Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations

Final Report

Massachusetts Program Administrators
Massachusetts Energy Efficiency Advisory Council
Prepared by KEMA, Inc., DMI Inc, and SBW.
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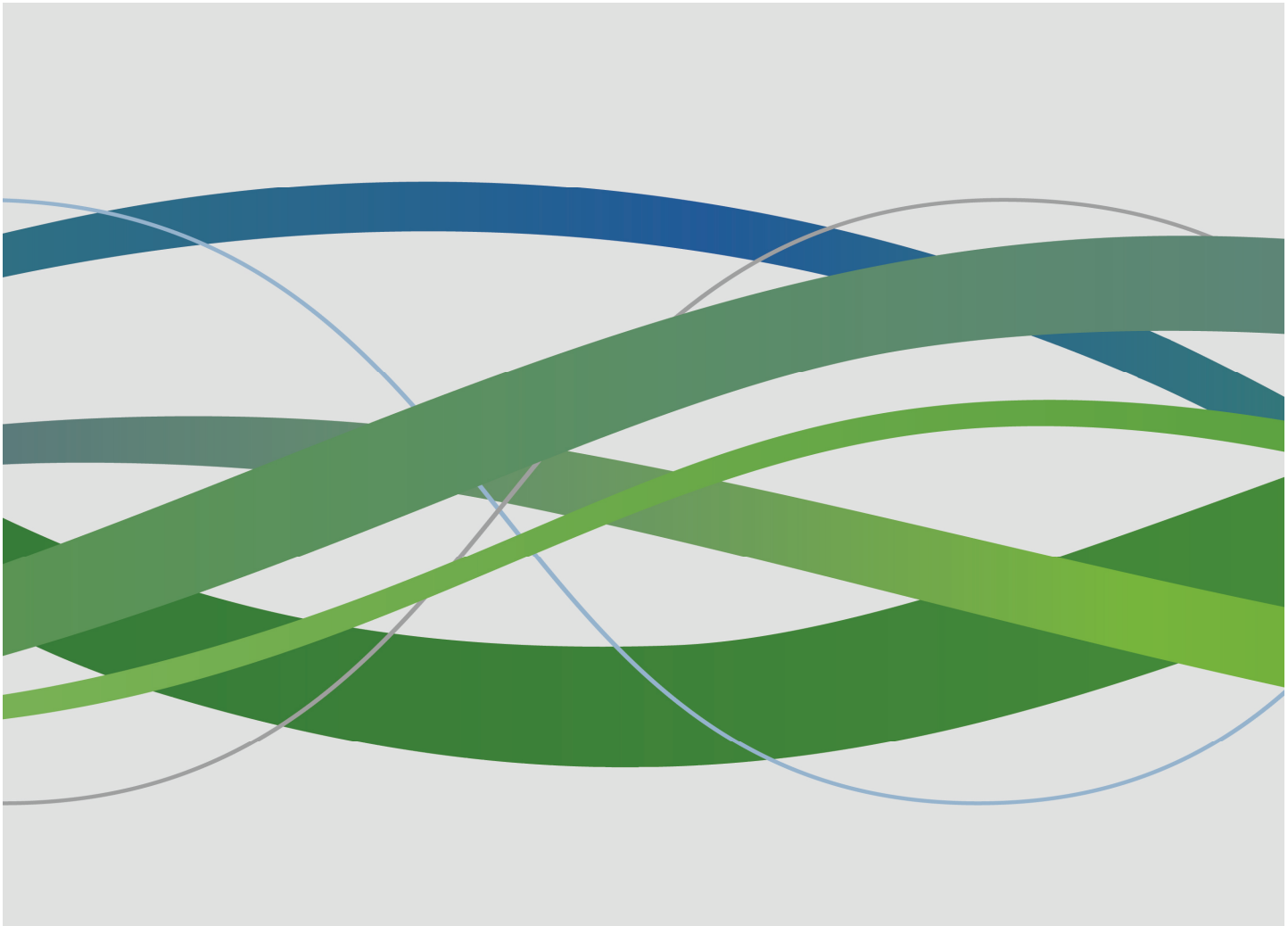

Table of Contents

Table of Contents

List of Exhibits

Table of Contents

1. Executive Summary

This document summarizes the work performed by DNV KEMA Energy and Sustainability (DNV KEMA), DMI and SBW Consulting during 2012 and 2013 to quantify the actual energy and demand savings due to the installation of 48 Custom Refrigeration, Motor and Other (RMO) 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 2011.

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 48 Custom RMO projects installed in 2011 through site-specific inspection, monitoring, and analysis. The results of this study will be used to determine the final realization rates to be applied to Custom RMO energy efficiency measures installed in 2012. 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 2011 Custom RMO end-uses, which include new equipment, equipment repair and/or control systems and strategies. This impact evaluation includes only measures which primarily reduce electricity consumption.

1.3 Sample Design

The Custom RMO 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).

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. The

final sample design presented here provides for the estimation of realization rates by measure and by PA. The target precision on energy savings is ±20% for each of the larger PAs for each of these measures. The smaller PAs are likely to utilize the statewide results of this study.

After running several scenarios based on different sample sizes and allocations, the team decided on a Custom RMO sample comprised of 48 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. The PA-specific results were expected to achieve relative precisions in the range of ±0% to ±19%.

Table 1: Custom RMO Final Sample Design

Measure Group	Program Administrator	2011 Projects	2011 Total Savings (kWh)	Error Ratio	Confidence Level	2011 Sample Size	2011 Anticipated Relative Precision
Refrigeration	Cape Light Compact	4	736,034	0.4	90%	2	±13.49%
Refrigeration	National Grid	139	10,750,409	0.4	90%	12	±18.46%
Refrigeration	NSTAR	45	4,066,138	0.4	90%	10	±18.99%
Refrigeration	Western Massachusetts Electric	9	1,797,119	0.4	90%	4	±17.60%
Refrigeration	**Total**	**197**	**17,349,700**	**0.4**	**90%**	**28**	**±12.42%**
Motor	National Grid	15	1,692,613	0.5	90%	7	±17.12%
Motor	NSTAR	3	198,059	0.5	90%	3	±0.00%
Motor	Western Massachusetts Electric	4	263,217	0.5	90%	3	±16.04%
Motor	**Total**	**22**	**2,153,889**	**0.5**	**90%**	**13**	**±13.60%**
Other	National Grid	15	4,936,961	0.6	90%	5	±15.17%
Other	Western Massachusetts Electric	2	702,587	0.6	90%	2	±0.00%
Other	**Total**	**17**	**5,639,548**	**0.6**	**90%**	**7**	**±13.28%**
All	**All**	**236**	**25,143,137**	**0.45**	**90%**	**48**	**±9.15%**

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 48 sites were included in the Custom RMO sample.

1.4 Description of Methodology

Following the final sample selection of 2011 Custom RMO applications and prior to beginning any site visits, DNV KEMA, SBW, and DMI developed detailed measurement and evaluation plans for each of the 48 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. Where possible, evaluators utilized actual power, time-of-use, or temperature metering to verify EMS trend data.

Collected data was analyzed to verify implementation and operation 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. A sample of these site reports were also reviewed by the EEAC consultant. The PA and EEAC review and comment process resulted in the final reports found in Appendix A: Site Report. 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.

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 Refrigeration 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 lower than the observed data. These sample data are somewhat scattered around the trend line, indicating that there is a bit of variation in the relationship between tracking and evaluated savings.

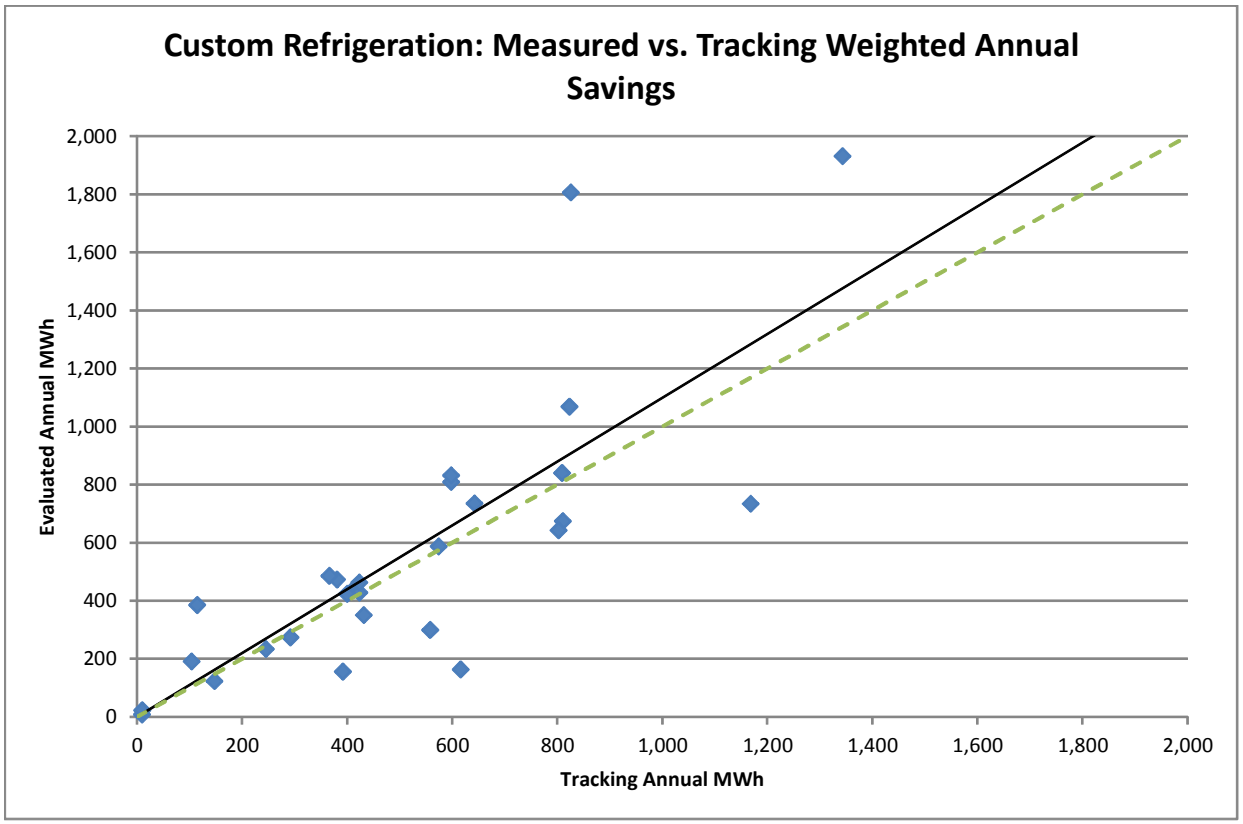

Figure 1: Scatter Plot of Evaluation Results for Annual MWh Savings for Custom Refrigeration

Figure 2 presents the same information for the Motor sample points. The Motor results tend to be clustered closely around the trend line, indicating little variation in the relationship between tracking and evaluated savings.

