

**Date:** July 14, 2011  
**To:** Gail Azulay, NSTAR  
**From:** Residential Retrofit Evaluation Team  
**Re:** Non-Electric Impact (NEI) Findings for the 2011 Mass Save Home Energy Services (Mass Save) program.

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This memorandum summarizes Cadmus' review of the non-electric impacts (NEI) claimed for the 2011 Mass Save Home Energy Services (Mass Save) program by Program Administrators (PAs).

Our review consisted of determining the source of the current NEI values and independently estimating measure-specific NEIs, using the best available PA program data and secondary sources to assess the reasonableness of the current values.

### Non-Energy Impacts vs. Non-Electric Impacts

There are two recognized and mutually exclusive types of program impacts beyond electricity and gas savings:

1. **Non-Energy Impacts:** Program-driven effects on customers, participants, and the utility or society. These include increased property value, increased comfort and safety, and avoided or lessened bill arrearages.
2. **Non-Electric Impacts:** Program-driven effects on the consumption of energy other than electricity, such as natural gas (not claimed by a gas PA), water, fuel oil and propane.

Cadmus' review focused exclusively on non-electric impacts, as non-energy impacts are currently being investigated as part of the cross-cutting evaluation.

### Findings

Cadmus determined current PA NEI values were generated based on summaries of audit tool outputs for each program home. These values were driven by inputs from Mass Save vendors regarding home characteristics for participants realizing NEIs. These are primarily from program homes for which the primary space heating fuel is neither electricity nor natural gas.

Cadmus has not yet had the opportunity to review the specific savings algorithms/models used by Mass Save vendors to estimate energy savings<sup>1</sup> (for electric, natural gas, or NEIs). However, we believe vendor-determined participant-specific estimates are currently the best source for NEI values until the 2011 impact evaluation is completed. Cadmus also conducted an independent assessment of NEI estimates and found the current vendor-provided values were reasonable. More information about Cadmus' estimates and assumptions is provided in the subsequent section.

## Recommendation

Cadmus recommends PAs continue to use vendor-provided estimates of NEIs as these estimates are reasonable, participant-specific, and estimated in a consistent manner to electric and natural gas savings.

## Supporting Documentation

Cadmus also independently developed measure-specific estimates of NEIs (Table 1). These deemed values are based on various assumptions (Table 2) that are not specific to the characteristics of the housing stock for any given PA; rather, these values are designed to be applicable statewide. This is one reason we recommend utilizing the data generated the Mass Save vendors, since that data are specific to the relevant housing stock.

**Table 1. Cadmus' Independent Estimates of Annual Mass Save Non-Electric Impacts**

Equipment	Measure	Units	Energy (MMBTUs)			Water (Gallons)		
			Gas	Oil	Propane	Gas	Oil	Propane
Space Heat	Air Sealing	Per Home	6.9	7.0	6.0	-	-	-
Space Heat	Duct Insulation	Per Home	3.5	3.5	2.6	-	-	-
Space Heat	Duct Seal	Per Home	3.7	3.7	2.7	-	-	-
Space Heat	ES Window	Per Home	4.5	4.6	3.8	-	-	-
Water Heat	Faucet Aerators	Per Unit	0.4	0.3	0.5	2,114	1,792	2,537
Space Heat	Heating System Replacement	Per Unit	32.5	9.6	24.2	-	-	-
Water Heat	Indirect Water Heater	Per Unit	2.3	2.2	2.3	-	-	-
Space Heat	Insulation	Per Home	27.6	17.3	16.9	-	-	-
Water Heat	Low flow Showerheads	Per Unit	2.2	1.9	2.2	5,547	4,703	5,547
Space Heat	Thermostats	Per Home	3.3	3.3	2.4	-	-	-
Space Heat	Weather Responsive Controls (Boiler Reset)	Per Home	4.5	4.6	3.4	-	-	-

<sup>1</sup> Cadmus will be reviewing all Mass Save vendor algorithms as part of the 2011 impact evaluation that begins this fall.

The specific input assumptions Cadmus used to estimate NEIs for each measure and fuel type are listed in Table 2. These input assumptions and the algorithms used to estimate NEI for each measure are also detailed in a supplementary Microsoft Excel workbook provided to the PAs.<sup>2</sup>

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<sup>2</sup> MA RR&LI - NEI Analysis - Cadmus Savings Estimates\_05JULY2011.xlsx

