ORNL/TM-2014/558

Evaluation of the Weatherization Assistance Program During Program Years 2009-2011 (American Recovery and Reinvestment Act Period): Energy Impact for Mobile Homes

Michael Blasnik
Greg Dalhoff
David Carroll
Ferit Ucar Ph.D.
Dan Bausch
Daya Bill Johnson

March 2015

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE US DEPARTMENT OF ENERGY

ORNL Principal Investigator
Dr. Bruce Tonn

Evaluation Team Task Manager
Michael Blasnik

ORNL/TM-2014/558

Environmental Sciences Division

EVALUATION OF THE WEATHERIZATION ASSISTANCE PROGRAM DURING PROGRAM YEARS 2009-2011 (AMERICAN RECOVERY AND REINVESTMENT ACT PERIOD): ENERGY IMPACTS FOR MOBILE HOMES

Michael Blasnik, Blasnik & Associates
Greg Dalhoff, Dalhoff & Associates
David Carroll, APPRISE
Ferit Ucar Ph.D., APPRISE
Dan Bausch, APPRISE
Daya Bill Johnson, APPRISE

March 2014

Prepared by
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6283
managed by
UT-BATTELLE, LLC
for the
US DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

CONTENTS

Page

LIST OF FIGURES

Figure **Page**

LIST OF TABLES

Table **Page**

ACRONYMS

AC	Air Conditioning
ANACOVA	Analysis of Covariance
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
CDD	Cooling Degree Days
CFM50	Cubic Feet per Minute @ 50 pascals
CFR	Code of Federal Regulations
DOE	Department of Energy
ECM	Energy Conservation Measure
HDD	Heating Degree Days
IR Camera	Infrared Camera
KWH	Kilowatt Hour
LIHEAP	Low Income Home Energy Assistance Program
MMBTU	Million British Thermal Units
NCDC	National Climatic Data Center
ORNL	Oak Ridge National Laboratory
PRISM	Princeton Scorekeeping Method
PY	Program Year
SFSB	Single Family Site-built
SIR	Savings-to-Investment Ratio
SOW	Scope of Work
SSE	Steady State Efficiency
TH	Therm
TIPS	Targeted Investment Protocol System
WAP	Weatherization Assistance Program

ACKNOWLEDGEMENTS

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 mobile homes treated by DOE's Weatherization Assistance Program (WAP) during Program Years 2009, 2010, and 2011.

The original design for this research was developed by staff from the Oak Ridge National Laboratory (ORNL) as one component of the ARRA Period Evaluation of the National Weatherization Assistance Program. (*Evaluation of the Weatherization Assistance Program During Program Years 2009-2011 – American Recovery and Reinvestment Act Period, ORNL/TM-2011/87*) This evaluation was designed to be consistent with, but independent of, the Weatherization Assistance Program Evaluation for Program Years 2007 and 2008.

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 881 subgrantees, as well as detailed information on weatherization jobs from 388 subgrantees. The cooperation and contributions made by the WAP program grantees and subgrantees were essential to the completion of the study.

The ECW staff responsible for the grantee and subgrantee data collection for the PY 2010 study were:

Julie Adamski
Jaime Barbian
Ingo Bensch
Ben Brush
Kristine Busche
Claire Cowan
Heather Driscoll
Jeremy Francis
LaShanta Goodwin
Ashleigh Keene
Karen Koski
Jeannette LeZaks
Andy Mendyk
Scott Pigg
Leslie Post
Jaimie Rule
Nick Sayen

Energy Supplier Data Collection

APPRISE was responsible for extracting client data from program databases made available to the evaluation team by grantees. The APPRISE staff who contributed to this process were:

Ferit Ucar
Daya Bill
Dan Bausch
Chisoo Kim
Zach Tausanovitch
Leah Harrell
Deena Mitlak
Jeffery Ho
Lauren Ashcraft
Carlos Salguero

APPRISE collected information on electric and gas usage from 365 electric companies and 220 gas companies. The cooperation of and contributions made by the electric and gas companies were essential to the completion of the study.

The APPRISE staff responsible for the electric and gas company data collection and analysis for the PY 2010 study were:

Lisa Courtney
James Devlin
Arlene Shipley
Camille D'Andrea
Michael Brach
Alex McEwan
Anne Worth
David Slayback

Finally, we would like to acknowledge the assistance and guidance of the Oak Ridge National Laboratory, Department of Energy Project Officers, and Department of Energy Headquarters Staff.

Michael Blasnik
Greg Dalhoff
David Carroll

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 single family mobile homes treated by DOE's Weatherization Assistance Program (WAP) during the Recovery Act Period - Program Years 2009, 2010, and 2011. The focus of this study is on PY 2010. The analysis characterizes the population of mobile homes served by the program, estimates the gross and net change in energy usage for treated homes, 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 four energy impact reports developed for the PY 2010 WAP Evaluation. 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 information on the overall program performance.

Background

The U.S. Department of Energy's (DOE) Weatherization Assistance Program 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 2011. DOE furnished funding to ORNL for the evaluation of the program during Program Years 2009-2011 (the American Recovery and Reinvestment Act Period). 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.

- 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 mobile home energy impacts is part of the Impact Assessment.

Study Overview

The mobile home energy impact report furnishes information on the households and housing units served by the program, documents the services delivered to those households and housing units, measures the change in energy consumption and energy costs experienced by those clients, and compares the cost of the installed measures to the energy cost savings. The study procedures included:

- Development of a representative sample of clients served by the program using data from DOE, grantees, and subgrantees.
- Collection of information from subgrantees on client characteristics, installed measures, and measure costs for sampled clients.
- Collection of energy usage information from energy suppliers and through direct metering in clients' homes.
- Statistical analysis of pre- and post-weatherization energy usage to develop robust 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 combined set of procedures furnishes estimates of the energy and cost impacts associated with the WAP program, identifies the explanatory factors associated with higher levels of energy impacts, and assesses the cost-effectiveness of measure packages and the overall program.

Program Characterization

The evaluation team collected information on the clients served and the services delivered by the WAP program. PY 2010 program statistics are available from the Department of Energy and WAP grantees (i.e., states). Detailed information about clients and client services was supplied by program subgrantees (i.e., local agencies). These data were used to characterize WAP clients in terms of housing unit type, geography, household demographics, housing unit characteristics, and program services.

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 331,865 housing units in PY 2010 with DOE funding. Table 1 shows the distribution of treated units by housing unit type. About 15 percent of the treated units were mobile homes. Table 2 shows the distribution of treated mobile homes by Climate Zone; the Cold Climate Zone had the largest share of mobile homes (30%) served by the program and the Hot/Dry Climate Zone has the smallest share (9%).

Table 1 PY 2010 WAP Clients by Housing Unit Type

Housing Unit Type	PY 2010 Weighted Count of Clients	Percent of PY 2010 Clients
Single Family Site-built (1-4)	215,445	65%
Single Family Mobile Home	48,267	15%
Multifamily (5+)	68,153	20%
TOTAL	331,865	100%

Table 2 PY 2010 WAP Clients in Mobile Homes by Climate Zone

Climate Zone	PY 2010 Clients	Percent of PY 2010 Clients
Very Cold Climate	10,138	21%
Cold Climate	14,551	30%
Moderate Climate	11,242	23%
Hot/Humid Climate	7,878	17%
Hot/Dry Climate	4,458	9%
TOTAL	48,267	100%

The WAP clients who live in mobile homes are diverse. For example:

- The median household income was $14,712. But, 10 percent of WAP clients had income of $3,000 or less and more than 10 percent of WAP clients had income of $25,000 or more.
- The average WAP client had 2.3 household members, but 23 percent of households were made up of an elderly person living alone.
- The majority of clients were white non-Hispanic households (78%), but 13 percent were black non-Hispanic households and 9 percent were other racial/ethnic groups.

WAP client mobile homes are not as diverse as site-built homes. Nationally, the average WAP client mobile home has 980 square feet of living space with very little variation by climate zone. About 60 percent of WAP client mobile homes were built after 1980 cc.

Table 3 shows how WAP client mobile homes varied with respect to a number of important housing unit characteristics. The most common main heating fuel for WAP client mobile homes was electricity (40%), but natural gas and delivered fuels also were used by a substantial share of the population (31% and 29% respectively). But, over two-thirds used electricity for water heating. About 78 percent of mobile home clients had some type of air conditioning. Some WAP clients use electric (21%) and/or wood (5%) supplemental heat.

Table 3 Characteristics of Mobile Homes Served by WAP in PY 2010

Characteristic			
Year Built	Pre 1970 = 8%	1970-1979 = 32%	1970 or Later = 60%
Space Heating Fuel	Gas = 31%	Electric = 40%	Delivered = 29%
Heating System	Central = 92%	Room = 7%	Other = 1%
Supplemental Heat	Electric = 21%	Wood = 5%	
Air Conditioning	Central = 43%	Window/Wall = 35%	None = 22%
Water Heating Fuel	Natural Gas = 21%	Electric = 70%	Other = 9%

The WAP program conducts extensive testing of clients' homes, 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 homes served by the program. The testing shows that homes vary considerably in terms of pre-weatherization conditions, including: air leakage rates, furnace efficiency, presence and amount of attic insulation, presence and amount of wall insulation, duct leakage rates, and refrigerator efficiency.

After this testing WAP subgrantees install a comprehensive set of measures matched to the needs of each home. For site-built homes, the analysis focused on four major measures: air sealing, attic insulation, wall insulation, and furnace replacement. These four measures are responsible for most of the space heating and space cooling energy savings in site-built homes. However, there are important differences between site-built homes and mobile homes that result in different measures being installed in mobile homes. Some of the similarities and differences include:

- Air Sealing – For both site-built homes and mobile homes, bypass air sealing can have a major impact on energy consumption.

- Furnace Replacement – For both site-built homes and mobile homes, furnace replacement can have a major impact on energy consumption.

- Insulation – Attic insulation and wall insulation can be cost-effective measures for mobile homes. However, since insulation procedures for mobile home are different than those for site-built homes, these measures are done less often in mobile homes than in site-built homes. However, because of the configuration of mobile homes, floor insulation is installed more often in mobile homes and can have a significant impact on energy usage.

- Duct Sealing – For many site-built homes, heating and cooling ducts are inside the thermal envelope; duct sealing in site-built homes might improve the performance of the distribution system but might not reduce energy consumption. Since mobile home ducts are more likely to be outside the thermal envelope, duct sealing can have a major impact on energy usage.

For mobile homes, the analysis will focus on the five major measures that appear to have the greatest impact on energy savings including: furnace replacement, air sealing, attic insulation, duct sealing, and floor insulation. For both site-built homes and mobile homes, furnace replacement, air sealing, and attic insulation are major measures. However, while wall insulation is a major measure for site-built homes, duct sealing and floor insulation are more common in and have a higher impact on energy savings for mobile homes.

Not every home needs every major measure. For example, a mobile home with attic insulation that meets or exceeds standards for the climate in which it is located would not save much energy if more insulation were added. For that reason, only measures that are projected to have a savings-to-investment ratio (SIR) greater than 1.0 are installed as energy conservation measures (ECMs).

WAP subgrantees also install some health and safety measures that are not expected to result in cost-effective energy savings. For example, some homes have a furnace or water heater that is not operating safely and needs to be replaced to protect the health and safety of clients. Testing procedures also may find that the home has insufficient ventilation to maintain a healthy indoor air quality; those homes may have mechanical ventilation added. Mechanical ventilation is expected to increase, rather than decrease, energy usage.

Table 4 shows the PY 2010 measure installation rates for mobile homes service by the WAP program by Climate Zone. The measures with the highest installation rates were bypass air sealing, duct sealing, floor insulation, and lighting; all of these measures were installed in 50 percent or more of the treated homes. Furnace replacement and attic insulation were installed in 30 percent and 24 percent of homes respectively. Other listed measures had installation rates that varied from 3 percent (wall insulation) to 26 percent (windows).

For many of the measures, installation rates did not vary much by Climate Zone. For example, duct sealing installation rates ranged from 50 percent in the Hot/Humid Climate Zone to 62 percent in the Very Cold Climate Zone. There were some measures that we installed at significantly lower rates in the Hot/Dry Climate Zone, including Mechanical Ventilation, Attic Insulation, Floor Insulation, and Programmable Thermostats. However, the Hot/Dry Climate Zone installation rates exceeded the national average for furnace replacement, water heater replacement, windows and lighting. In comparison, the Very Cold Climate Zone measure installation rates exceeded the national average for almost every measure.

Table 4 Measure Installation Rates for Mobile Homes Served by WAP in PY 2010

Measure	NATIONAL	Very Cold	Cold	Moderate	Hot/Humid	Hot/Dry
Air Sealing						
Bypass Air Sealing	90%	87%	91%	90%	98%	78%
Mechanical Ventilation	20%	22%	17%	22%	26%	7%
Duct Sealing	57%	62%	55%	60%	50%	57%
Insulation						
Attic Insulation	24%	30%	24%	27%	23%	<1%
Wall Insulation	3%	6%	4%	1%	1%	<1%
Floor, Rim Joist, Foundation	50%	61%	59%	57%	21%	2%
Equipment						
Furnace Replacement	30%	38%	33%	24%	22%	32%
Programmable Thermostat	16%	23%	15%	14%	16%	9%
Water Heater Replacement	13%	15%	13%	6%	16%	18%
Other						
Windows	26%	26%	29%	28%	12%	32%
Storm Windows	8%	14%	6%	10%	5%	2%
Refrigerator	22%	25%	19%	23%	21%	20%
Lighting	76%	68%	76%	70%	91%	80%

Gas and Electric Savings in Gas Heated Homes

The evaluation directly measured gas and electric usage for Treatment Group and Comparison Group homes 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 homes treated during PY 2010. Net program savings were estimated by comparing the savings for

Treatment Group homes to the savings for Comparison Group homes.[1] Table 5 shows that the gross gas savings for gas heated homes in PY 2010 were 82 therms per home per year. However, during the same period, the Comparison Group (PY 2011 clients) increased their usage by 7 therms per home per year without receiving any treatments. So, net savings due to the program are estimated to be 89 therms (12.9%) per home per year.

Table 5 PY 2010 WAP Energy Impacts for Mobile Homes Gross and Net Gas Savings (therms/year)

Group	# Homes	Use PreWAP	Use PostWAP	Gross Savings	Net Savings	% of Pre
Treatment	706	692	610	82 (±9)	89 (±11)	12.9% (±1.6%)
Comparison	293	685	692	-7 (±7)		

Energy savings varied significantly among the mobile homes weatherized by the program. An explanatory factors analysis found that several factors were associated with higher energy savings, including:

- Homes that got more major measures (Table 6).
- Homes with higher pre-weatherization gas usage (Table 7).
- Homes with higher levels of spending on weatherization measures (See Table 4.14).

Table 6 shows that the amount of natural gas saved increases substantially as the number of major measures installed in the home increased; homes that had three major measures saved more than twice the amount of energy saved by homes that only had one major measure installed. The tables also show that the average pre-weatherization usage was higher for homes that received more measures.

Table 6[2] PY 2010 WAP Energy Impacts for Mobile Homes Gas Savings for Homes with Natural Gas Main Heat By Measure Combination (therms/year)

Group/Breakout	# Homes	Gas Use Pre-WAP	Net Savings	% of Pre
No Major Measures	88	657	44 (±17)	6.6 (±2.6)
Any One Major Measure	174	696	58 (±15)	8.3 (±2.2)
Any Two Major Measures	209	735	106 (±17)	14.5 (±2.4)
Any Three Major Measures	141	752	132 (±21)	17.6 (±2.8)
Four or Five Major Measures	47	773	186 (±24)	24.1 (±3.1)

Table 7 shows that homes with higher pre-weatherization usage had higher energy savings, even when the analysis controlled for the number of major measures installed. For example, homes with pre-weatherization usage of 1,000 or more therms received an average of 2.1 major measures and had average savings of 184 therms, while homes with pre-weatherization usage of 600 to <800 therms received an average of 1.8 major measures and had average savings of 73 therms. The higher-usage homes saved more than twice as many therms of natural gas despite getting only slightly more installed measures.

[1] The Comparison Group includes homes 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.

[2] For this analysis, major measures include heating system replacement, floor insulation, attic insulation, duct sealing, and major air sealing (i.e., leakage reduction of at least 1,000 CFM50).

Table 7 PY 2010 WAP Energy Impacts for Mobile Homes Net Gas Savings for Natural Gas Main Heat by Pre-Weatherization Gas Usage (therms/year)

Pre-WAP Gas Use (therms/year)	# Major Measures	# Homes	Gas Use Pre-WAP	Net Savings	% of Pre
<400 therms/year	1.6	71	313	20 (±13)	6.5% (±4.3%)
400-<600	1.7	184	506	57 (±14)	11.2% (±2.7%)
600-<800	1.8	207	693	73 (±15)	10.6% (±2.2%)
800-<1000	1.9	148	895	146 (±28)	16.3% (±3.2%)
>=1000	2.1	96	1,161	184 (±39)	15.9% (±3.4%)

Note: Comparison Group, not shown, also was stratified by usage.

Savings for gas heated homes varied across Climate Zones, with higher savings in the Very Cold and Cold Climate Zones (Table 8). For those zones, average savings were about 100 therms. Relatively few cases were available for analysis in the Moderate, Hot/Humid, and Hot/Dry Climate Zones. Average usage and savings were low for those Climate Zones.

Table 8 PY 2010 WAP Energy Impacts for Mobile Homes Net Gas Savings for Natural Gas Main Heat by Climate Zone (therms/year)

Climate	# Major Measures	# Homes	Gas Use Pre-WAP	Net Savings	% of Pre
Very Cold	2.0	306	835	104 (±19)	12.5% (±2.3%)
Cold	1.8	289	671	100 (±18)	14.8% (±2.6%)
Moderate/Hot	1.7	111	476	44 (±18)	9.1% (±3.7%)

Note: Comparison Group, not shown, also was stratified by climate zone.

Weatherization of gas heated homes also can result in savings of electricity. Air sealing and insulation can reduce the use of a furnace fan in the winter and the demand for air conditioning in the summer. In addition, many WAP homes also have baseload measures such as refrigerators and energy efficient lights installed. Table 9 shows that the gross electric savings for gas heated homes in PY 2010 were 842 kWh and the net savings were 665 kWh (7.6%).

Table 9 PY 2010 WAP Energy Impacts for Mobile Homes Gross and Net Electric Savings for Natural Gas Main Heat by End Use

Group	# Homes	Elec Use Pre-WAP	Elec Use Post-WAP	Gross Savings	Net Savings	% of Pre
Treatment	695	8,792	7,949	842 (±107)	665 (±177)	7.6% (±2.0%)
Comparison	294	8,864	8,687	177 (±137)		

Electric Savings in Mobile Homes with Electric Main Heat

The evaluation directly measured electric usage for Treatment Group and Comparison Group mobile homes that use electric main heating fuel. Gross program savings were estimated by comparing pre-weatherization usage (weather-normalized) to the post-weatherization usage (weather-normalized) for homes treated during PY 2010. Net program savings were estimated by comparing the savings for Treatment Group homes to the savings for Comparison Group homes.[3] Table 10 shows that the gross savings for electric heat homes in PY 2010 was 2,137 kWh. During the same period, the Comparison Group reduced usage by 445 kWh without receiving any treatments; net program savings are estimated to be 1,692 kWh (8.7%).

