Assessment of Gas and Electricity Savings for Homes Treated under Wisconsin's Home Energy Plus Weatherization Program

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TABLE OF CONTENTS

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1.0 INTRODUCTION

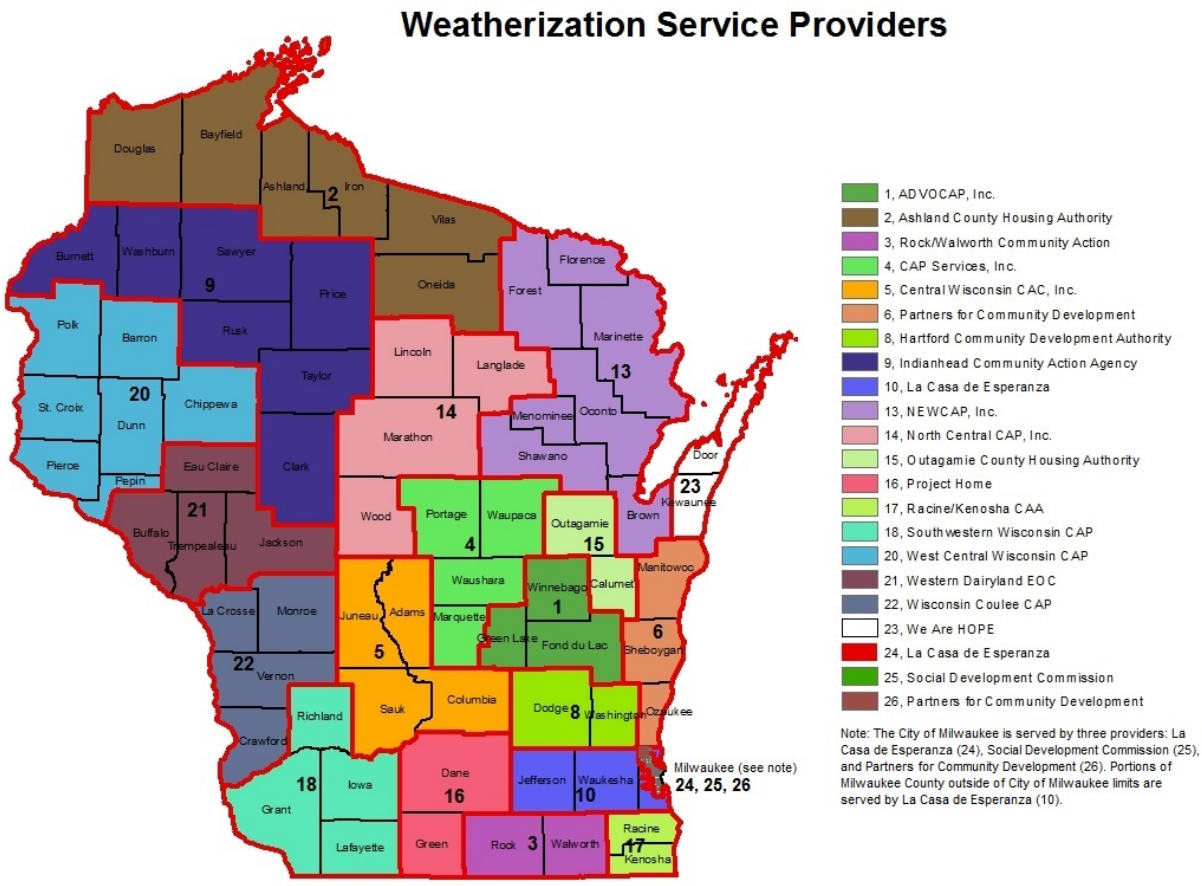
Since 2009, an annual evaluation has been conducted of delivered energy savings for homes that have been treated by the Wisconsin Weatherization Assistance Program (WisWAP) under the umbrella of Home Energy Plus services for eligible households. Weatherization services are provided by 20 agencies throughout the state and are available to qualified households with an income of 60 percent or less than the state's median income. The program targets homes with a high energy burden and those with elderly, very young, or disabled occupants.

The main objectives of the weatherization assistance program are:

1) Reduce home energy bills by saving energy
2) Make homes warmer in the winter and cooler in the summer

Figure 1 illustrates the geographical coverage of Wisconsin's weatherization service providers.

Figure 1. Wisconsin Weatherization Assistance Program service providers



Multiple forces, both internal and external, have had an impact on the program throughout the five years analyzed in this report, program years (PY) 2011 through 2015. These forces include the latter half of the American Reinvestment and Recovery Act (ARRA), when pressure to

accelerate production allowed for a more variable housing stock in the participant pool, and a significant decline in natural gas prices, which is an important determinant of program cost effectiveness. In addition, program policies are updated on an annual basis in an effort to increase cost effectiveness and enhance program delivery.

Some of the policy changes over the past five years include implementing computerized energy audits for single-family and 2-4 unit homes (versus using a qualifying measures list), implementing the use of actual fuel consumption in most energy audits, implementing additional oversight of non-conservation measure spending, and including savings for all water heater replacements. The program has also increased outreach to homes with high heating energy consumption, homes with possible electric-to-natural gas water heater conversions and decreased targeting of mobile homes.

Section 2 of this report presents trends in observed gas and electricity savings for housing units weatherized between PY11 and PY14. These savings are directly calculated from natural-gas and electric utility billing data, using a matched group of later program participants as a comparison group to control for non-program influences on energy consumption. Because adequate post-weatherization utility data are lacking for many homes treated in the most recent program year (PY15), savings estimates for this year are based on a modeling approach that applies measure-level savings estimates from prior years to known measure installation data for these homes. This technique is also used to extrapolate from homes heated with natural gas—where utility data are available—to homes with other heating fuels (primarily propane and fuel oil) for which obtaining actual consumption data is much more difficult.

Per-home and aggregate program energy savings are covered in Section 3, along with measure savings, incidence rates and contributions to aggregate savings.

In Section 4, program costs and savings-to-investment ratios are presented.

Section 5 (appendices) provides detailed data tables and methodologies for processing utility billing data and modeling energy savings.

The remainder of Section 1 illustrates trends in program participation. Figure 2 shows the number of housing units weatherized within each program year, broken out by housing type. While this report focuses only on housing units in 1-4 unit structures, large multifamily buildings (5+ units) are included in Figure 2 in order to provide a more complete picture of the changing proportions of home types weatherized by the program year to year. The increased number of homes treated by the program during the ARRA period (PY11 and the early part of PY12) is clearly visible. In addition to overall growth in program production, a special ARRA-period initiative called the ARRA Multi-family Project, or AMP, resulted in a dramatic increase in the number of participating large multi-family buildings. In the most recent program years, single-family, site-built homes have made up the majority (60 to 70 percent) of weatherized homes.

