Impact Evaluation: Rhode Island Income Eligible Services, Volume II

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Final

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Executive Summary

National Grid Rhode Island contracted with Cadmus to determine the savings achieved by their Rhode Island Income Eligible Services (IES) electric and gas program for the 2011 and 2012 program years. The IES Program has historically been administered alongside the low-income weatherization program offered by the Rhode Island State Office of Energy Resources (OER) and delivered through local Community Action Program (CAP) agencies. The program administration moved to the Department of Human Services (DHS) in 2012.

In 2013, National Grid released a request for proposals for organizations to manage and administer the IES Program. National Grid chose the vendor CLEAResult and transitioned program management from DHS to the new contractor. The local CAP agencies remain active in program delivery as the primary link between IES and low-income customers. Currently, seven CAP agencies deliver the program.

Program Description

IES targets customers who are eligible for the Low Income Heating Assistance Program (LIHEAP) and living in one- to four-unit residences within National Grid's Rhode Island service territory. Customers who qualify for LIHEAP are eligible for all IES Program services. Customers who do not qualify for LIHEAP but who are eligible for National Grid's residential low-income discount rate (A-60) are eligible to receive IES electric (Appliance Management Program [AMP]) services. All IES services are provided at no cost to the customer.

IES Program participants with gas heat may qualify to receive attic, wall, floor, and/or pipe insulation; air sealing; heating system repair or replacement; and health and safety inspections. Participants with electric heat or oil heat may qualify for the above weatherization measures and heating system replacements.

IES participants receive education about the electricity use of all home appliances, direct installation of energy-saving measures, and a household appliance audit. Some qualify for replacement of home appliances such as refrigerator and freezers (based on the appliance's average usage).

Methodology

Cadmus used two approaches to assess the gross per-unit savings generated by each measure: a billing analysis and an engineering review.

- ***Billing Analysis.*** Cadmus specified a fixed-effects, conditional savings regression model, with pre- and post-participation months; this provided estimated measure-level savings for electricity and natural gas measures installed through the program.
- ***Engineering Review.*** For those measures' that we could not confidently evaluate savings through the billing analysis, Cadmus completed an engineering review. This review consisted of comparing the measure and expected savings to results from the following recent impact evaluations conducted on similar programs within National Grid's service territory:
  - The Cadmus Group, Inc. *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid. 2009. (AMP 2009)
  - The Cadmus Group, Inc. *Rhode Island EnergyWise Single Family Impact Evaluation.* Prepared for National Grid. 2012. (RI EnergyWise 2012)
  - Cadmus. *Home Energy Services Impact Evaluation.* Prepared for The Electric and Gas Program Administrators of Massachusetts. 2012. (MA HES 2012)
  - Cadmus. Low Income Single Family Program Impact Evaluation. Prepared for The Electric and Gas Program Administrators of Massachusetts. 2012. (MA LI 2012)

In addition, Cadmus reviewed engineering algorithms and savings estimates contained in the Rhode Island Technical Reference Manual (RI TRM 2012) and other technical reference manuals (TRMs) to assess newer technologies, such as LEDs and Smart Strips.

Ultimately, for this evaluation, Cadmus either retained expected savings from prior evaluations or used an updated value based on results from the above publications or the billing analysis.

Findings

The IES Program went through some significant changes in the 2011 to 2012 program cycles. Some agencies struggled to meet production and two weathered scandal during this program cycle. National Grid contracted with CLEAResult as the new program administrator and, according to the Cadmus process evaluation, has instituted some program delivery changes.

The annual average participant natural gas, electric, and fuel oil savings for the IES Program are listed below in Table 1, Table 2, and Table 3, respectively.

Table 1. Evaluated Energy Savings for All Natural Gas Measures

Category	Measure	Natural Gas Savings (therms/year)
Weatherization	Insulation (overall) with Air Sealing and Duct Sealing (program)	188
	Furnace Fan (electric savings due to weatherization)	206 (kWh)
	Cooling (electric savings due to weatherization)	138 (kWh)
Heating System	Furnace/Boiler	184
	Furnace Fan (electric savings due to furnace replacement)	172 (kWh)
Water Heating	Overall (for homes installing at least one measure)	9

Table 2. Evaluated Energy Savings for All Electric Measures

Category	Measure	Electric Savings (kWh/year)
Weatherization	Overall Insulation with Air Sealing and Duct Sealing*	1,616
Lighting and Appliances	CFLs	21.78
	LEDs	48
	Refrigerator Replacement	384
	Freezer Replacement	484
	Refrigerator/Freezer Removal	1,180
	Smart Strips	75
	Waterbed	872
Water Heating	Overall (homes receiving at least one hot water measure)	134
Other	Tender Loving Care (TLC) Kit	21
	TLC Kit and Education	138

* This row refers to savings from any participant that received air sealing, duct sealing, or attic, wall, or basement/floor insulation.

Table 3. Evaluated Energy Savings for All Oil Measures

Category	Measure	Oil Savings (MMBtu/year)
Weatherization	Overall Insulation with Air Sealing and Duct Sealing*	28.1
	Electric Savings (cooling and fan replacement)	377 (kWh)
Heating System	Furnace/Boiler	18.4
	Electric Savings (furnace fan replacement)	132 (kWh)
Water Heating	Overall – for households the received at least one hot water measure	0.7

* This represents the average savings for a household that received at least one weatherization measure.

Conclusions

The total amount of energy savings achieved through the IES Program depends heavily on the amount of electric savings achieved through installing CFLs. On average, each home participating in the program received over 20 CFLs. Cadmus estimated that each CFL achieves an average of 21.78 kWh in savings per year. This 21.78 kWh estimate is an increase of 4.41 kWh from the 17.37 kWh estimated in RI IES Vol 1), but it is still lower than that typically estimated and observed for direct install programs. Based on our process evaluation research completed in 2014, the lower savings are most likely due to a combination of the following:

- ***The installation of 21.5 bulbs per home on average.*** Our analysis revealed that the amount of kWh saved per bulb decreases as more bulbs are installed in the home. Participants achieved the expected savings of 41 kWh per bulb when only installing 11 bulbs per home. However, the average number of bulbs supplied to participants of 21.5 yielded 21.78 kWh per bulb, as shown in Table 4.

Table 4. Energy Saving Based on Number of CFLs Installed

CFLs Received	Percentage of Analysis Dataset	Average Number of Installed CFLs	Billing Analysis (kWh Saved/CFL)
1-5	3%	3.7	80
6-15	31%	11.0	41
16-50	63%	25.9	17
Over 50	2%	64.9	17
Overall	**100%**	**21.5**	**21.78**

- ***Incandescent bulbs were left on the properties served.*** Multiple CAP agencies left incandescent bulbs for participants in case they did not like the CFLs installed. If those participants removed the installed CFLs or replaced failed CFLs with an incandescent, the savings for the home are reduced.
- ***Some CAP agencies left CFLs for the participant to self-install.*** If the participant did not install these bulbs or replaced an incandescent with a higher lumen CFL, then the achieved savings were lower than expected.

