567)						(331)		(561)
Manufacturing - Bio/Tech	MBT			(220)	(235)			(142)					(212)					(202)
Manufacturing - Light Industrial	MLI						(336)	(347)	(310)	(324)	(310)				(278)			(318)
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(313)	(292)	(302)	(300)	(290)	(280)	(263)	(277)	(306)	(279)	(287)	(277)	(274)	(306)	(280)	(279)	(288)
Office - Small	OfS						(283)	(267)	(271)	(288)	(261)			(240)	(255)	(215)	(254)	(259)
Res																		
Restaurant - Fast Food	RFF	(349)	(393)	(405)	(410)	(390)	(428)		(408)	(432)		(370)	(399)	(366)				(395)
Restaurant - Sit Down	RSD						(312)		(314)	(329)	(292)			(300)	(273)	(304)	(255)	(297)
Retail - 3 story	Rt3	(443)	(416)	(460)	(422)	(464)	(419)		(364)	(408)	(380)	(381)	(411)	(365)	(365)			(407)
Retail - Large 1 story	RtL						(440)	(442)	(420)	(430)	(398)			(379)	(416)	(331)	(416)	(408)
Retail - Small	RtS						(396)		(369)	(391)	(369)					(307)		(366)
Single Family Residential																		
Storage - Conditioned	SCn		(437)	(425)	(444)	(425)						(423)	(432)	(415)				(429)
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(0.07)	(0.05)	(0.04)	(0.06)	(0.05)		0.01		(0.01)	(0.04)	(0.03)	(0.10)		(0.03)		(0.04)
Education - Primary School	EPr		(0.01)	(0.00)	(0.02)		(0.02)		(0.03)	(0.07)	(0.07)	(0.08)	(0.06)	(0.09)	(0.09)	(0.10)		(0.05)
Education - Secondary School	ESe						(0.01)	(0.02)	(0.02)	(0.06)	(0.06)			(0.09)	(0.09)		(0.04)	(0.05)
Education - University	EUn						(0.05)		0.01	(0.05)								(0.03)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(0.08)	(0.09)	(0.07)	(0.08)	(0.07)		(0.05)	(0.05)	(0.03)	(0.06)	(0.05)	(0.05)	(0.05)	(0.04)		(0.06)
Health/Medical - Nursing Home	Nrs						(0.09)		(0.06)	(0.06)	(0.04)			(0.06)	(0.07)	(0.05)		(0.06)
Industrial																		
Lodging - Hotel	Htl		(0.01)	(0.03)		(0.01)	0.03		0.09	0.10						0.11		0.04
Manufacturing - Bio/Tech	MBT			(0.01)	(0.01)			0.01					0.02					0.00
Manufacturing - Light Industrial	MLI						(0.03)	(0.06)	(0.00)	(0.01)	0.00				0.02			(0.01)
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(0.08)	(0.05)	(0.07)	(0.06)	(0.06)	(0.05)	(0.03)	(0.02)	(0.04)	(0.00)	(0.04)	(0.00)	(0.04)	(0.04)	(0.02)	(0.04)	(0.04)
Office - Small	OfS						(0.06)	(0.03)	(0.01)	(0.04)				(0.03)	(0.01)	(0.00)	(0.04)	(0.03)
Res																		
Restaurant - Fast Food	RFF	(0.06)	(0.05)	(0.06)	(0.02)	(0.05)	(0.04)			(0.01)		(0.01)	(0.01)	(0.02)				(0.03)
Restaurant - Sit Down	RSD						(0.03)		0.01	0.00	0.04			(0.03)	0.04	(0.02)	(0.05)	(0.00)
Retail - 3 story	Rt3	(0.09)	(0.07)	(0.09)	(0.03)	(0.05)	(0.02)		0.01	(0.00)	0.02	(0.01)	(0.03)	(0.00)	0.02			(0.03)
Retail - Large 1 story	RtL						(0.03)	(0.01)	(0.01)	(0.01)	0.01			(0.01)	(0.02)	0.00	(0.04)	(0.01)
Retail - Small	RtS						(0.01)		0.01	0.01	0.02					0.01		0.01
Single Family Residential																		
Storage - Conditioned	SCn		(0.12)	(0.09)	(0.10)	(0.09)						(0.06)	(0.07)	(0.07)				(0.09)
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
11.6 - 20 Ton	2SPD	Tier2, 12.0EER, 1spd	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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(317)	(307)	(313)	(291)	(256)		(230)		(293)	(323)	(337)	(319)		(289)		(298)
Education - Primary School	EPr		(206)	(187)	(191)		(142)		(176)	(192)	(190)	(232)	(203)	(231)	(224)	(241)		(201)
Education - Secondary School	ESe						(189)	(149)	(191)	(221)	(217)			(275)	(253)		(240)	(217)
Education - University	EUn						(303)		(311)	(369)								(328)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(751)	(734)	(727)	(722)	(675)		(658)	(709)	(700)	(720)	(737)	(694)	(702)	(617)		(704)
Health/Medical - Nursing Home	Nrs						(809)		(788)	(802)	(780)			(763)	(767)	(715)		(775)
Industrial																		
Lodging - Hotel	Htl		(388)	(443)		(437)	(357)		(301)	(331)						38		(317)
Manufacturing - Bio/Tech	MBT			(127)	(143)			20					(136)					(96)
Manufacturing - Light Industrial	MLI						(279)	(279)	(241)	(276)	(260)				(228)			(261)
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(255)	(216)	(196)	(209)	(181)	(159)	(124)	(166)	(221)	(190)	(208)	(193)	(194)	(237)	(185)	(221)	(197)
Office - Small	OfS						(175)	(135)	(169)	(208)	(176)			(167)	(187)	(122)	(202)	(171)
Res																		
Restaurant - Fast Food	RFF	(348)	(355)	(360)	(362)	(336)	(373)		(344)	(387)		(315)	(358)	(308)				(350)
Restaurant - Sit Down	RSD						(230)		(226)	(268)	(220)			(244)	(203)	(223)	(229)	(230)
Retail - 3 story	Rt3	(390)	(327)	(325)	(311)	(305)	(250)		(188)	(292)	(267)	(298)	(331)	(274)	(281)			(295)
Retail - Large 1 story	RtL						(289)	(249)	(285)	(329)	(287)			(285)	(340)	(201)	(336)	(289)
Retail - Small	RtS						(261)		(242)	(295)	(274)					(191)		(253)
Single Family Residential																		
Storage - Conditioned	SCn		(431)	(425)	(437)	(425)						(400)	(418)	(389)				(418)
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(0.06)	(0.04)	(0.04)	(0.00)	(0.03)		0.04		0.02	(0.02)	(0.01)	(0.10)		(0.00)		(0.02)
Education - Primary School	EPr		(0.01)	(0.00)	(0.02)		(0.02)		(0.00)	(0.06)	(0.06)	(0.07)	(0.05)	(0.08)	(0.08)	(0.09)		(0.05)
Education - Secondary School	ESe						(0.01)	0.00	0.01	(0.06)	(0.06)			(0.08)	(0.08)		(0.03)	(0.04)
Education - University	EUn						(0.03)		0.03	(0.03)								(0.01)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(0.07)	(0.06)	(0.05)	(0.02)	(0.05)		(0.02)	(0.02)	(0.00)	(0.04)	(0.03)	(0.03)	(0.01)	(0.01)		(0.03)
Health/Medical - Nursing Home	Nrs						(0.08)		(0.05)	(0.04)	(0.02)			(0.05)	(0.04)	(0.03)		(0.05)
Industrial																		
Lodging - Hotel	Htl		0.04	0.04		0.08	0.10		0.18	0.19						0.22		0.12
Manufacturing - Bio/Tech	MBT			0.01	0.00			0.04					0.05					0.03
Manufacturing - Light Industrial	MLI						(0.02)	(0.03)	0.03	0.01	0.03				0.05			0.01
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(0.05)	(0.03)	(0.03)	(0.05)	(0.01)	(0.03)	(0.00)	0.01	(0.01)	0.03	(0.02)	0.03	(0.02)	(0.01)	0.01	(0.02)	(0.01)
Office - Small	OfS						(0.04)	(0.01)	0.01	(0.01)	0.03			(0.01)	0.02	0.03	(0.01)	0.00
Res																		
Restaurant - Fast Food	RFF	(0.06)	(0.03)	(0.05)			(0.02)		0.03	0.01		0.02	0.01	0.01				(0.01)
Restaurant - Sit Down	RSD						(0.01)		0.04	0.03	0.07			0.00	0.08	0.01	(0.02)	0.03
Retail - 3 story	Rt3	(0.09)	(0.05)	(0.03)	(0.00)	0.02	0.00		0.05	0.03	0.05	0.02	(0.00)	0.03	0.05			0.01
Retail - Large 1 story	RtL						(0.00)	0.01	0.02	0.01	0.05			0.02	0.01	0.04	(0.02)	0.01
Retail - Small	RtS						0.01		0.04	0.04	0.05					0.05		0.04
Single Family Residential																		
Storage - Conditioned	SCn		(0.12)	(0.09)	(0.09)	(0.09)						(0.04)	(0.05)	(0.05)				(0.08)
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
11.6 - 20 Ton	2SPD	Tier2, 12.0EER, 1spd	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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(341)	(359)	(347)	(347)	(315)		(289)		(320)	(348)	(359)	(347)		(315)		(335)
Education - Primary School	EPr		(227)	(225)	(220)		(193)		(214)	(220)	(215)	(253)	(227)	(252)	(244)	(259)		(229)
Education - Secondary School	ESe						(235)	(214)	(233)	(248)	(241)			(296)	(273)		(259)	(250)
Education - University	EUn						(378)		(371)	(406)								(385)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(821)	(825)	(809)	(817)	(786)		(759)	(785)	(773)	(785)	(809)	(764)	(763)	(676)		(782)
Health/Medical - Nursing Home	Nrs						(850)		(825)	(832)	(810)			(788)	(785)	(740)		(804)
Industrial																		
Lodging - Hotel	Htl		(451)	(542)		(538)	(464)		(390)	(396)						(10)		(399)
Manufacturing - Bio/Tech	MBT			(169)	(181)			(77)					(155)					(146)
Manufacturing - Light Industrial	MLI						(314)	(326)	(280)	(297)	(280)				(244)			(290)
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(287)	(255)	(267)	(261)	(254)	(236)	(216)	(231)	(265)	(233)	(242)	(233)	(227)	(263)	(215)	(245)	(246)
Office - Small	OfS						(243)	(225)	(228)	(249)	(217)			(195)	(209)	(150)	(223)	(216)
Res																		
Restaurant - Fast Food	RFF	(342)	(362)	(383)	(374)	(367)	(392)		(361)	(390)		(319)	(360)	(313)				(360)
Restaurant - Sit Down	RSD						(277)		(271)	(287)	(241)			(252)	(215)	(232)	(232)	(251)
Retail - 3 story	Rt3	(437)	(380)	(435)	(381)	(438)	(371)		(304)	(356)	(324)	(331)	(370)	(312)	(310)			(365)
Retail - Large 1 story	RtL						(397)	(399)	(372)	(385)	(345)			(324)	(369)	(244)	(390)	(358)
Retail - Small	RtS						(351)		(317)	(343)	(318)					(226)		(311)
Single Family Residential																		
Storage - Conditioned	SCn		(431)	(425)	(438)	(425)						(404)	(420)	(393)				(419)
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(0.06)	(0.04)	(0.03)	(0.04)	(0.03)		0.04		0.02	(0.02)	(0.00)	(0.09)		(0.00)		(0.02)
Education - Primary School	EPr		(0.01)	(0.00)	(0.02)		(0.02)		(0.00)	(0.06)	(0.06)	(0.07)	(0.05)	(0.08)	(0.08)	(0.09)		(0.05)
Education - Secondary School	ESe						(0.01)	0.00	0.01	(0.06)	(0.06)			(0.08)	(0.08)		(0.03)	(0.04)
Education - University	EUn						(0.03)		0.04	(0.03)								(0.01)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(0.07)	(0.08)	(0.05)	(0.07)	(0.05)		(0.02)	(0.02)	(0.00)	(0.04)	(0.03)	(0.03)	(0.01)	(0.01)		(0.04)
Health/Medical - Nursing Home	Nrs						(0.07)		(0.05)	(0.04)	(0.02)			(0.04)	(0.04)	(0.03)		(0.04)
Industrial																		
Lodging - Hotel	Htl		0.05	0.01		0.04	0.10		0.18	0.19						0.22		0.11
Manufacturing - Bio/Tech	MBT			(0.01)	0.00			0.04					0.05					0.02
Manufacturing - Light Industrial	MLI						(0.02)	(0.03)	0.03	0.01	0.03				0.05			0.01
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(0.07)	(0.03)	(0.06)	(0.04)	(0.05)	(0.03)	(0.00)	0.01	(0.01)	0.03	(0.02)	0.03	(0.02)	(0.01)	0.01	(0.02)	(0.02)
Office - Small	OfS						(0.04)	(0.01)	0.01	(0.01)	0.03			(0.01)	0.02	0.03	(0.01)	0.00
Res																		
Restaurant - Fast Food	RFF	(0.06)	(0.04)	(0.05)		(0.03)	(0.02)		0.03	0.01		0.02	0.01	0.01				(0.01)
Restaurant - Sit Down	RSD						(0.01)		0.04	0.03	0.07			0.00	0.08	0.01	(0.02)	0.03
Retail - 3 story	Rt3	(0.09)	(0.05)	(0.08)	(0.00)	(0.03)	0.00		0.05	0.03	0.05	0.02	(0.00)	0.03	0.05			(0.00)
Retail - Large 1 story	RtL						(0.00)	0.01	0.02	0.01	0.05			0.02	0.01	0.04	(0.02)	0.01
Retail - Small	RtS						0.01		0.04	0.04	0.05					0.05		0.04
Single Family Residential																		
Storage - Conditioned	SCn		(0.12)	(0.09)	(0.09)	(0.09)						(0.04)	(0.05)	(0.05)				(0.08)
Utilities																		

