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

5-24 Unit Buildings

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1.0 INTRODUCTION AND METHODOLOGY

This analysis of energy savings among 5-24-unit buildings is an extension of the savings evaluation conducted for 1-4-unit buildings treated under the Wisconsin Home Energy Plus Low-Income Weatherization Program. For structures treated between program years[1] (PY) 2013 and 2017, building-level energy usage is compared before and after weatherization to estimate natural gas and electricity savings.

Available program tracking data was used to help identify the number of treated units in each building, the building's primary space-heating and water-heating fuels, and installed-weatherization measures. Job completion dates were used to help identify the pre- and post-treatment periods for each building. At least one year of pre- and post-weatherization usage data was collected for three-fourths of the 213, 5-24-unit buildings treated within the analysis window. Unit-level and master-meter usage data was weather-normalized to help adjust for year-to-year variations in weather and aggregated to the building-level. Estimated savings represent the difference between adjusted, annualized pre- and post-treatment usage, expressed on a per-housing unit basis. Additional detail on methodology is provided in the Appendix.

Typically, building-level savings estimates would be compared to changes in usage for future program participants over the same period to help control for non-program related effects (such as changes in economic conditions) and errors in the weather-adjustment models. This control group-style comparison is done in the 1-4-unit savings evaluation, in which treatment-comparison pairings are selected based on geographic, temporal, and usage level similarities. Given the relatively small number of buildings for which billing data was available, no such comparison is made in this analysis. The results presented here are what are commonly referred to as "gross" savings. In future savings assessments of 5-24-unit buildings, a more relaxed comparison strategy could be considered in order to provide a basis for net savings estimates.

[1] A program year is a 12-month period ending on June 30 of that program year.

1.1 SUMMARY OF ANALYSIS POOL

Table 1 provides an overview of the 159 buildings for which billing data was collected. Information on the number of accounts and account type, by fuel type and pre- or post-weatherization period is presented below.

Table 1. Summary of buildings comprising final analysis pool

	All Buildings		Gas-heated Buildings	
Buildings in analysis pool	159	(100%)	107	(100%)
Gas data only	3	(2%)	3	(3%)
Electric data only	83	(52%)	35	(33%)
Gas and electric data	73	(46%)	69	(64%)

Figure 1 shows the breakout of buildings in the analysis pool, by year weatherization was performed. The steep decline in buildings in PY17 is not because drastically fewer buildings were weatherized but because about half of the buildings completed in that program year were completed late enough that it was not possible to acquire an entire year of post-weatherization consumption data.

