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Summary of the Massachusetts Behavioral Program Impact Evaluations

Final Report in the Cross-Cutting Research Areas of Behavior and Education

Prepared for:

Massachusetts Program Administrators and the Energy Efficiency Advisory Council

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1. INTRODUCTION

This report summarizes the impact analyses conducted by Navigant Consulting, Inc. and Illume Advising, LLC (referred to as the evaluation team) in 2015 of National Grid's and Eversource Energy's Home Energy Report (HER) programs.[1] At the end of 2014, there were a total of thirty-one evaluable cohorts in these Program Administrator's (PA) HER programs. This included fifteen electric cohorts, eight gas cohorts, and four dual fuel cohorts.[2]

The evaluation team conducted three distinct impact analyses related to these HER programs:

1. The **Cohort-Specific Impact Analysis** estimated 2014 savings for each of the National Grid and Eversource Energy cohorts and proposed savings estimate ratios for use by the PAs in future years when a third-party impact evaluation is not conducted.
2. The **Mapping Analysis** identified the overlap between different program cohorts, addressing potential implications for the experimental design and evaluability. This research found overlap of approximately 3% of customers (treatment and control). The overlap was generally small and not expected to impact the cohort-specific savings analysis using standard evaluation methods.
3. The **Dual Treatment Analysis** estimated whether there were statistically significant differences in savings for customers receiving a single dual-fuel report as compared to those receiving two single-fuel reports. Given the total increase in annual MMBTU savings from switching all customers to dual-fuel reports was small and that the process evaluation showed receiving multiple single-fuel reports was not an issue for cross-PA customers (the vast majority of dual-treatment customers), the evaluation team did not believe coordination across the PAs was warranted and recommended the PAs continue implementing the HER program in its current form.

The results of each of these analyses have been previously presented to the PAs and the Energy Efficiency Advisory Committee and are included as appendices of this report (Table 1).

Table 1. Summary of Appendices

Appendix	Description	Date Delivered
Appendix B	Cohort-Specific Impact Analysis	March 9, 2015
Appendix A	Mapping Analysis	March 25, 2015
Appendix B	Dual Treatment Analysis	December 4, 2015

In 2015, the evaluation team also conducted a process evaluation of National Grid and Eversource Energy's HER Program, as well as impact and process evaluations of the HER program for Berkshire

[1] Eversource Energy was formerly NSTAR and Western Massachusetts Electric Company (WMECO).
[2] Electric cohorts included nine for National Grid, five for NSTAR and one for WMECO. Gas cohorts included seven for National Grid and one for NSTAR. Dual Fuel cohorts included one for National Grid and three for NSTAR.

Gas and the Creating Awareness for Power Efficiency initiative for Cape Light Compact. Separate reports were delivered for each of these studies and as such they are not included in this report.[3]

The remainder of this report presents key findings and recommendations from each of the three analyses:

- Section 3 - Cohort-Specific Analysis
- Section 2 - Mapping Analysis
- Section 3 - Dual Treatment Analysis

[3] Navigant Consulting, Inc. and Illume Advising, LLC. 2015. *Massachusetts Behavioral Programs Process Evaluation: Report in the Cross-Cutting Research Areas of Behavior and Education.* Prepared for the Massachusetts Program Administrators and the Energy Efficiency Advisory Council.
Navigant Consulting, Inc. and Illume Advising, LLC. 2016. *Berkshire Gas Home Energy Report Program Evaluation*: *Final Report in the Cross-Cutting Research Areas of Behavior and Education.* Prepared for the Massachusetts Program Administrators and the Energy Efficiency Advisory Council.
Navigant Consulting, Inc. and Illume Advising, LLC. 2016. *Evaluation of Cape Light Compact's Creating Awareness for Power Efficiency Initiative: Draft Report in the Cross-Cutting Research Areas of Behavior and Education*. Prepared for the Massachusetts Program Administrators and the Energy Efficiency Advisory Council.

2. COHORT-SPECIFIC ANALYSIS

The purpose of this analysis was to estimate 2014 savings for the thirty-one evaluable cohorts in the HER program for National Grid and Eversource Energy.

Key findings and recommendations from this analysis included the following:

- Total net electric savings from the Massachusetts HER programs were 127,854,643 kWh. Total net gas savings were 643,157 MMBtu.

- The evaluation team recommended that the PAs adopt the following savings estimate ratios[4] in future years when third-party impact evaluations are not completed.
    - National Grid Electric: 95%
    - National Grid Gas: 98%
    - NSTAR Electric: 104%
    - NSTAR Gas: 98%
    - WMECo Electric: 104%

Table 2 presents the savings estimates after channeling adjustment by cohort.

[4] The saving estimate ratio was the calculated by dividing the modeled savings estimated by the evaluation team by the savings estimated by Opower.

Table 2. Savings Estimates after Channeling Adjustment, by Cohort

PA	Cohort Name	Fuel-Type	Total Number of Participants	TRM Baseline Usage (kWh/MMBtu)	Modelled Baseline Usage (kWh/MMBtu)	Average Annual Savings per Customer (kWh/MMBtu)*	Percentage Savings*	Total Savings (kWh/MMBtu)*
NGRID	Group 2009	Electric	24,005	11,233	10,669	252.85	2.37%	5,116,541
NGRID	Group 2010	Electric	65,170	12,370	11,815	186.68	1.58%	11,993,567
NGRID	Group 2010 Added	Electric	23,805	15,232	14,682	340.62	2.32%	6,772,880
NGRID	Group 2011	Electric	99,446	9,638	9,415	236.32	2.51%	18,673,469
NGRID	Group 2011 Added	Electric	60,605	6,121	5,986	93.99	1.57%	4,184,350
NGRID	Group 2012	Electric	86,898	6,126	6,003	135.41	2.20%	1,430,655
NGRID	Group 2012 Dual	Electric	12,621	6,239	6,155	93.64	1.56%	5,974,252
NGRID	Group 2013	Electric	324,002	8,036	8,053	105.50	1.31%	28,469,571
NGRID	Group 2013 Email	Electric	46,105	-	7,082	35.41	0.50%	1,443,224
NGRID	Group 2014	Electric	94,874	7,093	7,303	65.72	0.90%	4,033,771
NGRID	Group 2009	Gas	24,790	127.20	139.97	2.09	1.49%	43,727
NGRID	Group 2010	Gas	75,911	31.28	147.01	2.75	1.87%	172,435
NGRID	Group 2011	Gas	100,321	92.90	103.25	1.16	1.12%	86,660
NGRID	Group 2011 Add	Gas	25,673	19.44	86.94	1.03	1.19%	19,356
NGRID	Group 2012	Gas	86,279	81.00	86.73	1.54	1.77%	96,009
NGRID	Group 2012 Dual	Gas	13,416	84.20	95.91	1.05	1.09%	11,553
NGRID	Group 2013	Gas	149,442	76.18	82.67	0.74	0.89%	89,334
NGRID	Group 2014	Gas	49,741	-	112.27	0.92	0.82%	14,558
NSTAR	Group 2010 Dual	Electric	18,660	-	8,127	16.25	0.20%	124,152
NSTAR	Group 2011 Dual	Electric	8,451	-	7,031	39.37	0.56%	132,707
NSTAR	Group 2012a	Electric	55,857	13,027	13,041	281.68	2.16%	15,381,055
NSTAR	Group 2012b	Electric	17,033	11,388	11,085	228.36	2.06%	3,761,491
NSTAR	Group 2013	Electric	37,801	8,423	11,869	153.11	1.29%	5,467,905
NSTAR	Group 2013b	Electric	65,798	-	6,427	71.98	1.12%	4,448,962
NSTAR	Group 2013 Dual	Electric	20,991	-	6,876	107.95	1.57%	915,705
NSTAR	Group 2014	Electric	78,637	-	6,780	53.56	0.79%	2,868,936
NSTAR	Gas Group 2010 Dual	Gas	24,345	102.2	128.92	2.08	1.61%	39,059
NSTAR	Gas Group 2011 Dual	Gas	24,689	89.6	114.51	1.90	1.66%	35,002
NSTAR	Attrition Refill 2013	Gas	38,411	65.5	90.73	0.67	0.74%	21,771
NSTAR	Gas Group 2013 Dual	Gas	20,943	-	73.66	0.78	1.06%	13,693
WMECo	Group 2014	Electric	113,782	-	7,645	67.28	0.88%	6,661,450

Source: Evaluation team analysis

**All savings estimates are after channeling adjustment.*

3. MAPPING ANALYSIS

The objective of the mapping analysis was to identify the overlap between different program cohorts, providing frequency counts of households participating in multiple program cohorts.

The evaluation team identified 69,697 instances of overlapping programs, which is approximately 3% of all customers (treatment and control) in the National Grid and Eversource Energy HER cohorts. Table 3 presents the four categories of overlapping programs, household counts, and a discussion regarding the implications for evaluation. The overlap is generally small and is not expected to impact cohort-specific savings analysis using standard evaluation methods.

Table 3. Mapping Analysis Results

Dual Treatment	
Definition	Households assigned to a treatment group for both fuel-types across PAs or program-cohorts, excluding those who are assigned to a dual fuel cohort.
Household Count	20,909 (0.9% of all HER households)
Implications	Assuming the prevalence of electric treatment households being simultaneously treated for gas by a different PA is consistent with the prevalence of electric control households being treated for gas by a different PA (and vice versa), standard evaluation methods result in unbiased savings estimates. Given the limited number of overlapping households relative to the program population, these differences are not expected to impact cohort-specific savings analysis using standard evaluation methods. However, there may be synergistic effects associated with receiving a report for both fuel-types, potentially increasing or decreasing savings relative to if the programs did not overlap. In the cross-fuel savings analysis, the Navigant team will assess whether there are synergistic effects informing the implementation of the program in the future years. Most of these households (97.6%) were assigned to two treatment groups for different PAs (for example a gas report from NSTAR and an electric report from National Grid); this is to be expected since these programs are run, from the implementer's point of view, in isolation. However, a few households are assigned to two treatment groups for the same PA (an electric and gas report from NSTAR). Although the occurrence of households in two treatment groups for the same PA is of no additional concern from an evaluation perspective, the Navigant team recommends that the PAs follow-up with the program implementer to eliminate this overlap going forward.
Treatment – Control	
Definition	Households assigned to a treatment group for one fuel-type and a control group for another across PAs or program-cohorts
Household Count	8,841 (0.4% of all HER households)
Implications	Assuming the prevalence of electric treatment households being simultaneously assigned to a gas control group is consistent with the prevalence of electric control households being simultaneously assigned to a gas control group (and vice versa), standard evaluation methods result in unbiased savings estimates. Given the limited number of overlapping households relative to the program population, these differences are not expected to impact cohort-specific savings analysis using standard evaluation methods. However, if there are cross-fuel effects (e.g., gas savings when receiving electric HERs), average usage for the gas control group may be higher or lower than it otherwise would be. In the cross-fuel savings analysis, the Navigant team will assess whether there are cross-fuel effects informing the implementation of the program in future years.
Treatment – Control, Single Fuel-Type	
Definition	Households assigned to a treatment group *and* a control group for the same fuel-type by the same PA
Household Count	39,612 (1.7% of all HER households)
Implications	The majority of this category (99.5%) is attributed to National Grid purposefully reducing the size of early-cohort control groups by re-assigning households to later-cohort treatment groups. Due to the temporal nature of this reassignment, this is not true overlap in that a customer is not simultaneously in a treatment and control group. However, this intentional reassignment can be a cause for concern if the treatment and control groups become inconsistent with random assignment. Randomization of some of the early cohorts from which controls were pulled was affected, though the evaluation methodology appropriately accounts for observable differences between the treatment and control groups in the pre-program period. In the future, if customers are re-assigned, the evaluation team recommends that the randomization should be re-validated prior to implementation. The remaining 181 households in this category have been erroneously assigned to a treatment and control group for the same fuel-type and simultaneously exist in both groups. Due to the small number of households in this category relative to program populations, the overlap is of limited concern for the impact evaluation. However, the Navigant team recommends that the PAs follow-up with the program implementer to eliminate this overlap going forward.
Dual Treatment, Single Fuel-Type	
Definition	Households assigned to multiple treatment groups for the same fuel-type by the same PA
Household Count	335 (0.01% of all HER households)
Implications	These are customers who have, for some reason, been assigned to two treatment groups for the same fuel and who are, presumably, receiving two HERs. It is unclear how this overlap occurred. Due to the small number of households in this category relative to program populations, the overlap is of limited concern for the impact evaluation. However, the Navigant team recommends that the PAs follow-up with the program implementer to eliminate this overlap going forward.

Source: Evaluation team analysis

4. DUAL TREATMENT ANALYSIS

This analysis compared electric and gas savings for dual-fuel customers (those who are in a dual-fuel cohort and receive a single report which covers both fuel types) and dual-treatment customers (those who are assigned to a treatment group for both fuel types across PAs or program-cohorts and received two single-fuel reports) for National Grid and Eversource Energy.[5] The goal of this study was to determine if there were statistically significant differences in savings for customers receiving a single dual-fuel report as compared to those receiving two single-fuel reports.

The four dual-fuel cohorts included 61,518 treatment customers who receive a single dual-fuel report. The evaluation team identified 20,909 dual-treatment customers receiving two single-fuel reports in the mapping analysis.

Key findings and recommendations from this analysis included the following:

- Table 4 summarizes the per customer savings by report regime and fuel type. On the electric side, dual-fuel customers saved 1.10% and dual-treatment customers saved 1.41%; this difference was statistically significant at the 90% confidence level (p-value = 0.042). On the gas side, dual-fuel customers saved 1.44% and dual-treatment customers saved 1.24%; this difference was not statistically significant at the 90% confidence level (p-value = 0.882).

Table 4. Summary of Per Customer Savings

Report Regime	Fuel Type	Percentage Savings	Per Customer Annual Savings (kWh/therms)	Per Customer Annual Baseline Usage (kWh/therms)*	Per Customer Annual Savings (MMBTU)
Dual-Fuel	Electric	1.10%	75.11	6,838	0.256
Dual-Treatment	Electric	1.41%	124.68	8,823	0.425
Dual-Fuel	Gas	1.44%	14.41	997	1.441
Dual-Treatment	Gas	1.24%	14.81	1,195	1.481

Source: Evaluation team analysis
*Differences in baseline usage for the two report groups cause the discrepancies in the magnitudes of the absolute and percentage savings.

- Table 5 summarizes total annual savings under the current report configuration (61,518 dual-fuel customers and 20,909 dual-treatment customers) and annual savings if program implementation was modified such that all customers were either dual-fuel or dual-treatment. Coordination across PAs such that all customers received dual-fuel reports would result in a net gain of approximately 3,000 MMBTU or a 2% increase in savings for this group of customers. In total, the HER program saved just over one million MMBTU in 2014, thus this coordination would only increase total program savings by approximately 0.3%.[6]

[5] ***Dual-fuel customers*** are defined as households in a dual-fuel cohort for either National Grid or Eversource Energy; these households receive a single report which covers both fuel types. ***Dual-treatment customers*** are defined as households assigned to a treatment group for both fuel types across PAs or program-cohorts; these households receive two single-fuel reports.
[6] Total savings for the HER program were presented to the PAs in a memo titled "Massachusetts Cross-Cutting Behavioral Program Evaluation Opower Results" on June 25, 2015.

Table 5. Summary of Total Savings

Report Regime	Total Savings (MMBTU)	90% Confidence Bounds	Difference from Current Configuration (MMBTU)	Percent Difference from Current Configuration
Current Configuration	144,241	[116,838 – 171,644]	-	-
All Dual-Fuel	147,393	[123,742 – 171,044]	+3,152	+2%
All Dual-Treatment	136,151	[99,635 – 172,667]	-11,242	-8%

Source: Evaluation team analysis

- The evaluation team's process evaluation analyzed whether there were differences in satisfaction between dual-fuel and dual-treatment customers.[7] Cross-PA customers (a subset of dual-treatment customers who receive electric reports from one PA and gas reports from another[8]) were satisfied with the frequency at which they currently receive reports and they found the reports just as useful as dual-fuel customers.

- Given that the total increase in annual MMBTU savings from switching all customers to dual-fuel reports was small and not statistically significant at the 90% confidence level and the process evaluation showed that receiving multiple single-fuel reports was not an issue for cross-PA customers (the vast majority of dual-treatment customers), the evaluation team does not believe that coordination across the PAs is warranted and recommends that the PAs continue implementing the HER program in its current form.

[7] Navigant Consulting, Inc. and Illume Advising, LLC. 2015. *Massachusetts Behavioral Programs Process Evaluation: Report in the Cross-Cutting Research Areas of Behavior and Education.* Prepared for the Massachusetts Program Administrators and the Energy Efficiency Advisory Council.

[8] The remaining dual treatment customers received a gas report and an electric report from the same PA. Of all the dual-treatment customers, 97.6% were cross-PA customers and only 2.4% received two reports from the same utility.

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APPENDIX A. COHORT-SPECIFIC ANALYSIS

To: Massachusetts Program Administrators (PAs) and Energy Efficiency Advisory Council (EEAC)

From: Navigant Consulting, Inc. and Illume Advising, LLC.

