Impact Evaluation of 2010 Custom Process and Compressed Air Installations

FINAL REPORT

Massachusetts Energy Efficiency Programs' Large Commercial & Industrial Evaluation

Prepared for: Massachusetts Energy Efficiency Program Administrators
Massachusetts Energy Efficiency Advisory Council

Middletown, Connecticut, May 30, 2012

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1. Executive Summary

This document summarizes the work performed by DNV KEMA Energy and Sustainability (DNV KEMA), DMI and SBW Consulting during 2011 and 2012 to quantify the actual energy and demand savings due to the installation of 39 Custom Process and Compressed Air measures installed through the Massachusetts Energy Efficiency Program Administrator's (PAs) Commercial & Industrial (C&I) New Construction & Major Renovation and C&I Large Retrofit programs in 2010.

1.1 Purpose of Study

The objective of this impact evaluation is to provide verification or re-estimation of electric energy and demand savings estimates for 39 Custom Process and Compressed Air projects through site-specific inspection, monitoring, and analysis. The results of this study will be used to determine the final realization rates for Custom Process and Compressed Air energy efficiency measures installed in 2011. This evaluation report presents realization rates for gross energy savings for all PAs. It also provides realization rates for on-peak summer and winter demand savings for all PAs except for Western Massachusetts Electric (WMECO). For WMECO, realization rates for summer and winter seasonal peak savings are provided. For National Grid, realization rates for percent on-peak energy savings are also provided. Realization rates for each of these parameters are also provided at the statewide level. The evaluation sample for this study was designed in consideration of the 90% confidence level for energy (kWh) and the 80% confidence level for coincident peak summer demand (kW). Precision targets differed by end-use, and were developed based on the size of each end-use.

1.2 Scope

The scope of work of this impact evaluation covered the 2010 Custom Process and Compressed Air end-uses, which include new equipment and/or control systems and strategies. This impact evaluation includes only measures which primarily reduce electricity consumption.

1.3 Sample Design

The Custom Process and Compressed Air sample was designed to allow DNV KEMA to estimate realization rates for a number of savings parameters (annual kWh, percent of kWh savings on-peak, summer on-peak kW, and winter on-peak kW) with statistical precisions that meet PA requirements in two areas. While the primary variable of interest for the sample design was annual kWh savings, the PAs also were interested in coincident peak summer kW because it is used in the ISO-NE Forward Capacity Market (FCM).

DNV KEMA recommended targeting precision at the measure level based on the significance of the measure to the overall NLNH Custom Electric population. Since process measures represent approximately 40% of the NLNH Custom Electric population, it was recommended that the target precision on energy savings be ±20% for each PA for process measures. Due to the size of the measure relative to the overall NLNH Custom Electric population, the target precision on energy savings for compressed air measures was ±40% for each PA. All of the sample design results for annual kWh were calculated at the 90% confidence level. For summer and winter kW, all of the sample design results were calculated at the 80% confidence level.

After running several scenarios based on different sample sizes and allocations, the team decided on a Custom Process and Compressed Air sample comprised of 39 sites split between the PAs as indicated in Table 1. This table also includes estimates of the precisions that were anticipated at the time of this design, assuming an error ratio of 0.5. The PA-specific results were expected to achieve relative precisions in the range of ±16% to ±54%.

Table 1: Custom Process and Compressed Air Sample Design

Measure	Program Administrator	Accounts	Total Savings	Assumed Error Ratio	Confidence Level	Planned Sample Size	Anticipated Relative Precision
Process	National Grid	45	11,469,099	0.5	90%	13	±15.73%
Process	NSTAR	35	6,932,947	0.5	90%	8	±18.26%
Process	Unitil	4	145,641	0.5	90%	2	±48.51%
Process	WMECO	14	4,340,188	0.5	90%	5	±31.05%
Total		**98**	**22,887,875**			**28**	
Compressed Air	National Grid	22	3,936,025	0.5	90%	5	±32.04%
Compressed Air	NSTAR	6	1,170,288	0.5	90%	3	±37.45%
Compressed Air	WMECO	13	957,747	0.5	90%	3	±53.88%
Total		**41**	**6,064,060**			**11**	

This allocation by PA was further stratified by total savings, and sample sites were selected. After the sample selection, several adjustments were required based on observations made during initial file reviews and early site visits. In some cases, alternate sites were used, but in other cases there were no additional sites to select. In the end, a total of 39 sites were included in the Custom Process and Compressed Air sample.

1.4 Description of Methodology

Following the final sample selection of 2010 Custom Process and Compressed Air applications and prior to beginning any site visits, DNV KEMA, SBW, and DMI developed detailed measurement and evaluation plans for each of the 39 applications. The plans outlined on-site methods, strategies, monitoring equipment placement, calibration and analysis issues. The PAs provided comments and edits to clarify and improve the plans prior to them being finalized.

The site evaluation plan played an important role in establishing approved field methods and ensuring that the ultimate objectives of the study were met. Each site visit culminated in an independent engineering assessment of the actual (e.g. as observed and monitored) annual energy, on-peak energy, summer on-peak and seasonal demand, and winter on-peak and seasonal demand savings associated with each project.

Data collection included physical inspection and inventory, interview with facility personnel, observation of site operating conditions and equipment, and long-term metering of usage. At each site, the DNV KEMA team performed a facility walk-through that focused on verifying the installed conditions of each energy conservation measure (ECM). Several of the facilities utilized EMS controls, which were either part of the application itself or controlled equipment that was included in the application. Evaluators viewed EMS screens to verify schedules and operating parameters where applicable. Instrumentation such as power recorders, Time-Of-Use (TOU) current loggers, and temperature loggers were installed to monitor the usage of the installed equipment and associated affected spaces. EMS trends were also obtained when possible.

Collected data was analyzed to verify implementation of each ECM, and savings analyses were performed to estimate hourly energy use and diversified coincident peak demand. A typical meteorological year dataset of ambient temperatures was used for all temperature sensitive calculations.

Engineers submitted draft site reports to the PAs upon completion of each site evaluation, which after review and comment resulted in the final reports found in Appendix D: Site Reports. This executive summary provides a concise overview of the evaluation methods and findings.

1.5 Results

The results presented in this section include realization rates (and associated precision levels) for annual MWh savings, on-peak MWh savings, and on-peak and seasonal demand (kW) savings at the times of the winter and summer peaks, as defined by the ISO New England Forward Capacity Market (FCM). All coincident summer and winter peak reductions were calculated using the following FCM definitions:

- Coincident Summer On-Peak kW Reduction is the average demand reduction that occurs over all hours between 1 PM and 5 PM on non-holiday weekdays in June, July and August.
- Coincident Winter On-Peak kW Reduction is the average demand reduction that occurs over all hours between 5 PM and 7 PM on non-holiday weekdays in December and January.
- Seasonal Peak: Non-holiday week days when the Real-Time System Hourly Load is equal to or greater than 90% of the most recent "50/50" System Peak Load Forecast for the summer and winter seasons.[1]

Relative precision levels and error bounds are calculated at the 80% confidence level for demand values, since that is the requirement for participation in the FCM. For all MWh realization rates, the standard 90% confidence level is used.

Figure 1 presents a scatter plot of evaluation results from the Custom Process sample for annual MWh savings using all PA sample points. The sample observations are weighted to reflect the impact that each has on the study results. The slope of the solid line in this graph is an indication of the estimated population overall realization rate. The dashed green line represents a realization rate of 1, and is higher than the observed data. These sample data are not clustered closely around the trend line, indicating that there is a large variation in the relationship between tracking and evaluated savings.

[1] A description of the methodology used by DNV KEMA to determine the seasonal peak demand hours is presented in Appendix C: Seasonal Peak Period Coincidence.

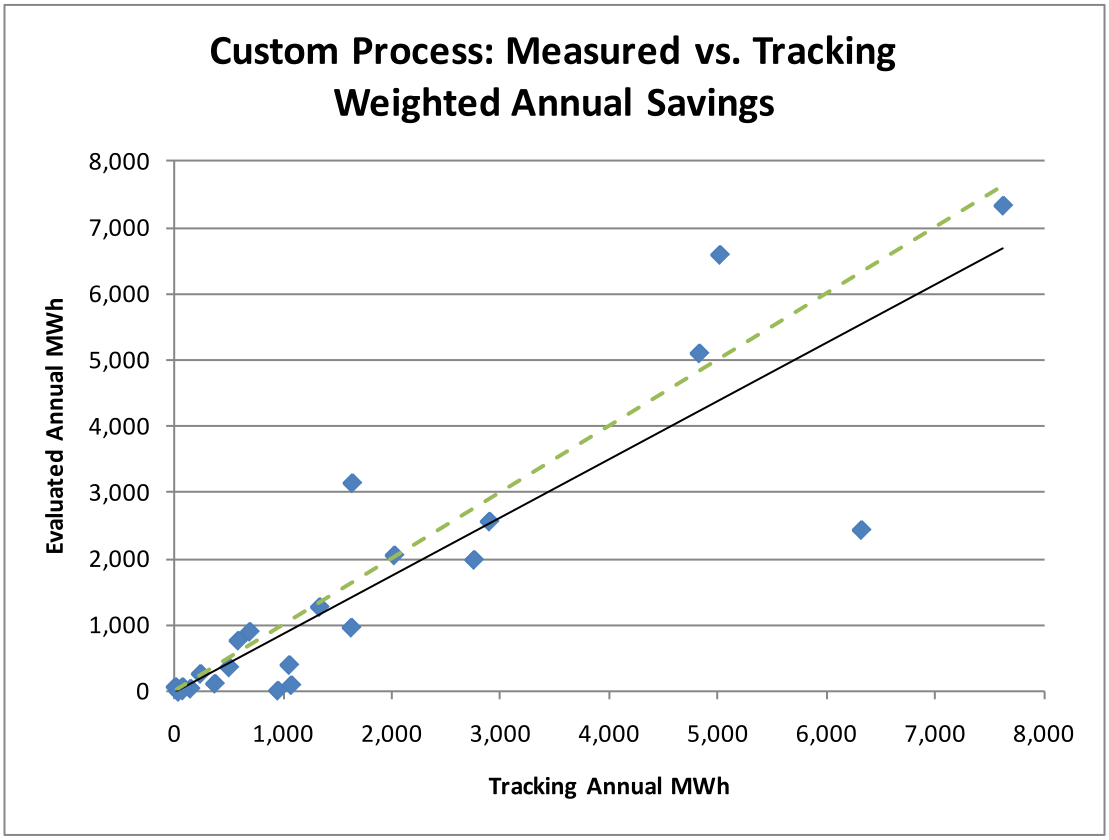

Figure 1: Scatter Plot of Evaluation Results for Annual MWh Savings for Custom Process

Figure 2 presents the same information for the Compressed Air sample points. As with the Custom Process sample, the Compressed Air results are widely scattered, and the trend line indicates a realization rate significantly less than 1.

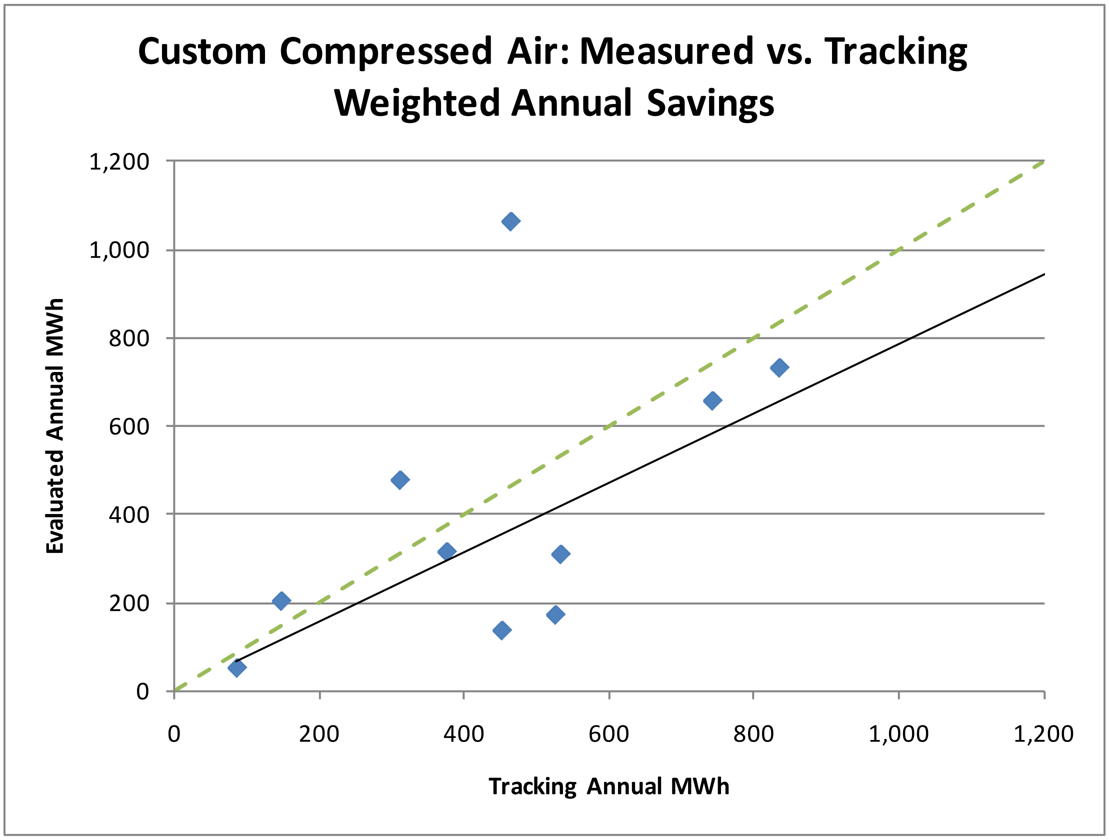

Figure 2: Scatter Plot of Evaluation Results for Annual MWh Savings for Compressed Air

The site-level evaluation results were aggregated using stratified ratio estimation. The PA realization rates are calculated, and then applied to each PA's total tracking savings to determine their total measured savings. The statewide realization rate is the ratio of the total measured savings to the total tracking savings, each of which is calculated by summing across the PAs.

Table 2 summarizes the PA-specific results of the Custom Process analysis. In the case of annual MWh savings, the realization rate for Custom Process measures ranged from 51.3% for WMECO to 144.1% for Unitil. The relative precision for these estimates was found to range from ±23.3% to ±51.3% at the 90% level of confidence, which is worse than was anticipated at the time of the design. This is because the error ratios were all above 0.5, which was used as an estimate during the design. The variation in the evaluated site results for this study was greater than expected, including 0 and negative savings at some sites. Table 2 also shows the results for the on-peak summer and winter coincident demand savings, measured in KW. Results for % On-Peak MWh are provided for National Grid only, as they are the only PA that uses this parameter. Since the design criteria for the demand realization rates were based on an 80%

confidence level, the precisions and error bounds at this level are reported in the appropriate rows in Table 2.

