

# **Assessment of Energy and Cost Savings for Homes Treated Under Wisconsin's Home Energy Plus Weatherization Program 2021**

***Prepared for and funded by:***

Wisconsin Department of Administration,  
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.*

## Table of Contents

<b>Executive Summary .....</b>	<b>1</b>
Cost Effectiveness.....	2
Natural Gas Savings.....	3
Electricity Savings .....	4
<b>1.0 Introduction .....</b>	<b>5</b>
<b>2.0 Observed Energy Savings .....</b>	<b>9</b>
2.1 Natural Gas Savings.....	10
2.2 Electricity Savings.....	14
<b>3.0 Modeled Energy And Cost Savings .....</b>	<b>18</b>
3.1 Per-Home Cost Savings.....	19
3.2 Individual Measure Energy Savings And Installation Rates.....	24
3.3 Measure Contributions To Aggregate Savings .....	26
3.4 Program-Wide Energy And Cost Savings Impacts .....	27
<b>4.0 Program Cost Effectiveness.....</b>	<b>28</b>
4.1 Job-Level Costs .....	28
4.2 Overall Program Cost Effectiveness .....	29
<b>5.0 Appendices.....</b>	<b>32</b>
5.1 Pre-Weatherization Consumption Trends .....	32
5.2 Detailed Energy Savings Tables .....	35
5.3 Weather Normalization Of Utility Billing Data .....	36
5.4 Measure-Level Analysis And Projected Savings .....	37
5.5 Cost Savings From Heating Fuel Conversions.....	38
5.6 Non-Energy Benefits: Cost Savings From Water Conservation.....	39
5.7 Life-Cycle Cost Savings .....	40

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## 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 a high energy burden 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. This report provides information separated by program years, 12-month periods ending on June 30<sup>th</sup> of each year. For each program year (PY) 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 report is a summary of natural gas and electric results for 1-4 unit buildings, by housing type, for program years PY16 through PY20.

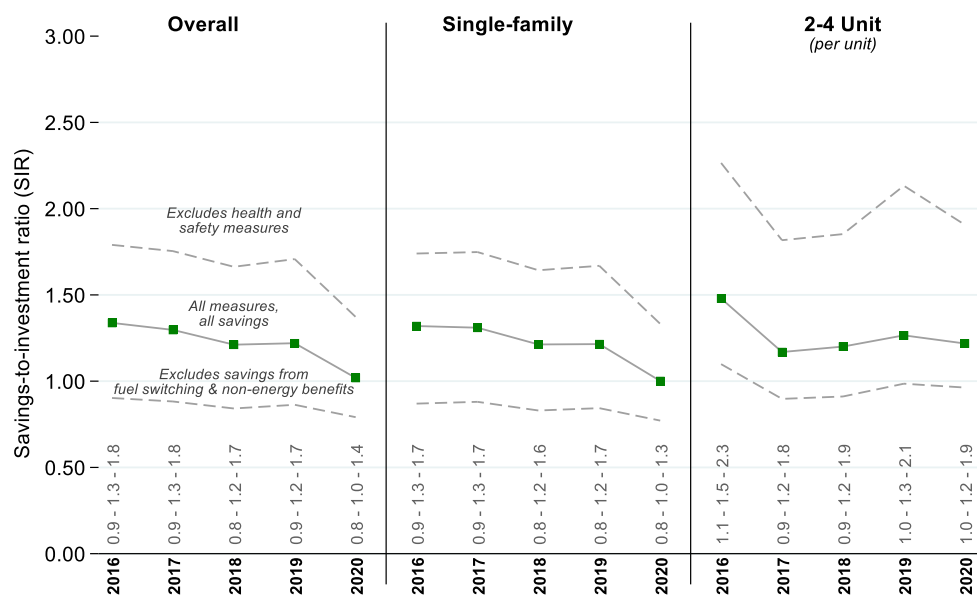
## COST EFFECTIVENESS

The weatherization services provided through Home Energy Plus in PY20 resulted in first-year cost savings of over \$1.5 million and lifetime cost savings of over \$35 million, which translates to about \$390 per home in the year following weatherization. Homes switched to natural gas for space and water heating saved roughly three times that amount. These cost savings are the result of over 630,000 therms and 4.3 million kilowatt hours (kWh) saved. Overall, these monetary savings outweigh the cost of retrofits, leading to a cost-effectiveness ratio of about 1.0 for all measures and 1.3 when excluding health and safety measures.

Figure 1 illustrates the savings-to-investment ratio (SIR) overall and across each housing type for the past 5 years.

Figure 1 illustrates that the overall SIR has stayed relatively constant across time.

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

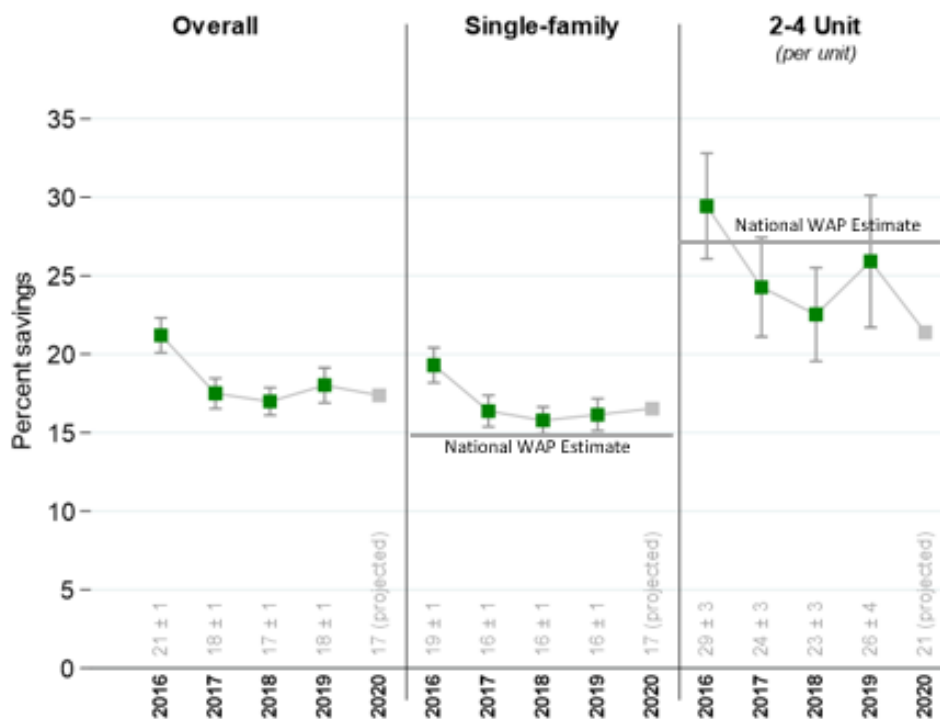


## NATURAL GAS SAVINGS

Natural gas savings from Home Energy Plus in PY20 continued to compare favorably to savings reported in the latest national WAP evaluation (2015). Natural gas savings for 1-4 unit homes are estimated at 176 therms per year (17 percent) in PY20.

Figure 2 illustrates natural gas savings over the past five years for single-family and 2-4 unit homes. The black horizontal line on the single-family and 2-4 unit panels provide a comparison to the latest national WAP evaluation conducted in 2015 and 2014 for single-family and small multifamily homes, respectively. The figure illustrates that natural gas savings are again hovering around historical levels and that the savings continue to be comparable with the results of the most recent national WAP evaluation.<sup>1</sup>

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

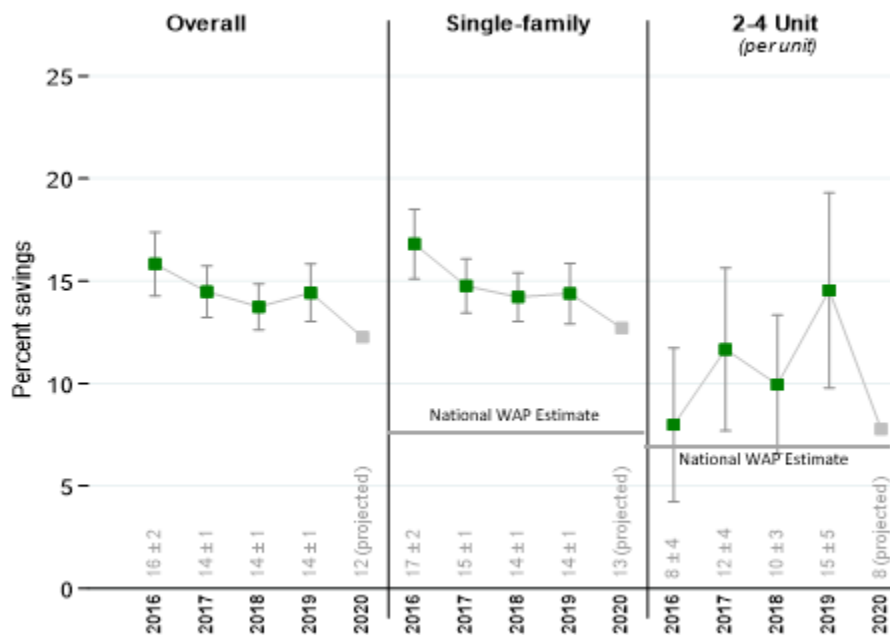


<sup>1</sup> Tonn, Bruce, Erin Rose, Richard Schmoyer, Joel Eisenberg, Mark Ternes, Martin Schweitzer, and Timothy Hendrick. *Evaluation of the National Weatherization Assistance Program during Program Years 2009-2011 (American Recovery and Reinvestment Act Period)*. No. ORNL/TM-2011/87. Oak Ridge National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

## ELECTRICITY SAVINGS

Electricity savings in PY20 are projected to be slightly lower than in the past several years. The overall savings are projected at 1,093 kWh (12 percent) in PY20. Figure 3 illustrates the electricity savings split out by housing type for the past five years. The figure includes a black horizontal line representing the national savings reported in the most recent national WAP evaluation. The savings from the Wisconsin program remain substantially higher than the national WAP average savings for single-family homes but are projected to be closer to the average for 2-4 units.

