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MEMORANDUM

To: Electric and Natural Gas Program Administrators of Massachusetts

From: The Residential Retrofit Evaluation Team

Subject: HES Realization Rate Results Memo

Date: June 28, 2012

INTRODUCTION

In May 2013, the Residential Retrofit Evaluation Team (the Evaluation Team) completed a targeted impact evaluation of two Home Energy Services (HES) program measures: insulation and air sealing.The HES program is available to single-family residential customers living in buildings with up to four units throughout the Commonwealth of Massachusetts.

The evaluation sought to develop realization rates (the ratio of *ex ante* and *ex post* savings) that each Program Administrator (PA) could use to adjust insulation and air-sealing savings, as estimated by the most recent home auditing software employed by each HES implementer, to more closely reflect evaluated savings. For each PA, Table 1 details if and when a software update occurred.

Table 1. Implementer Software Updates

PA	Implementer	Software Update
Berkshire Gas	CET*	Yes, July 2011
Cape Light Compact	Rise Engineering	No
Columbia Gas	Honeywell	Yes, January 2012
National Grid	Conservation Services Group	Yes, July 2011
New England Gas	Honeywell	Yes, January 2012
NSTAR	Conservation Services Group	Yes, July 2011
Unitil	Self-Implemented**	No
WMECO	Honeywell	Yes, January 2012

*Used same auditing software as Conservation Services Group.
**Used PSD Consulting's TREAT software.

METHODOLOGY

The methodology used to develop realization rates for insulation and air sealing largely mirrored the approach used for the HES impact evaluation, completed in August 2012. Since the previous evaluation estimated savings for 2010 and early 2011 participants—prior to the deployment of the current software—the Evaluation Team could not use its findings to develop an accurate realization rate for more recent participants. Also, since PAs work with a variety of implementers that deploy different auditing software, this impact evaluation sought PA-specific results and realization rates. The previous HES impact evaluation focused on Commonwealth-wide results.

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Specifically, we assessed *ex post* savings for both measures using two approaches: a billing analysis and an engineering analysis. A brief description of each follows:

- ***Billing Analysis.*** We specified a fixed-effects conditional savings regression model, using paired pre- and post-participation months to estimate savings for insulation and air sealing installed in homes heated by natural gas. The analysis utilized participation records from the High Efficiency Heating and Water Heating, Cool Smart, and Opower programs[1] to ensure we did not misattribute the efficiency measures installed or behavioral changes resulting from those programs to the two HES measures.
- ***Engineering Analysis.*** For homes heated by electricity, heating oil, or propane, we estimated savings using PA- and fuel-specific U.S. Department of Energy (DOE-2) based simulation models, calibrated using each PA's average observed pre-program energy consumption.[2] We updated the simulation models using detailed measure data and home characteristics recorded by HES implementers as well as a variety of weather files selected to best represent each PA.

Table 2 summarizes the specific methodology used to estimate savings for each measure and heating fuel type. The previous HES impact evaluation report[3] provides more detail about these two approaches.

Table 2. Methodology by Measure and Heating Fuel-Type

Measure	Natural Gas	Electric	Heating Oil	Propane
Insulation	Billing Analysis	Simulation	Simulation	Simulation
Air Sealing	Billing Analysis	Simulation	Simulation	Simulation

Weather Stations

As noted, we developed a separate calibrated building simulation model for each PA and heating fuel type, using the detailed measure data and home characteristics recorded by each implementer. Each model also relied on a DOE-2 typical meteorological year three (TMY3) weather file, selected to best represent the PA's overall service territory or the portion of the service territory primarily served by a given fuel type. The TMY3 weather files, derived from datasets of the National Solar Radiation Data Base archives for years 1991–2005, represent typical conditions for specific locations. Table 3 lists the location of the TMY3 weather file used for each PA and fuel type.

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1 Where appropriate; not all PAs offered Opower during the study period.

2 As information regarding the pre-program consumption of heating oil and propane was not available, we utilized the observed pre-consumption for customers heating with natural gas to calibrate these models (after adjusting for differences in equipment efficiencies).

