Assessment of Energy and Cost Savings for Homes Treated Under Wisconsin's Home Energy Plus Weatherization Program 2024

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Division of Energy, Housing and Community Resources

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Disclaimer – The findings of this report do not necessarily represent the opinions of the Wisconsin Department of Administration.

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1.0 EXECUTIVE SUMMARY

This report evaluates the energy savings of homes treated by Wisconsin's low-income Weatherization Assistance Program (WAP), Home Energy Plus for the most recent program year. The program, delivered by 18 agencies serving 20 service areas across the state, targets homes with high energy costs as well as those with elderly, very young, or disabled occupants. The main objectives are to: 1) reduce home energy bills, 2) save energy, and 3) make homes warmer in the winter and cooler in the summer.

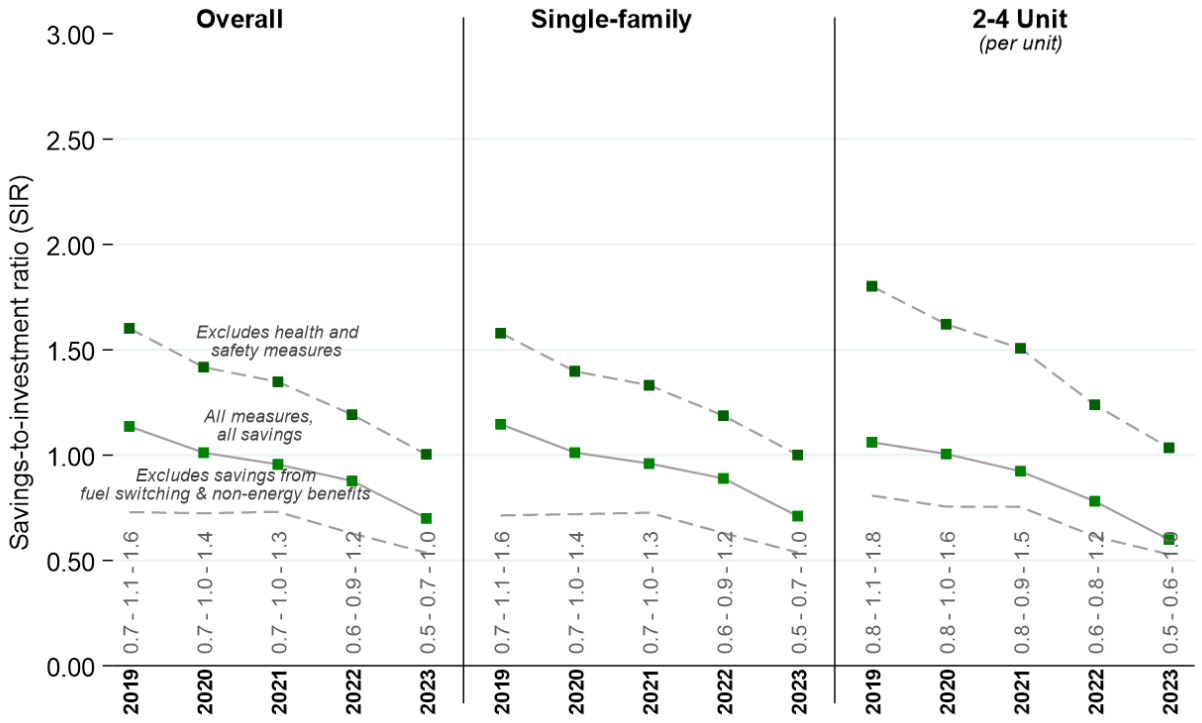
To determine energy savings, monthly natural gas and electric billing records for treated homes are collected from Wisconsin's five investor-owned utilities and one electric cooperative. Billing data from pre- and post-weatherization periods are weather-normalized and the difference between them is used to estimate natural gas and electricity savings for each treated home. For each program year analyzed, pre-weatherization billing data of future participants is used to correct for non-program effects and for errors in weather adjustment modeling. Savings estimates are then coupled with data taken from the program's tracking database to evaluate savings by housing type, local agency, and installed weatherization measures. This document is a summary of natural gas and electric results for 1-4 unit site-built buildings, by housing type, for program year 2023 (PY23).

1.1 COST EFFECTIVENESS

The weatherization services provided through Home Energy Plus in PY23 resulted in first-year cost savings of over $1.4 million and lifetime cost savings of over $31 million, which translates to about $330 per home in the year following weatherization. Homes switched to natural gas for space and water heating saved over three times that amount. These cost savings are the result of nearly 600,000 therms and 3.9 million kilowatt hours (kWh) saved per year in program homes. Overall, these monetary savings lead to a cost-effectiveness ratio of about 0.7 for all measures and 1.0 when excluding health and safety measures.

Figure 1 illustrates the savings-to-investment ratio (SIR) overall and across each housing type for the past five years. The decline over the last five years represents an increase in job costs, a response to the policy change of allowing a 0.8 cumulative SIR in buildings without DOE funds, and slightly declining cost savings. The increase in job costs, which can be seen in Figure 20, are disproportionately higher in PY23 than in previous years because of increased costs occurring in the construction market as well as high inflation rates.

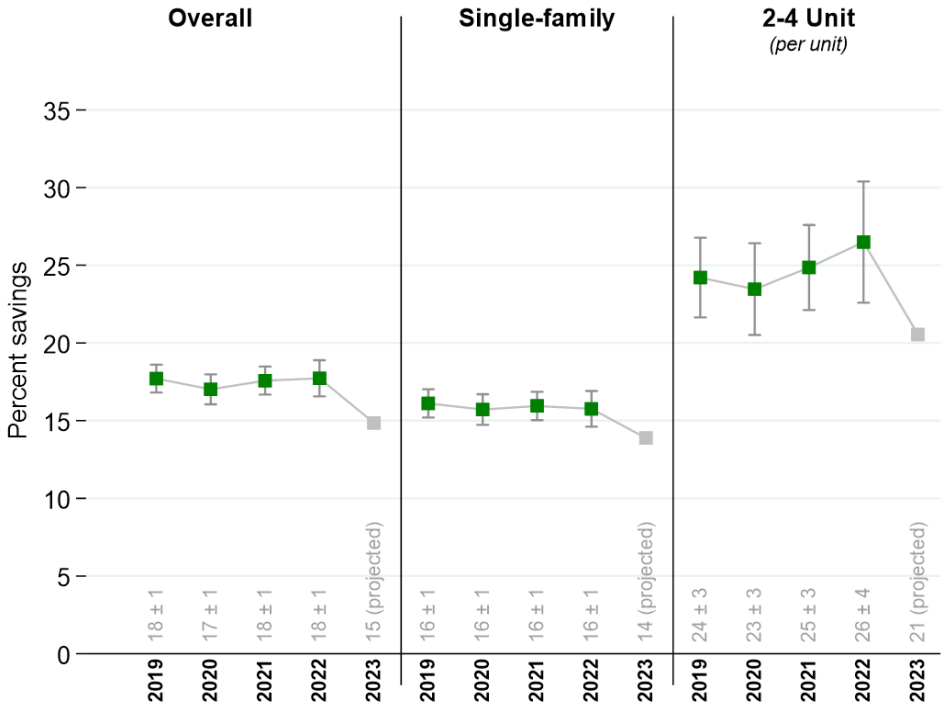
Figure 1-Program-wide SIRs, by housing type and program year



1.2 NATURAL GAS SAVINGS

In the most recent program year, natural gas savings stayed consistent compared to the past several years. In PY23, natural gas savings were 157 therms (15 percent) for 1-4 unit site-built homes. Figure 2 illustrates natural gas savings over the past five years for single-family and 2-4 unit homes.

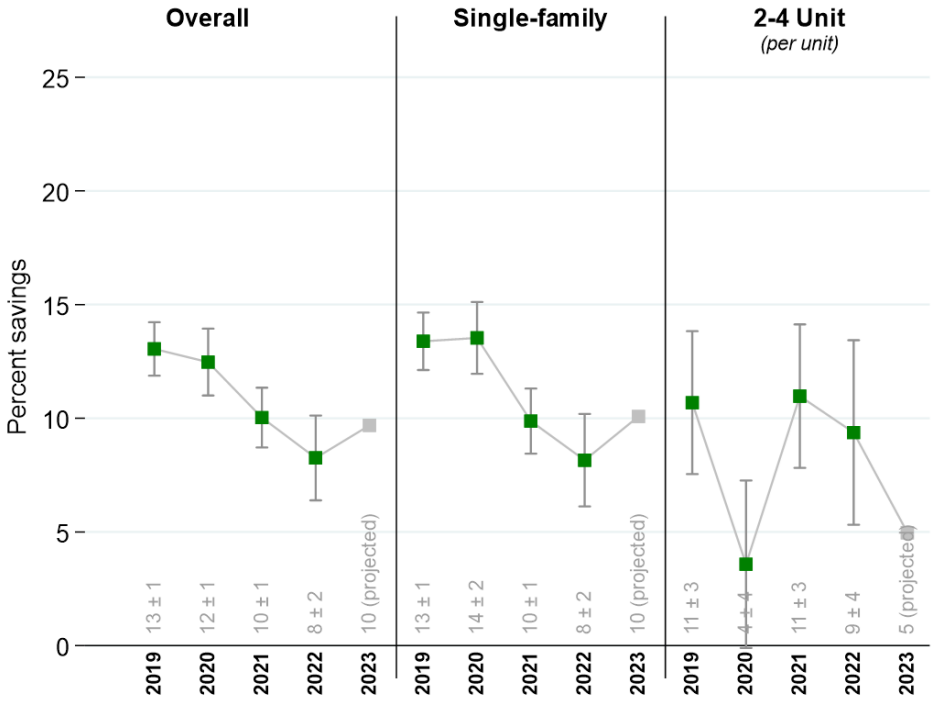
Figure 2-Annual natural gas savings, as a percentage of pre-weatherization usage by housing type and program year



1.3 ELECTRICITY SAVINGS

Electricity savings in PY23 are projected to increase for the first time in the past several years. The overall savings are projected at 915 kWh (10 percent) in PY23. Figure 3 illustrates the electricity savings split out by housing type for the past five years.

Figure 3-Annual electricity savings, as a percentage of pre-weatherization usage, for homes without electric heat, by housing type and program year



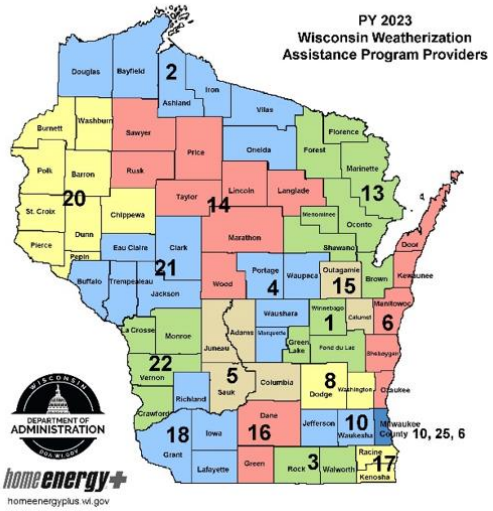
2.0 INTRODUCTION

Since 2009, an annual evaluation has been conducted of delivered energy savings for homes that have been treated by Wisconsin's low-income Weatherization Assistance Program (WAP), Home Energy Plus. Weatherization services are provided by 18 agencies throughout the state and are available to households meeting program eligibility requirements, which include a household income of 60 percent or less than the state's median income for a similar-size household. The program targets homes with a high energy burden as well as those with elderly, very young, or disabled occupants.

The main objectives of the Weatherization Assistance Program are:

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

The map below illustrates the geographical coverage of Wisconsin's weatherization service providers.



Weatherization Providers by Provider Number

1	ADVOCAP	15	Outagamie CHA
2	Ashland County Housing Authority	16	Project Home, Inc.
3	Community Action of Rock/Walworth	17	Racine/Kenosha CAA
4	CAP Services, Inc.	18	Southwestern Wisconsin CAP
5	Central Wisconsin CAC	20	West Central Wisconsin CAP
6	Partners for Community Development	21	Western Dairyland
8	Hartford CDA	22	Couleecap, Inc.
10	La Casa de Esperanza	25	Social Development Commission
13	Newcap, Inc.	6	Partners for Community Development
14	North Central CAP, Inc.	10	La Casa de Esperanza

This report is divided by program years, 12-month periods ending on June 30th of each year. The focus of this report is weatherization work completed largely between July 1, 2022 and June 30, 2023. It highlights findings from the last five program years as well as external influences and internal policy changes that affect program delivery and impacts. Shifting fuel prices, changes in the housing stock being weatherized, varying costs for weatherization materials and services, and COVID-19 are the primary external influences. The long-term trend of natural gas being the lowest cost fuel per delivered unit of heat prices is reflected in measure selection. This report represents ongoing efforts for improved program delivery and efficiency by assessing outcomes of program policy, procedures, and measures. This report includes site-built, single-family, and small multifamily homes (1-4 units).

Section 3.0 of this report presents trends in observed natural gas and electricity savings for housing units weatherized between PY19 and PY23. These savings are directly calculated from natural gas and electric utility billing data for PY19 through PY22 and projected for PY23. All billing data are weather-normalized to account for the effect of year-to-year temperature variation on household energy use. Weather normalization models are fit to individual households to capture the unique energy-temperature relationship of each home, allowing for a more nuanced adjustment of observed energy use to long-term average weather conditions. We create a comparison group to control for non-program influences unrelated to weather, which consists of a matched group of later program participants. Many participants of the most recent program year (PY23) have insufficient post-weatherization utility data for a typical billing analysis because they had not yet experienced a heating season before the start of this evaluation. Thus, we project energy savings estimates for PY23 homes using a modeling approach that applies average measure-level savings estimates from prior years to known measure installation data for these homes. This technique also extrapolates savings estimates for 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 more difficult.