Table 2: Summary of Custom Process Results by PA

Process Results by PA	Annual MWh	% On-Peak MWh	On-Peak MWh	On-Peak Summer kW	On-Peak Winter kW	Summer Season Peak kW	Winter Season Peak kW
National Grid							
Total Tracking Savings	11,469	45.7%	5,240	1,307	1,426	1,307	1,426
Total Measured Savings	7,767	46.0%	3,572	1,251	1,172	1,305	1,239
Realization Rate	67.7%	100.7%	68.2%	95.7%	82.2%	99.9%	86.8%
Relative Precision at 90% Confidence	23.9%	-	32.7%				
Error Bound at 90% Confidence	1,854	-	1,168				
Relative Precision at 80% Confidence				18.6%	25.5%	38.7%	40.3%
Error Bound at 80% Confidence				484	473	505	491
Error Ratio	0.84	-	0.82	1.65	1.75	1.56	1.67
NSTAR							
Total Tracking Savings	6,933	-	-	1,063	1,004	1,063	1,004
Total Measured Savings	7,229	-	-	848	1,110	844	1,091
Realization Rate	104.3%	-	-	79.8%	110.6%	79.4%	108.7%
Relative Precision at 90% Confidence	23.3%	-	-				
Error Bound at 90% Confidence	1,681,371	-	-				
Relative Precision at 80% Confidence				31.4%	17.2%	31.8%	17.0%
Error Bound at 80% Confidence				267	191	268	185
Error Ratio	0.68	-	0.73	0.87	0.76	0.87	0.77
Unitil							
Total Tracking Savings	146	-	-	18	15	18	15
Total Measured Savings	210	-	-	23	22	23	21
Realization Rate	144.1%	-	-	129.1%	147.3%	124.9%	141.0%
Relative Precision at 90% Confidence	48.1%	-	-				
Error Bound at 90% Confidence	101	-	-				
Relative Precision at 80% Confidence				12.8%	17.5%	15.0%	20.8%
Error Bound at 80% Confidence				3	4	3	4
Error Ratio	0.62	-	-	0.21	0.29	0.25	0.34
WMECO							
Total Tracking Savings	4,340	-	-	445	437	445	437
Total Measured Savings	2,227	-	-	202	226	209	222
Realization Rate	51.3%	-	-	45.4%	51.7%	46.9%	50.8%
Relative Precision at 90% Confidence	31.6%	-	-				
Error Bound at 90% Confidence	703	-	-				
Relative Precision at 80% Confidence				38.1%	35.6%	39.0%	36.3%
Error Bound at 80% Confidence				77	80	81	81
Error Ratio	0.59	-	-	1.02	0.86	1.05	0.87

DNV KEMA aggregated the PA results to determine statewide realization rates, for use by the smaller PAs as needed. These overall results follow in Table 3.

Table 3: Statewide Custom Process Results

Overall Process Results	Annual MWh	% On-Peak MWh	On-Peak MWh	On-Peak Summer kW	On-Peak Winter kW	Summer Season Peak kW	Winter Season Peak kW
Total Tracking Savings	22,888	-	-	2,833	2,883	2,833	2,883
Total Measured Savings	17,434	-	-	2,324	2,531	2,381	2,573
Realization Rate	76.2%	-	-	82.0%	87.8%	84.0%	89.3%
Relative Precision at 90% Confidence	14.9%	-	-				
Error Bound at 90% Confidence	2,602	-	-				
Relative Precision at 80% Confidence				24.0%	20.4%	24.3%	20.6%
Error Bound at 80% Confidence				558	516	578	531
Error Ratio	0.74	-	-	1.30	1.23	1.26	1.21

The statewide realization rate for Annual MWh savings is 76.2%, estimated with ±14.9% relative precision. The demand realization rates are all between 82.0% and 89.3%.

Aggregated results from the Compressed Air sample sites are presented in Table 4 and Table 5 below. Realization rates for Annual MWh savings range from 78.0% for WMECO and NSTAR to 89.1% for National Grid. The goal for this study was to achieve ±40% relative precision with 90% confidence for Annual MWh and 80% confidence for peak kW, by PA. For the most part, the results met these targets. The statewide realization rate for Compressed Air measures was 85.2% for Annual MWh, estimated with ±24.6% relative precision. The realization rates for the demand measurements were all between 74.1% and 76.3%.

Table 4: Summary of Compressed Air Results by PA

Compressed Air Results by PA	Annual MWh	% On-Peak MWh	On-Peak MWh	On-Peak Summer kW	On-Peak Winter kW	Summer Season Peak kW	Winter Season Peak kW
National Grid							
Total Tracking Savings	3,936	48.1%	1,893	485	476	485	476
Total Measured Savings	3,507	44.9%	1,575	381	395	367	402
Realization Rate	89.1%	93.4%	83.2%	78.6%	83.0%	75.6%	84.4%
Relative Precision at 90% Confidence	34.0%	-	33.8%				
Error Bound at 90% Confidence	1,191	-	532				
Relative Precision at 80% Confidence				40.3%	40.5%	39.9%	39.1%
Error Bound at 80% Confidence				154	160	146	157
Error Ratio	0.57	-	0.51	0.88	0.89	0.87	0.86
NSTAR							
Total Tracking Savings	1,170	-	-	143	144	143	144
Total Measured Savings	913	-	-	117	114	117	115
Realization Rate	78.0%	-	-	81.6%	79.2%	81.6%	79.6%
Relative Precision at 90% Confidence	45.1%	-	-				
Error Bound at 90% Confidence	412,081	-	-				
Relative Precision at 80% Confidence				34.6%	37.1%	34.7%	36.7%
Error Bound at 80% Confidence				40	42	41	42
Error Ratio	0.74	-	0.72	0.75	0.81	0.76	0.80
WMECO							
Total Tracking Savings	958	-	-	128	126	128	126
Total Measured Savings	747	-	-	78	44	85	43
Realization Rate	78.0%	-	-	61.3%	34.7%	66.8%	34.5%
Relative Precision at 90% Confidence	24.6%	-	-				
Error Bound at 90% Confidence	184	-	-				
Relative Precision at 80% Confidence				55.0%	95.9%	52.5%	98.0%
Error Bound at 80% Confidence				43	42	45	43
Error Ratio	0.32	-	-	0.80	1.42	0.75	1.43

Table 5: Summary of Statewide Compressed Air Results

Overall Compressed Air Results	Annual MWh	% On-Peak MWh	On-Peak MWh	On-Peak Summer kW	On-Peak Winter kW	Summer Season Peak kW	Winter Season Peak kW
Total Tracking Savings	6,064	-	-	756	746	756	746
Total Measured Savings	5,168	-	-	577	553	569	560
Realization Rate	85.2%	-	-	76.3%	74.1%	75.2%	75.1%
Relative Precision at 90% Confidence	24.6%	-	-				
Error Bound at 90% Confidence	1,274	-	-				
Relative Precision at 80% Confidence				28.6%	30.9%	27.8%	30.0%
Error Bound at 80% Confidence				165	171	158	168
Error Ratio	0.57	-	-	0.84	0.92	0.83	0.89

1.6 Conclusions and Recommendations

Overall, the Custom Process and Compressed Air program appears to be producing results that are lower than expected. The Custom Process end-use appears to be a bit more variable than Compressed Air. Below are the DNV KEMA evaluation team findings and recommendations that apply statewide, as well as to the individual PAs.

1.6.1 Statewide

- Require Adequate Savings Documentation
- Devote extra review time to calculation of operating hours
- Consider additional savings opportunities when conducting TA studies

1.6.2 National Grid

- Adjust savings estimates to match changing conditions
- Determine if original equipment has been removed, taken out of service, or is still in use
- Be aware of projects where several measures were proposed, but not all implemented
- Ensure adequate sampling procedures are used when conducting pre-installation metering
- Make use of all available data from the site
- Consider more rigorous post-installation check-up

1.6.3 NSTAR

- Identify changes in project scope and apply these changes to the tracking savings
- Confirm all assumptions about pre-existing equipment
- Review model outputs against tracking savings estimates

1.6.4 Unitil

- Consider all secondary sources of energy savings/penalties

1.6.5 Western Massachusetts Electric Company

- Account for all compressed air operation
- Consider pre-installation metering, especially in cases where the existing equipment is removed
- Confirm all assumptions about pre-existing equipment
- Provide appropriate level of documentation relative to the project savings
- Consider all secondary sources of energy savings/penalties
- Consider more rigorous post-installation check-up

2. Introduction

This document summarizes the work performed by DNV KEMA Energy and Sustainability (DNV KEMA), DMI and SBW Consulting during 2011 and 2012 to quantify the actual energy and demand savings due to the installation of 39 Custom Process and Compressed Air measures installed through the Massachusetts Energy Efficiency Program Administrator's (PAs) Commercial & Industrial (C&I) New Construction & Major Renovation and C&I Large Retrofit programs in 2010.

2.1 Purpose of Study

The objective of this impact evaluation is to provide verification or re-estimation of electric energy and demand savings estimates for 39 Custom Process and Compressed Air projects through site-specific inspection, monitoring, and analysis. Each of the PAs offers incentives for process and compressed air measures under their custom track for both their C&I New Construction and Major Renovation programs and C&I Large Retrofit programs. Gross energy and demand savings are typically developed based on detailed engineering analyses for all custom projects.

The results of this study will be used to determine the final realization rates for Custom Process and Compressed Air energy efficiency measures installed in 2011. This evaluation report presents realization rates for gross energy savings for all PAs. It also provides realization rates for on-peak summer and winter demand savings for all PAs except for Western Massachusetts Electric (WMECO). For WMECO, realization rates for summer and winter seasonal peak savings are provided. For National Grid, realization rates for percent on-peak energy savings are also provided. Realization rates for each of these parameters are also provided at the statewide level. The evaluation sample for this study was designed in consideration of the 90% confidence level for energy (kWh) and the 80% confidence level for coincident peak summer demand (kW). Precision targets differed by end-use, and were developed based on the size of each end-use.

This impact study consists of the following four tasks:

1. Develop Sample Design
2. Develop Site Measurement and Evaluation Plans
3. Data Gathering and Analysis
4. Report Writing and Follow-up

2.2 Scope

The scope of work of this impact evaluation covered the 2010 Custom Process and Compressed Air end-uses, which include new equipment and/or control systems and strategies. This impact evaluation includes only measures which primarily reduce electricity consumption.

3. Description of Sampling Strategy

Originally, the primary focus of the sample design was to examine various scenarios for non-Comprehensive, non-Lighting and non-HVAC (NLNH) Custom Electric programs including Process, Compressed Air, Refrigeration, Motor and Other measures in Massachusetts (MA). The goal of the design effort was to estimate sample sizes required to support the estimation of realization rates for a number of different savings estimates, including annual kWh savings, summer and winter demand reductions, and other factors that impact the calculation of net savings for various measures.

Ultimately, the Custom Electric evaluation was split into phases with Phase 1 including 2010 Custom Process and Compressed Air installations and the Phase 2 including 2011 Custom Refrigeration, Motor, and Other measures, planned for the summer and fall of 2012. The following section describes the sample design for Phase 1, while the full sample design from the initial Custom Electric Work Plan is presented in

Appendix A: Custom Electric Sample Design.

3.1 Population Analysis

The initial task was to define the population frame for the evaluation sample. 2010 tracking data were provided by the PAs for each project. The projects were reviewed, and classified into one of the five Custom Electric measure categories, with adjustments made in order to maintain consistency across PAs. More detail for the adjustment process is given in

Appendix A: Custom Electric Sample Design. After review and consolidation, the resulting population of 2010 Custom Process and Compressed Air projects reported by PA is summarized in Table 6.

Table 6: Population Statistics

Program Administrator	Measure Groups	Projects	Total Savings	Average Savings	Minimum	Maximum	StdDev	CV
National Grid	Process	45	11,469,099	254,869	17,052	1,580,593	356,484	1.40
National Grid	Compressed Air	22	3,936,025	178,910	13,006	826,260	226,488	1.27
NSTAR	Process	35	6,932,947	198,084	0	1,906,746	387,008	1.95
NSTAR	Compressed Air	6	1,170,288	195,048	21,563	452,312	171,134	0.88
Unitil	Process	4	145,641	36,410	4,588	74,460	26,448	0.73
WMECO	Process	14	4,340,188	310,013	6,569	919,019	311,348	1.00
WMECO	Compressed Air	13	957,747	73,673	2,964	299,472	75,191	1.02
Total		139	28,951,935					

3.2 Sample Design

The Custom Process and Compressed Air sample was designed to allow DNV KEMA to estimate realization rates for a number of savings parameters (annual kWh, percent of kWh savings on-peak, summer on-peak kW, and winter on-peak kW) with statistical precisions that meet PA requirements in two areas. While the primary variable of interest for the sample design was annual kWh savings, the PAs also were interested in coincident peak summer kW because it is used in the ISO-NE Forward Capacity Market (FCM).

DNV KEMA recommended targeting precision at the measure level based on the significance of the measure to the overall NLNH Custom Electric population. Since process measures represent approximately 40% of the NLNH Custom Electric population, it was recommended that the target precision on energy savings be ±20% for each PA for process measures. Due to the size of the measure relative to the overall NLNH Custom Electric population, the target precision on energy savings for compressed air measures was ±40% for each PA. All of the sample design results for annual kWh were calculated at the 90% confidence level. For summer and winter kW, all of the sample design results were calculated at the 80% confidence level.

After running several scenarios based on different sample sizes and allocations, the team decided on a Custom Process and Compressed Air sample comprised of 39 sites split between the PAs as indicated in Table 7. This table also includes estimates of the precisions that were anticipated at the time of this design, assuming an error ratio of 0.5. The PA-specific results were expected to achieve relative precisions in the range of ±16% to ±54%.

Table 7: Custom Process and Compressed Air Sample Design

Measure	Program Administrator	Accounts	Total Savings	Assumed Error Ratio	Confidence Level	Planned Sample Size	Anticipated Relative Precision
Process	National Grid	45	11,469,099	0.5	90%	13	±15.73%
Process	NSTAR	35	6,932,947	0.5	90%	8	±18.26%
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Process	WMECO	14	4,340,188	0.5	90%	5	±31.05%
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Compressed Air	National Grid	22	3,936,025	0.5	90%	5	±32.04%
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This allocation by PA was further stratified by total savings, and sample sites were selected. After the sample selection, several adjustments were required based on observations made during initial file reviews and early site visits. These changes are described in the following section. In some cases, alternate sites were used, but in other cases there were no additional sites to select. In the end, a total of 39 sites were included in the Custom Process and Compressed Air sample. The realization rate results for the final sample are presented in Section 5: Results.

3.3 Final Sample

Table 8 presents the list of 39 projects selected as the final sample for Custom Process and Compressed Air. Also presented in this table are the site assignments by evaluating company on the DNV KEMA Team. Of the 39 projects, DNV KEMA evaluated 11, SBW evaluated 15, and DMI evaluated 13. The final sample required the selection of seven back-up sample points. Of the seven dropped sites, four were due to customer refusals, one was found to have been done completely prescriptively, one was found not to have had an incentive provided, and at one, the customer would not allow for metering. The final sample resulted in having to utilize one less National Grid, Process, stratum 4 sample point due to not having any other back-ups in this stratum. An additional National Grid, Process, stratum 3 site was evaluated in its place.