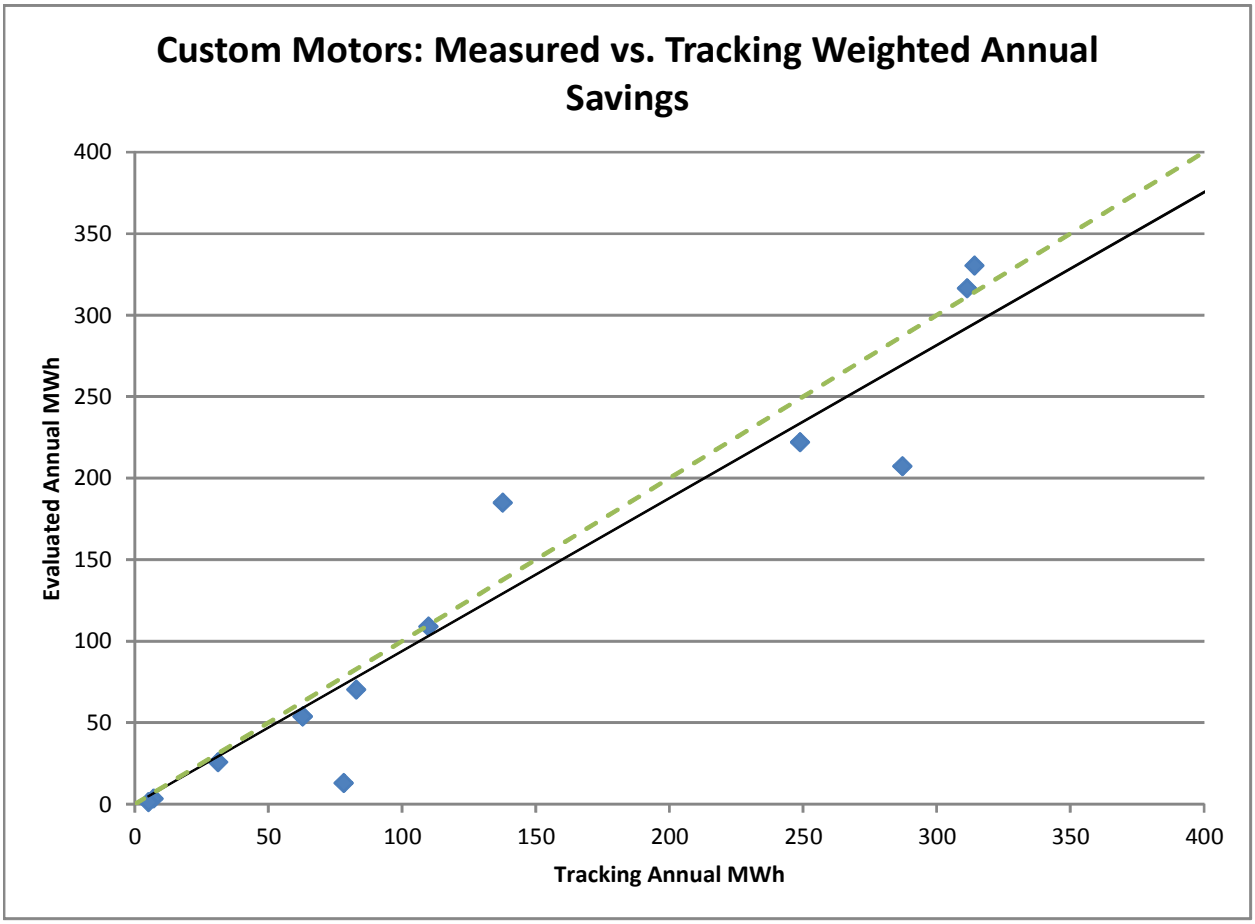

Figure 2: Scatter Plot of Evaluation Results for Annual MWh Savings for Motor

Figure 3 presents the same information for the Other sample points. Aside from one sample point, the Other results tend to be clustered closely around the trend line, indicating little variation in the relationship between tracking and evaluated savings. The evaluation team performed a standard outlier test on the very high realization rate sample point. It is plausible that this site's data could be considered an outlier in this relationship. Due to the smaller sample size and the mixture of measures in this grouping, it is difficult to have concrete evidence to make that assumption, however.

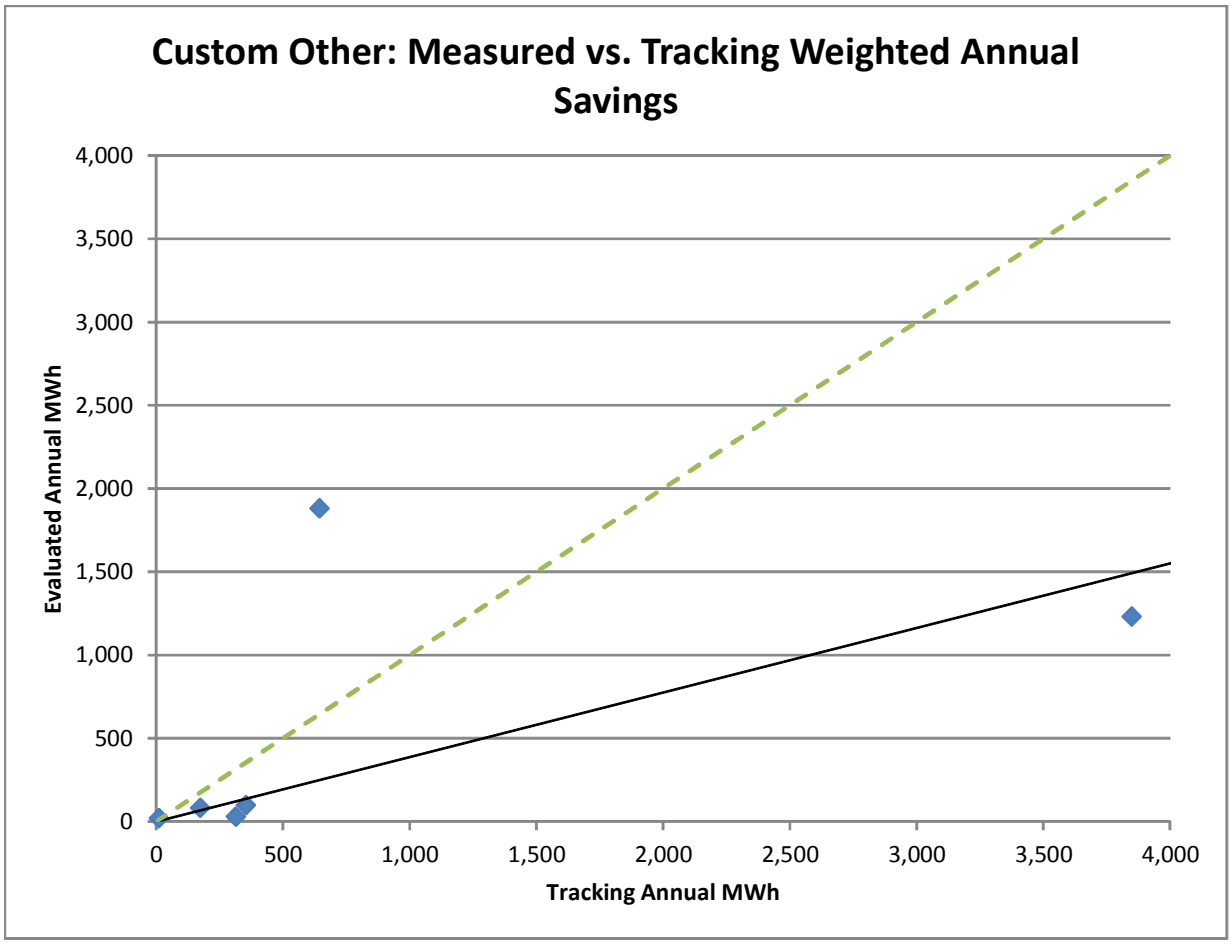

Figure 3: Scatter Plot of Evaluation Results for Annual MWh Savings for Other

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 Refrigeration analysis. In the case of annual MWh savings, the realization rate for Custom Refrigeration measures ranged from 65.8% for Western Massachusetts Electric to 118.8% for National Grid. The relative precision for these estimates was found to range from ±5.7% to ±73.2% at the 90% level of confidence. Aside from CLC, which only had two sites in the sample, the variation in the evaluated site results for this study was about what was expected based on the error ratios observed. 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 Refrigeration Results by PA

Refrigeration 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	10,750	44%	4,709	1,373	1,267	1,373	1,267
Total Measured Savings	12,772	46%	5,899	1,655	1,519	1,733	1,585
Realization Rate	118.8%	105%	125%	120.6%	119.9%	126.3%	125.1%
Relative Precision at 90% Confidence	17.7%	-	18%				
Error Bound at 90% Confidence	2,258	-	1,048				
Relative Precision at 80% Confidence				23.2%	18.2%	29.2%	20.7%
Error Bound at 80% Confidence				385	277	507	328
Error Ratio	0.36	-	0.36	0.62	0.52	0.76	0.56
NSTAR							
Total Tracking Savings	4,066	-	-	471	491	471	491
Total Measured Savings	4,582	-	-	649	542	759	523
Realization Rate	112.7%	-	-	137.9%	110.4%	161.2%	106.6%
Relative Precision at 90% Confidence	5.7%	-	-				
Error Bound at 90% Confidence	259	-	-				
Relative Precision at 80% Confidence				18.7%	14.7%	27.1%	15.2%
Error Bound at 80% Confidence				121	80	205	80
Error Ratio	0.13	-	-	0.60	0.44	0.92	0.47
Cape Light Compact							
Total Tracking Savings	736	-	-	8	22	8	22
Total Measured Savings	552	-	-	66	63	70	63
Realization Rate	75.0%	-	-	777.7%	281.7%	830.2%	282.7%
Relative Precision at 90% Confidence	73.2%	-	-				
Error Bound at 90% Confidence	404	-	-				
Relative Precision at 80% Confidence				10.4%	10.1%	10.4%	10.4%
Error Bound at 80% Confidence				7	6	7	7
Error Ratio	1.27	-	-	0.23	0.23	0.23	0.23
Western Massachusetts Electric							
Total Tracking Savings	1,613	-	-	251	131	251	131
Total Measured Savings	1,061	-	-	182	69	236	67
Realization Rate	65.8%	-	-	72.4%	52.7%	93.9%	51.0%
Relative Precision at 90% Confidence	18.3%	-	-				
Error Bound at 90% Confidence	195	-	-				
Relative Precision at 80% Confidence				13.1%	12.7%	13.3%	13.1%
Error Bound at 80% Confidence				24	9	31	9
Error Ratio	0.42	-	-	0.40	0.41	0.35	0.42

DNV KEMA aggregated the PA results to determine statewide realization rates. These overall results follow in Table 3.

Table 3: Statewide Custom Refrigeration Results

Overall Refrigeration 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	17,166	-	-	2,103	1,911	2,103	1,911
Total Measured Savings	18,967	-	-	2,552	2,192	2,798	2,237
Realization Rate	110.5%	-	-	121.3%	114.7%	133.1%	117.1%
Relative Precision at 90% Confidence	12.2%	-	-				
Error Bound at 90% Confidence	2,317	-	-				
Relative Precision at 80% Confidence				15.8%	13.2%	19.6%	15.1%
Error Bound at 80% Confidence				404	289	548	338
Error Ratio	0.33	-	-	0.59	0.49	0.76	0.53

The statewide realization rate for Annual MWh savings is 110.5%, estimated with ±12.2% relative precision. The demand realization rates are all between 114.7% and 133.1%.

Aggregated results from the Custom Motor sample sites are presented in Table 4 and Table 5 below. Realization rates for Annual MWh savings range from 77.7% for WMECO to 134.2% for NSTAR. The statewide realization rate for Custom Motor measures was 91.4% for Annual MWh, estimated with ±3.7% relative precision. The realization rates for the demand measurements were all between 74.5% and 90.2%.

Table 4: Summary of Custom Motor Results by PA

Motors 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	1,693	63%	1,075	349	188	349	188
Total Measured Savings	1,499	72%	1,085	311	139	249	125
Realization Rate	88.5%	114%	101%	89.1%	74.2%	71.5%	66.8%
Relative Precision at 90% Confidence	4.8%	-	16%				
Error Bound at 90% Confidence	72	-	177,710				
Relative Precision at 80% Confidence				7.4%	18.9%	7.3%	19.4%
Error Bound at 80% Confidence				23	26	18	24
Error Ratio	0.22	-	0.60	0.48	0.87	0.49	0.87
NSTAR							
Total Tracking Savings	198	-	-	26	27	26	27
Total Measured Savings	266	-	-	27	31	28	32
Realization Rate	134.2%	-	-	102.2%	114.9%	106.2%	116.4%
Relative Precision at 90% Confidence	0.0%	-	-				
Error Bound at 90% Confidence	-	-	-				
Relative Precision at 80% Confidence				0.0%	0.0%	0.0%	0.0%
Error Bound at 80% Confidence				-	0	-	0
Error Ratio	0.00	-	-	0.00	0.00	0.00	0.00
Western Massachusetts Electric							
Total Tracking Savings	263	-	-	14	34	14	34
Total Measured Savings	205	-	-	13	18	17	28
Realization Rate	77.7%	-	-	95.8%	52.4%	120.8%	83.6%
Relative Precision at 90% Confidence	0.0%	-	-				
Error Bound at 90% Confidence	-	-	-				
Relative Precision at 80% Confidence				0.0%	0.0%	0.0%	0.0%
Error Bound at 80% Confidence				-	-	-	-
Error Ratio	0.20	-	-	1.24	0.98	1.24	1.01

Table 5: Statewide Custom Motor Results

Overall Motors 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	2,154	-	-	389	248	389	248
Total Measured Savings	1,969	-	-	351	188	294	185
Realization Rate	91.4%	-	-	90.2%	75.7%	75.6%	74.5%
Relative Precision at 90% Confidence	3.7%	-	-				
Error Bound at 90% Confidence	72	-	-				
Relative Precision at 80% Confidence				6.5%	14.0%	6.2%	13.2%
Error Bound at 80% Confidence				23	26	18	24
Error Ratio	0.17	-	-	0.45	0.67	0.46	0.65

Aggregated results from the Custom Other sample sites are presented in Table 6 and Table 7 below. Realization rates for Annual MWh savings range from 31.0% for National Grid to 270.7% for WMECO. The statewide realization rate for Custom Other measures was 61.4% for Annual MWh, estimated with ±1.9% relative precision. The realization rates for the demand measurements were all around 63%.