Figure 2. Housing units weatherized, by housing type

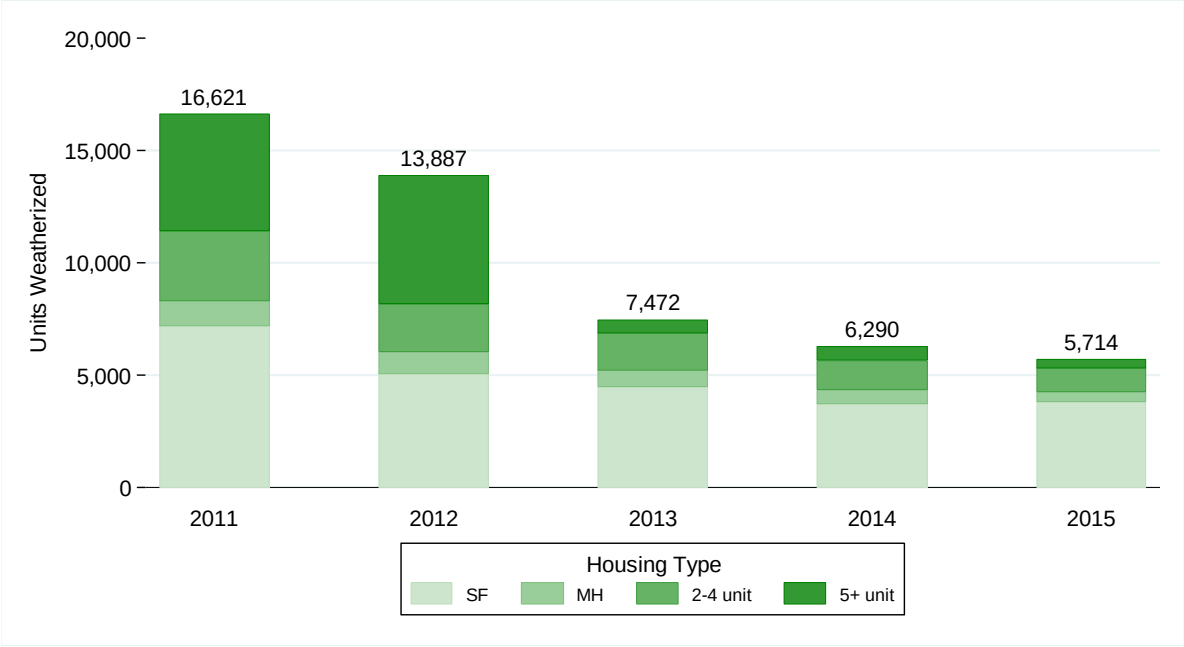
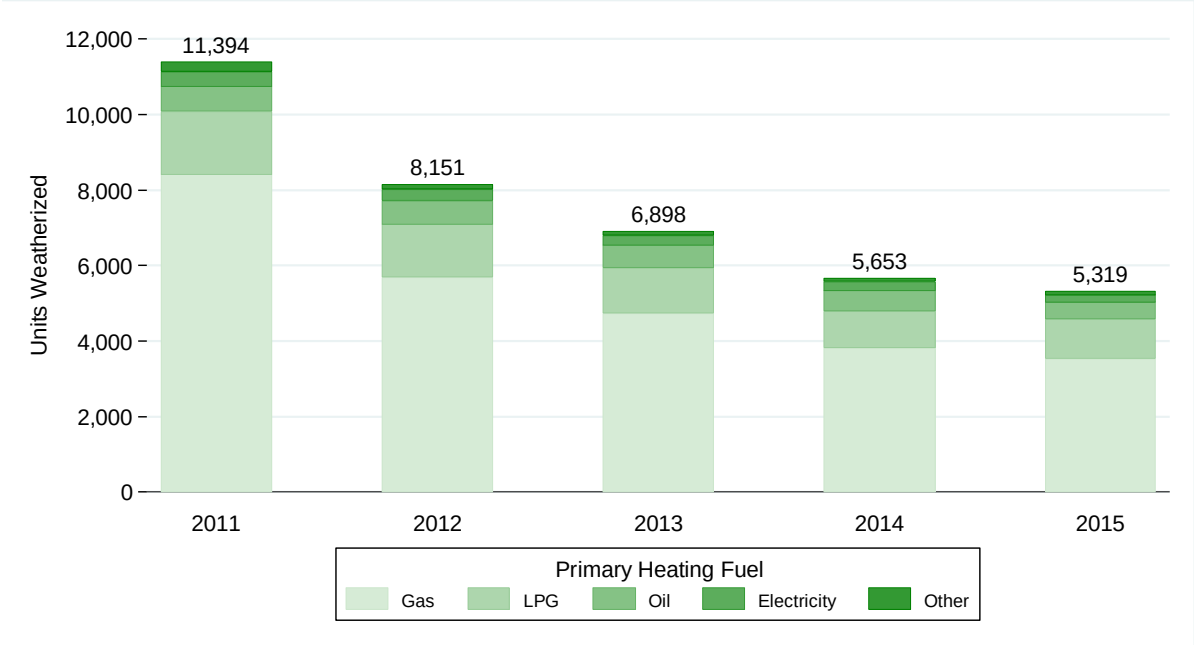


Figure 3 shows the distribution of treated homes in 1-4 unit buildings across primary heating fuels. Gas-heated homes have traditionally comprised approximately three-quarters of this pool; however, their relative proportion has decreased in the past two program years to roughly two-thirds.

Figure 3. Housing units in 1-4 unit buildings weatherized, by primary heating fuel



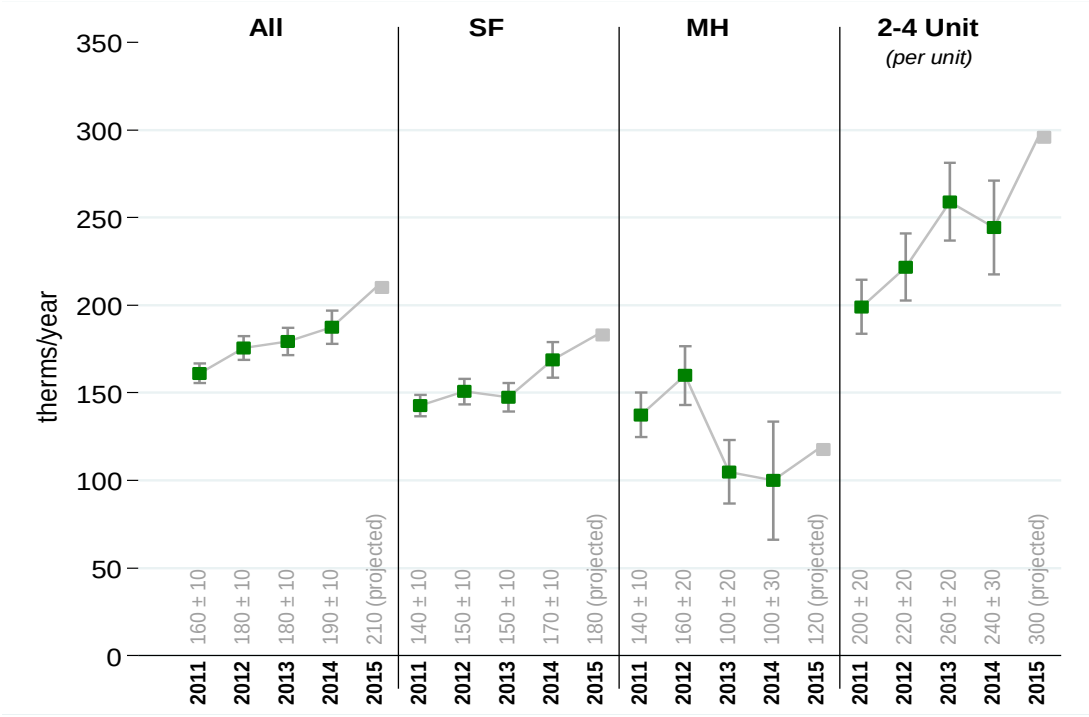
2.0 OBSERVED ENERGY SAVINGS

For all but the most recent program year, gas and electricity savings for weatherized homes are measured here using monthly utility billing data collected from Wisconsin's five major investor-owned utilities[1]. Billing data from pre- and post-weatherization periods are weather normalized and the difference between the two periods reflects the gas and electric savings for each treated home. Additionally, pre-weatherization billing data for future program participants are used to correct for non-program factors in any given year. Savings estimates are then coupled with data taken from the program's tracking database to evaluate savings by housing type and other characteristics. PY15 savings estimates shown below are preliminary projections based on measures installed and statistical modeling of energy savings. Descriptions of the weather normalization methodology and energy savings models are included in Section 5.2

2.1 NATURAL GAS SAVINGS

Overall, average natural gas savings among gas-heated single family homes have steadily increased over recent years, and are projected to increase further for PY15 homes, as shown in Figure 4. Savings among mobile homes and 2-4 unit buildings have been a bit more inconsistent. Savings for mobile homes and small multi families are also less well-determined, owing to the relatively small number of homes treated each year.

Figure 4. Annual gas savings for gas-heated homes, by housing type

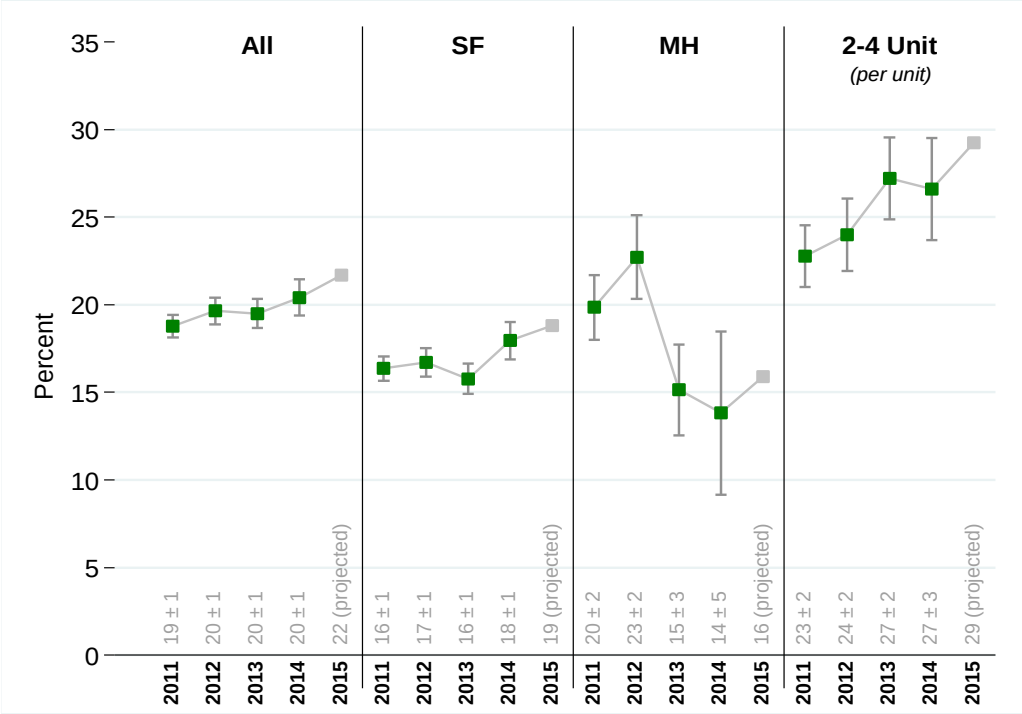


[1] The five utilities that supplied customer billing data are Alliant Energy, Madison Gas & Electric, We Energies, Wisconsin Public Service, Xcel Energy.