Date: March 9, 2015 (reissued June 25, 2015)

Re: Massachusetts Cross-Cutting Behavioral Program Evaluation Opower Results

Executive Summary

This memo was developed by the "evaluation team", including Navigant Consulting, Inc. (Navigant), the prime contractor, and Illume Advising, LLC. (ILLUME) to present results for the impact evaluation of the Home Energy Report (HER) programs for the Massachusetts Cross-Cutting Research in Behavior and Education. In particular, this memo presents results for National Grid and Eversource Energy (formerly NSTAR and Western Massachusetts Electric Company (WMECo)).

National Grid and NSTAR have long-standing HER programs, with both companies dramatically expanding their behavioral programs since the launch of the first program by National Grid in 2009. The last impact evaluation of the HER programs was completed for the 2012 program year and the last process evaluation was completed in 2011.

As of the end of 2014, there were a total of thirty-one evaluable cohorts in the Massachusetts HER programs. This includes fifteen electric cohorts (nine for National Grid, five for NSTAR, and one for WMECo), eight gas cohorts (seven for National Grid and one for NSTAR), and four dual fuel cohorts (one for National Grid and three for NSTAR).

Key Findings

- Total net electric savings from the Massachusetts HER programs are 127,854,643 kWh. Total net gas savings are 643,157 MMBtu.
- The evaluation team recommends that the PAs adopt the following savings estimate ratios[9] in future years when third-party impact evaluations are not completed.
    - National Grid Electric: 95%
    - National Grid Gas: 98%
    - NSTAR Electric: 104%
    - NSTAR Gas: 98%
    - WMECo Electric: 104%

[9] The saving estimate ratio is the calculated by dividing the modeled savings estimated by the evaluation team by the savings estimated by Opower.

Methodology

This section presents the methodology used for: (1) impact evaluation, (2) channeling analysis and (3) calculation of savings estimate ratios.

Impact Evaluation Methods

The evaluation team conducted multiple analyses to determine cohort-specific savings, including the post-program regression (PPR) and linear fixed effects regression (LFER) models. The PPR model combines both cross-sectional and time series data in a panel dataset. This model uses only the post-program data, with lagged energy use for the same calendar month of the pre-program period acting as a control for any small systematic differences between the participant and control customers. In particular, energy use in calendar month *t* of the post-program period is framed as a function of both the participant variable and energy use in the same calendar month of the pre-program period. The underlying logic is that systematic differences between participants and controls will be reflected in differences in their past energy use, which is highly correlated with their current energy use. The version we estimate includes monthly fixed effects and interacts these monthly fixed effects with the pre-program energy use variable. These interaction terms allow pre-program usage to have a different effect on post-program usage in each calendar month.

Formally, the model is,

Model 1. PPR Model

$$ADC_{kt} = \sum_{J} \beta_{1j} Month_{jt} + \sum_{J} \beta_{2j} Month_{jt} \cdot ADClag_{kt} + \beta_3 Participant_k + \varepsilon_{kt} ,$$

where,

ADC_{kt}	= The average daily consumption in kWh or therms for customer *k* during billing cycle *t*. This is the dependent variable in the model;
$Month_{jt}$	= A binary variable taking a value of 1 when *j=t* and 0 otherwise;[10]
$ADClag_{kt}$	= Customer *k*'s energy use in the same calendar month of the pre-program year as the calendar month of month *t*;
$Participant_k$	= A binary variable indicating whether customer *k* is in the participant group (taking a value of 1) or in the control group (taking a value of 0);
ε_{kt}	= The cluster-robust error term for customer *k* during billing cycle *t.* Cluster-robust errors account for heteroscedasticity and autocorrelation at the customer level.[11]

[10] If there are *T* post-program months, there are *T* monthly dummy variables in the model, with the dummy variable $Month_{tt}$ the only one to take a value of 1 at time t. These are, in other words, monthly fixed effects.

In this model, β_3 is the estimate of average daily energy savings due to the program. Program savings are the product of the average daily savings estimate and the total number of participant-days in the analysis.

To test the robustness of the savings estimate to model specification, the evaluation team also estimated savings using the standard regression approach for estimating electricity savings for a Randomized Controlled Trial (RCT), a linear fixed effects regression (LFER) model. Until the most recent advances in this field using the PPR approach, the LFER approach was viewed as the most appropriate regression approach for RCT programs. According to both LBNL (2012) and a M&V white paper produced by the Brattle Group (2011), this approach was the preferred method for the evaluation of the energy use impacts of behavioral programs.[12] Moreover, it has been used in the academic literature to evaluate other HER programs, and has been used in all evaluations of HER programs done by Navigant as a robustness check on the newer PPR method.[13]

The simplest version of a LFER model, the One-Way LFER model, is one in which average daily consumption of kWh by customer *k* in bill *t*, denoted by ADC_{kt}, is a function of two variables: the binary variable $Treatment_k$, taking a value of 1 if household *k* is assigned to the treatment group, and 0 otherwise; and the binary variable $Post_t$, taking a value of 0 if the observation *t* is before the *program start date* and 1 if the observation is after the program start date.

Formally, the model is,

Model 2. One-Way LFER Model

$$ADC_{kt} = \alpha_{0k} + \alpha_1 Post_t + \alpha_2 Treatment_k \cdot Post_t + \varepsilon_{kt}.$$

Three observations about this specification deserve comment. First, the coefficient α_{0k} captures *all* customer-specific effects on energy use that do not change over time, including those that are unobservable. Second, α_1 captures the average effect among control customers of being in the post treatment period. In other words, it captures the effects of exogenous factors, such as an economic recession, that affect control customers in the post treatment period but not in the pre-treatment period. Third, $\alpha_1 + \alpha_2$ captures the average effect among treatment customers of being in the post treatment

[11] Ordinary Least Squares (OLS) regression models assume that the data are homoscedastic and not autocorrelated. If either of these assumptions is violated, the resulting standard errors of the parameter estimates are incorrect (usually underestimated). A random variable is heteroscedastic when the variance is not constant. A random variable is autocorrelated when the error term in one period is correlated with the error terms in at least some of the previous periods.

[12] LBNL 2012: *Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations*. Prepared by A. Todd, E. Stuart, S. Schiller, and C. Goldman, Lawrence Berkeley National Laboratory. 2012. http://behavioranalytics.lbl.gov.
Brattle Group 2011: *Measurement and Verification Principles for Behavior-Based Efficiency Programs.* Sanem Sergici and Ahmad Fauqui. 2011.

[13] For examples of academic applications of the approach to energy behavioral programs see:
Alcott, Hunt. "Social Norms and Energy Conservation", Working paper, Massachusetts Institute of Technology (MIT), Cambridge, MA, 2009.
Ayres, I., S. Raseman and A. Shih. "Evidence from Two Large Field Experiments that Peer Comparison Feedback Can Reduce Residential Energy Usage", NBER working paper no. 15386, September 2009.
Costa, D.L. and M.E. Kahn. "Energy Conservation "Nudges" and Environmentalist Ideology: Evidence from a Randomized Residential Electricity Field Experiment", NBER working paper no. 15939, April 2010.

period, and so for these households the effect directly attributable to the program is captured by the coefficient α_2.

Both the PPR and LFER models produce unbiased estimates of the program effect. The evaluation team recommends reporting out results from the PPR model as this model has been shown in past studies to have slightly smaller standard errors on average.

Channeling Analysis Methods

There are two goals to cross-program participation channeling analysis: (1) to document the lift in other program participation due to the behavioral program treatment (participant lift), and (2) to remove the savings co-generated by behavioral and standard programs in order to avoid double counting savings across the portfolio at the program and measure level (savings adjustment).

For this evaluation, it was not possible to do a data-based channeling analysis to document the participant lift or savings adjustment due to the timing of the collection of the program tracking data which is typically not available until several months after year-end. Complete and reconciled program tracking for 2014 will be available later in 2015. Consequently, the evaluation team applied a channeled savings adjustment based on historical data as reported in the last behavioral evaluation report.[14] The last evaluation report cross-referenced utility program databases to calculate the difference in tracked participation in other energy efficiency programs between the treatment and control groups. These differences are the savings that can be attributed to both the HER program and other utility programs.

Using historical values can introduce uncertainty into the estimates. This analysis attempts to minimize the uncertainty by using the most general estimate possible. The team estimated channel savings impacts by taking a weighted average by fuel type of channel impacts for all National Grid and NSTAR cohorts for all program years reported in the 2013 evaluation report. The calculations used each program year's cohort participants as weights.

As shown in the Appendix, the electric weighted averages included 15 cohort-program year groups. Two cohorts spanned three years, two spanned two years, while the remaining five cohorts included only one year of implementation. The gas weighted averages included 15 cohort-program year groups with two cohorts spanning three years, three cohorts spanning two years and the remaining three cohorts comprising one year each.

The channel savings adjustments shown in Table 1 were applied by fuel type to all 2014 NGRID, NSTAR and WMECo cohorts.

[14] Opinion Dynamics Corporation, Navigant Consulting, and Evergreen Economics (2013). Massachusetts Cross-Cutting Behavioral Program Evaluation Integrated Report. Refer to section 3.1.1 for the channeling analysis methodology.

Table 1. Historical Weighted Average Channeling Impacts

Fuel- Type	Number of Cohort-Year Groups	Total Number of Participants	Historical Weighted Average % of HH Baseline Usage Saved by Channeling Impacts
Electric	15	711,923	0.075%
Gas	16	613,006	0.053%

Savings Estimate Ratio Calculation Methods

The evaluation team calculated savings estimate ratio for each of the HER program cohorts to examine the differences in savings as measured by the program implementer and the savings verified by our evaluation. For the individual cohorts, the savings estimate ratio is the ratio of estimated savings to the implementer-reported estimates as shown in Equation 1.

Equation 1. Savings Estimate Ratio by Cohort

$$RR_{ucf} = \frac{\text{Evaluation Team Estimated Savings}_{ucf}}{\text{OPOWER Reported Savings}_{ucf}}$$

Where,

RR_{ucf} = The savings estimate ratio for PA *u*, cohort *c*, and fuel-type *f*.

The evaluation team also calculated aggregate savings estimate ratios for each PA and fuel-type. To do this, for each PA and fuel-type we calculated the ratio of total estimated savings from the relevant cohorts to total implementer-reported estimates for the relevant cohorts, as shown in Equation 2. The evaluation team calculated individual cohort and aggregate savings estimate ratios before and after adjusting the estimated savings for channeling.

Equation 2. Aggregate Savings Estimate Ratio by PA and Fuel-Type

$$RR_{uf} = \frac{\sum_{c=1}^{C} \text{Evaluation Team Estimated Savings}_{ucf}}{\sum_{c=1}^{C} \text{OPOWER Reported Savings}_{ucf}}$$

Where,

RR_{uf} = The aggregate realization rate for PA *u* and fuel-type *f*.

The evaluation team recommends an approach for applying a savings estimate ratio by PA and fuel type to be used in future years to adjust implementer-reported savings when third-party impact evaluations do not take place.

Results

This section presents (1) impact evaluation results and (2) savings estimate ratio results.

Impact Evaluation Results

Table 2 presents detailed savings estimates for each cohort after the adjustment from the channeling analysis. Baseline usage is presented as both the value in the current TRM[15] and the value from the data for this analysis. A '-' in the TRM Baseline column indicates that the cohort does not have a baseline usage value listed in the TRM.

Two cohorts, NSTAR Group 2010 Dual and NSTAR Group 2011 Dual, have relatively low electric percentage savings estimates, 0.15% and 0.49% respectively. These two groups are relatively small (18,660 and 8,451 treatment customers respectively) and only started receiving dual fuel reports in July 2014. Given that these are estimates of savings after just six months, it is not surprising that these savings estimates are low and it is likely that percentage savings will increase for these cohorts going forward.

Table 2. Savings Estimates after Channeling Adjustment, by Cohort

PA	Cohort Name	Fuel-Type	Total Number of Participants	TRM Baseline Usage (kWh/MMBtu)	Modelled Baseline Usage (kWh/MMBtu)	Average Annual Savings per Customer (kWh/MMBtu)*	Percentage Savings*	Total Savings (kWh/MMBtu)*
NGRID	Group 2009	Electric	24,005	11,233	10,669	252.85	2.37%	5,116,541
NGRID	Group 2010	Electric	65,170	12,370	11,815	186.68	1.58%	11,993,567
NGRID	Group 2010 Added	Electric	23,805	15,232	14,682	340.62	2.32%	6,772,880
NGRID	Group 2011	Electric	99,446	9,638	9,415	236.32	2.51%	18,673,469
NGRID	Group 2011 Added	Electric	60,605	6,121	5,986	93.99	1.57%	4,184,350
NGRID	Group 2012	Electric	86,898	6,126	6,003	135.41	2.20%	1,430,655
NGRID	Group 2012 Dual	Electric	12,621	6,239	6,155	93.64	1.56%	5,974,252
NGRID	Group 2013	Electric	324,002	8,036	8,053	105.50	1.31%	28,469,571
NGRID	Group 2013 Email	Electric	46,105	-	7,082	35.41	0.50%	1,443,224
NGRID	Group 2014	Electric	94,874	7,093	7,303	65.72	0.90%	4,033,771
NGRID	Group 2009	Gas	24,790	127.20	139.97	2.09	1.49%	43,727
NGRID	Group 2010	Gas	75,911	31.28	147.01	2.75	1.87%	172,435
NGRID	Group 2011	Gas	100,321	92.90	103.25	1.16	1.12%	86,660
NGRID	Group 2011 Add	Gas	25,673	19.44	86.94	1.03	1.19%	19,356
NGRID	Group 2012	Gas	86,279	81.00	86.73	1.54	1.77%	96,009
NGRID	Group 2012 Dual	Gas	13,416	84.20	95.91	1.05	1.09%	11,553
NGRID	Group 2013	Gas	149,442	76.18	82.67	0.74	0.89%	89,334
NGRID	Group 2014	Gas	49,741	-	112.27	0.92	0.82%	14,558
NSTAR	Group 2010 Dual	Electric	18,660	-	8,127	16.25	0.20%	124,152
NSTAR	Group 2011 Dual	Electric	8,451	-	7,031	39.37	0.56%	132,707
NSTAR	Group 2012a	Electric	55,857	13,027	13,041	281.68	2.16%	15,381,055

[15] Massachusetts Technical Reference Manual. 2013-2015 Program Years.

NSTAR	Group 2012b	Electric	17,033	11,388	11,085	228.36	2.06%	3,761,491
NSTAR	Group 2013	Electric	37,801	8,423	11,869	153.11	1.29%	5,467,905
NSTAR	Group 2013b	Electric	65,798	-	6,427	71.98	1.12%	4,448,962
NSTAR	Group 2013 Dual	Electric	20,991	-	6,876	107.95	1.57%	915,705
NSTAR	Group 2014	Electric	78,637	-	6,780	53.56	0.79%	2,868,936
NSTAR	Gas Group 2010 Dual	Gas	24,345	102.2	128.92	2.08	1.61%	39,059
NSTAR	Gas Group 2011 Dual	Gas	24,689	89.6	114.51	1.90	1.66%	35,002
NSTAR	Attrition Refill 2013	Gas	38,411	65.5	90.73	0.67	0.74%	21,771
NSTAR	Gas Group 2013 Dual	Gas	20,943	-	73.66	0.78	1.06%	13,693
WMECo	Group 2014	Electric	113,782	-	7,645	67.28	0.88%	6,661,450

Source: Evaluation team analysis

*All savings estimates are after channeling adjustment.

Savings Estimate Ratio Results

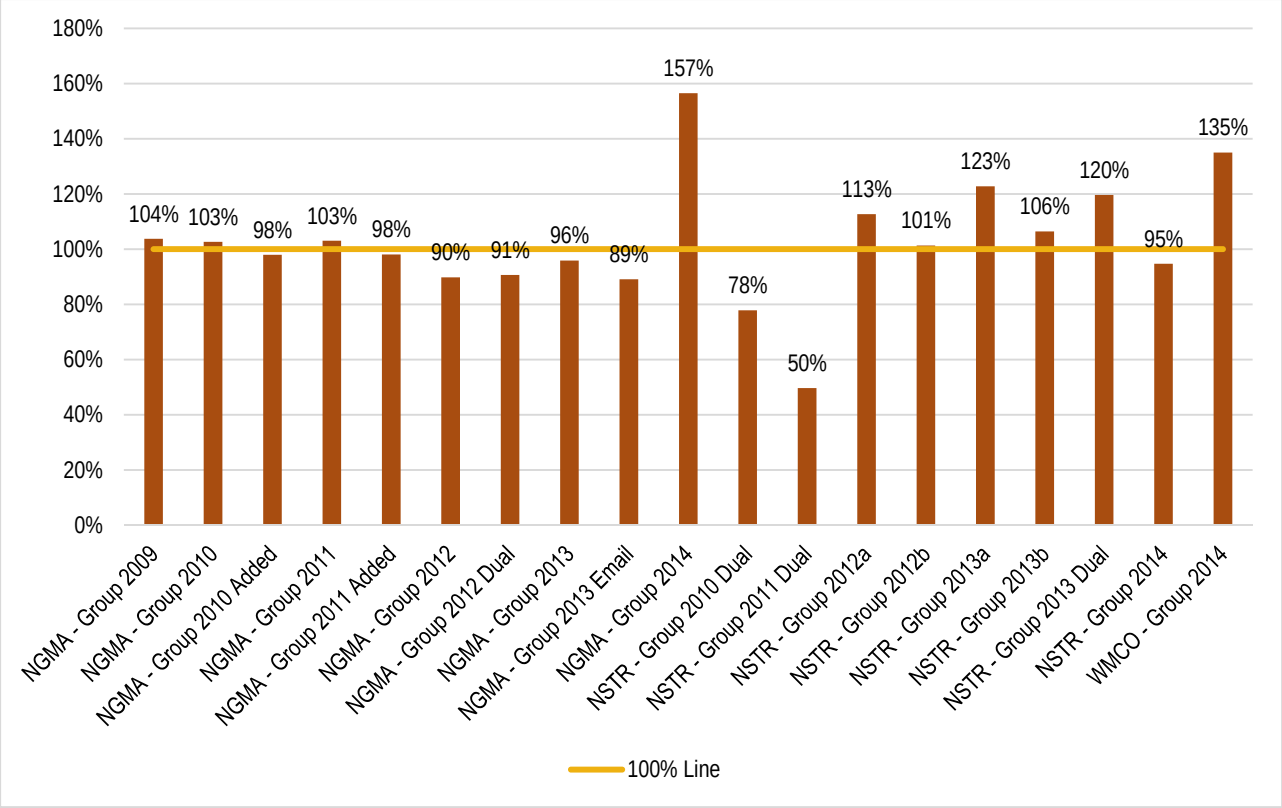
The evaluation team first presents cohort-specific savings estimate ratios followed by aggregate savings estimate ratio by PA and fuel-type.

