

Memorandum

To: Massachusetts Program Administrators and Energy Efficiency Advisory Council (EEAC) Consultants
From: Opinion Dynamics Evaluation Team
Date: May 10, 2018
Re: Education Kits Program Deemed Savings Review Results

1. Introduction

This interim memo provides deemed savings review results for the Cape Light Compact (CLC) and National Grid (NGRID) Be Energy Efficiency Smart (BEES) Program. The CLC and NGRID BEES Programs provide K-12 students with take-home kits containing energy efficient measures, including light-emitting diodes (LEDs), kitchen and bathroom faucet aerators, showerheads (NGRID only), thermostat temperature cards (CLC only), and hot water temperature cards.¹

Evaluation tasks included:

- Deemed savings updates based on Massachusetts TRM 2017 values, census and survey data on the single family and multifamily mix, and an engineering-based review of hot water and thermostat temperature card savings.
- Calculation of cumulative lifetime savings for LEDs, accounting for bulbs installed in future years.

A final report will include findings for spillover savings potential, recommendations for program implementation and survey design improvements, as well as recommendations for additional low-cost measures and educational materials.

1.1 Limitations

This study faces limitations in data availability. It is not possible to conduct surveys with students or their parents due to state policies prohibiting survey outreach to students' families. Thus, research into deemed savings assumptions must leverage results from the take-home surveys provided with the kits completed. For the CLC program, 980 out of 2,634 students (37%) completed and returned their take-home surveys from the 2015-2016 and 2016-2017 program years combined. These surveys included the necessary questions to determine the single family/multifamily mix for deemed savings assumptions. However, per conversations

¹ The take-home kits also include "draft stopper" outlet covers, flow rate test bags (CLC only), and appliance temperature cards for which the program does not claim savings.

with NEED and NGRID, the NGRID program has received no survey responses² and there was no opportunity to conduct additional surveys for this evaluation.

Finally, while the original scope of work included calculating in-service rates (ISRs), the evaluation team ultimately determined that additional data collection would be necessary to evaluate ISRs. It was discussed we may need further primary data collection (e.g., with parents) research will be required to confirm these ISRs. We will provide these recommendations in the final report. Considering these limitations, the study leverages the current ISR assumption of 50% for all kit measures.

2. Results

This section presents the high-level results of our deemed savings analysis by measure and for the kit overall for both programs.

Deemed Savings

The evaluation team recommends using the values in Table 1 as preliminary deemed gross savings estimates for CLC, and the values in Table 2 for NGRID. These calculated results incorporate the mix of single-family versus multifamily households and the weighted mix of fuel types for hot water and temperature cards. These tables also include the estimate useful life of each of the measures as established by the Massachusetts TRM³ (for LEDs, aerators, and showerheads) and the Illinois TRM (for temperature cards). Note, these savings values are “preliminary” because CLC and NGRID may make updates to the deemed savings values currently in the MA TRM (i.e., for LEDs, aerators, and showerheads). An excel-based calculator is available in Appendix B to allow the PAs to easily update the kit savings values.

Table 1. Deemed Gross Savings Per Kit (CLC)

Measures	Weighted Deemed Gross Savings Per Kit*						
	Quantity	Measure Life	Electric kWh	Gas MMBtu	Oil MMBtu	Propane MMBtu	Water Gallons
LEDs (60W equivalent)	3	7	113.55	0.00	0.00	0.000	0
Kitchen aerator	1	7	53.42	0.26	0.35	0.261	332
Bathroom aerator	1	7	53.42	0.26	0.35	0.261	332
Thermostat Temp Card (Heating)	1	5	29.77	1.79	0.83	0.064	0
Thermostat Temp Card (Cooling)	1	2	63.29	0.00	0.00	0.000	0
Hot Water Temp Cards	1	2	9.98	0.11	0.04	0.004	0
Weighted Kit Total	N/A	5.5**	323.42	2.42	1.57	0.589	664

Note: Some values do not sum to totals due to rounding.

*Weighted based on the mix of single family and multifamily customers as well as the mix of heating fuel types.

**Weighted based on measure quantities.

Please see Section 3.2 and 3.2 for more detail.

² Per NEED, some teachers encountered challenges encouraging students to return the surveys while others received surveys but did not provide them to NEED (e.g., they were too busy, or they felt there were too few surveys for it to be worthwhile). The evaluation team will investigate these challenges in the next phase of the study and provide recommendations for overcoming them.

