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Impact Evaluation of Energy Trust of Oregon's 2009-2011 Production Efficiency Program

Final Report

Prepared for:
Energy Trust of Oregon

Navigant Consulting, Inc.
1001 and 1003 Officers Row
Vancouver, WA 98660

360-808-4008
www.navigant.com

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Executive Summary

The Energy Trust of Oregon Production Efficiency Program (PE Program) provides incentives to industrial and agricultural customers to install or implement energy efficiency improvements at their facilities. Program measures include boiler upgrades; compressed air and air abatement improvements water treatment efficiency improvements; efficient pumping, heating, ventilation, and air conditioning (HVAC) upgrades; insulation measures; irrigation improvements; efficient lighting and lighting controls; variable frequency drives (VFDs); industrial process improvements; refrigeration controls and equipment; and a variety of equipment tune-ups. In addition, the PE Program provides incentives for whole facility improvements such as operations and maintenance (O&M), retro-commissioning, and strategic energy management (SEM) programs.

The purpose of Navigant's evaluation effort is to inform Energy Trust and program stakeholders of the effectiveness of the PE Program, how the PE Program can be improved, energy savings impacts, and market effects of the program. The specific goals of this evaluation were to:

- Develop reliable estimates of both program and measure specific electric and natural gas savings for the program years 2009-2011.
- Obtain feedback on program design and implementation that can be used to improve the implementation of the current program.
- Identify program achievements to ensure that successful program elements are incorporated into future program cycles.

Throughout the evaluation effort, Navigant reviewed the input assumptions, savings methodologies, and corresponding savings estimates for the PE Program and collaborated with Energy Trust to ensure that evaluation findings were mathematically correct and consistent with industry standards.

Program Impacts

Overall, Energy Trust's PE Program is generating considerable savings. Table E-1-1 through Table E-1-4 provide summaries of *ex ante* and *ex post* energy savings by measure category for electricity. Table E-1-1 combines the three evaluation years of 2009, 2010, and 2011 while

Table E-1-2 through Table E-1-4 represent each of the evaluation years, respectively. Along with the energy savings, realization rates by measure category are provided. The values in these four tables are not adjusted for consideration of closed facilities.

For the three years of electric measures combined, the overall realization rate is 94%. The highest realization rates were achieved by Strategic Energy Management at 107% and the lowest by miscellaneous measures at 42%. The low realization rate for miscellaneous measures is primarily driven by one problematic waste water treatment project, which had a 0% realization rate, and is not representative of the program overall. If that one site were not included, the realization rate for the miscellaneous measure category would improve to 90%.

Realization rates by program year varied with 2009 being the lowest at 78%, followed by 2010 having a realization rate of 98% and 2011 a 99% realization rate. The aforementioned waste water treatment plant accounted for a large portion of the lower 2009 realization rate. A Kaizen Blitz project was another contributor to the lower 2009 realization rate. The realization rate for this particular refrigeration Kaizen Blitz project is 47%. However, this may be due to the measures approaching or reaching their measure life by the time Navigant's evaluation was performed.

Table E-1-1. Summary of Realized Savings by Measure Category – Unadjusted Electric – 2009, 2010, and 2011 Combined

	Electric Savings (kWh)			
Measure Category	Unique Sites	*Ex ante*	*Ex post*	Realization Rate
O & M - Custom	29	22,935,811	19,694,620	85.9%
Strategic Energy Mgmt	18	39,174,249	41,742,039	106.6%
Lighting	63	37,833,267	38,525,350	101.8%
Process	25	42,900,934	37,003,987	86.3%
Motor	24	1,467,367	1,437,483	98.0%
Compressed Air	36	11,969,897	10,243,151	85.6%
Custom Air Abatement	5	4,135,601	3,663,693	88.6%
Refrigeration	10	8,207,391	6,313,170	76.9%
Insulation	5	267,437	251,096	93.9%
Tune-up	7	302,182	302,182	100.0%
HVAC	11	2,408,632	1,978,865	82.2%
Custom Pump	14	17,376,019	17,648,742	101.6%
Irrigation	9	1,017,440	1,011,320	99.4%
Miscellaneous	6	3,292,293	1,386,519	42.1%
Total (Unique Electric Sites)	**117**	**193,288,520**	**181,202,216**	**93.7%**

Table E-1-2. Summary of Realized Savings by Measure Category – Unadjusted Electric – 2009

	Electric Savings (kWh)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	1	541,368	1,015,109	187.5%
Strategic Energy Mgmt	2	5,363,190	2,168,237	40.4%
Lighting	15	6,630,406	6,514,586	98.3%
Process	9	15,951,388	12,043,276	75.5%
Motor	14	911,801	899,612	98.7%
Compressed Air	7	1,232,632	1,622,591	131.6%
Custom Air Abatement	4	3,047,523	2,439,997	80.1%
Refrigeration	4	4,390,677	2,851,479	64.9%
Insulation	0	0	0	-
Tune-up	0	0	0	-
HVAC	2	431,184	427,078	99.0%
Custom Pump	6	3,649,673	3,975,202	108.9%
Irrigation	2	165,600	165,600	100.0%
Miscellaneous	1	1,739,130	0	0.0%
Total (Unique Electric Sites)	**67**	**44,054,572**	**34,122,767**	**77.5%**

Table E-1-3. Summary of Realized Savings by Measure Category – Unadjusted Electric – 2010

	Electric Savings (kWh)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	15	15,701,588	13,090,444	83.4%
Strategic Energy Mgmt	9	20,530,218	22,999,582	112.0%
Lighting	40	15,488,210	15,931,836	102.9%
Process	9	12,275,518	11,260,680	91.7%
Motor	15	339,647	330,999	97.5%
Compressed Air	18	3,888,252	3,608,061	92.8%
Custom Air Abatement	2	1,088,078	1,223,696	112.5%
Refrigeration	4	970,760	903,468	93.1%
Insulation	4	201,304	201,304	100.0%
Tune-up	3	59,180	59,180	100.0%
HVAC	3	799,989	319,890	40.0%
Custom Pump	4	5,422,113	5,646,585	104.1%
Irrigation	7	543,370	537,370	98.9%
Miscellaneous	4	799,383	632,739	79.2%
Total (Unique Electric Sites)	**137**	**78,107,610**	**76,745,834**	**98.3%**

Table E-1-4. Summary of Realized Savings by Measure Category – Unadjusted Electric – 2011

	Electric Savings (kWh)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	17	6,692,855	5,589,066	83.5%
Strategic Energy Mgmt	7	13,280,841	16,574,220	124.8%
Lighting	29	15,714,651	16,078,928	102.3%
Process	15	14,674,028	13,700,031	93.4%
Motor	13	215,919	206,872	95.8%
Compressed Air	17	6,849,013	5,012,499	73.2%
Custom Air Abatement	0	0	0	-
Refrigeration	5	2,845,954	2,558,223	89.9%
Insulation	1	66,133	49,792	75.3%
Tune-up	5	243,002	243,002	100.0%
HVAC	9	1,177,459	1,231,897	104.6%
Custom Pump	8	8,304,233	8,026,955	96.7%
Irrigation	4	308,470	308,350	100.0%
Miscellaneous	1	753,780	753,780	100.0%
Total (Unique Electric Sites)	**131**	**71,126,338**	**70,333,615**	**98.9%**

Table E-1-5 through Table E-1-8 provide summaries of *ex ante* and *ex post* energy savings by measure category for natural gas. Table E-1-5 combines the three evaluation years of 2009, 2010, and 2011 while Table E-1-6 through Table E-1-8 represent each of the evaluation years, respectively. The values in these four tables are not adjusted for consideration of closed facilities or *ex post* estimates for savings from natural gas greenhouse HVAC measures, in which Navigant does not have full confidence.

For the three years of natural gas measures combined, the overall realization rate is 89%. The highest realization rates were achieved by boilers at 115% and the lowest by greenhouse–HVAC at 50%. Although Navigant did estimate a realization rate for greenhouse–HVAC, this measure type was difficult to evaluate for several reasons:

- Some sites were visited in the non-heating season and therefore direct metering was not possible.
- The vast majority of the claimed natural gas savings for greenhouse insulation measures were near or above billed natural gas levels, due to the way in which the Virtual Grower model was implemented for savings calculations.
- Heating profiles are very dependent on the plants/crops within the greenhouses. Records on the specific plants/crops as well as the timing of when they were in the greenhouses were not available.

Considering these difficulties, Navigant does not have full confidence in the *ex post* energy savings for the greenhouse-HVAC measure.

Realization rates by program year varied with 2009 being the lowest at 68%, followed by 2010 having a realization rate of 84% and 2011 a 97% realization rate. The increase in realization rates is due to a combination of factors, however the relative proportion of greenhouse HVAC measures, and their low realization rates, in each year is the most significant contributor. Greenhouse HVAC measures, constituted a decreasing percentage of *ex ante* savings in successive years, contributing substantially to the lower realization rates in earlier program years. The aforementioned greenhouse–HVAC measure accounted for most of the lower 2009 and 2010 realization rates.

Table E-1-5. Summary of Realized Savings by Measure Category – Unadjusted Natural Gas – 2009, 2010, and 2011 Combined

	Gas Savings (Therms)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	5	28,767	27,251	94.7%
Strategic Energy Mgmt	2	28,394	28,020	98.7%
Process	7	417,860	363,938	87.1%
Boiler	6	228,802	263,722	115.3%
Insulation	7	73,340	80,854	110.2%
Tune-up	6	52,942	52,942	100.0%
HVAC	3	28,712	28,655	99.8%
Greenhouse-HVAC	9	270,333	134,804	49.9%
Greenhouse-Other	9	270,190	268,354	99.3%
Miscellaneous	5	274,771	246,857	89.8%
Total (Unique Gas Sites)	**47**	**1,674,111**	**1,495,397**	**89.3%**

Table E-1-6. Summary of Realized Savings by Measure Category – Unadjusted Natural Gas – 2009

	Gas Savings (Therms)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	0	0	0	-
Strategic Energy Mgmt	0	0	0	-
Process	1	1,956	3,022	154.5%
Boiler	0	0	0	-
Insulation	1	22,471	30,128	134.1%
Tune-up	0	0	0	-
HVAC	0	0	0	-
Greenhouse-HVAC	5	137,271	59,908	43.6%
Greenhouse-Other	0	0	0	-
Miscellaneous	1	54,154	54,154	100.0%

Total (Unique Gas Sites)	**8**	**215,852**	**147,212**	**68.2%**

Table E-1-7. Summary of Realized Savings by Measure Category – Unadjusted Natural Gas – 2010

	Gas Savings (Therms)			
Measure Category	**Sites**	***Ex Ante***	***Ex Post***	**Realization Rate**
O & M - Custom	0	0	0	-
Strategic Energy Mgmt	0	0	0	-
Process	3	267,157	234,025	87.6%
Boiler	0	0	0	-
Insulation	5	41,819	41,676	99.7%
Tune-up	3	18,077	18,077	100.0%
HVAC	2	12,978	12,921	99.6%
Greenhouse-HVAC	1	89,055	45,773	51.4%
Greenhouse-Other	3	32,983	31,147	94.4%
Miscellaneous	1	39,840	39,840	100.0%
Total (Unique Gas Sites)	**18**	**501,909**	**423,459**	**84.4%**

Table E-1-8. Summary of Realized Savings by Measure Category – Unadjusted Natural Gas – 2011

	Gas Savings (Therms)			
Measure Category	**Sites**	***Ex Ante***	***Ex Post***	**Realization Rate**
O & M - Custom	5	28,767	27,251	94.7%
Strategic Energy Mgmt	2	28,394	28,020	98.7%
Process	3	148,747	126,891	85.3%
Boiler	6	228,802	263,722	115.3%
Insulation	1	9,050	9,050	100.0%
Tune-up	4	34,865	34,865	100.0%
HVAC	2	15,734	15,734	100.0%
Greenhouse-HVAC	4	44,007	29,123	66.2%
Greenhouse-Other	7	237,207	237,207	100.0%
Miscellaneous	4	180,777	152,863	84.6%
Total (Unique Gas Sites)	**38**	**956,350**	**924,727**	**96.7%**

The two issues of closed facilities and consideration of *ex post* estimates for savings from natural gas greenhouse HVAC measures significantly affect realization rates within certain measure and fuel categories and cloud the assessment for the measures in businesses still in operation.

Table E-1-9 through Table E-1-16 take into account these two issues and provide an adjusted assessment of *ex ante* and *ex post* energy savings by year, measure category and fuel type.

Adjusting for closed facilities (three facilities), the overall electric measure realization rate for the combined three years improved from 94% to 96%. Most of the end use categories are affected by this adjustment with the biggest changes in the compressed air category, which improved from 86% to 102%, and HVAC, which improved from 82% to 103%. The realization rates for each of the individual years also increased with both 2010 and 2011 being above 100%. The realization rate for 2009 is essentially unchanged at 78%

Table E-1-9. Summary of Realized Savings by Measure Category – Adjusted Electric – 2009, 2010, and 2011 Combined

	Electric Savings (kWh)			
Measure Category	**Unique Sites**	***Ex ante***	***Ex post***	**Realization Rate**
O & M - Custom	28	22,556,478	19,694,620	87.3%
Strategic Energy Mgmt	18	39,174,249	41,742,039	106.6%
Lighting	62	36,826,414	38,525,350	104.6%
Process	23	41,643,322	37,003,987	88.9%
Motor	23	1,460,548	1,437,483	98.4%
Compressed Air	34	10,094,116	10,243,151	101.5%
Custom Air Abatement	5	4,135,601	3,663,693	88.6%
Refrigeration	10	8,207,391	6,313,170	76.9%
Insulation	5	267,437	251,096	93.9%
Tune-up	7	302,182	302,182	100.0%
HVAC	10	1,928,533	1,978,865	102.6%
Custom Pump	13	17,319,701	17,648,742	101.9%
Irrigation	9	1,017,440	1,011,320	99.4%
Miscellaneous	6	3,292,293	1,386,519	42.1%
Total (Unique Electric Sites)	**115**	**188,225,705**	**181,202,216**	**96.3%**

Table E-1-10. Summary of Realized Savings by Measure Category – Adjusted Electric – 2009

	Electric Savings (kWh)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	1	541,368	1,015,109	187.5%
Strategic Energy Mgmt	2	5,363,190	2,168,237	40.4%
Lighting	14	6,618,353	6,514,586	98.4%
Process	8	15,840,532	12,043,276	76.0%
Motor	14	911,801	899,612	98.7%
Compressed Air	7	1,232,632	1,622,591	131.6%
Custom Air Abatement	4	3,047,523	2,439,997	80.1%
Refrigeration	4	4,390,677	2,851,479	64.9%
Insulation	0	0	0	-
Tune-up	0	0	0	-
HVAC	2	431,184	427,078	99.0%
Custom Pump	6	3,649,673	3,975,202	108.9%
Irrigation	2	165,600	165,600	100.0%
Miscellaneous	1	1,739,130	0	0.0%
Total (Unique Electric Sites)	**65**	**43,931,663**	**34,122,767**	**77.7%**

Table E-1-11. Summary of Realized Savings by Measure Category – Adjusted Electric – 2010

	Electric Savings (kWh)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	15	15,701,588	13,090,444	83.4%
Strategic Energy Mgmt	9	20,530,218	22,999,582	112.0%
Lighting	39	14,493,410	15,931,836	109.9%
Process	8	11,128,762	11,260,680	101.2%
Motor	14	338,975	330,999	97.6%
Compressed Air	17	3,859,739	3,608,061	93.5%
Custom Air Abatement	2	1,088,078	1,223,696	112.5%
Refrigeration	4	970,760	903,468	93.1%
Insulation	4	201,304	201,304	100.0%
Tune-up	3	59,180	59,180	100.0%
HVAC	2	319,890	319,890	100.0%
Custom Pump	4	5,422,113	5,646,585	104.1%
Irrigation	7	543,370	537,370	98.9%
Miscellaneous	4	799,383	632,739	79.2%
Total (Unique Electric Sites)	**132**	**75,456,770**	**76,745,834**	**101.7%**

Table E-1-12. Summary of Realized Savings by Measure Category – Adjusted Electric –2011

	Electric Savings (kWh)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	16	6,313,522	5,589,066	88.5%
Strategic Energy Mgmt	7	13,280,841	16,574,220	124.8%
Lighting	29	15,714,651	16,078,928	102.3%
Process	15	14,674,028	13,700,031	93.4%
Motor	12	209,772	206,872	98.6%
Compressed Air	16	5,001,745	5,012,499	100.2%
Custom Air Abatement	0	0	0	-
Refrigeration	5	2,845,954	2,558,223	89.9%
Insulation	1	66,133	49,792	75.3%
Tune-up	5	243,002	243,002	100.0%
HVAC	9	1,177,459	1,231,897	104.6%
Custom Pump	7	8,247,915	8,026,955	97.3%
Irrigation	4	308,470	308,350	100.0%
Miscellaneous	1	753,780	753,780	100.0%
Total (Unique Electric Sites)	**127**	**68,837,272**	**70,333,615**	**102.2%**

The effect of removing the natural gas greenhouse-HVAC realization rates from the overall natural gas realization rate for the combined three years is significant. Before the adjustment, the realization rate was 89% and after the adjustment, it improved to 97%. The realization rates for each of the individual years also increased with the 2009 realization rate improving from 68% to 111%, 2010 from 84% to 92%, and 2011 from 97% to 98%.