Second to CFLs, high-efficiency refrigerator installations deliver the most electricity savings to the program. Cadmus conducted a revised analysis and estimated that refrigerators installed through the IES Program achieve 384 kWh of savings per year on average. This is a decrease from our original estimate of 455 kWh of savings per year, and both values are lower than expected. There are a couple of factors that could contribute to this:

- Our process evaluation research revealed that the program protocol requires agencies to meter units for 75 minutes, while most low-income energy efficiency programs require metering for 120 minutes or longer.
- The program implementer replaced more recent models of refrigerators than in the past, and newer refrigerators are more efficient and lead to less savings.

Natural gas savings from the program are driven by weatherization and heating system replacements. The gas evaluation results are based on the billing analysis completed of gas participants. The program achieved higher than anticipated savings for both gas weatherization and gas heating system replacements.

Recommendations

Cadmus offers the following recommendations for future program implementation and evaluation:

- Continue to provide weatherization services where the program is able. Savings from weatherization were higher than expected for all fuels considered in this evaluation.
- To increase future evaluated savings for CFLs, National Grid could consider changing installation protocols to require removal of the replaced incandescent bulbs from the participant's property.
- The program could track directly installed CFLs separately from those left behind for installation by the resident. Savings for CFLs left behind for the resident to install would be calculated differently from savings for those bulbs directly installed. National Grid could also consider only claiming savings for those bulbs that are directly installed.
- National Grid and CLEAResult could conduct a refrigerator metering pilot project to record refrigerator usage both after 75 minutes and again at 120 minutes or later to determine if there is a difference between the results. The pilot could also be used to test the amount of strain on the CAP agencies to meter appliances for a longer period of time.
- Meter a sample of installed refrigerators (we recommend completing two hours of post-installation metering on this sample). These data, along with the rated consumption of the equipment and the pre-retrofit metering results, could be used to develop a more accurate estimate of replacement refrigerator savings.

In addition to our program recommendations, Cadmus offers these recommendations for National Grid to consider for the next IES Program impact evaluation.

- Complete a billing analysis of 2014 participants in early 2016 to assess changes in savings that occur based on program changes (CLEAResult becoming the implementation contractor in 2013, and the changes they have made to program operations).
- Continue to complete home verification visits to confirm measure installations, including the number and locations of installed CFLs. This information will help National Grid and its stakeholders better understand the program results. These visits should also be used to identify opportunities for improvements to program design and delivery.

Introduction

National Grid Rhode Island contracted with Cadmus to determine the savings achieved by their Rhode Island Income Eligible Services (IES) electric and gas program. Before 2013, this program existed as two interrelated income-eligible programs: the Appliance Management Program (AMP), for electric measures, and the Income-Eligible Weatherization Assistance Program (WAP), for gas measures. With the integrated IES Program, National Grid seeks to increase the energy efficiency of low-income customer homes by installing energy-efficient measures and educating customers about energy-efficient practices.

Program History

In 1995, National Grid formed a partnership with the income-eligible weatherization and fuel assistance network of Community Action Program (CAP) agencies in Massachusetts to develop a new electric, income-eligible conservation program. The AMP pilot program was one of the first low-income energy-efficiency programs in the United States to move beyond weatherization and address lighting, water heating, refrigeration, and other household energy uses. The program also offered customer energy education to help households reduce their energy usage through behavioral changes. The WAP Program was designed to increase energy efficiency among income-eligible natural gas customers through energy audits, the installation of insulation and air-sealing measures, and heating system replacements or repairs.

Since being implemented, the AMP and WAP programs became increasingly responsive to energy-savings opportunities and the needs of individual customers. Most participants received a detailed appliance assessment, including appliance monitoring and personalized education about the home energy usage and energy saving opportunities. When the Rhode Island Law of Energy Conservation extended to natural gas in 2007, the two programs began operating as one, and have operated as the IES Program since 2013.

Program management and delivery has changed over time. For over 20 years, the State of Rhode Island's Office of Energy Resources (OER) served as the programs' lead vendor. The OER simultaneously administered the federal Department of Energy Weatherization Assistance Program (DOE WAP) and the American Recovery and Reinvestment Act of 2009 programs. In July 2012, Rhode Island moved the administration and staff for their energy-efficiency programs from OER to the Department of Human Services (DHS) in an effort to consolidate low-income energy assistance programs.

As the lead vendor, the DHS has a long history of working with the local CAP agencies across the state to provide cost-effective energy-saving services to its residents. DHS (previously OER) manages the participating CAPs' delivery of energy-efficiency services. These seven local agencies serve as the primary link between the program and low-income customers. During the period covered by this impact evaluation (2011 and 2012), the following agency-related events occurred:

- In 2011, the Providence CAP (PROCAP) closed due to a scandal that forced it into bankruptcy.[1] In PROCAP's absence, work shifted to other CAP agencies. Additionally, National Grid shifted funding to the City of Providence's Green and Healthy Homes Initiative to weatherize homes in two Providence neighborhoods.[2]
- In 2012, an auditor from Comprehensive CAP, serving the Cranston, Rhode Island area, plead guilty to accepting kickbacks.[3]

In 2013, National Grid released a request for proposals for organizations to manage and administer the IES Program. National Grid chose the vendor CLEAResult and transitioned program management from DHS to the new contractor.

Program Description

IES targets customers who are eligible for the Low Income Heating Assistance Program (LIHEAP)[4] and living in one- to four-unit residences within National Grid's Rhode Island service territory. Customers who qualify for LIHEAP are eligible for all IES Program services. Customers who do not qualify for LIHEAP but who are eligible for National Grid's residential low-income discount rate (A-60)[5] are eligible to receive IES electric (AMP) services and measures. All IES services are provided at no cost to the customer.

IES Program participants with gas heat may qualify to receive attic, wall, floor, and/or pipe insulation; air sealing; heating system repair or replacement; and health and safety inspections. Participants with electric heat or oil heat may qualify for the same weatherization measures and heating system replacements.

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1 More information is available online: http://blogs.wpri.com/tag/providence-community-action-program/.

2 National Grid only funded measures eligible for IES.

3 More information is available online: http://www.justice.gov/usao/ri/news/2012/nov2012/lemoi.html.

4 LIHEAP income guidelines are available online: http://www.energy.ri.gov/lowincome/incomeguidelines.php.

5 National Grid customers who receive benefits from means-tested benefit programs (such as Supplemental Security Income, LIHEAP, Medicaid, Food Stamps, General Public Assistance, or Family Independence Program Assistance) are eligible for the A-60 rate.

IES participants receive education about the electricity usage of all home appliances, direct installation of energy-saving measures, and a household appliance audit. Specifically, these services include:

- Monitoring of refrigerators and freezers during the audit. Those with usage over a threshold amount may be replaced with a new, efficient unit. In some cases, the CAP agency removes older units without replacement or replaces two older units with one new, efficient unit.
- Efficiency measures such as CFLs, faucet aerators, showerheads, water heater tank wrap, pipe insulation, waterbed insulation, mattress replacements, thermostats, and air conditioning timers.
- Program audit staff collaborate with AMP participants on ideas for increasing the adoption of energy conservation behaviors, such as drying laundry on a clothesline or turning off lights and televisions in unoccupied rooms.