3 http://www.ma-eeac.org/Docs/8.1_EMV%20Page/2012/2012%20Residential%20Studies/MA%20RRLI%20-%20Home%20Energy%20Services%20%202011%20Impact%20Evaluation%20Report_FINAL_04SEPT2012.pdf

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Table 3. Building Simulation: Weather Station by PA and Fuel Type

PA	Natural Gas	Electric, Heating Oil, and Propane
Berkshire Gas	North Adams	n/a
Cape Light Compact	n/a	Barnstable
Columbia Gas	Worcester	N/A
National Grid	Boston	Worcester
New England Gas	Providence	n/a
NSTAR	Worcester	Boston (electric), Norwood (heating oil and propane)
Unitil	Lawrence	Lawrence
WMECO	n/a	North Adams

RESULTS

The following tables report *ex post* savings determined for insulation and air sealing by PA and all four fuel types. We compared these values to *ex ante* estimates provided by each PA's implementation vendor for the same customer sample to produce the realization rate.

As shown clearly in the tables, the *ex ante* and *ex post* savings as well as realization rates varied across PAs. This variation resulted from multiple factors, including: the profile of customers served, the mix of measures installed, the weather the service territory experiences, and the vendor-specific software used. The tables also include Commonwealth-wide averages, summarizing PA-specific results and offering comparison points.

Natural Gas

The billing analysis produced sufficiently precise (defined as less than or equal to ±21% relative precision at 90% confidence) PA-specific savings estimates for all PAs, except New England Gas.[4] The largest PAs—National Grid and NSTAR—had precisions at or less than ±5%. Table 4 summarizes our findings for each PA.

Table 4. Natural Gas: Insulation and Air Sealing Realization Rates (therms/year) by PA

PA	n	Model Precision (at 90% confidence)	*Ex Ante*	*Ex Post*	Realization Rate
Berkshire Gas	182	±17%	161	137	0.85
Columbia Gas	294	±10%	209	131	0.63
National Grid	2,889	±4%	188	140	0.74
New England Gas	18	±83%	107	119*	1.11
NSTAR	1,344	±5%	165	139	0.84
Unitil	22	±21%	256	175	0.68
Commonwealth-wide**	**4,749**	**±3%**	**183**	**139**	**0.76**

*Based on average Commonwealth-wide savings (more detail later in this section).
**Weighted by population of participants that received insulation and air sealing (not the billing analysis sample, which relied on a subset of participants with sufficient post-data to support the analysis).

[4] The previous HES impact evaluation defined "sufficiently precise" billing analysis results very similarly, using ±20% relative precision.

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At ±83% relative precision, the New England Gas-specific billing analysis savings estimate was well outside the identified threshold for acceptable precision. As a result, we estimated New England Gas' *ex post* savings by applying the Commonwealth-wide average savings as a percent of pre-program normalized annual energy consumption (11.6%, as shown in Table 5) to New England Gas' observed pre-program normalized annual energy consumption (1,025 therms). The result is an *ex post* savings estimate of 119 therms.[5]

Table 5 provides further details from the natural gas billing analysis. In addition to the combined *ex post* insulation and air sealing savings already presented, it shows *ex post* savings as a percentage of each PA's average, annual, and pre-program energy consumption.

The table also includes, for each PA, the percent of participants that increased and decreased their annual consumption after participating in HES. Increases in post-program energy consumption occur commonly in billing analysis, largely due to factors beyond the program's influence (e.g., a child returning from college). These participants should not be excluded from the analysis, as these participants are offset by other participants in the analysis sample that reduced their energy consumption due to factors beyond the program's influence (e.g., a child leaves for college).

As becomes evident in Table 5, the percentage of customers with greater post-program consumption remained relatively consistent across the larger PAs (ranging from 11% to 16%). None of Unitil's 22 participants increased usage, and that, at least in part, resulted in higher average *ex post* savings (175 therms). This is likely due to the small sample size rather than a difference in the program or the participants.

Table 5. Natural Gas: Insulation and Air Sealing Details (therms/year)

PA	*Ex Post* Savings	Average Pre-NAC*	Savings as Percent of Pre-NAC	Percent of Participants with Lower Post-NAC	Percent of Participants with Higher Post-NAC
Berkshire Gas	137	1,129	12.1%	86%	14%
Columbia Gas	131	1,066	12.3%	88%	12%
National Grid	140	1,240	11.3%	85%	15%
New England Gas	119**	1,025	11.6%**	89%	11%
NSTAR	139	1,154	12.0%	84%	16%
Unitil	175	1,070	16.3%	100%	0%
Commonwealth-wide* **	**139**	**1,195**	**11.6%**	**85%**	**15%**

*Pre-NAC: Pre-Program Normalized Annual Energy Consumption, or the average yearly energy consumption for participating customers during historically normal weather conditions.
**Based on average Commonwealth-wide savings.
***Weighted by population of participants that received insulation and air sealing (not billing analysis sample, which relied on a subset of participants with sufficient post-data).