Table E-1-13. Summary of Realized Savings by Measure Category – Adjusted Natural Gas– 2009, 2010, and 2011 Combined

	Gas Savings (Therms)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	5	28,767	27,251	94.7%
Strategic Energy Mgmt	2	28,394	28,020	98.7%
Process	7	417,860	363,938	87.1%
Boiler	6	228,802	263,722	115.3%
Insulation	7	73,340	80,854	110.2%
Tune-up	6	52,942	52,942	100.0%
HVAC	3	28,712	28,655	99.8%
Greenhouse-HVAC	0	0	0	-
Greenhouse-Other	9	270,190	268,354	99.3%
Miscellaneous	5	274,771	246,857	89.8%
Total (Unique Gas Sites)	**50**	**1,403,778**	**1,360,593**	**96.9%**

Table E-1-14. Summary of Realized Savings by Measure Category – Adjusted Natural Gas– 2009

	Gas Savings (Therms)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	0	0	0	-
Strategic Energy Mgmt	0	0	0	-
Process	1	1,956	3,022	154.5%
Boiler	0	0	0	-
Insulation	1	22,471	30,128	134.1%
Tune-up	0	0	0	-
HVAC	0	0	0	-
Greenhouse-HVAC	5	0	0	-
Greenhouse-Other	0	0	0	-
Miscellaneous	1	54,154	54,154	100.0%
Total (Unique Gas Sites)	**8**	**78,581**	**87,304**	**111.1%**

Table E-1-15. Summary of Realized Savings by Measure Category – Adjusted Natural Gas– 2010

	Gas Savings (Therms)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	0	0	0	-
Strategic Energy Mgmt	0	0	0	-
Process	3	267,157	234,025	87.6%
Boiler	0	0	0	-
Insulation	5	41,819	41,676	99.7%
Tune-up	3	18,077	18,077	100.0%
HVAC	2	12,978	12,921	99.6%
Greenhouse-HVAC	1	0	0	-
Greenhouse-Other	2	31,147	31,147	100.0%
Miscellaneous	1	39,840	39,840	100.0%
Total (Unique Gas Sites)	**17**	**411,018**	**377,686**	**91.9%**

Table E-1-16. Summary of Realized Savings by Measure Category – Adjusted Natural Gas–2011

	Gas Savings (Therms)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	5	28,767	27,251	94.7%
Strategic Energy Mgmt	2	28,394	28,020	98.7%
Process	3	148,747	126,891	85.3%
Boiler	6	228,802	263,722	115.3%
Insulation	1	9,050	9,050	100.0%
Tune-up	4	34,865	34,865	100.0%
HVAC	2	15,734	15,734	100.0%
Greenhouse-HVAC	4	0	0	-
Greenhouse-Other	7	237,207	237,207	100.0%
Miscellaneous	4	180,777	152,863	84.6%
Total (Unique Gas Sites)	**38**	**912,343**	**895,604**	**98.2%**

Recommendations

The Navigant evaluation staff carefully documented the impact evaluation process in an effort to capture and assess program feedback based on program data, installation reports, evaluation observations and discussions with participants. This information was used to develop recommendations that should improve the operation of the Production Efficiency Program as well as future impact evaluation efforts.

Include Detailed Calculation Spreadsheets with All Project Files - Many of the Energy Trust project files included detailed calculation spreadsheets, which facilitated efficient and accurate review of project savings. This has improved substantially since Energy Trust switched to electronic program files. However, some project files, particularly those with complicated models, did not include enough data to thoroughly evaluate the calculations used in determining *ex ante* savings. Although *ex post* savings are often calculated independently, the original calculation details are helpful in determining the reasons for any discrepancies between the two savings values. Navigant recommends that Energy Trust continue to include as much detailed data as possible in their program records.

Work with Participants in Compressed Air Leak Detection Studies to Ensure Continued, Efficient Leak Detection Program Implementation - Energy Trust incentivized compressed air leak detection and repair projects for a number of participants. Although all of these projects resulted in short term savings, compressed air leak detection and repair must be implemented every few months in order to maintain savings. In particular, after about six months to a year a system will have redeveloped leaks equivalent to those which were repaired. This is because pressure and vibration in the system drive leak formation, making leak detection a continuing priority to help maintain an efficient compressed air system.[1] Participants' long term activities pertaining to leak detection varied widely, from detailed ongoing monitoring to none at all. Many participants fell into the category of some monitoring by ear, which is less effective than full, detailed surveys. Navigant recommends Energy Trust expand their compressed air leak detection program to further educate participants about the most effective methods of leak detection and how often to implement them. Education about the recurrence of leaks could help provide incentive for facilities to implement ongoing leak detection programs.

Additionally, for two sites, it was found that the compressor curve did not match the installed equipment. This was due to the use of simplified curves and not the actual manufacturer curves. Manufacturer curves or facility data should be used wherever possible.

O&M Impacts Should Be Evaluated Soon After Implementation – O&M measures can have relatively short lifetimes and delayed evaluation of them can result in low realization rates due to timing rather than problems with implementation. For example, one Kaizen Blitz project was completed in 2009, but included in this evaluation in late 2011. The measure implementation included O&M and operational changes to the refrigeration system. The realization rate for this project is only 47%. Some of the controls changes implemented are subject to operator intervention, based on facility operational changes. Unless procedures are in place at the facility to implement periodic tuning with changing conditions, the savings will not persist.

Use Billing Data to Provide "Reality Check" for Modeled Savings on Greenhouses and HVAC Upgrades - For projects that claim large energy savings based on models, such as many of the greenhouse and large HVAC measures, Navigant recommends using site billing data to confirm the calculated savings are reasonable. Some greenhouse projects previously estimated savings that were on par with or in excess of the typical total consumption estimated for the greenhouse in which they were installed. Although it is difficult to precisely determine savings for greenhouse measures, and models

[1] U.S. Department of Energy's EERE and the Compressed Air Challenge®. *Improving Compressed Air System Performance: A Sourcebook for Industry*. Washington, D.C., 2003. p.29. http://industrial-energy.lbl.gov/files/industrial-energy/active/0/LBNL-43888.pdf

are usually the best choice for estimation, comparison to billing data could provide guidance as to any large scale problems with the model and provide guidance for model adjustments to better match actual onsite performance.

Variable Frequency Drives - Navigant found that realization rates for some variable frequency drive (VFD) installations were low mainly because those VFDs were installed on systems that were close to fully loaded.

Navigant recommends some steps to be taken to more accurately calculate the savings for these measures:

- Before recommending VFDs, implementers should assure that the system is running partially loaded for a large majority of the time.
- Additionally, trend data should be taken for any equipment that is manually controlled as it is very difficult to estimate operation of manually controlled equipment.

Lighting Controls - Energy Trust's lighting controls savings worksheet assumes all occupancy sensors savings bring a flat savings percentage, regardless of the room type in which the occupancy sensors are installed. This is a not an accurate assumption. For example, occupancy sensors will cause the lights to be off a larger percentage of time in a warehouse than in an open office space.

Navigant recommends Energy Trust employ values from an established source such as "Table 24-5. Occupancy Sensors Reduction in Operating Time" of California's "2012 Statewide Customized Offering Procedures Manual for Business" to determine occupancy sensor savings, according to space type.

MEMO

Date: December 26, 2013
To: Board of Directors
From: Phil Degens, Evaluation Manager
Kim Crossman, Industry and Agriculture Sector Lead
Subject: Staff Response to the 2009, 2010, and 2011 Production Efficiency Impact Evaluation Report

The 2009-2011 impact evaluation report shows that the Production Efficiency program is a complex program that has delivered a wide array of energy efficiency solutions to a broad swath of Energy Trust's diverse set of industrial and agricultural customers. In the three years analyzed, the program has generated significant and growing electric and gas savings each year, and has been doing a good job in accurately estimating the bulk of these savings. The program has been doing all this while rolling out new and innovative services focused on operations and maintenance (O&M) measures and strategic energy management (SEM) practices.

Energy Trust staff believe that the adjusted realization rates that the report presents provide the best estimate of program achievements. These adjustments remove the effects due to plant closures that are already incorporated into the program savings through the average measure lifetime. In the case of gas measures installed in greenhouses, Energy Trust program staff will research how best to improve the current calculation methods to obtain a robust baseline and better savings estimates in the future. In the coming year, Energy Trust also looks to update and improve its lighting control savings calculations.

Industrial behavior-based program initiatives such as SEM and O&M have grown to represent a significant share of program savings. The impact evaluation indicates that the savings estimates for this class of measure have been reasonably accurate. In 2014, Energy Trust evaluation staff plans to research on how to improve its evaluation methods in regards to these projects and will be performing a separate evaluation of sites that received these services.

Additionally, Energy Trust evaluation staff plans on obtaining impact evaluation results on an annual basis. The main reason for this is that more frequent and faster delivery of evaluation results will also provide the program more useful and timely information with which to improve program delivery. Another reason is that measures with shorter lifetimes make more sense to evaluate closer to the time they are provided or installed. Finally, longer-term, ongoing evaluation of SEM savings and the after effects of SEM interventions will help better establish average measure life, which is currently set at 3 years, and could capture other actions taken and potential spillover savings at sites.

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1. Introduction

1.1 Program Background

The Energy Trust of Oregon Production Efficiency Program (PE Program) provides incentives to industrial and agricultural customers to install or implement energy efficiency improvements at their facilities. Program measures include boiler upgrades; compressed air and air abatement improvements; water treatment efficiency improvements; efficient pumping, heating, ventilation, and air conditioning (HVAC) upgrades; insulation measures; irrigation improvements; efficient lighting and lighting controls; variable frequency drives (VFDs); industrial process improvements; refrigeration controls and equipment; and a variety of equipment tune-ups. In addition, the PE Program provides incentives for whole facility improvements such as operations and maintenance (O&M), retro-commissioning, and strategic energy management (SEM) programs.

1.2 Prior PE Program Evaluations

There have been several previous evaluations of the PE Program. Most recently, in 2009 and 2010, Navigant[2] performed impact and process evaluations of the 2007 and 2008 PE Program. Sites for both these program years were sampled separately, by site rather than individual project. The sample included the ten sites with the largest savings plus an additional random sample designed to represent measure types within the program, with a goal of 90% confidence and 15% precision. The 2007 sample included 26 sites and the 2008 sample included 24 sites, plus a review of 17 project files and savings calculators for the Small Industrial Initiative (SII). Gas projects were not included in the evaluation samples due to the limited nature of the gas savings program at the time. Overall, the 2007 program saw a 94% realization rate of gross electric savings and the 2008 program saw an 86% electric realization rate. The lower realization rate in 2008 was due, in part, to the economic slowdown at the time.

The primary recommendations of the past PE impact evaluations included:

1. Standardizing participant data requirements;
2. Evaluating the quality of project documentation and technical analysis study guidelines;
3. Incorporating a plant closure study into future evaluations, and defining and projecting future savings estimates at the program level;
4. Ensuring that participants are aware of monitoring and verification (M&V) activities as early as possible;
5. Conducting follow-up M&V on projects that were not fully implemented; and
6. Using consistent end-use classifications for the various pumping measure applications.

Energy Trust has implemented most of these recommendations since the last program cycle. In particular, project documentation (recommendation 2 above), a plant closure study (http://energytrust.org/library/reports/Plant_Closure_Report_final_110620.pdf) (recommendation 3), notification of participants concerning M&V activities (recommendation 4), the tracking of projects that were not completed was analyzed as part of the 2012 PE Process Evaluation (recommendation 5) and pumping classifications (recommendation 6) were noticeably better than in the previous evaluation.

[2] The evaluation was begun by Summit Blue, which was acquired by Navigant in 2010.

1.3 Evaluation Goals

The purpose of Navigant's evaluation efforts are to inform Energy Trust and program stakeholders of the effectiveness of the PE Program, how the PE Program can be improved, energy savings impacts, and market effects of the program. The specific goals of this evaluation were to:

- Develop reliable estimates of program and measure specific electric and natural gas savings for the program years 2009-2011.
- Obtain feedback on program design and implementation that can be used to improve the implementation of the current program.
- Identify program achievements to ensure that successful program elements are incorporated into future program cycles.

Overall, Energy Trust's PE Program is generating considerable savings. Throughout the evaluation effort, Navigant reviewed the input assumptions, savings methodologies, and corresponding savings estimates for the PE Program and collaborated with Energy Trust to ensure that evaluation findings were mathematically astute/consistent with industry standards.

1.4 Report Organization

The EM&V report is organized into the following sections:

Executive Summary

Section 1: Introduction

Section 2: Program Description

Section 3: Sampling

Section 4: Impact Evaluation Overview

Section 5: Impact Evaluation End-Use Detail

Section 6: Recommendations

Appendix: Site by Site Assessments (separate document)

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2. Program Description

The PE program seeks to help customers reduce energy-related operating costs while also improving productivity, product quality, and environmental performance. The program is available to all industrial and agricultural customers of Pacific Power and PGE, and to NW Natural and Cascade Natural Gas customers that pay the systems benefit charge. The program serves both new and existing industrial processes and support systems. In addition to offering incentives for efficient equipment, the program offers engineering and technical services, as well as training and project support, and engages market actors in helping customers reduce energy costs.

The program's components help participants generate energy savings by reducing costs associated with energy efficient equipment improvements, supporting projects with technical services, and targeting low and no-cost process improvements and energy management opportunities.

The PE Program provides incentives and resources to help participants complete energy efficiency projects and keeps incentive offers stable between program cycles. Project incentives are typically awarded on a per savings basis (kWh or therm) at a rate determined by the program component under which projects are completed; incentive rates are described in greater detail in the Program Track section below. The program also provides free analytical services for detailed technical analysis studies to identify prospective efforts.