When expressed as a percentage of pre-weatherization usage, natural gas savings have been relatively constant between PY12 and PY14—roughly 20 percent across all housing types, though lower in recent years for mobile homes. Percent savings are projected to have increased slightly in PY15 across all housing types.

As a point of comparison, natural-gas savings for the Wisconsin program are higher than found in the recent national evaluation of the Weatherization Assistance Program. That evaluation found an average of about 15 percent savings (147 ±9 therms/year) for single-family homes treated in the PY11 period in climate regions similar to Wisconsin.[2] The national evaluation found about 12.5 percent (104 ± 19 therms/year) savings for mobile homes.[3]

Figure 5. Annual gas savings, as a percentage of pre-weatherization usage among gas-heated homes, by housing type



The data points are quite clear that homes that use more natural gas prior to weatherization save more energy following weatherization (Figure 6). The highest users (1,400+ therms per year, which represent about 10 percent of treated homes) have realized the greatest savings, typically between 400 and 450 therms per year. This is no doubt due to the fact that high users typically are such because they have lower levels of existing insulation, less efficient heating

[2] See Blasnik, Michael, Greg Dalhoff, David Carroll, Ferit Ucar and Dan Bausch. 2015. "Evaluation of the Weatherization Assistance Program During Program Years 2009-2011 (American Recovery and Reinvestment Act Period): Energy Impacts for Single Family Homes," ORNL/TM-2014/582. Available at http://weatherization.ornl.gov/RecoveryActpdfs/ORNL_TM-2014_582.pdf

[3] See Blasnik, Michael, Greg Dalhoff, David Carroll, Ferit Ucar, Dan Bausch and Daya Bill Johnson. 2015. "Evaluation of the Weatherization Assistance Program During Program Years 2009-2011 (American Recovery and Reinvestment Act Period): Energy Impacts for Mobile Homes," ORNL/TM-2014/558. Available at http://weatherization.ornl.gov/RecoveryActpdfs/ORNL_TM-2014_558.pdf

systems and more uncontrolled air leakage—all of which are opportunities addressed by the program.

Not only do high users save more energy in absolute terms, high users tend to save a larger percent of their pre-weatherization usage amount (Figure 7). Homes in the highest usage quantile save about 25 percent of their prior gas consumption, compared to only 5-10 percent among homes in the lowest usage quantiles. On average, for every 150-200 therm increase in pre-weatherization usage level, natural gas savings increase by about 5 percent.

Figure 6. Annual gas savings for gas-heated, single-family homes, by pre-weatherization usage

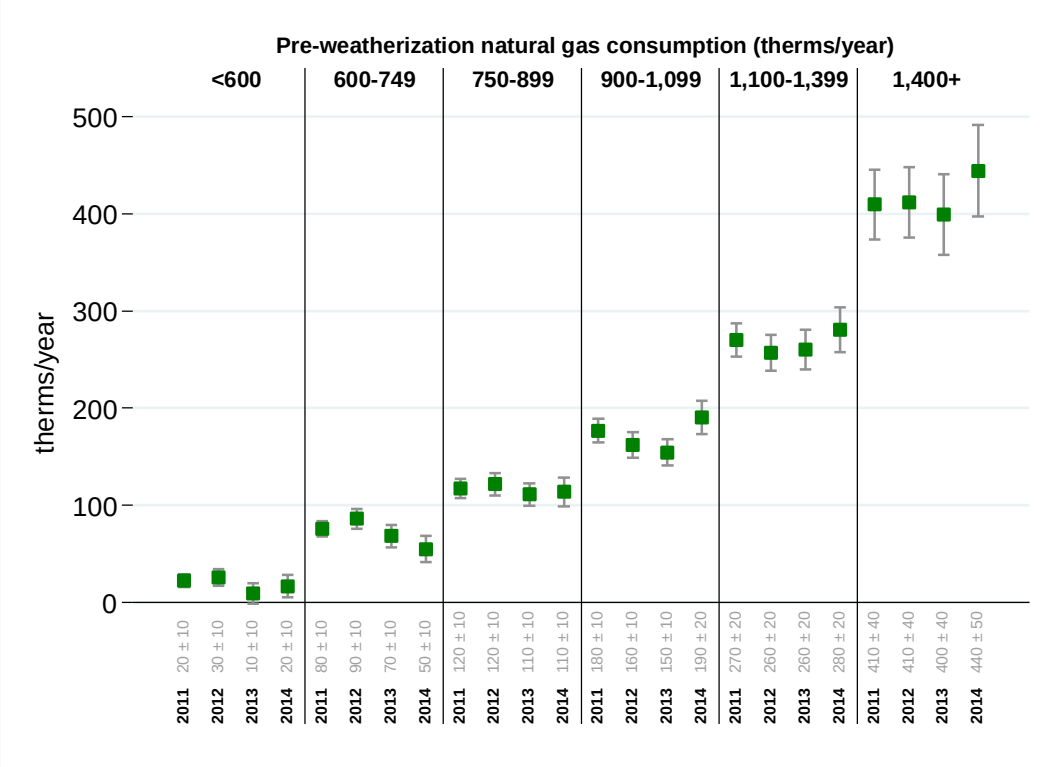
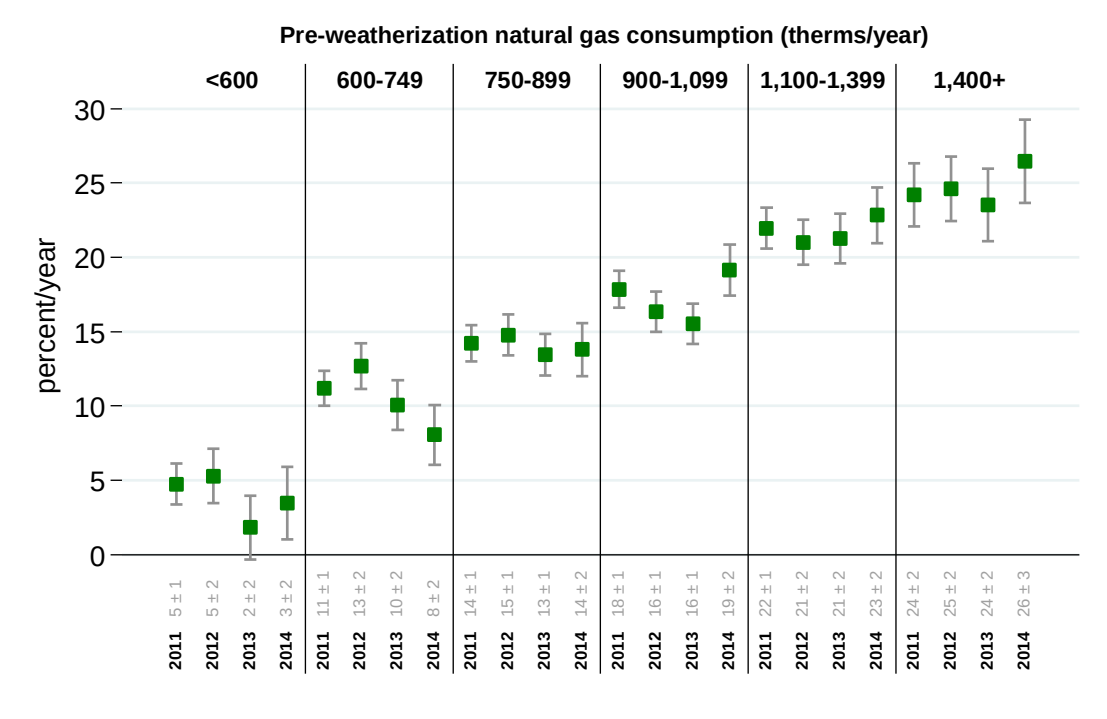


Figure 7. Annual gas savings, as a percentage of pre-weatherization usage among gas-heated, single-family homes, by pre-weatherization usage

