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National Weatherization Assistance Program Impact Evaluation: Energy Impacts for Small Multifamily Buildings

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National Weatherization Assistance Program Impact Evaluation

Energy Impacts for Small Multifamily Buildings

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ACRONYMS AND ABBREVIATIONS

AC	Air Conditioning
ANACOVA	Analysis of Covariance
BTU	British Thermal Unit
CDD	Cooling Degree Days
CFM50	Cubic Feet per Minute @ 50 Pascals
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EIA	U.S. Energy Information Administration
ECM	Energy Conservation Measure
FY	Fiscal Year
HDD	Heating Degree Days
IR	Infrared
kWh	Kilowatt Hour
LMF	Large Multifamily
MMBtu	Mean Million British Thermal Units
NCDC	National Climatic Data Center
ORNL	Oak Ridge National Laboratory
PRISM	Princeton Scorekeeping Method
PY	Program Year
SIR	Savings to Investment Ratio
SOW	Scope of Work
SSE	Steady State Efficiency
Therms	100,000 British Thermal Units
TIPS	Targeted Investment Protocol System
WAP	Weatherization Assistance Program

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The work presented in this report was funded by the U.S. Department of Energy's (DOE) Office of Weatherization and Intergovernmental Programs (OWIP).

The purpose of this report is to disseminate the findings from an analysis of the energy savings, cost savings, and cost-effectiveness for small multifamily buildings treated by DOE's Weatherization Assistance Program (WAP) during Program Years (PY) 2007, 2008, and 2009.

The original design for this research was developed by staff from the Oak Ridge National Laboratory (ORNL) as one component of the National Evaluation of the Weatherization Assistance Program. (*National Evaluation of the Weatherization Assistance Program: Preliminary Evaluation Plan for Program Year 2006 – ORNL/CON-498).* As part of the evaluation plan development, the design team consulted with and received feedback from the Network Planning Committee, 41 individuals from the weatherization network.

ORNL contracted with the research team of APPRISE Incorporated, the Energy Center of Wisconsin, Michael Blasnik and Associates, and Dalhoff Associates LLC to conduct the National Evaluation. The evaluation team implemented the specified data collection and analysis activities to develop statistics for this report.

Grantee and Subgrantee Data Collection

The Energy Center of Wisconsin (ECW) collected information on program funding and clients served from 51 grantees and 879 subgrantees, as well as detailed information on weatherization jobs from 379 subgrantees. The cooperation and contributions made by WAP grantees and subgrantees were essential to the completion of the study. The ECW team responsible for grantee and subgrantee data collection for the study included:

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Energy Supplier Data Collection

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EXECUTIVE SUMMARY

The purpose of this report is to disseminate the findings from an analysis of the energy savings, cost savings, and cost-effectiveness for small multifamily buildings (i.e., buildings with 2 to 4 units) treated by U.S. Department of Energy's (DOE) Weatherization Assistance Program (WAP) during Program Years (PY) 2007, 2008, and 2009.[1] The main focus of this study is on PY 2008. The analysis characterizes the population of small multifamily buildings served by the program, estimates the gross and net change in energy usage for treated buildings and housing units, makes projections for the first year and longer-term cost savings, and assesses the cost-effectiveness of the program in terms of direct energy benefits.

This is one of five energy impact reports developed for the National WAP Evaluation for PY 2008. The full set of reports covers all housing types (single family homes, mobile homes, and multifamily buildings) and summarizes overall program performance for all building types in terms of energy and nonenergy benefits. The reports give policymakers detailed information on program performance for each building type, as well as overall program performance.

Background

WAP was created by Congress in 1976 under Title IV of the Energy Conservation and Production Act. The purpose and scope of the Program as currently stated in the Code of Federal Regulations (CFR) 10 CFR 440.1 is "to increase the energy efficiency of dwellings owned or occupied by low-income persons, reduce their total residential energy expenditures, and improve their health and safety, especially low-income persons who are particularly vulnerable such as the elderly, persons with disabilities, families with children, high residential energy users, and households with high energy burden." (*Code of Federal Regulations, 2011)*

At the request of DOE, Oak Ridge National Laboratory (ORNL) developed a comprehensive plan for a national evaluation of WAP that was published in 2007. DOE furnished funding to ORNL in 2009 for the evaluation for Program Years 2007 and 2008, with a particular emphasis on PY 2008. The Scope of Work (SOW) for the evaluation includes the following components.

- Impact Assessment – Characterization of the weatherization network and low-income households, measurement and monetization of the energy and nonenergy impacts of the program, and assessment of the factors associated with higher levels of energy savings, cost savings, and cost-effectiveness.

- Process Assessment – Direct observation of how the weatherization network delivers services, assessment of how service delivery compares to national standards, and documentation of how weatherization staff and clients perceive service delivery.

- Special Technical Studies – Examination of the performance of the program with respect to technical issues such as air sealing, duct sealing, furnace efficiency, and refrigerators.

[1] The Census Bureau building categories include: mobile homes, single family detached buildings, single family attached buildings, small multifamily buildings (2-4 units), and large multifamily buildings (5+ units). That was the housing unit definition specified by the WAP Evaluation Plan. However, the Weatherization Assistance Program (WAP) asks grantees to report on: mobile homes, single family homes (1-4 units), small multifamily buildings (5-25 units), and large multifamily buildings (more than 25 units.) This report reviews the findings for small multifamily buildings as defined by the WAP Evaluation Plan (i.e., buildings with 2-4 units.) However, some grantees were not able to separate small multi-family buildings from single family homes since they used the WAP categories for tracking treated units.

- Synthesis Study – Synthesis of the findings to assess the program's success in meeting its goals and identify key areas for program enhancement.

This analysis of small multifamily building energy impacts is part of the Impact Assessment.

Study Overview

This study collected information on the small multifamily buildings served by the program and measured program impacts. The study procedures included:

- Development of a representative sample of buildings served by the program using data from DOE, grantees, and subgrantees.

- Collection of information from subgrantees on building characteristics, diagnostic tests conducted, installed measures, and measure costs for sampled buildings.

- Collection of energy usage information from energy suppliers.

- Statistical analysis of pre- and post-weatherization energy usage to develop estimates of the net energy impacts associated with service delivery.

- Projection of measure lifetimes and energy costs to estimate cost savings and program cost-effectiveness.

This report summarizes the study findings with respect to building characteristics, installed program measures, estimated energy savings, and program cost-effectiveness.

Program Characterization

The evaluation team collected information on the buildings served and the services delivered by WAP. PY 2008 program statistics are available from the Department of Energy and WAP grantees (i.e., states). Detailed information about buildings and the service delivered to those buildings was supplied by program subgrantees (i.e., local agencies).

WAP serves low-income households in all types of housing units and in all parts of the country. According to DOE statistics, the network of WAP-funded subgrantees served 97,965 housing units in PY 2008 with DOE funding. Table 1 shows the distribution of treated units by housing unit type. Only 5 percent of the treated units were categorized as small multifamily buildings. However, since DOE asks grantees to report on mobile homes, single family site built homes (1-4 units), and large multifamily buildings (5 or more units), it is likely that some grantees and subgrantees do not distinguish between single family homes and small multifamily buildings in their records. Table 2 shows the distribution of treated small multifamily buildings by Climate Zone; almost 90 percent of the treated small multifamily in PY 2008 were in the Very Cold and Cold Climate Zones.

Table 1. PY 2008 WAP Housing Units by Type

Housing Unit Type	PY 2008 Weighted Count of Units	Percent of PY 2008 Units
Single Family Site Built	57,518	59%
Single Family Mobile Home	17,754	18%
Small Multifamily (2-4)	5,317	5%
Large Multifamily (5+)	17,376	18%
TOTAL	97,965	100%

Table 2. PY 2008 WAP Housing Units in Small Multifamily Buildings by Climate Zone

Climate Zone	PY 2008 Units	Percent of PY 2008 Units
Very Cold Climate	2,264	43%
Cold Climate	2,368	44%
Moderate Climate	226	4%
Hot/Humid Climate	405	8%
Hot/Dry Climate	54	1%
TOTAL	5,317	100%

Table 3 shows how treated small multifamily buildings varied with respect to a number of important building characteristics. Most used natural gas as their main heating fuel, had a central heating system, and used gas water heat. Some buildings had electric main heat, or delivered fuel main heat and electric water heat. Supplemental heat was reported for relatively few housing units.

Table 3. Characteristics of Small Multifamily Buildings Served by WAP in PY 2008

Characteristic			
Number of Units	2 Units = 77%	3 or 4 Units = 16%	Unknown = 7%
Year Built	Pre-1940 = 49%	1940-1969 = 16%	1970 or Later = 35%
Space Heating Fuel	Gas = 67%	Electric = 20%	Delivered Fuels = 13%
Heating System	Central = 78%	Room = 22%	Other = <1%
Supplemental Heat	Electric = 4%	Wood = 5%	Other = <1%
Water Heating Fuel	Natural Gas = 68%	Electric = 26%	Other = 6%

WAP conducts extensive testing of clients' buildings, both to identify cost-effective energy saving opportunities and to ensure that the client's equipment is operating safely. One important finding from testing is that the pre-weatherization energy saving potential varies considerably across buildings served by the program.

- Infiltration Rates - Blower door tests conducted prior to weatherization show that the average air leakage rate was 4,317 CFM50.[2] That leakage rate is three to four times the required ventilation needs for the average WAP client, computed using the 62.2 standard and taking into account square footage and the number of household members. Clients in the average home would be likely to report that the home was very drafty; air sealing would be expected to make the home more efficient and comfortable.

- Furnace Efficiency – Pre-weatherization furnace testing found that the average WAP client home had an SSE rating of 80 percent. Those levels are consistent with what would be expected from older buildings where the furnace has not recently been replaced. This SSE rating is similar to that for single family homes.

After this testing, WAP subgrantees install a comprehensive set of measures matched to the needs of each building. Major measures such as bypass air sealing, attic insulation, wall insulation, heating equipment replacement, and refrigerator replacement are expected to have a significant impact on the buildings and units in which they are installed. Table 4 shows the rate at which the major measures were installed during PY 2008 and the share of the buildings receiving the measure where the maximum energy savings impact was expected. For example, most buildings received attic insulation (75 percent). However, the maximum savings impact would be observed only in buildings where no attic insulation existed prior to weatherization (24 percent of the buildings that received attic insulation). For other buildings that received attic insulation, the savings would vary depending on the amount of insulation that was added to bring the building up to the targeted insulation R-value. With respect to equipment, the highest savings would be expected when the equipment replacement can be justified as an energy measure (i.e., where inefficient equipment is replaced with equipment that has a much higher efficiency rating). There may be no energy savings if equipment is replaced because of health and safety problems. Table 4 shows that about 31 percent of buildings had a furnace replacement and that in over 80 percent, the replacement was justified as an energy efficiency measure and could be expected to deliver the maximum energy savings.

[2] Cubic Feet per Minute @ 50 Pascals (CFM). The average for units in small multifamily buildings are higher than those for single family homes, but those differences do not necessarily mean that small multifamily units are leakier than single family homes. The blower door readings for small multifamily buildings are often conducted for the individual unit rather than for the whole building. Since each unit in a small multifamily building is likely to the share an interior wall with other units, the reading for the unit does not just measure the leakage from the unit to the exterior of the building, but also includes leakage between the unit and the interior of the building. Therefore, a small multifamily unit that has a higher leakage rate than a single family home may not have a higher usage than the single family home if the main source of leakage is to the building rather than to the exterior.

Table 4. Major Measure Installation Rates for Small Multifamily Buildings Served by WAP in PY 2008

Measure	Rate for Single Family	Rate for Small Multifamily	Highest Expected Energy Impact
Bypass Air Sealing	79%	84%	w/Blower Door=81%
Attic Insulation	70%	75%	None Existing=24%
Wall Insulation	29%	38%	Dense Pack=21%
Other Insulation	36%	36%	Floor Insulation=44%
Furnace Replacement	22%	31%	Energy Measure=81%
Water Heater Replacement	9%	16%	Energy Measure=25%
Refrigerator	12%	32%	Energy Measure=88%

Gas and Electric Savings in Gas Heated Buildings

The evaluation directly measured gas and electric usage for treatment group and comparison group buildings that use natural gas main heating fuel. Gross program savings were estimated by comparing pre-weatherization usage (weather-normalized) to the post-weatherization usage (weather-normalized) for buildings treated during PY 2008. Net program savings were estimated by comparing the savings for treatment group buildings to the savings for comparison group buildings.[3] Table 5 shows that the gross gas savings for gas heated small multifamily buildings in PY 2008 were 199 therms[4]. During the same period, the comparison group (PY 2009 clients) reduced their usage by 38 therms without receiving any treatments, so net savings due to the program are 161 therms (17.4%). The percent savings for small multifamily buildings were similar to the percent savings for single family homes (17.4% vs. 17.8%). Small multifamily buildings saved about 10 percent fewer therms of gas per unit because they were smaller and had lower pre-weatherization gas usage.

Table 5. PY 2008 WAP Energy Impacts for Small Multifamily Buildings Gross and Net Gas Savings Per Unit (therms*/unit/year)

Group/Breakout	# of Accounts	Use Pre-WAP	Use Post-WAP	Gross Savings	Net Savings per Unit	% of Pre
Treatment Group	283	926	726	200	161 (±28)	17.4% (±3.0%)
Comparison	222	933	894	39		

*100,000 British Thermal Units

Since the buildings treated by WAP are quite variable in terms of their pre-weatherization condition, each building receives a different set of measures and has a different level of savings. Tabular analysis and regression models were used to identify the factors associated with higher savings. It found that savings were higher for:

- Buildings that received more major energy efficiency measures (Table 6).

[3] The comparison group includes buildings treated by WAP during PY 2009. The analysis estimates the year-over-year change of these households in the two years prior to delivery of WAP services.
[4] 100,000 British Thermal Units

- Buildings with higher pre-weatherization gas usage (Table 7).

Table 6 shows the estimated energy savings for buildings grouped by whether wall insulation and/or furnace replacements were installed. The analysis was limited to these two major measures because of the limited sample size for analysis. Other combinations of other major measures such as major air sealing, attic insulation, and floor/foundation insulation also would be expected to show differential levels of savings.

