Multifamily Impact Evaluation

National Grid Rhode Island

KEMA, Inc.

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1 INTRODUCTION AND STUDY OBJECTIVES

DNV GL is pleased to submit this report to National Grid of Rhode Island. This report provides the electric and natural gas impacts from the suite of National Grid Multifamily Retrofit Programs (Multifamily Program) as determined through a billing analysis.

The goal of this study is to provide realization rates for electric and gas overall for 2013. We used a two-stage, premise-level, difference-of-differences modelling approach for energy consumption analysis using a dataset combining consumption, weather, and participation information. This approach estimates gross energy savings and relies on a comparison group consisting of subsequent participants to control for non-program related change. The team performed this study from May through August, 2015.

1.1 Program Description and Participation

National Grid delivers multifamily retrofit services holistically through one vendor to facilities regardless of vendor or customer segment. Due to the various fuels and customer segments in multifamily buildings, National Grid reports on and screens these programs for cost-effectiveness separately as: EnergyWise Multifamily electric, Income Eligible Multifamily electric, EnergyWise Multifamily gas, Income Eligible Multifamily gas, and Commercial & Industrial Multifamily gas. The measures and incentive levels vary based on fuel and customer income level. For evaluation purposes, this report considers all of these fuels and customer segments as one population (National Grid Multifamily Program).

The National Grid Multifamily Program offering in Rhode Island offers on-site energy assessments that identify cost-effective electric and gas energy efficiency opportunities at facilities with five (5) or more dwelling units. This program focuses on insulation, air leakage conditions, lighting, and heating and cooling systems. The program customer interface includes the provision of guidance from a representative dedicated to multifamily energy efficiency, a no-cost energy assessment and assistance with rebate forms and paperwork[1].

Based on the no-cost assessment, the following improvements may be eligible for incentives:

- Insulation & air sealing
- Heating & cooling equipment
- Water heating equipment
- 7-day thermostats
- Efficient light bulbs, lighting fixtures & controls
- Refrigerators
- Faucet aerators & low flow showerheads
- Advanced power strips
- Custom measures

[1] https://www1.nationalgridus.com/MultifamilyRI-RI-RES

1.2 2013 Program Activity

This section of the report reviews the tracking savings associated with the 2013 Multifamily Program and the timing of facility participation.

1.2.1 Program Tracking Savings by Measure and Fuel

The following tables show the National Grid Rhode Island Multifamily Program tracking electric and gas savings for the 2013 program year by measure. The tracking data for this study was provided with measure installation and savings details at the facility level. There were 97 facilities with electric savings in the 2013 program year with 5,286 accounts and 831 accounts within the 56 facilities with gas savings. The number columns show the number of facilities with savings associated with installed measures while the bottom totals row shows unique participating facilities.

Table 1 shows the tracked 2013 multifamily activity electric savings by measure. There are several measure categories with low savings or that we were otherwise unable to categorize and have placed into a miscellaneous category. These include custom measures, LED exit signs, aerators, showerheads and some insulation. It is clear that lighting dominates the electric savings (nearly 88% of savings), driven by LED lighting which was installed in 86 of the 97 participating facilities and represents just short of 62% of program savings. Following lighting, the provision of smart strips through the program is estimated to be generating 286 MWh of savings, or roughly 6.5% of total 2013 electric impacts.

Table 1: 2013 Multifamily Program Tracking Electric Savings by Measure

Measure	Electric		
	N	kWh	% of Total
LED	86	2,707,169	61.7%
CFL	64	854,896	19.5%
Smart Strip	60	286,070	6.5%
Fluorescent Fixture	27	285,606	6.5%
Air Sealing	2	52,156	1.2%
Thermostat	3	41,225	0.9%
Refrigerator	10	25,476	0.6%
Misc.	18	138,455	3.2%
Total*	97	4,391,053	100.0%

*The total row shows the number of unique facilities and is not the sum of the N column.

Given the magnitude of savings associated with LED, CFL, fluorescent fixtures, and smart strips in the Multifamily Program (nearly 88% of tracked savings collectively), we examined the savings per unit (per bulb or strip) in the tracking system for each technology by using the savings and quantities provided therein. Based on this method, it appears that the per unit (bulb) estimate of LED bulbs is ~222.5 kWh while the per unit estimate of CFL bulbs is ~35.8 kWh and savings per smart strip is tracked at 78.3 kWh.

Table 2: Per unit Savings of Top 3 Electric Measures

Measure	Electric		
	Quantity Installed	Tracking Savings (kWh)	Per Unit Savings (kWh)
LED (Dwelling, Exterior and Common Area)	12,169	2,707,169	222.5
CFL (Dwelling, Exterior and Common Area)	23,888	854,896	35.8
Smart Strip	3,654	286,070	78.3

Table 3 presents savings in the same manner as Table 1, but for 2013 natural gas. The miscellaneous category in this table also contains measure categories with low savings or that we were otherwise unable to categorize and essentially includes insulation of various types (duct, wall, pipe, etc.). Much like the electric program savings, three measure types comprise the vast majority (nearly 85%) of tracked gas program impacts. Overall, air sealing represents the majority of tracked savings with just over 56% of all gas tracked impacts with attic insulation representing another fifth of impacts and thermostats rounding out the top three measures with 8.7%.

Table 3: 2013 Multifamily Program Tracking Natural Gas Savings by Measure

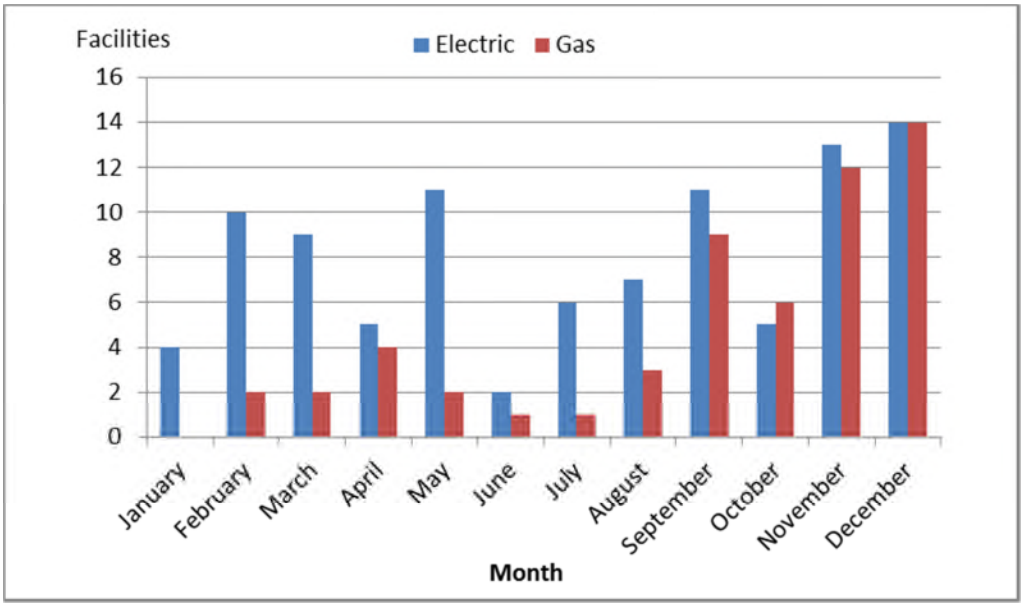
Measure	Natural Gas		
	N	Therms	% of Total
Air Sealing	40	177,287	56.1%
Attic Insulation	24	62,627	19.8%
Thermostat	26	27,619	8.7%
Custom	12	21,148	6.7%
Aerator	20	13,375	4.2%
Showerhead	19	11,092	3.5%
Misc	18	2,779	0.9%
Total*	56	315,927	100.0%