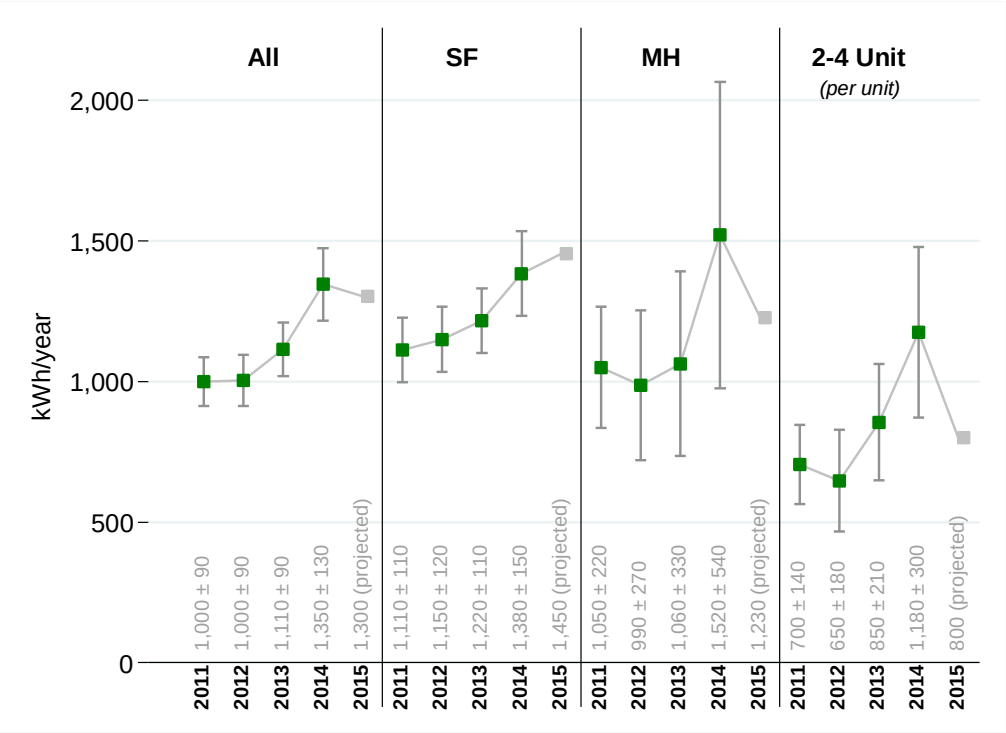


2.2 ELECTRICITY SAVINGS

Across all housing types, electricity savings increased for homes weatherized in PY13 and PY14, and are projected to hold constant at roughly 1,300 kWh per year for those treated in PY15 (Figure 8). The statistical uncertainty associated with electric savings estimates, particularly for mobile homes and 2-4 unit buildings, makes it difficult to assess year-to-year changes. Compared to natural gas, electricity savings are more difficult to pinpoint because usage levels vary more from home to home and because baseload consumption (largely electric) exhibits seasonal shifts that increase the uncertainty in the weather normalization process.

There is a clear upward trend in savings among single-family homes, with savings estimated to be 1,450 kWh per year for those treated in PY15. This trend aligns with the growing programmatic focus on electric-to-gas water heater conversions. Average annual savings among single-family and mobile homes in treated in PY14 or PY15 drop by 500-600 kWh (more than one-third) when the benefits of water heater fuel conversions are not included.

Figure 8. Annual electricity savings for homes with non-electric heat, by housing type

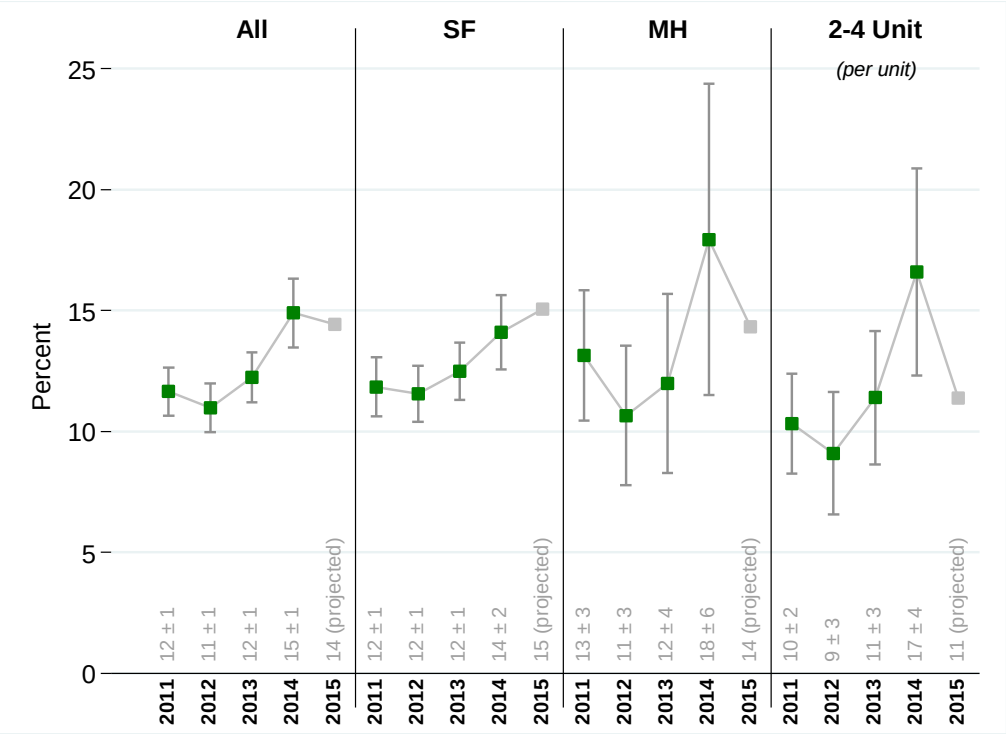


Trends in electricity savings as a percent of pre-weatherization follow absolute savings quite closely. Percent savings among single-family homes treated in PY15 is projected to increase, or at least hold constant, from the previous year, while percent savings among 2-4 unit buildings is projected to decrease (Figure 9). The uncertainty associated with mobile home savings estimates makes it difficult to discern changes from year to year.

As with natural gas, electricity savings for the Wisconsin program exceed those found for the recent national evaluation of the Weatherization Assistance Program, which found about 8 percent electric savings for homes with natural gas heat in climates like Wisconsin's[4].

[4] See Blasnik, Michael, Greg Dalhoff, David Carroll, Ferit Ucar and Dan Bausch. 2015. "Evaluation of the Weatherization Assistance Program During Program Years 2009-2011 (American Recovery and Reinvestment Act Period): Energy Impacts for Single Family Homes," ORNL/TM-2014/582. Available at http://weatherization.ornl.gov/RecoveryActpdfs/ORNL_TM-2014_582.pdf

Figure 9. Annual electricity savings, as a percentage of pre-weatherization usage among homes with non-electric heat, by housing type



Higher users of electricity tend to save more following weatherization (Figure 10), though the trend is not nearly as dramatic as that for natural gas. Furthermore, there is not a clear correlation between electricity savings as a percent of pre-weatherization usage and usage level (Figure 11). Barring a handful of savings estimates across usage bins over the past five years, treated homes typically save between 5 and 10 percent. This largely has to do with the fact that there are many electric end-uses in homes—and thus many more ways that a household can be a high user—not all of which are addressed by the program.

Figure 10. Annual electricity savings for single-family homes with non-electric heat, by pre-weatherization usage

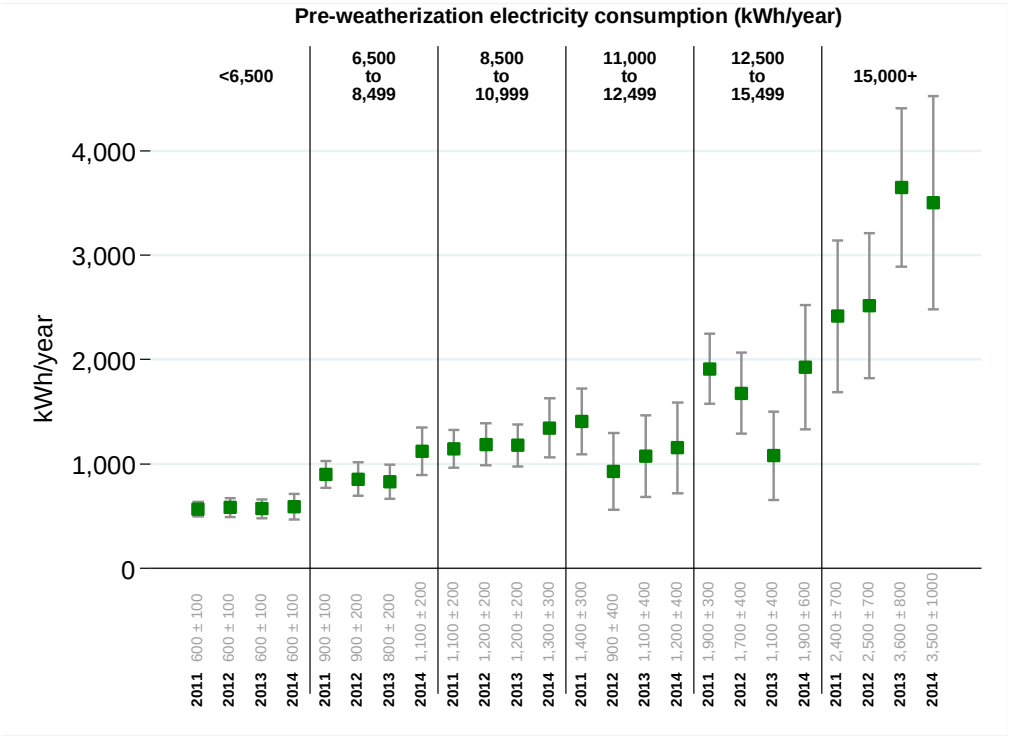
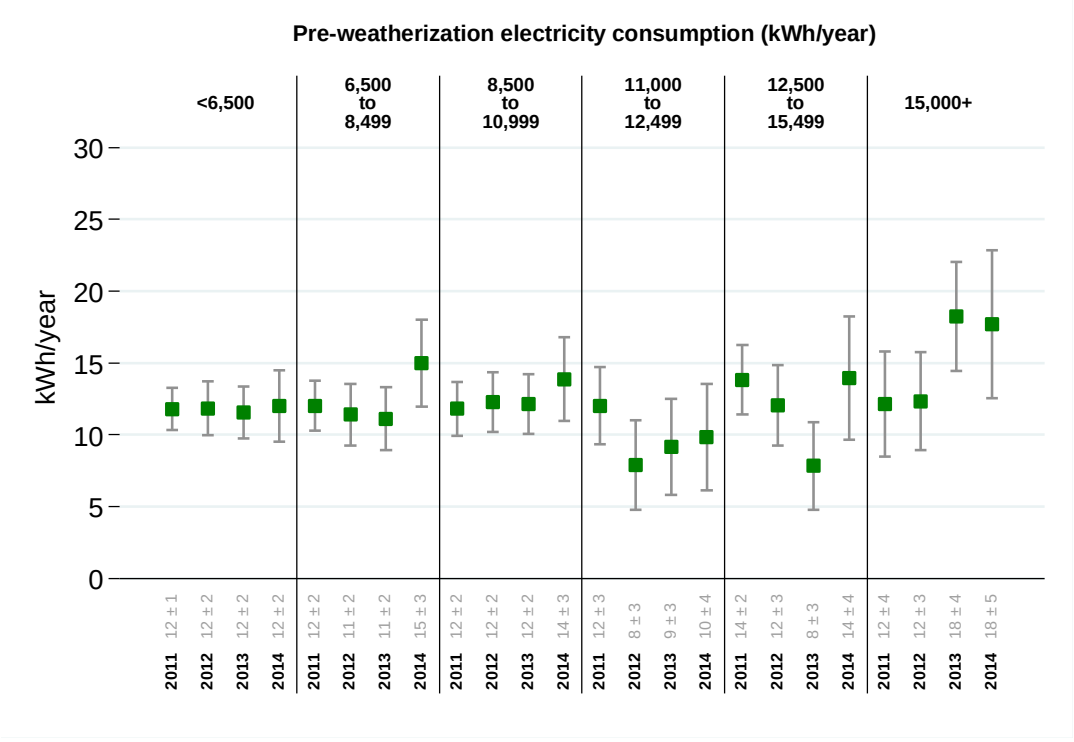