Section 4.0 details cost savings, measure savings, incidence rates and contributions to aggregate savings. **Section 5.0** shows program costs and savings-to-investment ratios. **Section 6.0** (appendices) provides pre-weatherization consumption trends for program participants and state-wide detailed data tables and methodologies for processing utility billing data, modeling energy savings, assessing heating fuel conversions, estimating one of the key non-energy benefits (water conservation), and fuel prices used in this analysis.

The remainder of this section illustrates trends in program participation.

Figure 4 shows the number of housing units weatherized in each program year broken out by housing type. While this report focuses only on housing units in 1-4 unit site-built structures, large multifamily buildings (5+ units) and manufactured homes are included in Figure 4 to provide a more complete picture of the changing composition of the program over time. During the most recent program years, single-family site-built homes have comprised between 61 and 69 percent of weatherized homes. The drop in PY20 shown reflects program adjustments to accommodate COVID pandemic work risks and responses. In PY21 and PY22, the number of units increased compared to PY20 but were still slightly lower than the historical trends. Most recently in PY23, the majority of the drop can be attributed to a lapse in database coverage during the middle 2-3 weeks of April 2023 which accounts for over 300 missing housing units. These missing housing units are not likely to shift results or impact conclusions because the measure mix is similar to other months in the dataset. It should still be noted that the number of housing units in PY23 is roughly 300 lower than last year even after factoring in the housing units that are missing from April 2023.

Figure 4-Weatherized housing units, by housing type and program year

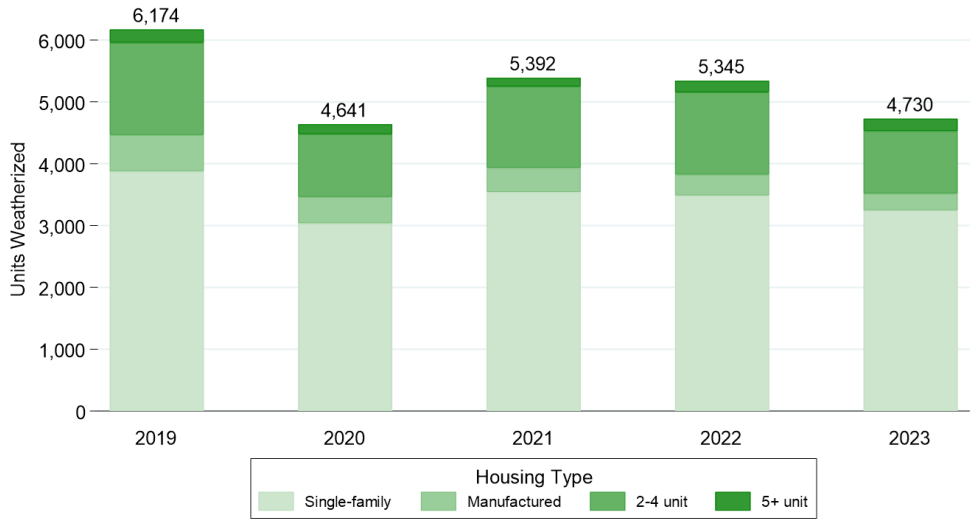
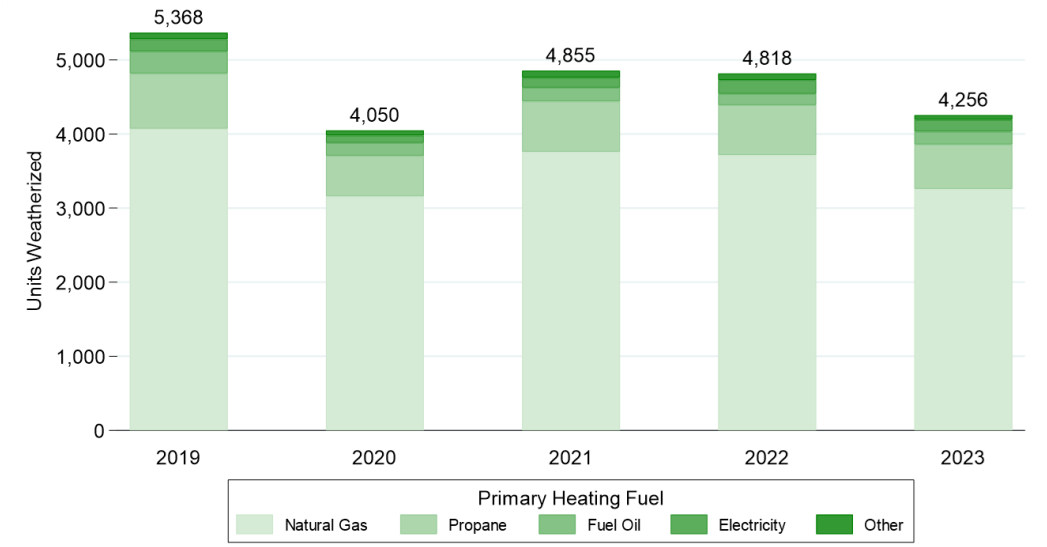


Figure 5 shows the distribution of treated homes in only 1-4 unit site-built buildings across primary heating fuels. Natural gas-heated homes have traditionally comprised most of this pool. Their relative proportion has remained above 75 percent since PY18.

Figure 5-Weatherized housing units in 1-4 unit site-built buildings, by primary heating fuel and program year



3.0 OBSERVED ENERGY SAVINGS

Natural gas and electricity savings for weatherized homes rely on monthly billing data collected from Wisconsin's five major investor-owned utilities and one electric cooperative. Alliant Energy, Madison Gas & Electric, We Energies, Wisconsin Public Service, and Xcel Energy all provide electric and natural gas data while WPPI Energy provides electric data only. Neither natural gas nor electricity savings include utility billing data for the most recent program year. Billing data from pre- and post-weatherization periods are weather-normalized, and the difference between the two periods reflects the natural gas and electric savings for each treated home. Additionally, pre-weatherization billing data for future program participants corrects 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. PY23 savings estimates 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 Appendix 6.3.

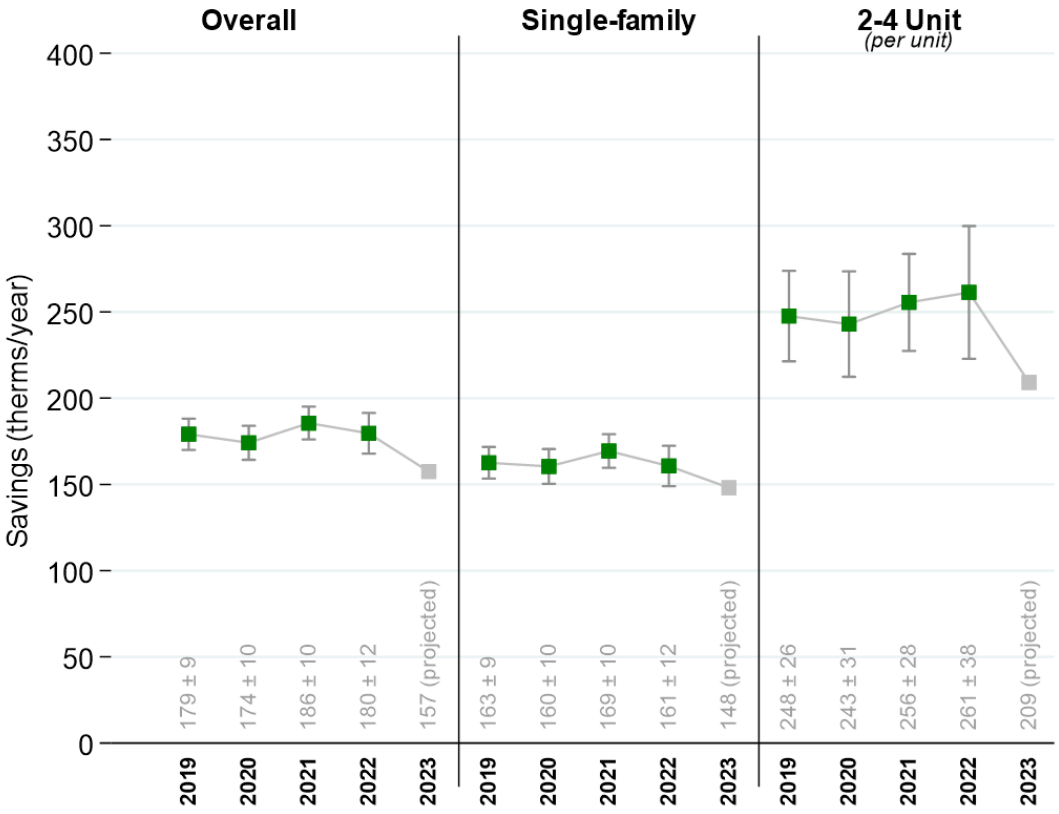
Fuel savings for homes that switch heating fuels from fuel oil, propane, or electricity to natural gas during weatherization are not reflected in observed energy savings. These homes typically have insufficient usage data for a billing analysis. Cost savings for fuel switches are discussed in **Section 5.0**.

3.1 NATURAL GAS SAVINGS

Natural gas savings from PY19 to PY23 are calculated as the difference between treatment and comparison group savings, which means the usage patterns of both groups impact savings. Figure 6 shows the last five years of natural gas savings for the program overall, single-family homes only, and 2-4 unit homes only.

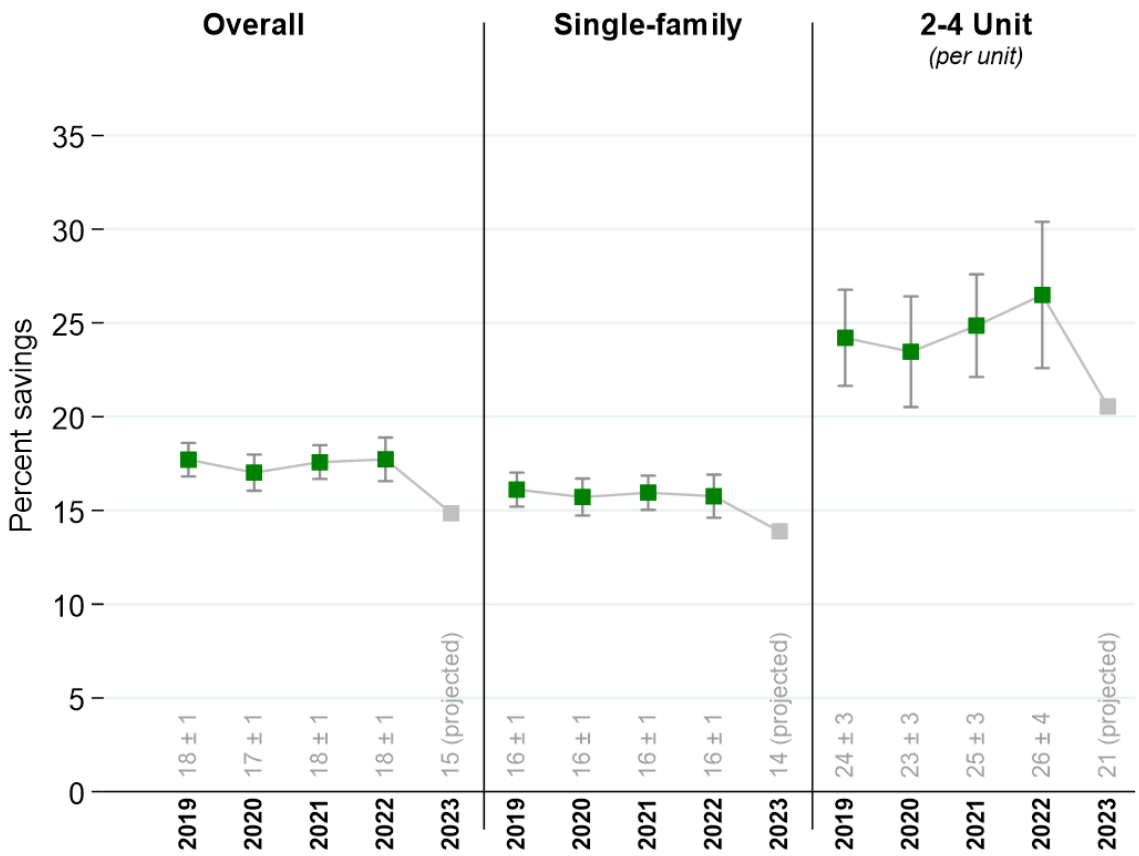
Natural gas savings for single-family homes have remained relatively stable over the past five years. Multifamily buildings (2-4 units) show more variation across time, most notably for the PY23 projection, but the wider confidence intervals observed for 2-4 unit buildings suggests that actual differences year-to-year are difficult to claim. Despite this, the overall natural gas savings still appear to be within a historically observed range.