Table 6: Summary of Custom Other Results by PA

Other 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	4,845	39%	1,904	559	554	559	554
Total Measured Savings	1,502	48%	726	187	183	189	184
Realization Rate	31.0%	123%	38%	33.5%	33.1%	33.9%	33.1%
Relative Precision at 90% Confidence	5.6%	-	6%				
Error Bound at 90% Confidence	83	-	43				
Relative Precision at 80% Confidence				4.3%	4.6%	3.3%	2.6%
Error Bound at 80% Confidence				6	5	7	5
Error Ratio	0.20	-	0.20	0.15	0.14	0.17	0.14
WMECO							
Total Tracking Savings	703	-	-	80	80	80	80
Total Measured Savings	1,902	-	-	217	217	217	217
Realization Rate	270.7%	-	-	270.1%	270.1%	270.1%	270.1%
Relative Precision at 90% Confidence	0.0%	-	-				
Error Bound at 90% Confidence	-	-	-				
Relative Precision at 80% Confidence				0.0%	0.0%	0.0%	0.0%
Error Bound at 80% Confidence				-	-	-	-
Error Ratio	0.22	-	-	0.22	0.22	0.22	0.22

Table 7: Statewide Custom Other Results

Overall Other 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	5,548	-	-	639	635	639	635
Total Measured Savings	3,404	-	-	405	401	406	401
Realization Rate	61.4%	-	-	63.3%	63.1%	63.6%	63.2%
Relative Precision at 90% Confidence	1.9%	-	-				
Error Bound at 90% Confidence	65	-	-				
Relative Precision at 80% Confidence				1.5%	1.2%	1.8%	1.2%
Error Bound at 80% Confidence				6	5	7	5
Error Ratio	0.13	-	-	0.12	0.12	0.13	0.12

1.6 Conclusions and Recommendations

Overall, the Custom Refrigeration program appears to be producing results that are greater than expected. The Custom Motor end-use appears to be producing slightly lower savings than expected. Custom Other did not perform as well as the other two measures. Below are the DNV KEMA evaluation team findings and recommendations that apply statewide, as well as to the individual PAs. Please note that the statewide recommendations should be considered by all PAs, since each of these were based on observations across all of the PAs. Likewise, the PA specific recommendations may also provide useful information for all PAs.

1.6.1 Statewide

- Make sure customers and TA vendors understand they need to be prepared for providing assistance if their project is selected for evaluation
- Ensure sufficient time is allowed for logging data for projects with seasonal variability
- All PAs should require more complete pre-retrofit or baseline documentation
- PAs should work together to require consistent methodologies and documentation for similar projects across different PAs
- Consider documenting which electrical panels/circuits serve the affected refrigerated casework
- Consider specifying documentation requirements for compressed air leak repairs
- Consider more of a whole system approach for grouping measures for evaluation
- Require TA vendors to provide metering for retrofit projects
- Consider specifying TA verification of savings via commissioning, and in some cases, pre/post metering for specific measures

1.6.2 Cape Light Compact

- Perform closer review of large savings measures
- Include interactive refrigeration savings

1.6.3 National Grid

- Require adequate savings documentation
- Verify proposed load assumptions as part of the final inspection of new construction projects
- Verify proposed item count assumptions as part of the final inspection
- Verify plant operating hours using whole building interval data
- Ensure consistent use of data throughout the calculations

1.6.4 NSTAR

- Provide sufficient documentation for understanding the determination of measure savings

2. Introduction

This document summarizes the work performed by DNV KEMA Energy and Sustainability (DNV KEMA), DMI and SBW Consulting during 2012 and 2013 to quantify the actual energy and demand savings due to the installation of 48 Custom Refrigeration, Motor and Other (RMO) 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 2011.

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 48 Custom RMO projects through site-specific inspection, monitoring, and analysis. Each of the PAs offers incentives for refrigeration, motor and other 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 RMO energy efficiency measures installed in 2012. 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 2011 Custom RMO end-uses, which include new equipment, equipment repair and/or control systems and strategies. This impact evaluation includes only measures which primarily reduce electricity consumption.

3. Description of Sampling Strategy

This study is the second phase of a two-phase research plan to evaluate all non-Comprehensive, non-Lighting and non-HVAC (NLNH) Custom Electric programs including Process, Compressed Air, Refrigeration, Motor and Other measures in Massachusetts (MA). The first phase study, which focused on Process and Compressed Air equipment, was completed in 20121.

The goal of the sample 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 percent on-peak energy savings. The following section describes the sample design for Phase 2, Custom RMO.

3.1 Population Analysis

The initial task was to define the population frame for the evaluation sample. 2011 tracking data were provided by the PAs for each project.

In order to maintain consistency of measure categorization by PA, some measures were reclassified. Table 8 presents the projects and measures that were reclassified by DNV 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 DNV KEMA), and the numbers of unique occurrences in the 2011 tracking data.

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. DNV 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. Similar to 2011, 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."

[1] MA-LCIEC-13 Custom Process and CAIR Report_FINAL, May 30, 2012

Table 8: Reclassified Custom Electric Measures

Program Administrator	Description	Original PA Measure Category	New Measure Category	Number of Occurrences
CLC	ECM Motor	Motor	Refrigeration	1
National Grid	Drives on HVAC Systems	Motor	HVAC	3
National Grid	Chiller	Motor	HVAC	3
National Grid	ECM Motors - Refrig	Motor	Refrigeration	10
National Grid	Building Shell	Other	HVAC	1
National Grid	Ultrasonic Humidifiers	Other	HVAC	3
National Grid	VSDs on vacuum pumps	Other	Motor	2
National Grid	Central Refrig System	Other	Refrigeration	1
National Grid	Milk plate cooler	Other	Process	3
National Grid	Install new gas-fired boiler with 200 gal storage tank	Other	Process	1
National Grid	Advanced building	Other	CDA	1
NSTAR	VSDs (non-HVAC Systems)	Process	Motor	1
Unitil	On-site cogeneration system	Process	CHP	1
WMECO	EMS	Other	HVAC	1
WMECO	VSD	Other	Motor	1
WMECO	VSD s on vacuum pumps	Process	Motor	2
WMECO	VSD	Process	Motor	1
WMECO	Compressed Air Leaks	Process	Other	2
WMECO	Compressed air systems	Process	Compressed Air	5

This impact evaluation included three measure categories, Refrigeration, Motor and Other. The refrigeration category includes mostly retail refrigeration type measures such as electronically commutated motors (ECM) in walk-in or reach-in cooler and freezer cases as well as new cooler or freezer case doors with no heat, or lower heat anti-condensate heaters and LED lighting. There were also some other types of refrigeration equipment and controls for process cooling and ice rinks. The motor category includes new motors and variable speed drives (VSDs) for non-HVAC equipment. The Other category included various measures such as compressed air leaks, centralized computer controls, and steam trap leak repair in an electricity generation plant.

After review and consolidation, the resulting population of 201 Custom RMO projects reported by PA is summarized in Table 9.

Table 9: Population Statistics

Measure	Program Administrator	2011 Projects	2011 Total Savings (kWh)	Average Savings	Minimum	Maximum	Std Dev	CV
Refrigeration	National Grid	139	10,750,409	77,341	423	905,623	124,308	1.61
Refrigeration	NSTAR	45	4,066,138	90,359	4,202	439,867	92,395	1.02
Refrigeration	Cape Light Compact	4	736,034	184,009	38,283	616,526	249,717	1.36
Refrigeration	Western Massachusetts Electric	9	1,613,438	179,271	4,545	645,279	237,076	1.32
Total		**197**	**17,166,019**					
Motor	National Grid	15	1,692,613	112,841	5,717	314,252	111,715	0.99
Motor	NSTAR	3	198,059	66,020	36,616	92,561	22,929	0.35
Motor	Western Massachusetts Electric	4	263,217	65,804	5,225	188,013	74,256	1.13
Total		**22**	**2,153,889**					
Other	National Grid	14	4,845,199	346,086	2,380	3,849,196	974,200	2.81
Other	Western Massachusetts Electric	2	702,587	351,294	58,223	644,364	293,071	0.83
Total		**16**	**5,547,786**					

3.2 Sample Design

The Custom RMO 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).

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, DNV KEMA looked at prior custom measure evaluation studies to determine likely error ratios. Based on studies that have been done for National Grid, 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 design was based on the error ratios provided in Table 10.

Table 10: Error Ratios used in the Sample Design

End Use	Annual kWh Savings	Summer kW Reduction	Winter kW Reduction
Refrigeration	0.40	0.80	1.30
Motor	0.50	0.60	0.60
Other	0.60	0.90	1.30

The final sample design presented here provides for the estimation of realization rates by measure and by PA. The target precision on energy savings is ±20% for each PA for each of these measures.

After running several scenarios based on different sample sizes and allocations, the team decided on a Custom RMO sample comprised of 48 sites split between the PAs as indicated in Table 11. This table also includes estimates of the precisions that were anticipated at the time of this design, assuming the above error ratios. The PA-specific results were expected to achieve relative precisions in the range of ±0% to ±19%.

Table 11: Custom RMO Final Sample Design

Measure Group	Program Administrator	2011 Projects	2011 Total Savings (kWh)	Error Ratio	Confidence Level	2011 Sample Size	2011 Anticipated Relative Precision
Refrigeration	CLC	4	736,034	0.4	90%	2	±13.49%
Refrigeration	NGRID	139	10,750,409	0.4	90%	12	±18.46%
Refrigeration	NSTAR	45	4,066,138	0.4	90%	10	±18.99%
Refrigeration	WMECO	9	1,797,119	0.4	90%	4	±17.60%
Refrigeration	**Total**	**197**	**17,349,700**	**0.4**	**90%**	**28**	**±12.42%**
Motor	NGRID	15	1,692,613	0.5	90%	7	±17.12%
Motor	NSTAR	3	198,059	0.5	90%	3	±0.00%
Motor	WMECO	4	263,217	0.5	90%	3	±16.04%
Motor	**Total**	**22**	**2,153,889**	**0.5**	**90%**	**13**	**±13.60%**
Other	NGRID	15	4,936,961	0.6	90%	5	±15.17%
Other	WMECO	2	702,587	0.6	90%	2	±0.00%
Other	**Total**	**17**	**5,639,548**	**0.6**	**90%**	**7**	**±13.28%**
All	**All**	**236**	**25,143,137**	**0.45**	**90%**	**48**	**±9.15%**

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

48 sites were included in the Custom RMO sample. The realization rate results for the final sample are presented in Section 5: Results.

3.3 Final Sample

Table 12 presents the list of 48 projects selected as the final sample for Custom RMO. Also presented in this table are the site assignments by evaluating company on the DNV KEMA Team. Of the 48 projects, DNV KEMA evaluated 16, SBW evaluated 16, and DMI evaluated 16. The final sample required the selection of fifteen back-up sample points. Of the fifteen dropped sites, seven were due to customer unresponsiveness or refusal, five were non-RMO measures, one was found to have been done completely prescriptively, one was found not yet be occupied, and one was found to have had the facility and equipment sold off.