Figure 11. Annual electricity savings for single-family homes with non-electric heat, by pre-weatherization usage



3.0 MODELED ENERGY AND COST SAVINGS

This study uses a statistical model of energy savings to accomplish two purposes: (1) to disaggregate overall observed natural gas and electricity savings by conservation measure; and, (2) to extrapolate observed savings for homes to adequate pre- and post-weatherization billing data to more-recently treated homes, as well as to homes that heat with bulk fuels for which actual consumption data are not readily available. More detail on the model can be found in section 5.3. The statistics that follow below are based on application of the model to all participating homes in recent years, using average fuel prices and projected fuel-price increases in future years.

3.1 PER-HOME ENERGY COST SAVINGS

Figure 12 shows modeled average energy cost savings for the program population in the first year following weatherization, broken out by housing type. Overall, participating households from the most recent program year are expected to save more than $400 annually on their energy bills as a result of the program The increase in cost savings in more recent years is largely attributable to the previously-noted increases in energy savings per home.

Figure 12. Average first year cost savings per home, by housing type

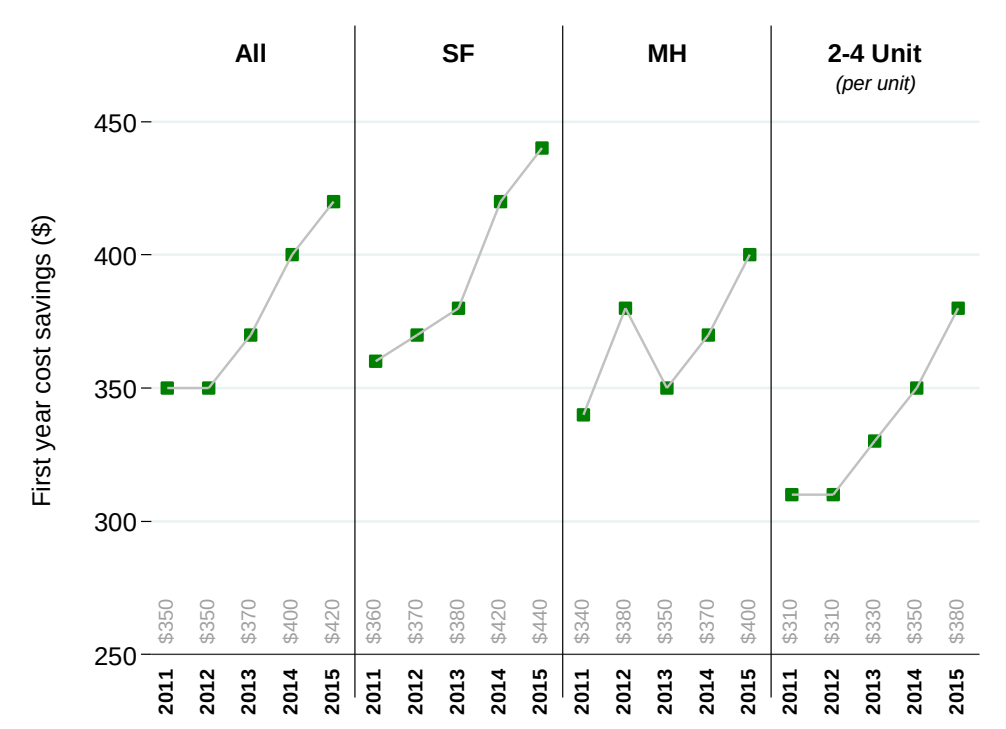


Table 1 expands on the data presented above, by detailing the estimated cost savings realized by homes treated in PY15 during the first year following weatherization and, cumulatively, over the useful life of installed measures. The cumulative estimate reflects the additive savings of each measure installed in a home, multiplied by the expected number of years for which that measure will continue to produce energy savings. The composition of heating fuels within each housing type is also provided.

Among single-family homes, those heated with fuel oil reap the largest cost savings, $820 during the first year following weatherization, on average, but they comprise only about 1-in-10 homes. Unsurprisingly, considering low natural gas prices, natural gas homes experience the lowest cost savings ($330 over the first year), but account for 6-in-10 homes. When these savings are extrapolated out to the life of measures, the difference in savings is about $1,300.

Mobile homes treated in PY15 were split fairly evenly between natural gas and propane heating; however, cost savings for propane-heated homes are roughly 60 percent higher during the first year than those associated with gas-heated homes. Most homes in 2-4 unit buildings treated in PY15 have natural gas heating, making costs savings associated with small multifamily buildings overall ($380), lower than the other two housing types.

Table 1. PY15 average energy cost savings per home, by housing type and fuel type

Housing type & primary heating fuel	Treated units	Average energy cost savings per home	
		First year	Life of measures (undiscounted)
Single family	**3,783**	**$440**	**$9,900**
Natural gas	61%	$330	$7,500
Propane	22%	$520	$11,500
Fuel oil	11%	$820	$18,800
Electricity	3%	$490	$10,600
Other	3%	$600	$12,000
***Mobile h*ome**	**461**	**$400**	**$8,200**
Natural gas	49%	$300	$6,300
Propane	46%	$480	$9,700
Fuel oil	2%	$790	$16,100
Electricity	2%	$670	$12,600
Other	2%	$680	$12,000
2-4 unit (per unit)	**1,075**	**$380**	**$8,600**
Natural gas	90%	$350	$8,000
Propane	2%	$540	$11,900
Fuel oil	4%	$800	$18,300
Electricity	4%	$580	$12,000
Other	0%	--	--