Figure 6-Annual natural gas savings for natural gas-heated homes, by housing type and program year



Similar trends are evident when savings are expressed as a percentage of pre-weatherization consumption (Figure 7). Natural gas savings for the Wisconsin program in the most recent program years compare similarly to the U.S. average for single-family homes[1] and slightly below small multifamily homes, as reported in the national evaluation of the WAP.[2]

Figure 7-Annual natural gas savings, as a percentage of pre-weatherization usage, for natural gas-heated homes, by housing type and program year

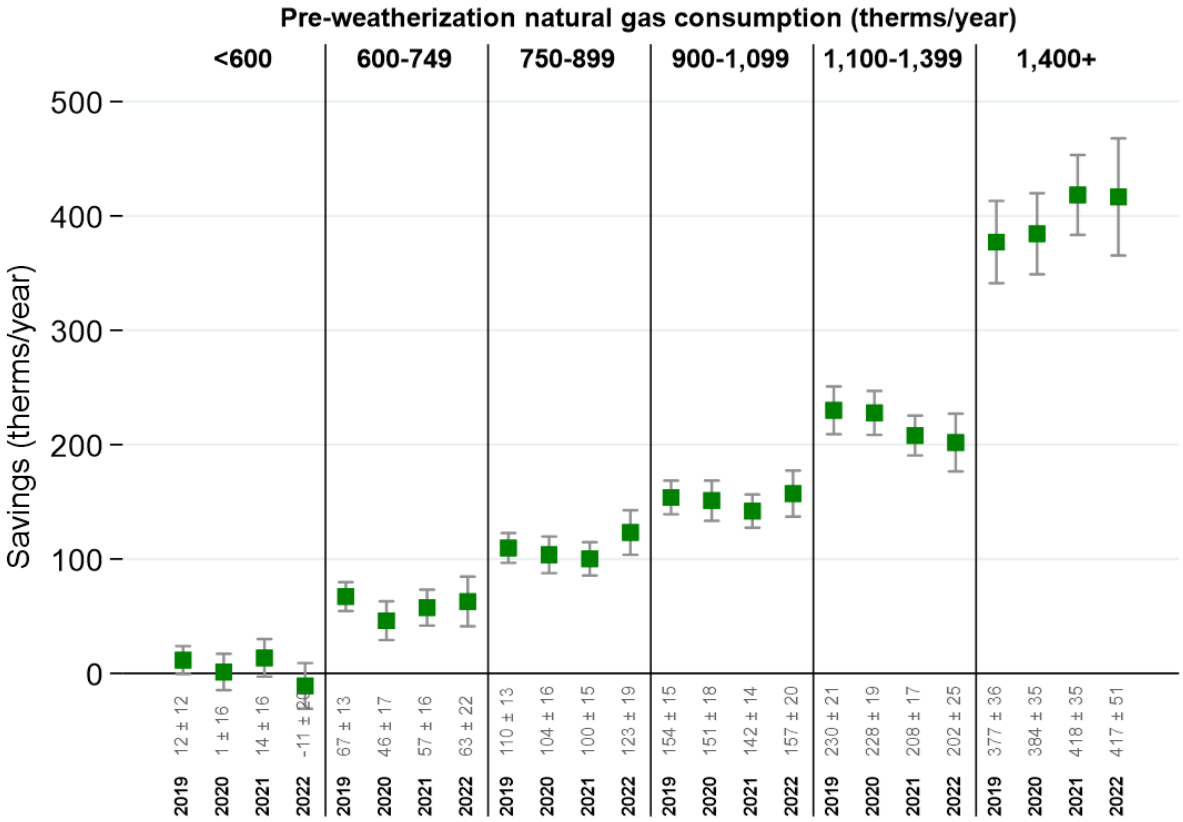


[1] Tonn, Bruce, Erin Rose, Richard Schmoyer, Joel Eisenberg, Mark Ternes, Martin Schweitzer, and Timothy Hendrick. *Evaluation of the National Weatherization Assistance Program during Program Years 2009-2011 (American Recovery and Reinvestment Act Period)*. No. ORNL/TM-2011/87. Oak Ridge National Lab. (ORNL), Oak Ridge, TN (United States), 2015. https://weatherization.ornl.gov/wp-content/uploads/pdf/WAPRecoveryActEvalFinalReports/ORNL_TM-2014_582.pdf

[2] Ibid, xxii

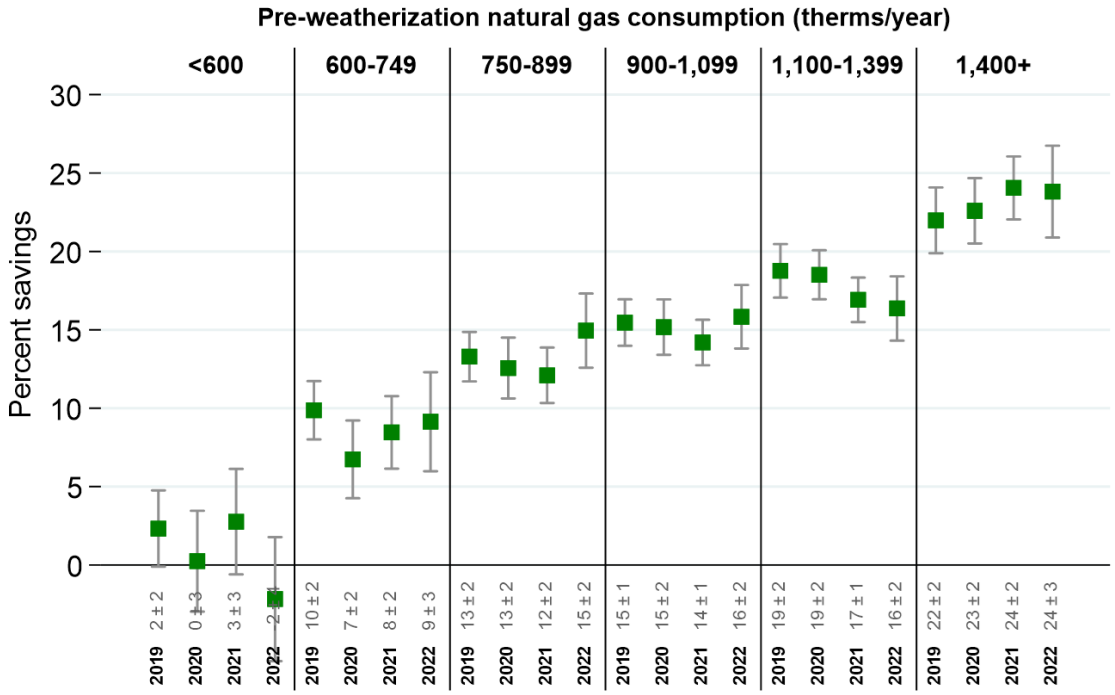
Figure 8 shows that homes using more natural gas prior to weatherization save more energy following weatherization. The highest users (1,400+ therms per year, representing about 15 percent of treated homes) yield the greatest savings, typically between 375 and 420 therms per year. Given the small number of units, the savings estimates for the highest users have high uncertainty. High users typically have lower levels of existing insulation, less efficient heating systems, and more uncontrolled air leakage which are all opportunities addressed by the program.

Figure 8-Annual natural gas savings for natural gas-heated single-family homes, by pre-weatherization usage bin and program year (PY23)



High users also tend to save a larger percentage of their pre-weatherization consumption (Figure 9). Homes in the highest-use group save about 23 percent of their pre-weatherization natural gas consumption, compared to no savings among homes in the lowest-use group. Natural gas savings increase an average of about five percentage points for every 150 to 200 therms of increased annual pre-weatherization usage. This trend persists largely because high users typically have lower levels of existing insulation, less efficient heating systems, and more uncontrolled air leakage, all opportunities addressed by the program.

Figure 9-Annual natural gas savings, as a percentage of pre-weatherization usage, for natural gas-heated single-family homes, by pre-weatherization usage bin and program year (PY23)



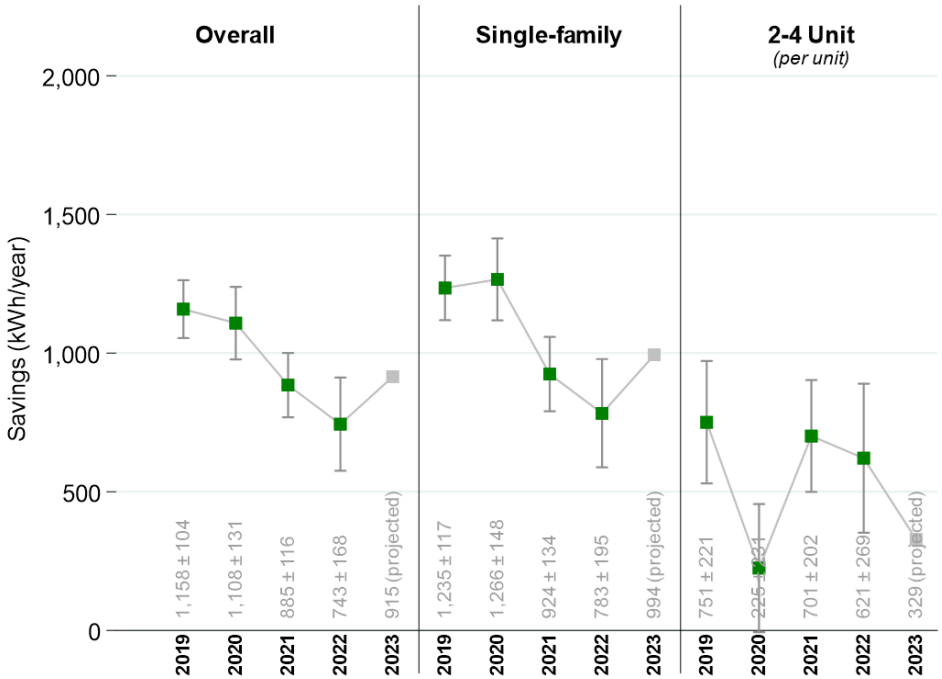
3.2 ELECTRICITY SAVINGS

Compared to the natural gas savings figures, the confidence intervals in Figure 10 show that electricity consumption is inherently more variable than natural gas use, making savings estimates less precise. Overall, savings estimates range from about 400 to 1,400 kWh per year per housing unit—less for multifamily properties and more for single-family homes.

Average single-family electricity savings from the program stayed relatively constant through PY20 and experienced a decline in PY21 and PY22, with PY23 showing a projected uptick in savings. Small multifamily buildings show more volatility across time and a projected decline in savings in PY23. The Wisconsin program still saves close to double that of the national average for single family[3] homes as well as more than the national average for multifamily homes in similar climates.[4]

The declining trend is partially the result of lower savings from fuel switches and refrigerators and freezers across the program. The other impact is the inherent variability in both the comparison group and treatment group's electricity use, which has a greater impact on savings compared to natural gas. This variability represents individuals' changing behavior regarding lighting, appliance, and plug load use. In PY22 the treatment group actually saved more energy than in PY21 but the difference *between* the treatment and comparison group in PY22 is smaller because the comparison group also reduced usage resulting in a lower savings estimate.

Figure 10-Annual electricity savings of homes without electric heat, by housing type and program year

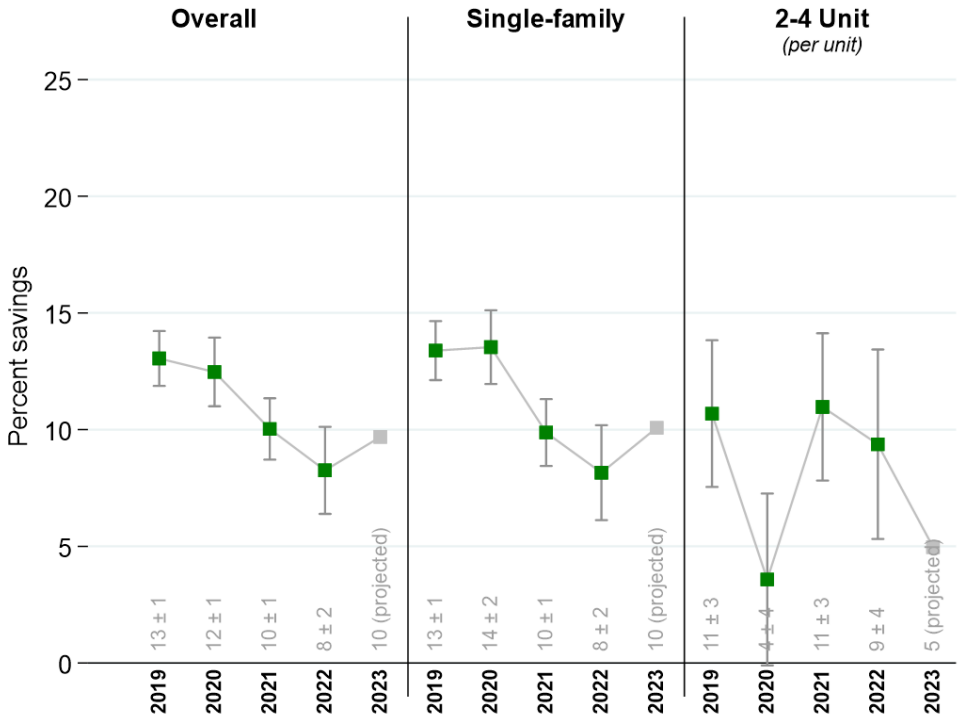


[3] Ibid, xxiii

[4] Ibid, xxiii

Savings trends are similar for savings expressed as a percentage of pre-weatherization consumption (Figure 11). From PY19 to PY20, electricity savings overall and for single-family homes stayed relatively consistent while in PY21 and PY22 we saw a small decrease. For 2-4 unit homes, there was a drop in percent electricity savings in PY20 before a large increase in PY21. Since PY21, savings have been stable. The electric savings on a percentage basis are similar to the savings found in the 2015 national WAP for homes in very cold climates like Wisconsin's.[5]

Figure 11-Annual electricity savings, as a percentage of pre-weatherization usage, for homes without electric heat, by housing type and program year



[5] Ibid, xxii

Like natural gas, higher users of electricity tend to save more following weatherization, though the trend is not as dramatic (Figure 12). This is because electricity end uses are much more numerous and diverse than for natural gas and other space heating fuels, and program rules do not allow most electric appliances to be treated. Since there are many more ways a household can be a high electricity user, weatherization treatment has somewhat less impact because it treats a smaller fraction of measures that create high electricity use.

