IMPACTS OF WEATHERIZING LOW-INCOME, MULTIFAMILY BUILDINGS

11/16/2017

A Summary Report of the Evaluations of the U.S. Department of Energy's Weatherization Assistance Program

Prepared by

Bruce Tonn

Erin Rose

Beth Hawkins

Michaela Marincic

Three^3, Inc.

Prepared for

the JPB Foundation

Executive Summary

This report is an amalgamation of findings generated from the recent evaluations of the U.S. Department of Energy's Weatherization Assistance Program (WAP) that pertain to the affordable multifamily (MF) housing sector. The report presents general overviews of WAP and the evaluations before presenting sector specific findings from the evaluations that fall into four categories: energy impacts, non-energy impacts, cost-effectiveness, and qualitative field observations of weatherization implementers. On balance, the findings indicate that MF weatherization can be cost-effective and beneficial for residents. Explanatory factors—variations due to climate, building characteristics, and methods of implementation—are offered. This report is designed to be a resource for those who work to advance and increase support for programs that improve the energy efficiency of affordable MF buildings, such as Energy Efficiency for All; Network for Energy, Water and Health in Affordable MF Buildings; state and local weatherization programs; and public utility commissions and utilities.

Table of Contents

List of Figures

List of Tables

Impacts of Weatherizing Low-income, Multifamily Buildings

A SUMMARY REPORT OF THE EVALUATIONS OF THE U.S. DEPARTMENT OF ENERGY'S WEATHERIZATION ASSISTANCE PROGRAM

1.0 Introduction

The Weatherization Assistance Program (WAP) provides free home upgrades for low-income families. These upgrades–air sealing, heating, ventilation, air conditioning (HVAC) replacements, insulation, and more–are designed to make the home more energy efficient. These measures have been observed to *save residents money* through lower utility bills and *improve health outcomes* by reducing exposure to hazards such as extreme indoor temperatures and environmental asthma triggers. The body of research gathered on WAP impacts has historically been focused on single-family (SF) and mobile homes (MH) and generally supports a broad range of both financial and health benefits accruing to both households and society. Given that multifamily (MF) buildings house more people in one structure, weatherization offers an opportunity to benefit many low-income families through one organized effort. Furthermore, the demographics of MF building residents suggest they are a more vulnerable population on average than the occupants of SF or MH in the areas of socio-economic status, psycho-social stress, and physical health.

This report presents findings from recent evaluations of the U.S. Department of Energy's (DOE) Weatherization Assistance Program (WAP) that pertain to the affordable MF housing sector. Insights gained through a targeted investigation of the potential and diverse benefits of weatherization can support the work of those charged with advancing program outcomes aiming to improve the energy efficiency of affordable MF buildings, such as Energy Efficiency for All; Network for Energy, Water and Health in Affordable MF Buildings; state and local weatherization programs; and public utility commissions and utilities.

Below, readers will find an overview of WAP (Section 2.0) and then an explanation of the two evaluations performed on the program, including key facts about the study's building stock and residents (Section 3.0). Section 4.0 presents the *quantitative* findings from the evaluations: the ways in which WAP might save energy, improve health and financial circumstances of its clients, reduce greenhouse gas emissions, and stimulate the economy. Section 5.0 then presents the *qualitative* findings: case studies of agencies that have successfully weatherized MF buildings, a review of the weatherization work itself, perceived barriers to MF weatherization, and additional observations from the field. The report ends with concluding thoughts and acknowledgments.

The three appendices contain additional tables, figures, and two case studies of leading MF weatherization programs in New York City. Findings presented in the main body of this text are referenced to the original evaluation reports and also to the tables and figures contained in Appendices A and B. Extensive summaries of the WAP evaluations that encompass results also pertinent to the SF and MH sectors can be found in Tonn et al., *Weatherization Works* [21,37].

2.0 WAP Overview

Congress created WAP 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) 10CRF 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) To be eligible for the program in program year (PY) 2008, households had to meet one of two criteria: (1) household income at or below 150% of the federal poverty rate or (2) household income at 60% or less of the state median income. In 2008, 35 million homes were income eligible for WAP. [12]

DOE provides annual grants to grantees (i.e., states, territories, District of Columbia, a small number of Tribes), and the grantees provide funds to their subgrantees (e.g., local weatherization agencies) to facilitate the actual weatherization work. Grantees (hereafter referred to as "states" that also include U.S. territories) and subgrantees (hereafter referred to as "agencies") also leverage their DOE funds to acquire additional dollars to enhance the WAP work completed in a home or building. For example, many states re-allocate portions of their Low-Income Home Energy Assistance Program (LIHEAP) funds to low-income weatherization. The program operates across all climate zones in the U.S. and weatherizes all types of homes, from SF to MH to large MF buildings.

A national weatherization network has evolved over the years. The National Association of State Community Services Programs (NASCSP) provides support for each state in managing WAP. NASCSP maintains the Weatherization Assistance Program Technical Assistance Center (WAPTAC), which provides up-to-date information about WAP, such as formal program notices issued by DOE, as well as training and technical assistance information.[1] The National Community Action Foundation (NCAF) connects professionals in the traditional weatherization agencies that operate as Community Action Agencies.[2]

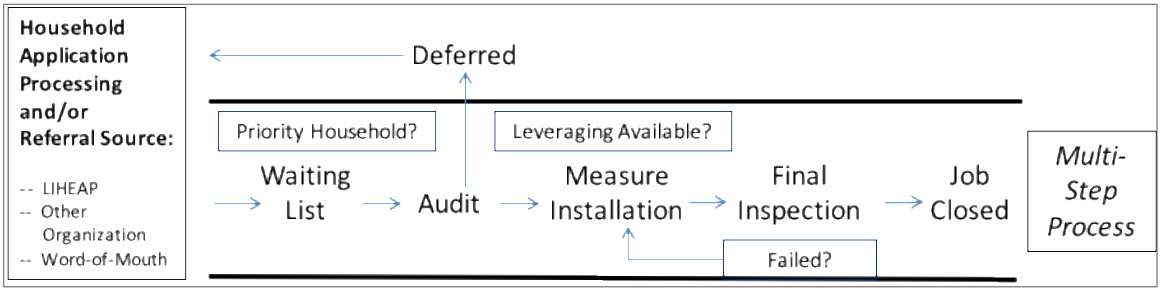
[1] See http://www.waptac.org

[2] See http://www.ncaf.org

2.1 The Weatherization Process

Figure 1 presents a graphical depiction of the weatherization process. In the SF and MH housing sectors, agencies first recruit clients and ensure they meet income eligibility guidelines. These clients might approach an agency directly or be referred when they apply to LIHEAP and other community service programs. Word-of-mouth communication about weatherization is also exceptionally strong. As a result, most local weatherization agencies do not have to market their programs in their communities. In fact, a substantial majority of local WAP agencies had waiting lists that extended many months and, in some cases, years into the future at the time of the PY 2008 research. [1, 35]

Figure 1. The Weatherization Process



Once a household or building is approved, an energy audit is coordinated to determine which measures to install (e.g., insulation, air sealing, heating system repair or replacement). Energy auditors use DOE-approved computerized audits (33%), priority lists (53%), or both (12%), to decide from a list of measures. [1] The priority lists allow agencies to approve the installation of measures known to be generally cost-effective without having to conduct computerized audits for every home. Auditors employ a range of diagnostic tests to support their assessments. The most common diagnostic test is the "blower door". Essentially, the auditor attaches a large fan to an outside door and depressurizes the home to locate major air leaks in the ductwork and building structure. Other common diagnostics include testing for carbon monoxide (CO) leaks from gas cooking stoves and in flues of space and water heating combustion systems.

In general, each installed measure needs to pass a savings-to-investment ratio (SIR) test, where the present value of the energy cost savings over the life of the measure (e.g., 20 years) needs to exceed the present value of its cost (i.e., SIR >= 1.0); if the measure cannot pass this test, it will not be installed. Additionally, during PY 2008, states and agencies were constrained to spend an average of $3,000 of DOE funds per weatherized home. Lastly, the local programs could invest a small amount of money to deal with health and safety issues found in homes (the cap is typically around 15% of funds invested in a weatherized unit,

and agencies usually use the full amount possible). It is common for agencies to encounter homes so structurally unsound that weatherization would have virtually no impact on energy consumption or be simply impossible. Houses also often pose health and safety risks to agency staff. In the cases where the agency does not have the resources to help rectify these problems, weatherization is deferred. The homes can re-enter the weatherization queue once the household has addressed the reason(s) for deferral.

After the energy audit is complete, agencies then schedule weatherization work for the home. Some agencies use "in-house" crews to do the weatherization work, while others hire private-sector contractors. Most agencies that use in-house crews contract out for heating and cooling system repair and replacement work. Most agencies that use contractors have in-house staff to conduct the initial audits.

Lastly, the agencies inspect the weatherized home. To address conflict-of-interest issues, inspectors typically do not inspect homes they had initially audited. State weatherization staff and DOE project officers also inspect a sample of weatherized homes as part of a larger quality assurance measure.

2.2 Multifamily Buildings in WAP

WAP has evolved considerably since its inception in 1976. For many years prior to the American Recovery and Reinvestment Act (ARRA), WAP received an annual appropriation from Congress of approximately $250 million. These funds supported the weatherization of roughly 100,000 units per year. Then in 2009, ARRA allocated $5 billion to WAP, and the production of weatherized units skyrocketed to more than 300,000 per year. Post-ARRA, WAP funding sank to a low of ~$70 million to current funding of approximately $190 million. Thus, the summary of evaluations of WAP presented below is split into two distinct periods: the year just prior to ARRA, PY 2008, and one program year during ARRA, PY 2010.

Because a large portion of low-income households live in large MF buildings, weatherization of this building stock was a point of emphasis during the ARRA period. DOE encouraged states and territories to allow and support agency weatherization work targeting MF buildings. Additionally, DOE entered into agreements to allow the weatherization of public housing and the U.S. Department of Housing and Urban Development (HUD) assisted properties. This shift resulted in 88% of WAP agencies tackling weatherization of large MF buildings during PY 2010. Among those weatherized MF units, 60% were found in privately owned large MF buildings, 15% in public housing, and 25% in HUD assisted private housing. Three quarters of WAP agencies reported weatherizing fewer than 1000 units in MF

buildings, 18% reported between 1000 and 5000 units, and 8% reported more than 5000 units. Nonetheless, units in large, MF buildings made up 21% of all units weatherized in PY 2010, up only slightly from 18% in PY 2008. Compare this to 63% and 64% of units labelled as SF in the same years, respectively.

DOE and others make a distinction between small and large MF buildings. The former contains 2-4 units and the latter 5+ units. Units in most small MF buildings are individually heated and cooled and have their own hot water systems. From a building science point of view, these units behave very similarly to SF homes and are therefore sometimes counted as SF units, allowing agencies to use similar audit tools and diagnostic procedures and install similar measures.

Large MF buildings, on the other hand, behave quite differently from SF and small MF structures. A significant number have central heating and hot water systems. Installing insulation in individual units ranges from difficult to nearly impossible. The buildings are too large for most common diagnostic procedures to provide meaningful insights. They consume energy in a variety of common spaces. Therefore, large MF buildings require special auditing and weatherization procedures. For example, replacing a central boiler in a 240-unit apartment in New York City takes a heavy construction or engineering plan, especially if the old boiler must come out of the basement in several pieces.

3.0 WAP Evaluations: Research Overview

Because WAP grew significantly between PY 2008 and PY 2010, researchers created two distinct evaluations for each program year, commonly referred to as the "Retrospective" and "ARRA Period" evaluations. Planning for the Retrospective evaluation began in spring 2005—years before the ARRA period. By the time the Retrospective evaluation was ready to field, the ARRA period had begun, and DOE decided to also evaluate WAP during this period. Evaluation activities began in spring of 2009. The evaluation concluded in early fall 2015 with the publication of all 37 evaluation reports.

The Retrospective evaluation concentrated on estimating program impacts (e.g., energy savings) and assessing program administration. To accomplish these tasks, researchers collected various data from up to 30,000 weatherized units (some variables have more units than others), such as:

- Building characteristics, including fuel type
- Occupant characteristics
- Weatherization measures
- Indoor environmental quality data
- Electricity and natural gas billing histories
- Demographic, health-related, energy-use behavior, and client satisfaction data

As well as:

- Detailed data on > 100 large MF buildings weatherized in New York City
- Program implementation survey data from 50+ grantees and ~900 subgrantees
- Demographic and career-related survey data from ~600 weatherization auditors, crew leaders, crew members
- Detailed in-field observations of ~450 weatherization audits, measure installation processes, and final inspections
- In-field assessments of 105 homes that saved much more/less energy than models predicted
- 14 in-depth case studies of high-performing and unique weatherization agencies
- Training experiences and career path expectations of over 800 individuals who received weatherization training from DOE

The ARRA period evaluation focused on the same topics but with slightly different data points, collecting information from up to 35,000 homes, including:

- Housing characteristics, including fuel type
- Weatherization measures
- Occupant characteristics
- Electricity and natural gas billing histories
- Demographic, energy-use behavior, and client satisfaction survey data from ~150 treatment households in Puerto Rico

As well as:

- Electricity-use data from 397 refrigerators
- Surveys and interviews about deferrals of weatherization services
- Cooling-system and whole-house electricity consumption before and after weatherization
- Program implementation survey data from 50+ grantees and ~900 subgrantees
- Post-ARRA demographic and career-related survey data from ~500 weatherization auditors, crew leaders, crew members
- 777 interviews to explore the impact of weatherization on energy-related decisions within client and employee social networks
- Medicaid records from 49 households to estimate the impacts of the Opportunity Council's Weatherization Plus Health Program that installed asthma-reduction measures in addition to typical weatherization measures

Rigorous methods ensured an appropriate and random sample of homes, occupants, and weatherization staff for most of the evaluation studies. National expert review panels convened to review evaluation plans and ensuing results. The U.S. Office of Management and Budget (OMB) reviewed and approved the research methods and information collection instruments.

The balance of the report draws upon the results of these data collection activities as they pertain specifically to the MF sector in order to offer insights to those working in this sector. It should be noted that data from PY 2008, or the Retrospective evaluation, are based on a sample of MF buildings in New York City. The sample for PY 2010 (ARRA) was larger and spread across more climate zones, so most tables and figures draw on this evaluation. However, the overhead program costs also increased during ARRA, making the weatherization work appear less cost-effective than usual, so PY 2008 data is generally included in discussions of cost-effectiveness.

3.1 WAP Demographics and Building Characteristics[3]

Renters in general and those who rent units in MF buildings in particular are, on average, at a lower socioeconomic status than those who live in owner-occupied, SF homes. A much higher percentage of households that rent their housing units are economically disadvantaged (39% are at 150% or below the poverty line versus 16% of households living in owner-occupied units) [40], minority (e.g., 20% of renters identify as African American versus the 9% that own their units)[40], and suffer food insecurity (15.5% of renters report suffering food insecurity versus 4.9% of owners)[41]. A majority of the 30 million U.S. citizens that live in housing with serious health and safety hazards live in MF buildings.

The demographics of WAP households tend to show similar patterns to the national trends, describing a vulnerable population residing in the MF housing receiving weatherization:

- In WAP PY 2010, the average income of a WAP occupant in a MF unit was approximately $10,000. In contrast, the average income of a WAP household living in a SF home and a MH was $15,700 and $13,400, respectively (Table A1).
- One third of MF households reported having an elderly individual, 16% a disabled individual, 25% having children (Table A2).
- The household sizes are small, under 2 individuals per household, compared to almost 2.5 individuals per SF home (Tables A1 and A2).
- 28% headed by a single parent and 27% single elderly person (Table A2).
- Higher proportion of Blacks and Hispanics live in WAP MF buildings than in general population and in other WAP home types (Table A1).

As referred to above, during WAP program years 2008 and 2010, WAP supported the weatherization of 98,000 and 331,000 units, with 18 and 21% of those units residing in MF buildings, respectively. In contrast, approximately 64% of units weatherized were SF, with the balance MH (Table A3). Compare this to the national building stock: there are over 100 million households in the U.S. Close to 40% of the housing units in the U.S. are renter-occupied. Twenty-three percent of the housing units in the U.S. are classified as MF, with 16% of the units being found in buildings having five or more units. Although MF housing tenants comprise an exceptionally vulnerable population, their homes remain underrepresented in the WAP building stock.

[3] See reports [35, 26].

Most units weatherized by WAP are found in the cold climate zone (Tables A5 and A6; see Figure A1 for a map of climate zones), though the number of units weatherized in hot climate zones increased during ARRA (Table A4). Over 70% of MF units weatherized by WAP in 2010 are located in just seven states: New York, Texas, California, Ohio, Wisconsin, Washington, and Illinois (Table A7). Most of the MF units weatherized in 2010 are found in buildings with more than 25 units (Table A8).

The MF building stock served by WAP is very diverse in size, age, and fuel types, all factors that can affect the energy savings and health impacts of weatherization:

- Average size of a weatherized MF unit was 842 square feet, with some variation by climate zone and size of building (Tables A9 and A10).
- Most MF weatherized units are found in buildings built after 1970 (69%), though 15% are found in buildings built before 1940 (Table below and Tables A9-10).
- Most heat with natural gas (56%), though a fair number in the very cold and cold climates heat with fuel oil (~12%) (Table and Table A11).
- About one third of the buildings are centrally heated, with the balance of units having their own heating systems (Tables A11 and A12).
- Over half of the buildings feature central air conditioning, though 25% do not have any AC systems (Table , A11 and A12).
- About two thirds of the buildings heat water with natural gas, with the balance heated by electricity (Table , A11 and A12).
- Electricity is somewhat more common for space and water heating in buildings with 10-15 units (Table A12).
- Weatherization approaches differ based on whether the buildings have central heating or individual unit heating and whether all the units in a building are weatherized or only individual units (Table A13).

Table 1. Characteristics of Housing Units in MF Served by WAP in PY 2010

Characteristic	Statistics for MF Units		
Year Built	Pre-1940 = 15%	1940-1969 = 16%	1970 or Later = 69%
Space Heating Fuel	Natural Gas = 56%	Electric = 35%	Delivered = 9%
Heating System	Central = 73%	Room = 23%	Other = 4%
Supplemental Heat	Electric = 13%	Other = 14%	
Air Conditioning	Central = 55%	Window/Wall = 20%	None = 25%
Water Heating Fuel	Natural Gas = 68%	Electric = 22%	Other = 10%

3.2 WAP Measures Installed[4]

There are two approaches to weatherizing MF buildings: the whole building can be weatherized or individual units, as well as combinations thereof (Table A13). With respect to the first approach, buildings with central heating units tend to focus on building wide systems whereas buildings where units have their own heating systems focus on weatherizing each unit in a building. WAP installs a wide range of measures in MF buildings:

- Two thirds of weatherized buildings receive some sort of air sealing measure– almost one third receive insulation and duct sealing (Tables A14 and A15).
- Weatherization work varies widely by climate zone (e.g., few centrally heated buildings in the moderate and hot climate zones received insulation whereas few individually heated units in the cold climate zones did), and size of building (e.g., centrally heated buildings with more than 25 units were much more unlikely to receive air sealing measures) (Tables A14 and A15).
- Weatherization included furnace replacements (33%), window installations (27%), and new refrigerators (23%) (Table A17).
- Many units also received smoke alarms (19%) and CO monitors (38%) (Table A18).
- The scope of weatherization measures installed in large MF buildings differs from those installed in SF homes (e.g., much fewer air sealing and insulation of all types) (Table A18).
- The majority of units in weatherized MF buildings received no or only one major measure, where major measures are defined to include: heating system repair and replacement, insulation, and air sealing (Tables A19 and A20). Lighting measures—installed in over 70% of buildings—is not considered a major measure (Table A17). As described in Section 4.0 (Figure A2), there is a positive correlation between the number of major measures installed and energy savings.

[4] Statistics in this section are drawn primarily from [1, 26, 35].

4.0 Impacts of Weatherization

The national evaluation of the WAP program revealed benefits to homeowners, local economies, and society at large. These benefits fall into three categories: energy savings; energy cost savings; and non-energy impacts (NEIs). Energy savings refer to reduced energy consumption resulting from increased energy efficiency. Energy cost savings capture both the savings on energy bills and the cost effectiveness of the weatherization investments. NEIs encompass health and household, environmental, and economic impacts.

The above variations in building characteristics, weatherization methods, and measure costs are factors used to help explain the energy savings, NEIs and cost savings results described below. The findings that follow represent averages for PY 2010 and occasionally 2008, and they are meant as a summary; more detailed and contextualized results can be found in the reports listed in the references at the end of this report.

The sections below outline the results of the WAP analysis with a focus on the benefits of weatherizing MF buildings relative to SF and MH. Figures and tables with detailed MF data generally use the PY 2010 (ARRA) numbers due to the larger and more climate-diverse sample for that evaluation relative to PY 2008.

4.1 Energy Savings[5]

The average unit in a MF building uses less energy than an entire SF or MH. Although the savings per unit are more modest, when multiplied across all the units in a building, the sum savings can be substantial. Tenants may not directly receive the cost savings benefits of energy reductions since utilities can be included in their rent–in this scenario, the monetary savings instead accrue to the property owner or an agency such as HUD.

Multiple factors affect the amount of energy savings in a home: fuel type for heating, climate zone, and measures installed, to name a few. Further details about the housing stock studied in this report can be found in Appendix A, Tables A1-7.

[5] See reports [3,4,5,6,23,24,26]

The graphs on the following pages present energy savings for MF units:

- Compared to SF and MH;
- According to the number of major energy efficiency measures installed;
- According to climate zone; and
- According to weatherization method.

The study defined "major energy efficiency measures" as "measures such as air sealing, attic insulation, heating equipment replacement, water heating equipment replacement, air conditioner replacement, and window replacement [that] are expected to have the greatest impact on the buildings and units in which they are installed." [26] The three weatherization methods discussed depend on two variables: (1) whether the building was weatherized as a whole or as individual units, and (2) whether the building had central heating or individual heating systems for individual units. Thus, the three weatherization approaches were: "1- building weatherization with building-level heating equipment; 2- building weatherization with unit-level heating equipment; and, 3- unit-level weatherization with unit-level heating equipment." [26]

The graphs employ two positive y-axes per x-axis: the upward y-axis displays net energy savings (savings observed in the treatment group minus savings observed in the comparison group), while the downward y-axis displays post-weatherization energy consumption. Thus, the two axes together add up to approximate the unit's energy consumption before weatherization. The percentages above each histogram bar represent the net savings as a percentage of the pre-weatherization usage. This presentation allows for easier comparison of the actual and relative energy savings simultaneously.

The specific numbers for therms and kilowatt-hours (kWh) saved can be found in Tables A21-34, as well as further categories by which to break down the data. In some cases, savings were only available for units where the main heating units were fueled by natural gas, and so main heating units fueled by electricity were omitted.

Figure 2 shows that while the amount of energy consumed and saved varied by housing type, the percent saved remained roughly equal across all types when averaged over the entire sample. See also Tables A21-23 for more detailed numbers on MF energy savings by fuel type.