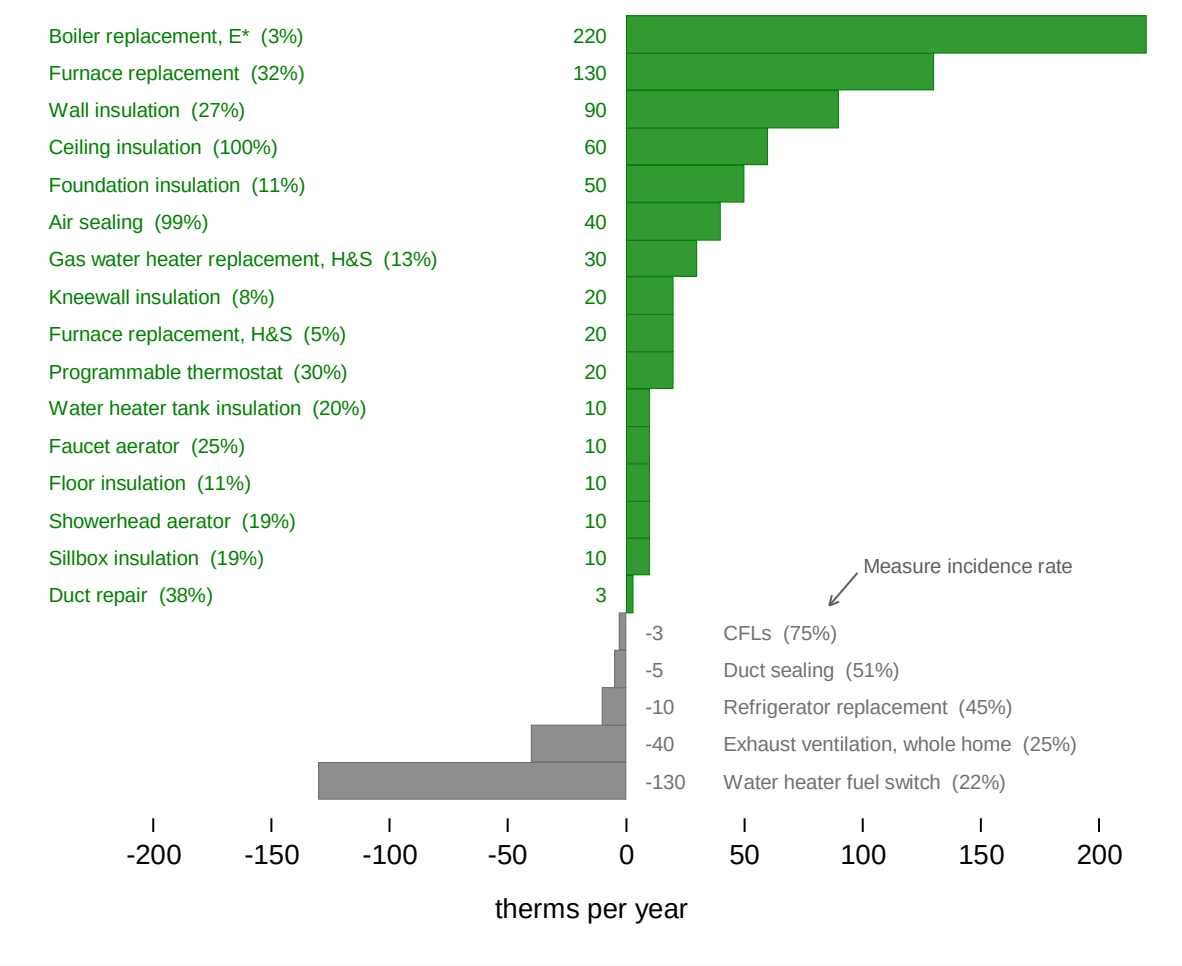
3.2 ESTIMATED INDIVIDUAL MEASURE SAVINGS AND INCIDENCE RATES

As mentioned above, the statistical model is used to estimate the average savings associated with individual measures. The model estimates gas and electricity savings associated with each measure installed in each housing type. Figure 13 and Figure 14 below present savings and measure incidence rates for single-family, site built homes since they comprise the largest portion of treated homes.

Individual measures that yield the largest gas savings are heating system replacements, wall insulation and ceiling insulation. Air sealing, is notable because it is done in nearly all homes.

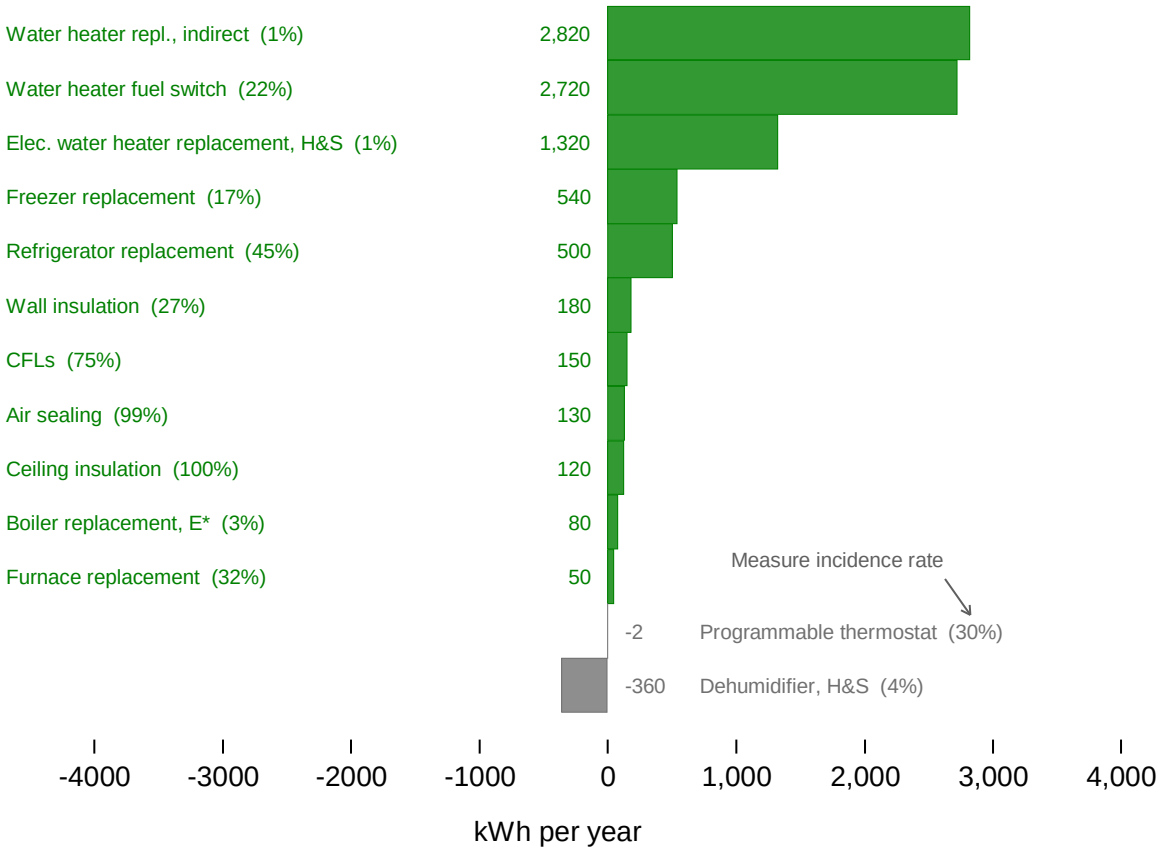
Some electricity-saving measures result in an increase in natural gas consumption. The most notable of these are electric-to-gas water heating fuel switching and mechanical exhaust ventilation (which increases air exchange rates and thus heating/cooling loads). Refrigerator replacements, duct sealing and CFL installations have small heating penalties because the inefficiencies that these measures resolve indirectly help offset the need for heating; when, for example, refrigerators are replaced, heating fuel usage increases slightly.

Figure 13. PY15 annual gas savings per measure, when installed in single-family homes



The measure-level analysis of electricity savings (Figure 14) shows that water heater fuel switching saves the most electricity when implemented, though water heater, refrigerator and freezer replacements also provide significant savings. Additionally the analysis reveals that the installation of a dehumidifier (for homes with moisture management issues) increases electricity consumption: these measures are not commonly installed, however.

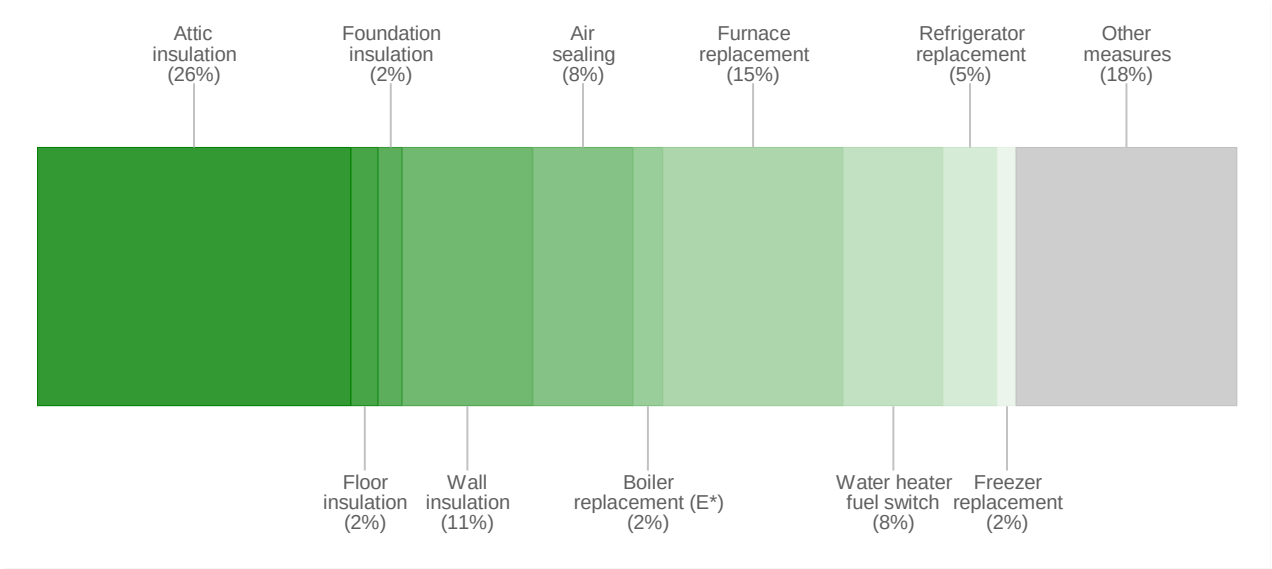
Figure 14. PY15 annual electric savings per measure, when installed in single-family homes



3.3 MEASURE CONTRIBUTIONS TO AGGREGATE SAVINGS

The model-estimated contributions of individual measures to total aggregate life-cycle energy cost savings for single-family homes are shown in Figure 15. The analysis indicates that insulation measures, air sealing, heating system replacement, water heater fuel switch and refrigerator/freezer replacement provide the large majority of the energy-cost savings from the program.