Figure 12-Annual electricity savings for single-family homes without electric heat, by pre-weatherization usage bin and program year

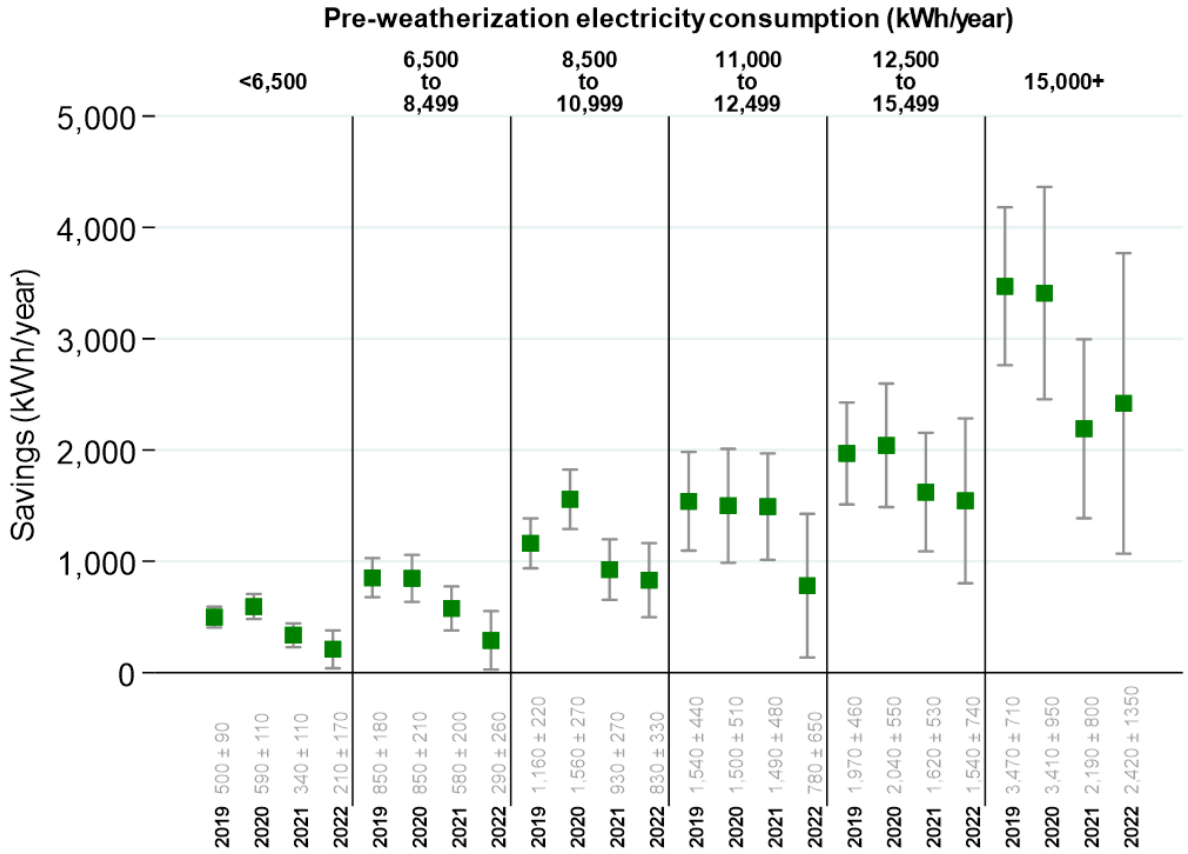
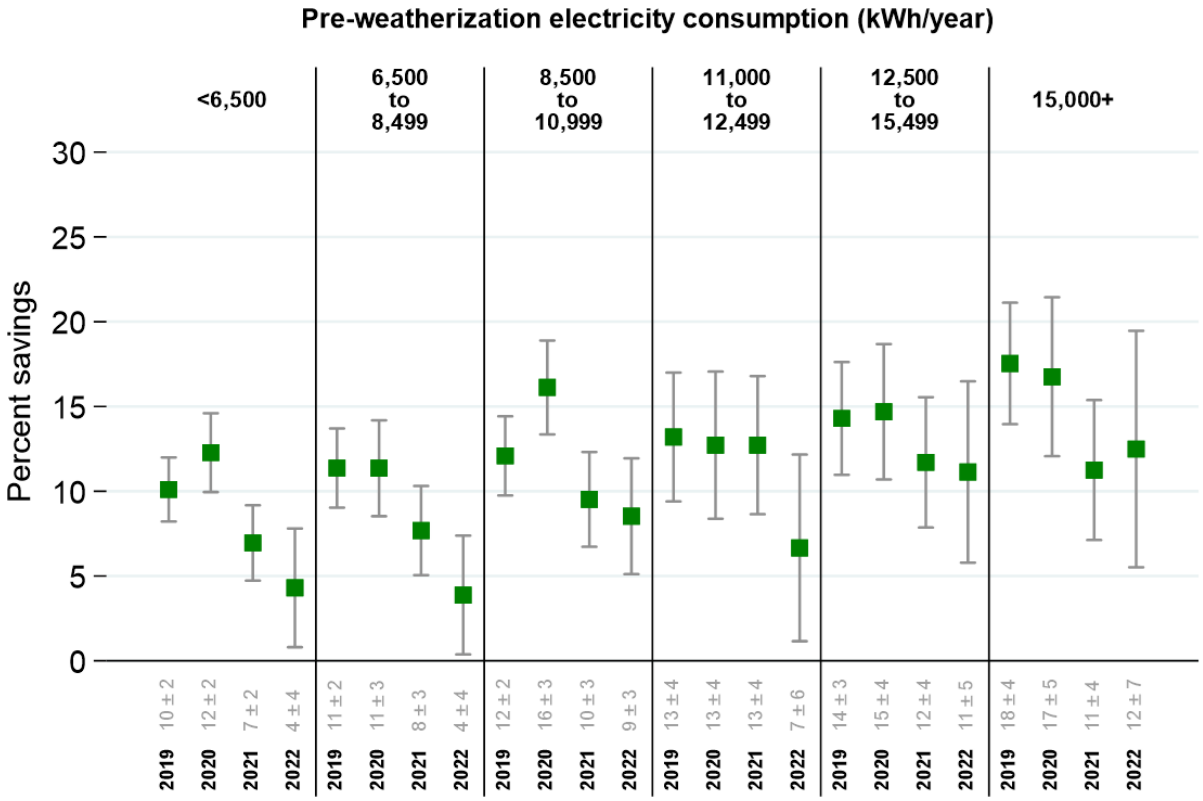


Figure 13 illustrates the percent electric savings across bins of pre-weatherization consumption. The trend shows that as pre-weatherization consumption increases, percent savings increases. However, this trend is less drastic than the natural gas trend. Still, treated homes see savings of between 4 and 18 percent, regardless of their pre-weatherization usage level.

Figure 13-Annual electricity savings, as a percentage of pre-weatherization usage, for single-family homes without electric heat, by pre-weatherization usage bin and program year



4.0 MODELED ENERGY AND COST SAVINGS

This study used a statistical model of energy savings for two purposes: 1) to disaggregate overall observed natural gas and electricity savings by energy conservation measure, and 2) to extrapolate observed savings for homes with adequate pre- and post-weatherization billing data to more recently treated homes and to homes heated with bulk fuels. Modeled energy savings for all participating homes are then combined with average fuel prices and projected fuel-price increases to estimate cost savings directly following weatherization and throughout the life of installed measures.

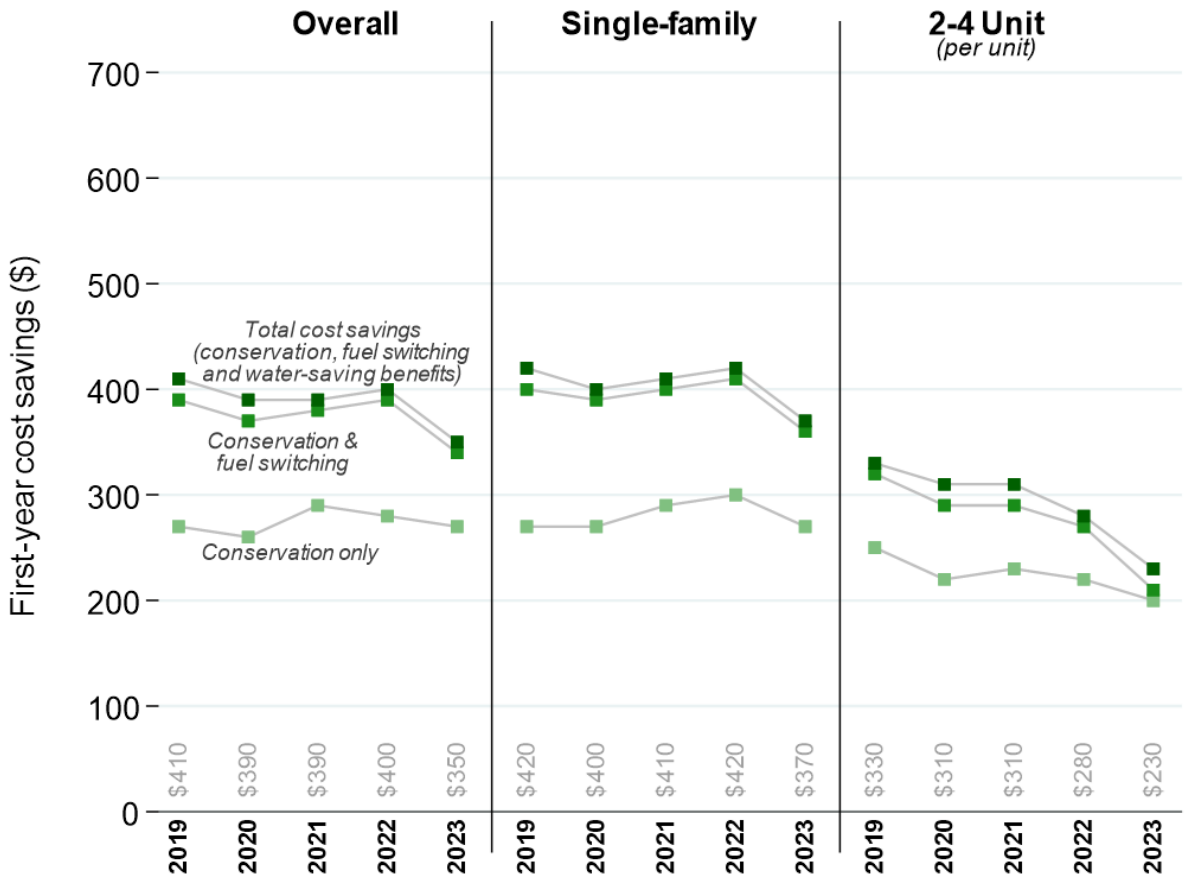
Estimating cost savings attributable to Wisconsin's program is a key element of this evaluation for determining the program's cost-effectiveness. This section measures cost-savings at three levels: 1) through the savings attributable simply to consuming less energy following weatherization (conservation only), 2) an additional level that includes savings from space heating fuel conversions (conservation and fuel switching), and 3) a level that adds water conservation savings from installed low-flow showerhead and faucet aerators (total cost savings). More detail on the energy savings model and conceptual approaches to estimating cost savings associated with heating fuel conversions and water conservation can be found in Appendix 6.4.

4.1 PER-HOME COST SAVINGS

Overall, participating households from PY23 are projected to save an average of $350 on their energy bills in the first year of post-weatherization from the program (Figure 14). However, this average obscures the wide variation in expected savings, dependent on housing type, heating fuel, and if the home received a space heating and/or water heating fuel switch. In Figure 14, average annual cost savings per home are presented by source(s) of savings (conservation measures, fuel switching, and reduced water use) and housing type.

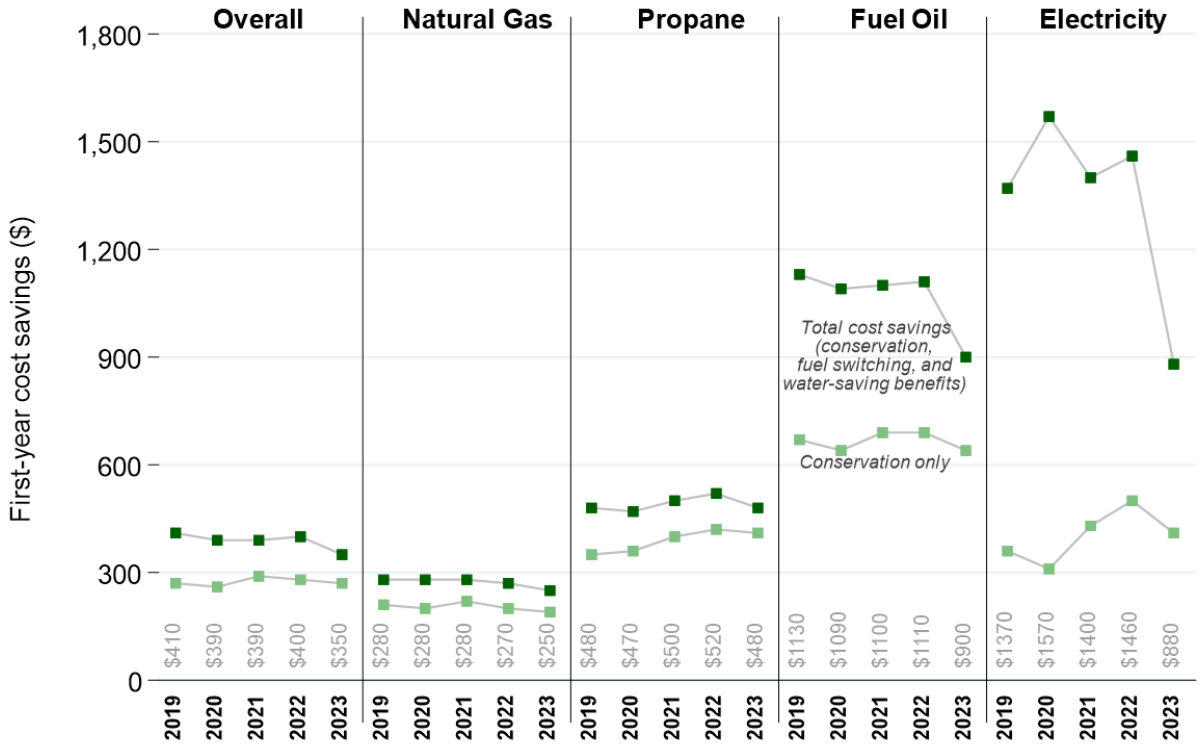
Savings from energy reduction measures account for about 70 percent of total cost savings. As the figure shows, the inclusion of fuel switching greatly increases the average per-home cost savings. Total cost savings remained relatively stable from PY19 through PY22, but these savings declined in PY23; the impacts of fuel switching on cost savings in PY23 is discussed below. Savings for conservation measures has been stable over the past 5 years.