Cohort-Specific Savings Estimate Ratio Results

Figure 1 and Figure 2 show the savings estimate ratios for each of the electric cohorts. Figure 1 is before the savings adjustment from the channeling analysis, and Figure 2 is after. Two cohorts, NSTAR Group 2010 Dual and NSTAR Group 2011 Dual, have lower savings estimate ratios than expected, 78% and 50% before channeling respectively. These two groups are relatively small (18,660 and 8,451 treatment customers respectively) and only started receiving dual fuel reports in July 2014. Given the small amount of data for these two cohorts, it is not surprising that small differences in modeling between the evaluation team and Opower result in large differences in the savings estimate ratios. Two cohorts, National Grid Group 2014 and WMECo Group 2014, have relatively high savings estimate ratios, 157% and 135% before channeling respectively. However, these savings estimate ratios are not outside the bounds found for first year electric cohorts in previous evaluations of this program.[16]

[16] Opinion Dynamics Corporation, Navigant Consulting, and Evergreen Economics (2013). Massachusetts Cross-Cutting Behavioral Program Evaluation Integrated Report.

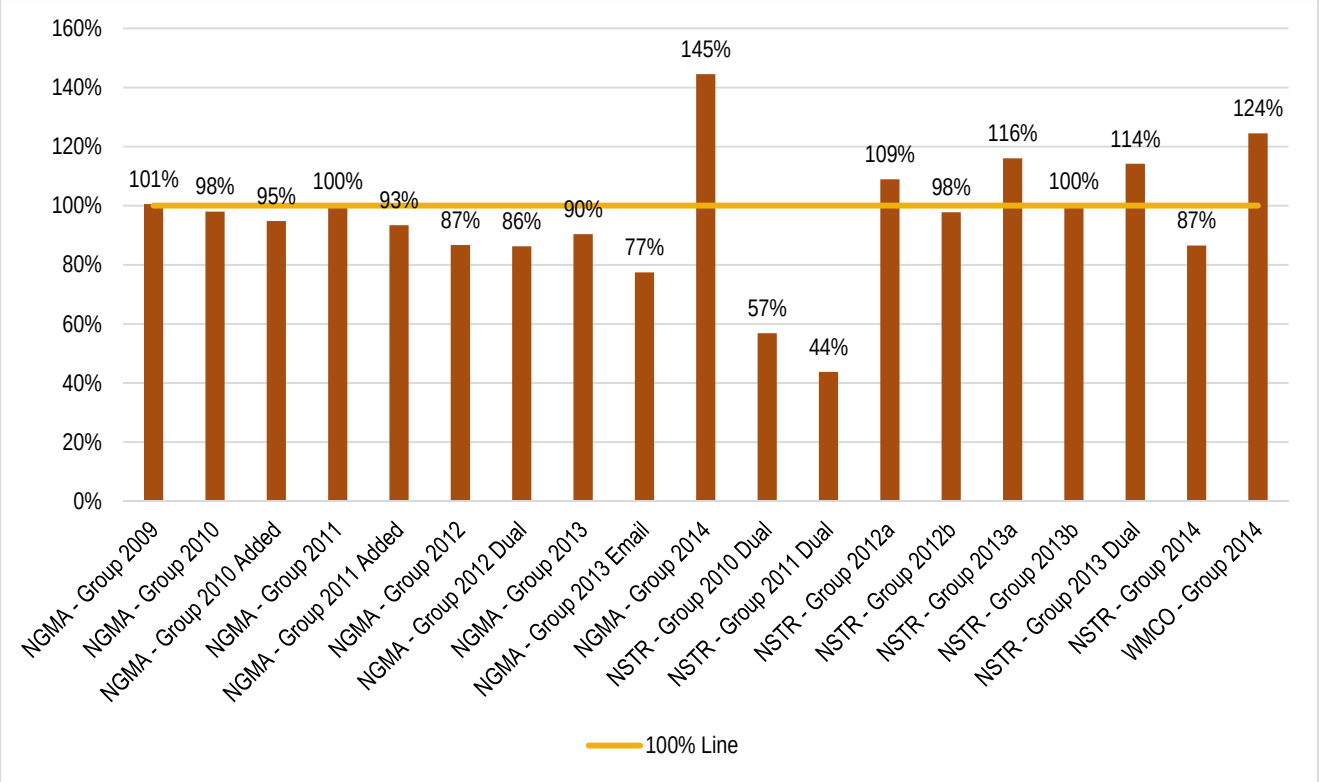
Figure 1. Electric Savings Estimate Ratios before Channeling Adjustment, by Cohort



Source: Evaluation team analysis

NGMA is National Grid Massachusetts, NSTR is NSTAR, and WMCO is WMECo.

Figure 2. Electric Savings Estimate Ratios after Channeling Adjustment, by Cohort

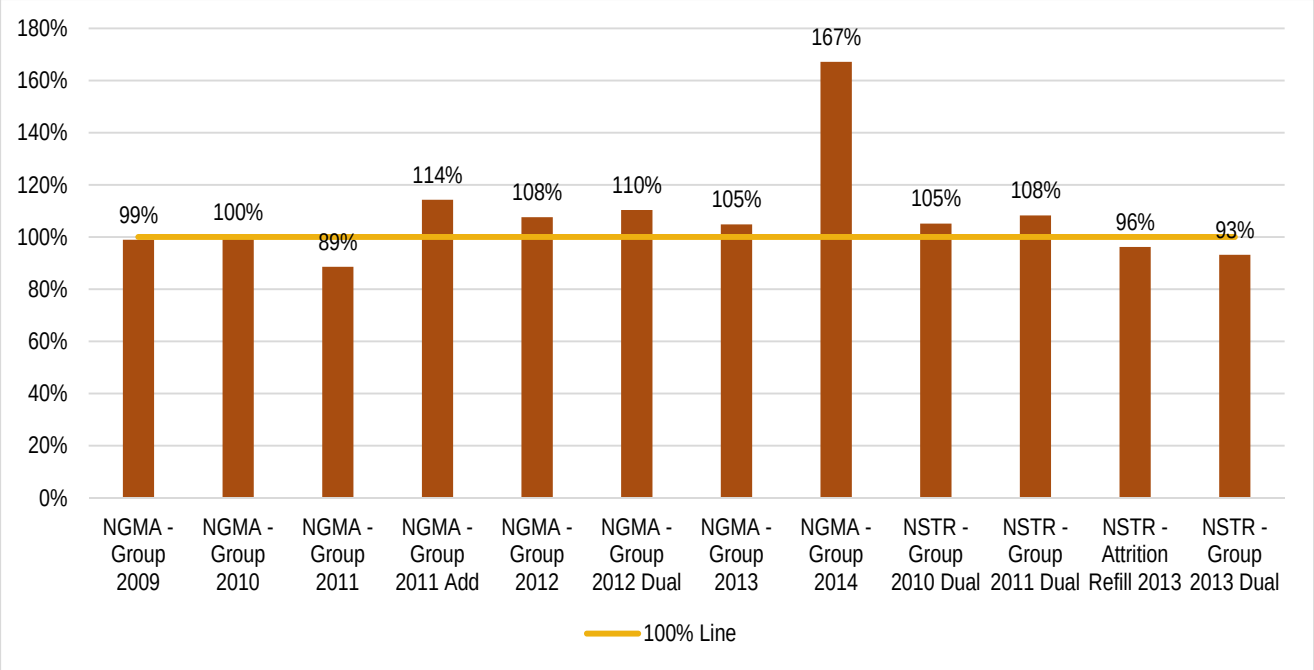


Source: Evaluation team analysis
NGMA is National Grid Massachusetts, NSTR is NSTAR, and WMCO is WMECo.

Figure 3 and Figure 4 show the savings estimate ratios for each of the gas cohorts. Figure 3 is before the savings adjustment from the channeling analysis, and Figure 4 is after. One cohort, National Grid Group 2014, has a relatively high savings estimate ratio of 167% before channeling. However, this savings estimate ratio is not outside the bounds found for first year gas cohorts in previous evaluations of this program.[17]

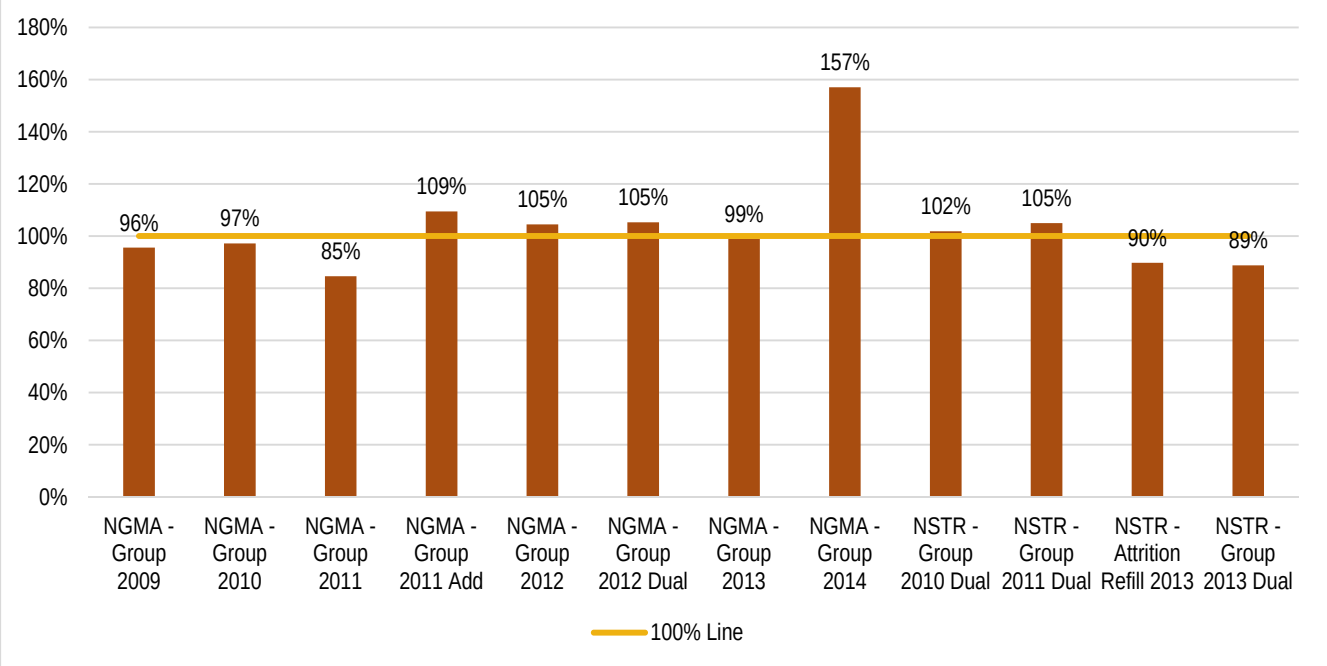
[17] Opinion Dynamics Corporation, Navigant Consulting, and Evergreen Economics (2013). Massachusetts Cross-Cutting Behavioral Program Evaluation Integrated Report.

Figure 3. Gas Savings Estimate Ratios before Channeling Adjustment, by Cohort



Source: Evaluation team analysis
NGMA is National Grid Massachusetts, NSTR is NSTAR, and WMCO is WMECo.

Figure 4. Gas Savings Estimate Ratios after Channeling Adjustment, by Cohort

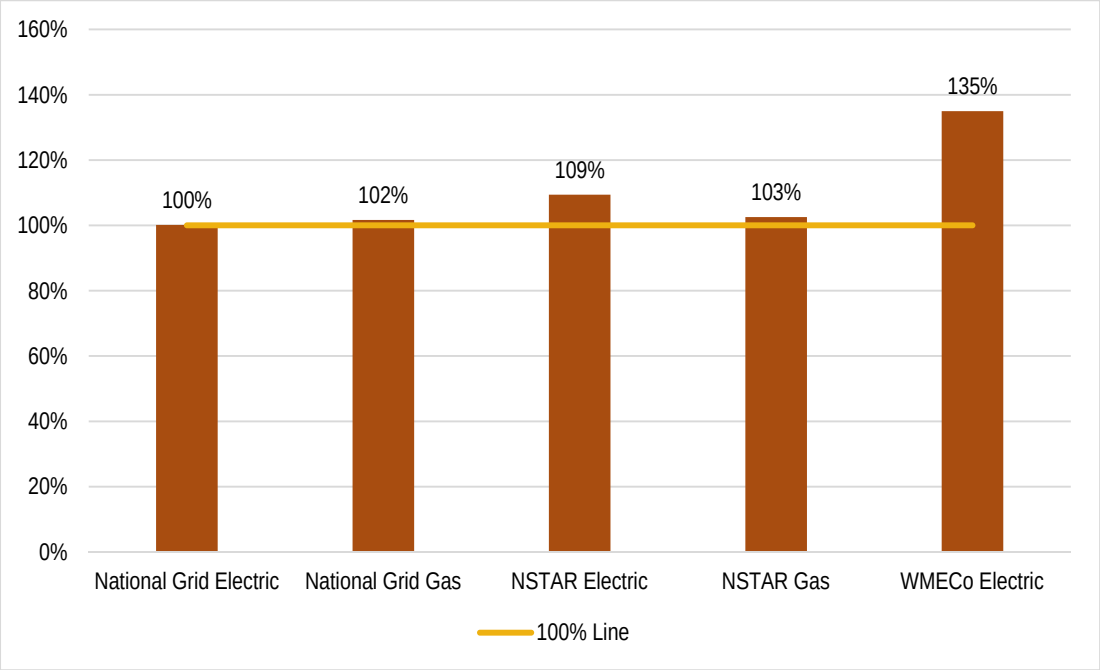


Source: Evaluation team analysis
NGMA is National Grid Massachusetts, NSTR is NSTAR, and WMCO is WMECo.

Aggregate Savings Estimate Ratio Results

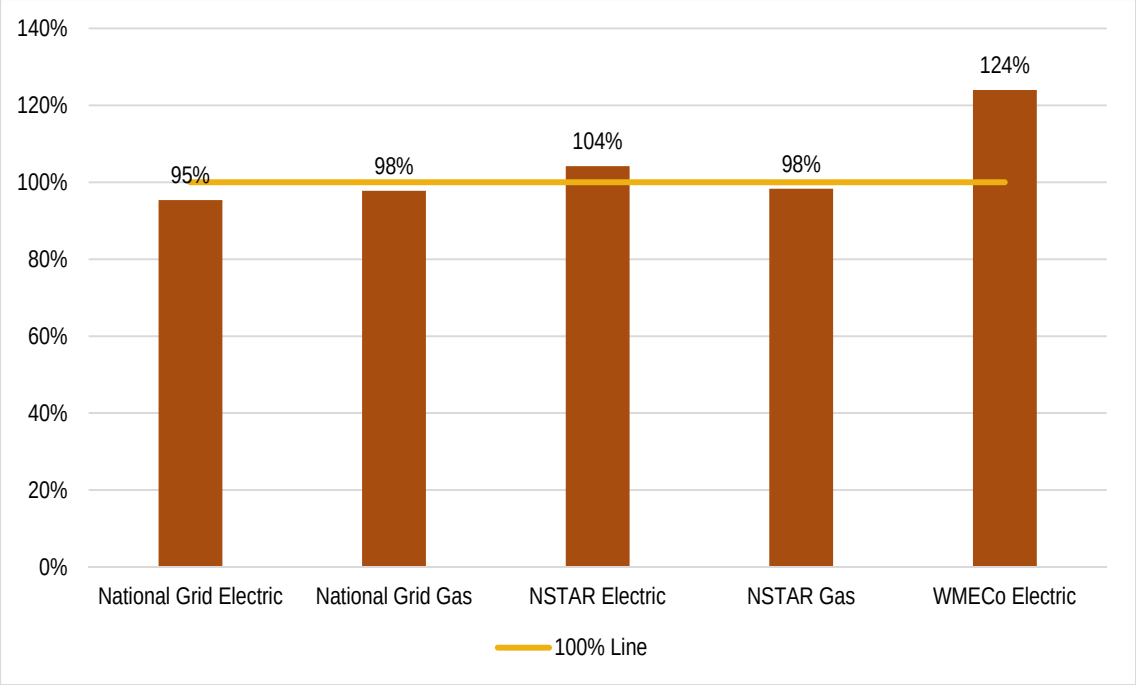
Figure 5 and Figure 6 show the aggregate savings estimate ratio for each PA and fuel-type. Figure 5 is before the savings adjustment from the channeling analysis, and Figure 6 is after. Note, because WMECo only has one cohort, the aggregate savings estimate ratio is equivalent to the cohort-specific savings estimate ratio.