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





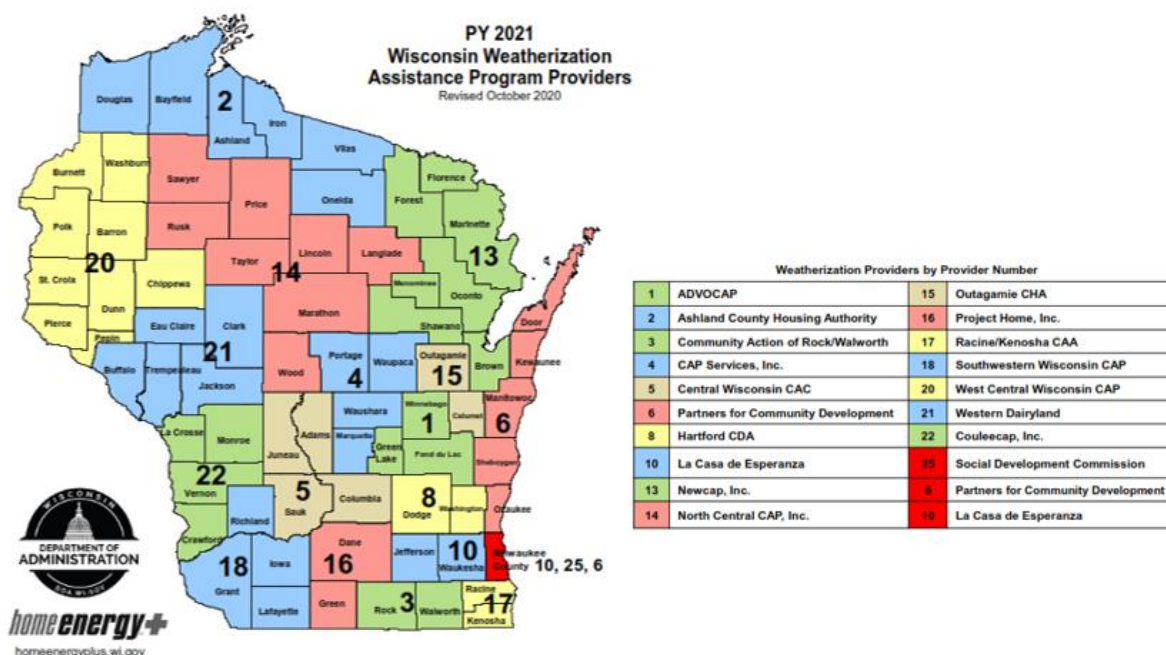
## 1.0 INTRODUCTION

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.



This report highlights findings from the last five PYs 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, and varying costs for weatherization materials and services are the primary external influences. The long-term trend toward lower natural gas prices is reflected in measure selection changes. 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 2.0** of this report presents trends in observed natural gas and electricity savings for housing units weatherized between PY16 and PY20. These savings are directly calculated from natural gas and electric utility billing data for PY16 through PY19. 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 (PY20) 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 PY20 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 3.0** focuses primarily on the evaluation of weatherization work completed between July 1, 2019, and June 30, 2020 (PY20). Details are provided for cost savings, measure savings, incidence rates and contributions to aggregate savings. **Section 4.0** shows program costs and savings-to-investment ratios. **Section 5.0** (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 PYs, single-family site-built homes have comprised between 55 and 65 percent of weatherized homes. The drop in PY20 shown here reflects program adjustments to accommodate COVID pandemic work risks and responses.

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

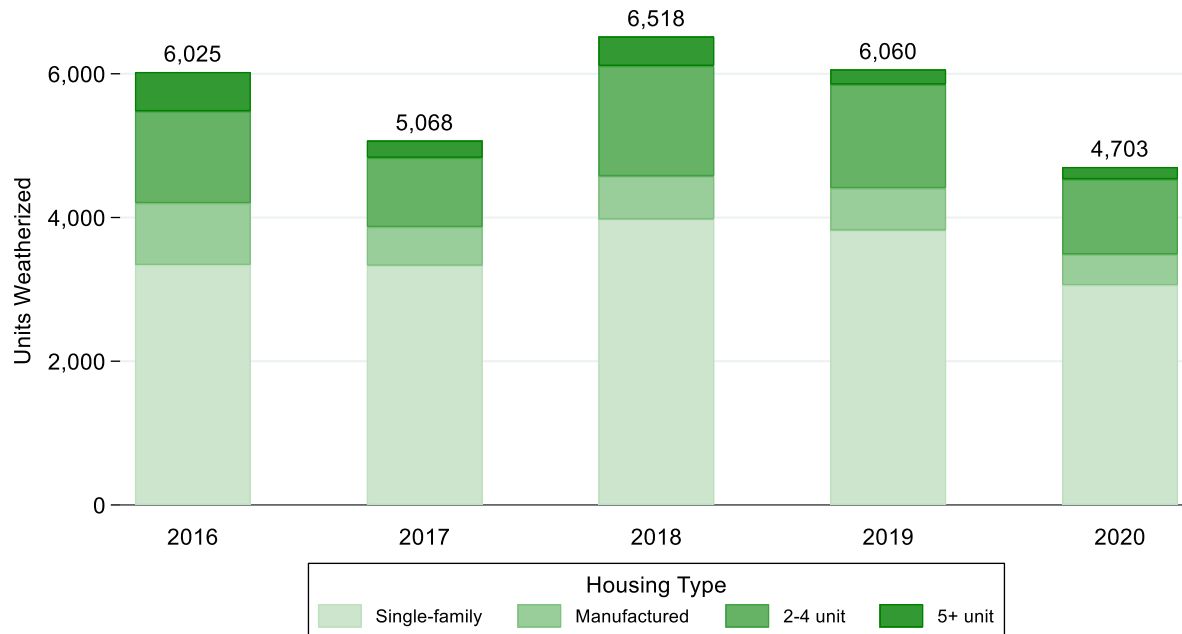
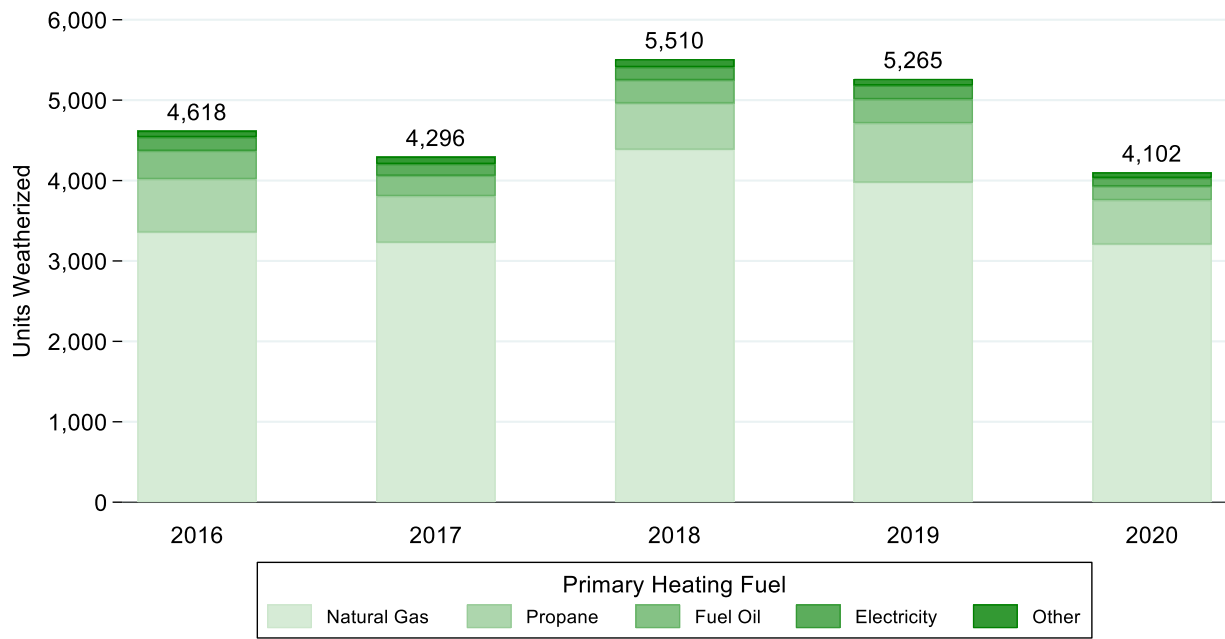


Figure 5 shows the distribution of treated homes in 1-4 unit site-built buildings across primary heating fuels. Natural gas-heated homes have traditionally comprised most of this pool. Their relative proportion has remained above 65 percent since PY16.

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



## 2.0 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. Program year 2020 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 5.3.

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 4.0**.

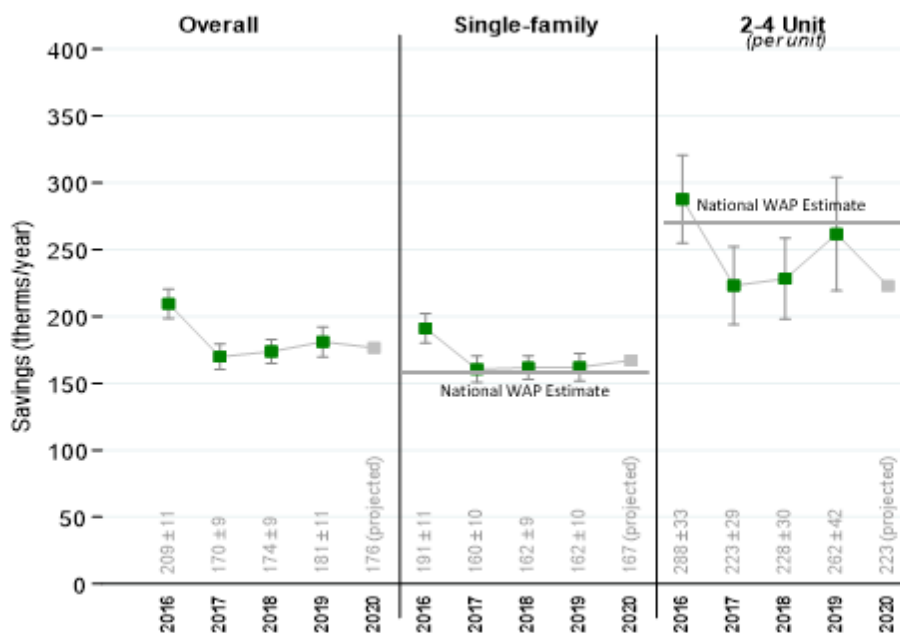
## 2.1 NATURAL GAS SAVINGS

The natural gas savings trend in single-family homes is clear and has remained stable over the past four years. Although with more statistical uncertainty due to fewer homes, 2-4 unit buildings have likely not changed significantly over the same timeframe.

Natural gas savings from PY16 to PY20 are composed of 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. The figure also includes a comparison to the latest national WAP evaluation conducted in 2015 for single family homes as a black horizontal line in the single-family pane. The last few years remain close to the savings seen in the national WAP evaluation.