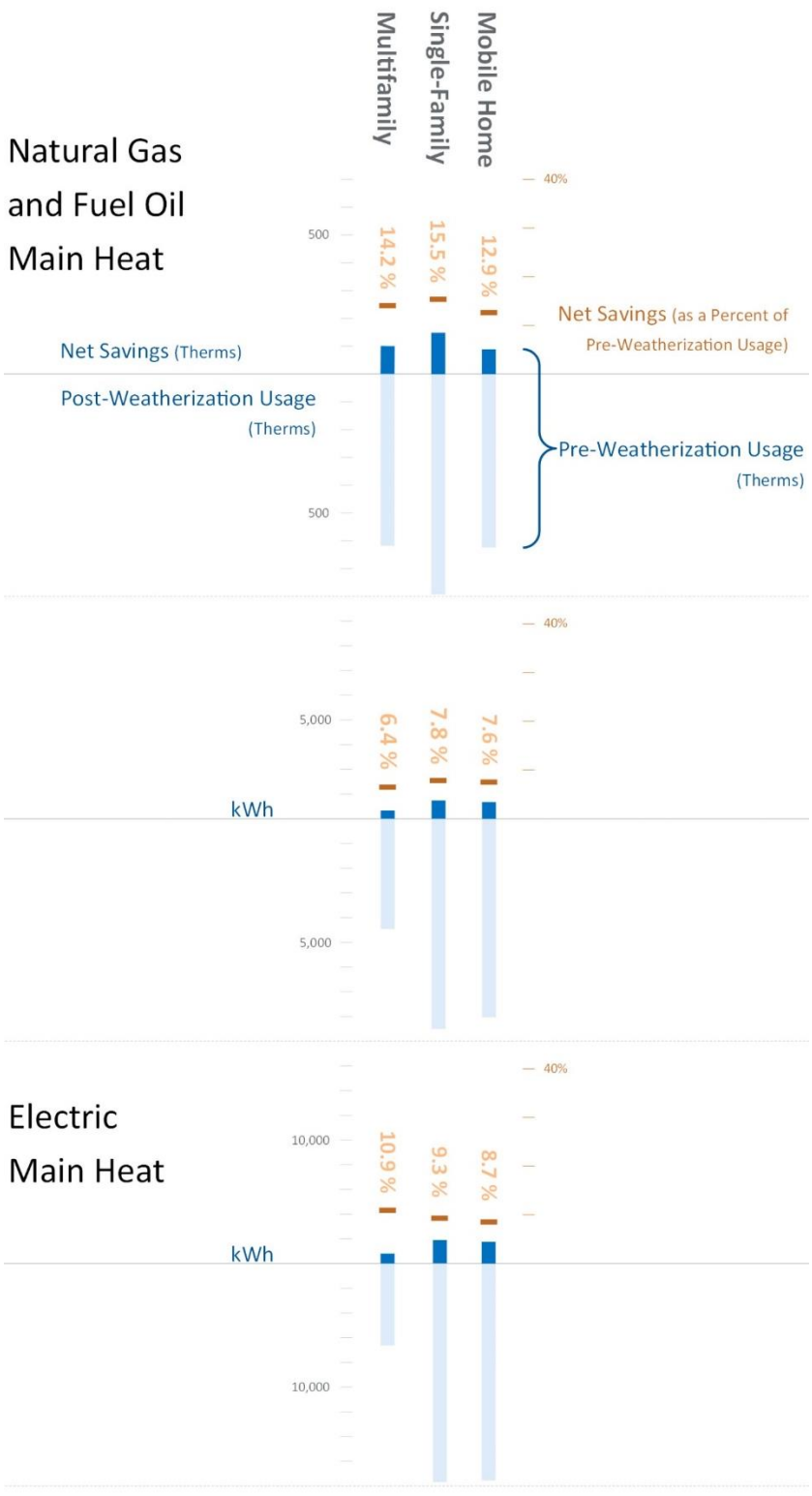


Figure 2. Average Energy Savings per Year for MF Units Compared with Single-Family and Mobile Homes (PY 2010)

Figure 3 below (and Table A29) reveals that energy savings generally increased with more major measures installed, which makes intuitive sense.

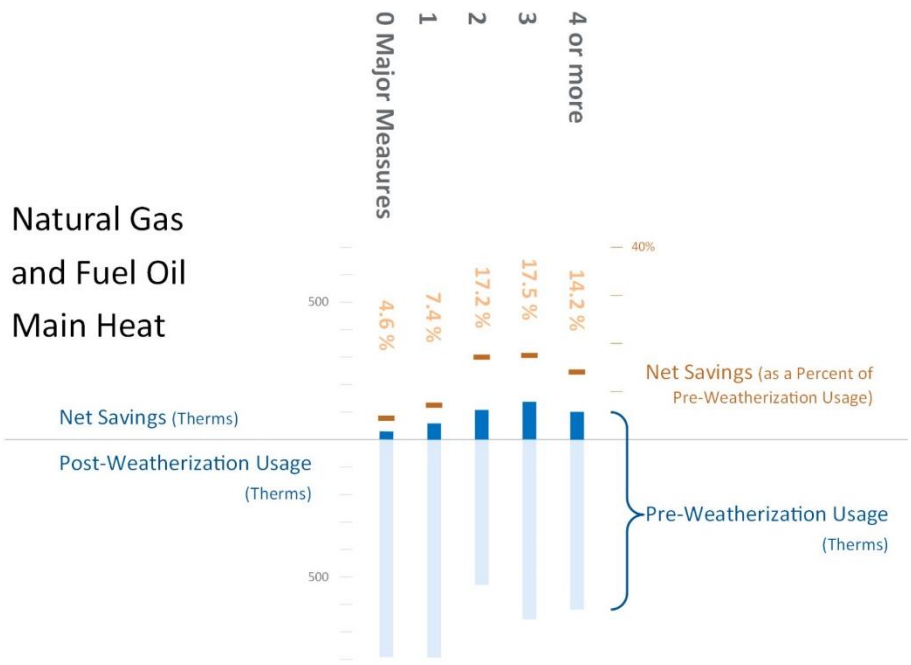


Figure 3. Energy Savings per Year by Number of Major Measures in MF Units

The results in Figure 4 may be less obvious: observed energy savings varied drastically by climate zone, with a peak in hot *and humid* areas but little to negative results in hot *and dry* regions. It should be noted that sample sizes for moderate, hot/humid, and hot/dry climate zones were significantly smaller than the cold and very cold regions. The hot/dry buildings also received 0.7 fewer major measures on average than their hot/humid counterparts, which may help explain the low savings observed. Overall, the main difference between buildings in cold and hot areas lies in the relative amount of heating and cooling they require; natural gas and fuel oil (used for heating) buildings tend to see greater savings in cold climates, while electric (used for air conditioning) buildings show better savings in hot zones. See Table A27 for detailed data.

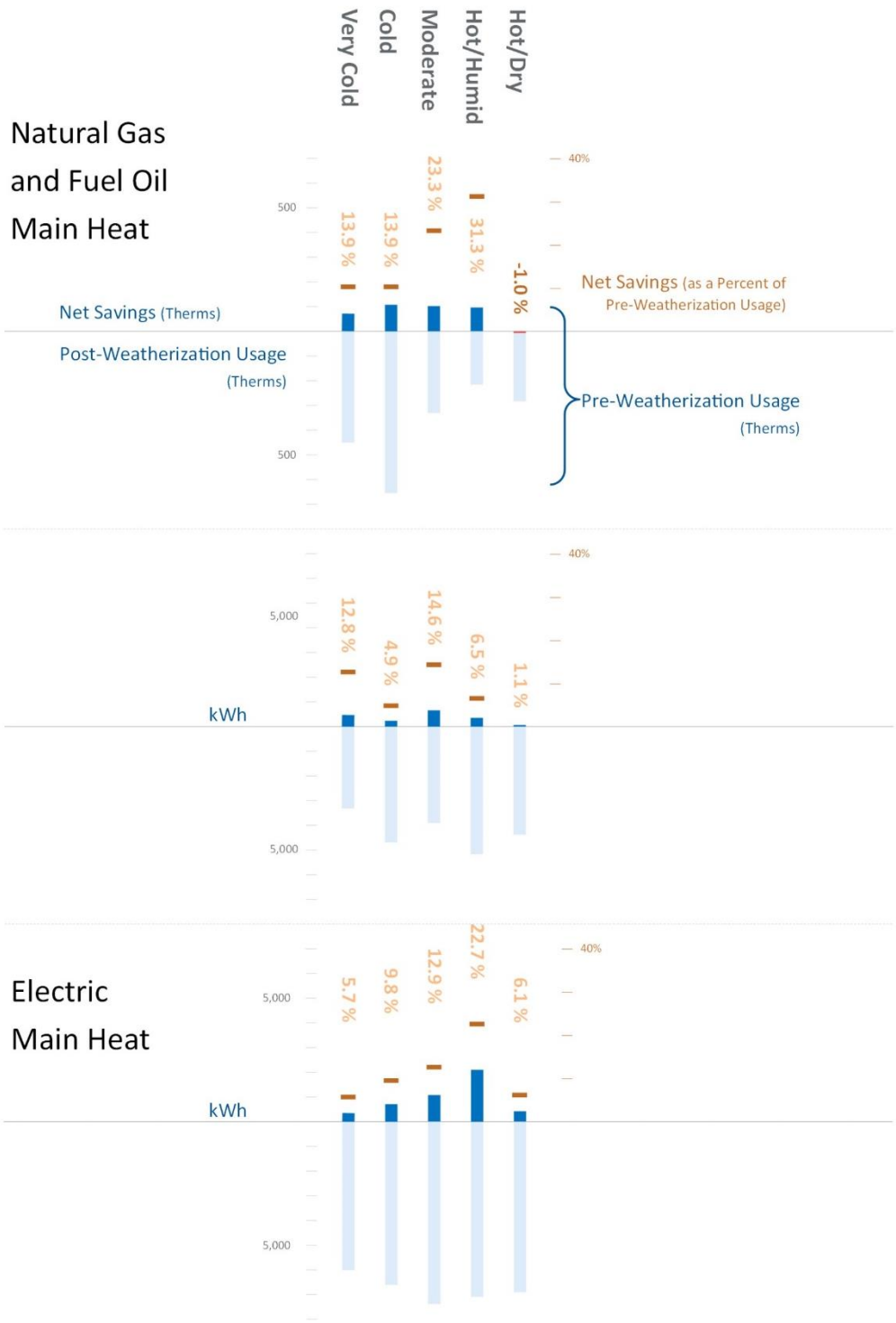


Figure 4. Energy Savings per Year by Climate Zone for MF Units

Lastly, Figure 5 represents three weatherization approaches: weatherization with building-level heating equipment; weatherization with unit-level heating equipment (or "mixed"); and unit-level weatherization with unit-level heating equipment. The graph indicates that building-level weatherization with unit-level heating was observed to work best in buildings mainly heated with natural gas and fuel oil, while unit-level weatherization and heating outstripped its counterparts in buildings mainly heated by electricity (See Tables A30-31).

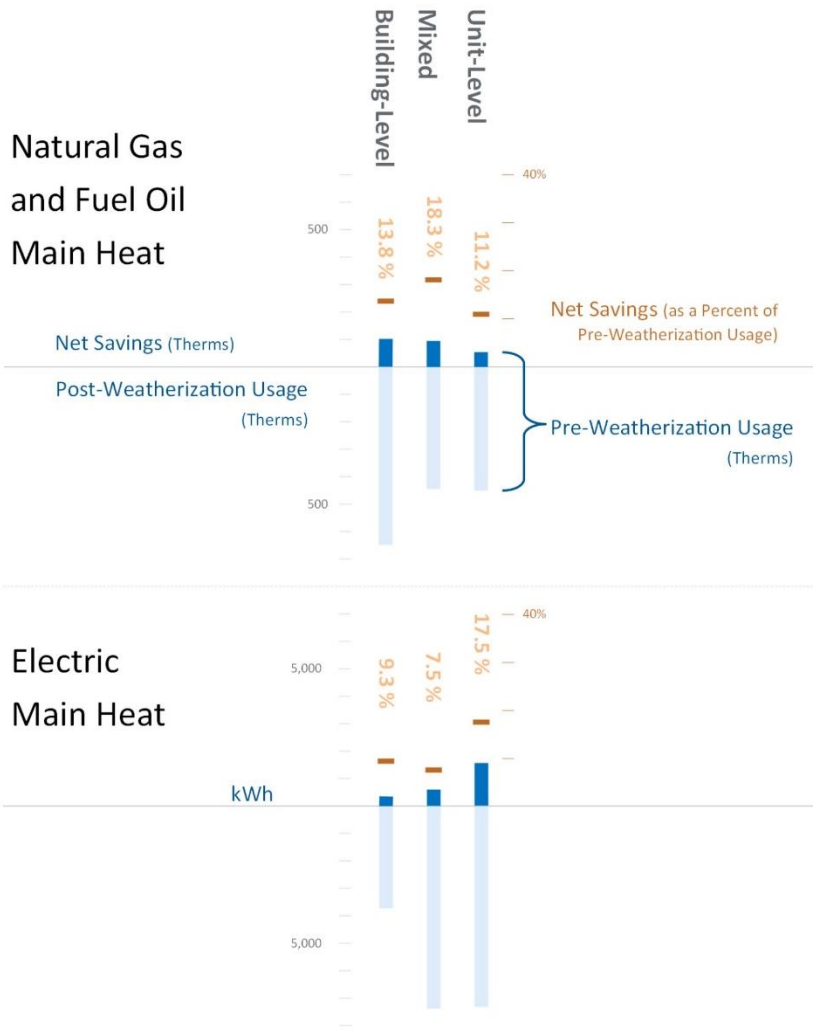


Figure 5. Energy Savings per Year by Weatherization Approach in MF Units

4.2 Non-Energy Impacts (NEIs)

As mentioned above, NEIs encompass health and household, environmental, and economic benefits. This section introduces NEIs and the quantification of these impacts.

Health and Household Benefits

Weatherization affects occupant health both directly through physical changes in the home and indirectly through lower energy bills that free up money for food or medicine, thereby reducing psycho-social stress attributable to financial hardship. This section attempts to capture how increases in health generally lead to increases in finances and vice versa.

In terms of direct effects, weatherization holds the potential to make homes less permeable to outdoor air pollutants and pests, less drafty, and more comfortable. These physical changes produce improvements in health outcomes. Measures commonly installed in SF and MH have been linked to such health benefits as:

- Reduced environmental asthma triggers (See Figure B5);
- Reduced temperature extremes that can cause thermal stress; and
- Fewer insect infestations.

Furthermore, a more comfortable and quieter home can lead to improvements in physical and mental health and improved rest and sleep.

Indirect effects on health come from the increased financial stability weatherization can bring. Households save money directly through improved energy efficiency (lower gas and electric bills) as well as water cost savings and reduced costs for utility disconnections and reconnections in some cases. Improved household financial situations allow households to spend more money on food and medicines, both having health benefits.

As health improves, it can also improve finances, creating a positive feedback loop of benefits for the household. For example, healthier occupants likely miss fewer days of work and spend less on healthcare, increasing household budgets. The financial uptick in turn can lead to even better health, as seen above, and the cycle of improvement continues.

Finally, combinations of improved health and budgets can have additional positive feedback effects, such as helping households avoid costly short-term, high-interest loans. It should be noted that comprehensive weatherization (i.e., air sealing, insulation, furnace repair and replacement) produces most of the health benefits, not special health and safety measures (e.g., smoke detectors, CO monitors). Figure 6 presents a pictorial summary of how weatherization can improve occupant health.

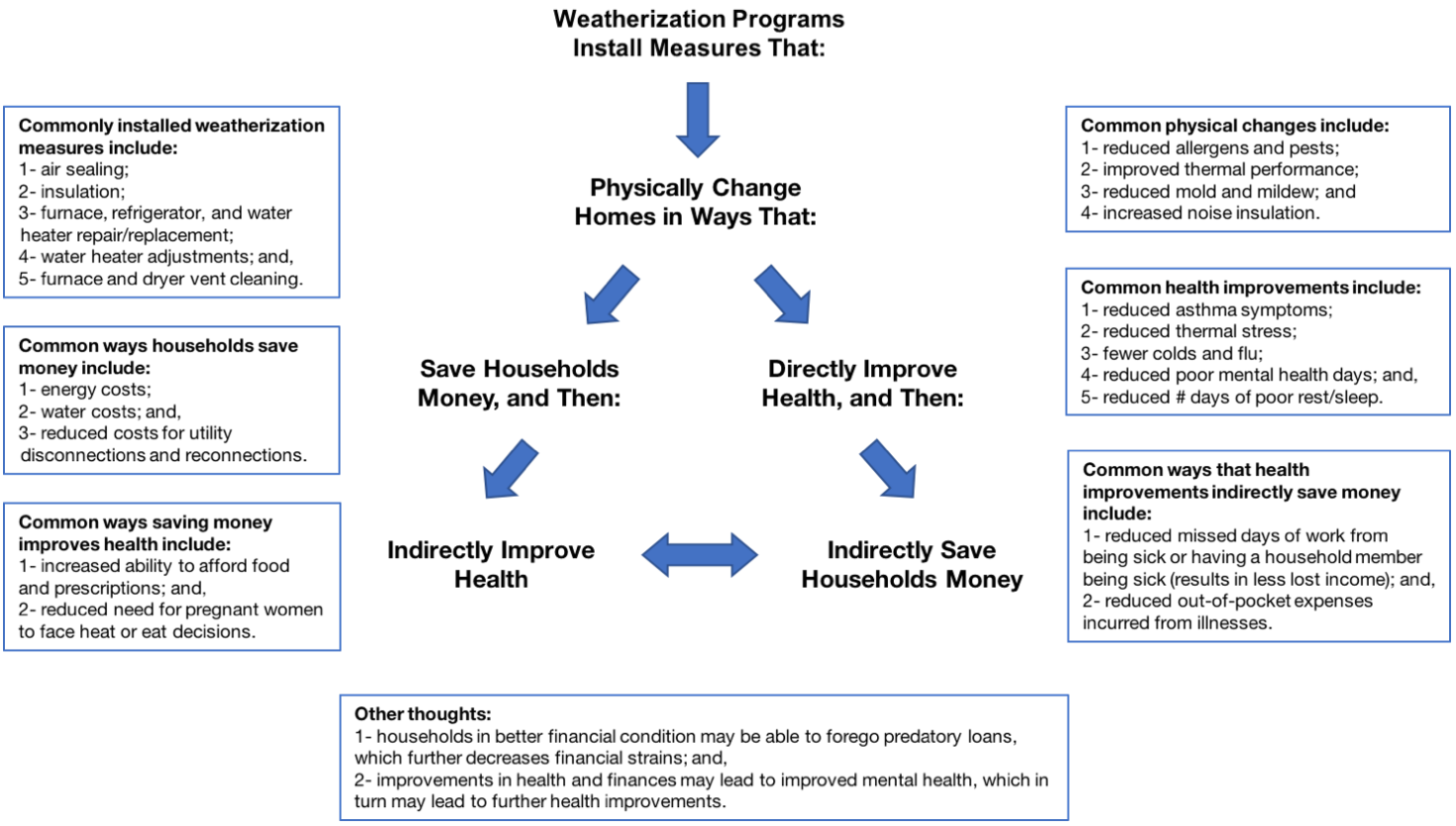


Figure 6. How Weatherization Can Yield Health Benefits

As a component of the WAP evaluations, a nationwide survey of randomly selected, SF and MH WAP households was conducted pre- and post-weatherization; the survey was also given to a comparison group in the same years. A large set of health and household benefits were found, including occupants reporting that:[6]

- "Home sometimes kept at unhealthy temperature" dropped from 18.0% to 9.2%
- "Home is infested by pests" dropped from 25.1% to 16.2%
- "Home has a CO monitor" increased from 44.7% to 77.1%
- "It is hard to pay energy bills" dropped from 74.6% to 58.5%
- "Household did not buy food to pay energy bills" dropped from 33.2% to 23.1%
- Asthma emergency department (ED) visits dropped from 15.8% to 4.3%
- Seeking medical attention from being too cold in home dropped from 3.2% to 1.5%

[6] Please refer to Tables A35-38 for additional survey findings and [20].

The benefits of twelve of these NEIs were monetized, as shown in Table 2. To produce these estimates, survey results were used to measure changes in health conditions, such as changes in asthma-related ED visits. Researchers also estimated benefits related to reducing fires and CO poisoning based on the frequencies of particular measures. Secondary databases and sources were used to estimate avoided costs (e.g., due to improved health from weatherization, the household avoided the cost of a physician's office visit). Value of lives saved were estimated for the reductions in thermal stress—for exposure to both extreme hot and cold indoor temperatures—and reduced incidences of home fires and CO poisoning. In the end, the average monetary benefits of weatherizing a SF or MH added up to just over $14,000, compared to an average weatherization job cost of just under $4,700 (See Table 9 below). Table A46 breaks these numbers out by societal and household benefits and with and without the value of life saved estimate.[7] The same methods were applied during a separate research project to a subset of these NEIs to estimate values for low-income energy efficiency programs as delivered by utility programs in the Commonwealth of Massachusetts. Using updated monetary estimates, the present value (PV) per SF home weatherized exceeds $25,000. [38]

Table 2. Estimated Monetary Benefits of Health and Household NEIs

Non-Energy Benefit	WAP PV (10 years)	MA PV (20 years)
Asthma	$2,009	$6,343
Thermal Stress-Cold	$3,911	$9,494
Thermal Stress-Heat	$870	$3,304
Food Assistance Reduction	$832	NA
Reduction Missed Days at Work	$201	$3,569
CO Poisoning	$154	$193
Improvement in Prescription Adherence	$1,929	NA
Reduction in Use of Short-Term Loans	$71	$90
Home Fires	$831	$2,134
Increased Productivity at Work Due to Improved Sleep	$1,813	NA
Increased Productivity at Home Due to Improved Sleep	$1,329	$721
Reduction in Low-Birth Weight Babies	$198	NA
Average Per Weatherized Home	**$14,148**	**$25,848**

[7] Government agencies have developed methods to monetize the value of lives saved, or deaths avoided, attributable to their policies and programs. In this research, the value of avoided deaths was estimated to be $7.5 million, the value used by the U.S. Environmental Protection Agency at the time.

The above evaluations did not include MF buildings; as a rigorous assessment of the health benefits attributable to weatherizing MF buildings does not yet exist. The researchers hypothesize that comprehensive MF weatherization can produce similar benefits; however, the *magnitude* of possible benefits remains a mystery. As noted previously, large MF buildings behave differently than SF and MH from a building science perspective, and they also receive different sets of measures.

Emissions Benefits

It is proven that weatherization reduces home energy consumption. Reduced energy consumption, in turn, reduces emissions in two ways: from burning fossil fuels on site (e.g., natural gas furnaces) and burning fossil fuels off-site to produce electricity. Reductions in energy consumption were translated into reductions in emissions for the two program years, for several home types (including MF), and for five pollutants, as summarized in Table 3. [13,25] The monetized benefits include public health benefits from reducing air pollution. As Table 5 indicates, weatherizing MF buildings contributes greatly to the overall emissions benefits attributable to WAP. The large reduction in SO_2 in PY 2008 resulted from burning less fuel oil to heat large MF buildings in New York City.

Table 3. Emissions Reductions Attributable to WAP for PY 2008 and PY 2010

	Thousands of Metric (CO_2)/Short Tons (lifetime of measures)					Monetized Benefit (PV millions 2013 dollars)					Total Monetized Benefit (millions $)
PY 2008	**CO_2**	**SO_2**	**NO_x**	**PM**	**VOC**	**CO_2**	**SO_2**	**NO_x**	**PM**	**VOC**	
SF	1633	2.2	1.3	0.08	.05	$62	$59	$11	$4	$0.4	**$136**
MH	302	0.4	0.2	0.02	.009	$12	$10	$2	$0.7	$0.05	**$25**
Small MF	132	0.2	0.1	.006	.004	$5	$3	$1	$0.3	$0.04	**$9**
Large MF	178	0.4	0.1	.005	.003	$7	$68	$5	$2	$0.1	**$82**
Total -- Aggregate	2246	3.3	1.8	0.1	0.07	$85	$139	$19	$8	$0.6	**$252**
PY 2010	**CO_2**	**SO_2**	**NO_x**	**PM**	**VOC**	**CO_2**	**SO_2**	**NO_x**	**PM**	**VOC**	
SF*	5583	7.9	4.4	0.3	0.2	$213	$194	$37	$15	$1.3	**$460**
MH	888	1.6	0.7	0.06	0.02	$34	$34	$4	$3	$0.1	**$75**
Large MF	912	1.0	0.7	0.03	0.03	$35	$58	$11	$4	$0.6	**$109**
Total -- Aggregate	7382	10.5	5.8	0.4	0.2	$282	$287	$52	$22	$2	**$645**

* SF category includes the small MF building category in PY 2010

Macroeconomic Benefits

Macroeconomic benefits were measured in terms of job creation/maintenance, income generation, and national economic output. WAP directly creates jobs by employing staff to implement the program and contractors to complete the construction. Weatherization material and equipment purchases at the local and state levels also likely have indirect

employment impacts at factories and stores. Moreover, households likely spend their energy cost savings on goods and services that may induce job creation.

To estimate the direct, indirect, and induced employment impacts, the retrospective evaluation team used a sophisticated macroeconomic modeling tool developed by Regional Economic Models, Inc. (REMI). The REMI model is a computable general equilibrium model, meaning that it simulates the multi-sector U.S. economy year-by-year over multiple decades. The model produces outputs in the form of changes in employment by sector, region, and year as well as changes in gross domestic product by region and year, reaching equilibrium of demand and supply for each modeled year.

