Impact Evaluation of 2014 Custom HVAC Installations

National Grid

Report No.: Draft Report
Date: Aug 30th, 2017

Table of contents

1 EXECUTIVE SUMMARY

This document summarizes the work performed by the DNV GL team, between 2016 and 2017 to quantify the actual energy and demand savings due to the installation of 88 custom heating, ventilation and air-conditioning (HVAC) measures installed through National Grid's 2012 (MA) and 2014 (RI) C&I New Construction and Major Renovation and C&I Large Retrofit programs.

This is the second evaluation of the large C&I custom HVAC programs for RI National Grid since 2011. The scope of work of this impact evaluation covered the 2014 custom HVAC end use, which includes high efficiency HVAC equipment, HVAC controls as part of Energy Management Systems (EMS), operations and maintenance (O&M) and retro-commissioning of HVAC measures, and building shell improvements that impact HVAC loads. This impact evaluation includes only measures which primarily reduce electricity consumption.

1.1 Methods

This evaluation of 2012, 2014 custom HVAC installations used an approach like those of previous evaluations. The primary objective of determining realization rates at the state (RI and MA National Grid territory) and overall end-use level was accomplished by conducting on-site M&V at a statistically selected sample of 57 participant sites from the 2012 (MA) and 31 participant sites from the 2014 (RI) program years. This impact study consists of the following five tasks:

1. Develop sample design.
2. Develop site measurement and evaluation plans.
3. On-site data gathering and site analysis.
4. Site report writing and follow-up.
5. Expansion analysis and evaluation report.

1.2 Sampling Strategy

The goal of the sample design was to monitor enough sites to produce aggregated realization rates for National Grid with reasonable precision. National Grid agreed that the target is 10% precision at the 90% confidence level for energy savings at a combined RI (state-wide) and MA (National Grid territory only) level. The sample design employed was a stratified ratio estimate approach, which is particularly efficient for programs with a wide variation in site-to-site savings and where a good predictor of site savings exists (the tracking savings).

1.3 Findings and Results

The site level evaluation results were aggregated using the final adjusted case weights. The realization rates were estimated and then applied to total tracking savings to determine their total measured savings. The state-level realization rate is the ratio of the total measured savings to the total tracking savings, each of which is calculated by summing across MA and RI. Table 1-1 summarizes the overall results of this analysis. The table shows the results for five of the six measures of savings.

The overall (MA+RI) realization rate for custom HVAC measures was found to be 78%. The relative precision for this estimate was found to be ±7.6% at the 90% level of confidence. The error ratio was found to be 0.37 and better than the estimate of 0.60 used in the sample design for this study. For the on-peak summer kW, the overall realization rate was 69%, with a relative precision of ±14.6% at an 80% confidence level. For on-peak winter kW, the realization rate was a bit lower, at 70% with a relative precision of ±14.7% at an 80% confidence level.

Table 1-1: 2012 (MA) + 2014 (RI) Custom HVAC Results

Level	Parameter	Annual Energy kWh (90% Confidence)	Summer On-Peak kW (80% confidence)	Winter On-Peak kW (80% confidence)	% On-peak (90% confidence)
Overall (MA-National Grid only+RI)	Tracking Savings	20,423,268	2,402	1,898	N/A
	Evaluated Savings	15,861,588	1,663	1,326	N/A
	Realization Ratio	78%	69%	70%	97%
	Relative precision	7.6%	14.6%	14.7%	13.5%
	Error ratio	0.37	1.05	0.88	0.84

The results of DNV GL's analysis of realization rates by states follow in Table 1-2. All relative precisions for kWh savings realization rates and %On-peak values were calculated at the 90% confidence interval, while all relative precisions for kW savings realization rates were calculated at the 80% confidence interval.