Table 8: Final Sample Selection

KEMA Site Number	Program Administrator	End Use	Stratum	Site ID	Evaluating Firm	Facility Type, Project Description	Program Type
2	National Grid	Process	1	591550	SBW	Apartment building, New central water heating system	New Construction
3	National Grid	Process	1	565615	DMI	Manufacturing, Process heating system replacement	Retrofit
4	National Grid	Process	1	660085	DMI	Manufacturing, Process heating element replacement	Retrofit
42	National Grid	Process	1	619132	SBW	Apartment building, New central water heating system	New Construction
5	National Grid	Process	2	549621	SBW	Bulk dry-cleaning facility, New efficient wash baths	Retrofit
7	National Grid	Process	2	535677	SBW	Wastewater treatment plant, New blowers with VFDs and controls	Retrofit
46	National Grid	Process	2	577718	KEMA	Ski Area, New snowmaking equipment	Retrofit
8	National Grid	Process	3	577753	SBW	Food packaging plant, Replaced a batch production line with a continuous one, permitting piping modifications and pump VFDs; elimination of compressed air requirements and refrigerated holding areas; and reduction in process temperatures	New Construction
9	National Grid	Process	3	565594	SBW	Wastewater treatment plant, Added automatic control valves to dissolved oxygen basins	Retrofit
10	National Grid	Process	3	528942	SBW	Food waste processing plant, New tricanter centrifuges	Retrofit
41	National Grid	Process	3	631903	DMI	Manufacturing, Repair of exhaust plenum	Retrofit
11	National Grid	Process	4	698744	DMI	Manufacturing, Powersave controls on process lines	Retrofit
13	National Grid	Process	4	560242	KEMA	Manufacturing, New six-tube furnace	Retrofit
29	National Grid	Compressed Air	1	569835	SBW	Manufacturing, New VSD air compressor with an integrated heat-of-compression air dryer	New Construction
30	National Grid	Compressed Air	1	624168	SBW	Manufacturing, New VSD compressor	New Construction
31	National Grid	Compressed Air	1	623103	SBW	Print shop, New VSD compressors, and new receiver	Retrofit
32	National Grid	Compressed Air	2	562035	KEMA	Manufacturing, New air compressor with inlet guide vane control	Retrofit
33	National Grid	Compressed Air	2	619394	SBW	Manufacturing, Reduced baseline compressed air demand and blower capacity, new VSD compressor with sequencer control	Retrofit
14	NSTAR	Process	1	CS8096	DMI	Auto Repair Shop, VFDs on process fans	New Construction
15	NSTAR	Process	1	CS7614	SBW	Domestic water treatment plant, Redesigned 3 pump-motor sets to serve a new piping system and be driven by new VFDs	New Construction
16	NSTAR	Process	2	BS8660	SBW	Manufacturing, New VSDs on process and HVAC water pumps	Retrofit
17	NSTAR	Process	2	CS6366	KEMA	Wastewater treatment plant, New efficient transformers	New Construction
18	NSTAR	Process	3	CS7763	SBW	TV transmitter station, New efficient transmitter	New

KEMA Site Number	Program Administrator	End Use	Stratum	Site ID	Evaluating Firm	Facility Type, Project Description	Program Type
							Construction
19	NSTAR	Process	3	CS7973	SBW	Food packaging plant, Replaced air knife systems with systems requiring much lower blower brake horsepower	New Construction
20	NSTAR	Process	4	BS8471	KEMA	Power plant, conversion of 4,160 volt motors on process blowers to a 480 volt system with high efficiency motors and VSD controls	Retrofit
21	NSTAR	Process	4	CS7503	DMI	Central Co-gen plant, VFD on boiler fan and new gas compressor	New Construction
34	NSTAR	Compressed Air	1	S7826C	KEMA	Vocational School, New air compressor with VSD and cycling dryer	Retrofit
35	NSTAR	Compressed Air	1	BS8907	KEMA	Manufacturing, New cycling refrigerated air dryer	Retrofit
36	NSTAR	Compressed Air	2	CS8205	KEMA	Manufacturing, New compressed air system with VSD control	New Construction
22	Unitil	Process	1	21093	KEMA	Manufacturing, New injection molding machine	Retrofit
23	Unitil	Process	1	21094	KEMA	Manufacturing, New blade server	Retrofit
24	WMECO	Process	1	WM10S215P	DMI	Foundry, Arc welder replacement with electric power equipment	Retrofit
25	WMECO	Process	1	WM10S205	KEMA	Manufacturing, New blowers with VSD control	Retrofit
26	WMECO	Process	2	WM10S304	DMI	Manufacturing, New hybrid injection molding machines	New Construction
27	WMECO	Process	2	WM09S216P	DMI	Manufacturing, Replace compressed air end use with blowers	Retrofit
44	WMECO	Process	3	WM10S263	DMI	Manufacturing, New process filtration system	Retrofit
37	WMECO	Compressed Air	1	WM10P365	DMI	Newspaper, VFD air compressor	Retrofit
39	WMECO	Compressed Air	1	WM10S206	DMI	Manufacturing, VFD air compressor and cycling air dryer	New Construction
45	WMECO	Compressed Air	1	WM10S215C	DMI	Manufacturing, Compressed air system upgrades	New Construction

4. Description of Methodology

4.1 Measurement and Evaluation Plans

Following the final sample selection of 2010 Custom Process and Compressed Air applications and prior to beginning any site visits, DNV KEMA, SBW, and DMI developed detailed measurement and evaluation plans for each of the 39 applications. The plans outlined on-site methods, strategies, monitoring equipment placement, calibration and analysis issues.

Evaluators utilized the savings analysis methodologies from the Technical Assistance study (TA) whenever possible. However, in some cases, the TA methodology was unavailable or found to be incorrect or inappropriate. In those cases, the evaluators performed an analysis more appropriate to the measure being evaluated. Adjustments to savings methodologies were presented and agreed upon in the measurement and evaluation plans. The PAs provided comments and edits to clarify and improve the plans prior to them being finalized.

The site evaluation plan played an important role in establishing approved field methods and ensuring that the ultimate objectives of the study were met. Each site visit culminated in an independent engineering assessment of the actual (e.g. as observed and monitored) annual energy, on-peak energy, summer on-peak and seasonal demand, and winter on-peak and seasonal demand savings associated with each project.

Following the establishment of a site evaluation plan, DNV KEMA, SBW and DMI field technicians contacted each customer in the sample to schedule a site visit. The objective of the site visit was to perform a comprehensive assessment of all operational characteristics of the lighting measure(s) installed at the site.

4.2 Data Gathering, Analysis, and Reporting

Data collection included physical inspection and inventory, interview with facility personnel, observation of site operating conditions and equipment, and long-term metering of usage.

4.2.1 Data Collection

At each site, the DNV KEMA team performed a facility walk-through that focused on verifying the installed conditions of each energy conservation measure (ECM). Several of the facilities utilized EMS controls, which were either part of the application itself or controlled equipment that was included in the application. Evaluators viewed EMS screens to verify schedules and operating parameters where applicable. Instrumentation such as power recorders, Time-Of-Use (TOU) current loggers, and temperature loggers were installed to monitor the usage of the installed equipment and associated affected spaces. EMS trends were also obtained when possible.

Collected data was analyzed to verify implementation of each ECM, and savings analyses were performed to estimate hourly energy use and diversified coincident peak demand. A typical meteorological year dataset of ambient temperatures was used for all temperature sensitive calculations. Each site report details the specific analysis methods used for each project including algorithms, assumptions and calibration methods where applicable.

4.2.2 Verification of Baseline

The Custom Process and Compressed Air installations observed in this impact evaluation included a mix of new construction or major renovation measures, as well as retrofit measures. All projects were examined to verify that the correct baselines were being applied. For new construction or major renovations, the MA building code current at the time of the project application was referred to by evaluating engineers. Evaluators verified that the proper baseline systems were used in all projects. In some cases, new construction projects used pre-existing equipment as the base case in the tracking analyses. In these cases, evaluators reviewed these base case conditions for appropriateness, and researched if a code system would be applicable. In some cases, the evaluation changed the base case if the tracking baseline system was deemed inappropriate.

4.2.3 Site Reports

Engineers submitted draft site reports to the PAs upon completion of each site evaluation, which after review and comment resulted in the final reports found in Appendix D: Site Reports. This executive summary provides a concise overview of the evaluation methods and findings.

4.3 Analysis Procedures

In order to aggregate the individual site results from the Custom Process and Compressed Air sample, DNV KEMA applied the model-assisted stratified ratio estimation methodology described in References [1] and [2] in

Appendix B: References. The key parameter of interest is the population realization rate, i.e., the ratio of the evaluated savings for all population projects divided by the tracking estimates of savings for all population projects. This rate is estimated for the overall Massachusetts program, as well as for individual PAs. Of course, the population realization rate is unknown, but it can be estimated by evaluating the savings in a sample of projects. The sample realization rate is the ratio between the weighted sum of the evaluated savings for the sample projects divided by the weighted sum of the tracking estimates of savings for the same projects. The total tracking savings in the population is multiplied by the sample realization rate to estimate the total evaluated savings in the population. The statistical precisions and error ratios are calculated for each level of aggregation.

The results presented in the following section include realization rates (and associated precision levels) for annual MWh savings, on-peak MWh savings, and on-peak and seasonal demand (kW) savings at the times of the winter and summer peaks, as defined by the ISO New England Forward Capacity Market (FCM). All coincident summer and winter peak reductions were calculated using the following FCM definitions:

- Coincident Summer On-Peak kW Reduction is the average demand reduction that occurs over all hours between 1 PM and 5 PM on non-holiday weekdays in June, July and August.
- Coincident Winter On-Peak kW Reduction is the average demand reduction that occurs over all hours between 5 PM and 7 PM on non-holiday weekdays in December and January.
- Seasonal Peak: Non-holiday week days when the Real-Time System Hourly Load is equal to or greater than 90% of the most recent "50/50" System Peak Load Forecast for the summer and winter seasons.[2]

Relative precision levels and error bounds are calculated at the 80% confidence level for demand values, since that is the requirement for participation in the FCM. For all MWh realization rates, the standard 90% confidence level is used.

[2] A description of the methodology used by DNV KEMA to determine the seasonal peak demand hours is presented in Appendix C: Seasonal Peak Period Coincidence.

5. Results

In preparation for analyzing the evaluation results collected for the Custom Process and Compressed Air sample points, the original 2010 population stratum boundaries were used to calculate case weights for the each sample observation. These weights reflect the number of projects that each sample point represents in their respective populations, and allow for the aggregation of results across strata and PAs. The final case weights for the studies are shown in the last column in Table 9 for Custom Process and Compressed Air.

Table 9: Custom Process and Compressed Air Case Weights

Measure	Program Administrator	Stratum	Total Accounts	Total Annual MWh	Accounts in Sample	Case Weight
Process	National Grid	1	30	1,941	4	7.50
Process	National Grid	2	7	2,130	3	2.33
Process	National Grid	3	5	3,564	4	1.25
Process	National Grid	4	3	3,834	2	1.50
Process	NSTAR	1	24	865	2	12.00
Process	NSTAR	2	6	1,086	2	3.00
Process	NSTAR	3	3	1,820	2	1.50
Process	NSTAR	4	2	3,162	2	1.00
Process	Unitil	1	4	146	2	2.00
Process	WMECO	1	9	965	2	4.50
Process	WMECO	2	3	1,537	2	1.50
Process	WMECO	3	2	1,838	1	2.00
Total			**98**	**22,888**	**28**	
Compressed Air	National Grid	1	18	1,419	3	6.00
Compressed Air	National Grid	2	4	2,517	2	2.00
Compressed Air	NSTAR	1	5	718	2	2.50
Compressed Air	NSTAR	2	1	452	1	1.00
Compressed Air	WMECO	1	13	958	3	4.33
Total			**41**	**6,064**	**11**	

5.1 Major Findings and Observable Trends

Figure 3 presents a scatter plot of evaluation results from the Custom Process sample for annual MWh savings using all PA sample points. The sample observations are weighted to reflect the impact that each has on the study results. The slope of the solid line in this graph is an indication of the estimated population overall realization rate. The dashed green line represents a realization rate of 1, and is higher than the observed data. These sample data are not clustered closely around the trend line, indicating that there is a large variation in the relationship between tracking and evaluated savings.

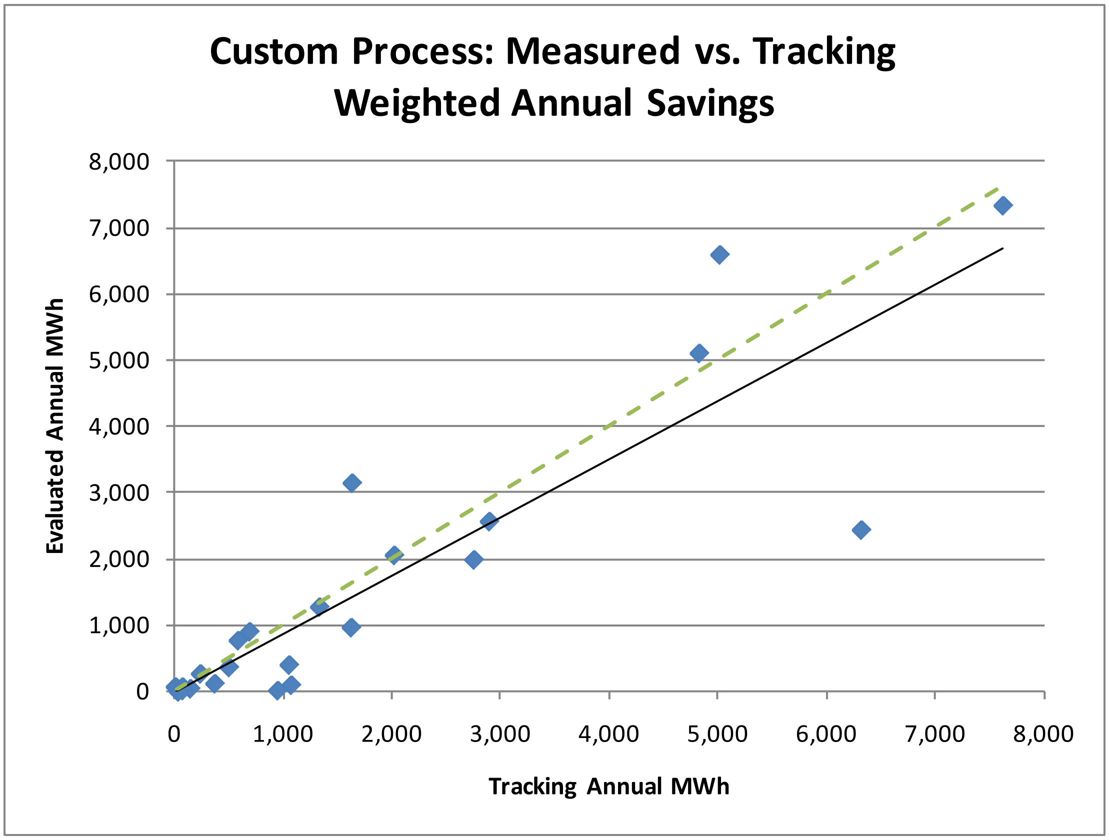

Figure 3: Scatter Plot of Evaluation Results for Annual MWh Savings for Custom Process

Figure 4 presents the same information for the Compressed Air sample points. As with the Custom Process sample, the Compressed Air results are widely scattered, and the trend line indicates a realization rate significantly less than 1.