The study team focused on estimating the macroeconomic benefits of WAP for PY 2008, including all leveraged funding spent in DOE units. The team apportioned WAP expenditures on energy efficiency measures to over 25 sectors of the U.S. economy, with the resulting impacts touching over 50 sectors. The findings suggest that:

- Directly and indirectly, WAP was responsible for a combined 8,435 jobs.
- WAP generated $476 million in incomes.
- WAP increased national economic output by $1.22 billion.
- The national economic multiplier is 2.93 (i.e., one dollar spent on weatherization generated another $2.93 in economic activity). [7]

4.3 Cost-Benefit Analysis

The average cost for measures installed by WAP in MF buildings is modest and varies by climate zone and building type:

- The average cost per unit weatherized was $3,111 (Tables A39-41).
- Average and median costs per unit weatherized vary considerably by climate zone (e.g., lower in the very cold climate zone and higher in the hot-humid climate zone), building size (e.g., highest in buildings with 10-15 units), and heating system type (e.g., highest for centrally heated buildings) (Tables A39-41).
- As one can imagine, costs increase as the number of major measures installed increases (e.g., $1,211 for no major measures to $5,719 with four major measures) (Tables A42 and A43).

Tables 4 and A42 present SIR estimates by home type and for the WAP program years 2008 and 2010. Overall, the SIRs are higher for SF homes than other housing types, though the highest SIR is for weatherizing large MF buildings in NYC in WAP for PY 2008. Table A44 presents overall WAP energy cost savings and average per unit energy cost savings by PY for these three housing types. The lower SIRs in PY 2010 were due in part to ramping up staff and overhead costs to keep up with the ARRA demands.

Table 4. Energy Cost Savings, Efficiency Measure Costs, and Cost-Effectiveness by Building and Fuel Type (2013 Dollars)

	PY 2008			PY 2010		
	PV Energy Cost Savings	Measure Costs	Savings to Investment Ratio	PV Energy Cost Savings	Measure Costs	Savings to Investment Ratio
SF*	$5,337	$3,096	1.72	$4,468	$3,990	1.12
MH	$3,053	$2,961	1.03	$2,957	$3,737	0.79
Small MF	$4,618	$2,878	1.60	--	--	--
Large MF**	$6,460	$3,336	1.82	$1,996	$2,976	0.67
All types	$4,890	$3,070	1.59	$3,681	$3,745	0.98

* SF category includes the small MF building category in PY 2010

**Large MF includes only buildings in NYC in PY 2008

Table 5 and A43 presents detailed results about the energy cost savings, measure costs, and SIRs for weatherized MF buildings that heat with natural gas, electricity, fuel oil, propane, and a few other fuels. The overall cost effectiveness is highest for buildings that heat with the two bulk fuels, fuel oil and propane. Note again that data in Table 5 comes from PY 2010, when overhead costs increased with growing programs.

Table 5. Projected PY 2013 WAP Energy Impacts for MF Housing Units 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	$1,607	$252	$1,859	$2,641	-$782	0.70
Electricity	-	$1,517	$1,517	$3,133	-$1,616	0.48
Fuel Oil	$5,107	$300	$5,407	$4,717	$690	1.15
Propane	$3,951	$146	$4,097	$3,246	$851	1.26
Other	$958	$193	$1,150	$1,335	-$185	0.86
All Clients	**$1,256**	**$740**	**$1,996**	**$2,976**	**-$980**	**0.67**

* SF category includes SMF in PY 2010

However, as noted previously, the actual cost savings extend beyond energy reduction. Once the set of monetized benefits of NEIs are included, the return on investment for the WAP program becomes clearer and more substantial; however, most states still do not consider these benefits when allocating funds for weatherization and determining the cost effectiveness of measures. Table 6 presents a big picture scorecard of the energy and non-energy benefits attributable to WAP for PYs 2008 and 2010, along with total costs. Energy cost savings and emissions benefits from MF are included in the top portion of the table, though as stated above, health benefits were not included for MF as they have not yet been monetized. Macroeconomic benefits are also not included. When the study's NEIs are included, the total benefits are 3 to 4 times program costs.

Table 6. Total Benefits and Costs for WAP PY 2008 and 2010

	Present Value Per Unit PY 2008	Present Value Program PY 2008	Present Value Per Unit PY 2010	Present Value Program PY 2010
Energy Cost Savings	$4,890*	$420,000,000	$3,681	$1,233,000,000
Accrued to Households	$3,814	$327,800,000	$2,872	$962,000,000
Accrued to Ratepayers	$1,075	$92,000,000	$809	$271,000,000
Environmental & Water Benefits	$3,118	$266,945,000	$2,130	$694,000,000
Emissions Tier 1	$2,932	$252,000,000	$1,944	$645,000,000
Water Savings Tier 3	$186	$14,945,000	$186	$49,000,000
Health & Household-related Benefits**	$14,148	$1,166,000,000	$14,148	$3,826,000,000
Tier 1	$7,823	$657,000,000	$7,823	$2,156,000,000
Tier 2	$2,154	$174,000,000	$2,154	$570,000,000
Tier 3	$4,171	$335,000,000	$4,171	$1,100,000,000
Total Benefits	$22,156	$1,852,945,000	$19,959	$5,753,000,000
Total Costs[1]	$4,695	$403,000,000	$6,812	$2,320,000,000
DOE	$2,295	$197,000,000	$5,926	$2,018,400,000
Leveraged Funds	$2,400	$206,000,000	$886	$301,600,000

* Excludes LMF outside of NYC

** Excludes LMF

5.0 Weatherization Implementation: Observations from the Field

In addition to conducting rigorous quantitative impact assessments, the WAP evaluations also conducted in-depth qualitative process evaluations. Two major studies that are summarized below entail case studies of a diverse set of high performing and notable local weatherization agencies and a field process evaluation of how weatherization is actually done on the ground. This section ends with a discussion of weatherization training needs vis-à-vis the MF sector.

5.1 Perceived Barriers

The national weatherization network has vocalized numerous barriers to weatherizing large MF buildings. Table A47 presents these barriers as well as the percentages of states and WAP agencies that reported perceiving each barrier as real. Generally, most agree that there are too few large MF buildings located within their territory to weatherize. Beyond this, the states and WAP agencies hold quite different perceptions, with the former perceiving many more barriers than the latter. The biggest barrier according to states is lack of qualified building auditors (55%), followed by few large MF buildings available (39%), and unclear owner contributions (34%). "Unclear owner contribution" refers to the fact that MF building owners are required by DOE to contribute to the weatherization, but the guidance provided by DOE can be vague. According to WAP agencies, the largest barrier was few large MF buildings available (42%) and uncooperative building owners (25%). The percentage of WAP agencies that weatherized large MF buildings in PY 2010 was below the percentage that were allowed to do so: 49% reported weatherizing privately owned large MF buildings, 63% public housing, and 44% HUD assisted properties. During PY 2010 these WAP agencies reported weatherizing on average 153, 72, and 122 units in privately owned, public housing, and HUD assisted large MF buildings, respectively. [1, 10]

Figures B6 and B7 suggest that–during PY 2010–the weatherization workforce was less well trained to do MF weatherization than the SF and MH stock. These findings are reinforced by results presented in Table A48, where states reported that 77% of the weatherization workforce is well trained with respect to the installation of measures in SF homes versus 40% for MF. WAP agencies reported even lower training levels for MF. Tables A49 and A50 suggests that there are numerous opportunities to improve MF weatherization training, including infiltration, insulation, and base loads.

5.2 Case Study: Exemplary Weatherization Agencies

Researchers visited over a dozen local agencies, talked with managers and crew, toured their facilities, observed representative and notable weatherization jobs, and visited homes and talked with clients to gather the findings summarized below. [19][8] The case studies documented the day-to-day operations of select WAP agencies and provided the opportunity for those involved to talk about weatherization outside of surveys and energy savings metrics. Going 'beyond the numbers', these case studies describe agency operations, philosophies, challenges faced and met, and prospects for the future. One main theme ran through the case studies: local weatherization agencies focus intently on their mission of helping low-income families through weatherization and other social services.

The material presented above and in the case studies themselves depicted a program that various agencies implemented in diverse ways at the local level. No one staffing model (e.g., all in-house crews vs. all contractor crews) worked best; agencies shaped themselves to their local contexts. Agencies also varied in the auditing tools they used (computer vs. general priority lists), the housing stock they served (SF, MH, or large MF), and the typical weatherization measures they installed (wall and ceiling insulation in cold climates like Colorado vs. rooftop solar water heaters in hot-humid climates like Puerto Rico).

This section will discuss commonalities among the weatherization agencies to show how successful programs flourish locally regardless of their distinct characteristics. As the case studies progressed, researchers' observations of successful programs organically aligned with the themes put forth by Peter Drucker in his seminal book, *Managing the Nonprofit Organization: Principles and Practices*. [39] Therefore, to provide structure and organization, key findings are grouped into Drucker's characteristics of nonprofit organizations that excel: mission, commitment, respect, quality, innovation, and resilience.

Mission – All agencies visited as part of the retrospective evaluation had a strong sense of mission. However, the philosophies underlying those missions vary. For example, the Lewiston, Idaho agency's mission, stenciled on its trucks, emphasizes a sense of community. Central Vermont Community Action Council (CVCAC) bills itself as a promoter of "weatherization, efficiency and innovation," in that order. Regardless of the mission statement or each agency's understanding of its larger impact, the work of weatherization infuses every day's shared effort.

[8] Appendix C details two case studies from New York City

Commitment – Weatherization staff demonstrated deep commitment to their jobs, and the agencies in turn supported and stood by their staff members. A substantial majority of the core weatherization staff observed had been at their jobs for decades. Agencies could provide only relatively low wages to their staffs, yet they worked hard to provide what benefits they could, and a collegial and comfortable working environment characterized the offices.

Staff members showed a deep love and commitment to their communities as well. Individuals repeatedly expressed concerns about community economic development, job training, and community stability during interviews. In 2001 in Minot, South Dakota, weatherization workers persevered during a historic flood to respond to emergency community needs while maintaining regular programming, even as many staff members had the added stress of flooded homes of their own. Staff at multiple sites, including the Social Development Corporation (SDC), Northern Manhattan Improvement Corporation (NMIC), Housing Resources of Western Colorado, and St. John's Housing Partnership (SJHP) regularly volunteer their time to causes and activities that range far beyond day-to-day weatherization. Staff also often continue helping clients in their off hours. Personal commitment was found to be a defining characteristic of the weatherization network.

Weatherization agencies also demonstrated their commitment to communities on a systemic level by offering services beyond low-income weatherization, such as training local contractors to perform home retrofitting work beyond the immediate low-income weatherization. Agencies also employed diverse individuals, such as one program that trained "at-risk" youth as weatherization contractors; in some cases, people discovered entirely new career paths.

Respect – The organizational cultures witnessed were infused with respect for the clients served by the weatherization agencies. Weatherization personnel are acutely cognizant that there are many paths into poverty and that there are many barriers to rising out of poverty. Many of the homes they work with are in poor physical condition, and many households struggle to survive from day-to-day. The case study team, as well as social scientists employed through the Field Process Study, observed weatherization staff interactions with clients in hundreds of households. Clients and household members were uniformly treated with respect. The crews were respectful of household property, as well, cleaning up after the completion of the work. The hundreds of grateful letters sent to agencies by clients attest to the respectful treatment given them.

It was also clear that agencies respect their staff; this can be seen in how staff is empowered in various ways; auditors are empowered to develop weatherization job plans that will best meet the needs of households. They also deal with challenging home construction, and work both within budget constraints and with the opportunities afforded by leveraged funding. In

most cases, the crew chiefs are empowered to revise job plans in the field when complicated conditions in the homes are revealed. The crew members, too, are trusted to do their work and empowered to make appropriate decisions. New crewmembers receive active management and mentoring, but veteran crews and crewmembers, upon entering a home on the first day of the job, quickly fan out through the house to work on their assignments without having to be micro-managed.

Quality – The weatherization agencies' sense of their mission, their commitment to their work and staff, and the mutual respect given their employers combine to facilitate a culture of high-quality work. A great deal of pride in the quality of agency employees' work among the long-term weatherization auditors, crew chiefs, and crew members was witnessed.

WAP policy requires agencies to inspect all homes following weatherization and for states to inspect a sample of weatherized homes. It was found that agencies are careful to assign auditing (pre-weatherization) and inspection (post-weatherization) tasks to different individuals in order to avoid conflict of interest issues.

A plethora of training opportunities, mentoring, and on-the-job training are available to support high quality work. We visited three organizations with their own state-of-the-art weatherization training facilities: Opportunity Council in Bellingham, WA; Corporation for Ohio Appalachian Development (COAD); and Association for Energy Affordability (AEA) in NYC. Each was well-designed, well maintained, and in high demand.

Innovation – Because they are constantly dealing with unforeseen situations as they enter a wide variety of homes in a wide variety of conditions, agencies need to be both innovative and creative, technically and organizationally, to deal with these situations. Over the longer term, several agencies have developed innovative approaches to and techniques for weatherizing homes. For example, a type of perimeter insulation for MH bellies, the "burrito", was developed by Housing Resources of Western Colorado. Great pride is taken in innovations related to outfitting and packing-up the trucks the agencies take to job sites. St. Johns Housing Partnership is experimenting with new air-conditioning technology, and AEA has launched a distance-learning program. These programs highlight the energy and creativity that many agencies are bringing to the field at large and to their jobs in particular.

Organizational innovation and creativity are also brought to bear in "braiding" or combining leveraged funds to meet client needs. Examples include COAD's ambitious plan to weatherize the entire town of Murray City, Ohio, and several local weatherization agencies that collaborated with shareholders to weatherize the seven building, twenty-two story, 2702 unit Lindsay Park housing development in New York City. Agencies also synthesize program services and cross-program referrals. Some, such as the Opportunity Council, are experimenting with fee-for-service programs.

Resilience – The agencies we visited exhibit the characteristic described by Drucker as resilient. That is, they find ways to survive year after year despite constrained and uncertain budgets, uncertainty about when funds will be available for expenditure, and often frustrating, confusing, and duplicative regulatory requirements. Many agencies were founded during the Johnson Administration, during the War on Poverty, and have been operating weatherization programs since the late 1970s. They have survived because they have built strong relationships with their key supporters – state weatherization offices, other state offices, utility companies, other community organizations, and MF building owners and because their management practices have adapted to fit changing circumstances.

The ARRA period's relatively rapid ramping-up and ramping-down periods tested the weatherization agencies. The case study team visited several agencies during the ARRA period's ramp-up and ramp-down stages. During the ramp-up, agency managers were under an enormous amount of stress to grow their staffs and meet production numbers. An element of the ARRA legislation, the Davis-Bacon pay-scale requirements, at first delayed production and then produced numerous reporting difficulties. However, the agencies visited persevered, largely without complaints, despite difficulties and the increased oversight implemented under ARRA. As ARRA approached its end, many agencies needed to shrink, not just to pre-ARRA levels, but to even lower levels of staffing because of anticipated cuts in federal weatherization funding. In response, agencies were forced to lay off staff and crew members; in fact, many of the individuals interviewed during the case-study visits no longer work at their agencies.

5.3 Field Process Study: Quality of Energy Audits, Measure Installations, and Inspections

The retrospective evaluation supported a comprehensive "Field Process Study" of weatherization services delivery. [2] In addition to identifying work subcategories and actions encompassed by each, weatherization technical experts and social scientists were sent into the field to observe audits, measure installation, and final inspections. On-site observations of 155 audits, 159 measure-installation periods, and 128 final inspections were conducted at 19 WAP agencies across the country. The experts were trained to observe work in the field, not to interfere or to provide their own advice. The weatherization technical experts documented when specific work subcategory actions were applicable and if applicable, whether they were carried out.

Table 7 summarizes findings of the Field Process Study. Overall, the technical quality of the work observed was competent. Auditors, weatherization crews, and inspectors were getting the job done. Auditors and inspectors could make better use of some diagnostics. Crews install measures well but frequently miss opportunities for additional air sealing.

Table 7. Summary of Findings from the Field Process Study

	Audits	Installation	Final Inspections
Technical Quality	Audits are comprehensive; blower tests done regularly; work orders are generally well done	Most installation work observed was high quality (e.g., insulation, ventilation, doors, windows, air sealing)	Final inspections are comprehensive, generally based on visual inspection; blower door test-outs are done regularly
	Use of additional diagnostics could be improved	Opportunities for additional air sealing frequently missed	Use of additional diagnostics could be improved
Professionalism	Auditors treat household members with respect	Crews treat household members with respect, protect household belongings, and clean up after themselves	Auditors treat household members with respect
Client Education	Auditors explain the auditing/weatherization processes well	Crews explain their work well	Inspectors explain their responsibilities well
	Auditors do not often engage household members in discussion about energy, bills, home conditions	Crews often do not engage household members about why certain measures are being installed	Inspectors often do not engage household members in discussions about energy use, health & safety issues, expected energy savings and energy cost savings

The field process evaluation team gave high marks for professionalism to auditors, crew, and inspectors they observed in the field. Staff members generally gave the appearance of being dedicated to their work and taking pride in it. Crews seemed to work well together and collectively solved problems encountered in homes.

On the other hand, the assessment found that auditors, crews and inspectors could engage households in more discussions about energy use, the performance of the home, utility bills, and the expected benefits of weatherization. However, client education was not a DOE reimbursable expense/measure, so agencies did not have a strong incentive to invest personnel time in this activity. Also, in discussions with agencies held during the case study visits, weatherization staff tended to shy away from giving energy savings and energy cost savings predictions to households because they can vary so much from home to home due to factors outside of the control of the weatherization agency.

5.4 Additional Observations

This section presents findings from other components of the WAP evaluations that can provide valuable insights into the improvement, effectiveness and expansion of affordable MF building weatherization. These are the topics addressed: client satisfaction; explanation for low and high energy savings; social network effects; deferral of weatherization; radon; take back effects; and refrigerators.

Client Satisfaction – Participants in the national occupant survey were surveyed a short time after their homes were weatherized. The survey results indicate that 94% of the clients were overall very satisfied or satisfied with the weatherization program. Well over 90% of respondents were very satisfied or satisfied with the work performed in the home and the final conditions left inside and outside of the home by the weatherization crews. Satisfaction was less (83%) for the length of time between the client's request to have their homes weatherized and when the work was done. [9]

Low & High Energy Savers – A special study was conducted to better understand why some homes appear to save less or more energy than expected given measures installed. Factors that influence unanticipated levels of energy savings include: changes in the number of occupants in a home (e.g., temporary addition of children); changes in the use of supplemental heating (i.e., reduction in use post-weatherization which results in increases in main heating fuel consumption but not necessarily increases in overall energy consumption); and changes in thermostat settings, in this case data showing that households lower thermostat settings post-weatherization in the winter. It was also found that record keeping about the extent of measures installed (e.g., amounts of insulation) acted to misidentify homes as low or high savers (e.g., less than average amounts of insulation were added because of pre-existing levels of insulation), and fixing broken heating systems led to 'low' energy savings. Quality of work was a minor contributor to 'low' energy savings. [17]

Social Network Effects – A special WAP evaluation study explored whether recipients of weatherization share their experience with their social networks and if so, what is communicated. Four key findings were revealed: (1) weatherization experiences are indeed communicated through social networks; (2) communications do influence action and behaviors as measured by counts of reported contacts with professional weatherization providers, completing "Do-It-Yourself" (DIY) home projects, and reported changes in energy conserving behavior; (3) WAP recipients can be trained to extract targeted information that might have otherwise been unattainable; and (4) opportunities exist to maximize the impact of social networks (i.e., provide individualized and transformative education and awareness for recipient understanding and adoption of energy and non-energy related behavior based

on underlying motivating factors and existing values). These findings suggest that weatherization does have a network effect and that this effect could be amplified by working closer with weatherization recipients. [30]

Deferral Issues – Weatherization can be deferred for several reasons. For example, weatherization will not save energy if the physical condition of homes is too deteriorated (e.g., roofs in need of major repair) and repair costs exceed program resources. Sometimes the physical condition inside a home may pose a danger to weatherization staff. Homes can be placed back in the weatherization queue once these types of problems are rectified. Unfortunately, it is quite difficult for low-income home owners to find the financial resources to rectify these problems. It can also be difficult for low-income renters to convince property owners to make these investments as well. Deferrals may be less frequent in the MF sector, since many buildings are subject to periodic health and safety inspections. Nevertheless, a challenge for the weatherization community is to blend weatherization funds with housing rehab and other funds to allow the programs to fix homes prior to weatherization. [31]

Radon – The WAP evaluation conducted an extensive Indoor Environmental Quality (IEQ) Study that involved over 500 homes across the country. [15] The study assessed levels of CO, radon, formaldehyde, and temperature pre- and post-weatherization, with a control group. With respect to radon, study technicians deployed 7-day, activated-charcoal canisters to measure radon levels in foundation spaces and first-floor living spaces before and after weatherization. These tests were conducted during the heating season under closed-home conditions. These short-term tests are thus not reflective of expected annual average radon levels in weatherization homes. Key findings from this radon study include:

- The study data indicate that the average SF home in the program has a heating-season indoor radon level of 1.9 ± 0.1 pCi/L.[9]
- Pre-weatherization radon levels are correlated with pre-weatherization air tightness: tighter homes tend to have higher radon levels.
- The study confirms that elevated radon is relatively rare in MH across the country and in site-built homes in counties identified by the U.S. Environmental Protection Agency (EPA) as having low radon potential.
- The data suggest that weatherization results in a slight increase in indoor radon levels. Nationally, the study data suggest an average increase of 0.4 ±0.2 pCi/L. [10]

[9] It should be noted that all homes that tested over the EPA threshold level of 4.0 pCi/L received radon remediation if the households agreed to have their homes remediated.

[9] While this study was able to statistically discern an average change in radon levels post-weatherization, it is not possible to determine with certainty with respect to any specific home baseline radon levels the impact of weatherization on radon levels due to many sources of uncertainty, including seasonality, weather conditions, and measurement variability.

- The impact of weatherization on radon appears to be generally proportional to pre-weatherization levels: homes with low pre-existing radon levels—which constitute the majority of program homes—experience only a slight increase in radon levels on average, while homes with pre-existing elevated radon experience a larger average increase following weatherization. On average, the radon impact is thus largest among site-built homes in EPA high-radon potential counties, and lowest among MH and homes in low-radon potential counties.
- Changes in measured air-leakage rates due to air-sealing efforts—which are intended to reduce air infiltration and yield energy savings—were found to be statistically correlated with changes in radon levels in study homes.
- The study provides some evidence that the installation of continuous mechanical ventilation reduces radon levels in homes.

A follow-up study explored the impacts that ventilation might have on indoor radon levels [16]. Specifically, the study sought to assess the impact of exhaust-only ventilation on indoor radon and humidity in 18 SF homes in Colorado, Iowa, Minnesota and Ohio that were part of the national study and had been shown to have moderately elevated radon levels. For the study, exhaust-only ventilation that was compliant with the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 62.2-2010, "Ventilation, and Acceptable Indoor Air Quality in Low-Rise Residential Buildings," was installed in each home to provide continuous background ventilation. The impact of the ventilation on radon and humidity was assessed with an experimental protocol that involved using a timer in each home to disable the installed ventilation on alternate weeks, thus allowing an examination of the difference in radon and humidity levels with and without the ventilation operating. Radon levels were monitored continuously on the lowest occupied level of the home, and humidity was tracked at the main thermostat. Key results are as follows:

- Radon levels declined or remained about the same for all homes in the study when the ventilation was operated. On average, the installed ventilation reduced radon levels by 12 ±7%.
- No homes experienced any practically-significant increase in radon with operation of the ventilation—though statistical uncertainty for individual sites does not preclude that possibility. This suggests that in most cases, the dilution effect of exhaust-only ventilation outweighs any tendency to increase the radon entry rate by depressurizing foundation spaces.
- Six homes showed a larger and more regular decline in radon with operation of the ventilation than the other sites. These included all three sites with ventilation in a basement, as well as the single site with slab-on-grade construction.
- Sites with higher ventilation flow rates relative to their estimated seasonal natural ventilation rate also tended to show a larger impact from the ventilation.

Takeback Effect – A frequent criticism of energy efficiency programs is that gains made in improving energy efficiency have the potential to be partially or largely offset by corresponding increases in energy consumption. In other words, energy consumption could rebound towards the pre-retrofit levels of energy consumption. This is also referred to as the "take-back" effect.