The program has a per-project incentive cap of $500,000 and facility cap of $1,000,000 per year. In November, 2003 a mechanism was put in place to fund projects over the per-project incentive cap—projects referred to as "mega-projects"; following the identification of several very large projects with high energy savings potential, Energy Trust's Board of Directors approved a waiver of the incentive cap on a case-by-case basis for certain extraordinarily cost-effective projects. In 2009 the site cap was raised from $500,000 to $1,000,000 per year, in order to meet the demands of a doubling of planned program savings. Projects that exceed the cap are reviewed for approval by Energy Trust in a process distinct from PE Program processes.

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3. Sample Selection

3.1 Program Population

The total number of PE Program measures by measure categories along with the total number of unique sites is listed in Table 3-1 for the combined program years of 2009, 2010, and 2011. The table identifies a total of 8,506 measures installed in 1,275 unique sites. Over the three year period, nearly 370 GWh and just over 2.3 million therms of savings are claimed for all projects.

Lighting provides the greatest share of claimed electricity savings at 28 percent. The other major electric measure categories included process at 16 percent, strategic energy management at 16 percent, and compressed air at 11 percent. For natural gas, the major therm savings measure categories are process at 23 percent, HVAC at 20 percent, greenhouses at 15 percent, and boilers at 12 percent.

Table 3-1. Energy Trust of Oregon's 2009-2011 Production Efficiency Program Participant Measures and Sites

Measure Category	Number	*Ex ante* Total kWh	*Ex ante* Total Therms	% of kWh Total	% of Therm Total
O & M - Custom	101	35,249,386	49,366	10%	2%
Strategic Energy Mgmt	45	57,088,856	163,394	16%	7%
Lighting	5,845	102,818,497	0	28%	0%
Process	118	59,238,215	534,725	16%	23%
Motor	702	3,270,720	0	1%	0%
Compressed Air	292	41,669,753	0	11%	0%
Custom Air Abatement	20	6,955,864	93,994	2%	4%
Refrigeration	61	16,630,978	0	5%	0%
Insulation	33	796,871	121,960	0%	5%
Tune-up	40	391,250	66,545	0%	3%
HVAC	100	8,281,643	453,340	2%	20%
Custom Pump	226	25,959,208	1,578	7%	0%
Irrigation	844	3,314,195	0	1%	0%
Miscellaneous	45	6,640,893	193,268	2%	8%
Boiler	11	0	287,522	0%	12%
Greenhouse	23	0	341,194	0%	15%
Total Number of Measures	8,506				
Total Number of Unique Sites	1,275				
Total kWh Savings (2009-2011)		368,306,329			
Total Therm Savings (2009-2011)			2,306,886		

3.2 Sample Draw

The sample selection method chosen was stratified ratio estimation at the site level. This method ensures that the sites providing the most savings have a greater chance of being part of the sample, but still ensures that sites of all sizes are included. In addition, because most sites implemented multiple measures, a large array of measure categories is included efficiently within the sites sampled.

Stratified ratio estimation combines a stratified sample design with a ratio estimator. Both stratification and ratio estimation take advantage of supporting information available for each project in the population. In this case, the supporting information is *ex ante* energy savings per project. The population of sites has a wide range of energy savings ranging from 18,500,000 kWh to 145 kWh for electricity and 200,000 therms to 43 therms for natural gas. Because the population coefficient of variation of the energy savings is large, simple random sampling is not considered an efficient sampling approach.

By using the *ex ante* energy savings per site as the stratification variable, the coefficient of variation in each stratum is reduced thereby improving the statistical precision. Moreover, the sampling fraction (the percent of sites from each stratum included in the overall sample) varies from stratum to stratum to further improve the statistical precision. A relatively small sample can be selected from the sites with small energy savings; the sample method is designed to include a higher proportion of the projects with larger levels of energy savings.

The sample was drawn using four energy savings strata and designed to meet statistical confidence of 90 percent ±10 percent. The initial sample draw included 99 unique sites. This initial sample draw was examined from the perspective of both the measure categories included and the distribution among the three years. Based on this review, 6 additional sites were added to the sample, bringing the total to 105 sites.

This sample of 105 sites was provided to Energy Trust for their review. Based on this review, Energy Trust decided to add 31 sites in order to get better coverage of small industrial sites and custom O&M sites, bringing the final sample size to 137 sites. The effects of how the sample was drawn and the addition of more sites on statistical precision are found in Table 3-2 and Table 3-3.

Table 3-2. Sample Statistics by Project, Year, and Fuel Type

Fuel	2009	2010	2011	Total
Total kWh Projects	2,088	3,221	3,085	8,394
Sample kWh Projects	403	831	537	1,771
Approximate Precision	> 95/5	> 95/5	> 95/5	> 95/5
Total Therm Projects	30	52	113	195
Sample Therm Projects	10	29	52	91
Approximate Precision	> 80/20	~ 90/10	> 90/10	> 90/10

Table 3-3. Sample Statistics by Site, Year, and Fuel Type

Fuel	2009	2010	2011	Total
Total kWh Sites	448	598	586	1,259
Sample kWh Sites	52	87	78	117
Approximate Precision	~ 90/10	> 90/10	> 90/10	> 90/10
Total Therm Sites	26	38	70	117
Sample Therm Sites	10	19	33	49
Approximate Precision	~ 90/20	~ 90/15	~ 90/10	~ 90/10

The next level of review considered geographic location of the sites. In order to reduce travel-related costs, geographic outliers were identified. Six sites were considered to be remotely located in relation to the other sampled sites, and were replaced by sites closer to the other sites. Replacement sites were drawn from the same measure category and energy savings stratum as the original sites.

Table 3-4 identifies the number of projects included in the final sample by measure category. Although the sample of 137 unique sites represents only 11% of the total number of unique sites, they do represent 52% of the total claimed electricity savings and 73% of the total claimed natural gas savings. The distribution across measure categories is similar between the sampled energy savings and the total population energy savings.

Table 3-4. Final Sample

Measure Category	Number	*Ex ante* Total kWh	*Ex ante* Total Therms	Total Population % of kWh	Sample Population % of kWh	Total Population % of Therms	Sample Population % of Therms
O & M - Custom	45	22,935,811	28,767	10%	12%	2%	2%
Strategic Energy Mgmt	17	36,647,579	28,394	16%	19%	7%	2%
Lighting	1,203	37,833,267	0	28%	20%	0%	0%
Process	47	42,900,934	417,860	16%	22%	23%	25%
Motor	253	1,467,367	0	1%	1%	0%	0%
Compressed Air	48	11,969,897	0	11%	6%	0%	0%
Custom Air Abatement	9	4,135,601	93,994	2%	2%	4%	6%
Refrigeration	19	8,207,391	0	5%	4%	0%	0%
Insulation	11	267,437	73,340	0%	0%	5%	4%
Tune-up	18	302,182	52,942	0%	0%	3%	3%
HVAC	38	2,408,632	299,045	2%	1%	20%	18%
Custom Pump	39	17,376,019	1,578	7%	9%	0%	0%
Irrigation	47	1,017,440	0	1%	1%	0%	0%
Miscellaneous	13	3,292,293	179,199	2%	2%	8%	11%
Boiler	6	0	228,802	0%	0%	12%	14%
Greenhouse	15	0	270,190	0%	0%	15%	16%
Total Number of Sample Measures	1,828						
Total Number of Measure	8,506						
Project Sample % of Population	21%						
Total Number of Sample Unique Sites	137						
Total Number of Unique Sites	1275						
Unique Site Sample % of Population	11%						
kWh Sample Total 2009-2011		190,761,850					
kWh Population Total 2009-2011		368,306,329					
kWh Sample % of Population		52%					
Therm Sample Total 2009-2011			1,674,111				
Therm Population Total 2009-2011			2,306,886				
Therm Sample % of Population			73%				

Table 3-5 compares the number of sample projects against the total number of measures by year and fuel. The distribution by year is similar for both electric and natural gas projects. The totals in Table 3-5

may not match the totals in Table 3-1 and Table 3-4 as the projects in these earlier tables include some that have both electricity and natural gas savings.

Table 3-5. Measures by Year and Fuel

Fuel	2009	2010	2011	Total
Total kWh Measures	2,088	3,221	3,085	8,394
Sample kWh Projects	403	831	537	1,771
Total Therm Measures	30	52	113	195
Sample Therm Projects	10	29	52	91

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4. Impact Evaluation Overview

4.1 Approach

On-site performance measurement and verification activities were undertaken during site visits with the exception of two sites where verification was performed over the phone. The phone survey verification approach was only used when the measures being verified were simple, prescriptive measures and when the location was far from the Portland metropolitan area. In general, on-site inspections encompassed a range of activities, including:

- Simple verification of measure installations;
- Confirmation of measure counts, capacities, and efficiencies;
- Observation of the quality of installation of the technology;
- Collection of nameplate and other performance data;
- Collection of trend data from facility monitoring systems;
- Collection of billing data from Energy Trust;
- Observation of control systems and schedules;
- Confirmation of baseline conditions (to the extent possible); and
- Discussions with building operators about building construction features, occupancy schedules, and energy systems characteristics and operation.

In addition to these on-site inspection and verification activities, on-site performance measurement activities fell into the following three broad categories:

» **Spot Measurements** – Spot measurements are the first and simplest level of on-site performance measurement and include one-time instantaneous measurements of technology, system, or environmental factors including temperature, voltage, current, true power, power factor, light levels, temperatures, boiler efficiencies, and other variables. As a general guide, these measures are used to quantify single operating parameters that do not vary significantly over time or are intended to provide a snapshot in time. They are not intended to capture seasonal or long-term effects. This approach is useful in assessing the savings of constant performance measures and confirming the accuracy of longer-term measurements.

» **Run-Time Hour Data Logging** – Run-time hour monitoring is used to record run-time profiles over a given time period or operating hour totals. Run-time hour monitoring is particularly useful for estimating long-term energy consumption from short-term measurements, particularly for technologies that exhibit constant performance characteristics. For example, this method is used extensively for assessing the operating hours of lighting systems and constant load motor systems. Monitoring is conducted with small, portable, and easy-to-use monitors, which typically hold several weeks of data.

» **Interval Metering** – Interval metering is the most sophisticated level of on-site performance measurement and involves real-time monitoring of the energy use of specific equipment over a specified time period. This may involve recording true energy use or "proxy" values such as current from which energy use is computed. Interval metering is often used to measure pre- and post-installation performance to obtain accurate data on measure performance. Typically, this strategy is not deployed over sufficiently long time periods to gauge seasonal effects; therefore,

the results of the measurements must be integrated into an analysis model with temperature correlations to compute annual and seasonal impacts.

The specific measurement and verification activity assigned to a particular project in the Impact Evaluation sample depended upon two factors:

- **Distribution of *Ex Ante* Savings** – Measures that contributed more to the PE Program's *ex ante* savings estimates were afforded a more rigorous measurement and verification strategy to ensure the accuracy of evaluation results.
- **Measure Uncertainty** – Measures with a high level of uncertainty were defined as those technologies which (1) possessed variable operating conditions, (2) yielded significant variability in claimed savings estimates, and (3) had not been investigated extensively in previous evaluation studies. PE projects with the highest level of uncertainty were also afforded more rigorous measurement and verification strategies to minimize the impact of this uncertainty on evaluation results.

Collectively, the prioritization of different evaluation strategies ensured that accurate Impact Evaluation results were cost-effectively procured. A useful construct for thinking about the range of measurement and verification strategies leveraged through the PE Impact Evaluation is the International Performance Measurement and Verification Protocol (IPMVP). Table 4-1 presents a listing of the IPMVP protocols, the nature of the performance characteristics of the measures to which M&V options typically apply, and an overview of the data requirements to support each option. The IPMVP protocols complemented the prioritization of different evaluation strategies previously discussed.

SEM and O&M projects provided unique challenges. These projects generally include multiple initiatives. Navigant used IPMVP Option C to analyze their overall savings, in conjunction with a combination of IPMVP Options A and B to adjust for specific measures that could be individually verified. Site by site approaches and results are discussed in the Appendix.

Table 4-1. Overview of M&V Options

IPMVP M&V Option	Measure Performance Characteristics	Data Requirements
Option A: Engineering calculations based on spot or short-term measurements, and/or historical data. Deemed energy savings fall in this Option.	Constant performance	» Verified installation » Nameplate or stipulated performance parameters » Spot measurements » Run-time hour measurements
Option B: Engineering calculations using metered data.	Constant or variable performance	» Verified installation » Nameplate or stipulated performance parameters » End-use metered data

IPMVP M&V Option	Measure Performance Characteristics	Data Requirements
Option C: Analysis of utility meter (or sub-meter) data using techniques from simple comparison to multi-variant regression analysis.	Variable performance	» Verified installation » Utility metered or end-use metered data » Engineering estimate of savings input to SAE model
Option D: Calibrated energy simulation/modeling; calibrated with hourly or monthly utility billing data and/or end-use metering	Variable performance	» Verified installation » Spot measurements, run-time hour monitoring, and/or end-use metering to prepare inputs to models » Utility billing records, end-use metering, or other indices to calibrate models

4.2 Economic Factors

Throughout the evaluation process, Navigant technical staff distinguished between reduced consumption achieved through improved controls and efficient measure installations, and a decrease in production throughput as a result of economic factors. Reductions realized through the latter case were not considered to be "savings" because they would not have been realized under normal conditions. Evaluation staff discounted savings from a reduction in site production activities using the following approach:

1. If the site was closed, then achieved savings were considered null, depending on the timing of the measure installation, the closing of the site, and the measure life.
2. If the changes in production levels were short term, then the realization rate was calculated using the site's normal operating characteristics.

Although this methodology often reduced a project's verified savings, it ensured that savings were appropriately allocated to program activities, independent of external conditions.

4.3 Baseline Adjustments

When available, Navigant utilized measured baselines. However, calculated baselines were used in simple cases or where measurement is not practical due to capacity increases, equipment removal, or the presence of medium and high voltage systems. Theoretical baselines use industry standards for new construction or equipment and a combination of the discussed methods is used where appropriate.

4.4 Summary of Results

Table 4-2Table E-1-1 through Table 4-5 provide summaries of *ex ante* and *ex post* energy savings by measure category for electricity. Table E-1-1 combines the three evaluation years of 2009, 2010, and 2011 while

Table 4-3 through Table 4-5 represent each of the evaluation years, respectively. Along with the energy savings, realization rates by measure category are provided. The values in these four tables are not adjusted for consideration of closed facilities.

For the three years of electric measures combined, the overall realization rate is 94%. The highest realization rates were achieved by Strategic Energy Management at 107% and the lowest by miscellaneous measures at 42%. The low realization rate for miscellaneous measures is primarily driven by one problematic waste water treatment project, which had a 0% realization rate, and is not representative of the program overall. If that one site were not included, the realization rate for the miscellaneous measure category would improve to 90%.

Realization rates by program year varied with 2009 being the lowest at 78%, followed by 2010 having a realization rate of 98% and 2011 a 99% realization rate. The aforementioned waste water treatment plant accounted for a large portion of the lower 2009 realization rate. A Kaizen Blitz project was another contributor to the lower 2009 realization rate. The realization rate for this particular Kaizen Blitz project is 35%. However, this may be due to the measures approaching or reaching their measure life by the time Navigant's evaluation was performed.