Table 12: Final Sample Selection

KEMA Site Number	Program Administrator	End Use	Stratum	Site ID	Track	Evaluating Firm	Facility Type, Project Description
1	CLC	Refrigeration	1	D026441272	Retrofit	DNV KEMA	Grocery, Refrigeration ECM Fan Motor
2	CLC	Refrigeration	2	D018660063	Retrofit	DNV KEMA	Grocery, Refrigeration ECM Fan Motor
3	NGRID	Refrigeration	1	550180	Retrofit	DMI	Restaurant, ECM motors in walkin freezer/cooler
4	NGRID	Refrigeration	1	820896	Retrofit	DMI	Grocery, Refrigerated casework improvements
5	NGRID	Refrigeration	1	872165	Retrofit	DNV KEMA	Grocery, Refrigerated casework improvements
6	NGRID	Refrigeration	1	872158	Retrofit	DNV KEMA	Grocery, Refrigerated casework improvements
7	NGRID	Refrigeration	2	735608	New Construction	DMI	Grocery, Refrigerated casework improvements
8	NGRID	Refrigeration	2	732180	Retrofit	DNV KEMA	Grocery, Refrigerated casework improvements
10	NGRID	Refrigeration	2	906877	New Construction	DNV KEMA	Grocery, Refrigerated casework improvements
11	NGRID	Refrigeration	3	863404	New Construction	DNV KEMA	Grocery, Refrigerated casework improvements
12	NGRID	Refrigeration	3	640749	Retrofit	SBW	Grocery, Refrigerated casework improvements
13	NGRID	Refrigeration	3	945474	Retrofit	DMI	Hockey Rink, Closed loop rink controller, temp and humidity sensors, VFDs on each compressor, Computer control.
15	NSTAR	Refrigeration	1	BS10386	Retrofit	DMI	Grocery, Refrigerated casework improvements
16	NSTAR	Refrigeration	1	BS9774	New Construction	SBW	School, Refrigerated casework improvements
17	NSTAR	Refrigeration	1	BS10434	Retrofit	DMI	Grocery, Refrigerated casework improvements
18	NSTAR	Refrigeration	1	BS10435	Retrofit	DMI	Grocery, Refrigerated casework improvements
19	NSTAR	Refrigeration	1	BS10061	Retrofit	DMI	Grocery, Refrigerated casework

KEMA Site Number	Program Administrator	End Use	Stratum	Site ID	Track	Evaluating Firm	Facility Type, Project Description
							improvements
20	NSTAR	Refrigeration	2	CS8862	New Construction	DNV KEMA	Grocery, Refrigerated casework improvements
21	NSTAR	Refrigeration	2	BS9056	Retrofit	SBW	Grocery, Refrigerated casework improvements
22	NSTAR	Refrigeration	2	CS8377	New Construction	DMI	Industrial Refrigeration
24	NSTAR	Refrigeration	2	CS8220	New Construction	SBW	Industrial, VFD chiller
25	WMECO	Refrigeration	1	WM11R106	Retrofit	DMI	Grocery, Refrigerated casework improvements
26	WMECO	Refrigeration	1	WM11S001	Retrofit	DNV KEMA	Grocery, Refrigerated casework improvements
28	WMECO	Refrigeration	2	11C130	New Construction	SBW	Agricultural, Dairy Processing Plant heat exchanger and glycol surge tank
30	NGRID	Motor	1	566448	New Construction	DNV KEMA	Agricultural, Dairy vacuum pump VFD
31	NGRID	Motor	2	830257	Retrofit	SBW	Agricultural, Dairy Processing Plant VFDs on pumps
33	NGRID	Motor	3	824160	Retrofit	DMI	Manufacturing, Two new VFDs on two 150 hp motors.
34	NGRID	Motor	3	822602	Retrofit	SBW	Agricultural, Dairy Process & Distribution VFD chiller
35	NGRID	Motor	3	643994	Retrofit	DNV KEMA	Other, VFDs an controls for off peak water pump operation
37	NSTAR	Motor	2	CS8723	New Construction	DNV KEMA	Industrial, Variable Speed Drives (non-HVAC Systems)
39	WMECO	Motor	1	WM10C105	Retrofit	DMI	Agricultural, Dairy vacuum pump VFD
40	WMECO	Motor	1	WM10S231	Retrofit	DNV KEMA	Manufacturing, Three 60HP VFDs
43	NGRID	Other	1	918162	New Construction	SBW	University, Upgraded UPS
44	NGRID	Other	2	713111	Retrofit	SBW	University, Centralized computer energy management
46	NGRID	Other	3	591245	Retrofit	SBW	Utility Plant & other manufacturing steam traps to make electric power generation more efficient
47	WMECO	Other	1	11S007	Retrofit	SBW	Manufacturing, Compressed air leak repairs
48	WMECO	Other	2	WM11P023	Retrofit	DMI	Manufacturing, Compressed air leak repairs
49	NGRID	Other	1	591663	Retrofit	DNV KEMA	Agriculture, Interval timer to cycle two evaporator fans.
50	NGRID	Other	2	931138	Retrofit	SBW	Manufacturing, Compressed air leak repair
52	NGRID	Motor	1	863414	Retrofit	DMI	Industrial, VFD on existing drive motor
54	WMECO	Motor	1	WM10R103	Retrofit	DMI	Agricultural, Dairy vacuum pump VFD
55	WMECO	Refrigeration	1	11C629	New Construction	SBW	Grocery, Refrigerated casework improvements

KEMA Site Number	Program Administrator	End Use	Stratum	Site ID	Track	Evaluating Firm	Facility Type, Project Description
57	NGRID	Motor	1	830236	Retrofit	SBW	Agricultural, Dairy Processing Plant VFDs on pumps
58	NGRID	Refrigeration	3	909408	New Construction	SBW	University, Ice rink chiller replacement
59	NGRID	Refrigeration	2	735605	New Construction	SBW	Retail, refrigerated casework improvements
61	NGRID	Motor	1	606038	Retrofit	DMI	Industrial, VFD on existing drive motor
62	NSTAR	Refrigeration	2	CS8448	New Construction	DNV KEMA	Grocery, Install two new refrigeration rack systems and five new hybrid condensers
63	NGRID	Motor	1	826274	New Construction	DNV KEMA	Fitness Club, Two new domestic hot water pumps with VSD.

4. Description of Methodology

4.1 Measurement and Evaluation Plans

Following the final sample selection of 2011 Custom RMO applications and prior to beginning any site visits, DNV KEMA, SBW, and DMI developed detailed measurement and evaluation plans for each of the 48 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 it was found that the TA analysis did not accurately characterize the proposed conditions. 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. Where possible, evaluators used power, time-of-use or temperature data to verify EMS trend data.

Collected data was analyzed to verify implementation and operation 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 RMO 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, or current industry standard was referred to by evaluating engineers. Evaluators verified that the proper baseline systems were used in all projects. In some cases, the evaluation changed the base case if the tracking baseline system was deemed inappropriate.

The baseline validity is a function of several factors. The installed equipment and technology, the facility type, and the operation of the installed equipment all played a role in the assessment of the baseline. In many cases, there was a lack of documentation on the baseline systems or baseline equipment used to develop the tracking savings. In these situations, the evaluation must rely on using the TA assumed baseline, or information gained from facility staff interviews. Project documentation should detail the assumed baselines as clearly as possible so that the evaluation can properly assess the validity of this component of the savings calculations.

Refrigeration

The refrigeration measures include electrically commutated motors on evaporator fans, reduced wattage anti-condensate heaters, LED lighting on reach-in freezer cases, and efficient condenser fans. These measures are not included in MA building codes. The baseline for these measures is provided by the customer; less efficient motors, heater, and lighting would have been installed in place of the efficient counterparts. This assumption was taken at face value. Whether less efficient equipment is installed in locations outside utility borders was not investigated.

The specifications for the existing installed equipment relied heavily upon manufacturers' data. Many of the project files included spreadsheets with the make and model of both the baseline and installed units. This data included the wattage for each of the technologies. The files also contained manufacturers' cut sheets. Online research and manufacturer outreach was conducted on selected equipment. The reviewed specifications and equipment matched the tracking documentation.

In the tracking documentation the baseline operating hours for each of the measures' technologies were obtained from discussions with store personnel. Corporate contacts provided information for chain stores as well. The same discussions were conducted for the evaluation. The installed monitoring provided the operating schedules for the equipment.

The discrepancies in the refrigeration measures include:

- There was lack of uniformity in calculating interactive refrigeration effects. No interactive refrigeration was included in two sites. Two sites did not use a power-to-heat diversity factor assuming 100% of the power saved was seen at the compressors.
- An existing waste heat reclamation system was not addressed or mentioned on a condenser fan measure at one location. This impacts winter run time of the fans, which may reduce energy savings. The baseline system did not account for this waste heat system.
- Two sites indicated that evaporator fan controls and humidity controls were in place for baseline operation. No such controls were proposed or installed with the refrigeration measures. Monitoring found the evaporator fans and anti-condensate heaters operated continuously over the monitoring period. This suggests that the controls may have been bypassed with the installation of the new equipment. However, this could not be confirmed so the evaluation assumed the same uncontrolled baseline in the evaluation as found on-site.

Motors and variable speed drives

This measure class included process pumps, process fans, vacuum pumps, and water pumping applications. The site evaluation determined that installed quantities of equipment matched tracking data. The process measures are not HVAC applications and can fall outside of MA building codes.

- A new vacuum pump was installed at a farm to replace an existing unit. The existing system was problematic and needed to be replaced. The baseline was a larger and less efficient replacement unit and not the existing system. This was driven by an industry standard. The existing system was repaired and changed over the years and was no longer in compliance with the requirements that would prevent infection and disease. The measure upgraded sections of the distribution system as well as installed efficient vacuum pumps to become compliant.
- The baseline domestic hot water (DHW) usage at a sports club was over estimated for a VSD/motor measure. The bin analysis assumed one pump operation for 80% of the time. A second pump kicked in at near full load for the remaining 20% of the time. The monitoring found that the time-of-day operation included morning and afternoon increases in usage. However, the maximum monitored usage entered the two pump operating range approximately 1% of the time. The baseline overstated the peak DHW load.

4.2.3 Site Reports

Engineers submitted draft site reports to the PAs upon completion of each site evaluation. A sample of these site reports were also reviewed by the EEAC consultant. The PA and EEAC reviews resulted in the final reports found in Appendix A: Site Report. 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 RMO sample, DNV KEMA applied the model-assisted stratified ratio estimation methodology.2,3 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.

[2] 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.

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

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.

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.

5. Results

In preparation for analyzing the evaluation results collected for the Custom RMO sample points, the original 2011 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 13 for Custom RMO.

Table 13: Custom RMO Case Weights

Measure	Program Administrator	Stratum	Total Accounts	Total Annual kWh Savings	Accounts in Sample	Case Weight
Refrigeration	NGRID	1	94	2,681,369	4	23.50
	NGRID	2	33	3,395,675	4	8.25
	NGRID	3	12	4,673,365	4	3.00
	NSTAR	1	34	1,741,641	5	6.80
	NSTAR	2	11	2,324,497	5	2.20
	CLC	1	3	119,508	1	3.00
	CLC	2	1	616,526	1	1.00
	WMECO	1	7	383,871	3	2.33
	WMECO	2	2	1,229,567	1	2.00
	Total		**197**	**17,166,019**	**28**	
Motor	NGRID	1	9	303,718	5	1.80
	NGRID	2	3	476,073	1	3.00
	NGRID	3	3	912,822	3	1.00
	NSTAR	1	1	36,616	-	-
	NSTAR	2	2	161,443	1	2.00
	WMECO	1	3	75,204	3	1.00
	WMECO	2	1	188,013	-	-
	Total		**22**	**2,153,889**	**13**	
Other	NGRID	1	10	379,941	2	5.00
	NGRID	2	3	616,062	2	1.50
	NGRID	3	1	3,849,196	1	1.00
	WMECO	1	1	58,223	1	1.00
	WMECO	2	1	644,364	1	1.00
	Total		**16**	**5,547,786**	**7**	

5.1 Major Findings and Observable Trends

Figure 4 presents a scatter plot of evaluation results from the Custom Refrigeration 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 lower than the observed data. These sample data are somewhat scattered around the trend line, indicating that there is a small amount of variation in the relationship between tracking and evaluated savings, which is reflected in the resulting error ratio of 0.33.