**Table 2. Mass Save Non-Electric Impacts Assumptions**

Assumptions	Gas	Oil	Propane	Source
Number of People	2.8	2.8	2.8	2010 Mass Save participant survey, number of people per home based on water heating fuel type
Size of Home (Sq.Ft.)	2,100	2,120	1,820	2010 Mass Save participant survey, square footage of home based on space heating fuel type
# of Floors	1.72	1.74	1.40	Weighted results from RECS 2005 raw data, broken out by space heating fuel.
Age of Home (yrs)	1953	1959	1972	2010 Mass Save participant survey, vintage of home based on space heating fuel type
Faucet Usage (min/day)	5.0	5.0	5.0	American Water Works Association Research Foundation, North American Residential End Use Study Progress Report, 1997
Showerhead Usage (min/day)	8.2	8.2	8.2	Mayer, P. W., De Oreo, W. B., Nelson, J. O., Opitz, E., and Allen, R. (1997) North American Residential End Use Study Progress Report. American Water Works Association Research Foundation, Denver, CO.
Hot Water Usage (gal/person/day)	23	23	23	Averaged from various sources: NY TRM, ACEEE, OH TRM, EPA, and others.
Furnace Capacity kBTUs per sqft	43	43	37	ENERGY STAR Furnace calculator assumptions, kBTU/sqft/yr values for the New England Census division using the survey results for average age of the home (1966, 1953, 1959, and 1972) broken out by heating fuel type
Existing Furnace Efficiency (AFUE %)	68%	78%	68%	ENERGY STAR Furnace calculator assumptions, assuming the home's initial furnace was replaced after the first 20 years of use. Average age of the home (1966, 1953, 1959, and 1972) and assumed average age of existing furnace (1985, 1975, 1980, and 1990). Assuming a 98% efficient electric furnace and that a propane furnace has an equivalent efficiency of a gas furnace.
Federal Standard Furnace Efficiency (AFUE %)	78%	78%	78%	IECC 2009 Warm Air Furnace Specifications, Table 503.2.3(4) Warm Air Furnaces and Combination Warm Air Furnaces/ Air-Conditioning Units, Warm Air Duct Furnaces and Unit Heaters, Minimum Efficiency Requirements. {AND} <a href="http://www.eia.doe.gov/neic/experts/heatcalc.xls">www.eia.doe.gov/neic/experts/heatcalc.xls</a>
ENERGY STAR Furnace Efficiency	90%	85%	90%	ENERGY STAR specifications for gas and oil furnaces. Assuming a propane furnace has the same efficiency as an ENERGY STAR gas furnace. Assuming no efficiency increase for electric furnace efficiency than baseline.
Federal Standard Water Heater Efficiency (EF %)	59%	51%	59%	IECC 2009 Water Heater Specifications, Table 504.2 Minimum Performance of Water Heating Equipment. Assuming a 40 gallon unit

Assumptions	Gas	Oil	Propane	Source
Air Sealing Savings per 1000 sqft	3.3	3.3	3.3	NY TRM 2009 Single Family Residential Measures. Pg 33-34. Using Albany as the reference city, which is in the same IECC climate zone as Massachusetts. Assuming Average vintage. Savings are based on an infiltration rate reduction of 30%.
Duct Insulation ESF (%)	3.9%	3.9%	3.9%	NY TRM Appendix H. Distribution Efficiencies. The values represent insulation improvements of an uninsulated duct to R-6 @ 20% duct leakage. For Albany reference city. Assuming 90% of ducts in unconditioned basement and 10% of ducts in attic.
Duct Seal ESF (%)	4.1%	4.1%	4.1%	NY TRM Appendix H. Distribution Efficiencies. A values represent air sealing impacts from duct sealing of a 20% to 8% reduction. For Albany reference city. Assuming 90% of ducts in unconditioned basement and 10% of ducts in attic.
Window Area (Sq.Ft.)	344	348	290	Engineering Calculation
ES Window Savings per 100 sqft	1.3	1.3	1.3	Assuming 1 pane glass to code U-value of 0.35 represents energy saving windows. Savings are from the NY TRM for the city Albany, which has the same IECC climate zone (zone 5) as Massachusetts.
Indirect Water Heater ESF	17%	17%	17%	Not applicable to electric water heaters as they are already more efficient than high efficiency gas boilers. Using average savings percentage of 17% of baseline water heater consumption, which is based on ACEEE 1998 claimed energy savings for a indirect-fired water heater (add-on) from a direct-fired water heater. Range of savings is 10 to 24%
Heating Degree Days	5,630	5,630	5,630	NOAA 30 yr Annuals Heating Degree Days at 65F (HDD@65), for the weather station "BOSTON LOGAN IN BOS"
Wall Area Insulated (Sq.Ft.)	1,950	1,971	1,641	Engineering Calculation, assumes a 2:1 aspect ratio, 9ft tall walls, and 15% window to wall ratio.
Wall Insulation Savings (R-4.1 to R-18.8)	50	51	42	R-values based on Mass Save Program Data. R-3.6 added to the Mass Save Program value of existing insulation of R-0.5 and installed insulation of R-15.2. 0" (R-3.6) Based on ENERGY-10 assumption for zero insulation. Other sources range from R-3 to 4.38. PA TRM and <a href="http://www.coloradoenergy.org/procorner/stuff/r-values.htm">http://www.coloradoenergy.org/procorner/stuff/r-values.htm</a> . Assumes adding R-6 per DOE recommendation on ENERGY STAR website for adding wall insulation to existing homes in Zones 5-8. Insulation may be loose fill in stud cavities or board insulation beneath siding. <a href="http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_insulation_table">http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_insulation_table</a>
Wall Insulation Weight	36%	7%	9%	Mass Save Program Data
Attic Area Insulated (Sq.Ft.)	1,222	1,218	1,296	Engineering Calculation

