Impact Evaluation of 2014 Custom Gas Installations in Rhode Island

National Grid

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1 EXECUTIVE SUMMARY

This report presents the results of DNV GL's Impact evaluation for National Grid's 2014 Custom Gas installations' in Rhode Island (RI). These results serve many purposes including independent estimation of program and measure gross savings, and provide findings and recommendations to improve programs and projects and measure effectiveness.

1.1 Evaluation Background

This study presents final realization rates for custom gas energy efficiency measures installed in 2014. The site specific results were aggregated to determine realization rates separately for National Grid's custom gas program in RI and MA combined. This evaluation's results were added to a previously completed Massachusetts (MA) sample (National Grid territory) to determine the overall impact of the program. And the combined sample for the study was designed in consideration of the 80% confidence level for energy (therms) with ±20% precision.

1.2 Evaluation Objectives

The objective of this Impact Evaluation of 2014 Custom Gas Installations is to provide verification or re-estimation of energy (Therms) savings for selected Custom Gas 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 gas program in RI, and review the impact on overall results of adding RI gas program evaluation results to a previously evaluated Massachusetts (MA) sample (National Grid territory).

1.3 Overview of Approach

DNV GL conducted the following steps in order to achieve the research goals and objectives and ensure that the National Grid's goals are met.

- Reviewed the 2014 RI custom gas population data;
- Designed an efficient sampling plan to select representative custom gas projects for on-site visits to achieve the expected statistical precision targets.
- Developed a project work plan outlining the sample design, scope of work, timeline, and budget for this evaluation;
- Reviewed the engineering formulas, calculations, and factors used in the development of the tracking savings for each sampled participant to develop site specific M&V plans;
- Performed an internal quality control review and submitted for review/approval of M&V plans by National Grid
- Performed comprehensive data collection at each sample site to support an independent analysis of achieved gross energy savings (therms)
- Produced site specific final site reports detailing the findings and results from each sample site, including a discussion of the reasons that evaluation results differ from the tracking estimate
- Extrapolate the final evaluated impact for the sample to the remaining population as reported in the program tracking system; and finally

- Produce a comprehensive report describing the program/project results, presenting final sample design and gross analysis methodology and providing findings and recommendations to improve the program and projects

1.4 Sample Design

1.4.1 Population Review

DNV GL utilized the data received as part of our most recent customer profile analysis to complete this review.

In order to be consistent with Massachusetts 2013 custom gas impact evaluation[1], sites with savings less than 1,000 therms per year were eliminated from the population. This was done to make good use of evaluation resources by focusing on sites that are most likely to be custom installations with significant savings (therms). A comparison of the custom gas projects' population data for both states is presented in Table 1 below.

Table 1: Population of 2013 (MA) and 2014 (RI) Custom Gas Projects

State	Projects	Total Savings (Annual Therms)	Average Savings	Minimum	Maximum	Standard Deviation	CV
Massachusetts	111	1,872,148	16,866	1,099	201,117	31,325	1.86
Rhode Island	83	2,228,376	26,848	1,026	376,622	58,767	2.19
Total	**194**	**4,100,524**					

The goal of the sample design was to monitor enough sites to produce aggregated realization rates by state with reasonable precision. An error ratio of 0.69 was assumed based on the results of the MA evaluation[1] and targeted an overall 80% confidence and 20% relative precision.

1.4.2 Sampling Size

For sampling purpose first both RI and MA gas population data were combined and then a stratified ratio estimation approach was used to develop a sample that was expected to meet an overall relative precision of ±20% at the 80% confidence as shown in Table 2. The RI sample design included a total of 7 sample points compared to 14 sample points in MA evaluation.

Table 2: Project Sample

State	Population	Sample Sites	Expected Relative Precision @ 80% Confidence	Final Sample
Massachusetts	111	15	19%	14[2]
Rhode Island	83	7	34%	7
Total	**194**	**22**	**20%**	**21**

[1] MA Impact Evaluation of PY2013 Custom Gas Installations
[2] One site from MA sample was dropped after the site-visit as it was not commissioned

1.5 Findings and Results

In preparation for analysis, the original 2013 population stratum boundaries for MA and 2014 RI population were used to calculate case weights for each final sample observation. The site-level evaluation results were aggregated by state using these weights. The results are summarized in Table 3. DNV GL determined the overall (MA+RI) custom gas realization rate to be 89% with 80% confidence at ±7.7% precision.