Table 4-2. Summary of Realized Savings by Measure Category – Unadjusted Electric – 2009, 2010, and 2011 Combined

	Electric Savings (kWh)			
Measure Category	**Unique Sites**	***Ex ante***	***Ex post***	**Realization Rate**
O & M - Custom	29	22,935,811	19,694,620	85.9%
Strategic Energy Mgmt	18	39,174,249	41,742,039	106.6%
Lighting	63	37,833,267	38,525,350	101.8%
Process	25	42,900,934	37,003,987	86.3%
Motor	24	1,467,367	1,437,483	98.0%
Compressed Air	36	11,969,897	10,243,151	85.6%
Custom Air Abatement	5	4,135,601	3,663,693	88.6%
Refrigeration	10	8,207,391	6,313,170	76.9%
Insulation	5	267,437	251,096	93.9%
Tune-up	7	302,182	302,182	100.0%
HVAC	11	2,408,632	1,978,865	82.2%
Custom Pump	14	17,376,019	17,648,742	101.6%
Irrigation	9	1,017,440	1,011,320	99.4%
Miscellaneous	6	3,292,293	1,386,519	42.1%
Total (Unique Electric Sites)	**117**	**193,288,520**	**181,202,216**	**93.7%**

Table 4-3. Summary of Realized Savings by Measure Category – Unadjusted Electric – 2009

	Electric Savings (kWh)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	1	541,368	1,015,109	187.5%
Strategic Energy Mgmt	2	5,363,190	2,168,237	40.4%
Lighting	15	6,630,406	6,514,586	98.3%
Process	9	15,951,388	12,043,276	75.5%
Motor	14	911,801	899,612	98.7%
Compressed Air	7	1,232,632	1,622,591	131.6%
Custom Air Abatement	4	3,047,523	2,439,997	80.1%
Refrigeration	4	4,390,677	2,851,479	64.9%
Insulation	0	0	0	-
Tune-up	0	0	0	-
HVAC	2	431,184	427,078	99.0%
Custom Pump	6	3,649,673	3,975,202	108.9%
Irrigation	2	165,600	165,600	100.0%
Miscellaneous	1	1,739,130	0	0.0%
Total (Unique Electric Sites)	**67**	**44,054,572**	**34,122,767**	**77.5%**

Table 4-4. Summary of Realized Savings by Measure Category – Unadjusted Electric – 2010

	Electric Savings (kWh)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	15	15,701,588	13,090,444	83.4%
Strategic Energy Mgmt	9	20,530,218	22,999,582	112.0%
Lighting	40	15,488,210	15,931,836	102.9%
Process	9	12,275,518	11,260,680	91.7%
Motor	15	339,647	330,999	97.5%
Compressed Air	18	3,888,252	3,608,061	92.8%
Custom Air Abatement	2	1,088,078	1,223,696	112.5%
Refrigeration	4	970,760	903,468	93.1%
Insulation	4	201,304	201,304	100.0%
Tune-up	3	59,180	59,180	100.0%
HVAC	3	799,989	319,890	40.0%
Custom Pump	4	5,422,113	5,646,585	104.1%
Irrigation	7	543,370	537,370	98.9%
Miscellaneous	4	799,383	632,739	79.2%
Total (Unique Electric Sites)	**137**	**78,107,610**	**76,745,834**	**98.3%**

Table 4-5. Summary of Realized Savings by Measure Category – Unadjusted Electric – 2011

	Electric Savings (kWh)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	17	6,692,855	5,589,066	83.5%
Strategic Energy Mgmt	7	13,280,841	16,574,220	124.8%
Lighting	29	15,714,651	16,078,928	102.3%
Process	15	14,674,028	13,700,031	93.4%
Motor	13	215,919	206,872	95.8%
Compressed Air	17	6,849,013	5,012,499	73.2%
Custom Air Abatement	0	0	0	-
Refrigeration	5	2,845,954	2,558,223	89.9%
Insulation	1	66,133	49,792	75.3%
Tune-up	5	243,002	243,002	100.0%
HVAC	9	1,177,459	1,231,897	104.6%
Custom Pump	8	8,304,233	8,026,955	96.7%
Irrigation	4	308,470	308,350	100.0%
Miscellaneous	1	753,780	753,780	100.0%
Total (Unique Electric Sites)	**131**	**71,126,338**	**70,333,615**	**98.9%**

Table 4-6 through Table 4-4-9 provide summaries of *ex ante* and *ex post* energy savings by measure category for natural gas. Table E-1-5 combines the three evaluation years of 2009, 2010, and 2011 while Table 4-4-7through Table 4-4-9 represent each of the evaluation years; respectively. The values in these four tables are not adjusted for consideration of closed facilities or *ex post* estimates for savings from natural gas greenhouse HVAC measure in which Navigant does not have full confidence.

For the three years of natural gas measures combined, the overall realization rate is 89%. The highest realization rates were achieved by boilers at 115% and the lowest by greenhouse–HVAC at 50%. Although Navigant did estimate a realization rate for greenhouse–HVAC, this measure type was difficult to evaluate for several reasons including:

- Some sites were visited in the non-heating season and therefore direct metering was not possible.
- Claimed natural gas savings were often near or above billed natural gas levels.
- Heating profiles are very dependent on the plants/crops within the greenhouses. Records on the specific plants/crops as well as the timing of when they were in the greenhouses were not available.

Considering these difficulties, Navigant does not have full confidence in the *ex post* energy savings for the greenhouse-HVAC measure.

Realization rates by program year varied with 2009 being the lowest at 68%, followed by 2010 having a realization rate of 84% and 2011 a 97% realization rate. The aforementioned greenhouse–HVAC measure accounted for most of the lower 2009 and 2010 realization rates.

Table 4-6. Summary of Realized Savings by Measure Category – Unadjusted Natural Gas – 2009, 2010, and 2011 Combined

	Gas Savings (Therms)			
Measure Category	**Sites**	***Ex Ante***	***Ex Post***	**Realization Rate**
O & M - Custom	5	28,767	27,251	94.7%
Strategic Energy Mgmt	2	28,394	28,020	98.7%
Process	7	417,860	363,938	87.1%
Boiler	6	228,802	263,722	115.3%
Insulation	7	73,340	80,854	110.2%
Tune-up	6	52,942	52,942	100.0%
HVAC	3	28,712	28,655	99.8%
Greenhouse-HVAC	9	270,333	134,804	49.9%
Greenhouse-Other	9	270,190	268,354	99.3%
Miscellaneous	5	274,771	246,857	89.8%
Total (Unique Gas Sites)	**47**	**1,674,111**	**1,495,397**	**89.3%**

Table 4-4-7. Summary of Realized Savings by Measure Category – Unadjusted Natural Gas – 2009

	Gas Savings (Therms)			
Measure Category	**Sites**	***Ex Ante***	***Ex Post***	**Realization Rate**
O & M - Custom	0	0	0	-
Strategic Energy Mgmt	0	0	0	-
Process	1	1,956	3,022	154.5%
Boiler	0	0	0	-
Insulation	1	22,471	30,128	134.1%
Tune-up	0	0	0	-
HVAC	0	0	0	-
Greenhouse-HVAC	5	137,271	59,908	43.6%
Greenhouse-Other	0	0	0	-
Miscellaneous	1	54,154	54,154	100.0%
Total (Unique Gas Sites)	**8**	**215,852**	**147,212**	**68.2%**

Table 4-4-8. Summary of Realized Savings by Measure Category – Unadjusted Natural Gas – 2010

	Gas Savings (Therms)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	0	0	0	-
Strategic Energy Mgmt	0	0	0	-
Process	3	267,157	234,025	87.6%
Boiler	0	0	0	-
Insulation	5	41,819	41,676	99.7%
Tune-up	3	18,077	18,077	100.0%
HVAC	2	12,978	12,921	99.6%
Greenhouse-HVAC	1	89,055	45,773	51.4%
Greenhouse-Other	3	32,983	31,147	94.4%
Miscellaneous	1	39,840	39,840	100.0%
Total (Unique Gas Sites)	**18**	**501,909**	**423,459**	**84.4%**

Table 4-4-9. Summary of Realized Savings by Measure Category – Unadjusted Natural Gas – 2011

	Gas Savings (Therms)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	5	28,767	27,251	94.7%
Strategic Energy Mgmt	2	28,394	28,020	98.7%
Process	3	148,747	126,891	85.3%
Boiler	6	228,802	263,722	115.3%
Insulation	1	9,050	9,050	100.0%
Tune-up	4	34,865	34,865	100.0%
HVAC	2	15,734	15,734	100.0%
Greenhouse-HVAC	4	44,007	29,123	66.2%
Greenhouse-Other	7	237,207	237,207	100.0%
Miscellaneous	4	180,777	152,863	84.6%
Total (Unique Gas Sites)	**38**	**956,350**	**924,727**	**96.7%**

The two issues of closed facilities and consideration of *ex post* estimates for savings from natural gas greenhouse HVAC measures significantly affect realization rates within certain measure and fuel categories and cloud the assessment for the measures in businesses still in operation.

Table 4-10 through Table 4-4-17 take into account these two issues and provide an adjusted assessment of *ex ante* and *ex post* energy savings by measure category and fuel type.

Adjusting for closed facilities (three facilities), the overall electric measure realization rate for the combined three years improved from 94% to 96%. Most of the end use categories are affected by this adjustment with the biggest changes in the compressed air category, which improved from 86% to 102%, and HVAC, which improved from 82% to 103%. The realization rates for each of the individual years also increased with both 2010 and 2011 being above 100%. The realization rate for 2009 is essentially unchanged at 78%.

Table 4-10. Summary of Realized Savings by Measure Category – Adjusted Electric – 2009, 2010, and 2011 Combined

	Electric Savings (kWh)			
Measure Category	**Unique Sites**	***Ex ante***	***Ex post***	**Realization Rate**
O & M - Custom	28	22,556,478	19,694,620	87.3%
Strategic Energy Mgmt	18	39,174,249	41,742,039	106.6%
Lighting	62	36,826,414	38,525,350	104.6%
Process	23	41,643,322	37,003,987	88.9%
Motor	23	1,460,548	1,437,483	98.4%
Compressed Air	34	10,094,116	10,243,151	101.5%
Custom Air Abatement	5	4,135,601	3,663,693	88.6%
Refrigeration	10	8,207,391	6,313,170	76.9%
Insulation	5	267,437	251,096	93.9%
Tune-up	7	302,182	302,182	100.0%
HVAC	10	1,928,533	1,978,865	102.6%
Custom Pump	13	17,319,701	17,648,742	101.9%
Irrigation	9	1,017,440	1,011,320	99.4%
Miscellaneous	6	3,292,293	1,386,519	42.1%
Total (Unique Electric Sites)	**115**	**188,225,705**	**181,202,216**	**96.3%**

Table 4-4-11. Summary of Realized Savings by Measure Category – Adjusted Electric – 2009

	Electric Savings (kWh)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	1	541,368	1,015,109	187.5%
Strategic Energy Mgmt	2	5,363,190	2,168,237	40.4%
Lighting	14	6,618,353	6,514,586	98.4%
Process	8	15,840,532	12,043,276	76.0%
Motor	14	911,801	899,612	98.7%
Compressed Air	7	1,232,632	1,622,591	131.6%
Custom Air Abatement	4	3,047,523	2,439,997	80.1%
Refrigeration	4	4,390,677	2,851,479	64.9%
Insulation	0	0	0	-
Tune-up	0	0	0	-
HVAC	2	431,184	427,078	99.0%
Custom Pump	6	3,649,673	3,975,202	108.9%
Irrigation	2	165,600	165,600	100.0%
Miscellaneous	1	1,739,130	0	0.0%
Total (Unique Electric Sites)	**65**	**43,931,663**	**34,122,767**	**77.7%**

Table 4-4-12. Summary of Realized Savings by Measure Category – Adjusted Electric – 2010

	Electric Savings (kWh)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	15	15,701,588	13,090,444	83.4%
Strategic Energy Mgmt	9	20,530,218	22,999,582	112.0%
Lighting	39	14,493,410	15,931,836	109.9%
Process	8	11,128,762	11,260,680	101.2%
Motor	14	338,975	330,999	97.6%
Compressed Air	17	3,859,739	3,608,061	93.5%
Custom Air Abatement	2	1,088,078	1,223,696	112.5%
Refrigeration	4	970,760	903,468	93.1%
Insulation	4	201,304	201,304	100.0%
Tune-up	3	59,180	59,180	100.0%
HVAC	2	319,890	319,890	100.0%
Custom Pump	4	5,422,113	5,646,585	104.1%
Irrigation	7	543,370	537,370	98.9%
Miscellaneous	4	799,383	632,739	79.2%
Total (Unique Electric Sites)	**132**	**75,456,770**	**76,745,834**	**101.7%**

Table 4-4-13. Summary of Realized Savings by Measure Category – Adjusted Electric –2011

	Electric Savings (kWh)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	16	6,313,522	5,589,066	88.5%
Strategic Energy Mgmt	7	13,280,841	16,574,220	124.8%
Lighting	29	15,714,651	16,078,928	102.3%
Process	15	14,674,028	13,700,031	93.4%
Motor	12	209,772	206,872	98.6%
Compressed Air	16	5,001,745	5,012,499	100.2%
Custom Air Abatement	0	0	0	-
Refrigeration	5	2,845,954	2,558,223	89.9%
Insulation	1	66,133	49,792	75.3%
Tune-up	5	243,002	243,002	100.0%
HVAC	9	1,177,459	1,231,897	104.6%
Custom Pump	7	8,247,915	8,026,955	97.3%
Irrigation	4	308,470	308,350	100.0%
Miscellaneous	1	753,780	753,780	100.0%
Total (Unique Electric Sites)	**127**	**68,837,272**	**70,333,615**	**102.2%**

The effect of removing the natural gas greenhouse-HVAC realization rates from the overall natural gas realization rate for the combined three years is significant. Before the adjustment, the realization rate was 89% and after the adjustment, it improved to 97%. The realization rates for each of the individual years also increased with the 2009 realization rate improving from 68% to 111%, 2010 from 84% to 92%, and 2011 from 97% to 98%.