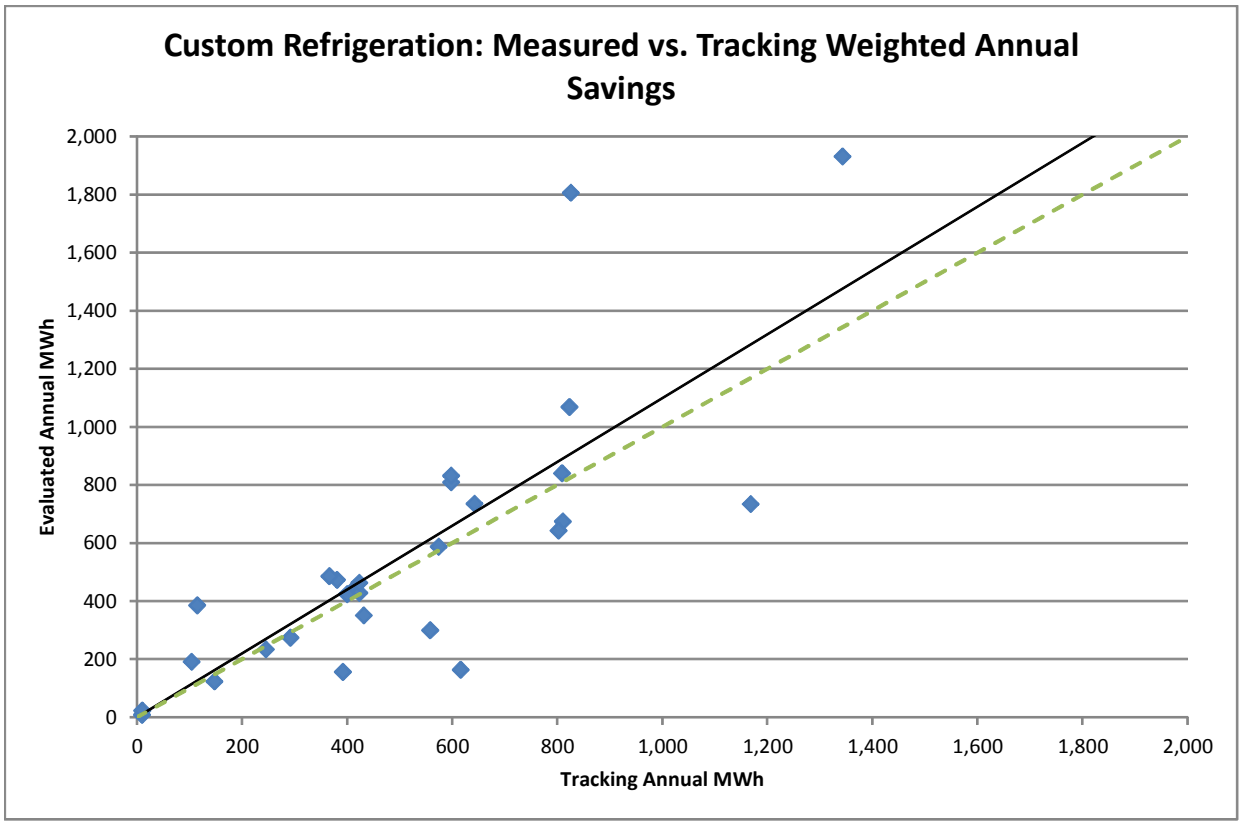

Figure 4: Scatter Plot of Evaluation Results for Annual MWh Savings for Custom Refrigeration

Figure 5 presents the same information for the Motor sample points. The Motor results tend to be clustered closely around the trend line, indicating little variation in the relationship between tracking and evaluated savings.

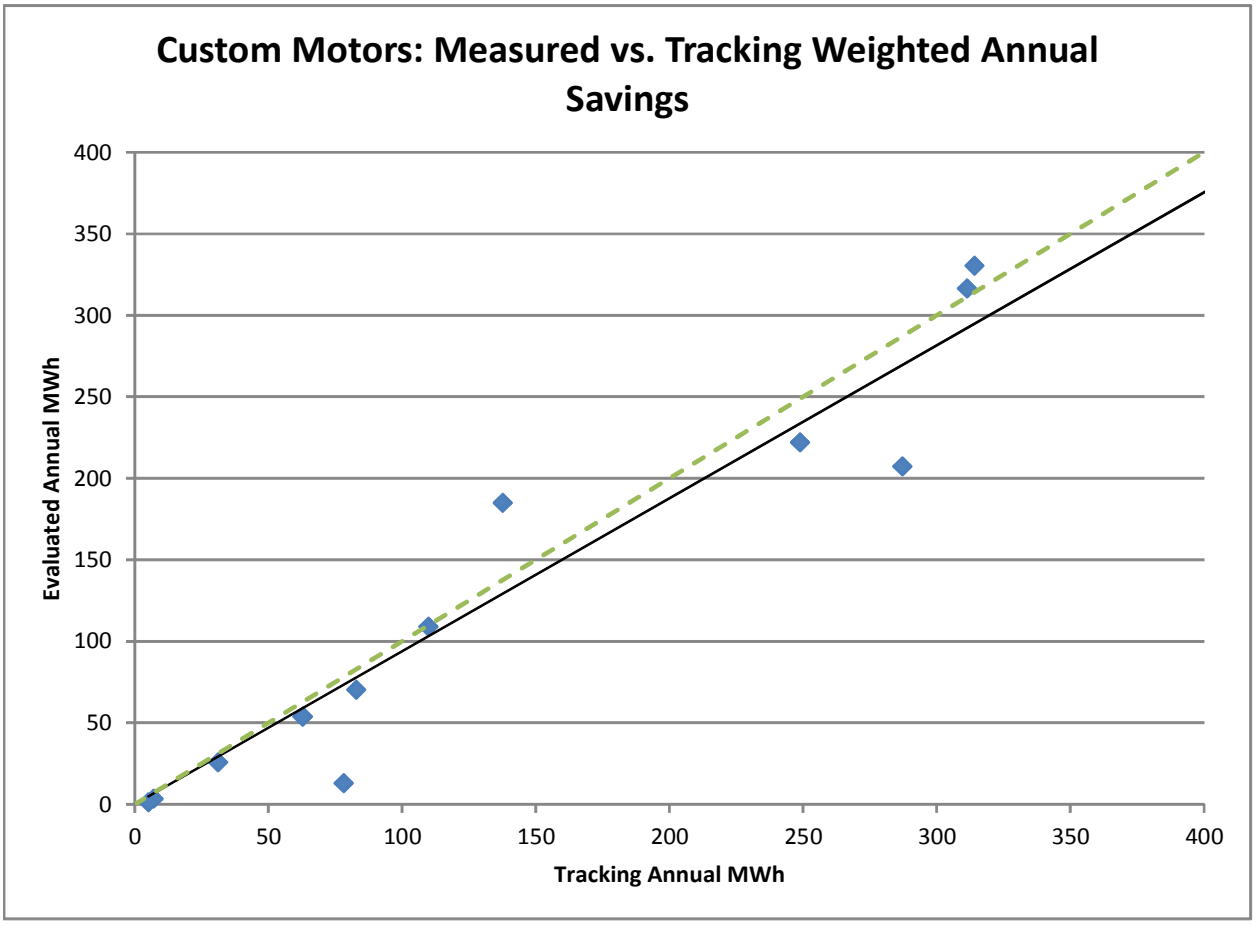

Figure 5: Scatter Plot of Evaluation Results for Annual MWh Savings for Motor

Figure 6 presents the same information for the Other sample points. Aside from one sample point, the Other results tend to be clustered closely around the trend line, indicating little variation in the relationship between tracking and evaluated savings.

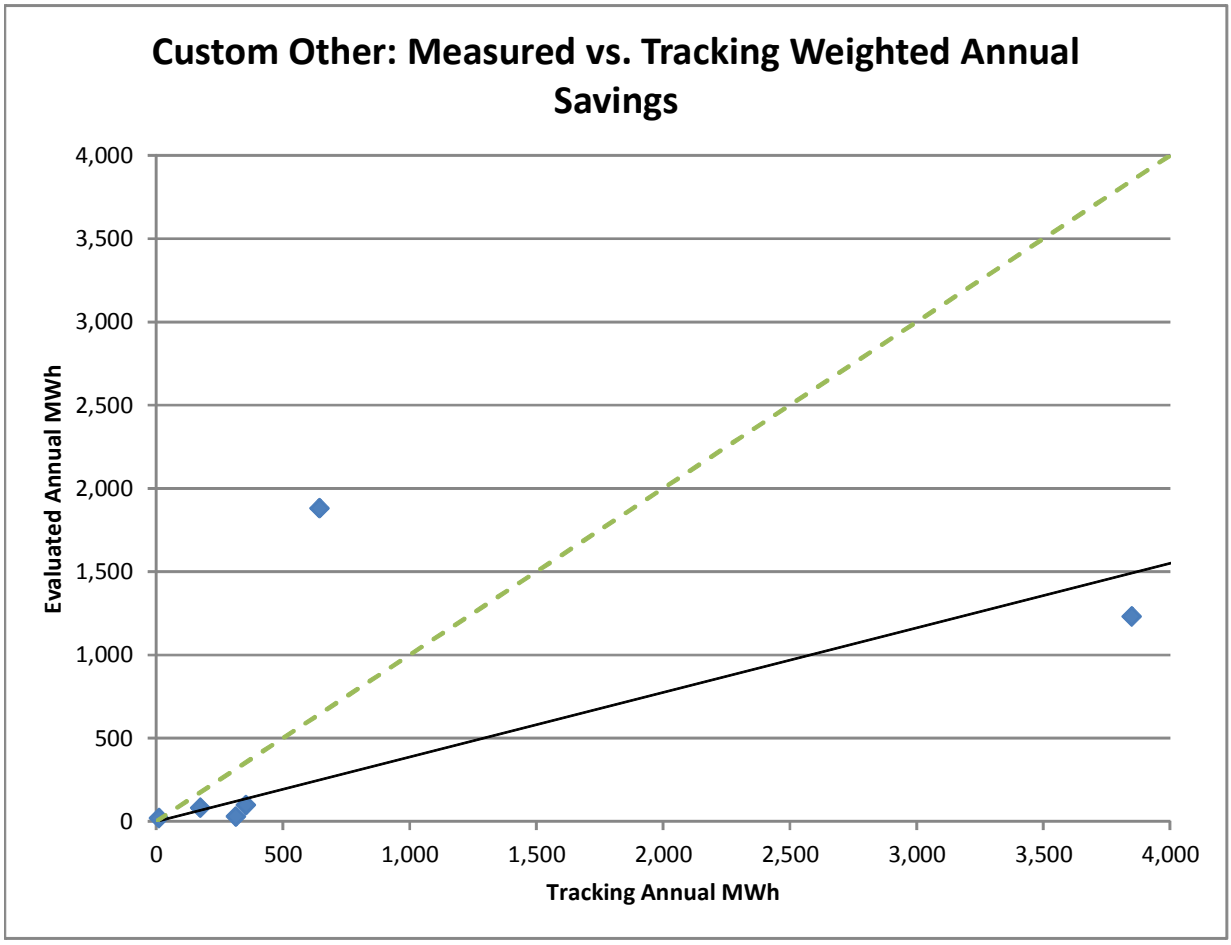

Figure 6: Scatter Plot of Evaluation Results for Annual MWh Savings for Other

5.2 Presentation of Results

Table 14 presents a summary of the Custom Refrigeration site level results for this impact evaluation. Table 15 summarizes the savings realization rates and primary reasons for discrepancies between the tracking and evaluation estimates of annual energy savings for Custom Refrigeration. The site energy savings realization rates ranged from a low of 26% for Site 2 to a high of 336% for Site 1. 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 14: Detailed Results for Custom Refrigeration