Table 6. PY 2008 WAP Energy Impacts for Small Multifamily Buildings Gas Savings for Buildings with Natural Gas Main Heat By Measure Combination (therms/unit/year)

Group/Breakout	# Buildings	Gas Use Pre-WAP	Net Savings per Unit	% of Pre
No Wall Insulation or Heater Replacement	96	820	45	5.4% (±4.2%)
Yes Wall Insulation / No Heater Replacement	53	1,106	158	14.3% (±7.6%)
No Wall Insulation / Yes Heater Replacement	52	1,007	197	19.5% (±7.9%)
Wall Insulation and Heater Replacement	82	890	278	31.2% (±2.1%)

Table 7 shows that energy savings increase substantially when buildings have higher pre-weatherization usage. The highest-usage buildings saved over 300 therms of natural gas in the first year post-weatherization. The moderate-use buildings (600 to 1,000 therms per unit) got substantial percent reductions of gas usage, even higher than the highest-usage buildings, but saved fewer than 200 therms of natural gas per unit.

Table 7. PY 2008 WAP Energy Impacts for Small Multifamily Buildings
Net Gas Savings for Natural Gas Main Heat by Pre-Weatherization Gas Usage (therms/unit/year)

Pre-WAP Gas Use (therms/unit/year)	# Buildings	Gas Use Pre-WAP	Net Savings per Unit	% of Pre
Gas Use < 600 therms/unit/year	165	441	46	10.5% (±2.3%)
Gas Use 600-1,000 therms/unit/year	315	770	190	24.6% (±2.0%)
Gas Use >=1,000 therms/unit/year	231	1,518	311	20.5% (±2.1%)

*Note – Comparison group, not shown, was also stratified by usage.

Savings were higher in the Very Cold Climate Zone (Table 8). While pre-weatherization usage per unit was higher in the Cold Climate Zone, buildings in the Very Cold Zone got more measures and had higher savings than those in the Cold Zone.

Table 8. PY 2008 WAP Energy Impacts for Small Multifamily Buildings
Net Gas Savings for Natural Gas Main Heat by Climate Zone (therms/unit/year)

Climate	# Buildings	Gas Use Pre-WAP	Net Savings per Unit	% of Pre
Very Cold	118	929	265 (±60)	28.5% (±6.4%)
Cold	147	1,029	96 (±48)	9.4% (±4.6%)

*Note – Comparison group, not shown, was also stratified by climate zone.

Weatherization of gas heated buildings also can result in savings of electricity. Air sealing and insulation can reduce the use of a furnace fan in the winter and demand for air conditioning in the summer. In addition, many WAP buildings also have baseload measures such as refrigerators and energy efficient lights installed. Table 9 shows that the gross electric savings for gas heated buildings in PY 2008 was 326 kWh and the net savings was estimated to be 412 kWh (7.2%).

Table 9. PY 2008 WAP Energy Impacts for Small Multifamily Buildings
Gross and Net Electric Savings Per Unit for Natural Gas Main Heat by End Use

Usage Component	# Buildings	Elec Use Pre-WAP	Elec Use Post-WAP	Gross Savings	Net Savings per Unit	% of Pre
Treatment Group	267	5,710	5,384	326	412 (±183)	7.2% (±3.2%)
Comparison	223	5,623	5,708	-85		

Projected Energy Savings

The overall goal of the evaluation is to project total energy savings and energy savings per unit for the PY 2008 WAP program. While the measured savings statistics furnish valuable information, they do not furnish direct estimates for the WAP population. A series of analysis procedures were used to develop savings estimates for the population of households served by WAP.

The starting point for the analysis was to compare measured energy savings for single family homes to measured energy savings for small multifamily buildings. The analysis showed that savings results for small multifamily buildings were consistent with savings for single family homes after adjusting for heating degree days (HDD) and floor area. A small multifamily savings adjustment factor was developed by comparing the projected savings from the single family gas heat explanatory factors model to the actual savings for the analysis sample of gas heated small multifamily buildings. After estimating that factor, the following procedures were used to estimate energy savings for all treated buildings for which data were collected.

- Gas Main Heat – Energy savings were estimated for each building with data on installed measures using the adjusted single family savings model for gas heated buildings.

- Electric Main Heat – Only 20 percent of small multifamily buildings have electric main heat. Electricity data were collected for these buildings, but only 43 buildings had valid data that could be used for analysis. Those sample sizes are too small to furnish reliable energy savings estimates. Energy savings were estimated for each home with data on installed measures using the single family savings model for electric heated buildings with the small multifamily home adjustment factor developed for gas heated buildings.

- Delivered Fuel Buildings – The evaluation included a field study in which single family homes with delivered fuels were metered to directly measure energy savings. By comparing the modeled estimates of energy savings using the gas heat single family home model with the metered estimates of delivered fuel energy savings, it was determined that the gas heat explanatory factors model could be used to represent the savings for buildings with delivered fuel main heat. For small multifamily buildings with delivered fuel main heat, the same procedures were applied as for small multifamily buildings with gas main heat.

Table 10 summarizes the small multifamily analysis estimates of savings by heating fuel for the entire national participant population.

Table 10. PY 2008 WAP Energy Impacts for Small Multifamily Buildings
Net Savings Per Unit by Main Heating Fuel

Main Heating Fuel	Number of Units	Heating Fuel Savings (MMBtu*/unit/year)	Electric Savings (kWh/unit/year)
Natural Gas	3,578	16.0	548
Fuel Oil	506	16.1	220
Propane	98	11.6	514
Other	15	19.7	161
Electricity	1,120	n/a	1,683
All Fuels	5,317	12.5	754

***** Mean Million British Thermal Units

Program Energy Cost Savings and Cost-Effectiveness

The evaluation estimated the cost savings and cost-effectiveness in the following way:

- Energy Savings – The time series of energy savings were estimated for each sampled housing unit based on first year savings and the estimated life of the measure.

- Cost Savings – Current and projected energy prices were used to transform the energy savings time series to a cost savings time series for each sampled housing unit.

- Service Delivery Costs – Subgrantees furnished information on the service delivery costs for each sampled housing unit.

- Cost-Effectiveness – Program cost-effectiveness was estimated by comparing the net present value of energy savings to the service delivery costs for energy measures.

The analysis is this report is restricted to a comparison of the energy benefits to the service delivery costs for energy measures and incidental home repairs. The overarching impact report will compare energy and non-energy benefits to total program costs.

This report presents information on energy savings for PY 2008. In this report, the energy cost savings and cost-effectiveness are presented from three different perspectives.

- Impact on PY 2008 Clients – The first scenario documents how the program impacted PY 2008 clients. It shows the clients' first year energy cost savings based on actual energy prices in 2008

and the estimated net present value of their energy cost savings based on actual energy prices for 2008 through 2012, projected energy prices beginning in 2013, and the discount rates in effect in 2008.

- PY 2013 Analysis Perspective – The second scenario is the most relevant to analysts making use of this report at the time of publication. It shows the energy cost savings and cost-effectiveness of a program implemented in PY 2013 using energy price projections beginning in 2013, and the discount rates in effect in 2013.

- Long Term Analysis Perspective – The third scenario is useful for longer-term program decision-making. It shows the energy cost savings and cost-effectiveness of a program using energy price projections beginning in 2013, and long-term average discount rates.

Each of these three scenarios is useful for understanding the program from a different perspective. However, the PY 2008 Client Perspective is the most useful for documenting what the program accomplished while the PY 2013 Analysis Perspective is probably the most useful for policymakers making decisions about the program going forward. Tables 12 and 13 reflect the assumptions under the PY 2008 Client Perspective and Tables 14 and 15 reflect the assumptions under the PY 2013 Analysis Perspective.

Table 11 shows the estimated average annual energy costs and first year cost savings for PY 2008 clients by main heating fuel type. On average, WAP clients had pre-weatherization energy bills of $$1,657 and energy savings of $231 (13.9%). The cost savings for fuel oil and propane heated homes is expected to be almost two times the cost savings for homes heating with other fuels. Though energy savings do not vary much across main heating fuel types, the cost per unit of energy for fuel oil and propane is more than twice the cost per unit for natural gas.

Table 11. PY 2008 WAP Energy Impacts for Small Multifamily Homes Energy Costs and Cost Savings by Main Heating Fuel (2008 Dollars)

	Annual Energy Costs			Annual Savings (first year)			
Heating Fuel	**Fuel**	**Electric**	**Total$**	**Fuel**	**Electric**	**Total$**	**% Savings**
Natural Gas	$935	$645	$1,580	$162	$62	$224	14.1%
Electricity	$0	$1,205	$1,205	$0	$170	$170	14.1%
Fuel Oil	$2,143	$757	$2,900	$357	$32	$389	13.4%
Propane	$2,458	$796	$3,254	$304	$64	$368	11.3%
Other	$925	$569	$1,493	$172	$19	$191	12.8%
All Clients	$881	$776	$1,657	$149	$82	$231	13.9%

Table 12 furnishes a projection of the energy cost-effectiveness of the program for small multifamily homes. It compares the net present value of lifetime energy cost savings to the energy measure costs to calculate the savings to investment ratio (SIR) by main heating fuel. The SIR is estimated to be 1.36 for the overall program and is greater than 1.0 for all main heating fuel types. However, because of the much higher cost savings for homes heated with fuel oil or propane, the SIR is much higher for those heating fuel types.

Table 12. PY 2008 Energy WAP Impacts for Small Multifamily Buildings
Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Main Heating Fuel
(2008 Dollars)

	Energy Cost Savings per Unit (present value of lifetime savings)			Costs & Cost Effectiveness		
Heating Fuel	Fuel	Electric	Total	Measure Costs	Net Benefits	Savings/ Investment Ratio
Natural Gas	$2,655	$650	$3,304	$2,877	$427	1.15
Electricity	-	$2,432	$2,432	$2,208	$224	1.10
Fuel Oil	$7,573	$294	$7,867	$2,121	$5,746	3.71
Propane	$5,255	$700	$5,955	$2,169	$3,786	2.75
Other	$3,881	$139	$4,020	$2,448	$1,572	1.64
All Clients	$2,615	$991	$3,606	$2,645	$961	1.36

Table 13 shows the projected average annual energy costs and first year cost savings for PY 2013 clients by main heating fuel type. On average, WAP clients would be projected to have pre-weatherization energy bills of $1,572 and first year energy savings of $211 (13.5%). When compared to the PY 2008 energy cost savings, Table 13 shows that the projected energy cost savings for a program implemented in PY 2013 are lower than the energy cost savings experienced by clients served in 2008 because the prices of natural gas and propane are lower in 2013 than they were in 2008.

Table 13. PY 2008 WAP Energy Impacts for Small Multifamily Homes Energy Costs and Cost Savings by Main Heating Fuel (2013 Dollars)

	Annual Energy Costs			Annual Savings (first year)			
Heating Fuel	Fuel	Electric	Total$	Fuel	Electric	Total$	% Savings
Natural Gas	$739	$682	$1,421	$127	$63	$190	13.4%
Electricity	$0	$1,254	$1,254	$0	$176	$176	14.0%
Fuel Oil	$2,321	$785	$3,105	$387	$33	$420	13.5%
Propane	$1,968	$835	$2,804	$243	$68	$311	11.1%
Other	$1,006	$607	$1,613	$187	$20	$207	12.8%
All Clients	$757	$815	$1,572	$127	$84	$211	13.5%

However, Table 14 shows that, despite the lower first year projected energy savings for PY 2013 WAP clients, the net present value of those energy cost savings are higher because the specified discount rate for Fiscal Year (FY) 2013 is lower than the specified discount rate for FY 2008; a lower discount rate means that future energy cost savings have a higher net present value. Using the PY 2013 assumptions, the SIR is estimated to be 1.60 for the overall program, somewhat higher than the SIR of 1.36 experienced by the clients served by the PY 2008 program. Despite lower projected energy costs, investments in weatherization have a higher economic value because of the lower discount rate.

Table 14. Projected PY 2013 WAP Energy Impacts for Small Multifamily Buildings
Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Main Heating Fuel
(2013 Dollars)

	Energy Cost Savings per Unit (present value of lifetime savings)			Costs & Cost Effectiveness		
Heating Fuel	**Fuel**	**Electric**	**Total**	**Measure Costs**	**Net Benefits**	**Savings/ Investment Ratio**
Natural Gas	$3,410	$788	$4,199	$3,131	$1,068	1.34
Electricity	-	$3,027	$3,027	$2,402	$625	1.26
Fuel Oil	$10,209	$347	$10,556	$2,307	$8,249	4.58
Propane	$6,574	$850	$7,424	$2,359	$5,064	3.15
Other	$4,849	$162	$5,011	$2,663	$2,348	1.88
All Clients	$3,401	$1,217	$4,618	$2,878	$1,741	1.60

1. INTRODUCTION

The purpose of this report is to disseminate the findings from an analysis of the energy savings, cost savings, and cost-effectiveness for small multifamily buildings treated by U.S. Department of Energy's (DOE) Weatherization Assistance Program (WAP) during Program Years (PY) 2007, 2008, and 2009. The main focus of this study is on PY 2008. The analysis uses data from a number of sources to characterize the population of small multifamily buildings that were served by the program, estimate the gross and net change in energy usage for treated buildings, make projections for the first year and longer-term cost savings associated with the energy savings, and assess the cost-effectiveness of the program in terms of direct energy benefits.

This is one of a number of impact reports developed for the National WAP Evaluation. The full set of reports includes:[5]

- Energy Impacts for Mobile Homes
- Energy Impacts for Single Family Homes
- Energy Impacts for Small Multifamily Buildings
- Energy Impacts for Large Multifamily Buildings
- Nonenergy Impacts (Environmental, Economic, and Health and Household Benefits) of the Weatherization Assistance Program

To the extent possible, WAP applies consistent procedures across all clients. However, there are substantial differences in energy equipment, building configuration, and retrofit opportunities across building types. By furnishing reports for each building type, the evaluation is able to give policymakers an understanding of the specific challenges associated with maximizing energy impacts from each building type. The summary report then furnishes comprehensive information on the program's energy and nonenergy impacts.