Report Organization

This report is organized into the following sections:

- ***Methodology***, which outlines the impact evaluation tasks and how Cadmus gathered and analyzed project data.
- ***Findings***, which detail the key impact evaluation results.
- ***References,*** outlining full bibliography entries for the reports and documents referenced throughout the report.
- ***Appendix A***, containing detailed billing analysis model specifications and outputs.

Methodology

Cadmus used two approaches to assess the gross per-unit savings generated by each measure: a billing analysis and an engineering review. A brief description of each method follows:

- ***Billing Analysis.*** Cadmus specified a fixed-effects, conditional savings regression model, with pre- and post-participation months; this provided estimated measure-level savings for electricity and natural gas measures installed through the program.
- ***Engineering Review.*** For those measures' that we could not confidently evaluate savings through the billing analysis, Cadmus completed an engineering review. This review consisted of comparing the measure and expected savings to results from the following recent impact evaluations conducted on similar programs within National Grid's service territory:
  - The Cadmus Group, Inc. *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid. 2009. (AMP 2009)
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  - Cadmus. *Low Income Single Family Program Impact Evaluation.* Prepared for The Electric and Gas Program Administrators of Massachusetts. 2012. (MA LI 2012)

In addition, Cadmus reviewed engineering algorithms and savings estimates contained in the Rhode Island Technical Reference Manual (RI TRM 2012) and other technical reference manuals (TRMs) to assess newer technologies, such as LEDs and Smart Strips. Very few applicable impact evaluations have been accomplished to assess savings from these newer technologies in the field.

Ultimately, for this evaluation, Cadmus either retained expected savings from prior evaluations or used an updated value, based on results from the above publications. These publications provided an efficient impact assessment for measures with a low overall program impact.

Table 5 details all the approaches we used to determine savings for each program measure by fuel type, and provides the precision associated with each billing analysis-based savings estimate.

Table 5. Methodological Approach to Calculating Savings by Measure and Primary Fuel Type

Category	Measure	Natural Gas (therms/year)	Electric (kWh/year)	Oil (MMBtu/year)
Weatherization	Insulation (overall) Air Sealing and Duct Sealing*	Billing Analysis (±21%)	MA LI 2012	MA LI 2012
	Furnace Fan (electric savings due to weatherization)	--	MA LI 2012	--
	Cooling (electric savings due to weatherization)	--	MA LI 2012	--
Heating System Replacement	Furnace/Boiler	Billing Analysis (±33%)	MA LI 2012	MA LI 2012
Lighting and Appliances	CFLs	--	Billing Analysis (±17%)	--
	LEDs	--	RI TRM 2012	--
	Refrigerator Replacement	--	Billing Analysis (±28%)	--
	Freezer Replacement	--	Billing Analysis (±65%)	--
	Refrigerator/Freezer Removal	--	MA LI 2012	--
	Smart Strips	--	RI TRM 2012	--
	Waterbed Insulation	--	AMP 2009	--
Water Heating	Overall**	AMP 2009	AMP 2009	MA LI 2012
Other	Tender Loving Care (TLC) Kit	--	MA LI 2012	--
	TLC Kit and Education	--	AMP 2009	--
	All Other Measures***	--	Billing Analysis (±60%)	--

* This includes savings for all weatherization measures implemented in the home.

** Cadmus determined the average savings for a household that received at least one domestic hot water measure.

*** Since this measure category contains miscellaneous measures, Cadmus assessed savings in aggregate through the billing analysis.

Data Sources

In addition to the TRMs for Rhode Island and other states, and previous reports and engineering analyses of specific measures as outlined above, Cadmus used data from the following sources to inform the impact evaluation:

- Measure tracking data (provided by National Grid)
- Customer billing data (provided by National Grid)

- Weather data (obtained from the National Climatic Data Center)
- CAP agency data or DHS data showing details on homes with measures funded outside of the program

Measure Tracking Data

For the majority of our analysis, Cadmus used the detailed measure-tracking data provided by National Grid. These data included records of each gas and electric measure installed from January 2011 through July 2013. Cadmus grouped measure tracking data by account number.

Customer Billing Data

National Grid provided participants' energy consumption records up to January 2014. Cadmus included data from 2010 through the last available month in the billing analysis.

Weather Data

To account for weather impacts in the billing analysis, Cadmus collected weather data from the National Climatic Data Center for three stations across Rhode Island. For each station, we calculated the base-65 heating degree days (HDDs) and cooling degree days (CDDs). Cadmus matched each billing data period to the associated HDDs and CDDs, based on the nearest weather station (using participants' zip codes).[6]

Recent Evaluation Results from Comparable Programs

For measures where the billing analysis could not be used to confidently determine measure impacts, Cadmus estimated measure impacts using the evaluation results from comparable impact evaluation reports. These reports provided an efficient and reliable source of savings. Where available, Cadmus relied on studies of similar weatherization programs serving low-income populations. In particular, we adopted savings for several measures from the *Low Income Single Family Program Impact Evaluation* conducted in Massachusetts (MA LI 2012). Similar to this evaluation, in the MA LI 2012 evaluation, the majority of natural gas impacts were calculated through billing analysis. For the MA LI 2012 evaluation, most electric savings and all heating oil savings were calculated through engineering simulation modeling, using a DOE-2-based simulation model calibrated to the average energy consumption of low-income program participants. For measures not typically subject to interactive effects, the MA LI 2012 evaluation used standard industry engineering algorithms.

[6] These base-65 HDDs were: 6,009 electric all (n=1,614); 6,061 gas all (n=184); and 6,056 gas weatherization (n=162).

We used the MA LI 2012 evaluation as a proxy for savings for several reasons:

- The Massachusetts low-income program is operated according to the same protocols as the Rhode Island IES Program
- Participants from both programs live in low-income households, have similar usage patterns and housing stock, and require similar home treatments
- The climates of Massachusetts and Rhode Island are similar; both are considered humid, continental climates with warm summers and cold winters

Where possible, Cadmus also benchmarked savings against similar programs in other areas and in the Northeast region to provide some context for the savings estimates.

CAP Agency Data Showing Homes with Measures Funded by Non-Program Funds

National Grid requested data from DHS to document homes that received measures funded by sources outside of IES (including from DOE WAP and LIHEAP). Although National Grid did not receive these data, it received installation data from one CAP agency that documented homes receiving additional measures installed with non-IES Program funds. Cadmus matched these data to addresses in the program database and removed these participants from the analysis.

Billing Analysis

Cadmus evaluated several different specification options for modeling savings before selecting the fixed-effects, conditional savings analysis (CSA), paired-months modeling approach detailed in this section. The CSA model offered an advantage for gas measures: when savings interact with weather changes, it provides the best method for calculating normalized annual savings.

Appendix A provides details on the models we specified for the natural gas and electric analysis, along with an explanation of all independent variables included in the model.

Analysis Period

To conduct the billing analysis, Cadmus focused on changes to participants' energy consumption from January 2010 to December 2013. We based the pre- and post-periods on the dates of each participant's initial and final measure installations. Specifically, Cadmus designated billing data months occurring before each participant's earliest install date as the pre-period and designated those after the last measure installation date as the post-period. This approach ensured that we excluded billing records from the analysis that occurred during the measure installation process.