KEMA Site Number	Program Administrator	Site ID	Tracking Estimated Savings				Evaluation Savings					
				On-Peak	Peak Coinc.			On-Peak	On-Peak		Seasonal	
			kWh/yr	%	Sum. kW	Wint. kW	kWh/yr	%	Sum. kW	Wint. kW	Sum. kW	Wint. kW
1	CLC	D026441272	38,283	N/A	1.7	4.4	128,449	46.6%	15.0	14.3	16.0	14.4
2	CLC	D018660063	616,526	N/A	3.3	8.6	163,352	46.1%	19.1	18.3	20.4	18.2
3	NGRID	550180	423	47%	0.1	0.1	349	46.0%	0.0	0.0	0.0	0.0
4	NGRID	820896	35,161	46%	3.4	4.6	76,861	48.0%	12.3	9.2	15.3	11.7
5	NGRID	872165	25,454	46%	3.2	2.7	35,385	46.2%	4.4	3.8	5.2	3.8
6	NGRID	872158	25,454	46%	3.2	2.7	34,433	46.7%	4.3	3.8	5.2	3.7
7	NGRID	735608	98,105	46%	8.0	14.3	101,829	47.6%	9.7	14.2	9.8	14.0
8	NGRID	732180	97,357	46%	11.1	11.1	77,936	46.5%	9.1	8.8	9.4	8.8
10	NGRID	906877	162,858	46%	24.7	12.8	234,064	49.7%	29.9	28.5	31.9	28.4
11	NGRID	863404	214,201	46%	33.8	16.3	245,055	49.2%	35.2	24.2	35.5	23.8
12	NGRID	640749	270,428	40%	32.9	39.7	224,597	43.6%	16.0	30.1	13.5	33.7
13	NGRID	945474	186,168	50%	40.5	40.5	99,693	50.0%	14.8	15.7	13.3	15.9
58	NGRID	909408	191,595	48%	14.7	30.3	195,568	55%	20.1	40.2	0.0	36.0
59	NGRID	735605	52,395	46%	4.3	7.6	42,447	51.1%	5.3	5.4	5.2	5.3
15	NSTAR	BS10386	60,847	N/A	7.0	7.0	65,122	48.0%	11.0	5.8	11.5	5.5
16	NSTAR	BS9774	21,730	N/A	2.1	2.1	18,075	4.61%	2.0	2.1	2.0	2.1
17	NSTAR	BS10434	62,266	N/A	7.1	7.1	62,890	54.0%	10.5	7.3	11.9	7.0
18	NSTAR	BS10435	62,266	N/A	7.1	7.1	68,047	48.0%	11.7	6.0	12.1	5.7
19	NSTAR	BS10061	42,941	N/A	6.3	6.3	40,282	52.0%	8.3	8.0	5.6	5.0
20	NSTAR	CS8862	111,672	N/A	8.0	8.0	105,997	40.3%	10.8	10.4	11.4	10.4
21	NSTAR	BS9056	182,000	N/A	17.2	17.2	192,549	46.4%	21.4	22.7	21.3	23.3
22	NSTAR	CS8377	374,394	N/A	70.0	70.0	485,604	50.2%	61.3	51.4	69.5	52.2
24	NSTAR	CS8220	173,155	N/A	23.8	23.8	215,057	53%	19.9	39.7	20.6	41.0
62	NSTAR	CS8448	166,582	N/A	0.7	0.2	220,853	48.3%	43.2	17.9	84.1	19.4
25	WMECO	WM11R106	44,784	N/A	6.6	6.6	81,530	47.0%	11.7	8.4	13.0	8.2
26	WMECO	WM11S001	4,545	N/A	0.1	0.1	9,504	61.9%	1.5	1.5	1.6	1.5
28	WMECO	WM11C130	584,288	N/A	83.9	83.9	367,093	47.6%	58.3	39.6	81.2	37.8
55	WMECO	WM11C629	168,027	N/A	19.3	19.3	66,793	47.1%	7.8	7.8	7.7	7.8
	CLC	**Total**	**654,809**	**N/A**	**4.9**	**13.0**	**291,802**	**N/A**	**34.1**	**32.6**	**36.4**	**32.6**
	NGRID	**Total**	**1,359,599**	**46%**	**179.9**	**182.6**	**1,368,217**	**49%**	**161.2**	**183.9**	**144.4**	**185.1**
	NSTAR	**Total**	**1,257,853**	**N/A**	**149.3**	**148.8**	**1,474,475**	**N/A**	**200.1**	**171.3**	**250.1**	**171.6**
	WMECO	**Total**	**801,644**	**N/A**	**109.8**	**109.8**	**524,921**	**N/A**	**79.2**	**57.2**	**103.5**	**55.3**
	Statewide	**Total**	**4,073,905**	**N/A**	**443.9**	**454.2**	**3,659,415**	**N/A**	**474.6**	**445.0**	**534.4**	**444.6**

Table 15: Primary Site Discrepancies for Custom Refrigeration

KEMA Site Number	Program Administrator	Site ID	Realization Rates						Primary Reasons For Discrepancies
				On-Peak	On-Peak		Seasonal		
			kWh/yr	%	Sum. kW	Wint. kW	Sum. kW	Wint. kW	
1	CLC	D026441272	336%	N/A	905%	327%	966%	329%	Tracking savings as provided by the customer's vendor omitted 178

KEMA Site Number	Program Administrator	Site ID	Realization Rates						Primary Reasons For Discrepancies
			kWh/yr	On-Peak %	On-Peak		Seasonal		
					Sum. kW	Wint. kW	Sum. kW	Wint. kW	
									ECMs and interactive refrigeration savings.
2	CLC	D018660063	26%	N/A	584%	213%	623%	212%	Large documentation error
3	NGRID	550180	83%	98%	41%	40%	42%	39%	Reduced watt per motor savings than predicted by the TA
4	NGRID	820896	219%	104%	358%	199%	445%	254%	Higher than expected refrigeration system energy use results in more savings than predicted for case doors.
5	NGRID	872165	139%	100%	139%	140%	165%	139%	Higher savings resulting from reduced anti-condensate heater (ACH) operation, and increased refrigeration efficiency/savings.
6	NGRID	872158	135%	101%	137%	138%	164%	137%	Higher savings due to higher lighting hours of operation, and increased refrigeration efficiency/savings.
7	NGRID	735608	104%	103%	121%	100%	122%	98%	Reduced lighting fixture operating hours compared to the hours predicted by the TA
8	NGRID	732180	80%	101%	82%	79%	84%	79%	TA assumed 100% of the difference in ACH power as waste heat to be removed by the compressors. Evaluation assumed 50%.
10	NGRID	906877	144%	108%	121%	223%	129%	222%	Increased operating hours and increased interactive refrigeration savings
11	NGRID	863404	114%	107%	104%	149%	105%	146%	ACH operating hours more than twice the TA estimate, which resulted in higher savings.
12	NGRID	640749	83%	109%	49%	76%	41%	85%	Differences in loads among the evaluated measures
13	NGRID	945474	54%	100%	37%	39%	33%	39%	The evaluation does not claim savings for ice temperature reset because temperature was reset manually in the pre-retrofit case.
58	NGRID	909408	102%	114%	137%	133%	0%	119%	Longer operating hours; TA used existing condition as baseline, but equipment was at the end of its useful life, which required a standard baseline.
59	NGRID	735605	81%	111%	124%	71%	121%	69%	Case lights that were turned off at night were assumed to save energy due to motion sensors installed for one of the measures TA treated one 2-door case as a three-door case
15	NSTAR	BS10386	107%	N/A	159%	83%	165%	79%	Primary reason for the increase in savings was the installation of larger motors than the pre-existing case.

			Realization Rates						
KEMA Site Number	Program Administrator	Site ID	kWh/yr	On-Peak %	On-Peak Sum. kW	On-Peak Wint. kW	Seasonal Sum. kW	Seasonal Wint. kW	Primary Reasons For Discrepancies
16	NSTAR	BS9774	83%	N/A	97%	100%	97%	100%	Evaporator fan controls were found to have been bypassed
17	NSTAR	BS10434	101%	N/A	148%	103%	167%	99%	While savings lighting savings and fan motor savings were lower than the tracking value, from cooler door installation are higher and contributed to the increase in total annual energy savings.
18	NSTAR	BS10435	109%	N/A	164%	84%	171%	80%	Primary reason for the increase in savings was the installation of larger motors than the existing case.
19	NSTAR	BS10061	94%	N/A	132%	127%	89%	80%	Improved refrigeration system performance than predicted by the TA, which decreases the savings from reduced motor heat output
20	NSTAR	CS8862	95%	N/A	134%	130%	142%	129%	Decrease due to higher wattage ECMs
21	NSTAR	BS9056	106%	N/A	125%	132%	124%	135%	Uncertain due to lack of detailed methods used to determine tracking estimates of savings
22	NSTAR	CS8377	130%	N/A	88%	73%	99%	75%	Increase in the evaluation base case annual energy consumption compared to the base case of the tracking analysis. Incorrect assumptions of the site refrigeration system's operating conditions in the tracking analysis were identified by the evaluator, and this report adjusts those base case conditions using evaluation trend data and metering data.
24	NSTAR	CS8220	124%	N/A	84%	167%	87%	172%	Installed Loads were found to be lower than those assumed for the tracking analysis. Baseline did not change resulting in higher savings.
62	NSTAR	CS8448	133%	N/A	5997%	10549%	11685%	11406%	Lower loads than estimated in the tracking savings. Baseline did not change resulting in higher savings.
25	WMECO	WM11R106	182%	N/A	177%	128%	196%	125%	Incorrect data entry in tracking system underreported savings by 100%.
26	WMECO	WM11S001	209%	N/A	1495%	1456%	1566%	1457%	Incorrect data entry in tracking system underreported savings by 100%.
28	WMECO	WM11C130	63%	N/A	70%	47%	97%	45%	TA used full-load efficiency for all chiller loading while evaluation used part-load performance curves Error in TA calculations
55	WMECO	WM11C629	40%	N/A	40%	40%	40%	40%	Refrigeration compressor efficiency difference and

KEMA Site Number	Program Administrator	Site ID	Realization Rates						Primary Reasons For Discrepancies
			kWh/yr	On-Peak %	On-Peak		Seasonal		
					Sum. kW	Wint. kW	Sum. kW	Wint. kW	
									differences in casework lighting and defrost schedules

Table 16 presents a summary of the Custom Motor site level results for this impact evaluation. Table 17 summarizes the savings realization rates and primary reasons for discrepancies between the tracking and evaluation estimates of annual energy savings for Custom Motor. The site energy savings realization rates ranged from a low of 17% for Site 61 to a high of 134% for Site 37. 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 16: Detailed Site Results for Custom Motor

KEMA Site Number	Program Administrator	Site ID	Tracking Estimated Savings				Evaluation Savings					
			kWh/yr	On-Peak %	Peak Coinc.		kWh/yr	On-Peak %	On-Peak		Seasonal	
					Sum. kW	Wint. kW			Sum. kW	Wint. kW	Sum. kW	Wint. kW
30	NGRID	566448	5,717	49%	1.2	1.6	6,188	48.8%	1.0	1.7	1.1	1.2
31	NGRID	830257	82,966	37%	7.8	7.8	74,019	44.1%	7.4	7.1	7.4	7.3
33	NGRID	824160	314,252	65%	82.7	0.0	330,376	76.0%	96.5	4.5	51.6	4.3
34	NGRID	822602	287,173	39%	34.0	19.1	207,294	51.9%	28.2	33.2	23.5	32.6
35	NGRID	643994	311,397	100%	65.7	65.7	316,506	68.4%	73.6	61.6	73.5	48.6
52	NGRID	863414	61,097	0%	20.0	20.0	60,506	99.0%	13.6	-0.3	12.4	-0.3
57	NGRID	830236	46,069	40%	4.6	4.6	39,062	39.6%	4.1	4.3	4.2	4.4
61	NGRID	606038	43,418	91%	9.9	9.9	7,222	80.0%	1.1	1.2	1.2	1.2
63	NGRID	826274	17,347	0%	11.6	5.8	14,279	48.1%	1.7	1.8	1.7	1.8
37	NSTAR	CS8723	68,882	N/A	13.4	13.4	92,471	70.1%	13.7	15.4	14.2	15.6
39	WMECO	WM10C105	7,136	N/A	3.0	3.0	3,396	28.0%	0.0	0.6	0.0	1.0
40	WMECO	WM10S231	62,843	N/A	5.0	5.0	53,801	56.4%	10.3	4.9	13.0	8.0
54	WMECO	WM10R103	5,225	N/A	2.9	2.9	1,270	20.0%	0.1	0.2	0.2	0.2
	NGRID	**Total**	**1,169,436**	**61%**	**237.4**	**134.5**	**1,055,452**	**66%**	**227.1**	**115.1**	**176.6**	**101.3**
	NSTAR	**Total**	**68,882**	**N/A**	**13.4**	**13.4**	**92,471**	**N/A**	**13.7**	**15.4**	**14.2**	**15.6**
	WMECO	**Total**	**75,204**	**N/A**	**10.9**	**10.9**	**58,467**	**N/A**	**10.4**	**5.7**	**13.2**	**9.1**
	Statewide	**Total**	**1,313,522**	**N/A**	**261.7**	**158.8**	**1,206,389**	**N/A**	**251.2**	**136.2**	**203.9**	**125.9**

Table 17: Primary Site Discrepancies for Custom Motor

KEMA Site Number	Program Administrator	Site ID	Realization Rates						Primary Reasons For Discrepancies
			kWh/yr	On-Peak %	On-Peak		Seasonal		
					Sum. kW	Wint. kW	Sum. kW	Wint. kW	