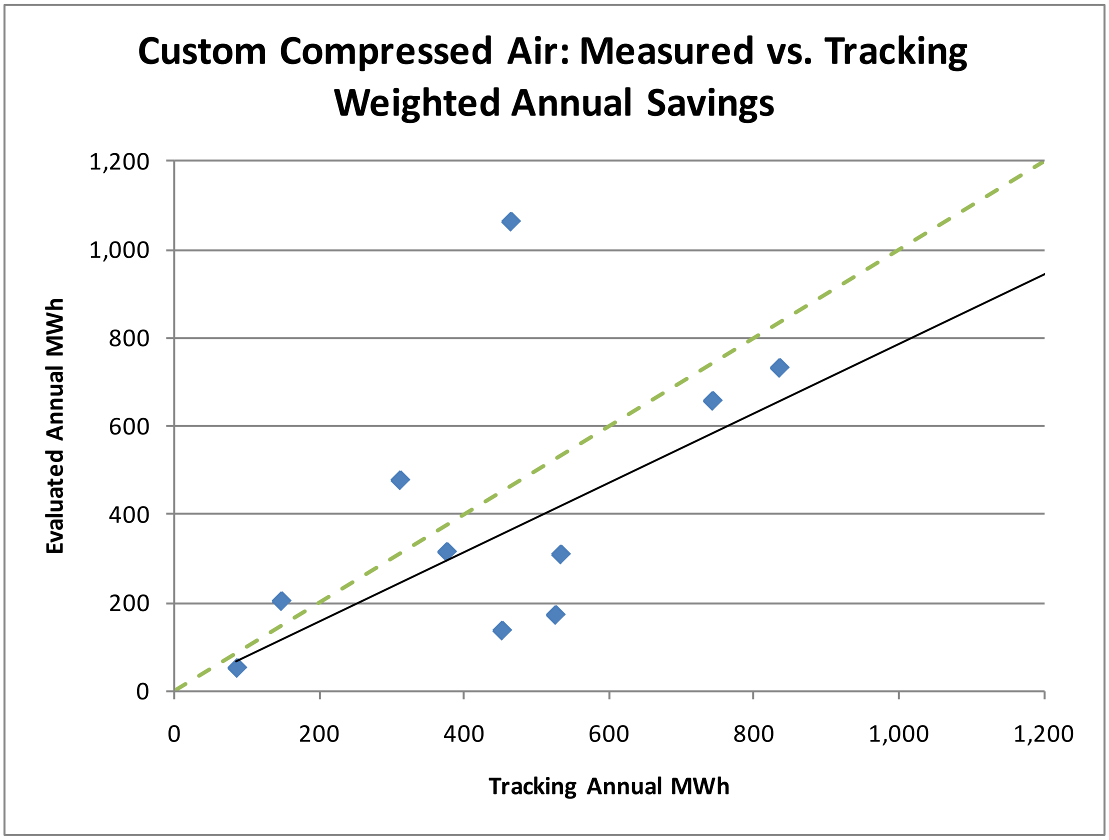

Figure 4: Scatter Plot of Evaluation Results for Annual MWh Savings for Compressed Air

5.2 Presentation of Results

Table 10 presents a summary of the Custom Process site level results for this impact evaluation. Table 11 summarizes the savings realization rates and primary reasons for discrepancies between the tracking and evaluation estimates of annual energy savings for Custom Process. The site energy savings realization rates ranged from a low of -176% for Site 2 to a high of 969% for Site 15. Note that some of the ratios are "N/A" for the on-peak % and peak demand reductions because the tracking estimates were zero for some of these values.

Table 10: Detailed Site Results for Custom Process

				Tracking Estimated Savings				Evaluation Savings					
					On-	Peak Coinc.			On-	On-Peak		Seasonal	
KEMA Site Number	Program Administrator	End Use	Site ID	kWh/yr	Peak %	Sum. kW	Wint. kW	kWh/yr	Peak %	Sum. kW	Wint. kW	Sum. kW	Wint. kW
2	National Grid	Process	591550	27,017	44%	2.4	0.0	-47,603	60%	-8.1	-7.8	-8.1	-6.1
3	National Grid	Process	565615	147,000	100%	40.0	40.0	47,328	89%	19.0	0.0	17.8	0.0
4	National Grid	Process	660085	61,351	86%	13.1	13.1	-31,424	83%	-6.5	-7.3	-6.4	-7.6
42	National Grid	Process	619132	27,017	44%	2.4	0.0	29,308	49%	0.6	3.6	1.9	4.4
5	National Grid	Process	549621	293,304	65%	13.1	6.7	386,552	71%	0.0	0.0	4.7	0.0
7	National Grid	Process	535677	346,100	33%	13.8	26.3	453,364	41%	162.2	146.3	173.3	154.6
46	National Grid	Process	577718	185,699	34%	0.0	73.9	61,414	29%	0.0	22.1	0.0	22.1
8	National Grid	Process	577753	966,113	23%	59.3	60.5	856,716	22%	29.7	28.7	36.3	40.9
9	National Grid	Process	565594	545,220	46%	48.0	114.0	1,049,944	44%	240.2	372.0	111.8	307.5
10	National Grid	Process	528942	860,067	46%	173.0	173.0	80,624	87%	27.6	17.3	57.6	31.6
41	National Grid	Process	631903	542,506	48%	61.9	61.9	323,176	48%	36.9	36.9	36.9	36.9
11	National Grid	Process	698744	1,580,593	20%	60.0	90.0	610,495	43%	54.7	67.9	54.7	67.9
13	National Grid	Process	560242	1,207,549	48%	132.4	132.4	1,276,968	46%	145.8	145.8	145.8	145.8
14	NSTAR	Process	CS8096	76,375	N/A	30.6	0.0	21,712	99%	7.0	2.6	6.7	2.0
15	NSTAR	Process	CS7614	7,619	N/A	1.6	1.6	73,808	46%	9.6	10.2	9.5	10.1
16	NSTAR	Process	BS8660	251,677	N/A	39.8	39.8	184,889	46%	22.8	22.8	22.8	22.8
17	NSTAR	Process	CS6366	119,501	N/A	13.6	13.6	135,616	46%	15.4	15.3	16.0	15.8
18	NSTAR	Process	CS7763	674,520	N/A	77.0	77.0	686,650	46%	79.2	78.1	79.6	78.0
19	NSTAR	Process	CS7973	445,113	N/A	57.2	57.2	426,455	55%	50.4	51.2	50.2	52.0
20	NSTAR	Process	BS8471	1,254,925	N/A	149.9	149.9	1,648,687	50%	202.7	207.5	201.6	207.3
21	NSTAR	Process	CS7503	1,906,746	N/A	244.0	242.3	1,834,223	45%	199.4	185.4	199.0	176.7
22	Unitil	Process	21093	45,910	N/A	5.5	4.5	38,091	58%	5.8	5.0	5.4	4.5
23	Unitil	Process	21094	20,683	N/A	4.2	3.4	57,889	46%	6.6	6.6	6.6	6.6
24	WMECO	Process	WM10S215P	37,009	N/A	19.0	19.0	0	0%	0.0	0.0	0.0	0.0
25	WMECO	Process	WM10S205	74,080	N/A	12.0	12.0	72,494	80%	13.0	10.5	14.9	9.8
26	WMECO	Process	WM10S304	475,476	N/A	75.0	75.0	9,401	60%	1.5	1.4	1.5	1.4
27	WMECO	Process	WM09S216P	527,826	N/A	60.0	60.0	202,587	49%	28.3	24.8	27.2	23.6
44	WMECO	Process	WM10S263	919,019	N/A	70.0	119.9	663,872	48%	57.9	107.1	57.9	107.1
	National Grid	**Process**	**Total**	**6,789,536**	**39%**	**619.4**	**791.9**	**5,096,860**	**43%**	**702.0**	**825.6**	**626.3**	**798.1**

				Tracking Estimated Savings				Evaluation Savings					
KEMA Site Number	Program Administrator	End Use	Site ID	kWh/yr	On-Peak %	Peak Coinc. Sum. kW	Peak Coinc. Wint. kW	kWh/yr	On-Peak %	On-Peak Sum. kW	On-Peak Wint. kW	Seasonal Sum. kW	Seasonal Wint. kW
	NSTAR	**Process**	**Total**	**4,736,476**	**N/A**	**613.7**	**581.4**	**5,012,042**	**N/A**	**586.4**	**573.1**	**585.2**	**564.7**
	Unitil	**Process**	**Total**	**66,593**	**N/A**	**9.6**	**7.9**	**95,980**	**N/A**	**12.4**	**11.6**	**12.1**	**11.1**
	WMECO	**Process**	**Total**	**2,033,410**	**N/A**	**236.0**	**285.9**	**948,354**	**N/A**	**100.7**	**143.7**	**101.5**	**141.8**
	Statewide	**Process**	**Total**	**13,626,015**	**N/A**	**1,478.7**	**1,667.0**	**11,153,235**	**N/A**	**1,401.5**	**1,554.0**	**1,325.1**	**1,515.6**

Table 11: Primary Site Discrepancies for Custom Process

				Realization Rates						
KEMA Site Number	Program Administrator	End Use	Site ID	kWh/yr	On-Peak %	On-Peak Sum. kW	On-Peak Wint. kW	Seasonal Sum. kW	Seasonal Wint. kW	Primary Reasons For Discrepancies
2	National Grid	Process	591550	-176%	137%	-334%	N/A	-332%	N/A	Negative savings from 2 water heaters operating simultaneously, rather than staged 2-heater operation anticipated in TA study. Post-installation used more energy than base case system.
3	National Grid	Process	565615	32%	89%	48%	0%	45%	0%	A reduction in plant operating hours had the biggest impact on the savings results.
4	National Grid	Process	660085	-51%	97%	-50%	-56%	-49%	-58%	Negative savings because the site is not using all of the energy saving features of the installed equipment. Post-installation used more energy than base case system.
42	National Grid	Process	619132	108%	112%	24%	N/A	78%	N/A	Increased savings because only one water heater operates currently, rather than staged two-heater operation assumed in the TA study.
5	National Grid	Process	549621	132%	109%	0%	0%	36%	0%	Increased savings from including indirect savings from air compressor, air dryer, and boiler condensate pump.
7	National Grid	Process	535677	131%	125%	1175%	555%	1255%	587%	Increased savings because TA study overestimated required airflow.
46	National Grid	Process	577718	33%	84%	N/A	30%	N/A	30%	Savings were decreased due to two factors: an error in the load projection and an incorrect pre-existing gun performance curve.
8	National Grid	Process	577753	89%	96%	50%	48%	61%	68%	Savings decreased from votators operating at much higher loads than expected, and errors in calculating process cooling loads. Savings increased because of higher product throughput and lower process cooking temperature than TA study assumed.
9	National Grid	Process	565594	193%	96%	501%	326%	233%	270%	Increased savings because evaluation directly compared against baseline , instead of against a rolling baseline in the TA study from a measure that ultimately was not installed.
10	National Grid	Process	528942	9%	190%	16%	10%	33%	18%	Savings much lower because 1 of 2 new machines remains out of service, and old equipment is still being used. Also, annual plant production was less than had been predicted due to business downturn.
41	National Grid	Process	631903	60%	100%	60%	60%	60%	60%	The primary reasons for the decrease in savings are the overstatement of equipment operational hours in the existing case and the understatement of equipment operation in the installed case.

KEMA Site Number	Program Administrator	End Use	Site ID	Realization Rates: kWh/yr	Realization Rates: On-Peak %	Realization Rates: On-Peak Sum. kW	Realization Rates: On-Peak Wint. kW	Realization Rates: Seasonal Sum. kW	Realization Rates: Seasonal Wint. kW	Primary Reasons For Discrepancies
11	National Grid	Process	698744	39%	216%	91%	75%	91%	75%	The primary reason for the decrease in savings is due to a small sample of machines used in the TA analysis, most of which had a higher than average demand.
13	National Grid	Process	560242	106%	97%	110%	110%	110%	110%	Increased savings due to increased production.
14	NSTAR	Process	CS8096	28%	N/A	23%	N/A	22%	N/A	The primary reason for the decrease in savings is due to the tracking analysis calculation methodology and reduced operating hours.
15	NSTAR	Process	CS7614	969%	N/A	598%	637%	591%	628%	Savings much higher because TA study did not account for new VFDs, which were added to the project after the original application had been submitted. Also, actual water production was about 3 times greater than originally assumed.
16	NSTAR	Process	BS8660	73%	N/A	57%	57%	57%	57%	Lower savings because overall pumping demands were greater than assumed in TA study, requiring higher pump speeds and power draw.
17	NSTAR	Process	CS6366	113%	N/A	113%	112%	117%	116%	Savings closely matched tracking estimates. Increased savings due to increase in power consumption of the plant.
18	NSTAR	Process	CS7763	102%	N/A	103%	101%	103%	101%	Increased savings from adjusting baseline transmitter kW, using metered transmitter kW rather than manufacturer data, and accounting for cooling energy associated with the transmitter.
19	NSTAR	Process	CS7973	96%	N/A	88%	90%	88%	91%	Decreased savings because TA study assumed fixed speed motors, while the evaluation found them to be variable speed and operating slightly faster on average than had been presumed.
20	NSTAR	Process	BS8471	131%	N/A	135%	138%	134%	138%	Savings increased due to differences in the baseline estimates for the fan power. The tracking analysis used generalized assumptions to determine a baseline power draw. In contrast, the evaluation's baseline estimates used the actual design fan curve in conjunction with established power estimates.
21	NSTAR	Process	CS7503	96%	N/A	82%	77%	82%	73%	No obvious discrepancies between the TA and Evaluation reports. There is likely a difference in results due to the use of an 8,760 hour model in the evaluation versus a typical day of each month in the TA analysis.
22	Unitil	Process	21093	83%	N/A	106%	111%	100%	100%	Decreased savings due to higher average power consumption of the installed injection molding machine.