Table 10 PY 2010 WAP Energy Impacts for Mobile Homes Gross and Net Electric Savings for Electric Main Heat (kWh/year)

Analysis Group	# Homes	Elec Use Pre-WAP	Gross Savings	Net Savings	% of Pre
Treatment	696	19,408	2,137 (±246)	1,692 (±330)	8.7% (±1.7)
Comparison	276	19,713	445 (±211)		

As with gas heated homes, both tabular data analysis and regression models show that certain factors are associated with higher levels of savings for WAP clients who use electricity as their main heating fuel. Savings were higher for:

- Homes that got more major measures (Table 11).
- Homes with higher pre-weatherization electric usage (Table 12).

Table 11 shows that increasing the number of major measures installed in a home increased the net savings; homes that had three major measures saved almost three times the amount of energy saved by homes that only had one major measure installed. The tables also show that the average pre-weatherization usage was higher for homes that received more measures.

Table 11 PY 2010 WAP Energy Impacts for Mobile Homes Net Electric Savings for Electric Main Heat (kWh/yr) By Number of Major Measures

# Major Measures	# Homes	Elec Use Pre-WAP	Net Savings	% of Pre
No Major Measures	110	16,794	112 (±598)	0.7% (±3.6%)
One Major Measure	176	18,521	1,053 (±413)	5.7% (±2.2%)
Two Major Measures	193	20,326	1,938 (±529)	9.5% (±2.6%)
Three or More Major Measures	174	21,168	3,069 (±430)	14.5% (±2.0%)

Table 12 shows that higher savings were observed for homes with higher usage. Homes that used 20,000 or more kWh prior to weatherization had average savings of more than 2,500 kWh/year. In comparison, homes with less than 15,000 kWh of pre-weatherization usage saved only 444 kWh/year.

[3] The Comparison Group includes homes 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.

Table 12 PY 2010 WAP Energy Impacts for Mobile Homes Gross and Net Electric Savings for Electric Main Heat by Pre-Weatherization Electric Usage

Pre-WAP Use	# Homes	Elec Use Pre-WAP	Net Savings	% of Pre
<15,000 kWh/yr.	184	11,791	444 (±350)	3.8% (±3.0%)
15,000-<20,000	221	17,596	1,736 (±418)	9.9% (±2.4%)
20,000-< 25,000	152	22,474	2,691 (±753)	12.0% (±3.3%)
>=25,000 kWh/yr.	139	29,611	2,514 (±956)	8.5% (±3.2%)

Note: Comparison Group, not shown, also was stratified by pre-WAP electric use.

Energy Savings in Homes that Heat with a Delivered Fuel

The procedure for estimating the energy savings for homes that heat with a delivered fuel involved the following steps:

- Direct Metering of Homes – Energy use was directly metered for a sample of 120 site-built homes during the 2010-2011 heating season.

- Measured Energy Savings – Gross energy savings were estimated by comparing pre-weatherization metered usage to post-weatherization metered usage for treated homes. Net energy savings were estimated by comparing the change in energy consumption for the Treatment Group to the change in usage for the Comparison Group.

- Comparative Analysis – The measured energy savings for delivered fuel homes were compared to projected savings for those same homes using the model developed for homes heated with natural gas. The analysis found that there was only a small difference between the measured savings and projected savings for delivered fuel homes.

- Projected Energy Savings – The natural gas energy savings models were used to project energy savings for the population of delivered fuel homes treated in PY 2010.

Table 13 shows the estimated energy savings for delivered fuel homes for PY 2010. These homes represent about 30 percent of the population of mobile homes treated in PY 2010. The average energy savings of 11.2 MMBtu for delivered fuel main heat homes is somewhat higher than the average energy savings of 8.9 MMBtu for natural gas main heat homes (Table 5).

Table 13 PY 2010 WAP Energy Impacts for Mobile Homes Net Savings for Delivered Fuel Main Heat

Main Heating Fuel	Heating Fuel Savings (MMBtu/yr)	Electric Savings (kWh/yr)
Fuel Oil	11.5	321
Propane	10.7	370
Other	12.1	321
All Delivered Fuels	**11.2**	**342**

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 cost 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 in 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 nonenergy benefits to total program costs.

This report presents information on energy savings for PY 2010. In this report, the energy cost savings and cost-effectiveness are presented from three different perspectives.

- Impact on PY 2010 Clients – The first scenario documents how the program impacted PY 2010 clients. It shows the clients' first year energy cost savings based on actual energy prices in 2010 and the estimated net present value of their energy cost savings based on actual energy prices for 2010 through 2012, projected energy prices beginning in 2013, and the discount rates in effect in 2010.
- PY 2013 Policy Perspective – The second scenario is the most relevant to policymakers 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 Policy 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 2010 Client Perspective is the most useful for documenting what the program accomplished while the PY 2013 Policy Perspective is probably the most useful for policymakers making

decisions about the program going forward. Tables 14 and 15 reflect the assumptions under the PY 2010 Client Perspective and Tables 16 and 17 reflect the assumptions under the PY 2013 Policy Perspective.

Table 14 shows the estimated average annual energy costs and first year cost savings for PY 2010 clients by main heating fuel type. On average, WAP clients had pre-weatherization energy bills of $1,926 and energy savings of $190 (9.9%). The cost savings for fuel oil and propane heated homes is expected to be substantially higher than 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 that for natural gas.

Table 14 PY 2010 WAP Energy Impacts for Mobile Homes Energy Costs and Cost Savings by Main Heating Fuel (2010 Dollars)

Heating Fuel	Annual Energy Costs			Annual Savings (First Year)			
	Fuel	Electric	Total$	Fuel	Electric	Total$	% Savings
Natural Gas	$517	$874	$1,391	$77	$59	$136	9.8%
Electricity	-	$1,855	$1,855	-	$153	$153	8.2%
Fuel Oil	$1,477	$1,090	$2,567	$199	$59	$258	10.1%
Propane	$1,792	$951	$2,744	$232	$61	$293	10.7%
Other	$671	$1,099	$1,770	$97	$73	$169	9.6%
All Clients	**$835**	**$1,091**	**$1,926**	**$114**	**$76**	**$190**	**9.9%**

Note: Other heating fuels include wood, kerosene, and coal.

Table 15 furnishes a projection of the energy cost-effectiveness of the program for mobile 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 0.72 for the overall program. The SIR is less than 1.0 for homes heated with natural gas or electricity. It is greater than 1.0 for homes heated with fuel oil or propane because of the much higher energy cost savings for those homes.

Table 15 PY 2010 WAP Energy Impacts for Mobile Homes Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Main Heating Fuel (2010 Dollars)

Heating Fuel	Energy Cost Savings (Present Value of Lifetime Savings)			Costs & Cost-Effectiveness		
	Fuel	Electric	Total	Measure Costs	Net Benefits	SIR
Natural Gas	$1,298	$553	$1,850	$3,353	-$1,503	0.55
Electricity	-	$2,221	$2,221	$3,792	-$1,571	0.59
Fuel Oil	$4,382	$528	$4,910	$3,409	$1,501	1.44
Propane	$2,964	$561	$3,525	$3,502	$22	1.01
Other	$1,658	$631	$2,290	$3,627	-$1,337	0.63
All Clients	**$1,329**	**$1,219**	**$2,549**	**$3,538**	**-$989**	**0.72**

While it is useful to know how the program performed for PY 2010 clients, today's policymakers need to make decisions based on current energy prices, price projections, and discount rates. Table 16 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 $1,921 and first year energy savings of $189 (9.8%). When compared to the PY 2010 energy cost savings, Table 16 shows that the projected energy cost savings for a program implemented in PY 2013 are about the same

as those experienced by clients served in 2010; natural gas and electric prices are about the same as they were in 2010, propane prices are lower, and fuel oil prices are higher.

Table 16 Projected PY 2013 WAP Impacts for Mobile Homes Energy Costs and Cost Savings by Main Heating Fuel (2013 Dollars)

Heating Fuel	Annual Energy Costs			Annual Savings (first year)			
	Fuel	Electric	Total$	Fuel	Electric	Total$	% Savings
Natural Gas	$502	$876	$1,379	$75	$60	$134	9.8%
Electricity	-	$1,868	$1,868	-	$154	$154	8.3%
Fuel Oil	$1,827	$1,125	$2,952	$246	$60	$307	10.4%
Propane	$1,525	$961	$2,486	$197	$61	$258	10.4%
Other	$709	$1,135	$1,844	$102	$75	$177	9.6%
All Clients	**$819**	**$1,103**	**$1,921**	**$112**	**$76**	**$189**	**9.8%**

Note: Other heating fuels include wood, kerosene, and coal.

However, Table 17 shows that first year projected energy savings for PY 2013 WAP clients are about the same as those for PY 2010 clients, but the net present value of those energy cost savings are higher because the specified discount rate for FY 2013 is lower than the specified discount rate for FY 2010; 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 0.79 for the overall program, somewhat higher than the SIR of 0.72 experienced by the clients served by the PY 2010 program. Despite having similar projected energy cost savings, investments in weatherization have a higher economic value because of the lower discount rate.

Table 17 Projected PY 2013 WAP Energy Impacts for Mobile Homes Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Main Heating Fuel (2013 Dollars)

Heating Fuel	Energy Cost Savings (present value of lifetime savings)			Costs & Cost-Effectiveness		
	Fuel	Electric	Total	Measure Costs	Net Benefits	SIR
Natural Gas	$1,554	$620	$2,174	$3,542	-$1,368	0.61
Electricity	-	$2,555	$2,555	$4,005	-$1,451	0.64
Fuel Oil	$5,252	$584	$5,836	$3,601	$2,235	1.62
Propane	$3,411	$628	$4,040	$3,700	$340	1.09
Other	$1,910	$702	$2,612	$3,831	-$1,219	0.68
All Clients	**$1,565**	**$1,392**	**$2,957**	**$3,737**	**-$780**	**0.79**

The energy savings analysis showed that certain treatment characteristics were associated with higher levels of energy savings. The cost-effectiveness analysis shows that higher energy savings do not always result in a higher cost-effectiveness ratio. For example:

- Climate Zone – The Cold Zone had the highest SIR because it had the lowest average energy measures costs. (See Table 7.3)

- Major Measures – Homes that received more major measures saved more energy, and the estimated cost-effectiveness increased as the number of major measures increased. (See Table 7.4)

- Pre-Weatherization Usage – Homes with the highest level of pre-weatherization usage had the highest energy savings and the highest SIR. (See Table 7.5)

- DOE vs. non-DOE Funds – Homes that were treated with both DOE and nonDOE funds had both lower energy cost savings and a low SIR than homes that were treated with DOE funds alone. (See Table 7.6)

These analyses show that there are important differences in the outcomes for different WAP subpopulations. Furthermore, there are some differences between findings with respect to energy savings, cost savings, and cost-effectiveness. The energy savings analysis is clear: by treating homes with higher pre-weatherization usage and installing more measures, the program can save more energy per home. The cost savings analysis shows that the highest direct benefit to clients (i.e., reduction in energy bills) is achieved by focusing on the clients who used the highest-cost fuels (i.e., fuel oil and propane). Finally, the cost-effectiveness analysis shows that the highest cost-effectiveness ratios are achieved by maximizing cost savings per dollar spent (i.e., targeting higher usage homes, installing more measures in those homes, and serving clients that are using the highest cost fuels).

It is clear that WAP policies can have a significant impact on the average levels of energy savings, cost savings, and cost-effectiveness for the program by encouraging changes in the way that the program is implemented. However, it is also clear that there are important trade-offs among those three goals that might result from any individual policy change. Finally, it is important to remember that this analysis has only focused on energy cost savings and the cost of energy efficiency measures and incidental repairs. Policy changes that are designed to change the level of energy savings, cost savings, or cost-effectiveness may have either positive or negative effects on program nonenergy benefits.[4]

[4] Nonenergy benefits include benefits to clients (e.g., reduced late payment charges, increased home value, and improved health), benefits to ratepayers (e.g., reduced payment subsidies), and benefits to society (e.g., reduced emissions and increased employment).

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 single family mobile homes treated by DOE's Weatherization Assistance Program (WAP) during Program Years 2009, 2010, and 2011 (the American Recovery and Reinvestment Act Period). The main focus of this study is on PY 2010. The analysis uses data from a number of sources to characterize the population of mobile homes that were served by the program, estimate the gross and net change in energy usage for treated homes, 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 energy impact reports developed for the National WAP Evaluation. The full set of energy impact reports consists of:

- Energy Impacts for Single Family Homes
- Energy Impacts for Mobile Homes
- Energy Impacts for Multifamily Buildings
- Energy and Nonenergy Impacts of the Weatherization Assistance Program

To the extent possible, the WAP program 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

The U.S. Department of Energy's (DOE) Weatherization Assistance Program 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 2011. DOE furnished funding to ORNL for a national evaluation for Program Years 2009, 2010, and 2011 (the American Recovery and Reinvestment Act Period), with a particular emphasis on PY 2010. ORNL subcontracted evaluation research to APPRISE Incorporated and its partners the Energy Center of 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.

- 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 mobile home energy impacts is part of the program Impact Assessment.

1.2 MOBILE HOME ENERGY IMPACT STUDY OVERVIEW

The mobile home energy impact report furnishes information on the households and housing units served by the program, documents the services delivered to those households and housing units, measures the change in energy consumption and energy costs experienced by those clients, and compares the cost of the installed measures to the energy cost savings.

The data collection and analysis conducted to develop this report involved a series of complementary tasks, including:

- Client Sample – The evaluation team worked with grantees and subgrantees to select a representative sample of clients served by the program in PYs 2009, 2010, and 2011.

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

- Energy Data Collection – The evaluation team collected information from energy suppliers and through direct metering in clients' homes to assess the amount of energy used in the clients' homes before and after the installation of weatherization measures.

- Energy Data Analysis - Statistical procedures were used to develop normalized estimates of the usage difference in the pre- and post-weatherization periods and develop robust 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 program cost-effectiveness.

This combined set of procedures was designed to furnish estimates of the energy and cost impacts associated with the 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.

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.

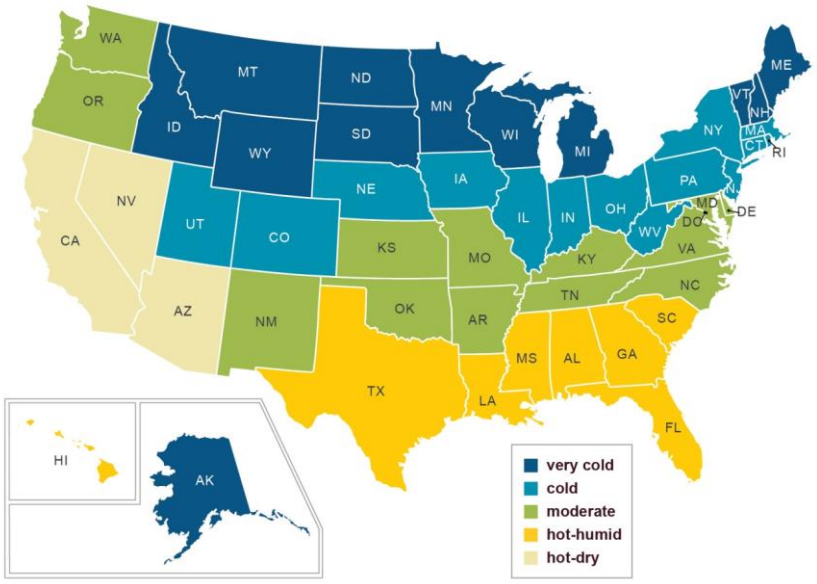

Figure 1.1: Climate Zone Map for the PY 2010 Evaluation

1.3 ORGANIZATION OF THE MOBILE HOME ENERGY IMPACT REPORT

The report consists of eight sections, including:

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

- Section 3 – Program Production, Participants, Housing Units, and Treatments: Furnishes information on the number of clients in mobile homes served by the WAP, the household and housing unit characteristics of these clients, the diagnostics performed, and the services delivered.

- Section 4 – Energy Impacts for Mobile Homes with Gas Main Heat: Furnishes estimates of the natural gas and electric impacts for homes with natural gas main heat.

- Section 5 – Energy Impacts for Mobile Homes with Electric Main Heat: Furnishes estimates of the electric impacts for homes with electric main heat.

- Section 6 – Energy Impacts for Mobile Homes with Delivered Fuel Main Heat: Reports on how submeter data and program production data were used to estimate the energy impacts for mobile homes that use a delivered fuel as their main source of heating.

- Section 7 – Cost Savings, Measure Costs, and Cost-Effectiveness: Compares the investments made in the treated homes to the energy costs savings that accrue to clients, and summarizes how the program performed with respect to weatherization of mobile homes in terms energy savings, cost savings, and cost-effectiveness.

This report is designed to complement other Energy Impact Reports and to contribute to the Summary Report on Energy and Nonenergy Impacts of the WAP.

2. OVERVIEW OF DATA COLLECTION METHODOLOGY

The purpose of the mobile home energy impact study is to measure the energy savings, cost savings, and cost-effectiveness for mobile homes treated by WAP during Program Years 2009, 2010, and 2011. The main focus of the study is on PY 2010. 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
- EIA Energy Price Data and Projections
- NCDC Weather Data

This section of the report describes the data collection procedures and outcomes for grantees, subgrantees, and electric and gas utilities. The analysis methods used in this study were specified in the program evaluation plan and are consistent with energy program evaluation best practices. The analysis procedures used to estimate the program impacts for each main heating fuel type are discussed in the relevant impact sections of the report.

2.1 SUBGRANTEE AND CLIENT SAMPLE

The first step in the data collection process was to select a representative sample of clients served in PYs 2010 and 2011.[5] 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 clients was selected from sampled subgrantees.

2.1.1 Subgrantee Sampling Procedures

The Evaluation Team selected a two-stage sample of 451 agencies. First, the sample included all subgrantees (N=95) that received SERC (Sustainable Energy Resources for Consumers) program funding. Second, a sample of subgrantees was selected with probability proportionate to PY 2010 funding. The sampling procedure was:

- Grantee Allocation – Each grantee was allocated a share of the sample of 356 subgrantees based on its share of PY 2010 program funding.[6]

- Subgrantee Sample – For each grantee, a set of subgrantees was sampled with probability proportionate to size based on PY 2010 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 Client Sampling Procedures

The Evaluation Team contacted each of the sampled agencies to get information on clients served in PYs 2010 and 2011. The client sampling procedures involved the following steps:

[5] The sample of clients for PY 2009 was collected as part of the PY 2008 National Weatherization Assistance Program Evaluation. The procedures and statistics presented in this section refer to PY 2010 and PY 2011 clients.

[6] This report focuses on the clients served by the 50 state grantees and the District of Columbia. The grantee sample included two territory grantees and one tribal grantee. Separate reports are being prepared for those grantees.