For 2-4 unit homes where uncertainty is higher, the national WAP evaluation found that annual therm savings in a similar climate to Wisconsin are between 205 and 325 therms per year 90 percent of the time. Therefore, although average savings are lower than the average found in the national WAP evaluation, they fall squarely within the confidence interval of savings, which is more representative of expected savings.

**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). As the figure shows, natural gas savings for the Wisconsin program in the most recent PYs compare similarly to the U.S. average for single family homes and slightly below small multifamily homes, as reported in the national evaluation of the WAP.

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

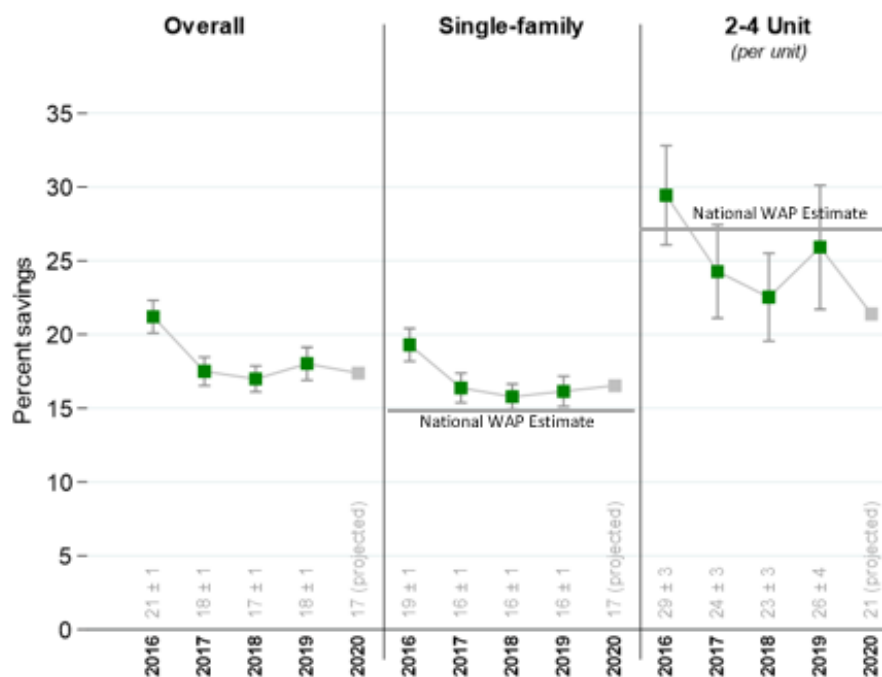
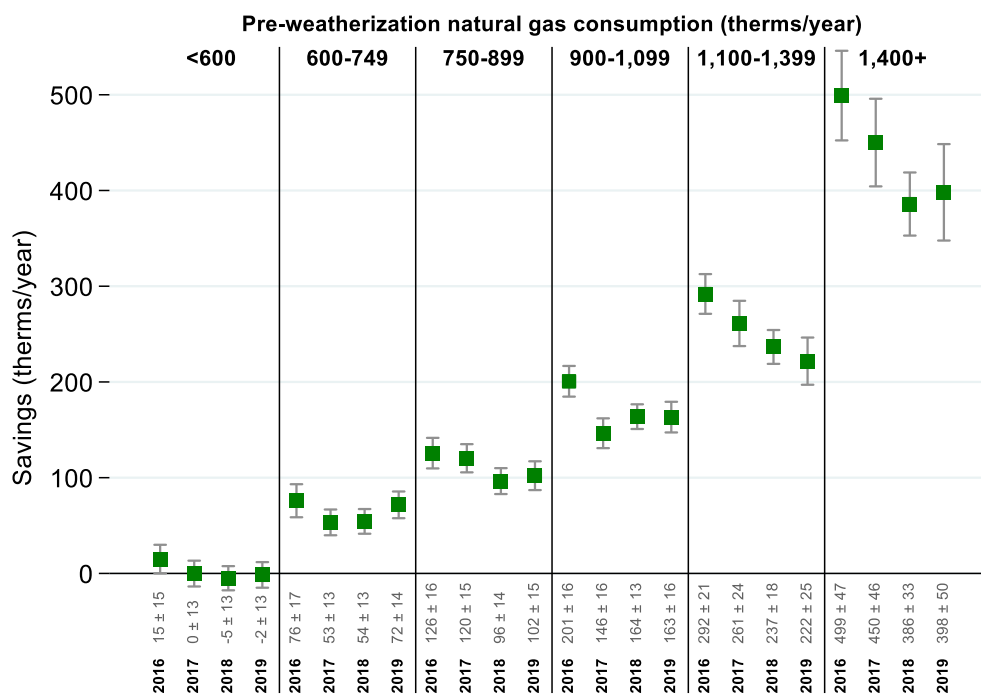


Figure 8 shows that homes using more natural gas prior to weatherization save more energy following weatherization. The highest users (1,400+ therms per year, representing about 14 percent of treated homes) yield the greatest savings, typically between 400 and 500 therms per year. Given the small number 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.

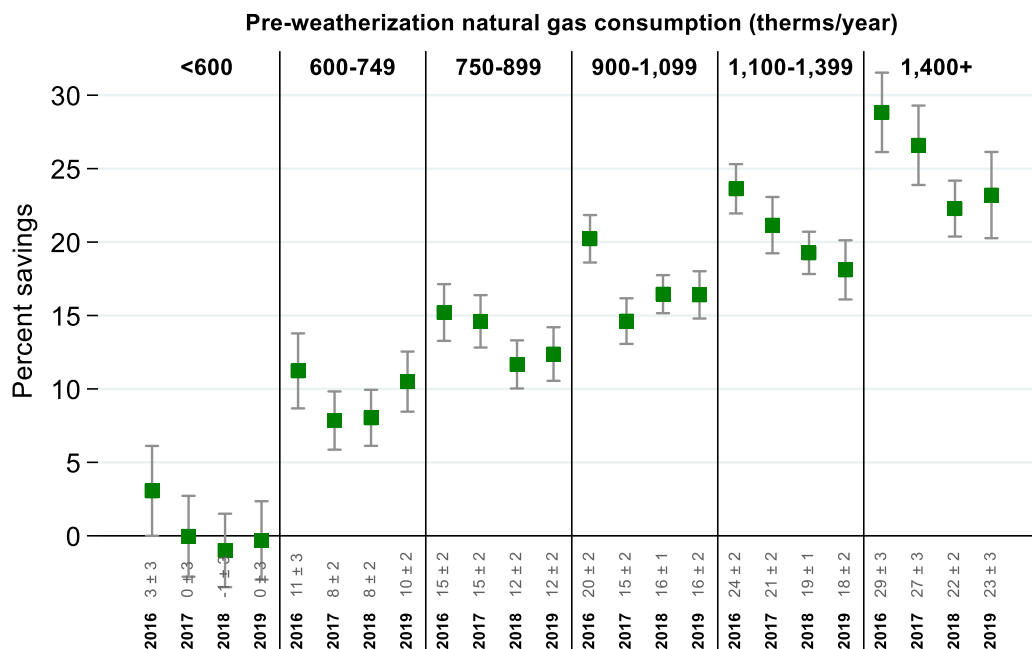
**Figure 8-Annual natural gas savings for natural gas-heated single-family homes, by pre-weatherization usage bin and program year**





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 on average of about five percentage points for every 150 to 200 therms of increased annual pre-weatherization usage. This trend persists largely because weatherization measures directly target heating-energy consumption.

**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**



## 2.2 ELECTRICITY SAVINGS

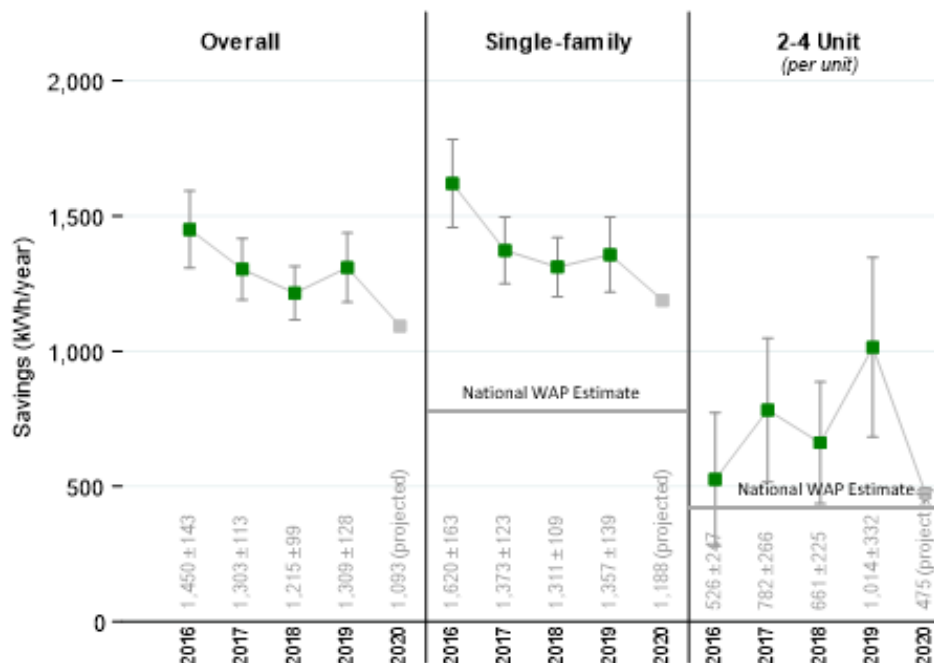
Compared to the natural gas savings figures, the confidence intervals in Figure 10 show that electricity consumption is inherently more variable than natural gas use, making savings estimates less precise. Overall, savings estimates range from about 500 to 1,500 kWh per year per housing unit—less for multifamily properties and more for single-family homes.

Average single-family electricity savings from the program dropped between PY16 and PY17, stayed relatively constant between PY17 and PY19, and experienced a decline in PY20. Small multifamily buildings show more volatility across time and a projected decline in savings in PY20.

There are a couple of trends in measure savings that help explain this decline. Notably, the incidence of water heating fuel switches declined from PY19 to PY20 by about 5 percent. This decline can primarily be linked to a decrease in the percent of total applications that come from homes that have electric water heating, which decreased 7 percent between PY19 and PY20. Additionally, we see a gradual decline in savings per installation for both air sealing and water heating fuel switches from PY16 to PY20, contributing to declines in overall savings per home.

Lastly, it is important to note that PY20 savings are only predictions, and that the Wisconsin program still saves close to double that of the national average for single family as well as more than the national average multifamily home in similar climates.