Figure 5. Aggregate Savings Estimate Ratio before Channeling Adjustment, by PA and Fuel-Type



Source: Evaluation team analysis

Figure 6. Aggregate Savings Estimate Ratio after Channeling Adjustment, by PA and Fuel-Type



Source: Evaluation team analysis

Recommended Approach for Applying Savings Estimate Ratio for HER Program

The evaluation team recommends applying the savings estimate ratios presented in Table 3 in future years when third-party impact evaluations do not occur. These ratios should remain in effect until they are supplanted by a future impact evaluation.

Table 3. Savings Estimate Ratio

PA	Fuel Type	Savings Estimate Ratio
National Grid	Electric	95%
National Grid	Gas	98%
NSTAR	Electric	104%
NSTAR	Gas	98%
WMECO	Electric	104%

The evaluation team recommends that National Grid and NSTAR adopt the aggregate savings estimate ratio after channeling as presented in Figure 6 above. For WMECo, the evaluation team recommends applying the NSTAR Electric aggregate savings estimate ratio for use in future years. Given that the calculated savings estimate ratio for WMECo is based on only a partial year of program implementation, it may be inappropriate to apply in future years. In particular, the calculated savings estimate ratio may over-estimate savings due to first year ramping typical of HER programs.

Appendix. Historic Channeled Savings Estimates

Table A-1. Electric Channeled Savings Estimate

PA	Cohort Name	Program Year	Total Number of Participants	% per HH incremental savings from other programs
NSTAR	Wave 3	Y1	59,030	0.24%
NSTAR	Wave 4	Y1	17,514	0.23%
NGRID	2009	Y1	24,853	0.00%
NGRID	2009	Y2	23,309	0.00%
NGRID	2009	Y3	21,155	0.17%
NGRID	2010	Y1	68,194	0.06%
NGRID	2010	Y2	67,980	0.10%
NGRID	2010	Y3	62,305	0.01%
NGRID	2010 Add	Y1	23,427	0.05%
NGRID	2010 Add	Y2	21,224	0.22%
NGRID	2011	Y1	94,322	0.00%
NGRID	2011	Y2	82,417	0.06%
NGRID	2011 Add	Y1	55,055	0.08%
NGRID	2012 DF	Y1	12,074	0.06%
NGRID	2012	Y1	79,064	0.05%
			Weighted Average	**0.075%**

Source: Opinion Dynamics Corporation, Navigant Consulting, and Evergreen Economics (2013). Massachusetts Cross-Cutting Behavioral Program Evaluation Integrated Report.

Table A-2. Gas Channeled Savings Estimate

PA	Cohort Name	Program Year	Total Number of Participants	% per HH incremental savings from other programs
NSTAR	Wave 1	Pilot Y1	23,247	0.00%
NSTAR	Wave 1	Y1	22,840	0.04%
NSTAR	Wave 1	Y2	21,599	0.01%
NSTAR	Wave 2	Y1	22,108	0.03%
NSTAR	Wave 2	Y2	20,415	0.03%
NGRID	2009	Y1	24,994	0.00%
NGRID	2009	Y2	23,685	0.00%
NGRID	2009	Y3	19,408	0.19%
NGRID	2010	Y1	74,759	0.00%
NGRID	2010	Y2	69,750	0.18%
NGRID	2011	Y1	87,691	0.00%
NGRID	2011	Y2	80,472	0.16%
NGRID	2011 Add	Y1	25,048	0.00%
NGRID	2011 DF	Y1	13,052	0.04%
NGRID	2012	Y1	83,938	0.005%
			Weighted Average	**0.053%**

Source: Opinion Dynamics Corporation, Navigant Consulting, and Evergreen Economics (2013). Massachusetts Cross-Cutting Behavioral Program Evaluation Integrated Report.

APPENDIX B. MAPPING ANALYSIS

To: Massachusetts Program Administrators and the Energy Efficiency Advisory Council

From: Navigant Consulting and ILLUME Advising

Date: March 25, 2015

Re: Cross-Cutting Research: Behavior Impact and Process Evaluation, Task 4.2 Mapping Analysis

One of the primary goals of the 2014 Behavioral Program Impact and Process Evaluation is to assess the appropriateness of the existing experimental design of the Home Energy Report (HER) Program, with a particular emphasis on overlapping Program Administrator (PA) programs (e.g., customers simultaneously assigned to treatment and control groups depending on PA, or to more than one treatment group) and to measure the cross-fuel savings that have not been measured to date.

To achieve this objective, the evaluation team will conduct a mapping and cross-fuel savings analysis. The objective of the mapping analysis is to identify the overlap between different program cohorts, providing frequency counts of households participating in multiple program cohorts. The cross-fuel savings analysis will determine whether the HER program is generating savings in commodities in addition to the targeted commodity or commodities, and whether there are synergistic effects from receiving treatment in both commodities. The results of the cross-fuel savings analysis will inform the evaluability of the HER program and the integrity of the experimental design. This memorandum presents the results of the mapping analysis.

Key findings:

The Navigant team identified **69,697 instances of overlapping programs**; this is approximately 3% of all customers (treatment and control) in the HER program. Table 1 presents the four categories of overlapping programs, household counts, and a discussion regarding the implications for evaluation.

Table 1. Mapping Analysis Results

Dual Treatment	
Definition	Households assigned to a treatment group for both fuel-types across PAs or program-cohorts, excluding those who are assigned to a dual fuel cohort.
Household Count	20,909 (0.9% of all HER households)
Implications	Assuming the prevalence of electric treatment households being simultaneously treated for gas by a different PA is consistent with the prevalence of electric control households being treated for gas by a different PA (and vice versa), standard evaluation methods result in unbiased savings estimates. Given the limited number of overlapping households relative to the program population, these differences are not expected to impact cohort-specific savings analysis using standard evaluation methods. However, there may be synergistic effects associated with receiving a report for both fuel-types, potentially increasing or decreasing savings relative to if the programs did not overlap. In the cross-fuel savings analysis, the Navigant team will assess whether there are synergistic effects informing the implementation of the program in the future years. Most of these households (97.6%) were assigned to two treatment groups for different PAs (for example a gas report from NSTAR and an electric report from National Grid); this is to be expected since these programs are run, from the implementer's point of view, in isolation. However, a few households are assigned to two treatment groups for the same PA (an electric and gas report from NSTAR). Although the occurrence of households in two treatment groups for the same PA is of no additional concern from an evaluation perspective, the Navigant team recommends that the PAs follow-up with the program implementer to eliminate this overlap going forward.
Treatment – Control	
Definition	Households assigned to a treatment group for one fuel-type and a control group for another across PAs or program-cohorts
Household Count	8,841 (0.4% of all HER households)
Implications	Assuming the prevalence of electric treatment households being simultaneously assigned to a gas control group is consistent with the prevalence of electric control households being simultaneously assigned to a gas control group (and vice versa), standard evaluation methods result in unbiased savings estimates. Given the limited number of overlapping households relative to the program population, these differences are not expected to impact cohort-specific savings analysis using standard evaluation methods. However, if there are cross-fuel effects (e.g., gas savings when receiving electric HERs), average usage for the gas control group may be higher or lower than it otherwise would be. In the cross-fuel savings analysis, the Navigant team will assess whether there are cross-fuel effects informing the implementation of the program in future years.
Treatment – Control, Single Fuel-Type	
Definition	Households assigned to a treatment group *and* a control group for the same fuel-type by the same PA
Household Count	39,612 (1.7% of all HER households)
Implications	The majority of this category (99.5%) is attributed to National Grid purposefully reducing the size of early-cohort control groups by re-assigning households to later-cohort treatment groups. Due to the temporal nature of this reassignment, this is not true overlap in that a customer is not simultaneously in a treatment and control group. However, this intentional reassignment can be a cause for concern if the treatment and control groups become inconsistent with random assignment. Randomization of some of the early cohorts from which controls were pulled was affected, though the evaluation methodology appropriately accounts for observable differences between the treatment and control groups in the pre-program period. In the future, if customers are re-assigned, the evaluation team recommends that the randomization should be re-validated prior to implementation. The remaining 181 households in this category have been erroneously assigned to a treatment and control group for the same fuel-type and simultaneously exist in both groups. Due to the small number of households in this category relative to program populations, the overlap is of limited concern for the impact evaluation. However, the Navigant team recommends that the PAs follow-up with the program implementer to eliminate this overlap going forward.
Dual Treatment, Single Fuel-Type	
Definition	Households assigned to multiple treatment groups for the same fuel-type by the same PA
Household Count	335 (0.01% of all HER households)
Implications	These are customers who have, for some reason, been assigned to two treatment groups for the same fuel and who are, presumably, receiving two HERs. It is unclear how this overlap occurred. Due to the small number of households in this category relative to program populations, the overlap is of limited concern for the impact evaluation. However, the Navigant team recommends that the PAs follow-up with the program implementer to eliminate this overlap going forward.

Methodology

The Navigant team utilized billing and tracking data provided by the Residential Behavior program implementer (Opower) to identify households across PAs. The Navigant team identified households across PAs by name and address and created a unique identifier to complete the mapping analysis.

Through the mapping analysis, Navigant identified the PA and program cohort to which each household is assigned, including identifying the target fuel of the program and assignment to the treatment or control group. Navigant then used this database to identify overlap in assignment to treatment and control groups across PA and fuel-types. In addition to providing counts of households, Navigant also illustrates overlap by zip code using maps.

Results

The mapping analysis resulted in four categories of overlapping programs, as identified in Table 2.

Table 2. Overlapping Programs

Categories	Description
Dual Treatment*	Households assigned to a treatment group for both fuel-types across PAs or program-cohorts.
Treatment – Control	Households assigned to a treatment group for one fuel-type and a control group for another across PAs or program-cohorts.
Treatment – Control, Single Fuel-Type	Households assigned to a treatment group *and* a control group for the same fuel-type by the same PA.
Dual Treatment, Single Fuel-Type	Households assigned to multiple treatment groups for the same fuel-type by the same PA.

* Within the same PA, this category includes customers assigned to two distinct cohorts. Customers assigned to a single dual-fuel cohort are not counted here.

Table 3 provides a more detailed breakdown of the mapping analysis results. Notably, the most common occurrences of overlapping programs are (1) households assigned to an *electric* treatment group and an *electric* control group[18], and (2) households assigned to both an *electric* and a *gas* treatment group across PAs or program-cohorts[19]. The following sections provide additional detail regarding each of these categories, identifying the PA to which the household is assigned.

[18] The majority of this category is attributed to National Grid purposefully reducing the size of early-cohort control groups by re-assigning households to later-cohort treatment groups.
[19] Within the same PA, this category includes customers assigned to two distinct cohorts. Customers assigned to a single dual-fuel cohort are not counted here.

Table 3. Mapping Analysis Results

Categories	Electric		Gas		Household Count	Percent of Total HER Population
	Treatment	Control	Treatment	Control		
Dual Treatment	✓		✓		20,909	0.88%
Treatment – Control	✓			✓	4,299	0.18%
Treatment – Control		✓	✓		4,542	0.19%
Treatment – Control, Single Fuel-Type	✓	✓			39,596	1.67%
Treatment – Control, Single Fuel-Type			✓	✓	16	0.00%
Dual Treatment, Single Fuel-Type	✓✓				303	0.01%
Dual Treatment, Single Fuel-Type			✓✓		32	0.00%
				Total	**69,697**	**2.94%**

Dual Treatment

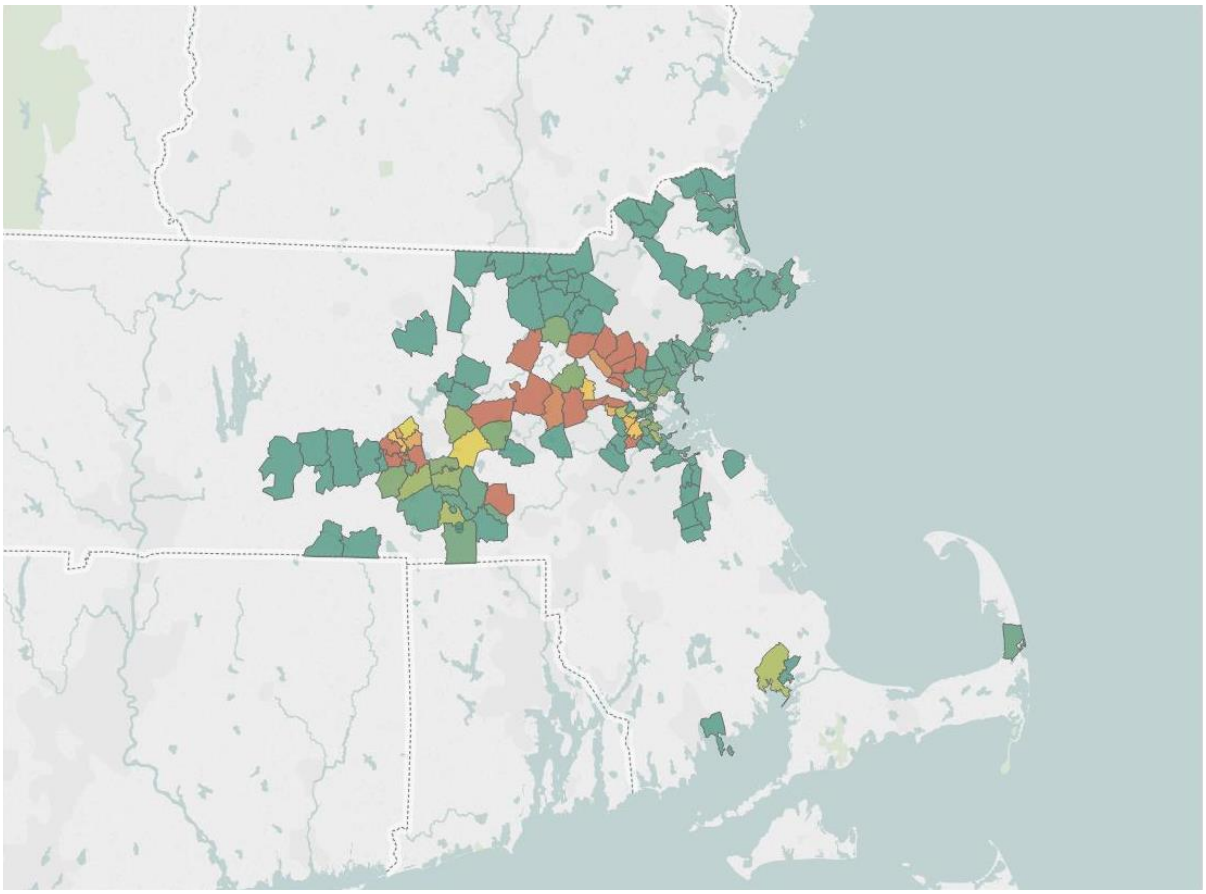
Table 4 shows that the majority of dual treatment households are assigned to different PAs. Most dual treatment households assigned to different PAs (13,790 out of 20,909) receive electric reports from NSTAR and gas reports from National Grid, while the remaining households (6,624) receive electric reports from National Grid and gas reports from NSTAR. A small number of households (495) were assigned to an electric treatment group *and* a gas treatment group by the same PA. Figure 1 illustrates, by zip code, dual treatment households (i.e., households assigned to a treatment group for both fuel-types across PAs or program-cohorts).

Table 4. Dual Treatment

Electric PA	Gas PA	Household Count	Percent of Total HER Population
National Grid	National Grid	487	0.02%
National Grid	NSTAR	6,624	0.28%
NSTAR	National Grid	13,790	0.58%
NSTAR	NSTAR	8	0.00%
	Total	**20,909**	**0.88%**

Table A-1 in the Appendix provides a detailed breakdown of the cohorts to which these households are assigned.

Figure 1. Dual Treatment



If the prevalence of electric treatment households being simultaneously treated for gas by a different PA is consistent with the prevalence of electric control households being treated for gas by a different PA (and vice versa), then standard evaluation methods result in unbiased savings estimates. As shown in Table 5, 1.49% of electric treatment households are also assigned to a gas treatment group, while 1.24% of electric control households are also assigned to a gas treatment group. For gas, 3.64% of treatment households are also assigned to an electric treatment group, while 1.81% of gas control households are assigned to an electric treatment group.

While the prevalence of electric treatment households among the gas treatment group is twice as large as that of the gas control group, in absolute terms these differences are quite small (1.8 percentage points). Given the limited number of overlapping households relative to the program population, these differences

are not expected to have a meaningful impact on the cohort-specific savings analysis using standard evaluation methods.[20]

Table 5. Dual Treatment

	Electric, Also in a Gas Treatment Group	Gas, Also in an Electric Treatment Group
Treatment	1.49% (19,103 out of 1,278,616)	3.64% (19,103 out of 524,867)
Control	1.24% (4,096 out of 329,404)	1.81% (4,096 out of 175,495)

Note: Dual fuel households are excluded from this analysis.