1.1 NATIONAL WEATHERIZATION ASSISTANCE PROGRAM EVALUATION OVERVIEW

WAP was created by Congress in 1976 under Title IV of the Energy Conservation and Production Act. The purpose and scope of the Program as currently stated in the Code of Federal Regulations (CFR) 10 CFR 440.1 is "to increase the energy efficiency of dwellings owned or occupied by low-income persons, reduce their total residential energy expenditures, and improve their health and safety, especially low-income persons who are particularly vulnerable such as the elderly, persons with disabilities, families with children, high residential energy users, and households with high energy burden." (*Code of Federal Regulations, 2011*)

At the request of DOE, Oak Ridge National Laboratory (ORNL) developed a comprehensive plan for a national evaluation of WAP that was published in 2007.[6] DOE furnished funding to ORNL in 2009 for a national evaluation for PY 2007 and PY 2008, with a particular emphasis on PY 2008. ORNL subcontracted evaluation research to APPRISE Incorporated and its partners (the Energy Center of

[5] These and other reports produced by the evaluation can be found at http://weatherization.ornl.gov

[6] See Ternes, M., Schweitzer, M., Tonn, B., Schmoyer, R., and Eisenberg, J. 2007. National Evaluation of the Department of Energy's Weatherization Assistance Program (WAP): Program Year 2006 Experimental Plan. ORNL/CON-498, Oak Ridge National Laboratory, Oak Ridge, TN, February.

Wisconsin, Michael Blasnik and Associates, and Dalhoff Associates LLC). The Scope of Work (SOW) for the evaluation includes the following components:

- Impact Assessment – Characterization of the weatherization network and the households that are income-eligible for WAP, measurement and monetization of the energy and nonenergy impacts of the program, and assessment of the factors associated with higher levels of energy savings, cost savings, and cost-effectiveness.

- Process Assessment – Direct observation of how the weatherization network delivers services and assessment of how service delivery compares to national standards and documentation of how weatherization staff and clients perceive service delivery.

- Special Technical Studies – Examination of the performance of the program with respect to technical issues such as air sealing, duct sealing, furnace efficiency, and refrigerators.

- Synthesis Study – Synthesis of the findings from this evaluation into a comprehensive assessment of the success of the program in meeting its goals and identification of key areas for program enhancement.

This analysis of multifamily building energy impacts is part of the program Impact Assessment.

1.2 SMALL MULTIFAMILY BUILDING STUDY OVERVIEW

This report furnishes information on how housing units in small multifamily buildings were served by WAP in PY 2008. This analysis is complex because weatherization of a small multifamily building can vary on several dimensions:

Energy Equipment – Some buildings have centralized energy equipment (e.g., one heating system for all units in the building) while others have energy equipment for each unit (e.g., electric baseboard heater for each unit).

Air Sealing and Insulation – In some buildings, the program can seal and insulate individual housing units (i.e., apartments) while in others the entire building must be treated as an integrated system for air sealing and insulation.

Common Areas – In some buildings, there are significant common areas including lobbies, stairways, and hallways. In other buildings, each housing unit has direct access to the outside and there are no common areas.

As a result, program resources are sometimes focused on building-level measures, at other times are restricted to unit-level measures, and often include both types of measures. This report documents the number of housing units in small multifamily buildings that were served by the program, furnishes statistics on the weatherization measures installed at the unit and building levels, estimates unit-level and building-level energy savings, and assesses the cost-effectiveness of installed measures.

National Sample of Weatherized Housing Units

At the national level, the evaluation team collected information on all types of weatherized housing units from a representative sample of subgrantees (i.e., local weatherization agencies). Data for the national sample of multifamily buildings analyzed in this report were collected are part of that process. The data collection and analysis included:

- Building and Housing Unit Sample – The evaluation team worked with grantees and subgrantees to select a representative sample of weatherized buildings served by the program in PYs 2007, 2008, and 2009. When a sampled building was determined to be a small multifamily building, the data collection process included development of a list of qualified housing units in each building.

- Diagnostics and Measures – Subgrantees supplied information on diagnostic tests conducted, installed measures, and measure costs for a sample of buildings and units that were treated by WAP.

- Energy Data Collection – The evaluation team collected information from energy suppliers to assess the amount of energy used at the building level and unit level before and after the installation of weatherization measures.

- Energy Data Analysis - Statistical procedures were used to develop normalized estimates of the differences in usage in the pre- and post-weatherization periods and develop estimates of the net energy impacts associated with service delivery.

- Energy Cost Savings and Cost-Effectiveness Analysis – The evaluation team collected energy price data and projections, transformed energy savings into cost savings, and estimated measure cost-effectiveness.

This combined set of procedures was designed to furnish national estimates of the energy and cost impacts associated with WAP, to identify the explanatory factors associated with higher levels of energy impacts, and to assess the cost-effectiveness of individual measure packages and the overall program.

Climate Zone Analysis Framework

The study assessed whether there were important differences in energy impacts, cost savings, and cost effectiveness by Climate Zone. Throughout the report, tables furnish results by Climate Zone. Figure 1.1 shows how states were assigned to Climates Zones for purposes of this study.

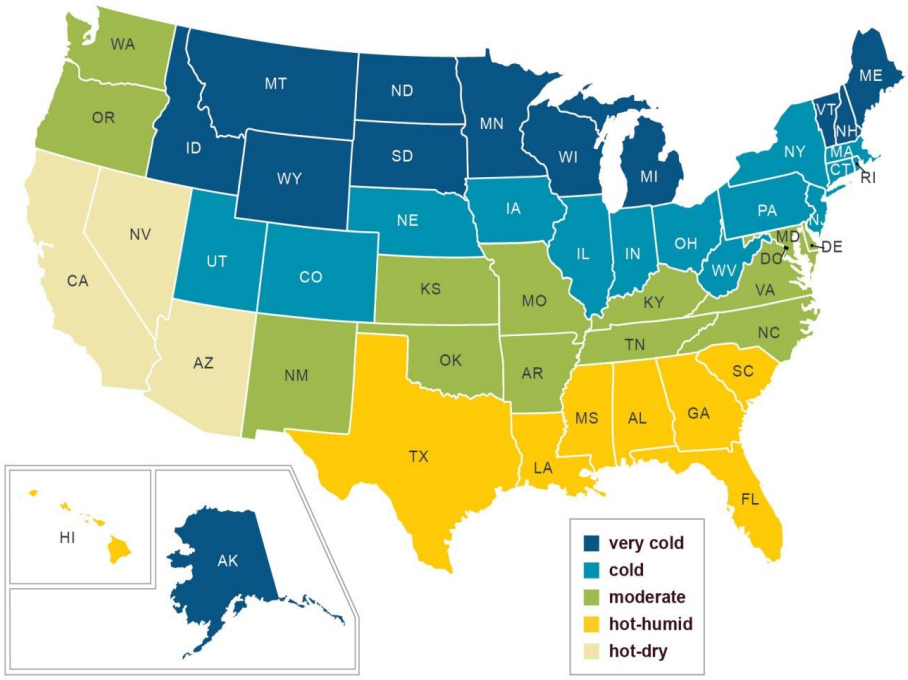

Figure 1.1. Climate Zone Map for the PY 2008 Evaluation

1.3 ORGANIZATION OF THE SMALL MULTIFAMILY IMPACT REPORT

The report consists of five sections, including:

- Section 1 - Introduction: Furnishes an overview of the WAP Evaluation and the evaluation of small multifamily buildings.

- Section 2 – Overview of Data Collection Methodology: Documents the data sources that were used to conduct the study and prepare this report.

- Section 3 – Program Production, Housing Unit Characteristics, and Installed Measures: Furnishes information on the number and distribution, building and housing unit characteristics, pre-weatherization conditions, installed measures, and post-weatherization conditions for small multifamily buildings served by WAP.

- Section 4 – Energy Usage Impacts: Furnishes estimates of the energy savings and the determinants of energy savings for small multifamily buildings served by the program.

- Section 5 – Cost Savings, Measure Costs, and Cost-Effectiveness: Furnishes estimates of the cost savings and cost-effectiveness for small multifamily buildings served by the program.

This report is designed to complement other Energy and Nonenergy Impact Reports.

2. OVERVIEW OF DATA COLLECTION METHODOLOGY

The purpose of the small multifamily building energy impact study is to measure the energy savings, cost savings, and cost effectiveness for small multifamily buildings treated by WAP during PYs 2007, 2008, and 2009. The main focus of the study is on PY 2008. The study used data from a number of sources, including:

- Grantees (i.e., States)
- Subgrantees (i.e., Local Agencies)
- Electric and Gas Utilities
- Delivered Fuel Submeter Studies
- U.S. Energy Information Administration (EIA) Energy Price Data and Projections
- U.S. National Climatic Data Center (NCDC) Weather Data

This section of the report describes the data collection procedures and outcomes for grantees, subgrantees, and electric and gas utilities.

2.1 SUBGRANTEE AND BUILDING/CLIENT SAMPLE

The first step in the data collection process was to select a representative sample of buildings and clients served in PY 2007, 2008, and 2009. The evaluation used a two-stage sampling procedure. In the first stage, a sample of subgrantees was selected. In the second stage, a sample of buildings and clients was selected from sampled subgrantees.

2.1.1 Subgrantee Sampling Procedures

The ORNL Evaluation Team selected a sample of 400 agencies with probability proportionate to size. The measure of size was planned program funding for PY 2008. The sampling procedure involved the following steps:

- Grantee Allocation – Each grantee was allocated a share of the sample of 400 subgrantees based on its share of PY 2008 program funding.

- Subgrantee Sample – For each grantee, a set of subgrantees was sampled with probability proportionate to size based on PY 2008 planned program funding.

The outcome of this procedure was that states with higher WAP funding had more sampled subgrantees and the larger subgrantees had a higher probability of selection. These procedures furnished a representative and statistically efficient sample of clients.

2.1.2 Building/Client Sampling Procedures

The APPRISE Evaluation Team contacted each of the sampled agencies to get information on the buildings and clients served in PYs 2007, 2008, and 2009. The sampling procedures involved the following steps:

- Building/Client List – Each subgrantee furnished a list of buildings weatherized for PYs 2007, 2008, and 2009.

- Building/Client Sample – Subgrantees' lists were stratified into two groups, utility main heat (i.e., electric or natural gas) and delivered fuel main heat (i.e., fuel oil, propane, wood, or coal). Sampling procedures selected one-third of the buildings in the utility main heat stratum and one-fourth of the buildings in the delivered fuel main heat stratum; for each subgrantee a minimum of 7 buildings was selected for each fuel group for each year.[7]

- Client Information – As part of the data collection process, information was collected for each eligible client in a weatherized building. For single family site built homes and mobile homes, there was only one client listed per building. However, for multifamily buildings, there often was more than one eligible client listed for the building.

2.1.3 Subgrantee and Client Sampling Statistics and Response Rates

The ORNL Evaluation Team selected a census of 51 grantees and a sample of 400 subgrantees. The following statistics describe the sample and the response rates.

- Grantees
    - Population - 51 grantees received WAP funding in PY 2008.
    - Census - All 51 grantees were included in the sample.
    - Response - All 51 grantees responded to information requests (100%).

- Subgrantees
    - Population
        - 905 subgrantees were listed in grantee plans for PY 2008.
        - 879 subgrantees received WAP funding in PY 2008.
    - Sample
        - 400 of 905 subgrantees were sampled.
        - 395 of 879 funded subgrantees were sampled.

- Response – 379 of 395 funded subgrantees furnished a list of buildings (96%).

Not all subgrantees reported that they weatherized small multifamily buildings. This evaluation defines small multifamily buildings as those with 2-4 housing units. However, since DOE defines buildings with 1-4 housing units as single family, some grantees only asked their subgrantees to categorize weatherized buildings as mobile homes, single family (1-4 units), or multifamily (5 or more units). Of the 379 funded subgrantees that furnished a list of buildings and clients, 212 subgrantees in 35 states reported that they weatherized small multifamily buildings in PY 2008.

For the national sample, the Evaluation Team selected a sample of 22,134 PY 2008 clients from the 379 funded subgrantees that furnished a list of clients. That sample included 1,171 small multifamily buildings with 2,168 clients.

[7] The initial specifications called for sampling 25 percent of treated units. That is the number of units that was needed to furnish statistically robust estimates of the households and housing units served by the program and the measures installed by WAP. The sampling rate was increased for homes heated with natural gas and electricity to account for the attrition in available usage data; the evaluation needed to start with a larger number of homes so that the sample size after attrition would be sufficient to furnish statistically reliable results of energy usage impacts.

2.2 SUBGRANTEE DATA COLLECTION

Subgrantees were asked to furnish two kinds of client data to support the evaluation, utility account information and service delivery data.

2.2.1 Utility Account Information

Subgrantees were asked to furnish main heating fuel, utility account numbers, and copies of data release waivers for sampled buildings and clients that heated with either natural gas or electricity. For small multifamily buildings, this was more complex than for other building types because several different kinds of accounts may need to be collected to accurately track all of the energy used in the building. Some small multifamily buildings have master meter accounts for all building uses, others have master meter accounts for centralized heating and common areas but electric accounts for each unit, and for some all energy accounts are at the unit level. The utility account data collection needed to be tailored to the account configuration in each building.

The following statistics describe the response rate to the overall utility account data request:

- Sample – 395 funded subgrantees were asked to furnish a list of clients.
- Client List Response – 379 of 395 funded subgrantees furnished a list of clients (96%).
- Utility Data Response – 368 of 395 funded subgrantees furnished utility account information for sampled clients (93%).

The following statistics describe the response rate for small multifamily buildings:

- Sample – The Evaluation Team selected a sample of 1,008 PY 2008 small multifamily buildings with natural gas or electric main heat from the 212 funded subgrantees that reported having small multifamily buildings and furnished client lists.
- Responding Subgrantees – Of the 212 subgrantees that reported weatherizing small multifamily buildings, 191 responded to the utility data request. These subgrantees had 971 of the 1,008 small multifamily buildings in the sample (96%).
- Main Heating Supplier – The 191 subgrantees that responded furnished the heating energy supplier information for 869 of their 971 small multifamily buildings (89%).
- Electric Data Supplier – The 191 subgrantees that responded furnished electric supplier information for 837 of their 971 small multifamily buildings at either the building level or the housing unit level (86%).

Some subgrantees collected supplier information only for the main heating fuel and did not collect information for the client's electric company if it was not the main heating fuel. Some subgrantees collected common area electric account information. Some subgrantees collected unit-level account information.

