Energy and Cost Savings Assessment for Wisconsin's Home Energy Plus Weatherization Program: Manufactured Home Analysis 2020

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1.0 INTRODUCTION

This report presents energy and cost savings for manufactured homes weatherized as part of Wisconsin's low-income weatherization program, Home Energy Plus. At the start of program year (PY[1]) 2016, the program underwent a substantial policy shift in its approach to weatherizing manufactured homes. Prior to PY16, a computerized audit was required for all participating homes, including manufactured homes, but starting in July 2015, weatherization measures installed in natural gas-heated manufactured homes have been prescribed using a measures list. Manufactured homes heated with other fuels continue to undergo a computerized audit using the Manufactured Home Energy Audit (MHEA) software to determine measure selection.

The motivation for the policy change to a measures-list approach resulted from energy-cost savings that barely met costs, on average.[2] While the average cost to weatherize a manufactured home is, on average, lower than the cost to weatherize a single-family home, the relative difference in cost savings, over the life of the measures, is lower. For example, in PY15 the average cost to weatherize a manufactured home was about 95 percent of the cost of weatherizing a single-family home. However, the average lifetime energy cost savings associated with manufactured homes was only 75 percent of that for single-family homes.

The measures-list approach simplifies the energy audit process by limiting the range of measures installed, which cuts job costs. Table 1 shows in PY18, 400 of the roughly 610 (66 percent) manufactured homes weatherized were natural gas-heated, all of which received measures list treatments instead of MHEA audits. As Table 2 shows, in PY19, natural-gas heated homes made up a lower percent (56 percent) of weatherized homes but all continue to receive measure lists treatments instead of MHEA audits. Together, natural gas and propane heated manufactured homes comprise approximately 95 percent of homes weatherized.

Table 1. Counts of manufactured homes weatherized in PY18, by approach and primary heating fuel

	Number of homes	Primary heating fuel			Electricity	Other
		Natural gas	Fuel oil	Propane		
All Manufactured Homes	609	400	2	180	11	16
MHEA Audit	209	0	2	180	11	16
Measures list	400	400	0	0	0	0

Table 2. Counts of manufactured homes weatherized in PY19, by approach and primary heating fuel

	Number of homes	Primary heating fuel			Electricity	Other
		Natural gas	Fuel oil	Propane		
All Manufactured Homes	586	332	4	228	11	13
MHEA Audit	254	0	4	226	11	13
Measures list	332	332	0	0	0	0

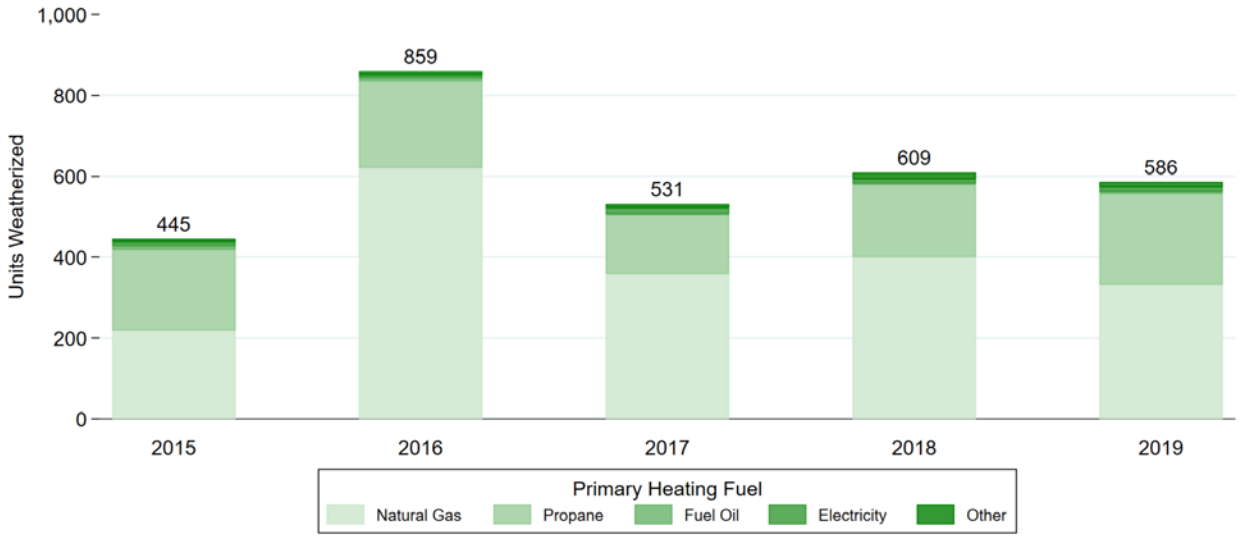
[1] A program year is a 12-month period ending on June 30 of a calendar year.
[2] Using the former approach to calculating energy cost savings, which did not include cost savings from heating system fuel switching and water conservation, average cost-effectiveness ratios were in the range of 0.8 to 0.9 between PY13 and PY15.

Section 2 of this report provides a historical overview of job counts and year-to-year comparisons of energy and cost savings, and cost-effectiveness statistics for homes weatherized between PY15 and PY19. Section 3 offers a detailed analysis of the two most recent program years (PY18 and PY19), including savings and cost-effectiveness comparisons between audit and measures-list approaches. Section 4 focuses on homes treated in PY18 and PY19 and provides program impacts at the agency-level.

2.0 HISTORICAL TRENDS

The number of manufactured homes weatherized in PY18 and PY19 increased relative to the number of homes weatherized in PY17. From PY18 to PY19, there was about a 5 percent decrease in total number of manufactured homes weatherized. Figure 1 illustrates this by showing the number of manufactured homes weatherized in the program, broken out by primary heating fuel. In the first two years after the policy shift to a measures-list approach for gas-heated manufactured homes, weatherized homes heated with natural gas made up about two-thirds of all weatherized homes. This represented a significant increase compared to before the policy shift as before PY16, natural gas-heated homes comprised approximately half of all manufactured homes weatherized. However, in PY19, the proportion of natural gas heated homes fell again, compromising around 55 percent of all weatherized homes. Propane heated homes consist of the next largest proportion of homes. Together, natural gas- and propane-heated homes consistently make up approximately 95 percent of all homes.

Figure 1. Manufactured homes weatherized, by primary heating fuel and program year

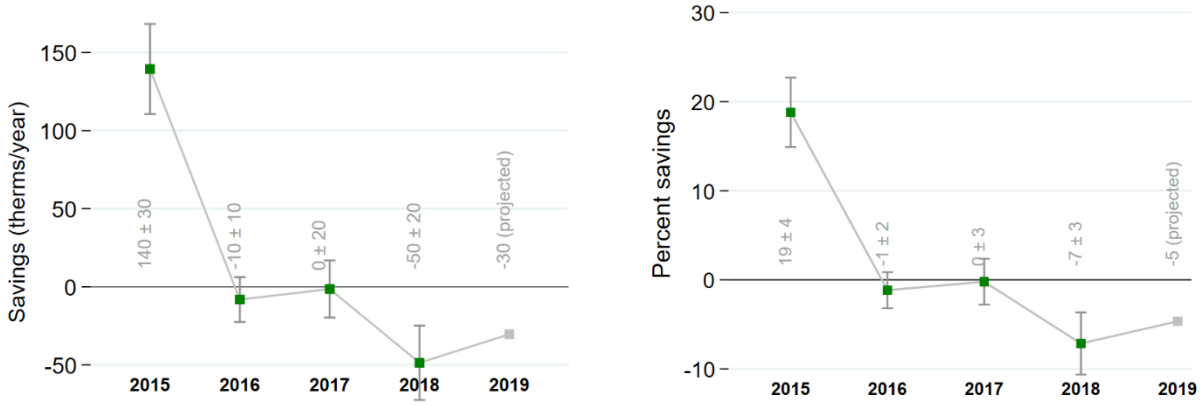


2.1 OBSERVED NATURAL GAS AND ELECTRICITY SAVINGS

Observed energy savings are based on usage data from natural gas and electric utility bills that were compiled and analyzed for homes weatherized between PY15 and PY19. Billing data from pre- and post-weatherization periods are weather normalized with the difference between the two periods reflecting the energy savings for a treated home. Additionally, pre-weatherization billing data for future program participants are used to correct for non-program factors in any given year. It should be noted that fuel savings for homes that switch heating fuels (from fuel oil, propane, or electricity to natural gas, or, in some cases, to propane) during weatherization, are not reflected in observed energy savings because these homes have insufficient usage data for a billing analysis. Usage data for bulk heating fuels are not incorporated into this part of the evaluation since collection and usage allocation are extremely difficult.