KEMA Site Number	Program Administrator	End Use	Site ID	Realization Rates: kWh/yr	On-Peak %	On-Peak Sum. kW	On-Peak Wint. kW	Seasonal Sum. kW	Seasonal Wint. kW	Primary Reasons For Discrepancies
23	Unitil	Process	21094	280%	N/A	159%	194%	159%	194%	Savings increased due to a lower power draw of the installed system as compared to tracking estimates. In addition, interactive cooling savings were not accounted for in the tracking estimate, but were included in the evaluation estimate.
24	WMECO	Process	WM10S215P	0%	N/A	0%	0%	0%	0%	The measure has not been implemented.
25	WMECO	Process	WM10S205	98%	N/A	108%	88%	124%	81%	The TA analysis assumed longer operating hours for the pre-existing and installed cases than the evaluation analysis, but assumed greater average loading for the installed case blowers. The longer hours served to increase the savings relative to the evaluation estimate, while the increased installed case loading served to decrease the savings.
26	WMECO	Process	WM10S304	2%	N/A	2%	2%	2%	2%	The primary reason for the decrease in savings is the decrease in annual machine operational hours due to the loss of the site's largest customer.
27	WMECO	Process	WM09S216P	38%	N/A	47%	41%	45%	39%	The primary reason for the decrease in savings is due a significant difference in the number of production lines in regular operation than estimated in the original study. Additionally, the original study assumed that both the pre-retrofit compressed air and installed blowers would operate continuously which is not the case.
44	WMECO	Process	WM10S263	72%	N/A	83%	89%	83%	89%	The primary reasons for the decrease in savings are increased overall installed case power demand and more installed case operating hours.

Table 13 presents a summary of the Custom Compressed Air site level results for this impact evaluation. Table 14 summarizes the savings realization rates and primary reasons for discrepancies between the tracking and evaluation estimates of annual energy savings for Custom Compressed Air. The site energy savings realization rates ranged from a low of 30% for Site 36 to a high of 229% for Site 31. Note that some of the ratios are "N/A" for the on-peak % and peak demand reductions because the tracking estimates were zero for some of these values.

Table 12: Detailed Site Results for Custom Compressed Air

					Tracking Estimated Savings				Evaluation Savings						
						On-	Peak Coinc.			On-	On-Peak		Seasonal		
KEMA Site Number	Program Administrator	End Use	Stratum	Site ID	kWh/yr	Peak %	Sum. kW	Wint. kW	kWh/yr	Peak %	Sum. kW	Wint. kW	Sum. kW	Wint. kW
29	National Grid	Compressed Air	1	569835	123,940	47%	14.4	14.4	109,562	49%	12.7	12.6	12.0	12.3
30	National Grid	Compressed Air	1	624168	87,729	45%	18.6	16.5	28,467	57%	0.5	0.4	1.4	0.5
31	National Grid	Compressed Air	1	623103	77,429	45%	10.7	10.8	177,458	44%	18.8	19.0	18.7	19.0
32	National Grid	Compressed Air	2	562035	418,127	50%	10.3	3.8	366,162	40%	38.2	37.0	35.5	36.3
33	National Grid	Compressed Air	2	619394	603,608	51%	81.0	81.0	370,589	46%	40.6	41.1	36.6	45.2
34	NSTAR	Compressed Air	1	S7826C	34,300	N/A	0.0	0.0	20,123	100%	0.0	0.0	0.0	0.0
35	NSTAR	Compressed Air	1	BS8907	124,535	N/A	14.1	14.1	190,822	46%	21.7	21.8	21.7	21.8
36	NSTAR	Compressed Air	2	CS8205	452,312	N/A	54.5	54.5	135,369	56%	18.9	16.6	18.9	17.0
37	WMECO	Compressed Air	1	WM10P365	86,763	N/A	2.5	2.5	72,472	48%	8.0	6.6	8.6	7.0
39	WMECO	Compressed Air	1	WM10S206	33,932	N/A	2.1	2.1	46,663	46%	5.3	5.4	5.3	5.1
45	WMECO	Compressed Air	1	WM10S215C	123,135	N/A	38.5	38.5	71,168	80%	13.2	3.0	14.9	2.8
	National Grid	**Compressed Air**	**Total**		**1,310,833**	**38%**	**135.0**	**126.4**	**1,052,238**	**42%**	**110.9**	**110.1**	**104.1**	**113**
	NSTAR	**Compressed Air**	**Total**		**611,147**	**N/A**	**68.6**	**68.6**	**346,314**	**N/A**	**40.7**	**38.4**	**40.6**	**39**
	WMECO	**Compressed Air**	**Total**		**243,830**	**N/A**	**43.1**	**43.1**	**190,303**	**N/A**	**26.4**	**15.0**	**28.8**	**15**
	Statewide	**Compressed Air**	**Total**		**2,165,810**	**N/A**	**246.7**	**238.1**	**1,588,855**	**N/A**	**177.9**	**163.5**	**173.5**	**167**

Table 13: Primary Site Discrepancies for Custom Compressed Air

KEMA Site Number	Program Administrator	End Use	Stratum	Site ID	Realization Rates: kWh/yr	On-Peak %	On-Peak Sum. kW	On-Peak Wint. kW	Seasonal Sum. kW	Seasonal Wint. kW	Primary Reasons For Discrepancies
29	National Grid	Compressed Air	1	569835	88%	103%	88%	87%	83%	86%	Lower savings because measured kW data showed new compressor operated less time than TA study assumed. This was partially offset by lower air demand, which yields greater savings when compressor does run.
30	National Grid	Compressed Air	1	624168	32%	127%	3%	2%	7%	3%	Decreased savings because trim compressor hours are much lower than assumed in the TA study. Since the project replaced the trim compressor, lower usage directly affects savings.
31	National Grid	Compressed Air	1	623103	229%	97%	175%	177%	174%	177%	Higher savings because evaluated post-installation air demand, based on measured kW and compressor performance curves, was much less than TA study assumed. Also, compressed air system operates continuously, providing more hours over which savings can accrue.
32	National Grid	Compressed Air	2	562035	88%	80%	370%	988%	344%	969%	Savings decreased primarily because the installed compressor meets greater loads than projected in the TA analysis. As such, the savings derived from the installed compressor's improved turndown capabilities were partially mitigated.
33	National Grid	Compressed Air	2	619394	61%	90%	50%	51%	45%	56%	Lower savings because reduced compressed air loads were offset by 2 new production lines, thus increasing overall demand. A baseline modulating compressor continuously ran unloaded in the TA study, but is actually provided compressed air under current conditions, thereby making the baseline system more efficient.
34	NSTAR	Compressed Air	1	S7826C	59%	N/A	N/A	N/A	N/A	N/A	No documentation was provided on the TA analysis methodology and therefore a discussion of why there is a discrepancy between these two values cannot be provided.

KEMA Site Number	Program Administrator	End Use	Stratum	Site ID	Realization Rates: kWh/yr	On-Peak %	On-Peak Sum. kW	On-Peak Wint. kW	Seasonal Sum. kW	Seasonal Wint. kW	Primary Reasons For Discrepancies
35	NSTAR	Compressed Air	1	BS8907	153%	N/A	154%	154%	154%	154%	The compressed air energy savings component from the elimination of the purging step were higher than originally estimated. The cycling thermal mass dryer was also shown to cycle much more frequently than anticipated and resulted in overall lower energy consumption than what was initially presumed which also pushed up the realization rate.
36	NSTAR	Compressed Air	2	CS8205	30%	N/A	35%	30%	35%	31%	The primary reason for the decrease in savings comes from a likely documentation error in the reporting. When the AIRMaster+ model outputs used to calculate the energy savings were examined in the documentation provided, it was found that the energy savings predicted by the model do not match the value reported for this measure. Outputs from the AIRMaster+ model predict energy savings at 167,525 kWh whereas the measure itself claimed 452,312 kWh.
37	WMECO	Compressed Air	1	WM10P365	84%	N/A	320%	263%	344%	280%	The primary reason for the decrease in savings is due to more compressor operation at lower airflow rates. This is partially offset by additional cooling savings that result from improved compressor performance, and were overlooked in the original TA study.
39	WMECO	Compressed Air	1	WM10S206	138%	N/A	253%	260%	254%	247%	The primary reason for the increase in savings is a larger performance improvement than originally predicted. This improvement in performance is due to more operation at lower airflow rates than predicted in the original study.
45	WMECO	Compressed Air	1	WM10S215C	58%	N/A	34%	8%	39%	7%	The primary reason for the decrease in savings are an increase in the VFD compressor load stemming from increased facility production and reduced operating hours of the pre-existing and base case refrigerated dryers. The increased compressor load minimizes the performance benefit of the variable frequency drive.

The site-level evaluation results were aggregated using stratified ratio estimation. The PA realization rates are calculated, and then applied to each PA's total tracking savings to determine their total measured savings. The statewide realization rate is the ratio of the total measured savings to the total tracking savings, each of which is calculated by summing across the PAs.

Table 14 summarizes the PA-specific results of the Custom Process analysis. In the case of annual MWh savings, the realization rate for Custom Process measures ranged from 51.3% for WMECO to 144.1% for Unitil. The relative precision for these estimates was found to range from ±23.3% to ±51.3% at the 90% level of confidence, which is worse than was anticipated at the time of the design. This is because the error ratios were all above 0.5, which was used as an estimate during the design. The variation in the evaluated site results for this study was greater than expected, including 0 and negative savings at some sites. Table 14 also shows the results for the on-peak summer and winter coincident demand savings, measured in KW. Results for % On-Peak MWh are provided for National Grid only, as they are the only PA that uses this parameter. Since the design criteria for the demand realization rates were based on an 80% confidence level, the precisions and error bounds at this level are reported in the appropriate rows in Table 14.

Table 14: Summary of Custom Process Results by PA

Process Results by PA	Annual MWh	% On-Peak MWh	On-Peak MWh	On-Peak Summer kW	On-Peak Winter kW	Summer Season Peak kW	Winter Season Peak kW
National Grid							
Total Tracking Savings	11,469	45.7%	5,240	1,307	1,426	1,307	1,426
Total Measured Savings	7,767	46.0%	3,572	1,251	1,172	1,305	1,239
Realization Rate	67.7%	100.7%	68.2%	95.7%	82.2%	99.9%	86.8%
Relative Precision at 90% Confidence	23.9%	-	32.7%				
Error Bound at 90% Confidence	1,854	-	1,168				
Relative Precision at 80% Confidence				18.6%	25.5%	38.7%	40.3%
Error Bound at 80% Confidence				484	473	505	491
Error Ratio	0.84	-	0.82	1.65	1.75	1.56	1.67
NSTAR							
Total Tracking Savings	6,933	-	-	1,063	1,004	1,063	1,004
Total Measured Savings	7,229	-	-	848	1,110	844	1,091
Realization Rate	104.3%	-	-	79.8%	110.6%	79.4%	108.7%
Relative Precision at 90% Confidence	23.3%	-	-				
Error Bound at 90% Confidence	1,681,371	-	-				
Relative Precision at 80% Confidence				31.4%	17.2%	31.8%	17.0%
Error Bound at 80% Confidence				267	191	268	185
Error Ratio	0.68	-	0.73	0.87	0.76	0.87	0.77
Unitil							
Total Tracking Savings	146	-	-	18	15	18	15
Total Measured Savings	210	-	-	23	22	23	21
Realization Rate	144.1%	-	-	129.1%	147.3%	124.9%	141.0%
Relative Precision at 90% Confidence	48.1%	-	-				
Error Bound at 90% Confidence	101	-	-				
Relative Precision at 80% Confidence				12.8%	17.5%	15.0%	20.8%
Error Bound at 80% Confidence				3	4	3	4
Error Ratio	0.62	-	-	0.21	0.29	0.25	0.34
WMECO							
Total Tracking Savings	4,340	-	-	445	437	445	437
Total Measured Savings	2,227	-	-	202	226	209	222
Realization Rate	51.3%	-	-	45.4%	51.7%	46.9%	50.8%
Relative Precision at 90% Confidence	31.6%	-	-				
Error Bound at 90% Confidence	703	-	-				
Relative Precision at 80% Confidence				38.1%	35.6%	39.0%	36.3%
Error Bound at 80% Confidence				77	80	81	81
Error Ratio	0.59	-	-	1.02	0.86	1.05	0.87

DNV KEMA aggregated the PA results to determine statewide realization rates, for use by the smaller PAs as needed. These overall results follow in Table 15.

Table 15: Statewide Custom Process Results

Overall Process Results	Annual MWh	% On-Peak MWh	On-Peak MWh	On-Peak Summer kW	On-Peak Winter kW	Summer Season Peak kW	Winter Season Peak kW
Total Tracking Savings	22,888	-	-	2,833	2,883	2,833	2,883
Total Measured Savings	17,434	-	-	2,324	2,531	2,381	2,573
Realization Rate	76.2%	-	-	82.0%	87.8%	84.0%	89.3%
Relative Precision at 90% Confidence	14.9%	-	-				
Error Bound at 90% Confidence	2,602	-	-				
Relative Precision at 80% Confidence				24.0%	20.4%	24.3%	20.6%
Error Bound at 80% Confidence				558	516	578	531
Error Ratio	0.74	-	-	1.30	1.23	1.26	1.21

The statewide realization rate for Annual MWh savings is 76.2%, estimated with ±14.9% relative precision. The demand realization rates are all between 82.0% and 89.3%.

Aggregated results from the Compressed Air sample sites are presented in Table 16 and Table 17 below. Realization rates for Annual MWh savings range from 78.0% for WMECO and NSTAR to 89.1% for National Grid. The goal for this study was to achieve ±40% relative precision with 90% confidence for Annual MWh and 80% confidence for peak kW, by PA. For the most part, the results met these targets. The statewide realization rate for Compressed Air measures was 85.2% for Annual MWh, estimated with ±24.6% relative precision. The realization rates for the demand measurements were all between 74.1% and 76.3%.