Aside from implications for evaluability, there may be synergistic effects associated with receiving a report for both fuel-types from different PAs, either increasing or decreasing savings relative to if the programs did not overlap. It is also possible that receiving one dual fuel report has a different effect from receiving two reports, one for each fuel. In the cross-fuel savings analysis, the Navigant team will assess whether there are synergistic effects associated with dual treatment, including the effect of one dual fuel report versus two single fuel reports, and discuss implications for program design, implementation and evaluation.

Treatment-Control

Table 6 shows that the majority of households assigned to both a treatment group and a control group are assigned to different PAs. In total, 8,841 households (0.4% of all HER households) were assigned to a treatment group by one PA and a control group by another. A small number of households were assigned to a treatment group for one fuel-type *and* a control group for the other fuel-type by the same PA. Figure 2 illustrates, by zip code, treatment-control households (i.e., households assigned to a treatment group for one fuel-type and a control group for another across PAs or program-cohorts).

Table 6. Treatment - Control

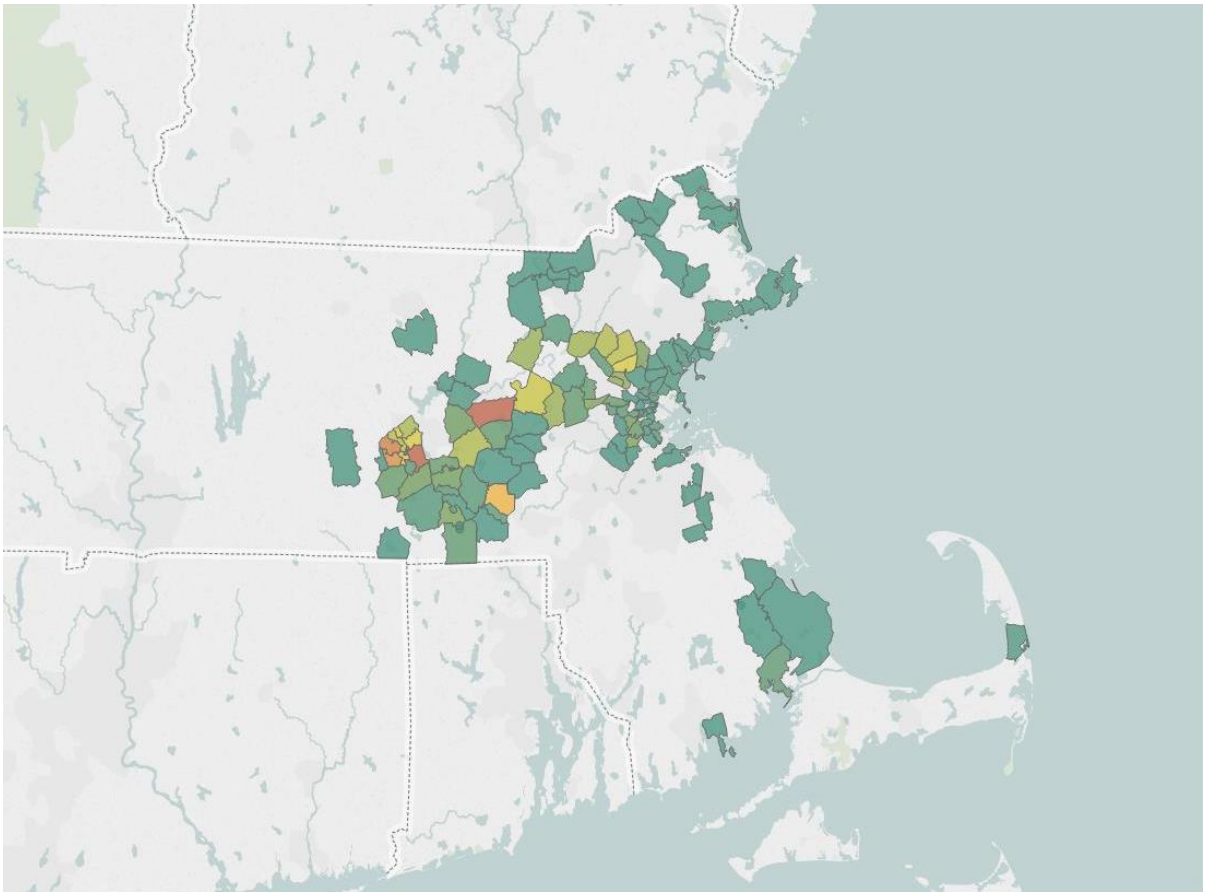
	Treatment PA	Control PA	Household Count	Percent of Total HER Population
Electric Treatment and Gas Control	National Grid	National Grid	107	0.00%
	National Grid	NSTAR	3,193	0.13%
	NSTAR	National Grid	988	0.04%
	NSTAR	NSTAR	11	0.00%
Gas Treatment and Electric Control	National Grid	National Grid	98	0.00%
	NSTAR	National Grid	1,478	0.06%

[20] Navigant analyzed cohort-specific savings excluding dual treatment households and found the savings estimates were not statistically different than when dual treatment households were included.

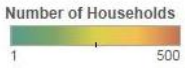
National Grid	NSTAR	2,926	0.12%
NSTAR	NSTAR	40	0.00%
	Total	**8,841**	**0.37%**

Table A-2 and Table A-3 in the Appendix provide a detailed breakdown of the cohorts to which these households are assigned.

Figure 2. Treatment – Control



Color shows the sum of the number of households by zip code.



If the prevalence of electric treatment households being simultaneously assigned to a gas control group by a different PA is consistent with the prevalence of electric control households being assigned to a gas control group by a different PA (and vice versa), then standard evaluation methods result in unbiased savings estimates. As shown in Table 7, 0.25% of electric treatment and control households are also assigned to a gas control group. For gas, 0.78% of treatment households are also assigned to an electric control group while 0.47% of gas control households are assigned to an electric control group. Given the limited number of overlapping households relative to the program population, these differences are not expected to have an impact on cohort-specific savings analysis using standard evaluation methods.

Table 7. Treatment - Control

	Electric, Also in a Gas Control Group	Gas, Also in an Electric Control Group
Treatment	0.25% (3,185 out of 1,278,616)	0.78% (3,185 out of 524,867)
Control	0.25% (819 out of 329,404)	0.47% (819 out of 175,495)

Note: Dual fuel households are excluded from this analysis.

Aside from implications for evaluability, if there are cross-fuel effects (e.g., gas savings when receiving electric HERs), average usage for the gas control group may be higher or lower than it otherwise would be. In the cross-fuel savings analysis, the Navigant team will assess cross-fuel effects and discuss implications for program design, implementation and evaluation.

Treatment-Control, Single Fuel-Type

Table 8 shows the number of households assigned to a treatment group *and* a control group for the same fuel-type by the same PA. The most common occurrence (39,431 out of 39,612 households) are households assigned to an electric treatment group and an electric control group by National Grid. National Grid purposefully reduced the size of early-cohort control groups by reassigning households to later-cohort treatment groups. Due to the temporal nature of this reassignment, this is not true overlap in that a customer is not simultaneously in a treatment and control group. However, this intentional reassignment can be a cause for concern if the treatment and control groups become inconsistent with random assignment. Randomization of some cohorts was affected though the evaluation methodology appropriately accounts for observable differences between the treatment and control groups in the pre-program period. In the future, if customers are re-assigned, randomization should be re-validated prior to implementation.

The remaining customers in this category (181 out of 39,612 households) have been erroneously assigned to a treatment and control group for the same fuel-type and simultaneously exist in both groups. Due to the small number of households in this category relative to program populations, the overlap is of limited concern for the impact evaluation. However, the Navigant team recommends that the PAs follow-up with the program implementer to eliminate this overlap going forward.

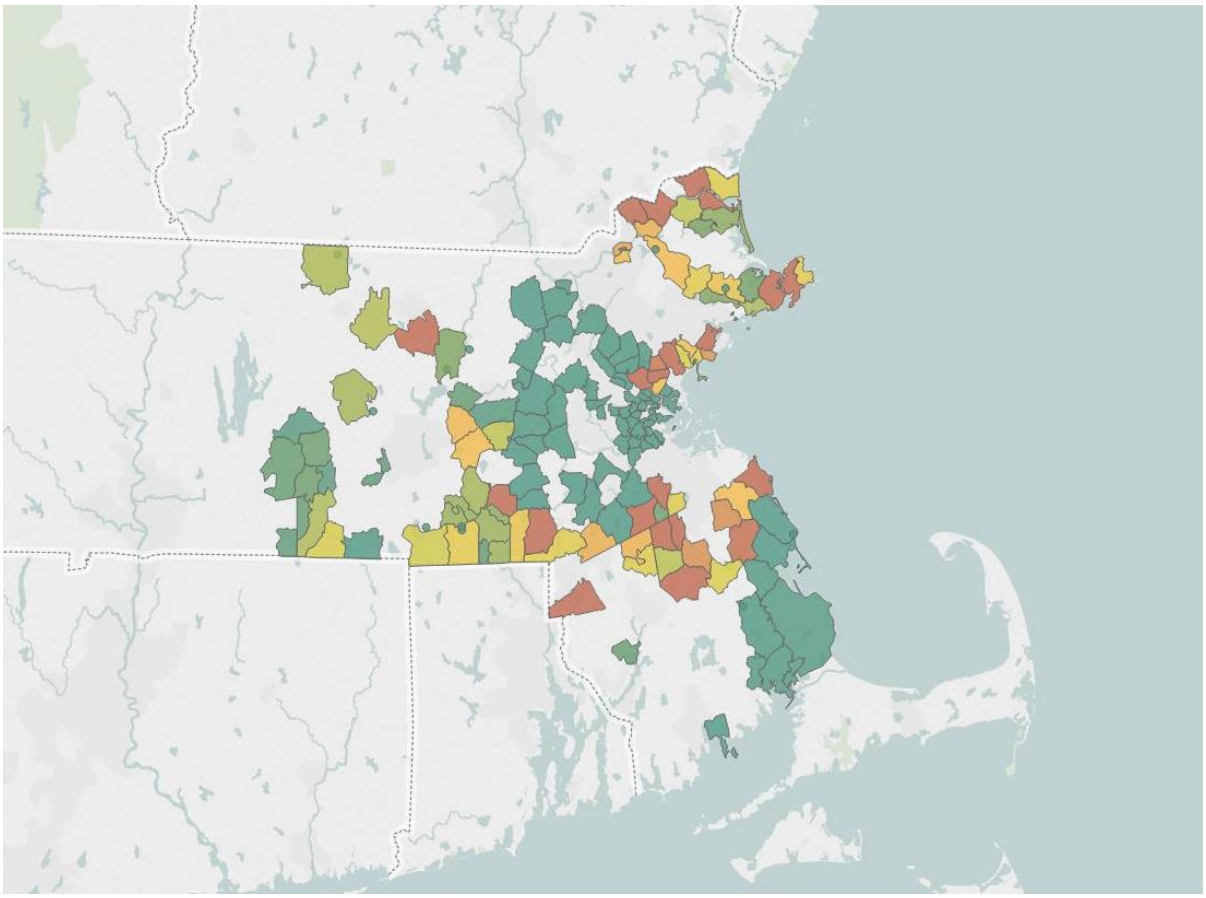
Figure 3 illustrates, by zip code, treatment-control/single fuel-type households (i.e., households assigned to a treatment group *and* a control group for the same fuel-type by the same PA).

Table 8. Treatment - Control, Single Fuel-Type

Fuel-Type	PA	Household Count	Percent of Total HER Population
Electric	National Grid	39,431	1.67%
	NSTAR	165	0.01%
Gas	National Grid	12	0.00%
	NSTAR	4	0.00%
	Total	**39,612**	**1.67%**

Table A-4 and Table A-5 in the Appendix provide a detailed breakdown of the cohorts to which these households are assigned.

Figure 3. Treatment - Control, Single Fuel



Color shows the sum of the number of households by zip code.

Dual Treatment, Single Fuel-Type

Table 9 shows the number of households assigned to a treatment group multiple times for the same fuel-type. Navigant only identified 335 cases (0.01% of all HER households), with the majority (252) having been assigned to an electric treatment group in multiple NSTAR cohorts. Due to the small number of households in this category relative to program populations, the overlap is of limited concern for the impact evaluation. However, the Navigant team recommends that the PAs follow-up with the program implementer to eliminate this overlap going forward. Figure 4 illustrates, by zip code, dual-treatment single fuel-type households (i.e., households assigned to multiple treatment groups for the same fuel-type by the same PA).

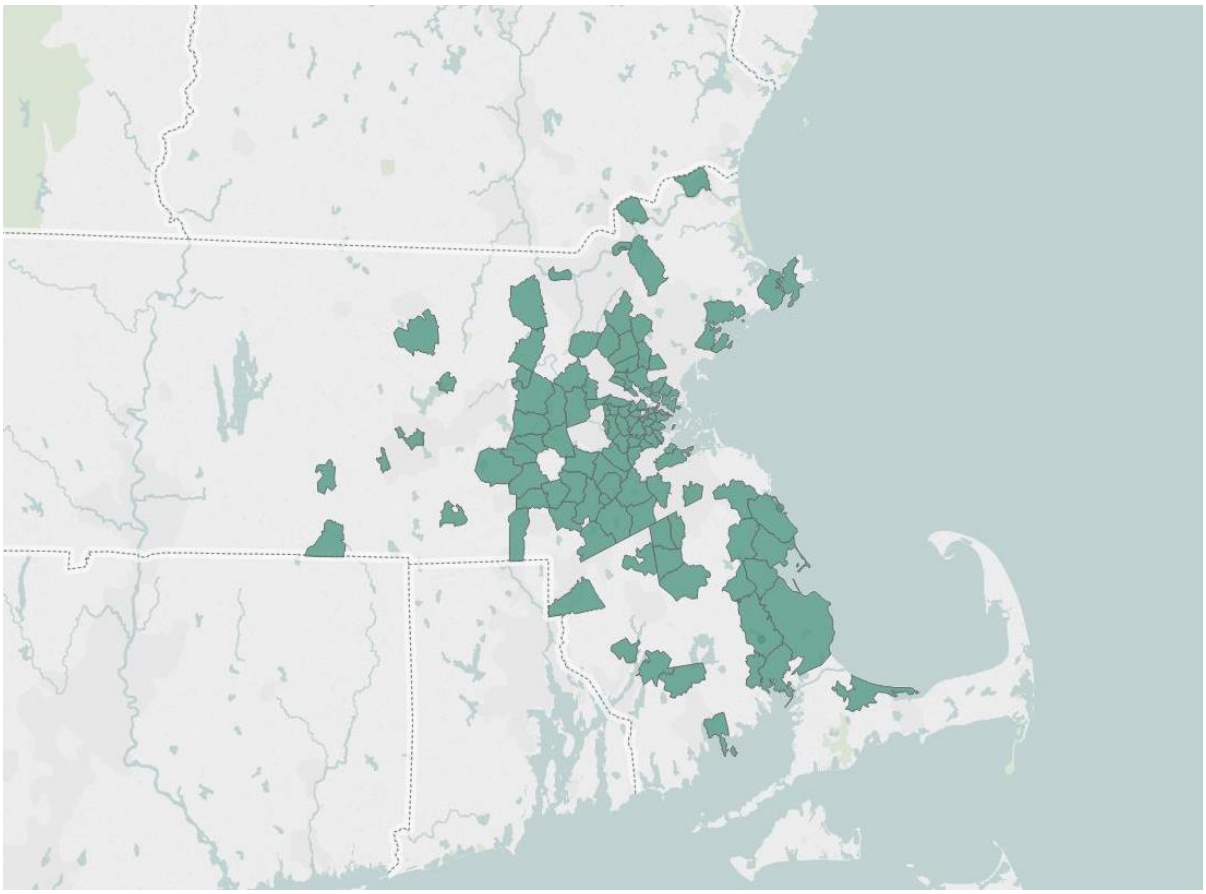
Table 9. Dual Treatment, Single Fuel-Type

Fuel-Type	PA	Household Count	Percent of Total HER Population

Electric	National Grid	51	0.00%
	NSTAR	252	0.01%
Gas	National Grid	29	0.00%
	NSTAR	3	0.00%
	Total	**335**	**0.01%**

Table A-6 and Table A-7 in the Appendix provide a detailed breakdown of the cohorts to which these households are assigned.

Figure 4. Dual Treatment - Single Fuel



Color shows the sum of the number of households by zip code.

Next Steps

Navigant will conduct the cross-fuel savings analysis informing the implementation of the program in future years. In particular, the cross-fuel savings analysis will provide insight regarding

- **Synergistic Effects of Dual Treatment.** Navigant will estimate savings associated with receiving dual treatment from different PAs informing whether savings have increased, decreased, or not changed relative to if the programs had been implemented in isolation. Furthermore, we will

explore whether receiving two single fuel reports leads to different savings than receiving a single dual-fuel report.

- **Cross-Fuel Effects of Treatment-Control.** Navigant will estimate cross-fuel effects (e.g., gas savings when receiving electric HERs) informing whether the baseline (average usage of the control group) has increased, decreased, or not changed relative to if the programs had been implemented in isolation.

Appendix

This appendix includes tables showing the breakdown of customers by treatment and control cohort. Cohorts are identified by their PA and the year and month of their planned start date (YYYYMM); in cases where a PA started two cohorts for the same fuel in the same month an additional identifier is included such as email or drop.[21]

Dual Treatment

Table A-1 shows the breakdown of dual treatment customers by cohort. Electric cohorts run down the rows of Table A-1, while gas cohorts run across the columns. The number of customers in the three dual fuel cohorts are excluded from this table to emphasize that these customers were not considered in the counts of dual treatment customers.