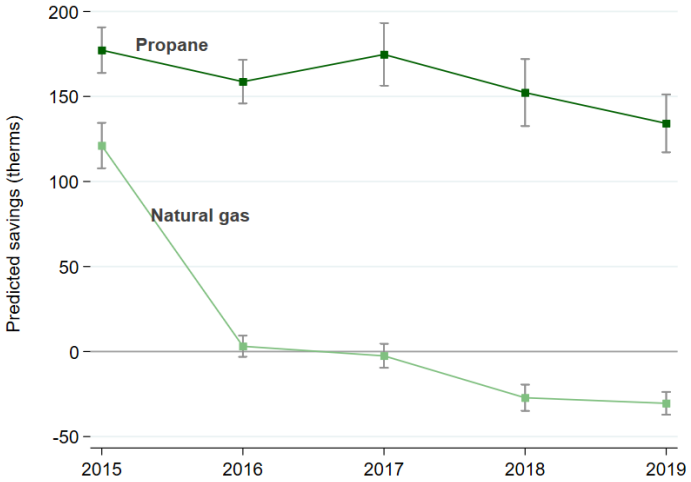
Figure 2 presents average savings and the 90 percent confidence interval for each program year. Before the policy shift in PY15, natural gas savings among manufactured homes was relatively stable and positive. However, starting in PY16, savings declined significantly and have hovered around zero for the past four years. The reduced savings after PY16 is a direct result of the adoption of the measures-list approach. Before the introduction of the measures-list approach, homes heated with natural gas that received MHEA audits saved close to 150 therms per year, on average. After the introduction, savings decreased to zero and slightly negative, on average. Savings expressed in percentage terms mirrors that of straight-therm savings.

Figure 2. Annual natural gas savings and percent savings for gas-heated, manufactured homes by program year



To further illustrate the impact from the policy shift, Figure 3 illustrates predicted savings for natural gas and propane over the past five years.[3] Propane savings have stayed relatively stable and positive over the past five years while natural gas savings have hovered around zero and below.

Figure 3. Annual predicted savings of natural gas and propane, therms

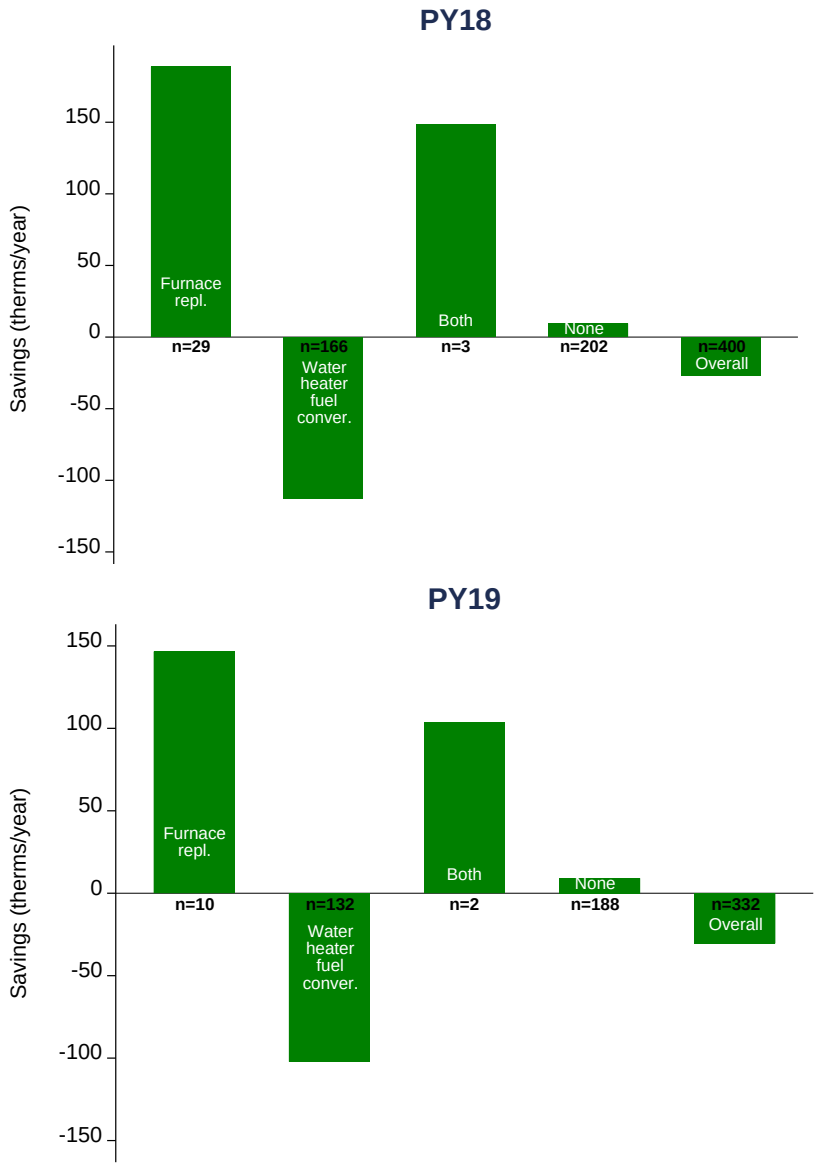


The starkness of this trend at this fully aggregated view hides an important feature of natural gas savings. Included in the measures-list approach are two high-impact weatherization measures: a water heating fuel conversion, which increases rather than decreases natural gas consumption, and a furnace replacement, which leads to large, positive natural gas savings. Figure 4 shows the impact of these measures on natural gas consumption as average savings associated with each measure or group of measures. Furnace replacements lead to average savings of about 200 therms but are installed in less than 10 percent of homes. Conversely, water heater conversions take place in about 40 percent of homes and increase natural gas consumption. When both measures are installed, savings reach about 100 therms and when neither measure is installed, savings are small but positive

[3] The figure relies on predicted savings as utility billing data doesn't exist for propane-heated homes.

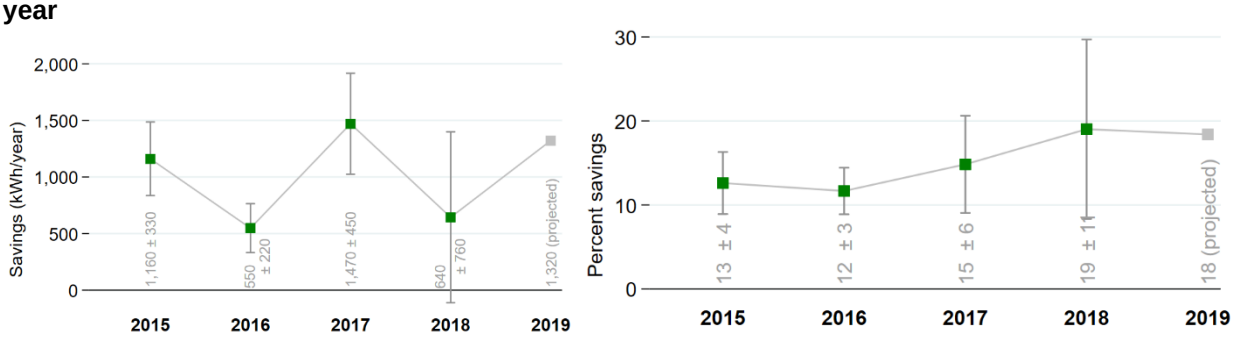
Overall savings, which considers all measures installed together, renders savings slightly negative for the two most recent PYs. This shows that the high incidence of negative savings from water heating fuel conversions outweighs the low incidence of positive savings from furnace replacements. Note the incidence of water heating fuel conversion versus furnace replacement indicated in Figure 4 in black corresponding to each bar. In PY18 there were 166 water heating fuel conversions that increased natural gas usage while there were only 29 furnace replacements driving overall savings slightly negative. The same story accounts for the negative projected natural gas savings in PY19 in Figures 2 and 3.