Table 1-2: 2012 Custom HVAC Results by State

Level	Parameter	Annual Energy kWh (90% Confidence)	Summer On-Peak kW (80% confidence)	Winter On-Peak kW (80% confidence)	% On-peak (90% confidence)
MA (National Grid only)	Tracking Savings	17,372,884	1,823	1,736	N/A
	Evaluated Savings	13,087,095	1,274	1,167	N/A
	Realization Ratio	75%	70%	67%	105%
	Relative precision	8.8%	18.7%	16.7%	18.9%
	Error ratio	0.40	1.26	0.95	1.05
RI Statewide	Tracking Savings	3,050,384	579	162	N/A
	Evaluated Savings	2,774,494	389	159	N/A
	Realization Ratio	91%	67%	98%	84%
	Relative precision	12.6%	11.7%	9.6%	7.9%
	Error ratio	0.24	0.34	0.35	0.35

1.4 Recommendations

1.4.1 Program Improvement Recommendations

More Refined Savings Assumptions

The accuracy of the tracking savings calculations will improve with more refined assumptions. For example, one project calculated savings from a reduction in hours of use of exhaust fans in a hospital. The tracking analysis assumed almost all values for the exhaust fans were equal, other than the motor horsepower. This significantly altered the savings rate for each exhaust fan. The evaluation recommends that the program request a more refined analysis that incorporates the inherent differences of varying motor sizes and motor use cases.

Improve Baseline or Pre-Retrofit Documentation

For any future retrofit projects, DNV GL recommends National Grid to record ample pre-retrofit data. Several sites did not clearly document the pre-retrofit equipment operation or the basis for the base case in their project applications. For example, some technologies that use controls to change operations, such as ventilation control measures, economizers and others, are very common and the supporting documentation and baseline assumptions provided for HVAC control measures, were not as comprehensive as with other technologies. It is recommended that National Grid collect and document information on the actual HVAC system operations such as damper positions, outside air ventilation levels, etc. for existing equipment undergoing controls improvements.

Conduct Pre-Installation Metering for More Retrofit Projects

Short term pre-installation metering could be used to confirm assumptions about pre-existing equipment for some retrofit projects, particularly control type projects. The evaluator may not be able to simulate pre-retrofit operating conditions; therefore, metering done by the implementation vendor prior to installation could improve confidence in the pre-retrofit assumptions.

Improve use of Post Inspection to Verify Measure Operation

On few occasions, evaluators identified sites in which the controls or equipment installed were not operational. Post inspections are generally occurring on all custom projects, but the effectiveness of the post inspection could be improved by observing and documenting operating conditions at the time of the inspection rather than only verifying if the measure was installed. It is recommended that National Grid continue to use more rigorous post-installation inspections to further build on the efforts made in this area.

Use of prescriptive calculation methodology should be reduced

DNV GL recommends National Grid reduce the use of prescriptive demand values for custom measures especially when the measure involves pump or fan motors. For example, prescriptive deemed savings value (TRM) for a VSD retrofit on a pump motor (kWh/hp) may not produce accurate savings estimates in a custom project; the pre- and post- conditions could vary significantly therefore, deviating from the TRM savings estimate.

Require Trend Data Acquisition

Stipulate in customer participation agreements that for sites receiving controls measures, either customer staff are to be trained or the controls contractor will be required to assist with subsequent EMS trending in the event customer is chosen as an evaluation site. It would be helpful to include in the contract specifically which trends should be made available to National Grid and evaluators for evaluation. The engineers developing the project scopes could specify the required trends. Consider the feasibility of configuring controls systems to allow remote access by evaluators to allow for data downloads.

2 INTRODUCTION

2.1 Study Objectives

The objective of this Impact Study is to verify and re-estimate energy (kWh) savings for selected custom HVAC projects through site specific inspections, end use monitoring and analysis. The site-specific results will be aggregated to determine realization rates separately for National Grid's custom HVAC program in RI, and review the impact on overall results of adding RI custom HVAC program evaluation results to the Massachusetts (MA) sample (National Grid territory) which was evaluated in 2015. The evaluation sample for this study was designed in consideration of the 90% confidence level for energy (kWh) savings.

2.2 Background

In 2011 National Grid completed a similar type of impact study comprised of various Custom HVAC Installations for program year 2010. Like the 2011 study this impact evaluation will serve many purposes including independent estimation of program and measure impacts and provide recommendations to improve programs and projects.

2.3 Scope

The scope of work of this impact evaluation covered the 2012 (MA) and 2014 (RI) custom HVAC end use, which includes high efficiency HVAC equipment, HVAC controls as part of Energy Management Systems (EMS), operations and maintenance (O&M) and retro-commissioning of HVAC measures, and building shell improvements that impact HVAC loads. This impact evaluation includes only measures which primarily reduce electricity consumption.