The retrospective evaluation studied this issue through the IEQ study, mentioned above. As part of this study, indoor temperature data for the study homes were obtained from data loggers that were hung from the central thermostat for about one month preceding and following weatherization during closed-home conditions. Indoor temperature was also measured in a set of control homes located in the same local weatherization agency jurisdictions who agreed to have their weatherization delayed for the duration of the study. The temperature data for homes monitored during the heating season showed that:

- Wintertime indoor temperatures in program homes average 70.3 ± 0.5°F, but range from less than 60°F to more than 80°F.
- The temperature increased post-weatherization in the weatherized homes by 0.14°F and decreased in the comparison homes by 0.13°F, resulting in an estimated increase of 0.27°F.

Thus, for this sample of homes and the time period encompassed by the data collection, one can conclude that there was essentially no rebound effect related to home heating. This means that almost all of the energy cost savings derivable from weatherization were available to these households to spend on non-energy related needs. These findings are consistent with those from previous research.

The aforementioned national occupant survey contained numerous questions about household energy use behaviors. Descriptive statistics developed from these questions indicate that households did not change their energy use behaviors post-weatherization, either to save more energy or to take back energy cost savings. [34] The above mentioned low and high energy savers study also explored whether take back effects underlie low energy saving. As mentioned above, this was not the case. In fact, households reported keeping their thermostats set lower because their homes were more energy efficient. [17]

Refrigerators – Data were collected on the operation and energy use of refrigerators as part of the just mentioned IEQ study. Several interesting findings came out of this study. Only 27% of the primary refrigerators are located in kitchens and 34% are not located in air conditioned spaces. Only 23% of the refrigerators had an energy-saver switch and of these, only 48% of the switches were observed to be in the on position. The preponderance of the refrigerators' inside temperatures was below the recommended 42°F, though this threshold

was exceeded the entire metering time for three refrigerators. The average annualized electricity consumption for a refrigerator in the sample was 756 kWh/year. The median was 651 kWh/year. The variation in consumption has many possible explanations, including: refrigerator capacity, age, indoor temperatures, location in unconditioned spaces, number of individuals in the household (e.g., influencing the number of door openings), number of operating options, and simple disrepair. These results suggest that beyond replacing energy inefficient refrigerators, much can be done to reduce refrigerator energy use, such as locating them in conditioned spaces and ensuring that energy savings features are in use. [32]

6.0 Concluding Thoughts

Many aspects of the WAP evaluation directly addressed the MF sector. Among the important take home points are these:

- The WAP population living in MF buildings exhibits high levels of vulnerability in the areas of socio-economic status, psycho-social stress, and physical health.
- The MF building space is quite diverse in structure, size, age, fuel type, and heating system location (i.e., central versus in-unit); subsequently, approaches to weatherizing MF are quite diverse as well.
- Geographic location of buildings (e.g., climate zones) greatly impacts approaches to MF weatherization.
- Energy savings and energy cost savings in MF buildings have similar energy savings potential as SF homes.
- Comprehensive weatherization of MF buildings reduces emissions and can have significant macro-economic benefits.
- One can strongly argue that weatherizing MF buildings can also produce significant health benefits.
- Adverse IEQ impacts of weatherization are possible, especially with respect to radon.
- Weatherization requires an institutional infrastructure, composed of well-trained local weatherization organizations that are capable of blending weatherization and other resources to best serve their clients; and
- This infrastructure faces special challenges when addressing MF weatherization, which include training and outreach with building operators and tenants, and negotiating with building owners.

In summary, research in the SF and MH sectors strongly suggests lives are saved and significant health and household-related benefits are realized when dwelling quality is improved through weatherization. Weatherization has the potential to serve as a mitigation, adaptation, and preparedness strategy for extreme weather events, which are projected to increase in magnitude and duration because of climate change. This area of research is important because findings will support evidence-based policy and practice for programs seeking to create parity for vulnerable populations (e.g., communities of color, households of low-socioeconomic status) residing in the affordable MF housing stock that is more likely to be adversely impacted by energy affordability issues, climate change and poor IEQ.

Acknowledgements

The main authors of this paper conducted the research presented herein while at Oak Ridge National Laboratory (ORNL) with funding from the U.S. Department of Energy. Many of the tables, figures and reports are provided courtesy of ORNL. APPRISE, Inc., Seventhwave (formerly known as the Energy Center of Wisconsin) and numerous others who are listed as co-authors or acknowledged in the individual reports also contributed to this research. Many thanks are also due to the WAP grantees and subgrantees that provided the evaluations with key survey, weatherization and other data.

References

Retrospective Evaluation Reports

[1] Bensch, I., Keene, A., Cowan, C., and Koski, K. 2014. National Weatherization Assistance Program Characterization: Describing the Pre-ARRA Program. ORNL/TM-2013/188, Oak Ridge National Laboratory, Oak Ridge, Tennessee, April.

[2] Berger, J., Lenahan, T., and Carroll, D. 2014. National Weatherization Assistance Program Process Field Study: Findings from Observations and Interviews at 19 Local Agencies Across the Country. ORNL/TM- 2014/304, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[3] Blasnik, M., Dalhoff, G., Carroll, D., and Ucar, F. 2014a. National Weatherization Assistance Program Impact Evaluation – Energy Impacts for Mobile Homes. ORNL/TM-2014/84, Oak Ridge National Laboratory, Oak Ridge, Tennessee, November.

[4] Blasnik, M., Dalhoff, G., Carroll, D., and Ucar, F. 2014b. National Weatherization Assistance Program Impact Evaluation: Energy Impacts for Small Multifamily Buildings. ORNL/TM-2014/325, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[5] Blasnik, M., Dalhoff, G., Carroll, D., and Ucar, F. 2014c. National Weatherization Assistance Program Impact Evaluation: Energy Impacts for Large Multifamily Buildings. ORNL/TM-2014/332, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[6] Blasnik, M., Dalhoff, G., Pigg, S., Mendyk, A., Carroll, D., and Ucar, F. 2014d. National Weatherization Assistance Program Impact Evaluation: Energy Impacts for Single Family Homes. ORNL/TM-2015/13, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[7] Burton, M. et al. 2014. Macro-economic Impacts of the Weatherization Assistance Program for PY 2008. ORNL/TM-2014/98, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[8] Carroll, D., Berger, J., Miller, C., and Driscoll, C. 2014a. National Weatherization Assistance Program Impact Evaluation - Baseline Occupant Survey: Assessment of Client Status and Needs. ORNL/TM- 2015/22, Oak Ridge National Laboratory, Oak Ridge, Tennessee, October.

[9] Carroll, D., Berger, J., Miller, C., and Driscoll, C. 2014b. National Weatherization Assistance Program Impact Evaluation - Client Satisfaction Survey: WAP Service Delivery from the Client's Perspective. ORNL/TM-2014/335, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[10] Carroll, D., Berger, J., Miller, C., and Johnson, DB. 2014c. National Weatherization [11] Assistance Program Impact Evaluation: Weatherization Staff Survey. ORNL/TM-2014/323, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[12] Carroll, D., Kim, C., and Driscoll, C. 2014d. National Weatherization Assistance Program Impact Evaluation: Eligible Population Report. ORNL/TM-2014/312, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[13] Carroll, D. et al. 2014e. Environmental Emissions Non-energy Benefits: Working Paper. ORNL/TM- 2015/126, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[14] Hawkins, B., Tonn, B., and Bensch, I. 2014. Findings from Survey Administered to Trainees of Weatherization Training Centers. ORNL/TM-2014/306, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[15] Pigg, S., Cautley, D., Francisco, P. with Hawkins, B., and Brennan, T. 2014a. Weatherization and Indoor Air Quality: Measured Impacts in Single Family Homes Under the Weatherization Assistance Program. ORNL/TM-2014/170, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[16] Pigg, S. 2014b. National Weatherization Assistance Program Impact Evaluation: Impact of Exhaust-Only Ventilation on Radon and Indoor Air Quality – A Field Investigation. ORNL/TM-2014/367, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[17] Pigg, S. 2014c. National Weatherization Assistance Program Impact Evaluation: A Field Investigation of Apparent Low and High Savers. ORNL/TM-2014/308, Oak Ridge National Laboratory, Oak Ridge, Tennessee, October.

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

[19] Tonn, B., Rose, E., and Hawkins, B. 2014a. Weatherization Beyond the Numbers: Case Studies of Fifteen High-Performing Weatherization Agencies – Conducted May 2011 Through July 2012. ORNL/TM- 2014/317, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[20] Tonn, B., Rose, E., Hawkins, B., and Conlon, B. 2014b. Health and Household-Related Benefits Attributable to the Weatherization Assistance Program. ORNL/TM-2014/345, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[21] Tonn, B., Carroll, D., Pigg, S., Blasnik, M., Dalhoff, G., Berger, J., Rose, E., Hawkins, B., Eisenberg, J., Umar, F., Bensch, I., and Cowan, C. 2014c. Weatherization Works – Summary of Findings from the Retrospective Evaluation of the U.S. Department of Energy's Weatherization Assistance Program. ORNL/TM-2014/338, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

[22] Treitler, I., Gregory, J. with Rose, A. and Schilling, P. 2013. Personal Insights and Anecdotes about the Weatherization Assistance Program. ORNL/TM-2015/21, Oak Ridge National Laboratory, Oak Ridge, Tennessee, July.

Recovery Act Evaluation Reports

[23] Blasnik, M., Dalhoff, G., Carroll, D., Ucar, F., Bausch, D., and Johnson, D. 2015a. "Evaluation of the National Weatherization Assistance Program During Program Years 2009-2011 (American Recovery and Reinvestment Act Period): Energy Impact for Mobile Homes. ORNL/TM-2014/558, Oak Ridge National Laboratory, Oak Ridge, TN, July.

[24] Blasnik, M., Dalhoff, G., Carroll, D., Ucar, F., and Bausch, D. 2015b. Evaluation of the National Weatherization Assistance Program During Program Years 2009-2011 (American Recovery and Reinvestment Act Period): Energy Impacts for Single Family Homes. ORNL/TM-2014/582, Oak Ridge National Laboratory, Oak Ridge, TN, July.

[25] Carroll, D. and Bausch, D. 2015. Environmental Emissions Nonenergy Benefits Working Paper: ARRA Period. ORNL/TM-2015/127, Oak Ridge National Laboratory, Oak Ridge, TN, July.

[26] Carroll, D., Dalhoff, G., Johnson, D., Bausch, D., and Blasnik, M. 2015a. Energy Impacts for Multifamily Buildings: Evaluation of the National Weatherization Assistance Program During Program Years 2009-2011 (American Recovery and Reinvestment Act Period). ORNL/TM-2014/583, Oak Ridge National Laboratory, Oak Ridge, TN, July.

[27] Conlon, B. and Tonn, B. 2015. Findings from Surveys Administered to Weatherization Training Centers. ORNL/TM-2015/84, Oak Ridge National Laboratory, Oak Ridge, TN, July.

[28] Pigg, S. 2015. National Weatherization Assistance Program Impact Evaluation – A Pilot Monitoring Study of Cooling System Consumption and Savings under the WAP Program. ORNL/TM-2014/339, Oak Ridge National Laboratory, Oak Ridge, TN, July.

[29] Rose, E., Hawkins, B., Tonn, B., Paton, D. and Shah, L. 2015a. Exploring the Potential of Weatherization and Healthy Homes Interventions on Asthma-related Medicaid Claims and Costs in a Small Cohort in Washington State. ORNL/TM-2015/213, Oak Ridge National Laboratory, Oak Ridge, TN, July.

[30] Rose, E., Hawkins, B., Tonn, B., Conlon, B., Treitler, I. 2015b. Assessing the Potential of Social Networks as a Means for Information Diffusion – the Weatherization Experiences (WE) Project. ORNL/TM-2014/405, Oak Ridge National Laboratory, Oak Ridge, TN.

[31] Rose, E., Hawkins, B., Tonn, B., Ashcraft, L., and Miller, C. 2015c. Exploratory Review of State, Agency and Client Experiences with Deferred Services Under the Weatherization Assistance Program. ORNL/TM-2014/364 Oak Ridge National Laboratory, Oak Ridge, TN, July.

[32] Tonn, B. and Goeltz, R. 2015. National Weatherization Assistance Program Evaluation: Assessment of Refrigerator Energy Use. ORNL/TM-2015/150, Oak Ridge National Laboratory, Oak Ridge, TN, March.

[33] Tonn, B. and Rose, E. 2015. U.S. Territories and Weatherization Assistance Program During the Recovery Act Period. ORNL/TM-2014/592, Oak Ridge National Laboratory, Oak Ridge, TN, March.

[34] Tonn, B., Rose, E., and Hawkins, B. 2015a. Survey of Recipients of Weatherization Assistance Program Services: Assessment of Household Budget and Energy Behavior Pre- to Post-Weatherization. ORNL/TM-2015/64, Oak Ridge National Laboratory, Oak Ridge, TN, March.

[35] Tonn, B., Rose, E., and Hawkins, B. 2015b. National Weatherization Assistance Program Characterization Describing the Recovery Act Period. ORNL/TM-2015/195, Oak Ridge National Laboratory, Oak Ridge, TN, March.

[36] Tonn, B., Rose, E., Schmoyer, R., Eisenberg, J., Ternes, M., Schweitzer, M., and Hendrick, T., 2011. Evaluation of the National Weatherization Assistance Program During Program Years 2009-2011 (American Recovery Act and Reinvestment Period). ORNL/TM-2011/87, Oak Ridge National Laboratory, Oak Ridge, TN, December.

[37] Tonn, B., Carroll, D., Rose, E., Hawkins, B., Pigg, S., Blasnik, M., Eisenberg, J., Cowan, C., and Conlon, B. 2015. "Weatherization Works II - Summary of Findings from the ARRA Period Evaluation of the U.S. Department of Energy's Weatherization Assistance Program," ORNL/TM-2015/139, Oak Ridge National Laboratory, Oak Ridge, TN, September.

Other References

[38] Hawkins, B., Tonn, B., Rose, E., Clendenning, G., and Abraham, L. 2016. Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts (NEIs) Study. Three[3], Inc., Knoxville, Tennessee, August 5.

[39] Drucker, P. 1990. Managing the Non-profit Organization: Principles and Practices. HarperCollins, New York.

[40] U.S. Census Bureau, https://www.census.gov/programs-surveys/ahs/data.html

[41] U.S. Census Bureau, 2016. Renters More Likely to be Food Insecure than Homeowners. https://www.census.gov/newsroom/press-releases/2016/cb16-193.html

Appendix A: Supplemental Tables

Table A1. PY 2010 Clients Household Characteristics by Building Unit Type

Statistic	All Housing Units	SF	MH	Small MF	Large MF
Income and Poverty					
Median Income	$14,400	$15,700	$13,400	$11,800	$10,400
High Energy User	38%	41%	42%	35%	14%
High Energy Burden	37%	40%	37%	36%	16%
Vulnerability Status					
% w/ Elderly Individual	39%	42%	39%	24%	35%
% w/Persons with Disabilities	30%	30%	39%	19%	20%
% w/Children	31%	32%	33%	34%	22%
Household Status					
% Homeowner	71%	86%	90%	19%	2.3%
Mean Household Size	2.35	2.47	2.26	2.40	1.82
% Single Parent	22%	21%	21%	34%	26%
% Single Elderly	30%	31%	30%	21%	32%
Race/Ethnicity					
% White non-Hispanic	61%	59%	77%	48%	50%
% Black non-Hispanic	28%	31%	15%	31%	24%
% Hispanic	10%	8%	7%	17%	23%
% Asian	0.6%	0.5%	0.1%	1.9%	1.7%
% Native American	1.4%	1.3%	1.4%	1.4%	1.7%
% Other	0.2%	0.2%	0.1%	0.0%	0.2%

Table A2. PY 2010 WAP/ARRA Clients in MF Buildings 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	$10,388*	$11,496*	$9,999*	$11,310*	$9,600*	$12,168
Median % of Poverty	86%*	95%*	84%*	83%*	78%*	94%
% < 100% of Poverty	63%*	53%*	64%*	58%*	69%*	63%
Vulnerability Status						
% w/Elderly Individual	32%	50%	29%	29%*	24%*	37%
% w/Disabled Individual	16%	34%	10%	17%*	11%*	24%
% w/Children	25%	16%	18%	28%*	48%*	37%
Household Status						
% Homeowner	2%*	1%	3%*	<1%*	0%*	5%
Mean Household Size	1.9	1.5	1.8	1.8*	2.3*	2.5
% Single Parent	28%**	25%**	***	25%**	38%**	14%**
% Single Elderly	27%	47%	24%	24%*	20%*	27%
Race/Ethnicity						
% White non-Hispanic	37%**	81%**	35%**	65%*	20%*	***
% Black non-Hispanic	27%**	15%**	30%**	11%*	30%*	***
% Hispanic	32%**	4%**	33%**	14%*	43%*	***
% Asian	3%**	0%**	2%**	<1%*	6%	***
% Native American	1%**	<1%**	<1%**	7%*	0%	***
% Other	<1%**	0%**	0%**	2%*	1%*	***

***10% to < 50% missing. **50% to < 90% missing. ***More than 90% missing.**

Table A3. Weatherized Units in Program Years 2008 and 2010 by Housing Type

Housing Type	2008 Units	2008 by %	2010 Units	2010 by %
Site Built Homes (1-4 units)	62,835	64%	215,445	65%
MH	17,754	18%	48,267	14.5%
Large MF Units (5+)	17,376	18%	68,153	20.5%
Total	**97,965**	**100%**	**331,865**	**100%**

Table A4. Weatherized Units in Program Years 2008 and 2010 by Climate Zone

Climate Zone	2008 Units	2008 by %	2010 Units	2010 by %
Very Cold	24,749	25%	58,584	18%
Cold	42,233	43%	127,386	38%
Moderate	18,794	19%	56,006	17%
Hot/Humid	6,390	7%	55,157	17%
Hot/Dry	5,799	6%	34,732	10%
Total	**97,965**	**100%**	**331,865**	**100%**

Table A5. PY 2010 WAP/ARRA Housing Units by Climate Zone and Housing Unit Type*

Climate Zone	SF	MH	MF Building	All Housing Unit Types
Very Cold Climate	70%	17%	13%	100%
Cold Climate	62%	11%	27%	100%
Moderate Climate	68%	16%	16%	100%
Hot/Humid Climate	65%	14%	21%	100%
Hot/Dry Climate	57%	13%	30%	100%
TOTAL	64%	14%	22%	100%

*Excludes shelter units

Table A6. PY 2010 WAP/ARRA Housing Units in MF Buildings by Climate Zone

Climate Zone	PY 2010 Housing Units in MF Buildings	Percent of PY 2010 Housing Units in MF Buildings
Very Cold Climate	7,576	10%
Cold Climate	34,454	47%
Moderate Climate	9,195	13%
Hot/Humid Climate	11,429	16%
Hot/Dry Climate	10,586	14%
TOTAL	73,240	100%

Table A7. PY 2010 WAP/ARRA Housing Units in MF Buildings by State

Climate Zone	PY 2010 Housing Units in MF Buildings	Percent of PY 2010 Housing Units in MF Buildings
New York	15,579	21%
Texas	11,046	15%
California	8,176	11%
Ohio	6,496	9%
Wisconsin	4,398	6%
Washington	4,308	6%
Illinois	3,959	6%
All Other States	19,278	26%
TOTAL	73,240	100%

Table A8. PY 2010 WAP/ARRA Housing Units in MF Buildings by Number of Units in Building

Building Type	Number of Units	Percent of Units
Units Not Reported*	14,971	22%
5-9 Units (SMF)	15,128	22%
10-25 Units (SMF)	11,786	17%
More than 25 Units (LMF)	26,268	39%
TOTAL	68,153	100%

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

Table A9. PY 2010 WAP/ARRA Housing Units in MF Buildings Housing Unit Characteristics by Climate Zone

Statistic	National	Very Cold Climate	Cold Climate	Moderate Climate	Hot/ Humid Climate	Hot/Dry Climate
Heated Space Per Unit (Ft²)						
Median Heated Space	825*	759*	871*	668	773	840*
Mean Heated Space	842*	780*	894*	723	783	817*
Building Vintage						
% pre 1940	15%*	5%*	23%*	0%*	0%*	0%**
% 1940-1969	16%*	11%*	17%*	11%*	18%*	18%**
% 1970 or later	69%*	84%*	60%*	89%*	82%*	82%**
Number of Stories						
1 to 4	74%*	82%*	61%*	98%	100%*	100%*
5 to 9	19%*	14%*	28%*	2%	0%*	0%*
10 or More	7%*	5%*	11%*	0%	0%*	0%*
Number of Units						
Units Not Reported	22%	7%	4%	9%	67%	49%
5 to 9	22%	22%	25%	18%	15%	23%
10 to 25	17%	23%	20%	40%	10%	3%
More than 25	39%	48%	51%	33%	8%	25%
Type/Equipment						
Whole Building/Central	32%	48%*	54%	1%	0%	0%
Whole Building/Unit	29%	45%*	37%	27%	12%	11%
Individual Unit	40%	7%*	10%	72%	88%	89%

***10% to < 50% missing. **50% to < 90% missing.**

Table A10. PY 2010 WAP/ARRA Housing Units in MF Buildings Housing Unit Characteristics by Number of Units in Building

Statistic	National	5-9 Units	10-25 Units	>25 Units	Units Not Reported
Heated Space Per Unit					
Median Heated Space	825*	822*	819*	851*	800*
Mean Heated Space	842*	878*	828*	849*	810*
Building Vintage					
% pre 1940	15%*	8%*	21%*	19%*	1%**
% 1940-1969	16%*	14%*	10%*	19%*	23%**
% 1970 or later	69%*	78%*	69%*	63%*	76%**
Number of Stories					
1 to 4	74%*	100%*	95%*	48%	100%**
5 to 9	19%*	<1%*	5%*	37%	0%**
10 or More	7%*	0%*	0%*	15%	0%**
WX Type/Equipment					
Whole Building/Central	32%	15%	34%	60%	2%
Whole Building/Unit	29%	52%	43%	20%	7%
Individual Unit	40%	33%	23%	20%	91%

***10% to <50% missing. **50% to <90% missing.**

Table A11. PY 2010 WAP/ARRA Housing Units in MF Buildings 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	56%	48%	67%	30%	31%	62%
% Electric	35%	38%	19%	70%	69%	34%
% Fuel Oil	8%	12%	13%	0%	0%	0%
% Other	1%	2%	1%	0%	0%	3%
Heating System Type						
% Central Forced Air	41%	15%*	31%*	50%	78%	49%
% Boiler (hydronic/steam)	32%	51%*	53%*	0%	0%	0%
% Wall/Room Heater	7%	<1%*	0%*	0%	2%	41%
% Electric Baseboard	16%	31%*	14%*	37%	16%	1%
% Other or None	4%	3%*	2%*	13%	4%	10%
Heating System Location						
% Building Level	34%	50%	55%	1%	0%	2%
% Unit Level	66%	50%	45%	99%	100%	98%
Supplemental Heat						
% Electric	13%**	57%**	7%*	35%*	6%**	5%**
% Other	14%**	10%**	14%*	12%*	18%**	15%**
Air Conditioning Type						
% Central AC	55%**	14%**	28%**	61%*	86%	44%
% Window/Wall	17%**	13%**	55%**	24%*	6%	10%
% Evaporative Cooler	3%**	0%**	1%**	0%*	7%	1%
% None	25%**	72%**	16%**	16%*	1%	45%
Water Heating Fuel						
% Natural Gas	68%	64%*	73%	37%	49%*	79%
% Electric	22%	22%*	12%	63%	51%*	17%
% Other	10%	13%*	15%	<1%	0%*	4%

***10% to <50% missing. **50% to <90% missing.**

Table A12. PY 2010 WAP/ARRA Housing Units in MF Buildings Heating and Cooling System Characteristics by Number of Units in Building

Statistic	National	5-9 Units	10-25 Units	More Than 25 Units
Heating Fuel				
% Natural Gas	56%	69%	52%	59%
% Electric	35%	29%	37%	25%
% Fuel Oil	8%	2%	10%	15%
% Other	1%	1%	1%	1%
Heating System Type				
% Central Forced Air	41%	63%	40%	16%
% Boiler (hydronic/steam)	32%	12%	32%	60%
% Wall/Room Heater	7%	9%	1%	5%
% Electric Baseboard	16%	10%	25%	16%
% Other or None	4%	6%	2%	3%
Heating System Location				
% Building Level	34%	15%	35%	62%
% Unit Level	66%	85%	65%	38%
Supplemental Heat				
% Electric	13%**	7%**	13%**	16%*
% Other	14%**	22%**	5%**	19%*
Air Conditioning Type				
% Central AC	55%**	44%**	51%**	52%**
% Window/Wall	17%**	22%**	33%**	20%**
% Evaporative Cooler	3%**	1%**	1%**	3%**
% None	25%**	33%**	15%**	26%**
Water Heating Fuel				
% Natural Gas	68%	73%*	57%	70%
% Electric	22%	24%*	32%	12%
% Other	10%	3%*	11%	18%