Billing Data Screening

To ensure the analysis included only the highest-quality data, Cadmus excluded customers with insufficient billing data, customers with extreme consumption values (high or low outliers) and customers with months of no data. Table 6 shows details of our data screening efforts.

Table 6. Billing Data Screening Criteria

Screen	Number of Sites Remaining in Analysis	
	Electric Customers	Gas Customers
Matched billing data sample (only participant accounts that matched to a billing data addresses)	4,433	630
Removed accounts known to have received measures with non-National Grid funding sources	4,296	626
Removed accounts with less than 300 days (10 months) in the pre- or post-period	1,935	244
Removed accounts where consumption changed by more than 50% from pre- to post-period	1,876	234
Removed billing data outliers, vacancies, and seasonal usage	1,614	184
Final Sample Available for Analysis	**1,614**	**184**

Findings

This section presents evaluated gross savings for all program measures by primary heating fuel type (natural gas, electric, and oil).

Energy Savings: Natural Gas

Table 7 summarizes the billing analysis results for gas weatherization and gas heating systems: the evaluated percentage savings were 16% and 18% of pre-installation usage, respectively.

Table 7. Billing Analysis Natural Gas Savings Results

Measure	n	Energy Savings (therms/year)	Relative Precision at 90% Confidence Level	Pre-Period Usage (therms)	Percentage Savings
Weatherization	162	168	21%	1,058	16%
Heating System	29	184	33%	1,037	18%
Other*	116	-20	-217%	1,022	-2%
Overall	**184**	**164**	**12%**	**1,050**	**16%**

* Participants in the billing analysis received these measures that are outside of weatherization and heating system replacement (including windows, doors, and ventilation measures). This category also includes other variances in the models used to calculate savings. The precision associated with this estimate is too wide to be considered in the overall savings.

The program achieved average annual savings of 188 therms for homes receiving weatherization.[7] Homes receiving heating system installations achieved gas savings of 184 therms per year. Overall, gas participant homes saved an average of 164 therms a year.

Electric Savings in Natural Gas Homes

Weatherization measures and heating system replacements in natural gas-heated homes generate a small amount of electric savings. Higher efficiency heating systems result in reduced fan run-times, which translates into electric furnace fan savings. The MA LI 2012 outlines a simulation model to estimate the savings associated with this measure. Those models calculated average electric savings of 172 kWh per year for natural gas homes with heating system replacements.

Weatherization measures generate electric savings from reduction in furnace fan run-times and reduction in cooling system usage in homes heated with natural gas. Cadmus constructed simulation models of homes in the MA LI 2012 evaluation to determine the electric savings associated with weatherization in natural gas heated homes. We determined savings of 206 kWh for the reduction in electric fan usage after weatherization, and of 138 kWh in electric cooling savings.

[7] The realization rate derived from the billing analysis is 137%, based on the analysis sample of 162 participants, averaging 168 therms per household. When applied to the program population, the average claimed savings results in a slight difference from the average evaluated savings of 188 therms.

Water Heating Measures

Cadmus carried forward the results of the AMP 2009 engineering analysis to calculate savings for domestic hot water (DHW) measures (aerators, showerheads, and pipe wrap). A relatively small number of homes received DHW measures in the 2011/2012 program period. Table 8 summarizes the findings.

Table 8. Evaluated Natural Gas Savings from Water Heating Measures

Category	Measure	Evaluated Savings (therms/year)
Water heating	Overall (for households receiving at least one hot water measure)	9

Summary of Natural Gas Savings

Table 9 summarizes the overall evaluation findings for all natural gas measures.

Table 9. Evaluated Energy Savings for All Natural Gas Measures

Category	Measure	Natural Gas Savings (therms/year)
Weatherization	Insulation (overall) with Air Sealing and Duct Sealing (program)	188
	Furnace Fan (electric savings due to weatherization)	206 (kWh)
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	Furnace Fan (electric savings due to furnace replacement)	172 (kWh)
Water Heating	Overall (for homes installing at least one measure)	9

Benchmarking Natural Gas Impacts

Table 10 compares measure-level gas savings between this study (RI IES Vol 2), the Volume I analysis (RI IES Vol 1), AMP 2009 (which relied on a combination of billing analysis and simulation modeling), and MA LI 2012 (which used a combination of billing analysis, simulation modeling, and engineering reviews).

Table 10. Comparison of Gas Measure Savings Estimates

Category	Measures	Savings (therms/year)			
		MA LI 2012	AMP 2009	RI IES Vol 1	RI IES Vol 2
Heating System Replacement	Furnace/Boilers	199	122	179	184
Weatherization	Insulation, Air Sealing, Duct Sealing	208	137	155	188
Water Heating	Aerators, Showerheads, Pipe Wrap	5	9	9	9

In this study, Cadmus found gas savings associated with weatherization measures to be significantly higher (approximately 20% higher) than in the RI IES Vol 1 evaluation the same program, while savings

for water heating and heating system replacements were largely unchanged.

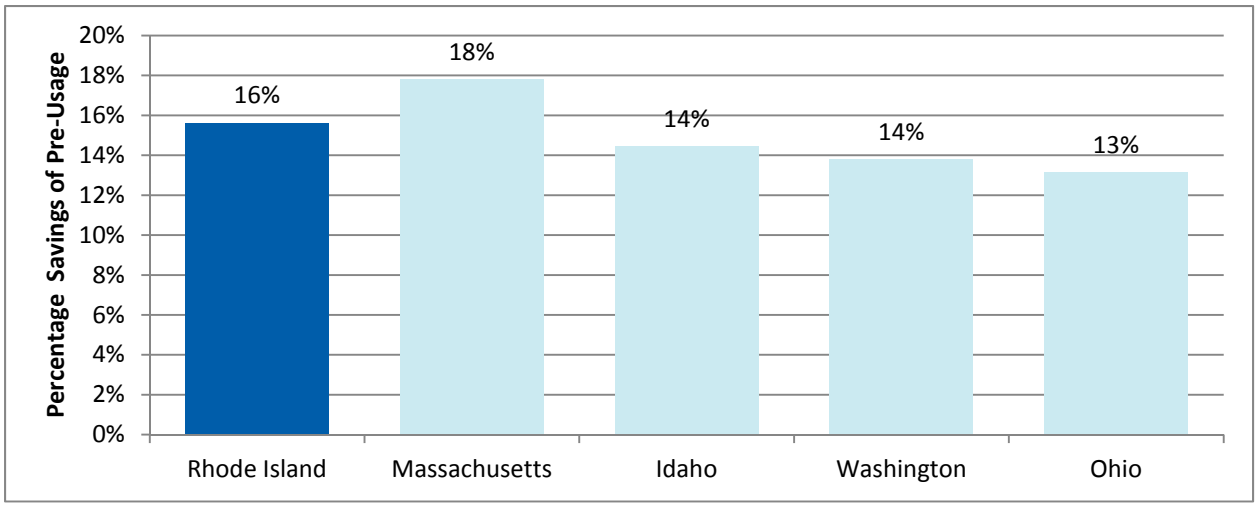
While the evaluated natural gas weatherization and heating system savings from the MA LI 2012 study are nominally higher than those reported in the current study, the results are roughly the same proportion of average household therms usage (1,168 therms average in Massachusetts versus 1,050 therms average in Rhode Island).