Figure 14-Average first-year cost savings per home, by housing type and program year



The impact of fuel conversions is more evident in Figure 15 which shows average cost savings (total and conservation-based savings only) broken out by primary heating fuel. Homes heated with fuel oil or electricity experience large cost savings but represent a small but impactful subset of the program. In PY23, fuel oil- and electric-heated homes each made up about 4 percent of annual site-built homes; these two heating fuel types also saw a notable drop in savings from fuel switching which is the primary driver in the reduction of savings seen in Figure 15.

Figure 15-Average first-year cost savings per home, by heating fuel type and program year



We investigated this reduction in savings from fuel switching for electricity in single-family homes more closely and found that the incidence of fuel switching – both water heating and space heating – and the savings per job has declined from PY22 to PY23. One potential explanation for this decline is that homes that switch fuels for space and water heating have lower pre-weatherization consumption in PY23 compared to PY22. This is true for jobs that got either a water heating fuel *or* a space heating fuel switch but not for the jobs that received *both* so we consider this a partial explanation. Overall, lower savings per job combined with fewer jobs where fuel switching occurred are likely what is driving lower savings for fuel switch jobs.

To investigate the impact of fuel switches, Figure 16 plots the predicted first-year cost savings for each home weatherized in PY23 compared to PY22 by the type of fuel switch. The box-and-whisker plots show the distribution of first-year cost savings across homes: boxes indicate the range for the middle 50 percent of homes in each group, and the whiskers show the range between the fifth and ninety-fifth percentiles.

The largest difference results from homes that received a space heating fuel switch. Homes not receiving a heating fuel switch measure, regardless of housing type or primary heating fuel are, on average, expected to save around $210 during the first year following weatherization. By contrast, homes receiving a heating fuel-switch measure are, on average, expected to save above $1,000. Figure 16 also shows that first year cost savings for space heating fuel switches have lowered by approximately $200 on average.

Figure 16-First-year cost savings for individual homes treated in PY22 and PY23 as a result of fuel switching

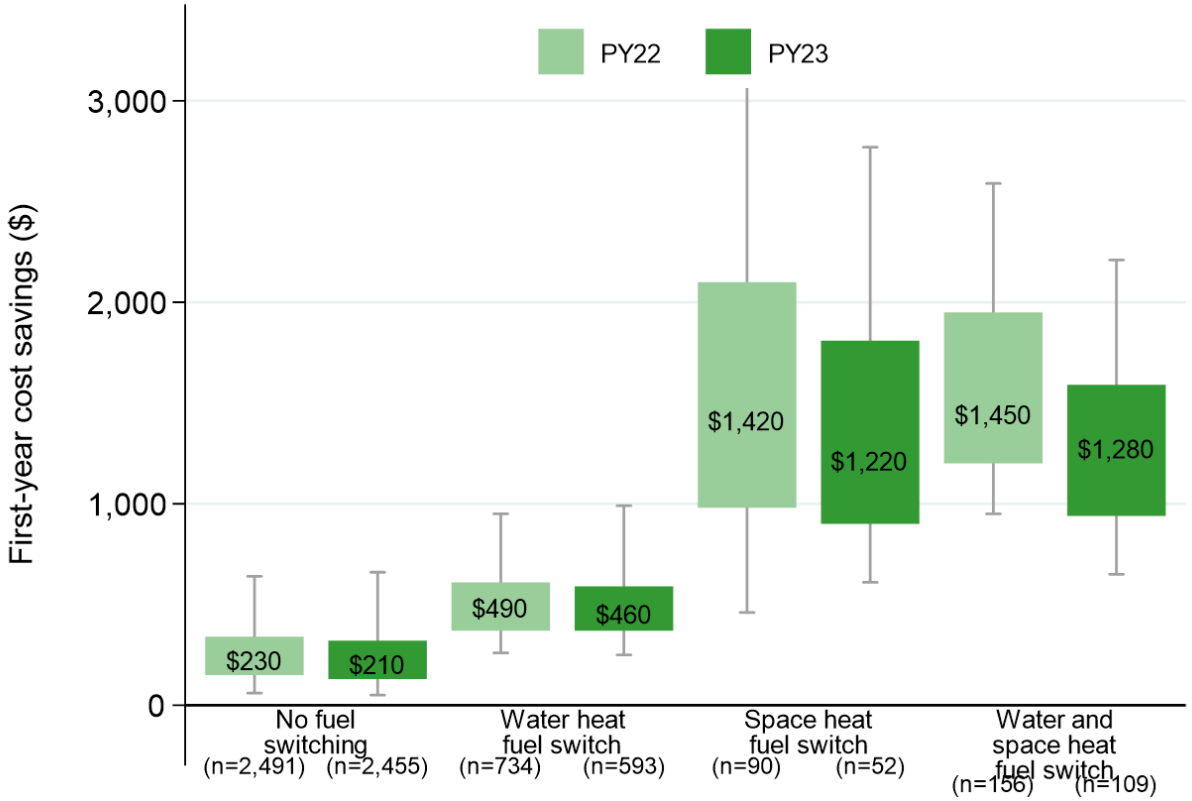


Table 1 presents average, per-home cost savings expected during the initial year after weatherization for more specific subgroups: by housing type, heating fuel, and if a heating fuel conversion measure was installed. A similar table showing projected cumulative savings over the useful life of installed measures is included in the appendices (Appendix 6.2). Notably, about 71 percent of single-family homes and about 95 percent of small multifamily homes are heated with natural gas. Even though savings from fuel switching is a significant contributor to savings, most homes did not experience a fuel switch measure.

Overall, average energy cost savings are higher among single-family homes than among small multifamily homes. Significant minorities of the former were heated with more expensive fuels (fuel oil and electricity) before weatherization, while nearly all multifamily properties had natural gas heat. Generally, cost savings among all single-family homes is driven by homes with natural gas heat.

Table 1-Average first-year cost savings for homes treated in PY23, by housing type and fuel type

Housing type & primary heating fuel	Units with no fuel switching			Units with a water heating fuel switch		Units with a space heating fuel switch	
	Treated units	% of units	First-year savings	% of units	First year savings	% of units	First-year savings
Single Family	**3,246**	**76%**	**$260**	**18%**	**$520**	**6%**	**$1,280**
Natural Gas	2,300	80%	$210	20%	$460	0%	$540
Propane	597	79%	$400	16%	$650	5%	$1,110
Fuel Oil	164	28%	$390	7%	$870	65%	$1,110
Electricity	121	55%	$420	17%	$710	29%	$2,050
Other	64	52%	$600	11%	$1,190	38%	$1,290
2-4 Unit	**10,10**	**93%**	**$200**	**7%**	**$410**	**1%**	**$1,150**
Natural Gas	958	93%	$200	6%	$390	-	-
Electricity	40	95%	$320	5%	$890	-	-
Fuel Oil	8	25%	$710	-	-	75%	$1,420
Propane	4	50%	$190	50%	$660	-	-

4.2 INDIVIDUAL MEASURE ENERGY SAVINGS AND INSTALLATION RATES

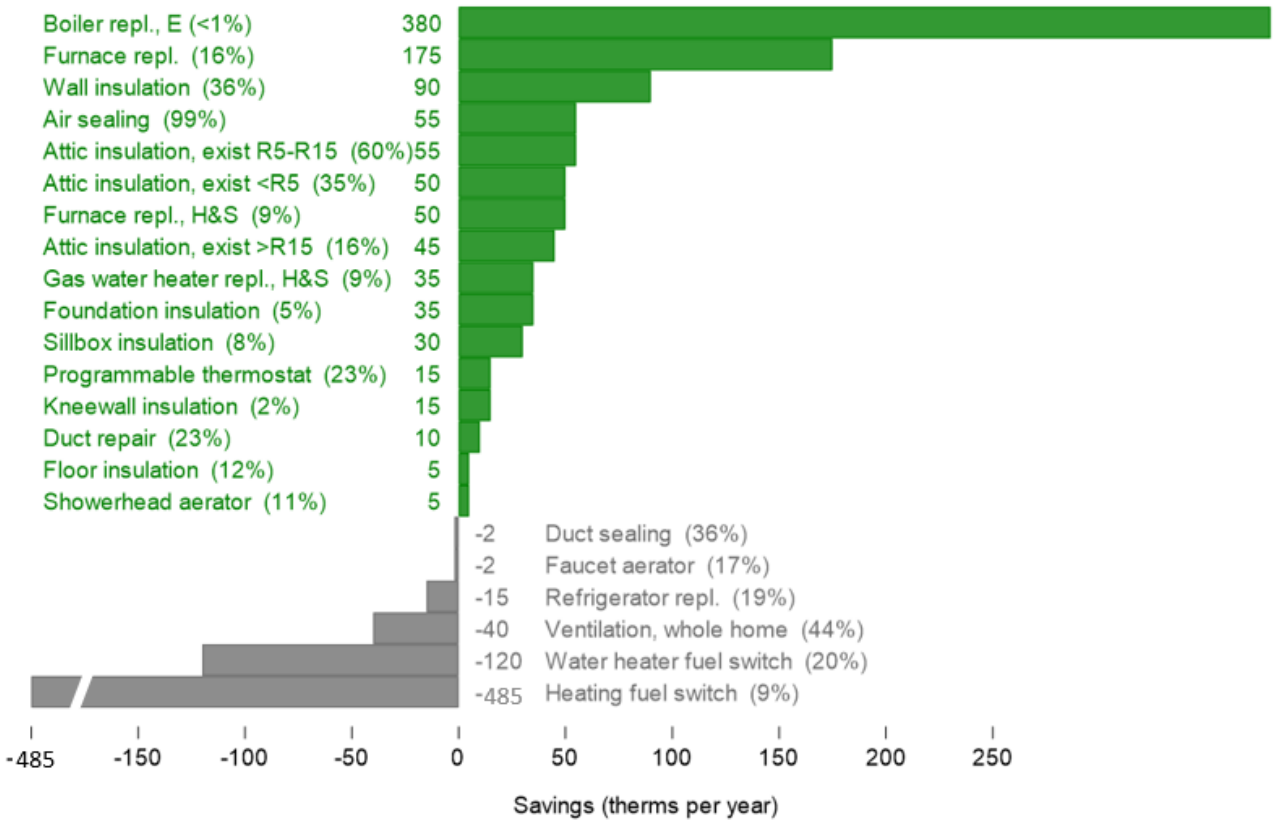
As mentioned previously, a statistical model estimates average natural gas and electricity savings for individual measures. Figure 17 presents savings and measure installation rates for single-family homes, since they make up the largest portion of treated site-built homes. The figures only include measures with an incidence rate above five percent except for boiler replacements.

Individual measures yielding the greatest natural gas savings include heating system replacements and insulation, especially for walls and attics. Boiler replacements produce the highest savings, but only occur in less than one percent of homes in PY23. Furnace replacements produce the next highest savings and occur in 16 percent of homes in PY23. Air sealing, while not a large energy saver (55 therms per year), is notable because it is completed in nearly all homes.

Other measures increase natural gas consumption. The most notable of these is fuel switching. Converting a central heating system to natural gas is shown in Figure 17 as a truncated bar on the bottom of the graph because it *adds* an average of 485 therms to a home's annual natural gas load. Mechanical exhaust ventilation also carries a natural gas penalty by influencing heating loads via increased air flow exchange.

Of the other measures listed in Figure 17, duct sealing and refrigerator replacements also have negative savings. Duct sealing and repair have little effect on savings and are largely done to enhance the health and safety of occupant. Negative savings for refrigerator replacements follows a theoretical basis for a natural gas penalty in which the electricity saved by these measures reduces the amount of heat generated indoors by refrigerators, demanding more from the heating system.