*The total row shows the number of unique facilities and is not the sum of the N column.

1.2.2 Timing of Participation

The following figures show number of participating facilities in 2013 by month and fuel savings. Participation among facilities with electric savings is much more stable across the year than gas participation, which tended to increase as the year progressed. Around 57% of facilities with gas savings that participated in 2013 completed their project in the last quarter of the year.

Figure 1: Profile of 2013 Electric Program Participant Activity by Month



2 METHODOLOGY

The billing analysis conducted in this study was comprised of a two-stage, premise-level, difference-of-differences modelling approach for energy consumption analysis using a panel dataset combining consumption and weather. This approach estimates gross energy savings and relies on a comparison group consisting of subsequent participants to control for non-program related change. The method used in this evaluation is compliant with the International Performance Measurement and Verification Protocol (IPMVP) option Method C, Whole Facility, and was recently published in the Department of Energy's Uniform Methods Project (UMP) Whole-Building Retrofit Evaluation Protocol[2].

2.1 Method Overview

A billing analysis was selected as the primary method of determining impacts for the Multifamily Program. This approach was selected because a) the program was expected to have savings of sufficient magnitude to be observable in consumption patterns, b) a billing analysis inherently captures interactive and behavioral changes that might have accompanied the program treatment, and c) the baseline for the savings is the pre-retrofit condition. Challenges that accompany this approach include how to account for changes in consumption due to non-weather related exogenous factors, how to handle self-selection bias, and the possible influence of vacancy on the savings estimate.

Our billing analysis approach was designed to help overcome these challenges through use of weather normalization, examination and cleaning of billing data, and use of the program's pipeline (non-treatment year participants) as a comparison group. In summary, we employed a two-step statistical regression method for the billing analysis. The impact evaluation utilized premise-level regression models to predict weather-normalized annual consumption in the first step. The second step used a difference-in-differences approach to estimate the gross program savings.

2.1.1 Discussion of Current vs Historical Billing Analysis Methods

National Grid has performed billing analysis approaches of the Rhode Island multifamily program numerous times, the last published in July of 2011[3]. In that report, the evaluators reported a natural gas realization rate of 121%.The model approach they used was a statistically adjusted engineering (SAE) regression analysis of consumption by participating facilities in a pooled, fixed-effects specification. In contrast, the current study uses a two-stage, premise-level, difference-of-differences modelling approach.

This current approach has some advantages over the previous approach. These advantages include the ability to establish optimal HDD and CDD for each premise or facility as opposed to fitting a single model with fixed HDD and CDD bases across all premises or facilities. In a multifamily application, this modelling attribute can be particularly important given the diverse configuration and location that premises can have within a building. For example, a premise with three walls exposed to weather on the top floor of a building requires a different HDD and CDD than one with only one exposed and three shared walls near the middle of the same building. The ability to determine these parameters uniquely

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[2] The Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol. Chapter 8 of The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. NREL April, 2013. http://energy.gov/sites/prod/files/2013/11/f5/53827-8.pdf

[3] http://www.rieermc.ri.gov/documents/evaluationstudies/2011/RI%20MF%20Gas%20Evaluation%20-%20Final%20Report-%2012JUL2011.pdf

at the premise or facility level, rather than forcing all premises or facilities into the same structure, results in a better determination of weather dependent consumption in the savings analysis.

The determination of whether weather normalization should be applied at the premise or facility level follows a similar line of consideration but is less clear-cut. Individual premise level models offer the maximum amount of modeling flexibility, but rely complete data that may not be realistic in the multifamily context. Individual facility models will capture the unique characteristics of each facility and will do so despite data limitations. In this study, we used premise level models.

A second element of the current method that is advantageous over the previous approach is the use of a comparison group. The previous approach was based on a participant only analysis that would have allowed the conflation of exogenous factors with the savings estimate. For example, a general reduction in consumption across the whole utility population due to economic conditions would unintentionally increase the savings estimate. The approach in this study used a comparison group comprised of subsequent participants to account for exogenous factors that might influence the savings estimate. This is referred to as a difference of differences approach and helps isolate program impacts from economic and other external factors. This is discussed further in the next section.

2.1.2 Construction of Comparison Group

The typical difference-in-differences approach uses a comparison group with similar energy consumption characteristics to control for the non-program, exogenous change in energy consumption through the evaluation period. In a randomized control trial experimental setting, where customers are randomly assigned to the control and treatment groups, this allows for an unbiased measure of program savings, by design. However, the Multifamily Program is an opt-in program where it is not feasible to obtain randomly selected customers in control and treatment groups. In this case, it is necessary to construct a comparison group. Following the guidance of DOE's Universal Methods Project the analysis uses subsequent years' participants to populate the comparison group.[4] It is reasonable to expect that the comparison group units and facilities faced the same kind of building and system issues for which the participants' spaces are being treated.

The evaluation used 2014 participants as the comparison group for estimating energy savings of 2013 participants. For the comparison group, DNV GL constructed a two-year pre-installation period that mirrors the pre- and post-installation of the participants being evaluated. The first of the two pre-installation years of the comparison group corresponds to participant's pre-installation period while the second pre-installation year of the comparison group corresponds to the post-installation period of the participants. For the comparison group, the second year of pre installation period does not include the installation date. The year over year change in comparison group's consumption during the two years of pre-program consumption data provide a basis for addressing non-program change in the estimates of savings.

Because future participants will soon participate in the program, they are unlikely to install program measures on their own during their pre-participation period. The self-selection into the program makes participants unique and different from the rest of the population. Because of this, the use of future

[4] *Ibid.*

participants as a comparison group can address the issue of self-selection bias in ways that a comparison group constructed from the general population cannot do.