Assumptions	Gas	Oil	Propane	Source
Attic Insulation Savings (R-11.7 to R-33.0)	9.1	9.1	9.7	R-values based on Mass Save Program Data. R-3.6 added to the Mass Save Program value of existing insulation of R-8.1 and installed insulation of R-29.4. 0" (R-3.6) Based on ENERGY-10 assumption for zero insulation. Other sources range from R-3 to 4.38. PA TRM and <a href="http://www.coloradoenergy.org/procorner/stuff/r-values.htm">http://www.coloradoenergy.org/procorner/stuff/r-values.htm</a> . Assumes adding R-6 per DOE recommendation on ENERGY STAR website for adding wall insulation to existing homes in Zones 5-8. Insulation may be loose fill in stud cavities or board insulation beneath siding. <a href="http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_insulation_table">http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_insulation_table</a>
Attic Insulation Weight	45%	66%	70%	Mass Save Program Data
Floor Area Insulated (Sq.Ft.)	1,222	1,218	1,296	Engineering Calculation
Floor Insulation Savings (R-4.7 to R-24.2)	28.3	28.2	30.0	R-values based on Mass Save Program Data. R-3.6 added to the Mass Save Program value of existing insulation of R-1.1 and installed insulation of R-20.6. 0" (R-3.6) Based on ENERGY-10 assumption for zero insulation. Other sources range from R-3 to 4.38. PA TRM and <a href="http://www.coloradoenergy.org/procorner/stuff/r-values.htm">http://www.coloradoenergy.org/procorner/stuff/r-values.htm</a> . Assumes adding R-6 per DOE recommendation on ENERGY STAR website for adding wall insulation to existing homes in Zones 5-8. Insulation may be loose fill in stud cavities or board insulation beneath siding. <a href="http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_insulation_table">http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_insulation_table</a>
Floor Insulation Weight	19%	27%	21%	Mass Save Program Data
Insulation Savings	27.6	17.3	16.9	Engineering Calculation
Thermostat (Heating Only) ESF	3.6%	3.6%	3.6%	From PA TRM: Report to KeySpan Energy Delivery on Energy Savings and Cost Effectiveness", GDS Associates, Marietta, GA. 2002. 3.6% factor includes 56% realization rate.
Boiler Reset Controls ESF	5%	5%	5%	NY 2010 TRM assumption, Baseline assumes constant hot water setpoint temperature of 180F and measure reflects resetting hot water temperature to 160F
Density of Water	8.33	8.33	8.33	Constant
Heat Capacity of Water	1	1	1	Constant
Water Inlet (F)	57.8	57.8	57.8	For Boston, MA. Averaged monthly water main temperature calculated using the methodology provided in Building America Research Benchmark Definition, updated December 2009. Pg.19-20. Using NOAA 30yr normals data for BOSTON LOGAN INTL AP. <a href="http://www.nrel.gov/docs/fy10osti/47246.pdf">http://www.nrel.gov/docs/fy10osti/47246.pdf</a> ;

Assumptions	Gas	Oil	Propane	Source
Water Heater Tank Setpoint Temperature (F)	126.5	126.5	126.5	CPUC Residential Retrofit - High Impact Measure Evaluation Report Draft. Dec. 7, 2009. Pg 76. Average temperature setpoints for two utilities.
Hours per Day	24	24	24	Constant
Days per year	365	365	365	Constant
BTU to MMBTU conversion	1,000,000	1,000,000	1,000,000	Constant
kBTU to MMBTU Conversion	1,000	1,000	1,000	Constant
kWh to BTU	3,412	3,412	3,412	Constant
Number of Faucets	1.20	1.40	1.00	Mass Save Program Data
Number of Showerheads	1.20	1.40	1.20	Mass Save Program Data, for propane water heating assuming a similar number showerheads per home as natural gas
Faucet Temperature (F)	80	80	80	Default faucet outlet temperature (80°) in the Vermont TRM 2009 p. 280. Also source is consistent with the Connecticut Energy Efficiency Fund; CL&P and UI Program Savings Documentation for 2008 Program Year.
Shower Temperature (F)	105	105	105	A BPA study measured average shower temperatures 104 - 106 <a href="http://www.bpa.gov/energy/n/reports/evaluation/residential/faucet_aerator.cfm">http://www.bpa.gov/energy/n/reports/evaluation/residential/faucet_aerator.cfm</a> . 105 is the Default Temperature of Showers in the Vermont TRM 2009 p. 278
Faucet Baseline GPM	2.2	2.2	2.2	Federal Standard
Faucet Measure GPM	1.7	1.7	1.7	Mass Save Program Data, Average GPM comes from NGRID dataset only
Showerhead Baseline GPM	2.5	2.5	2.5	Federal Standard
Showerhead Measure GPM	1.7	1.7	1.7	Mass Save Program Data, Average GPM comes from NGRID dataset only