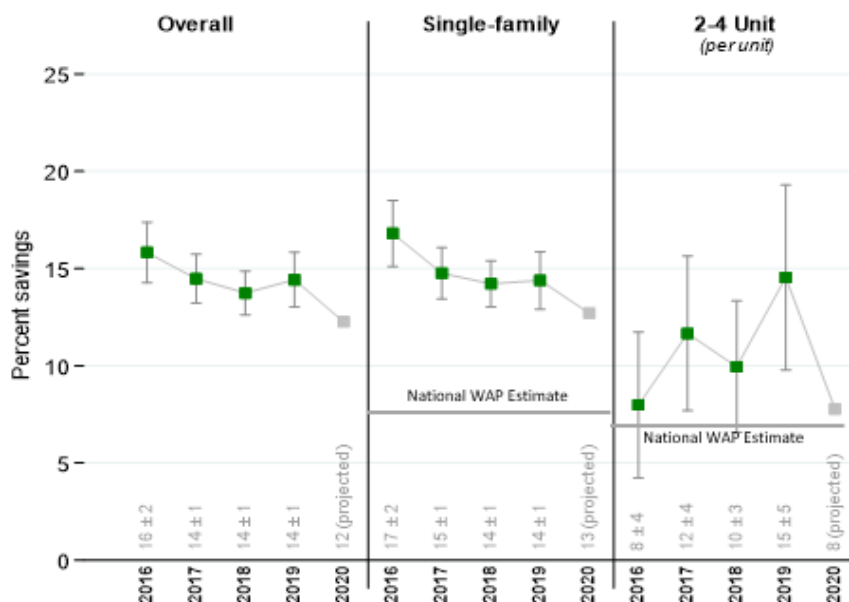
Figure 10-Annual electricity savings for homes without electric heat, by housing type and program year



Savings trends are similar for savings expressed as a percentage of pre-weatherization consumption (

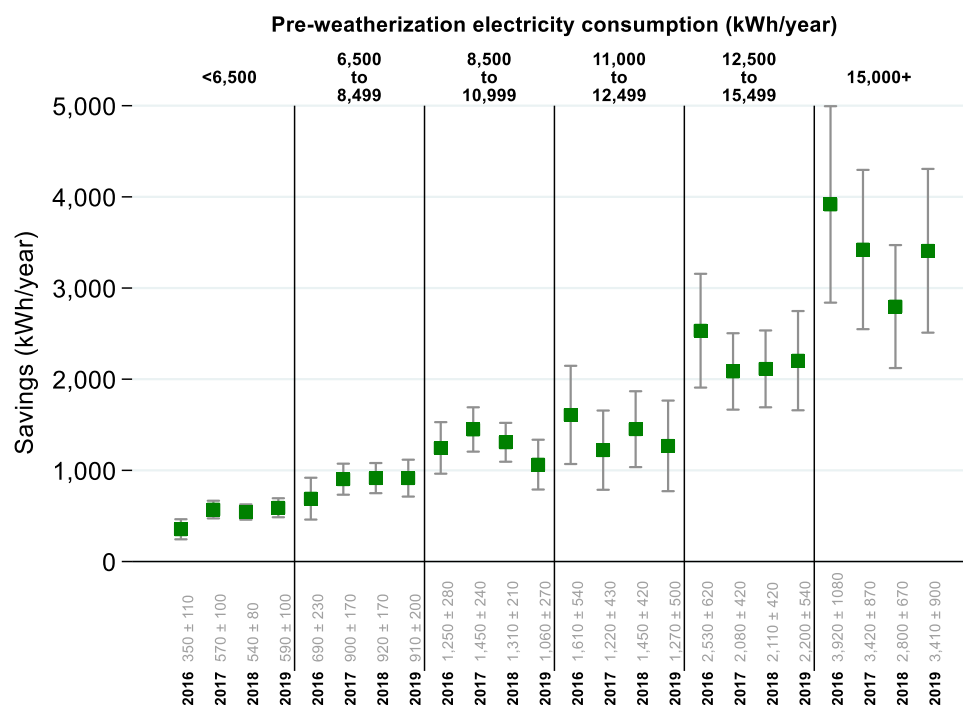
Figure 11). From PY16 to PY20, electricity savings for the Wisconsin program exceeded the percent savings documented in the 2015 national evaluation of the WAP, which found about eight percent electric savings for single family homes (with natural gas heat) and 7 percent small multifamily homes in very cold climates like Wisconsin's.

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



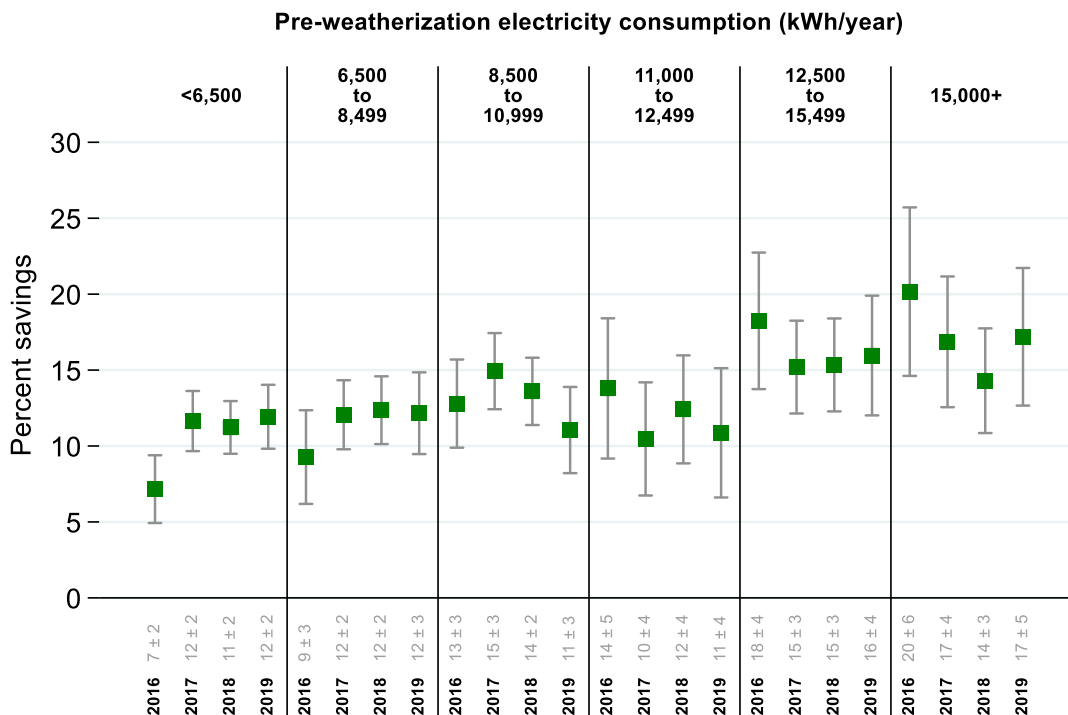
Like natural gas, higher users of electricity tend to save more following weatherization (Figure 12), though the trend is not as dramatic.

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



The correlation between electricity savings as a percent of pre-weatherization usage levels is not as clear as for natural gas (Figure 13). 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 use. Still, treated homes typically see savings of between 11 and 17 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**



### **3.0 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.

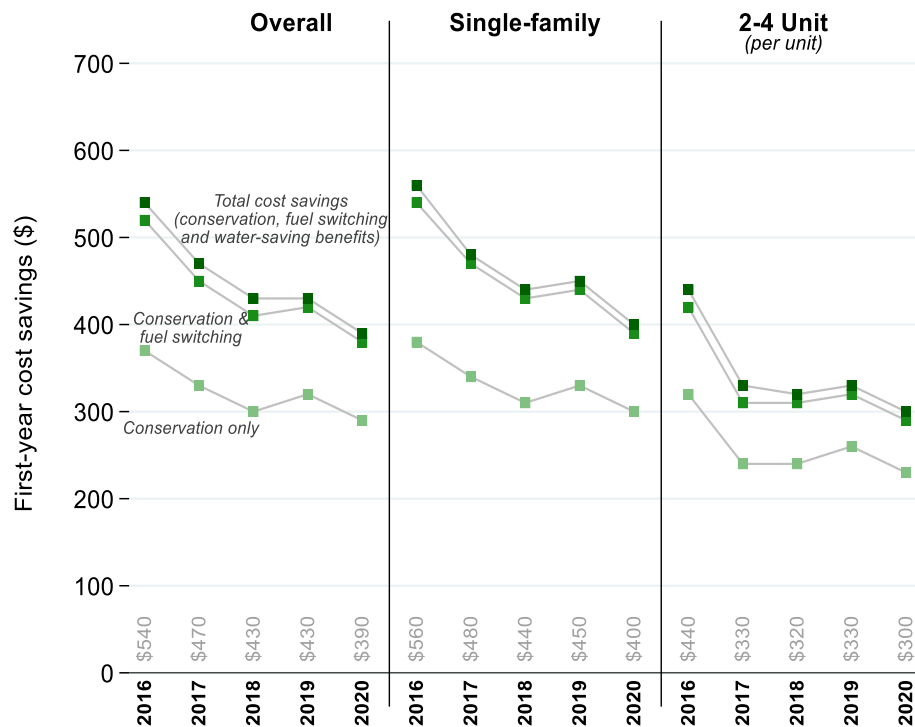
Estimating cost savings attributable to Wisconsin's program is a key element of this evaluation for determining the program's cost-effectiveness. This section measures cost-savings at three levels: (1) through the savings attributable simply to consuming less energy following weatherization (conservation 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 5.4.

### 3.1 PER-HOME COST SAVINGS

Overall, participating households from PY20 are projected to save an average of \$390 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.