Table 3: Statewide Summary Results

State	Total Tracking Savings (Therms)	Total Measured Savings (Therms)	Realization Rate	Relative Precision at 80% Confidence	Error Ratio
MA	1,872,148	1,471,779	78.6%	17.5%	0.68
RI	2,228,376	2,177,141	97.7%	5.3%	0.14
Overall	**4,100,524**	**3,648,920**	**89.0%**	**7.7%**	**0.36**

1.6 Conclusion and Recommendations

The Custom Gas program continues to provide energy savings for National Grid in MA and RI. Below are the major findings and recommendations.

The impact evaluation of 2013 – 2014 Custom Gas installations in MA and RI produced results that are reliable (±7.7%) at 80% confidence. The realization rate was found to be 89.9%. This is an improvement over the results from the previous impact evaluation of 2010 Custom Gas installations which produced a National Grid RI realization rate of 75.5% with a relative precision of ±8.7% at 80% confidence.

Based on results of this year's evaluation, it was found that National Grid had made improvements to estimating savings as compared to the previous year's evaluation. In particular:

The evaluation results from this year and from previous years indicate National Grid did a good job insuring equipment is installed as planned.

Most of the projects' documentation included working analysis spreadsheets in original form.

Savings estimates were found to be better supported with back-up information, combustion measurements, and other site specific data.

1.6.1 Recommendations

The evaluation team reviewed project files, conducted detailed analysis of the information provided in the files, and quantified discrepancies to make the following recommendations.

- DNV GL recommends National Grid to increase the duration of pre-metering from 1 or 2 days to at least 1 week (Monday thru Sunday) to capture the weekly operating profile. Including holidays/weekends in the metering period would give a better estimate of the weekly usage.
- When using a proxy machine to estimate savings, check if the proxy is actually representing the installed measure. For example: To calculate the amount of DHW used in a university dormitory/residence hall the TA study used a proxy residence hall that has different number of students which alters the savings estimate.

- Project documentation should provide more details on the assumptions used for estimating savings. For one of the sampled sites, the R-values of building envelope components have been adjusted to account for infiltration; this assumption was not clearly mentioned in TA report but was learnt via reverse engineering the savings calculations.
- National Grid should enhance the post installation visit/commissioning by recording measure related operating parameters like on-site temperature set-points, occupancies and other schedules. These parameters that are used in the savings calculations when updated affect the savings estimate significantly.

2 INTRODUCTION

This report presents the results of DNV GL's Impact Evaluation of 2013 (MA) and 2014 (RI) custom gas installations for National Grid.

2.1 Evaluation Background

This study presents final realization rates for custom gas energy efficiency measures installed in 2014. The site specific results were aggregated to determine realization rates separately for National Grid's custom gas program in RI and MA combined. This evaluation's results were added to a previously completed Massachusetts (MA) sample (National Grid territory) to determine the overall impact of the program. And the combined sample for the study was designed in consideration of the 80% confidence level for energy (therms) with ±20% precision.

2.2 Evaluation Objectives

The objective of this Impact Evaluation of 2014 Custom Gas Installations is to provide verification or re-estimation of energy (Therms) savings for selected Custom Gas 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 gas program in RI, and review the impact on overall results of adding RI gas program evaluation results to a previously evaluated Massachusetts (MA) sample (National Grid territory).

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DNV GL conducted the following steps in order to achieve the research goals and objectives and ensure that the National Grid's goals are met.