Figure 4. Gas savings for from furnace replacements and water heating fuel conversion measures in measures-list jobs in PY 18 and 19



The manufactured homes measures list approach only applied to homes heated with natural gas so electricity savings trends less obvious compared to natural gas savings. Figure 5 shows average electricity savings per weatherized home, along with the 90 percent confidence level. The left-hand panel shows a change in average savings from PY15 to PY19, which, despite year-to-year changes, have stayed relatively constant in the right-hand panel showing electricity savings in percentage terms.

Figure 5. Annual electricity savings and percent savings for manufactured homes, by program year



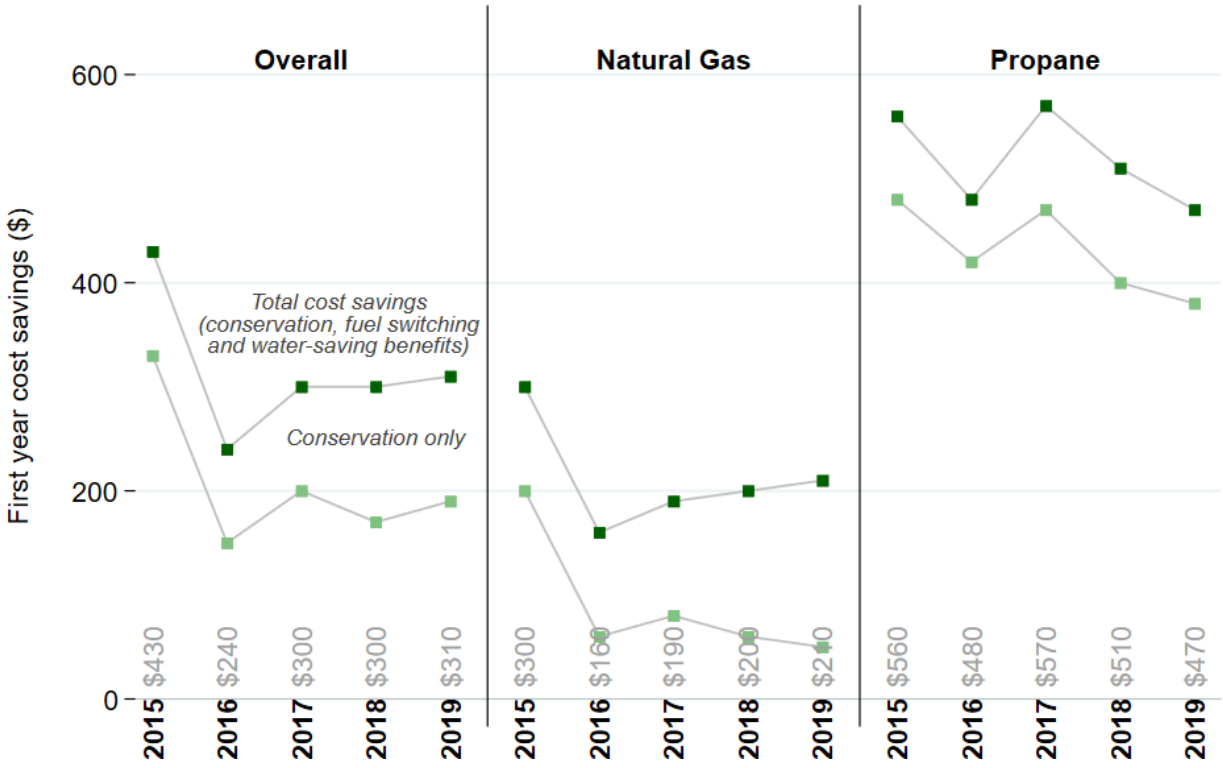
2.2 MODELED ENERGY AND COST SAVINGS

Observed natural gas and electricity savings are used to model energy savings for individual weatherization measures and are extrapolated to homes with insufficient billing data, namely homes that were recently treated and those that heat with bulk fuels. Modeled energy savings for all participating homes are combined with average fuel prices and projected fuel-price increases to estimate cost savings directly following weatherization (first year) and throughout the life of installed measures.

This evaluation includes two additional sources of cost savings (beyond energy conservation): space-heating fuel conversions and water conservation from two commonly installed measures (showerhead and faucet aerators). The inclusion of these cost-saving components reflects the dual purpose of the Home Energy Plus program: to reduce participants' energy consumption and reduce their energy costs.

Figure 6 shows first year cost savings both overall and by the two dominant primary heating fuels; natural gas and propane. Fuel oil, electricity, and other heating fuels are not shown because when combined they represent less than five percent off all homes in this analysis. After a sharp decline from PY15 to PY16, cost savings increased by a small margin both overall and for natural gas heated or measures-list homes. Homes receiving an MHEA audit, or propane-heated homes, saw a decline in cost savings.

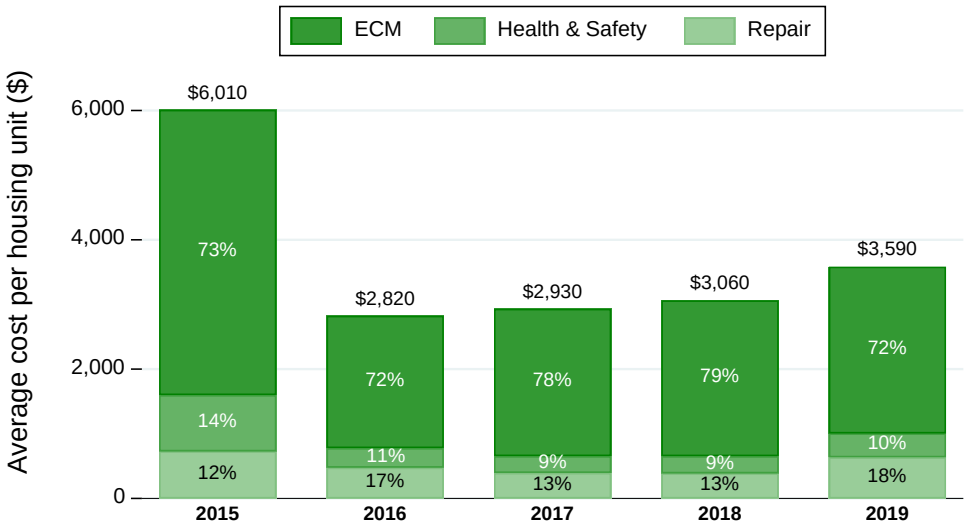
Figure 6. Annual cost savings for manufactured homes, by program year