- Client List – Each sampled subgrantee furnished a list of clients for PYs 2010 and 2011. (Note: In many cases, the grantee furnished a database of clients from which the subgrantee list could be developed.)

- Client Sample – Subgrantee 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 a targeted percentage of clients in each of the two strata (i.e., utility main heat and the delivered fuel main heat); the targeted percentage varied by Climate Zone.

2.1.3 Subgrantee and Client Sampling Statistics and Response Rates

The sample consisted of 51 state grantees (including the District of Columbia) and 448 of their subgrantees. The following statistics describe the sample and the response rates for those grantees and subgrantees:

- Grantees (States and District of Columbia)
    - Population – 51 grantees received WAP funding in PY 2010.
    - Census – All 51 grantees were included in the sample.
    - Response – All 51 grantees (100%) responded to information requests.
- Subgrantees
    - Population – 1,020 subgrantees were listed in grantee plans, but only 929 completed units in PY 2010.
    - Sample – 448 of the 929 subgrantees with PY 2010 units were sampled.
    - Response – 438 of the 448 sampled subgrantees (98%) furnished client lists.

The Evaluation Team selected a sample of 39,115 PY 2010 clients from the 438 sampled subgrantees that furnished a list of clients; 5,632 of those clients lived in mobile homes.

2.2 SUBGRANTEE DATA COLLECTION

Subgrantees were asked to furnish two kinds of client data to support the evaluation, utility account information and client service delivery data. (Note: In some cases, the utility account information was included in the grantee database.)

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 clients who heated with either natural gas or electricity. The following statistics describe the response rate to this data request:

- Sample – 448 sampled subgrantees were asked to furnish a list of clients.
- Client List Response – 438 of 448 sampled subgrantees (98%) furnished client lists.
- Utility Data Response – 409 of 448 sampled subgrantees (91%) furnished utility data for sampled clients.

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

- Sample – The Evaluation Team selected a sample of 4,735 PY 2010 clients who lived in a mobile home heated with natural gas or electricity from the 438 sampled subgrantees that furnished client lists.

- Responding Subgrantees – The 409 subgrantees that responded to the utility data request had 4,371 of these 4,735 sampled clients (92%).

- Main Heating Supplier – The 409 subgrantees that responded furnished the heating energy supplier information for 3,718 of their 4,371 mobile home clients (85%). That represents 79 percent of all sampled clients.

- Electric Data Supplier - The 409 subgrantees that responded furnished electric supplier information for 3,715 of their 4,371 mobile home clients (85%). That represents 78 percent of all sampled mobile home clients.

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.

2.2.2 Client Service Delivery Data

Subgrantees were asked to furnish client service delivery information for all PY 2010 sampled clients. The requested service delivery data included:

- Household demographics
- Housing unit characteristics
- Pre-Weatherization conditions
- Installed measures and costs
- Post-Weatherization conditions

The following statistics describe the response rate to this data request:

- Sample – 448 sampled subgrantees were asked to furnish a list of clients.
- Client List Response – 438 of 448 sampled subgrantees (98%) furnished a list of clients.
- Service Delivery Data Response – 390 of 448 sampled subgrantees (87%) furnished client service delivery data.

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

- Sample – The Evaluation Team selected a sample of 5,250 PY 2010 clients who lived in mobile homes from the 438 sampled subgrantees that furnished client lists.

- Responding Subgrantees – The 390 subgrantees that responded to the client service delivery data request had 5,027 of the 5,250 sampled clients (96%).

- Client Data – The 390 subgrantees that responded furnished service delivery data for 4,752 of their 5,027 mobile home clients (95%). That represents 91 percent of all sampled mobile home clients.

Note that subgrantees did not always furnish detailed records for every client who was sampled.

2.3 NATURAL GAS AND ELECTRIC USAGE DATA COLLECTION

For all sampled clients who heated with either natural gas or electricity, the evaluation team requested data from the company that supplied the client's main heating fuel. The supplier was asked to furnish

monthly data for the period 1/1/2008 through 12/31/2012. The following statistics describe the response rates:

- Natural Gas or Electric Main Heating Fuel
    - Companies – 302 natural gas and electric companies were identified for one or more sampled PY 2010 mobile home clients.
    - Company Response – 251 of the 302 companies (83%) furnished data for one or more of the sampled clients.
    - Client Response – Data were received for 2,484 of the 3,566 PY 2010 mobile home clients for whom a supplier was listed (70%). That is 52 percent of the 4,735 sampled mobile home clients who heat with either natural gas or electricity.
- Electric Usage for Natural Gas Main Heat Clients
    - Companies – 156 electric companies were identified as the electric supplier for one or more PY 2010 mobile home clients who heat with natural gas.
    - Company Response – 137 of the 156 electric companies (86%) furnished data for one or more of the sampled clients.
    - Client Response - Data were received for 1,085 of the 1,520 PY 2010 mobile home clients (71%) for whom an electric supplier was listed. That is 54 percent of the 2,026 sampled clients who heat with natural gas.

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, PARTICIPANTS, HOUSING UNITS, AND TREATMENTS

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

- Household Demographics
- Housing Unit Characteristics
- Pre-Weatherization Conditions
- Installed Measures
- Post-Weatherization Conditions
- Weatherization Costs

The evaluation furnishes robust information that can be used to characterize all housing units served by the WAP program in PY 2010. This report focuses on characterizing mobile homes.

3.1 METHODOLOGY

For PY 2010, WAP grantees reported information to DOE on program production. However grantees were not asked to report detailed information on the characteristics of the households and housing units served, nor were they asked to report detailed information on installed measures and measure costs. The data collected for this evaluation furnishes detailed statistics on the characteristics of clients served by the program in PY 2010.

The primary data source for this section of the report was furnished by 385 subgrantees for a sample of 35,030 clients, including 5,250 clients who occupy mobile homes. Table 3.1 shows the number of sampled clients by Climate Zone and Table 3.2 shows the number of sampled clients by Housing Unit Type.

Table 3.1 PY 2010 Sampled Clients by Climate Zone

Climate Zone	PY 2010 Sampled Clients	Percent of PY 2010 Sample
Very Cold Climate	6,430	19%
Cold Climate	12,249	35%
Moderate Climate	7,124	20%
Hot/Humid Climate	5,646	16%
Hot/Dry Climate	3,581	10%
TOTAL	35,030	100%

Table 3.2 PY 2010 Sampled Clients by Housing Unit Type

Housing Unit Type	PY 2010 Sampled Clients	Percent of PY 2010 Sample
Single Family Site-Built (1-4 Units)	24,680	70%
Single Family Mobile Home	5,250	15%
Multifamily (5+)	5,100	15%
TOTAL	35,030	100%

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

- Base Weight – The base weight was the inverse of the client's probability of selection.
- State-Level Adjustment – For each state, the client weights were adjusted to match state production control totals by housing unit type.

Table 3.3 shows the weighted count of WAP clients by Climate Zone; it shows that 56 percent of the weatherized units were in the Very Cold and Cold Climate Zones. Table 3.4 shows the weighted count of WAP clients by Housing Unit Type; it shows that mobile homes were 15 percent of the total units weatherized in PY 2010.

Table 3.3 PY 2010 Weighted Clients by Climate Zone

Climate Zone	PY 2010 Weighted Count of Clients	Percent of PY 2010 Clients
Very Cold Climate	58,584	18%
Cold Climate	127,386	38%
Moderate Climate	56,006	17%
Hot/Humid Climate	55,157	17%
Hot/Dry Climate	34,732	10%
TOTAL	331,865	100%

Table 3.4 PY 2010 Weighted Clients by Housing Unit Type

Housing Unit Type	PY 2010 Weighted Count of Clients	Percent of PY 2010 Clients
Single Family Site-Built	215,445	65%
Single Family Mobile Home	48,267	15%
Multifamily (5+)	68,153	20%
TOTAL	331,865	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. Mobile homes were about 15 percent of all weatherized units; the mobile homes share of units was highest in the Moderate Climate Zone (20%) and lowest in the Cold Climate Zone (11%).

Table 3.5 PY 2010 Weighted Clients by Climate Zone and Housing Unit Type

Climate Zone	Single Family	Mobile Home	Large Multifamily	All Housing Unit Types
Very Cold Climate	70%	17%	13%	100%
Cold Climate	62%	11%	27%	100%
Moderate Climate	72%	20%	8%	100%
Hot/Humid Climate	65%	15%	20%	100%
Hot/Dry Climate	57%	13%	30%	100%
TOTAL	65%	15%	20%	100%

Table 3.6 shows the number and percent of mobile homes by Climate Zone. The Cold Climate Zone had the largest share of mobile homes served by the program (30%) and the Hot/Dry Climate Zone had the smallest share (9%).

Table 3.6 PY 2010 WAP Weighted Clients in Mobile Homes by Climate Zone

Climate Zone	PY 2010 Units	Percent of PY 2010 Units
Very Cold Climate	10,138	21%
Cold Climate	14,551	30%
Moderate Climate	11,242	23%
Hot/Humid Climate	7,878	17%
Hot/Dry Climate	4,458	9%
TOTAL	48,267	100%

3.2 HOUSEHOLD CHARACTERISTICS

Table 3.7 furnishes national and Climate Zone statistics on the household characteristics for PY 2010 clients in mobile homes. The overall finding is that the mobile homes served by the WAP program are primarily homeowners with incomes close to the poverty line who have a vulnerable individual in the home.

Some important household characteristics vary by Climate Zone, including:

- Income – Households in the Hot/Humid Climate Zone have the lowest average income; 62 percent of the households have income at or below the poverty line.

- Vulnerability Status – Households in the Hot/Dry Climate Zone have the highest percent of households with an elderly member (57%); households in the Very Cold Climate Zone have the highest percent of households with a child (40%).

- Race/Ethnicity – White non-Hispanic households are the majority of mobile home clients in most Climate Zones. The Hot/Humid Climate Zone has the highest incidence of Black non-Hispanic clients and the Hot/Dry Climate Zone has the highest incidence of Hispanic clients and Native American clients in mobile homes.

Table 3.7 PY 2010 Clients in Mobile Homes Household Characteristics by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
Income and Poverty						
Median Income	$14,138	$15,504	$14,712	$13,140	$12,372	$15,511
Median % of Poverty	100%	109%	105%	94%	85%	118%
% < 100% of Poverty	50%	46%	46%	54%	62%	41%
Vulnerability Status						
% w/Elderly Individual	40%	35%	39%	38%	41%	57%
% w/Disabled Individual	39%	37%	31%	48%	40%	43%
% w/Children	32%	40%	27%	32%	36%	25%
Household Status						
% Homeowner	90%	90%	91%	90%	93%	84%
Mean Household Size	2.3	2.4	2.2	2.3	2.3	2.1
% Single Parent	19%	16%	15%	17%	35%	15%
% Single Elderly	23%	20%	21%	23%	22%	36%
Race/Ethnicity						
% White non-Hispanic	78%	87%	97%	78%	45%	74%
% Black non-Hispanic	13%	1%	1%	11%	47%	0%
% Hispanic	6%	5%	2%	9%	8%	12%
% Asian	<1%	0%	0%	<1%	0%	0%
% Native American	3%	7%	<1%	2%	0%	14%
% Other	<1%	1%	0%	0%	0%	0%

Table 3.8 furnishes details on the distribution of income and poverty for households.

- Income - In most Climate Zones, almost all of the households have incomes at or below $30,000 per year. Median income ranged from a low of $12,372 in the Hot/Humid Climate Zone to a high of $15,511 in the Hot/Dry Climate Zone.

- Poverty – In the Moderate and Hot/Humid Climate Zones, more than one-half of the mobile home clients had incomes below the poverty line. In PY 2009, the income eligibility standard increased from 150 percent of poverty to 200 percent of poverty. In all Climate Zones, at least 10 percent of households had incomes above 150 percent of poverty. In the Hot/Dry Climate Zone, more than 25 percent of participating households had incomes that exceeded that level.

Table 3.8 PY 2010 Clients in Mobile Homes Distribution of Income and Poverty by Climate Zone

	Percent of Population				
Variable	**10%**	**25%**	**Median**	**75%**	**90%**
Income					
Very Cold Zone	$3,920	$9,303	$15,504	$22,463	$30,187
Cold Zone	$2,393	$8,417	$14,712	$20,780	$26,532
Moderate Zone	$5,100	$8,352	$13,140	$18,960	$25,840
Hot/Humid Zone	$1,028	$8,088	$12,372	$18,924	$26,212
Hot/Dry Zone	$8,088	$10,512	$15,511	$20,880	$26,359
ALL ZONES	$3,000	$8,556	$14,138	$20,520	$26,823
Percent of Poverty					
Very Cold Zone	25%	65%	109%	146%	178%
Cold Zone	19%	68%	105%	137%	170%
Moderate Zone	27%	67%	94%	128%	159%
Hot/Humid Zone	8%	54%	85%	123%	167%
Hot/Dry Zone	46%	85%	118%	161%	186%
ALL ZONES	22%	66%	100%	137%	173%

Table 3.9 shows how ownership status varies by demographic group. Households with an elderly member were most likely to be homeowners. However, more than 80 percent of households in each of the listed demographic groups were homeowners.

Table 3.9 PY 2010 Clients in Mobile Homes Home Ownership by Demographic Group

Demographic Group	% Owners	% Renters
Elderly Households	93%	7%
Disabled Households	90%	10%
Households with Children	86%	14%
Single Parent Households	84%	16%
Single Elderly Households	94%	6%

3.3 HOUSING UNIT CHARACTERISTICS

Table 3.10 furnishes national and Climate Zone statistics on the housing unit characteristics for PY 2010 clients in mobile homes. The overall finding is that mobile homes treated by the WAP program are most likely to be small and were constructed after 1970. There is relatively little variation among these homes across Climate Zones, with the exception that homes in the Very Cold and Hot/Dry Climate Zones tend to have lower pre-weatherization infiltration rates (CMF50), while those in the Hot/Humid Climate Zone tend to be leakier.

Table 3.10 PY 2010 Clients in Mobile Homes Housing Unit Characteristics by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
Housing Unit						
Median Heated Space	980	980	980	980	1,152	924
Mean Heated Space	1,077	1,045	1,042	1,074	1,211	1,037
Housing Vintage						
% pre 1940	1%	1%	1%	<1%	0%	0%
% 1940-1969	7%	7%	8%	8%	4%	8%
% 1970 or later	92%	92%	91%	92%	96%	92%
PreWX Status						
Mean CFM50	2,653	2,387	2,620	2,725	3,117	2,433

Table 3.11 shows the distribution of homes with respect to important pre-weatherization indicators. It appears that in most Climate Zones, more than 50 percent of the homes have significant potential for air leakage reduction to improve energy efficiency (i.e., have air leakage rates of 2,000 CFM50 or more).

Table 3.11 PY 2010 Clients in Mobile Homes Distribution of PreWX Status by Climate Zone

	Percent of Population				
Variable	10%	25%	Median	75%	90%
CFM50					
Very Cold Zone	1,281	1,650	2,261	2,995	3,665
Cold Zone	1,371	1,816	2,408	3,223	3,996
Moderate Zone	1,358	1,764	2,383	3,236	4,461
Hot/Humid Zone	1,553	2,274	3,038	3,700	4,650
Hot/Dry Zone	1,284	1,683	2,274	2,960	3,470
ALL ZONES	1,362	1,764	2,450	3,246	4,071

Table 3.12 furnishes national and Climate Zone statistics on the heating and cooling systems for PY 2010 clients in mobile homes. Mobile homes served by the WAP program most often had electric main heat, but natural gas and propane also were common heating sources. Most have a central heating system, air conditioning, and an electric water heater. The detailed Climate Zone statistics show that the dominant energy use patterns for households served by the WAP program vary across the country. Important findings include:

- Heating Fuel – In the Very Cold, Cold, and Hot/Dry Climate Zones, natural gas is the main heat in about half of the homes, while electric heat is most common in the Moderate and Hot/Humid zones.

- Main Heating Equipment – In all climate zones, most households had a central heating system (CFA or Heat Pump).

- Supplemental Heat – A significant share of homes use supplemental heat. Electric supplemental heat use varies from 6 percent in the Hot/Dry Climate Zone to 39 percent in the Hot/Humid

Climate Zone. The use of wood supplemental heat varies from a low of 2 percent to a high of 12 percent.

- Air Conditioning – The share of clients with air conditioning is lowest in the Very Cold Climate Zone and highest in the Hot/Humid Climate Zone.

- Water Heat – Electricity was the most common main water heating fuel in all climate zones except for the Hot/Dry zone.

The energy use patterns and energy efficiency opportunities vary considerably by Climate Zone.

Table 3.12 PY 2010 Clients in Mobile Homes Heating and Cooling System Characteristics by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
Heating Fuel						
% Natural Gas	31%	43%	46%	10%	5%	51%
% Electric	40%	11%	21%	77%	80%	10%
% Fuel Oil	7%	13%	12%	2%	0%	3%
% Propane	18%	27%	18%	9%	12%	34%
% Other	3%	6%	3%	2%	2%	3%
Heating System Type						
% Central Forced Air	85%	94%	95%	74%	64%	94%
% Boiler (hydronic/steam)	<1%	<1%	1%	0%	0%	0%
% Wall/Room Heater	4%	4%	1%	6%	9%	1%
% Electric Baseboard	1%	1%	1%	2%	<1%	2%
% Heat Pump	6%	<1%	<1%	14%	14%	2%
% Portable Space Heater	2%	1%	1%	2%	8%	1%
% Cooking Stove	<1%	0%	1%	0%	<1%	0%
% No Heating Source	1%	0%	<1%	1%	5%	<1%
Supplemental Heat						
% Electric	21%	13%	14%	29%	39%	6%
% Wood	5%	11%	2%	3%	3%	12%
Air Conditioning Type						
% Central AC	43%	12%	34%	55%	58%	32%
% Window/Wall	24%	23%	28%	23%	29%	6%
% Evaporative Cooler	11%	16%	5%	7%	2%	53%
% None	22%	49%	32%	16%	10%	8%
Water Heating Fuel						
% Natural Gas	21%	29%	24%	8%	4%	51%
% Electric	70%	60%	68%	88%	91%	13%

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
% Other	10%	11%	8%	4%	5%	36%

3.4 WAP INSTALLED MEASURES

Table 3.13 shows the diagnostic approach used by subgrantees for the sample of homes treated in PY 2010. At the national level, about 53 percent of client homes were assessed using an audit tool and 47 percent were treated using a priority list.

Table 3.13 PY 2010 Clients in Mobile Homes Diagnostics Approach by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
Diagnostic Approach						
% Priority List	47%	22%	45%	42%	86%	48%
% Calculation Procedure	53%	78%	55%	58%	14%	52%
% Other	<1%	1%	<1%	0%	0%	0%

Table 3.14 shows the rate at which air sealing and shell measures were installed in PY 2010.

- Air Sealing – Subgrantees reported doing air sealing in 90 percent of homes. For about 26 percent of homes, CFM50 air leakage reductions of 1,000 or more were documented using blower door tests.