- Reviewed the 2014 RI custom gas population data;
- Designed an efficient sampling plan to select representative custom gas projects for on-site visits to achieve the expected statistical precision targets.
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- Performed comprehensive data collection at each sample site to support an independent analysis of achieved gross energy savings (therms)
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3 ON-SITE M&V METHODS

This section describes the site methodology generally for both the development of site evaluation plans, the execution of the plans, and the final process for producing program results. And also, the site M&V plan plays an important role in establishing approved field methods and ensuring that the ultimate project objectives are met.

3.1 Measurement and Evaluation Plans

Following the final sample selection of Custom Gas applications and prior to beginning a site visit, the evaluators developed detailed measurement and evaluation plans applications. These plans outlined on-site methods, strategies, monitoring equipment placement, calibration, and analysis issues. National Grid provided comments and edits to clarify and improve the plans prior to them being finalized.

Evaluators utilized the savings analysis methodologies from the Technical Assistance study (TA) whenever possible. In few cases where TA study analysis methodology was found inappropriate or incorrect, 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.

3.2 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, and short-term metering. At each site, the evaluator performed a facility walk-through that focused on verifying the post-retrofit or installed conditions of the energy efficiency measure. Few facilities utilized EMS controls which were either part of the application itself or controlled equipment that was included in the application. At times, the EMS was utilized to log key parameters, or previously trended data was extracted from the system. Instrumentation such as current loggers, motor status, and temperature loggers were installed to monitor the usage of the installed HVAC equipment and associated affected spaces. At most sites, combustion efficiency measurements were taken of the heating equipment. Gas bills were acquired from National Grid.

Weather sensitive measures were assessed using historical weather data from periods matching the metering period or the gas billing. Savings estimates were normalized to a typical year using a typical

meteorological year (TMY3). Weather stations located closest to each facility were used for all weather-sensitive calculations.

Each site report details the analysis methods used specific to each project including algorithms, assumptions, and calibration methods where applicable. The actual analytical techniques employed depended upon the applicant's methods, the measure, and site conditions. The methods included:

Hourly temperature spreadsheet models - Condensing boiler, boiler, boiler controls, EMS, heat recovery, ventilation improvement, and water heater savings were estimated using an 8760 hour model. Historical hourly weather data for a twelve month post installation period forms the basis of the model, permitting an hourly calculation of thermal load and equipment efficiency. The temperature and runtime logged measurements are utilized to identify a relationship between operation and outdoor air temperature. Operating schedules are also incorporated into the model. Boiler efficiency is based on the measured efficiencies extrapolated across the firing range of the boiler. For condensing boilers, the latent efficiency component was typically modelled as a function of the return water temperature. The final model is usually calibrated to actual customer bills.

Bin temperature spreadsheet models - A bin temperature model is a simplified version of the hourly model. While the thermal load and efficiency calculations are similar, the weather is represented by the number hours of occurrence of an outdoor temperature by temperature bin (usually in five degree increments). The bin model was used in cases where the applicant had also used a bin model and for some of the simpler measures.

Billing analysis - A few sites that had installed measures such as: Steam traps, insulation, low flow fixtures, programmable thermostats, demand controlled ventilation, and energy monitoring systems, were evaluated using a two-sided billing analysis, where the savings was determined to the difference between the weather adjusted pre and post billing data. Billing analysis was used if the baseline conditions could not be confirmed and no other significant changes had occurred at the site. In some cases, a one-sided billing analysis was used, where the current facility load was determined from the post-installed weather normalized billing data. The pre and post-efficiency conditions were then applied to the determined gas usage to calculate the savings. For all forty-six sites, bills were reviewed to ensure the results were reasonable in light of the bills.

At almost all of the sites, customer billing usage was used to corroborate the savings. Engineers submitted draft site reports to National Grid upon completion of each site evaluation, which after review and comment resulted in the final reports.

3.3 Aggregate Analysis Procedures

In order to aggregate the individual site results from the Custom Gas sample, DNV applied the model-assisted stratified ratio estimation methodology. 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 program (MA and RI combined), as well as at state-level. The sample realization rate is the ratio between the weighted sums 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.