***10% to <50% missing. **50% to <90% missing.**

Table A13. PY 2010 WAP/ARRA Housing Units in MF Buildings Heating and Cooling System Characteristics by Weatherization Type/Equipment Type

Statistic	National	Whole Building with Central Heating	Whole Building with Unit Heating	Individual Unit with Unit Heating
Heating Fuel				
% Natural Gas	56%	71%	55%	41%
% Electric	35%	3%	45%	57%
% Fuel Oil	8%	25%	0%	0%
% Other	1%	1%	1%	2%
Heating System Type				
% Central Forced Air	41%	10%	59%*	57%
% Boiler (hydronic/steam)	32%	90%	2%*	1%
% Wall/Room Heater	7%	0%	2%*	16%
% Electric Baseboard	16%	0%	35%*	17%
% Other or None	4%	0%	3%*	9%
Heating System Location				
% Building Level	34%	100%	0%	0%
% Unit Level	66%	0%	100%	100%
Supplemental Heat				
% Electric	13%**	8%*	27%**	11%*
% Other	14%**	17%*	10%**	11%*
Air Conditioning Type				
% Central AC	55%**	2%**	46%**	60%*
% Window/Wall	17%**	36%**	30%**	13%*
% Evaporative Cooler	3%**	0%**	4%**	3%*
% None	25%**	62%**	19%**	23%*
Water Heating Fuel				
% Natural Gas	68%	71%	74%*	58%
% Electric	22%	1%	26%*	41%
% Other	10%	28%	<1%*	1%

***10% to <50% missing. **50% to <90% missing.**

Table A14. PY 2010 WAP/ARRA Housing Units in MF Buildings 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						
% Building	37%	70%	47%	17%	10%	8%
% Unit	28%	10%	12%	70%	68%	37%*
% Any Installed	66%	80%	59%	87%	78%	45%*
Blower Door						
% Building	18%**	47%**	20%**	12%*	12%*	14%**
% Unit	40%*	17%*	34%**	60%	46%*	23%**
% Any Installed	58%**	64%**	54%**	72%*	58%*	37%**
Ceiling/Attic/Roof Insulation						
% Building	21%	27%	34%	5%	3%	2%
% Unit	11%	5%	3%*	26%	33%	6%
% Any Installed	31%	32%	37%	31%	36%	7%
Wall Insulation						
% Building	3%	5%	4%	0%	1%	0%
% Unit	2%	0%	2%*	0%	3%	0%
% Any Installed	4%	5%	6%	0%	4%	0%
Other Insulation						
% Building	6%	17%	5%	4%	0%	10%
% Unit	1%*	1%	1%*	8%	0%	0%**
% Any Installed	7%*	18%	6%*	12%	0%	10%**
Duct Sealing						
% Building	11%*	30%**	12%*	19%**	9%**	5%*
% Unit	20%	3%	2%*	35%**	22%*	22%*
% Any Installed	31%*	33%*	13%**	54%**	31%*	27%*
Ventilation						
% Installed	10%**	***	8%**	42%**	4%*	0%**

***10% to <50% missing. **50% to <90% missing. ***More than 90% missing.**

Table A15. PY 2010 WAP/ARRA Housing Units in MF Buildings Air Sealing and Shell Measures by Number of Units in Building

Statistic	National	5 to 9 Units	10 to 25 Units	More Than 25 Units
Air Sealing				
% Building	37%	51%	50%	37%
% Unit	28%	24%*	23%	19%*
% Any Installed	66%	76%*	73%	56%
Blower Door				
% Building	18%**	16%**	33%**	19%**
% Unit	40%*	36%*	39%*	37%**
% Any Installed	58%**	52%**	72%**	56%**
Ceiling/Attic/Roof Insulation				
% Building	21%	22%	35%	24%
% Unit	11%	9%	8%	4%
% Any Installed	31%	31%	43%	28%
Wall Insulation				
% Building	3%	1%	8%	3%
% Unit	2%	3%	<1%	1%
% Any Installed	4%	4%	8%	4%
Other Insulation				
% Building	6%	7%	11%	5%
% Unit	1%*	1%*	2%	<1%*
% Any Installed	7%*	8%*	13%	5%
Duct Sealing				
% Building	11%*	8%**	32%*	10%*
% Unit	20%	28%*	14%	16%
% Any Installed	31%*	36%*	45%*	26%
Ventilation				
% Installed	10%**	7%**	24%**	20%**

***10% to <50% missing. **50% to <90% missing.**

Table A16. PY 2010 WAP/ARRA Housing Units in MF Buildings Air Sealing and Shell Measures by Weatherization Type/Equipment Type

Statistic	National	Whole Building with Central Heating	Whole Building with Unit Heating	Individual Unit with Unit Heating
Air Sealing				
% Any Installed	66%	53%	68%	76%*
Blower Door				
% Any Installed	58%**	50%**	68%**	55%*
Ceiling/Attic/Roof Insulation				
% Any Installed	31%	44%	28%	25%
Wall Insulation				
% Any Installed	4%	5%	4%	4%
Other Insulation				
% Any Installed	7%*	8%	9%	3%**
Duct Sealing				
% Any Installed	31%*	6%**	51%*	27%
Ventilation				
% Installed	10%**	***	***	11%*

***10% to <50% missing. **50% to <90% missing. ***More than 90% missing.**

Table A17. Measure Installation Rates for MF Units Served by WAP in PY 2010

Measure	National	Very Cold	Cold	Moderate	Hot/Humid	Hot/Dry
Air Sealing						
Bypass Air Sealing	66%	80%	59%	87%	78%	45%
Mechanical Ventilation	10%**	***	8%**	42%**	4%	0%**
Duct Sealing	31%*	33%*	13%**	54%**	31%*	27%*
Insulation						
Attic Insulation	31%	32%	37%	31%	36%	7%
Wall Insulation	4%	5%	6%	0%	4%	0%
Other Insulation (floor, rim joist, foundation)	7%*	18%	6%*	12%	0%	10%**
Equipment						
Furnace Replacement	33%	35%	27%	52%	61%	13%
Programmable Thermostat	18%*	9%**	15%**	12%	32%	10%
Water Heater Replacement	11%	35%	10%*	23%	3%	4%
Air Conditioner Replacement	16%	0%*	2%	25%	65%	7%
Other						
Windows	27%	5%	38%	25%	26%	8%
Refrigerator	23%*	20%*	22%*	47%	28%	9%
Lighting	72%	88%	62%*	77%	78%	77%

***10% to 50% missing. **50% to 90% missing. ***90% or more missing.**

Table A18. PY 2010 Clients Shell Measures by Building Type

Weatherization Measure	SF	MH	SMF	LMF
Air Sealing				
Any Bypass Sealing Or Caulking	89%	90%	83%	74%
Bypass Sealing w/ Blower Door	87%	87%	62%	69%
Attic Insulation				
% Installed (All Types)	65%	23%	37%	26%
Wall Insulation				
% Installed (All Types)	24%	3%	4%	3%
Other Insulation				
% Floor Insulation	18%	43%	2%	4%
% Rim/Band Joist Insulation	18%	1%	6%	3%
Windows				
Any Window Measure	18%	26%	21%	17%
If Any Window Measure, Then New Window (ECM)	78%	80%	100%	95%
Air Leakage				
CFM Pre	3130	2680	1780	1370
CFM post	2290	1860	1420	1120
Heating Equipment				
New Heating System	30%	32%	35%	34%
If New Heating System, Then New Heating System (ECM)	66%	64%	59%	62%
Heating Ducts				
Duct Sealing	36%	53%	32%	33%
Duct Insulation	11%	14%	2%	1%
Water Heating Equipment				
Water Heater Installed?	14%	14%	17%	9%
If New Water Heater, Then New Water Heater (ECM)	53%	49%	76%	94%
Ventilation				
Whole House, Kitchen, Bath Fan	21%	20%	17%	10%
Air Conditioning				
New Air Conditioner	7%	10%	21%	19%
IF New AC, Then New Air Conditioner (ECM)	91%	85%	95%	99%
Other Measures				
Refrigerator	19%	23%	21%	29%
Smoke Alarm	50%	57%	22%	19%
CO Monitor	63%	58%	55%	38%
Setback Thermostat	16%	16%	15%	14%

Table A19. PY 2010 WAP/ARRA Housing Units in MF Buildings Percent of Units by Number of Major Measures and Climate Zone

Major Measures	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
No Major Measures	34%*	39%*	28%*	18%*	10%	77%
One Major Measure	27%*	22%*	32%*	51%*	24%	13%
Two Major Measures	27%*	18%*	31%*	9%*	49%	7%
Three Major Measures	11%*	22%*	9%*	14%*	17%	2%
Four Major Measures	1%*	0%*	0%*	8%*	<1%	2%
All Jobs	100%*	100%*	100%*	100%*	100%	100%
Mean # of Measures	1.2*	1.2*	1.2*	1.4*	1.7	0.4

***10% to <50% missing.**

Table A20. PY 2010 WAP/ARRA Housing Units in MF Buildings Percent of Units by Number of Major Measures and Number of Units in Building

Major Measures	NATIONAL	5-9 Units	10-25 Units	More Than 25 Units
No Major Measures	34%*	53%*	33%*	27%*
One Major Measure	27%*	21%*	35%*	32%*
Two Major Measures	27%*	15%*	19%*	30%*
Three Major Measures	11%*	8%*	13%*	11%*
Four Major Measures	1%*	3%*	<1%*	1%*
All Jobs	100%*	100%*	100%*	100%*
Mean # of Measures	1.2*	0.9*	1.1*	1.3*

***10% to <50% missing.**

Table A21. PY 2010 and 2011 WAP Energy Impacts for MF Housing Units Gross and Net Energy Savings (therms/year) for Units with Natural Gas and Fuel Oil Main Heat

Group	# Units	Pre-WAP Use	Post-WAP Use	Gross Savings	Net Savings	% of Pre
Treatment	1,205	700	608	92 (±6)	99 (±8)	14.2% (±1.2%)
Comparison	979	702	710	-7 (±5)		

Table A22. PY 2010 and 2011 WAP Energy Impacts for MF Housing Units Gross and Net Electric Savings (kWh/year) for Natural Gas and Fuel Oil Main Heat

Usage Component	# Units	Pre-WAP Use	Post-WAP Use	Gross Savings	Net Savings	% of Pre
Treatment	1,556	4,740	4,425	315 (±103)	304 (±61)	6.4% (±1.3%)
Comparison	948	5,246	5,235	11 (±49)		

Table A23. PY 2010 WAP Energy Impacts for MF Housing Units Gross and Net Electric Savings per Unit for Electric Main Heat (kWh/year)

Usage Component	# Units	Pre-WAP Use	Gross Savings	Net Savings	% of Pre
Treatment	707	7,402	864 (±100)	810 (±152)	10.9% (±2.1%)
Comparison	400	8,142	54 (±97)		

Table A24. PY 2010 and 2011 Energy Impacts for MF Housing Units Gross and Net Gas and Fuel Oil Savings Total and by End Use (therms/year)

Group/Breakout	Units	Pre-WAP Use	Post-WAP Use	Gross Savings	Net Savings	% of Pre
Total Use	1,205	700	608	92 (±6)	99 (±8)	14.2% (±1.2%)
Comparison	979	702	710	-7 (±5)		
Heating Use	1,205	486	418	68 (±6)	72 (±9)	14.9% (±1.9%)
Comparison	979	480	485	-4 (±7)		
Baseload Use	1,205	214	189	25 (±5)	27 (±7)	12.7% (±3.3%)
Comparison	979	222	225	-2 (±5)		

Table A25. PY 2010 and 2011 WAP Energy Impacts for MF Housing Units Gross and Net Electric Savings for Natural Gas and Fuel Oil Main Heat by End Use (kWh) Unit Level Savings

Usage Component	# Units	Pre-WAP Use	Post-WAP Use	Gross Savings	Net Savings	% of Pre
Total Use	1,556	4,740	4,425	315 (±103)	304 (±61)	6.4% (±1.3%)
Comparison	948	5,246	5,235	11 (±49)		
Heating/Winter Use	1,556	338	272	67 (±58)	26 (±38)	7.7% (±11.3%)
Comparison	948	510	469	40 (±13)		
Cooling/Summer Use	1,556	514	491	24 (±31)	47 (±46)	9.1% (±9.0%)
Comparison	948	444	467	-23 (±29)		
Baseload Use	1,556	3,887	3,662	225 (±23)	231 (±83)	5.9% (±2.1%)
Comparison	948	4,293	4,299	-6 (±95)		

Table A26. PY 2010 and 2011 WAP Energy Impacts for MF Housing Units Gross and Net Electric Savings for Electric Main Heat by End Use (kWh/year) Unit Level Savings

Usage Component	# Units	Pre-WAP Use	Gross Savings	Net Savings	% of Pre
Total Use	707	7,402	864 (±100)	810 (±152)	10.9% (±2.1%)
Comparison	400	8,142	54 (±97)		
Heating/Winter Use	707	1,994	396 (±108)	263 (±177)	13.2% (±8.9%)
Comparison	400	2,769	132 (±137)		
Cooling/Summer Use	707	340	85 (±51)	31 (±86)	9.2% (±25.3%)
Comparison	400	375	54 (±69)		
Baseload Use	707	5,068	384 (±152)	516 (±244)	10.2% (±4.8%)
Comparison	400	4,999	-132 (±181)		

Table A27. PY 2010 and 2011 WAP Energy Impacts for MF Housing Units Net Savings (therms per year) for Natural Gas and Fuel Oil Main Heat by Climate Zone

Climate Zone	# Major Measures	# Units	Pre-WAP Use	Net Savings	% of Pre
All Clients	1.9	1,205	700	99 (±8)	14.2% (±1.2%)
Very Cold	2.4	120	515	71 (±22)	13.9% (±4.2%)
Cold	1.9	1,017	746	105 (±9)	13.9% (±1.2%)
Moderate	1.5	30	424	99 (±43)	23.3% (±10.1%)
Hot/Humid	2.0	16	304	95 (±35)	31.3% (±11.4%)
Hot/Dry	1.3	22	273	-3 (±39)	-1.0% (±14.2%)

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

Table A28. PY 2010 and 2011 WAP Energy Impacts for MF Housing Units Electric Savings (kWh per year) for Natural Gas and Fuel Oil Main Heat by Climate Zone

Climate	Refrigerator Replacement %	# Units	Pre-WAP Use	Net Savings	% of Pre
All Clients	31%	1,556	4,740	304 (±61)	6.4% (±1.3%)
Very Cold	22%	170	3,716	474 (±154)	12.8% (±4.3%)
Cold	31%	1,088	4,822	237 (±67)	4.9% (±1.4%)
Moderate	43%	58	4,485	653 (±531)	14.6% (±11.8%)
Hot/Humid	36%	185	5,394	349 (±355)	6.5% (±6.6%)
Hot/Dry	33%	55	4,330	50 (±368)	1.1% (±8.5%)

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

Table A29. PY 2010 and 2011 WAP Energy Impacts for MF Housing Units Savings for Units with Natural Gas or Fuel Oil Main Heat by Number of Major Measures (therms/year)

Group/Breakout	# Units	Pre-WAP Use	Net Savings	% of Pre
No Major Measures	50	805	30 (±28)	4.6% (±4.2%)
Any One Major Measure	194	835	61 (±19)	7.4% (±8.8%)
Any Two Major Measures	371	627	108 (±15)	17.2% (±.2.3%)
Any Three Major Measures	141	779	136 (±23)	17.5% (±3.0%)
Four Major Measures or More	45	707	100 (±47)	14.2% (±6.7%)

Table A30. PY 2010 and 2011 WAP Energy Impacts for Multifamily Housing Units Net Savings for Natural Gas or Fuel Oil Main Heat by Weatherization Type/Heating Equipment Type (therms/year)

Weatherization and Heating Equipment Type	# Major Measures	# Units	Pre-WAP Use	Net Savings	% of Pre
Building WX and Heating Equipment	1.9	976	740	102 (±9)	13.8% (±1.2%)
Building WX and Unit Heating Equipment	1.6	168	532	97 (±21)	18.3% (±3.9%)
Unit WX and Heating Equipment	2.1	55	496	55 (±51)	11.2% (±10.2%)
All Units	1.9	1,205	700	99 (±8)	14.2% (±1.2%)

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

Table A31. PY 2010 and 2011 WAP Energy Impacts for Multifamily Housing Units Net Savings for Electric Main Heat by Weatherization Type/Heating Equipment Type (kWh/year)

Weatherization and Heating Equipment Type	# Units	Pre-WAP Use	Net Savings	% of Pre
Building WX and Heating Equipment	126	4,005	371 (±148)	9.3% (±3.7%)
Building WX and Unit Heating Equipment	357	7,808	587 (±219)	7.5% (±2.8%)
Unit WX and Heating Equipment	224	8,665	1,515 (±389)	17.5% (±4.5%)
All Units	707	7,402	810 (±152)	10.9% (±2.1%)

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

Table A32. PY 2010 and 2011 WAP Energy Impacts for MF Housing Units Energy Savings (therms/year) by Measure for Natural Gas and Fuel Oil Main Heat

Measure	% of Units	Savings per installation	Contribution to Overall Savings	% of Total Savings
Air Sealing	62%	48	29	37%
Attic Insulation	36%	56	20	26%
Heater Replacement	32%	48	15	19%
Water Heating Replacement	13%	27	3	4%
Window Replacement	30%	33	10	12%
No Major Measures	10%	44	4	6%
Other/Unattributed	100%	-4	-4	-5%
Total			79	100%

Table A33. Estimated Energy Savings by House Type for PY 2008 and 2010

Program Year/Home Type	2008		2010	
	Total MMBtu Saved	MMBtu/ Unit Saved	Total MMBtu Saved	MMBtu/ Unit Saved
Site Built Homes (1-4 units)	1,8400,000	29.3	5,730,000	26.6
MH	284,000	16.0	790,000	16.4
Large Multi-family	144,000 (NYC LMF)	26.9	1,086,554	15.9
Total	2,268,000		7,609,628	

Table A34. Percent Energy Savings

	2008 NG NG Heat	2008 Elect NG Heat	2008 Elect Elect Heat	2010 NG NG Heat	2010 Elect NG Heat	2010 Elect Elect Heat
Site Built Homes (1-4 units)	17.8%	7.1%	9.0%	15.5%	7.8%	9.3%
MH	12.6%	5.6%	7.5%	12.9%	7.6%	8.7%
Large MF	18% (NG & FO)	18.3% (NG & FO)	---	14.2% (NG & FO)	6.4% (NG & FO)	10.9%

Note: 1989 SFSB Akk Fuels 13.5%

Table A35. Occupant Survey Findings for Dwelling Quality from Pre-Weatherization to Post-Weatherization

Survey Item	Preaudit Incidence	PostWX Incidence	Change
Home sometimes at unhealthy temperature	18.0%	9.2%	-8.8%
Home was observed to be drafty	70.2%	37.2%	-33.0%
Observed standing water in home	33.0%	19.3%	-13.7%
Frequent mildew odor or musty smell	30.2%	16.4%	-13.8%
Have seen mold in home	27.4%	18.7%	-8.7%
Home is somewhat, very, or extremely infested by insects	25.1%	16.2%	-8.9%
Home is somewhat, very or extremely infested by mice	10.4%	6.1%	-4.3%

Table A36. Occupant Survey Findings for Equipment from Pre-Weatherization to Post-Weatherization

Survey Item	Preaudit Incidence	PostWX Incidence	Change
Broken Heating Equipment (last 12 months)	14.9%	8.5%	-6.4%
Broken Cooling Equipment (last 12 months)	9.9%	5.5%	-4.5%
Clothes Dryer Vents Outdoors	80.9%	86.6%	+5.7%
Bathroom With Working Vent Fan	47.5%	60.5%	+13.0%
Home Has CO Monitor	44.7%	77.1%	+32.4%
Home Has Smoke Detector	88.4%	97.3%	+8.9%

Table A37. Occupant Survey Findings for Trade Offs from Pre-Weatherization to Post-Weatherization

Survey Item	Preaudit Incidence	PostWX Incidence	Change
It is hard or very hard to pay energy bills	74.6%	58.5%	-16.1%
Did not buy food to pay energy bills	33.2%	23.1%	-10.1%
Went without food in the last four weeks	7.1%	5.7%	-1.4%
Worried household members would not have nutritious food	23.2%	14.9%	-8.3%
Did not fill prescriptions to pay energy bills	27.5%	18.5%	-9.0%

Table A38. Occupant Survey Findings for Health and Safety Impact from Pre-Weatherization to Post-Weatherization

Survey Item	Pre-Weatherization	Post-Weatherization	Change
Asthma Symptoms (<3 months since last)	70.5%	58.7%	-11.8%
Asthma Emergency Department Visits	15.8%	4.3%	-11.5%
Asthma Hospitalizations	13.7%	10.6%	-3.1%
Medical attention too hot	2.4%	1.5%	-0.9%
Medical attention too cold	3.2%	1.5%	-1.7%
Persistent cold symptoms	21.0%	12.0%	-9.0%
Number of days previ9ous month physical health not good	10.3	5.4	-48%
Number of days previous month mental health not good	7.1	3.7	-48%
Number of days previous month did not get enough rest or sleep	11.7	6.6	-44%

Table A39. PY 2010 WAP/ARRA Housing Units in MF Buildings Mean and Median Cost Per Unit by Climate Zone

Climate Zone	Mean Cost per Unit	Median Cost per Unit
Very Cold Climate	$2,132	$1,845
Cold Climate	$3,266	$2,951
Moderate Climate	$2,975	$2,945
Hot/Humid Climate	$5,096	$5,439
Hot/Dry Climate	$1,203	$434
TOTAL	$3,111	$2,651

Table A40. PY 2010 WAP/ARRA Housing Units in MF Buildings Mean and Median Cost Per Unit by Number of Units in Building

Number of Units	Mean Cost per Unit	Median Cost per Unit
5-9 Units	$2,298	$1,202
10-25 Units	$3,582	$3,378
More Than 25 Units	$3,255	$3,017
TOTAL	$3,111	$2,651

Table A41. PY 2010 WAP/ARRA Housing Units in MF Buildings Mean and Median Cost Per Unit by Weatherization Type/Equipment Type

Weatherization Type	Mean Cost per Unit	Median Cost per Unit
Whole Building/Central Heating	$4,122	$3,655
Whole Building/Unit Heating	$2,531	$1,763
Individual Unit/Unit Heating	$2,955	$2,129
TOTAL	$3,111	$2,651

Table A42. PY 2010 WAP/ARRA Housing Units in MF Buildings Mean Cost by Number of Major Measures and Climate Zone

Number of Measures	NATIONAL	Very Cold Climate	Cold Climate	Moderate Climate	Hot/Humid Climate	Hot/Dry Climate
No Major Measures	$1,211*	$1,944*	$1,183*	$1,683*	$4,738	$487
One Major Measure	$3,109*	$1,871*	$3,177*	$2,340*	$4,277	$2,667
Two Major Measures	$5,195*	$2,980*	$5,658*	$2,822*	$5,267	$3,754
Three Major Measures	$5,222*	$2,571*	$6,173*	$4,223*	$5,954	$5,659
Four Major Measures	$5,719*	NA	NA	$6,322*	$3,910	$4,833
All Jobs	$3,316*	$2,249*	$3,686*	$2,863*	5,098	$1,176

*10% to <50% missing.

Table A43. PY 2010 WAP/ARRA Housing Units in MF Buildings Mean Cost by Number of Major Measures and Number of Units in Building

Number of Measures	NATIONAL	5-9 Units	10-25 Units	More Than 25 Units
No Major Measures	$1,211*	$1,347*	$2,362*	$1,143*
One Major Measure	$3,109*	$2,390*	$3,293*	$3,146*
Two Major Measures	$5,195*	$4,857*	$5,965*	$5,103*
Three Major Measures	$5,222*	$5,356*	$6,086*	$4,105*
Four Major Measures	$5,719*	$5,479*	$6,622*	$6,036*
All Jobs	$3,316*	$2,542*	$3,880*	$3,335*

*10% to 50% missing.