2.4 JOB COSTS AND COST-EFFECTIVENESS

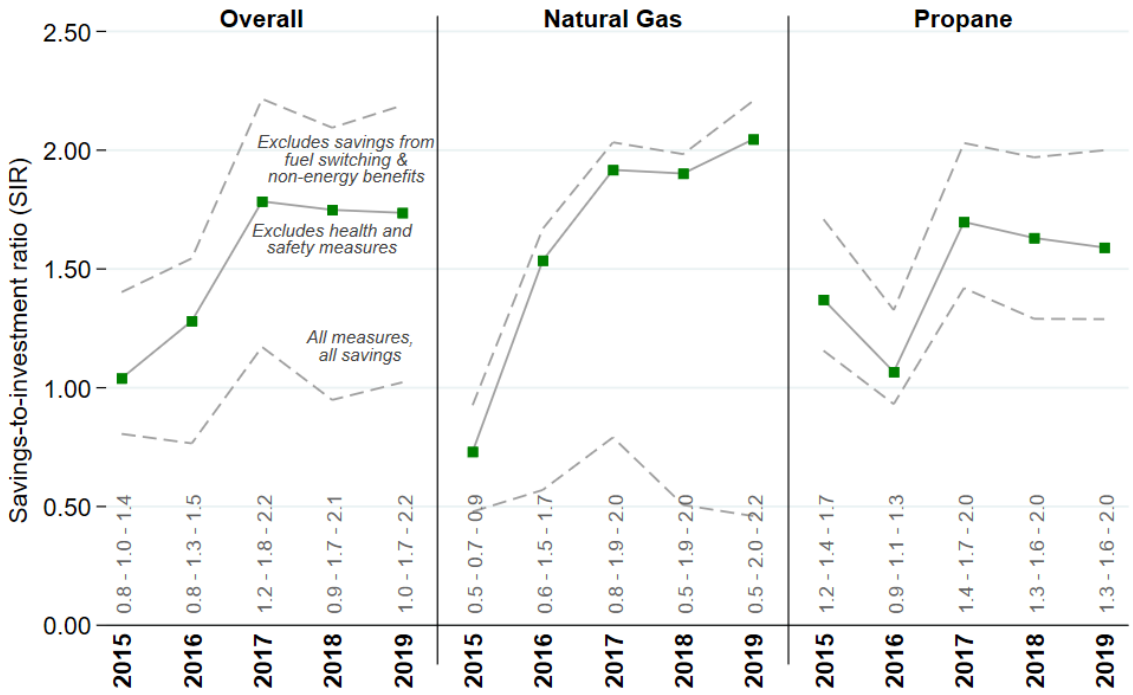
With the shift to the measures-list approach for natural gas-heated homes, average per-home weatherization costs decreased from their historical level of $5,000-$6,000 to around $3,000 in PYs 16 through 18, a dramatic decrease. From PY18 to PY19, average per-home cost increased slightly, by roughly $500 per home. The cost breakdown between energy conservation, health and safety, and repairs has stayed relatively constant over the past five years – with energy and conservation making up three-fourths of the cost.

Figure 7. Average weatherization costs for manufactured homes, by program year



Since the introduction of the measures-list approach, overall cost-effectiveness—especially for natural-gas heated homes—has increased significantly. Figure 8 shows overall savings-to-investment ratio (SIR) values ranged between 0.9 and 2.2 in PY18 and between 1.0 and 2.2 in PY19, depending on the inclusion of fuel switching and/or the inclusion of health and safety measures in the calculation. Decreased job costs, specifically less spending on health and safety measures, and a focus on high-savings measures are the primary ways the measures-list approach has improved SIR values dramatically among natural gas homes. Although natural gas savings have declined with the measures-list approach, it achieves savings more cost-efficiently indicated by natural gas SIRs experiencing a doubling following three years (not shown here) where savings did not cover costs. Weatherization of propane-heated homes have been cost effective over the past five years and continued to be in both PY18 and PY19.

Figure 8. Average SIR for manufactured homes, by program year



3.0 MANUFACTURED HOMES WEATHERIZED IN PROGRAM YEAR 2018 AND 2019

The energy-savings and spending impacts of the measure-list approach are clear when compared to estimates for manufactured homes that were audited using MHEA. In both PY18 and PY19, measures-list homes show less than half the annual and lifetime savings and have a much higher proportion of savings from fuel conversions. They also cost less on average and have a much lower portion of costs spent on health and safety measures. In PY18, the average SIR for the measure-list subgroup was 1.9 and 1.63 for the MHEA audit subgroup. The results from PY19 are similar, with an average SIR of 2.05 for the measure-list subgroup and 1.59 for the MHEA audit subgroup.

Table 3. Cost savings and cost effectiveness for manufactured homes weatherized in PY18

	Number of homes	First year cost savings	Percent of savings from fuel switching	Average lifecycle savings (discounted)	Average job cost	Percent of costs spent on health & safety	SIR
All manufactured homes	609	$300	33%	$5,120	$3,060	10%	1.75
MHEA Audit	209	$510	18%	$7,860	$4,880	21%	1.63
Measures list	400	$200	60%	$3,150	$1,660	2%	1.9

Table 4. Cost savings and cost effectiveness for manufactured homes weatherized in PY19

	Number of homes	First year cost savings	Percent of savings from fuel switching	Average lifecycle savings (discounted)	Average job cost	Percent of costs spent on health & safety	SIR
All manufactured homes	586	$310	32%	$5,390	$3,590	12%	1.74
MHEA Audit	254	$470	15%	$7,860	$4,910	23%	1.59
Measures list	332	$210	62%	$3,130	$1,530	3%	2.05

3.1 PROGRAM-WIDE COST SAVINGS AND MEASURE-LEVEL CONTRIBUTIONS

In PY18 and PY19, the statewide weatherization program saved participating households around $210,000 during the first year after weatherization. Over the life of the installed measures, the program is projected to yield over $4.2 million in energy cost savings for the group of households weatherized in both PY18 and PY19. After an initial decline in lifetime cost savings, the past two years have saved more of the lifetime of the measures than before the policy shift.

Table 5. Program-wide energy and cost savings for manufactured homes, by program year

		Aggregate energy savings				Aggregate cost savings				
PY	**Treated units**	**NG** (therms)	**LPG** (gals)	**FO** (gals)	**ELEC** (kWh)	**Energy conservation**	**Fuel switching**	**Non-energy benefits**	**Total, first year**	**Total, life of measures** (undiscounted)
2015	445	37,000	44,000	2,300	518,000	$159,000	$38,000	$10,000	$207,000	$3,882,000
2016	860	27,000	42,000	1,300	821,000	$139,000	$62,000	$19,000	$220,000	$3,633,000
2017	531	13,000	34,000	100	706,000	$120,000	$50,000	$14,000	$183,000	$3,615,000
2018	609	9,000	38,000	600	917,000	$122,000	$71,000	$15,000	$208,000	$4,211,000
2019	586	5,000	42,000	400	863,000	$128,000	$69,000	$13,000	$209,000	$4,281,000

Figures 9 and 10 show the model-estimated contributions of individual measures to total aggregate lifecycle energy-cost savings for manufactured homes in PY18 and PY19. Contributions are the combined effects of per-installation savings and installation rates on overall program cost savings.

Figure 9. Measure-level contributions to PY18 program-wide cost savings

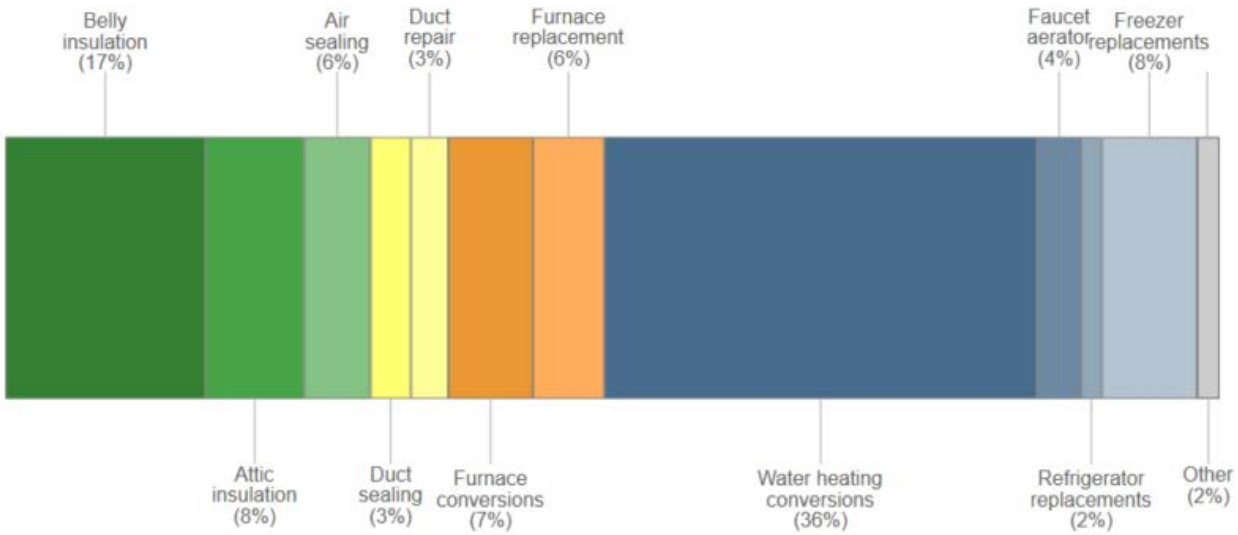
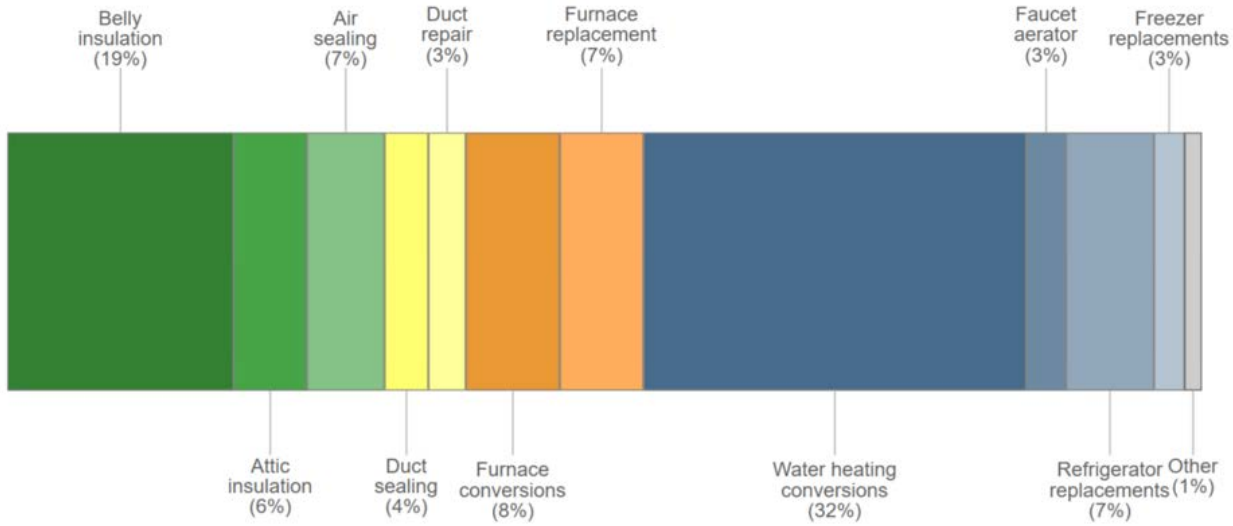