Table 16: Summary of Compressed Air Results by PA

Compressed Air Results by PA	Annual MWh	% On-Peak MWh	On-Peak MWh	On-Peak Summer kW	On-Peak Winter kW	Summer Season Peak kW	Winter Season Peak kW
National Grid							
Total Tracking Savings	3,936	48.1%	1,893	485	476	485	476
Total Measured Savings	3,507	44.9%	1,575	381	395	367	402
Realization Rate	89.1%	93.4%	83.2%	78.6%	83.0%	75.6%	84.4%
Relative Precision at 90% Confidence	34.0%	-	33.8%				
Error Bound at 90% Confidence	1,191	-	532				
Relative Precision at 80% Confidence				40.3%	40.5%	39.9%	39.1%
Error Bound at 80% Confidence				154	160	146	157
Error Ratio	0.57	-	0.51	0.88	0.89	0.87	0.86
NSTAR							
Total Tracking Savings	1,170	-	-	143	144	143	144
Total Measured Savings	913	-	-	117	114	117	115
Realization Rate	78.0%	-	-	81.6%	79.2%	81.6%	79.6%
Relative Precision at 90% Confidence	45.1%	-	-				
Error Bound at 90% Confidence	412,081	-	-				
Relative Precision at 80% Confidence				34.6%	37.1%	34.7%	36.7%
Error Bound at 80% Confidence				40	42	41	42
Error Ratio	0.74	-	0.72	0.75	0.81	0.76	0.80
WMECO							
Total Tracking Savings	958	-	-	128	126	128	126
Total Measured Savings	747	-	-	78	44	85	43
Realization Rate	78.0%	-	-	61.3%	34.7%	66.8%	34.5%
Relative Precision at 90% Confidence	24.6%	-	-				
Error Bound at 90% Confidence	184	-	-				
Relative Precision at 80% Confidence				55.0%	95.9%	52.5%	98.0%
Error Bound at 80% Confidence				43	42	45	43
Error Ratio	0.32	-	-	0.80	1.42	0.75	1.43

Table 17: Summary of Statewide Compressed Air Results

Overall Compressed Air Results	Annual MWh	% On-Peak MWh	On-Peak MWh	On-Peak Summer kW	On-Peak Winter kW	Summer Season Peak kW	Winter Season Peak kW
Total Tracking Savings	6,064	-	-	756	746	756	746
Total Measured Savings	5,168	-	-	577	553	569	560
Realization Rate	85.2%	-	-	76.3%	74.1%	75.2%	75.1%
Relative Precision at 90% Confidence	24.6%	-	-				
Error Bound at 90% Confidence	1,274	-	-				
Relative Precision at 80% Confidence				28.6%	30.9%	27.8%	30.0%
Error Bound at 80% Confidence				165	171	158	168
Error Ratio	0.57	-	-	0.84	0.92	0.83	0.89

5.3 Implications for Future Studies

From a statistical perspective it appears that the Custom Process results are less stable, and the variation across sample sites is greater than expected. Unless the underlying causes of the variability change, future designs should assume higher error ratio values to determine sample size requirements. The Compressed Air sample demonstrated somewhat less variability.

5.4 Conclusions and Recommendations

Overall, the Custom Process and Compressed Air program appears to be producing results that are lower than expected. The Custom Process end-use appears to be a bit more variable than Compressed Air. Below are the DNV KEMA evaluation team findings and recommendations that apply statewide, as well as to the individual PAs.

5.4.1 Statewide

Require Adequate Savings Documentation. At one site savings were claimed following a typical prescriptive measure approach of using a kWh/motor hp, but the basis for the kWh/hp value is not provided. The source of the compressed air profiles for two sites (hours at different air flows) were not provided with the tracking documentation. Another site did not provide documentation on the pre-retrofit metering used in the tracking study. Two other sites did not include documentation on the equipment performance that was used in the tracking study. One site did not provide backup documentation for the installed case equipment demand. The documentation issues were found with each of the PAs. It is recommended that all savings documentation be retained so that tracking savings can be reproduced for evaluation purposes, or other purposes.

Devote extra review time to calculation of operating hours. One other finding that all PAs can benefit from is that estimates of operation can be improved throughout the state. The primary reason for lower than predicted savings for several of the sites was the result of a reduction in equipment operating hours. It is recommended that all PAs more closely review a project's estimated operating hours, as this was an area where savings were reduced.

Consider additional savings opportunities when conducting TA studies. The TA study is a great time to consider all savings opportunities within sites. There were some cases where increased savings could have been realized by installing more efficient systems, or improving the current systems within these facilities. It is recommended that PAs encourage TA vendors to consider all areas of opportunity while conducting their studies.

5.4.2 National Grid

Adjust savings estimates to match changing conditions. Project tracking savings at one site was based on the owner's original estimation of future production despite evidence presented in multiple documents obtained by the PA prior to the evaluation that actual post-installation production was much different. It is recommended that PAs reevaluate tracking savings when incoming program documentation suggests that conditions used in the analysis might be extreme, one way or the other, compared to physical site data..

Determine if original equipment has been removed, taken out of service, or is still in use. At the same site, original equipment that was expected to be obsolete after the completion of the project was allowed to remain in place and was found during the evaluation to continue its operation. While it was evident during the site visit that the original equipment continued to operate, its status during commissioning had not been fully understood. It is recommended that when original equipment is allowed to be left in place, the commissioning team and the post-installation inspection team should be able to thoroughly investigate and document the disposition of the old equipment. Tracking estimates should be re-evaluated according to their findings.

Be aware of projects where several measures were proposed, but not all implemented. At one site, a rolling baseline was used to calculate individual savings for multiple proposed measures. Only one of these measures was installed (the evaluated measure), and this measure's savings was calculated using another measure's energy usage as the baseline. As the measure used for the baseline was never installed, in the tracking analysis underestimated savings. We recommend that if a rolling baseline is used, each measure used in the rolling baseline calculation should be verified as installed. If not, the savings calculation should be updated before the savings being finalized.

Ensure adequate sampling procedures are used when conducting pre-installation metering. One site involved a large number of process lines, but the evaluation found the TA metering did not provide a representative sample of lines from which to draw savings estimates from. At another site, it was assumed that the instantaneous metering performed for the TA study was representative of annual operation, which was not the case. A long sample of metering or in depth analysis would have likely improved the accuracy of the tracking study. Pre-installation metering is very beneficial to developing accurate estimates energy savings. It is recommended that this process be continued, but enhanced in certain cases where there is a high degree of uncertainty.

Make use of all available data from the site. At one site, it was assumed that the equipment operation did not vary over the course of year. The evaluation found that this was not the case, and that these variations resulted in savings adjustments. Evaluators believe that trend data from the facility could have been used to confirm equipment staging assumptions throughout the year. It is recommended that all available information be used to inform estimates of savings, particularly trend data that may provide historical variations in usage.

Consider more rigorous post-installation check-up. At one site, the installed case equipment was found not to be using all of the energy saving features outlined in the MRD due to complications with their product. Savings were reduced as a result of this measure not operating optimally. The post-installation inspection is the ideal time to identify issues such as these. It is not clear to evaluators if the energy savings features were disabled prior to or following the post-installation inspection. However, this recommendation is being made to emphasize that for each site, the post-installation inspection show that the energy savings measures are installed, and are functioning, and tracking savings adjusted accordingly.

5.4.3 NSTAR

Identify changes in project scope and apply these changes to the tracking savings. The TA study addressed an early version of one customer's project that omitted a significant aspect to the project's final scope of work. It is recommended that tracking savings are reevaluated whenever changes in the customer's project scope are made evident through incoming program documentation.

Confirm all assumptions about pre-existing equipment. The TA study for one site assumed that pre-existing equipment was operating continuously. The evaluation found that this was not the case. It is recommended that assumptions involving the continuous operation of pre-existing equipment receive greater scrutiny so large variations in savings are not driven by inaccurate assumptions around pre-existing operation. The PA should attempt to obtain any historical records of pre-existing equipment such as production logs or trend data, which may help inform these estimates.

Review model outputs against tracking savings estimates. There was one compressed air project that lost a significant component of its claimed energy savings due to a documentation error. When the AIRMaster+ model outputs used to calculate the energy savings were examined in the documentation provided, it was found that the energy savings predicted by the model do not match the value reported for this measure.

5.4.4 Unitil

There were two Unitil sample sites included in the 2010 Custom Process Impact Evaluation, which makes it difficult to propose recommendations regarding Unitil's program. However, there are some observations that could be made from reviewing these sample sites.

Consider all secondary sources of energy savings/penalties. Savings were much higher at one of the projects evaluated because the tracking estimates did not include any cooling interaction. The evaluation found that with this particular measure, there was a significant amount of savings relative to the overall measure savings due to cooling interaction. It is recommended that all sources of energy savings and penalties be investigated so that additional savings are not lost.

5.4.5 Western Massachusetts Electric Company

Account for all compressed air operation. There were two compressed air projects where compressors continued to run even during non-production hours. This was identified in the evaluation, but the tracking studies did not assume continuous operation. It is recommended that compressed air systems are reviewed to determine the full spectrum of operation rather than only during times of production.

Consider pre-installation metering, especially in cases where the existing equipment is removed. Pre-installation metering is an ideal way to confirm compressor operating hours and assumptions about pre-existing equipment. Some compressed air sites did not include metering of the pre-retrofit equipment, which was removed from the site as part of the measure implementation. It is recommended that the PA consider pre-installation metering to help inform the existing system usage during the TA study.

Confirm all assumptions about pre-existing equipment. The TA study for one site assumed that pre-existing equipment was operating continuously. The evaluation found that this was not the case. It is recommended that assumptions involving the continuous operation of pre-existing equipment receive greater scrutiny so large variations in savings are not driven by inaccurate assumptions around pre-existing operation. The PA should attempt to obtain any historical records of pre-existing equipment such as production logs or trend data, which may help inform these estimates.

Provide appropriate level of documentation relative to the project savings. Equipment at one site operates 8,760 hours per year. Therefore small errors in equipment demand assumptions have large impact on annual savings. It is recommended that assumptions used to estimate equipment power are more closely reviewed in cases where high operating hours may cause large variations in savings.

Consider all secondary sources of energy savings/penalties. Savings were much higher at two of the projects evaluated because the tracking estimates did not include secondary sources of savings. The evaluation found that with some measures, there were a significant amount of savings relative to the overall measure savings due to these secondary sources. It is recommended that all sources of energy savings and penalties be investigated so that additional savings are not lost.

Consider more rigorous post-installation check-up. Evaluators found that the customer has not yet fully implemented the proposed measure at one site; therefore no savings were able to be claimed. It is recommended that the application not be finalized until the installed equipment is operating per the MRD.

6. Appendix A: Custom Electric Sample Design

6.1 Population Analysis

The primary focus of the sample design was to examine various scenarios for Custom Electric programs (Non-Comprehensive, Non-HVAC, non-Lighting) in Massachusetts (MA). The goal of the design effort is to estimate sample sizes required to support the estimation of realization rates for a number of different realization rates, including annual kWh savings, summer and winter demand reductions, and other factors that impact the calculation of net savings for various measures.

The custom measure categories of interest are: Refrigeration, Process, Compressed Air, Motor/Drive, and Other (any measure category that did not fit the other four measure description or lighting or HVAC). PA tracking data were reviewed to determine whether these groups could be defined clearly from the available information. The approach was to classify measures according to the categories in which they are evaluated currently and will be evaluated going forward, rather than how they were classified when they were installed. Follow-up investigations with the PAs provided additional clarification, and projects classifications were adjusted as needed.

6.1.1 Reclassification and Exclusion of Measures

In order to maintain consistency of measure categorization by PA, some measures were reclassified into one of the five categories above. Table 18 presents the projects and measures that were reclassified by KEMA for each PA. The table provides a general description of the measure based on descriptions provided by the PAs, the original measure category (from PA), the new measure category (according to KEMA), and the numbers of applications and overall measures.

The largest measure from a quantity standpoint that was reclassified was the electrically commutated motors (ECMs). These motors are typically installed on fans in refrigerated areas such as walk-in coolers and freezers in grocery stores. KEMA verified that each of the ECMs in this population was installed in refrigerated areas based on descriptions provided by the PAs, and through follow-up with each PA if the description did not indicate this. As shown in the table, these measures are sometimes classified as "Motor" by the PAs. Note that there were also ECMs, not included in this table, that were originally classified by the PAs as "Refrigeration." Based on the large interactive impacts of installing these types of motors in refrigerated spaces, evaluators believe this technology should fall within the “Refrigeration” measure category. Currently, these measures are split between categories, but it is recommended that ECMs, if confirmed to be in refrigerated spaces, should be consistently categorized as “Refrigeration.” Each PA, except NSTAR and Unitil had measures in this category that were reclassified.

Evaluators next identified two NGRID measures that were reclassified based on their measure description. One was higher efficiency pumps that were reclassified as “Motor” from “Process” because motor efficiency measures typically fall within the “Motor” category. The second measure was an upgrade to dimmable LEDs with occupancy sensors. These were originally classified as “Refrigeration,” but this appears to be a lighting measure, so evaluators reclassified it in the Custom Lighting population.

Evaluators identified several WMECO measures that were reclassified so as to maintain consistency between PAs. The largest was air compressors, which WMECO traditionally classifies as “Process,” while each other PA puts these into their own “Compressed Air” category. Therefore, KEMA reclassified all WMECO air compressors into the “Compressed Air” category. There were also some O&M measures related to compressed air that were reclassified from “Process” to “Other” to maintain consistency between PAs. Next, KEMA reclassified all non-HVAC VFDs as “Motors” rather than “Process.”[3] Finally, a measure called “Turbo Blowers” was reclassified from “Other” to “Motor” because this looks to be an installation of new blowers. In order for the measure level results to be applied correctly, the PAs must use these same classifications in the year that the realization rates are applied.

[3] Note that VFDs integrated into new air compressors, injection molding machines, or other process equipment were left in their respective original categories (Compressed Air, Process) because they were part of new equipment installations within these categories.

Table 18: Reclassified Custom Electric Measures

Program Administrator	General Description	Original Measure Category	New Measure Category	Number of Applications	Number of Measures
CLC	Electrically Commutated Motors - Refrig	Motor	Refrigeration	1	1
NGRID	Electrically Commutated Motors - Refrig	Motor	Refrigeration	38	38
NGRID	Higher Efficiency Pumps	Process	Motor	1	1
NGRID	Upgrade to Dimmable LEDs with Occ Sensors	Refrigeration	Lighting	1	1
WMECO	Electrically Commutated Motors - Refrig	Motor	Refrigeration	5	15
WMECO	Turbo Blowers	Other	Motor	1	1
WMECO	VFDs	Process	Motor	1	1
WMECO	Air Compressors	Process	Compressed Air	13	19
WMECO	Compressed Air O&M (i.e. Air Leaks)	Process	Other	4	7
WMECO	VFDs on Dairy Pumps	Process	Motor	3	3

KEMA also excluded some Custom Electric measures because they would fall within the HVAC category, which was evaluated in 2010. Table 19 presents the measures that were excluded from the Custom Electric population. Each of these measures is HVAC related with the exception of NGRID's "auto response to price events." This measure was to install controls on a refrigeration system so that it would be able to quickly respond to price events. KEMA believes that this measure cannot be evaluated and recommends that it be removed from the population.

Table 19: Excluded Custom Electric Measures

Program Administrator	General Description	Original Measure Category	Number of Applications	Number of Measures
CLC	VFDs on HVAC	Motor	2	3
NGRID	Ultrasonic Humidifiers	Other	5	5
NGRID	Auto Response to Price Events	Refrigeration	1	1
NGRID	Chiller	Motor	3	3
NGRID	VFDs on HVAC	Motor	12	12
Unitil	Roof Insulation	Envelope	1	1
WMECO	EMS	Other	3	3
WMECO	ERVs on AHUs	Other	1	1
WMECO	VFDs on HVAC	Other	1	1

In addition, and not shown in Table 2, all Comprehensive Design Approach (CDA) projects were excluded because of they were already evaluated the recent 2010/11 impact evaluation of 2008-2009 CDA installations.

Based on the entire set of PA tracking data, a total of 390 projects were classified as Custom Electric non-CDA, no-HVAC and non-lighting (NLNH) measures. The resulting population of 2010 NLNH Custom Electric projects reported by PA and measure group is summarized in Table 20.