To provide additional context for the household-level program savings estimates, Table 11 and Figure 1 show a comparison of results from Cadmus' other low-income program evaluation efforts. All of the programs cited in the table and figure operate under the DOE WAP protocols. Furnaces are replaced both to save energy and as a health and safety measure, while insulation and air sealing are provided to decrease air infiltration and increase energy savings.

Table 11. Comparison of Natural Gas Savings in Income-Eligible Homes

State	Program Year	Pre-Period Usage (therms)	Savings (therms)	Percentage Savings
Rhode Island	2011/2012	1,050	164	16%
Massachusetts	2010	1,168	208	18%
Idaho	2010	850	123	14%
Washington	2010	753	104	14%
Ohio	2009	1,180	155	13%

Figure 1. Comparison of Whole-House Natural Gas Savings as Percentage of Pre-Period Usage



As shown, the IES Program savings percentages of pre-period usage are within the range of estimates observed from other low-income weatherization programs.

Energy Savings: Electric

Cadmus' billing analysis provided reliable estimate of electric savings for three unique program measure groups: lighting (including CFLs and the TLC kit),[8] refrigerator replacements, and freezer replacements. Cadmus used previous studies to determine electric savings estimates for all other measures presented in this section including: weatherization Smart Strips, LEDs, appliance removal, waterbeds, hot water measures, and TLC kits and education.

Table 12 summarizes the billing analysis results for electric measures.

Table 12. Billing Analysis Electricity Savings Results

Measure	N	Energy Savings (kWh)	Relative Precision at 90% Confidence Level	Pre-Period Usage (kWh)	Percentage Savings
CFLs and TLC Kit	1,552	443	17%	6,995	6.3%
Refrigerator Replacement	590	384	28%	7,109	5.4%
Freezer Replacement	53	484	65%	7,486	6.5%
Other (all other electric measures)	435	207	60%	7,274	2.8%
Overall	**1,614**	**638**	**8%**	**7,027**	**9.1%**

The evaluated percentage savings for CFLs/TLC kits, refrigerator replacements, and freezer replacements were each 5% to 7% of pre-installation usage. CFLs and TLC kits together saved 443 kWh per year, refrigerator replacements saved 384 kWh per year, and freezer replacements saved 484 kWh per year.

Given the weighted mix of CFLs, TLC kits, refrigerator replacements, freezer replacements, and other electric measures, the average electric participant receiving any of these measures achieved 9.1% savings over pre-installation usage.

Weatherization

During 2011 and 2012, very few participants heated their home with electricity. Those who did received weatherization measures such as insulation and air sealing. This is an insufficient number of installations to confidently estimate energy savings through a billing analysis. Cadmus reviewed the methodology and results from AMP 2009, MA LI 2012, and RI EnergyWise 2012. Table 13 shows the comparison.

Table 13. Comparison of Electric Weatherization Results

Measures	Savings (kWh/year)		
	MA LI 2012	AMP 2009	RI EnergyWise 2012
Weatherization: Insulation, Air Sealing, Duct Sealing	1,616	374	1,558

[8] Over 90% of the customers who received CFLs also received a TLC kit.

Cadmus considered the simulation models used in MA LI 2012 for electric weatherization to be an appropriate proxy for this study. The Massachusetts program follows the same installation practices and protocols as the IES Program. Participants are also low-income, and there were similarities to the IES Program in baseline home characteristics and services completed on the homes.

Appliance Replacement

In an effort to decrease program participants' electric baseload usage, National Grid pays for the installation of new, ENERGY STAR® refrigerators that replace eligible older and less efficient models. The billing analysis dataset of 1,614 electric participants included 590 homes where old refrigerators were replaced with newer models. The billing analysis revealed that these homes achieved 384 kWh savings per refrigerator replacement.

Similarly, the billing analysis revealed savings of 484 kWh for the 53 participants who received a new freezer. While this result had a precision of ±65%, Cadmus determined that it still provides the best estimate of savings from freezer replacements for the IES Program.

Lighting

Cadmus determined the electric energy savings from CFLs and LED nightlights offered in the TLC kits through billing analysis. While CFLs produce relatively small per-unit savings, the large number of bulbs installed in participating homes (21.5 on average) and the large number of homes receiving bulbs and included in the analysis (n=1,552) allowed us to calculate CFL savings with the greatest precision of any program measure assessed through billing analysis (±17%).

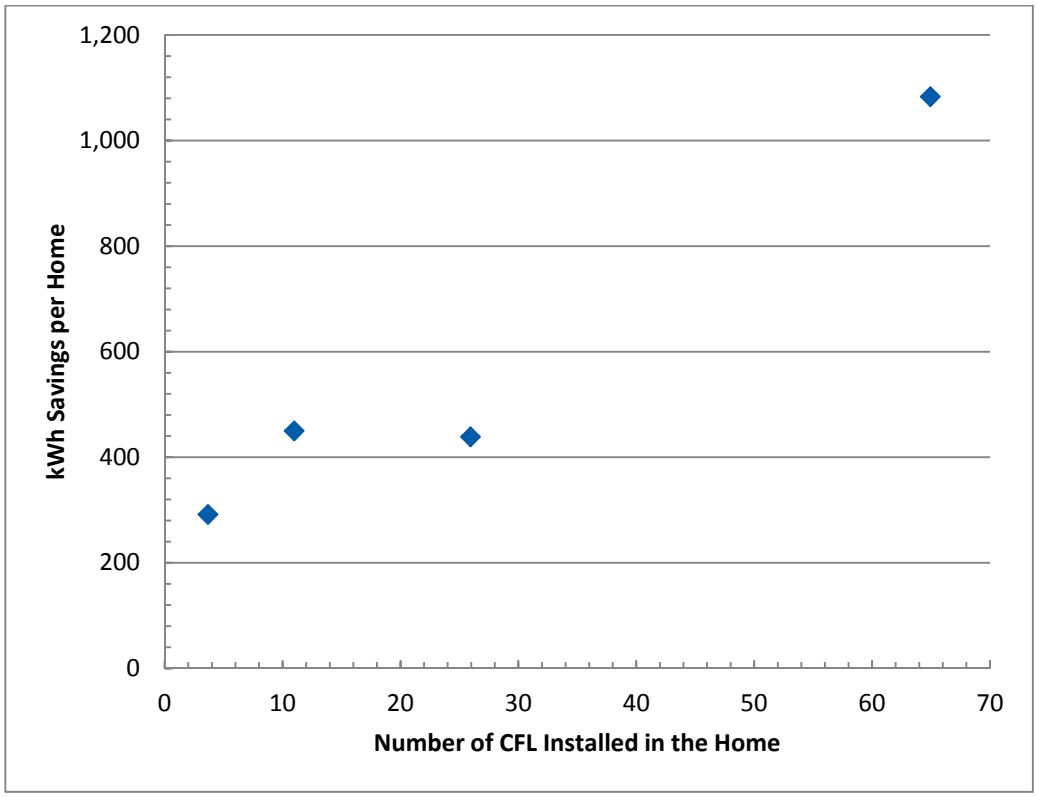
Specifically, Cadmus determined average energy savings of 422 kWh per household per year from program CFLs,[9] equating to average per-CFL savings of 21.78 kWh per year. The amount of CFL savings is largely a result of the number of hours the bulb is used (known as hours-of-use [HOU]), and is also affected by the change in wattage between existing and replacement bulbs. The prevailing evaluation theory is that HOU decreases as a greater number of bulbs are installed within a home (as CFL saturation increases, bulbs increasingly get installed in less frequently used locations).[10] The billing analysis results

[9] The engineering analysis revealed that TLC kits saved 21 kWh. Cadmus calculated CFL savings as the total home lighting savings determined through the billing analysis minus the TLC kit savings (443-21=422 kWh).