- Attic Insulation – Attic insulation was reported for 24 percent of homes compared to a rate of 60 percent for site-built homes. Attic insulation procedures for mobile homes are different from those for site-built homes. The lower rate of attic insulation for mobile homes may be an indicator that additional training is needed or that installation costs are different for the two housing unit types.

- Wall Insulation – Only a small percent (3%) of homes had wall insulation installed, compared to 23 percent of site-built homes. Wall insulation procedures for mobile homes are different from those for site-built homes. The lower rate of wall insulation for mobile homes may be an indicator that additional training is needed or that installation costs are different for the two housing unit types.

- Other Insulation – Floor insulation was installed in 46 percent of homes. This is a common mobile home measure.

Air sealing and floor insulation are common and important measures installed in homes. Some homes received attic insulation, but very few received wall insulation.

Table 3.14 PY 2010 Clients in Mobile Homes Air Sealing and Shell Measures by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
Air Sealing						
<500*	35%	43%	34%	31%	33%	36%
500-<1,000*	23%	29%	26%	23%	20%	6%
1,000+*	26%	25%	29%	25%	27%	14%
No Data	17%	3%	11%	22%	21%	44%
Any Air Sealing	90%	87%	91%	90%	98%	78%
Attic Insulation						
% Installed	24%	30%	24%	27%	23%	<1%
Wall Insulation						
% Installed	3%	6%	4%	1%	1%	<1%
Other Insulation						
% Floor	46%	56%	64%	54%	20%	2%
% Rim	1%	3%	<1%	<1%	1%	0%
% Foundation	2%	3%	5%	<1%	1%	0%
% Any Installed	50%	61%	59%	57%	21%	2%
CFM50						
Mean Reduction	834	768	847	929	863	620
Ventilation						
% Installed	20%	22%	17%	22%	26%	7%

*Pre/Post CFM50 Reduction

Table 3.15 shows the rate at which heating and water heating equipment measures were installed in PY 2010.

Table 3.15 PY 2010 Clients in Mobile Homes Heating and Water Heating Equipment Measures by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
Heating Equipment Replacement						
Furnace (non-ECM)	8%	7%	14%	7%	1%	0%
Furnace (ECM)	14%	21%	12%	14%	15%	1%
Furnace (unknown)	9%	11%	7%	3%	5%	31%
Any Furnace	30%	38%	33%	24%	22%	32%
Heating Ducts (% of systems with ducts)						
Duct sealing	57%	62%	55%	60%	50%	57%
Duct insulation	3%	1%	5%	2%	5%	0%
Water Heating Equipment						
Heater (non-ECM)	5%	6%	8%	1%	1%	6%
Heater (ECM)	4%	5%	3%	3%	4%	1%
Heater (unknown)	4%	3%	1%	1%	11%	11%
Any Water Heater	13%	15%	13%	6%	16%	18%

The key findings from Table 3.15 include:

- Heating Equipment – Heating equipment replacement was reported for about 30 percent of client homes, with about one-half being identified as an energy conservation measure (ECM). Equipment replacement rates were highest in the Very Cold Climate Zone.

- Ducts – Duct sealing was reported in more than one-half of homes. Duct sealing rates were consistent across climate zones.

- Water Heating Equipment – A small share of homes had water heater equipment measures; nationally only about 13 percent of equipment was replaced, with about one-third identified as ECM measures.

Equipment measures are less common than air sealing and floor insulation. However, duct sealing was done in more than one-half of homes. At least one-half of furnace replacements and one-third of water heater replacements were listed as ECMs.

Table 3.16 shows the installation rate for other measures in PY 2010, including windows, air conditioning equipment, programmable thermostats, and baseload electric measures.

- Windows – The statistics show that 26 percent of homes had new windows installed, and that about one-half of those were reported to be ECMs. Storm windows were installed in 8 percent of homes. The window installation rate was above 25 percent for all areas except the Hot/Humid Climate Zone.

- Air Conditioning – Nationally less than 10 percent of clients received air conditioner replacements. But, installation rates were higher for the Hot/Humid Climate Zone (28%) and the Hot/Dry Climate Zone (16%).

- Other Electric Measures – About 76 percent of clients received some form of energy efficient lighting and about 22 percent received new refrigerators or freezers. Energy efficient lighting installation rates were over 90 percent in the Hot/Humid Climate Zone.

These statistics show that the WAP program made some investments in air conditioning and electric baseload measures, but at lower rates than for weatherization measures.

Table 3.16 PY 2010 Clients in Mobile Homes Other Measures by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
Windows						
Window (non-ECM)	2%	1%	5%	1%	0%	1%
Window (ECM)	14%	23%	10%	19%	7%	2%
Window (unknown)	10%	1%	14%	8%	5%	29%
Window (any reason)	26%	26%	29%	28%	12%	32%
Storm Window	8%	14%	6%	10%	5%	2%
Air Conditioner						
AC Unit (non-ECM)	1%	0%	2%	<1%	0%	0%
AC Unit (ECM)	3%	2%	0%	5%	9%	<1%
AC Unit (unknown)	5%	0%	<1%	2%	18%	16%
Any AC Unit	9%	2%	2%	7%	28%	16%
Other Equipment						
Programmable T-stat	16%	23%	15%	14%	16%	9%
Lighting	76%	68%	76%	70%	91%	80%
Refrigerator	22%	25%	19%	23%	21%	20%

For site-built homes, statistical analysis showed that four major measures – air sealing, attic insulation, wall insulation, and furnace replacement – were responsible for most of the space heating and space cooling energy savings in site-built homes. However, there are important differences between site-built homes and mobile homes that result in different measures being installed in mobile homes. Some of the similarities and differences include:

- Air Sealing - For both site-built homes and mobile homes, bypass air sealing can have a major impact on energy consumption.

- Furnace Replacement – For both site-built homes and mobile homes, furnace replacement can have a major impact on energy consumption.

- Attic Insulation - Attic insulation can be a cost-effective measure for mobile homes. However, since insulation procedures for mobile home are different than those for site-built homes, these measures are done less often in mobile homes than in site-built homes, only 23 percent of mobile homes compared to 60 percent of site-built homes.

- Wall Insulation - Wall insulation can be cost-effective measures for mobile homes. However, because the insulation procedures for mobile homes are very different from those for site-built homes, wall insulation was rarely done in mobile homes in PY 2010, only 3 percent compared to 23 percent for site-built homes.

- Floor Insulation - Because of the configuration of mobile homes, floor insulation is done more often in mobile homes; 50 percent of mobile homes got floor insulation compared to only 36 percent of site-built homes.

- Duct Sealing – For many site-built homes, heating and cooling ducts are inside the thermal envelope; duct sealing in site-built homes might improve the performance of the distribution system but might not reduce energy consumption. Since mobile home ducts are more likely to be outside the thermal envelope, duct sealing can have a major impact on energy usage. Overall, 57 percent of mobile homes had duct sealing compared to 39 percent of site-built homes.

For mobile homes, the analysis will focus on the five major measures that appear to have the greatest impact on energy savings: furnace replacement, air sealing, attic insulation, duct sealing, and floor insulation. For both site-built homes and mobile homes, furnace replacement, air sealing, and attic insulation are major measures. However, while wall insulation is a major measure for site-built homes, duct sealing and floor insulation are more common and have a higher impact on energy savings for mobile homes.

Table 3.17 shows the distribution of homes by the number of the five major measures installed by Climate Zone. On average, 2.0 major measures were installed. The average installation rate was highest in the Cold Climate Zone (2.2) and lowest in the Hot/Dry Climate Zone (1.4).

Table 3.17 PY 2010 Clients in Mobile Homes Percent of Homes by Major Measures and Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
Major Measures						
No Major Measures	12%	11%	8%	11%	18%	26%
One Major Measure	26%	22%	23%	26%	38%	28%
Two Major Measures	29%	27%	29%	29%	29%	32%
Three Major Measures	23%	26%	26%	25%	12%	13%
Four or More	10%	14%	14%	9%	3%	1%
All Jobs	100%	100%	100%	100%	100%	100%
Mean # of Measures	2.0	2.1	2.2	2.0	1.4	1.3

3.5 WEATHERIZATION JOB COSTS

Subgrantees have developed systems to track the costs of each weatherization job. These systems allow subgrantees to track the average cost per job and the share of funding that is allocated to health and safety measures. In addition, many grantees and subgrantees leverage DOE funding with other funding sources, including LIHEAP funds, other Federal funds, and utility system benefit charge funds. Subgrantees that have leveraged funding have cost tracking systems that allocate job costs among different funding sources.

Table 3.18 shows the mean and median total job cost for PY 2010 by Climate Zone. These are the costs allocated to individual jobs. These statistics do not include program administration or training costs. They also exclude program operations costs incurred at the agency for functions like intake and job scheduling. The mean cost per job is $4,287. Average costs in the Very Cold are almost 20 percent above the national average. Average costs in the Cold Climate Zone are almost 20 percent below the national average.

Table 3.18 PY 2010 Clients in Mobile Homes Mean and Median Cost Per Job by Climate Zone

Climate Zone	Mean Job Cost	Median Job Cost
Very Cold Climate	$5,086	$4,650
Cold Climate	$3,539	$3,418
Moderate Climate	$4,437	$3,546
Hot/Humid Climate	$4,709	$4,860
Hot/Dry Climate	$3,805	$3,375
TOTAL	$4,287	$3,891

Table 3.19 shows the distribution of total job cost for PY 2010 by Climate Zone. The table shows that there is substantial variation in the cost of each job. As discussed throughout this section, there are differences both in the average home conditions across Climates Zones and in the average home conditions within Climate Zones. The program does not treat every home in the same way. Subgrantees carefully examine the pre-weatherization conditions of each home and select the set of measures that are estimated to furnish cost-effective energy savings and to address any outstanding health and safety issues in the home. The variability in job costs across climate zones and within climate zones is the expected outcome of that process.

Table 3.19 PY 2010 Clients in Mobile Homes Distribution of Job Cost by Climate Zone

	Percent of Population				
Variable	**10%**	**25%**	**Median**	**75%**	**90%**
Job Cost					
Very Cold Zone	$1,676	$2,750	$4,650	$6,725	$9,394
Cold Zone	$1,286	$2,121	$3,418	$4,695	$5,989
Moderate Zone	$1,055	$2,023	$3,546	$5,699	$8,575
Hot/Humid Zone	$1,686	$3,060	$4,860	$5,794	$7,704
Hot/Dry Zone	$348	$795	$3,375	$6,416	$8,269
ALL ZONES	$1,161	$2,246	$3,891	$5,590	$7,835

One important factor in job cost is the number of measures installed in each home. Table 3.20 shows the average job cost by the number of major measures installed. The average job cost for those homes that did not get any major measures was $2,356. Those homes were likely to get air sealing measures, but did not achieve a CFM50 reduction of 1,000 or higher. They also were likely to have received one or more of the other measures listed in Tables 3.14, 3.15, and 3.16. As the number of major measures increased, the average job cost increased.

Table 3.20 PY 2010 Clients in Mobile Homes Mean Job Costs by Number of Major Measures and Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
Job Cost						
No Major Measures	$2,356	$2,256	$1,999	$1,874	$3,244	$2,338
One Major Measure	$2,998	$3,448	$2,729	$2,601	$3,636	$2,034
Two Major Measures	$4,267	$4,903	$3,036	$4,258	$4,894	$5,759
Three Major Measures	$5,550	$6,441	$4,105	$6,203	$5,226	$7,519
Four or More	$6,770	$7,023	$5,058	$10,059	$7,049	N/A
All Jobs*	$4,267	$4,998	$3,465	$4,548	$4,220	$4,046

*Mean costs in Table 3.20 are different from those in Table 3.18 because jobs with missing measure data are excluded.

Table 3.20 shows that, nationally, each additional measure added about $1,100 (on average) to the cost of the weatherization job. However, the incremental cost varied by measure type and Climate Zone. Table 3.21 shows the average cost per job for homes that got one major measure. At the national level, the average cost for jobs with a furnace replacement was almost $3,000 more than the average for jobs with no major measures. The average cost for jobs with attic insulation was only $731 more than the average cost for jobs with no major measures.[7]

[7] Careful examination of the Climate Zone measure differentials shows that the analysis is more complex than just looking at measure-level additions. For example, the average cost of a weatherization job with Duct Sealing in the Cold Climate Zone was $1,662. That was $337 dollars *less than* the average cost of a weatherization job with No Major Measures in the Cold Climate Zone. As noted previously, a job with no major measures does have other measures costs that can be significant.

Table 3.21 PY 2010 Clients in Mobile Homes Mean Job Costs by Major Measure and Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
Job Cost						
No Major Measures	$2,356	$2,256	$1,999	$1,874	$3,244	$2,338
CFM50 Only	$3,365	$5,237	$2,413	$2,926	$3,617	N/A
Attic Insulation Only	$3,087	$3,273	$2,042	$4,743	$3,240	N/A
Floor Insulation Only	$2,901	$2,513	$3,107	$2,340	$5,120	N/A
Duct Sealing Only	$2,424	$3,332	$1,662	$2,092	$2,929	$1,879
Furnace Only	$5,318	$6,144	$4,185	$4,527	$6,363	N/A
One Major Measure	$2,998	$3,448	$2,729	$2,601	$3,636	$2,034

The WAP program installs energy saving measures and addresses health and safety problems that are identified in the home. Table 3.22 shows the share of job costs allocated between ECM and nonECM (i.e., health and safety) costs. On average, 15 percent of job costs were spent on nonECM measures. Jobs in the Hot/Dry Climate Zone had the highest nonECM share of spending (27%). Jobs in the other Climate Zones all averaged 10-17 percent of total jobs costs.

Table 3.22 PY 2010 Clients in Mobile Homes CM and nonECM Costs by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
Costs per Job						
Mean ECM Costs	$3,661	$4,216	$3,012	$3,767	$4,222	$2,722
Mean nonECM Costs	$670	$869	$533	$681	$485	$1,002
Mean nonECM %	15%	17%	15%	15%	10%	27%
Mean TOTAL Costs*	$4,331	$5,084	$3,545	$4,448	$4,707	$3,724

*Mean costs in Table 3.22 are different from those in Table 3.18 because jobs with missing ECM data are excluded.

Many grantees make other funds available for weatherization (e.g., LIHEAP, SBC funds, and other Federal program funds) that are used to pay for some measures in DOE-funded weatherization jobs. In addition, sometimes WAP subgrantees receive direct grants (i.e., not through the WAP grantee) for leveraged funds that also are used to pay for some measures in DOE-funded weatherization jobs. Table 3.23 shows the share of the costs for DOE jobs that were allocated to nonDOE funds. On average, nonDOE funds covered about 15 percent of job costs. The Moderate Climate Zone had the highest level of nonDOE funding relative to total funding.

Table 3.23 PY 2010 Clients in Mobile Homes DOE and nonDOE Costs for DOE Jobs by Climate Zone

Statistic	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
Costs per Job						
Mean DOE Costs	$3,668	$4,176	$3,235	$3,432	$4,435	$3,068
Mean NonDOE Costs	$638	$919	$303	$1,015	$274	$737
Mean nonDOE %	15%	18%	9%	23%	6%	19%
Mean TOTAL Costs*	$4,306	$5,095	$3,537	$4,447	$4,710	$3,805

*Mean costs in Table 3.23 are different from those in Table 3.18 because jobs with missing DOE data are excluded.

Sections 4 and 5 of this report have statistics that show the relationship between spending and energy savings. Section 7 of this report has statistics that show the relationship between spending and program cost-effectiveness.

4. ENERGY IMPACTS FOR MOBILE HOMES WITH GAS MAIN HEAT

The WAP evaluation directly measured gas and electric usage for treated mobile homes that use natural gas as their main heating fuel. This section presents the findings with respect to overall energy impacts as well as breaking out savings by:

- End Use – The share of savings attributable to changes in heating, cooling, and baseload usage levels.
- Installed Measures – Differences in savings for groups of homes that received different major measures and common combinations of measures.
- Pre-Weatherization Usage Level – Variation in the amount of savings and the percent savings for groups of households characterized by pre-weatherization usage levels.
- Climate Zone – Comparison of savings levels among the different Climate Zones.
- Technical Approach – Assessment of differential savings by energy audit procedure, type of advanced building diagnostics used, and crew vs. contractor work.
- Expenditures and Leveraging – Variation in savings levels for levels of spending on efficiency measures, total job costs, job funding sources, and agency funding sources.

These analyses help to show how program services and impacts vary by population subgroup. A further statistical analysis of explanatory factors related to observed energy savings were performed to estimate the energy savings attributable to individual program measures and to extrapolate the savings from the gas analysis sample to the full program population of gas heated mobile homes as well as homes heated by delivered fuels.

4.1 METHODOLOGY

The gas and electric savings were analyzed using multiple approaches. 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[8] 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. The Energy Impact Methodology Report contains details about the methods used to clean and prepare the usage data, assign weather stations to homes, and perform the weather-normalization.

Gross energy savings for each home were calculated as the difference in the normalized annual consumption between the pre-treatment and post-treatment periods. A Comparison Group of untreated homes was also analyzed to reflect changes in usage which may have occurred without the program. The Comparison Group was created using later participants – mobile homes treated in PY 2011 were used as a Comparison Group for the PY 2010 analysis. Comparison Group usage was analyzed by subtracting one year from the actual treatment date to create pseudo pre-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.

[8] See "PRISM: An Introduction," Margaret Fels, Energy and Buildings 9, #1-2, pp. 5-18 (1986).

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.

4.1.1 Sample Attrition

A total of 1,896 gas heated mobile homes were sampled for analysis. Table 4.1 summarizes the disposition of this sample for the gas and electric use analysis. The utility data collection process was successful in obtaining gas and electric data for 57 percent of the sampled homes. The usage data provided were not sufficient for developing savings estimates for 14 percent of the gas analysis homes and 16 percent of the electric analysis homes. Most of this attrition was due to too little pre-retrofit data – the analysis required a minimum of 183 days of gas data and 270 days of electric data (in addition to some requirements about weather). The weather-normalization itself indicated a poor model fit in either the pre or post periods for about 2 percent of the sampled cases. Many of these cases had less than a full year of data in either the pre or post periods. An additional 4 percent of sampled cases in the gas analysis had gas usage too low to be considered gas heated and occupied during both periods. Just 0.4 percent of cases were classified as having electric usage either too low to be occupied or too high to be mobile homes. Less than 1 percent of the sampled homes were removed from the analysis because they were declared savings outliers[9].

Table 4.1 PY 2010 WAP Mobile Homes Gas and Electric Usage Sample Attrition - Gas Main Heat

	Gas Analysis		Electric Analysis	
Sample Group / Attrition Cause	**Homes**	**% of Sample**	**Homes**	**% of Sample**
Sampled	1,896	100%	1,896	100%
Utility Company Unknown	299	16%	376	20%
No Usage data from utility	519	27%	500	26%
Insufficient Data	257	14%	300	16%
Poor Model Fit	32	2%	2	0.1%
Usage Outlier: Vacant, Unheated, Not SF	77	4%	8	0.4%
Savings Outlier	6	0.3%	15	0.8%
Total Usable Cases	706	37%	695	37%

The same screening criteria were also applied to the Comparison Group analysis; the attrition rates were generally similar with the main exception of more cases lost due to insufficient post period data due to the start of actual weatherization treatment, truncating the available data.