2.2.2 Client Service Delivery Data

Subgrantees were asked to furnish service delivery information for all PY 2008 sampled buildings. The requested service delivery data included:

- Housing unit characteristics
- Pre-weatherization conditions
- Installed measures and costs
- Post-weatherization conditions

The following statistics describe the response rate to this data request for small multifamily buildings:

- Building Lists – 212 funded subgrantees reported that they weatherized small multifamily buildings.
- Service Delivery Data Response – 182 of the 212 subgrantees that weatherized small multifamily buildings furnished service delivery data (86%).

The following statistics describe the response rate in terms of buildings:

- Sample – The Evaluation Team selected a sample of 1,171 PY 2008 small multifamily buildings from the subgrantees that weatherized this type of building.
- Building Data – The subgrantees that responded furnished service delivery data for 982 of the 1,171 small multifamily buildings (84%).
- Housing Units – The buildings for which service delivery data were furnished included 1,798 of the 2,168 housing units in sampled small multifamily buildings (83%).

Overall, the agencies furnished service delivery data for a large share of the small multifamily buildings and the housing units in small multifamily buildings.

2.3 NATURAL GAS AND ELECTRIC USAGE DATA COLLECTION

For all sampled clients that heated with either natural gas or electricity, the evaluation team requested data from the company that supplied the client's main heating fuel - natural gas or electricity. The supplier was asked to furnish monthly data for the period January 1, 2006 through December 31, 2010.

The following statistics describe the response rates for small multifamily buildings:

- Natural Gas or Electric Main Heating Fuel
    - Companies – 106 natural gas and electric companies were identified for one or more sampled PY 2008 small multifamily buildings.
    - Company Response – 74 of the 106 companies furnished data for one or more of the sampled buildings (70%).
    - Building Response – Data were received for 656 of the 1,171 sampled PY 2008 small multifamily buildings (56%).
- Electric Usage for Natural Gas Main Heat Clients

- Companies – 86 electric companies were identified as the electric supplier for one or more PY 2008 small multifamily buildings that heat with natural gas.

- Company Response – 59 of the 86 electric companies furnished data for one or more of the sampled buildings (69%).

- Building Response – Data were received for 671 of the 1,171 sampled PY 2008 small multifamily buildings (57%).

- Housing Unit Response – Unit-level electric data were received for 1,039 of the 2,168 in those buildings (48%).

These statistics furnish information on clients for whom *any* data were furnished. Not all usage records were adequate for all parts of the billing analysis procedures.

3. PROGRAM PRODUCTION, HOUSING UNIT CHARACTERISTICS, AND INSTALLED MEASURES

This section of the report uses detailed service delivery data furnished by the sampled subgrantees to characterize the population of housing units served by the program, including:

- Geographic Distribution of Treated Buildings
- Housing Unit Characteristics
- Pre-Weatherization Conditions
- Installed Measures
- Post-Weatherization Conditions

This report focuses on characterizing small multifamily buildings. Since one important purpose of this analysis is to assess how weatherization of small multifamily buildings is similar to or different from weatherization of single family homes, small multifamily statistics are compared to those for single family homes.

3.1 WAP PRODUCTION – ALL HOUSING UNIT TYPES

The primary data source for this section of the report was data furnished by subgrantees for a sample of buildings. In total, 365 subgrantees furnished detailed information for 19,496 housing units that were served by WAP in PY 2008, including 1,798 housing units in 982 small multifamily buildings (2-4 units). Table 3.1 shows the number of sampled housing units by Climate Zone and Table 3.2 shows the number of sampled housing units by type.

Table 3.1. PY 2008 Sampled Housing Units by Climate Zone

Climate Zone	PY 2008 Sampled Housing Units	Percent of PY 2008 Sample
Very Cold Climate	5,340	27%
Cold Climate	10,539	54%
Moderate Climate	2,464	13%
Hot/Humid Climate	623	3%
Hot/Dry Climate	530	3%
TOTAL	19,496	100%

Table 3.2. PY 2008 Sampled Housing Units by Type

Housing Unit Type	PY 2008 Sampled Units	Percent of PY 2008 Sample
Single Family Site Built	10,340	53%
Single Family Mobile Home	2,826	15%
Small Multifamily (2-4)	1,798	9%
Large Multifamily (5+)	4,532	23%
TOTAL	19,496	100%

The sample of clients supplied by WAP subgrantees was weighted to account for client-level sampling rates and to adjust for survey nonresponse. The weighting procedures included the following steps:

- Base Weight – Each sampled housing unit was assigned a base weight that was the inverse of the client's probability of selection.

- State-Level Adjustment – For each state, the housing unit weights were adjusted to match state production control totals by housing unit type.

Applying the adjusted case weights allows one to estimate the total number of housing units served by WAP by Climate Zone and Housing Unit Type. Table 3.3 shows the weighted count of WAP housing units by Climate Zone; it shows that 68 percent of the weatherized units were in the Very Cold and Cold Climate Zones. Table 3.4 shows the weighted count of WAP units by Housing Unit Type; it shows that small multifamily buildings were 5 percent of the units weatherized in PY 2008.

Table 3.3. PY 2008 Weighted Housing Units by Climate Zone

Climate Zone	PY 2008 Weighted Count of Units	Percent of PY 2008 Units
Very Cold Climate	24,749	25%
Cold Climate	42,233	43%
Moderate Climate	18,794	19%
Hot/Humid Climate	6,390	7%
Hot/Dry Climate	5,799	6%
TOTAL	97,965	100%

Table 3.4. PY 2008 Weighted Clients by Housing Unit Type

Housing Unit Type	PY 2008 Weighted Count of Clients	Percent of PY 2008 Clients
Single Family Site Built	57,518	59%
Single Family Mobile Home	17,754	18%
Small Multifamily (2-4)	5,317	5%
Large Multifamily (5+)	17,376	18%
TOTAL	97,965	100%

The distribution of the housing unit types weatherized varies somewhat by Climate Zone. Table 3.5 shows the weighted percent of units in each Climate Zone by housing unit type. The Very Cold Climate Zone reported the largest percent of small multifamily buildings. Very few small multifamily buildings were reported in the Moderate and Hot/Dry Climate Zones.

Table 3.5. PY 2008 Weighted Clients by Climate Zone and Housing Unit Type

Climate Zone	Single Family	Mobile Home	Small Multifamily	Large Multifamily	All Housing Unit Types
Very Cold Climate	58%	19%	9%	14%	100%
Cold Climate	57%	14%	6%	24%	100%
Moderate Climate	65%	27%	1%	7%	100%
Hot/Humid Climate	70%	17%	6%	7%	100%
Hot/Dry Climate	43%	19%	1%	36%	100%
TOTAL	59%	18%	5%	18%	100%

3.2 WAP PRODUCTION – SMALL MULTIFAMILY BUILDINGS

DOE program statistics do not furnish information on the number of small multifamily weatherization jobs; grantees are asked to report on the number of mobile homes, site built buildings (i.e., 1-4 unit buildings), and multifamily buildings (i.e., building with 5 or more units). However, since a small multifamily building presents different challenges than does a single family site built home, many grantees and subgrantees track the number of small multifamily buildings. Further, the ORNL Evaluation Plan specified that the evaluation should develop separate estimates of energy impacts for single family homes and small multifamily buildings. The evaluation data collection forms asked those subgrantees that do segment single family and small multifamily buildings to report on them separately.

Table 3.6 shows the distribution of small multifamily units by climate zone. Almost all of the 5,317 treated small multifamily units reported by subgrantees were in the Very Cold and Cold Climate Zones. Table 3.7 shows that close to two-thirds of all small multifamily buildings were reported by Wisconsin, Ohio, New York, Illinois, and Massachusetts. It is not clear whether grantees in other program do not weatherize small multifamily buildings or simply report them as “site built buildings” since those are the reporting procedures specified by DOE for WAP grantees. This report can only furnish data for those small multifamily buildings that were reported by grantees and subgrantees.

Table 3.6. PY 2008 WAP Weighted Clients in Small Multifamily Units by Climate Zone

Climate Zone	PY 2008 Units	Percent of PY 2008 Units
Very Cold Climate	2,264	43%
Cold Climate	2,368	44%
Moderate Climate	226	4%
Hot/Humid Climate	405	8%
Hot/Dry Climate	54	1%
TOTAL	5,317	100%

Table 3.7. PY 2008 WAP Weighted Clients in Small Multifamily Units by State

State	PY 2008 Units	Percent of PY 2008 Units
Wisconsin	1,493	28%
Ohio	606	11%
New York	514	10%
Illinois	483	9%
Massachusetts	380	7%
All Other States	1,841	35%
TOTAL	5,317	100%

Table 3.8 shows the distribution of small multifamily buildings by the number of units in the building and Table 3.9 shows the distribution of total weatherized units. Most of the small multifamily buildings treated in the program are reported to have two housing units; the two-unit buildings represent 77 percent of the small multifamily buildings and 74 percent of the small multifamily units weatherized in the program.

Table 3.8. PY 2008 WAP Weighted Small Multifamily Buildings by Number of Units in Building

Climate Zone	Number of Buildings	Percent of Buildings
1 Unit*	188	7%
2 Units	2,153	77%
3 Units	236	8%
4 Units	222	8%
TOTAL	2,799	100%

* Note: Some grantees did not report the total units in the building.

Table 3.9. PY 2008 WAP Weighted Small Multifamily Units by Number of Units in Building

Climate Zone	Number of Units	Percent of Buildings
1 Unit*	185	4%
2 Units	3,914	74%
3 Units	449	8%
4 Units	769	14%
TOTAL	5,317	100%

* Note: Some grantees did not report the total units in the building.

3.3 SMALL MULTIFAMILY BUILDING CHARACTERISTICS

Table 3.10a furnishes national and Climate Zone statistics on the housing unit characteristics for PY 2008 small multifamily buildings treated by the program. The overall finding is that these buildings vary considerably by Climate Zone. Small multifamily buildings treated by WAP in the Cold Climate Zone are generally larger, older, and have a higher infiltration rate than those buildings in other zones. Small multifamily buildings treated by WAP in the Moderate and Hot Climate Zones are smaller, newer, and have much lower infiltration rates. These statistics might suggest that treated units in the Cold Climate Zone would have more energy savings potential.

Table 3.10a. PY 2008 Small Multifamily Buildings Housing Unit Characteristics by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Other Zones
Heated Space (SF) per Unit				
Median	1,054	1,024	1,140	700
Mean	1,149	1,124	1,253	828
Housing Vintage				
% pre-1940	49%	44%	61%	3%
% 1940-1969	16%	13%	19%	12%
% 1970 or Later	35%	42%	20%	84%
PreWX Status				
Mean Furnace SSE	80%	81%	79%	74%
Mean CFM50*	4,317	4,409	4,777	2,122
Mean HDD65**	5,961	6,991	5,860	2,643
Mean CDD65^{+}	873	600	776	2,222

* Cubic Feet per Minute @ 50 Pascals

** Heating Degree Days

$^{+}$ Cooling Degree Days

Table 3.10b furnishes statistics on the housing unit characteristics for PY 2008 small multifamily buildings by the number of units in the dwelling and compares the statistics for the small multifamily building to single family homes. The overall finding is that the 2-unit buildings are similar to 3-unit and 4-unit buildings, except that the 2-unit buildings are older. In comparison to single family homes, small

multifamily buildings are about 20 percent smaller, are more likely to be built before 1940 or after 1970, and tend to have higher measured infiltration rates than do single family homes.[8]

Table 3.10b. PY 2008 Small Multifamily Buildings
Housing Unit Characteristics by Number of Units in Building

Statistic	All Small Multifamily Buildings	2 Units	3 or 4 Units	Single Family Homes
Heated Space (SF) per Unit				
Median	1,054	1,056	1,015	1,272
Mean	1,149	1,155	1,126	1,418
Housing Vintage				
% pre-1940	49%	54%	35%	32%
% 1940-1969	16%	16%	15%	43%
% 1970 or Later	35%	30%	50%	26%
PreWX Status				
Mean Furnace SSE	80%	80%	80%	81%
Mean CFM50	4,317	4,380	4,315	3,638
Mean HDD65	5,961	5,877	6,250	5,398
Mean CDD65	873	912	751	1,042

Table 3.11a furnishes national and Climate Zone statistics on the heating and water heating systems for PY 2008 small multifamily buildings. The overall findings are that the Cold Climate Zone buildings are more likely to use gas heat, more likely to have central heating systems, and are less likely to use supplemental heat than the buildings in other Climate Zones. In the Moderate and Hot Climate Zones, a large share of the buildings use electric heat and have baseboard electric or room heaters.

[8] The average for units in small multifamily buildings are higher than those for single family homes, but those differences do not necessarily mean that small multifamily units are leakier than single family homes. The blower door readings for small multifamily buildings are often conducted for the individual unit rather than for the whole building. Since each unit in a small multifamily building is likely to share an interior wall with other units, the reading for the unit does not just measure the leakage from the unit to the exterior of the building, but also includes leakage between the unit and the interior of the building. Therefore, a small multifamily unit that has a higher leakage rate than a single family home may not have a higher usage than the single family home if the main source of leakage is to the building rather than to the exterior.

Table 3.11a. PY 2008 Small Multifamily Buildings
Heating System Characteristics by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Other Zones
Heating Fuel				
% Natural Gas	67%	61%	80%	43%
% Electric	20%	21%	9%	57%
% Fuel Oil	10%	10%	11%	0%
% Propane	3%	7%	<1%	<1%
% Other	<1%	<1%	<1%	0%
Heating System Type				
% Central Forced Air	51%	58%	52%	21%
% Boiler (Hydronic/Steam)	26%	20%	36%	1%
% Wall/Room Heater	14%	15%	5%	44%
% Electric Baseboard	8%	7%	6%	20%
% Heat Pump	2%	<1%	<1%	14%
% Portable Space Heater	<1%	<1%	<1%	0%
% Cooking Stove	0%	0%	0%	0%
% No Heating Source	< 1%	< 1%	< 1%	0%
Supplemental Heat				
% Electric	4%	3%	4%	5%
% Wood	5%	6%	2%	16%
% Kerosene	< 1%	0%	< 1%	0%
Water Heating Fuel				
% Natural Gas	68%	52%	84%	57%
% Electric	26%	37%	14%	43%
% Fuel Oil	4%	7%	2%	0%
% Propane	1%	3%	< 1%	< 1%

Table 3.11b furnishes national and Climate Zone statistics on the heating and water heating systems for PY 2008 small multifamily buildings by the number of units in the dwelling and compares the statistics for the small multifamily buildings to single family homes. The overall finding is that 2-unit buildings are more likely to have natural gas heating and water heating systems when compared to 3- or 4-unit buildings. While the averages for small multifamily buildings appear to be similar to those for single family homes, 2-unit buildings are more likely to have gas heat and water heat than are single family homes, while 3- and 4-unit buildings are much less likely to have gas heat and water heat than are single family homes.