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																		
		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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		51	24	50	26	54		75		74	88	64	87		152		68
Education - Primary School	EPr		29	16	34		39		39	42	48	53	45	56	57	98		46
Education - Secondary School	ESe						31	32	40	41	49			60	62		22	42
Education - University	EUn						70		84	75								76
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		64	38	77	39	86		108	107	112	117	88	129	133	231		102
Health/Medical - Nursing Home	Nrs						30		49	53	63			77	83	157		73
Industrial																		
Lodging - Hotel	Htl		281	176		181	308		378	382						792		357
Manufacturing - Bio/Tech	MBT			53	77			109					91					82
Manufacturing - Light Industrial	MLI						38	26	56	51	59				76			51
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	8	57	35	61	42	72	68	79	68	83	86	77	91	80	141	51	69
Office - Small	OfS						63	58	73	67	81			92	90	146	50	80
Res																		
Restaurant - Fast Food	RFF	4	60	26	68	28	56		85	81		116	82	121				66
Restaurant - Sit Down	RSD						76		98	95	119			116	139	175	59	110
Retail - 3 story	Rt3	5	74	35	82	41	89		125	105	120	118	89	126	131			88
Retail - Large 1 story	RtL						75	68	94	91	113			126	108	207	53	104
Retail - Small	RtS						82		104	98	111					194		118
Single Family Residential																		
Storage - Conditioned	SCn		12	1	14	0						46	28	53				22
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.03	0.00	0.02	0.03	0.03		0.08		0.07	0.03	0.06	0.02		0.06		0.04
Education - Primary School	EPr		0.00		0.00		0.00		0.06	0.01	0.01	0.02	0.01	0.02	0.02	0.02		0.02
Education - Secondary School	ESe						0.00	0.06	0.07	0.01	0.01			0.02	0.02		0.01	0.03
Education - University	EUn						0.04		0.08	0.05								0.06
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.04	0.01	0.05	0.03	0.05		0.06	0.07	0.07	0.05	0.06	0.06	0.08	0.08		0.06
Health/Medical - Nursing Home	Nrs						0.03		0.04	0.05	0.05			0.05	0.06	0.06		0.05
Industrial																		
Lodging - Hotel	Htl		0.14	0.09		0.12	0.18		0.24	0.26						0.29		0.19
Manufacturing - Bio/Tech	MBT			0.01	0.02			0.07					0.09					0.05
Manufacturing - Light Industrial	MLI						0.04	0.05	0.08	0.05	0.08				0.07			0.06
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.00	0.05	0.01	0.04	0.03	0.05	0.06	0.07	0.06	0.08	0.05	0.08	0.06	0.07	0.08	0.06	0.05
Office - Small	OfS						0.05	0.06	0.07	0.06	0.08			0.06	0.08	0.08	0.06	0.07
Res																		
Restaurant - Fast Food	RFF		0.04	0.01	0.05	0.03	0.05		0.07	0.07		0.07	0.06	0.07				0.05
Restaurant - Sit Down	RSD						0.06		0.08	0.08	0.10			0.08	0.11	0.08	0.06	0.08
Retail - 3 story	Rt3		0.04	0.02	0.06	0.05	0.06		0.08	0.08	0.09	0.08	0.07	0.08	0.10			0.07
Retail - Large 1 story	RtL						0.06	0.06	0.07	0.07	0.08			0.08	0.08	0.09	0.06	0.07
Retail - Small	RtS						0.07		0.08	0.08	0.09					0.09		0.08
Single Family Residential																		
Storage - Conditioned	SCn		0.00		0.02							0.05	0.04	0.06				0.03
Utilities																		