4.2 KEY PROGRAM FACTORS FOR HOMES WITH GAS MAIN HEAT

Table 4.2 summarizes data on climate, demographics, housing stock, and program measures for site-built homes, all mobiles homes, and mobile homes with gas heat. The last two columns summarize these same characteristics for the gas and electric usage analysis samples. The table shows that, compared to site-built homes, treated mobile homes are smaller and newer, and their occupants have lower incomes but are more likely to be homeowners. Mobile homes have a similar geographic distribution to site-built homes

[9] 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).

with a modest skew toward the Moderate Zone and away from the Cold Zone. Mobile homes are also much more likely to have duct sealing work and are a little more likely to receive a heating system replacement compared to site-built homes, but they are much less likely to receive attic and especially wall insulation.

The table also shows that mobile homes with gas heat are less common in the Moderate and Hot Climate Zones and are a little older than mobile homes heated by other fuels. The gas and electric analysis samples are generally quite similar to the gas heated mobile home population on all listed characteristics.

Table 4.2 Characteristics of Mobile Homes

			Gas Heated Mobile Homes		
Characteristic	**All Site-Built Homes**	**All Mobile Homes**	**All Gas Heated**	**Gas Analysis Sample**	**Electric Analysis Sample**
Climate					
Very Cold	19%	21%	29%	43%	32%
Cold	36%	30%	44%	45%	51%
Moderate	19%	23%	8%	3%	7%
Hot/Humid	17%	16%	3%	1%	1%
Hot/Dry	9%	9%	16%	8%	10%
Demographics					
Median Income	$15,600	$13,668	$13,962	$14,784	$14,124
Homeowner	81%	90%	90%	91%	93%
Elderly	41%	39%	38%	43%	43%
# Occupants	2.5	2.3	2.3	2.2	2.2
Housing Characteristics					
Heated Area	1,388	1,081	1,028	1,034	1,031
Median Age	57	27	37	37	37
HDD65	4,793	4,781	5,538	6,126	5,756
CDD65	1,274	1,227	1,059	932	983
Central heating	89%	94%	97%	99%	97%
Central A/C	40%	40%	37%	42%	36%
Major Measures					
Heater replacement	28%	31%	41%	41%	41%
Attic Insulation	63%	25%	19%	19%	23%
Wall Insulation	25%	3%	4%	4%	4%
Floor Insulation	36%	43%	39%	43%	44%
Air Sealing >1000 CFM50	36%	29%	28%	27%	33%
Duct Sealing	39%	52%	57%	56%	66%
Refrigerator Replaced	20%	22%	25%	29%	29%

Note: Results weighted by sample design selection probabilities.

4.3 ENERGY SAVINGS OVERALL AND BY END USE

Table 4.3 summarizes natural gas impacts and shows a breakout of savings by weather-normalization component – heating[10] vs. baseload (non-heating) consumption. The gas savings are estimated at 89 therms per year, equal to 12.9 percent of pre-program gas usage. Space heating was 80 percent of the gas usage and 74 percent of the gas savings. These savings are considerably less than the 147 therms (15.5 percent of 947 therm pre-program usage) for site-built homes. In comparison to site-built homes, the average mobile home was 22 percent smaller (1,081 vs. 1,388 ft²) and used 27 percent less natural gas. There was a gas savings differential for both the heating and baseload portion of usage.

Table 4.3 PY 2010 WAP Energy Impacts for Mobile Homes Gross and Net Gas Savings Total and by End Use (therm/year)

Group/Breakout	# Homes	Gas Use Pre-WAP	Gas Use Post-WAP	Gross Savings	Net Savings	% of Pre
Total Use	706	692	610	82 (±9)	89 (±11)	12.9% (±1.6%)
Comparison	293	685	692	-7 (±7)		
Heating Use	706	552	491	61 (±8)	75 (±11)	13.6% (±2.0%)
Comparison	293	542	556	-14 (±9)		
Baseload Use	706	140	119	21 (±4)	14 (±9)	10.2% (±6.2%)
Comparison	293	143	136	7 (±6)		

The distribution of participants' pre-program total gas use is shown in Figure 4.1. The median annual gas use for participants was 689 therms; half of all homes use between 525 and 884 therms. Ten percent of homes used less than 400 therms and ten percent used more than 1,051 therms. The Comparison Group distribution (not shown) was very similar.

[10] The space heating portion of the load actually includes some of the water heating load (and any other seasonal end uses) as gas water heating usage increases in the winter due to lower incoming cold water temperatures and other factors. See "*Seasonality of Non-heating Consumption and Its Effect on PRISM Results", Fels, M.F., J. Rachlin, and R.H. Socolow, Energy and Buildings, V:1-2, pp.139-148, 1986*" for an in-depth discussion of these findings.

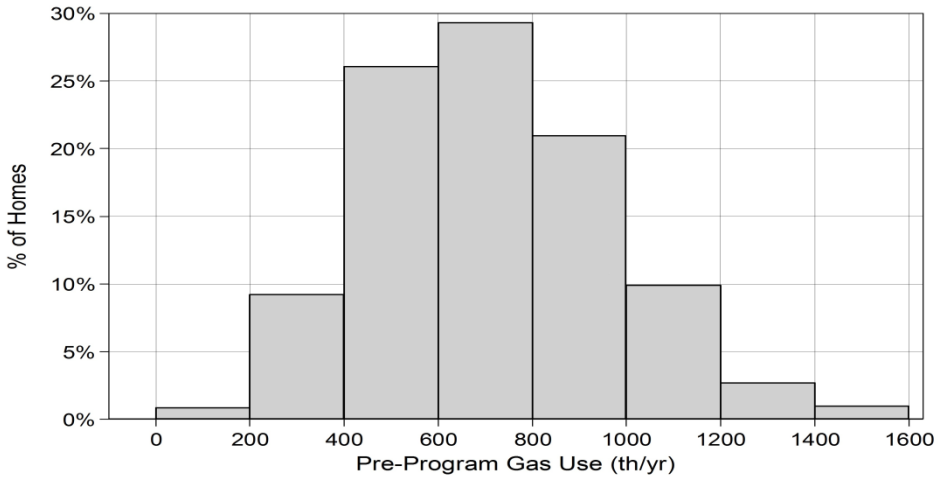

Figure 4.1: Distribution of Pre-Program Gas Use for Mobile Home Participants

The distribution of percent gas savings for participants and the Comparison Group are shown in Figure 4.2. The Comparison Group line graph shows the distribution of the year-over-year change in gas use that was observed for households that did not receive weatherization services. The line graph for those households is centered on 0 percent and shows that about one quarter of the Comparison Group households had a weather-normalized change in gas use of less than 2.5% (i.e., between -2.5% and +2.5%) and more than half had a change in gas use of less than 7.5%. About one in six comparison households had an increase in gas use of more than 12.5 percent and one in eight households had gas use decline by more than 12.5%. Some of the sources of these changes in gas use include: increases or decreases in the number of household members (e.g., child graduates and moves out; elderly parent gets ill and moves in), changes in the number of people at home during the day (e. g., someone gets a job; someone loses a job), or changes in the way the home is used (e.g., a room is closed off to save money; the household starts using a porch as living space). These are normal events that affect households at all income levels and in all areas. Table 4.3 shows that, with all of those potential changes, the average weather-normalized gas savings for Comparison Group households was -7 therms (i.e., gas use increased by 7 therms – or by about 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 a median value at 10.8 percent, showing that the Participant Group households had substantially higher gas savings then the Comparison Group households. Second, the graph for the Participant Group is more spread out indicating the greater variability in gas savings due to variations in treatments and their impacts.

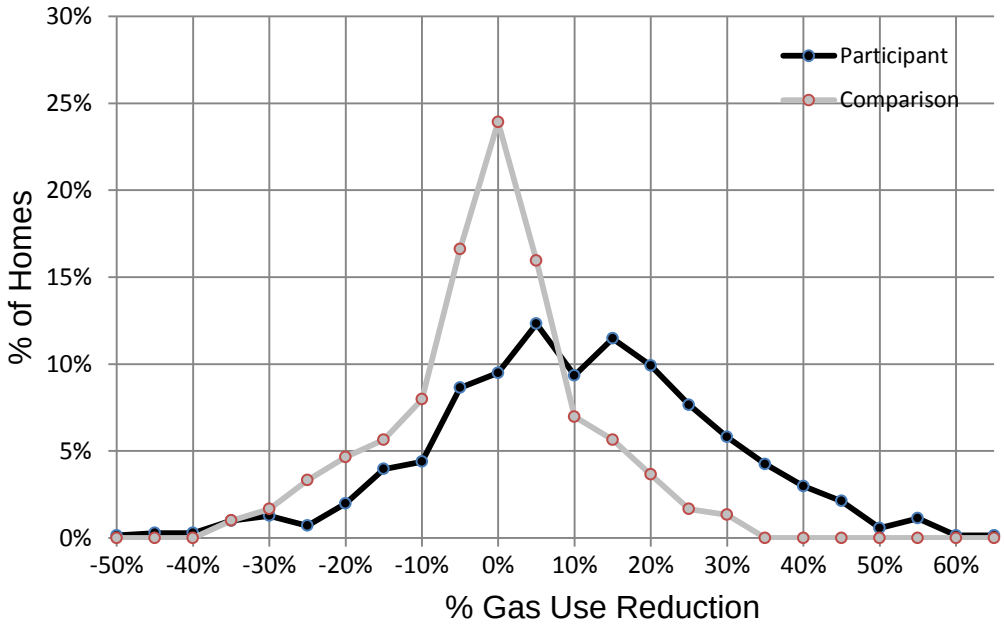

Figure 4.2: Distribution of Natural Gas Savings – Participant and Comparison Groups

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

- Weather-normalized usage for Treatment Group households fell by about 12 percent while usage increased by about 1 percent for Comparison Group households; the net impact of weatherization was to shift the gas savings graph to the right by about 13 percent.

- Treated homes each received a different set of measures. (See Tables 3.14 through 3.16). Homes with few measures are expected to have small energy savings while those homes that received a full set of measures are expected to have large energy savings, other things being equal. Since each Treatment Group home is expected to have a different level of savings, the distribution of gas savings is more variable (spread out) for Treatment Group homes than for 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 gas savings for the Comparison Group may help explain this apparent anomaly. As shown in Figure 4.2 above, some Comparison Group homes increased usage by 20 percent or more due to nonprogram factors. So, if a home *would have had* an increase in usage of 20 percent without treatment, but had only a 5 percent increase in usage after treatment, the net program impact is 15 percent savings over what would have occurred without weatherization.

Table 4.4 summarizes electric impacts overall and by end use among gas heated homes. The terms "Heating/Winter" and "Cooling/Summer" are used to describe the end uses rather than just heating and cooling because many electric end uses vary seasonally, such as refrigerators and lighting, and so a portion of their consumption is statistically allocated to the heating or cooling component. Approximately three-fourth of the electric use and savings are classified as baseload (i.e., nonseasonal).

Table 4.4 PY 2010 WAP Energy Impacts for Mobile Homes Gross and Net Electric Savings for Natural Gas Main Heat by End Use

Usage Component	# Homes	Elec Use Pre-WAP	Elec Use Post-WAP	Gross Savings	Net Savings	% of Pre
Total Use	695	8,792	7,949	842 (±107)	665 (±177)	7.6% (±2.0%)
Comparison	294	8,864	8,687	177 (±137)		
Heating/Winter Use	695	1,001	804	197 (±77)	169 (±118)	19.1% (±24.8%)
Comparison	294	979	950	29 (±83)		
Cooling/Summer Use	695	1,212	1,022	190 (±54)	12 (±87)	1.0% (±7.1%)
Comparison	294	1,434	1,256	178 (±82)		
Baseload Use	695	6,579	6,124	455 (±103)	484 (±185)	7.4% (±2.8%)
Comparison	294	6,452	6,481	-29 (±149)		

The heating/winter electric use averaged about 1,000 kWh annually. Much of this usage could be accounted for by a gas furnace fan and seasonality in other loads such as lighting. However, about 11 percent of gas heated homes had apparent electric heating usage large enough to indicate some use of supplemental electric heat. The estimated annual heating component was between 2,000 and 4,000 kWh in 7 percent of the homes and exceeded 4,000 kWh in 4 percent of the homes. Annual net electric savings averaged 1,385 kWh in gas heated homes with apparent electric heating use greater than 2,000 kWh.

The annual cooling/summer use averaged 1,212 kWh, indicating modest use of air conditioning on average in these homes since seasonality in refrigerator energy use, fans, and other seasonal loads could account for about half of this value. The cooling/summer load averaged about two and a half times as large in homes reported to have central air conditioning as those without – 2,325 kWh vs. 928 kWh but neither group had cooling savings that were statistically significant.[11]

The distribution of participants' pre-program total electric use is shown in Figure 4.3. The median annual electric use for participants was 7,718 kWh with half of all homes using between 5,574 and 11,203 kWh. Ten percent of homes used less than 4,393 kWh and ten percent used more than 14,801 kWh. The Comparison Group distribution was similar.

[11] Table 4.4 shows that the electric savings for homes with natural gas main heat were statistically significant (i.e., we can reject the null hypothesis that the savings were zero). However, the heating/winter and cooling/summer end use estimates were not statistically significant.

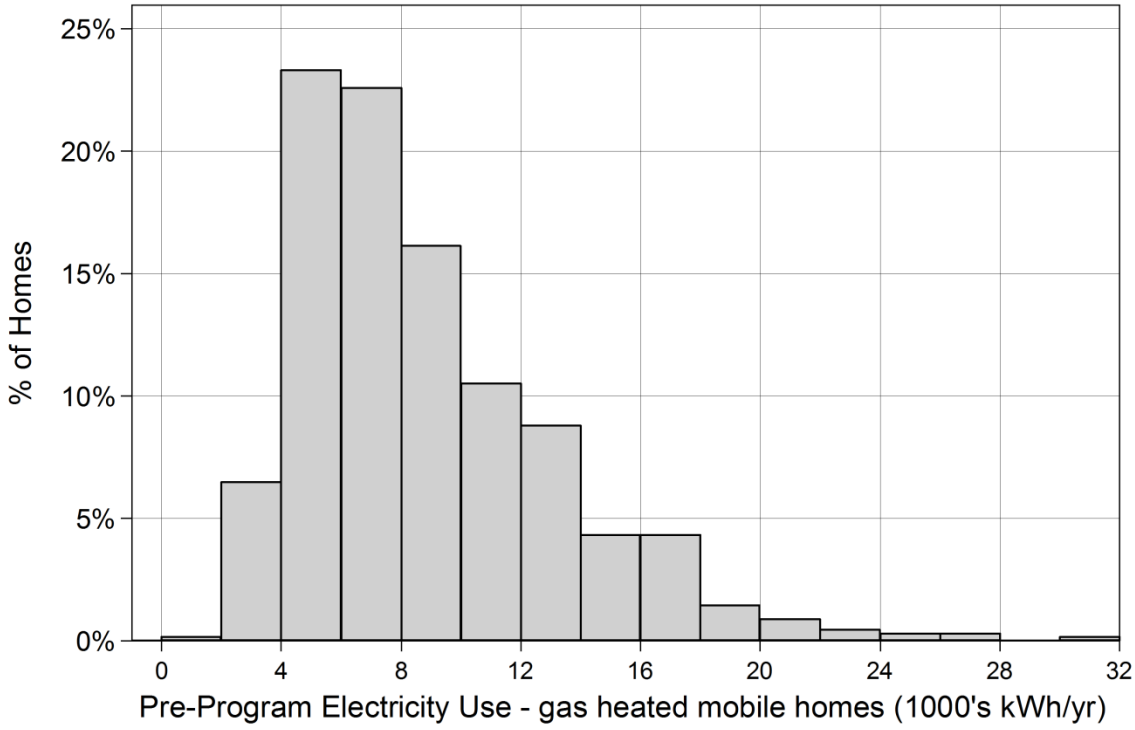

Figure 4.3: Distribution of Pre-Program Electric Use for Gas Heated Mobile Home Participants

The distribution of percent electric savings for gas heated participants and the Comparison Group are shown together in Figure 4.4. The Comparison Group line graph shows the distribution of the year-over-year reduction in electric use that was observed for households that did not receive weatherization services. The line for those households has two peaks – at -5 percent and +5 percent and shows that about one-third of comparison households had a weather-normalized change in electric use between -7.5% and +7.5%. For about one in four households, the change in electric use was more than 22.5% – either a reduction (13% of households) or an increase (11% of households). Some of the sources of these apparent savings or usage increases include: increases or decreases in the number of household members, changes in the number of people at home during the day, or changes in the way the home is used. These are normal changes that affect households at all income levels and in all areas. Table 4.4 shows that, with all of those potential changes, the average weather-normalized usage for Comparison Group households declined by 177 kWh per year (about 2%).

The line graph for the Participant Group is similar to the Comparison Group except it is shifted over to the right with its median value at 8.2 percent, consistent with program savings. The Participant Group is also a little more spread out revealing some variability in energy savings from program treatments.

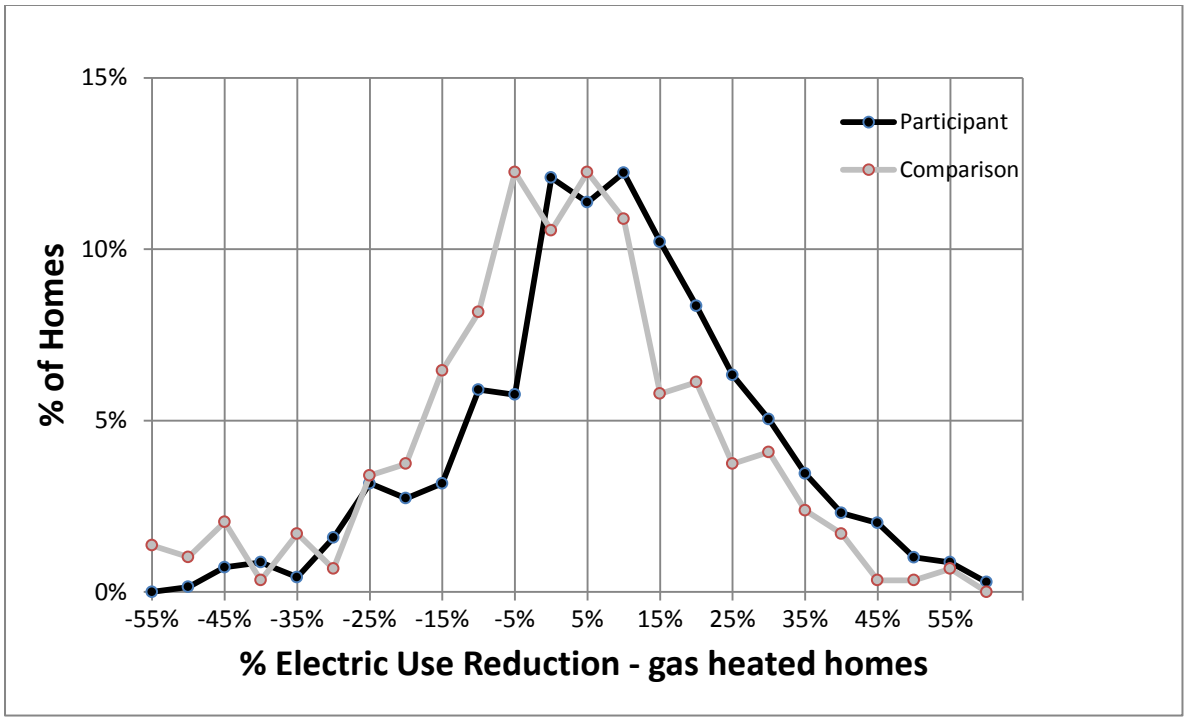

Figure 4.4: Distribution of Electric Savings – Participant and Comparison Groups (Gas Main Heat)

The distributions for electric savings are much closer together than they were for gas savings, reflecting the lower 7.6 percent average savings and the fact that many gas heated homes received few measures designed to reduce electric use (i.e., refrigerators or lighting). The median savings were 8.2 percent with half of the participants saving between -2.3 percent and +20.4 percent. A total of 31 percent of participants had an apparent increase in electric use after treatment compared to 46 percent of the Comparison Group.