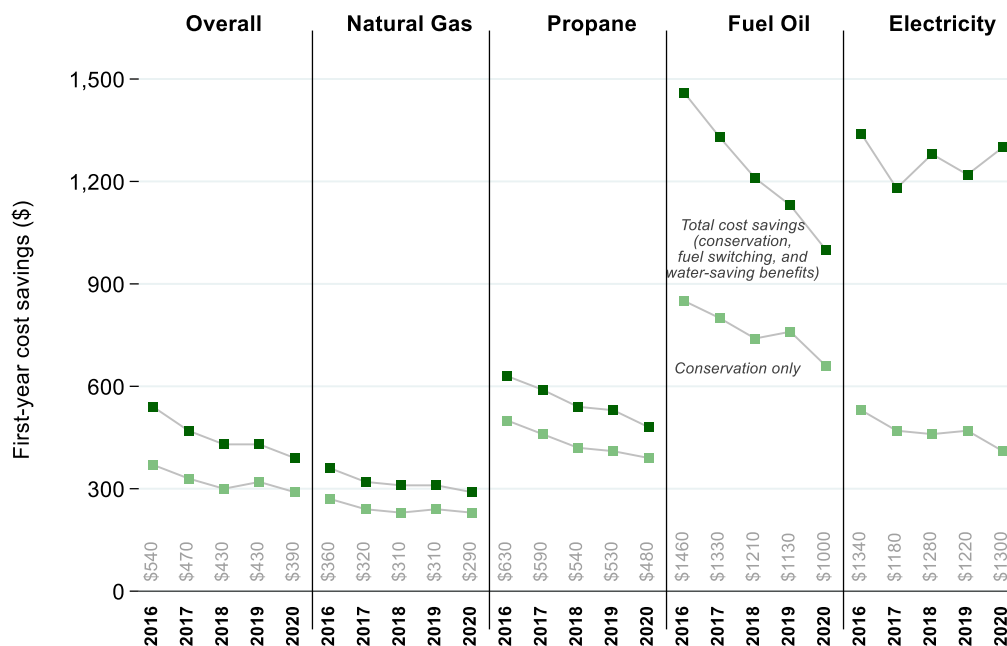
Savings from energy reduction measures account for about 70 percent of total cost savings. As the figure shows, the inclusion of fuel switching greatly increases the average per home cost savings. These savings have been gradually declining over the past five program years with slight variation across housing types. We attribute the decline in cost savings from PY19 to PY20 to decreasing fuel oil prices, decreasing savings resulting from fuel switching measures. Subsequent figures and discussion disaggregate those effects.

**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 heating with fuel oil or electricity experience large cost savings but represent a small but impactful subset of the program. Fuel oil-heated homes make up around 4 percent of annual program participation and electric-heated homes account for about 3 percent.

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

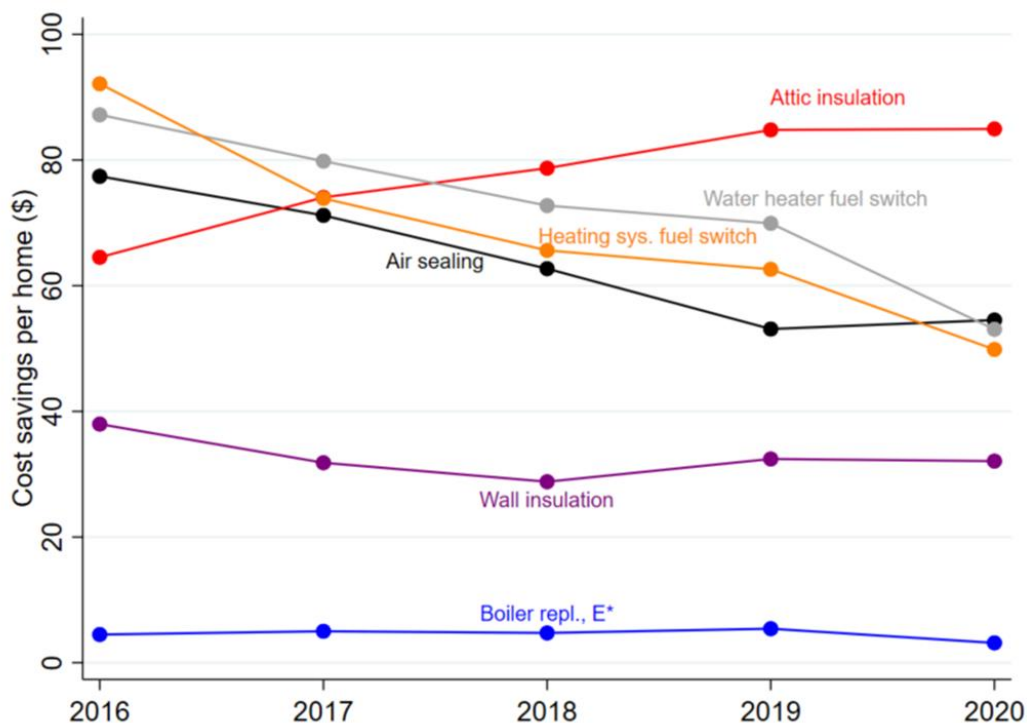


Both Figure 14 and Figure 15 show a steady decline in cost savings across time. The most noticeable decline is for fuel oil when fuel switching is included. As Figure 15 shows, fuel switching from expensive heating fuels like electricity and fuel oil to natural gas produces significant energy-cost savings in addition to the savings gleaned from efficiency improvements. However, the price of fuel oil has been declining (see Appendix Table 6) thus reducing this energy-cost savings. In addition to the fuel oil price decline, we also see declines in propane prices over the same time period, explaining that slight decline in savings.



Figure 16 shows a complete picture of the multiple factors influencing the decline in cost savings per home. It illustrates the cost savings per home, factoring in both the incidence rate and the expected savings per installation. Figure 16 illustrates a steady drop in air sealing cost savings per home as well as fuel-switch savings per home. The primary reason for the observed decrease in cost savings per home are measure incidence rate changes and energy cost changes. Water-heating fuel switches and heating-system fuel switches both experienced a decline due to lower fuel oil costs over time (see Appendix). Water-heating fuel switches also have experienced a decline in incidence over this time period. A secondary reason for the decreases is a decline in electricity savings per installation for air sealing and water-heating fuel switches over the past five years.

**Figure 16-Aggregate average cost savings per home for important measures**



To investigate the impact of fuel switches in more depth, Figure 17 plots the predicted first-year cost savings for each home weatherized in PY20 compared to PY19 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 \$260 during the first year following weatherization. By contrast, homes receiving a heating fuel-switch measure are, on average, expected to save between \$930 and \$1,200.

**Figure 17-First-year cost savings for individual homes treated in PY19 and PY20 as a result of fuel switching**

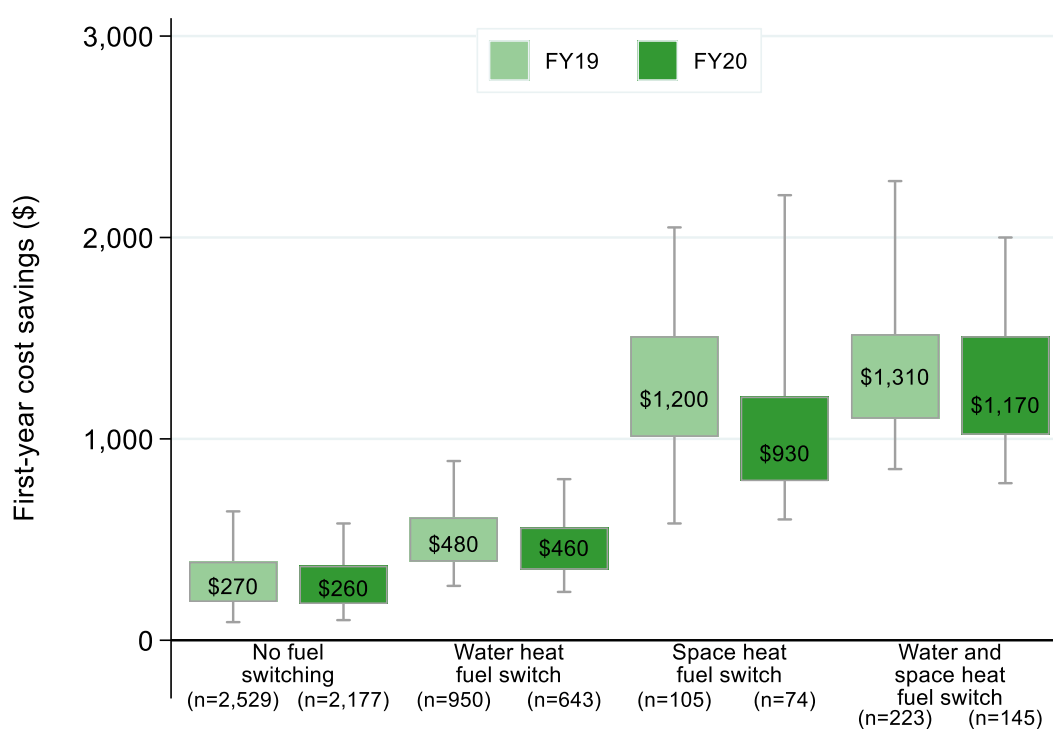


Table 1 presents average, per-home cost savings expected during the initial year after weatherization for more specific subgroups: by housing type, heating fuel, and if a heating fuel conversion measure was installed. A similar table showing projected cumulative savings over the useful life of installed measures is included in the appendices (Appendix 5.2). Notably, about 72 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 of both home types 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 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 PY20, by housing type and fuel type**

Housing type & primary heating fuel	Units with no fuel switching			Units with a <u>water</u> heating fuel switch		Units with a <u>space</u> heating fuel switch	
	Treated units	% of units	First-year savings	% of units	First-year savings	% of units	First-year savings
<b>Single Family</b>	3057	71%	\$290	21%	\$480	8%	\$1210
Natural Gas	2217	78%	\$260	22%	\$450		
Propane	543	69%	\$410	26%	\$580	5%	\$920
Fuel Oil	160	18%	\$420	3%	\$510	80%	\$1130
Other	69	42%	\$520	4%	\$630	54%	\$1100
Electricity	68	29%	\$400	3%	\$560	68%	\$1690
<b>2-4 Unit</b>	1045	88%	\$240	9%	\$350	3%	\$1950
Natural Gas	990	91%	\$240	9%	\$340		
Electricity	37	51%	\$280	5%	\$330	43%	\$2450
Fuel Oil	12					100%	\$1300
Propane	6	33%	\$520	67%	\$500		