Table 4-14. Summary of Realized Savings by Measure Category – Adjusted Natural Gas – 2009, 2010, and 2011 Combined

	Gas Savings (Therms)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	5	28,767	27,251	94.7%
Strategic Energy Mgmt	2	28,394	28,020	98.7%
Process	7	417,860	363,938	87.1%
Boiler	6	228,802	263,722	115.3%
Insulation	7	73,340	80,854	110.2%
Tune-up	6	52,942	52,942	100.0%
HVAC	3	28,712	28,655	99.8%
Greenhouse-HVAC	0	0	0	-
Greenhouse-Other	9	270,190	268,354	99.3%
Miscellaneous	5	274,771	246,857	89.8%
Total (Unique Gas Sites)	**50**	**1,403,778**	**1,360,593**	**96.9%**

Table 4-4-15. Summary of Realized Savings by Measure Category – Adjusted Natural Gas– 2009

	Gas Savings (Therms)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	0	0	0	-
Strategic Energy Mgmt	0	0	0	-
Process	1	1,956	3,022	154.5%
Boiler	0	0	0	-
Insulation	1	22,471	30,128	134.1%
Tune-up	0	0	0	-
HVAC	0	0	0	-
Greenhouse-HVAC	5	0	0	-
Greenhouse-Other	0	0	0	-
Miscellaneous	1	54,154	54,154	100.0%
Total (Unique Gas Sites)	**8**	**78,581**	**87,304**	**111.1%**

Table 4-4-16. Summary of Realized Savings by Measure Category – Adjusted Natural Gas– 2010

	Gas Savings (Therms)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	0	0	0	-
Strategic Energy Mgmt	0	0	0	-
Process	3	267,157	234,025	87.6%
Boiler	0	0	0	-
Insulation	5	41,819	41,676	99.7%
Tune-up	3	18,077	18,077	100.0%
HVAC	2	12,978	12,921	99.6%
Greenhouse-HVAC	1	0	0	-
Greenhouse-Other	2	31,147	31,147	100.0%
Miscellaneous	1	39,840	39,840	100.0%
Total (Unique Gas Sites)	**17**	**411,018**	**377,686**	**91.9%**

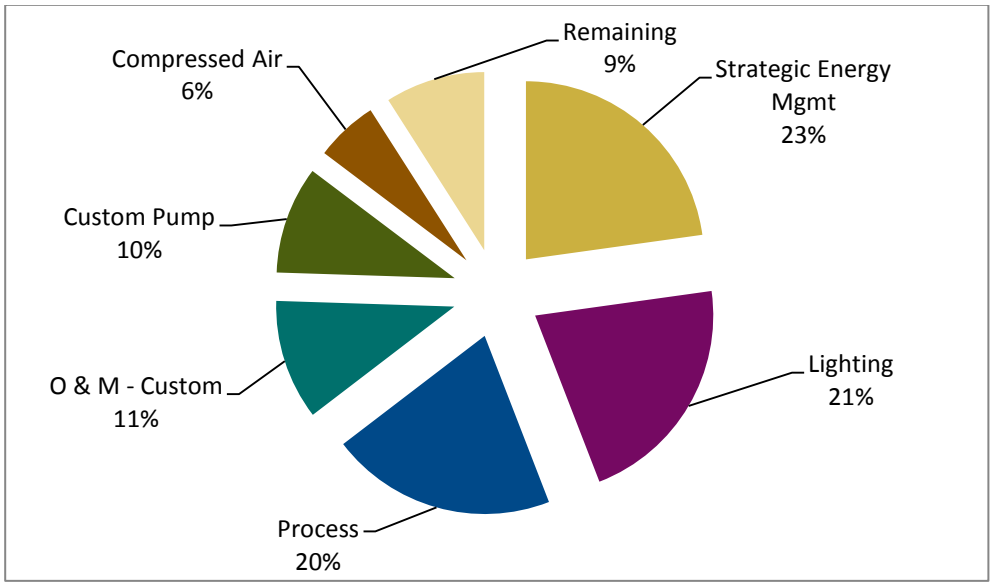
Table 4-4-17. Summary of Realized Savings by Measure Category – Adjusted Natural Gas–2011

	Gas Savings (Therms)			
Measure Category	Sites	*Ex Ante*	*Ex Post*	Realization Rate
O & M - Custom	5	28,767	27,251	94.7%
Strategic Energy Mgmt	2	28,394	28,020	98.7%
Process	3	148,747	126,891	85.3%
Boiler	6	228,802	263,722	115.3%
Insulation	1	9,050	9,050	100.0%
Tune-up	4	34,865	34,865	100.0%
HVAC	2	15,734	15,734	100.0%
Greenhouse-HVAC	4	0	0	-
Greenhouse-Other	7	237,207	237,207	100.0%
Miscellaneous	4	180,777	152,863	84.6%
Total (Unique Gas Sites)	**38**	**912,343**	**895,604**	**98.2%**

The remaining tables and graphs in this section of the report will only include the adjusted values.

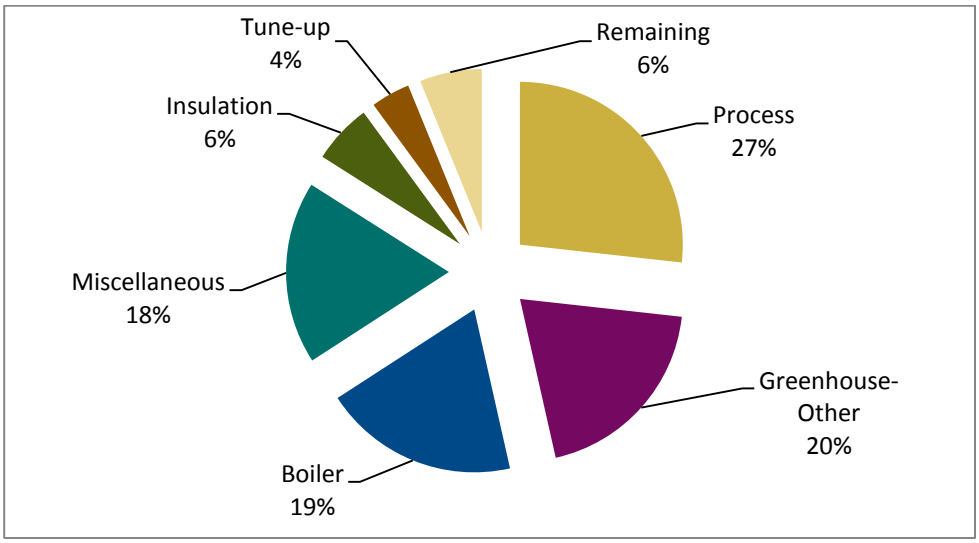
Figure 4-1 illustrates the share of total *ex post* electric savings by measure category. The Strategic Energy Management measure group comprises the largest share (23%) followed by Lighting (21%), and Process (20%).

Figure 4-1. Share of Adjusted Electric *ex post* Savings by Measure Category



As shown in Figure 4-2, the three measure categories with the largest share of natural gas *ex post* savings are Process (27%), Boilers (19%), and Greenhouse-Other (20%).

Figure 4-2. Share of Adjusted Natural Gas *ex post* Savings by Measure Category



Another representation of the evaluation results is a disaggregation by program category.

Table 4-18 provides this disaggregation for electric measures. The program category with the greatest realization rate is Small Industrial with 121%. The lowest is Custom O&M with 87%.

Table 4-18. Summary of Realized Savings by Program Category – Adjusted Electric

	Electric Savings (kWh)			
Program Category	**Sites**	***Ex ante***	***Ex post***	**Realization Rate**
Custom Capital	54	82,161,368	74,681,775	90.9%
Custom O&M	28	22,556,478	19,694,620	87.3%
Lighting	62	36,826,414	38,525,350	104.6%
Prescriptive	42	2,454,207	2,429,760	99.0%
Green Rewind	18	429,080	411,199	95.8%
Small Industrial	18	2,097,239	2,541,512	121.2%
Strategic Energy Mgmt	18	39,174,249	41,742,039	106.6%
Total (Unique Sites)	**115**	**185,699,035**	**180,026,254**	**96.9%**

Table 4-19 provides the natural gas evaluation results by program category. As with electric the program category with the greatest realization rate is Small Industrial with 123%. The Custom Capital program category has the lowest realization rate with 90%.

Table 4-19. Summary of Realized Savings by Program Category – Adjusted Natural Gas

	Gas Savings (Therms)			
Program Category	**Sites**	***Ex Ante***	***Ex Post***	**Realization Rate**
Custom Capital	12	814,847	732,480	89.9%
Custom O&M	5	28,767	27,251	94.7%
Prescriptive	23	526,400	568,506	108.0%
Small Industrial	2	3,534	4,336	122.7%
Strategic Energy Mgmt	2	28,394	28,020	98.7%
Total (Unique Sites)	**42**	**1,401,942**	**1,360,594**	**97.1%**

Figure 4-3 illustrates the share of total *ex post* electric savings by program category. The Custom Capital program category is the largest with 42% and Green Rewind the smallest with less than 1%.

Figure 4-3. Share of Adjusted Electric *ex post* Savings by Program Category

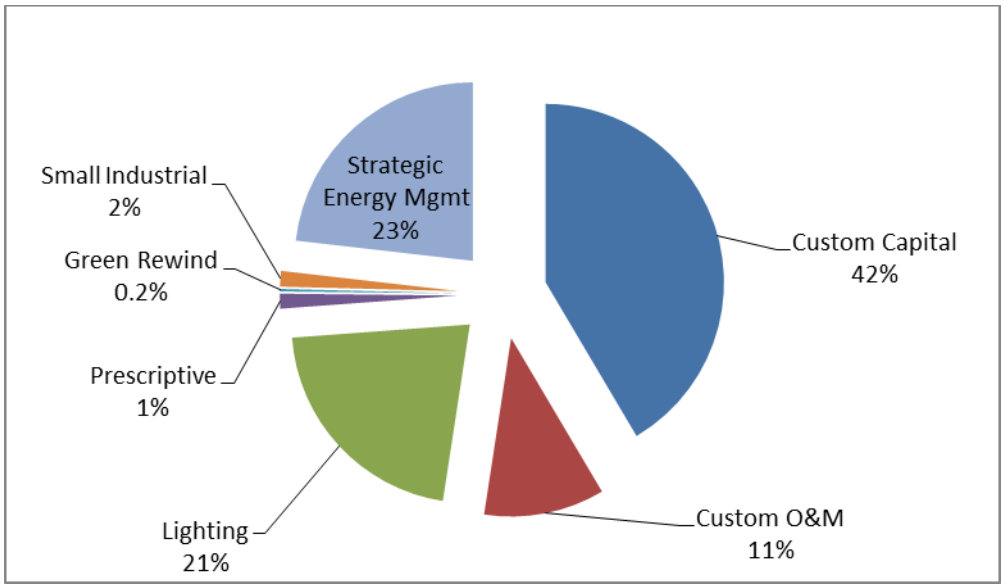
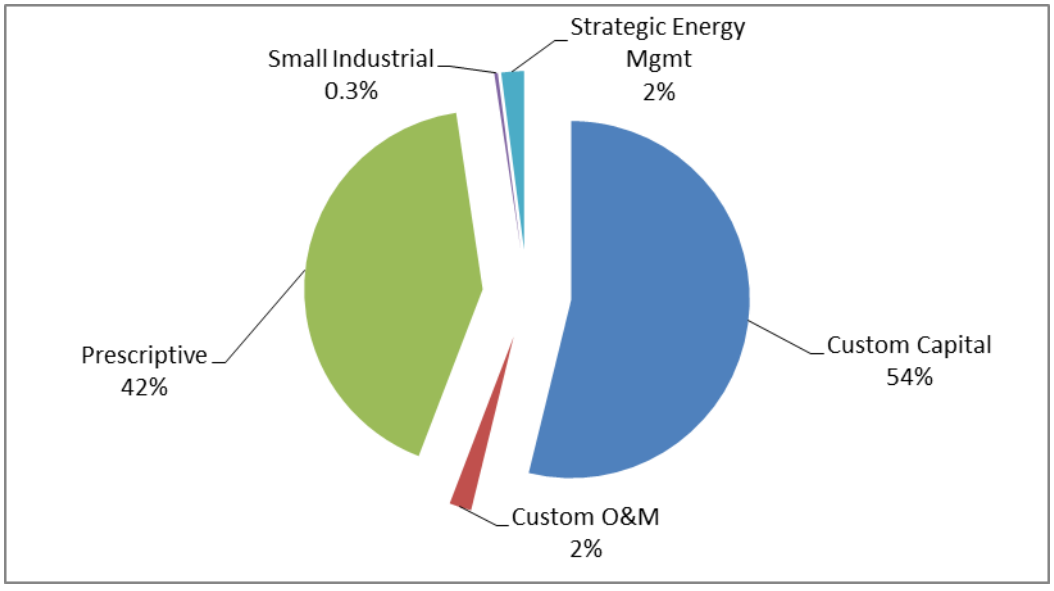


Figure 4-4 illustrates the share of total *ex post* natural savings by program category. The Custom Capital program is the largest with 54% and Small Industrial the smallest with less than 1%.

Figure 4-4. Share of Adjusted Natural Gas *ex post* Savings by Program Category



A final representation of the evaluation results is by business type.

Table 4-20 provides this disaggregation for electric measures. The business type with the greatest realization rate is Apparel Products (162%) followed by Furniture and Fixtures (134%). The lowest is Water and Waste Water with 35% followed by Petroleum and Coal with 72%.

Table 4-20. Summary of Realized Savings by Business Type – Adjusted Electric

	Electric Savings (kWh)			
Business Type	**Sites**	***Ex ante***	***Ex post***	**Realization Rate**
Apparel Products	1	178,695	289,852	162.2%
Chemicals	1	2,270,370	2,587,955	114.0%
Cold Storage	4	10,437,837	7,393,006	70.8%
Computers and Electronic Mfg	9	41,365,454	43,235,902	104.5%
Fabricated Metals	10	4,489,899	4,342,399	96.7%
Food Products	18	11,186,324	9,796,255	87.6%
Furniture and Fixtures	1	38,719	52,020	134.4%
Irrigation	12	8,857,923	9,953,951	112.4%
Metals	5	6,380,880	6,622,438	103.8%
Misc-manufacturing	10	8,716,731	10,340,067	118.6%
Non-Metals Mfg	1	3,564,894	3,881,171	108.9%
Other	12	8,169,503	8,648,323	105.9%
Paper Mfg	4	31,344,363	26,399,859	84.2%
Petroleum and Coal	2	172,692	124,688	72.2%
Printing and Publishing	3	2,674,944	2,627,119	98.2%
Rubber and Plastics	1	871,839	1,016,655	116.6%
Transportation and Aerospace	5	11,768,226	10,370,922	88.1%
Water and Wastewater	3	2,733,910	966,640	35.4%
Wood Products	13	33,002,502	32,552,994	98.6%
Total	**115**	**188,225,705**	**181,202,216**	**96.3%**

Table 4-21 provides the natural gas evaluation results by business type. The Other business type category has the highest realization rate (107%) and Petroleum and Coal the lowest (47%).

Table 4-21. Summary of Realized Savings by Business Type – Adjusted Natural Gas

	Gas Savings (Therms)			
Business Type	**Sites**	***Ex Ante***	***Ex Post***	**Realization Rate**
Chemicals	3	3,724	2,208	59.3%
Computers and Electronic Mfg	4	67,824	46,926	69.2%
Fabricated Metals	3	31,099	32,165	103.4%
Food Products	8	401,301	383,165	95.5%
Furniture and Fixtures	1	7,359	7,216	98.1%
Greenhouse	8	322,732	322,468	99.9%
Misc. Manufacturing	6	43,056	43,056	100.0%
Other	5	95,969	102,294	106.6%
Petroleum and Coal	1	30,849	14,488	47.0%
Printing and Publishing	1	16,808	16,808	100.0%
Wood Products	2	381,221	389,799	102.3%
Total	**42**	**1,401,942**	**1,360,594**	**97.1%**

Figure 4-5 illustrates the share of total *ex post* electric savings for the four largest business types. The Computer and Electronic Mfg. industry is the largest (24%) followed by the Wood Products industry (18%).