Table 20: Population Statistics

PA	Measure Groups	Projects	Total Savings	Average Savings	Minimum	Maximum	StdDev	CV
CLC	Refrigeration	1	90,228	90,228	90,228	90,228	0	0.00
NGRID	Process	45	11,469,099	254,869	17,052	1,580,593	356,484	1.40
NGRID	Refrigeration	95	6,928,794	72,935	832	1,636,616	170,615	2.34
NGRID	Compressed Air	22	3,936,025	178,910	13,006	826,260	226,488	1.27
NGRID	Motor	31	2,972,311	95,881	3,799	500,343	115,578	1.21
NGRID	Other	17	6,145,431	361,496	12,884	2,133,121	523,229	1.45
NSTAR	Process	37	8,834,867	238,780	0	1,906,746	437,428	1.83
NSTAR	Refrigeration	79	7,791,343	98,625	1,612	650,437	116,699	1.18
NSTAR	Compressed Air	6	1,170,288	195,048	21,563	452,312	171,134	0.88
NSTAR	Motor	3	38,185	12,728	9,567	16,898	3,077	0.24
Unitil	Process	4	145,641	36,410	4,588	74,460	26,448	0.73
Unitil	Motor	4	926,909	231,727	32,675	494,155	176,266	0.76
WMECO	Process	14	4,340,188	310,013	6,569	919,019	311,348	1.00
WMECO	Refrigeration	9	1,188,178	132,020	24,488	318,863	102,942	0.78
WMECO	Compressed Air	13	957,747	73,673	2,964	299,472	75,191	1.02
WMECO	Motor	6	241,334	40,222	8,435	101,856	42,736	1.06
WMECO	Other	4	1,652,580	413,145	25,946	797,698	324,604	0.79
Total		390	58,829,148					

6.2 Preliminary Sample Design

The primary variable of interest for the sample design was annual kWh savings. The PAs were also interested in the impact that the designed sample would have on the summer kW savings precision, in order to continue to meet the ISO New England (ISO-NE) guidelines for 80/10 precision for the overall portfolio. Both are assessed in the following sections.

All of the sample design results for annual kWh were calculated at the 90% confidence level. For summer and winter kW, all of the sample design results were calculated at the 80% confidence level.

Since the number of sample points required to achieve a desired level of precision depends upon the expected variability of the observed realization rates, KEMA looked at prior custom measure evaluation studies to determine likely error ratios. Based on studies that have been done for NGRID, NSTAR and WMECO, the error ratios for realization rates for annual energy savings have ranged from about 0.3 to 0.5. For demand savings, error ratios tend to be slightly higher, ranging from about 0.4 to 0.9 for summer kW and 0.5 to 1.2 for winter kW. To be conservative and provide confidence that precision targets will be met, the sample designs presented here are based on the error ratios provided in Table 21.

Table 21: Error Ratios used in the Preliminary Sample Design

End Use	Annual kWh Savings	Summer kW Reduction	Winter kW Reduction
Process	0.50	0.80	0.85
Refrigeration	0.40	0.80	1.30
Motor	0.50	0.60	0.60
Compressed Air	0.50	1.00	1.00
Other	0.60	0.90	1.30

The recommended sample design presented here provides for the estimation of realization rates by measure and by PA. KEMA recommends targeting precision at the measure level based on the significance of the measure to the overall custom electric population. Since process and refrigeration measures represent approximately 70% of the custom NLNH electric population, it is recommended that the target precision on energy savings is ±20% for each PA for each of these measures. The target precision on energy savings for the remaining three measures (motor, compressed air, other) is ±40% for each PA.

6.2.1 Annual kWh Sample Design

Table 22 presents preliminary sample designs stratified by annual kWh for the Massachusetts PAs for the Custom Electric NLNH program. The analysis looked at the impacts of various sample sizes on the anticipated precision of the resulting realization rate, assuming error ratios from Table 21 and a confidence level of 90%. The anticipated precisions are relative to the estimated realization rate. That is, an achieved precision of ±10% for an estimated realization rate of 100% means that we are 90% confident that the true realization rate is between 90% and 110%.

As evidenced by the table, the expected relative precisions range from a low of ±0.0% for cases where there are only 1 to 2 projects and both are selected, to a high of ±67.16% when 1 of 3 projects is selected. For the larger groups, most of the precisions run from about ±15% to ±30% for the range of potential sizes included in this table. A wider range of planned sample sizes can be provided upon request. The smaller the planned sample size, the higher the anticipated relative precision.

Table 22: Sample Planning 90% Confidence

Program Administrator	Measure Group	Projects	Total Savings	Desired Relative Precision	Required Sample Size	Planned Sample Size	Anticipated Relative Precision
CLC	Refrigeration	1	90,228	20%	1	1	±0.00%
NGRID	Process	45	11,469,099	20%	12	8	±26.37%
NGRID	Process	45	11,469,099	20%	12	10	±22.94%
NGRID	Process	45	11,469,099	20%	12	12	±20.33%
NGRID	Refrigeration	95	6,928,794	20%	10	6	±26.00%
NGRID	Refrigeration	95	6,928,794	20%	10	9	±20.87%
NGRID	Refrigeration	95	6,928,794	20%	10	12	±17.75%
NGRID	Compressed Air	22	3,936,025	40%	4	2	±55.45%
NGRID	Compressed Air	22	3,936,025	40%	4	4	±37.20%
NGRID	Compressed Air	22	3,936,025	40%	4	6	±28.64%
NGRID	Motor	31	2,972,311	40%	4	2	±56.25%
NGRID	Motor	31	2,972,311	40%	4	4	±38.38%
NGRID	Motor	31	2,972,311	40%	4	6	±30.15%
NGRID	Other	17	6,145,431	40%	4	2	±65.56%
NGRID	Other	17	6,145,431	40%	4	4	±43.16%
NGRID	Other	17	6,145,431	40%	4	6	±32.41%
NGRID	Total	210	31,451,660	0%	34	20	±19.13%
NGRID	Total	210	31,451,660	0%	34	31	±14.04%
NGRID	Total	210	31,451,660	0%	34	42	±11.46%
NSTAR	Process	37	8,834,867	20%	12	6	±30.74%
NSTAR	Process	37	8,834,867	20%	12	8	±25.74%
NSTAR	Process	37	8,834,867	20%	12	10	±22.22%
NSTAR	Refrigeration	79	7,791,343	20%	10	6	±25.82%
NSTAR	Refrigeration	79	7,791,343	20%	10	9	±20.65%
NSTAR	Refrigeration	79	7,791,343	20%	10	12	±17.49%
NSTAR	Compressed Air	6	1,170,288	40%	2	2	±47.49%
NSTAR	Compressed Air	6	1,170,288	40%	2	3	±33.58%
NSTAR	Compressed Air	6	1,170,288	40%	2	4	±23.74%
NSTAR	Motor	3	38,185	40%	2	1	±67.16%
NSTAR	Motor	3	38,185	40%	2	2	±33.58%
NSTAR	Motor	3	38,185	40%	2	3	±0.00%

Program Administrator	Measure Group	Projects	Total Savings	Desired Relative Precision	Required Sample Size	Planned Sample Size	Anticipated Relative Precision
NSTAR	Total	125	17,834,683	0%	26	15	±19.20%
NSTAR	Total	125	17,834,683	0%	26	22	±15.78%
NSTAR	Total	125	17,834,683	0%	26	29	±13.49%
Unitil	Process	4	145,641	20%	3	2	±41.13%
Unitil	Process	4	145,641	20%	3	3	±23.74%
Unitil	Process	4	145,641	20%	3	4	±0.00%
Unitil	Motor	4	926,909	40%	2	1	±71.23%
Unitil	Motor	4	926,909	40%	2	2	±41.13%
Unitil	Motor	4	926,909	40%	2	3	±23.74%
Unitil	Total	8	1,072,550	0%	5	3	±61.81%
Unitil	Total	8	1,072,550	0%	5	5	±35.69%
Unitil	Total	8	1,072,550	0%	5	7	±20.52%
WMECO	Process	14	4,340,188	20%	8	2	±53.85%
WMECO	Process	14	4,340,188	20%	8	4	±34.76%
WMECO	Process	14	4,340,188	20%	8	6	±25.38%
WMECO	Refrigeration	9	1,188,178	20%	5	3	±31.02%
WMECO	Refrigeration	9	1,188,178	20%	5	4	±24.52%
WMECO	Refrigeration	9	1,188,178	20%	5	5	±19.62%
WMECO	Compressed Air	13	957,747	40%	3	2	±53.50%
WMECO	Compressed Air	13	957,747	40%	3	3	±41.65%
WMECO	Compressed Air	13	957,747	40%	3	4	±34.22%
WMECO	Motor	6	241,334	40%	2	2	±47.49%
WMECO	Motor	6	241,334	40%	2	3	±33.58%
WMECO	Motor	6	241,334	40%	2	4	±23.74%
WMECO	Other	4	1,652,580	40%	2	2	±49.35%
WMECO	Other	4	1,652,580	40%	2	3	±28.49%
WMECO	Other	4	1,652,580	40%	2	4	±0.00%
WMECO	Total	46	8,380,027	0%	20	11	±30.51%
WMECO	Total	46	8,380,027	0%	20	17	±19.78%
WMECO	Total	46	8,380,027	0%	20	23	±14.01%

Based on the results of the preliminary planning scenarios and based on a design that would be at the PA level for all measure groups, samples were designed based on the population data provided by the PAs and the sample sizes required to meet the target precision levels by PA and measure group. The total sample size under this scenario would be 80. Table 23 shows the corresponding stratum cut points and distribution of sample sites.

Table 23: Sample Design based on Preliminary Scenario

Program Administrator	Measure Group	Stratum	Maximum Savings	Projects	Total Savings	Planned Sample	Inclusion Probabilities
CLC	Refrigeration	1	90,228	1	90,228	1	1.0000
NGRID	Process	1	185,399	30	1,941,334	4	0.1333
NGRID	Process	2	474,105	7	2,130,475	3	0.4286
NGRID	Process	3	966,113	5	3,563,665	3	0.6000
NGRID	Process	4	1,580,593	3	3,833,625	3	1.0000
NGRID	Refrigeration	1	58,306	56	1,436,482	3	0.0536
NGRID	Refrigeration	2	90,333	25	1,764,076	3	0.1200
NGRID	Refrigeration	3	368,945	13	2,091,620	2	0.1538
NGRID	Refrigeration	4	1,636,616	1	1,636,616	1	1.0000
NGRID	Compressed Air	1	225,414	18	1,419,422	3	0.1667
NGRID	Compressed Air	2	826,260	4	2,516,603	2	0.5000
NGRID	Motor	1	113,880	25	1,175,924	3	0.1200
NGRID	Motor	2	500,343	6	1,796,387	2	0.3333
NGRID	Other	1	378,984	13	1,650,262	2	0.1538
NGRID	Other	2	948,936	3	2,362,048	2	0.6667
NGRID	Other	3	2,133,121	1	2,133,121	1	1.0000
NSTAR	Process	1	103,385	24	864,867	2	0.0833
NSTAR	Process	2	251,677	6	1,086,239	2	0.3333
NSTAR	Process	3	700,537	3	1,820,170	2	0.6667
NSTAR	Process	4	1,906,746	2	3,161,671	2	1.0000
NSTAR	Refrigeration	1	85,279	52	1,990,738	4	0.0769
NSTAR	Refrigeration	2	256,272	18	2,434,319	3	0.1667
NSTAR	Refrigeration	3	650,437	9	3,366,286	3	0.3333
NSTAR	Compressed Air	1	406,178	5	717,976	2	0.4000
NSTAR	Compressed Air	2	452,312	1	452,312	1	1.0000
NSTAR	Motor	1	16,898	3	38,185	1	0.3333
Unitil	Process	1	74,460	4	145,641	2	0.5000
Unitil	Motor	1	494,155	4	926,909	2	0.5000
WMECO	Process	1	406,773	9	965,179	2	0.2222
WMECO	Process	2	533,688	3	1,536,990	2	0.6667
WMECO	Process	3	919,019	2	1,838,019	1	0.5000
WMECO	Refrigeration	1	182,629	6	438,003	2	0.3333
WMECO	Refrigeration	2	318,863	3	750,175	2	0.6667
WMECO	Compressed Air	1	299,472	13	957,747	3	0.2308
WMECO	Motor	1	101,856	6	241,334	2	0.3333
WMECO	Other	1	797,698	4	1,652,580	2	0.5000

Table 24 lists the calculated precision estimates for this scenario, following stratification. The anticipated precisions are shown by Measure Group and overall for each PA.

Table 24: Estimated Precision for Preliminary Sample

Program Administrator	Measure Group	Projects	Total Savings	Error Ratio	Confidence Level	Planned Sample Size	Anticipated Relative Precision
CLC	Refrigeration	1	90,228	0.4	90%	1	±0.00%
CLC	Total	1	90,228	0.4	90%	1	±0.00%
NGRID	Process	45	11,469,099	0.5	90%	13	±15.73%
NGRID	Refrigeration	95	6,928,794	0.4	90%	9	±20.70%
NGRID	Compressed Air	22	3,936,025	0.5	90%	5	±32.04%
NGRID	Motor	31	2,972,311	0.5	90%	5	±35.26%
NGRID	Other	17	6,145,431	0.6	90%	5	±31.99%
NGRID	Total	210	31,451,660	0.5	90%	37	±10.95%
NSTAR	Process	35	6,932,947	0.5	90%	8	±18.26%
NSTAR	Refrigeration	79	7,791,343	0.4	90%	10	±19.84%
NSTAR	Compressed Air	6	1,170,288	0.5	90%	3	±37.45%
NSTAR	Motor	3	38,185	0.5	90%	1	±68.39%
NSTAR	Total	123	15,932,763	0.5	90%	22	±12.84%
Unitil	Process	4	145,641	0.5	90%	2	±48.51%
Unitil	Motor	4	926,909	0.5	90%	2	±49.03%
Unitil	Total	8	1,072,550	0.5	90%	4	±42.88%
WMECO	Process	14	4,340,188	0.5	90%	5	±31.05%
WMECO	Refrigeration	9	1,188,178	0.4	90%	4	±25.13%
WMECO	Compressed Air	13	957,747	0.5	90%	3	±53.88%
WMECO	Motor	6	241,334	0.5	90%	2	±64.08%
WMECO	Other	4	1,652,580	0.6	90%	2	±60.36%
WMECO	Total	46	8,380,027	0.5	90%	16	±21.31%
Statewide	**Total**	**388**	**56,927,228**	**0.5**	**90%**	**80**	**±7.75%**

6.2.2 Summer kW Sample Design

In order to ensure that ISO-NE requirements for the Forward Capacity Market are met, it is useful to examine the estimated summer kW precision that could be achieved with a sample of this size. The error ratios for summer kW savings realization rates tend to be higher than those for annual energy savings, so the error ratios provided in Table 21 for summer kW were used. Given the ISO-NE requirement of 80/10 precision for each PAs portfolio of resources, this analysis was run at an 80% confidence level.