Table 3.11b. PY 2008 Small Multifamily Buildings
Heating and Cooling System Characteristics by Number of Units in Building

Statistic	All Small Multifamily Buildings	2 Units	3 or 4 Units	Single Family Homes
Heating Fuel				
% Natural Gas	67%	72%	49%	60%
% Electric	20%	18%	28%	14%
% Fuel Oil	10%	8%	15%	14%
% Propane	3%	2%	7%	9%
% Other	0%	0%	0%	3%
Heating System Type				
% Central Forced Air	51%	55%	38%	67%
% Boiler (Hydronic/Steam)	26%	21%	40%	12%
% Wall/Room Heater	14%	17%	5%	11%
% Electric Baseboard	8%	5%	15%	4%
% Heat Pump	2%	2%	1%	2%
% Portable Space Heater	<1%	<1%	<1%	2%
% Cooking Stove	0%	0%	0%	<1%
% No Heating Source	<1%	<1%	1%	3%
Supplemental Heat				
% Electric	4%	4%	4%	9%
% Wood	5%	6%	2%	8%
% Kerosene	<1%	<1%	0%	1%
Water Heating Fuel				
% Natural Gas	68%	75%	47%	55%
% Electric	26%	22%	40%	35%
% Fuel Oil	4%	2%	8%	4%
% Propane	1%	0%	3%	6%

3.4 SMALL MULTIFAMILY ENERGY DIAGNOSTICS

Table 3.12a shows the diagnostic approach used by subgrantees for the sample of buildings treated in PY 2008 by Climate Zone. At the national level, over 50 percent of small multifamily buildings were assessed using audit tools while 44 percent were treated using priority lists. Buildings in the Very Cold Zone were the most likely to have an audit tool used as the diagnostic device.

Table 3.12a. PY 2008 Clients in Small Multifamily Buildings
Diagnostics Approach by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Other Zones
Diagnostic Approach				
% Weatherization Assistant	24%	54%	2%	2%
% TIPS	7%	0%	15%	< 1%
% Other Audit	23%	14%	25%	49%
% Priority List	44%	30%	56%	49%
% Other	1%	2%	1%	<1%

Table 3.12b shows the overall diagnostic approach used by subgrantees for the sample of buildings treated in PY 2008 by number of units in the building. Buildings with 2 units were most likely to receive an audit. A higher percentage of small multifamily buildings received an audit than did single family homes.

Table 3.12b. PY 2008 Clients in Small Multifamily Buildings
Diagnostics Approach by Number of Units in Building

Statistic	All Small Multifamily Buildings	2 Units	3 or 4 Units	Single Family Homes
Diagnostic Approach				
% Weatherization Assistant	24%	24%	24%	21%
% TIPS	7%	8%	3%	5%
% Other Audit	23%	24%	22%	15%
% Priority List	44%	42%	50%	56%
% Other	1%	1%	1%	3%

Table 3.13a shows the specific air leakage and heat loss diagnostics completed by subgrantees for the buildings treated in PY 2008 by Climate Zone. The findings include:

- Pressure Testing – Subgrantees reported that about two-thirds of buildings received a blower door test. Zonal pressure tests were reported for about three in ten buildings and room-to-room pressure balancing was reported in about one out of ten buildings.

- Duct Testing – For about 20 percent of buildings that had ducts, some form of duct leakage testing was conducted. Pressure pan tests were most common.

- Infrared (IR) Scanning – IR cameras were used for testing in about three in ten client buildings.

Most client buildings receive diagnostics that go beyond what the auditor can directly observe. However, blower door tests and duct tests were done at higher rates in the Cold Climate Zone than in other zones.

Table 3.13a. PY 2008 Clients in Small Multifamily Buildings
Air Leakage and Insulation Diagnostics by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Other Zones
Pressure Testing				
% Blower Door	65%	52%	76%	68%
% Zonal Pressure	28%	37%	24%	10%
% Room-to-Room Balance	11%	2%	22%	7%
Duct Testing (% for Buildings with Ducts)				
% Any Duct Test	17%	2%	32%	21%
% Pressure Pan	14%	1%	25%	21%
% Duct Blaster	3%	1%	6%	0%
% Blower Door Subtraction	3%	0%	7%	0%
Infrared Scanning	29%	30%	34%	7%

Table 3.13b shows the specific air leakage and heat loss diagnostics completed by subgrantees for the buildings treated in PY 2008 by number of units. The overall findings are that small multifamily buildings are less likely to receive blower door tests than are single family homes. However, duct testing was more often completed for 3- or 4-unit buildings than for single family homes, while such tests were conducted at a much lower rate in 2-unit buildings.

Table 3.13b. PY 2008 Clients in Small Multifamily Buildings
Air Leakage and Insulation Diagnostics by Number of Units

Statistic	All Small Multifamily Buildings	2 Units	3 or 4 Units	Single Family Homes
Pressure Testing				
% Blower Door	65%	66%	56%	87%
% Zonal Pressure	28%	34%	13%	29%
% Room-to-Room Balance	11%	10%	14%	17%
Duct Testing (% for buildings with ducts)				
% Any Duct Test	17%	13%	40%	25%
% Pressure Pan	14%	10%	37%	22%
% Duct Blaster	3%	3%	6%	4%
% Blower Door Subtraction	3%	4%	0%	6%
Infrared Scanning	29%	27%	36%	19%

Table 3.14a shows the specific equipment testing completed by subgrantees for the buildings treated in PY 2008 by Climate Zone. Combustion equipment can be tested both for the efficiency and for safety, while electric equipment can be tested for safety.

- Furnaces – Overall testing was conducted in about 60 percent of buildings nationally. But testing was much more common in the Very Cold and Cold Climate Zones.

- Water Heaters – About 60 percent of water heaters had flue gas analysis; the highest rate was in the Cold Climate Zone where almost three-fourths of buildings were tested. Water flow rates were tested for about one in ten buildings nationally with the highest testing rate reported in the Cold Climate Zone.

- Refrigerators – Three in ten refrigerators were metered nationwide. The highest rate was in the Cold Climate Zone where almost one-half of refrigerators were metered.

There is substantial variation in the number and types of diagnostic tests that are conducted; the variation by Climate Zone is significant.

Table 3.14a. PY 2008 Clients in Small Multifamily Buildings
Equipment Diagnostics by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Other Zones
Furnace Testing (% for Buildings Applicable)				
% Flue Gas Analysis	63%	62%	76%	25%
% Temperature Rise	19%	8%	37%	1%
% Thermostat Anticipator	5%	4%	8%	0%
Water Heater Testing (% for Buildings Applicable)				
% Flue Gas Analysis	63%	59%	74%	40%
% Hot Water Temperature	28%	14%	48%	6%
% Showerhead Flow Rate	10%	5%	18%	2%
% Faucet Flow Rate	7%	5%	11%	1%
Refrigerator Usage Metering	30%	18%	44%	22%

Table 3.14b shows the specific equipment testing completed by subgrantees for the buildings treated in PY 2008 by number of units. The data shows that testing rates for 2-unit buildings were similar to those for 3- or 4-unit buildings, and that testing rates for small multifamily buildings were similar to rates for single family homes.

Table 3.14b. PY 2008 Clients in Small Multifamily Buildings
Equipment Diagnostics by Number of Units in Building

Statistic	All Small Multifamily Buildings	2 Units	3 or 4 Units	Single Family Homes
Furnace Testing (% for Buildings Applicable)				
% Flue Gas Analysis	63%	64%	62%	59%
% Temperature Rise	19%	20%	15%	31%
% Thermostat Anticipator	5%	5%	5%	10%
Water Heater Testing (% for Buildings Applicable)				
% Flue Gas Analysis	63%	65%	57%	49%
% Hot Water Temperature	28%	25%	37%	39%
% Showerhead Flow Rate	10%	10%	9%	12%
% Faucet Flow Rate	7%	7%	6%	9%
Refrigerator Usage Metering	30%	30%	28%	38%

3.5 WAP MEASURES INSTALLED IN SMALL MULTIFAMILY BUILDINGS

Table 3.15, 3.16, 3.17, and 3.18 furnish information on the rates at which different types of measures were installed in PY 2008.

Table 3.15a shows the rate at which air sealing and shell measures were installed in PY 2008 by Climate Zone.

- Air Sealing – Subgrantees reported that air sealing was completed in over 90 percent of buildings; bypass sealing using a blower door was reported for about two-thirds of buildings. Air sealing using a blower door was reported at the highest rate in the Very Cold Climate Zone.

- Attic Insulation – Attic insulation was reported for three-fourths of buildings. It was installed at the highest rate in the Very Cold Climate Zone.

- Wall Insulation – Nationally, about four in ten buildings received wall insulation. However, very few small multifamily buildings in the Moderate and Hot Climate Zones received wall insulation.

- Other Insulation – Floor insulation was installed in 16 percent of buildings. It was installed at a lower rate in the Moderate and Hot Climate Zones.

Most small multifamily buildings received air sealing and attic insulation. Almost half of the buildings received wall insulation. Installation rates varied considerably by Climate Zone.

Table 3.15a. PY 2008 Clients in Small Multifamily Buildings
Air Sealing and Shell Measures by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Other Zones
Air Sealing				
Bypass Sealing w/Blower Door	68%	77%	64%	52%
Bypass Sealing w/o Blower Door	16%	12%	18%	22%
Caulking w/o Bypass Sealing	9%	10%	9%	8%
Any Bypass Sealing or Caulking	93%	99%	91%	82%
Attic Insulation				
% Installed (None Existing)	18%	11%	29%	3%
% Installed (Over Existing)	51%	73%	33%	44%
% Installed (Unknown)	6%	1%	11%	2%
% Installed (All Types)	75%	85%	73%	49%
Wall Insulation				
% Installed (Regular)	30%	35%	32%	7%
% Installed (Dense Pack)	8%	6%	12%	1%
% Installed (All Types)	38%	41%	44%	7%
Other Insulation				
% Floor Insulation	16%	18%	15%	11%
% Rim/band joist Insulation	16%	18%	18%	1%
% Foundation Insulation	4%	6%	4%	0%

Table 3.15b shows the rate at which air sealing and shell measures were installed in PY 2008 by the number of units in the building. There does not appear to be important differences between buildings with 2 units and those with 3 or 4 units. The only significant difference between small multifamily buildings and single family homes is that wall insulation was most often reported as dense pack for single family homes, while for small multifamily buildings regular wall insulation was reported.

Table 3.15b. PY 2008 Clients in Small Multifamily Buildings
Air Sealing and Shell Measures by Number of Units in Building

Statistic	All Small Multifamily Buildings	2 Units	3 or 4 Units	Single Family Homes
Air Sealing				
Bypass Sealing w/Blower Door	68%	70%	64%	68%
Bypass Sealing w/o Blower Door	16%	17%	15%	11%
Caulking w/o Bypass Sealing	9%	7%	12%	13%
Any Bypass Sealing or Caulking	93%	94%	91%	92%
Attic Insulation				
% Installed (None Existing)	18%	21%	9%	26%
% Installed (Over Existing)	51%	50%	61%	38%
% Installed (Unknown)	6%	6%	5%	6%
% Installed (All Types)	75%	76%	76%	70%
Wall Insulation				
% Installed (Regular)	30%	32%	25%	8%
% Installed (Dense Pack)	8%	8%	7%	21%
% Installed (All Types)	38%	32%	27%	29%
Other Insulation				
% Floor Insulation	16%	16%	17%	15%
% Rim/band Joist Insulation	16%	17%	12%	17%
% Foundation Insulation	4%	3%	9%	4%

Table 3.16a shows the rate at which equipment measures were installed in PY 2008 by Climate Zone. The key findings include:

- Heating Equipment – Heating equipment replacement was reported for about 31 percent of client buildings, with most – about 80 percent – characterized as an energy conservation measure (ECM) and the rest characterized as primarily for health and safety. Overall, one-half of the buildings had some heating system work completed. Equipment replacement rates were much higher in the Very Cold Climate Zone than in the other areas.

- Ducts – Duct sealing was reported in about six in ten buildings. Duct sealing rates were highest in the Very Cold Climate Zone. Very few buildings had duct insulation.

- Water Heating Equipment – A small share of buildings had water heater equipment measures; nationally only about 16 percent of equipment was replaced and most were for health and safety reasons. Replacement rates were highest in the Very Cold Climate Zone.

- Other Water Measures – The most common water measure was pipe wrap, delivered to about six in ten buildings. In addition, about one-fourth of buildings had water heater wraps, and one-third had low-flow showerheads and/or faucet aerators installed.

Equipment measures are less common than are air sealing and insulation with the exception of the Very Cold Climate Zone. Subgrantees reported relatively few replacements of heating systems and water heaters where the replacement was judged to be a cost-effective energy efficiency measure. However, in the Very Cold Climate Zone, subgrantees report ECM furnace replacements in about one-half of the homes. It was more common to replace the equipment because it wasn't operating safety, or wasn't working at all. Sealing ducts and installing other water heating measures were more commonly reported measures.

Table 3.16a. PY 2008 Clients in Small Multifamily Buildings
Heating and Water Heating Equipment Measures by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Other Zones
Heating Equipment				
New Furnace (ECM)	25%	47%	8%	0%
New Furnace (nonECM)	6%	2%	8%	11%
Heating System Tune-Up	19%	14%	29%	6%
Other Heating System Repairs	2%	2%	3%	0%
Programmable Thermostat	2%	2%	3%	0%
Any Heating System Measure	54%	68%	51%	17%
Heating Ducts (% of Systems with Ducts)				
Duct Sealing	59%	76%	45%	35%
Duct Insulation	4%	4%	3%	<1%
Water Heating Equipment				
New Water Heater (ECM)	4%	8%	1%	0%
New Water Heater (nonECM)	12%	22%	5%	3%
Water Heater Repair	13%	9%	18%	14%
Water Measures				
Tank Wrap	25%	28%	22%	22%
Pipe Wrap	58%	75%	49%	26%
Temperature Reduction	12%	11%	12%	18%
Showerhead	34%	50%	17%	34%
Faucet Aerator	35%	60%	11%	28%

Table 3.16b shows the rate at which equipment measures were installed in PY 2008 by number of units in the building and for single family homes. The table shows that, in general, installation rates were higher for 2-unit buildings than for 3- or 4-unit buildings. Almost all measures were installed at a higher rate in small multifamily buildings than in single family homes.