Figure 4-5. Share of Adjusted Electric *ex post* Savings by Business Type

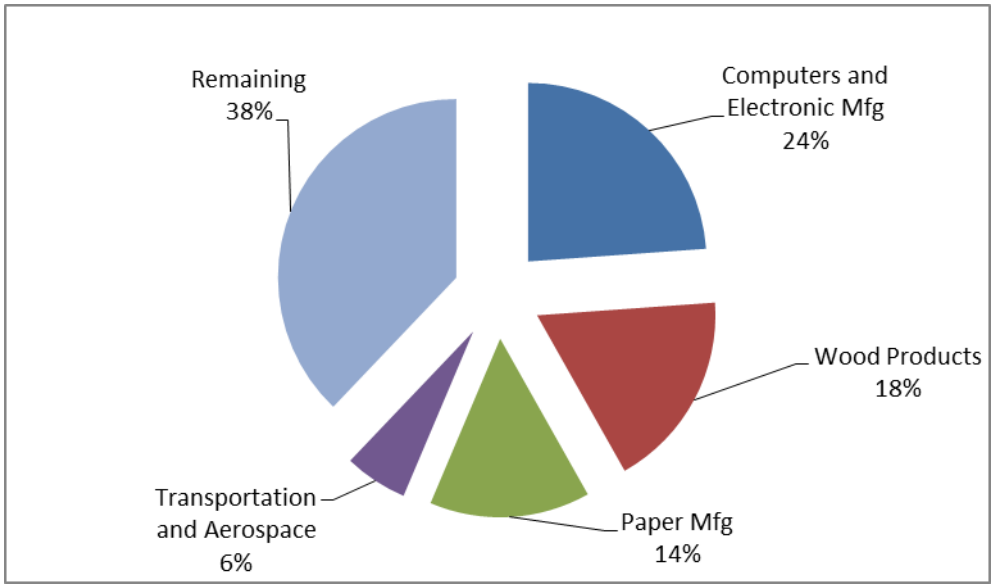
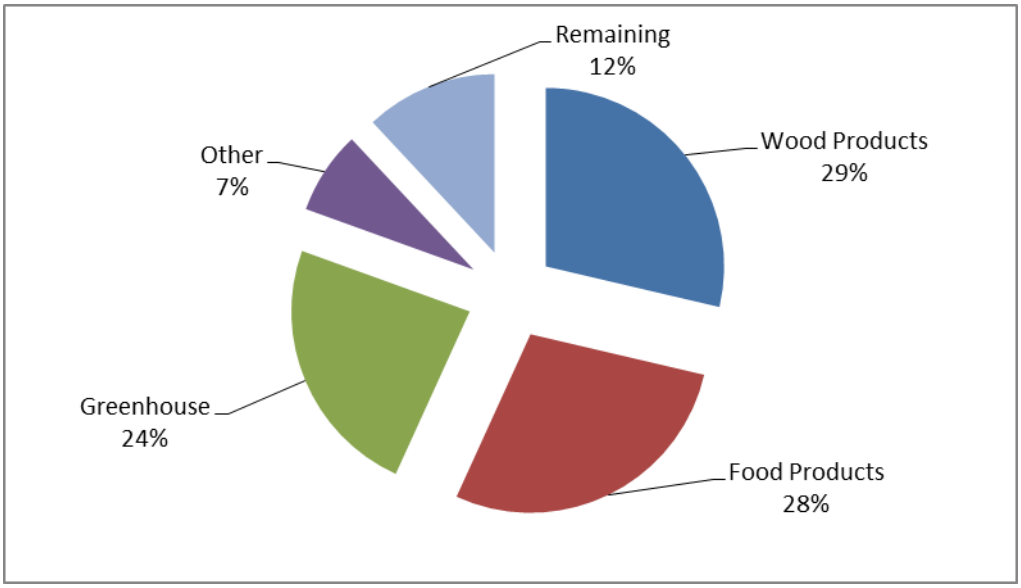


Figure 4-6 illustrates the share of total *ex post* natural savings for the four largest business types. The Wood Products industry is the largest (29%) followed by the Food Products industry (28%).

Figure 4-6. Share of Adjusted Natural Gas *ex post* Savings by Business Type



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5. Impact Evaluation End-Use Detail

Individual site reports and analyses are available in the Appendix. This section summarizes results of most of the end-use categories. The summaries are arranged first by affected fuel and second alphabetically. However, the Strategic Energy Management (SEM) program is addressed in its own subsection between the electric and gas end-uses.

5.1 Electric End-Use Categories

Brief reviews of the following electric end-use categories are provided. These categories include:

- Compressed Air
- Custom Air Abatement
- Custom Pump
- HVAC
- O&M Custom
- Lighting
- Prescriptive
  - Motors
  - Insulation
  - Irrigation
  - Miscellaneous
- Process
- Refrigeration
- Strategic Energy Management

5.1.1 Compressed Air

The compressed air measures were implemented by a variety of contractors and included new VFD air compressors and other high efficiency equipment or controls. The *ex ante* savings for these measures were primarily calculated using simple spreadsheet calculations. Table 5-1 provides details for the type of measures included in compressed air end-use category.

Table 5-1. Measure Details for Compressed Air

Compressed Air Measures				
Measure Type	# of Projects	*Ex ante*	*Ex post*	Realization Rate
VFD Compressor	29	7,202,054	7,484,729	104%
Air compressor Dryer	4	637,343	765,058	120%
Air Compressor Control/O &M	3	510,335	354,308	69%
Misc New Equipment (load reduction)	2	166,498	138,160	83%

5.1.1.1 Program and Evaluation Objectives and Methods

Due to the variety of measure included in this category *ex post* savings were calculated in a variety of ways.

- Monitoring equipment was left on VFD compressors. This equipment provided operating information that was used to calculate the *ex post* savings.
- Spot measurements were taken off of air compressor dryers and other equipment to calculate actual operating power.
- Trending or billing data was collected to calculate large impact measures

5.1.1.2 Evaluation Findings and Recommendations

Overall, the evaluation team found the compressed air program resulted in a realization rate of 102%. Although this is a good overall realization rate, over half of the measures were off by 20% or more when ex *ante* was compared to *ex post*. Table 5-2 provides an overview of the major factors that affected the final savings.

Table 5-2. Factors Affecting Project Level Realization Rates

Factors	# of Projects	*Ex ante*	*Ex post*	Realization Rate
Different load/operating hours than estimated	13	2,416,777	3,332,890	138%
Controls not operating as expected	2	465,054	143,000	31%
Did not use correct compressor curve	2	180,957	296,446	164%
Equipment failed	1	28,513	0	0%
Did not maintain leak detection program (installation included tuning compressed air controls and leak repair)	1	169,276	137,257	81%

Out of the 38 projects, 19 were off by 20% or more when ex *ante* was compared to *ex post*. Thirteen of these projects resulted in different *ex post* savings due to change in operating conditions. VFD savings are very sensitive to change in load and the estimates use in the ex *ante* calculations were often rough estimates based on past projects. The *ex post* savings used measured operating conditions resulting in different saving than were reported *ex ante*.

There were two measures that did not use compressor curves that matched the installed equipment. The model used simplified curves and not the actual manufacturer curves.

There were several projects that had unique issues:

- PE 2042- The night setback controls were not operating as expected resulting in reduced savings.
- PE 2659- Although a VFD was installed on the air compressor, controls were not in place to operate the compressor as the trim. The compressor instead operated at 100% or not at all resulting in a realization rate of 0%.
- PE 2780- The compressed air leak detection measure that was part of this project was not maintained resulting in reduced energy savings
- PE 2944- The VFD caused issues with the motor and burned up several motor until it was removed. It had not been replaced resulting in a realization rate of 0%

5.1.1.3 Conclusions and Recommendations

The compressed air program was found to have a good realization rate of 102%. Although this is a good overall realization rate, over half of the measures were off by 20% or more when *ex ante* was compared to *ex post*. A large portion of these measures were VFD air compressors that are very sensitive to load and it is difficult to estimate *ex ante* estimates beyond using rough estimates based on past projects. Although there may be a high variance between *ex ante* and *ex post* savings, history from past projects is still a reasonable source for estimating *ex ante* savings.

Although it may be difficult to address the operational issues for VFD compressors, curves should be carefully chosen to match the installed compressor whenever possible.

5.1.2 Custom Air Abatement

The custom air abatement program was implemented by a variety of contractors and included system upgrades and consolidation. The *ex ante* savings for these measures were primarily calculated through simple spreadsheet calculations.

The majority of these measures included equipment upgrade and retrofits to scrubbers, dust collection and bughouse equipment. These upgrade included more efficient media and fan controls. Table 5-3 provides details for the type of measures included.

Table 5-3. Measure Details for Custom Air Abatement

Custom Air Abatement Measures				
Measure Type	# of Projects	*Ex ante*	*Ex post*	Realization Rate
Equipment Retrofit	7	2,978,851	3,123,538	105%
Equipment Consolidation	2	1,156,750	540,155	47%
Total	9	4,135,601	3,663,693	89%

5.1.2.1 Program and Evaluation Objectives and Methods

Due to the variety of measures included in this category, *ex post* savings were calculated in several ways.

- Simple spreadsheet calculations using average operating power and operating hours were used to calculate the *ex ante* savings for these measures. Spot measurement and monitoring was performed in order to verify the *ex post* saving for these measures.

5.1.2.2 Evaluation Findings and Recommendations

Overall, the evaluation team found the custom air abatement program to have a realization rate of 89%.

Table 5-4 provides an overview of the major factors that affected savings.

Table 5-4. Factors Affecting Project Level Realization Rates

Factor Affecting Realization Rates	# of Projects	*Ex ante*	*Ex post*	Realization Rate
Reduced load/ operating hours	4	1,192,106	1,874,124	157%
Systems removed	1	875,200	0	0%

In general, changes in load and operating hours resulted in higher realization rates. These higher rates were counteracted by the removal of one system. This specific project (PE 1962) was a system consolidation but due to major process changes at the site, the entire system was removed prior to startup resulting in a realization rate of 0%.

5.1.2.3 Conclusions and Recommendations

Overall, the evaluation team found the custom air abatement program to have a reasonable realization rate of 89%. The major factors that affected this lower realization rate were changes in load or operation. These changes are very difficult to predict but should be expected for these types of measures.

5.1.3 Custom Pump

The Custom Pump measures were implemented by a variety of contractors and included pump VFDs and pump controls. The savings for these measures were originally calculated primarily through simple spreadsheet calculations. Table 5-5 provides details for the type of measures included.

Table 5-5. Measure Details for O&M Custom

Custom Pump Measures				
Measure Type	# of Projects	*Ex ante*	*Ex post*	Realization Rate
Equipment removal/ Consolidation	8	3,663,929	2,901,204	79%
Pump VFD	19	8,065,904	9,640,415	120%
Controls	4	928,862	520,702	56%
Retrofit/Resize	6	4,661,006	4,586,421	98%

5.1.3.1 Program and Evaluation Objectives and Methods

Due to the variety of measures included in this category, *ex post* savings were calculated in a variety of ways.

- Spreadsheet calculations were adjusted to match onsite measurements and operation.
- Monitoring was performed on the VFDs, and savings were calculated based on operation over time.
- Trend data was collected when available and used to calculate both pre and post energy use.

5.1.3.2 Evaluation Findings and Recommendations

Overall, the evaluation team found the Custom Pump program to have a good realization rate of 102%. Several factors were involved that affected the overall savings.
Table 5-6 provides an overview of the major factors that affected the final savings.

Table 5-6. Factors Affecting Project Level Realization Rates

Factor Affecting Realization Rates	# of Projects	*Ex ante*	*Ex post*	Realization Rate
Operational Changes	9	6,168,673	7,024,132	114%
Shut Off/Removal	4	801,088	0	0%

For nine of the 37 projects evaluated, the *ex ante* kWh savings were off due to changes in load and operation hours on the pumps. These factors are very difficult to account for as they change based on non-programmatic factors.

Four of the 37 projects were removed completely due to large portions of a site being shut down. PE 2615, PE 2930, PE 3555, and PE 4671 were completely removed from the sites after around a year, substantially less than their expected lifetimes, and were no longer operating. The decision to invest in the energy efficiency measure was made before the decision to shut the process down and the latter decision is an overriding decision.

5.1.3.3 Conclusions and Recommendations

The majority of the projects installed under this program were pump VFD measure. Out of the 30 projects installed 13 of the projects had a realization rate that was off by 20% or more. The main factors that affected final energy savings were operational changes, such as change in hour and load. These factor are difficult to account for but should be expected for these types of measures.

5.1.4 HVAC

The HVAC measures were implemented by a variety of contractors and included new energy efficient equipment and fan VFDs. The savings for these measures were originally calculated primarily using spreadsheets. Table 5-7 provides details on the types of measures included.

Table 5-7. Measure Details for HVAC

HVAC Measures				
Measure Type	# of Projects	*Ex ante*	*Ex post*	Realization Rate
New Energy Efficient Equipment	8	772,107	693,315	90%
Insulation Upgrades	1	1,867	1,867	100%
Fan VFD	5	593,219	654,197	110%
Controls	3	561,340	629,486	112%

5.1.4.1 Program and Evaluation Objectives and Methods

Due to the variety of measures included in this category *ex post* savings were calculated two ways.

- The new equipment was confirmed to be installed on site and spot measurements were taken to assess operational power of the new equipment.

- For VFD and controls measures, trend or monitoring data was collected to measure operating power over time of the equipment impacted.

5.1.4.2 Evaluation Findings and Recommendations

Overall, the evaluation team found the HVAC program to have a good realization rate of 103%. Several factors were involved that affected overall savings. Table 5-8 provides an overview of the major factors that affected the final savings.

Table 5-8. Factors Affecting Project Level Realization Rates

Factor Affecting Realization Rates	# of Projects	*Ex ante*	*Ex post*	Realization Rate
Operational Changes	2	143,750	271,253	189%
Calculation Methodology	1	75,928	22,563	30%

Changes in load affected two of the projects. These two projects had higher operating hours than expected in the *ex ante* calculations.

The original *ex ante* calculations for site PE 2384 were based on constant load throughout the cooling period and did not account for the effects of variations in outdoor air temperature. When these adjustments were made, the calculations showed the baseline system used much less energy than expected, resulting in a lower realization rate.

5.1.4.3 Conclusions and Recommendations

The majority of the projects installed under this program were new energy efficient heating and cooling equipment. When calculating load for HVAC systems it is important to account for changes in outdoor air temperature throughout the year. Typical meteorological year (TMY) data are available to represent the weather data for a variety of locations for a typical year and should be used.

5.1.5 O & M - Custom

The O & M – Custom measures were implemented by a variety of contractors and included air compressor CFM reduction and several O&M projects. The savings for these measures were originally calculated in a variety of ways including spreadsheet calculations and whole system energy models. Table 5-9 provides details for the type of measures included.

Table 5-9. Measure Details for O&M Custom

Custom O&M Measures				
Measure Type	# of Projects	*Ex ante*	*Ex post*	Realization Rate
Air Compressor CFM Reduction	26	14,366,335	12,806,081	89%
Refrigeration O&M	5	1,062,120	789,639	74%
Custom Air Compressor O&M	2	3,809,676	3,168,211	83%
HVAC O&M	4	792,810	826,590	104%
Misc O&M	3	2,584,532	1,904,244	74%

5.1.5.1 Program and Evaluation Objectives and Methods

Due to the variety of measures included in this category *ex post* savings were calculated in a number of ways:

- For the CFM reduction measures, compressor information was collected from the manufacturer as well as any compressor operation data that was available. This information was used to calculate the savings due to the reduction in compressor CFM.
- For the O&M measures trend data was collected to analyze the effects of O&M on the system. If detailed trend data was not available, equipment monitoring was used to calculate current system operation.

5.1.5.2 Evaluation Findings and Recommendations

Overall, the evaluation team found the Custom O&M program has a reasonable realization rate of 87%. Table 5-10 provides an overview of the major factors affecting savings.