4.4 PARTICIPANT AND TREATMENT CHARACTERISTICS BY LEVEL OF NATURAL GAS SAVINGS

Table 4.5 summarizes the same participant and treatment characteristics that were shown in Table 4.2 but broken out by the level of gas savings. Three savings categories were created:

- Low savers were defined as participants who saved less than the 25th percentile of gas savings (<-5 therms)
- High savers were defined as saving more than the 75th percentile of gas savings (>160 therms), and
- Mid-savers were defined as participants with savings between these limits.

The table shows that largest differences between high- and low-saving homes were in the pre-program gas use and in the measure installation rates. Compared to low savers, high savers used much more gas before participating and were more likely to have their heating system replaced and their attic insulated. High savers also were more likely to receive all of the other listed measures. High savers were also less likely to be elderly and less likely to live in the Hot/Dry climate zone.

Table 4.5 Characteristics of Homes with Low, Medium and High Gas Savings Natural Gas Main Heat Mobile Homes

Characteristic	Low Saver	Mid-Saver	High Saver
Gas use and Savings (th/yr)			
Pre-Program Gas Use	658	660	884
Net Gas Savings	-69	79	280
Climate			
Very Cold	42%	39%	51%
Cold	39%	49%	42%
Moderate	4%	3%	3%
Hot/Humid	3%	1%	1%
Hot/Dry	12%	9%	4%
Demographics			
Median Income	$15,156	$14,467	$15,240
Homeowner	94%	92%	88%
Elderly	45%	46%	33%
# Occupants	2.27	2.07	2.20
Housing Characteristics			
Heated Area	1,119	1,005	1,012
Median Age	37	27	37
HDD65	5,814	6,056	6,564
CDD65	1,052	964	753
Central heating	99%	99%	99%
Central A/C	50%	44%	39%
Major Measures			
Heater Replacement	30%	38%	59%
Attic Insulation	9%	17%	34%
Wall Insulation	1%	4%	6%
Floor Insulation	36%	44%	46%
Air Sealing >1,000 CFM50	24%	26%	34%
Duct Sealing	47%	57%	62%
Refrigerator Replaced	30%	29%	32%

Note: Results weighted by sample design selection probabilities.

4.5 ENERGY SAVINGS BY INSTALLED MEASURES

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 PY 2008 evaluation identified five major measures that appeared to drive a significant fraction of the observed gas savings in mobile homes: heating system replacement, floor insulation, attic insulation, duct sealing, and major air sealing[12]. For consistency, the same five major measures are used for this analysis. Table 4.6 summarizes the gas savings results with participants grouped by the number of these major measures they received.

[12] Major air sealing was defined as a leakage reduction measured by blower door testing of at least 1,000 CFM50.

Table 4.6 PY 2010 WAP Energy Impacts for Mobile Homes Gas Savings for Homes with Natural Gas Main Heat By Number of Major Measures (therms/year)

Group/Breakout	# Homes	Gas Use Pre-WAP	Net Savings	% of Pre
No Major Measures	88	657	44 (±17)	6.6 (±2.6)
Any One Major Measure	174	696	58 (±15)	8.3 (±2.2)
Any Two Major Measures	209	735	106 (±17)	14.5 (±2.4)
Any Three Major Measures	141	752	132 (±21)	17.6 (±2.8)
Four or Five Major Measures	47	773	186 (±24)	24.1 (±3.1)

Savings averaged 6.6 percent of pre-program gas usage for homes that did not receive any of the five major measures. Savings increased as the number of measures increased; mobile homes that got four or more measures saved 186 therms of natural gas (over 20 percent of pre-program usage). But, the majority of mobile homes received two or fewer major measures.

Table 4.7 summarizes the electric savings associated with two key electric baseload measures – refrigerator replacements and lighting retrofits (primarily CFLs). Both measures appear to be associated with higher electric savings but the difference between those that were reported to have lighting measures vs. not have lighting measures wasn't large or statistically significant. It is suspected that some of the homes in the no lighting group actually may have received lighting retrofits from a utility program. Homes that received replacement refrigerators saved much more than homes that did not. These results are consistent with findings for site-built homes.

Table 4.7 PY 2010 WAP Energy Impacts for Mobile Homes Net Electric Savings for Homes with Natural Gas Main Heat By Measure Combination (kWh/year)

Measures	# Homes	Elec Use Pre-WAP	Net Savings	% of Pre
No Lighting or Refrigerator	97	9,436	416 (±309)	4.4% (±3.3)
Lighting, but no Refrigerator	358	9,053	521 (±206)	5.8% (±2.3)
Refrigerator (either Lighting)	200	7,846	1,015 (±253)	12.9% (±3.2)

4.6 ENERGY SAVINGS BY PRE-WEATHERIZATION USAGE LEVEL

Previous research has shown that homes 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 homes with higher pre-participation energy use. Table 4.8 summarizes gas use and savings by level of pre-weatherization gas use. (For this analysis, the Comparison Group was stratified into the same categories to provide a net savings adjustment.) Gas savings increase dramatically with pre-weatherization usage; therm savings are nine times larger for the highest users than for the lowest users, and percent savings more than double over this range.

Table 4.8 PY 2010 WAP Energy Impacts for Mobile Homes Net Gas Savings for Natural Gas Main Heat by Pre-Weatherization Gas Usage (therms/year)

Pre-WAP Gas Use (therms/year)	# Major Measures	# Homes	Gas Use Pre-WAP	Net Savings	% of Pre
<400 therms/year	1.6	71	313	20 (±13)	6.5% (±4.3%)
400-<600	1.7	184	506	57 (±14)	11.2% (±2.7%)
600-<800	1.8	207	693	73 (±15)	10.6% (±2.2%)
800-<1000	1.9	148	895	146 (±28)	16.3% (±3.2%)
>=1000	2.1	96	1,161	184 (±39)	15.9% (±3.4%)

Note: Comparison Group, not shown, also was stratified by usage.

Table 4.9 shows electric savings by pre-weatherization electric usage level for homes with gas main heat. There does not appear to be any relationship between pre-weatherization electric usage and savings except for the very large savings among homes in the highest usage category. The lack of a relationship for the lower usage categories is likely due to the negative correlation between refrigerator replacement rate and usage across these categories. These differences are largely driven by differences in state-level policies toward refrigerator replacement.

Table 4.9 PY 2010 WAP Energy Impacts for Mobile Homes Net Electric Savings for Homes with Natural Gas Main Heat by Pre-Weatherization Electric Use (kWh/year)

Pre-WAP Usage	Refrigerator Replacement %	# Homes	Elec Use Pre-WAP	Net Savings	% of Pre
<6,000 kWh/yr.	37%	208	4,706	462 (±154)	9.8% (±3.3%)
6-<9,000	35%	218	7,394	356 (±260)	4.8% (±3.5%)
9-<12,000	21%	124	10,369	438 (±439)	4.2% (±4.2%)
>=12,000 kWh/yr.	23%	145	15,543	1,758 (±548)	11.3% (±3.5%)

Note: Comparison Group, not shown, also was stratified by usage.

4.7 CLIMATE ZONE ANALYSIS

The Climate Zones were defined to provide insight into how energy use and program savings vary due to climatic differences. In general, one might expect that gas usage and savings potential would be higher in the colder climate zones while electric usage and savings potential would be higher in warmer climates for homes with air conditioning. However, since relatively few WAP mobile home clients in the Moderate and Hot/Humid Climate Zones used gas as a main heating fuel (10% and 5% respectively) and the sample size for the Hot/Dry Climate Zone was relatively small, the majority of the analysis sample for gas heated mobile homes was concentrated in the Cold and Very Cold Climate Zones. To address this issue, the Moderate, Hot/Dry, and Hot/Humid climate zones were combined for the mobile home analysis and are referred to as the "Moderate/Hot" Climate Zone. Table 4.10 summarizes gas impacts for homes with natural gas main heat by Climate Zone. Pre-program gas use was the highest in the Very Cold Climate Zone and so was the count of major measures installed, but therm savings were about the same in the Cold and Very Cold zones. The usage and savings were much lower in the combined Moderate/Hot zones, although percent savings were only a little lower than the Very Cold zone.

Table 4.10 PY 2010 WAP Energy Impacts for Mobile Homes Net Gas Savings for Natural Gas Main Heat by Climate Zone (therms/year)

Climate Zone	# Major Measures	# Homes	Gas Use Pre-WAP	Net Savings	% of Pre
Very Cold	2.0	306	835	104 (±19)	12.5% (±2.3%)
Cold	1.8	289	671	100 (±18)	14.8% (±2.6%)
Moderate/Hot	1.7	111	476	44 (±18)	9.1% (±3.7%)

Note: Comparison Group, not shown, also was stratified by climate zone.

Table 4.11 shows the gross and net electric impacts for gas heated homes by Climate Zone. Savings appear to be largest in the Cold Climate Zone and lowest in the Moderate/Hot Climate Zone but the sample size is small and differences between zones are not statistically significant.

Table 4.11 PY 2010 WAP Energy Impacts for Mobile Homes Electric Savings for Natural Gas Main Heat by Climate Zone (kWh/year)

Climate Zone	Refrigerator Replacement %	# Homes	Elec Use Pre-WAP	Net Savings	% of Pre
Very Cold	39%	230	7,994	698 (±313)	8.7% (±3.9)
Cold	21%	323	9,272	752 (±254)	8.1% (±2.7)
Moderate/Hot	29%	142	8,877	437 (±383)	4.9% (±4.3)

Note: Comparison Group, not shown, also was stratified by climate zone.

4.8 ANALYSIS OF OTHER FACTORS

Table 4.12 compares savings for different job funding sources and also includes average spending on efficiency measures (ECM = energy conservation measure). The first comparison is based on whether the work was performed with just DOE funds or whether there were also nonDOE funds involved. Jobs that received nonDOE funds appeared to save a little less natural gas than DOE-only jobs but this difference wasn't statistically significant. The spending on efficiency measures was only slightly lower in the DOE-only jobs.

The second part of Table 4.12 is based on the relative amount of funds leveraged by the subgrantee that did the work, not necessarily the spending on the specific job. Gas savings were slightly larger for homes treated by agencies that received substantial funding from sources other than DOE or LIHEAP, but spending on energy efficiency measures did not differ much and savings differences were modest.

Table 4.12 PY 2010 WAP Energy Impacts for Mobile Homes Net Gas Savings for Natural Gas Main Heat By Use of nonDOE Funds and by Subgrantee Wx Funding Sources (therms/year)

Funding Sources	# Homes	ECM Measure $/Home	Gas Use Pre-WAP	Net Savings	% of Pre
Job Funding Sources					
Only DOE Funds	355	$3,456	710	102 (±12)	14.4% (±1.7%)
DOE & nonDOE Funds	298	$3,738	737	92 (±17)	12.5% (±2.3%)
Subgrantee Wx Funding Sources					
DOE WAP-Dominated	116	$3,802	699	89 (±19)	12.7% (±2.7%)
WAP+LIHEAP Dominated	150	$3,442	651	81 (±17)	12.5% (±2.6%)
WAP+LIHEAP Majority/Some Other	374	$3,693	767	106 (±16)	13.8% (±2.1%)

Table 4.13 summarizes gas savings by the amount of spending on efficiency measures for each job. This cost breakout was not available for about 15 percent of the cases in the analysis. The savings were about the same for the higher two categories of spending and considerably lower for homes in the lowest category. Heating system replacement rates drove a large portion of the spending differences – 76% of homes in the highest spending category received heating system replacements compared to 15% in the lowest spending category. Pre-program gas use was about the same for all levels of spending.

Table 4.13 PY 2010 WAP Energy Impacts for Mobile Homes Net Gas Savings for Natural Gas Main Heat By Efficiency Measure Cost

Efficiency Measure Costs	# Homes	ECM Measure $/home	Gas Use Pre-WAP	Net Savings	% of Pre
<$2,000	173	$1,112	717	41 (±15)	5.7% (±2.1%)
$2,000-<$4,000	204	$3,051	709	103 (±14)	14.5% (±2.0%)
$4,000-< $6,000	135	$4,894	766	146 (±20)	19.1% (±2.6%)
>=$6,000	90	$7,741	713	144 (±28)	20.2% (±4.0%)

Table 4.14 shows a breakout of gas savings by whether or not total job costs exceeded $8,000. The $8,000 figure was selected to represent about the 10 percent highest-cost jobs. On average, high-cost jobs saved much more than other jobs (62% more therms) but measure costs increased at an even higher rate (156% more dollars).

Table 4.14 PY 2010 WAP Energy Impacts for Mobile Homes Net Gas Savings for Natural Gas Main Heat By High Cost ($8,000+) Job

Total Job Cost	# Homes	ECM Measure $/home	Gas Use Pre-WAP	Net Savings	% of Pre
Total Job Cost <$8,000	572	$3,021	719	91 (±11)	12.7% (±1.5%)
Total Job Cos >=$8,000	80	$7,741	740	147 (±32)	19.9% (±4.3%)

4.9 PROGRAM YEAR 2009 AND PROGRAM YEAR 2011 ENERGY SAVINGS

Program Year 2010 was the primary focus of the impact analysis and the only year for which detailed treatment data were collected from local agencies. But basic data, including utility account number and treatment dates, also were collected for homes that participated in Program Years 2009 and 2011.

The PY 2011 data were collected primarily for creating the Comparison Group for the PY 2010 analysis. However, PY 2011 net impacts can be assessed if the PY 2010 data are analyzed as a "post/post" Comparison Group based on the principles of difference-in-difference estimation. Similarly, the PY 2009 data were collected primarily for creating the Comparison Group for the PY 2008 program evaluation, but net impacts can be assessed if the PY 2008 data are analyzed as a "post/post" Comparison Group.

Table 4.15 summarizes the gas savings results for PY 2009 and PY 2011. For comparison, the PY 2010 gas savings averaged 89 therms net (82 therms gross), equal to 12.9 percent of the 692 therms pre-program annual gas use.

Table 4.15 PY 2009 and PY 2011 WAP Energy Impacts for Mobile Home Gross and Net Gas Savings (therms/year)

Program Year	# Homes	Gas Use Pre-WAP	Gas Use Post-WAP	Gross Savings	Net Savings	% of Pre
PY 2009	487	784	670	114	115 (±19)	14.6% (±2.5%)
Comparison	712	696	697	-1		
PY 2011	364	741	659	82	87 (±15)	11.8% (±2.0%)
Comparison	608	629	634	-5		

*Not Available

Table 4.16 summarizes the electric savings results for gas heated homes in PY 2009 and PY 2011. For comparison, the PY 2010 savings were 665 kWh/year net (842 kWh/yr gross), equal to 7.6 percent of the 8,792 kWh/year pre-program electric use.

Table 4.16 PY 2007 and PY 2009 WAP Energy Impacts for Mobile Homes Gross and Net Electric Savings for Natural Gas Main Heat

Program Year	# Homes	Elec Use Pre-WAP	Elec Use Post-WAP	Gross Savings	Net Savings	% of Pre
PY 2009	344	8,250	7,246	1004 (±311)	1,097 (±376)	8.2% (±1.3%)
Comparison	574	8,590	8,683	-93 (±102)		
PY 2011	363	8,502	7,763	739	748 (±196)	8.8% (±2.3%)
Comparison	606	8,057	8,066	-9		

4.10 EXPLANATORY FACTORS AND ESTIMATED ENERGY SAVINGS FOR ALL GAS HEATED HOMES

The breakouts of savings presented throughout this section have summarized program impacts for various groups of interest. But such breakouts may provide a false impression of cause and effect. For example, differences in savings between climate zones or by pre-program usage levels may be accounted for as much by differences in the mix of measures installed than by the specific characteristic used to define groups. To better assess how different factors affect energy savings, regression modeling was used to explore how variations in observed savings relate to the measure installed and other factors.

In addition to providing potentially useful estimates of measure savings and other insights into factors associated with savings, the regression analysis of savings also was used to estimate the overall savings for the population of gas heated mobile homes and for homes heated by delivered fuels (e.g., oil and propane). Table 4.2 summarized characteristics of mobile homes in the analysis sample compared to those in the gas heated population and all mobile homes in the program. There were some differences in measure installation rates and other factors. The regression model developed using the billing analysis sample was used to estimate the savings for homes without usable savings results based on the location and climate of the home and the mix of measures installed.

The explanatory factors model also played a key role in developing cost savings estimates as energy prices vary geographically yet sample attrition led to many states having few or even no cases with usable results. To develop savings estimates for all homes in all states, a multi-level or mixed-effects[13] modeling approach was employed that estimates fixed effects for program measures but then also estimates state-level effects that were nested within climate region effects. This approach estimates state-level impacts that are a pooled combination of state-level savings in the sample and impacts estimated by the mix of measures. The savings for states with large samples were primarily based on those results while savings for states with few results were primarily driven by the mix of measures adjusted for climate region effects. For the states with no billing analysis savings results, savings were estimated entirely based on the mix of measures and climate.

The explanatory factors model was developed by examining a wide range of measures and other factors for potential inclusion in a model of observed savings. Factors were assessed based on explanatory power, practical and statistical significance, and having the "right" sign. Attic insulation, heating system replacement, and air leakage reduction were found to account for the bulk of the savings. The small sample and geographic skew limited the ability of the modeling to provide the same level of reliability as the modeling done for the site-built homes. Many potential measures were dropped from the model due to weak explanatory power. Floor insulation was a significant factor in the PY 2008 analysis but was not

[13] The xtmixed command in the statistics package Stata was used to fit these models.

significant for PY 2010. The gas savings results from the explanatory factors model are summarized in Table 4.17.