Table 3.16b. PY 2008 Clients in Small Multifamily Buildings
Heating and Water Heating Equipment Measures by Number of Units in Building

Statistic	All Small Multifamily Buildings	2 Units	3 or 4 Units	Single Family Homes
Heating Equipment				
New Furnace (ECM)	25%	29%	15%	12%
New furnace (nonECM)	6%	5%	6%	10%
Heating System Tune-Up	19%	20%	18%	18%
Other Heating System Repairs	2%	2%	4%	4%
Programmable Thermostat	2%	2%	1%	2%
Any Heating System Measure	54%	58%	44%	48%
Heating Ducts (% of Systems with Ducts)				
Duct Sealing	59%	64%	45%	42%
Duct Insulation	4%	4%	2%	3%
Water Heating Equipment				
New Water Heater (ECM)	4%	4%	4%	3%
New Water Heater (nonECM)	12%	16%	3%	6%
Water Heater Repair	13%	16%	6%	8%
Water Measures				
Tank Wrap	25%	28%	16%	26%
Pipe Wrap	58%	64%	46%	44%
Temperature Reduction	12%	14%	9%	9%
Showerhead	34%	38%	24%	22%
Faucet Aerator	35%	42%	19%	22%

Table 3.17a shows the rate at which door and window measures were installed in PY 2008 by Climate Zone. The statistics show that three in ten buildings had some form of window measures and about three in ten buildings had some form of door measure. About one in ten buildings had one or more windows replaced for energy efficiency reasons and less than one in ten buildings had a door replaced for energy efficiency reasons.

Table 3.17a. PY 2008 Clients in Small Multifamily Buildings
Door and Window Measures by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Other Zones
Windows				
New Window (ECM)	11%	3%	17%	15%
New Window (nonECM)	7%	8%	4%	15%
Storm Window	1%	1%	2%	0%
Window Glazing	5%	3%	7%	4%
Other Window Repair	6%	5%	9%	1%
Any Window Measure	30%	20%	39%	36%
Doors				
New Door (ECM)	7%	4%	10%	6%
New Door (nonECM)	6%	7%	5%	11%
Storm Door	1%	2%	0%	0%
Door Repair	2%	0%	5%	2%
Other Door Measure	11%	9%	16%	3%
Any Door Measure	28%	21%	35%	22%

Table 3.17b shows the rate at which door and window measures were installed in PY 2008 by number of units and for single family homes. The table shows that there are small differences by number of units and that small multifamily buildings and single family homes had measures installed at similar rates.

Table 3.17b. PY 2008 Clients in Small Multifamily Buildings
Door and Window Measures by Number of Units in Building

Statistic	All Small Multifamily Buildings	2 Units	3 or 4 Units	Single Family Homes
Windows				
New Window (ECM)	11%	10%	13%	11%
New Window (nonECM)	7%	9%	2%	6%
Storm Window	1%	1%	1%	3%
Window Glazing	5%	5%	3%	8%
Other Window Repair	6%	5%	10%	9%
Any Window Measure	30%	29%	29%	37%
Doors				
New Door (ECM)	7%	8%	4%	11%
New Door (nonECM)	6%	6%	7%	7%
Storm Door	1%	1%	0%	<1%
Door Repair	2%	2%	3%	9%
Other Door Measure	11%	10%	12%	13%
Any Door Measure	28%	27%	26%	40%

Table 3.18a shows the rate at which electric baseload equipment measures were installed in PY 2008 by Climate Zone.

- Lighting Measures – Seventy percent of buildings received some form of energy efficient lighting. Over 90 percent of buildings in the Very Cold Climate Zone received lighting measures.

- Refrigerators – More than one-third of buildings received a new refrigerator. Over one-half of buildings in the Very Cold Climate Zone had a new refrigerator installed.

These statistics show that WAP made significant investments in electric lighting and refrigerators.

Table 3.18a. PY 2008 Clients in Small Multifamily Buildings
Electric Baseload Equipment Measures by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Other Zones
Other Electric Measures				
Lighting (Inside or Outside)	70%	91%	52%	60%
Refrigerator (ECM)	32%	52%	17%	13%
Refrigerator (nonECM)	4%	0%	2%	22%
Freezer	4%	8%	1%	0%
Other Baseload Measures	5%	9%	3%	0%

Table 3.18b shows the rate at which electric baseload equipment measures were installed in PY 2008 by number of units and for single family homes. The installation of measures did not vary much by number of units. Installation rates for small multifamily buildings were somewhat higher than that for single family homes.

Table 3.18b. PY 2008 Clients in Small Multifamily Buildings
Electric Baseload Equipment Measures by Number of Units in Building

Statistic	All Small Multifamily Buildings	2 Units	3 or 4 Units	Single Family Homes
Other Electric Measures				
Lighting (Inside or Outside)	70%	73%	62%	63%
Refrigerator (ECM)	32%	34%	27%	12%
Refrigerator (nonECM)	4%	3%	5%	1%
Freezer	4%	5%	1%	2%
Other Baseload Measures	5%	7%	2%	4%

4. ENERGY USAGE IMPACTS

The WAP evaluation directly measured energy usage changes for treated small multifamily buildings that used natural gas as their as their main heating fuel. Based on the findings from the analysis of single family homes with electric heat, energy savings were projected for small multifamily buildings with electric main heat. Based on the findings from a delivered fuel metering study, energy savings were projected for small multifamily buildings that heated with a delivered fuel. This section of the report presents the findings with respect to energy usage impacts, including:

- Measured Energy Savings – The average energy savings and distribution of savings for small multifamily buildings.

- Energy Savings Factors – An analysis of how energy usage savings varies by different housing unit, usage, and installed measures furnishes insights into what factors are associated with higher levels of savings.

- Projected Energy Savings – The average and total energy savings for all small multifamily buildings treated by the Weatherization Assistance Program based on energy savings models developed from the cases with measured energy savings.

These findings document the energy impacts of the program on small multifamily buildings. A report drafted by ORNL entitled *Weatherization Works*[9] includes a summary of energy impacts for all building types as well as information on cost-effectiveness and nonenergy impacts.

4.1 METHODOLOGY

This study developed estimates of measured energy savings and factors, projected energy savings, and cost savings and cost-effectiveness. Natural gas and electric usage data were collected for buildings that are heated with natural gas or electricity. Several different analytic models were used to estimate the energy savings for treated buildings.

- Building-Level Analysis – The primary analysis approach was a standard pre/post treatment/comparison design using weather normalized utility billing data. The weather-normalization approach employed was similar to PRISM[10] and produces estimates of weather-adjusted annual energy consumption for each home based on monthly usage data and daily outdoor temperatures using a variable degree day base regression analysis.

    - Gross Savings – Gross energy savings for each home were calculated as the difference in the normalized annual consumption between the pre-treatment and post-treatment periods.

    - Net Savings – A comparison group of untreated buildings was also analyzed to reflect changes in usage which may have occurred without the program. The comparison group was created using later participants – small multifamily buildings treated in PY 2009 were used as a comparison group for the PY 2008 analysis. Comparison group usage was analyzed by subtracting one year from the actual treatment date to create pseudo pre-

[9] Tonn et al. 2014. Weatherization Works – Summary of Findings from the Retrospective Evaluation of the U.S. Department of Energy's Weatherization Assistance Program. ORNL/TM-2014/338, Oak Ridge National Laboratory, Oak Ridge, Tennessee. National Laboratory, Oak Ridge, TN.
[10] See "PRISM: An Introduction," Margaret Fels, Energy and Buildings 9, #1-2, pp. 5-18 (1986).

treatment and post-treatment periods after removing actual post-treatment usage data. Net program savings were then calculated as the average gross savings for participants minus the average savings (i.e., change in usage) found for the comparison group.

- Factors Analysis – The results of the weather normalization analysis were also summarized in a variety of ways to address research questions and were further explored using statistical models to estimate savings by measure and the relationship between observed savings and other factors.

- Pooled Analysis Procedures – In addition to the pre/post treatment/comparison approach just described, the usage data were also analyzed using two alternative approaches as both a cross-check of the primary results and to assess whether further insights could be gained:

    - Fixed Effects Regression Model – The first alternative approach was to employ a pooled fixed effects regression analysis[11] to estimate net savings. As the name implies, this approach involves pooling all of the monthly billing data together across all buildings into a single statistical model to explain monthly variations in energy use as a function of weather (degree day variables) and program interventions. The analysis included several alternative modeling specifications.

    - Aggregate Analysis Model (ORNL Aggregate Model) – The second approach employed a variation on the pooled model that aggregates the energy use and weather data for each home and then statistically analyzes this aggregate data set to estimate program impacts. This method was developed at ORNL and is referred to as the ORNL aggregate model.

The potential advantage of pooled analysis modeling approaches is that the data from buildings that have too little usage data to develop good savings estimates using the primary normalization approach can still be included as part of these pooled models. One of the prime motivating factors behind the development of the ORNL aggregate model was due to high sample attrition rates that sometime occur using the standard house-level approach.

4.2 ENERGY USAGE DATA ATTRITION FOR BUILDINGS HEATED WITH NATURAL GAS

A total of 793 small multifamily gas heated units were sampled for analysis. Table 4.1 summarizes the disposition of this sample for the gas and electric use analysis.

[11] This approach goes by multiple names in the energy program evaluation literature including times-series cross sectional regression modeling, Analysis of Covariance (ANACOVA), fixed effects modeling, and sometimes, more broadly, just econometric modeling.

Table 4.1. PY 2008 WAP Small Multifamily Units
Gas and Electric Usage Sample Attrition - Gas Main Heat

	Gas SMF* Analysis		Electric SMF* Analysis	
Sample Group / Attrition Cause	**Units**	**% of Sample**	**Units**	**% of Sample**
Sampled	793	100%	793	100%
No Usage Data from Utility	132	17%	165	21%
Insufficient Data	216	27%	243	31%
Poor Model Fit	48	6%	43	5%
Unheated / Vacant	9	1%	0	0%
Savings Outlier	2	0.3%	3	0.4%
Ambiguous # Units Served by Account	103	13%	72	9%
Usable Cases for Analysis	283	36%	267	34%

*small multifamily (SMF)

The following analysis documents the specific reasons for data attrition.

- Data Retrieval – The utility data collection process was successful in obtaining gas and electric data for more than 80% of the sampled buildings.

- Insufficient Data – The usage data were insufficient for developing savings estimates for 27% of the gas analysis units and 31% of the electric analysis units. Most of this attrition was due to too little pre-retrofit data.

- Poor Model Fit – The weather normalization itself indicated a poor model fit in either the pre or post periods for about 5% of the sampled cases. About 1% of sampled cases in the gas analysis had gas usage too low to be considered gas heated and occupied during both periods. Less than one-half of a percent of the sampled units were removed from the analysis because they were declared savings outliers[12].

- Alignment of Data and Weatherized Unit – A significant additional source of sample attrition in the multifamily analysis was due to having utility data where it wasn't clear if the account served just one unit or more than one unit. The data collection process asked about master meter accounts but these data didn't appear to be reliable as some accounts had usage levels that were too high to be considered a single unit. A multi-step process was used to classify accounts as master or unit-level but many accounts had usage levels that could be either and so the usage results were not used in the savings summaries.

The same screening criteria were also applied to the comparison group analysis and the attrition rates were generally similar.

[12] Outliers were defined as having percent savings more than 2.5 inter-quartile ranges from the median percent savings for the analysis group (participant or comparison).

4.3 HOUSING UNIT CHARACTERISTICS AND INSTALLED MEASURES FOR ANALYSIS SAMPLE

Table 4.2 summarizes data on climate, housing stock, and program measures for site built buildings, all small multifamily buildings, and small multifamily buildings with gas heat.

Table 4.2. Characteristics of Small Multifamily Buildings

Characteristic	All Single Family Site Built Homes	All Small Multifamily Buildings	All Gas Heated Small Multifamily Buildings
Climate			
Very Cold	25%	41%	37%
Cold	42%	48%	56%
Moderate	21%	3%	1%
Hot/Humid	8%	7%	6%
Hot/Dry	4%	1%	0%
Housing Characteristics			
Units per Building	1.0	2.2	2.1
Heated Area	1,421	1,149	1,193
Median Age	67	87	97
HDD65	5,438	5,955	6,006
CDD65	1,026	872	848
Central Heating	86%	86%	89%
Central A/C	36%	23%	22%
Weatherization Diagnostics			
Weatherization Assistant Audit	22%	23%	23%
Building Leakage Test	88%	66%	72%
Duct Leakage Test	19%	11%	11%
Major Measures			
Heater Replacement	21%	31%	37%
Attic Insulation	69%	75%	75%
Wall Insulation	29%	39%	46%
Air Sealing >1,000 CFM50	42%	31%	36%
Duct Sealing	31%	34%	41%
Refrigerator Replaced	13%	34%	33%

*Note – Results weighted by sample design selection probabilities.

The table shows that, compared to treated site built buildings, treated small multifamily buildings are much smaller and older. Homes characterized as small multifamily are more likely to be located in the Very Cold and Cold Climate Zones. Small multifamily buildings were less likely to receive leakage tests than were single family homes. It is likely that the lower rate of testing relates to complications with getting access to all units in the building at the time of the audit. Small multifamily buildings were more likely to receive heater replacement, attic insulation, and wall insulation. However, most of those

differences are likely to result from the geographic distribution of single family homes in those Climate Zones where those measures are more likely to be cost-effective.

4.3 ENERGY SAVINGS FOR HOMES HEATED WITH NATURAL GAS

Table 4.3 summarizes natural gas impacts for small multifamily buildings. The net gas savings are estimated at 161 therms[13] per year, equal to 17.4% of pre-program gas usage. These savings are lower in absolute value than the 181 therms found for single family site built homes, but about the same as the 17.8% of pre-program gas usage observed for single family homes. In comparison to the site built buildings, the average small multifamily home was about 21% smaller (1,193 vs. 1,504 ft²) and used 9% less natural gas prior to weatherization.