Figure 1. Year weatherized, by billing data type collected

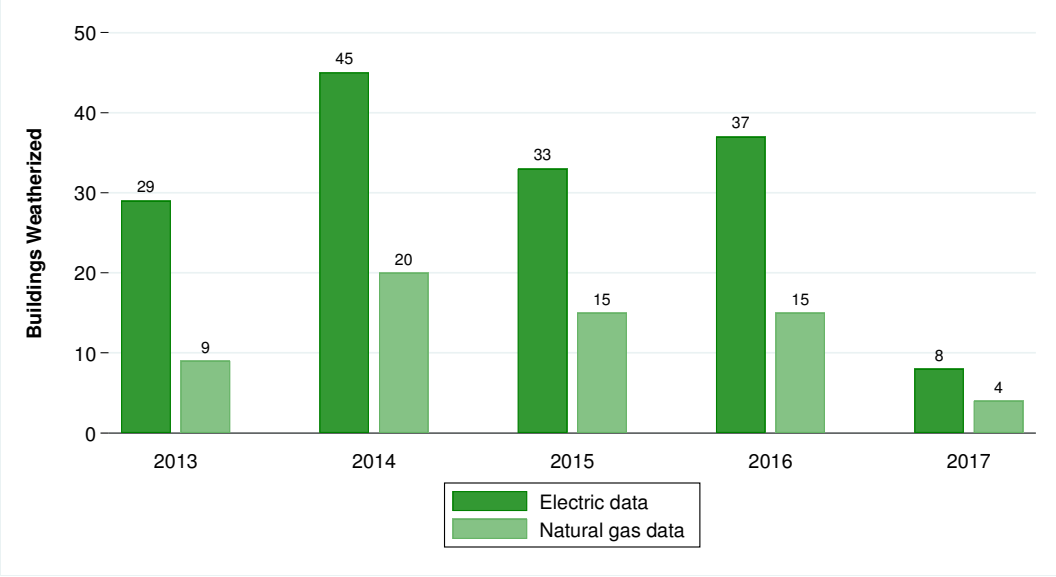
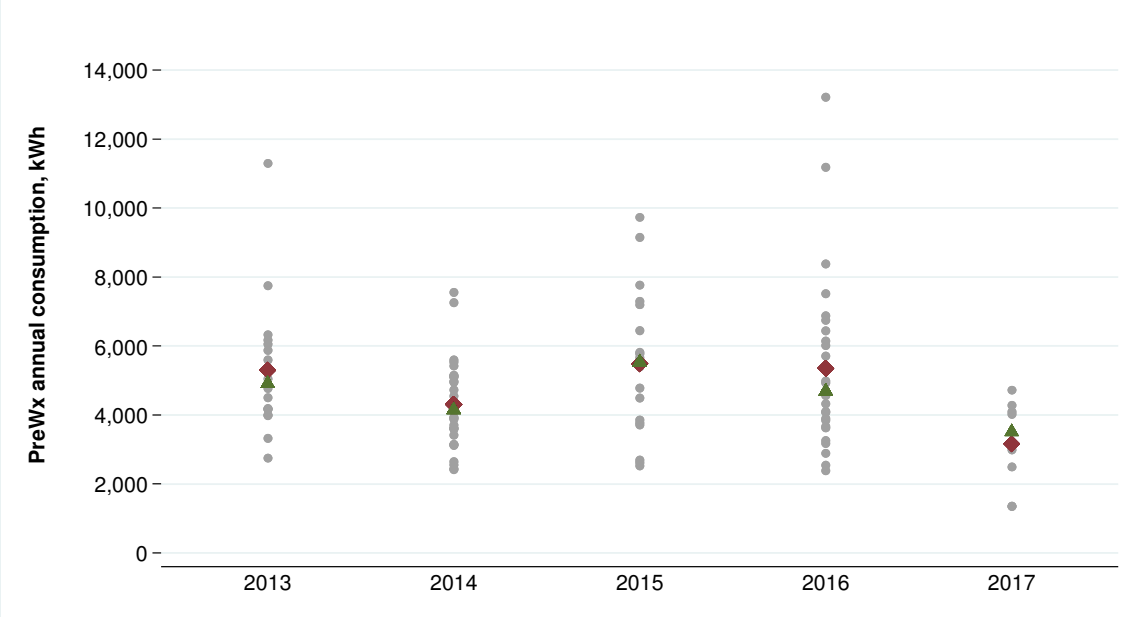


Figure **2** and Figure 3 illustrate the distribution of pre-weatherization natural gas and electricity use, respectively, among buildings in the analysis pool. Red diamonds represent mean and green triangles represent median unit-level pre-weatherization consumption. Each grey dot represents the average unit-level consumption for an individual building. Both measures of central tendency show that even with relatively small samples compared to that of single-family

homes analysis, the “average” annual natural gas consumption per unit, has been in the 400 to 600 therm range over the past five years and average annual electricity use, per unit, has ranged from 3,500 to 5,500 kWh.

Figure 2. Average annual pre- weatherization natural gas use per unit, by program year (gas-heated buildings only)

Figure 3. Average annual pre- weatherization electricity use per unit, by program year (non-electric-heated buildings only)



2.0 GAS AND ELECTRICITY SAVINGS AMONG 5-24 UNIT BUILDINGS

2.1 GAS SAVINGS

Mean annual natural gas savings was 110 ± 20 therms per housing unit, or 20 ± 4 percent of pre-weatherization usage, for the 107 gas-heated buildings weatherized between PY13 and PY17, for which billing data was available. The range of average savings in any given program year spans from 10 percent in PY15 to 28 percent in PY14; however, it is important to note savings estimates at the program-year level are based on relatively few buildings and are sensitive to savings at the ends of the distribution.[2] Figure 4 shows average-annual savings at the unit-level among gas-heated buildings. Each grey dot represents an individual building and PY averaged is marked.

Figure 4. Average annual natural gas savings per unit, by program year (gas-heated buildings only)

Key weatherization measures that significantly impact gas savings include air sealing and added insulation, and upgraded space and water heating systems.

[2] Savings estimates at the tails of the distribution are too extreme to reasonably reflect *only* program-attributable savings. They are likely impacted by unaccounted for non-program effects (changes in occupancy or economic factors) or errors in the weather normalization process. To assess the sensitivity of savings statistics presented for the entire group, average savings were calculated using only buildings whose post-treatment savings were with ±50% of pre-weatherization usage. Very few buildings were excluded using this more conservative criterion, so the point estimates and confidence intervals were quite close to those calculated using all buildings.

Table 2 shows overall gas savings. Gas-heated buildings that received heating systems and water-heating system upgrades were not estimated because there were fewer than 10 observations which resulted in very high uncertainty.