Table 4 provides a diagram of how the difference-in-differences approach works after constructing comparison groups. For participants that installed a measure in 2013, the difference in consumption between the pre- and post-periods provides an estimate that combines program-related effect and exogenous (non-program-related, natural trend) change. Their comparison group is made up of units that were program participants a year later (2014). The consumption difference from their two year-long pre-program period for the comparison group captures only exogenous changes. Removing the comparison group's pre-post difference (exogenous, natural trend only) from the 2013 participants' group pre-post difference (program + exogenous, natural trend) provides an estimate of change in consumption due to the Multifamily Program.

Table 4: Pre- and Post- Differences of Participants and Comparison Groups

Group	Pre	Post	Pre-post difference within group	Pre-post difference between groups
2013 Participants	Non-program trend	Non-program trend + Program effect	Program impact + Non-program impact	Program impact
Subsequent participants 2014* Comparison	Non-program trend	Non-program trend	Non-program impact	

*Installed a year after the units in the impact group for comparison purposes

2.1.3 Analysis Method

Gross program savings are estimated using a two-stage billing analysis approach where the first stage involves site-level modelling and the second stage applies a difference-in-differences method to measure program savings. The manner in which these two phases are performed and interact with one another are each presented below and further detailed thereafter.

Site-level Modelling: DNV GL conducted site-level modelling[5] to estimate: (a) individual outdoor temperatures that trigger cooling and heating for each program participant (account), and (b) a weather-adjusted consumption that reflects a typical weather year for each site.

The site-level modelling covers a range of cooling and heating degree day bases to estimate normalized annual consumption for pre- and post- installation periods of each unit in the participant and comparison group. This modelling approach searches for the optimal reference temperature that yields the best model fit, separately for each unit during the pre- and post-periods.

Using the coefficient estimates of the best model selected for each site, we then calculated normalized annual consumption using the parameter estimates. Weather normalized annual consumption is

5 The site-level modelling approach was originally developed for the Princeton Scorekeeping Method (PRISM™) software, which was developed in the 1980s for estimating normalized annual consumption estimates. The structure used for this software is still the basis for most billing analysis approaches.

particularly important for application of billing results to unit savings estimates that are used for program planning and tracking estimation.

Difference-in-Differences: The second stage of our analysis followed a difference-in differences method that compares the change in the average normalized consumption of the participant group during pre- and post-program period with the change in usage during the same period for the comparison group.

The difference-in-differences approach is a simple, robust approach to measuring program-related savings. The participant group pre-post difference captures all changes between the two periods including those related to the Multifamily Program. The comparison group captures all changes between the two periods with the exception of those related to the Multifamily Program. Removing the non-program differences, as represented by the comparison group difference, from the treatment difference produces an estimate of the Multifamily Program's isolated effect on consumption.

Stage 1: Site-level Modelling

The billing analysis consisted of two different sets of billing regressions each applied to both gas and electric. The evaluation team estimated separate site-level regressions for pre- and post-installation periods for both gas and electric. The electric site-level regression consisted of the following basic PRISM structure. This basic structure is the same for gas, but without the cooling term.

$\boldsymbol{E_{im}} = \boldsymbol{\mu_i} + \boldsymbol{\beta_H H_{im}(\tau_H)} + \boldsymbol{\beta_C C_{im}(\tau_C)} + \boldsymbol{\varepsilon_{im}}$ ---- Equation (1)

where:

E_{im}	Average electric or gas consumption per day for participant *i* during billing period *m*
μ_i	Base load usage (intercept) for participant *i*,
$\boldsymbol{H_{im}(\tau_H)}$	Heating degree-days (HDD) at the heating base temperature τ_H
$\boldsymbol{C_{im}(\tau_C)}$	Cooling degree-days (CDD) at the cooling base temperature τ_C,
β_H	Heating coefficient, determined by the regression,
β_C	Cooling coefficient, determined by the regression,
$\boldsymbol{\tau_H}$	Heating base temperatures, determined by choice of the optimal regression,
$\boldsymbol{\tau_C}$	Cooling base temperatures, determined by choice of the optimal regression, and
$\boldsymbol{\varepsilon_{im}}$	Regression residual.

Rather than force the same degree-day base temperature on all of the sites used in this study, we estimated consumption across a range of heating and cooling degree day bases. The range of CDD bases included in the models ranged from 64°F to 84°F while the HDD bases covered 50°F to 70°F. The table below shows the average CDD and HDD across the different bases for sites with cooling and heating loads.

Table 5: Summary of CDD and HDD

Average Annual Degree Days	Participants		Comparison	
	Pre	Post	Pre	Post
Electric				
Cooling Degree Days	249	273	239	257
Heating Degree Days	4,386	4,294	4,310	4,306
Gas				
Heating Degree Days	4,717	4,508	3,974	4,095

The electric consumption analysis includes four different models: 'heating and cooling,' 'cooling only,' 'heating only,' and 'baseload only' models. For the gas consumption analysis, the models include 'heating only' and 'baseload only' models. For each site we chose the model specification and the cooling and/or heating degree base that produced the best R-square. In instances where the models indicated the presence of heating or cooling but did not provide clear guidance on the optimal degree day base, we defaulted to the mean heating or cooling degree day base across the analysis population.

We then calculated normalized annual consumption using the parameter estimates from the best model selected for each site. Normalized annual consumption (NAC) is calculated with the help of parameters estimated from site-level regression modelling (see Equation 2). Weather normalized annual consumption is particularly important for application of billing results to development of deemed unit savings estimates that can be used for program planning and administration.

Normalized Annual Consumption is calculated as follows:

$\mathrm{NAC_i} = (365.25 \times \hat{\mu}_i) + \hat{\beta}_H \mathrm{H_0} + \hat{\beta}_C \mathrm{C_0}$ ---- Equation (2)

Where:

NAC_i	Normalized annual consumption for customer i,
H_0	Average ten-year heating degree days calculated at the optimal heating base temperature $\hat{\tau}_H$ for participant i,
C_0	Average ten-year cooling degree days calculated at the optimal cooling base temperature $\hat{\tau}_C$ for participant, and
$\hat{\mu}_i, \hat{\beta}_H, \hat{\beta}_C$	Baseload and heating parameter estimates from the site-level models.

Stage 2: Difference-in-Differences

The second stage follows a difference-in difference method that compares the change in the average normalized consumption of the participant group during pre- and post-program period with the change in usage during the same period for the comparison group.