Figure 10. Measure-level contributions to PY19 program-wide cost savings



Approximately two-thirds of PY18 and PY19 savings is attributable to key measures, belly insulation, furnace replacements and conversions, and water heating fuel switches, which have by far the largest impact on savings.

4.0 AGENCY ANALYSIS

Manufactured homes represent approximately 10 percent of weatherized homes across all housing types. Agency 5 had the largest proportion of manufactured homes in PY18 and PY19. Figures 11 and 12 show the number of manufactured homes treated by each agency and the proportion heated by each fuel type. There is wide variation by agency in both number and proportion.

Figure 11. Manufactured homes weatherized in PY18, by agency and heating fuel

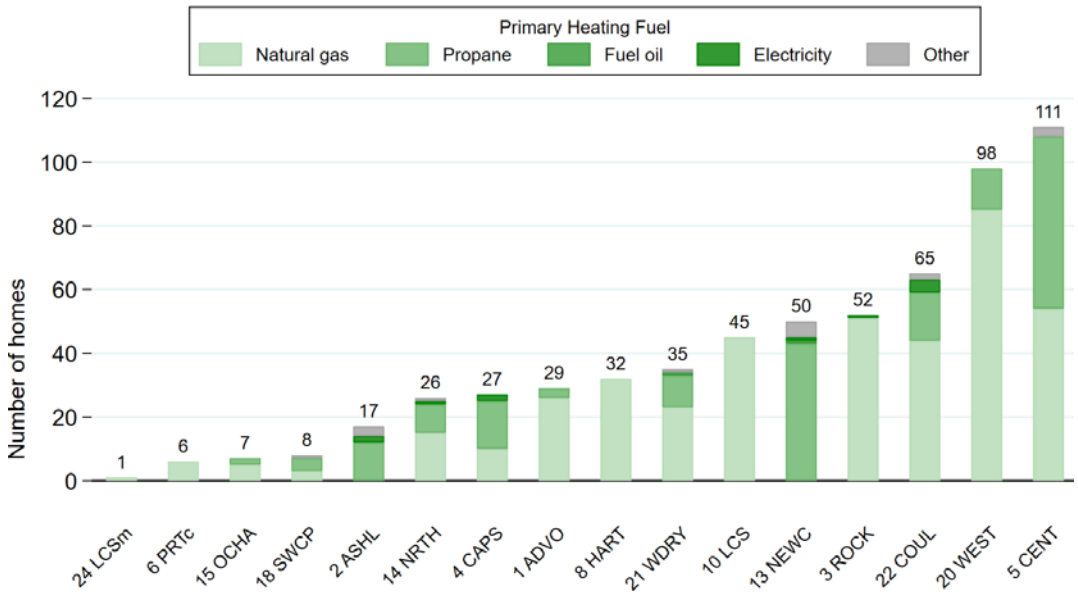


Figure 12. Manufactured homes weatherized in PY19, by agency and heating fuel

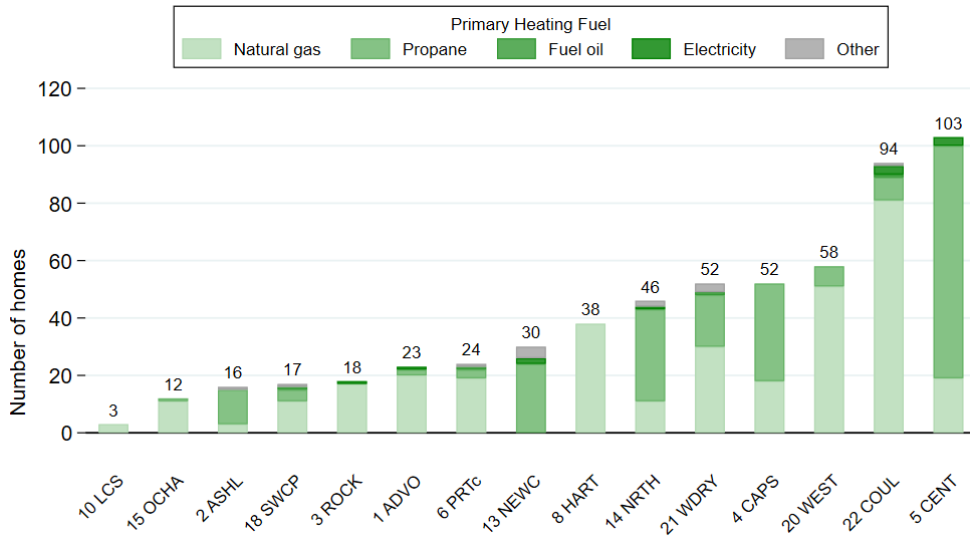


Figure 13 and Figure 14 show the same group of homes by weatherization approach broken out by homes weatherized based on MHEA audits and the measures list. Again, there is wide variation in the proportion of measures list versus audit jobs across agencies with roughly the same number of jobs being done by each agency.