This impact study consists of the following five tasks:

1. Develop sample design.
2. Develop site measurement and evaluation plans.
3. On-site data gathering and site analysis.
4. Site report writing and follow-up.
5. Expansion analysis and evaluation report.

2.4 Methods

2.4.1 Description of Sample Design

The primary focus of the sample design was to examine various precision scenarios for the custom HVAC measures in Massachusetts (National Grid territory) and Rhode Island. The study population of 88 Custom HVAC projects from the 2012 and 2014 program years is summarized in Table 2-1.

Table 2-1: Population of 2012/14 Custom HVAC Projects

State	Projects	Total Savings	Average Savings	Minimum	Maximum	Standard Deviation	CV
Massachusetts	57	17,372,884	304,787	629	2,288,693	472,612	1.55
Rhode Island	31	3,050,384	98,399	1,647	694,220	148,048	1.50
Total	**88**	**20,423,268**					

The goal of the study was to design a sample that will allow DNV GL to estimate realization rates for several measurements (annual kWh, percent of kWh savings on-peak, summer on-peak and seasonal kW, and winter on-peak and seasonal kW) with a relative precision of ±10% at the statewide level. The target for annual kWh was set at the traditional ±10% at 90% confidence, while the target for summer kW was set at ±10% precision at 80% confidence during the design. The summer kW target is based on the ISO-NE overall portfolio precision requirements, but need not be achieved in each individual study because the FCM precision may be calculated for each PA's overall portfolio of demand resources. Both energy and summer demand savings sample design considerations are assessed in the following sections.

All the sample design results for annual kWh were calculated at the 90% confidence level, while results for summer kW were calculated at the 80% confidence level.

2.4.1.1 Annual kWh Sample Design

For sampling purpose, both RI and MA HVAC population data were combined and then a Stratified Ratio Estimation approach was used to develop a sample design that expected to meet an overall relative precision of ±10% at the 90% confidence as shown in Table 2-3. The RI sample design includes a total of 6 sample points compared to 23 sample points in MA evaluation. The details of sample design considerations and constraints, and confidence and targeted relative precision are discussed in the Sample Design Memo that was submitted to National Grid July 30th, 2015.

Table 2-2 shows the stratum cut points and distribution of sample sites for the selected sample design.

Table 2-2: Sample Design Selected with Stratum Cut Points

State	Stratum	Maximum Total Gross Savings (kWh)	Projects	Total Gross Savings (kWh)	Planned Sample Size
MA	1	163,931	34	2,419,819	6
MA	2	360,197	11	3,036,824	6
MA	3	795,362	7	3,919,023	6
MA	4	2,288,693	5	7,997,218	5
RI	1	67,945	20	569,277	2
RI	2	138,880	6	700,290	2
RI	3	501,356	4	1,086,597	1
RI	4	694,220	1	694,220	1

Table 2-3 lists the calculated precision estimates for this scenario, following stratification. A precision of ±10% was estimated for the overall results at the 90% confidence level.

Table 2-3: Estimated kWh Precision for Selected Sample Design

State	Population (N)	Sample Sites (n)	Expected Relative Precision @ 90% Confidence	Program Savings (kWh)
Massachusetts	57	23	10%	85%
Rhode Island	31	6	38%	15%
Total	88	29	10%	100%

2.4.2 Description of Methodology

This section describes the methodology generally for both the development of site evaluation plans, the execution of the plans, and the final process for producing program results.

2.4.2.1 Measurement and Evaluation Plans

Following the final sample selection of custom HVAC applications and prior to beginning any site visits, the DNV GL team developed detailed measurement and evaluation plans for each of the 29 projects. The plans outlined: on-site methods and strategies; monitoring equipment selection, placement, calibration; and analysis issues. National Grid provided comments and edits to clarify and improve the plans prior to the plans being finalized.

Evaluators utilized the savings analysis methodologies from the Technical Assistance Study (TA) whenever possible. However, in a small number of cases, the TA methodology was unavailable or found to be incorrect or inappropriate.

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, diversified summer peak demand, and diversified winter peak demand savings associated with each project.