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																		
		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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		71	53	74	55	87		105		96	104	84	103		164		91
Education - Primary School	EPr		38	29	45		54		53	54	58	60	53	63	63	104		56
Education - Secondary School	ESe						46	50	55	52	59			67	68		27	53
Education - University	EUn						114		122	105								114
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		110	113	132	111	161		178	161	161	152	130	165	167	259		154
Health/Medical - Nursing Home	Nrs						50		67	65	73			85	90	164		85
Industrial																		
Lodging - Hotel	Htl		320	237		239	373		436	429						815		407
Manufacturing - Bio/Tech	MBT			128	133			166					143					142
Manufacturing - Light Industrial	MLI						52	48	74	65	73				82			66
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	61	92	82	96	87	109	115	112	99	114	112	108	117	105	160	82	103
Office - Small	OfS						97	104	104	95	110			114	112	164	76	108
Res																		
Restaurant - Fast Food	RFF	20	78	55	90	57	90		116	103		129	97	136				88
Restaurant - Sit Down	RSD						91		111	106	129			122	144	181	63	118
Retail - 3 story	Rt3	11	89	57	100	58	119		151	126	139	126	102	136	138			104
Retail - Large 1 story	RtL						103	104	119	110	130			135	115	218	61	122
Retail - Small	RtS						112		130	118	129					205		139
Single Family Residential																		
Storage - Conditioned	SCn		12	1	14	0						47	28	55				22
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.03	0.01	0.02	0.04	0.03		0.08		0.07	0.03	0.06	0.02		0.06		0.04
Education - Primary School	EPr		0.00		0.00		0.00		0.06	0.01	0.01	0.02	0.01	0.02	0.02	0.02		0.02
Education - Secondary School	ESe						0.00	0.06	0.07	0.01	0.01			0.02	0.02		0.01	0.03
Education - University	EUn						0.04		0.08	0.05								0.06
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.04	0.03	0.05	0.04	0.05		0.06	0.07	0.07	0.05	0.06	0.06	0.08	0.08		0.06
Health/Medical - Nursing Home	Nrs						0.03		0.04	0.05	0.05			0.05	0.06	0.06		0.05
Industrial																		
Lodging - Hotel	Htl		0.14	0.10		0.13	0.18		0.24	0.26						0.29		0.19
Manufacturing - Bio/Tech	MBT			0.02	0.02			0.07					0.09					0.05
Manufacturing - Light Industrial	MLI						0.04	0.05	0.08	0.05	0.08				0.07			0.06
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.03	0.05	0.02	0.04	0.04	0.05	0.06	0.07	0.06	0.08	0.05	0.08	0.06	0.07	0.08	0.06	0.06
Office - Small	OfS						0.05	0.06	0.07	0.06	0.08			0.06	0.08	0.08	0.06	0.07
Res																		
Restaurant - Fast Food	RFF	0.01	0.03	0.01	0.05	0.03	0.05		0.07	0.07		0.07	0.06	0.07				0.05
Restaurant - Sit Down	RSD						0.06		0.08	0.08	0.10			0.08	0.11	0.08	0.06	0.08
Retail - 3 story	Rt3		0.04	0.03	0.06	0.05	0.06		0.08	0.08	0.09	0.08	0.07	0.08	0.10			0.07
Retail - Large 1 story	RtL						0.06	0.06	0.07	0.07	0.08			0.08	0.08	0.09	0.06	0.07
Retail - Small	RtS						0.07		0.08	0.08	0.09					0.09		0.08
Single Family Residential																		
Storage - Conditioned	SCn		0.00		0.02							0.05	0.04	0.06				0.03
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
11.6 - 20 Ton	2SPD	Tier3, 12.5EER, 1spd	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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(242)	(239)	(236)	(237)	(235)		(232)		(244)	(227)	(230)	(248)		(230)		(236)
Education - Primary School	EPr		(161)	(162)	(160)		(163)		(165)	(167)	(167)	(184)	(184)	(180)	(170)	(165)		(169)
Education - Secondary School	ESe						(188)	(189)	(196)	(196)	(195)			(194)	(188)		(189)	(192)
Education - University	EUn						(278)		(280)	(286)								(282)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(727)	(720)	(699)	(708)	(643)		(618)	(669)	(658)	(675)	(704)	(646)	(651)	(530)		(665)
Health/Medical - Nursing Home	Nrs						(796)		(769)	(781)	(756)			(733)	(734)	(655)		(746)
Industrial																		
Lodging - Hotel	Htl		(285)	(380)		(372)	(245)		(163)	(190)						329		(186)
Manufacturing - Bio/Tech	MBT			(111)	(116)			54					(104)					(69)
Manufacturing - Light Industrial	MLI						(265)	(269)	(221)	(257)	(238)				(200)			(242)
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(254)	(196)	(185)	(188)	(168)	(134)	(102)	(139)	(196)	(160)	(177)	(166)	(161)	(207)	(133)	(203)	(173)
Office - Small	OfS						(153)	(116)	(143)	(184)	(147)			(134)	(153)	(69)	(184)	(143)
Res																		
Restaurant - Fast Food	RFF	(347)	(333)	(351)	(338)	(326)	(353)		(313)	(357)		(272)	(328)	(264)				(326)
Restaurant - Sit Down	RSD						(204)		(191)	(233)	(177)			(202)	(151)	(159)	(209)	(191)
Retail - 3 story	Rt3	(388)	(300)	(313)	(281)	(292)	(220)		(145)	(254)	(224)	(255)	(298)	(229)	(232)			(264)
Retail - Large 1 story	RtL						(262)	(226)	(251)	(295)	(246)			(239)	(299)	(125)	(316)	(251)
Retail - Small	RtS						(233)		(205)	(260)	(234)					(120)		(210)
Single Family Residential																		
Storage - Conditioned	SCn		(426)	(424)	(431)	(425)						(382)	(407)	(368)				(409)
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.02	0.02	0.03	0.02	0.01		0.02		0.01	(0.01)	(0.02)	(0.04)		0.01		0.01
Education - Primary School	EPr		(0.02)	(0.03)	(0.03)		(0.04)		(0.04)	(0.05)	(0.05)	(0.07)	(0.07)	(0.06)	(0.03)	(0.01)		(0.04)
Education - Secondary School	ESe						(0.03)	(0.03)	(0.04)	(0.04)	(0.04)			(0.03)	(0.02)		(0.02)	(0.03)
Education - University	EUn						0.02		0.04	0.02								0.03
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(0.06)	(0.06)	(0.03)	(0.01)	(0.03)		0.00	0.00	0.02	(0.02)	(0.01)	(0.01)	0.01	0.02		(0.01)
Health/Medical - Nursing Home	Nrs						(0.07)		(0.03)	(0.03)	(0.00)			(0.03)	(0.02)	(0.01)		(0.03)
Industrial																		
Lodging - Hotel	Htl		0.09	0.07		0.12	0.16		0.27	0.29						0.33		0.19
Manufacturing - Bio/Tech	MBT			0.01	0.01			0.07					0.08					0.04
Manufacturing - Light Industrial	MLI						(0.00)	(0.01)	0.05	0.03	0.06				0.08			0.03
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(0.05)	(0.01)	(0.03)	(0.03)	0.00	(0.01)	0.02	0.03	0.01	0.05	(0.00)	0.06	0.00	0.02	0.04	0.01	0.01
Office - Small	OfS						(0.02)	0.02	0.04	0.01	0.06			0.01	0.05	0.06	0.01	0.03
Res																		
Restaurant - Fast Food	RFF	(0.06)	(0.02)	(0.04)	0.02	0.01			0.05	0.03		0.04	0.03	0.03				0.01
Restaurant - Sit Down	RSD						0.01		0.06	0.06	0.11			0.03	0.12	0.03	0.01	0.06
Retail - 3 story	Rt3	(0.09)	(0.04)	(0.02)	0.02	0.03	0.03		0.08	0.06	0.08	0.05	0.02	0.06	0.09			0.03
Retail - Large 1 story	RtL						0.02	0.03	0.04	0.04	0.08			0.05	0.04	0.07	0.01	0.04
Retail - Small	RtS						0.04		0.07	0.07	0.08					0.08		0.07
Single Family Residential																		
Storage - Conditioned	SCn		(0.12)	(0.09)	(0.08)	(0.09)						(0.03)	(0.04)	(0.02)				(0.07)
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
11.6 - 20 Ton	2SPD	Tier3, 12.5EER, 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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		(281)	(278)	(272)	(271)	(268)		(263)		(269)	(251)	(255)	(286)		(277)		(270)
Education - Primary School	EPr		(190)	(190)	(187)		(190)		(190)	(190)	(189)	(204)	(204)	(204)	(199)	(196)		(194)
Education - Secondary School	ESe						(219)	(219)	(221)	(221)	(220)			(225)	(217)		(220)	(220)
Education - University	EUn						(336)		(334)	(340)								(337)
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(776)	(779)	(755)	(772)	(722)		(689)	(721)	(709)	(724)	(756)	(699)	(697)	(576)		(721)
Health/Medical - Nursing Home	Nrs						(828)		(798)	(804)	(781)			(754)	(749)	(676)		(770)
Industrial																		
Lodging - Hotel	Htl		(331)	(452)		(448)	(323)		(227)	(236)						291		(247)
Manufacturing - Bio/Tech	MBT			(121)	(131)			(16)					(102)					(93)
Manufacturing - Light Industrial	MLI						(293)	(307)	(251)	(272)	(252)				(213)			(265)
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(262)	(219)	(235)	(224)	(220)	(194)	(173)	(189)	(227)	(190)	(199)	(192)	(182)	(223)	(154)	(213)	(206)
Office - Small	OfS						(206)	(185)	(188)	(213)	(175)			(152)	(167)	(88)	(195)	(174)
Res																		
Restaurant - Fast Food	RFF	(335)	(333)	(363)	(341)	(346)	(357)		(318)	(351)		(271)	(324)	(263)				(327)
Restaurant - Sit Down	RSD						(244)		(229)	(247)	(194)			(207)	(162)	(164)	(210)	(207)
Retail - 3 story	Rt3	(432)	(346)	(412)	(343)	(415)	(325)		(248)	(309)	(273)	(283)	(331)	(261)	(258)			(326)
Retail - Large 1 story	RtL						(357)	(358)	(326)	(343)	(296)			(274)	(325)	(162)	(366)	(312)
Retail - Small	RtS						(309)		(268)	(299)	(270)					(149)		(259)
Single Family Residential																		
Storage - Conditioned	SCn		(426)	(424)	(432)	(425)						(385)	(409)	(372)				(410)
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.02	0.02	0.03	0.02	0.02		0.02		0.01	(0.01)	(0.01)	(0.04)		0.01		0.01
Education - Primary School	EPr		(0.02)	(0.03)	(0.03)		(0.04)		(0.04)	(0.05)	(0.05)	(0.07)	(0.07)	(0.06)	(0.03)	(0.01)		(0.04)
Education - Secondary School	ESe						(0.03)	(0.03)	(0.04)	(0.04)	(0.04)			(0.03)	(0.02)		(0.02)	(0.03)
Education - University	EUn						0.03		0.04	0.03								0.03
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		(0.05)	(0.07)	(0.03)	(0.05)	(0.03)		0.00	0.00	0.02	(0.02)	(0.01)	(0.01)	0.01	0.02		(0.02)
Health/Medical - Nursing Home	Nrs						(0.06)		(0.03)	(0.03)	(0.00)			(0.03)	(0.02)	(0.01)		(0.03)
Industrial																		
Lodging - Hotel	Htl		0.10	0.05		0.09	0.16		0.27	0.29						0.33		0.18
Manufacturing - Bio/Tech	MBT			(0.00)	0.01			0.07					0.08					0.04
Manufacturing - Light Industrial	MLI						(0.00)	(0.01)	0.05	0.03	0.06				0.08			0.03
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	(0.06)	(0.01)	(0.05)	(0.03)	(0.03)	(0.01)	0.02	0.03	0.01	0.05	(0.00)	0.06	0.00	0.02	0.04	0.01	0.00
Office - Small	OfS						(0.02)	0.02	0.03	0.01	0.06			0.01	0.05	0.06	0.01	0.03
Res																		
Restaurant - Fast Food	RFF	(0.06)	(0.03)	(0.05)	0.02	(0.02)			0.05	0.03		0.04	0.03	0.03				0.00
Restaurant - Sit Down	RSD						0.01		0.06	0.06	0.11			0.03	0.12	0.03	0.01	0.06
Retail - 3 story	Rt3	(0.09)	(0.04)	(0.06)	0.02	(0.01)	0.03		0.08	0.06	0.08	0.05	0.02	0.06	0.09			0.02
Retail - Large 1 story	RtL						0.02	0.03	0.04	0.04	0.08			0.05	0.04	0.07	0.01	0.04
Retail - Small	RtS						0.04		0.07	0.07	0.08					0.08		0.07
Single Family Residential																		
Storage - Conditioned	SCn		(0.12)	(0.09)	(0.08)	(0.09)						(0.03)	(0.04)	(0.02)				(0.07)
Utilities																		