Table 5-10. Factors Affecting Project Level Realization Rates

Factor Affecting Realization Rates	# of Projects	*Ex ante*	*Ex post*	Realization Rate
Interaction with other measures	3	4,388,160	2,967,826	68%
Change in Power per CFM (lower)	2	1,272,457	804,494	63%
Change in Power per CFM (higher)	1	541,368	1,015,109	188%
Change in Operating Hours	3	2,456,490	1,275,700	52%

For three of the 40 projects evaluated, the *ex ante* kWh savings calculations overstated savings by not accounting for interactive effects between the projects and other measures installed at the facilities. For two of the three measures (PE 3706 and PE 3357), large reductions in compressed air load reduced available potential savings from other measures. For the third project (PE 4073) several interacting refrigeration measures were installed at the same time, resulting in fewer savings than originally calculated. It can be difficult to account for these types of effects, but if a single contractor is installing several measures, their staff need to consider the impacts of each measure on the overall project.

Ex post power per airflow for compressed air systems was calculated through system monitoring, spot measurements, or manufacturer specifications at the operating air pressure, depending on which were available. Due to the simplified *ex ante* spreadsheet calculators that were used in some cases, these values were not always the same. This can be avoided in the future either by taking measurements once the system is running or by ensuring that the correct manufacturer information is being used for the installed air compressors.

Modified production schedules are also difficult to anticipate, and are affected by non-programmatic factors. During Navigant's evaluation, several sites were operating at lower production or operational hours than during the original project implementation.

Three measures resulted in 0% realization:

- PE 2159 - based on timer controls to reduce compressor operation at night. These controls have been removed invalidating the savings for this measure.
- PE 3964 - due to leak detection and repair. These activities were not carried out, resulting in no savings.
- PE 4007 - due to large part of the facility being shut down. The systems involved with this project were shut down and are not expected to operate in the future.

5.1.5.3 Conclusions and Recommendations

The majority of the projects installed within this end-use category were air compressor airflow reduction, including leak repair and equipment replacement. Of the 40 projects installed, only one-fourth had *ex post* savings that were off by 20% or more from the *ex ante* value.

Some steps can be taken to more accurately calculate the savings for these measures:

- Ensure that projected savings estimates properly account for other measures installed at the site.
- Confirm that the energy per airflow value used in calculations accurately represents the installed equipment, through manufacturer specifications or measurements of the operating equipment.

5.1.6 Lighting

The Lighting projects' *ex ante* energy savings estimates were calculated mainly through the use of the Energy Trust Lighting Tool. Navigant's evaluation site visits included 111 lighting projects.

5.1.6.1 Program and Evaluation Objectives and Methods

Lighting counts or sample counts were done for each project. When controls were implemented, Navigant used lighting trend loggers to confirm sensor operation. Any adjustments to fixture or control numbers were then used to recalculate *ex post* impacts using the Energy Trust Lighting Tool with modified numbers based on data gathered during the site visit.

5.1.6.2 Evaluation Findings and Recommendations

Overall, the evaluation team found the lighting projects to have a good realization rate of 105%. Several factors were involved that affected overall savings. Table 5-11 provides an overview of the major factors affecting savings.

Table 5-11. Factors Affecting Project Level Realization Rates

Factors affecting realization rates	# of Projects	*Ex ante*	*Ex post*	RR
Change in fixture numbers (Delamping, more no. of retrofits than originally est.)	6	1,284,004	1,712,382	133%
Operational Changes	10	1,841,283	2,242,478	122%
Difference in calculation method for controls	2	19,875	31,728	160%

The *ex post* savings calculations for several projects included changes in operational hours and numbers of fixtures. In some cases, certain building areas had different operating hours than the site as a whole, resulting in energy use being over or under estimated. For projects PE 2744 and PE 3324, Navigant was unable to access certain areas of the facility where lighting controls had been installed, and instead used standard savings of 45% to calculate savings from the controls[3] based on the area type.

5.1.6.3 Conclusions and Recommendations

The Energy Trust Lighting Tool is a very effective method to calculate savings for lighting retrofits. The issues Navigant encountered during site visits had little impact on the overall savings.

5.1.7 Prescriptive

Prescriptive measures were implemented through Energy Trust's prescriptive calculators. The savings for these measures were based on the prescriptive counts for each individual measure. Table 5-12 provides details for the type of measures included.

Table 5-12. Measure Details for Prescriptive

Custom O&M Measures				
Measure Type	# of Projects	*Ex ante*	*Ex post*	Realization Rate
Green Rewind	66	422,933	405,052	96%
High Efficiency Motor	185	1,040,397	1,035,213	100%
Insulation	6	267,437	251,096	94%
Demand Control Ventilation	9	302,182	302,182	100%
Irrigation Upgrades	20	1,017,440	1,017,440	100%

5.1.7.1 Program and Evaluation Objectives and Methods

The prescriptive measure *ex ante* savings were accepted as long as the equipment was installed and operating as originally reported in the calculations. Navigant interviewed site personnel to confirm equipment operation.

5.1.7.2 Evaluation Findings and Recommendations

During the evaluation, Navigant collected additional information about these prescriptive measures:

- Green Rewind - Site personnel seem to have little knowledge about these measures. They are typically being recommended by the rewind contractors not requested specifically in advance by site personnel.
- HE Motor - For several of the sites, the installation of high efficiency motors; especially large motors, is standard practice, and this measure is being phased out due to the increased efficiency required by new government standards.

[3] page 132, Table 24-5 from http://www.aesc-inc.com/download/spc/2012spcdocs/UnifiedManual/Customized%202.0%20Energy%20Savings.pdf

- Demand Control Ventilation - Navigant confirmed that the equipment was installed and operating correctly but it was very difficult to verify the impact of these measures in the absence of detailed EMS trend logs.
- Irrigation - The evaluation team applied the original (2010) deemed savings for agricultural irrigation projects because those savings were appropriate at the time the program was designed. However, the Regional Technical Forum (RTF) changed the status of the deemed savings for prescriptive irrigation measures to "out-of-compliance" in February 2011. As of April 2013 the RTF updated this measure back to "Active" but the measure category has been changed to "Small Saver", with a sunset date of April 2018.

5.1.7.3 Conclusions and Recommendations

The prescriptive measure tools that are available to provide clear guidance to both the implementers and evaluation team and should be continued.

5.1.8 Process

Process projects were implemented by a variety of contractors and included new energy efficient equipment and system consolidation. Savings for these measures were originally calculated in a variety of ways ranging from basic spreadsheet calculations to complex predictive models based on utility billing data. Table 5-13 provides details for the types of measures included in the process category.

Table 5-13. Measure Details for Process

Process Measures				
Measure Type	# of Projects	*Ex ante*	*Ex post*	Realization Rate
New Energy Efficient Equipment	15	7,589,732	7,680,507	101%
Equipment Retrofit/Repairs	4	1,508,965	1,443,467	96%
Motor VFD's	7	5,990,510	2,235,093	37%
System Consolidation/ Optimization	10	25,912,991	24,969,979	96%
Equipment Removal	1	36,792	36,792	100%

5.1.8.1 Program and Evaluation Objectives and Methods

Due to the variety of measure included in this category *ex post* savings were calculated in a variety of ways.

- For energy efficient equipment, motor VFDs, and equipment retrofit or repair, spot measurements and current or power trend logging were used to calculate operating power and load. Navigant then compared this information to baseline operation and energy use to calculate savings.
- For system consolidation and optimization projects, facility trend data and/or billing data were used for calculations, due to the large scale impact of these measures. Pre- and post-installation data were collected, and savings were calculated from the difference in operation during these two periods.

- For equipment removal, Navigant confirmed the equipment had been removed and, when possible, took spot measurements of power use of similar equipment.

5.1.8.2 Evaluation Findings and Recommendations

Overall, the evaluation team found the process program has a reasonable realization rate of 89%. Table 5-14 provides an overview of the major factors that affected savings.

Table 5-14. Factors Affecting Project Level Realization Rates

Factors	# of Projects	*Ex ante*	*Ex post*	Realization Rate
Fully loaded (VFD)	3	5,034,051	1,091,378	22%
Change in load	5	4,497,221	4,094,463	91%
Change in operational set points	1	231,370	356,731	154%
Low baseline estimate	1	133,018	42,507	32%

For three of the 37 projects evaluated, the *ex ante* kWh savings calculations overstated realized savings due to the system being fully loaded. VFDs provide savings when the system is underloaded, and can run at reduced speed. Because the equipment was nearly fully loaded, the VFD installations resulted in minimal savings. When installing VFDs it is important to understand the operation of the load and motor on which the VFD is to be installed. Equipment that is fully loaded will get no benefit from VFD installation.

Ex post estimates of measure savings varied from *ex ante* estimates primarily due to changes in operation. System load and operational set points can be difficult to predict and are affected by non-programmatic factors. Navigant adjusted the *ex post* calculations to reflect current operating conditions.

PE 2341 resulted in lower than expected savings due to increased operation relative to the prediction used in the *ex ante* calculations. The system was manually controlled, so it is difficult to estimate actual baseline operation without pre-installation system monitoring. Navigant installed monitoring equipment to measure operation after the upgrades had been installed. Although a reduction in operational hours was found, it was not as high as originally expected. It is possible that the reported baseline conditions may have underestimated baseline operating hours and savings may be greater than Navigant was able to confirm, but without detailed baseline data there is no way to verify if this is the case.

5.1.8.3 Conclusions and Recommendations

The majority of the savings for this program came from system optimization and consolidation projects. The programs lower realization rate was mainly due to VFDs being installed on systems that were close to fully loaded.

Some steps can be taken to more accurately calculate the savings for these measures:

- Before recommending or installing VFDs for energy savings, implementers should confirm that the affected system is running partially loaded much of the time.

- Additional measurements should be taken for any equipment that is manually controlled as it is very difficult to accurately determine operation of manually controlled equipment without trend data.

5.1.9 Refrigeration

The refrigeration program was implemented by a variety of contractors and included fan controls, system commissioning and system upgrades. The *ex ante* savings for these measures were primarily calculated through system modeling or complex billing analysis. Table 5-15 provides details for the type of measures included.

Table 5-15. Measure Details for Refrigeration

Refrigeration				
Measure Type	# of Projects	*Ex ante*	*Ex post*	Realization Rate
Evaporator VFD	6	2,818,765	2,379,791	84%
Compressor VFD	3	1,046,754	1,075,403	103%
Oversized Condenser/Fan VFD	2	947,904	878,614	93%
System Controls and set point changes	4	3,329,554	1,819,396	55%
Fast Acting Doors	2	146,017	126,164	86%
New Construction- Efficient Equipment and Controls	1	616,249	439,195	71%
Misc- Efficient Secondary Equipment	2	94,446	107,890	114%

5.1.9.1 Program and Evaluation Objectives and Methods

Due to the variety of measures included in this category, *ex post* savings were calculated several ways:

- Monitoring equipment was left on the VFD compressors and fans. This equipment provided operating information that was used to calculate the *ex post* savings.
- Facility trend logs and/or utility billing data were collected to calculate savings from large scale measures. Trend data was more readily available for large refrigeration projects than for many of the other programs.
- Spot measurements and on site operation confirmation were often used to verify that all of the measures were installed and operating as expected for complicated, multi-measure projects.

5.1.9.2 Evaluation Findings and Recommendations

Overall, the evaluation team found the refrigeration program to have a relatively low realization rate of 76%.

Table 5-16 provides an overview of the major factors that affected the final savings.

Table 5-16. Factors Affecting Project Level Realization Rates

Factor Affecting Realization Rates	# of Projects	*Ex ante*	*Ex post*	Realization Rate
Different load	4	1,445,806	1,082,263	75%
Double Counting	1	2,526,670	1,175,962	47%
Not Installed	1	152,506	0	0%
New Construction- System Performance	1	616,249	439,195	71%

Of the 20 projects, seven varied by 20% or more when *ex ante* savings were compared to *ex post* savings. Four of these projects had different *ex post* savings due to changes in operating conditions, resulting in loading changes. VFD savings are very sensitive to changes in load and several of these projects included VFD installation. *Ex post* savings were calculated using monitored operating conditions but *ex ante* savings had to be calculated based on estimated loads.

There were several projects that had unique issues:

- PE 1654 - Several measures were installed at the same time for this project, affecting a large portion of facility energy use, so utility billing data were used to calculate *ex ante* savings. When reviewing the bills, it was noted the site was reducing its year to year energy use based on several additional energy efficiency measures installed each year. The *ex ante* calculation did not account for these reductions in annual energy use from installation of additional measures, resulting in double counting of these measures when facility billing data were used for calculations. The additional savings from these measures were removed from the *ex post* calculations resulting in a realization rate of 47%.
- PE 1688 - This project covered the efficient construction of a new refrigerated warehouse. The *ex ante* baseline and savings were calculated using predicted load and operational conditions. Navigant obtained data from the facility showing current operating conditions, and adjusted the baseline to account for changes in operation. The changes in operational conditions resulted in a 71% realization rate.
- PE 3367 - Although the equipment for this project was at the site at the time of Navigant's evaluation it had not been installed and the client was unsure when or if it would be installed, resulting in a 0% realization rate.

5.1.9.3 Conclusions and Recommendations

The major factor contributing to this relatively low realization rate was the double counting of measures for a large commissioning project. This project was very complex and *ex ante* savings were calculated using facility utility bills. When using billing analyses to calculate savings it is very important to identify trends within the billing information and to account for outside factor that might affect the site's energy usage. The Program Delivery Contractors' (PDC) should detail more carefully why a particular baseline was chosen especially if there is a trend in it.

5.2 Strategic Energy Management (SEM) Program

SEM projects involve lengthy engagements between participants and Industrial Technical Service Providers (ITSPs). Projects focus on either improving energy efficiency through technical aspects of operations or developing organizational goals and practices concentrated on energy efficiency. SEM

components have a three-year measure life and can be organized into three sub-categories: enabling tools, technical, and comprehensive.

Enabling tools program components offer tools to monitor energy use and estimate energy savings resulting from process improvements. Information from these tools provides organizations with custom dashboards of their real-time energy usage by key processes and equipment. These tools support other SEM initiatives.

Technical program components drive savings through a process of identifying system energy savings opportunities and delivering training to facility staff focused on achieving savings from these identified opportunities. Under these components, ITSPs study processes for savings opportunities, and train systems operators' how to improve the efficiency of the systems they manage.

Comprehensive program components target savings across participating organizations through initiatives designed to focus company goals on energy efficiency.

The following section summarizes Navigant's impact evaluation findings of the SEM offering, along with actionable recommendations that seek to improve the efficiency and savings achieved through future program cycles.

5.2.1.1 Program and Evaluation Objectives

The goal of the SEM program is to put into operation a process of continuous energy management improvements which enables energy savings and reductions in energy intensity. Energy savings are expected to be achieved through operational and maintenance (O&M) improvements, incremental increases in capital energy efficiency projects (e.g.: more lighting efficiency), additional capital projects that would not otherwise have been considered (e.g.: process changes, consideration of energy efficiency in all capital efforts), and improved persistence for O&M and capital projects. The impact evaluation of the SEM program both characterized and quantified:

- Project and program-level energy savings achieved through continuous energy management improvements;
- The persistence of achieved savings; and
- Customer feedback on the SEM program to determine which program elements were most successful while soliciting opportunities for future program improvements.

5.2.1.2 Evaluation Findings

Overall, the evaluation team found the SEM program to be operating successfully; evaluation efforts verified 107% of *ex ante* kWh savings and 99% of *ex ante* therm savings. Table 5-17 and Table 5-18 provide an overview of the 18 SEM projects evaluated by Navigant.

The evaluation team also confirmed that a majority of projects demonstrated persistence of achieved energy savings attributed to continuous energy management improvements, and a high level of customer satisfaction. The majority of the participants continue to maintain their energy teams while expecting to undertake additional energy savings measures in the future.