			Realization Rates						
KEMA Site Number	Program Administrator	Site ID	kWh/yr	On-Peak %	On-Peak Sum. kW	On-Peak Wint. kW	Seasonal Sum. kW	Seasonal Wint. kW	Primary Reasons For Discrepancies
30	NGRID	566448	108%	100%	88%	106%	92%	78%	New vacuum pump operated at lower power than tracking estimate.
31	NGRID	830257	89%	119%	95%	91%	95%	94%	Improper assumption of pump energy converted to heat that increased compressor load
33	NGRID	824160	105%	117%	117%	N/A	62%	N/A	Lower than expected installed fan airflow resulting in a lower input motor demand. Baseline motor power remained constant.
34	NGRID	822602	72%	133%	83%	174%	69%	171%	TA accounted for savings from a pump that should not have been included; differences in TA projected operating conditions vs. actual operating conditions used for evaluation
35	NGRID	643994	102%	68%	112%	94%	112%	74%	Increased flow through the pumps, and decreased hours.
52	NGRID	863414	99%	N/A	68%	-1%	62%	-1%	Reduction in facility production hours combined with higher pre-retrofit power demand and lower post-retrofit power demand compared to the tracking analysis. Facility did not operate during winter peak hours, but one motor was left energized during non-production hours on weekday afternoons and nights resulting in negative winter demand savings.
57	NGRID	830236	85%	99%	90%	93%	91%	97%	Reduction in pre-retrofit operating hours and an improper assumption of pump energy converted to heat that increased compressor load
61	NGRID	606038	17%	88%	11%	12%	12%	12%	Decrease in savings due to an incorrect TA baseline characterization, reduction of expected annual operation hours, decrease in expected demand reduction
63	NGRID	826274	82%	N/A	14%	32%	14%	31%	Pump operating at lower loads (both pre and post) than tracking estimate.
37	NSTAR	CS8723	134%	N/A	102%	115%	106%	116%	Increased operating hours and lower motor loads.
39	WMECO	WM10C105	48%	N/A	1%	19%	1%	33%	Higher than expected post-retrofit average kW and lower than expected annual operating hours
40	WMECO	WM10S231	86%	N/A	206%	99%	260%	159%	Lower operating hours than tracking estimate. TA demand savings represent the average demand savings throughout the year. The evaluation demand savings are based on operation observed during demand peak periods.
54	WMECO	WM10R103	24%	N/A	4%	7%	5%	6%	Higher than expected post-retrofit average kW and lower than expected annual operating hours

Table 18 presents a summary of the Custom Other site level results for this impact evaluation. Table 19 summarizes the savings realization rates and primary reasons for discrepancies between the tracking and evaluation estimates of annual energy savings for Custom Other. The site energy savings realization rates

ranged from a low of 9% for Site 44 to a high of 292% for Site 48. 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 18: Detailed Site Results for Custom Other

			Tracking Estimated Savings				Evaluation Savings					
KEMA Site Number	Program Administrator	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
43	NGRID	918162	34,916	46%	4.0	4.0	16,211	46%	1.9	1.9	1.9	1.9
44	NGRID	713111	209,969	0%	0.0	0.0	18,962	82%	3.9	1.9	4.9	2.1
46	NGRID	591245	3,849,196	39%	439.0	439.0	1,230,350	46%	140.0	140.0	140.0	140.0
49	NGRID	591663	2,380	46%	0.5	0.5	3,943	42%	0.4	0.5	0.4	0.5
50	NGRID	931138	236,148	75%	36.0	36.0	65,767	67%	10.6	10.6	10.6	10.6
47	WMECO	WM11S007	58,223	N/A	6.8	6.8	20,915	46%	2.4	2.4	2.4	2.4
48	WMECO	WM11P023	644,364	N/A	73.6	73.6	1,881,264	46%	214.8	214.8	214.8	214.8
	NGRID	**Total**	**4,332,609**	**39%**	**479.5**	**479.5**	**1,335,233**	**48%**	**156.8**	**154.9**	**157.8**	**155.1**
	WMECO	**Total**	**702,587**	**N/A**	**80.4**	**80.4**	**1,902,180**	**N/A**	**217.1**	**217.1**	**217.1**	**217.1**
	Statewide	**Total**	**5,035,196**	**N/A**	**559.9**	**559.9**	**3,237,413**	**N/A**	**373.9**	**372.0**	**374.9**	**372.2**

Table 19: Primary Site Discrepancies for Custom Other

			Realization Rates						
KEMA Site Number	Program Administrator	Site ID	kWh/yr	On-Peak %	On-Peak Sum. kW	On-Peak Wint. kW	Seasonal Sum. kW	Seasonal Wint. kW	Primary Reasons For Discrepancies
43	NGRID	918162	46%	101%	47%	47%	47%	47%	TA assumed greater loads on system than actual
44	NGRID	713111	9%	N/A	N/A	N/A	N/A	N/A	Fewer computers controlled by central software than assumed for tracking estimate and savings offset by existing computer power controls
46	NGRID	591245	32%	119%	32%	32%	32%	32%	Plant loads following measure implementation were reduced from pre-retrofit conditions which required an adjustment to the TA's pre-retrofit loads, resulting in reduced opportunity for savings; .
49	NGRID	591663	166%	92%	66%	99%	79%	94%	Lower installed operating hours than tracking estimate
50	NGRID	931138	28%	90%	29%	29%	29%	29%	Fewer compressed air leaks were repaired than assumed for the tracking analysis and reduced compressor operating hours
47	WMECO	WM11S007	36%	N/A	35%	35%	35%	35%	Tracking estimate of savings was based on a more efficient compressor than was installed

			Realization Rates						
KEMA Site Number	Program Administrator	Site ID	kWh/yr	On-Peak %	On-Peak		Seasonal		Primary Reasons For Discrepancies
					Sum. kW	Wint. kW	Sum. kW	Wint. kW	
48	WMECO	WM11P023	292%	N/A	292%	292%	292%	292%	Increase in savings due to larger increase in reduction of compressed air flow than was originally predicted

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 20 summarizes the PA-specific results of the Custom Refrigeration analysis. In the case of annual MWh savings, the realization rate for Custom Refrigeration measures ranged from 65.8% for Cape Light Compact to 118.8% for National Grid. The relative precision for these estimates was found to range from ±5.7% to ±73.2% at the 90% level of confidence. Aside from CLC, which only had two sites in the sample, the variation in the evaluated site results for this study was about what was expected based on the error ratios observed. Table 20 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 20.

Table 20: Summary of Custom Refrigeration Results by PA

Refrigeration 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
NGRID							
Total Tracking Savings	10,750	44%	4,709	1,373	1,267	1,373	1,267
Total Measured Savings	12,772	46%	5,899	1,655	1,519	1,733	1,585
Realization Rate	118.8%	105%	125%	120.6%	119.9%	126.3%	125.1%
Relative Precision at 90% Confidence	17.7%	-	18%				
Error Bound at 90% Confidence	2,258	-	1,048				
Relative Precision at 80% Confidence				23.2%	18.2%	29.2%	20.7%
Error Bound at 80% Confidence				385	277	507	328
Error Ratio	0.36	-	0.36	0.62	0.52	0.76	0.56
NSTAR							
Total Tracking Savings	4,066	-	-	471	491	471	491
Total Measured Savings	4,582	-	-	649	542	759	523
Realization Rate	112.7%	-	-	137.9%	110.4%	161.2%	106.6%
Relative Precision at 90% Confidence	5.7%	-	-				
Error Bound at 90% Confidence	259	-	-				
Relative Precision at 80% Confidence				18.7%	14.7%	27.1%	15.2%
Error Bound at 80% Confidence				121	80	205	80
Error Ratio	0.13	-	-	0.60	0.44	0.92	0.47
CLC							
Total Tracking Savings	736	-	-	8	22	8	22
Total Measured Savings	552	-	-	66	63	70	63
Realization Rate	75.0%	-	-	777.7%	281.7%	830.2%	282.7%
Relative Precision at 90% Confidence	73.2%	-	-				
Error Bound at 90% Confidence	404	-	-				
Relative Precision at 80% Confidence				10.4%	10.1%	10.4%	10.4%
Error Bound at 80% Confidence				7	6	7	7
Error Ratio	1.27	-	-	0.23	0.23	0.23	0.23
WMECO							
Total Tracking Savings	1,613	-	-	251	131	251	131
Total Measured Savings	1,061	-	-	182	69	236	67
Realization Rate	65.8%	-	-	72.4%	52.7%	93.9%	51.0%
Relative Precision at 90% Confidence	18.3%	-	-				
Error Bound at 90% Confidence	195	-	-				
Relative Precision at 80% Confidence				13.1%	12.7%	13.3%	13.1%
Error Bound at 80% Confidence				24	9	31	9
Error Ratio	0.42	-	-	0.40	0.41	0.35	0.42

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 21.

Table 21: Statewide Custom Refrigeration Results

Overall Refrigeration 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	17,166	-	-	2,103	1,911	2,103	1,911
Total Measured Savings	18,967	-	-	2,552	2,192	2,798	2,237
Realization Rate	110.5%	-	-	121.3%	114.7%	133.1%	117.1%
Relative Precision at 90% Confidence	12.2%	-	-				
Error Bound at 90% Confidence	2,317	-	-				
Relative Precision at 80% Confidence				15.8%	13.2%	19.6%	15.1%
Error Bound at 80% Confidence				404	289	548	338
Error Ratio	0.33	-	-	0.59	0.49	0.76	0.53

The statewide realization rate for Annual MWh savings is 110.5%, estimated with ±12.2% relative precision. The demand realization rates are all between 114.7% and 133.1%.

Aggregated results from the Custom Motor sample sites are presented in Table 22 and Table 23 below. Realization rates for Annual MWh savings range from 77.7% for WMECO to 134.2% for NSTAR. The statewide realization rate for Custom Motor measures was 87.9% for Annual MWh, estimated with ±3.8% relative precision. The realization rates for the demand measurements were all between 70.6% and 85.5%.

Table 22: Summary of Custom Motor Results by PA

Motors 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
NGRID							
Total Tracking Savings	1,693	63%	1,075	349	188	349	188
Total Measured Savings	1,499	72%	1,085	311	139	249	125
Realization Rate	88.5%	114%	101%	89.1%	74.2%	71.5%	66.8%
Relative Precision at 90% Confidence	4.8%	-	16%				
Error Bound at 90% Confidence	72	-	177,710				
Relative Precision at 80% Confidence				7.4%	18.9%	7.3%	19.4%
Error Bound at 80% Confidence				23	26	18	24
Error Ratio	0.22	-	0.60	0.48	0.87	0.49	0.87
NSTAR							
Total Tracking Savings	198	-	-	26	27	26	27
Total Measured Savings	266	-	-	27	31	28	32
Realization Rate	134.2%	-	-	102.2%	114.9%	106.2%	116.4%
Relative Precision at 90% Confidence	0.0%	-	-				
Error Bound at 90% Confidence	-	-	-				
Relative Precision at 80% Confidence				0.0%	0.0%	0.0%	0.0%
Error Bound at 80% Confidence				-	0	-	0
Error Ratio	0.00	-	-	0.00	0.00	0.00	0.00
WMECO							
Total Tracking Savings	263	-	-	14	34	14	34
Total Measured Savings	205	-	-	13	18	17	28
Realization Rate	77.7%	-	-	95.8%	52.4%	120.8%	83.6%
Relative Precision at 90% Confidence	0.0%	-	-				
Error Bound at 90% Confidence	-	-	-				
Relative Precision at 80% Confidence				0.0%	0.0%	0.0%	0.0%
Error Bound at 80% Confidence				-	-	-	-
Error Ratio	0.20	-	-	1.24	0.98	1.24	1.01

Table 23: Statewide Custom Motor Results

Overall Motors 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	2,154	-	-	389	248	389	248
Total Measured Savings	1,969	-	-	351	188	294	185
Realization Rate	91.4%	-	-	90.2%	75.7%	75.6%	74.5%
Relative Precision at 90% Confidence	3.7%	-	-				
Error Bound at 90% Confidence	72	-	-				
Relative Precision at 80% Confidence				6.5%	14.0%	6.2%	13.2%
Error Bound at 80% Confidence				23	26	18	24
Error Ratio	0.17	-	-	0.45	0.67	0.46	0.65

Aggregated results from the Custom Other sample sites are presented in Table 24 and Table 25 below. Realization rates for Annual MWh savings range from 31.0% for National Grid to 270.7% for WMECO. The statewide realization rate for Custom Other measures was 61.4% for Annual MWh, estimated with ±1.9% relative precision. The realization rates for the demand measurements were all around 63%.