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																		
		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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		69	33	69	36	74		103		101	120	88	118		207		92
Education - Primary School	EPr		40	22	46		53		53	58	65	72	61	76	77	133		63
Education - Secondary School	ESe						43	44	55	56	67			82	84		30	57
Education - University	EUn						96		115	102								104
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		87	52	104	54	117		148	145	153	160	120	176	182	316		139
Health/Medical - Nursing Home	Nrs						41		67	72	85			105	114	214		100
Industrial																		
Lodging - Hotel	Htl		384	240		247	421		516	522						1,081		487
Manufacturing - Bio/Tech	MBT			72	105			148					125					113
Manufacturing - Light Industrial	MLI						51	35	77	69	80				103			69
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	11	77	48	83	57	99	93	108	93	113	117	105	124	109	193	69	94
Office - Small	OfS						86	80	100	91	111			126	122	199	68	109
Res																		
Restaurant - Fast Food	RFF	5	82	35	93	39	77		116	111		158	112	166				90
Restaurant - Sit Down	RSD						104		133	129	163			158	190	238	80	150
Retail - 3 story	Rt3	7	101	48	112	55	121		170	143	164	161	122	171	179			120
Retail - Large 1 story	RtL						102	93	128	124	154			172	147	283	72	142
Retail - Small	RtS						112		142	134	151					264		161
Single Family Residential																		
Storage - Conditioned	SCn		16	1	19	0						62	39	73				30
Utilities																		