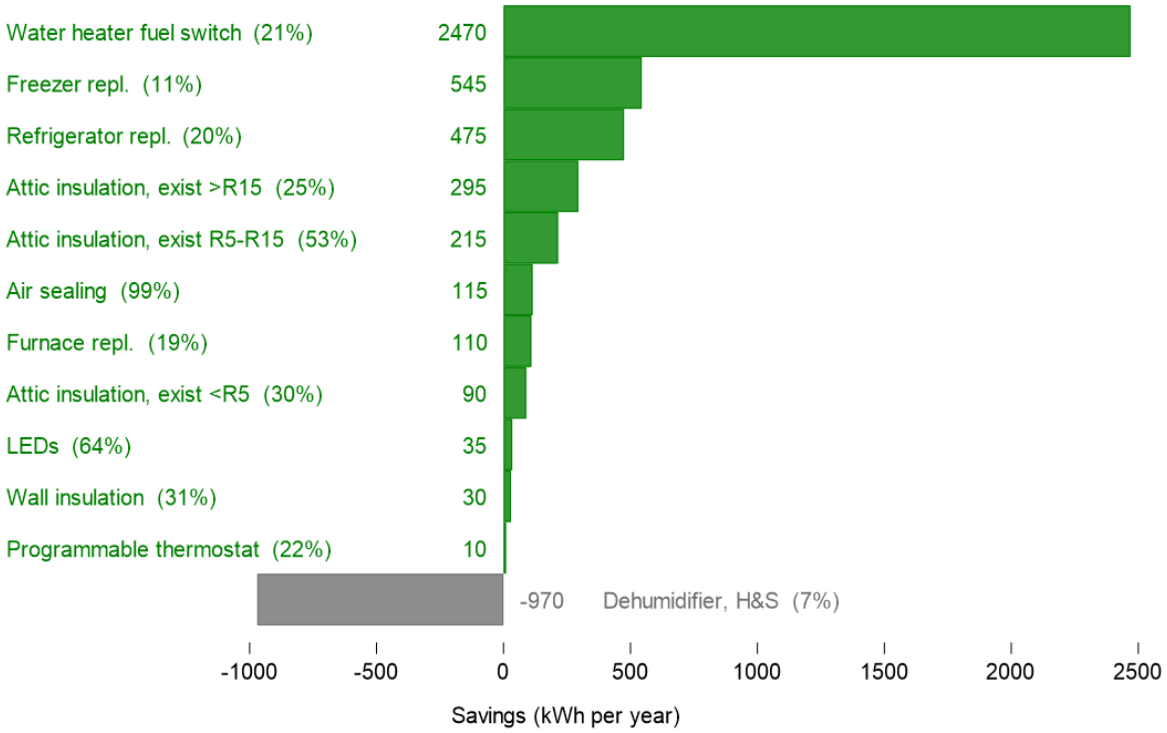
Figure 17-PY23 annual natural gas savings per measure, when measures installed in single-family site-built homes (measure incidence rate in parentheses)



Most electrical savings derive from electric-to-natural gas primary space heating system conversions. In PY23, less than two percent of homes converted an electric heating system to natural gas, so it is not shown in Figure 18. The savings associated with this measure was about 8,185 kWh, which is more than three times greater than the savings of the next highest-saving measure. After primary space heating system fuel switches, water heater fuel switches show the greatest electrical savings. In PY23, refrigerator replacements, freezer replacements, and attic insulation also provide significant electricity savings.

This analysis indicates that the installation of a dehumidifier (for homes where moisture management is necessary) increases electricity consumption. However, as indicated by the low incidence rate, these measures are not commonly installed. The measure also provides health benefits to residents. Furnace replacements, which have historically been associated with a small amount of negative savings, show positive savings of 110 kWh in PY23. These are unlikely to have a significant effect on electricity savings.

Figure 18-PY23 annual electric savings per measure, when installed in single-family site-built homes (measure incidence rate in parentheses)

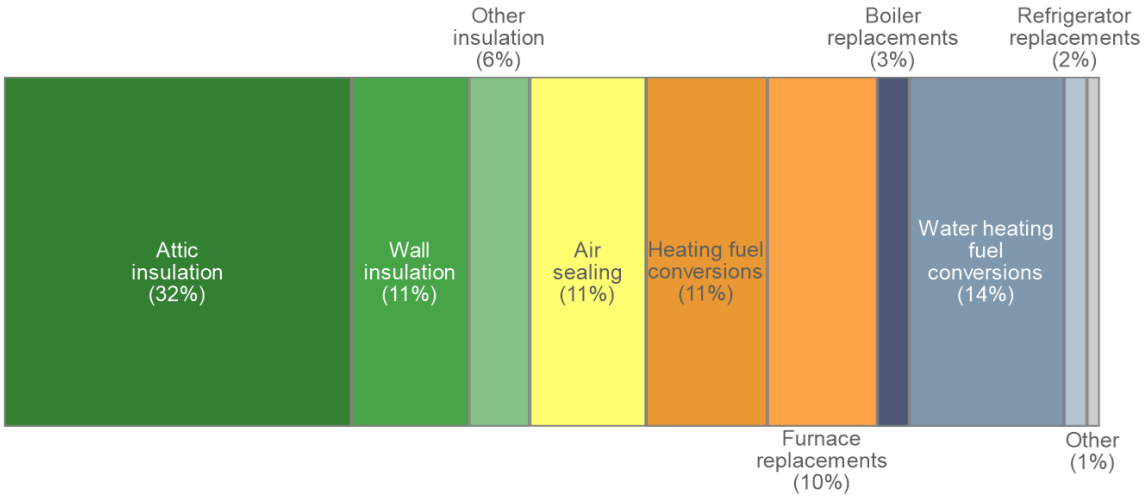


4.3 MEASURE CONTRIBUTIONS TO AGGREGATE SAVINGS

The model-estimated contributions of individual measures to total aggregate life-cycle-energy-cost savings for single-family homes are shown in

Figure 19. Almost all of energy cost savings for each year are from insulation measures (49 percent), fuel switching (25 percent), heating system replacements (13 percent), and air sealing (11 percent). Measures with smaller contributions to overall cost savings are bundled together in "Other" and cumulatively account for one percent of savings. The "Other" category includes the effects of health and safety and repair measures, some of which may result in negative savings.

Figure 19-PY23 measure contributions to life-cycle cost savings when installed in single-family site-built homes



4.4 PROGRAM-WIDE ENERGY AND COST SAVINGS IMPACTS

For single-family and small multifamily units treated in PY23, the statewide program saved participating households around a total of $1.4 million during the first year after weatherization. Over the life of the installed measures, the program is projected to yield a total of $31.2 million in energy cost savings for those homes. It should be noted that these savings estimates do not account for the roughly 300 jobs that are missing due to the lapse in database coverage which likely causes the estimates to come in around 7% lower than actual values.

Aggregate cost and energy savings were lower in PY20 to PY23 compared to PY19. There were fewer homes treated between PY20 and PY22 due to COVID, which explains much of the decline in aggregate savings in recent years.

Table 2-Program-wide energy savings for single-family and multifamily homes, by heating fuel type and program year

PY	Treated units	Aggregate energy savings				Aggregate cost savings				
		NG (therms)	LPG (gals)	FO (gals)	ELEC (kWh)	Energy conservation	Fuel switching	Non-energy benefits	Total, first-year	Total, life of measures (undiscounted)
PY19	5,368	750,000	119,000	69,000	6,275,000	$1,430,000	$603,000	$77,000	$2,111,000	$50,649,000
PY20	4,050	565,000	100,000	39,000	4,445,000	$1,043,000	$414,000	$64,000	$1,521,000	$36,012,000
PY21	4,855	774,000	142,000	46,000	4,971,000	$1,340,000	$438,000	$73,000	$1,851,000	$40,901,000
PY22	4,818	744,000	152,000	39,000	5,094,000	$1,307,000	$482,000	$57,000	$1,846,000	$41,293,000
PY23	4,256	595,000	124,000	42,000	3,911,000	$1,080,000	$290,000	$45,000	$1,414,000	$31,237,000

5.0 PROGRAM COST EFFECTIVENESS

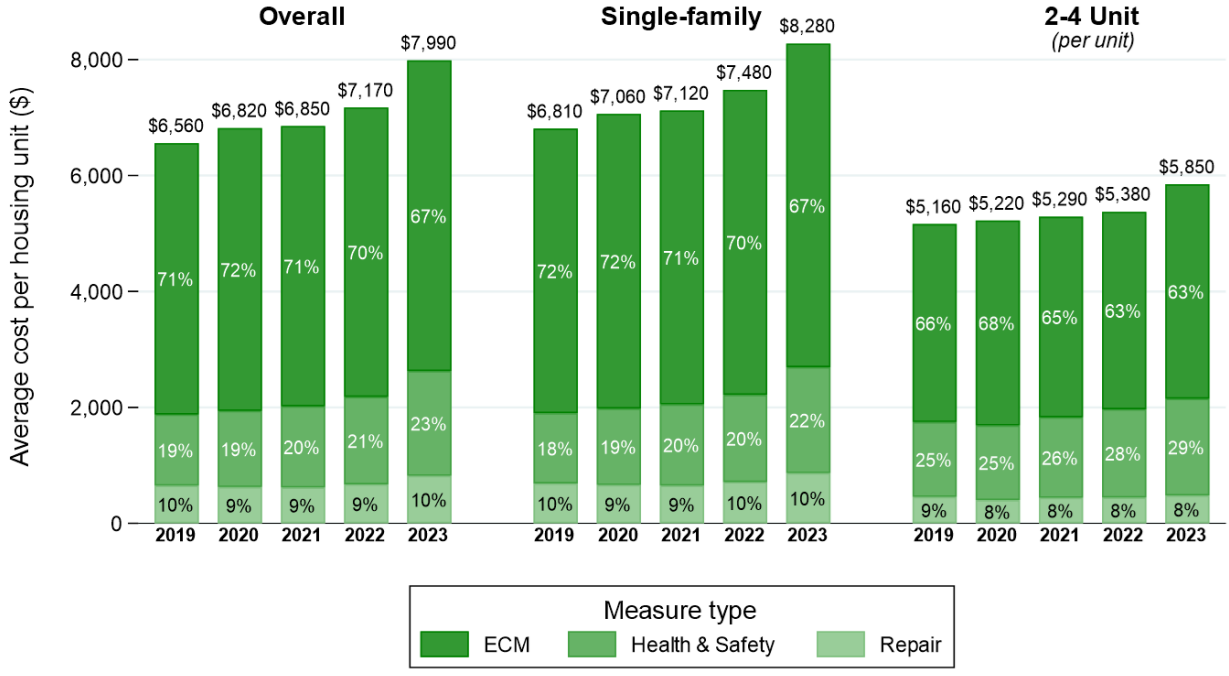
This section brings together information about program costs and projected savings. Job-level costs broken out by measure type (energy conservation, health and safety, or repair) are presented first, followed by an analysis of program-wide cost effectiveness.

5.1 JOB-LEVEL COSTS

Overall, the average cost of weatherizing a housing unit has shown increases year-over-year. Disaggregating average cost per housing unit (Figure 20) shows a similar pattern. The proportion of energy conservation measures, health and safety, and repair measures have remained close to historical levels, as has the aggregate cost of those treatments. The comparatively larger job cost increase in 2023 is likely associated with high inflation rates which were approximately 7.5 percent during the program year.

In PY23, the cost for single-family homes averaged almost $8,300. The cost for homes in 2-4 unit buildings averaged $5,850 per housing unit. Throughout the program, spending is dominated by energy conservation measures (ECMs) at about $5,500 per single-family home and $3,700 per small multifamily unit. Costs to address health and safety issues, as well as home repairs needed to enable installation of ECMs and other costs, amount to a little over $2,000 per small multifamily unit and $2,800 for single family units.

Figure 20-Job costs per housing unit, by housing type, measure type, and program year



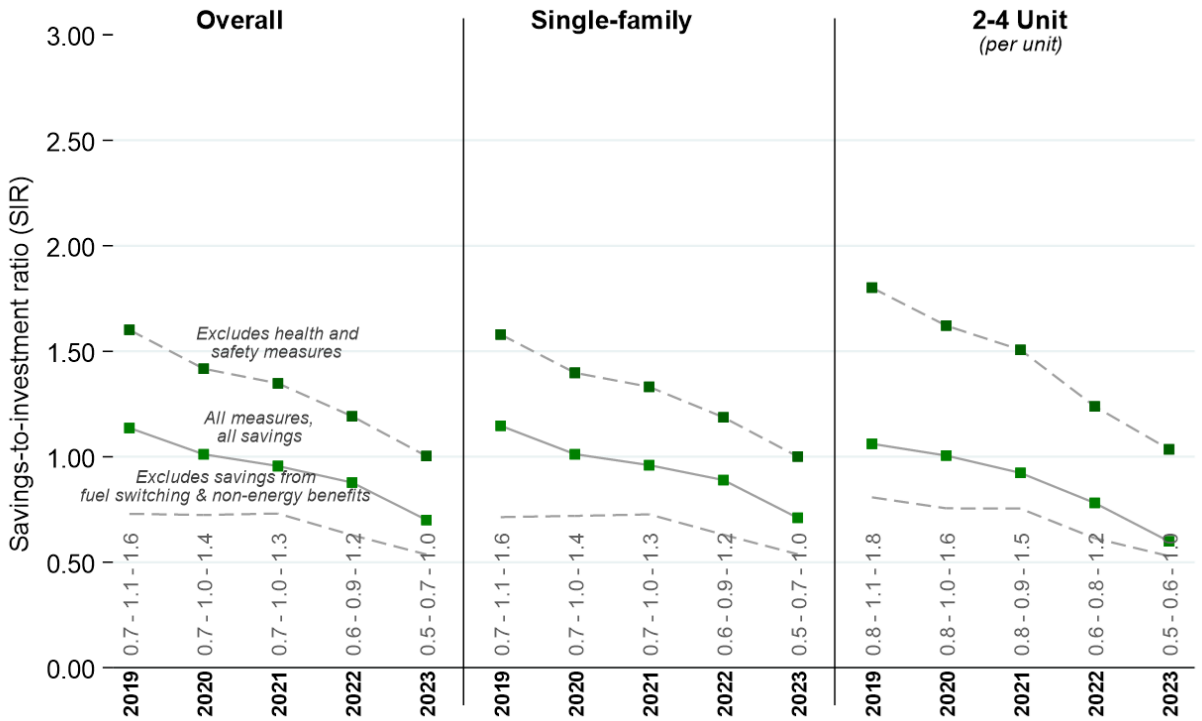
5.2 OVERALL PROGRAM COST EFFECTIVENESS

Average cost savings and information on per-unit spending is used to estimate discounted life-cycle program savings-to-investment ratios (SIRs) for each housing type and primary heating fuel. Three sets of SIRs are provided for each subgroup:

- The primary series (middle) includes all sources of cost savings and all measure categories.
- One alternative series (bottom) is calculated using only energy conservation-related cost savings (i.e., savings associated with fuel switching or water conservation are not included).
- Another alternative series (top) is calculated using savings and costs associated with energy conservation and repair measures only (health and safety measures are excluded).