The difference-in-differences approach is a simple, robust approach to measuring program-related savings. The approach compares normalized annual consumption between the pre- and post-installation periods for both the participants and the comparison groups. The participant group pre-post difference captures all changes between the two periods including those related to the program. The comparison group captures all changes with the exception of those related to the program. Removing the non-program differences, as represented by the comparison group difference, from the treatment difference produces an estimate of the program's isolated effect on consumption.

$$\Delta NAC_i = \alpha + \beta T_i + \varepsilon_i$$

where:

ΔNAC_i	=	Pre-post difference in annual consumption for household i;
α	=	Intercept
T	=	Participant indicator (value of 1 if participant and 0 comparison)
β	=	Treatment effect or savings estimate
ε	=	error term

2.1.4 Data Summary

This section describes the data used in the impact evaluation of the Rhode Island Multifamily Program. DNV GL collected the program tracking databases and billing data from National Grid, and weather data from NOAA[6] and NREL[7]. Prior to analysis, we examined all data for completeness and potential data issues such as extreme values and missing observations. Table 6 describes the tracking, billing, customer, and weather datasets used in this evaluation.

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[6] National Oceanic and Atmospheric Administration Hourly Weather Data

[7] National Renewable Energy Laboratory (NREL), U.S.., U.S. Department of Energy Typical Meteorological Year weather data.

Table 6: Datasets Used in Analysis

Data	Fuel	Source/File Name	Number/ Available
Tracking Data	Electric	EW Insulation Measures.xls EW Lighting Measures.xls EW Non-Lighting Measures.xls	Facilities: 97 participating facilities in 2013
	Natural Gas	EW Gas Measures.xls	Facilities: 56 participating facilities in 2013
Billing Data	Electric	RI_ele_dtl.txt RI_ele_dtl_hist.txt	JAN2010 to MAY2015 for 20,187 premises
	Natural Gas	RI_gas_dtl.txt RI_gas_dtl_hist.txt	FEB2010 to MAY2015 for 5,665 premises
Weather Data	N/A	Source: NOAA, NREL Actual weather data and TMY3	Jan2010 to May2015

Table 7 summarizes the program population by installation year and the final sample used in the billing analysis for both electric and gas. These premises were located in 97 facilities with electric savings and 56 facilities with gas savings. We began with a total of 5,286 participating premises in our electric analysis and 831 in gas. In the tracking data, it was noted that 42 out of 97 electric facilities and 4 out of 56 gas facilities that participated in 2013 also participated in the Multifamily Program in other program years. Including 2013 premises from facilities that participated in other program years in the analysis can confound the ability to isolate 2013 impacts as the pre and post consumption around the 2013 program year treatment group might include changes in consumption due to program effects from other participation events. To isolate 2013 program impacts we decided to remove facilities and their treated premises from our analysis that had also participated in other program years. The consumption from the 2,843 electric participants treated exclusively in 2013 is 20,919 MWh while consumption among the 541 gas participants is 1,938,776 therms.

We also received activity on 19 participating gas premises in 2013 only that had commercial and industrial accounts that are not included in this table. We removed these participants to ensure the final overall gas level realization rate not include savings that are credited and evaluated as part of other programs (e.g., the Low Income Multifamily program or the C&I MF program), although we do provide a commercial gas realization rate based on a sample of these accounts later in this report. The comparison group (2014 participants, as discussed earlier) were comprised of more premises than the treatment group (4,767 and 1,334 electric and gas premises, respectively). After matching the premises in the tracking data with the billing data, we limited our analysis to those with at least 10 months of pre and post billing data to be sure both heating and cooling season periods were present in the analysis.

Finally, we also limited the premises in our analysis to those that had only had two or fewer estimated reads and no more than 2 electric zero reads or 8 gas zero reads. These conditions were placed on the analysis as a way to ensure the quality of billing data used. The final electric analysis included billing data for 98% of the premises in 2013 treated facilities (2,795 out 2,837) while the gas analysis included 96% of the premises in 2013 treated facilities.

Table 7: Number of Premises and Consumption Used in Billing Analysis

Data Disposition	Count		Treatment Raw Consumption		Treatment Annualized Consumption	
	Electric (kWh)	Gas (therms)	Electric (kWh)	Gas (therms)	Electric (kWh)	Gas (therms)
Initial no. of premises						
2013 Total	5,285	289	51,700,260	2,126,605	51,432,741	1,993,056
2013 and other year participation (76 Electric Facilities, 7 Gas Facilities – excluded from final analysis)	2,442	289	30,780,264	187,829	30,703,327	132,245
2013 Only Participants (53 Electric Facilities, 43 Gas Facilities, treatment group)	2,843	541*	20,919,996	1,938,776	20,729,414	1,860,811
2014 Participants/Comparison Group (110 Electric Facilities, 83 Gas Facilities)	5,546	1,744**	41,356,292	2,651,547	39,933,685	2,201,103
Premises with enough data (>10 months pre/post) and single year (2013) install						
2013 Participants/Treatment Group	2,837	537	20,917,886	1,935,691	20,724,996	1,857,464
2014 Participants/Comparison Group	4,767	1,334	35,353,117	2,058,954	33,990,789	1,663,510
Premises with enough data, single year install, not more than 2 estimated reads, not more than 2 zero electric reads or 8 zero gas reads						
2013 Participants/Treatment Group	2,795	516	20,037,608	1,909,596	19,848,981	1,832,507
2014 Participants/Comparison Group	4,597	1,274	34,055,957	2,003,732	32,758,910	1,627,661

*Excludes 19 commercial premises

**Excludes 33 commercial premises

Table 16 shows a comparison of measures installed in the population and analysis sample for both the comparison and treatment groups. For ease of comparison, we have removed those measures where savings are at or less than 1% in all sub segments. This table illustrates that the measure savings mix in the population and final analysis sample are very similar, even after having edited the data to remove units with multiple years of participation and inadequate billing data.

Table 8: Comparison of Measures Installed in Comparison and Treatment Groups

Measure Category	Population				Sample			
	Savings		Percent savings		Savings		Percent savings	
	Treatment	Comparison	Treatment	Comparison	Treatment	Comparison	Treatment	Comparison
Electric								
Aerator	8,342	58,200	0%	1%	6,305	38,703	0%	1%
CFL	854,896	931,131	19%	13%	346,651	668,311	18%	15%
Custom	52,288	156,314	1%	2%	-	-	0%	0%
Fluorescent Fixt.	285,606	457,326	7%	7%	128,240	279,965	6%	6%
Led	2,707,169	4,587,021	62%	66%	1,313,183	3,009,715	66%	67%
Miscellaneous	67,907	52,908	2%	1%	3,733	30,862	0%	1%
Smart Strip	286,070	410,879	7%	6%	144,858	297,435	7%	7%
Thermostat	41,225	120,694	1%	2%	17,990	49,958	1%	1%
Total	4,391,053	6,975,501	100%	100%	1,980,389	4,506,577	100%	100%
Natural Gas								
Aerator	13,375	22,759	4%	5%	9,376	16,150	4%	6%
Air Sealing	177,287	221,936	56%	50%	134,959	146,040	58%	51%
Attic Insulation	62,627	82,823	20%	19%	38,811	54,235	17%	19%
Custom	21,148	47,917	7%	11%	21,148	30,471	9%	11%
Pipe insulation	1,285	11,503	0%	3%	824	3,576	0%	1%
Showerhead	11,092	13,224	4%	3%	5,758	9,043	2%	3%
Thermostat	27,619	36,239	9%	8%	20,461	19,876	9%	7%
Total	315,927	443,316	100%	100%	232,570	286,304	100%	100%

Table 9 presents a comparison of the size of facilities in the electric and gas treatment and comparison groups. Overall, the size of facilities in the electric comparison and treatment groups are relatively similar, in particular the median sizes which are nearly the same. The gas treatment group, however, is much larger than the comparison group, including a mean estimate that shows it as less than half the size. We understand from National Grid that several large housing authorities participated in 2013, which is believed to be the primary driver of the size difference.