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 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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC		0.05	0.00	0.02	0.05	0.04		0.10		0.10	0.04	0.09	0.02		0.09		0.05
Education - Primary School	EPr		0.00		0.01		0.00		0.08	0.02	0.02	0.02	0.02	0.03	0.03	0.03		0.02
Education - Secondary School	ESe						0.00	0.08	0.09	0.02	0.02			0.03	0.03		0.01	0.03
Education - University	EUn						0.06		0.11	0.07								0.08
Gasoline Stations with Convenience Stores																		
Grocery	Gro																	
Health/Medical - Hospital	Hsp		0.05	0.02	0.07	0.04	0.07		0.09	0.09	0.10	0.07	0.08	0.09	0.11	0.10		0.08
Health/Medical - Nursing Home	Nrs						0.04		0.06	0.06	0.07			0.07	0.08	0.08		0.07
Industrial																		
Lodging - Hotel	Htl		0.19	0.12		0.16	0.24		0.33	0.35						0.39		0.25
Manufacturing - Bio/Tech	MBT			0.01	0.03			0.10					0.12					0.07
Manufacturing - Light Industrial	MLI						0.05	0.07	0.11	0.07	0.11				0.10			0.09
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.01	0.07	0.01	0.05	0.04	0.07	0.08	0.09	0.09	0.11	0.07	0.11	0.08	0.10	0.11	0.08	0.07
Office - Small	OfS						0.07	0.08	0.09	0.09	0.11			0.08	0.11	0.11	0.09	0.09
Res																		
Restaurant - Fast Food	RFF		0.05	0.01	0.07	0.04	0.07		0.09	0.09		0.09	0.09	0.10				0.07
Restaurant - Sit Down	RSD						0.08		0.10	0.11	0.13			0.11	0.14	0.10	0.09	0.11
Retail - 3 story	Rt3		0.06	0.03	0.09	0.06	0.09		0.11	0.11	0.12	0.10	0.09	0.11	0.13			0.09
Retail - Large 1 story	RtL						0.08	0.08	0.09	0.10	0.12			0.11	0.11	0.12	0.08	0.10
Retail - Small	RtS						0.09		0.11	0.11	0.12					0.13		0.11
Single Family Residential																		
Storage - Conditioned	SCn		0.01		0.03							0.06	0.06	0.08				0.05
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
20 - 63.3 ton	2SPD	10.5EER, VAV	Yes, Yes	Large 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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC	13	29	26	39	30	43	49	52	42	50	40	34	53	46	79	24	41
Education - Primary School	EPr	3	24	14	29	21	21	31	37	35	44	35	31	49	41	78	14	32
Education - Secondary School	ESe	6	23	18	28	22	26	36	36	32	40	33	28	45	39	73	14	31
Education - University	EUn	16	34	31	45	40	46	54	59	50	57	45	40	58	51	83	27	46
Gasoline Stations with Convenience Stores																		
Grocery	Gro	2	30	13	32	16	23	27	40	46	54	45	39	61	53	95	23	37
Health/Medical - Hospital	Hsp	22	46	42	63	52	73	75	89	76	85	66	57	79	74	118	39	66
Health/Medical - Nursing Home	Nrs	9	33	26	43	29	47	56	62	54	60	48	42	58	55	96	27	47
Industrial																		
Lodging - Hotel	Htl	16	45	36	54	41	60	72	78	69	79	63	55	75	73	124	34	61
Manufacturing - Bio/Tech	MBT	11	49	33	59	45	58	71	81	73	85	66	61	79	77	128	35	63
Manufacturing - Light Industrial	MLI	1	28	14	33	20	30	30	45	44	54	44	40	57	50	100	19	38
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	16	34	29	40	36	45	49	51	46	56	43	39	47	46	70	26	42
Office - Small	OfS	13	29	25	35	31	38	44	46	41	45	38	34	42	43	66	22	37
Res																		
Restaurant - Fast Food	RFF	5	46	24	55	28	43	55	65	66	90	70	61	93	80	146	34	60
Restaurant - Sit Down	RSD	7	56	28	62	32	53	62	72	72	90	76	75	102	86	143	45	66
Retail - 3 story	Rt3	18	42	37	54	47	49	54	67	61	71	56	49	68	59	88	40	54
Retail - Large 1 story	RtL	7	56	32	64	36	57	51	79	78	95	75	67	96	84	143	43	66
Retail - Small	RtS	7	56	31	61	41	57	66	78	76	96	74	72	90	86	131	41	66
Single Family Residential																		
Storage - Conditioned	SCn	0	18	2	17	2	9	14	28	30	36	30	27	48	40	81	9	24
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC	0.01	0.03	0.02	0.04	0.03	0.03	0.04	0.04	0.03	0.04	0.03	0.03	0.01	0.04	0.05	0.03	0.03
Education - Primary School	EPr	0.01	0.01	0.00	0.01	0.04	0.00	0.05	0.05	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.02
Education - Secondary School	ESe	0.01	0.01	0.00	0.01	0.03	0.00	0.04	0.04	0.01	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.02
Education - University	EUn	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.04	0.03	0.04	0.03	0.03	0.01	0.04	0.04	0.03	0.03
Gasoline Stations with Convenience Stores																		
Grocery	Gro	0.01	0.04	0.03	0.04	0.02	0.03	0.02	0.03	0.04	0.05	0.04	0.04	0.05	0.05	0.05	0.04	0.04
Health/Medical - Hospital	Hsp	0.01	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.04	0.03	0.03
Health/Medical - Nursing Home	Nrs	0.01	0.03	0.03	0.04	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.03	0.03
Industrial																		
Lodging - Hotel	Htl	0.01	0.04	0.03	0.04	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04
Manufacturing - Bio/Tech	MBT	0.02	0.07	0.05	0.06	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.08	0.06	0.06
Manufacturing - Light Industrial	MLI	0.01	0.07	0.05	0.06	0.04	0.05	0.04	0.05	0.06	0.07	0.07	0.07	0.07	0.07	0.08	0.06	0.06
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.01	0.03	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.04	0.04	0.03	0.03
Office - Small	OfS	0.01	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.03	0.03
Res																		
Restaurant - Fast Food	RFF	0.01	0.06	0.04	0.06	0.03	0.04	0.04	0.05	0.06	0.07	0.06	0.06	0.07	0.07	0.07	0.05	0.05
Restaurant - Sit Down	RSD	0.01	0.07	0.05	0.07	0.04	0.05	0.05	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.07	0.06
Retail - 3 story	Rt3	0.01	0.04	0.03	0.04	0.03	0.03	0.03	0.03	0.04	0.05	0.04	0.04	0.05	0.04	0.05	0.05	0.04
Retail - Large 1 story	RtL	0.02	0.07	0.05	0.07	0.04	0.05	0.04	0.06	0.07	0.07	0.06	0.07	0.07	0.07	0.08	0.07	0.06
Retail - Small	RtS	0.02	0.07	0.05	0.06	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.08	0.06	0.06
Single Family Residential																		
Storage - Conditioned	SCn	0.00	0.04	0.02	0.04	0.02	0.02	0.02	0.04	0.05	0.05	0.04	0.05	0.06	0.06	0.06	0.04	0.04
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
20 - 63.3 ton	2SPD	10.8EER, VAV	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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC	20	45	40	60	46	66	76	80	65	78	61	53	82	71	122	37	63
Education - Primary School	EPr	4	33	19	41	29	29	44	51	48	62	48	43	68	56	108	20	44
Education - Secondary School	ESe	10	34	27	42	33	39	54	54	48	60	49	41	67	57	107	22	46
Education - University	EUn	24	53	48	70	62	70	83	91	76	87	69	62	89	78	127	41	71
Gasoline Stations with Convenience Stores																		
Grocery	Gro	2	41	19	45	23	32	37	56	64	75	62	54	85	74	132	32	52
Health/Medical - Hospital	Hsp	34	72	65	97	81	113	116	138	118	133	102	89	122	115	183	60	102
Health/Medical - Nursing Home	Nrs	15	52	40	67	45	73	87	95	83	93	73	65	89	85	148	42	72
Industrial																		
Lodging - Hotel	Htl	24	67	54	81	63	91	109	118	105	119	95	83	113	109	186	52	92
Manufacturing - Bio/Tech	MBT	15	69	46	81	63	80	99	112	101	118	92	84	110	106	177	49	88
Manufacturing - Light Industrial	MLI	2	39	19	46	27	42	42	63	62	75	61	55	79	69	138	27	53
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	25	53	45	62	56	70	76	79	71	87	67	61	73	72	108	41	65
Office - Small	OfS	21	45	38	54	48	58	68	71	64	70	58	53	66	67	102	35	57
Res																		
Restaurant - Fast Food	RFF	7	64	34	77	39	59	76	90	92	124	97	85	130	111	203	47	83
Restaurant - Sit Down	RSD	10	77	39	86	44	74	86	100	100	125	106	103	142	119	199	62	92
Retail - 3 story	Rt3	27	66	57	84	72	77	84	104	94	110	87	76	106	91	136	62	83
Retail - Large 1 story	RtL	9	78	45	89	50	80	70	110	109	132	104	94	133	117	198	60	92
Retail - Small	RtS	9	78	43	85	57	79	92	108	105	133	103	100	125	119	183	57	92
Single Family Residential																		
Storage - Conditioned	SCn	0	18	2	17	2	9	14	28	30	36	30	27	48	40	81	9	24
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC	0.02	0.05	0.04	0.06	0.04	0.04	0.06	0.06	0.05	0.06	0.05	0.05	0.02	0.06	0.07	0.05	0.05
Education - Primary School	EPr	0.02	0.02	0.00	0.01	0.05	0.00	0.06	0.07	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.01	0.03
Education - Secondary School	ESe	0.02	0.02	0.01	0.01	0.04	0.01	0.06	0.06	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.01	0.02
Education - University	EUn	0.02	0.04	0.04	0.05	0.05	0.04	0.05	0.06	0.05	0.05	0.05	0.05	0.02	0.06	0.07	0.05	0.05
Gasoline Stations with Convenience Stores																		
Grocery	Gro	0.01	0.05	0.04	0.05	0.03	0.04	0.03	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.05	0.05
Health/Medical - Hospital	Hsp	0.02	0.05	0.05	0.06	0.04	0.04	0.04	0.05	0.05	0.06	0.05	0.05	0.06	0.06	0.06	0.05	0.05
Health/Medical - Nursing Home	Nrs	0.02	0.05	0.04	0.05	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.05	0.05
Industrial																		
Lodging - Hotel	Htl	0.02	0.06	0.05	0.06	0.04	0.05	0.05	0.06	0.06	0.07	0.06	0.06	0.07	0.07	0.07	0.06	0.06
Manufacturing - Bio/Tech	MBT	0.03	0.10	0.07	0.09	0.07	0.07	0.08	0.09	0.09	0.10	0.09	0.10	0.10	0.10	0.11	0.09	0.09
Manufacturing - Light Industrial	MLI	0.01	0.09	0.07	0.09	0.06	0.07	0.06	0.07	0.09	0.10	0.09	0.09	0.10	0.10	0.11	0.08	0.08
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.02	0.05	0.04	0.05	0.03	0.04	0.04	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.06	0.05	0.05
Office - Small	OfS	0.02	0.05	0.04	0.05	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.05	0.05
Res																		
Restaurant - Fast Food	RFF	0.02	0.08	0.06	0.08	0.05	0.05	0.06	0.07	0.08	0.09	0.08	0.09	0.10	0.09	0.10	0.07	0.07
Restaurant - Sit Down	RSD	0.02	0.09	0.06	0.10	0.05	0.07	0.07	0.08	0.09	0.10	0.09	0.10	0.11	0.10	0.11	0.10	0.08
Retail - 3 story	Rt3	0.02	0.06	0.05	0.07	0.05	0.04	0.04	0.05	0.06	0.07	0.07	0.06	0.08	0.07	0.07	0.07	0.06
Retail - Large 1 story	RtL	0.02	0.09	0.08	0.09	0.06	0.07	0.06	0.08	0.09	0.10	0.09	0.09	0.10	0.10	0.11	0.09	0.08
Retail - Small	RtS	0.02	0.09	0.07	0.09	0.07	0.07	0.07	0.08	0.09	0.10	0.09	0.10	0.10	0.10	0.11	0.09	0.08
Single Family Residential																		
Storage - Conditioned	SCn	0.00	0.06	0.02	0.05	0.02	0.03	0.03	0.05	0.07	0.07	0.06	0.07	0.09	0.08	0.09	0.05	0.05
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
20 - 63.3 ton	2SPD	11.5EER, VAV	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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC	23	92	63	96	66	111	126	138	116	130	143	111	140	152	238	73	114
Education - Primary School	EPr	8	44	27	53	38	66	59	61	66	74	80	70	86	88	151	33	63
Education - Secondary School	ESe	20	59	45	71	53	76	84	87	85	94	100	83	104	110	181	46	81
Education - University	EUn	27	102	76	111	82	131	143	142	128	141	148	124	147	152	239	77	123
Gasoline Stations with Convenience Stores																		
Grocery	Gro	1	35	10	38	10	30	22	49	55	67	78	53	83	77	140	26	48
Health/Medical - Hospital	Hsp	27	112	90	140	83	170	185	202	193	196	201	155	207	204	347	97	163
Health/Medical - Nursing Home	Nrs	27	95	75	121	68	139	140	164	161	166	166	134	171	177	301	80	136
Industrial																		
Lodging - Hotel	Htl	44	135	103	157	108	191	222	200	189	202	205	163	219	200	365	116	176
Manufacturing - Bio/Tech	MBT	33	112	89	125	102	178	176	163	152	168	158	143	172	167	266	92	143
Manufacturing - Light Industrial	MLI	1	50	22	62	19	65	53	97	80	91	104	74	124	120	209	45	76
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	27	93	71	105	80	126	125	134	118	134	133	119	136	135	214	76	114
Office - Small	OfS	19	79	58	89	64	108	107	119	109	123	123	100	131	129	215	70	103
Res																		
Restaurant - Fast Food	RFF	8	88	41	104	52	90	93	141	120	155	167	120	180	168	334	75	121
Restaurant - Sit Down	RSD	25	100	61	113	63	134	129	166	147	187	176	170	178	213	280	95	140
Retail - 3 story	Rt3	39	127	88	141	97	161	200	207	176	196	182	144	192	205	316	95	160
Retail - Large 1 story	RtL	50	103	61	121	88	121	135	156	139	170	172	126	189	161	336	88	138
Retail - Small	RtS	11	113	51	115	62	125	150	150	137	167	179	150	203	200	333	91	140
Single Family Residential																		
Storage - Conditioned	SCn	0	26	3	30	1	27	15	50	57	66	74	49	88	92	185	21	49
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC	0.05	0.13	0.07	0.13	0.08	0.11	0.12	0.13	0.14	0.16	0.14	0.12	0.13	0.16	0.16	0.09	0.12
Education - Primary School	EPr	0.04	0.02	0.00	0.14	0.08	0.12	0.11	0.11	0.17	0.18	0.04	0.03	0.03	0.17	0.17	0.02	0.09
Education - Secondary School	ESe	0.05	0.02	0.01	0.13	0.07	0.10	0.11	0.11	0.15	0.16	0.04	0.03	0.03	0.16	0.16	0.02	0.08
Education - University	EUn	0.06	0.13	0.08	0.13	0.09	0.12	0.13	0.13	0.14	0.16	0.13	0.12	0.12	0.16	0.16	0.09	0.12
Gasoline Stations with Convenience Stores																		
Grocery	Gro	0.01	0.08	0.05	0.07	0.03	0.06	0.05	0.07	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.05	0.07
Health/Medical - Hospital	Hsp	0.04	0.10	0.07	0.09	0.06	0.08	0.08	0.10	0.11	0.12	0.11	0.10	0.10	0.11	0.12	0.07	0.09
Health/Medical - Nursing Home	Nrs	0.03	0.09	0.06	0.09	0.05	0.07	0.06	0.08	0.10	0.11	0.09	0.09	0.09	0.10	0.10	0.06	0.08
Industrial																		
Lodging - Hotel	Htl	0.05	0.14	0.10	0.13	0.08	0.11	0.11	0.12	0.14	0.15	0.13	0.12	0.13	0.13	0.15	0.10	0.12
Manufacturing - Bio/Tech	MBT	0.06	0.15	0.11	0.13	0.10	0.13	0.12	0.13	0.15	0.17	0.16	0.15	0.16	0.16	0.17	0.12	0.14
Manufacturing - Light Industrial	MLI	0.02	0.16	0.10	0.15	0.05	0.13	0.11	0.16	0.17	0.19	0.17	0.15	0.17	0.19	0.19	0.11	0.14
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.05	0.12	0.09	0.12	0.08	0.10	0.09	0.11	0.12	0.14	0.12	0.13	0.12	0.12	0.13	0.09	0.11
Office - Small	OfS	0.04	0.12	0.09	0.12	0.07	0.10	0.09	0.11	0.13	0.15	0.13	0.12	0.13	0.13	0.15	0.10	0.11
Res																		
Restaurant - Fast Food	RFF	0.03	0.15	0.10	0.14	0.08	0.09	0.11	0.13	0.15	0.18	0.14	0.13	0.14	0.14	0.17	0.10	0.12
Restaurant - Sit Down	RSD	0.05	0.16	0.11	0.15	0.07	0.13	0.12	0.15	0.18	0.19	0.16	0.17	0.15	0.18	0.16	0.12	0.14
Retail - 3 story	Rt3	0.04	0.14	0.10	0.13	0.07	0.11	0.13	0.14	0.16	0.17	0.14	0.13	0.14	0.15	0.16	0.10	0.13
Retail - Large 1 story	RtL	0.07	0.17	0.12	0.15	0.09	0.12	0.13	0.14	0.17	0.19	0.15	0.14	0.16	0.15	0.18	0.12	0.14
Retail - Small	RtS	0.05	0.17	0.12	0.16	0.10	0.14	0.15	0.15	0.17	0.19	0.17	0.17	0.17	0.18	0.20	0.13	0.15
Single Family Residential																		
Storage - Conditioned	SCn	0.00	0.11	0.04	0.08	0.01	0.07	0.06	0.09	0.14	0.14	0.11	0.10	0.12	0.13	0.14	0.07	0.09
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
20 - 63.3 ton	2SPD	12.5EER, VAV	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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC	34	138	96	144	100	168	190	208	174	196	215	167	210	228	357	110	171
Education - Primary School	EPr	12	64	40	77	56	97	87	89	96	109	118	103	125	128	221	48	92
Education - Secondary School	ESe	31	89	69	107	80	115	126	131	128	142	151	126	157	165	272	70	122
Education - University	EUn	42	154	115	167	124	196	216	213	193	212	222	186	221	228	360	116	185
Gasoline Stations with Convenience Stores																		
Grocery	Gro	2	51	15	55	14	44	32	71	80	98	114	78	122	113	204	37	71
Health/Medical - Hospital	Hsp	41	170	137	212	126	258	281	305	292	297	303	234	312	308	523	146	247
Health/Medical - Nursing Home	Nrs	41	143	114	184	104	211	214	250	244	250	251	204	257	267	453	121	207
Industrial																		
Lodging - Hotel	Htl	67	203	157	237	163	289	335	302	285	305	308	245	329	301	549	175	265
Manufacturing - Bio/Tech	MBT	50	167	134	187	153	267	264	245	228	251	237	214	257	249	399	138	215
Manufacturing - Light Industrial	MLI	1	72	32	91	28	95	77	142	117	134	152	108	182	176	306	66	111
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	41	141	107	159	121	189	188	202	177	202	200	178	204	203	322	114	172
Office - Small	OfS	29	119	88	134	97	162	161	178	164	185	185	150	196	194	322	105	154
Res																		
Restaurant - Fast Food	RFF	12	129	60	152	76	131	136	205	176	226	244	176	264	246	489	109	177
Restaurant - Sit Down	RSD	37	146	89	165	92	195	189	242	216	273	257	249	261	312	409	139	204
Retail - 3 story	Rt3	59	190	133	212	146	242	300	310	264	294	272	216	288	308	473	143	241
Retail - Large 1 story	RtL	73	150	89	177	128	177	198	228	203	248	251	184	276	235	492	128	202
Retail - Small	RtS	15	166	74	168	90	183	220	220	200	245	262	219	297	293	488	132	205
Single Family Residential																		
Storage - Conditioned	SCn	0	38	4	44	1	40	22	74	83	97	108	72	129	135	270	30	72
Utilities																		