Figure 21 shows program-wide SIRs broken out by housing type and program year. Overall, average SIRs prior to PY23 are at or above the key policy threshold of 0.8 and reflect the impact of cost savings associated with space and water heating fuel switching. For PY23, average SIRs drop to 0.7 which can be attributed to rising job costs (Figure 20) and a reduction in savings from fuel switching. As previously mentioned, the job costs in PY23 are notably higher than in previous years due to inflation and increased costs in construction markets. The decline since PY22 also represents the change in policy from a 1.0 SIR to a 0.8 SIR requirement, which allows the program to install more measures within each home. Without savings from fuel switching, average SIRs for single-family homes hover around 0.5. Excluding health and safety measures increases average SIRs by about 0.5.

Figure 21-Program-wide SIRs, by housing type and program year



Even without savings from fuel switching measures, SIRs for propane, fuel oil, and electric homes are higher than those for natural gas (Figure 22). The dominant feature of this plot is the large disparity between the cost effectiveness of fuel switching to natural gas heating systems from fuel oil and electric space heating, though the cost effectiveness for switches from electric space heating experienced a significant drop in PY23. Despite this observed drop, the higher cost per unit of delivered energy for fuel oil and electricity still allows for cost effective fuel switching. Overall, with the exception of fuel oil, program SIRs have remained stable when excluding the impact of fuel switching. The downward trend in fuel oil is largely a result of the declining cost of fuel oil.

Figure 22-Program-wide SIRs, by heating fuel type and program year

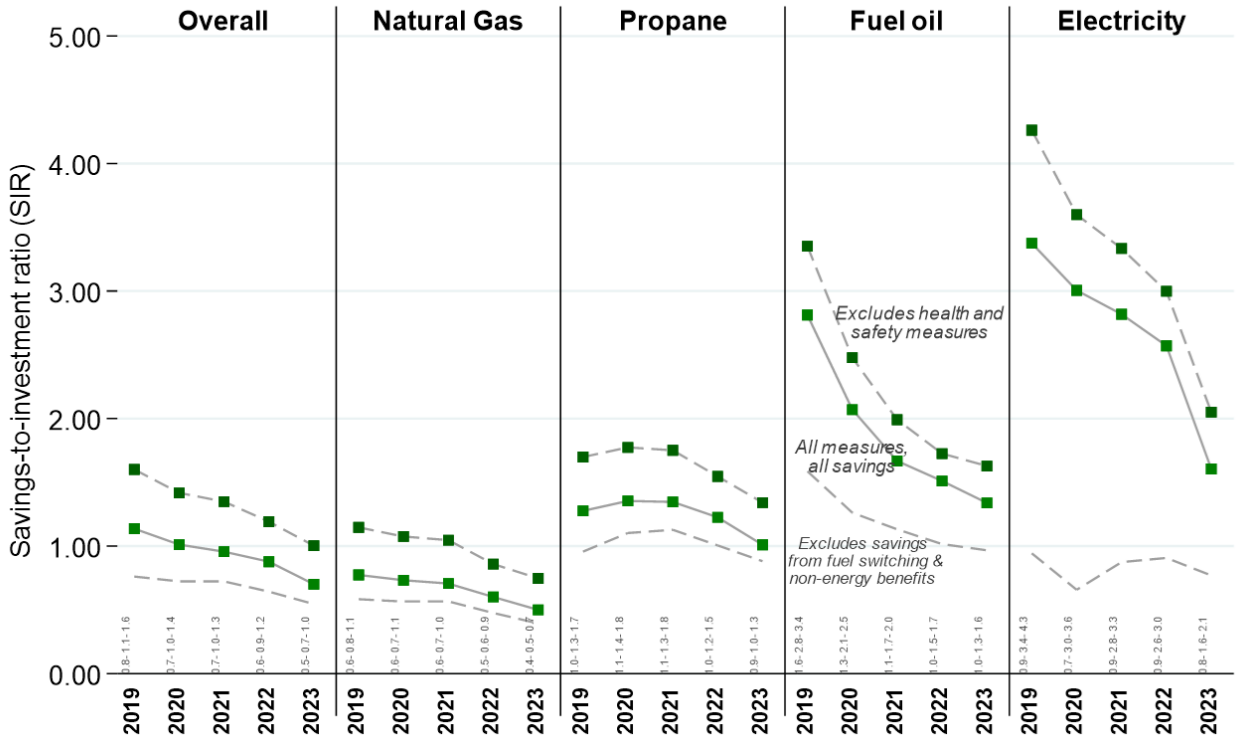


Table 3 further breaks out estimated PY23 SIRs and job costs by housing type and heating fuel. For both years, across housing types, SIRs are highest for homes heated with fuel oil or electricity, and average job cost is higher for single-family homes.

Table 3-Average SIRs and job costs for homes treated during PY23, by housing type and heating fuel

Housing Type & Primary Heat Fuel	Includes health and safety measures			Excludes health and safety measures	
	SIR (using energy cons. cost savings only)	SIR (using total cost savings)	Average job cost	SIR (using total cost savings)	Average job cost
Single family	**0.55**	**0.71**	**$8,552**	**1.00**	**$6,171**
Fuel oil	0.96	1.33	$11,667	1.60	$9,915
Natural gas	0.38	0.49	$8,275	0.72	$5,696
Propane	0.88	1.01	$8,495	1.34	$6,466
Electricity	0.74	1.61	$9,001	2.03	$7,414
Other	1.29	1.42	$10,208	1.76	$8,500
2-4 unit	**0.53**	**0.60**	**$6,076**	**1.04**	**$3,506**
Fuel oil	1.38	1.89	$11,093	3.99	$4,760
Natural gas	0.50	0.56	$6,084	0.95	$3,517
Propane	0.55	0.83	$7,749	1.94	$3,497
Electricity	1.37	1.47	$4,173	2.55	$2,840

*Note the small discrepancy between average job cost in Figure 20. Those averages are calculated by measure types, while these are not.

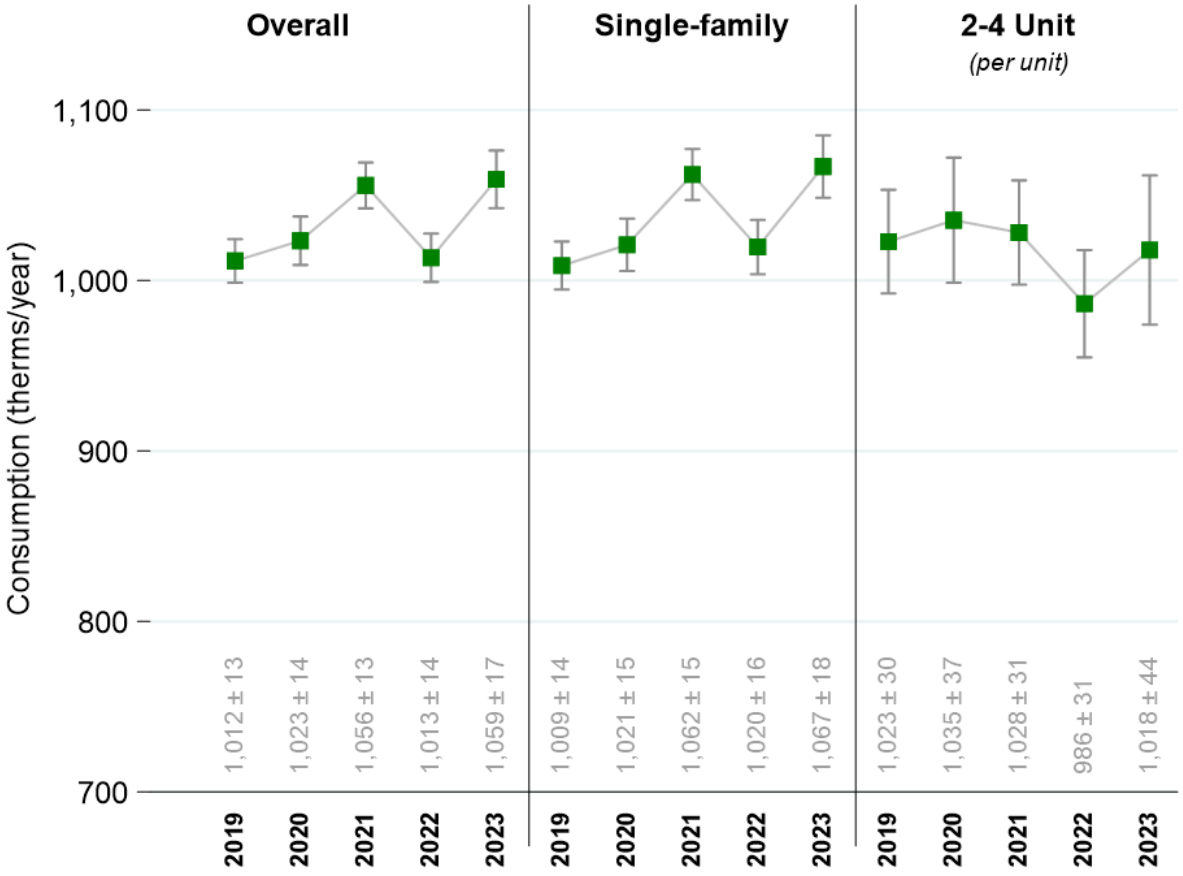
6.0 APPENDICES

6.1 PRE-WEATHERIZATION CONSUMPTION TRENDS

The following graphs present trends in natural gas and electricity consumption in context to the savings estimates presented in the report.

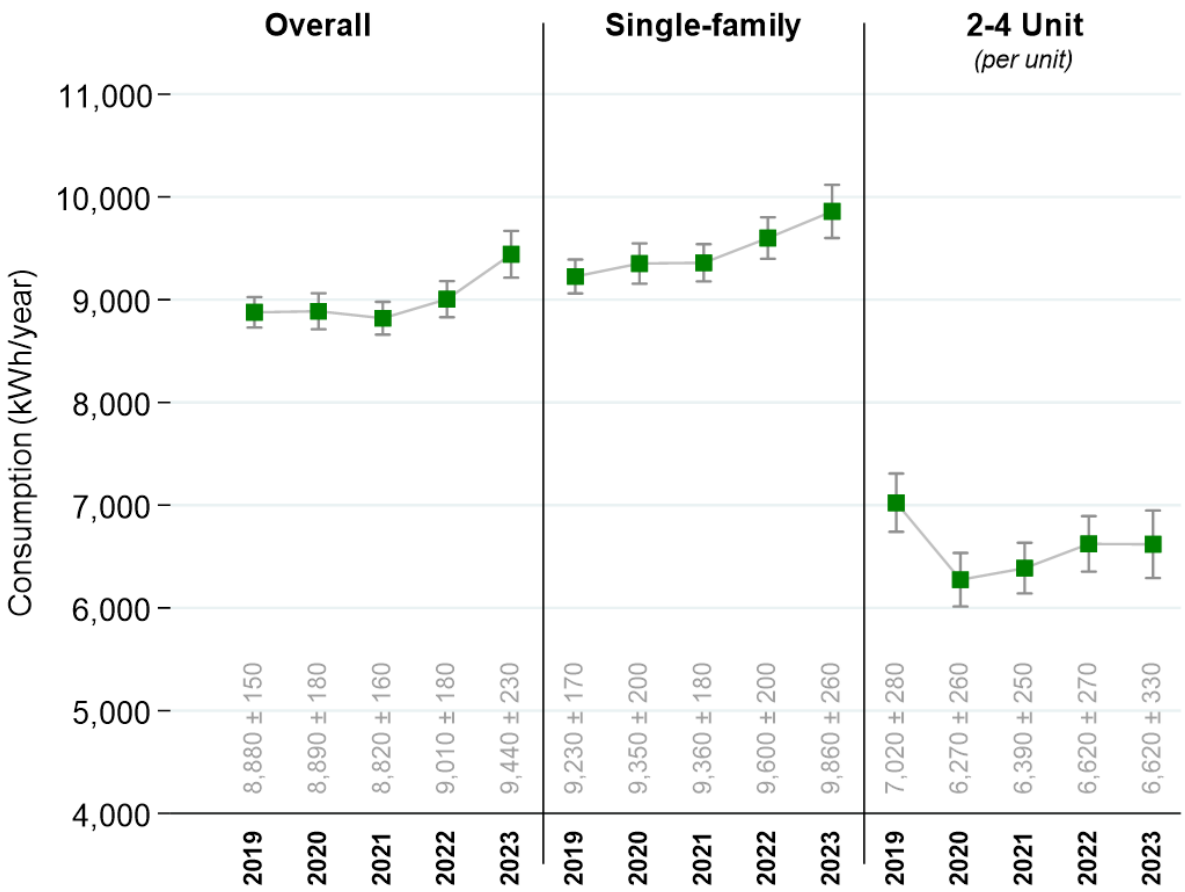
Figure 23 shows that natural gas consumption has changed within a range of approximately 50 therms from PY19 to PY23.