Table 2. Average annual natural gas savings per unit (gas-heated buildings only), PY13 –17

	Number of buildings	Average pre-wx usage (therms ± 90% CI)	Average savings (therms ± 90% CI)	Average savings as % of pre-wx usage (% ± 90% CI)
Gas heating	107	550 ± 50	110 ± 20	20% ± 4%
Gas heating with heating system upgrade	75	600 ± 50	130 ± 30	22% ± 5%
Gas heating with heating system and water heater upgrades	6	Estimates not presented for subgroups with <10 buildings.		

2.2 ELECTRICITY SAVINGS

Mean electricity savings was 620 ± 160 kWh per unit, or 11 ± 3 percent of pre-weatherization usage, among the 159 buildings for which billing data was collected throughout the PY13 to PY17 window. Figure 5 shows average annual savings at the unit-level among buildings with gas heat. Each grey dot represents an individual building and program year with mean and median savings indicated by red diamonds and green triangles, respectively.

Figure 5. Average annual electricity savings per unit, by program year (non-electric-heated buildings only)

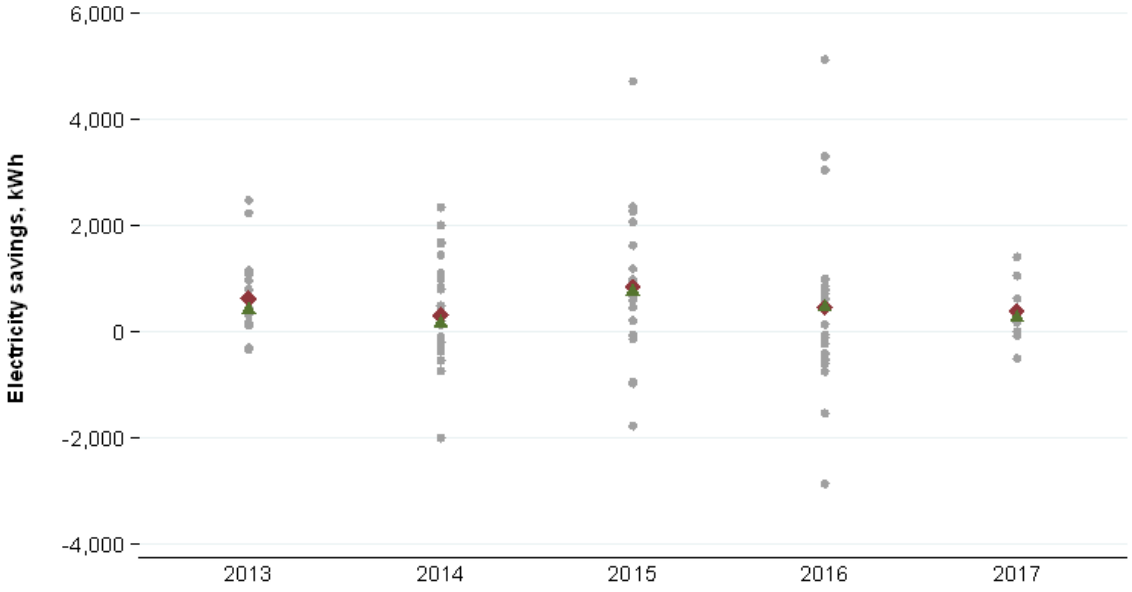


Table 3 shows the inability to discern a statistically significant difference in unit-level savings between those aggregated at the level of all buildings and those with and without electric heat. Like overall gas savings, estimates of savings in units with electric heat with heating system upgrades are not shown due to small sample size.

Table 3. Electricity savings estimates per housing unit, PY13 – 17

	Number of buildings	Average pre-wx usage (kWh ± 90%CI)	Average savings (kWh ± 90% CI)	Average savings as % of pre-wx usage (% ± 90% CI)
All buildings	159	5880 ± 360	620 ± 160	11% ± 3%
Gas heating	107	4880 ± 340	510 ± 200	10% ± 4%
Electric heating	52	7810 ± 650	840 ± 250	11% ± 3%
Electric heating with heating system upgrade	2	Estimates not presented for subgroups with <10 buildings.		

3.0 MEASURE INCIDENCE

Table 4 summarizes the incidence rates of key multifamily measures, and provides mean quantity and cost statistics for buildings where a given measure is installed. Refrigerator replacements, attic insulation, air sealing, heating system replacements, and mechanical ventilation are the most commonly installed measures.