Table A44. Summary of Lifetime Energy Cost Savings by Housing Type and Program Year

	2008 Total $ Saved	2008 $ Saved/ Unit	2010 Total $ Saved	2010 $ Saved/ Unit
Site Built (1-4 units)	$331,300,000	$5,200	$963,000,000	$4,468
MH	$54,200,000	$3,053	$143,000,000	$2,957
Large MF	$34,500,000 (NYC LMF)	$6,460 (NYC LMF)	$117,000,000	$1,710
Total	**$420,000,000**		**$1,223,000,000**	

Table A45. Projected PY 2013 WAP Impacts for MF Housing Units 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	$465	$599	$1,065	$69	$35	$104	9.8%
Electricity	$0	$863	$863	$0	$114	$114	13.2%
Fuel Oil	$1,860	$341	$2,201	$235	$42	$277	12.6%
Propane	$1,138	$453	$1,591	$186	$21	$208	13.0%
Other*	$493	$584	$1,077	$49	$27	$76	7.1%
All Clients	**$393**	**$681**	**$1,074**	**$55**	**$66**	**$121**	**11.3%**

***Other heating fuels include wood, kerosene, and coal.**

Table A46. Present Value of Per Unit and WAP Program Health-Related Benefits of Weatherization

Non-Energy Benefit (Present Value Per Unit)	Total	Total (Value of Life Excluded)	Tier 1		Tier 2		Tier 3	
			Societal	Household	Societal	Household	Societal	Household
Asthma	$2,009	-	$1,852	$157				
Thermal Stress-Cold	$3,911	$172	$3,892	$19				
Thermal Stress-Heat	$870	$85	$855	$15				
Food Assistance Reduction	$832	-	$832					
Reduction in Missed Days at Work	$201	-	$40	$161				
CO poisoning	$154	$7			$153	$1		
Improvement in Prescription Adherence	$1,929	-			$1,929	-		
Reduction in Use of Short-Term Loans	$71	-			-	$71		
Home Fires	$831	$175					$768	$63
Increased Productivity at Work Due to Improved Sleep	$1,813	-					$1,813	-
Increased Productivity at Home Due to Improved Sleep	$1,329	-					-	$1,329
Reduction in Low-Birth Weight Babies from Heat-or-Eat Dilemma	$198	-					$198	-
Total by Tiers (Present Value Per Unit)	$14,148	-	$7,471	$352	$2,082	$72	$2,779	$1,392
			$7,823		$2,154		$4,171	
Total by Tiers (Present Value WAP Program)	$1,165,653,232	-	$623,764,142	$33,074,012	$167,886,445	$5,751,867	$223,333,983	$111,842,783
			$656,838,154		$173,638,312		$335,176,766	

Table A47. Barriers to Weatherizing Large MF (LMF) Buildings

Barriers	Grantees	Subgrantees
Few LMF buildings present	39%	42%
LMF building owners are uncooperative	27%	25%
Lack of LMF building auditors	55%	18%
Unclear owner contributions	34%	16%
Energy savings are not high enough	11%	15%
Too expensive to weatherize LMF buildings	34%	14%
Lack of LMF weatherization crews	27%	10%

Table A48. Perceptions of Grantees and Subgrantees on Training/Preparedness In Key Topic Areas By Subgrantee Weatherization Staff

	Well trained		Moderately well trained		Not well trained		Not applicable	
	grantee	subgr.	grantee	subgr.	grantee	subgr.	grantee	subgr.
Diagnostic procedures (n = 49 - state) (n = 321 - local)	62%	74%	28%	18%	11%	4%	0%	5%
SF measures (n = 49 - state) (n = 321 - local)	77%	67%	17%	18%	5%	7%	0%	8%
MH measures (n = 49 - state) (n = 321 - local)	72%	61%	20%	15%	6%	8%	2%	15%
MF measures (n = 49 - state) (n = 321 - local)	40%	31%	20%	11%	23%	13%	17%	44%
administrative topics (n = 49 - state) (n = 320 - local)	55%	60%	27%	19%	16%	6%	2%	15%
health & safety topics (n = 49 - state) (n = 319 - local)	40%	44%	31%	21%	25%	16%	4%	19%

Table A49. Formal Training Topics in Last Five Years – MF

On which weatherization topics have you received formal training in the past five years?			
Weatherization Topic	**MF**		
	Auditor	**Chief**	**Member**
Number of Respondents	350	268	264
Infiltration / Air Sealing Measures	44%	52%	57%
Insulation	43%	50%	53%
Space Heating, Ventilation, Air Conditioning	32%	24%	21%
Base Loads (e.g., Lighting, Refrigerators)	35%	21%	22%
Hot Water Heating	30%	16%	21%
Doors and Window Installation / Repair	27%	37%	45%

Table A50. Topics On Which Training Is Needed – MF Homes

In what areas do you feel more training would be useful in your current weatherization job?			
Weatherization Topic	**MF**		
	Auditor	**Chief**	**Member**
Number of Respondents	350	268	264
Space Heating, Ventilation, Air	16%	15%	20%
Hot Water Heating	13%	13%	17%
Doors and Window Installation / Repair	11%	9%	13%
Base Loads (e.g., Lighting, Refrigerators)	11%	12%	18%
Auditing / Estimating	17%	21%	21%
Infiltration / Air Sealing Measures	13%	10%	13%
Insulation	12%	8%	12%

Appendix B: Supplemental Figures

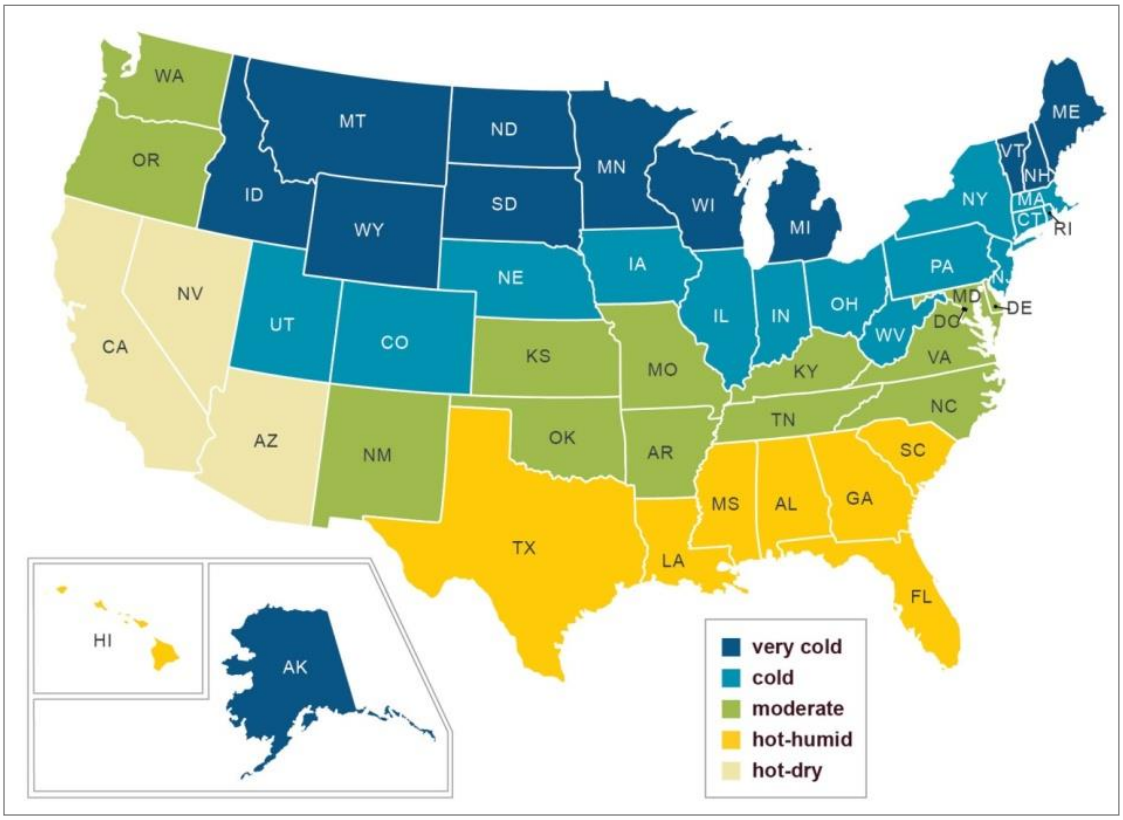


Figure B1. Climate Zones

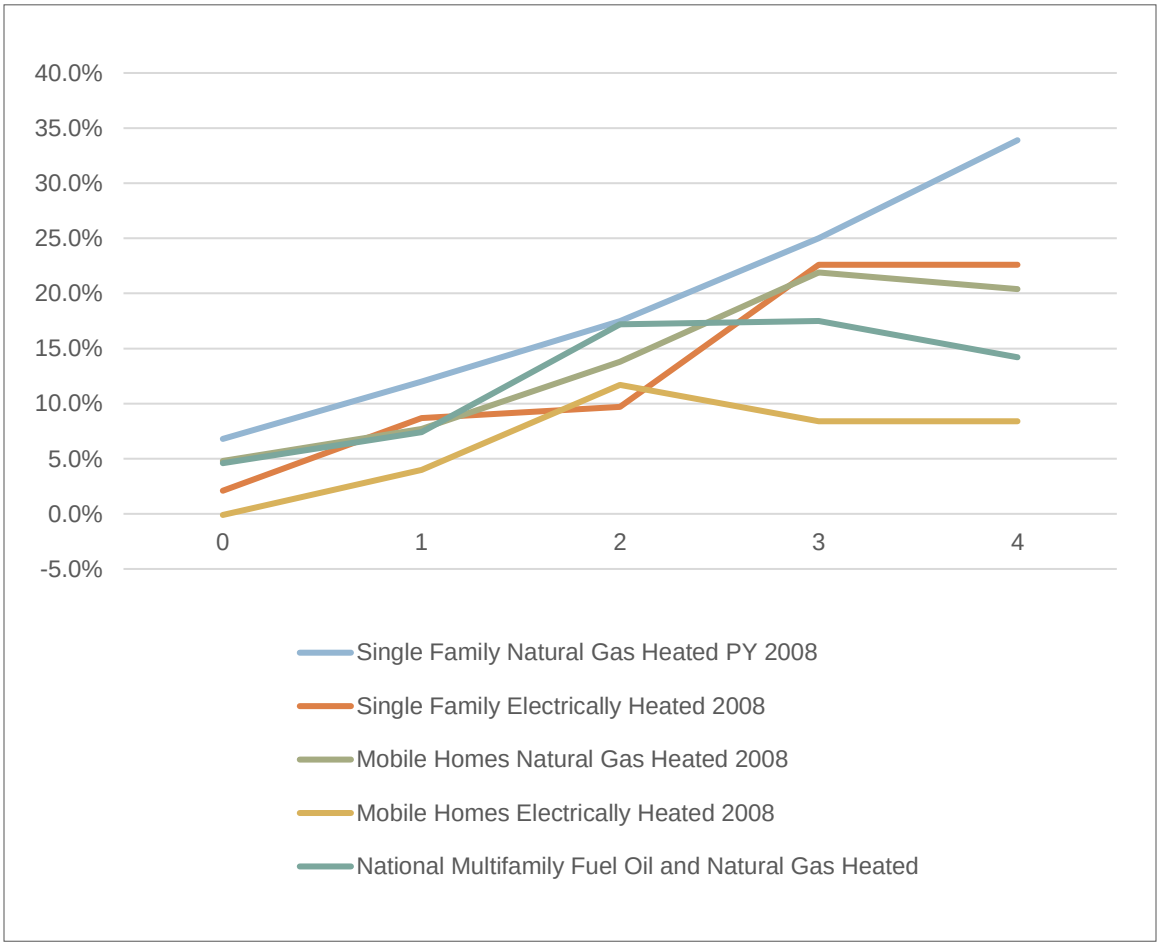


Figure B2. Percent Energy Savings by Measures Installed

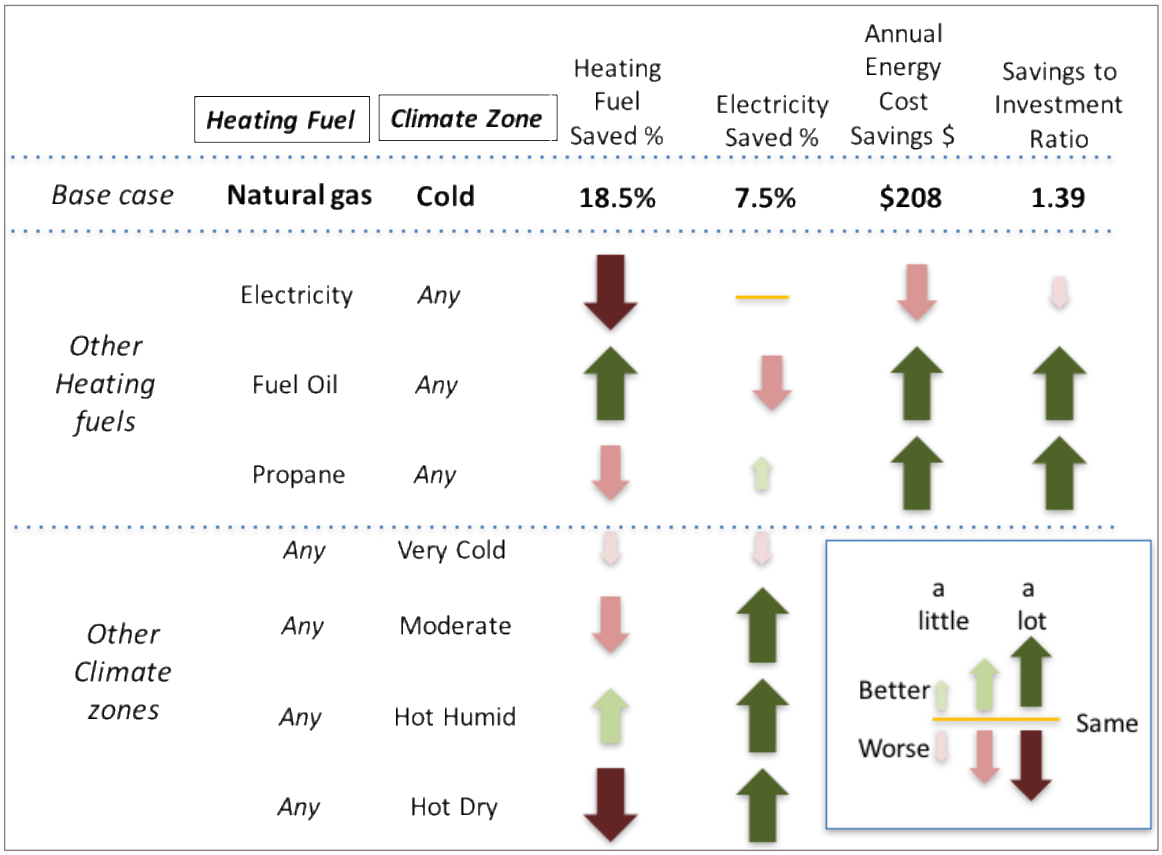


Figure B3. Comparisons of how savings and cost-effectiveness for SF home vary by heating fuel and climate zone

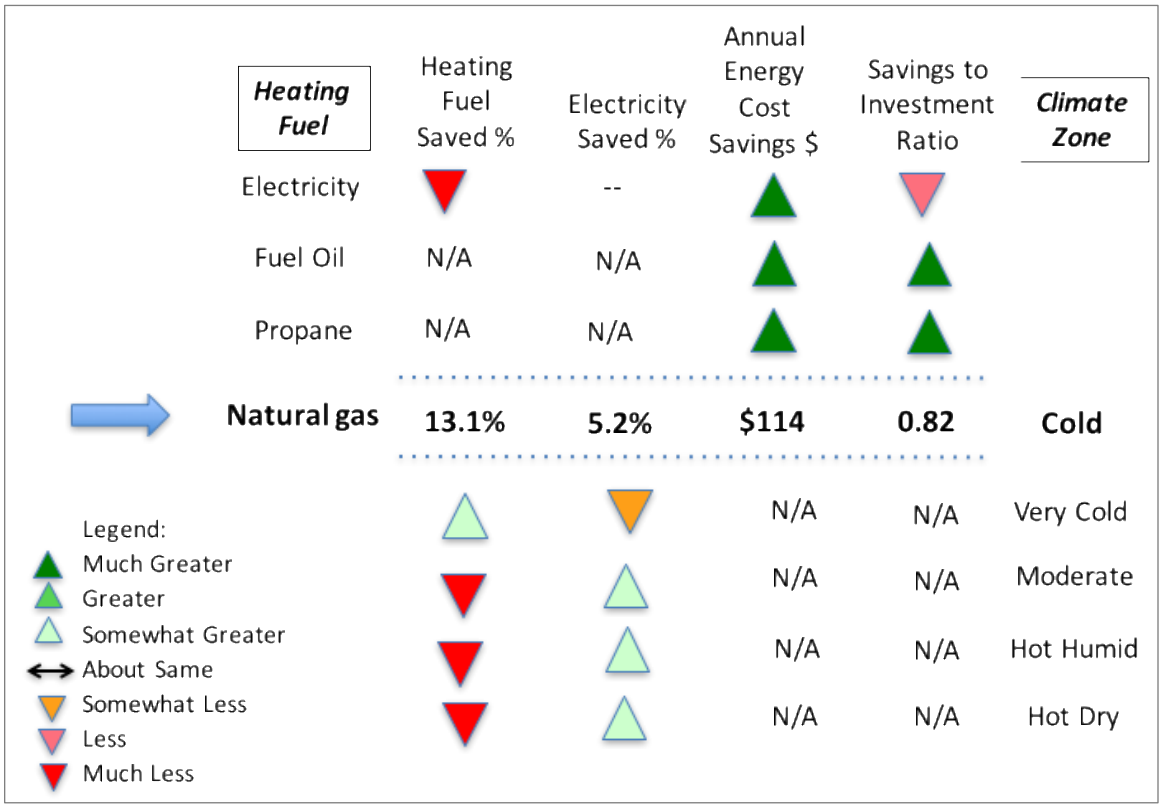


Figure B4. Comparisons to the Most Commonly Weatherized MH by Heating Fuel and Climate Zone (2008)

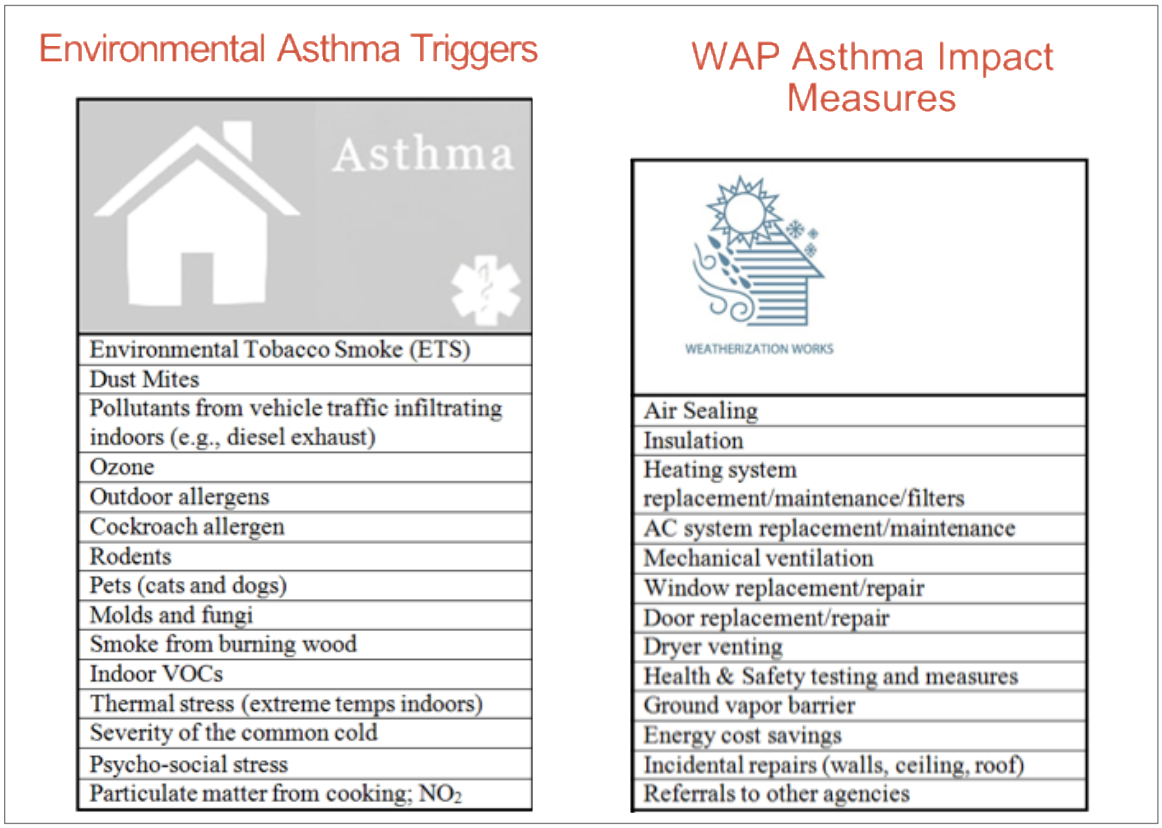


Figure B5. Environmental Asthma Triggers and WAP Asthma Impact Measures

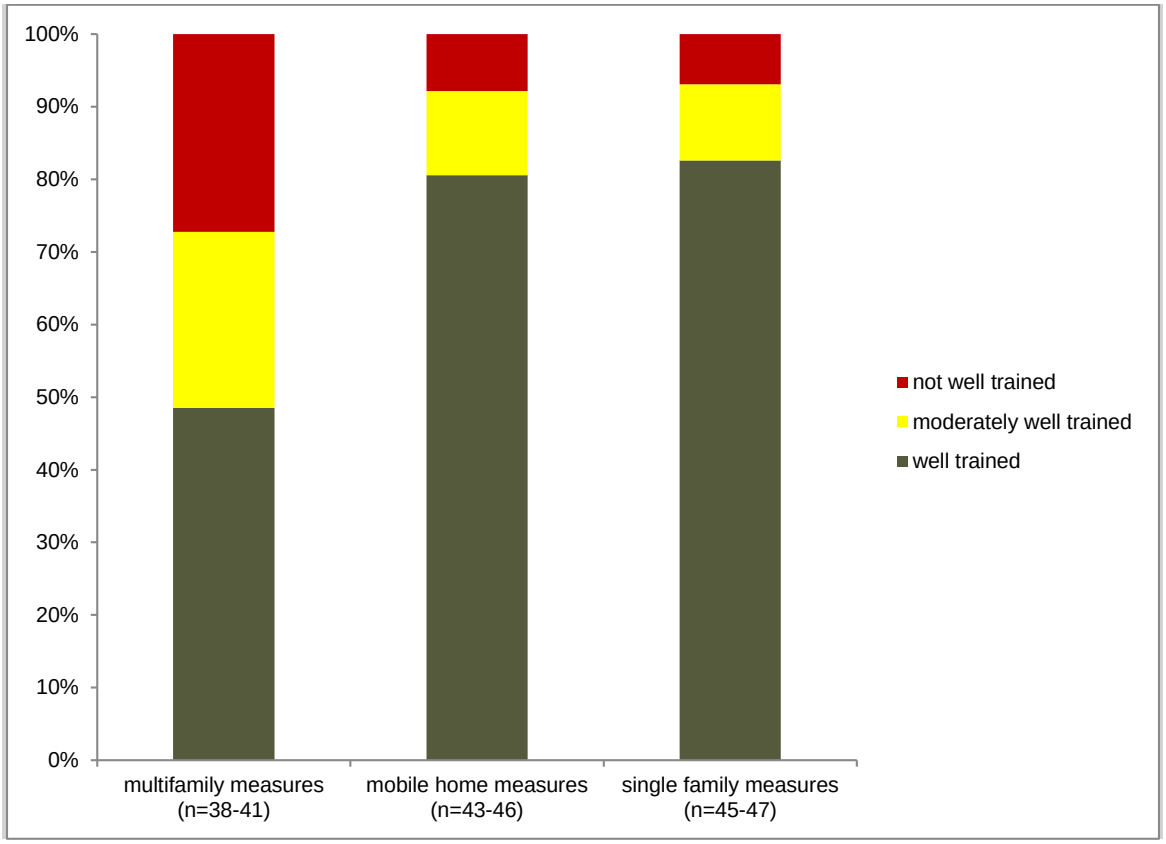


Figure B6. Grantee Assessment of Staff Knowledge On Technical Weatherization Topics, By Housing Type