³ The assumptions from the MA TRM are cited based on the Massachusetts Common Assumptions.

Table 2. Deemed Gross Savings Per Kit (NGRID)

Measures	Weighted Deemed Gross Savings Per Kit*						
	Quantity	Measure Life	Electric kWh	Gas MMBtu	Oil MMBtu	Propane MMBtu	Water Gallons
LEDs (60W equivalent)	2	7	62.69	0.00	0.00	0.000	0
Kitchen aerator	1	7	59.08	0.34	0.42	0.339	332
Bathroom aerator	1	7	59.08	0.34	0.42	0.339	332
Showerheads	1	7	214.32	1.19	1.27	1.187	2,351
Hot Water Temp Cards	1	2	9.98	0.11	0.04	0.004	0
Weighted Kit Total	N/A	6.2**	233.92	1.97	2.14	1.869	3,015

Note: Some values do not sum to totals due to rounding.

*Weighted based on the mix of single family and multifamily customers as well as the mix of heating fuel type.

**Weighted based on measure quantities.

The sources for deemed savings values are provided in Table 3 below.

Table 3. Deemed Savings Values Sources

Measures	Source
LEDs (60W equivalent)	Massachusetts TRM 2017 values for Home Energy Services (HES) and Multifamily Retrofit
Kitchen aerator	Massachusetts TRM 2017 values for HES and Multifamily Retrofit
Bathroom aerator	Massachusetts TRM 2017 values for HES and Multifamily Retrofit
Showerhead	Massachusetts TRM 2017 values for HES and Multifamily Retrofit
Thermostat temperature card (Heating)	Engineering-based review; see Section 3.2
Thermostat temperature card (Cooling)	Engineering-based review; see Section 3.2
Hot water temperature card	Engineering-based review; see Section 3.2

3. Detailed Methods

3.1 Temperature Card Savings

The BEES program kits contained temperature cards that suggested ideal temperature settings for both thermostats (CLC only) and hot water heaters. The Massachusetts TRM does not provide a deemed value for temperature cards, so the evaluation team developed deemed savings through an engineering analysis. The engineering team leveraged TRMs, survey data and program-specific measure details to arrive at deemed savings values. Based on our review of several TRMs across the country, a measure life specific to temperature cards does not exist. Therefore, in the absence of any better assumptions, we recommend using the following:

- Water heater temperature setback card – 2-year measure life based on the IL TRM version 6 for Water Heater Temperature Setback

- HVAC temperature setback card – 2-year measure life based on IL TRM version 6 for Programmable Thermostat Adjustments.

A more detailed summary of exact assumptions is outlined in Appendix A.

3.2 Hot Water and HVAC Fuel Type Weighting

The hot water and thermostat temperature cards will result in savings across different fuel types based on the type of systems in use in student households. The evaluation team estimated the savings for each fuel type based on the distinct mix of fuel types (electric, natural gas, fuel oil, and propane) across both CLC and NGRID customers. Table 4 and Table 5 contains the distributions of fuel type for thermostat and water heater cards.

Table 4. HVAC Heating Fuel Type Proportions (For Thermostat Cards)

Fuel Type	CLC	NGRID	Source
Electric	15%	11%	CLC Participant Survey responses and Residential Energy Consumption Survey (RECs) Microdata.
Natural Gas	50%	53%	
Fuel Oil	19%	32%	
Propane	4%	2%	
Other	12%	2%	

Table 5. Hot Water Heater Fuel Type Proportions (For Hot Water Cards)

Fuel Type	CLC	Source
Electric	22%	2009 Massachusetts RECs Microdata (CLC survey did not provide water heating fuel types).
Natural Gas	56%	
Fuel Oil	19%	
Propane	2%	

3.3 Single Family/Multifamily Weighting

Deemed savings values differ for single versus multifamily homes due to intrinsic factors associated with these dwelling types.⁴ On average, multifamily units are older than single family homes with technology that is less efficient, offering greater potential savings (e.g. faucet aerator savings). In contrast, the average energy usage per home is higher in single family homes which typically have more square footage, which in this case explains the greater potential for savings in thermostat settings adjustments.

Due to these difference, it is necessary to estimate the relative percentage of participating students living in the two dwelling types. We used the ratio of single-family to multifamily households from CLC student survey data for CLC and 2015 American Community Survey (ACS) census data for NGRID. We also examined the CLC mix using census data and found the values to be fairly consistent with the survey results. However, because the dwelling mix for families with school-aged children may differ from the overall territory, the evaluation team

⁴ Quantifying Energy Efficiency in Multifamily Rental Housing. (www.huduser.gov/portal/periodicals/em/summer11/highlight1.html)

feels the survey results are the best source of data to determine the mix (see Table 6). We applied the proportions to the respective deemed savings values for each measure.