[10] Program implementers train IES Program auditors to first install CFLs in the highest-usage locations to maximize savings.

supported this theory: the per-bulb savings decreased as more bulbs were installed in a home.[11] While total household savings increased due to installing more CFLs (as shown in Figure 2), the per-CFL savings decreased (as shown in Figure 3).

Figure 2. CFL Savings per Household Based on Number of CFLs Installed



As shown in Figure 3, the per-CFL savings dropped dramatically after bulbs were already installed in the highest-usage areas.

[11] The trend of CFL HOU decreasing with installations of more energy-efficient bulbs appears to contradict NMR Group, Inc. and DNV GL 2014. That study found higher HOU for energy-efficient vs. inefficient bulbs, and this relationship did not change with socket saturation (i.e., the percentage of sockets filled with energy-efficient bulbs). However, the 2011–2012 IES Program impact evaluation and the regional HOU study cannot be directly compared. The regional HOU study primarily focused on bulbs obtained from retail stores, with home occupants deciding where to install bulbs. In this case, even the homes with the highest energy-efficient socket saturations have many (sometimes 50% or more) sockets filled with inefficient bulbs.

Figure 3. Savings per CFL Based on Number of CFLs Installed

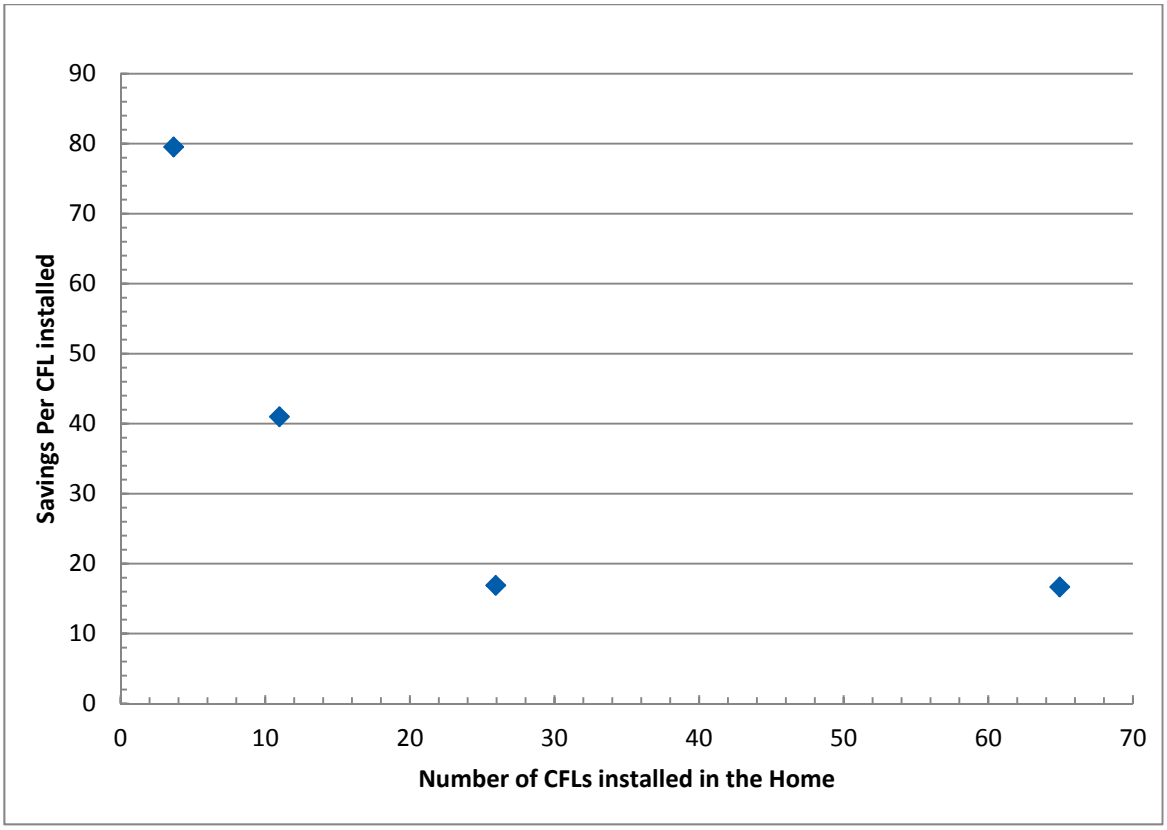


Table 14 presents the information shown in Figure 3 in tabular form.

Table 14. Energy Saving Based on Number of CFLs Installed

CFLs Received	Percentage of Analysis Dataset	Average Number of Installed CFLs	Billing Analysis (kWh Saved/CFL)
1-5	3%	3.7	80
6-15	31%	11.0	41
16-50	63%	25.9	17
Over 50	2%	64.9	17
Overall	**100%**	**21.5**	**21.78**

Table 15 summarizes savings Cadmus determined through the billing analysis for lighting and appliance measures.

Table 15. Electric Energy Savings for Lighting and Appliances

Category	Measures	Evaluated Savings (kWh/year)
Lighting and Appliances	CFLs	21.78
	Refrigerator Replacement	384
	Freezer Replacement	484

National Grid learned of the lower-than-expected CFL savings, and decided to conduct a process evaluation to investigate any program issues that may impact the savings. As part of that process evaluation, Cadmus completed agency interviews and participant surveys to better understand how CFLs were delivered and installed during 2011 and 2012. We identified the following items that may contribute to lower-than-anticipated CFL savings:

- Some agencies left incandescent bulbs with participants in case they decided they prefer incandescent bulbs.
- Some agencies left CFLs for participants to self-install (instead of directly installing the bulbs).

LED Lighting

Through the Rhode Island IES Program, CAP agencies installed LEDs in a small number of homes during 2011 and 2012, accounting for 0.7% of the overall program savings. The CAPs generally offered LEDs in small quantities to customers who were averse to having CFL lighting in their home. Cadmus calculated LED savings based on engineering algorithms presented in the RI TRM 2012. This provided an estimate of 48 kWh per LED installed.