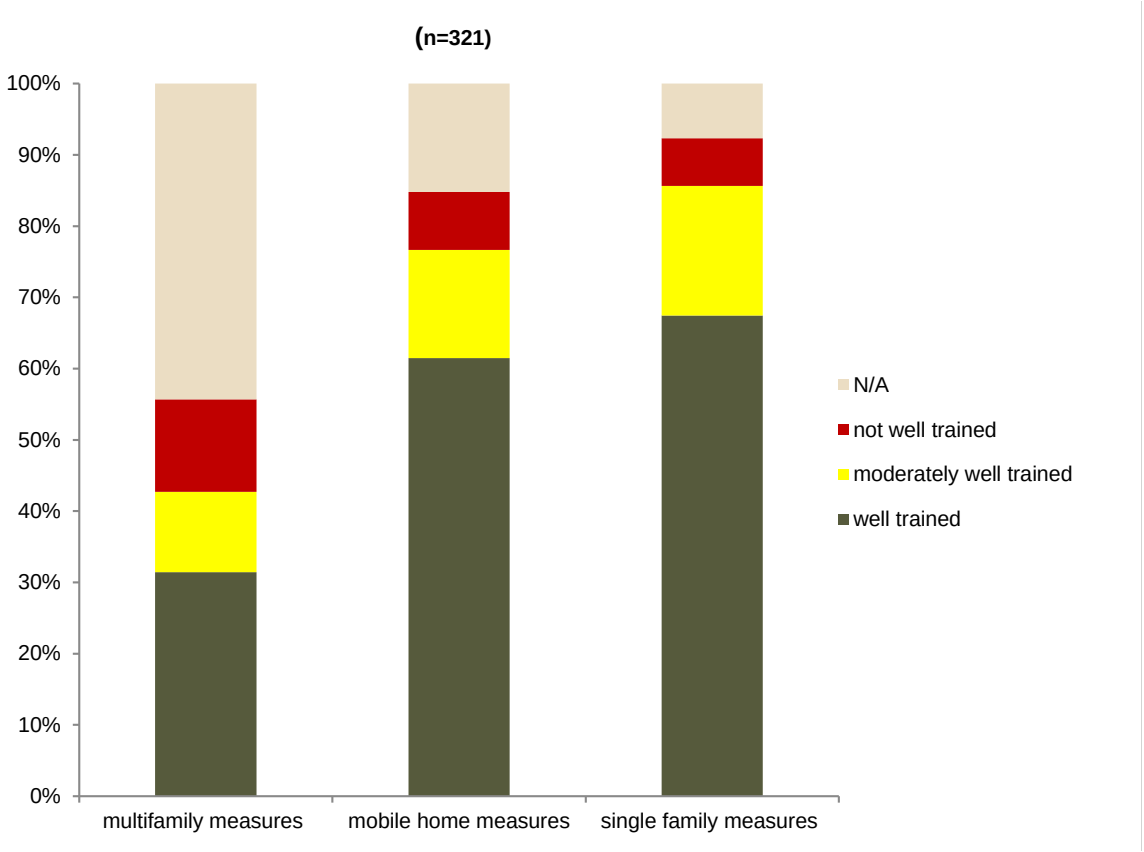


Figure B7. Subgrantee Assessment of Staff Knowledge On Technical Weatherization Topics, By Housing Type

Appendix C: Selected MF Case Studies

C1. Association for Energy Affordability – Bronx, New York

C1.1 Introduction

The Association for Energy Affordability (AEA), located in the Bronx in New York City, is one of the nation's leading weatherization agencies targeting the MF housing sector (See Figure C1.1).[11] The organization was founded in 1992 as the Weatherization Coalition. It changed its name to AEA in 1994.

Figure C1.1. Association for Energy Affordability, Bronx Office

Due to the expertise it has developed, AEA has a presence on National boards and committees addressing and producing guidance, certifications, regulation, training curricula, and other resources for improving the energy efficiency of buildings. AEA also maintains office space in midtown Manhattan and has a satellite office in Emoryville, California.

Beginning by offering technical assistance and weatherization training, AEA's portfolio of services has grown and diversified over the years. In the mid-1990s, AEA assumed responsibility for conducting weatherization audits for almost all large and small MF buildings in New York City.

[11] See http://aea.us.org/

At the request of the State of New York, AEA also performs quality assurance on large MF audits conducted by others outside of New York City.

In recent years, AEA has added a state-of-the-art hands-on training facility, initiated a distance-learning program, and taken responsibility for operating a full-service low-income weatherization program in the Bronx. It also offers a fee-for-service program in the residential and commercial building sectors. These programs are discussed in more depth below. In addition, the following programs fall under AEA's weatherization programs:

- New York State Energy Research and Development Authority (NYSERDA) Home Performance with Energy Star
- Con Edison MF Energy Efficiency Program
- NYSERDA EmPower New York℠
- NYSERDA MF Performance Program
- Energy Upgrade California
- Clean Boilers Program for Weatherization

C1.2 Philosophy

The large MF (LMF) buildings typically served by AEA are privately owned, although many are owned by non-profit organizations and house senior citizens or serve as supportive housing for vulnerable populations. AEA's guiding philosophy is that energy-efficient buildings are vital to community development and economic health, and that weatherization is key to energy efficiency. Thus, weatherization is at the core of AEA's efforts to serve low-income neighborhoods, keep housing affordable, and help make communities better places to live.

C1.3 MF Weatherization Approach

The barriers to comprehensive, whole-building weatherization of large MF buildings may seem insurmountable, but AEA works hard to dispel that perception. For example, DOE regulations governing weatherization of LMF buildings state that successful weatherization programs must meet two criteria: they must benefit building occupants, and owners must financially contribute to the weatherization project. AEA strives to overcome this barrier by establishing strong working relationships with LMF building owners, negotiating with them to meet the two basic requirements. With respect to the first requirement, owners are usually asked not to raise rents for several years post-weatherization. With respect to the second requirement, AEA has found that owners are more open to contributing toward weatherization when it is pointed out to them that they are actually investing in energy savings measures that will benefit them in the long run. In addition, AEA often informs owners that DOE WAP funds can supplement their investments in their buildings, thus facilitating the purchase and installation of new heating and cooling systems, new hot-water systems, more effective energy-management systems, more energy-efficient lights, and new

windows. Owners are allowed to invest in measures that they really desire but that do not meet the SIR threshold, such as windows. In general, AEA tries to get owners to contribute 50 percent of the cost of the weatherization project, although the State of New York has provided AEA a waiver to reduce that amount to approximately 25 to 35 percent. Before an audit is conducted, owners are required to place into escrow a good-faith deposit of approximately $200 for every unit in the building(s) to be weatherized.

Another myth that AEA works hard to dispel is that LMF weatherization is too complex to be practicable. The agency has found that the three keys to tackling the technical challenges of LMF weatherization are good data, good audit models, and a highly trained staff. To collect good data, AEA acquires two years of pre-weatherization energy bill records before they do the audit. Because almost all LMF buildings in NYC are centrally heated, this entails contacting local fuel oil and/or natural gas suppliers. AEA also collects electricity bills for master meter and individual unit accounts. These data provide the foundation for understanding how a particular LMF building is operating.

C1.4 Weatherization Delivery

Determining Eligibility for WAP

To identify buildings needing weatherization, AEA works with local weatherization agencies, passing along audit results and construction-oriented recommendations for associated agencies to implement.

Before weatherizing LMF buildings, AEA must first determine whether the building meets income thresholds for WAP funding. To be eligible for WAP funding, per New York's state plan, and a DOE rule defined in the Federal regulations, 66 percent or more of the households in a MF building must be identified as low-income; however, it is time-consuming to contact every household and obtain the requisite documentation. The determination of income eligibility for a building is always done before the building is audited.

In addition, AEA must determine whether a building's condition may force a weatherization job to be deferred. WAP regulations [12] allow 15 percent of WAP funds that are spent on a home or building

[12] If a Grantee's plan calls for 15 percent or more of their budget to be spend on health and safety, that budget will be reviewed by a DOE committee. The 15 percent is a benchmark that most WAP agencies refer to. "As a part of the Health and Safety Plan, Grantees must set health and safety expenditure limits for their subgrantees, providing justification by explaining the basis for setting these limits and providing related historical experience. It is possible that these limits may vary depending upon conditions found in different geographical areas. These limits must be expressed as a percentage of the average cost per dwelling unit. For example, if the average cost per dwelling is $5000, 10 percent would equal an average of $500 per dwelling unit for health and safety. These funds are to be expended by subgrantees in direct weatherization activities." (Source: WPN 11-6)

to target health-and-safety issues. However, this amount is often not enough to deal with many issues, such as roof problems or asbestos remediation, or to remove health-and-safety risks for weatherization auditors` and staff, such as rats in boiler rooms. AEA has to ensure that owners will deal with such building code violations before it will conduct an audit. AEA reports that more SF homes than LMF buildings are deferred because NYC conducts regular and rigorous inspections on the latter, so they are generally in better condition.

Audits

AEA conducts numerous LMF audits per year and has a normal waiting list period of about one year, though the waiting list for LMF buildings during the ARRA period was two years. AEA's thorough energy audits document building characteristics as well as noting the normal energy-use information. AEA also asks the building superintendent and building manager about the building's energy system operation and maintenance as well as any complaints received from occupants about the warmth or coolness of their units. The auditors also query tenants directly about their experiences with the building's energy systems. Lastly, AEA's staff engineers perform technical analysis of the boilers and other high-cost, central systems.

After all of this information is appropriately structured for input into a computerized MF audit tool called EA-QUIP, AEA selects measures to install in the building and generates a formal Apartment Building Work Scope (ABWS) document that details the recommended measures and estimated costs. This is then submitted to the building owner for approval of the measures and confirmation of the amount of owner contribution.

Implementation

After the owner approves the ABWS, the local weatherization agency implements the plan. For very complex jobs, AEA provides construction management services to the local weatherization agencies (e.g., for help with removal of old boilers and the installation of new ones). Every weatherized LMF building is inspected after weatherization.

The last step in the process is handing over the care of the weatherized building to its owners, manager, superintendent, and tenants. AEA has begun a program to provide formal energy system management training—a 5-day required class—to building managers and superintendents. In addition, boiler installers may be asked to provide training in the new systems they install. This program is funded by the NYSERDA.

To follow up, AEA tracks energy use in newly weatherized buildings and intervenes if energy reductions use do not occur. AEA also educates tenants about energy use, showing tenants how they can better regulate heat in their units, for example, without opening windows in the winter.

Organizational Structure

Before the ARRA period, AEA employed 56 staff members (See Figure C1.3). This number grew to 138 at the peak of the ARRA period. At the time of the site visit (February 21, 2012), this number had decreased to 129.

Figure C1.2. AEA management and staff in a boiler room during site visit

Because AEA works in an extraordinarily rich multi-cultural environment, it takes care to hire culturally sensitive staff members with a range of foreign-language skills. To support its community-development goals, AEA also frequently hires career shifters and even former prison inmates, as long as the latter have earned their GEDs. To make this hiring strategy work effectively, AEA has a very strong mentoring program.

Leveraging and Partnerships

AEA works hard to leverage outside funding and to build partnerships that can help further its activities. Its main sources of leveraged funding are NYSERDA, the State of New York, and Consolidated Edison. Partners include the state's Department of Homeless Services, Office of Mental Health, Department of Aging, and Department of Labor, as well as the Consortium for Worker Education, the Osborne Association Green Careers Center, the Northern Manhattan Improvement Corporation, and various local community colleges.

C1.5. Training Center

AEA has a state-of-the-art training facility and is committed to sharing its knowledge about best practices. The facility contains simulated buildings and hands-on training stations related to air sealing, insulation, heating system repair and replacement, and AC system replacement (See Figures C1.4 – C1.6). For example, a mock-up can be configured to present students with air sealing and insulation challenges frequently found in attics of SF homes. The mock-up is extensive enough (i.e.,

containing enough rooms) to allow students to do real-life blower-door pressure diagnostics and even combustion appliance zone (CAZ) testing and duct blasting. Instructors can change and/or set dampers to create different air-leakage and air-sealing challenges for students. The facility also supports CO testing on gas appliances and refrigerator metering (See Figure C1.6) and has a simulated crawlspace and a fully working bathroom. Overall, the facility allows instructors to replicate just about any situation that their students may face in the field.

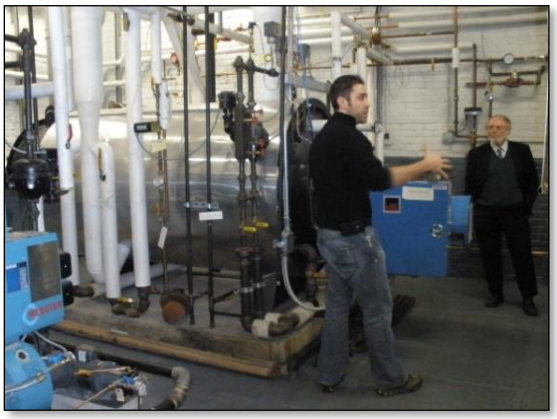


Figure C1.3. Training station at AEA's training facility

Figure C1.4. At AEA's training facility, kitchen mock-up for CO testing on gas range and fridge metering

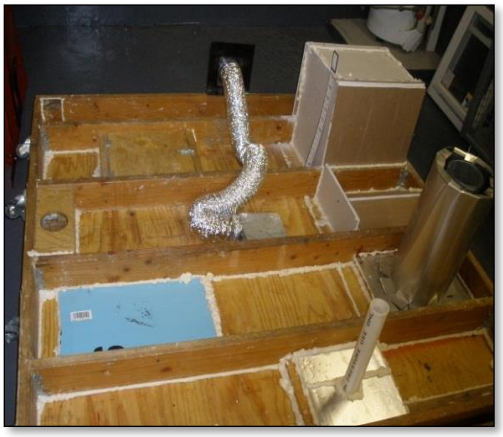


Figure C1.5. At AEA's training facility, a training station for hands-on work

Approximately half of AEA's students are involved with MF weatherization; the rest focus on SF homes. AEA offers multiple certifications:

- BPI certification for crew chiefs and crew members
- Air Barrier Association of America certification training
- Continuing Education Units
- Passive House Consultant and Tradespersons certifications, and
- USGBC certification for Green Professionals.

AEA has also offered various custom-designed courses for interested businesses and organizations. In addition, the agency trains state weatherization office staff, NYSERDA home-retrofit contractors, and some Home Performance with Energy Star contractors. Finally, AEA collaborates with local community colleges, such as Hudson Valley Community College, to offer weatherization training, some of which can lead to BPI certification. Many students are hired by AEA after their training.

A good deal of effort is needed for AEA to maintain its training program. Collaborations with a wide range of organizations have to be established and nurtured; cash flow is often an issue, since students may have trouble paying for classes; the organization must leverage federal, state, local, utility, and foundation grants to subsidize training and support; and the funding seems to come and go. For example, NYSERDA's MF Performance Program reimbursed 50 percent of AEA costs for several training offerings for many years, until this past year.

C1.6 ARRA Period

The ARRA period brought, along with heightened funding and expectations, additional administrative burdens. As with many weatherization organizations, the Davis-Bacon provisions of the American Recovery and Reinvestment Act of 2009 initially adversely affected AEA. For example, at the beginning of the ARRA period, AEA had already completed audits for approximately 100 LMF buildings but had to postpone weatherization for many months until the labor category wage rate was settled. Once the labor rates were determined, AEA costs for electricians went up significantly during the ARRA period.

C1.7 Post-ARRA Period

As AEA contemplates the post-ARRA period, it would strongly prefer to retain the $6500 average cost-per-unit allowance instead of returning to the pre-ARRA $2500 per-unit amount; the higher average has allowed for a more comprehensive approach in LMF buildings.

Going forward, AEA hopes that DOE will continue to expand its awareness of and support for LMF weatherization. AEA and other agencies have demonstrated that barriers to LMF weatherization can be overcome and that New York City's experiences can be applied around the country. AEA suggests that the following actions would make weatherization more effective in LMF:

- Make training for building superintendents an allowable cost under WAP
- Allow agencies to offer refresher training to building superintendents
- Allow agencies to return to LMF buildings to fine-tune newly installed boiler systems (See Figure C1.7 and C1.8)
- Institute more formal tenant protection regulations (e.g., prohibiting rent increases post-weatherization), and
- Allow environmental benefits to be added to the numerator of the Savings-to-Investment Ratio equation.

Figure C1.6. Boiler installed by AEA

Figure C1.7. Boiler system installed by AEA

Challenges for the Future

AEA hopes that more LMF building owners, both low-income and non-low-income, will consider weatherizing their properties. The biggest obstacle is a lack of confidence on the part of building owners and finance organizations that LMF weatherization will result in enough energy savings to provide a sound payback to the investment. To answer those doubts, AEA cooperated with a study supported by Deutsche Bank to estimate the energy cost savings attributable to the weatherization of LMF buildings.[13] Overall, the study found that weatherization, on average, is a cost-effective investment but that energy cost savings varied considerably between buildings. To deal with this variation, financial institutions need to treat weatherization loans, like every other type of loan, from a portfolio perspective.

[13] See https://www.db.com/usa/img/DBLC_Recognizing_the_Benefits_of_Energy_Efficiency_01_12.pdf

Whatever the future holds, AEA will continue to innovate. Currently, it is experimenting with rooftop photovoltaic cells, a green roof, and even a green wall on its rooftop (See Figure C1.9). It is also testing out two different solar thermal panels for their applicability to the LMF environment. In its facility, it has begun testing new equipment for manufacturers, starting with condensing boilers. Recently, it has entered into a partnership to promote passive housing. Lastly, AEA will continue to evolve and innovate to develop markets, such as new construction; the municipal/state, university, school, and hospital markets; and training for market-rate commercial building retrofits.

Figure C1.8. Green wall (in February) – AEA rooftop

C1.8 Profiles

Distance Learning

AEA has developed a sophisticated distance-learning capability, the first of its kind in the weatherization community. The hub of this operation is a studio-classroom in its Bronx office. The room is equipped with three cameras and is manned by a communication systems professional with experience in daytime television and the production of independent films. The system has a T1 connection, which allows high band-width communications with its partner sites:

- New River Center for Energy Research and Training
- Corporation for Ohio Appalachian Development (COAD)
- Community and Economic Development Association of Cook County
- Building Performance Center/Opportunity Council
- Indiana Community Action Association
- Southwest Building Science Training Center
- FSL Home Energy Solutions
- Southface

Using its high-tech classroom, AEA can offer conventional distance learning courses in which experts can lecture and share their PowerPoint slides and whiteboard images, and in which students from other sites can interact with the teacher and other students in real time.

Additionally, AEA is developing powerful educational software. For example, AEA has developed detailed animations of the combustion systems typically found in LMF buildings. The animation graphically illustrates important combustion-related concepts that are otherwise quite difficult to teach in a lecture-only format (See Figure C1.10). AEA's future vision for this facility and program is to offer the best weatherization training, available anywhere in the United States over its distance-learning network.

Figure C1.9. Animated demonstration for distance and in-class instruction

Senior Housing

The case-study team visited several LMF buildings in New York City that had received weatherization services. Shown in Figure C1.11 is a 145-unit building that houses senior citizens. Just under $400,000 was invested in this building (including a 25 percent owner contribution).

Figure C1.10. Senior Citizen home weatherized by AEA.

(Note: Upper-floor windows are closed, which is indicative of uncomfortable heat distribution. Uneven heat distribution is a common issue with MF buildings).

The AEA staff audit of the existing heating system found an over-sized non-condensing boiler system that was ineffective and inefficient and did not allow the temperatures inside to reach a comfortable level for the elderly residents. The boiler was replaced with a 90+ efficient condensing boiler system. Upon installation, the levels of modulation, or appropriate minimum and maximum water temperatures, were set.

The 90+ efficiency referenced above is not automatically achievable; however, AEA's training and follow-up protocols ensure that the boiler efficiency target can be met. A superintendent is now trained to be able to fine-tune the system through a complete heating and cooling season. Occupants' feedback on comfort levels, and actual energy-savings impacts are being tracked.

C2. Northern Manhattan Improvement Corp., New York

C2.1 Introduction

In 1981, the Northern Manhattan Improvement Corporation (NMIC) enlisted the federal Weatherization Assistance Program in its quest to preserve affordable housing for economically distressed households. For more than 30 years, NMIC has dedicated itself to establishing and implementing social service programs and projects that target the needs of vulnerable populations in Manhattan's Washington Heights and Inwood communities. This WAP agency contributes to the preservation of affordable housing by educating, negotiating and partnering with owners, managers, supers and tenants of affordable housing buildings to achieve reductions in energy and water usage at both the building and the unit levels. Testimonials from these stakeholders attest to the change occurring as a result of NMIC's WAP projects. But the complexities of MF weatherization are such that even members within the National WAP network hesitate to take them on.

NMIC and its weatherization program are closely identified with the people who brought it into being and have since dedicated themselves to its cause. Twenty years ago, Dan Rieber (See Figure C2.1) joined NMIC's weatherization team and is currently the Director of Weatherization. Dan has been instrumental in establishing partnerships, promoting tenant advocacy, and negotiating with building owners. Other key members of the NMIC team is are its crew staff who brings both technical skill and a tremendous capacity for empathy for the people this program serves. Their imprints are defined and preserved in the work they do, and in the very buildings they weatherize (See Figure C2.2). A representative from New York State's WAP monitoring office emphasized that it is the people of NMIC who have made the organization what it is. It is the people that effect change.

Figure C2.1. Dan Rieber, NMIC Weatherization Director

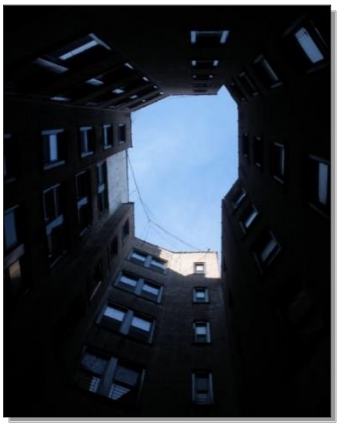


Figure C2.2. View of sky from courtyard of MF residence recently weatherized by NMIC

C2.2 Northern Manhattan Improvement Corporation

NMIC and its 100 staff members oversee a number of social-service programs, of which WAP is only one. The programs operate separately from one another but communicate with each other to comprehensively address poverty-related issues through both direct services and capacity-building opportunities. The following programs are included under NMIC's umbrella:

- Adult and Community Education
- Capitalize Benefits Screening and Enrollment
- Community Health
- Domestic Violence Services
- Employment and Training
- Immigration
- Organizing and Housing Development
- Legal Services
- Weatherization

Service Territory

NMIC provides WAP services in northern sections of Manhattan (See Figure C2.3); it also partners with other WAP Subgrantee in other service territories in Manhattan. In addition to working in the Washington Heights and Inwood communities, NMIC partners with the Cooper Square Committee, a community development committee/businessmen's association, "working to preserve and develop affordable and environmentally healthy housing and community/cultural spaces on the Lower East Side."[14] At the time of this case study, NMIC also weatherized about four small MF buildings per year for the neighboring Harlem CDC WAP Subgrantee, as that agency does not weatherize small residential buildings within its service territory.

Weatherization Philosophy

NMIC's general mission, which also guides its weatherization philosophy, is to "[s]erve as a catalyst for positive change in the lives of people in our community on their paths to secure, violence-free, and prosperous futures." Dan Rieber and his agency's vision for WAP provide a means for achieving this mission through the energy and non-energy benefits directly observed and generally attributed to weatherization. The non-energy benefits accruing to tenants through NMIC's WAP services include but are not limited to:

[14] http://westbeth.org/

- Preservation of affordable housing by driving down utility costs and entering into agreements with building owners that limit or prevent rent increases.
- Health and safety benefits related to ventilation, pest management, and the installation CO and smoke detectors.
- Improving comfort in the home.

According to Rieber, Washington Heights contains the largest number of affordable housing units in New York City. NMIC also promotes weatherization as a key ingredient in the "green" movement. In its view, conserving energy is a means to reduce the consumption of fossil fuels and their greenhouse gas emissions, as well as a way to decrease U.S. dependence on foreign oil.