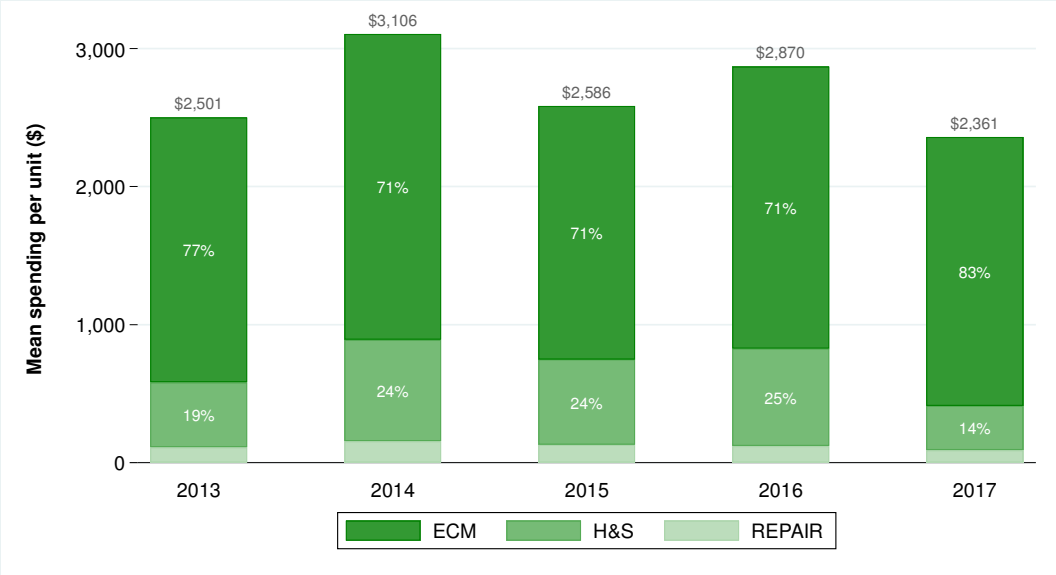
Table 4. Measure incidence, average quantity and average cost at the building level

Measure	Percent of buildings where installed	Average cost for buildings receiving measure
Refrigerator replacement	85%	$2,600
Attic insulation	75%	$4,600
Air sealing	60%	$4,700
Heating system replacement	53%	$10,600
Mechanical ventilation (building)	43%	$5,400
Mechanical ventilation (local)	31%	$4,300
Furnace replacement (ECM)	28%	$10,100
Boiler replacement (ECM)	19%	$12,500
Water heater replacement (H&S)	9%	$7,200
Water heater fuel conversion	8%	$11,000
Boiler replacement (H&S)	7%	$1,400
Furnace replacement (H&S)	6%	$6,400
Wall insulation	3%	$13,600
Freezer replacement	2%	$480

4.0 BUILDING-LEVEL SPENDING

The mean cost of weatherization jobs in 5-24-unit buildings have ranged between $2,000 and $3,000 per unit over the past five program years. Per-unit costs in PY17 fell to the low end of that range. Energy conservation measures (ECMs) typically represent 75 to 85 percent of total costs and health and safety measures (H&S) account for another 15 to 25 percent. Repair measures generally account for 5 percent or less of overall costs.

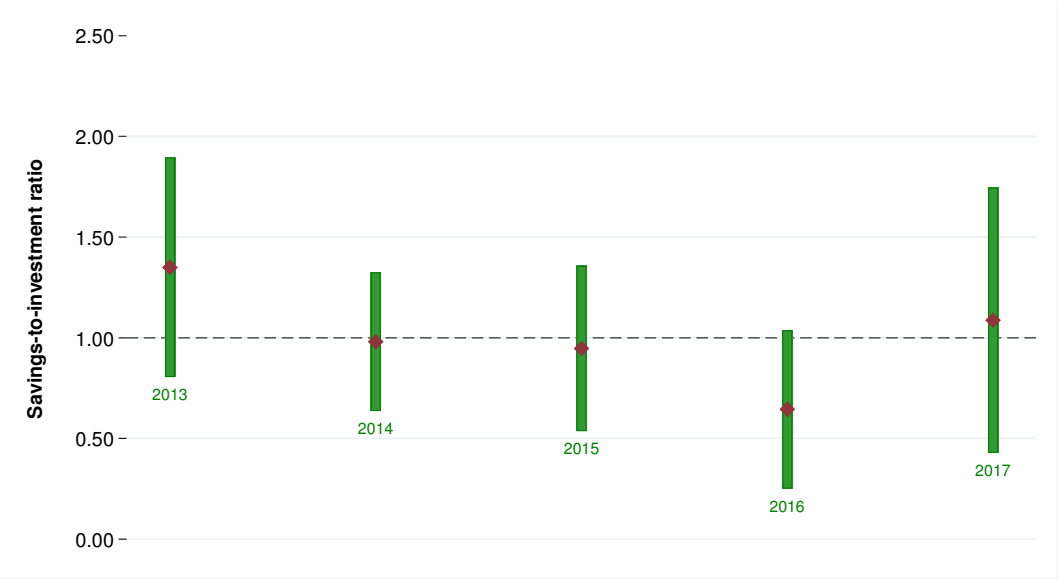
Figure 6. Average job costs per housing unit, by program year and measure type