Figure 13. Manufactured homes weatherized in PY18, by agency and approach

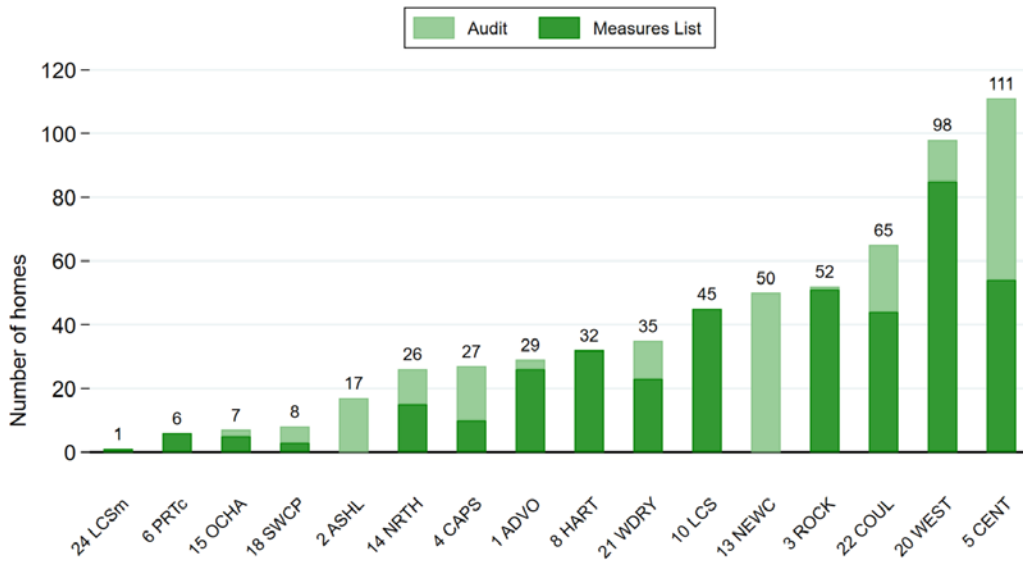
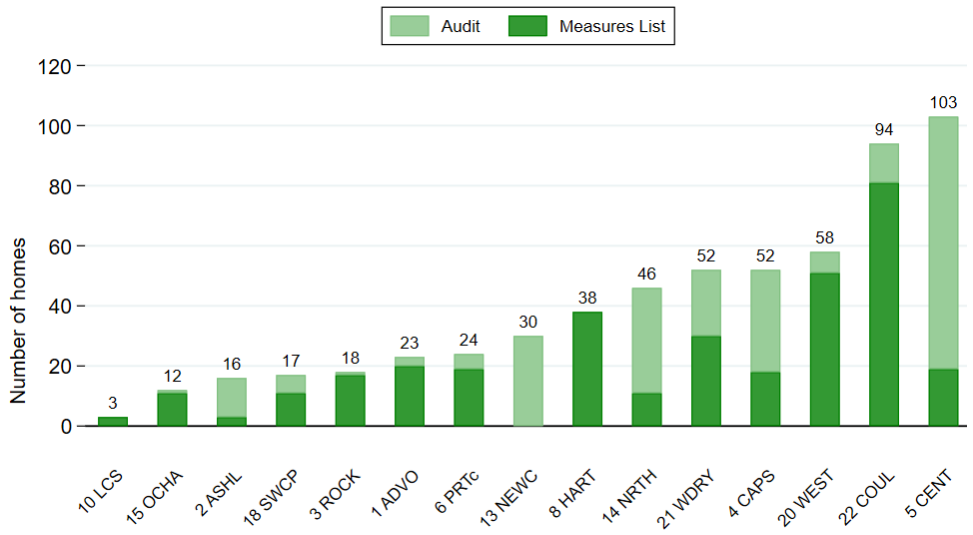


Figure 14. Manufactured homes weatherized in PY19, by agency and approach



4.1 PER-HOME COST SAVINGS

When observed, savings for natural gas and electricity are projected across all fuel types (mainly propane) and applied to the full PY18 and PY19 the population of treated-manufactured homes, annual household energy cost savings typically averages between $100 and $600 per agency. Much of the variation across agencies is due to differences in heating fuels and therefore, differences in weatherization approach. Agencies with the highest average cost tend to have high proportions of weatherized homes based on MHEA audits whereas those with the lowest costs have high proportions of weatherized homes based on the measures-list approach. An intervening factor in this trend is the role played by space and water heating fuel switching.

Agencies with large savings from these measures tend to cluster at the high end of first year cost savings show in Figures 15 and 16.

Figure 15. Average energy cost savings for all homes treated between in PY18, by agency

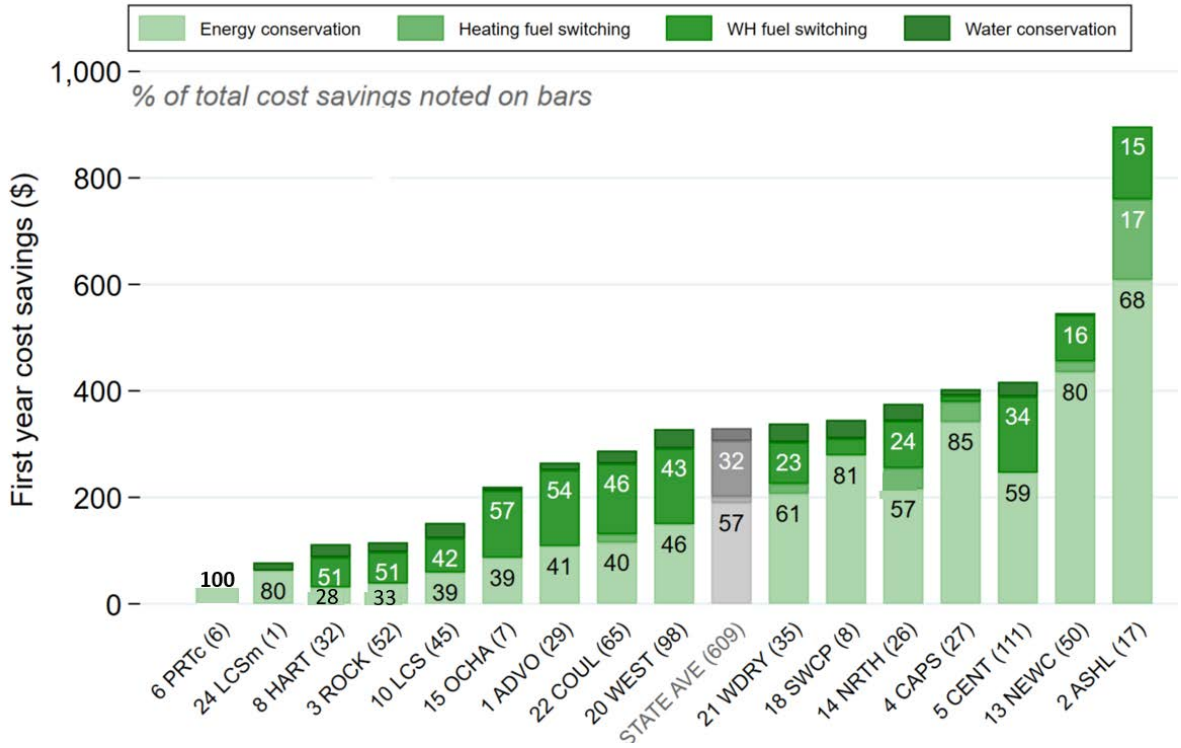
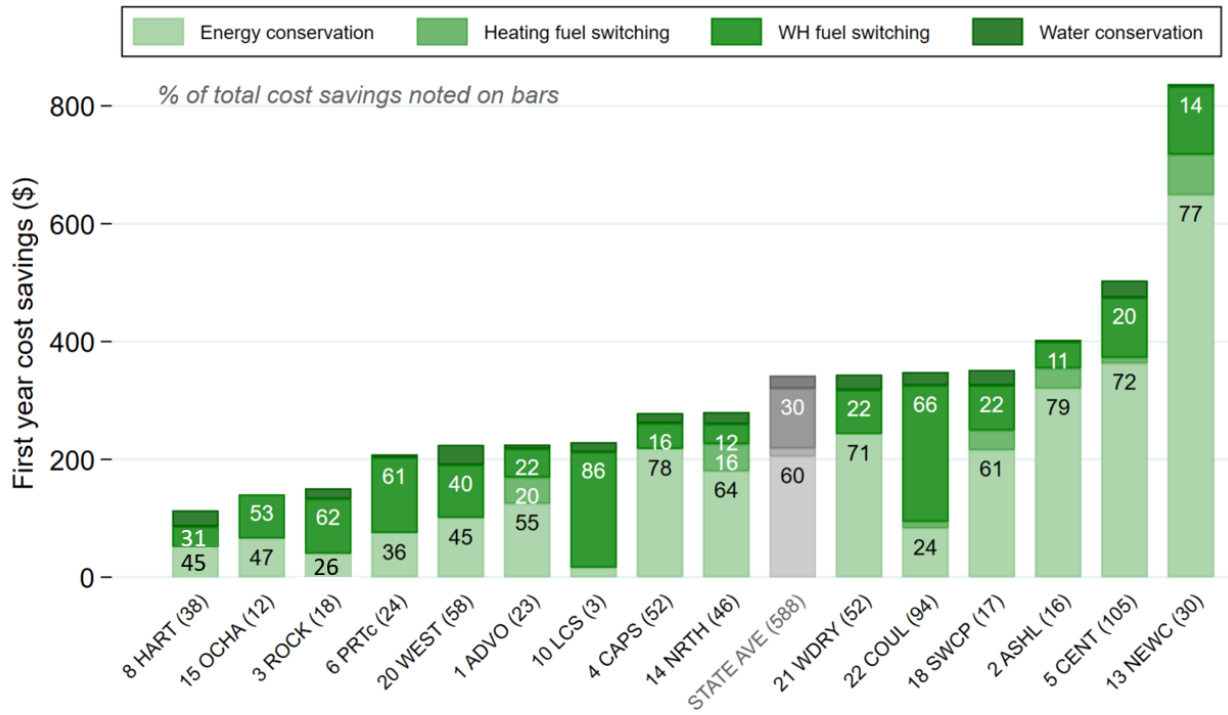