Average Ex-post savings kW/ton																		
bldgtype		w01	w02	w03	w04	w05	w06	w07	w08	w09	w10	w11	w12	w13	w14	w15	w16	Average
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC	0.08	0.20	0.11	0.19	0.12	0.16	0.18	0.20	0.21	0.24	0.20	0.18	0.19	0.24	0.24	0.14	0.18
Education - Primary School	EPr	0.06	0.03	0.01	0.21	0.11	0.17	0.16	0.17	0.24	0.26	0.05	0.04	0.05	0.25	0.25	0.02	0.13
Education - Secondary School	ESe	0.07	0.03	0.01	0.19	0.11	0.15	0.16	0.17	0.22	0.24	0.06	0.05	0.05	0.24	0.24	0.03	0.13
Education - University	EUn	0.09	0.19	0.12	0.20	0.13	0.17	0.19	0.19	0.22	0.24	0.19	0.18	0.18	0.23	0.24	0.13	0.18
Gasoline Stations with Convenience Stores																		
Grocery	Gro	0.01	0.12	0.07	0.10	0.04	0.08	0.07	0.10	0.13	0.13	0.12	0.11	0.12	0.11	0.12	0.08	0.10
Health/Medical - Hospital	Hsp	0.06	0.15	0.11	0.14	0.09	0.12	0.12	0.14	0.17	0.18	0.16	0.15	0.16	0.17	0.17	0.11	0.14
Health/Medical - Nursing Home	Nrs	0.04	0.14	0.09	0.13	0.08	0.10	0.10	0.13	0.15	0.17	0.14	0.14	0.14	0.16	0.16	0.09	0.12
Industrial																		
Lodging - Hotel	Htl	0.08	0.21	0.14	0.19	0.12	0.16	0.17	0.17	0.21	0.23	0.20	0.18	0.20	0.20	0.22	0.15	0.18
Manufacturing - Bio/Tech	MBT	0.10	0.23	0.17	0.20	0.16	0.19	0.18	0.19	0.23	0.25	0.23	0.23	0.23	0.24	0.26	0.19	0.20
Manufacturing - Light Industrial	MLI	0.03	0.24	0.14	0.22	0.08	0.19	0.17	0.23	0.25	0.27	0.25	0.22	0.25	0.27	0.28	0.17	0.20
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.08	0.18	0.13	0.17	0.12	0.14	0.14	0.16	0.18	0.21	0.19	0.19	0.18	0.18	0.20	0.14	0.16
Office - Small	OfS	0.06	0.18	0.13	0.17	0.11	0.14	0.13	0.16	0.19	0.22	0.19	0.18	0.19	0.20	0.22	0.14	0.16
Res																		
Restaurant - Fast Food	RFF	0.05	0.22	0.14	0.21	0.11	0.14	0.16	0.20	0.22	0.26	0.20	0.19	0.21	0.20	0.25	0.14	0.18
Restaurant - Sit Down	RSD	0.08	0.24	0.16	0.22	0.11	0.19	0.18	0.21	0.26	0.28	0.23	0.25	0.23	0.27	0.23	0.18	0.21
Retail - 3 story	Rt3	0.06	0.21	0.15	0.19	0.11	0.17	0.19	0.21	0.23	0.25	0.20	0.19	0.21	0.23	0.24	0.15	0.19
Retail - Large 1 story	RtL	0.11	0.24	0.17	0.22	0.13	0.18	0.19	0.21	0.25	0.27	0.22	0.20	0.23	0.22	0.27	0.17	0.21
Retail - Small	RtS	0.07	0.26	0.17	0.23	0.14	0.21	0.22	0.22	0.26	0.28	0.25	0.25	0.25	0.27	0.29	0.19	0.22
Single Family Residential																		
Storage - Conditioned	SCn	0.00	0.16	0.05	0.12	0.02	0.10	0.08	0.14	0.20	0.20	0.17	0.15	0.18	0.19	0.20	0.10	0.13
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
>63.3 ton	2SPD	10.2EER, VAV	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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC	14	31	28	41	32	45	52	55	45	54	42	36	56	49	84	25	43
Education - Primary School	EPr	3	25	15	31	22	23	33	39	37	47	37	33	52	43	83	15	34
Education - Secondary School	ESe	7	24	19	30	23	28	38	38	34	43	35	30	48	41	77	15	33
Education - University	EUn	17	36	33	48	43	48	57	63	53	60	48	43	62	54	88	29	49
Gasoline Stations with Convenience Stores																		
Grocery	Gro	2	32	14	34	17	25	28	43	49	57	48	41	65	57	101	24	40
Health/Medical - Hospital	Hsp	23	49	45	66	56	77	79	94	80	91	70	61	83	78	125	41	70
Health/Medical - Nursing Home	Nrs	10	35	27	46	31	50	60	65	57	64	50	45	61	59	102	29	49
Industrial																		
Lodging - Hotel	Htl	17	48	38	57	44	64	76	83	74	84	67	58	80	77	132	36	65
Manufacturing - Bio/Tech	MBT	11	52	35	62	48	61	76	86	77	90	70	65	84	81	136	37	67
Manufacturing - Light Industrial	MLI	1	30	15	35	21	32	32	48	47	58	47	42	60	53	106	21	40
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	17	36	31	42	38	48	52	54	48	60	46	42	50	49	74	28	45
Office - Small	OfS	14	31	26	37	33	40	47	48	44	48	40	36	45	46	70	24	39
Res																		
Restaurant - Fast Food	RFF	5	49	26	59	30	45	58	69	71	95	74	65	99	85	155	36	64
Restaurant - Sit Down	RSD	8	59	30	66	34	56	66	76	76	96	81	79	109	91	152	47	70
Retail - 3 story	Rt3	19	45	39	57	49	52	57	71	64	75	59	52	72	62	93	43	57
Retail - Large 1 story	RtL	7	60	34	68	38	61	54	84	83	101	80	72	102	89	152	46	71
Retail - Small	RtS	7	60	33	65	44	61	70	83	81	102	79	77	95	91	140	43	71
Single Family Residential																		
Storage - Conditioned	SCn	0	19	2	18	2	10	15	29	32	39	31	28	51	43	86	10	26
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC	0.01	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.03	0.04	0.04	0.04	0.01	0.04	0.05	0.04	0.03
Education - Primary School	EPr	0.01	0.01	0.00	0.01	0.04	0.00	0.05	0.05	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02
Education - Secondary School	ESe	0.01	0.01	0.00	0.01	0.03	0.00	0.04	0.04	0.01	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.02
Education - University	EUn	0.02	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.03	0.04	0.04	0.03	0.01	0.04	0.05	0.03	0.03
Gasoline Stations with Convenience Stores																		
Grocery	Gro	0.01	0.04	0.03	0.04	0.02	0.03	0.02	0.04	0.05	0.05	0.04	0.04	0.06	0.05	0.05	0.04	0.04
Health/Medical - Hospital	Hsp	0.02	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03
Health/Medical - Nursing Home	Nrs	0.01	0.03	0.03	0.04	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03
Industrial																		
Lodging - Hotel	Htl	0.01	0.04	0.03	0.04	0.03	0.03	0.04	0.04	0.04	0.05	0.04	0.04	0.05	0.05	0.05	0.04	0.04
Manufacturing - Bio/Tech	MBT	0.03	0.07	0.06	0.07	0.06	0.05	0.06	0.07	0.07	0.08	0.07	0.08	0.08	0.08	0.08	0.07	0.07
Manufacturing - Light Industrial	MLI	0.01	0.07	0.05	0.07	0.04	0.05	0.04	0.06	0.07	0.08	0.07	0.07	0.08	0.08	0.09	0.06	0.06
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.01	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03
Office - Small	OfS	0.01	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03
Res																		
Restaurant - Fast Food	RFF	0.01	0.06	0.04	0.06	0.04	0.04	0.05	0.06	0.06	0.07	0.06	0.07	0.07	0.07	0.08	0.06	0.06
Restaurant - Sit Down	RSD	0.02	0.07	0.05	0.07	0.04	0.05	0.05	0.06	0.07	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.06
Retail - 3 story	Rt3	0.01	0.04	0.03	0.05	0.03	0.03	0.03	0.04	0.04	0.05	0.04	0.04	0.05	0.05	0.05	0.05	0.04
Retail - Large 1 story	RtL	0.02	0.07	0.06	0.07	0.04	0.05	0.04	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.07	0.06
Retail - Small	RtS	0.02	0.07	0.06	0.07	0.05	0.06	0.06	0.06	0.07	0.08	0.07	0.07	0.08	0.08	0.08	0.07	0.06
Single Family Residential																		
Storage - Conditioned	SCn	0.00	0.05	0.02	0.04	0.02	0.02	0.02	0.04	0.05	0.06	0.05	0.05	0.07	0.06	0.07	0.04	0.04
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
>63.3 ton	2SPD	11EER, VAV	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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC	21	87	60	91	63	105	119	131	109	123	135	105	132	143	225	69	107
Education - Primary School	EPr	8	42	26	50	36	63	57	58	63	71	77	67	82	83	144	32	60
Education - Secondary School	ESe	19	55	43	67	50	72	79	82	80	89	94	79	98	104	171	44	76
Education - University	EUn	26	96	72	104	77	123	135	134	121	133	140	117	139	143	226	73	116
Gasoline Stations with Convenience Stores																		
Grocery	Gro	1	33	9	36	9	28	21	47	52	64	74	51	79	74	133	24	46
Health/Medical - Hospital	Hsp	25	106	85	132	78	160	174	190	182	185	189	146	195	193	327	91	153
Health/Medical - Nursing Home	Nrs	25	89	70	114	64	130	132	155	151	156	157	127	160	167	284	75	128
Industrial																		
Lodging - Hotel	Htl	41	128	98	148	102	180	209	188	178	191	194	153	207	189	345	110	166
Manufacturing - Bio/Tech	MBT	31	106	84	118	97	169	167	154	144	158	149	135	163	158	252	87	136
Manufacturing - Light Industrial	MLI	1	47	21	60	18	62	50	93	77	87	99	71	118	115	199	43	73
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	25	88	67	99	76	119	118	127	111	126	126	112	129	128	202	72	108
Office - Small	OfS	18	75	55	84	60	102	101	112	103	116	116	94	124	122	203	66	97
Res																		
Restaurant - Fast Food	RFF	8	84	39	99	49	85	89	134	115	148	159	115	172	160	319	71	115
Restaurant - Sit Down	RSD	24	96	58	108	60	127	123	158	140	178	167	162	170	203	267	91	133
Retail - 3 story	Rt3	37	119	83	133	92	152	189	195	166	185	171	136	182	194	298	90	151
Retail - Large 1 story	RtL	47	98	58	115	84	115	129	148	132	162	164	120	180	153	320	84	132
Retail - Small	RtS	10	108	48	110	59	119	143	143	131	160	170	143	193	191	318	86	133
Single Family Residential																		
Storage - Conditioned	SCn	0	25	3	29	1	26	14	48	54	63	70	47	84	88	176	20	47
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC	0.05	0.12	0.07	0.12	0.07	0.10	0.11	0.13	0.14	0.15	0.13	0.11	0.12	0.15	0.15	0.09	0.11
Education - Primary School	EPr	0.04	0.02	0.00	0.13	0.07	0.11	0.11	0.11	0.16	0.17	0.04	0.03	0.03	0.16	0.16	0.01	0.09
Education - Secondary School	ESe	0.04	0.02	0.01	0.12	0.07	0.09	0.10	0.11	0.14	0.15	0.04	0.03	0.03	0.15	0.15	0.02	0.08
Education - University	EUn	0.06	0.12	0.08	0.13	0.08	0.11	0.12	0.12	0.14	0.15	0.12	0.11	0.12	0.15	0.15	0.08	0.11
Gasoline Stations with Convenience Stores																		
Grocery	Gro	0.01	0.08	0.05	0.07	0.03	0.05	0.05	0.06	0.08	0.09	0.08	0.07	0.08	0.07	0.08	0.05	0.06
Health/Medical - Hospital	Hsp	0.04	0.09	0.07	0.09	0.06	0.07	0.08	0.09	0.11	0.11	0.10	0.09	0.10	0.10	0.11	0.07	0.09
Health/Medical - Nursing Home	Nrs	0.03	0.09	0.06	0.08	0.05	0.06	0.06	0.08	0.10	0.11	0.09	0.09	0.09	0.10	0.10	0.06	0.08
Industrial																		
Lodging - Hotel	Htl	0.05	0.13	0.09	0.12	0.08	0.10	0.11	0.11	0.13	0.14	0.12	0.12	0.12	0.12	0.14	0.09	0.11
Manufacturing - Bio/Tech	MBT	0.06	0.14	0.10	0.13	0.10	0.12	0.12	0.12	0.15	0.16	0.15	0.15	0.15	0.15	0.16	0.12	0.13
Manufacturing - Light Industrial	MLI	0.02	0.15	0.09	0.14	0.05	0.12	0.11	0.15	0.16	0.18	0.16	0.14	0.17	0.18	0.18	0.11	0.13
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.05	0.11	0.08	0.11	0.07	0.09	0.09	0.10	0.11	0.13	0.12	0.12	0.11	0.12	0.13	0.09	0.10
Office - Small	OfS	0.04	0.12	0.08	0.11	0.07	0.09	0.08	0.10	0.12	0.14	0.12	0.12	0.12	0.12	0.14	0.09	0.10
Res																		
Restaurant - Fast Food	RFF	0.03	0.14	0.09	0.13	0.07	0.09	0.10	0.13	0.14	0.17	0.13	0.13	0.14	0.13	0.16	0.09	0.12
Restaurant - Sit Down	RSD	0.05	0.16	0.11	0.14	0.07	0.12	0.12	0.14	0.17	0.18	0.15	0.16	0.15	0.17	0.15	0.11	0.14
Retail - 3 story	Rt3	0.04	0.14	0.09	0.12	0.07	0.11	0.12	0.13	0.15	0.16	0.13	0.12	0.13	0.15	0.15	0.09	0.12
Retail - Large 1 story	RtL	0.07	0.16	0.11	0.15	0.08	0.12	0.13	0.14	0.16	0.18	0.14	0.13	0.15	0.14	0.17	0.11	0.13
Retail - Small	RtS	0.05	0.17	0.11	0.15	0.09	0.13	0.14	0.15	0.17	0.18	0.16	0.16	0.17	0.18	0.19	0.12	0.14
Single Family Residential																		
Storage - Conditioned	SCn	0.00	0.11	0.03	0.08	0.01	0.07	0.05	0.09	0.13	0.13	0.11	0.10	0.12	0.12	0.13	0.07	0.08
Utilities																		