Table 4.17 PY 2010 WAP Energy Impacts for Mobile Homes Gas Savings (therms/year) by Measure for Natural Gas Main Heat

Measure	% of Homes	Savings per installation	Contribution to Overall Savings	% of Total Savings
Sealing	100%	34	34	38%
Heater Replacement	41%	54	23	25%
Other/Unattributed	100%	17	17	19%
Attic Insulation	19%	73	14	15%
Duct Sealing	57%	6	3	3%
Total			91	100%

The measures in the table are ordered by their overall contribution to program gas savings. Air sealing work is estimated to have provided the largest fraction of program savings – an average of 34 therms per home equal to nearly 40 percent of the overall gas savings. Heating system replacements is the second largest source of savings – producing 54 therms per home in 41 percent of all mobile homes. Attic insulation was estimated to provide the most savings per installation at 73 therms but was only performed in 19 percent of mobile homes. The estimated savings from duct sealing were estimated to be just 6 therms per home compared to 39 therms per home found in the PY 2008 study. Floor insulation was not estimated to provide any savings in PY 2010 compared to the 32 therms estimated in PY 2008. These savings estimates have considerable uncertainty and could be biased by confounding factors (e.g., factors that affect overall energy savings that are also correlated with measure installation rates). Some of the "missing" savings from these measures may have ended up in the Other/Unattributed category which added 17 therms per home in average savings.

The three major measures account for an estimated 71 therms in average savings per mobile home with an additional 17 therms unattributed and 3 therms attributed to duct sealing. Overall, the gas explanatory factors model estimates that the program produced average annual natural gas savings of 91 therms – essentially identical to the 89 therms net savings found in the billing analysis sample.

An explanatory factors model was also developed to estimate electric savings in gas heated homes. The results of this analysis are summarized in Table 4.18.

Table 4.18 PY 2010 WAP Energy Impacts for Mobile Homes Electric Savings (kWh/year) by Measure for Natural Gas Main Heat

Measure	% of Homes	Savings per installation	Contribution to Overall Savings	% of Total Savings
Lighting	81%	242	196	34%
Refrigerator Replacement	25%	536	136	23%
Other/Unattributed	100%	246	246	43%
Total			578	100%

Lighting retrofits are estimated to have saved 242 kWh per home for the 81 percent of homes that received that measure. Refrigerator replacements are estimated to have saved 536 kWh for the 25 percent of homes receiving this measure. Another 246 kWh in electricity savings in gas heated mobile homes are not attributed to either of these two measures but may be due to reduced electric use of the gas furnace fan, reductions in cooling use from building shell measures and duct sealing/insulation, or reduction in the use of electric space heaters.

Overall national electricity savings in gas heated homes are estimated at 578 kWh – 87 kWh less than the 665 kWh found from the billing analysis sample. This small reduction in savings is due to differences between the analysis sample and the population.

5. ENERGY IMPACTS FOR MOBILE HOMES WITH ELECTRIC MAIN HEAT

The WAP evaluation directly measured electric usage for treated homes that use electricity as their main heating fuel. This section presents the findings with respect to overall energy impacts as well as breaking out savings by:

- End Use Savings – The share of electric savings attributable to heating, cooling, and baseload usage.
- Installed Measures – Differences in energy savings for groups of homes that received different packages of installed measures.
- Pre-Weatherization Usage Level – Differences in energy savings and installed measures associated with different levels of pre-weatherization usage.
- Climate Zone – Comparison of energy savings, installed measures, and usage by Climate Zone.

These analyses help to show how the program services and impacts vary by population subgroup. The small sample size of electrically heated homes limited this analysis when compared to the analyses conducted for the homes heated with natural gas.

5.1 METHODOLOGY

The electric savings in mobile homes with electric heat were analyzed using the same approach employed for the electric savings analysis in gas heated mobile homes – a standard pre/post treatment/comparison design using weather-normalized utility billing data. The small number of homes in the electric heat analysis sample limited the extent of further analysis and exploration.

5.1.1 Sample Attrition

A total of 2,499 mobile homes with electric heat were sampled for analysis. Table 5.1 summarizes the disposition of this sample for the electric use analysis. The utility data collection process was successful in obtaining electric data for 48 percent of the sampled homes. One significant challenge in collecting data was that subgrantees did not collect utility company names for about 21 percent of electric accounts. The usage data provided were not sufficient for developing savings estimates for 12 percent of the electric analysis homes. Most of this attrition was due to too little pre-retrofit data – the analysis required a minimum 270 days of electric data (in addition to some requirements about weather). The weather-normalization itself indicated a poor model fit in either the pre or post periods for less than 1 percent of the sampled cases. An additional 6 percent of sampled cases in the analysis had electric usage too low to be considered electrically heated and occupied during both periods. About 1 percent of the sampled homes were removed from the analysis because they were declared savings outliers[14].

[14] 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).

Table 5.1 PY 2010 WAP Mobile Homes Electric Usage Sample Attrition – Electric Main Heat

	Electric Analysis	
Sample Group / Attrition Cause	**Homes**	**% of Sample**
Sampled	2,499	100%
Utility Company Unknown	530	21%
No Usage data from utility	782	31%
Insufficient Data	311	12%
Poor Model Fit	12	<1%
Usage Outlier: Vacant, Unheated, Not MH	151	6%
Savings Outlier	17	1%
Total Usable Cases	696	28%

The same screening criteria were also applied to the Comparison Group analysis, which experienced greater attrition due to insufficient data because of the actual weatherization work truncating the "post" period.

5.2 KEY PROGRAM FACTORS FOR HOMES WITH ELECTRIC MAIN HEAT

Table 5.2 summarizes information about climate, demographics, housing stock, and major program measures for the mobile home sample compared to mobile homes with electric heat and the electric heat usage analysis sample. The table shows that electric heat homes were concentrated in the Moderate and Hot/Humid Climate Zones. Participants that lived in electric heated mobile homes tended to have lower incomes than participants with other heating fuels and their homes were more likely to have central air conditioning. The analysis sample attrition has created a group skewed slightly toward colder climates but generally similar to the larger electric heated mobile home population.

Table 5.2 Characteristics of Mobile Homes with Electric Heat

Characteristic	All Site-Built Homes	All Mobile Homes	Electric Heat Population	Electric Heat Analysis Sample
Climate				
Very Cold	19%	21%	6%	7%
Cold	36%	30%	16%	24%
Moderate	19%	23%	43%	35%
Hot/Humid	17%	16%	33%	32%
Hot/Dry	9%	9%	2%	2%
Demographics				
Median Income	$15,600	$13,668	$12,384	$12,384
Homeowner	81%	90%	90%	92%
Elderly	41%	39%	38%	43%
# Occupants	2.50	2.28	2.32	2.26
Housing Characteristics				
Heated Area	1,388	1,081	1,134	1,142
Median Age	57	27	27	27
HDD65	4,793	4,781	3,588	3,689
CDD65	1,274	1,227	1,593	1,554
Central Heating	89%	94%	93%	95%
Central A/C	40%	40%	54%	49%
Major Measures				
Heater Replacement	28%	31%	26%	26%
Attic Insulation	63%	25%	29%	30%
Wall Insulation	25%	3%	2%	2%
Floor Insulation	36%	43%	44%	48%
Air Sealing >1,000 CFM50	36%	29%	29%	27%
Duct Sealing	39%	52%	50%	53%
Refrigerator Replaced	20%	22%	18%	16%

Note: Results weighted by sample design selection probabilities.

5.3 ENERGY SAVINGS OVERALL AND BY END USE

Table 5.3 summarizes overall electric savings and savings separated into baseload, heating / winter, and cooling / summer usage. Electric savings averaged 1,691 kWh equal to 8.7 percent of total pre-program usage. The percent savings are lower than the 12.9 percent found for gas heated mobile homes but much of this difference is due to greater number of electric end uses that are not affected by WAP measures. The savings in the heating portion of electric use averaged 13.3 percent, which is similar to the 13.6 percent heating savings found in gas heated mobile homes. The baseload component savings estimate is larger than the 484 kWh average net baseload savings in the gas heated analysis sample. (See Table 4.4) Cooling use was small and savings averaged 9.1 percent but were just barely statistically different from zero.

Table 5.3 PY 2010 WAP Energy Impacts for Mobile Homes Gross and Net Electric Savings for Electric Main Heat by End Use (kWh/year)

Usage Component	# Homes	Elec Use Pre-WAP	Gross Savings	Net Savings	% of Pre
Total Use	696	19,408	2,137 (±246)	1,691 (±330)	8.7% (±1.7)
Comparison	276	19,713	445 (±211)		
Heating/Winter Use	696	6,609	1,154 (±260)	882 (±217)	13.3% (±3.3)
Comparison	276	6,470	271 (±196)		
Cooling/Summer Use	696	1,746	201 (±79)	159 (±153)	9.1% (±8.8)
Comparison	276	2,000	42 (±117)		
Baseload Use	696	11,052	782 (±211)	650 (±361)	5.9% (±3.3)
Comparison	276	11,243	131 (±305)		

The distribution of participants' pre-program total electric use is shown in Figure 5.1. The median annual electric use for electric heated participants was 18,914 kWh and one-half of all homes used between 14,601 and 23,709 kWh annually. Ten percent of homes used less than 11,403 kWh and ten percent used more than 28,328 kWh. The Comparison Group distribution was almost identical with a median of 19,160 kWh and quartiles of 14,284 kWh and 24,205 kWh.

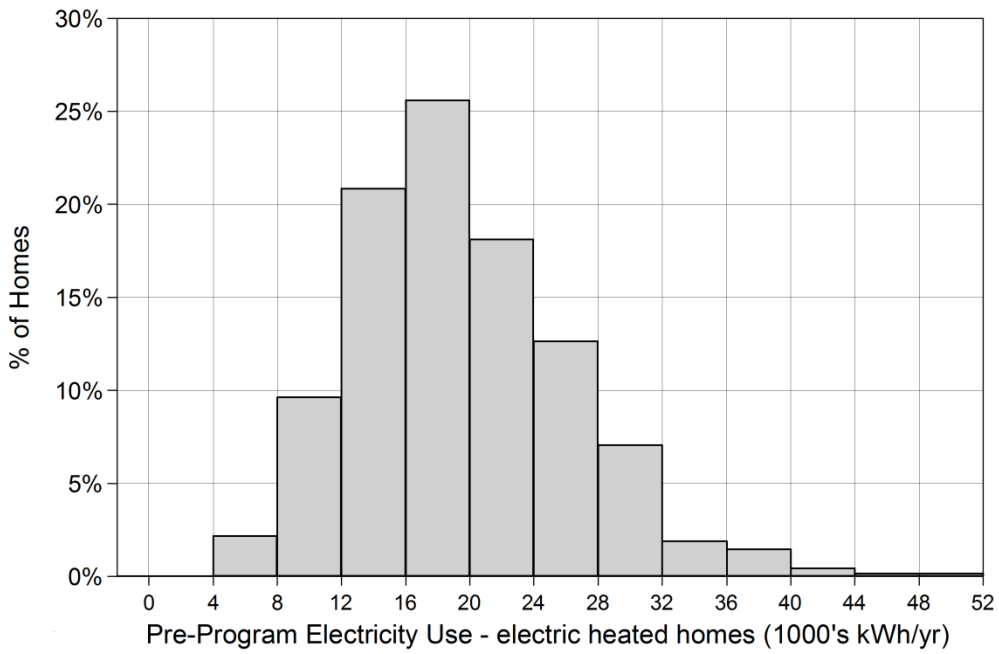

Figure 5.1: Distribution of Pre-Program Electric Use for Electric Heat Mobile Home Participants

The distribution of percent electric savings for electric heat participants and the Comparison Group households are shown together in Figure 5.2. The Comparison Group line graph shows the distribution of the year-over-year energy savings that was observed for households that did not receive weatherization services. The line graph for those households has a plateau centered on 0% that comprises half of the

Comparison Group and covers changes in electric use between +/-7.5 percent. A little more than one-quarter of the Comparison Group homes experienced a decrease in electric use of more than 7.5% and the remaining 22 percent experienced an increase of more than 7.5%. Some of the reasons for these changes in electric use may include: increases or decreases in the number of household members, changes in the number of people at home during the day, or changes in the way the home is used. These are normal events that affect households at all income levels and in all areas. Table 5.3 shows that, with all of those potential changes, the average weather-normalized electric savings for Comparison Group households was about 445 kWh (2.3%).

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 9.8 percent showing that the Participant Group households had substantially higher electric savings than did the Comparison Group households. Second, the graph for the Participant Group is more spread out – 38% of participants are in the middle three savings bins compared to 50% of the Comparison Group – reflecting the variability in electric savings associated with varying treatment impacts.

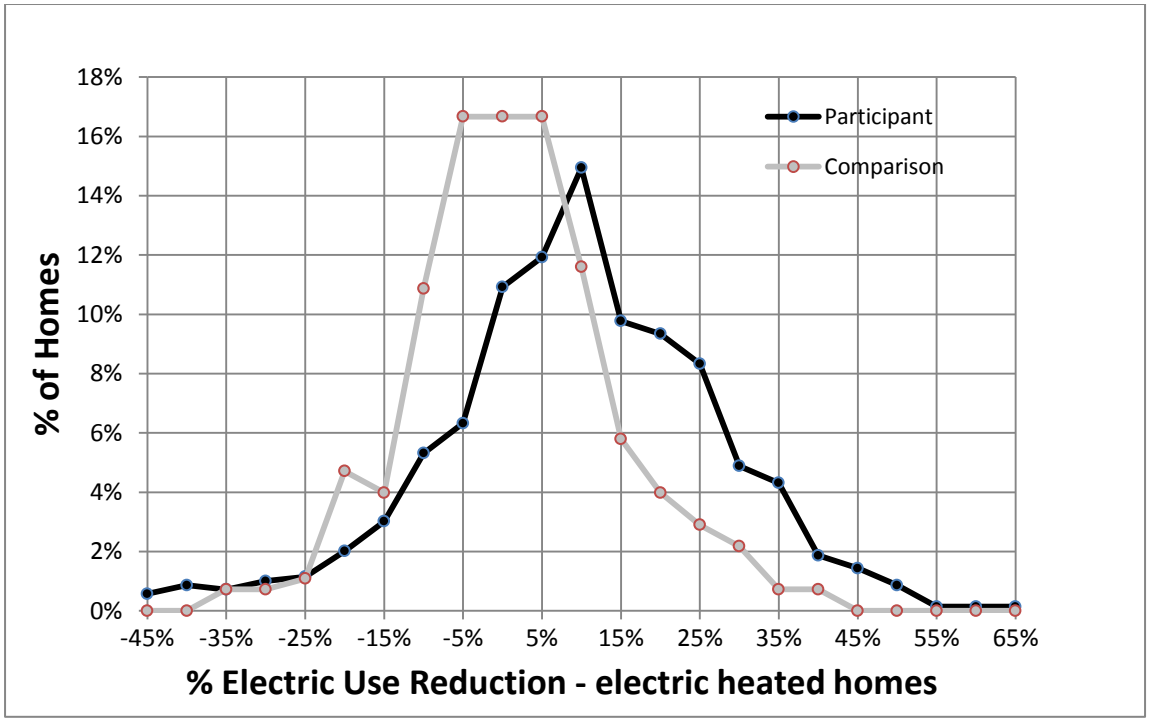

Figure 5.2: Distribution of Percent Electric Savings – Participant and Comparison Groups

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

- Weather-normalized usage for Treatment Group households fell by 11.0 percent and by 2.3 percent for Comparison Group households; the net impact of weatherization was to shift the electric savings graph to the right by about 8.7 percent.

- Treated homes each received a different set of measures. (See Tables 3.14 through 3.16). Homes with few measures are expected to have small energy savings while those homes that received a

full set of measures are expected to have large energy savings, other things being equal. Since each Treatment Group home is expected to have a different level of savings, the distribution of savings is more variable (spread out) for Treatment Group homes than for 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 electric savings for the Comparison Group may help explain this apparent anomaly. As shown in Figure 5.2 above, some Comparison Group homes increased usage by 20 percent or more due to nonprogram factors. So, if a home *would have had* an increase in usage of 20 percent without treatment, but had only a 5 percent increase in usage after treatment, the net program impact is 15 percent savings over what would have occurred without weatherization.

5.4 MEASURE LEVEL ENERGY IMPACTS

Table 5.4 summarizes electric use and savings for homes with different numbers of major measures using the same major measures as for gas heated homes: air sealing, attic insulation, floor insulation, duct sealing, and heating equipment replacement. Homes that received no major measures achieved no or little savings. Savings increased as the number of major measures increased; homes with one major measure saved 1,053 kWh/year (5.7%) compared to homes with three or more major measures that saved 3,069 kWh/year (14.5%).

Table 5.4 PY 2010 WAP Energy Impacts for Mobile Homes Net Electric Savings for Electric Main Heat (kWh/yr) By Number of Major Measures

# Major Measures	# Homes	Elec Use Pre-WAP	Net Savings	% of Pre
No Major Measures	110	16,794	112 (±598)	0.7% (±3.6%)
One Major Measure	176	18,521	1,053 (±413)	5.7% (±2.2%)
Two Major Measures	193	20,326	1,938 (±529)	9.5% (±2.6%)
Three or More Major Measures	174	21,168	3,069 (±430)	14.5% (±2.0%)

5.5 ENERGY IMPACTS BY PRE-WEATHERIZATION USAGE LEVEL

Similar to the gas analysis, the relationship between pre-weatherization total electric use and electric savings in electrically heated homes was explored by examining net savings by level of pre-program electric usage. The results of this analysis are shown in Table 5.5. Homes with pre-weatherization usage of less than 15,000 kWh had savings of just 444 kWh (3.8%) while homes with usage of 20,000 kWh or more of pre-weatherization usage saved over 2,500 kWh per year on average.

Table 5.5 PY 2010 WAP Energy Impacts for Mobile Homes Net Electric Savings for Electric Main Heat by Pre-Weatherization Electric Usage

Pre-WAP Use	# Homes	Elec Use Pre-WAP	Net Savings	% of Pre
<15,000 kWh/year	184	11,791	444 (±350)	3.8% (±3.0%)
15,000-<20,000	221	17,596	1,736 (±418)	9.9% (±2.4%)
20,000-<25,000	152	22,474	2,691 (±753)	12.0% (±3.3%)
>=25,000	139	29,611	2,514 (±956)	8.5% (±3.2%)

Note: Comparison Group, not shown, also was stratified by pre-WAP electric use.

5.6 CLIMATE ZONE IMPACTS

The analysis sample included just 20 electrically heated mobile homes in the Hot/Dry Climate Zone and so the two hot Climate Zones were combined for the analysis. Table 5.6 summarizes the savings results for the resulting four climate zones.

Table 5.6 PY 2010 WAP Energy Impacts for Mobile Homes Gross and Net Electric Savings for Electric Main Heat by Climate (kWh/year)

Climate Zone	# Homes	Elec Use Pre-WAP	Net Savings	% of Pre
Very Cold	45	19,795	2,402 (±621)	12.1% (±3.1%)
Cold	145	22,361	1,572 (±676)	7.0% (±3.0%)
Moderate	246	18,872	1,350 (±557)	7.2% (±3.0%)
Hot	260	18,460	1,871 (±666)	10.1% (±3.6%)

Note: Comparison Group, not shown, also was stratified by climate zone.