2.4.2.2 On-Site Data Gathering, Analysis and Reporting

Data collection included physical inspection and inventory, interview with facility personnel, observation of site operating conditions and equipment, short-term metering of usage and EMS trends. At each site, the DNV GL team performed a facility walk-through that focused on verifying the post-retrofit or 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) lighting loggers, TOU current loggers, and temperature loggers were installed to monitor the usage of the installed HVAC equipment and conditions of the associated affected spaces. EMS trends were also collected, when available.

Savings analyses were used to estimate hourly energy use and diversified coincident peak demand. A typical meteorological year (TMY3) dataset of ambient temperatures from Chicopee Falls, MA and Providence, RI were used for all temperature sensitive calculations. Evaluators have been using one weather station for custom electric impact studies so that evaluated savings generated from 8,760 hourly TMY3 datasets may be additive across all sites. The ability to add peak savings values across sites using different TMY3 datasets is problematic due to the differences in how each individual TMY3 dataset is created. Each site report details the specific analysis methods used specific for each project including algorithms, assumptions and calibration methods where applicable. One site in RI was analyzed using building simulation models, including eQuest.

Engineers submitted draft site reports to National Grid upon completion of each site evaluation, which after review and comment resulted in the final reports found in Appendix B. This report provides a concise overview of the evaluation methods and findings.

2.4.2.3 Analysis Procedures

To aggregate the individual site results from the custom HVAC sample, DNV GL applied the model-assisted stratified ratio estimation methodology described in References [1] and [2] in Appendix A. 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 at the statewide level, as well as overall National Grid territory in both states combined. The sample realization rate is the ratio between the weighted sum of the evaluated savings for the sample projects divided by the weighted sum of the tracking estimates of savings for the same projects. The total tracking savings in the population is multiplied by the sample realization rate to estimate the total evaluated savings in the population. The statistical precisions and error ratios are calculated for each level of aggregation.

The results presented in the following section include realization rates (and associated precision levels) for annual kWh savings, on-peak kWh savings, and on-peak 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.

3 RESULTS

The sample was post-stratified based on the final disposition of sample points. Case weights were recalculated based on this final sample and are shown in Table 3-1. The weights reflect the number of projects that each of the sample points represents in their respective populations and allow for the aggregation of results across the strata and PAs.

Table 3-1: Final 2012 Custom HVAC Case Weights

State	Stratum	Maximum Total Gross Savings (kWh)	Projects	Total Gross Savings (kWh)	Projects in Sample	Case Weights
MA	1	291,398	37	4,077,167	9	4.11
MA	2	394,967	11	1,379,476	6	1.83
MA	3	924,382	6	4,834,931	5	1.20
MA	4	1,802,999	3	7,081,310	3	1.00
RI	1	53,398	22	384,175	3	7.33
RI	2	644,500	6	1,967,752	1	6.00
RI	3	752,987	3	1,342,098	2	1.50

3.1 Site Level Results

Figure 3-1 presents a scatter plot of weighted evaluated annual kWh savings plotted against the National Grid tracking savings. The dashed line represents a realization rate of 100%. The slope of the solid line in this graph is an indication of the statewide realization rate and how it relates to a realization rate of 100%. This sample data is scattered widely around the trend line, which is indicative of the variation in savings between the tracking estimates and evaluated savings.

Figure 3-1: Evaluated Savings vs. Tracking Savings (Weighted)