### 3.2 INDIVIDUAL MEASURE ENERGY SAVINGS AND INSTALLATION RATES

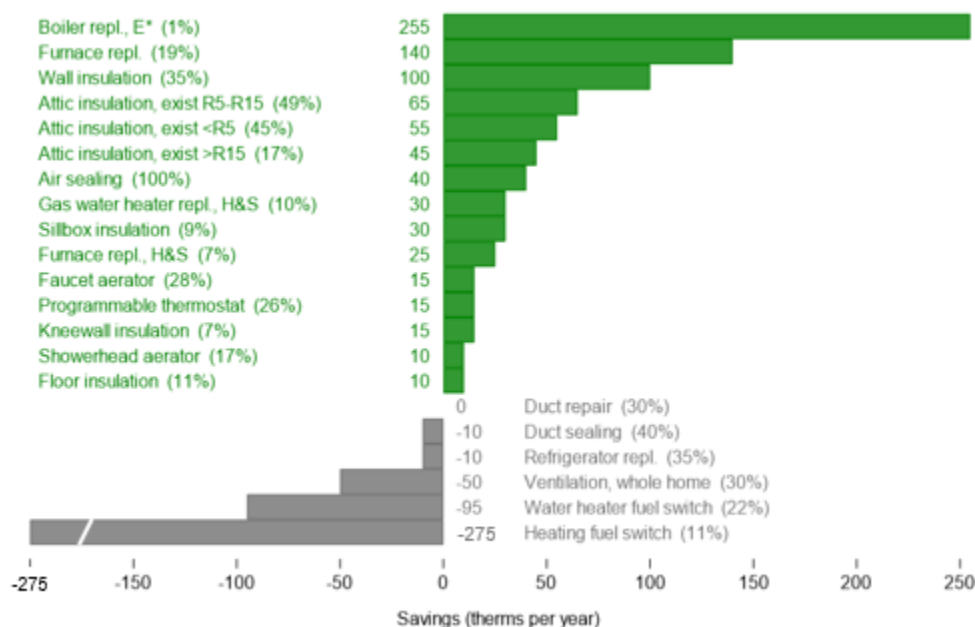
As mentioned previously, a statistical model estimates average natural gas and electricity savings for individual measures. Figure 18 presents savings and measure installation rates for single-family homes, since they make up the largest portion of treated site-built homes. The figures only include measures 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 one percent of homes in PY20. Furnace replacements produce the next highest savings and occur in 19 percent of homes in PY20. Air sealing, while not a large energy saver (40 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 18 as a truncated bar on the bottom of the graph because it *adds* an average of 275 therms to a home's annual natural gas load. Mechanical exhaust ventilation also carries a natural gas penalty by influencing heating loads via increased airflow exchange.

Of the other measures listed in Figure 18, duct sealing, and refrigerator replacements also have negative savings. Duct sealing does not have a large effect on savings. 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.

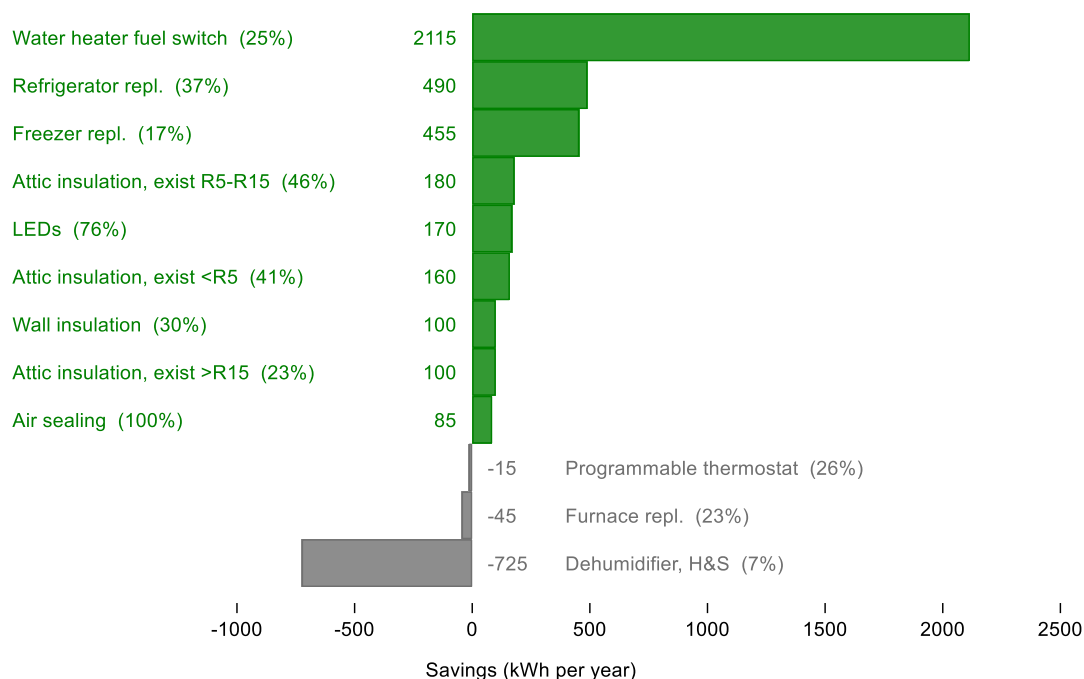
**Figure 18-PY20 annual natural gas savings per measure, when measures installed in single-family site-built homes (measure incidence rate in parentheses)**



Most electrical savings derive from electric-to-natural gas primary space heating system conversions. In PY20, two percent of homes converted an electric heating system to natural gas, so it is not shown in Figure 19. The savings associated with this measure was about 10,160 kWh, which is over four 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 PY20, 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. Furnace replacements and programmable thermostats are also associated with a small amount of negative savings and have historically varied between slightly positive and negative savings. These are unlikely to have a significant effect on electricity savings.

**Figure 19-PY20 annual electric savings per measure, when installed in single-family site-built homes (measure incidence rate in parentheses)**

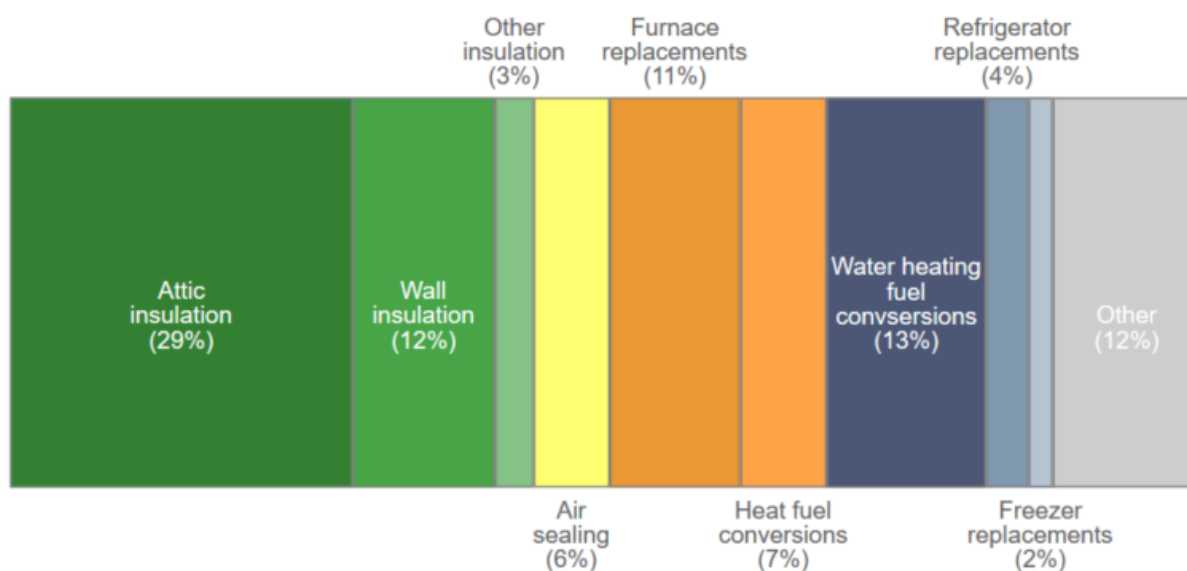


### 3.3 MEASURE CONTRIBUTIONS TO AGGREGATE SAVINGS

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

Figure 20. Just under 80 percent of energy cost savings for each year are from fuel switching (20 percent), attic and wall insulation measures (29 and 12 percent), heating system replacements (11 percent), and air sealing (seven percent). Measures with smaller contributions to overall cost savings are bundled together in “Other” and cumulatively account for two 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 20-PY20 measure contributions to life-cycle cost savings when installed in single-family site-built homes**



### 3.4 PROGRAM-WIDE ENERGY AND COST SAVINGS IMPACTS

For single-family and small multifamily units treated in PY20, the statewide program saved participating households around a total of \$1.5 million during the first year after weatherization. Over the life of the installed measures, the program is projected to yield a total of \$36 million in energy cost savings for those homes.

Aggregate cost and energy savings are lower for PY20 compared to the past few program years. There were far fewer homes treated in PY20 due to COVID affecting half of the program year, which explains much of the decline in aggregate savings.

**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)
PY16	4,618	819,000	137,000	78,000	6,530,000	\$1,668,000	\$636,000	\$85,000	\$2,389,000	\$51,032,000
PY17	4,296	658,000	114,000	57,000	5,719,000	\$1,344,000	\$500,000	\$69,000	\$1,913,000	\$42,783,000
PY18	5,510	883,000	115,000	66,000	6,724,000	\$1,582,000	\$578,000	\$79,000	\$2,240,000	\$50,291,000
PY19	5,265	818,000	135,000	76,000	6,662,000	\$1,622,000	\$513,000	\$70,000	\$2,205,000	\$51,850,000
PY20	4,102	639,000	107,000	40,000	4,328,000	\$1,155,000	\$325,000	\$51,000	\$1,531,000	\$35,687,000

## 4.0 PROGRAM COST EFFECTIVENESS

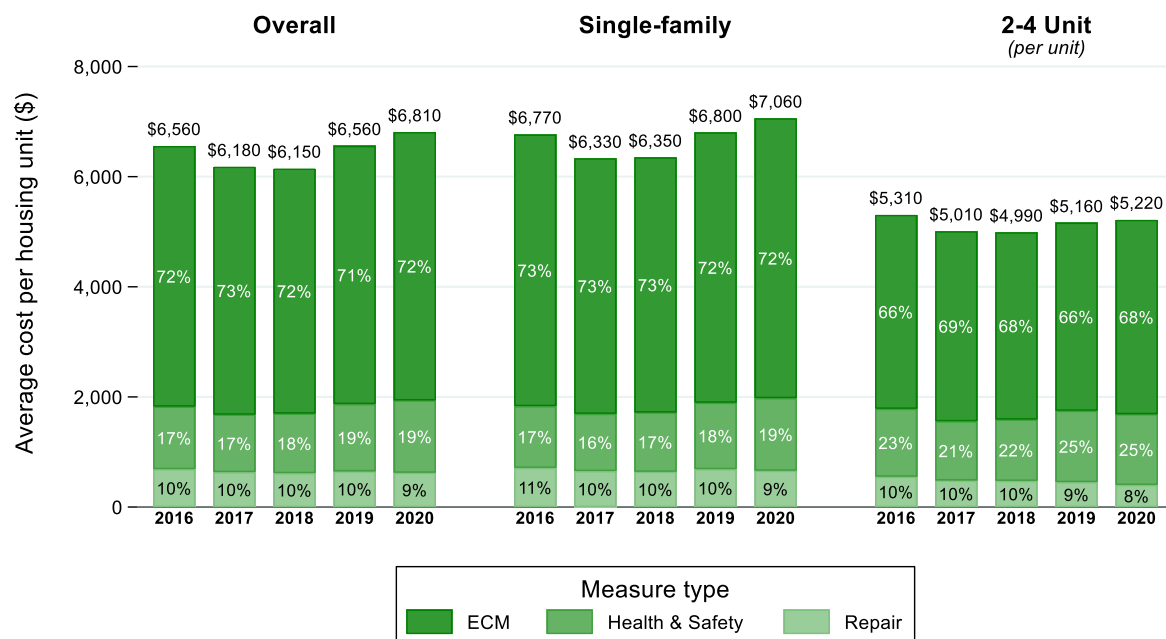
This section brings together information about program costs and projected savings. Job-level costs broken out by measure type (energy conservation, health and safety, or repair) are presented first, followed by an analysis of program-wide cost effectiveness.