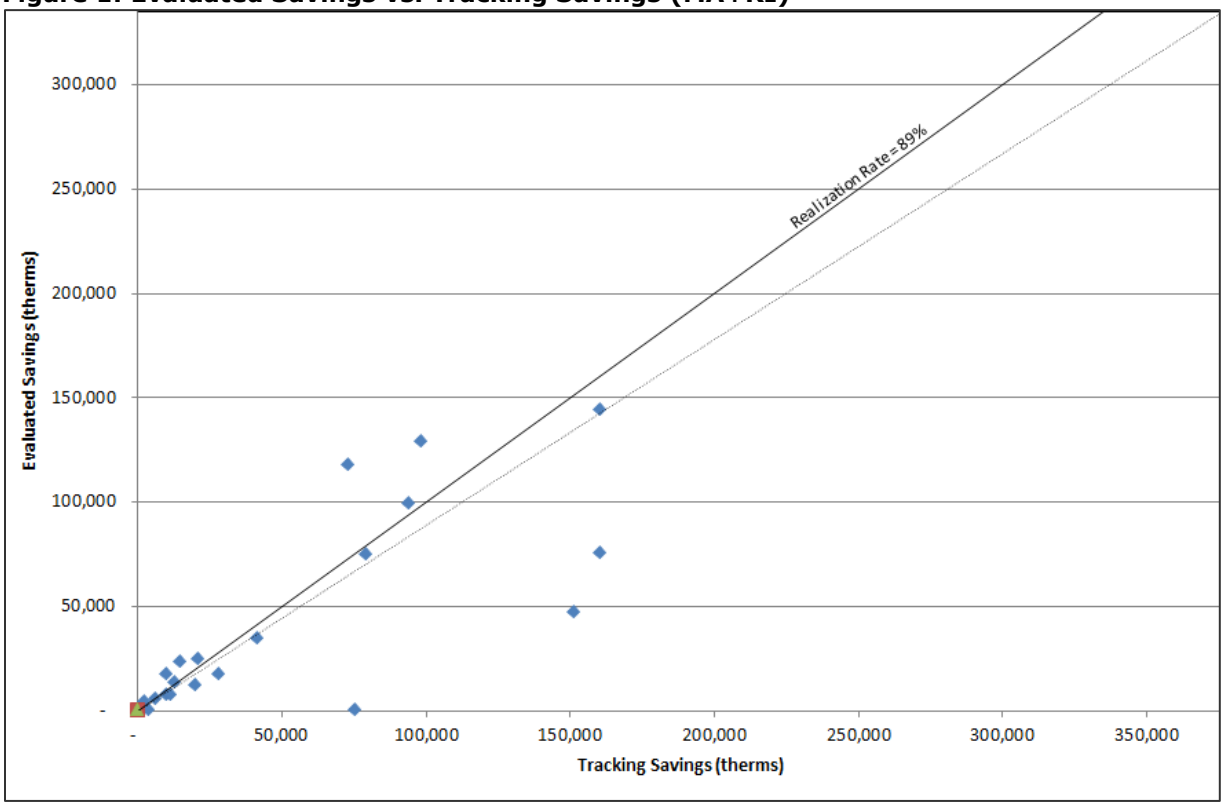
4 FINDINGS AND RESULTS

This section presents the on-site and population level results. The site level results include the level estimates of savings and a quantitative breakdown of the factors that caused the realization rates to deviate from 100%. The population level analysis includes a presentation of the final case weights and the resulting realization rates.

4.1 Site Level Results

Table 3 presents a scatter plot of weighted evaluated results for annual therm savings plotted against the National Grid tracking savings. The dashed line represents a realization rate of one. The slope of the solid line in this graph is an indication of the overall realization rate and how it relates to a realization rate of 100%.

Figure 1: Evaluated Savings vs. Tracking Savings (MA+RI)



A description of a few sites with a relatively low and high realization rates (RR) and their findings are summarized as follows:

- DNV 77 (131% RR) –This is a retrofit project at hazardous waste recycling facility. The primary differences between the TA assumptions and the site analysis are the differences in boiler operating temperatures and operating hours. The monitored steam temperature was 21% less than estimated, 22% decrease in condensate temperature but the operating hours have increased by almost 70% improving the realization rate to 131%.
- Site DNV 66 (60% RR) - the project installed an EMS system in a large warehouse with savings coming from the heating equipment controlled through a central EMS for occupied and unoccupied scheduling. The primary differences for savings between the tracking analysis and

the evaluation calculation come from a greater number of occupied hours and unoccupied temperatures being higher than the expected.