Figure 15. PY15 measure contributions to lifecycle cost savings when installed in single-family homes



3.4 PROGRAM WIDE ENERGY SAVINGS IMPACTS

For units treated in PY15, the statewide program saved participating households a total of $2.3 million during the first year after weatherization. Over the life of the installed measures, the program is projected to yield upwards of $50 million in energy savings for PY15 homes. Greater per-home energy savings has made up for some of the decrease in program production (number of treated units) over the past five years. While program-wide savings were lower in PY15 compared to PY11 and PY12, the rate of decline in savings is less than that of production. In fact, despite roughly 300 fewer weatherized units from PY14 to PY15, program-wide energy savings increased.

Table 2. Program wide energy savings, by fuel type

Program year	Treated units	Natural gas (Therms/ year)	Propane (Gallons/ year)	Fuel oil (Gallons/ year)	Electricity (MWh/ year)	Aggregate energy savings	
						First year	Life of measures (undiscounted)
PY11	11,392	1,474,000	289,000	100,000	13,914,000	$3,931,000	$83,424,000
PY12	8,151	977,000	256,000	95,000	10,057,000	$2,884,000	$61,343,000
PY13	6,898	860,000	240,000	89,000	8,454,000	$2,518,000	$55,008,000
PY14	5,653	733,000	181,000	85,000	7,933,000	$2,243,000	$49,385,000
PY15	5,319	738,000	195,000	75,000	7,405,000	$2,253,000	$50,329,000

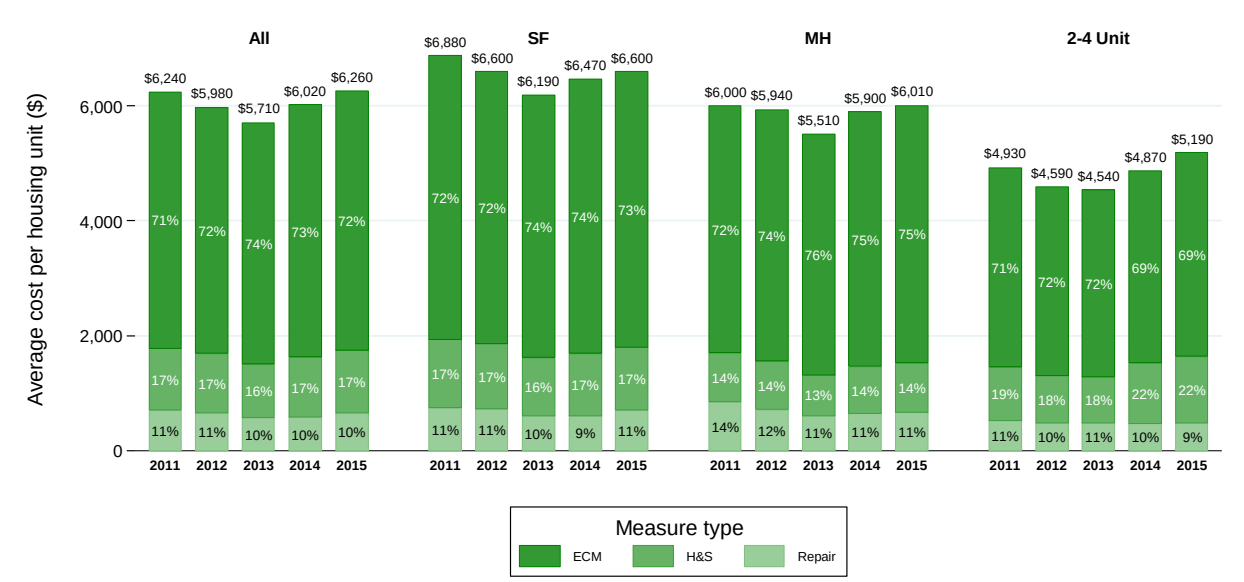
4.0 PROGRAM COST EFFECTIVENESS

This section brings together information about program costs and projected savings. Job-level costs, broken out by measure type (energy conservation, health and safety or repair), are presented first, and followed by an analysis of program-wide cost effectiveness.

4.1 JOB-LEVEL COSTS

The average cost for weatherizing a housing unit dropped between PY11 and PY13, before rebounding in PY14 and PY15. As discussed earlier in this report, homes that consume high levels of energy typically experience greater savings after weatherization because they are less efficient to begin with. The program's increased marketing to high user homes in recent years has resulted in more measures being installed and higher job costs. During the ARRA years, the push for production, particularly with 2-4 unit buildings, meant more homes were weatherized, but not necessarily high user homes, and jobs tended to have slightly lower costs.
In PY15, the cost for single-family homes averaged nearly $7,000, followed by mobile homes ($6,470) and homes in 2-4 unit buildings ($5,710). PY15 costs were on par with PY11 costs. Spending in homes is dominated by energy conservation measures (ECMs), but costs to address health-and-safety issues as well as home repairs needed to enable installation of ECMs and other costs amount to about $2,000 per home.

Figure 16. Job costs per housing unit, by housing type and measure type



4.2 OVERALL PROGRAM COST EFFECTIVENESS

Average fuel savings and information on per-unit spending was used to estimate discounted lifecycle program savings-to-investment ratios (SIRs) for each housing type and primary heating fuel. Two sets of SIRs are provided for each subgroup: one set is calculated using only energy conservation measure and repair costs; the second adds in health and safety costs as well.

Figure 17 shows program-wide SIRs, broken out by housing type. SIRs have been steadily increasing over the past five years, owing mainly to increases in average savings without commensurate increases in program costs. Single-family, site-built homes tend to have SIRs that are higher than those for mobile homes but lower than SIRs for 2-4 buildings.

Figure 17. Program-wide SIRs, by housing type

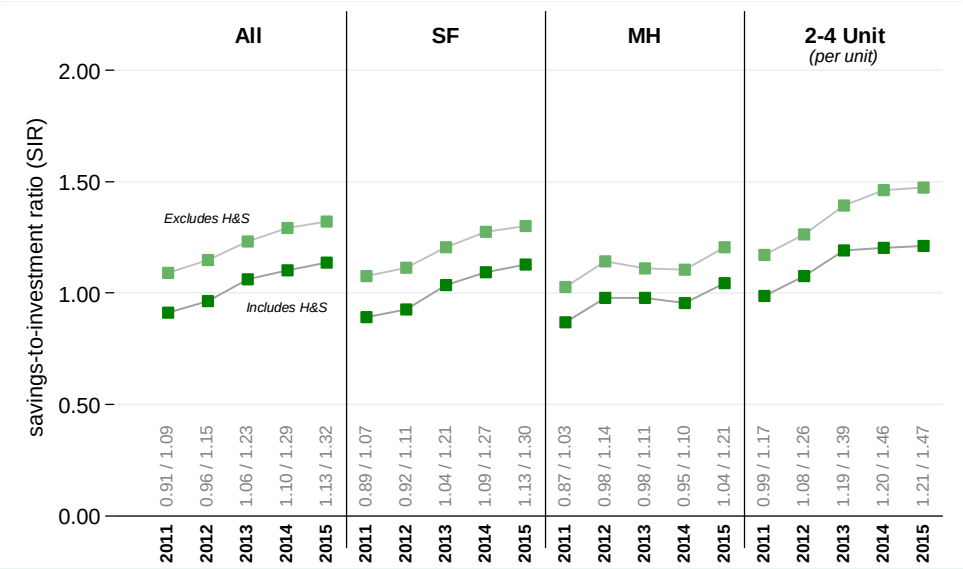


Figure 18 presents the same SIR data, analyzed by primary heating fuel. SIRs for propane and fuel-oil homes are higher than those for natural gas, owing to their higher purchase costs: each unit of energy saved by the program for these fuels is simply worth more than a unit of natural gas savings.