Figure 16. Average energy cost savings for all homes treated between in PY19, by agency



4.2 JOB COSTS AND COST-EFFECTIVENESS

As with energy and cost savings, average per-home spending varies widely by agency (17 and 18). In PY18, most agencies spent between $1,000 and $4,000 per manufactured home weatherized. However, agency 2 spent far more than any other agency. Even though the proportions of costs coming from the three categories of measures are like other agencies, agency 2 simply spend more in each category. In PY19, again, most agencies spent between $1,000 and $4,000 per manufactured home weatherized, although agencies 2 and 13 spent nearly $7,000 per home. Overall, agencies typically spent between 70 and 90 percent of overall job spending on energy conservation measures (including fuel switching). Health and safety spending varied between 0 to 34 percent, and repairs, from 0 to 35 percent. Any category with less than 10 percent of cost coming from a category is not indicated.

Figure 17. Average spending per manufactured home treated in PY18, by agency

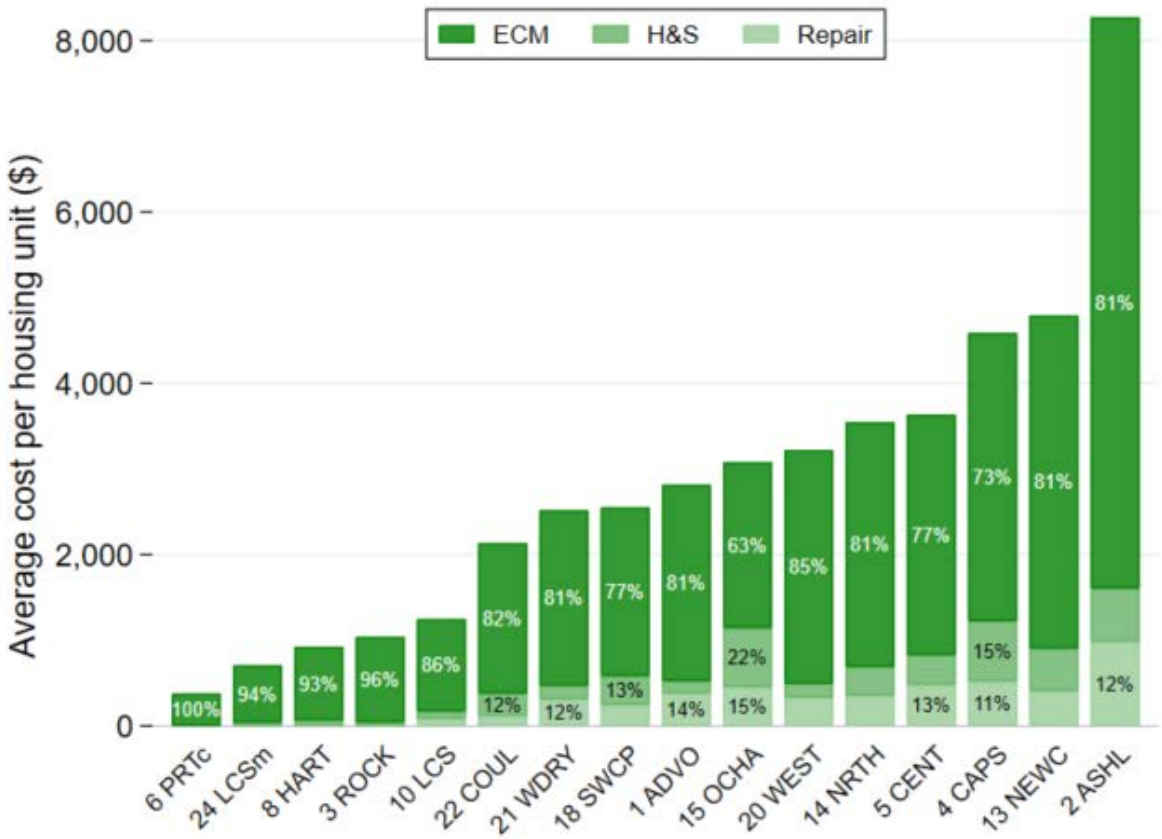
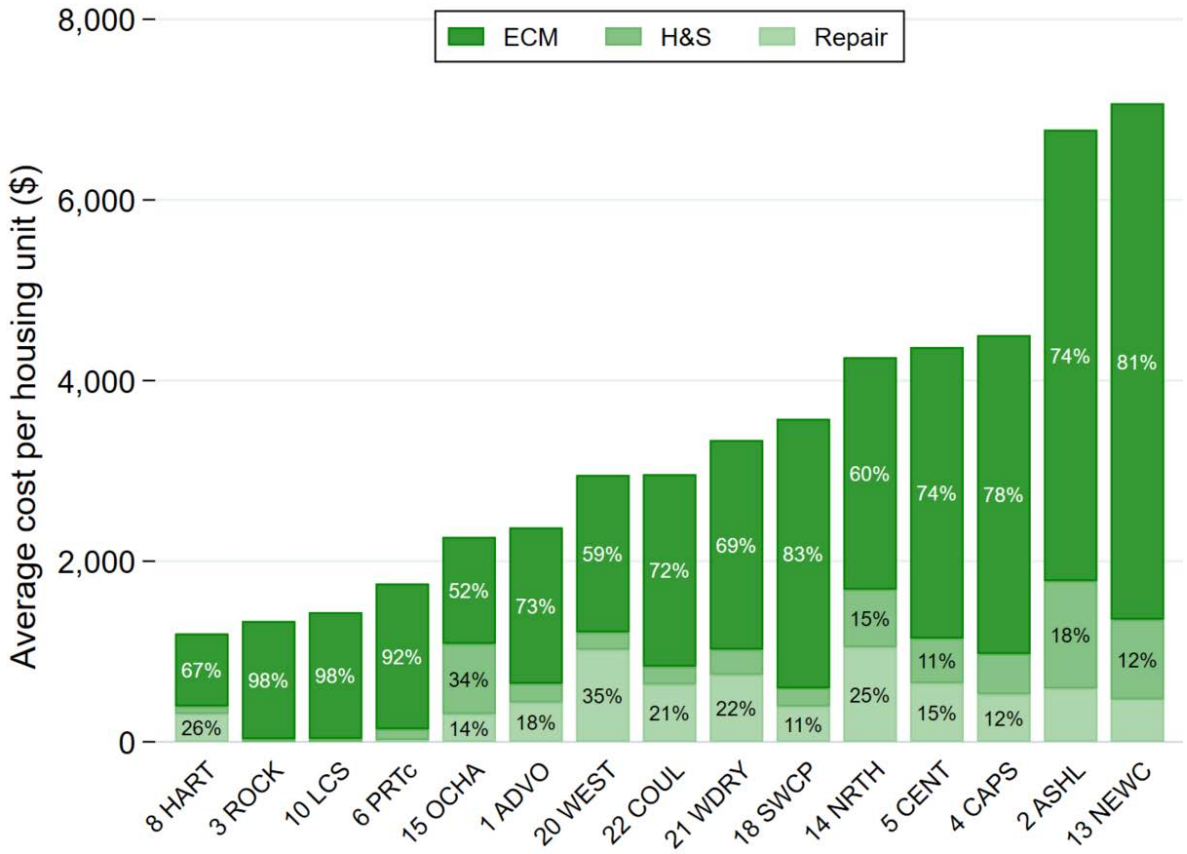


Figure 18. Average spending per manufactured home treated in PY19, by agency



Cost savings estimates and information on per-unit spending is used to calculate SIRs for each agency overall, and by primary heating fuel, for homes weatherized in PY18 and PY19. The savings (Table 6) and a series of fuel price escalators. Future savings are discounted at a rate of three percent.