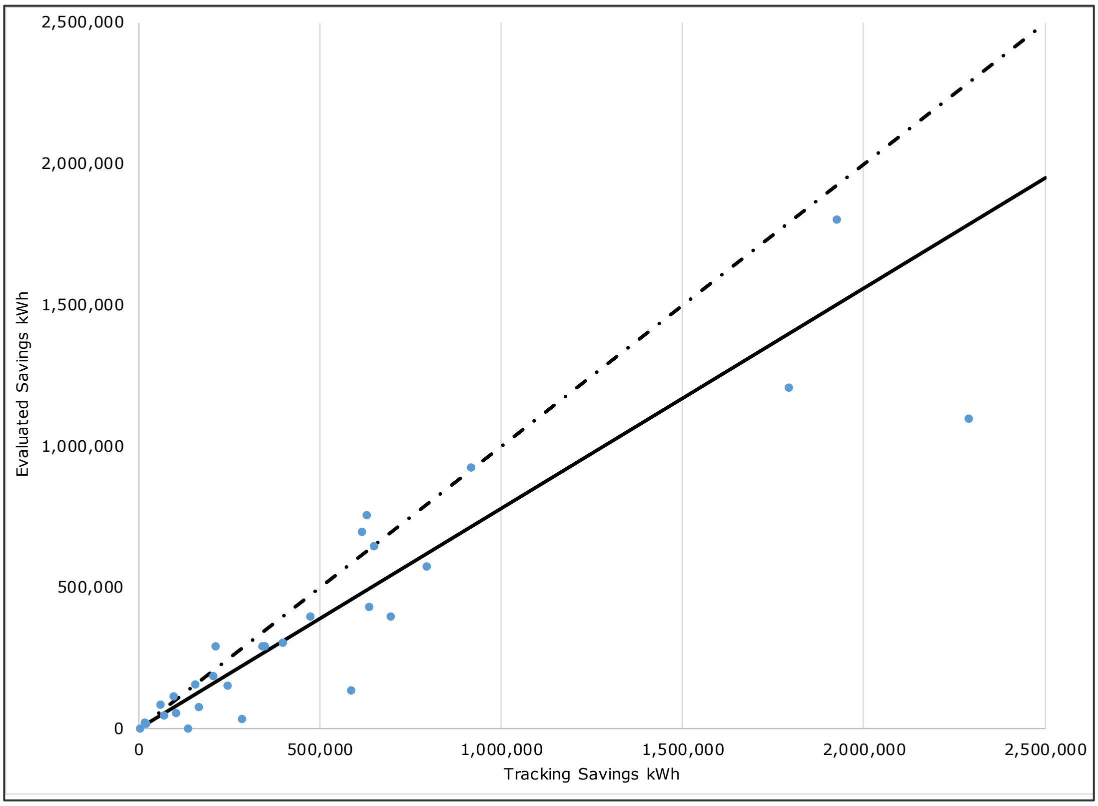

Table 3-2 presents a summary of the site level results for this impact evaluation.

Table 3-2: Detailed Site Results[1]

DNV GL Site ID	State	Application ID	Tracking Estimated Savings				Evaluation Savings			
			Annual Savings kWh/yr	On-Peak %	On-Peak demand Summer kW	On-Peak demand Winter kW	Annual Savings kWh/yr	On-Peak %	On-Peak demand Summer kW	On-Peak demand Winter kW
08	RI	2994828	16,205	50%	2.75	2.75	18,223	33%	0.68	2.97
09	RI	3544317	18,513	46%	4.20	1.00	17,688	46%	5.90	0.00
21	RI	3822272	100,820	57%	27.00	2.00	53,398	48%	22.04	0.00
25	RI	3575544	647,878	50%	124.09	57.40	644,500	43%	74.61	55.79
30	RI	2845921	626,695	72%	54.13	40.80	752,987	46%	80.40	76.35
31	RI	3786298	694,220	50%	129.29	65.00	393,660	58%	48.95	41.20

Table 3-3 summarizes the energy savings realization rates and primary reasons for discrepancies between the tracking and evaluation estimates of annual energy savings. The site energy savings realization rates ranged from a low of 0% for Site 8 to a high of 146% for Site 2 in MA and a low of 53% for site 21 to a high of 120% for site 30 in RI.

Table 3-3: Primary Site Discrepancies (RI Only)

DNV GL Site ID	State	Application ID	kWh RR	Primary Reasons for Discrepancies
08	RI	2994828	112%	This measure, exhaust fan savings, resulted from reduced exhaust fan operating hours when compared to the baseline's continuous 24/7 fan operations. The exhaust fans range in use cases such as for kitchen hoods, dish washers, and air handling units.
09	RI	3544317	96%	Savings for this project were expected to result from use of drier return air which improved the overall RTU's system efficiency. The annual estimated electric savings is 18,513 kWh. This includes interactive effects assumed to occur in the building.
21	RI	3822272	53%	The cooling loads in the facility are significantly different from tracking assumptions and are the primary reason for the savings reduction. The decrease in summer demand savings is also

[1] MA sampled sites' findings can be found in the MA report in the MA EEAC website (@2012 MA Custom HVAC Impact Evaluation)