Figure 23-Per-home pre-weatherization natural gas consumption for program participants, 2019-2023



Compared to natural gas consumption, single-family electricity consumption has remained more consistent over the past five years though there appears to be an upward trend in consumption emerging over the past 3 program years (Figure 24). Multifamily homes experienced a notable decline in energy consumption between PY19 and PY20.

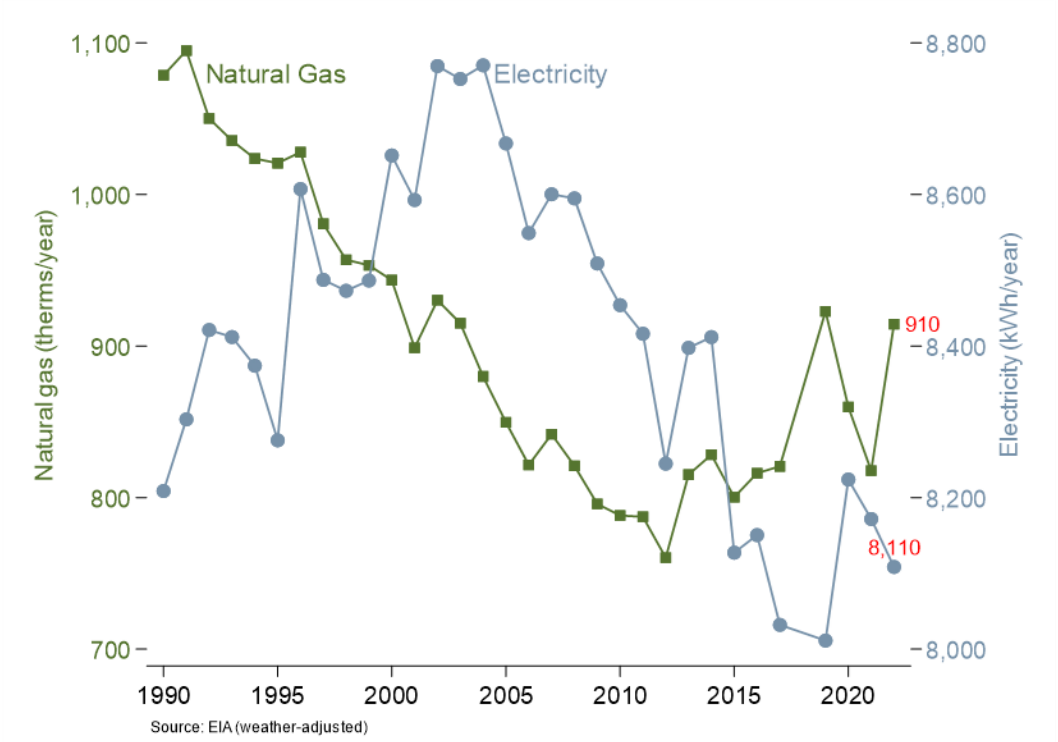
Figure 24-Per-home pre-weatherization electricity consumption for program participants, 2019-2023



As a point of comparison, Figure 25 shows long-term trends in average residential consumption of natural gas and electricity in Wisconsin, derived from aggregate sales data reported by Wisconsin utilities. The latest data available are for 2022 and are noted in red. These data cover all residential customers, not just low-income households. Also, because the aggregate data include a significant proportion of apartment dwellers, average consumption per customer tends to be lower than that of participants in the program, which is more heavily weighted toward single-family homes.

Nonetheless, statewide trends in consumption are not dissimilar from those observed for the program in recent years. In the most recent 5 years, natural gas consumption per customer has shown an increase, then a decrease, followed most recently by another increase which closely follows the trends observed for the program. Electricity consumption per customer has been on a general downward decline of about 0.5 percent per year since about 2004 with more volatile swings occurring between 2014 and 2020.

Figure 25-Statewide average natural gas and electricity consumption per residential customer



6.2 DETAILED ENERGY SAVINGS TABLES

The tables below provide more detailed statistics (and 90 percent confidence intervals) for measured savings from the program.

Table 4-Per-home natural gas savings for natural gas-heated homes in 1-4 unit buildings, by program year

Natural gas	2019	2020	2021	2022	2023
All					
Pre-weatherization annual usage (therms)	1,010 ± 10	1,020 ± 10	1,060 ± 10	1,010 ± 10	1,060 ± 20
Estimated annual savings (therms)	180 ± 10	170 ± 10	190 ± 10	180 ± 10	160
Estimated annual % savings	18 ± 1	17 ± 1	18 ± 1	18 ± 1	15
Units weatherized	3,327	2,636	3,084	2,998	2,715
Single family					
Pre-weatherization annual usage (therms)	1,010 ± 10	1,020 ± 20	1,060 ± 10	1,020 ± 20	1,070 ± 20
Estimated annual savings (therms)	160 ± 10	160 ± 10	170 ± 10	160 ± 10	150
Estimated annual % savings	16 ± 1	16 ± 1	16 ± 1	16 ± 1	14
Units weatherized	2,680	2,198	2,504	2,434	2,300
2-4 unit					
Pre-weatherization annual usage (therms)	1,020 ± 30	1,040 ± 40	1,030 ± 30	990 ± 30	1,020 ± 40
Estimated annual savings (therms)	250 ± 30	240 ± 30	260 ± 30	260 ± 40	210
Estimated annual % savings	24 ± 3	23 ± 3	25 ± 3	26 ± 4	21
Units weatherized	647	438	580	564	415

Table 5-Per-home electricity savings for non-electrically heated homes in 1-4 unit buildings, by program year

Electricity	2019	2020	2021	2022	2023
All					
Pre-weatherization annual usage (kWh)	8,880 ± 150	8,890 ± 180	8,820 ± 160	9,010 ± 180	9,440 ± 230
Estimated annual savings (kWh)	1,160 ± 100	1,110 ± 130	880 ± 120	1,030	910
Estimated annual % savings	13 ± 1	12 ± 1	10 ± 1	8 ± 2	10
Units weatherized	5,198	3,949	4,720	4,631	4,095
Single family					
Pre-weatherization annual usage (kWh)	9,230 ± 170	9,350 ± 200	9,360 ± 180	9,600 ± 200	9,860 ± 260
Estimated annual savings (kWh)	1,230 ± 120	1,270 ± 150	920 ± 130	1,130	990
Estimated annual % savings	13 ± 1	14 ± 2	10 ± 1	8 ± 2	10
Units weatherized	3,781	2,969	3,440	3,340	3,125
2-4 unit					
Pre-weatherization annual usage (kWh)	7,020 ± 280	6,270 ± 260	6,390 ± 250	6,620 ± 270	6,620 ± 330
Estimated annual savings (kWh)	750 ± 220	220 ± 230	700 ± 200	410	330
Estimated annual % savings	11 ± 3	4 ± 4	11 ± 3	9 ± 4	5
Units weatherized	1,417	980	1,280	1,291	970

6.3 WEATHER NORMALIZATION OF UTILITY BILLING DATA

To account for the influence of year-to-year weather variation on household energy use, we fit electricity and natural gas consumption models for each household. The models disaggregate pre- and post-weatherization 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 observed energy use to long-term average weather conditions.

This process is somewhat affected by seasonal variation in non-space-conditioning end uses, such as lighting and domestic hot water consumption that also vary with, but are not driven by, changes in outdoor temperature. The weather-normalization models cannot distinguish such variation from space heating, and consequently tend to somewhat overestimate heating consumption. However, since this occurs among both participants and the comparison group of untreated homes, it does not affect estimates of the savings from the program.

6.4 MEASURE-LEVEL ANALYSIS AND PROJECTED SAVINGS

Hierarchical fixed and random effects models were used to estimate the average natural gas and electric savings associated with individual measures. In each model, natural gas and electric weather-normalized annual savings for individual households were regressed against installation indicators for various measures. The model also includes interaction terms to account for variation of measure-level effects among housing types and weatherization agencies for a few key 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. In effect, estimated savings for large agencies with many homes in the analysis sample are more highly customized to that agency, while estimates for small agencies with few homes in the analysis tend to hew more closely to the statewide average for lack of better information. This enables greater specificity of measure-level savings when feasible, while still retaining estimates for agencies that have fewer data points. Finally, the model is run on a trailing three-year set of data, with allowances for year-to-year variation in savings.

While many measures are installed by the program, some are not amenable to this type of analysis because of the small impact on natural gas or electricity consumption or are installed too infrequently to be statistically discerned from the available data. In the case of heating fuel conversions from bulk fuels, no pre-weatherization usage data is available to enable modeling (the analytical approach to estimate impacts for these measures is described in the next section). Moreover, a wide variety of model specifications are possible, and different specifications can lead to a very different savings estimate for the same measure. Finally, measures are typically installed together or are associated with distinct household characteristics that can make it difficult for this type of analysis to discern individual savings effects. Thus, measure-level savings estimates should not be taken as definitive, especially for measures with smaller estimated savings.

To help guard against misleading results, the analysis was implemented only for households with reasonably reliable consumption data (based on weather-normalization-fit statistics) and was restricted to cases where annual savings were estimated to lie within 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 natural gas and electricity savings estimates. Natural gas savings were converted to gallons for homes heated with propane or fuel oil.

6.5 COST SAVINGS FROM HEATING FUEL CONVERSIONS

The natural gas and electricity savings models described above require a comparison of pre- versus post-weatherization consumption. For homes that switch their primary heating fuel from a higher cost fuel to natural gas, or in some instances to propane, pre-weatherization usage information is unavailable. To estimate the cost savings associated with heating system fuel conversions, the modeled energy cost savings associated with a natural gas furnace replacement (to account for the energy efficiency gains of a newer furnace) is combined with the calculated cost savings of using a cheaper fuel to heat the home. The latter is calculated by multiplying the price difference between the pre- and post-conversion fuels and the average annualized heating load after weatherization.

Another challenge in estimating the impacts of heating fuel switching is accurately identifying homes that received a conversion. Unlike water heater fuel switches, the Home Energy Plus (HE+) tracking database does not have a unique energy conservation measure code for recording space heating fuel conversions. (Note: a heating fuel switch repair measure exists, but it is not associated with all jobs that received a heating fuel switch and appears to be used to indicate water heater fuel switches as well.) Instead, post-weatherization heating fuel types were extracted from computerized audits and linked, where possible, to job information in the HE+ System. For the portion of jobs without a matched audit, post-weatherization fuel type was imputed to match the relative proportions within the pool of matched audits. Space heating fuel switches were then identified based on installation of a heating system replacement ***and*** non-matching pre- and post-weatherization fuel types.

6.6 NON-ENERGY BENEFITS: COST SAVINGS FROM WATER CONSERVATION

Cost savings from water conservation is estimated by applying a representative water and sewer rate to typical water savings based on assumptions about a typical household in the program. The water and sewer rates used in this analysis is the median for about 400 Wisconsin municipalities, contained in the “Residential Water Use: Cost and Savings Calculator for WI”. The volume of the reduction in water consumption per installed showerhead or faucet aerator is estimated using the following assumptions:

Showerheads	**Faucet aerators**
2.5 household members per participating home	2.5 household members per participating home
0.75 showers per person per day	14 gallons per person per day
7.5 minutes per shower	50% of fixture flow affected by replacing aerator
0.5 gallon per day reduction in shower flow rate	50% reduction in flow

6.7 LIFE-CYCLE COST SAVINGS

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

Fuel Prices. Reference fuel prices are calculated at the start of each program year using a five-year historical average for propane, fuel oil, and electricity. The reference fuel price for natural gas is a seven-year average of the previous historical five years plus two future years. The reference fuel prices used for each of the program years covered in this analysis are listed in the table below.

Table 6-Reference fuel prices

Program Year	Fuel oil (gallons)	Natural Gas (therms)	Propane (gallons)	Electricity (kWh)	Wood (MMBtu)
PY23	$2.56 ↑ 10%	$0.81 ↑ 9%	$1.79 ↑ 20%	$0.15 ↑ 7%	$11.14 0%
PY22	$2.33 ↓ 3%	$0.74 ↓ 3%	$1.49 ↓ 2%	$0.14 0%	$11.14 0%
PY21	$2.41 ↓ 7%	$0.76 ↓ 3%	$1.52 ↓ 11%	$0.14 0%	$11.14 0%
PY20	$2.59 ↓ 8%	$0.78 ↑ 1%	$1.69 ↑ 2%	$0.14 0%	$11.14 0%
PY19	$2.81 ↓ 10%	$0.77 0%	$1.65 ↓ 6%	$0.14 0%	$11.14 0%

Fuel price escalators and discount rate. Fuel prices are adjusted using a set of fuel price escalators derived from the price indices being used in audits completed during PY23. Future savings are discounted at a rate of 3 percent per year.

Measure life. Measure lives range from 10 to 30 years. Below are the values used for measures commonly installed.

Measure Type	Lifetime
Attic Insulation	30 Years
Wall Insulation	30 Years
Floor/Foundation Insulation	30 Years
Air Sealing	10 Years
Heating System Replacement	20 Years
Water Heater Replacement	15 Years
Refrigerator/Freezer Replacement	15 Years
Lighting Replacement	10 Years (average)