Table 6. Single-Family Multifamily Mix

PA	Single-Family	Multifamily	Source
CLC	91%	9%	CLC Survey
	93%	7%	Census Data
NGRID	79%	21%	Census Data

Note: Census Data is from the ACS 2015 Housing Characteristics.

Table 7 and Table 8 provide the unweighted deemed savings values, broken out by single family and multifamily dwellings, for the CLC and NGRID programs, respectively.

Table 7. Deemed Gross Savings Per Kit by Customer Type (CLC)⁵

Measure	Electric (kWh)		Gas (MMBtu)		Oil (MMBtu)		Propane (MMBtu)		Water Gallons	
	Single Family	Multifamily	Single Family	Multifamily	Single Family	Multifamily	Single Family	Multifamily	Single Family	Multifamily
LEDs (60W equiv.)	37.85	37.85	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Kitchen aerator	49.00	97.00	0.200	0.860	0.300	0.860	0.200	0.860	332	332
Bathroom aerator	49.00	97.00	0.200	0.860	0.300	0.860	0.200	0.860	332	332
Thermostat temperature card (Heating)	30.62	21.33	1.817	1.527	0.851	0.572	0.066	0.043	N/A	N/A
Thermostat temperature card (Cooling)	63.29	63.29	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hot water temperature card	9.98	9.98	0.109	0.109	0.037	0.037	0.004	0.004	N/A	N/A
Total	239.74	326.45	2.33	3.36	1.49	2.33	0.47	1.77	664	664

Table 8. Deemed Gross Savings Per Kit by Customer Type (NGRID)

Measure	Electric (kWh)		Gas (MMBtu)		Oil (MMBtu)		Propane (MMBtu)		Water Gallons	
	Single Family	Multifamily	Single Family	Multifamily	Single Family	Multifamily	Single Family	Multifamily	Single Family	Multifamily
LEDs (60W equiv.)	37.85	37.85	0.000	0.000	0.000	0.000	0.000	0.000	N/A	N/A
Kitchen aerator	49.00	97.00	0.200	0.860	0.300	0.860	0.200	0.860	332	332
Bathroom aerator	49.00	97.00	0.200	0.860	0.300	0.860	0.200	0.860	332	332
Showerheads	237.00	129.00	1.200	1.140	1.300	1.140	1.200	1.140	2401	2165
Hot water temperature card	9.98	9.98	0.109	0.109	0.037	0.037	0.004	0.004	N/A	N/A
Total	382.83	370.83	1.71	2.97	1.94	2.90	1.60	2.86	3,065	2,829

⁵ PAs will use the most recent savings values to calculate the deemed savings for the program, based on updates from PAs or evaluation results.

Appendix A. Engineering Algorithms and Input Assumptions

The engineering team applied the following algorithms and assumptions to estimate the deemed values presented in earlier sections of this memo. Table 9 and Table 10 document the hot water temperature card and the thermostat set back card assumptions respectively.

Table 9. Hot Water Temperature Card Algorithms and Input Assumptions

Algorithms		
$\Delta \text{ kWh} = (U * A * (\Delta \text{ Temp}) * \text{Hours}) / (3412 * \text{RE}_{\text{electric}})$		
$\Delta \text{ mmbtu} = [(U * A * (\Delta \text{ Temp}) * \text{Hours} * \text{ISR}) / \text{RE}] / 1,000,000$		
Input Assumptions		
Parameter	Value	Source
U-value of tank	0.083	Illinois (IL) TRM (Assumes R-12, or U-0.083.)
Surface area of tank (A) SF and MF	23.33	Average tank size from RECs 2009 data. Surface areas calculated using average size from the IL TRM.
$\Delta \text{ Temp}$ (°F)	8.87	CLC survey data.
Hours	8,766	Hours in a year that the savings occur, assumed to be constant over the year (IL TRM).
Conversion	3,412	Converts btu to kWh (3,412 Btu/kWh)
RE _{electric}	0.98	Recovery efficiency of electric hot water heater (IL TRM)
RE _{Gas/Oil/Propane}	0.780	Recovery efficiency of gas hot water heater in single family home (IL TRM). We assumed single family value as the average tank size for single and multifamily units from the RECs data are roughly the same size. The natural gas recovery efficiency is assumed for oil and propane from the heating fuel comparison calculator from the Energy Information Administration (EIA).
Conversion	1,000,000	Converts btu to mmbtu (1,000,000 btu/mmbtu)
Other Assumptions		
Parameter	Value	Source
Measure Life	2	IL TRM v6 for Water Heater Temperature Setback