[5] This result (119 therms) is similar to the billing analysis result of 115 therms, which – albeit with a large confidence interval around it – is the billing analysis' best point estimate of actual savings.

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The Evaluation Team also investigated whether differences in *ex post* savings occurred between customers served by HES lead vendors and those served through Home Performance Contractors (HPCs).[6] As shown in Table 6, lead vendors generated higher natural gas insulation and air sealing savings (absolute and percent) than HPCs for all three of the assessed PAs. The table compares only the two measures assessed as part of this study (insulation and air sealing). The Evaluation Team did not assess *ex ante* or *ex post* savings associated with any other measures installed within the sample of homes—therefore, this analysis does not offer a comprehensive or definitive assessment of lead vendor and HPC performance because it is not a complete comparison of all inputs and savings of the audit.

While the difference in savings and realization rates found between lead vendors and HPCs is interesting, it does not provide a definitive measure of relative performance. These results suggest that more extensive comparison of lead vendor and HPC performance should be done.

Table 6. Natural Gas: Comparison of Lead Vendors and HPCs (therms/year)

PA*	Provider	n	Percent of Participants	Model Precision (at 90% confidence)	Average Pre-NAC	*Ex Post* Savings	Savings as Percent of Pre-NAC	*Ex Ante* Savings	Realization Rate
Columbia Gas	Lead Vendor	211	72%	±10%	1,089	145	13.3%	218	67%
	HPCs	83	28%	±26%	1,007	96	9.6%	185	52%
National Grid	Lead Vendor	1,578	55%	±5%	1,224	148	12.1%	185	80%
	HPCs	1,311	45%	±6%	1,258	132	10.5%	191	69%
NSTAR	Lead Vendor	912	68%	±6%	1,171	146	12.5%	169	87%
	HPCs	432	32%	±10%	1,120	118	10.5%	156	75%

*No Berkshire Gas or New England Gas participants were served by an HPC, while Until exclusively uses HPCs.

Electric

The engineering analysis for electric heating systems produced relatively consistent results across PAs, with an overall Commonwealth-wide realization rate of 57%. Neither WMECO nor Unitil had any electric weatherization participants during this time period.

Table 7. Electric: Insulation and Air Sealing Realization Rates (kWh/year)

PA	n	*Ex Ante*	*Ex Post*	Realization Rate
Cape Light Compact	101	2,693	1,360	0.51
National Grid	383	2,423	1,459	0.60
NSTAR	124	2,712	1,468	0.54
Commonwealth-wide	**608**	**2,527**	**1,445**	**0.57**

Heating Oil

The engineering analysis for heating oil systems determined relatively high realization rates across the PAs, except for Unitil and WMECO.As becomes evident in Table 8, Unitil's and WMECO's lower

[6] Table 9 provides a similar comparison for heating oil participants. The Evaluation Team did not compare participants using electric or propane for heat due to lower levels of participation for those heating fuel types.

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realization rate primarily results from higher *ex ante* savings estimates as compared to the *ex ante* estimates of other PAs. An overall Commonwealth-wide realization rate of 85% resulted.

Table 8. Heating Oil: Insulation and Air Sealing Realization Rates (MMBtus/year)

PA	n	*Ex Ante*	*Ex Post*	Realization Rate
Cape Light Compact	748	16.4	16.4	1.00
National Grid	5,365	18.9	16.7	0.88
NSTAR	4,192	19.8	16.8	0.85
Unitil	128	38.6	13.9	0.36
WMECO	329	34.7	19.0	0.55
Commonwealth-wide	**10,762**	**19.8**	**16.8**	**0.85**

Similar to Table 6, the Evaluation Team investigated whether differences in *ex post* savings existed between heating oil participants served by HES lead vendors and those served by HPCs. As shown, lead vendors and HPCs generated savings that were more similar for heating oil participants than for natural gas participants. Again, the table only compares the two HES measures assessed as part of this study: insulation and air sealing. The Evaluation Team did not assess *ex ante* or *ex post* savings associated with any other measures installed within the sample of heating oil homes. Therefore, as previously noted, this study does not offer a comprehensive or definitive assessment of lead vendor and HPC performance.