Figure 18. Program-wide SIRs, by heating fuel type

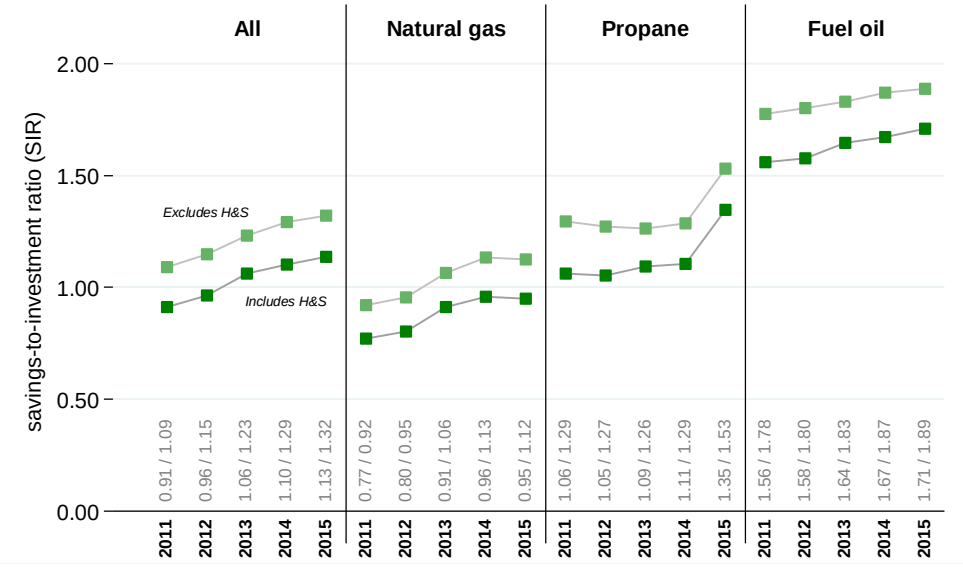


Table 3 further breaks out estimated PY15 SIRs and job costs by housing type and heating fuel (excluding the small number of homes heated with electricity or wood). Again, SIRs are highest for bulk fuels within housing type, and highest for 2-4 unit multifamily buildings.

Table 3. PY15 average SIRs and job costs, by housing type and heating fuel

Housing type & primary heating fuel	With Health &Safety measures		Without Health &Safety measures	
	SIR	Job cost ($)	SIR	Job cost ($)
Single family	1.12	$6,484	1.29	$5,650
Natural gas	0.90	$6,225	1.05	$5,315
Propane	1.36	$6,311	1.54	$5,618
Fuel Oil	1.68	$8,279	1.85	$7,590
***Mobile h*ome**	1.02	$5,904	1.19	$5,218
Natural gas	0.79	$5,914	0.91	$5,217
Propane	1.26	$5,797	1.46	$5,114
Fuel Oil	1.43	$8,462	1.55	$8,004
2-4 unit	1.20	$5,265	1.46	$4,265
Natural gas	1.14	$5,225	1.39	$4,200
Propane	1.63	$5,491	1.89	$4,812
Fuel Oil	2.23	$6,118	2.47	$5,567

5.0 APPENDICES

5.1 DETAILED ENERGY SAVINGS TABLES

Table 4. Per-home natural gas savings for gas-heated homes in 1-4 unit buildings

Natural gas	2011	2012	2013	2014	2015
All					
Pre-weatherization annual usage (therms)	860	890	920	920	970
Estimated annual savings (therms)	161 ± 6	176 ± 7	179 ± 8	187 ± 10	210
Estimated annual % savings	19 ± 0.7	20 ± 0.8	20 ± 0.8	20 ± 1.0	22
Units weatherized	8,408	5,684	4,715	3,814	3,513
Single family					
Pre-weatherization annual usage (therms)	870	900	930	940	970
Estimated annual savings (therms)	143 ± 6	151 ± 7	147 ± 8	169 ± 10	183
Estimated annual % savings	16 ± 0.7	17 ± 0.8	16 ± 0.9	18 ± 1.1	19
Units weatherized	4,891	3,291	2,829	2,348	2,314
Mobile home					
Pre-weatherization annual usage (therms)	690	700	690	720	740
Estimated annual savings (therms)	137 ± 13	160 ± 17	105 ± 18	100 ± 34	118
Estimated annual % savings	20 ± 1.8	23 ± 2.4	15 ± 2.6	14 ± 4.7	16
Units weatherized	715	471	386	279	227
2-4 unit					
Pre-weatherization annual usage (therms)	870	920	950	920	1010
Estimated annual savings (therms)	199 ± 15	222 ± 19	259 ± 22	244 ± 27	296
Estimated annual % savings	23 ± 1.8	24 ± 2.1	27 ± 2.3	27 ± 2.9	29
Units weatherized	2,802	1,922	1,500	1,187	972

Table 5. Per-home electricity savings for non-electrically heated homes in 1-4 unit buildings

Electricity	2011	2012	2013	2014	2015
All					
Pre-weatherization annual usage (kWh)	8,580	9,140	9,110	9,030	9,030
Estimated annual savings (kWh)	999 ± 86	1003 ± 91	1114 ± 95	1345 ± 129	1,302
Estimated annual % savings	12 ± 1.0	11 ± 1.0	12 ± 1.0	15 ± 1.4	14
Units weatherized	11,015	7,841	6,642	5,429	5,143
Single family					
Pre-weatherization annual usage (kWh)	9,400	9,940	9,730	9,800	9,650
Estimated annual savings (kWh)	1112 ± 115	1149 ± 116	1215 ± 114	1383 ± 151	1,453
Estimated annual % savings	12 ± 1.2	12 ± 1.2	12 ± 1.2	14 ± 1.5	15
Units weatherized	7,003	4,901	4,342	3,599	3,657
Mobile home					
Pre-weatherization annual usage (kWh)	7,990	9,260	8,860	8,480	8,560
Estimated annual savings (kWh)	1049 ± 215	987 ± 266	1062 ± 328	1520 ± 545	1,227
Estimated annual % savings	13 ± 2.7	11 ± 2.9	12 ± 3.7	18 ± 6.4	14
Units weatherized	1,118	946	736	579	452
2-4 unit					
Pre-weatherization annual usage (kWh)	6,820	7,120	7,500	7,080	7,040
Estimated annual savings (kWh)	704 ± 141	647 ± 180	855 ± 206	1175 ± 303	801
Estimated annual % savings	10 ± 2.1	9 ± 2.5	11 ± 2.8	17 ± 4.3	11
Units weatherized	2,894	1,994	1,564	1,251	1,034

5.2 WEATHER NORMALIZATION

To account for influence of year-to-year weather variation on household energy use, we fitted electricity and natural gas consumption models to each household. The models disaggregate energy use into space-heating, cooling (on the electric side) and non-space-conditioning components. Fitting the models to individual households, versus the entire group of treated homes, captures the unique energy-temperature relationship of each home and allows for a more accurate adjustment of energy use to the regional long term trend.

It is worth noting that because the electric model is susceptible to being somewhat confounded by end-uses such as lighting and water heating that typically vary seasonally, but are not strictly weather-related. Lighting use tends to increase in the winter when days are shorter and decrease in the summer when days are longer: This seasonal variation is indistinguishable in the model from that of electric space heating, which is highly weather dependent. Without end-use level data, there is little that can be done about this, but we do not consider it to be a factor that significantly affects our overall conclusions.

5.3 MEASURE-LEVEL ANALYSIS AND PROJECTED SAVINGS

Hierarchical fixed and random effects models were used to estimate the average gas and electric savings associated with individually installed measures. In each model, gas and electric, weather normalized annual savings for individual households were regressed against installation indicators for various measures, as well as interaction terms that account for the variation of measure effects between housing types for a handful of measures. Furthermore, the hierarchical nature of the models allows for estimation of random measure effects at the agency level when sufficient data (measure installations) are available. For example, the coefficients for less frequently installed measures within a small agency are probably quite similar to the state-level coefficients for those measures because there is insufficient data to adjust the agency-level coefficients with much accuracy. This enables greater specificity of measure-level savings when feasible while retaining accurate estimates for agencies that have fewer data points. Finally, program years are included in both models to capture year-to-year variation in measure-specific savings.

While a large number of measures are installed by the program, some are not amenable to this type of analysis because they either have too small of an impact on gas or electricity consumption, or are installed too infrequently to be statistically discerned from the available data. Moreover, a wide variety of model specifications are possible and different specifications can lead to very different savings estimate for the same measure. Finally, measures are sometimes typically installed together or are associated with particular household characteristics that can make it difficult for this type of analysis to tease out individual savings effects. To help guard against misleading results, the analysis was implemented only for households with reasonably reliable consumption data, and was restricted to cases where annual savings were estimated to lie with the range of -75 to +75 percent of pre-weatherization consumption.

Measure-specific savings coefficients from this model were then applied to the weatherization program tracking database to project per home gas and electricity savings estimates. Gas savings were converted to gallons for homes heated with propane or fuel oil.

5.4 ASSUMPTIONS USED IN LIFECYCLE COST SAVINGS ESTIMATES

Key assumptions related to the calculation of program SIRs are discussed below.

Fuel Prices. An average reference fuel price describing the four-year period was calculated for each fuel. Each year's price is weighted by the number of homes treated for each housing type and fiscal year. The historic fuel prices that were used are listed in the table below.

Table 6. Reference fuel prices.

Program year	Natural Gas ($/therm)	Propane ($/gallon)	Fuel oil ($/gallon)	Electricity ($/kWh)
2011	$1.00	$1.80	$2.29	$0.110
2012	$0.99	$1.89	$2.69	$0.117
2013	$0.93	$2.00	$2.89	$0.122
2014	$0.88	$1.44	$3.01	$0.128
2015	$0.85	$1.92	$3.25	$0.130

Fuel price escalators and discount rate. Fuel prices were adjusted using a set of fuel price escalators derived from the price indices being used in audits completed during FY15. Future savings were discounted at a rate of 3 percent per year.

Measure life. Incidences of therm and electricity saving measures were used to calculate aggregated measure lives, which were then used to estimate the present value of future savings. Measure lives ranged from 5-25 years, with an average life of 16 years.