Table 9: Size of Facilities in Treatment and Comparison Group

Group	No. of Facilities	Mean (Sq Ft)	Median (Sq Ft)
Electric			
Treatment	52	63,276	38,400
Comparison	99	82,669	36,000
Natural Gas			
Treatment	42	104,098	45,000
Comparison	77	49,426	28,500

Table 10 provides the heating fuel types used among the electric and gas treatment and comparison groups in the analysis. In the electric and gas analyses, the percent of facilities heated by the various fuel types are very close. Nearly all treatment and comparison group facilities in the gas analysis are heated by gas. The treatment and comparison group facilities in the electric analysis both have 8% electrically heated and roughly 83% gas heated.

Table 10: Heating Fuel Types in Treatment and Comparison Groups

<table>
<tr><th rowspan="2">Group</th><th rowspan="2">Heating Type</th><th colspan="2">Electric</th><th colspan="2">Natural Gas</th></tr>
<tr><th>Count</th><th>Percent</th><th>Count</th><th>Percent</th></tr>
<tr><td rowspan="4">Treatment</td><td>Electric</td><td>4</td><td>8%</td><td>0</td><td>0</td></tr>
<tr><td>Gas</td><td>43</td><td>83%</td><td>42</td><td>100%</td></tr>
<tr><td>Oil or others</td><td>5</td><td>10%</td><td>0</td><td>0</td></tr>
<tr><td>Total</td><td>52</td><td>100%</td><td>42</td><td>100%</td></tr>
<tr><td rowspan="4">Comparison Group</td><td>Electric</td><td>8</td><td>8%</td><td>0</td><td>0</td></tr>
<tr><td>Gas</td><td>83</td><td>84%</td><td>75</td><td>97%</td></tr>
<tr><td>Oil or others</td><td>8</td><td>8%</td><td>1</td><td>1%</td></tr>
<tr><td>Total</td><td>99</td><td>100%</td><td>77</td><td>100%</td></tr>
</table>

3 RESULTS

This section presents the gross electric and gas savings for the 2013 Multifamily Program year in Rhode Island. Following the premise-level modelling results, we provide overall program results that rest upon the expansion of the premise results up to the facility level.

3.1 Site-Level Model Results

DNV GL estimated weather-adjusted electric and gas consumption for each site using site-level models. The normalized annual consumption (NAC) from these models allowed for a pre- and post-installation comparison of energy consumption under a normal weather year. NAC was estimated for the pre- and post-installation period of the participants using the optimal degree-day base for each site. This individual degree day base is a representation of the outdoor temperature at which each treated space needs heating or cooling. Each treated space has a unique degree day base due to its level of envelope insulation, infiltration, internal/solar gains, and thermostat set point schedule (i.e., presence level in space during the day, preferred set points). This modelling approach allows the underlying structure of the degree-day data to conform to the unique characteristics of each treated premise instead of imposing a fixed degree-day basis on all sites.

Table 11 compares the average actual and normalized consumption level between the pre- and post-period for participating electric and gas premises in the analysis. Results show that, on average, participating electric premises reduced their normalized annual consumption 4% while participating gas premises reduced their normalized energy consumption by 6.4%. During this same period, our electric comparison group experienced an increase in normalized consumption of 1.6% while the gas comparison group reduced consumption 2.2% (although as we note later, we did not employ the difference in differences calculation for gas impacts).

One item noted during the analysis of gas premises is that the participant group in 2013 has consumption notably higher than the comparison group. In discussion with National Grid, we believe there is a greater proportion of master metered and/or larger premises such as housing authorities that participated in 2013 vs 2014. There is some concern that this substantial size difference and change in facility types and their attendant dissimilarity in billing structures make them too unique to be an appropriate comparison group. In addition, we note that the decrease in consumption between pre and post among the gas comparison group may be signaling influences on their energy use beyond those intended for use in this study. As such, we have decided to not use the gas comparison group in our final estimates of savings (i.e., we did not use the difference in difference approach to estimate savings for gas).

Table 11: Average Actual and Normalized Pre/Post Electric and Gas Consumption

Consumption	Electric (kWh)			Gas (Therms)		
	Pre	Post	% Change	Pre	Post	% Change
Actuel Consumption						
2013 Participants	7,302	6,935	-5.0%	3,548	3,559	0.3%
Comparison	7,158	7,023	-1.9%	1,255	1,331	6.1%
Normalized Consumption						
2013 Participants	7,123	6,836	-4.0%	3,601	3,370	-6.4%
Comparison	6,910	7,021	1.6%	1,278	1,250	-2.2%

The following figures illustrate the information provided in Table 11. Seen in this way, the difference in gas consumption between the comparison and treatment groups is clearly observed while the consumption among electric comparison and treatment groups are relatively similar in size.