[21] NSTAR originally planned to stop reports for the two cohorts labeled 'drop' but these cohorts continued to receive reports through 2014.

Table A-1. Dual Treatment

Gas Cohorts→ Electric Cohorts ↓	National Grid 200910	National Grid 201010	National Grid 201102	National Grid 201111	National Grid 201201 (dual)	National Grid 201201	National Grid 201301	National Grid 201409	NSTAR 201009 (dual)	NSTAR 201102	NSTAR 201309	NSTAR 201309 (dual, drop)
National Grid 200910	0	0	0	0	0	0	0	18	0	0	0	0
National Grid 201002	0	0	0	0	0	0	1	20	0	0	368	0
National Grid 201012	0	0	0	0	0	0	0	0	0	0	35	0
National Grid 201102	0	0	0	0	0	0	0	43	0	0	214	0
National Grid 201111	0	0	0	0	0	0	0	14	0	0	162	0
National Grid 201201 (dual)	0	0	0	0	-	0	0	0	0	0	0	0
National Grid 201201	0	0	0	0	0	0	0	21	0	0	222	0
National Grid 201301	1	0	3	0	0	0	312	42	0	972	3126	0
National Grid 201301 (email)	0	0	0	0	1	0	9	0	0	314	733	0
National Grid 201404	1	0	0	0	1	0	0	0	0	14	464	0
NSTAR 201009 (dual)	0	0	0	0	0	0	0	0	-	3	0	0
NSTAR 201203	428	1571	376	107	0	375	449	13	0	0	0	0
NSTAR 201206	91	351	130	28	0	96	145	2	1	0	0	0
NSTAR 201304	0	0	0	0	0	0	0	1	0	0	0	0
NSTAR 201304 (drop)	0	0	0	0	0	0	0	0	1	1	0	0
NSTAR 201309 (dual, drop)	0	0	0	0	0	0	0	0	0	0	0	-
NSTAR 201404	763	2877	1317	354	0	1216	1955	1145	1	1	0	0
WMECo 201402	0	0	0	0	0	0	0	0	0	0	0	0

Treatment-Control

Table A-2 shows the breakdown of electric treatment-gas control customers by cohort. Electric cohorts run down the rows of Table A-2, while gas cohorts run across the columns.

Table A-2. Electric Treatment - Gas Control

Gas Cohorts→ Electric Cohorts ↓	National Grid 200910	National Grid 201010	National Grid 201102	National Grid 201111	National Grid 201201 (dual)	National Grid 201201	National Grid 201301	National Grid 201409	NSTAR 201009 (dual)	NSTAR 201102	NSTAR 201309	NSTAR 201309 (dual, drop)
National Grid 200910	0	0	0	0	0	0	0	3	0	0	0	0
National Grid 201002	0	0	0	0	0	0	0	5	0	0	158	0
National Grid 201012	0	0	0	0	0	0	0	0	0	0	16	0
National Grid 201102	0	0	0	0	0	0	0	10	0	0	70	0
National Grid 201111	0	0	0	0	0	0	1	3	0	0	58	0
National Grid 201201 (dual)	0	0	0	0	0	0	0	0	0	0	0	0
National Grid 201201	0	0	0	0	0	0	0	5	0	0	100	0
National Grid 201301	0	0	0	0	0	0	62	13	0	755	1255	0
National Grid 201301 (email)	0	0	0	0	0	0	4	0	0	248	327	0
National Grid 201404	0	0	0	0	1	0	0	0	0	7	199	0
NSTAR 201009 (dual)	0	0	0	0	0	0	0	0	0	2	0	0
NSTAR 201203	177	146	18	80	0	78	98	6	0	0	0	0
NSTAR 201206	42	35	7	12	0	15	18	2	3	0	0	0
NSTAR 201304	0	0	0	0	0	0	0	0	1	2	0	0
NSTAR 201304 (drop)	0	0	0	0	0	0	0	0	0	1	0	0
NSTAR 201309 (dual, drop)	0	0	0	0	0	0	0	0	0	0	0	0
NSTAR 201404	1	1	0	0	0	2	3	247	0	2	0	0
WMECo 201402	0	0	0	0	0	0	0	0	0	0	0	0

Table A-3 shows the breakdown of gas treatment-electric control customers by cohort. Electric cohorts run down the rows of Table A-3, while gas cohorts run across the columns.

Table A-3. Gas Treatment - Electric Control

Gas Cohorts→ Electric Cohorts ↓	National Grid 200910	National Grid 201010	National Grid 201102	National Grid 201111	National Grid 201201 (dual)	National Grid 201201	National Grid 201301	National Grid 201409	NSTAR 201009 (dual)	NSTAR 201102	NSTAR 201309	NSTAR 201309 (dual, drop)
National Grid 200910	0	0	0	0	0	0	0	9	0	0	0	0
National Grid 201002	0	0	0	0	0	0	0	9	0	0	148	0
National Grid 201012	0	0	0	0	0	0	0	0	0	0	8	0
National Grid 201102	0	0	0	0	0	0	0	5	0	0	56	0
National Grid 201111	0	0	0	0	0	0	0	8	0	0	83	0
National Grid 201201 (dual)	0	0	0	0	0	0	1	1	0	0	0	0
National Grid 201201	0	0	0	0	0	0	0	4	0	0	117	0
National Grid 201301	0	0	0	0	0	1	49	8	0	130	414	0
National Grid 201301 (email)	0	0	0	0	0	0	3	0	0	139	298	0
National Grid 201404	0	0	0	0	0	0	0	0	0	0	85	0
NSTAR 201009 (dual)	0	0	0	0	0	0	0	0	0	2	0	0
NSTAR 201203	127	513	114	42	0	128	137	7	33	4	0	0
NSTAR 201206	61	251	83	16	0	74	76	6	0	0	0	0
NSTAR 201304	0	0	0	0	0	0	0	2	0	0	0	0
NSTAR 201304 (drop)	0	0	0	0	0	0	0	0	0	1	0	0
NSTAR 201309 (dual, drop)	0	0	0	0	0	0	0	0	0	0	0	0
NSTAR 201404	101	381	173	56	0	153	260	165	0	0	0	0
WMECo 201402	0	0	0	0	0	0	0	0	0	0	0	0

Treatment-Control, Single Fuel-Type

Table A-4 shows the breakdown of electric treatment-electric control customers by cohort within the same PA. There are no cases where a customer is in an electric treatment cohort and an electric control cohort across PAs. The top half of Table A-4 shows counts for National Grid cohorts, while the bottom half shows counts for NSTAR cohorts. Treatment runs down the rows of Table A-4, while control runs across the columns.

Table A-4. Electric Treatment - Electric Control

Control → Treatment ↓	Nat Grid 200910	Nat Grid 201002	Nat Grid 201012	Nat Grid 201102	Nat Grid 201111	Nat Grid 201201 (dual)	Nat Grid 201201	Nat Grid 201301	Nat Grid 201301 (email)	Nat Grid 201404
Nat Grid 200910	0	0	0	0	0	0	0	0	0	1
Nat Grid 201002	0	0	0	0	0	0	0	0	0	0
Nat Grid 201012	0	0	0	0	0	0	0	0	0	0
Nat Grid 201102	0	1	0	0	0	0	0	5	0	2
Nat Grid 201111	0	0	0	0	0	0	0	0	0	1
Nat Grid 201201 (dual)	0	0	0	0	0	0	0	0	0	0
Nat Grid 201201	1	1	0	0	0	0	0	0	0	0
Nat Grid 201301	8638	13980	2060	7066	3	0	4	0	0	1
Nat Grid 201301 (email)	2129	3038	168	2325	0	0	0	0	0	0
Nat Grid 201404	0	1	0	0	2	1	3	0	0	0
	NSTAR 201009 (dual)	**NSTAR 201203**	**NSTAR 201206**	**NSTAR 201304**	**NSTAR 201304 (drop)**	**NSTAR 201309 (dual, drop)**	**NSTAR 201404**			
NSTAR 201009 (dual)	0	33	0	0	0	0	0			
NSTAR 201203	0	0	0	19	0	0	8			
NSTAR 201206	3	0	0	12	0	0	2			
NSTAR 201304	1	15	7	0	0	0	0			
NSTAR 201304 (drop)	0	0	1	0	0	0	5			
NSTAR 201309 (dual, drop)	0	0	0	0	0	0	0			
NSTAR 201404	0	20	15	15	9	0	0			

Table A-5 shows the breakdown of gas treatment-gas control customers by cohort within the same PA. There are no cases where a customer is in a gas treatment cohort and a gas control cohort across PAs. Treatment runs down the rows of Table A-5, while control runs across the columns.

Table A-5. Gas Treatment - Gas Control

Control → Treatment ↓	Nat Grid 200910	Nat Grid 201010	Nat Grid 201102	Nat Grid 201111	Nat Grid 201201 (dual)	Nat Grid 201201	Nat Grid 201301	Nat Grid 201409	NSTAR 201009 (dual)	NSTAR 201102	NSTAR 201309	NSTAR 201309 (dual, drop)
Nat Grid 200910	0	0	0	0	0	0	0	0				
Nat Grid 201010	0	0	0	0	0	0	1	0				
Nat Grid 201102	0	0	0	0	0	0	0	0				
Nat Grid 201111	0	0	0	0	0	0	1	1				
Nat Grid 201201 (dual)	0	0	0	0	0	0	0	0				
Nat Grid 201201	0	0	0	0	0	0	0	1				
Nat Grid 201301	0	1	0	0	1	0	0	0				
Nat Grid 201409	3	0	0	1	1	0	1	0				
NSTAR 201009 (dual)									0	2	0	0
NSTAR 201102									2	0	0	0
NSTAR 201309									0	0	0	0
NSTAR 201309 (dual, drop)									0	0	0	0

Dual Treatment, Single Fuel-Type

Table A-6 shows the breakdown of customers in multiple electric cohorts by cohort within the same PA. There are no cases where a customer is in multiple electric treatment cohorts across PAs. The top half of Table A-6 shows counts for National Grid cohorts, while the bottom half shows counts for NSTAR cohorts. This table is symmetric so only the upper-diagonal is shown.

Table A-6. Electric Treatment - Electric Treatment

	Nat Grid 200910	Nat Grid 201002	Nat Grid 201012	Nat Grid 201102	Nat Grid 201111	Nat Grid 201201 (dual)	Nat Grid 201201	Nat Grid 201301	Nat Grid 201301 (email)	Nat Grid 201404
Nat Grid 200910	-	0	0	0	0	0	0	0	1	0
Nat Grid 201002		-	0	0	0	0	0	3	0	1
Nat Grid 201012			-	0	0	0	1	2	0	2
Nat Grid 201102				-	0	0	0	9	0	7
Nat Grid 201111					-	0	0	5	0	3
Nat Grid 201201 (dual)						-	0	0	1	1
Nat Grid 201201							-	4	0	5
Nat Grid 201301								-	0	6
Nat Grid 201301 (email)									-	0
Nat Grid 201404										-

	NSTAR 201009 (dual)	NSTAR 201203	NSTAR 201206	NSTAR 201304	NSTAR 201304 (drop)	NSTAR 201309 (dual, drop)	NSTAR 201404
NSTAR 201009 (dual)	-	0	1	0	1	0	1
NSTAR 201203		-	0	33	6	0	86
NSTAR 201206			-	12	1	0	34
NSTAR 201304				-	0	0	32
NSTAR 201304 (drop)					-	0	45
NSTAR 201309 (dual, drop)						-	0
NSTAR 201404							-

Table A-7 shows the breakdown of customers in multiple gas cohorts by cohort within the same PA. There are no cases where a customer is in multiple gas treatment cohorts across PAs. This table is symmetric so only the upper-diagonal is shown.

Table A-7. Gas Treatment - Gas Treatment

	Nat Grid 200910	Nat Grid 201010	Nat Grid 201102	Nat Grid 201111	Nat Grid 201201 (dual)	Nat Grid 201201	Nat Grid 201301	Nat Grid 201409	NSTAR 201009 (dual)	NSTAR 201102	NSTAR 201309	NSTAR 201309 (dual, drop)
Nat Grid 200910	-	0	0	0	0	0	0	1				
Nat Grid 201010		-	0	0	0	0	2	4				
Nat Grid 201102			-	1	0	0	5	5				
Nat Grid 201111				-	0	0	0	3				
Nat Grid 201201 (dual)					-	0	0	0				
Nat Grid 201201						-	1	3				
Nat Grid 201301							-	4				
Nat Grid 201409								-				
NSTAR 201009 (dual)									-	3	0	0
NSTAR 201102										-	0	0
NSTAR 201309											-	0
NSTAR 201309 (dual, drop)												-

APPENDIX C. DUAL TREATMENT ANALYSIS

To: Massachusetts Program Administrators (PAs) and Energy Efficiency Advisory Council (EEAC)

From: Navigant Consulting, Inc. and Illume Advising, LLC.

Date: December 4, 2015

Re: Massachusetts Cross-Cutting Behavioral Program Evaluation: Dual Treatment Study Results

Executive Summary

This memo was developed by the "evaluation team", including Navigant Consulting, Inc. (Navigant) and Illume Advising, LLC. (ILLUME) to present results for the dual treatment study of the Home Energy Report (HER) programs for the Massachusetts Cross-Cutting Research in Behavior and Education. Specifically, this memo compares electric and gas savings for dual-fuel customers (those who are in a dual-fuel cohort and receive a single report which covers both fuel types) and dual-treatment customers (those who are assigned to a treatment group for both fuel types across PAs or program-cohorts and received two single-fuel reports) for National Grid and Eversource Energy (formerly NSTAR and Western Massachusetts Electric Company (WMECo)).[22] The goal of this study was to determine if there are statistically significant differences in savings for customers receiving a single dual-fuel report as compared to those receiving two single-fuel reports.

National Grid and NSTAR have long-standing HER programs, with both companies dramatically expanding their behavioral programs since the launch of the first program by National Grid in 2009. This is the first time the issue of savings for dual-fuel customers compared to dual-treatment customers has been examined.

As of the end of 2014, there were a total of thirty-one evaluable cohorts in the Massachusetts HER programs, including:

- Fifteen electric cohorts (nine for National Grid, five for NSTAR, and one for WMECo),
- Eight gas cohorts (seven for National Grid and one for NSTAR), and
- Four dual-fuel cohorts (one for National Grid and three for NSTAR).

The four dual-fuel cohorts include 61,518 treatment customers who receive a single dual-fuel report. The evaluation team identified 20,909 dual-treatment customers receiving two single-fuel reports in the mapping analysis done earlier this year.[23]

[22] ***Dual-fuel customers*** are defined as households in a dual-fuel cohort for either National Grid or Eversource Energy; these households receive a single report which covers both fuel types. ***Dual-treatment customers*** are defined as households assigned to a treatment group for both fuel types across PAs or program-cohorts; these households receive two single-fuel reports.

[23] The results of the mapping analysis were presented to the PAs in a memo titled "Cross-Cutting Research: Behavior Impact and Process Evaluation, Task 4.2 Mapping Analysis" on March 25, 2015.

Key Findings and Recommendations

- Table 1 summarizes the per customer savings by report regime and fuel type. On the electric side, dual-fuel customers save 1.10% and dual-treatment customers save 1.41%; this difference is statistically significant at the 90% confidence level (p-value = 0.042). On the gas side, dual-fuel customers save 1.44% and dual-treatment customers save 1.24%; this difference is not statistically significant at the 90% confidence level (p-value = 0.882).

Table 1. Summary of Per Customer Savings

Report Regime	Fuel Type	Percentage Savings	Per Customer Annual Savings (kWh/therms)	Per Customer Annual Baseline Usage (kWh/therms)*	Per Customer Annual Savings (MMBTU)
Dual-Fuel	Electric	1.10%	75.11	6,838	0.256
Dual-Treatment	Electric	1.41%	124.68	8,823	0.425
Dual-Fuel	Gas	1.44%	14.41	997	1.441
Dual-Treatment	Gas	1.24%	14.81	1,195	1.481

Source: Evaluation team analysis

*Differences in baseline usage for the two report groups cause the discrepancies in the magnitudes of the absolute and percentage savings.

- Table 2 summarizes total annual savings under the current report configuration (61,518 dual-fuel customers and 20,909 dual-treatment customers) and annual savings if program implementation was modified such that all customers were either dual-fuel or dual-treatment. Coordination across PAs such that all customers received dual-fuel reports would result in a net gain of approximately 3,000 MMBTU or a 2% increase in savings for this group of customers. In total, the HER program saved just over one million MMBTU in 2014, thus this coordination would only increase total program savings by approximately 0.3%.[24]

Table 2. Summary of Total Savings

Report Regime	Total Savings (MMBTU)	90% Confidence Bounds	Difference from Current Configuration (MMBTU)	Percent Difference from Current Configuration
Current Configuration	144,241	[116,838 – 171,644]	-	-
All Dual-Fuel	147,393	[123,742 – 171,044]	+3,152	+2%
All Dual-Treatment	136,151	[99,635 – 172,667]	-11,242	-8%

Source: Evaluation team analysis

[24] Total savings for the HER program were presented to the PAs in a memo titled "Massachusetts Cross-Cutting Behavioral Program Evaluation Opower Results" on June 25, 2015.