Since LEDs are a newer technology, there are not many impact studies of the measures completed. Therefore, Cadmus compared this estimate of savings to those from other state TRMs from the same year (listed in Table 16).

Table 16. TRM Estimates of LED Savings

State	kWh Savings	Notes
Pennsylvania	45.7	Upstream program
Indiana	48.0	Upstream program
Maine	37.0	Upstream program
Massachusetts	54.7	Low-Income program
Connecticut	37.4	Low-Income program

The estimate of 48 kWh per LED in the IES Program is within the range of expected savings for this technology in 2011 and 2012. However, in future years, savings may decrease as the baseline incandescent bulb available to participants becomes more efficient (as a result of the Energy Independence and Security Act of 2007).

Appliance Removal

Through the program, CAPs removed secondary refrigerators or freezers from participant homes in order to help reduce electric bills. Auditors work with customers to determine if their secondary refrigerator could be removed or if two older appliances could be replaced with one new appliance. This measure accounted for 0.7% of the evaluated program savings for 2011 and 2012.

Cadmus assessed the savings from appliance removals by comparing results from the previous evaluation (1,321 kWh/year) with results from the MA LI 2012 evaluation (1,180 kWh/year). In the MA LI 2012 evaluation, Cadmus calculated the usage of appliances removed as the average expected annual kWh usage from program metering data. This provided first-hand data on the average usage of refrigerators and freezers in low-income households in the region. Since the protocols for appliance removal are the same between the Massachusetts and Rhode Island programs, the MA LI 2012 results provide an accurate estimate of energy savings achieved through the IES Program.

Smart Strips

Cadmus based savings for the IES Program Smart Strips on algorithms presented in RI TRM 2012, resulting in 75 kWh per strip. As this measure is relatively new, there are few studies that have directly assessed the impacts of Smart Strips in the field. Cadmus reviewed over 10 reports on potential and measured savings from installing a Smart Strip in residential settings. Estimates of savings vary widely, as shown in Table 17.

Table 17. Smart Strip References and Estimated Savings

Source	Savings (kWh)
Arkansas TRM, Version 3.0, 2013	141
Ecos Field Study, 2009	79
NYSERDA Report, 2011	75
ECEEE 2009 Summer Study, Jensen & Fjorkbak	61
PECO's Smart House Call Program Filing, 2013	57
Advanced Power Strip Measure Workbook, Regional Technical Forum, 2013	40
SDG&E Report, 2009	22

Cadmus reviewed the RI TRM 2012 methodology and estimated savings, which are consistent with the more in-depth study conducted on behalf of NYSERDA in 2011. Therefore, Cadmus determined the savings estimate for this measure from the RI TRM 2012 to be reasonable.

Waterbeds

Waterbeds represented a small portion of the IES Program savings in 2011 and 2012: 0.2%. In the AMP 2009 report, we used building simulation models to estimate savings for individual program measures. Due to the low level of savings from this measure, Cadmus did not expend resources to provide an updated estimate but instead used the value from the AMP 2009 evaluation of 872 kWh.

Water Heating Measures

As with natural gas water heating measures, Cadmus used engineering algorithms to estimate savings for all three electric hot water measures: showerheads, faucet aerators, and pipe wrap. Our overall approach matches that described in the Energy Savings: Natural Gas section.

Table 18 summarizes the evaluation findings for the average home receiving at least one hot water measure.

Table 18. Evaluated Electric Energy Savings for Hot Water Measures

Category	Measure	Evaluated Savings (kWh/year)
Water heating	Overall (savings for homes receiving at least one hot water measure)	134

TLC Kits and Education

Through the IES Program, CAP agencies deliver a TLC kit to most participants. The kit includes two LED nightlights, a refrigerator brush, a refrigerator thermometer, and a shower timer. This is similar to the kits National Grid delivers through its Massachusetts low-income program. Cadmus completed an engineering review of this kit as part of our MA LI 2012 evaluation, estimating that the kit nightlights saved 21 kWh per year.

All participants in the IES Program receive individualized energy education when an auditor visits their home. In the AMP 2009 evaluation, we estimated savings achieved through the TLC kits and associated education as 138 kWh per year.

We completed a billing analysis for this IES Program evaluation, estimating energy savings of 207 kWh (with ±60% relative precision) for electric measures other than CFLs, TLC kits, refrigerators, and freezers. The measures include more than just education: weatherization, Smart Strips, waterbeds, appliance removals, and water heating measures. Cadmus retained the 138 kWh savings (2% of total consumption) from AMP 2009 for the energy education portion of the program. This is consistent with the 1% to 3% savings achieved by other evaluated energy education programs.[12]

The participants we surveyed for the recent RI IES process evaluation identified changes they had made in their energy usage behavior due to the program education. These responses justify energy savings for education in addition to the 21 kWh of savings from kit measures.

Summary of Electric Savings

Table 19 summarizes all electric energy savings estimates for the program.

[12] Recent evaluations of energy education programs show 2.2% savings in Connecticut, and 1.4% to 2.3% savings in North and South Carolina.

Table 19. Evaluated Energy Savings for All Electric Measures

Category	Measure	Electric Savings (kWh/year)
Weatherization	Overall Insulation with Air Sealing and Duct Sealing*	1,616
Lighting and Appliances	CFLs	21.78
	LEDs	48
	Refrigerator Replacement	384
	Freezer Replacement	484
	Refrigerator/Freezer Removal	1,180
	Smart Strips	75
	Waterbed	872
Water Heating	Overall (homes receiving at least one hot water measure)	134
Other	TLC Kit	21
	TLC Kit and Education	138

* This row refers to any participant that received air sealing, duct sealing, or attic, wall, or basement/floor insulation.

Benchmarking Electric Impacts

Table 20 compares electric savings between the current study, the Volume I analysis (RI IES Vol 1), the AMP 2009 evaluation (which relied on a combination of billing analysis and simulation modeling), and the MA LI 2012 evaluation (which relied on a combination of billing analysis, simulation modeling, and engineering algorithms).

Table 20. Comparison of Electric Measure Savings to Previous Evaluation

Category	Measures	Savings (kWh/year)			
		MA LI 2012	AMP 2009	RI IES Vol 1	RI IES Vol 2
Weatherization	Insulation, air sealing, duct sealing	1,616	374	1,558	1,616
Lighting and Appliances	CFLs*	45	41	17	21.78
	Refrigerator replacement	762	1,122	455	384
	Freezer replacement	239	637	539	484
Water Heating	Aerators, showerheads, pipe wrap	128	134	134	134

* The MA LI 2012 and AMP 2009 CFL savings estimates are based on engineering algorithms. The RI IES Vol 2 CFL savings estimate is based on the billing analysis completed for this evaluation.

Aside from weatherization, most electric savings estimates from the current analysis were less than those reported in National Grid's AMP 2009 program evaluation. These differences may result, in part, to differences in the evaluation methodology, as Cadmus relied heavily on simulation modeling for the AMP 2009 study. Additionally, only 53 participants replaced a freezer, and this small sample size could affect the accuracy and comparability of results.

To provide additional context for the program household-level savings estimates, Table 21 shows a comparison of results from other income-eligible program efforts evaluated by Cadmus. These programs offer measures similar to those provided through IES.