Table 25 estimates the summer kW precision estimates using these parameters. Since CLC was not able to provide tracking system data for summer kW savings, they are excluded from this calculation. Due to the higher error ratio, the anticipated precisions are higher than those for annual energy savings.

Table 25: Estimated Precision for Summer kW using Preliminary Sample Sizes

Program Administrator	Measure Group	Projects	Total Summer kW Savings	Error Ratio	Confidence Level	Planned Sample Size	Anticipated Relative Precision
CLC	Refrigeration	1	.	0.8	80%	1	±0.00%
CLC	Total	1	.	0.8	80%	1	±0.00%
NGRID	Process	45	1,307	0.8	80%	12	±21.33%
NGRID	Refrigeration	95	795	0.8	80%	9	±32.27%
NGRID	Compressed Air	22	485	1.0	80%	5	±49.94%
NGRID	Motor	31	651	0.6	80%	6	±28.22%
NGRID	Other	17	578	0.9	80%	5	±37.39%
NGRID	Total	210	3,815	0.8	80%	37	±13.93%
NSTAR	Process	35	1,063	0.8	80%	8	±22.76%
NSTAR	Refrigeration	79	770	0.8	80%	10	±30.93%
NSTAR	Compressed Air	6	143	1.0	80%	3	±58.38%
NSTAR	Motor	3	5	0.6	80%	1	±63.96%
NSTAR	Total	123	1,981	0.8	80%	22	±17.65%
Unitil	Process	4	18	0.8	80%	2	±60.49%
Unitil	Motor	4	134	0.6	80%	2	±45.85%
Unitil	Total	8	152	0.6	80%	4	±41.04%
WMECO	Process	14	704	0.8	80%	5	±38.72%
WMECO	Refrigeration	9	466	0.8	80%	4	±39.17%
WMECO	Compressed Air	13	432	1.0	80%	3	±83.98%
WMECO	Motor	6	29	0.6	80%	2	±59.92%
WMECO	Other	4	432	0.9	80%	2	±70.56%
WMECO	Total	46	2,062	0.9	80%	16	±27.95%
Statewide	**Total**	**388**	**8,011**	**0.8**	**80%**	**80**	**±10.74%**

6.2.3 Winter kW Sample Design

A sample designed around winter kW reduction was not required by the PAs, but the relative precisions for the above sample design is presented here for completeness. Again, the winter kW error ratios tend to be higher than for annual kWh and summer kW. See Table 21 above for a listing of the winter kW error ratios used in this analysis. Table 26 estimates the winter kW precision estimates using these parameters. Again, since CLC was not able to provide tracking system data for winter kW savings, they are excluded from this calculation.

Table 26: Estimated Precision for Winter kW using Preliminary Sample Sizes

Program Administrator	Measure Group	Projects	Total Winter kW Savings	Error Ratio	Confidence Level	Planned Sample Size	Anticipated Relative Precision
CLC	Refrigeration	1	.	1.3	80%	1	±0.00%
CLC	Total	1	.	1.3	80%	1	±0.00%
NGRID	Process	45	1,426	0.9	80%	12	±22.66%
NGRID	Refrigeration	95	765	1.3	80%	9	±52.44%
NGRID	Compressed Air	22	476	1.0	80%	5	±49.94%
NGRID	Motor	31	499	0.6	80%	6	±28.22%
NGRID	Other	17	569	1.3	80%	5	±54.01%
NGRID	Total	210	3,735	1.0	80%	37	±17.68%
NSTAR	Process	35	1,004	0.9	80%	8	±24.19%
NSTAR	Refrigeration	79	879	1.3	80%	10	±50.25%
NSTAR	Compressed Air	6	144	1.0	80%	3	±58.38%
NSTAR	Motor	3	5	0.6	80%	1	±63.96%
NSTAR	Total	123	2,032	1.1	80%	22	±25.16%
Unitil	Process	4	15	0.9	80%	2	±64.27%
Unitil	Motor	4	110	0.6	80%	2	±45.85%
Unitil	Total	8	125	0.6	80%	4	±41.12%
WMECO	Process	14	687	0.9	80%	5	±41.13%
WMECO	Refrigeration	9	496	1.3	80%	4	±63.65%
WMECO	Compressed Air	13	428	1.0	80%	3	±83.98%
WMECO	Motor	6	30	0.6	80%	2	±59.92%
WMECO	Other	4	432	1.3	80%	2	±101.91%
WMECO	Total	46	2,073	1.1	80%	16	±34.20%
Statewide	**Total**	**388**	**7,965**	**1.0**	**80%**	**80**	**±13.77%**

The sample design presented here is recommended because these measure types are significant enough to justify the measure level rigor. The target precisions by measure reflect the significance of each measure type. KEMA understands that the resources required by both the consultant team and the PAs would be very large to complete a study of this size. Therefore, KEMA proposes splitting this evaluation into two phases. In the first year of the study, 39 sites will be evaluated. This includes all sites from the Process and Compressed Air measure categories. In order to meet the targeted precisions at the measure level, the evaluation team will evaluate the remaining 41 sites from the Refrigeration, Motor and Other measure categories in 2012 using projects from the 2011 population.

The advantages of staging this evaluation are numerous. First, the evaluation team can focus on a smaller number of sites, which will help to keep within the proposed timeline. The second phase of the evaluation also broadens the population by using the most recent projects from 2011.

Under this plan, a complete evaluation report will be delivered following each phase of evaluation. The second phase evaluation report will roll the phase 2 results into the phase 1 results to complete the full evaluation at these target precisions.

7. Appendix B: References

[1] *The California Evaluation Framework,* prepared for Southern California Edison Company and the California Public Utility Commission, by the TecMarket Works Framework Team, June 2005, Chapters 12-13.

[2] *Model Assisted Survey Sampling,* C. E. Sarndal, B. Swensson, and J. Wretman, Springer, 1992.

8. Appendix C: Seasonal Peak Period Coincidence

This section describes DNV KEMA's methodology to estimating seasonal peak demand in this impact evaluation of the 2010 Large C&I programs.

8.1 Peak Period Definitions

In the ISO New England Forward Capacity Market, a participant may submit energy-efficiency "other demand resources" as one of three different types: On-Peak, Seasonal Peak, and Critical Peak. For this purpose of this discussion, the Critical Peak will be omitted. The important point is that some readers may be more familiar with the On-Peak Demand Resource, but Western Massachusetts Electric participates in FCM as a Seasonal Peak Demand Resource. The distinction is simply that the demand reduction value is computed as the average demand across the corresponding "Peak Hours" period. The following definitions are taken from ISO New England's FERC Electric Tariff No. 3:

> **"Demand Resource On-Peak Hours** are hours ending 1400 through 1700, Monday through Friday on non-holidays during the months of June, July, and August and hours ending 1800 through 1900, Monday through Friday on non-holidays during the months of December and January.
>
> **"Demand Resource Seasonal Peak Hours** are those hours in which the actual, Real-Time hourly load for Monday through Friday on non-holidays, during the months of June, July, August, December, and January, as determined by the ISO, is equal to or greater than 90% of the most recent 50/50 system peal load forecast, as determined by the ISO, for the applicable summer or winter season."[4]

It is considerably more complex to assess coincidence relative to the Demand Resource Seasonal Peak Hours because they are conditional in nature and depend upon the relationship between real time system load and the most recent 50/50 system peak load forecast. The remainder of this section details DNV KEMA's analytical approach to this challenge.

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[4] ISO New England, FERC Electric Tariff No. 3, General Terms and Conditions, Section I.2 – Rules of Construction; Definitions, Effective: January 24, 2010, Original Sheet No. 15L.

8.2 Summer Seasonal kW Reduction

The calculation of the summer seasonal peak demand reduction was based on the performance hours that were used to evaluate the Demand Reduction Values (DRV). Seasonal demand performance hours for ISO-NE FCM are defined as hours when the real time ISO-NE system load meets or exceeds 90% of the predicted seasonal peak from the most recent Capacity, Electricity, Load and Transmission Report (CELT report). The peak load forecast for the summer 2010 season was 27,190 kW, and 90% of which was 24,471 kW. There were 30 hours during the summer 2010 season when the load exceeded 24,471 kW. The evaluation used Worcester, MA real weather data for the summer of 2010 to calculate the weighted Total Heat Index (THI) at each hour. The Total Heat Index is a forecast variable used by ISO-NE and it is calculated as follows;

THI = 0.5 x DBT + 0.3 x DPT + 15 Where,

THI = Total Heat Index

DBT = Dry Bulb Temperature (°F)

DPT = Dew Point Temperature (°F)

Table 27 provides the summer 2010 seasonal peak hours along with the system load, percent of CELT forecast peak and the Total Heat Index (THI) for Worcester, MA.

Table 27: 2010 Summer Seasonal Peak Hours and System Load

Date	Hour	System Load (kW)	Percent of Peak	THI
7/6/2010	11	24,856	91%	80.4
7/6/2010	12	25,837	95%	80.8
7/6/2010	13	26,455	97%	81.0
7/6/2010	14	26,974	99%	81.8
7/6/2010	15	27,102	100%	81.4
7/6/2010	16	27,079	100%	81.4
7/6/2010	17	26,970	99%	82.5
7/6/2010	18	26,787	99%	81.2
7/6/2010	19	26,271	97%	80.8
7/6/2010	20	25,577	94%	80.0
7/6/2010	21	25,153	93%	78.8
7/7/2010	12	25,295	93%	80.2
7/7/2010	13	25,914	95%	80.9
7/7/2010	14	26,321	97%	81.1
7/7/2010	15	26,447	97%	81.3

Date	Hour	System Load (kW)	Percent of Peak	THI
7/7/2010	16	26,498	97%	80.8
7/7/2010	17	26,387	97%	80.9
7/7/2010	18	25,969	96%	80.7
7/7/2010	19	25,187	93%	79.3
7/8/2010	15	24,636	91%	75.8
7/8/2010	16	24,760	91%	77.0
7/8/2010	17	24,768	91%	76.2
7/8/2010	18	24,492	90%	76.0
7/16/2010	17	24,512	90%	79.1
8/31/2010	14	24,880	92%	79.3
8/31/2010	15	25,340	93%	78.3
8/31/2010	16	25,594	94%	79.5
8/31/2010	17	25,691	94%	78.5
8/31/2010	18	25,380	93%	78.4
8/31/2010	19	24,645	91%	75.7

ISO-NE also uses a variable called a Weighted Heat Index (WHI) which is a three day weighted average of the THI and is calculated as follows;

$$WHI = 0.59 \times THI_{di\ hi} + 0.29 \times THI_{d(i-1)\ hi} + 0.12 \times THI_{d(i-2)\ hi}$$ Where,

WHI = Weighted Heat Index

$THI_{di\ hi}$= Total Heat Index for the current day and hour

$THI_{d(i-1)\ hi}$= Total Heat Index for previous day and same hour

$THI_{d(i-2)\ hi}$= Total Heat Index for two days prior and same hour

The peak load data and the weighted THI and WHI data for 2010 were used to create linear regressions of peak system load as a function of THI and WHI. The analysis focused on non-holiday weekdays from June through August during hours ending 11 through 21. Evaluators used the time window of hours ending 11 to 21 because of the above observed peaks in the 2010 season that occurred outside of the 1 pm to 5 pm daily peak time period.

The following THI & WHI cutoff points were the result of the regression analyses. These represent the selection points at which both the THI and WHI from a Worcester, MA TMY3 weather file must be greater than in order to trigger a summer seasonal peak hour.

THI Cutoff Point: 78.2

WHI Cutoff Point: 77.6

Table 28 provides a summary of the THI, WHI and number of summer seasonal hours for the Worcester, MA TMY3 weather file used in the analysis by month and for the summer season. These are the total number of TMY3 hours applied to the 2010 evaluation year that meet the above criteria for being selected as a summer seasonal peak hour.

Table 28: Summary of Summer Seasonal Hours for Worcester, MA TMY3 File

	Mean THI	Mean WHI	# of Hours
June	NA	NA	0
July	78.7	76.7	9
August	78.9	76.1	1
Summer	78.7	76.6	10

8.3

8.4 Winter Seasonal kW Reduction

The calculation of the winter seasonal peak demand reduction was based on the performance hours that were used to evaluate the Demand Reduction Values (DRV). Seasonal demand performance hours for ISO-NE FCM are defined as hours when the real time ISO-NE system load meets or exceeds 90% of the predicted seasonal peak from the most recent Capacity, Electricity, Load and Transmission Report (CELT report).

The peak load forecast for the winter 2010/2011 season was 22,085 kW, and 90% of which was 19,877 kW. There were a total of 18 hours during the winter 2010/2011 season when the load was 19,877 kW or greater. Table 29 provides a list of the winter seasonal peak hours along with the system load, the percentage of forecasted peak and the dry bulb temperature (DBT) for each hour for Worcester, MA.

Table 29: Winter 08/09 Seasonal Peak Hours and System Loads

Date	Hour	System Load (kW)	Percent of Peak	DBT
12/9/2010	18	20,197	91%	18.0
12/9/2010	19	20,105	91%	17.0
12/14/2010	18	20,099	91%	17.0
12/14/2010	19	20,054	91%	17.0
12/15/2010	18	20,622	93%	15.0
12/15/2010	19	20,451	93%	15.0
12/15/2010	20	20,104	91%	15.0
12/16/2010	18	19,925	90%	26.0
12/20/2010	18	20,409	92%	25.0
12/20/2010	19	20,327	92%	24.0
12/20/2010	20	19,941	90%	24.0
12/27/2010	18	20,233	92%	15.0
12/27/2010	19	19,949	90%	14.0
1/24/2011	18	20,878	95%	6.0
1/24/2011	19	21,060	95%	5.0
1/24/2011	20	20,710	94%	5.0
1/24/2011	21	19,991	91%	3.0
1/25/2011	19	19,897	90%	21.0

The 2010/2011 peak load data and the Worcester, MA temperature data were used to create linear regressions of peak system load as a function of dry bulb temperature. The results of the regression were used to identify the seasonal peak hours using the Worcester, MA TMY3 weather data. The analysis focused on low temperature periods in December and January during hours ending 18, 19, and 20. Evaluators included hour ending 20 because of the above observed peaks in the 2010/2011 season that occurred outside of the 5 pm to 7 pm daily peak time period.

The following DBT cutoff point was the result of the regression analysis. This represents the selection point at which the DBT from the Worcester, MA TMY3 weather file must be less than in order to trigger a winter seasonal peak hour.

DBT Cutoff Point: 19.4°F

Table 30 provides a summary of the Dry Bulb Temperature (DBT) and number of winter seasonal hours for the Worcester, MA TMY3 weather file use in the analysis by month and for the winter season.

Table 30: Summary of Winter Seasonal Hours for Worcester, MA TMY3 File

	Mean DBT	# of Hours
December	17.2	6
January	11.3	28
Winter	12.3	34

9. Appendix D: Site Reports