Table 10. Thermostat Temperature Card Algorithms and Input Assumptions

Algorithms		
$\Delta\text{kWh cool} = (\text{FLHcool} * \text{Capacity} * 1/\text{SEER})/1000 * \% \text{savings}$		
$\Delta\text{kWh heat} = \text{Elec_Heating_Consumption} * \% \text{savings Heat} * \text{HF}$		
$\Delta\text{mmbtu} = \text{Gas_Heating_Consumption} * \text{HF} * \% \text{savings}/1,000,000$		
Input Assumptions		
Parameter	Value	Source
FLHcool	1,172	MA TRM.
AC Capacity	3	Assumes a 3 ton average equipment size based on climate zone and average home sq. ft. from CLC survey data.
SEER	13	2015 federal minimum efficiency.
Conversion	12,000	ton to btuh conversion (12,000 btu/ton)
Conversion	1,000	kW to kWh conversion (1,000 kW/ kWh)
%savings AC	5%	Assumes manual set back saves 5% annually based on the CLC survey responses; 85% of surveyed homeowners set back their thermostat less than 4 degrees. This estimate falls in line with assumptions from both Energy.gov and the MA TRM for programmable thermostats: Energy.gov estimates turning down thermostat 5-15 degrees for 8 hours a day saves up to 10% on energy used for heating. The mass TRM assumes a programmable thermostat saves 6.2% on energy every year.
Electric Heating Consumption (kWh) SF	4,208	Average kWh space heating consumption from RECs 2009 database for single family homes in MA.
Electric Heating Consumption (kWh) MF	2,931	Average kWh space heating consumption from RECs 2009 database for Multifamily homes in MA.
%savings heat	5%	Similar AC savings, assume manual set back sees 5% savings based on the survey responses, 78% of surveyed homeowners set their thermostat less than 4 degrees hotter
HF SF	1.00	IL TRM
HF MF	0.65	IL TRM.
Natural Gas Heating Consumption (btu) SF	72,089,367	Average Natural gas BTU heating consumption from RECs 2009 database for single family homes in MA.
Natural Gas Heating Consumption (btu) MF	60,600,214	Average Natural gas BTU heating consumption from RECs 2009 database for multi family homes in MA.
Propane Heating Consumption (btu) SF	37,479,029	Average Propane BTU heating consumption from RECs 2009 database for single family homes in MA.
Propane Heating Consumption (btu) MF	46,579,029	Average Propane BTU heating consumption from RECs 2009 database for multi family homes in MA.
Fuel Oil Heating consumption (btu) SF	87,665,652	Average Fuel oil BTU heating consumption from RECs 2009 database for single family homes in MA.
Fuel Oil Heating consumption (btu) MF	58,921,469	Average fuel oil BTU heating consumption from RECs 2009 database for multi family homes in MA.
FLHheat	530	MA TRM.
Conversion	1,000,000	btu to mmbtu (1,000,000 btu / mmbtu).
Other Assumptions		
Parameter	Value	Source
Measure Life	2	IL TRM v6 for Programmable Thermostat Adjustments

Appendix B. Deemed Savings Calculator

The following file contains the calculator using the deemed savings values, kit component ISRs, and quantities that can be edited for each service territory to determine the deemed savings for different variations of the kits.



Deemed Savings
Calculator_FINAL_v2

Appendix C. Key References

The table below includes the key sources for the development of the ISRs, deemed savings values, and associated assumptions for this memo.

Reference	Source
CLC Survey Data	Cape Light Compact education kit program participant survey
EIA	Heating fuel calculator (HEAT-CALC-Vsn-D_1-09.xls)
IL TRM	Illinois Statewide Technical Reference Manual. Version 5.0. February 11, 2016.
RECS Data	U.S. Energy Information Administration, 2009 Residential Energy Consumption Survey (RECS), Massachusetts.
MA TRM	Massachusetts Technical Reference Manual. 2016-2018 Program Years—Plan Version. October 2015.
LED Lifetime Savings	NMR Group, Inc. (2017). RLPNC 16-7: LED In-Service Rate Calculations.