5.0 COST-EFFECTIVENESS

Measure cost information and fuel savings estimates for gas heated buildings having both pre- and post-weatherization gas and electricity usage data were used to approximate an average savings-to-investment ratio (SIR). On average, weatherization jobs in 5-24-unit buildings were cost-effective in four of the five program years analyzed in this report but even in 2016 the mean SIR is not statistically different than 1.0. Figure 7 presents SIRs for gas-heated buildings where both gas and electricity savings estimates were available. SIRs include repairs and health and safety costs, which tended to be a small portion of overall measure spending in the buildings. Detailed descriptions of the assumptions that were made when calculating the SIRs are included in the Appendix.

Figure 7. Average SIRs, by program year



APPENDIX

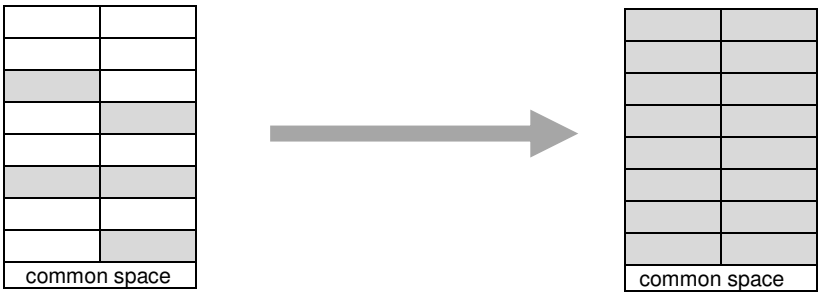
BILLING DATA

The data in this analysis is a combination of master meter accounts and individual accounts taken from the Wisconsin Low-Income Weatherization Assistance Program's (WisWAP) tracking database. It is possible that, in some cases, one or more master meter or individual accounts could be missing from the data we received from utilities. Almost certainly, some individual accounts are missing where individual account data was received (i.e., only some residents were program applicants.

We obtained billing data for a subset of weatherized units whose occupants qualified for Wisconsin's Energy Assistance Program. For each account, we calculated a rough estimate of unit-level, annualized usage under two scenarios: one, the account represented an individual unit only, and two, the account represented all units in the treated building. We then manually assessed which of the two scenarios was most reasonable, given usage level, primary heating fuel(s) within the building, and number of distinct accounts within the building for which we had billing data.

We also searched for accounts representing non-unit, common space within a treated building, using billing address and number of distinct accounts with a given building. Common spaces include foyers, hallways, laundry and storage areas, etc. While we know these accounts exist, we did not find any such instances within the billing data. Given that we have billing data for only master-metered buildings and qualified units within individually-metered buildings, our assumption is that billing data was not requested for these accounts. As a result, the process of energy usage extrapolation to the building level does not include such common spaces. The visual below illustrates the general process of extrapolation.

Collected data on shaded areas of building — extrapolated to shaded areas of building



Where possible, gas and electric usage data was fitted to one of three weather-adjustment models (heating only, cooling only or heating and cooling). Gas usage data was fit to a heating only model, while electric data was fit to all three models. Model selection was guided by information on the primary heating system type and fuel) and model fit. Annualized usage (non-weather adjusted) was used in instances where model fit was poor.

SIR CALCULATIONS

The SIR calculations presented in the report include the following components:

Fuel Prices. An average reference fuel price describing the five-year period was calculated for each fuel. Each year's price is weighted by the number of homes treated for each housing types and program 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)
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
2016	$0.79	$1.90	$3.32	$0.135
2017	$0.77	$1.76	$3.11	$0.135

Fuel Price Escalators. Fuel prices were adjusted using a set of fuel price escalators derived from the price indices being used in audits completed during PY17.

Discount rate. Future savings were discounted at a rate of three percent per year.

Measure life. The measure lives used to calculate the SIRs in this analysis are 25 years for gas savings and 15 years for electricity savings. These assumed measure lives are consistent with the assumed measure lives used to analyze 1-4 unit buildings; however, they are longer than those used in the NEAT audit (for example, boilers are evaluated in NEAT using a measure life of 20 years).