Table 4.3. PY 2008 WAP Energy Impacts for Small Multifamily Buildings
Gross and Net Gas Savings Total and by End Use (therms*/unit/year)

Group	# of Units in Buildings	# of Accounts	Gas Use Pre-WAP	Gas Use Post-WAP	Gross Savings	Net Savings per Unit	% of Pre
Treatment	616	283	926	726	199	161 (±58)	17.4% (±6.3%)
Comparison	512	222	933	894	38		

*100,000 British Thermal Units

The distribution of percent gas savings for participants and the comparison group are shown in Figure 4.1. The Comparison Group line graph shows the distribution of year-over-year change in energy usage that was observed for buildings that did not receive weatherization services. The line graph for those buildings is centered on 0% and shows that 25 percent of households had a weather-normalized change in gas usage of between -2.5% and +2.5%. For about 10 percent of buildings, the savings were less than -12.5% and for about 20 percent the savings was greater than +12.5%. Some of the potential sources of change for individual buildings include: increases or decreases in the numbers of households in the building and/or the numbers of members of each household in the building, changes in the number of people in the building during the day (e.g., someone gets a job or loses a job), or changes in the way the building is used (e.g., a household closes off a room to save on energy use; a household starts using a porch as living space). These are normal changes that affect all households at all income levels and in all areas. Table 4.3 shows that, with all of those potential changes, the average weather-normalized change in gas usage is about 38 therms (4.1%).

The line graph for the Participant Group is different from the line graph for the Comparison Group in two ways. First, the graph for the Participant Group is shifted to the right, with its median value at about 20%, showing that the Participant Group buildings reduced their gas usage by substantially more than did the Comparison Group. Second, the graph for the Participant Group is more spread out; a little over 10 percent of the buildings had their usage change by +/-2.5% from the median change, compared to 25 percent in that bin for the Comparison Group buildings. This shows that the variability in the change in gas usage is greater for the Participant Group buildings than for the Comparison Group.

[13] 100,000 British Thermal Units

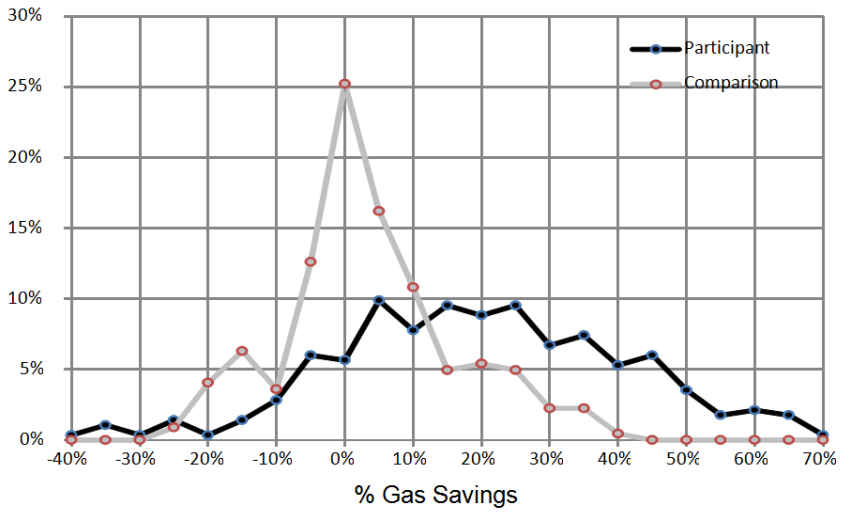

Figure 4.1. Distribution of Percent Gas Use Reduction – Small Multifamily Units

These graphs taken together demonstrate the impact of WAP on treated buildings.

- Weather-normalized usage for Participant Group buildings fell by about 21.5 percent and by 4.1 percent for Comparison Group buildings; the net impact of weatherization was to shift the gas savings graph to the right by about 17.4 percent.

- Treated buildings each received a different set of program measures. Buildings with few measures are expected to have small energy savings, while those that received a full set of measures are expected to have larger energy savings, other things being equal. Since each Participant Group building is expect to have a different level of savings, the distribution for the change is more variable (spread out) than for the Comparison Group homes.

A common question about savings is why some participants appear to increase their usage after weatherization; how can savings be negative? The distribution of the change in use for the Comparison Group may help to explain this apparent anomaly. As shown in Figure 4.1 above, some Comparison Group buildings increased usage by 20 percent or more due to nonprogram factors. So, if a building *would have* had an increase of 20 percent without treatment, but only had a 5 percent increase in usage, the net program impact is 15 percent savings over what would have occurred without weatherization.

Table 4.3 shows that the gas savings estimates have a relatively large confidence interval. Net savings are estimated to be 161 +/- 58 therms. In comparison, the gas savings estimates for the single family home population was 181 +/- 13 therms. The narrower confidence interval for single family homes results from having a larger sample size (over 3,000 buildings) and a more homogeneous population. To help assess the stability of the estimates, Table 4.4 shows the small multifamily gas savings results for PY 2007 and PY 2009.

Table 4.4. PY 2007 and PY 2009 WAP Energy Impacts for Small Multifamily Units
Gross and Net Fuel Savings Per Unit (therms/unit/year)

Group/Breakout	# Accounts	Fuel Use Pre-WAP	Fuel Use Post-WAP	Gross Savings	Net Savings per Unit	% of Pre
Small MF 2007	245	876	688	188	155 (±39)	17.7% (±4.4%)
Comparison	409	918	885	33		
Small MF 2009	183	874	706	168	136 (±47)	15.6% (±5.4%)
Comparison	247	836	804	32		

The net savings in 2007 are very close to the 2008 results. The 2009 results show a little lower savings but all three years have net savings within about a 2 percentage point range. The general similarity of savings across years allowed for some analyses using pooled results.

Table 4.5 summarizes electric impacts overall and by end use among gas-heated buildings. The net electric savings are estimated to be 412 kWh. These savings are lower in absolute value than the 680 kWh found in single family site built homes, but about the same as the 7.1% of pre-program usage. In comparison to the site built buildings, the average small multifamily home used 40% less electricity prior to weatherization.

Table 4.5. PY 2008 WAP Energy Impacts for Small Multifamily Buildings
Gross and Net Electric Savings for Natural Gas Main Heat by End Use (kWh/unit/year)

Usage Component	# of Accounts	Electric Use Pre-WAP	Electric Use Post-WAP	Gross Savings	Net Savings per Unit	% of Pre
Treatment	267	5,710	5,384	326	412 (±183)	7.2% (±3.2%)
Comparison	223	5,623	5,708	-85		

4.4 FACTORS ASSOCIATED WITH DIFFERENTIAL ENERGY SAVINGS

WAP provides a customized set of measures for each home prescribed by an energy auditor who follows the local program design and measure selection approach based on cost-effectiveness and health and safety requirements. The factors analysis found that gas savings varied significantly based on the major measures installed in each building. Given the small sample size, only a limited number of group breakouts could be provided. The two measures that provided the largest differences between groups were wall insulation and heating system replacement. Table 4.6 summarizes net gas savings by measure combination for these two measures. (Note that many of the buildings that received wall insulation and/or heater replacement also received major air sealing, attic insulation, and other weatherization measures. So, the statistics in the table do not show the impacts for wall insulation by itself but rather the impacts for buildings that received wall insulation and other measures.)

Table 4.6. PY 2008 WAP Energy Impacts for Small Multifamily Units
Gross Fuel Savings Per Unit by Major Measures Installed (therms/unit/year)

Major Measure	# Accounts	Fuel Use Pre-WAP	Net Savings per Unit	% of Pre
No Wall Insulation or Heater Replacement	96	820	45	5.4% (±4.2%)
Yes Wall Insulation / No Heater Replacement	53	1,106	158	14.3% (±7.6%)
No Wall Insulation / Yes Heater Replacement	52	1,007	197	19.5% (±7.9%)
Wall Insulation and Heater Replacement	82	890	278	31.2% (±2.1%)

The table shows that buildings that received a heating system replacement and wall insulation had average savings of more than 30% of pre-retrofit gas use. Buildings that received neither of these two measures averaged net savings of about 5%.

The small multifamily analysis group is dominated by buildings from the Cold and Very Cold Climate zones. Table 4.7 summarizes savings by Climate Zone for these buildings. The savings were more than twice as large in the Very Cold Climate Zone than in the Cold Zone. This difference may be largely explained by the fact that 76% of the Very Cold units received heating system replacements compared to 26% in the Cold Climate Zone.

Table 4.7. PY 2008 WAP Energy Impacts for Small Multifamily Units
Gross and Net Fuel Savings Per Unit (therms/unit/year) by Climate Zone

Group/Breakout	# Accounts	Fuel Use Pre-WAP	Fuel Use Post-WAP	Gross Savings	Net Savings per Unit	% of Pre
Very Cold	118	929	644	285	265 (±60)	28.5% (±6.4%)
Comparison	110	832	811	21		
Cold	147	1,029	868	161	96 (±48)	9.4% (±4.6%)
Comparison	110	1,138	1,073	65		

Previous research has shown that buildings with higher levels of pre-weatherization usage tend to achieve greater energy savings. This relationship may be driven in part by greater opportunities to install major measures in buildings with higher pre-participation energy use. Table 4.8 summarizes gross savings by pre-retrofit gas use for all three years combined. The table shows gross gas savings were substantially higher for buildings with higher pre-weatherization consumption, although percent savings are highest for the middle usage range of 600-1,000 therms/year per unit.

Table 4.8. PY 2007, 2008, and 2009 WAP Energy Impacts for Small Multifamily Units
Gross Fuel Savings Per Unit by Pre-Weatherization Usage (therms/unit/year)

Pre-Retrofit Gas Use	# Accounts	Fuel Use Pre-WAP	Fuel Use Post-WAP	Gross Savings	% of Pre
Gas Use < 600 therms/year	165	441	395	46	10.5% (±2.3%)
Gas Use 600-1,000 therms/year	315	770	580	190	24.6% (±2.0%)
Gas Use >=1,000 therms/year	231	1,518	1,207	311	20.5% (±2.1%)

4.5 PROJECTED PY 2008 ENERGY SAVINGS

The overall goal of the evaluation is to project total energy savings and energy savings per unit for the PY 2008 WAP program. While the measured savings statistics furnish valuable information, they do not furnish direct estimates for the WAP population. A series of analysis procedures was used to develop savings estimates for the population of households served by WAP.

The starting point for the analysis was to compare measured energy savings for single family homes to measured energy savings for small multifamily buildings. The analysis showed that savings results for small multifamily buildings were consistent with savings for single family homes after adjusting for heating degree days (HDD) and floor area. A small multifamily savings adjustment factor was developed by comparing the projected savings from the single family gas heat explanatory factors model to the actual savings for the analysis sample of gas heated small multifamily buildings. After estimating that factor, the following procedures were used to estimate energy savings for all treated buildings for which data were collected.

- Gas Main Heat – Energy savings were estimated for each building with data on installed measures using the adjusted single family savings model for gas heated buildings.

- Electric Main Heat – Only 20 percent of small multifamily buildings have electric main heat. Electricity data were collected for these buildings, but only 43 buildings had valid data that could be used for analysis. And, there were only 8 comparison buildings. Those sample sizes are too small to furnish reliable energy savings estimates. Energy savings were estimated for each building with data on installed measures using the single family savings model for electric heated buildings with the small multifamily home adjustment factor developed for gas heated buildings.

- Delivered Fuel Buildings – The evaluation included a field study in which single family homes with delivered fuels were metered to directly measure energy savings. By comparing the modeled estimates of energy savings using the gas heat single family home model with the metered estimates of delivered fuel energy savings, it was determined that the gas heat explanatory factors model could be used to represent the savings for buildings with delivered fuel main heat. For small multifamily buildings with delivered fuel main heat, the same procedures were applied as for small multifamily buildings with gas main heat.

Table 4.9 summarizes the small multifamily analysis estimates of savings by heating fuel for the entire national participant population.

Table 4.9
PY 2008 WAP Energy Impacts for Small Multifamily Buildings
Net Fuel and Electric Savings per Unit, by Heating Fuel

Heating Fuel	# Units	Fuel Savings (MMBtu*/year /unit)	Electric Savings (kWh/year/unit)
Natural Gas	3,578	16.0	548
Oil	506	16.1	220
Propane	98	11.6	514
Wood/Other	15	19.7	161
Electric	1,120	N/A	1,683
All Fuels	5,317	12.5	754

***** Mean Million British Thermal Units

The estimated natural gas savings are nearly identical to the analysis sample result of 161 therms per year, suggesting that any differences between the analysis sample and the treated population in terms of geographic distribution and measure installation frequencies tend to even out in terms of expected savings. Savings in oil heated units are estimated to be nearly identical to gas savings in energy terms but propane heated buildings are estimated to have saved less. Electric savings vary across fuels mostly due to differences in refrigerator replacement rates.

5. COST SAVINGS, MEASURE COSTS, AND COST-EFFECTIVENESS

The WAP evaluation assesses program cost-effectiveness along multiple dimensions that are related to the various goals of the program and how resources are allocated. Some of the main issues in this analysis include:

- Energy Savings – The evaluation developed estimates of the first-year energy savings from the program and used the estimated life of individual measures to project total energy savings over time.

- Energy Cost Savings – The evaluation used data on current energy prices and price projections to estimate the cost savings associated with the projected energy savings.

- Non-Energy Benefits – The evaluation collected data and referencing literature sources to estimate and monetize the non-energy benefits.

- Service Delivery Costs – The evaluation collected information from agencies to assess the service delivery costs for each home, including breakouts of energy efficiency measures, health and safety measures, and home repairs.

- Total Program Costs – The evaluation collected information from DOE, states, and agencies to document program administration and training costs.

- Cost-Effectiveness – Program cost-effectiveness has been computed from multiple perspectives that assess the benefits and costs in terms of both energy and non-energy aspects of the program.

The analysis here focuses narrowly on two specific elements of cost-effectiveness: (1) the cost to install measures meant to save energy (and incidental repairs that enable their installation); and, (2) the value of the energy savings from those measures. As such, the measure of cost-effectiveness reported here excludes costs for health-and-safety measures and indirect program costs. It also excludes potential non-energy benefits from the program. This focus is only concerned with the effectiveness of efficiency measures at saving energy.

5.1 PRICE AND DISCOUNT RATE SCENARIOS

This report presents information on energy savings for PY 2008. In this section, the energy cost savings and cost-effectiveness are presented from three different perspectives.