Figure C2.3. NMIC Service

C2.3Weatherization and the MF Housing Sector

Eligibility

NMIC works with many varying building characteristics across Manhattan's residential building sector, including types of buildings, fuel type, metering type, and types of mechanical systems. However, they must adhere to DOE WAP guidance on inclusion criteria for a MF property to be eligible for WAP services. If a building is deemed eligible, all units in the building receive cost-effective measures, not just the units with income-eligible households. The following conditions must be met per DOE rules:

- A minimum of 66 percent of the dwelling units in the building must be occupied by families that meet the income requirement (as required under 10 CFR 440.22(b)(2)); or 50 percent if there are four or fewer units.
- Households must be income-eligible--below 60 percent of New York's state median income or 200 percent of poverty level (by household size).
- For a reasonable period of time after weatherization work has been completed, the eligible dwelling unit will not be subject to rent increases as a result of the weatherization (as required under 10 CFR 440.22(b)(3)(i)).
- No undue or excessive enhancement has occurred to the value of the dwelling unit (as required under 10 CFR 440.22(b)(3)(i)).

Tenant meetings are conducted as part of the NMIC weatherization process. NMIC will hold as many as three meetings at one building. NMIC income-certification staff members facilitate the tenant meetings. These staff members go door to door requesting eligibility information from the tenants and to educate them on the weatherization process. This is where tenant advocacy "bubbles up" into the weatherization program. This is not always done at other agencies. Unfortunately, this is where some buildings fall out of the process due to lack of building owner cooperation in setting up the meetings with tenants, and their buildings thus lose weatherization services. For NMIC, however, this has been a rare occurrence.

To streamline the process for certifying WAP income eligibility for MF buildings and properties, DOE and HUD have agreed to a Memorandum of Understanding (MOU) (See Exhibits section C2.8). NMIC utilizes the HUD eligibility list, improving the efficiency of verifying income eligibility for buildings.

Recruitment

Prior to ARRA, NMIC had little need to engage in outreach or marketing efforts to recruit building owners for weatherization. According to Rieber, "They just came in." NMIC reported that information regarding weatherization and its benefits was shared by building owners through word of mouth communication, and through NMIC's involvement with active tenant associations. Prior to

ARRA, NMIC was able to weatherize 9-15 multi-family buildings per year and was able to secure the work through this informal marketing approach. This social networking mechanism among building owners continued into the ARRA period. General agency marketing and the assistance of a city helpline that directs weatherization inquiries to NMIC helped NMIC secure partnerships with building owners. During the ARRA period, 2,044 units were weatherized and all ARRA grant money was spent.

Pre-Audit

NMIC requires a good-faith deposit of $2000 as part of the building owner contribution prior to any work being completed. When the initial meeting with a building owner has taken place, and a good-faith deposit has been received, a pre-audit of the building is performed. Pre-audits include roof sketches, window counts, and basic heating-system information concerning pipes and boiler type. The superintendents or "supers" of the buildings are interviewed by the NMIC team to learn more about heat-distribution problems and other needs of the building. NMIC measures each unit to determine the optimal size of the boiler for heating the space and also interviews the tenants about heat distribution. NMIC reports that 90 percent of building owners follow through with weatherization after the pre-audit is conducted and that only 1 percent are "walk-aways" situations where NMIC walks away from a job for reasons of either cost-effectiveness or safety. The remaining 9 percent involve building owners walking away from the negotiations.

NMIC does not exclude buildings cited for Code C health and safety violations. Instead, the agency informs the building owner that the violations must be remediated before weatherization work can begin. For example, only after a pest infestation is mitigated can work commence. However, NMIC does assess the level of infestation to determine whether deferral is necessary, as the weatherization work itself (e.g., caulking around baseboards or installing door sweeps) will generally address minor infestations.

The Audit

The majority of building energy audits are conducted by the agency in house. For more complicated buildings, such as those with massive HVAC systems on the roof, or properties like West Beth (See Exhibits section C2.8), NMIC will subcontract out the energy audit work to the Association for Energy Affordability (AEA), a WAP technical service provider and Subgrantee that serves the Bronx (See Case Study on AEA).

The projected scope of work is based on a formula that measures the amount of energy saved versus the cost of a given measure; this formula yields the cost-effectiveness of that measure (i.e., SIR).

Building Owner Negotiations and Contribution

Although WAP does not require building owners to contribute to major capital improvements completed for the building, NMIC typically requires owners to contribute at least 25 percent and

may require up to 40 percent, depending on the audit, the scope of work, and negotiations with the building owners related to measures not supported by the audit without owner contribution. NMIC makes exceptions to the owner contribution requirements for non-profits with 501(c) 3 tax credit status, or low-income co-ops (i.e., co-opportunities) that have no money to contribute. For example, the Department of Homeless Services owned a shelter in need of weatherization but could not afford to have the work done. NMIC did not require any contribution because the department had no additional funds in their budget. In that instance and in similar situations where there are no owner funds that can contribute to the "buy-down" of the major measures' cost in order for them to meet SIR, WAP dollars are restricted to the cost-effective measures identified in the energy audit only– usually resulting in a reduced scope of work. For this particular homeless shelter, NMIC installed some windows, but it could only install what the audit showed as cost-effective measures. NMIC reports not dealing with these situations very often.

Leveraging

NMIC leverages its weatherization program dollars with utility money mostly secured through NYSERDA programs aimed at improving energy efficiency in MF buildings. NMIC started supplementing WAP dollars with utility ratepayer funds through a program called ULEEP (Utility Low-income Electric Efficiency Program), funded by Con Edison. In 1997, NYSERDA took over the ratepayer fund. NMIC continues to leverage utility money through NYSERDA's MF Performance Program (MPP) and uses Con Edison funds to install electric measures in both apartments and the common areas of MF buildings. NMIC plans to utilize MPP and Con Edison programs more extensively after the ARRA grant funding expires.

Unit and Common Area Measures

NMIC has two in-house crews and three workforce development interns. The crews perform most in-unit and common area (See Figure C2.4) work installing CFLs, low-flow shower heads, door sweeps, smoke alarms, covers for window air conditioners. In addition, NMIC can seal air leaks with using weather-stripping, caulking and spray-foam insulation.

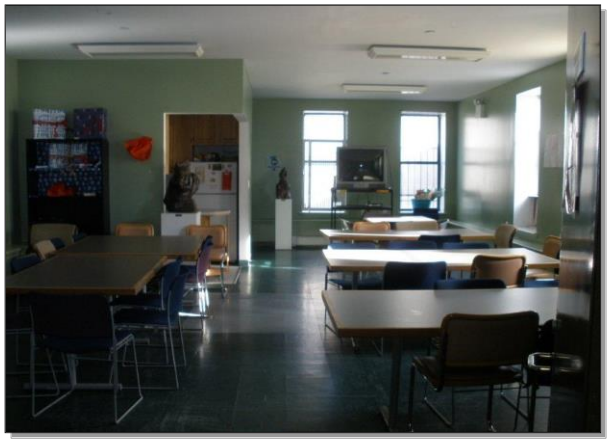


Figure C**2.4. Common Area in NMIC's Lead Safe House**

Over the years, the crews have learned to identify and can often anticipate tenant needs and behaviors. For example, in HUD buildings with through-the-wall air-conditioning units, sleeves for the units are distributed to the tenants to reduce drafts. Crews have noticed that often, tenants do not have space to store the sleeves during the seasons when they are not in use. The crews now consider storage capacity for the sleeves while they are working in the unit and will identify alternative storage elsewhere in the building if necessary. Crew members appreciate the importance of tenant comfort and the lengths tenants will go to achieve control over the temperature within their units, and the impact this has on the efficiency of the building.

Major Measures

In addition to the unit and general usage area installations by the in-house crew, NMIC subcontracts out for the cleaning, testing, and maintenance of equipment and for major measures including the:

- replacement of heating system equipment
- replacement of domestic water heating equipment
- replacement of windows
- insulation in walls and roof cavities

Weatherization services may also include other energy-related improvements, such as water heater repair/replacement, roof repair/replacement, chimney repairs, lighting fixture replacement, ventilation systems, heating distribution system replacement, refrigerator replacement, installation of GFCI outlets, and electrical service upgrades.

Training and Education

NMIC believes that education is key to maximizing the energy efficiency of a building. The crew chiefs and heating contractors train superintendents, ("supers"), on operating the newly installed heating systems (See Figure C2.5). Building owners are required to pay for supers to attend a five-day training offered by AEA. NMIC staff members believe DOE should consider superintendent education as an allowable expense. In fact, in NMIC's opinion, there should be a combination of super-plus-tenant education where supers are schooled in basic building science and tenants are educated on how their behaviors impact the building's efficiency and comfort. There is an observed "perceived comfort issue," which can lead to tenants overheating, or "cooking" the building. Tenants may receive education in steam heated buildings on the operation of their radiators and the impacts of opening windows in overheated buildings. Addressing heating system issues, engaging in dialogue with tenants, supers, managers and building owners, and education are all components of NMIC's approach to achieving both energy savings potential and improved tenant comfort.

Figure C2.5.
Heating System
Controls

NMIC makes it a point to engage both tenants and staff in a discussion on the selection of measures for a given apartment. For example, they explain to tenants why they are replacing showerheads as a measure to conserve water and to reduce energy consumption related to heating it. There are "layers to this." NMIC believes that in order to achieve maximum savings in a building, the human factors related to superintendents' knowledge and skill, as well as tenant behavior, must not only be considered but taken seriously.

Accrual of Benefits to the Tenant

By law, tenants are required to be the primary beneficiaries of WAP. In recognizing that there are instances in which tenants do not pay directly for the energy they consume, DOE has issued guidance on ways that WAP agencies can ensure accrual of benefits to the tenant. General assertions of potential benefits are not adequate. The following is a list of acceptable examples of tenant benefits under DOE WAP guidance:

- Longer-term preservation of the property as affordable housing;
- Continuation of protection against rent increases beyond that required under the WAP regulations (10 CFR 440.22(b)(3)(ii));
- Investment of the energy savings in facilities or services that offer measurable direct benefits to tenants;
- Investment of the energy savings from the weatherization work in specific health and safety improvements with measurable benefits to tenants;
- Improvements to heat and hot water distribution, as well as ventilation, to improve the comfort of residents; and
- Establishment of a shared savings program.

Consistent with NMIC's commitment to preserving affordable housing, the agency encourages protection against rent increases after weatherization has taken place. The tradeoff for the building owner is a more energy-efficient building, resulting in energy cost savings and NYC tax credits. Otherwise, tenants could face rent increases as a result of major capital improvements completed by

the building owner without WAP involvement. The only reported instance of rent increases appears in the case of lease renewals, when rent is allowed to be raised by a rent guidance board. This issue appears to be beyond the control of WAP or NMIC.

Health and safety measures include the installation of CO and smoke detectors, testing ovens and heating appliances for CO and gas leaks, pest management as a result of air-sealing measures, cleaning ducts and repair ventilators in the ventilation systems and improved lighting in common areas. These measures are intended to improve health and quality of living standards for tenants.

NMIC's weatherization program also supports the agency in promoting secure and violence-free environments for inhabitants. In a recent AEA documentary, one of the building occupants described the stress and pressure of residing in an unsafe and unhealthy apartment building before weatherization. She stated she felt as though she was "pressed on," and that weatherization created a safe living space relieving that pressing sensation. Ameliorating the physiological and psychological symptoms of oppression and poverty through work like weatherization is a benefit that is often overlooked, but is important to the residents and a meaningful outcome.

C2.4 Barriers to Weatherizing the MF Housing Sector in New York City

NMIC's weatherization program staff identified on-going barriers to weatherizing eligible buildings in their service territory, as well as barriers to the weatherization of MF buildings in general. Some, such as internal bureaucratic problems endemic to nonprofits and supportive housing administrations, are beyond NMIC's control. However, there are also some WAP rules and guidance that can impede a WAP agency's ability to achieve the goals of the program within this housing sector. For example, NMIC staff are not supposed to revisit buildings after work has been completed, but often need to go back to a building to "tweak" settings on heating equipment; sometimes they even drive by a building in the winter, checking for open windows on the upper floors that would indicate problems with heat distribution. Although they do this with the blessing of their state monitors, they believe WAP should allow them to observe seasonal variation so they can check on their work. It makes no sense, in their opinion, to install a sophisticated heating system in the middle of the summer and then walk away without returning to assess performance in the following seasons. A WAP rule preventing fuel switching[15] (for example, from oil to natural gas) limits both NMIC and the building owners regarding cost performance. Building owners expressed a desire to convert to natural gas because it is cheaper than fuel oil, but the WAP rules prevent this.

[15] "5.11 FUEL SWITCHING: WAP does not permit the general practice of non-renewable fuel switching when replacing furnaces/appliances. However, DOE does allow the changing or converting of a furnace/appliance using one fuel source to another on a limited, case-by-case basis only." (2010, WPN 11-1, pg. 22)

Deutsche Bank Americas Foundation Study: "Recognizing the Benefits of Energy Efficiency in MF Underwriting"

In 2011, NMIC participated in a research study initiated by Deutsche Bank Americas Foundation.[16] The study sought to determine the feasibility and potential success for the financial industry to invest in energy efficiency retrofits in MF buildings in New York City. To encourage private capital lending in an industry dominated, but limited by, public subsidies, stakeholders in the energy efficiency industry furnished data to support the claim that energy savings pay for investments, and identified ideal strategies and conditions for achieving projected savings. It is unclear whether the results from this study will have an impact on NMIC, which deals mostly with publicly subsidized buildings as opposed to privately owned buildings. Market transformation has yet to occur, and as NMIC had only recently starting exploring the fee-for-service market. NMIC staff did report that the study validated the worth of their work.

C2.5 The American Recovery and Reinvestment Act (ARRA)

During the ARRA grant period, NMIC's weatherization program was allocated $14.4 million to weatherize 2,044 units between PY 2009 and 2012. The agency exceeded its charge, completing 2,853 units. New York State's total for the period was 62,143 units with 86 percent of those units completed in MF buildings with five or more units. Before the ARRA grant, 3,000 units were on the waiting list for NMIC's weatherization program. During ARRA, the waiting list shrank to 1,200 units.

Prior to ARRA, NMIC had employed six full-time equivalent staff to support its weatherization program, but during ARRA, the program was able to support 12 full-time staff. Four persons were added to the in-house crew, one was added to assist with tenant income verification, and one person was added to support compliance with Davis-Bacon regulations. The plan for post-ARRA funding and a 40 percent cut in their base contract for regular program funding was to only let go of the workforce development interns. This anticipated reduction in staff was observed across the WAP network nationwide.

Davis-Bacon

According to NMIC representatives, Davis-Bacon reporting requirements had a crippling effect on their weatherization program; they believe only the field staff benefitted. A new position was needed to ensure Davis-Bacon compliance, and the entire accounting and payroll system required change. In addition, waiting for Davis-Bacon rules to flow down from the federal office delayed weatherization work for approximately seven months.

[16] https://www.db.com/usa/content/en/ee_in_MF_underwriting.html

C2.6 Building Owner Debriefing

ORNL WAP evaluation researchers met with three MF building owners—Lee Mosier, David Freeman and Paul Salib. Together, these business partners have weatherized three of their MF buildings. They were initially referred to NMIC through NYSERDA in 2010. Salib viewed WAP as an opportunity to save money by weatherizing his buildings and thus being free to invest the saved capital in other areas, thereby creating a better environment for tenants while improving the building. For him, the 25–30 percent owner contribution was worth the investment; he reported that the investments pay off in two to five years, depending on which major measures are installed. The owners reported that after a building is purchased, they complete the building's to-do list with the following items:

1. Installing security cameras as a signal to tenants that the new owner(s) wants to create a safer living space for those residing in the building (See Figure C2.6).
2. Dealing with violations; buildings can have hundreds of city health and safety violations. A violation team goes through a building unit-by-unit to address the violations.
3. Signing up all buildings with the local District Attorney's office which has a program, in which a building owner can give an empty apartment to the police department to work out of, increasing safety for building residents.
4. Fire-escape repairs
5. Changing boilers to run on natural gas if necessary; Salib reported a 35 percent energy savings and reports if there was no fuel switching the projected savings were at 25 percent.

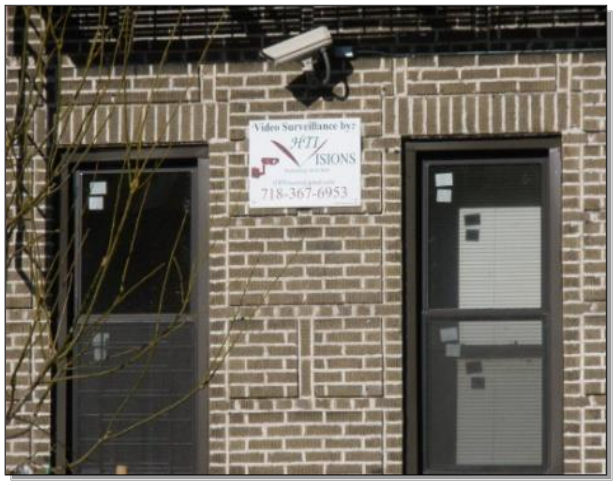


Figure C2.6. Camera and Surveillance System

The three building owners described their experience with one of the properties they had purchased and eventually weatherized. The Sherman Avenue property (93 units; 56,000 square feet) was bought in fairly poor condition. They reported that there was a time when investors would buy buildings looking to make money. What resulted was a property with numerous city violations and

buildings infested with pests and drug dealers due to the investors having little interest in managing the property. After purchasing the buildings and dealing with the building's city violations and crime issues, the new owners looked to NMIC to help. Weatherization involved a comprehensive scope of work, which included air sealing in the apartments, a new boiler, new refrigerators, and installation of pipe insulation, roof insulation, and common-area lighting. Salib reported the test-in and test-out numbers are proving "tremendous" energy saving results, noting that he is now able to put that capital into other places, such as the revamping of common areas and the installation of an elaborate camera and security system. On the wish list: solar water heating technology.

In addition to seeking energy savings, the building owners reported interest in the quality of life of their tenants. They reported viewing the footage from AEA's weatherization film with tenant testimonials, and reported that it was "eye-opening" to hear the tenant story. Prior to weatherization, tenants reported not being able to breathe in their units, and now they can. The owners also opted to install temperature sensors in the top floor to prevent over-heating.

The owners reported being very satisfied with the work completed. They reported achieved energy savings and the ability to re-invest in the building for the benefit of the property, and for its tenants. They reported NMIC staff went "above and beyond" to ensure quality work was completed.

C2.7 Site Visits

Independence House

The researchers conducted a site visit to Independence House, a weatherized building in the Washington Heights community (See Figure C2.7). The building is owned by an organization called Assistance for Case Management and Housing (ACMH). The building consists of three floors with a total of 24 residential units. There is one common kitchen and six shared bathrooms. NMIC installed CO and smoke detectors in all units, CFLs in common areas, and provided insulation blankets for the window AC units, which had poor "wings." Before weatherization, the building had a cast-iron atmospheric boiler, which was replaced with a high-efficiency condensing boiler. While the unit was being switched out, a temporary boiler was brought in with hoses run from a truck outside the building. Weatherization also involved duct sealing and installation of a circulating domestic water heating system.

Figure C2.7. Independence House

NMIC's Lead Safe House and Renewable Energy

NMIC asserts that the children most at risk for exposure to lead [in its territory] reside in the Washington Heights and Inwood communities. For this reason, NMIC operates a Lead Safe House program for families with children with high lead levels. One component of this program provides temporary shelter to families while lead remediation work is conducted in their apartments. There are a total of 15 housing units in the building that NMIC operates for this purpose (See Figure C2.8). Some of these are rented out at market rates to offset the costs of operating the building.

Figure C2.8. Virginia Fields Manhattan Lead Safe House

To further offset energy related costs of the lead-safe shelter building, NMIC has partnered with Morgan Stanley, a financial advising corporation, seeking tax credits.

Morgan Stanley donated money for the installation of a photo-voltaic system that supplies 4.7 Kilowatts of energy. The system provides for the electrical needs of the common spaces, including the meeting room, elevators, hall lighting, and electrical heating. Developing these partnerships and projects targeting the reduction of energy consumption in MF buildings is further testament to this agency's commitment to the preservation of affordable housing and the families that they house.

C2.8 Exhibits

Westbeth

During ARRA, NMIC completed weatherization work at Westbeth, an artist community managed by a nonprofit with an old HUD mortgage. NMIC titled this weatherization job the "Most Complicated Weatherization Case in New York." The property contained nine structures all connected by underground heating pipes. The structures had old steam-heating units that were replaced by NMIC with a high-efficiency boiler. To complicate this already complex job, Westbeth is a multi-use property supporting a synagogue and numerous art studios (See Figure C2.9). Because WAP dollars can only be spent on residential areas of a building, the property owners contributed $250,000 and MPP funding was also secured from NYSERDA. This project is a demonstration of how a multi-use property can be weatherized using both WAP and leveraged funding.

[NOTE: The lead author had an opportunity to re-visit Westbeth in winter 2017. The building was hit hard by Hurricane Sandy. Water surging from the Hudson River flooded the extensive below grade space of the building. Several building maintance staff were almost trapped in their offices by the rapidly rising water. The newly installed furnace modules were inundated and became unoperational. Power was lost to the entire building. Water pressure was not sufficient to supply water to the upper floors. Artists who had studios and storage room below grade lost everything. As part of the recovery effort, funds have been allocated to elevate the furnace modules and better seal the ground-level windows to make the building more resilient.]

Figure C2.9. Westbeth

The DOE and HUD Memorandum of Understanding (MOU)

The partnership between DOE and HUD was announced on February 27, 2009, outlining a plan to streamline and stimulate home energy conservation through weatherization services in public and assisted housing. The goal was to create a more affordable housing stock for low-income populations, and to spur job growth within the sectors of home energy efficiency. A MOU was created in May of the same year with a list of commitments consistent with the mission of both federal agencies. Highlighted tasks of the MOU included the following actions, which have since been accomplished:

- HUD provided DOE with a list of HUD Qualified Housing projects and Low-Income Housing Tax Credit (LIHTC) projects meeting WAP eligibility criteria for MF housing to reduce the burden of income verification and eligibility on local weatherization agencies.
- HUD and DOE provided guidance to all entities impacted by the partnership, educating stakeholders on the theoretical and logistical implications of aligning resources.
- HUD and DOE developed a system for training and technical assistance to assure successful implementation and execution of the program
- HUD and DOE will evaluate the process and outcomes of the partnership to inform future policy, explore other innovative ways to partner within common missions, and identify approaches for future leveraging initiatives.

A Final Rule, effective February 24, 2010, was published on January 25, 2010 in Vol. 75, No. 15, page 3847 of the Federal Register, stating that under Title 10 CFR, Part 440:

"The U.S. Department of Energy (DOE) is amending the eligibility provisions applicable to multi-unit buildings under the Weatherization Assistance Program for Low-Income Persons. As a result of today's final rule, if a multi-unit building is under an assisted or public housing program and is identified by the U.S. Department of Housing and Urban Development (HUD), and included on a list published by DOE, that building will meet certain income eligibility requirements, and will also satisfy one or both of the procedural requirements to protect against rent increases and undue or excessive enhancement of the weatherized building, as indicated by the list, under the Weatherization Assistance Program without the need for further evaluation or verification."

The Final Rule provides details about these and additional requirements relating to the benefits that must accrue primarily to the occupants of the rental unit.

Neither states nor local weatherization agencies are required or expected to set aside weatherization funds for public or assisted housing. This determination is left to the discretion of the state, which may or may not then leave to the discretion of a WAP subgrantee. States that have not set aside funds specific for this project allow local weatherization agencies to determine approval for public or assisted MF housing retrofits based on timing and available funds or resources. States may also set aside funds for state assisted public housing, but not for HUD-assisted public housing.

HUD bears the burden of the financing and furnishing of three lists supplying data on public or assisted MF properties, buildings, and projects meeting WAP income eligibility requirements. HUD is responsible for verifying eligibility and DOE is then responsible for publishing the list. It is understood that if a building, property or project is on the list, it is eligible for WAP and no further verification of eligibility is required on the part of DOE, grantees or subgrantees. DOE stated intentions to support the HUD and DOE partnership aimed at streamlining the weatherization process for this housing stock by adhering to the Final Rule published in the Federal Register.

HUD excluded the following public or assisted MF buildings from the lists:

- Buildings where income could not be verified as a result of non-reporting.
- Buildings that did not meet income eligibility.
- Indian Housing, as HUD does not collect data on housing type or occupant income. These tasks are delegated to the Indian Housing authorities.

Excluded buildings or properties may still be eligible for weatherization services but require income verification by the local weatherization agency.