The highest savings were found in the Very Cold climate zone and the lowest savings were in the Moderate climate zone. The difference in savings between these two zones was the only statistically significant difference between zones. An analysis by end use component found larger summer/cooling use and savings in the hot zone which offset some of the much lower heating usage and savings found in that zone.

5.7 PROGRAM YEAR 2009 AND PROGRAM YEAR 2011 ELECTRICITY SAVINGS

Table 5.7 summarizes the electric savings results for electric heated homes that participated in PY 2009 and PY 2011. For comparison, the PY 2010 savings averaged 1,691 kWh net (2,137 kWh gross), equal to 8.7 percent of the 19,408 kWh pre-program annual electric use. *(Insert net savings data for PY 2011 and discuss findings.)*

Table 5.7 PY 2009 and PY 2011 WAP Energy Impacts for Mobile Homes Gross and Net Electric Savings for Electric Main Heat

Program Year	# Homes	Elec Use Pre-WAP	Elec Use Post-WAP	Gross Savings	Net Savings	% of Pre
PY 2009	193	21,520	18,266	3,255 (±1831)	3,138 (±1,848)	14.6% (±8.6%)
Comparison	302	19,429	19,313	117 (±265)		
PY 2011	346	19,967	17,785	2,182 (±350)	*	*
Comparison	*	*	*	*		

5.8 ESTIMATED ENERGY SAVINGS FOR ALL ELECTRIC HEATED HOMES

Similar to the approach described in section 4.10, an explanatory factors model was also developed to assess electric savings in electric heated mobile homes. The results of this analysis are summarized in Table 5.8. Air sealing, duct insulation, and duct sealing were estimated to have the largest overall contributions to program savings. The overall national savings are estimated at 1,660 kWh per home – very similar to the billing analysis sample estimate of 1,691 kWh – indicating that the sample and population were similar.

Table 5.8 PY 2010 WAP Energy Impacts for Mobile Homes Electric Savings (therms/year) by Measure for Electric Main Heat

Measure	% of Homes	Savings per installation	Contribution to Overall Savings	% of Total Savings
Air Sealing	100%	595	595	36%
Duct Insulation/Sealing	50%	1,111	556	33%
Attic Insulation	29%	1,082	315	19%
Floor Insulation	44%	723	314	19%
Air Conditioner Replacement	7%	1,811	127	8%
Refrigerator Replacement	18%	686	123	7%
Other/Unattributed	100%	-369	-369	-22%
Total			1,660	100%

6. ENERGY IMPACTS FOR MOBILE HOMES WITH DELIVERED FUEL MAIN HEAT

About 21 percent of mobile homes that participated in PY10 are heated with delivered fuels – fuel oil, propane, kerosene, and wood. Since the consumption of delivered fuels for a particular time period cannot be directly measured from purchase records – and such records are often incomplete and difficult to access – the evaluation directly metered the pre- and post-weatherization usage for a sample of homes that heat with fuel oil and compared the impacts for these homes to those that heat with natural gas. The purpose of that metering study was to test whether savings among oil-heated homes differ significantly from savings among gas heated homes.

The study was conducted in site-built homes and is described in greater detail in the Single Family Site-built Homes Impact Report. The study found that savings in oil heated homes were very similar (slightly larger, but not a statistically significant difference) to the savings that would be expected if these had been gas heated homes in the same locations that received the same mix of measures. In other words, the results supported the hypothesis that fuel savings in oil heated homes are similar to those in gas heated homes when receiving the same measures in the same climates.

Given the findings of the metering study, the gas explanatory factors model savings estimation approach described in Section 4.10 was applied to all mobile homes heated with delivered fuels. Similarly, electric baseload savings were estimated based on electric savings found in gas heated homes as a function of electric measures.

Table 6.1 summarizes the resulting estimated net energy savings for mobile homes that heat with delivered fuels. The differences in energy savings are a function of differences in measure installation rates and locations.

Table 6.1 PY 2010 WAP Energy Impacts for Mobile Homes Net Savings for Delivered Fuel Main Heat

Main Heating Fuel	Heating Fuel Savings (MMBtu/yr)	Electric Savings (kWh/yr)
Fuel Oil	10.1	469
Propane	8.0	554
Other	8.8	545
All Delivered Fuels	**8.6**	**531**

7. 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.

- Nonenergy Benefits – The evaluation collected data and referencing literature sources to estimate and monetize the nonenergy 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 nonenergy 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 nonenergy benefits from the program. This analysis is only concerned with the effectiveness of efficiency measures at saving energy.

7.1 PRICE AND DISCOUNT RATE SCENARIOS

This report presents information on energy savings for PY 2010. In this section, the energy cost savings and cost-effectiveness are presented from three different perspectives.

- Impact on PY 2010 Clients – The first scenario documents how the program impacted PY 2010 clients. It shows the clients' first year energy cost savings based on actual energy prices in 2010 and the estimated net present value of their energy cost savings based on actual energy prices for 2010 through 2012, projected energy prices beginning in 2013, and discount rates in effect in 2010.

- PY 2013 Policy Perspective – The second scenario is the most relevant to policymakers 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 Policy 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 2013 Perspective is probably the most useful for policymakers at this time.

7.2 IMPACT ON PY 2010 CLIENTS

This section presents the estimated energy cost savings and cost-effectiveness for clients that were served during PY 2010. The following parameters are used in this analysis.

- First Year Energy Savings – Procedures are presented in Sections 4, 5, and 6 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 2010.
- 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 2010-2012 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 2010.
- Energy Cost-Effectiveness – Compares the net present value of energy cost savings to the cost of installed energy measures.

Table 7.1 summarizes the average energy costs and annual cost savings for the first year after participation in WAP in 2010 dollars.

Table 7.1 PY 2010 WAP Energy Impacts for Mobile Homes Energy Costs and Cost Savings by Main Heating Fuel (2010 Dollars)

Heating Fuel	Annual Energy Costs			Annual Savings (First Year)			
	Fuel	Electric	Total$	Fuel	Electric	Total$	% Savings
Natural Gas	$517	$874	$1,391	$77	$59	$136	9.8%
Electricity	-	$1,855	$1,855	-	$153	$153	8.2%
Fuel Oil	$1,477	$1,090	$2,567	$199	$59	$258	10.1%
Propane	$1,792	$951	$2,744	$232	$61	$293	10.7%
Other	$671	$1,099	$1,770	$97	$73	$169	9.6%
All Clients	**$835**	**$1,091**	**$1,926**	**$114**	**$76**	**$190**	**9.9%**

Participant annual energy costs averaged $1,926 prior to WAP, and WAP reduced these costs by an average of $190, equal to a 9.9 percent reduction in total energy costs. The pre-weatherization annual energy costs for homes heated by fuel oil or propane were almost twice the costs for homes heated by

natural gas. The energy cost savings for homes heated by fuel oil or propane were considerably higher than the savings for homes heated by natural gas or electricity.

Table 7.2 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 the lifetime energy cost 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 interval on the SIR is also 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 $2,549 worth of energy bill savings over the lifetime of the measures (discounted to present value) and spent an average of $3,538 on efficiency measures in these homes, yielding an SIR of 0.72, meaning that measure costs exceeded energy savings. This finding stands in contrast to the analysis of site-built homes which found an overall SIR of 1.01. Site-built homes achieved energy cost savings that were 49 percent greater than those for mobile homes at a measure cost just 7 percent greater.

Table 7.2 PY 2010 WAP Energy Impacts for Mobile Homes Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Main Heating Fuel (2010 Dollars)

	Energy Cost Savings (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	$1,298	$553	$1,850	$3,353	-$1,503	0.55	0.45 - 0.70
Electricity	-	$2,221	$2,221	$3,792	-$1,571	0.59	0.48 - 0.71
Fuel Oil	$4,382	$528	$4,910	$3,409	$1,501	1.44	1.08 - 1.97
Propane	$2,964	$561	$3,525	$3,502	$22	1.01	0.80 - 1.30
Other	$1,658	$631	$2,290	$3,627	-$1,337	0.63	0.51 - 0.79
All Clients	**$1,329**	**$1,219**	**$2,549**	**$3,538**	**-$989**	**0.72**	**0.61 - 0.87**

The significant uncertainties in future energy prices as well as in the energy savings and costs yield a 90% confidence interval that extends from 0.61 to 0.87. The uncertainty is not symmetric around the estimate due to the greater potential for energy cost increases vs. decreases. Therefore, if energy prices increase at a greater pace than assumed, the retrofits may be considered cost-effective (from an energy-only perspective).

Although the SIR is estimated to be less than one for mobile homes overall, the retrofits were cost-effective for mobile homes heated with fuel oil and propane due to the high costs of these fuels.

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 7.3. The Cold Climate Zone produced the highest SIR due to having the lowest

spending on efficiency measures and relatively high savings. The Very Cold Climate Zone mobile homes achieved the largest energy cost savings but also had the greatest measure costs.

Table 7.3 PY 2010 WAP Energy Impacts for Mobile Homes Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Climate Zone (2010 Dollars)

	Energy Cost Savings (Present Value of Lifetime Savings)			Costs & Cost-Effectiveness		
Climate	Fuel	Electric	Total	Measure Costs	Net Benefits	Savings/ Investment Ratio
Very Cold	$2,429	$725	$3,154	$3,975	-$821	0.79
Cold	$1,873	$955	$2,828	$3,005	-$177	0.94
Moderate/Hot	$521	$1,596	$2,117	$3,679	-$1,562	0.58

One issue to consider is whether delivering more measures per home leads to greater cost-effectiveness. Previously, Table 4.6 showed that savings were higher among gas heated homes where more measures were installed. Table 7.4[15] helps assess whether the higher level of investment per home resulted in both higher levels of energy cost savings and in a higher level of cost-effectiveness. Overall, the cost-effectiveness as measured by SIR increases with the number of measures, but stays below unity for all categories.

The overall SIR of 0.61 is 0.06 higher than the 0.55 value shown in Table 7.2 for gas heated homes. This discrepancy is due to this subset of the analysis sample – cases with energy measure cost data – having higher savings and marginally higher measure costs than the overall gas heated population. Due to this sample bias, the SIR values should be looked at relative to each other more than as absolute numbers in this and the remaining tables in this section.

Table 7.4 PY 2010 WAP Impacts for Mobile Homes with Natural Gas Main Heat Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Number of Major Measures (Analysis Sample) (2010 Dollars)

	Energy Cost Savings (Present Value of Lifetime Savings)			Costs & Cost-Effectiveness		
# Major Measures	Fuel	Electric	Total	Measure Costs	Net Benefits	Savings/ Investment Ratio
No Major Measures	$488	$378	$867	$2,102	-$1,235	0.41
1 Major Measure	$767	$776	$1,542	$2,672	-$1,130	0.58
2 Major Measures	$1,459	$695	$2,154	$3,969	-$1,815	0.54
3 or More	$2,126	$1,056	$3,183	$4,366	-$1,183	0.73
All Clients (N=602)	**$1,331**	**$833**	**$2,164**	**$3,577**	**-$1,413**	**0.61***

* See footnote 15 for explanation of lower SIR.

[15] Note that cost-effectiveness results shown in Tables 7.4 through 7.6 differ from Tables 7.2 and 7.3 due to different analysis approaches. Tables 7.2 and 7.3 used the explanatory factors model to impute savings for all sampled homes with all heating fuels and then employed survey-based analysis to summarize energy savings and measure costs by fuel and state. This approach accounts for differences in measure installation rates across fuels, states, and sample attrition. Tables 7.4 and after used the analysis sample directly with survey-based estimation only for cases that had both usable gas savings results and reliable efficiency measure costs. There is no imputation or adjustment for sample attrition except that electric savings values are based on cases that have gas and measure cost information. The resulting sample is biased – it has higher measure costs, but lower savings and cost-effectiveness than the overall population.

Another issue examined is whether targeting homes with higher pre-weatherization usage results in higher cost-effectiveness. Previously, Table 4.8 showed that gas heated homes with higher pre-weatherization usage received more major measures and had higher savings. Table 7.5 shows how measure costs and cost-effectiveness vary with pre-weatherization gas use. The SIR increases dramatically with pre-weatherization gas use, most notably for mobile homes that used 1,000 therms or more of natural gas annually.

Table 7.5 PY 2010 WAP Impacts for Mobile Homes with Natural Gas Main Heat Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Pre-Weatherization Gas Usage (2010 Dollars)

	Energy Cost Savings (Present Value of Lifetime Savings)			Costs & Cost-Effectiveness		
Pre-WAP Gas Use (therms/year)	Fuel	Electric	Total	Measure Costs	Net Benefits	Savings/ Investment Ratio
<400	$367	$1,402	$1,768	$4,896	-$3,127	0.36
400-<600	$726	$1,016	$1,742	$3,261	-$1,519	0.53
600-<800	$1,191	$572	$1,763	$3,207	-$1,444	0.55
800-<1,000	$1,619	$396	$2,015	$3,628	-$1,613	0.56
>=1,000	$2,895	$788	$3,683	$4,176	-$493	0.88

Table 7.6 summarizes the cost-effectiveness of program treatments based on whether the home was treated using just DOE funds or with DOE funds plus other funding sources. The DOE-only jobs were more cost-effective than jobs that received other funds. The DOE-only jobs produced 18 percent higher bill savings at 93 percent of the energy measure cost compared to jobs that received funds from DOE and other sources. Measure installation data for these homes show that DOE+ jobs had higher measure installation rates: furnace replacement (29% DOE-only vs. 34% DOE+), attic insulation (23% DOE-only vs. 26% DOE+), floor insulation (47% DOE-only vs. 46% DOE+) and duct sealing (53% DOE-only vs. 65% DOE+). However, despite installing more measures, the DOE+ jobs did not have the same level of energy savings as did the DOE-only jobs.

Table 7.6 PY 2010 WAP Impacts for Mobile Homes with Natural Gas Main Heat Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Use of nonDOE Funds (2010 Dollars)

	Energy Cost Savings (Present Value of Lifetime Savings)			Costs & Cost-Effectiveness		
Job Funding	Fuel	Electric	Total	Measure Costs	Net Benefits	Savings/ Investment Ratio
Only DOE Funds	$1,544	$835	$2,378	$3,439	-$1,061	0.69
DOE + Non-DOE Funds	$1,220	$804	$2,023	$3,699	-$1,676	0.55

Based on these cost-effectiveness results that focus on solely the value of the energy savings compared to the cost of the efficiency measures, WAP work in mobile homes, for the packages of measures included in this evaluation and the low frequency in which high-saving measures were installed, is only cost-effective in homes with oil or propane heat.

7.3 PY 2013 POLICY 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 Policy Perspective and the Longer-Term Policy 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 Policy 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 Sections 4, 5, and 6 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 7.7 summarizes the average energy costs and annual cost savings for the first year after participation in WAP in 2013 dollars.

Table 7.7 Projected PY 2013 WAP Energy Impacts for Mobile Homes Energy Costs and Cost Savings by Main Heating Fuel (2013 Dollars)

Heating Fuel	Annual Energy Costs			Annual Savings (First Year)			
	Fuel	Electric	Total$	Fuel	Electric	Total$	% Savings
Natural Gas	$502	$876	$1,379	$75	$60	$134	9.8%
Electricity	-	$1,868	$1,868	-	$154	$154	8.3%
Fuel Oil	$1,827	$1,125	$2,952	$246	$60	$307	10.4%
Propane	$1,525	$961	$2,486	$197	$61	$258	10.4%
Other	$709	$1,135	$1,844	$102	$75	$177	9.6%
All Clients	**$819**	**$1,103**	**$1,921**	**$112**	**$76**	**$189**	**9.8%**

For PY 2013 participants, annual energy costs are expected to average $1,921 prior to WAP, and it is projected that WAP would reduce these costs by an average of $189, equal to a 9.8 percent reduction in total energy costs. The energy costs and value of the savings are expected to be around two times as large in homes heated by fuel oil or propane than in homes heated by natural gas.

Table 7.8 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 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 interval on the SIR is also presented based on a Monte Carlo simulation using estimated uncertainties of the inputs.

The table shows that a PY 2013 program would be expected to produce an average of $2,957 worth of energy bill savings over the lifetime of the measures (discounted to present value) and spend an average of $3,737 on efficiency measures in these homes, yielding a SIR of 0.79. The significant uncertainties in future energy prices as well as in the energy savings and costs yield a 90% confidence interval that extends from 0.66 to 0.97. The uncertainty is not symmetric around the estimate due to the greater potential for energy cost increases vs. decreases.

Table 7.8 Projected PY 2013 WAP Energy Impacts for Mobile Homes Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Main Heating Fuel (2013 Dollars)

	Energy Cost Savings (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	$1,554	$620	$2,174	$3,542	-$1,368	0.61	0.49 - 0.79
Electricity	-	$2,555	$2,555	$4,005	-$1,451	0.64	0.51 - 0.78
Fuel Oil	$5,252	$584	$5,836	$3,601	$2,235	1.62	1.19 - 2.25
Propane	$3,411	$628	$4,040	$3,700	$340	1.09	0.85 - 1.43
Other	$1,910	$702	$2,612	$3,831	-$1,219	0.68	0.54 - 0.87
All Clients	**$1,565**	**$1,392**	**$2,957**	**$3,737**	**-$780**	**0.79**	**0.66 - 0.97**

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

7.4 LONGER TERM POLICY 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 Policy Perspective and the PY 2013 Policy Perspective is that a different discount rate is used.
For more general policy 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 percent real discount rate.

For future participants, the first year savings are similar to those of the PY 2013 Policy Perspective. Annual energy costs are expected to average $1,921 prior to WAP, and it is projected that WAP would reduce these costs by an average of $189, equal to a 9.8 percent reduction in total energy costs. (Table 7.7)

Table 7.9 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 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 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 $2,419 worth of energy bill savings over the lifetime of the measures (discounted to 2013 dollars), and spend an average of $3,737 on efficiency measures in these homes, and a SIR of 0.65. The significant uncertainties in future energy prices as well as in the energy savings and costs yield a 90% confidence interval that extends from 0.55 to 0.78. The uncertainty is not symmetric around the estimate due to the greater potential for energy cost increases vs. decreases.

Table 7.9 Projected Future WAP Energy Impacts for Mobile Homes Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Main Heating Fuel (2013 Dollars)

	Energy Cost Savings (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	$1,254	$533	$1,787	$3,542	-$1,756	0.50	0.41 - 0.64
Electricity	-	$2,095	$2,095	$4,005	-$1,910	0.52	0.43 - 0.62
Fuel Oil	$4,219	$505	$4,724	$3,601	$1,123	1.31	0.98 - 1.77
Propane	$2,760	$539	$3,299	$3,700	-$401	0.89	0.71 - 1.14
Other	$1,553	$604	$2,158	$3,831	-$1,674	0.56	0.46 - 0.71
All Clients	**$1,263**	**$1,157**	**$2,419**	**$3,737**	**-$1,318**	**0.65**	**0.55 - 0.78**

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