### 4.1 JOB-LEVEL COSTS

Overall, the average cost of weatherizing a housing unit has shown increases year-over-year between PY18 and PY20. Disaggregating average cost per housing unit (Figure 21) 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.

In PY20, the cost for single-family homes averaged just above \$6,800. The cost for homes in 2-4 unit buildings averaged just above \$5,200 per housing unit. Throughout the program, spending is dominated by energy conservation measures (ECMs) at about \$5,000 per single-family home and \$3,500 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 about \$1,900 per home.

Figure 21-Job costs per housing unit, by housing type, measure type, and program year





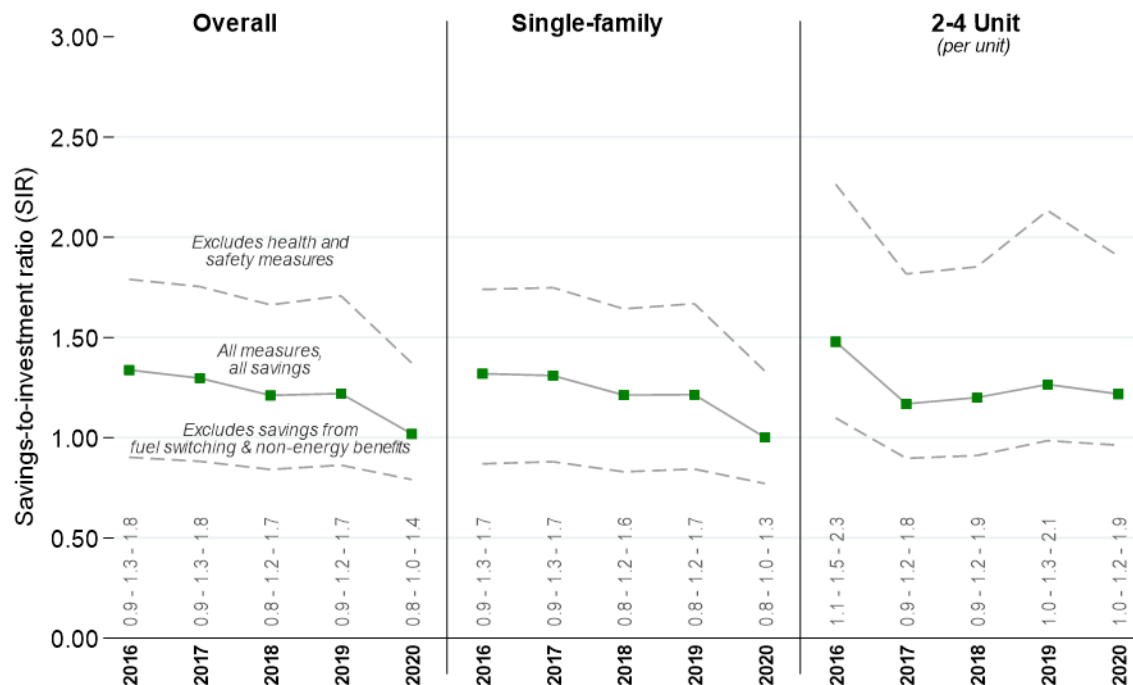
## 4.2 OVERALL PROGRAM COST EFFECTIVENESS

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 (with green squares) 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 22 shows program-wide SIRs broken out by housing type and program year. Overall, average SIRs are at or above the key threshold of 1.0 and reflect the impact of cost savings associated with space and water heating fuel switching. Without savings from fuel switching, average SIRs for single-family homes hover around 1.0, but are slightly higher for units in small multifamily buildings. Excluding health and safety measures increases average SIRs by about 0.5. The slight decline in PY20 can be explained by the drop in average cost savings as well as the slight increase in job costs.

Figure 22-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 23). 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. The source of these differences owes to the higher cost per unit of delivered energy for fuel oil and electricity.

**Figure 23-Program-wide SIRs, by heating fuel type and program year**

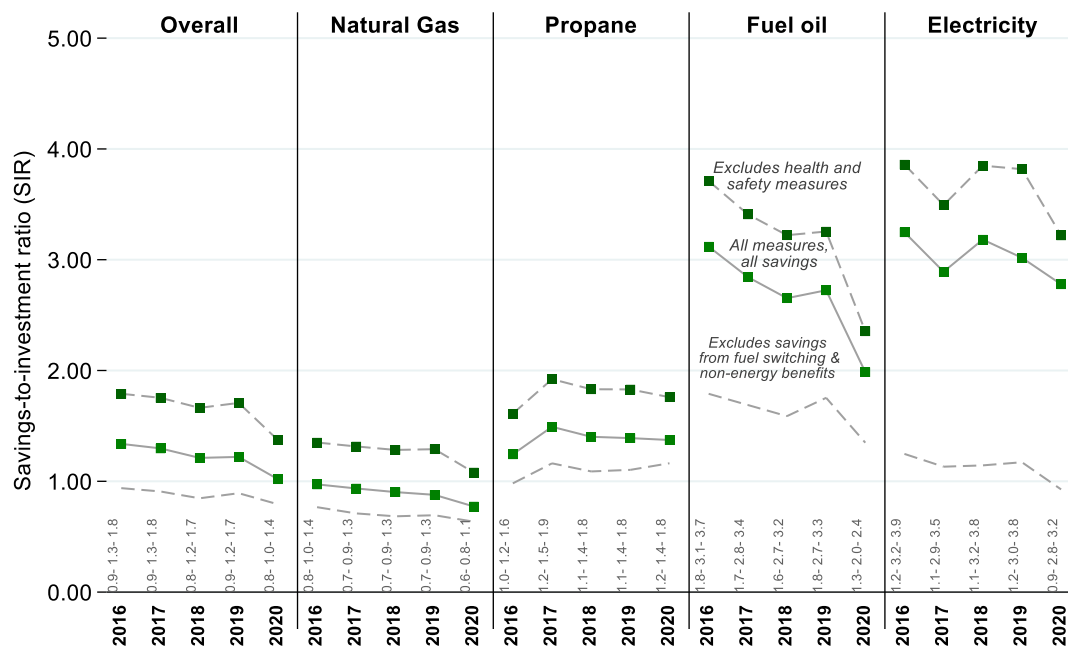


Table 3 further breaks out estimated PY20 SIRs and job costs by housing type and heating fuel. For both years, across housing types, SIRs are highest for homes heated with fuel oil or electricity, and average job cost is higher for single-family homes.

**Table 3-Average SIRs and job costs for homes treated during PY20, by housing type and heating fuel**

<b>Housing Type &amp; Primary Heat Fuel</b>	Includes health and safety measures			Excludes health and safety measures	
	<b>SIR (using energy cons. cost savings only)</b>	<b>SIR (using total cost savings)</b>	<b>Average job cost</b>	<b>SIR (using total cost savings)</b>	<b>Average job cost</b>
<b>Single family</b>	0.78	1.00	\$7,015	1.33	\$5,380
Fuel oil	1.34	1.94	\$9,155	2.29	\$7,874
Natural gas	0.60	0.75	\$6,810	1.03	\$5,053
Propane	1.16	1.37	\$6,839	1.75	\$5,450
Electricity	0.87	2.41	\$8,304	2.75	\$7,293
Other	1.39	1.52	\$8,789	1.78	\$7,666
<b>2-4 unit</b>	0.97	1.22	\$4,055	1.91	\$2,602
Fuel oil	1.90	4.07	\$5,808	6.15	\$3,555
Natural gas	0.92	1.00	\$4,052	1.57	\$2,583
Propane	2.10	2.24	\$4,528	3.44	\$3,082
Electricity	1.55	6.56	\$3,402	8.67	\$2,692

\*Note the small discrepancy between average job cost in Figure 21. Those averages are calculated by measure types, while these are not.

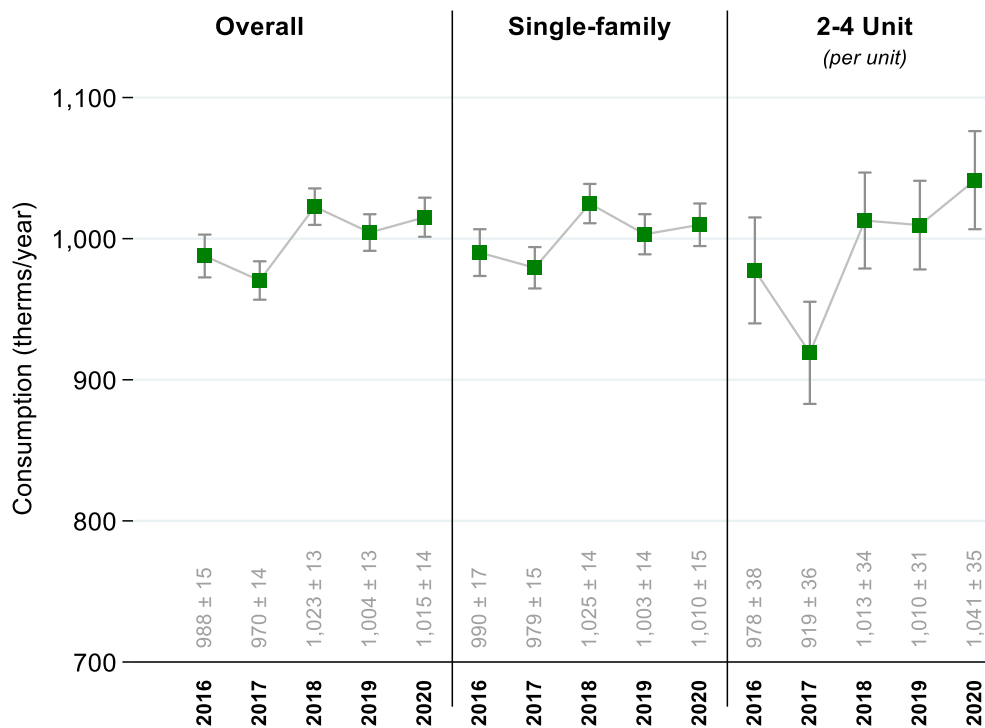
## 5.0 APPENDICES

### 5.1 PRE-WEATHERIZATION CONSUMPTION TRENDS

Given the correlation between consumption and savings (i.e., higher users tend to save more energy after weatherization), the following graphs present trends in natural gas and electricity consumption in context to the savings estimates presented in the report.