DNV GL Site ID	State	Application ID	kWh RR	Primary Reasons for Discrepancies
				attributed to the change in cooling loads during the summer peak period.
25	RI	3575544	99%	Overall the measures are operating and working as per the designed criteria. There is some decrease in the cooling savings due to the revised AHU schedule in the post-retrofit condition of ECM2. The operational hours have increased by approximately 72% compared to the tracking analysis assumption of 3,393 hours. There was a discrepancy in ECM2 because the air handler savings in the evaluation calculation used metered data and the load of the AHUs varied in comparison to the tracking calculation. But the supply fan air flow in the tracking calculation was based on an estimate. Discrepancy in ECM3 was also due to the use of metered data vs some estimated hours and VFD speed. For ECM6, evaluation assumed that other VAV boxes that supply air are compensating by supplying less air.
30	RI	2845921	120%	Most of the tracking savings were calculated using prescriptive deemed savings values [kWh/HP; RI EE TRM])
31	RI	3786298	57%	The primary reason for the savings variance is the annual operating hours assigned to AHU operation. The tracking analysis assumed the AHUs operating hours as 8,760 both in the pre- and proposed conditions whereas the evaluation found the AHUs to be operating 4,654 a year which is 53.1% of full 8,760 annual operation. A data entry error was also made when the savings were entered the tracking savings database. The savings linked to the condenser water pumps were 9,277 kWh less than what was calculated in the TA report. Savings for all other measures were the same in the tracking database and the TA report. The total annual savings in the TA report is 703,497 kWh.

3.2 Realization Rates

The site level evaluation results were aggregated using the final adjusted case weights. 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 state. Table 3-4 summarizes the overall and state-level results of this analysis. The table shows the results for four measures of savings.

The statewide realization rate for custom HVAC measures was found to be 78%. The relative precision for this estimate was found to be ±7.6% at the 90% level of confidence. The error ratio was found to be 0.37, which is better than 0.48 found in the prior study, and better than the estimate of 0.6 used in the sample design for this study. For the on-peak summer kW, the overall realization rate was 69%, with a relative precision of ±14.6% at an 80% confidence level. For on-peak winter kW, the realization rate was at 70%.

Table 3-4: 2012 (MA)+ 2014 (RI) Custom HVAC Overall Results

Level	Parameter	Annual Energy kWh (90% Confidence)	Summer On-Peak kW (80% confidence)	Winter On-Peak kW (80% confidence)	% On-peak (90% confidence)
Overall (MA-National Grid only+ RI statewide)	Tracking Savings	20,423,268	2,402	1,898	N/A
	Evaluated Savings	15,861,588	1,663	1,326	N/A
	Realization Ratio	78%	69%	70%	97%
	Relative precision	7.6%	14.6%	14.7%	13.5%
	Error ratio	0.37	1.05	0.88	0.84

The results of DNV GL's analysis of realization rates at state-level follow in Table 3-5. All relative precisions for kWh savings realization rates were calculated at the 90% confidence interval, while all relative precisions for kW savings realization rates were calculated at the 80% confidence interval.

Table 3-5: 2012 Custom HVAC Results by PA

Level	Parameter	Annual Energy kWh (90% Confidence)	Summer On-Peak kW (80% confidence)	Winter On-Peak kW (80% confidence)	% On-peak (90% confidence)
MA (National Grid only)	Tracking Savings	17,372,884	1,823	1,736	N/A
	Evaluated Savings	13,087,095	1,274	1,167	N/A
	Realization Ratio	75%	70%	67%	105%

	Relative precision	8.8%	18.7%	16.7%	18.9%
	Error ratio	0.40	1.26	0.95	1.05
RI Statewide	Tracking Savings	3,050,384	579	162	N/A
	Evaluated Savings	2,774,494	389	159	N/A
	Realization Ratio	91%	67%	98%	84%
	Relative precision	12.6%	11.7%	9.6%	7.9%
	Error ratio	0.24	0.34	0.35	0.35

3.3 Sites with Largest Influence

DNV GL reviewed all sites to determine those that had the largest influence on the results based on a combination of site savings and sample weight.

Table 3-6 presents a list of the ten MA and two RI sites that had the largest influence on their overall realization rate in order of their impact after weighting. National Grid had one site with zero savings due to the measure not operating (free cooling). One site resulted in fewer saving due to interactivity with other equipment that was not captured by the TA study. One site lost savings from not implementing the occupancy on/off control measure on all units that were proposed. The remaining sites differed mostly for operational reasons.