- The evaluation team's process evaluation analyzed whether there were differences in satisfaction between dual-fuel and dual-treatment customers.[25] Cross-PA customers (a subset of dual-treatment customers who receive electric reports from one PA and gas reports from another[26]) are satisfied with the frequency at which they currently receive reports and they find the reports just as useful as dual-fuel customers.

- Given that the total increase in annual MMBTU savings from switching all customers to dual-fuel reports is small and not statistically significant at the 90% confidence level and the process evaluation showed that receiving multiple single-fuel reports was not an issue for cross-PA customers (the vast majority of dual-treatment customers), the evaluation team does not believe that coordination across the PAs is warranted and recommends that the PAs continue implementing the HER program in its current form.

Background

Dual-Fuel Customers

As of the end of 2014, the Massachusetts HER program included four dual-fuel cohorts. Table 3 shows the number of dual-fuel treatment and control customers for whom we had both gas and electric billing data in each of the four dual-fuel cohorts.

Table 3. Dual-Fuel Customer Counts, by Cohort

PA	Cohort Name	Number of Treatment Customers	Number of Control Customers
National Grid	Group 2012 Dual	13,454	13,490
NSTAR	Group 2010 Dual	18,654	18,398
NSTAR	Group 2011 Dual	8,445	6,707
NSTAR	Group 2013 Dual	20,936	15,713
	Total	**61,489**	**54,308**

Source: Evaluation team analysis

Dual-Treatment Customers

The Massachusetts HER program did not intentionally include any dual-treatment customers, however, as of the end of 2014, 20,909 customers, approximately 0.88% of the total HER population, had been placed into two treatment groups for different fuel cohorts. Of these, 20,892 had both gas and electric billing data and thus were considered for this study. The majority of these customers were cross-PA customers meaning they received an electric report from one PA and a gas report from another, however, a handful of customers received both an electric and a gas report from the same PA. Table 4 shows the break-down of the dual-treatment customers by gas and electric PA.

[25] Navigant Consulting, Inc. and Illume Advising, LLC. 2015. "Massachusetts Behavioral Programs Process Evaluation: Report in the Cross-Cutting Research Areas of Behavior and Education."
[26] The remaining dual treatment customers receive a gas report and an electric report from the same PA. Of all the dual-treatment customers, 97.6% are cross-PA customers and only 2.4% receive two reports from the same utility.

Table 4. Dual-Treatment Customer Counts, by PA

Electric PA	Gas PA	Number of Treatment Customers
National Grid	National Grid	485
National Grid	NSTAR	6,624
NSTAR	National Grid	13,783
NSTAR	NSTAR	0
	Total	**20,909**

Source: Evaluation team analysis

Dual-treatment customers do not have a random control group so controls were selected via matching as described in the methodology section. Table 5 shows the number of dual-treatment customers and matched controls in each of the program cohorts after the matching was completed. Note that each treatment customer shows up in one electric cohort and one gas cohort and they have one control selected separately for each fuel type.

Table 5. Dual-Treatment and Matched Control Customer Counts, by Cohort

PA	Cohort Name	Fuel-Type	Number of Treatment Customers	Number of Matched Control Customers
National Grid	Group 2009	Electric	16	459
National Grid	Group 2010	Electric	370	500
National Grid	Group 2010 Added	Electric	33	150
National Grid	Group 2011	Electric	232	381
National Grid	Group 2011 Added	Electric	160	981
National Grid	Group 2012	Electric	231	1,235
National Grid	Group 2013	Electric	3,122	1,350
National Grid	Group 2013 Email	Electric	672	210
National Grid	Group 2014	Electric	464	34
NSTAR	Group 2012a	Electric	2,727	4,574
NSTAR	Group 2012b	Electric	722	1,875
NSTAR	Group 2013	Electric	1	1,505
NSTAR	Group 2013b	Electric	0	2,495
NSTAR	Group 2014	Electric	8,970	1,971
		Electric Total	**17,720**	**17,720**
National Grid	Group 2009	Gas	1,279	6,143
National Grid	Group 2010	Gas	4,780	2,628
National Grid	Group 2011	Gas	1,814	860
National Grid	Group 2011 Add	Gas	484	892
National Grid	Group 2012	Gas	1,677	1,341
National Grid	Group 2013	Gas	2,665	1,871
National Grid	Group 2014	Gas	1,192	156
NSTAR	Attrition Refill 2013	Gas	5,187	5,187
		Gas Total	**19,078**	**19,078**

Source: Evaluation team analysis
Note: As described in the methodology section, matched controls have to be from the same PA as the treatment customer but they do not have to be from the same cohort, they could be from any non-dual-fuel cohort for that PA. Therefore, the distribution of treatment customers across cohorts is not the same as the distribution of matched controls.

Methodology

This section presents the methodology used for: (1) the selection of matched controls for the dual-treatment customers[27] and (2) estimating savings.

Matched Control Methods

The dual-treatment customers do not have a random control group so controls must be selected via non-random assignment. The evaluation team use the industry standard method of matching to select a matched control for each of the dual-treatment customers. Matching methods rely on a set of matched non-participant households to estimate program savings. For each dual-treatment customer, the pool of non-participant households available for matching consisted of all of the HER program control customers for the same PA in a non-dual-fuel cohort.[28] We require that the matched controls come from the same PA as the treatment customer but do not require that they come from the same cohort; this gives a larger matching pool for each participant resulting in better matches.

For each program participant with monthly billing data extending to at least twelve months before the start of their cohort, energy consumption in each month in the twelve months before the cohort start date was compared to that of all non-participant customers in the available pool with billing data over the same twelve months. For the sake of expositional clarity below, we denote by t_k=0 the month t in which customer k enrolled in the program, with t_k -1 denoting the month before enrollment, t_k +1 denoting the month after enrollment, and so on.

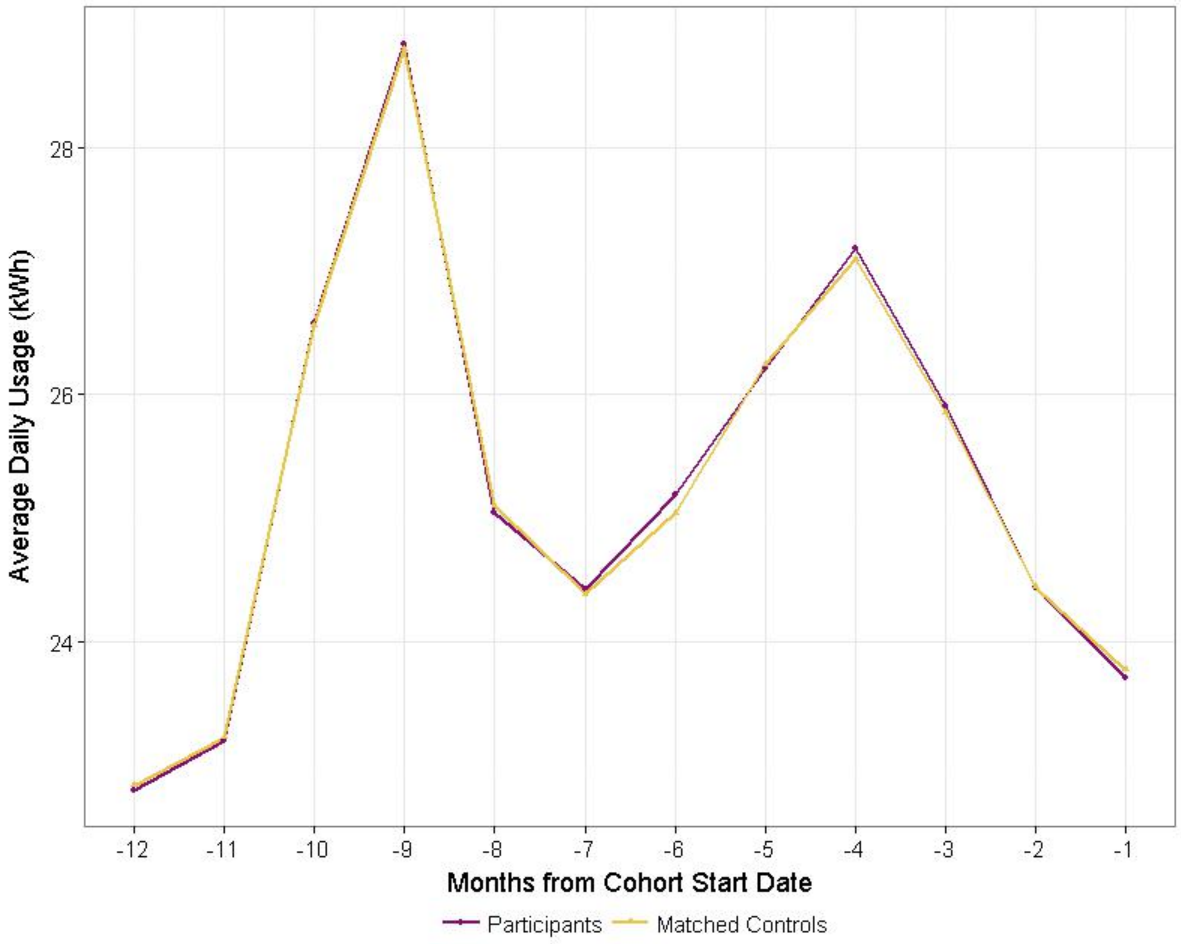
The basis of the comparison is the difference in monthly energy use between a participant and a potential match, D_{PM} (**D**ifference between **P**articipant and potential **M**atch). The quality of a match is denoted by the Euclidean distance to the participant over the twelve values of monthly D_{PM} used for matching; that is, denoting by SSD the sum of squared D_{PM} over the matching period, it is denoted by $SSD^{1/2}$. The non-participant customer with the shortest Euclidean distance to a participant was chosen as the matched comparison for the participant. Matching was done with replacement, meaning that a given non-participant could be matched to more than one participant.

Each dual-treatment customer was matched to one control for electric and one control for gas; the control customer could be, but does not have to be, the same for the two fuel types. Figure 1 shows average electricity usage by participants and their matches for the period twelve more before the participant's cohort start date and Figure 2 shows average gas usage over the same period. These figures illustrate that on average energy usage by matched controls is very similar to that of participants.

[27] The dual-fuel customers had a control group randomly assigned as part of the program implementation and therefore we do not need to match to find controls for them.

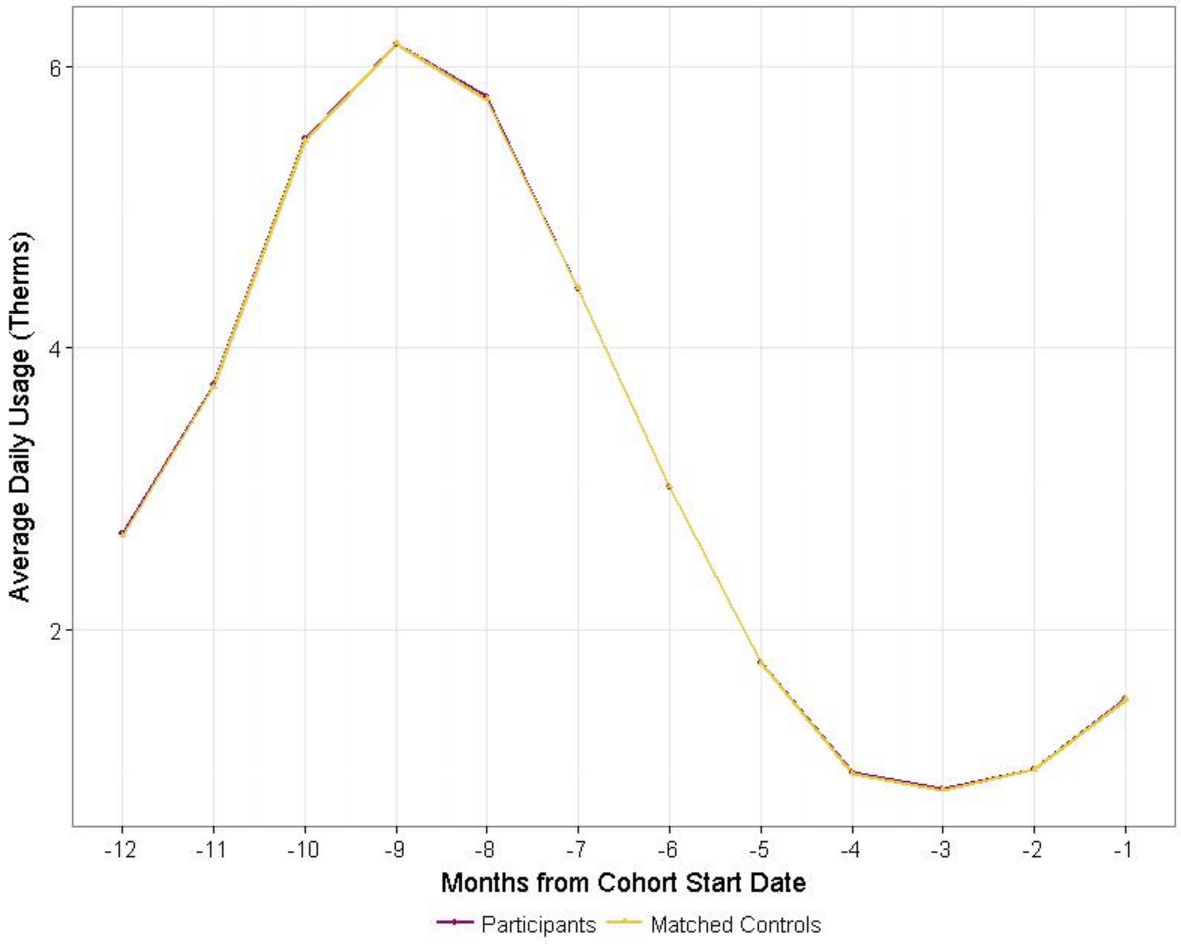
[28] The control customers in the dual-fuel cohorts are already the controls for the dual-fuel treatment customers so we do not allow them to also be controls for the dual-treatment customers.

Figure 1. Electric Usage by Participants and Matched Controls in the 12 Months before the Start of the Participant's Cohort



Source: Evaluation team analysis

Figure 2. Gas Usage by Participants and Matched Controls in the 12 Months before the Start of the Participant's Cohort



Source: Evaluation team analysis

Savings Estimation Methods

The evaluation team conducted regression analysis using a post-program regression (PPR) model to estimate savings for dual-fuel and dual-treatment customers for each fuel type; this model is very similar to the PPR model used in the behavior program impact evaluation.[29] The PPR model combines both cross-sectional and time series data in a panel dataset. This model uses the post-program data for the dependent variable and uses lagged energy use for the same calendar month of the pre-program period to control for any small systematic differences between the participant and control customers. In particular, energy use in calendar month *t* of the post-program period is framed as a function of both the participant variable and energy use in the same calendar month of the pre-program period. The underlying logic is that systematic differences between participants and controls will be reflected in differences in their past energy use, which is highly correlated with their current energy use. The version

[29] The results of the impact evaluation were presented to the PAs in a memo titled "Massachusetts Cross-Cutting Behavioral Program Evaluation Opower Results" on June 25, 2015.

we estimate includes monthly fixed effects and interacts these monthly fixed effects with the pre-program energy use variable. These interaction terms allow pre-program usage to have a different effect on post-program usage in each calendar month. Additionally, we interact the monthly fixed effects and the interaction of the monthly fixed effects with pre-program usage with a dummy for the Opower cohort. This allows the impact of the fixed effect and pre-program usage to differ for each cohort included in the study.

For the dual treatment study, in addition to controlling for monthly fixed effect and pre-program usage, we have controls for program cohort and receiving two-single fuel reports or one dual-fuel report. These controls help account for differences in the baseline usage between the two report groups. The model specification for electric savings in shown in Equation 1 and the model specification for gas in Equation 2.

Equation 1. PPR Model - Electric

$$ADElec_{kt} = \sum_{L} \beta_1 TwoS_k \cdot Treatment_k \cdot OpowerCohort_{kl} + \sum_{L} \beta_2 DF_k \cdot Treatment_k \cdot OpowerCohort_{kl} + \sum_{J} \beta_{3j} YrMo_{jt} \cdot OpowerCohort_{kl} + \sum_{J} \beta_{4j} YrMo_{jt} \cdot ADEleclag_{kt} \cdot OpowerCohort_{kl} + \beta_6 TwoS_k + \beta_7 DF_k + \varepsilon_{kt}$$

Equation 2. PPR Model – Gas

$$ADGas_{kt} = \sum_{L} \beta_1 TwoS_k \cdot Treatment_k \cdot OpowerCohort_{kl} + \sum_{L} \beta_2 DF_k \cdot Treatment_k \cdot OpowerCohort_{kl} + \sum_{J} \beta_{3j} YrMo_{jt} \cdot OpowerCohort_{kl} + \sum_{J} \beta_{4j} YrMo_{jt} \cdot ADGaslag_{kt} \cdot OpowerCohort_{kl} + \beta_6 TwoS_k + \beta_7 DF_k + \varepsilon_{kt}$$

The variables are defined as follows:

$ADElec_{kt}$	=	average daily electricity usage by household *k* in bill period *t*;
$ADGas_{kt}$	=	average daily gas usage by household *k* in bill period *t*;
$Treatment_k$	=	a 0/1 dummy equal to 1 if household *k* is a treatment customer and 0 otherwise;
$TwoS_k$	=	a 0/1 dummy equal to 1 if household *k* is a dual-treatment customer receiving two single-fuel reports or their matched control;
DF_k	=	a 0/1 dummy equal to 1 if household *k* is a treatment or control customer in a dual-fuel cohort and 0 otherwise;
$OpowerCohort_{kt}$	=	a set of 0/1 dummies taking a value of 1 when household *k* is a treatment or control customer in Opower cohort *l* and 0 otherwise, these are fixed effects for each of the *L* Opower cohorts;
$YrMo_{jt}$	=	a set of 0/1 dummies taking a value of 1 when *j*=*t* and 0 otherwise, these capture monthly fixed effects for each of the *J* year-months in the post period;
$ADEleclag_{kt}$	=	household *k*'s electricity usage in the same calendar month of the pre-program year as the calendar month of bill period *t*;
$ADGaslag_{kt}$	=	household *k*'s gas usage in the same calendar month of the pre-program year as the calendar month of bill period *t*.