Unit Size	Base	Scenario	Working Economizer	Sample Group
>63.3 ton	2SPD	12.0EER, VAV	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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC	34	138	95	144	99	166	189	207	173	194	214	166	208	226	355	109	170
Education - Primary School	EPr	12	64	40	77	55	97	87	88	96	108	117	102	125	127	220	48	91
Education - Secondary School	ESe	30	88	68	106	79	114	125	130	126	142	150	125	155	164	270	70	121
Education - University	EUn	41	152	114	166	122	195	214	212	191	210	221	184	220	226	357	115	184
Gasoline Stations with Convenience Stores																		
Grocery	Gro	2	51	15	55	14	43	32	71	80	98	113	77	121	113	204	37	70
Health/Medical - Hospital	Hsp	40	169	136	211	125	256	278	303	290	295	300	232	310	306	519	145	245
Health/Medical - Nursing Home	Nrs	41	142	113	182	103	209	212	247	242	249	250	202	255	265	450	120	205
Industrial																		
Lodging - Hotel	Htl	66	202	155	235	162	286	333	299	283	303	306	243	327	299	545	174	264
Manufacturing - Bio/Tech	MBT	49	166	133	185	152	265	263	243	227	249	235	212	255	248	396	137	213
Manufacturing - Light Industrial	MLI	1	72	32	91	28	95	77	141	117	133	151	108	181	175	305	66	111
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	40	139	106	157	120	188	186	200	176	200	199	177	203	202	319	113	170
Office - Small	OfS	28	119	87	133	96	161	159	177	163	184	183	149	194	193	320	104	153
Res																		
Restaurant - Fast Food	RFF	12	128	60	151	75	130	136	205	175	225	243	175	262	245	487	108	176
Restaurant - Sit Down	RSD	36	146	89	165	91	195	188	241	215	272	256	248	260	311	408	138	204
Retail - 3 story	Rt3	59	189	132	211	145	240	297	308	262	292	270	215	286	306	470	142	239
Retail - Large 1 story	RtL	72	149	89	176	128	176	197	227	202	247	250	183	275	234	490	128	201
Retail - Small	RtS	15	165	74	168	90	182	219	219	199	244	260	218	295	291	486	132	204
Single Family Residential																		
Storage - Conditioned	SCn	0	38	4	44	1	40	22	73	83	96	108	72	128	134	269	30	71
Utilities																		