Table 21. Electric Whole-House Income-Eligible Impact Comparison

State/Region	Program Year	Pre-Period Usage (kWh)	Savings (kWh)	Percentage Savings
Rhode Island	2011/2012	7,027	638	9%
Pennsylvania	2010	11,764	969	8%
Pennsylvania	2011	10,303	913	9%
Ohio	2009	10,533	868	8%

This table shows the average per participant savings for each program. For the Rhode Island IES, this includes all participants that had CFLs installed, received new refrigerators, or received TLC kits and education, as well as a few participants with electric heat who had whole-house weatherization. As shown, the average program savings percentage fell within the range of estimates observed in other similar programs. However, the average pre-period electric usage of Rhode Island participants was significantly below that of participants in programs in other states, which indicates higher saturations of non-electric heating in the State of Rhode Island.

Energy Savings: Oil

To evaluate savings for homes heated by oil, Cadmus relied on the results from the MA LI 2012 evaluation. In that report, Cadmus used an engineering algorithm approach for oil measures, leveraging the gas customer model to estimate oil savings and changing the input assumptions where necessary. The Massachusetts low-income program uses the same protocols for delivering services to participant homes as the IES Program, and serves the same customer population. Table 22 summarizes the overall evaluated energy savings for all oil fuel measures.

Table 22. Evaluated Energy Savings for All Oil Measures

Category	Measure	Oil Savings (MMBtu/year)
Weatherization	Overall Insulation with Air Sealing and Duct Sealing*	28.1
	Electric Savings (cooling and fan replacement)	377 (kWh)
Heating System	Furnace/Boiler	18.4
	Electric Savings (furnace fan replacement)	132 (kWh)
Water Heating	Overall (for households that received at least one hot water measure)	0.7

* This represents the average savings for a household that received at least one weatherization measure.

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Appendix A. Billing Analysis Model Specifications and Model Outputs

Model Specification–Gas Measure Detail

To obtain model savings for gas measures, Cadmus used a fixed-effects model specification, as follows:

$$ADC_{it} = \alpha_i + \lambda_i * HDD_{it} + \beta_1 * Weatherization_i * POST_{it} * HDD_{it} + \beta_2 * HeatingSystem_i * POST_i + \beta_3 * Other_i * POST_{it} + \varepsilon_{it}$$

Where, for customer 'i' and billing month 't':

ADC_{it}	=	The average daily therm consumption in the pre- and post-periods
HDD_{it}	=	The average daily base 65 HDDs for the nearest weather station
β_1	=	The savings per HDD for weatherization measure participants
$Weatherization_i * POST_{it} * HDD_{it}$	=	An interaction between the weatherization participant flag, the $POST_{it}$ indicator, and average daily HDDs
$POST_{it}$	=	An indicator variable that is 1 in the post-installation period and 0 in the pre-installation period
β_2	=	The savings per day for heating system replacement participants
$HeatingSystem_i * POST_{it} * HDD_{it}$	=	An interaction between the heating system replacement participant flag and the $POST_{it}$ indicator
β_3	=	The savings per day for other measure participants
$Other_i * POST_{it}$	=	An interaction between the other measure participant flag and the $POST_{it}$ indicator
ε_{it}	=	The model error term

The following shows how Cadmus derived the final savings estimates from the model coefficients:

$\beta_1 * 6{,}056$[13]	=	Annual **weatherization** savings using normal TMY3 HDDs
$\beta_2 * 365$	=	Annual **heating system replacement** savings
$\beta_3 * 365$	=	Annual savings from **other measures**

Table 23 provides the model parameters and parameter estimates.[14].

[13] This 6,056 is the average of the typical meteorological year (TMY3; 1991-2005) series HDDs across all the weatherization participants. The 6,056 HDDs presented here are for the gas weatherization customers (n=162). Cadmus matched each site in the electric and gas analyses to the nearest weather stations by zip code. Then we averaged the HDDs across all customers included in the analysis.

[14] Due to the large number of separate intercepts and interactions of customer indicators with HDDs, Cadmus excluded the outputs for those model parameters.

Table 23. Gas Savings Measure-Level Model Parameters and Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Weatherization * HDD * POST	1	-0.02204	0.001576	-13.98	<0.0001
Heating System * POST	1	-0.49112	0.059165	-8.30	<0.0001
Other * POST	1	0.06361	0.032955	1.93	0.0537

Model Specification–Electric Measure Detail

To obtain savings for electric baseload measures, Cadmus used a fixed-effects model specification, as follows:

$$ADC_{it} = \alpha_i + \lambda_i * HDD_{it} + \delta_i * CDD_{it} + \beta_1 * Lighting\_TLCKits_i * POST_t + \beta_2 * Refrigerator_i * POST_{it} + \beta_3 * Freezer_i * POST_{it} + \beta_4 * Fan_i * POST_{it} * HDD_{it} + \varepsilon_{it}$$

Where, for customer 'i' and billing month 't':

ADC_{it}	=	The average daily kWh consumption in the pre- and post-periods
HDD_{it}	=	The average daily base 65 HDDs for the nearest weather station
CDD_{it}	=	The average daily base 65 CDDs for the nearest weather station
β_1	=	The average daily savings for CFLs and TLC kits
$LightingTLCKits_i * POST_{it}$	=	An interaction between the CFL and TLC kit participant flag and the $POST_{it}$ indicator
$POST_{it}$	=	An indicator variable that is 1 in the post-installation period and 0 in the pre-installation period
β_2	=	The average daily savings for refrigerator participants
$Refrigerator_i * POST_{it}$	=	An interaction between the refrigerator participant flag and the $POST_{it}$ indicator
β_3	=	The average daily savings for freezer participants
$Freezer_i * POST_{it}$	=	An interaction between the freezer participant flag and the $POST_{it}$ indicator
β_4	=	The average daily savings for other measure participants
$Other_i * POST_{it}$	=	An interaction between the other measure participant flag and the $POST_{it}$ indicator
ε_{it}	=	The model error term

Where:

$\beta_1 * 365$ = Annual **CFL and TLC kit** savings[15]

$\beta_2 * 365$ = Annual **refrigerator** savings

$\beta_3 * 365$ = Annual **freezer** savings

$\beta_4 * 365$ = Annual savings from **other measures**

Table 24 provides the model parameters and parameter estimates.[16]

Table 24. Electric Base Load Savings Measure-Level Parameters and Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
CFL_TLC * POST	1	-1.059226	0.091354	-11.59	<.0001
Refrigerator * POST	1	-1.245787	0.130008	-9.58	<.0001
Freezer * POST	1	-1.478028	0.358284	-4.13	<.0001
Other * POST	1	-0.422767	0.141508	-2.99	0.0028

[15] To develop the lighting savings, Cadmus subtracted the 21 kWh kit savings from the total savings for this group. The model savings for the combined CFL/TLC kit are 443 kWh. CFL savings alone are 422 kWh (443 kWh – 21 kWh).

[16] Due to the large number of separate intercepts and interactions of customer indicators with HDDs and CDDs, Cadmus excluded the outputs for those model parameters.