In both of these models the weighted average of the β_1 coefficients over the relevant Opower cohorts[30] captures the treatment effect for dual-treatment customers receiving two single-fuel reports and the weighted average of the β_2 coefficients over the relevant Opower cohorts captures the treatment effect for dual-fuel customers receiving a single dual-fuel report.

Interacting the savings estimate, along with the monthly fixed effect and pre-program usage, with dummies for each Opower cohort allows the model to control for differences across the various cohorts, for example baseline usage or how long each cohort has been running. For each individual cohort, the model should estimate savings that are very similar to the savings if we estimated that cohort individually using just the customers in this analysis. For the dual-fuel cohorts, we show this comparison in the appendix.

The evaluation team performed F-tests to determine whether the two treatment effects were statistically different from one another for each fuel type. This test involves estimating an unrestricted model which includes all of the variables listed above and a restricted model where β_2 is left out. The residual sum of squares from each model is used to calculate an F-statistic. The null hypothesis is that the weighted average of the β_1 coefficients equals the weighted average of the β_2 coefficients (i.e., that savings do not differ across dual-treatment and dual-fuel customers); this hypothesis will be rejected if the F-statistic is greater than the critical value at a 90% significance level.

The evaluation team also calculated what savings would be if customers were switched from one report regime to the other (e.g., all dual-fuel or all dual-treatment). First, we determined counter-factual usage which is the actual usage by participants for one report regime plus the estimated savings for that report regime. Second, counter-factual usage was multiplied by the percentage savings for the other report regime giving hypothetical savings if the customers were switched. This calculation is illustrated in Equation 3.

Equation 3. Savings from Switching Report Regime

$$Savings\ from\ Switching\ df\ to\ dt = (AvgUsage.df + AvgSavings.df) * (\%Savings.dt)$$
$$Savings\ from\ Switching\ dt\ to\ df = (AvgUsage.dt + AvgSavings.dt) * (\%Savings.df)$$

The variables are defined as follows:

$AvgUsage$	=	average daily electricity usage by participants in the post period
$AvgSavings$	=	average savings
$\%Savings$	=	percentage savings
df	=	Dual-Fuel participants
dt	=	Dual-Treatment participants

Results

This section presents savings estimates for dual-fuel and dual-treatment customer for each fuel type.

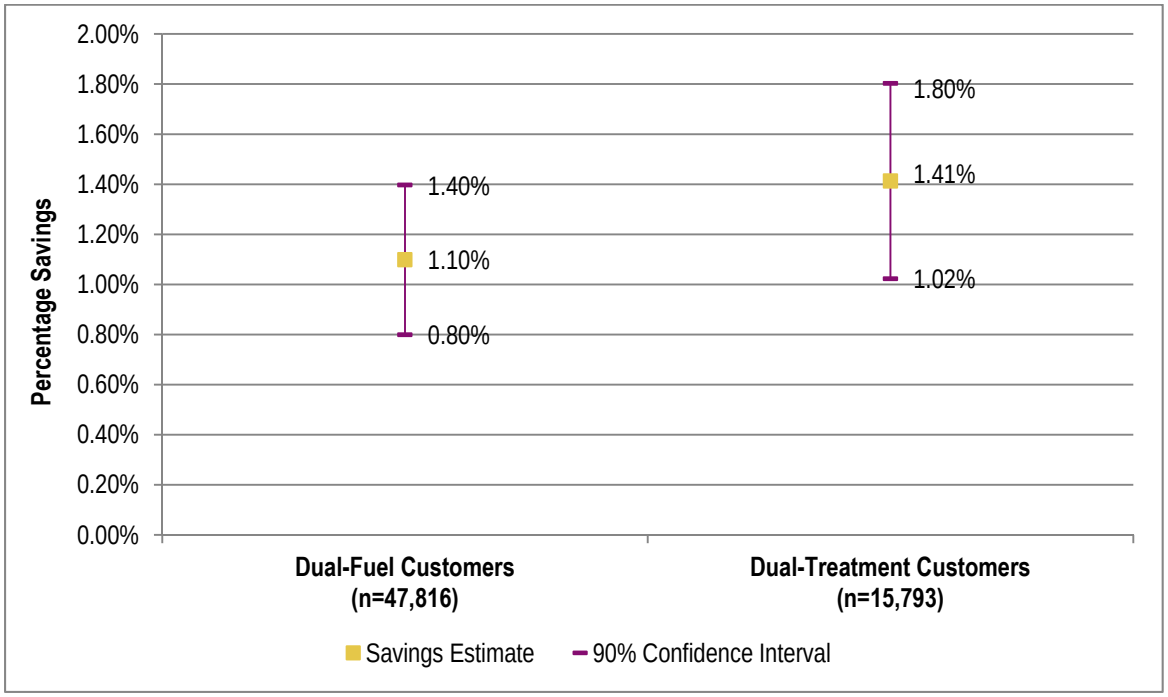
Figure 3 shows the electric percentage savings estimates and 90% confidence intervals for dual-fuel and dual-treatment customers. Dual-fuel customers have estimated savings of 1.10% with a 90% confidence interval from 0.80% to 1.40%. Dual treatment customers have estimated savings of 1.41% with a 90%

[30] The average is weighted by the number of customers in each cohort.

confidence interval from 1.02% to 1.80%. The difference between these two estimates is 0.31 percentage points. This difference is statistically significant at the 90% level suggesting that electric savings are higher for dual-treatment customers than dual-fuel customers.[31]

In absolute terms, electric customers receiving dual-fuel reports save 75.11 kWh per year and those receiving two single fuel reports save 124.86 kWh per year. If the dual-fuel customers were switched to dual-treatment customers they would save 96.62 kWh per year, which is an increase of 21.50 kWh or 29%.[32]

Figure 3. Electric Savings Estimates

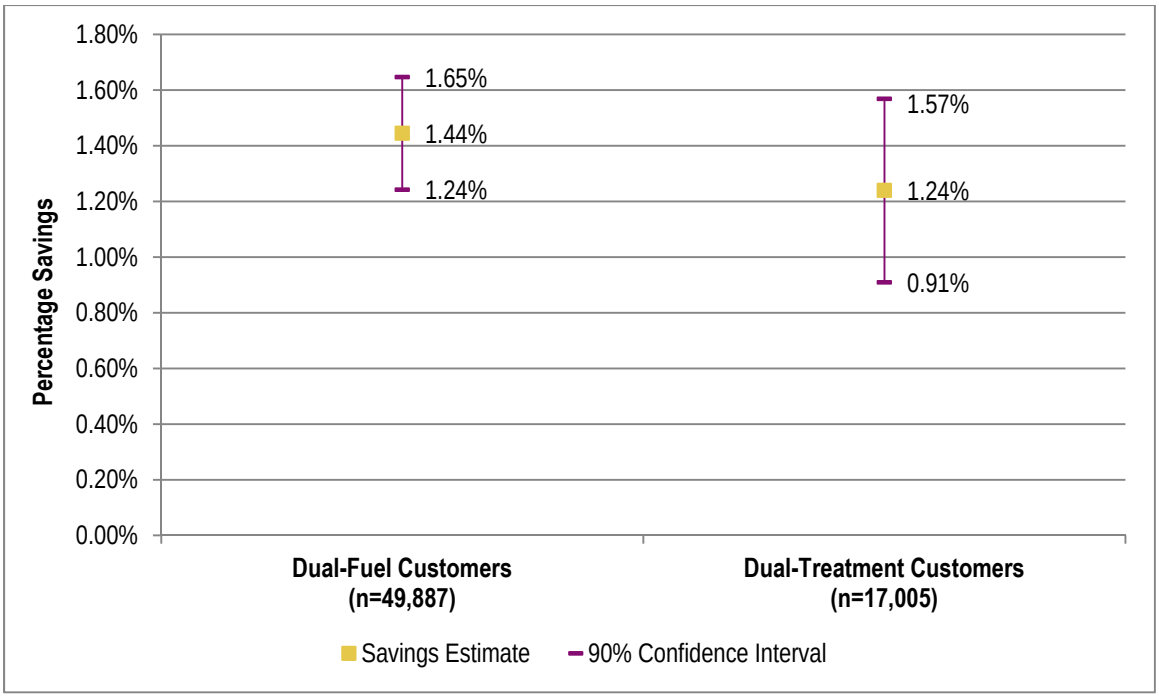


Source: Evaluation team analysis

Figure 4 shows the gas percentage savings estimates and 90% confidence intervals for dual-fuel and dual-treatment customers. Dual-fuel customers have estimated savings of 1.44% with a 90% confidence interval from 1.24% to 1.65%. Dual treatment customers have estimated savings of 1.24% with a 90% confidence interval from 0.91% to 1.57%. The difference between these two estimates is 0.21 percentage points. This difference is not statistically significant at the 90% level suggesting that gas savings are no different between dual-treatment and dual-fuel customers.[33]

[31] The F-statistic for this test was 4.1538 and the p-value was 0.04154.
[32] Dual-fuel customers used an average of 6,763 kWh per year and the estimated program savings were 75 kWh per year making their counter-factual usage 6,838 kWh per year. If these customers were switched to dual-treatment customers they would save 1.41%, making their annual savings 97 kWh (6,838*0.0141).
[33] The F-statistic for this test was 0.0219 and the p-value was 0.8824.

Figure 4. Gas Savings Estimates



Source: Evaluation team analysis

In absolute terms, gas customers receiving dual-fuel reports save 14.41 therms per year and those receiving two single fuel reports save 14.81 therms per year. If the dual-treatment customers were switched to dual-fuel customers they would save 17.26 therms per year, which is an increase of 2.45 therms or 17%.[34]

The fact that dual-treatment customers save statistically more than dual-fuel customers on the electric side but not on the gas side is an interesting finding. The evaluation team has two hypotheses for why this may be the case; both hypotheses relate to the idea that there are more opportunities for energy saving behaviors for electricity than for gas.

1. Receiving two reports may reinforce savings behavior for both fuels regardless of which fuel is targeted. However, greater opportunity for electric savings may contribute to the incremental savings associated with two reports on the electric side.
2. It is possible there are cross-fuel savings from gas reports but not electric reports due to greater opportunity for electric savings; that is, gas reports result in electric savings, but electric reports do not result in gas savings.[35]

To make comparisons between the two report regimes across fuel-types the evaluation team also converted these savings to MMBTU.[36] Figure 5 summarizes total savings in MMBTU under the current

[34] Dual-treatment customers used an average of 1,180 therms per year and the estimated program savings are 15 therms per year making their counter-factual usage 1,195 therms per year. If these customers were switched to dual-fuel customers they would save 1.44%, making their annual savings 17 therms (1,195*0.0144).
[35] The evaluation team has plans to do a cross-fuel savings study that could support or refute this hypothesis.

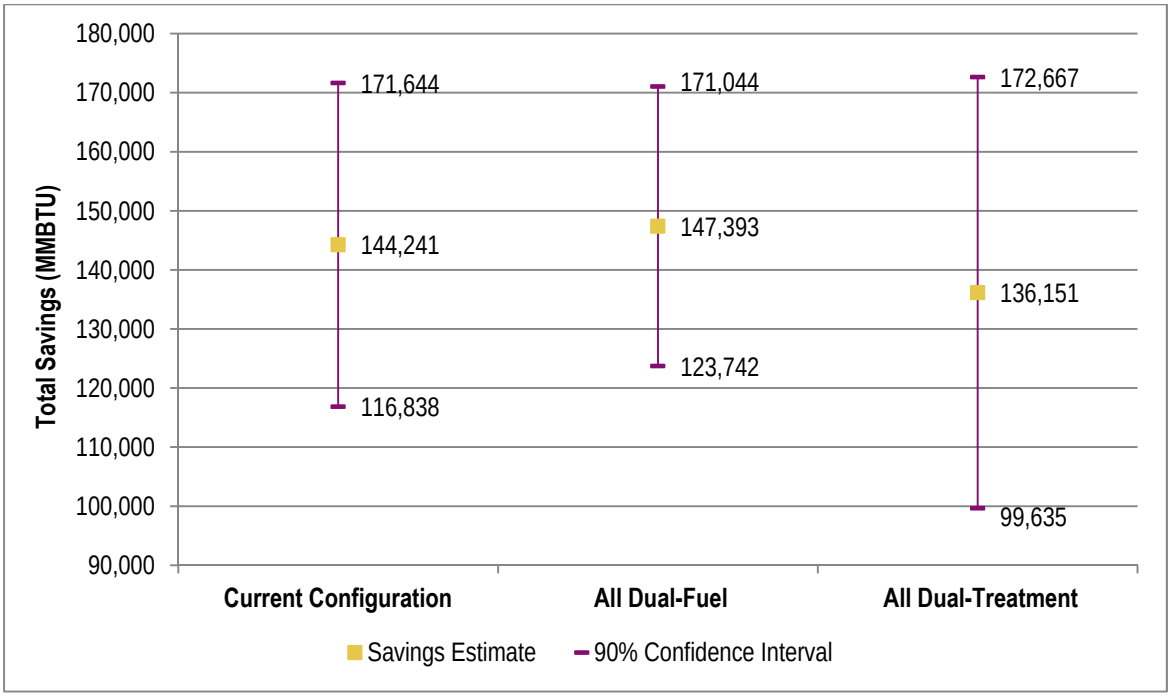
configuration of customers (61,518 dual-fuel customers and 20,909 dual-treatment customers) and if the program were changed such that all 82,427 customers were dual-fuel or dual-treatment.

Under the current configuration, our estimate of total savings is 144,241 MMBTU per year.

- If all customers were dual-fuel customers the annual savings would be 147,393 MMBTU, an increase of 3,152 MMBTU or 2%.
- If all customers were dual-treatment customers the annual savings would be 136,151 MMBTU, a decrease of 11,242 MMBTU or 8%.
- The changes in MMBTU are quite small compared to the sampling error illustrated by the 90% confidence bounds in Figure 5.

In total the HER program saved just over one million MMBTU in 2014, thus the increase from switching all of these customers to dual-fuel reports would only increase total program savings by approximately 0.3%.

Figure 5. Total Savings Estimates



Source: Evaluation team analysis

Recommendations

- The evaluation team's process evaluation analyzed whether there were differences in satisfaction between dual-fuel and dual-treatment customers.[37] Cross-PA customers (a subset of dual-treatment customers who receive electric reports from one PA and gas reports from another[38])

[36] The evaluation team used a conversion of 1 kWh = 0.0034095106405145 MMBTU and 1 therm = 0.10 MMBTU.
[37] Navigant Consulting, Inc. and Illume Advising, LLC. 2015. "Massachusetts Behavioral Programs Process Evaluation: Report in the Cross-Cutting Research Areas of Behavior and Education."
[38] The remaining dual treatment customers receive a gas report and an electric report from the same PA. Of all the dual-treatment customers, 97.6% are cross-PA customers and only 2.4% receive two reports from the same utility.

are satisfied with the frequency at which they currently receive reports and they find the reports just as useful as dual-fuel customers.

- Given that the total increase in annual MMBTU savings from switching all customers to dual-fuel reports is small and not statistically significant at the 90% level and the process evaluation showed that receiving multiple single-fuel reports was not an issue for cross-PA customers (the vast majority of dual-treatment customers), the evaluation team does not believe that coordination across the PAs is warranted and recommends that the PAs continue implementing the HER program in its current form.

Appendix

One test of whether or not Equation 1 and Equation 2 are properly estimating the effect of treatment for each Opower cohort is whether the estimates of average daily savings from these models are similar to the estimates if we ran individual regressions for each cohort. Estimates of savings from running the dual-fuel cohorts individually already exist from the behavior program impact evaluation.[39] Table 6 shows that the coefficients from the individual regressions and from this analysis are quite similar.

Table 6. Regression Coefficients

PA	Cohort Name	Elec Savings - Individual Regressions	Elec Savings – Model 1	Gas Savings - Individual Regressions	Gas Savings – Model 2
National Grid	Group 2012 Dual	-0.383	-0.391	-0.030	-0.029
NSTAR	Group 2010 Dual	-0.062	-0.077	-0.059	-0.058
NSTAR	Group 2011 Dual	-0.122	-0.118	-0.054	-0.054
NSTAR	Group 2013 Dual	-0.311	-0.214	-0.022	-0.023

Source: Navigant analysis

[39] The results of the impact evaluation were presented to the PAs in a memo titled “Massachusetts Cross-Cutting Behavioral Program Evaluation Opower Results” on June 25, 2015.