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
Agriculture																		
Amusement and Recreation																		
Education - Community College	ECC	0.08	0.19	0.11	0.19	0.11	0.16	0.18	0.20	0.21	0.24	0.20	0.18	0.19	0.24	0.24	0.14	0.18
Education - Primary School	EPr	0.06	0.03	0.01	0.20	0.11	0.17	0.16	0.17	0.24	0.26	0.05	0.04	0.05	0.25	0.25	0.02	0.13
Education - Secondary School	ESe	0.07	0.03	0.01	0.19	0.11	0.15	0.16	0.17	0.22	0.24	0.06	0.05	0.05	0.24	0.23	0.03	0.13
Education - University	EUn	0.09	0.19	0.12	0.20	0.13	0.17	0.19	0.19	0.21	0.24	0.19	0.18	0.18	0.23	0.23	0.13	0.18
Gasoline Stations with Convenience Stores																		
Grocery	Gro	0.01	0.12	0.07	0.10	0.04	0.08	0.07	0.10	0.13	0.13	0.12	0.11	0.12	0.11	0.12	0.08	0.09
Health/Medical - Hospital	Hsp	0.06	0.15	0.11	0.14	0.09	0.11	0.12	0.14	0.17	0.18	0.16	0.15	0.15	0.17	0.17	0.11	0.14
Health/Medical - Nursing Home	Nrs	0.04	0.14	0.09	0.13	0.07	0.10	0.09	0.13	0.15	0.17	0.14	0.14	0.14	0.15	0.16	0.09	0.12
Industrial																		
Lodging - Hotel	Htl	0.08	0.21	0.14	0.19	0.12	0.16	0.17	0.17	0.21	0.23	0.19	0.18	0.20	0.20	0.22	0.15	0.18
Manufacturing - Bio/Tech	MBT	0.09	0.23	0.16	0.20	0.15	0.19	0.18	0.19	0.23	0.25	0.23	0.23	0.23	0.24	0.26	0.18	0.20
Manufacturing - Light Industrial	MLI	0.03	0.24	0.14	0.22	0.08	0.19	0.16	0.23	0.25	0.27	0.25	0.22	0.25	0.27	0.28	0.17	0.20
Miscellaneous																		
Multiple																		
Multiple - Any																		
Multiple - Commercial																		
Office - Large	OfL	0.07	0.18	0.13	0.17	0.11	0.14	0.14	0.16	0.18	0.21	0.18	0.19	0.18	0.18	0.20	0.14	0.16
Office - Small	OfS	0.06	0.18	0.13	0.17	0.11	0.14	0.13	0.16	0.19	0.22	0.19	0.18	0.19	0.20	0.22	0.14	0.16
Res																		
Restaurant - Fast Food	RFF	0.05	0.22	0.14	0.20	0.11	0.14	0.16	0.19	0.22	0.26	0.20	0.19	0.21	0.20	0.25	0.14	0.18
Restaurant - Sit Down	RSD	0.08	0.24	0.16	0.22	0.11	0.19	0.18	0.21	0.26	0.28	0.23	0.25	0.22	0.27	0.23	0.18	0.21
Retail - 3 story	Rt3	0.06	0.21	0.15	0.19	0.11	0.17	0.19	0.20	0.23	0.25	0.20	0.19	0.21	0.23	0.24	0.15	0.19
Retail - Large 1 story	RtL	0.11	0.24	0.17	0.22	0.13	0.18	0.19	0.21	0.25	0.27	0.22	0.20	0.23	0.22	0.27	0.17	0.20
Retail - Small	RtS	0.07	0.25	0.17	0.23	0.14	0.21	0.22	0.22	0.25	0.28	0.24	0.25	0.25	0.27	0.29	0.19	0.22
Single Family Residential																		
Storage - Conditioned	SCn	0.00	0.16	0.05	0.12	0.02	0.10	0.08	0.13	0.20	0.20	0.17	0.15	0.18	0.19	0.20	0.10	0.13
Utilities																		

Appendix C. EVALUABILITY ASSESSMENT OF MINI-SPLIT AND VRF SYSTEMS



Mini Split literature
review Memo Final.pc

Appendix D. 2013 MINI-SPLIT ESPI MEASURE



2013 ESPI Mini-split
Memo Final.pdf

Appendix E. METERING PILOT



Report_Metering
Pilot_121215.pdf

Appendix F. M&V PLAN CHILLER MEASURES



HVAC_1 Upstream
research plan final.pdf

Appendix G. M&V PLAN-UNITARY COOLING MEASURES



HVAC 1 DX Detailed
EMV plan 102315.pdf

Appendix H. SAMPLING PLAN FOR M&V

Sampling methodology

The sampling methodology for this study uses a stratified ratio estimation model that first places participants into segments of interest (by IOU) and then into strata by size, measured in kWh savings. The methodology then estimates appropriate sample sizes based on an assumed error ratio.

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

In practice, error ratios cannot be determined until after the data are collected and savings are evaluated. The sample design and projected precision are therefore based on assumed error ratios from past experience with similar work. For this study, the evaluation team assumed an error ratio of 0.6 by IOU, based on previous experience with similar studies. Other types of studies use higher or lower estimated error ratios; for example, a simple verification study might use an error ratio of 0.5, and a study looking to measure annual or peak consumption might use a ratio between 0.7 and 1.0 depending on buildings and climates covered.¹⁹

Participant data and aggregation

From the IOU tracking data, the evaluation team designed three samples covering the period of Q1 2013 to Q4 2014. 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.

The tracking data file had 15,678 measures tracked from Q1 2013 to Q4 2014. Approximately 58% of measures (9,072 records) were from PGE, 41% (6,453 records) from SCE, and 1% (153 records) from SDGE. There were multiple measures at a site, so the evaluation team began with aggregating savings by site based on site identification number. Counts of the sites across each IOU and measure group, along with their percentage with respect to the total, are shown in Table 47 and Table 48, respectively.

Table 47. Counts of sites, total kWh, and percentage of total by IOUs

IOU	# of Sites	% of Total	kWh Savings	% of Total
PGE	9,072	57.8%	41,735,525	35.3%
SCE	6,453	41.2%	76,307,850	64.5%
SDGE	153	1.0%	209,775	0.2%
Total	15,678	100%	118,253,150	100%

¹⁹ California Commercial End-Use Survey, Itron, Inc.; JJ Hirsh and Associates; Kema Inc.; ADM 2006, CALMAC ID CEC 0023.01

Table 48. Count of sites, total kWh, and percentage of total by measure groups

Measure Group	# of Sites	% of Total	kWh Savings	% of Total
Chillers	546	3.48%	49,380,218	41.76%
Economizer addition	7	0.04%	31,620	0.03%
Rooftop or split system	15,125	96.48%	68,841,312	58.21%
Total	15,678	100%	70,576,827	100%

As shown in the tables above, chillers and rooftop/split-systems both contribute a sizeable portion of savings. Economizer additions were performed for projects that had rooftop or split systems, so they were kept in a pool with rooftop/split systems.

Sample design for chillers

The evaluation team determined that, in order to achieve $\pm 10\%$ relative precision for each IOU at a 90% confidence level, 100 sample points were required (Table 49). Note that, based on the tracking data received, there were no chiller measures in SDGE program territory in the upstream HVAC program; thus we have not included a row for SDGE in the following tables.

Table 49. Chiller sample sizes by IOU (10% relative precision at 90% confidence)

Chillers					
IOU	Sample Sites	Population Sites	Relative Precision at 90% Confidence	Relative Precision at 80% Confidence	Percent Program Savings (kWh)
PGE	48	127	10%	8%	20%
SCE	52	161	10%	8%	80%
Total	100	288	8%	6%	100%

Sample design for rooftop package and split systems

The evaluation team drew two samples for package or split systems:

3. Large package and split systems (those exceeding 20 tons cooling capacity). This was a verification-only sample.
4. Small package and split systems (20 tons or less). For this sample, the evaluation team estimated unit energy savings (UES) based on field measurements and simulation analysis.

In order to achieve $\pm 10\%$ relative precision for each IOU at a 90% confidence level, 193 samples were required. The large unit verification sample was 53 sites and the small-unit UES sample was 140 sites. CZ and building type combinations with low claimed savings were not included in the sample; however, the evaluation team designed the samples to ensure that the most popular building types and CZs in the population received adequate representation.

To achieve $\pm 10\%$ relative precision for each IOU at 90% confidence level for small rooftop package or split systems—those with a cooling capacity no greater than 20 tons—140 sample points were required (Table 50).

Table 50. Small rooftop package or split systems sample sizes

Package or Split Systems					
IOU	Sample Sites	Population Sites	Relative Precision at 90% Confidence	Relative Precision at 80% Confidence	Percent Program Savings (kWh)
PGE	50	2,812	19%	15%	21.4%
SCE	80	1,669	12%	10%	78.2%
SDGE	10	21	20%	16%	0.4%
Total	140	4,502	10%	8%	100%

The sample described in Table 50 includes only sites associated with the rooftop package/split systems measure group; it has no sample points from the economizer additions group. This is because the number of sites and the total savings from the economizer addition group was not significant enough for the sample design algorithm to pick samples for evaluation.

Appendix I. 2013-14 MINI-SPLIT SURVEY



2013-14 Mini-Split
ESPISurvey Memo.pdf



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.