Figure 2: Comparison of Average Actual and Normalized Electric Consumption

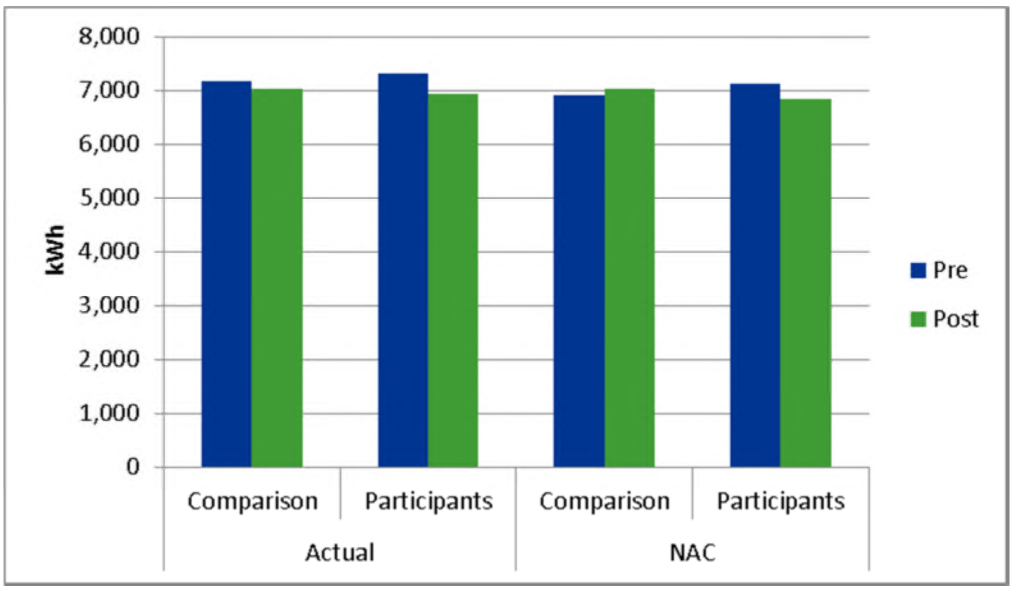

Figure 3: Comparison of Average Actual and Normalized Gas Consumption

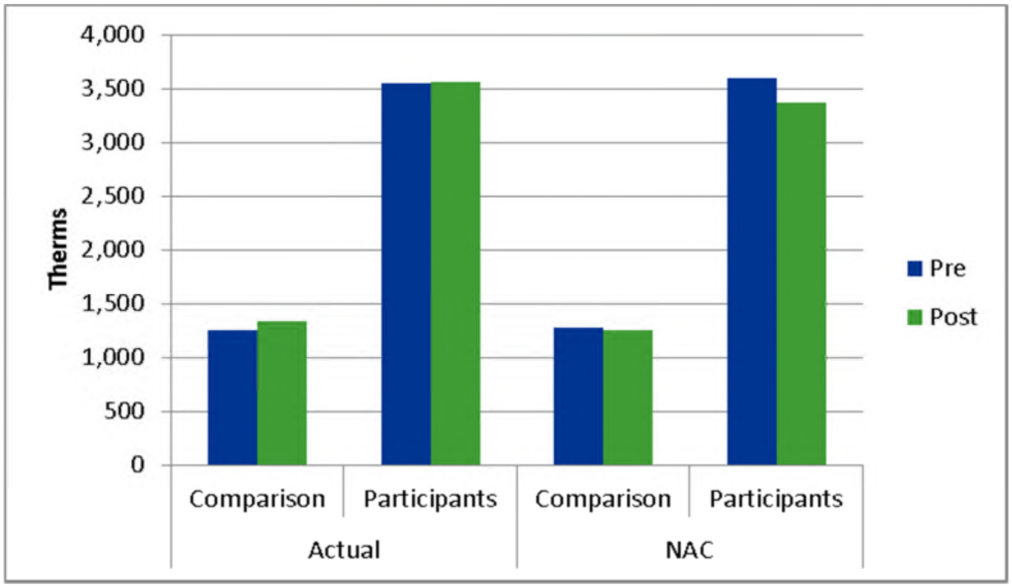

Table 12 summarizes the results from the Difference of Differences Model with a comparison group for electric and no comparison group for gas for reasons discussed earlier. These results were developed from those premises that only participated in 2013, where consumption data was available for at least 10 months before after program treatment and for which there were limited estimated and zero reads (as discussed earlier). Recall, these results do not include gas C&I premise level activity. Our estimate of savings per premise is 399 kWh and 230.7 therms. When we compare these results to the tracking system savings estimates for these same premises, we calculate a realization rate of 57% for electric savings with a precision of ±31% at the 90% confidence interval and a 53% realization rate for gas with a precision of ±25%. The savings as a percent of pre normalized energy consumption is 5.6% for electric and 6.4% for gas.

Table 12: Overall Results by Fuel Type from Difference of Differences Model with Comparison Group

Fuel	N	Estimated Savings per Premise	Std Error	Precision @ 90% Confidence	Pre-NAC per Premise	Savings as Percent of Pre-NAC	Tracking savings	Realization rate
Electric (kWh)	2,795	398.7	75.6	±31%	7,123	5.6%	696	57.3%
Gas (Therms)	516	230.7	34.8	±25%	3,601	6.4%	438	52.7%

Table 13 provides a summary of results by program based under the same conditions as those provided at the fuel level above. We note that in this table the 18 facilities removed from the overall gas realization rate modeling have been included in the commercial gas realization rate provided. The nature of using a comparison group makes the process of breaking out sub levels of results not perfectly linear. In this case, the overall realization rates and those broken out by program are close, with the overall electric realization rates slightly lower than the two disaggregated residential program rates and the overall gas realization rate in the midst of those at the program level. The realization rates for the electric standard income and low income results are nearly the same at 59% and 65%, respectively. The realization rates for the gas standard income and low income results are moderately different at 33.4% and 58.3%, respectively.

Table 13: Program Level Results from Difference of Differences Model with Comparison Group

Fuel/Program	N	Estimated Savings per Premise	Std Error	Precision @ 90% Confidence	Pre-NAC per Premise	Savings as Percent of Pre-NAC	Track savings	Realization rate
Electric (kWh)								
MF Standard Income	1,654	351.8	60.6	±28%	5,033	7.0%	593	59.3%
MF Low Income	1,141	548.1	184.3	±55%	10,154	5.4%	846	64.8%
Gas (Therms)								
MF Standard Income	274	61.8	9.8	±26%	1,179	5.2%	185	33.4%
MF Low Income	242	422	71.6	±28%	6,342	6.7%	724	58.3%
Commercial	18	907.2	738.2	±147%	22,485	4.7%	2,299	46.4%

National Grid provided meter type in addition to program type in the data used in this analysis. The relationship between the meter and program types is provided in Table 14. The first column shows the meter type, the second column the program type and the final column shows the number of participants. In other words, the top two rows show that there were a total of 63 participants in the residential low income program with a commercial meter and 237 in the standard income program with a commercial meter. We note that this type of relationship might be expected for a multifamily program where a facility is designated to be a participant in a particular program although meters within that facility might not be consistent with that program type. For example, if 50% of the units in a facility are low income, the entire facility (all meters) are treated as Low Income.

Table 14: Meter versus Program Designations

<table>
<tr><th>Meter Type</th><th>Program</th><th>n</th></tr>
<tr><td colspan="3">Electric</td></tr>
<tr><td rowspan="2">Commercial</td><td>Residential Low Income</td><td>63</td></tr>
<tr><td>Residential Standard Income</td><td>237</td></tr>
<tr><td>Residential Low Income</td><td>Residential Low Income</td><td>255</td></tr>
<tr><td>Residential Standard Income</td><td>Residential Low Income</td><td>823</td></tr>
<tr><td>Commercial</td><td>Residential Standard Income</td><td>1,417</td></tr>
<tr><td colspan="3">Natural Gas</td></tr>
<tr><td rowspan="3">Commercial</td><td>Commercial</td><td>19</td></tr>
<tr><td>Residential Low Income</td><td>89</td></tr>
<tr><td>Residential Standard Income</td><td>127</td></tr>
<tr><td rowspan="2">Residential Standard Income</td><td>Residential Low Income</td><td>153</td></tr>
<tr><td>Residential Standard Income</td><td>147</td></tr>
</table>

Table 15 provides a summary of results by meter type based under the same conditions as those provided in the program level results above. Some of the sample sizes are relatively small; however, it is apparent that commercial electric meters have a quite reasonable realization rate as compared to the others than the other electric meter types. Although the low income electric meter result has a negative realization rate, we also note that the precision around it exceeds 230%, which makes its result effectively inconclusive.