Table 5-17. SEM Category Level Evaluated Savings (kWh)

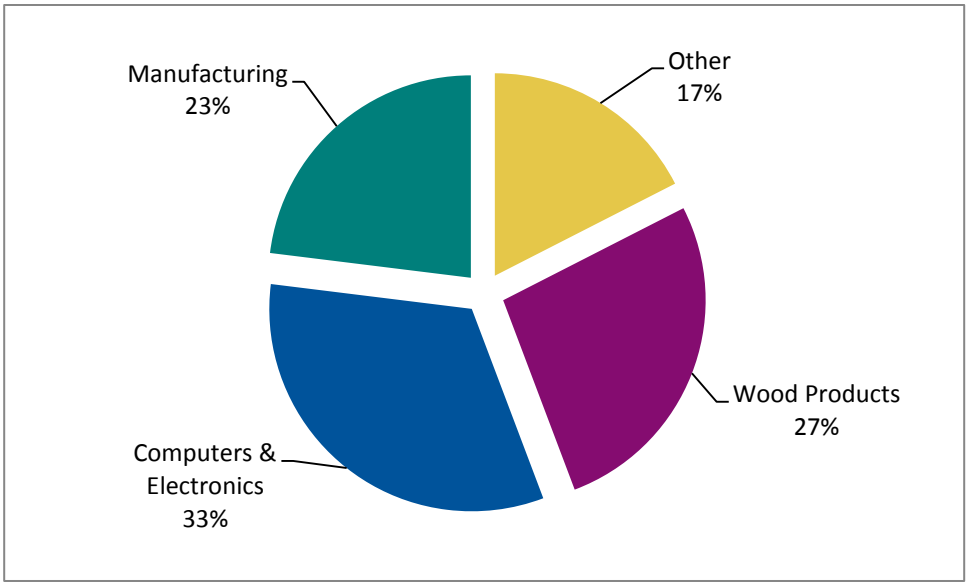
SEM Measure Category	*Ex ante* Savings (kWh)	*Ex post* Savings (kWh)	Realization Rate
Custom O&M	10,948,549	9,044,176	83%
Industrial Energy Improvement (IEI)	28,225,700	32,697,863	116%
Total	**39,174,249**	**41,742,039**	**107%**

Table 5-18. SEM Category Level Evaluated Savings (Therms)

SEM Measure Category	*Ex ante* Savings (therms)	*Ex post* Savings (therms)	Realization Rate
Custom O&M	394	20	5%
Industrial Energy Improvement (IEI)	28,000	28,000	100%
Total	**28,394**	**28,020**	**99%**

Figure 5-1 illustrates the distribution of *ex post* kWh savings based on participating facility type. The most prevalent type of industry is Computers & Electronics (33%) followed by Wood Products (27%) and Manufacturing (23%). There were only two natural gas SEM projects with 99% of the *ex post* therm savings coming from one project; in the Industrial Metals manufacturing sector.

Figure 5-1. SEM *Ex post* Savings (kWh) by Facility Type (Program Years 2010 & 2011)



Measures implemented through the SEM initiative typically fell into two categories:

1. Custom refrigeration initiatives, including:
    a. Fan cycling;
    b. Floating head pressure control; and

   c. Freezer temperature set point increase.
2. Operation & Maintenance (O&M) which had a much broader scope, including:
   a. Production line consolidation;
   b. Compressed air leak detection initiatives; and
   c. Air compressor adjustments.

Factors affecting project-level realization rates for the SEM initiative are provided in Table 5-19.

Table 5-19. Factors Affecting Project Level Realization Rates[4]

Factor Affecting Realization Rates	# of Projects	*Ex ante* kWh	*Ex post* kWh	Realization Rate
Interactive Effects	4	11,938,190	4,482,959	38%
Modified Production Schedule	5	8,865,796	15,349,182	173%

At four of the 18 SEM projects evaluated, the *ex post* kWh savings calculations overstated realized savings by not accounting for interactive effects between SEM initiatives and other incented measures at participating facilities. These were primarily projects that implemented controls modifications. Moving forward, ensuring that projected SEM savings estimates properly account for other, interactive measure savings reductions to prior projects that are incentivized through different program paths will minimize overstatement of savings and improve the consistency between *ex ante* and *ex post* project savings which contributed to the relatively low realization rate for affected projects.

Modified production schedules are also difficult to control, and are affected by non-programmatic factors. The industrial sector is particularly sensitive to economic changes because production throughput, occupancy, and operating schedules are driven by customer demand. Collectively, the realization rate for the four affected projects was 173%, but the standard deviation around this realization rate is high because project-level realization rates could be higher or lower than 100% based on production increase or decrease. Another useful metric to gauge SEM performance independent of non-programmatic factors affecting production schedules would be to calculate "as installed" savings using the same production levels at the time of SEM implementation. This would provide a more accurate portrayal of the quality of project documentation and project savings assumptions:

1.) *Full Production (Ex ante) Baseline Operating Schedule:* Both pre- and post-installation energy consumption is calculated using the production schedule observed at the time of participation (i.e.: full production schedule).

2.) *Current Production (Ex post) Baseline Operating Schedule:* Post-installation energy consumption is calculated using the production schedule observed during the on-site M&V process (i.e.: current production schedule).

[4] It should be noted that the *ex ante* kWh values do not sum to the total SEM *ex ante* savings because some projects had multiple, overlapping factors affecting the *ex ante* savings estimates.

5.2.1.3 Evaluation Methodology

The following subsections provide a detailed description of the evaluation strategies used to verify SEM *ex ante* Savings estimates for all projects evaluated in the sample. In general, Navigant adhered to International Performance, Measurement and Verification Protocols[5] to verify SEM *ex ante* savings estimates (Table 4-1 and
Table 5-18), prioritizing data collection and evaluation resources on measure parameters that had the largest influence on project savings (e.g., efficiency, hours of production, etc.).

Key steps in the evaluation process, included:

- **Review of Program Application Data and Assumptions:** An in-depth review of all SEM project documentation allowed Navigant to verify the accuracy of input assumptions and calculated savings, thereby ensuring that they were representative of installation conditions and consistent with industry standards. Additionally, the thorough review of program application data and assumptions provided guidance on the most appropriate data collection strategy for key project performance variables that may have been missing (e.g.: operating hours, loading capacity, etc.).
- **Physical Observation of SEM Initiatives:** On-site observations of equipment performance complemented the review of program application data and assumptions. Physical observation activities ranged from simple verification to IPMVP Options B (engineering calculations using metered data) and C (analysis of utility meter data) in cases where additional spot measurements or trending information would provide better accuracy of *ex post* savings estimates.
- **Discussions with Plant Personnel:** For evaluated SEM projects, Navigant conducted interviews with site personnel involved in the SEM decision making process to capture recollections about the SEM experience within the context of their energy intensity reductions. Interview feedback informed realization rate calculations and explained deviations between *ex ante* and *ex post* project savings. Navigant solicited feedback on a number of SEM project factors, including:
    - Participant challenges in achieving energy savings goals, and progress made;
    - Strengths and weaknesses of SEM offerings;
    - Recommendations for future SEM changes or augmentation;
    - Economic and production baselines and current production status;
    - Participant long term energy efficiency plans, strategies, and outlook;
    - Status of the energy teams; and
    - Convenient times to check back on the facilities' progress in the future.
- **Procurement of Energy Billing Data and Facility Trend Data:** Where billing and trend data could be procured from the Energy Trust or participants, Navigant conducted an energy consumption analysis based on the weekly or monthly production and consumption data provided by the facility. The participant's energy consumption in the pre-period (the baseline period) was compared against consumption in the post-periods after the SEM initiatives had been implemented (typically six months to a year). The savings estimates depended on weather, facility production, and other observable factors that can affect energy consumption (including some energy-efficiency related capital measures).

[5] International Performance, Measurement and Verification Protocols, Concepts and Options for Determining Energy and Water Savings, Volume I, 2012. http://www.evo-world.org/

5.2.1.4 Conclusions and Recommendations

Overall, the evaluation team found the SEM program to be operating successfully; evaluation efforts verified 105% of *ex ante* kWh savings and 99% of *ex ante* therm savings. The evaluation team also confirmed that a majority of projects demonstrated persistence of achieved energy savings attributed to continuous energy management improvements, and procured high customer satisfaction. A majority of the participants continue to maintain their energy teams while expecting to undertake additional energy savings measures in the future. Based on the feedback obtained through the interviews with program participants, and analysis of factors affecting realization rates, the evaluation team offers the following SEM recommendations to continually improve the program in future program cycles:

- Ensure that projected SEM savings estimates properly account for other, interactive measure savings that are incentivized through different program paths. This will minimize double counting savings and improve the consistency between *ex ante* and *ex post* project savings.
- Ensure that SEM marketing materials emphasize knowledge transfer and sharing to ensure that savings persist in the event of staff or organizational turnover.
- In future evaluations, a second useful metric to gauge SEM performance independent of non-programmatic factors affecting production schedules would be to calculate "as installed" savings using the same production levels at the time of SEM implementation. This would provide a more accurate portrayal of the quality of project documentation and project savings assumptions.
- Have participants provide the Monitoring, Targeting, and Reporting (MT&R) data on a regular basis and provide feedback to the customers on the results. This will make collecting the MT&Rs more relevant and also allow Energy Trust to track those that are no longer using the MT&R.
- Continue the SEM as a regular component of the PE Program:
    - Ensure high-level management support and a mix of involvement, including team members from multiple levels of the company.
    - The executive sponsor can support the energy team by freeing up the resources necessary to undertake the SEM activities and requiring that the team show progress at regular status update meetings.

5.3 Greenhouse Natural Gas Measures

Energy Trust included several measures for its greenhouses program. They provided prescriptive *ex ante* savings for several measures including thermal curtains, under bench heating, infrared (IR) poly film covers, and greenhouse controls.

They also provided a custom track for other more complex measures. These measures where typically modeled in a United States Department of Agriculture (USDA) software model called Virtual Grower 3. These measures were categorized as HVAC and included greenhouse wall and roof upgrades, thermal curtain, and new high efficient heaters. When comparing the *ex ante* savings of Virtual Grower to onsite billing data, Navigant noted that gas usage seemed much higher than expected. This was due to very low modeled heater efficiency and resulted in unrealistically high baseline gas usage when compared to utility bills.

Navigant created a simple conduction model to calculate *ex post* savings of the measures modeled in Virtual Grower. Using local weather data each greenhouse was modeled with its upgrades as originally done in Virtual Grower. Due to the adjustments made in heater efficiency these models resulted in *ex post* with realizations rates of 50% to 60%.

A second review of these measures revealed that the bills were changing very little after a measure had been installed. Due to several factors it was difficult to quantify the impact of these measures.

- It was difficult to associate billing data with site usage as it was unclear what percentage of the greenhouse area was affected.
- Space temperature control often varied substantially from year to year based on the needs of the plants being grown in the greenhouse.
- Small changes in space temperature had the potential to greatly impact the savings of greenhouse measures.

Due to these factors it is impossible to reliably calculate the savings seen at these sites so no realization rates have been applied to these measures.

For the prescriptive measures, the numbers of units were confirmed at each site. The values provided in the prescriptive calculator were accepted to be correct as long as the number of units and proper operation were verified.

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6. Recommendations

The Navigant evaluation staff carefully documented the impact evaluation process in an effort to capture and assess program feedback based on program data, installation reports, evaluation observations and discussions with participants. This information was used to develop recommendations that should improve the operation of the Production Efficiency Program as well as future impact evaluation efforts.

Include Detailed Calculation Spreadsheets with All Project Files - Many of the Energy Trust project files included detailed calculation spreadsheets, which facilitated efficient and accurate review of project savings. This has improved substantially since Energy Trust switched to electronic program files. However, some project files, particularly those with complicated models, did not include enough data to thoroughly evaluate the calculations used in determining *ex ante* savings. Although *ex post* savings are often calculated independently, the original calculation details are helpful in determining the reasons for any discrepancies between the two savings values. Navigant recommends that Energy Trust continue to include as much detailed data as possible in their program records.

Work with Participants in Compressed Air Leak Detection Studies to Ensure Continued, Efficient Leak Detection Program Implementation - Energy Trust incentivized compressed air leak detection and repair projects for a number of participants. Although all of these projects resulted in short term savings, compressed air leak detection and repair must be implemented every few months in order to maintain savings. In particular, after about six months to a year a system will have redeveloped leaks equivalent to those which were repaired. This is because pressure and vibration in the system drive leak formation, making leak detection a continuing priority to help maintain an efficient compressed air system.[6] Participants' long term activities pertaining to leak detection varied widely, from detailed ongoing monitoring to none at all. Many participants fell into the category of some monitoring by ear, which is less effective than full, detailed surveys. Navigant recommends Energy Trust expand their compressed air leak detection program to further educate participants about the most effective methods of leak detection and how often to implement them. Education about the recurrence of leaks could help provide incentive for facilities to implement ongoing leak detection programs.

Additionally, for two installations, it was found that the compressor curve did not match the installed equipment. This was due to the use of simplified curves and not the actual manufacturer curves. Manufacturer curves or facility data should be used wherever possible.

O&M Impacts Should Be Evaluated Soon After Implementation – O&M measures can have relatively short lifetimes and delayed evaluation of them can result in low realization rates due to timing rather than problems with implementation. For example, one Kaizen Blitz project was completed in 2009, but included in this evaluation in late 2011. The measure implementation included O&M and operational changes to the refrigeration system. The realization rate for this project is only 47%. Some of the controls changes implemented are subject to operator intervention, based on facility operational changes. Unless

[6] U.S. Department of Energy's EERE and the Compressed Air Challenge®. *Improving Compressed Air System Performance: A Sourcebook for Industry*. Washington, D.C., 2003. p.29. http://industrial-energy.lbl.gov/files/industrial-energy/active/0/LBNL-43888.pdf

procedures are in place at the facility to implement periodic tuning with changing conditions, the savings will not persist.

Use Billing Data to Provide "Reality Check" for Modeled Savings on Greenhouses and HVAC Upgrades - For projects that claim large energy savings based on models, such as many of the greenhouse and large HVAC measures, Navigant recommends the using site billing data to confirm the calculated savings are reasonable. Some greenhouse projects previously estimated savings that were on par with or in excess of the typical total consumption estimated for the greenhouse in which they were installed. Although it is difficult to precisely determine savings for greenhouse measures, and models are usually the best choice for estimation, comparison to billing data could provide guidance as to any large scale problems with the model and provide guidance for model adjustments to better match actual onsite performance.

Variable Frequency Drives - Navigant found that realization rates for some variable frequency drive (VFD) installations were low mainly because those VFDs were installed on systems that were close to fully loaded.

Navigant recommends some steps to be taken to more accurately calculate the savings for these measures:

- Before recommending VFDs, implementers should assure that the system is running partially loaded for a large majority of the time.
- Additionally, trend data should be taken for any equipment that is manually controlled as it is very difficult to estimate operation of manually controlled equipment.

Lighting Controls - Energy Trust's lighting controls savings worksheet assumes all occupancy sensors savings bring a flat savings percentage, regardless of the room type in which the occupancy sensors are installed. This is a not an accurate assumption. For example, occupancy sensors will cause the lights to be off a larger percentage of time in a warehouse than in an open office space.

Navigant recommends Energy Trust employ values from an established source such as "Table 24-5. Occupancy Sensors Reduction in Operating Time" of California's "2012 Statewide Customized Offering Procedures Manual for Business" to determine occupancy sensor savings, according to space type.