Table 6. PY15-19 reference fuel prices

Program year	Natural Gas ($/therm)	Propane ($/gallon)	Fuel oil ($/gallon)	Electricity ($/kWh)	Other ($/MMBtu)
2019	$0.78	$1.69	$2.59	$0.14	$22
2018	$0.77	$1.65	$2.81	$0.14	$22
2017	$0.77	$1.76	$3.11	$0.14	$22
2016	$0.79	$1.90	$3.32	$0.14	$22
2015	$0.85	$1.92	$3.25	$0.13	$22

The SIRs shown in Figures 19 and 20 are based on savings and cost data for all manufactured homes treated in PY18 and PY19, respectively. On average, the weatherization program was cost effective for all agencies in both project years regardless of whether health and safety measures were included in the calculation. With the inclusion of health and safety measures, SIRs for both PY18 and PY19 years for most agencies near 2.0. The health and safety measures installed at agency 6 in PY18 had an upward rather than downward effect on SIR, which is not usually the case. Also note that agency 15 in PY19 has SIR values for propane jobs that are much higher than any other agency. This is likely because there were only two jobs where propane was the primary heating fuel for that agency.

Figure 19. SIRs for homes treated in PY18, by agency and primary heating fuel (Agencies ordered by overall SIR)

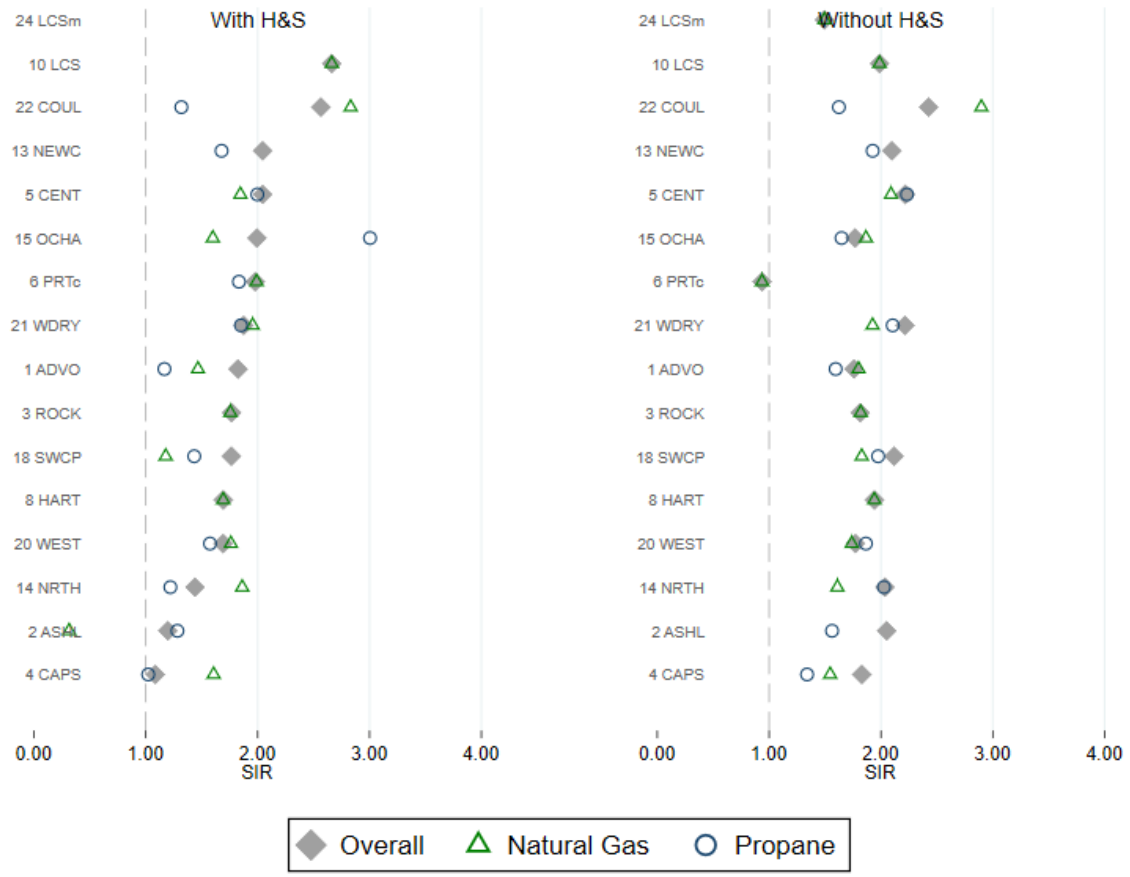
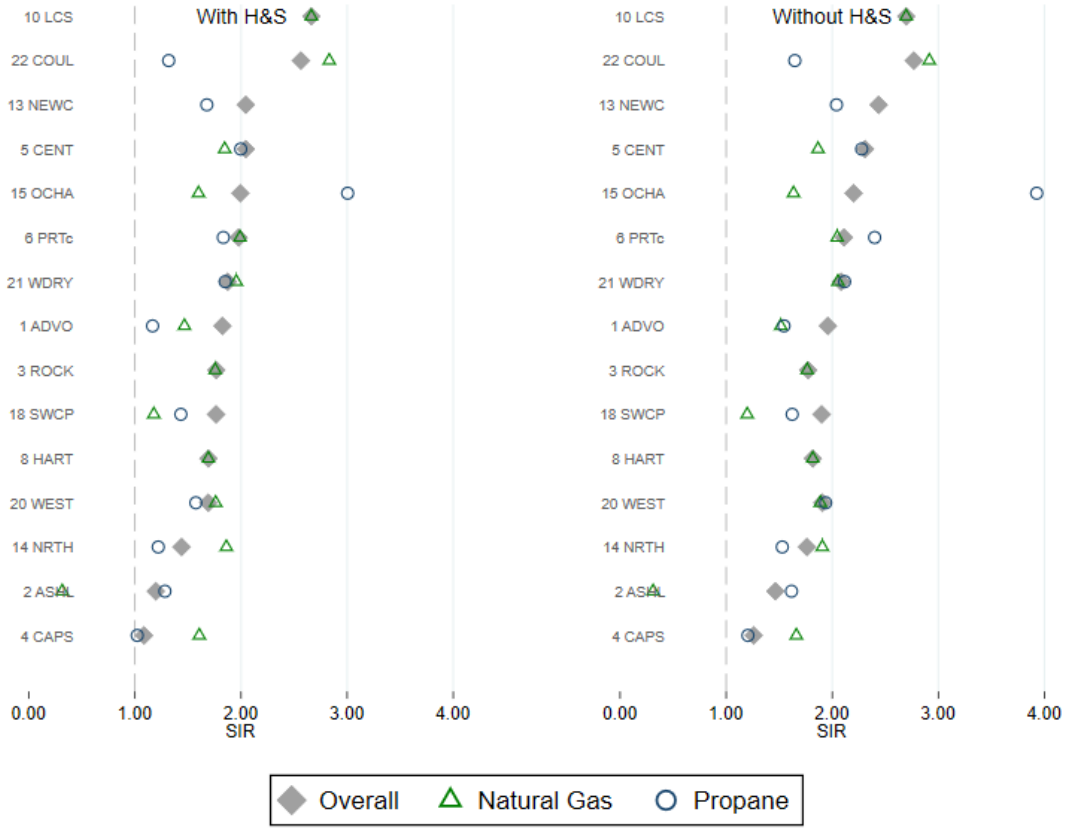


Figure 20. SIRs for homes treated in PY19, by agency and primary heating fuel *(Agencies ordered by overall SIR)*



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