Table 15: Meter Level Results from Difference of Differences Model with Comparison Group

Fuel/Meter Type	N	Estimated Savings per Participant	Std Error	Precision	Track savings	Pre-NAC per Participan t	Savings as Percent of Pre-NAC	Realization rate
Electric (kWh)								
MF Standard Income	2,240	336	60.1	±29%	501	5,353	6.3%	67.1%
MF Low Income	255	-353	497.2	±232%	926	4,342	-8.1%	-38.1%
Commercial	300	1,944	451	±38%	1,957	22,705	8.6%	99.3%
Gas (Therms)								
MF Standard Income	300	110	20	±30%	211	1,912	5.8%	52.2%
Commercial	234	259	129	±82%	872	7,185	3.6%	29.7%

3.2 Examining Realization Rate Drivers

The low realization rates observed in this study can be driven by many things. It can be due to any one or combination of issues in persistence, lower than anticipated installation rates, general quality of measure installation or the overestimation of measure savings in the tracking system estimates. Based on our knowledge of this program and its operations, however, we suspect that the driver of the realization rates in this study are due to the overestimation of measure savings in the tracking system (the ex-ante estimates). In this section, we review the largest contributors to both the electric and gas tracking savings to determine which might be causing the low realization rates.

3.2.1 Electric

The 2013 Multifamily Program electric realization rate calculated in this study is 57% precision of ±31% at the 90% confidence interval. As indicated earlier in this report, nearly 88% of the total tracked 2013 electric savings in this program is comprised of CFLs, LEDs and smart strips. While this billing analysis is unable to provide savings at the measure level, to better understand what might be driving this realization rate, we performed some research to examine the ex-ante (tracked) savings of these the CFL and LED technologies.

- CFL: The current per bulb estimate of CFL savings in the 2013 Multifamily Program tracking system is 35.8 kWh. While there have been many studies of CFL impacts over the years, at the end of 2014 NEEP issued a lighting strategy update that synthesized savings inputs from across the region for CFLs (and LEDs). We believe this report provides a reasonable basis for assessing the reasonableness of the current assumed value used by National Grid for this program. Using the 2013 savings inputs from the NEEP study[8] and assuming 100% installation of bulbs, the per unit savings estimate is 41.8 kWh, which is moderately higher than that assumed in the Rhode Island Multifamily Program. However, considering the downward pressure vacancy might have on savings, the National Grid estimate of 35.8 kWh/year appears reasonable.
- LED: In our review of program installed LED bulbs, we noted many are installed in exterior fixtures or common area lighting. The hours of operation among these uses can vary substantially from those in a dwelling space. The table below summarizes the average daily hours of operation observed in the tracking system versus other recent sources of average daily hours. The average estimate of 3.2 hours a day assumed for dwellings is only moderately higher than the 2.9 hours assumed in the NEEP study and the large regional hours of use study performed by NMR in 2014.

In considering common exterior hours, we note that the overall average estimate of exterior hours from the tracking system is 9.5 hours per day. This compares to an overall value from the regional HOU study of 7.5 for multifamily (based on 5 sites) and 15 for non-low income multifamily (based on 2 sites). This small sample in the HOU study present uncertainty around those results, however, to the extent the overall multifamily estimate of 7.5 is the more stable estimate, it suggests that the National Grid hours of use for common exterior fixtures may be overstated.

[8] http://www.neep.org/sites/default/files/resources/2014-2015%20RLS%20Update.pdf

Common interior fixtures in the tracking system average 15 hours of use per day. The HOU study does not provide a point of comparison for this value and unfortunately, we were unable to find a secondary source to compare this value to.

Zone	Avg. Tracking Daily Hours	Avg. Secondary Source Daily Hours (90% CI)	Notes/Source
Common Exterior	9.5	Overall: 7.5 (5.2,9.2) Non-low income: 15 (13.3,16.6)	NMR HOU Study Appendix A
Common Interior	15.0	N/A	N/A
Dwelling Interior	3.2	2.9 (2.8, 3.0)	NMR HOU Study[9]
		2.9	NEEP LED Study[10]

- Smart Strip: The current per smart strip estimate of savings in the 2013 Multifamily Program tracking system is 78.3 kWh. To assess the reasonableness of this per unit savings estimate, we identified a 2013 measure profile study by e-source[11] that summarizes the deemed savings assumed in 10 (non-Rhode Island) jurisdictions as well as the results of an impact evaluation performed on smart strips by OPA[12]. While the array of deemed savings from this report ranges from 23 kWh/unit to 184 kWh/unit, the average savings estimate is 80 kWh/unit (with most estimates ranging from 50 kWh/unit to 103 kWh/unit). The OPA impact evaluation provided a gross per unit savings of 16.9 kWh, which is much lower than the savings assumed by National Grid, although we were not able to find any other impact studies on savings from smart strips to corroborate this estimate. We believe that while there is some evidence that the per unit savings of smart strips might be lower than the 78.3 kWh assumed, it remains a reasonable estimate and is not a likely driver of the realization rates observed in this study.

3.2.2 Gas

The 2013 Multifamily Program gas realization rate calculated in this study is 53% with a precision of ±25% at the 90% confidence interval. As indicated earlier in this report, nearly 85% of the total tracked 2013 gas savings in this program is comprised of air sealing, attic insulation and smart thermostats. To examine possible causes of the gas realization rate, we focused on these three measures. Unlike the discussion on the drivers of the electric realization rates, we found an examination of gas savings at a per unit level to be more difficult to establish. To help inform possible drivers of the gas realization rate, we therefore examined the average measure level savings assumed in the tracking system versus the pre-NAC and heating consumption estimates from our billing analysis. These results are shown in Table 16 and are further discussed below.