Table 24: Summary of Custom Other Results by PA

Other 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
NGRID							
Total Tracking Savings	4,845	39%	1,904	559	554	559	554
Total Measured Savings	1,502	48%	726	187	183	189	184
Realization Rate	31.0%	123%	38%	33.5%	33.1%	33.9%	33.1%
Relative Precision at 90% Confidence	4.3%	-	5%				
Error Bound at 90% Confidence	65	-	34				
Relative Precision at 80% Confidence				4.3%	4.6%	3.3%	2.6%
Error Bound at 80% Confidence				6	5	7	5
Error Ratio	0.20	-	0.20	0.15	0.14	0.17	0.14
WMECO							
Total Tracking Savings	703	-	-	80	80	80	80
Total Measured Savings	1,902	-	-	217	217	217	217
Realization Rate	270.7%	-	-	270.1%	270.1%	270.1%	270.1%
Relative Precision at 90% Confidence	0.0%	-	-				
Error Bound at 90% Confidence	-	-	-				
Relative Precision at 80% Confidence				0.0%	0.0%	0.0%	0.0%
Error Bound at 80% Confidence				-	-	-	-
Error Ratio	0.22	-	-	0.22	0.22	0.22	0.22

Table 25: Statewide Custom Other Results

Overall Other 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	5,548	-	-	639	635	639	635
Total Measured Savings	3,404	-	-	405	401	406	401
Realization Rate	61.4%	-	-	63.3%	63.1%	63.6%	63.2%
Relative Precision at 90% Confidence	1.9%	-	-				
Error Bound at 90% Confidence	65	-	-				
Relative Precision at 80% Confidence				1.5%	1.2%	1.8%	1.2%
Error Bound at 80% Confidence				6	5	7	5
Error Ratio	0.13	-	-	0.12	0.12	0.13	0.12

5.3 Implications for Future Studies

From a statistical perspective it appears that the Custom Refrigeration, Motor and Other results are quite stable, and the variation across sample sites is lower than expected. Unless there are significant programmatic changes going forward, future designs should assume a similar error ratio (0.4) to determine sample size requirements for Custom Refrigeration evaluations. The Custom Motor and Other results produced very low error ratios, but there were a relatively small number of sample points in each category. It is recommended that any future Custom Motor and Other sample designs assume an error ratio in the 0.3 to 0.4 range to try to ensure that precision targets will be achieved.

5.4 Conclusions and Recommendations

Overall, the Custom Refrigeration program appears to be producing results that are greater than expected. The Custom Motor end-use appears to be producing slightly lower savings than expected. Custom Other did not perform as well as the other two measures. Below are the DNV KEMA evaluation team findings and recommendations that apply statewide, as well as to the individual PAs. Please note that the statewide recommendations should be considered by all PAs, since each of these were based on observations across all of the PAs. Likewise, the PA specific recommendations may also provide useful information for all PAs.

5.4.1 Statewide

5.4.1.1 General Evaluation Recommendations

Make sure customers and TA vendors understand they need to be prepared for providing assistance if their project is selected for evaluation. Some customers do not anticipate the level of commitment evaluation requires and may not be willing to allow sufficient time for the evaluator to perform the planned site work. This sometimes can result in adjustments to the plan while on-site and can sometimes result in less than ideal data collection. We recommend recording the name of a person agreeing to this requirement prior to project approval. We found customers to more likely to be short on time than TA vendors.

Ensure sufficient time is allowed for logging data for projects with seasonal variability. Some of the evaluated measures were affected by weather conditions; however insufficient time was available to collect metering data during the cooling season. It is recommended that the evaluation team work together early on to ensure that metering data is collected at the most ideal time.

5.4.1.2 General Documentation Recommendations

All PAs should require more complete pre-retrofit baseline documentation. NGRID Site 3 (restaurant refrigeration) did not include any cut sheets or documentation on the pre-retrofit equipment; therefore the pre-retrofit case could not be properly verified. NSTAR Sites 15, 17, 18 and WMECO Site 25 (all retail refrigeration) did not clearly document the pre-retrofit equipment layout and specifications. NSTAR Site 19 did not include model information or cut sheets for pre-retrofit equipment. It is recommended that PAs always require consistent forms of documentation including pre-existing or baseline and proposed equipment specifications, descriptions of the systems affected, and conditions at the time of the project implementation, and in some cases, pre-retrofit metering (see additional recommendation below). This is not an exhaustive list, but some suggestions for improved documentation requirements. It may be useful to establish a working group to examine the types of items that may help improve the custom programs.

PAs should work together to require consistent documentation for similar projects across different PAs. NGRID Site 4, NSTAR Sites 15, 17, 18 and WMECO Site 25 (all retail refrigeration) are part of the same chain in different PA territories. The documentation provided for each of these sites varied significantly across the PAs. This is one example of a chain of stores implementing the same measures across the state, but providing inconsistent documentation between them. It is recommended that the PAs attempt to develop consistent project documentation requirements for all similar measures. One requirement should be some type of report for all custom measures. Several projects across PAs did not include reports. The proposed cases for some of these sites were not clear due to the lack of a report. This means that the proposed equipment was not always clearly stated, the baseline conditions were not always described, and analysis methods were not always apparent.

5.4.1.3 Measure Specific Documentation

Measures involving refrigerated casework. Multiple measures implemented in refrigerated casework were difficult to meter because electrical distribution panels were mislabeled. Due to time constraints normally encountered when performing on-site work, identification of which circuits serve end uses of interest is not feasible. We recommend that implementation vendors consider documenting which panels/circuits serve the affected casework.

Consider specifying documentation requirements for compressed air leak repairs. Compressed air leak repairs are inherently difficult to verify due to the fact that new leaks can be expected to appear over time and inspecting for leak repairs implies looking for something that no longer exists. We recommend

development of a leak repair procedure that would require tagging leaks as they are discovered and leaving some visible form of identification for each leak proposed for repair. An inventory indicating which leaks were repaired and which ones were not, would provide a checklist for both inspection and evaluation purposes. Evaluations would still be difficult as measurements will include both unrepaired and new leaks, but evaluators would be able to better verify the leaks that were repaired. .

Consider more of a whole system approach for grouping measures for evaluation. The "Other" category included compressed air leak repair measures, which were part of compressed air systems upgrades. Traditionally, compressed air leak repairs have been treated as an operations and maintenance (O&M) type measure, which falls into the "Other" category. However, this could result in the same site being drawn in separate evaluations, but both looking at compressed air to estimate savings. It is recommended that PAs adopt more of a whole system approach for tracking measures, especially for evaluation purposes.

5.4.1.4 Pre-Retrofit Metering and Commissioning

Require TA vendors to provide metering for retrofit projects. Metering, as well as the TA's characterization of the facility/equipment operating conditions at the time of metering, could be used to confirm assumptions about pre-existing equipment. The evaluator may not be able to simulate pre-retrofit operating conditions; therefore metering by the TA vendor is sometimes critical. NGRID Site 3 (restaurant refrigeration) did not include metering of the pre-retrofit equipment, which was removed from the site as part of the measure implementation. NGRID Site 61 (industrial VSD) including only short term metering, but this was a process facility and long term metering could have been used to verify variation in production throughout the day. Several other sites, including WMECO Sites 39 and 54 (agricultural VSD), and NGRID site 52 (industrial VSD), did not include metering of the pre-retrofit equipment. These were all VFD retrofits, which is one type of measure that should always require pre-metering. Evaluators also believe TA metering could be useful for other measures such as compressed air leaks, injection molding machines, and controls measures.

Consider specifying TA verification of savings via commissioning, and in some cases, pre/post metering for specific measures. Several sites including NSTAR Site 22 (industrial refrigeration), NGRID Site 33 (industrial VSD), and WMECO Site 48 (manufacturing compressed air leaks) all had tracking savings over 300,000 kWh, but none of them were commissioned. It is recommended that commissioning be considered for all large savings, or complex projects. In these cases, commissioning would have updated some of the assumptions in the tracking analysis, which likely would have improved the evaluation results. We recommend that TAs be required to quantify the energy performance of

affected systems for certain types of measures. Two good examples are VFDs on chilled water pumps and compressed air leak repairs. The former would require metering of both the pump and chiller performance during periods of similar system loads and the latter can be accomplished by either metering compressor performance when air-using equipment is shut off (i.e. only leaks are being fed) or by determining distribution system volume and timing system pressure decay when air-using equipment is shut off and no compressors are operating. These techniques would not be applicable in all situations, but in many cases would benefit both savings estimates and evaluation efforts, not to mention the benefits that the customers may see.

5.4.2 Cape Light Compact

Perform closer review of large savings measures. Evaluated savings for CLC Site 2 (retail refrigeration) were 26% of the tracking savings (616,526 kWh). This was almost entirely due to a documentation error, which increased the tracking savings for one component of the project by a factor of 10. It is believed that this error was fixed at one point after the tracking savings were already reported. It is recommended that a thorough review of tracking savings values, especially for large projects, is done to help minimize these large documentation errors.

Include interactive refrigeration savings. Interactive refrigeration savings are a large component of the overall savings associated with refrigerated casework improvements. The reduction in motor loads and heat going into the casework results in significant savings on the refrigeration systems. However, both CLC measures that were evaluated omitted the interactive refrigeration savings from their tracking estimates. It is unclear why these savings were omitted in these applications. However, the interactive savings are significant, which means this PA is leaving a lot of savings on the table. Additionally, there is a risk that the evaluation results may result in greater error ratios, and lower precision estimates for this PA. It is recommended that CLC move to include interactive refrigeration saving in all refrigerated casework measures.

5.4.3 National Grid

Require adequate savings documentation. NGRID Site 3 (restaurant refrigeration) assumed a percent power reduction, but the basis for the assumption was not provided in the documentation. NGRID Site 13(ice rink refrigeration) did not provide the source of the assumed power reduction. NGRID Site 7 (retail refrigeration) did not include sources for the refrigeration load assumptions. The evaluation of these sites used different assumptions for some key variables, as the tracking assumptions were not

documented. It is recommended that all key tracking savings assumptions require some form of back-up documentation, such as metering results or manufacturer's specifications.

Verify proposed load assumptions as part of the final inspection of new construction projects. Savings estimates based on assumed loads for new construction projects, which by definition have no baseline data to inform the assumed loads, can be significantly erroneous. For projects in which such loads can be expected to vary slowly over time, taking measurements of such loads during the final site inspection could be used to adjust estimated savings. This type of process could have helped improve the savings realization rate for NGRID Site 43 (university upgraded UPS).

Verify proposed item count assumptions as part of the final inspection. Savings estimates based on an assumed number of installed energy-conserving items will be affected by the actual installed number of those items. Verification of these counts during the final site inspection would allow for adjustments to savings values. NGRID Site 44 (university central computer control) saw significant savings decreases, partially due to reduced quantities found versus the proposed estimates.

Verify plant operating hours using whole building interval data. The assumed operating hours for NGRID Sites 33 and 61(industrial VSDs) could have been improved through the use of whole building interval data. It was found that operating hours were less than predicted, and a review of whole building interval data helped to corroborate these findings. It is recommended that the TAs consider using whole building interval data in their development of project tracking savings for projects that are 10% or more of whole building energy use.

Ensure consistent use of data throughout the calculations. NGRID Site 61 (industrial VSD) used spot metering of the pre-existing case to determine the percent energy savings, but did not use the same data set to determine the pre-existing case demand. This presented a discrepancy of the data used to develop tracking demand savings. It is recommended that TA vendors utilize the same methodology and/or data when developing energy and demand savings to avoid these types of discrepancies. There doesn't appear to be much consistency across TAs within the state, which may be improved through PAs providing feedback to the TAs.

5.4.4 NSTAR

Provide sufficient documentation for understanding the determination of measure savings. We recommend project documentation be reviewed to ensure savings estimates within the documentation reflect the tracking savings. If tracking savings have been adjusted after the analysis documentation was complete, additional documentation should be included to indicate how the final tracking savings were

determined. At least one site, NSTAR Site 21 (retail refrigeration), did not have the documentation associated with the final tracking savings. This piece of information is very important for evaluation.

A. Site Report