Note: MA sampled sites' findings can be found in the MA Report[1].

4.2 Discrepancy analysis

At the conclusion of each site analysis, the engineer catalogued and classified all the sources of discrepancies between the applicant and the evaluated state of the project and estimated the independent impact of each source. These are reconciled to the actual site realization rate and then aggregated to the program level. The results are useful for identifying the major sources of discrepancies in the program.

Table 4 presents a summary of this discrepancy analysis category for the 7 sampled sites in RI. Since parameters can be over or under-estimated, both negative and positive discrepancies are included in the figure. Majority of the discrepancies are due to operating schedules assumptions and in some cases, the gas usage both pre- and post-installation.

Table 4: Summary of Differences (RI Only)

RI Site ID	Difference in category	Impact of Differnce
DNV 40	Difference in boiler supply temperatures, equivalent full days of occupancy	-6%
DNV 54	Increase in equipment usage	8%
DNV 66	Difference in Occupancy schedules	-40%
DNV 75	Increase in operating hours	6%
DNV 77	Increase in Operating hours (70%), decrease in condensate temperatures(22%), decrease in steam temperatures (21%)	31%
DNV 80	Increase in boiler efficiency, boiler surface temperatures, deration factors, condensate tank temperatures	0.40%
DNV 83	Decrease in condensate recovery (27%), decrease in steam production (24%)	-10%

4.2.1 Better performing measures

The industrial sector generally outperformed the other sectors, with large savings measures and good realization rates. The regularity of production and pervasiveness of in-house equipment metering are an element of more reliable savings estimates. The biggest threat to savings is the identification of an incorrect baseline.

5 CONCLUSIONS AND RECOMMENDATIONS

National Grid should be pleased with the generally steady improvement in realization rates since the evaluation PY2010.

The Custom Gas program continues to provide energy savings for National Grid in MA and RI. Below are the major findings and recommendations.

The impact evaluation of 2013 – 2014 Custom Gas installations in MA and RI produced results that are reliable (±7.7%) at 80% confidence. The realization rate was found to be 89.9%. This is an improvement over the results from the previous impact evaluation of 2010 Custom Gas installations which produced a National Grid RI realization rate of 75.5% with a relative precision of ±8.7% at 80% confidence.

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Appendix A: Final Sample - Sites Summary

Site ID	Measures per Site	Stratum	Verified Measures	Facility Type
S_NGR327	1	3	HVAC	Industrial
S_NGR357	4	4	HVAC, OTHER	College/Univ
S_NGR371	3	2	Heat recovery Ventilation	Industrial
S_NGR373	1	3	HVAC	Hospital
S_NGR386	1	1	OTHER	K-12
S_NGR400	1	1	HVAC	College/Univ
S_NGR409	1	2	CDA	College/Univ
S_NGR413	1	2	HVAC	K-12
S_NGR427	1	4	CDA	Office building
S_NGR436	2	2	Heat recovery Ventilation, OTHER	Apart/Condo
S_NGR440	1	4	OTHER	Apart/Condo
S_NGR444	10	4	HVAC, OTHER	Hospital
S_NGR465	4	4	OTHER	Industrial
S_NGR471	2	3	HVAC	Hospital
DNV 40	1	1	DHW/Boiler	College/Univ
DNV 54	1	1	Steam Traps, Insulation	Industrial
DNV 66	1	2	EMS, HVAC	Warehouse
DNV 75	2	2	Steam Traps	College/Univ
DNV 77	2	3	Boiler Controls	Industrial
DNV 80	2	3	Steam Traps, Insulation	Industrial
DNV 83	1	4	Condensate Return Piping	Office building

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