In general, the percent of heating consumption estimated as saved in the tracking system for thermostats is what we might expect for programmable thermostat technology at 4% of heating consumption. The tracking system suggests these are smart thermosets, however, which would make

9 http://www.ripuc.org/eventsactions/docket/4527-NGrid-HOU_Study.pdf

10 http://www.neep.org/sites/default/files/resources/2014-2015%20RLS%20Update.pdf

11 http://www.efi.org/docs/studies/esource_aps.pdf

12 We note that this study also cited an evaluation of smart strips in New Hampshire; however, that source appeared to also contain planning savings estimates and not formally evaluated estimates.

the savings as a percent of heating consumption at the lower end of what we might expect. Although there is not a lot of research available on smart thermostats (as they are relatively new), we were able to find a white paper that suggests they can save 12-13% of gas heating consumption[13]. In this regard, the tracked estimates of savings appear reasonable for programmable thermostats and conservative for smart thermostats, although we note that behaviors and overrides can substantially hinder thermostat savings, regardless of thermostat technology.

Similarly, the percent of heating consumption estimated as saved in the tracking system for attic insulation appear at the low end of what we might expect, at 5% of heating consumption. In a billing analysis of the Rhode Island EnergyWise Single Family Impact Evaluation in 2012[14] and in a Home Energy Services Impact Evaluation[15] that same year, we note these studies estimated that attic insulation saved 10% and 9% of heating consumption, respectively. These were studies of programs that largely represent activity in single family houses where installation conditions might be different than in the multifamily market. However, when taken as a whole, we conclude that the tracking estimates of attic insulation also appear to be reasonable, if not conservative. As such we do not believe the estimates of attic insulation in the tracking system are driving the realization rate.

In reviewing the percent of heating consumption represented by air sealing tracking savings, the numbers are a higher than for the other measures presented, at 14% of heating consumption. While these portions do not appear excessive, they do appear higher than expected. In examining the two reports cited in the previous paragraph, where we again note that difference in installation conditions and building types do not make results directly comparable, the results suggest that air sealing might be expected to represent 6% to 10% of heating consumption. This observation, in combination with the level of program savings that are due to air sealing (56% of gas savings), make it a logical measure for National Grid to further examine how ex ante savings are being estimated.

Table 16: Premise Level Gas Measure Tracking Savings as Percent of Consumption

Measure Type	Premises In Sample	Average Savings	Average Premise Pre NAC (Therms)	Average Premise Heating Load (Therms)	% of Total Pre-NAC	% of Heating Consumption
Air Sealing	502	1,178	11,599	8,247	10%	14%
Attic Insulation	196	517	14,017	9,848	4%	5%
Thermostats	249	522	17,661	13,279	3%	4%

13 http://ilsagfiles.org/SAG_files/Meeting_Materials/2015/6-23-15_Meeting/CLEAResult_Smart_Thermostat_WhitePaper_20150505.pdf

14 http://www.rieermc.ri.gov/documents/evaluationstudies/2012/National%20Grid%20Rhode%20Island%20-%20EnergyWise%20Single%20Family%20Impact%20Evaluation_FINAL_31OCT2012.pdf

15 http://ma-eeac.org/wordpress/wp-content/uploads/Home-Energy-Services-Impact-Evaluation-Report_Part-of-the-Massachusetts-2011-Residential-Retrofit-and-Low-Income-Program-Area-Evaluation.pdf

4 STUDY CONCLUSIONS AND RECOMMENDATIONS

Based on the research findings presented and our examination of likely drivers of the realization rate, we provide the following conclusions and recommendations regarding the Rhode Island Multifamily Program.

4.1 Conclusions

The purpose of performing this billing analysis was to produce electric and gas realization rates for activity in the 2013 Multifamily Program. The following two conclusions provide these key results.

- Based on the electric billing analysis, we estimate the 2013 Multifamily Program electric realization rate to be 57% with a precision of ±31% at the 90% confidence interval. This result provides a final estimate of electric program savings of 2,503 MWh. Based on our examination of tracking savings, we believe this realization rate is being driven by a tracking savings calculation error and overestimated LED lighting hours of use.
- Based on the gas billing analysis, we estimate the 2013 overall Multifamily Program gas realization rate without commercial activity to be 53% with a precision of ±25% at the 90% confidence interval. It is more difficult to discern the possible drivers of the gas realization rate. However, based on our examination of tracking savings, we believe this realization rate is being driven by overestimated air sealing impacts. We further note that National Grid is considering a review of custom measure tracking system estimates as it is believed these savings may also be overinflated, although we did not examine this measure specifically as part of this study.
- The precision around the results in this study are high, but reasonable for a billing analysis. Using the electric realization rate and precision as an example, a result of +/-31% means we are 90 % confident the results is within 31% above or below the point estimate. This is a much better level of precision than statistical significance; evidence that a result is different than zero.

4.2 Recommendations

The following recommendations rest upon the activities undertaken as part of this study. Some of these recommendations may already be planned and/or undertaken as part of National Grid's ongoing commitment to improving program operations and tracking of impacts.

- Based on our examination of the hours of use for LED bulbs, we recommend that National Grid re-assess inputs used to estimate the savings for this measure. While our findings were not conclusive on this issue, we believe there is sufficient evidence to warrant a review of the hours estimated for tracking purposes. In 2013, LED bulbs were the largest contributor to program savings according to the tracking data and as the LED technology becomes more ubiquitous and displaces CFLs in program offerings, it is likely to become increasingly important to have a savings estimate based upon well founded hours of use assumptions.
- Based on our examination of the tracking savings for the top three gas saving measures and their relationship to pre normalized energy consumption, as well as the magnitude of program savings that would be needed to drive the realization rate, we recommend that National Grid re-examine the way in which air sealing savings are being calculated for the Multifamily Program. We also recommend that the custom measure category be examined as part of the process of understanding ex ante estimates and whether they might be overestimated. While

this measure did not make the top three gas saving measures and did not received much scrutiny in our examination, we understand that National Grid has existing concerns about the tracking savings for gas custom measures and we believe it makes a great deal of sense to examine them in the wake of this study.

- Currently, National Grid uses an air sealing unit of measure installation of amount of time used to perform the treatment (per hour). We recommend that National Grid begin tracking the quantity of program installed units for air sealing activity by linear feet, CFM reduced or some other unit that can be normalized in a meaningful way. The current Rhode Island Technical Manual drives its air sealing savings off CFM reduction, so this unit of installation may already be available for use. Air sealing is one of the primary measures driving the savings in the Multifamily Program.
- We do not believe the realization rates observed in this study are due to quality of measure installation. However, as a next step in understanding program impacts, National Grid might consider a limited set of inspections at participating facilities to ensure this issue is not a contributor to the realization rates observed in this study. An alternative would be to review findings from quality control work performed by CMC on the program to be sure those observations are not signaling a possible issue that might be causing the realization rate.
- In this study we provide both fuel and program level realization rates. The program level results are provided to help understand whether performance in one program might be driving the overall realization rate. The realization rates among the various electric and gas programs are stable and without significant differences among them. These results do not indicate that there is a difference between the different program modes under each fuel type with respect to effectiveness of installed savings. This suggests that fuel level results are appropriate for application at the program level despite differences in the program level realization rates.

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