Table 9. Heating Oil: Comparison of Lead Vendors and HPCs (MMBtus /year)

PA*	Provider	n	Percent of Participants	*Ex Ante* Savings	*Ex Post* Savings	*Realization Rate*
National Grid	Lead Vendor	4,386	82%	19.4	16.7	0.86
	HPCs	979	18%	17.1	17.1	1.00
NSTAR	Lead Vendor	2,664	64%	20.1	17.0	0.84
	HPCs	1,528	36%	19.1	16.5	0.86

*Samples sizes were insufficient to compare providers for other PAs

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Propane

The engineering analysis for propane heating systems produced relatively high realization rates among all PAs, except for Unitil and WMECO. Similar to the heating oil analysis, the lower realization rate for Unitil and WMECO resulted from high *ex ante* savings. As shown in Table 10, WMECO had the highest average *ex post* savings (14.7 MMBtus) of all PAs serving propane customers. An overall Commonwealth-wide realization rate of 83% resulted.

Table 10. Propane: Insulation and Air Sealing Realization Rates (MMBtus/year)

PA	n	*Ex Ante*	*Ex Post*	Realization Rate
Cape Light Compact	70	14.3	12.2	0.86
National Grid	216	14.3	12.6	0.88
NSTAR	91	14.2	13.5	0.95
Unitil	5	63.2	12.7	0.20
WMECO	10	33.4	14.6	0.44
Commonwealth-wide	**391**	**15.4**	**12.8**	**0.83**

SUMMARY

Comparing Commonwealth-wide realization rates for insulation and air sealing from the August 2012 evaluation (based on data prior to the software updates) and the current evaluation (based on data after the software updates) indicates that the updated software produces *ex ante* savings estimates that are closer to the *ex post* estimates determined by the Evaluation Team. Specifically, this evaluation resulted in a Commonwealth-wide realization rate of 76% as compared to the 61% realization rate found in the previous evaluation (for insulation and air sealing only). It should also be noted that the average savings per participating home—using natural gas for heat—also increased for the participant homes included in the 2013 evaluation (139 therms) versus participant homes included in the 2012 evaluation (92 therms) due to the increased adoption of recommended measures.

Table 11. Realization Rate Comparison—Insulation and Air Sealing (Natural Gas, therms/year)

Study	*Ex Ante*	*Ex Post*	Realization Rate
HES Impact Evaluation (August 2012)	152	92	0.61
HES Realization Rate Task (June 2013)	183	139	0.76

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PREVIOUS RESULTS

Table 12 lists the previous evaluation findings for all HES measures, other than insulation and air sealing. The Evaluation Team did not assess propane savings as part of the previous HES impact evaluation.

Table 12. Annual *Ex Post* Gross Savings by Measure and Primary Fuel Type

Category	Measure	Natural Gas (therms/year)	Electric (kWh/year)	Oil (MMBtus/year)
Heating System	Oil System Replacement*	–	–	6.5
	Oil Furnace Replacement	–	–	8.4
	Furnace Fan (due to oil furnace replacement)	–	–	98 (kWh)
	Oil Boiler Replacement	–	–	6.0
	Boiler Reset Controls	45	–	4.7
	Boiler Pipe Wrap	13	–	1.4
	Programmable Thermostat	32	330	3.4
Lighting & Appliances	Refrigerator Replacement	–	714	–
	CFLs	–	37	–
Domestic Hot Water	Overall**	11.7	283	1.6
	- Showerhead	11.7	237	1.3
	- Faucet Aerator	2.4	49	0.3
	- Pipe Wrap	2.3	64	0.4
	Indirect Water Heater	40	–	6.4
Distribution	Duct Insulation	68	1,613	7.7
	Duct Sealing	36	428	4.1

*Oil system replacement results from the weighted average of oil and furnace savings, based on the number of installations observed in 2010 and Q1-Q3 2011.

**Average savings for a household receiving at least one DHW measure (does not include indirect water heaters).

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