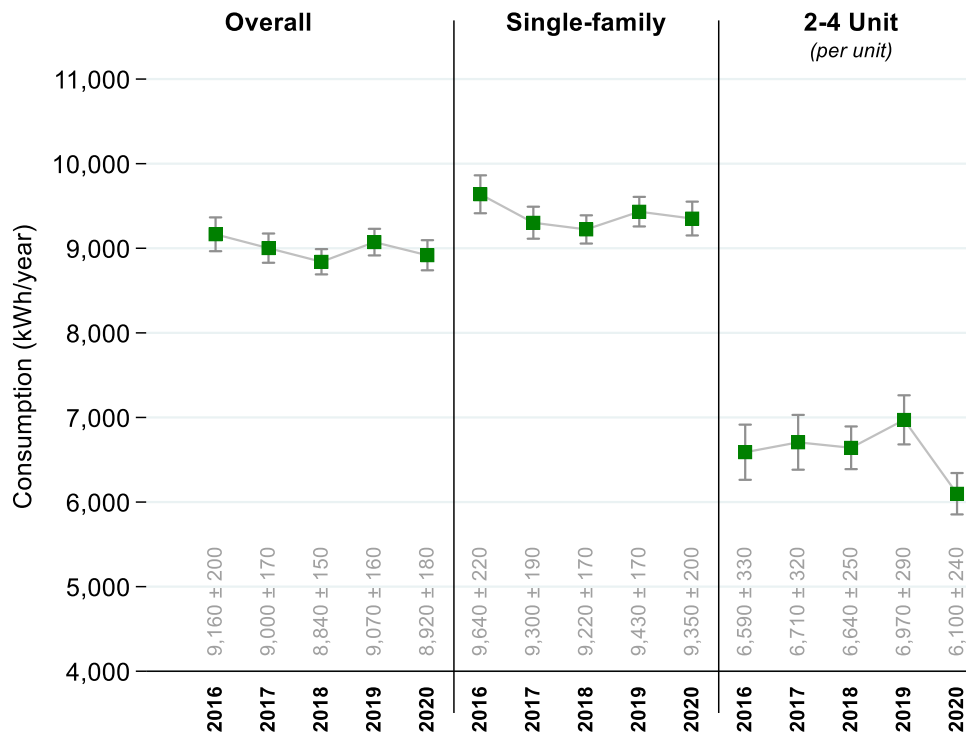
Figure 24 shows single family natural gas consumption has been relatively constant from PY16 to PY20. However, average natural gas use among small multifamily homes has been more variable – showing a decline from PY16 to PY17 before increasing back up in PY18-PY20. This variability is to be expected given the small number of multifamily homes treated.

**Figure 24-Per-home pre-weatherization natural gas consumption for program participants, 2016-2020**



Single-family electricity consumption has remained relatively consistent over the past five years for homes in the program (Figure 25). There is more variation for small multifamily buildings, with PY20 projected to show a notable drop.

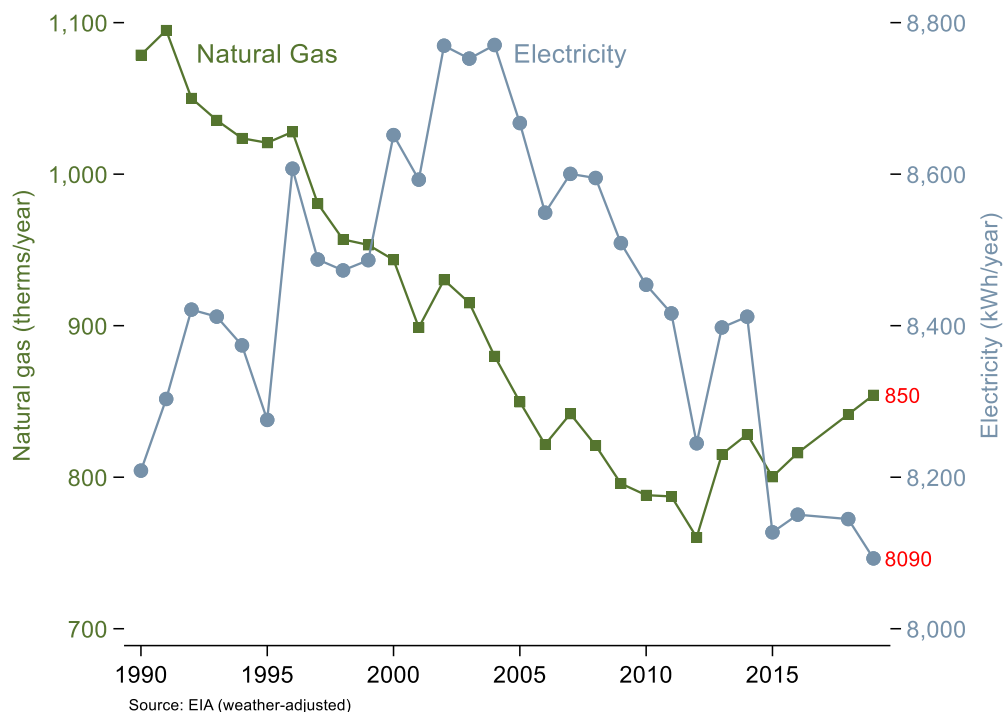
**Figure 25-Per-home pre-weatherization electricity consumption for program participants, 2016-2020**



As a point of comparison, Figure 26 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 2019 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. After declining one to two percent per year, natural gas consumption per customer has shown a recent uptick. Electricity consumption per customer has been on a general downward decline of about 0.5 percent per year since about 2004.

**Figure 26-Statewide average natural gas and electricity consumption per residential customer**



## 5.2 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	2016	2017	2018	2019	2020
<b>All</b>					
Pre-weatherization annual usage (therms)	990 ± 20	970 ± 10	1,020 ± 10	1,000 ± 10	1,020 ± 10
Estimated annual savings (therms)	210 ± 10	170 ± 10	170 ± 10	180 ± 10	180
Estimated annual % savings	21 ± 1	18 ± 1	17 ± 1	18 ± 1	17
Units weatherized	2689	2724	3585	3260	2668
<b>Single family</b>					
Pre-weatherization annual usage (therms)	990 ± 20	980 ± 10	1,020 ± 10	1,000 ± 10	1,010 ± 20
Estimated annual savings (therms)	190 ± 10	160 ± 10	160 ± 10	160 ± 10	170
Estimated annual % savings	19 ± 1	16 ± 1	16 ± 1	16 ± 1	17
Units weatherized	2177	2317	2936	2637	2217
<b>2-4 unit</b>					
Pre-weatherization annual usage (therms)	980 ± 40	920 ± 40	1,010 ± 30	1,010 ± 30	1,040 ± 30
Estimated annual savings (therms)	290 ± 30	220 ± 30	230 ± 30	260 ± 40	220
Estimated annual % savings	29 ± 3	24 ± 3	23 ± 3	26 ± 4	21
Units weatherized	512	407	649	623	451

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

Electricity	2016	2017	2018	2019	2020
<b>All</b>					
Pre-weatherization annual usage (kWh)	9,160 ± 200	9,000 ± 170	8,840 ± 150	9,070 ± 160	8,920 ± 180
Estimated annual savings (kWh)	1,450 ± 140	1,300 ± 110	1,210 ± 100	1,310 ± 130	1,080
Estimated annual % savings	16 ± 2	14 ± 1	14 ± 1	14 ± 1	12
Units weatherized	4447	4150	5348	5093	3997
<b>Single family</b>					
Pre-weatherization annual usage (kWh)	9,640 ± 220	9,300 ± 190	9,220 ± 170	9,430 ± 170	9,350 ± 200
Estimated annual savings (kWh)	1,620 ± 160	1,370 ± 120	1,310 ± 110	1,360 ± 140	1,170
Estimated annual % savings	17 ± 2	15 ± 1	14 ± 1	14 ± 1	13
Units weatherized	3230	3217	3870	3728	2989
<b>2-4 unit</b>					
Pre-weatherization annual usage (kWh)	6,590 ± 330	6,710 ± 320	6,640 ± 250	6,970 ± 290	6,100 ± 240
Estimated annual savings (kWh)	530 ± 250	780 ± 270	660 ± 220	1,010 ± 330	470
Estimated annual % savings	8 ± 4	12 ± 4	10 ± 3	15 ± 5	8
Units weatherized	1217	933	1478	1365	1008

### **5.3 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.



#### 5.4 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 the 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.

## 5.5 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 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.

## 5.6 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**

2.5 household members per participating home  
0.75 showers per person per day  
7.5 minutes per shower  
0.5 gallon per day reduction in shower flow rate

### **Faucet aerators**

2.5 household members per participating home  
14 gallons per person per day  
50% of fixture flow affected by replacing aerator  
50% reduction in flow

## 5.7 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**

Year	Fuel oil (gallons)	Natural Gas (therms)	Propane (gallons)	Electricity (kWh)	Wood (MMBtu)
2020	\$2.41 ↓ 7%	\$0.76 ↓ 3%	\$1.52 ↓ 11%	\$0.14 0%	\$11.14 0%
2019	\$2.59 ↓ 8%	\$0.78 ↑ 1%	\$1.69 ↑ 2%	\$0.14 0%	\$11.14 0%
2018	\$2.81 ↓ 10%	\$0.77 0%	\$1.65 ↓ 6%	\$0.14 0%	\$11.14 0%
2017	\$3.11 ↓ 6%	\$0.77 ↓ 3%	\$1.76 ↓ 8%	\$0.14 0%	\$11.14 0%
2016	\$3.32	\$0.79	\$1.90	\$0.14	\$11.14

**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 PY20. Future savings are discounted at a rate of 3 percent per year.

**Measure life.** Measure lives range from 10 to 30 years. Below are 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)