- Impact on PY 2008 Clients – The first scenario documents how the program impacted PY 2008 clients. It shows the clients' first-year energy cost savings based on actual energy prices in 2008 and the estimated present value of their energy cost savings based on actual energy prices for 2008 through 2012, projected energy prices beginning in 2013, and discount rates in effect in 2008.

- PY 2013 Analysis Perspective – The second scenario is the most relevant to analysts making use of this report at the time of publication. It shows the energy cost savings and cost-effectiveness of a program implemented in PY 2013 using energy price projections beginning in 2013 and discount rates in effect in 2013.

- Long-Term Analysis Perspective – The third scenario is useful for longer-term program decision-making. It shows the energy cost savings and cost-effectiveness of a program using energy price projections beginning in 2013 and long-term average discount rates.

Each of these scenarios is useful for understanding the program from a different perspective. However, the PY 2013 Perspective is probably the most useful for analysts at this time.

5.2 IMPACT ON PY 2008 CLIENTS

This section presents the estimated energy cost savings and cost-effectiveness for clients that were served during PY 2008. The following parameters are used in this analysis.

- First-Year Energy Savings – Procedures are presented in Section 4 of this report.

- First-Year Cost Savings – Estimated by multiplying first year energy savings per client by the average price per unit for each state for 2008.

- Long-Term Energy Savings – Developed by applying measure life estimates to first-year energy savings.

- Long-Term Cost Savings – Estimated by multiplying projected energy savings by actual energy prices (inflation-adjusted) for 2009-2012 and projected inflation-adjusted energy prices for each state.

- Net Present Value of Cost Savings – Developed by discounting the stream of future cost savings by the inflation-adjusted discount rate experienced in PY 2008.

- Energy Cost-Effectiveness – Compares the net present value of energy cost savings to the cost of installed energy measures.

Table 5.1 summarizes the average energy costs and annual cost savings for the first year after participation in WAP in 2008 dollars. Participant annual energy costs averaged $1,657 prior to WAP, and WAP reduced those costs by an average of $231, equal to a 13.9 percent reduction in total energy costs. The energy costs and value of the savings are about two times larger in homes heated by fuel oil or propane than in homes heating by natural gas.

Table 5.1. PY 2008 WAP Energy Impacts for Small Multifamily Homes
Energy Costs and Cost Savings by Main Heating Fuel (2008 Dollars)

	Annual Energy Costs			Annual Savings (first year)			
Heating Fuel	**Fuel**	**Electric**	**Total$**	**Fuel**	**Electric**	**Total$**	**% Savings**
Natural Gas	$935	$645	$1,580	$162	$62	$224	14.1%
Electricity	$0	$1,205	$1,205	$0	$170	$170	14.1%
Fuel Oil	$2,143	$757	$2,900	$357	$32	$389	13.4%
Propane	$2,458	$796	$3,254	$304	$64	$368	11.3%
Other	$925	$569	$1,493	$172	$19	$191	12.8%
All Clients	$881	$776	$1,657	$149	$82	$231	13.9%

Table 5.2 summarizes the estimated life-cycle energy cost savings, the cost of installing energy efficiency measures, and the cost-effectiveness for the national program by main heating fuel. Cost-effectiveness is summarized in two ways:

- The net benefits, equal to the present value of lifetime energy costs savings minus efficiency measure costs.

- The savings-to-investment ratio - SIR - which is the present value of the lifetime energy cost savings divided by the efficiency measure costs. An estimated 90% confidence interview on the SIR also is presented based on a Monte Carlo simulation using estimated uncertainties of the inputs.

The table shows that the program is projected to generate an average of $3,606 worth of energy bill savings over the lifetime of the measures (discounted to present value) and spent an average of $2,645 on efficiency measures in these homes, yielding a net benefit of $961 per home and an SIR of 1.36. In other words, the energy savings are worth 36 percent more that the cost of the efficiency measures. The significant uncertainties in future energy prices as well as in the energy savings and costs yield a 90% confidence interval that extends from 1.07 to 1.77. The uncertainty is not symmetric around the estimate due to the greater potential for energy cost increases vs. decreases.

Table 5.2. PY 2008 Energy WAP Impacts for Small Multifamily Buildings
Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Main Heating Fuel
(2008 Dollars)

	Energy Cost Savings per Unit (present value of lifetime savings)			Costs & Cost Effectiveness			
Heating Fuel	**Fuel**	**Electric**	**Total**	**Measure Costs**	**Net Benefits**	**Savings/ Investment Ratio**	**SIR 90% c.i.**
Natural Gas	$2,655	$650	$3,304	$2,877	$427	1.15	0.89 - 1.52
Electricity	-	$2,432	$2,432	$2,208	$224	1.10	0.73 - 1.52
Fuel Oil	$7,573	$294	$7,867	$2,121	$5,746	3.71	2.62 - 5.31
Propane	$5,255	$700	$5,955	$2,169	$3,786	2.75	1.67 - 4.28
Other	$3,881	$139	$4,020	$2,448	$1,572	1.64	1.25 - 2.21
All Clients	$2,615	$991	$3,606	$2,645	$961	1.36	1.07 - 1.77

The SIR is greater than unity across all heating fuels, but is much larger for oil- and propane-heated homes due to the high costs of these fuels. On a Btu basis, fuel oil cost 2.2 times more than natural gas and propane cost 2.1 times more than natural gas in PY 2008.

A number of factors, including differences in investment levels and heating fuel mix have an impact on the cost-effectiveness of the program by Climate Zone. Cost effectiveness results by Climate Zone are summarized in Table 5.3. The Cold Climate Zone produced a SIR substantially greater than one due to having the lowest spending on efficiency measures. The Very Cold zone buildings achieved the largest energy cost savings but also had the greatest measure costs. A significant portion of this cost difference is that heating system replacements are more often classified as efficiency measures in the Very Cold climate due to differences in state program rules.

Table 5.3. PY 2008 WAP Energy Impacts for Small Multifamily Buildings
Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Climate Zone
(2008 Dollars)

	Energy Cost Savings per Unit (present value of lifetime savings)			Costs & Cost Effectiveness		
Climate	**Fuel**	**Electric**	**Total**	**Measure Costs**	**Net Benefits**	**Savings/ Investment Ratio**
Very Cold	$2,788	$1,067	$3,855	$3,467	$388	1.11
Cold	$3,142	$641	$3,783	$1,921	$1,862	1.97
Moderate/Hot	$221	$1,948	$2,169	$2,404	-$235	0.90

Overall, the analysis shows that WAP installs cost-effective energy efficiency measures in small multifamily buildings treated by the program. The analysis shows that the cost-effectiveness ratio is substantially higher for fuels with high relative prices – fuel oil and propane.

5.3 PY 2013 ANALYSIS PERSPECTIVE

This section presents the estimated energy cost savings and cost-effectiveness from the perspective of policy decisions made for PY 2013. The difference between the PY 2013 Analysis Perspective and the Longer-Term Analysis Perspective (discussed in the following section) is that a different discount rate is used. On an annual basis, OMB issues an estimate of the inflation-adjusted discount rate for the current program year. That rate can change significantly between one year and the next. The estimates used for this analysis refer to values published in OMB Circular A-94 for 2013. It's important to note that the OMB projected rates are currently at historic lows. However near-term policy decisions across all Federal programs currently use these rates for budgetary decision-making. Consequently, the PY 2013 Analysis Perspective is most useful for budget decisions being made at the present time.

The following parameters are used in this analysis.

- First Year Energy Savings – Procedures are presented in Section 4 of this report.
- First Year Cost Savings – Estimated by multiplying first year energy savings per client by the average projected price per unit for each state for 2013.
- Long Term Energy Savings – Developed by applying measure life estimates to first year energy savings.
- Long Term Cost Savings – Estimated by multiplying projected energy savings by projected inflation-adjusted energy prices for each state.
- Net Present Value of Cost Savings – Developed by discounting the stream of future cost savings by the inflation-adjusted discount rate projected for PY 2013.
- Energy Cost-Effectiveness – Compares the net present value of energy cost savings to the cost of installed energy measures.

Table 5.4 summarizes the average energy costs and annual costs savings for the first year after participation in WAP in 2013 dollars. For PY 2013 participants, annual energy costs are expected to

average $1,572 prior to WAP, and it is projected that WAP would reduce these costs by an average of $211, equal to a 13.5 percent reduction in total energy costs. The energy cost and value of the savings are expected to be more than twice as large in homes heating by fuel oil or propane than for homes heated by natural gas.

Table 5.4. PY 2008 WAP Energy Impacts for Small Multifamily Homes
Energy Costs and Cost Savings by Main Heating Fuel (2013 Dollars)

	Annual Energy Costs			Annual Savings (first year)			
Heating Fuel	**Fuel**	**Electric**	**Total$**	**Fuel**	**Electric**	**Total$**	**% Savings**
Natural Gas	$739	$682	$1,421	$127	$63	$190	13.4%
Electricity	$0	$1,254	$1,254	$0	$176	$176	14.0%
Fuel Oil	$2,321	$785	$3,105	$387	$33	$420	13.5%
Propane	$1,968	$835	$2,804	$243	$68	$311	11.1%
Other	$1,006	$607	$1,613	$187	$20	$207	12.8%
All Clients	$757	$815	$1,572	$127	$84	$211	13.5%

Table 5.5 summarizes the projected life-cycle energy cost savings, the cost of installing energy efficiency measures, and the cost-effectiveness for the national program by main heating fuel. Cost-effectiveness is summarized in two ways:

- The net benefits, equal to the present value of the lifetime energy cost savings minus efficiency measure costs.

- The SIR which is the present value of the lifetime energy cost savings divided by the efficiency measure costs. An estimated 90% confidence interval on the SIR is also presented based on a Monte Carlo simulation using estimated uncertainties of the inputs.

The table shows that future programs would be expected to produce an average of $4,618 worth of energy bill savings over the lifetime of the measures (discounted to 2013 dollars) and spend an average of $2,878 on efficiency measures in these homes, yielding a net benefit of $1,741 per home and an SIR of 1.60. In other words, the projected energy savings would be worth 60% more than the cost of the efficiency measures. The significant uncertainty in future energy prices as well as in the energy savings and costs yields a 90% confidence interval that extends from 1.23 to 2.16. The uncertainty is not symmetric around the estimate due to the greater potential for energy cost increases vs. decreases.

Table 5.5. Projected PY 2013 WAP Energy Impacts for Small Multifamily Buildings
Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Main Heating Fuel
(2013 Dollars)

	Energy Cost Savings per Unit (present value of lifetime savings)			Costs & Cost Effectiveness			
Heating Fuel	**Fuel**	**Electric**	**Total**	**Measure Costs**	**Net Benefits**	**Savings/ Investment Ratio**	**SIR 90% c.i.**
Natural Gas	$3,410	$788	$4,199	$3,131	$1,068	1.34	1.00 - 1.84
Electricity	-	$3,027	$3,027	$2,402	$625	1.26	0.82 - 1.75
Fuel Oil	$10,209	$347	$10,556	$2,307	$8,249	4.58	3.16 - 6.71
Propane	$6,574	$850	$7,424	$2,359	$5,064	3.15	1.87 - 4.95
Other	$4,849	$162	$5,011	$2,663	$2,348	1.88	1.41 - 2.55
All Clients	$3,401	$1,217	$4,618	$2,878	$1,741	1.60	1.23 - 2.16

The projected SIR is greater than unity across all heating fuels, but is much larger for oil and propane-heated homes due to the high costs of these fuels. On a Btu basis, fuel oil costs 2.3 times more than natural gas, and propane costs 2.0 times more than natural gas in PY 2013.

5.4 LONGER TERM ANALYSIS PERSPECTIVE

This section presents the estimated energy cost savings and cost-effectiveness from the perspective of policy decisions made in the future. The difference between the Longer-Term Analysis Perspective and the PY 2013 Analysis Perspective is that a different discount rate is used. For more general analyses (e.g., what investment should be made in weatherization over the next five years), OMB Circular A-4 suggests that analysts use a 3% real discount rate.

Table 5.6 summarizes the projected life-cycle energy cost savings, the cost of installing energy efficiency measures, and the cost-effectiveness for the national program by main heating fuel. Cost-effectiveness is summarized in two ways:

- The net benefits, equal to the present value of the lifetime energy cost savings minus efficiency measure costs.

- The SIR which is the present value of the lifetime energy cost savings divided by the efficiency measure costs. An estimated 90% confidence interval on the SIR is also presented based on a Monte Carlo simulation using estimated uncertainties of the inputs.

The table shows that future programs would be expected to produce an average of $3,706 worth of energy bill savings over the lifetime of the measures (discounted to 2013 dollars) and spend an average of $2,878 on efficiency measures in these homes, yielding a net benefit of $828 per home and an SIR of 1.29. In other words, the projected energy savings would be worth 29% more than the cost of the efficiency measures. The significant uncertainty in future energy prices as well as in the energy savings and costs yields a 90% confidence interval that extends from 1.00 to 1.68. The uncertainty is not symmetric around the estimate due to the greater potential for energy cost increases vs. decreases.

Table 5.6. Projected Future WAP Energy Impacts for Small Multifamily Buildings
Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Main Heating Fuel
(2013 Dollars)

	Energy Cost Savings per Unit (present value of lifetime savings)			Costs & Cost Effectiveness			
Heating Fuel	**Fuel**	**Electric**	**Total**	**Measure Costs**	**Net Benefits**	**Savings/ Investment Ratio**	**SIR 90% c.i.**
Natural Gas	$2,702	$666	$3,368	$3,131	$238	1.08	0.82 - 1.44
Electricity	-	$2,483	$2,483	$2,402	$81	1.03	0.68 - 1.42
Fuel Oil	$8,065	$297	$8,362	$2,307	$6,055	3.62	2.55 - 5.20
Propane	$5,180	$715	$5,894	$2,359	$3,535	2.50	1.50 - 3.87
Other	$3,878	$143	$4,020	$2,663	$1,357	1.51	1.16 - 1.99
All Clients	$2,693	$1,013	$3,706	$2,878	$828	1.29	1.00 - 1.68

The projected SIR is greater than unity across all heating fuels, but is much larger for oil- and propane-heated homes due to the high costs of these fuels. On a Btu basis, as with the PY 2013 projection, fuel oil costs 2.3 times more than natural gas, and propane costs 2.0 times more than natural gas.