Table 3-6: National Grid Largest Influencers (RI Only)

Application ID	State	Measure Type	Tracking kWh/yr	Evaluated kWh/yr	Influence	Primary Reason
3822272	RI	VSD and Controls	100,820	53,398	Negative	Overestimated cooling loads
2845921	RI	Drives and pump upgrades	626695	752987	Positive	Tracking used prescriptive deemed savings value for pump savings for a custom project

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Realization Rates

The overall energy realization rate precision was ±7.6%. The energy realization rate precision levels for MA and RI were ±8.8% and ±12.6%, respectively. The sample was designed to target 10% precision at the 90% confidence level for a combined National Grid territory in MA and RI states.

4.2 Program Improvement and Evaluation Recommendations

More Refined Savings Assumptions

The accuracy of the tracking savings calculations will improve with more refined assumptions. For example, one project calculated savings from a reduction in hours of use of exhaust fans in a hospital. The tracking analysis assumed almost all values for the exhaust fans were equal, other than the motor horsepower. This significantly altered the savings rate for each exhaust fan. The evaluation recommends that the program request a more refined analysis that incorporates the inherent differences of varying motor sizes and motor use cases. In RI, sites with these issues include:

- 2994828
- 3786298

Improve Baseline or Pre-Retrofit Documentation

For any future retrofit projects, DNV GL recommends National Grid to record ample pre-retrofit data. Several sites did not clearly document the pre-retrofit equipment operation or the basis for the base case in their project applications. For example, some technologies that use controls to change operations, such as ventilation control measures, economizers and others, are very common and the supporting documentation and baseline assumptions provided for HVAC control measures, were not as comprehensive as with other technologies. It is recommended that National Grid collect and document information on the actual HVAC system operations such as damper positions, outside air ventilation levels, etc. for existing equipment undergoing controls improvements. In RI, sites with these issues include:

- 2845921
- 3575544

Encourage More Comprehensive Commissioning and Updating of Tracking Estimates with Findings from Commissioning

Commissioning is a useful tool to help improve savings estimates for HVAC controls projects. While National Grid currently use commissioning in some capacity, there are areas where this tool can be improved. This will result in reducing any over-estimation pre-retrofit conditions more so than post-installation operation.

Conduct Pre-Installation Metering for More Retrofit Projects

Short term pre-installation metering could be used to confirm assumptions about pre-existing equipment for some retrofit projects, particularly control type projects. The evaluator may not be able to simulate pre-retrofit operating conditions; therefore, metering done by the implementation vendor prior to installation could improve confidence in the pre-retrofit assumptions. In RI, sites with these issues include:

- 2845921
- 3575544

Improve use of Post Inspection to Verify Measure Operation

On few occasions, evaluators identified sites in which the controls or equipment installed were not operational. Post inspections are generally occurring on all custom projects, but the effectiveness of the post inspection could be improved by observing and documenting operating conditions at the time of the inspection rather than only verifying if the measure was installed. It is recommended that National Grid continue to use more rigorous post-installation inspections to further build on the efforts made in this area. In RI, sites with these issues include:

- 3575544
- 3544317
- 3786298

Use of prescriptive calculation methodology should be reduced

DNV GL recommends National Grid reduce the use of prescriptive demand values for custom measures especially when the measure involves pump or fan motors. For example, prescriptive deemed savings value (TRM) for a VSD retrofit on a pump motor (kWh/hp) may not produce accurate savings estimates in a custom project; the pre- and post- conditions could vary significantly therefore, deviating from the TRM savings estimate. In RI, site with these issues include:

- 2845921

Require Trend Data Acquisition

Stipulate in customer participation agreements that for sites receiving controls measures, either customer staff are to be trained or the controls contractor will be required to assist with subsequent EMS trending in the event customer is chosen as an evaluation site. It would be helpful to include in the contract specifically which trends should be made available to National Grid and evaluators for evaluation. The engineers developing the project scopes could specify the required trends. Consider the feasibility of configuring controls systems to allow remote access by evaluators to allow for data downloads.

APPENDIX A: REFERENCES

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

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

APPENDIX B: SITE REPORTS