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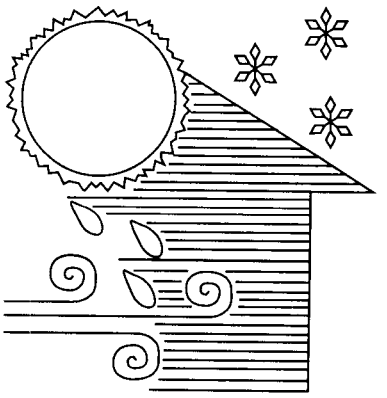
Description of the Weatherization Assistance Program in Larger Multifamily Buildings for Program Year 1989

J. M. MacDonald



Weatherization Assistance Program

MANAGED BY
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FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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Energy Division

Description of the Weatherization Assistance Program in Larger Multifamily Buildings for Program Year 1989

J. M. MacDonald

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EXECUTIVE SUMMARY

The efforts of the U.S. Department of Energy (DOE) Weatherization Assistance Program (the Program) in larger multifamily buildings were examined for Program Year 1989. The results show that about 20,000 dwellings in these multifamily buildings were served under the Program that year. This is 9% of the total number of units served nationally, while costs were 7% of total national costs. High levels of activity in larger multifamily buildings were reported for some States, with New York accounting for half of all the residences treated. Owner investment is an important strategy in New York for improving their efforts.

A wide range of measures was installed, but the materials costs for the measures are dominated by the cost of windows (80% of the total for that year). Where the whole building was treated, $561 was invested per unit, while for partial-building work the total invested was $417. The energy savings and cost effectiveness of the Program were not estimated, because energy use and cost data adequate for developing such estimates could not be obtained (see Section 1.4 on Obtaining Energy Use Data).

Background

This report describes the nature and extent of weatherization activities under the DOE Weatherization Assistance Program in larger multifamily buildings (buildings with five or more dwelling units). DOE initiated this study to provide policy makers and program implementers with up-to-date, credible, and reliable information on the Program for making effective decisions. With assistance from Oak Ridge National Laboratory (ORNL), a National Evaluation of the Program was designed. The evaluation includes five studies overall, and this study is one of them. Two national surveys were conducted as part of this study: one of the States and one of local weatherization agencies. These data are the source for the results presented in this study.

Findings

The survey of the States yielded direct responses from 33 States. High levels of activity in multifamily buildings were reported for 11 of the 33 States. A few States indicated they do not have significant numbers of these types of buildings with more than 66% of the households income-qualified. New York is the only State which has conducted an evaluation of multifamily work under the Program in larger buildings in the past 10 years.

Special audit procedures for dealing with larger multifamily buildings were used by 9 of the 33 States. Strategic partnerships for multifamily buildings have been used or developed in 7 of the 33 States. The "66% Rule" causes difficulty with qualifying buildings for eligibility under the Program in 6 of the 33 States. Policies regarding owner investment are

in place for multifamily buildings in 11 of the 33 States, and 11 of the 33 States have considered or implemented policy changes regarding larger multifamily buildings recently. Nine of the 33 States offer some training related to field inspections of buildings and selection of measures to be installed that was felt to be applicable to multifamily buildings, with 6 of these States having very extensive training.

Overall, better understanding of "good" retrofit packages applicable to the Program (probably developed by region) appears needed. New York and Massachusetts provide important evidence that the impact of the Program for these buildings can be expanded. However, despite important improvements achieved to date, weatherization personnel from New York assert that much more still needs to be learned about the performance of measures in larger multifamily buildings, and they are currently working to plan additional research in this area.

Recommendations

Considering the importance of better information on measure performance and recent changes in States with advanced programs, specific recommendations are:

1. Begin initial case study evaluations of specific buildings and the measures installed in those multifamily buildings. A case study of one large multifamily building provides results for many dwellings that are specific to a State or region. The initial case studies should be conducted to better understand the current state-of-the-art in multifamily weatherization under the Program. These case studies should be selected from cities in States with significant levels of multifamily activity, such as New York, Illinois, Minnesota, and Washington.

2. The reporting of these the initial case studies should include a summary on the benefits of specific measures, groups of measures, field procedures, or management procedures found in the case studies. This summary should also include recommendations regarding measures or procedures that deserve further refinement or assessment.

3. The Program should change data reporting requirements for Grantees to include specification of the amount of work accomplished in larger multifamily buildings. This change is important for highlighting the importance and also the different nature of this sector. For both small and large multifamily, Grantees should report the number of multifamily residences that were not treated as part of the whole building.

4. The impact of partial-building work on cost effectiveness should be studied at some time in the future. Many States have building stock where only individual apartments can be retrofitted under rules of the Program, and the cost effectiveness of this partial retrofit work must be understood better to determine if it should be continued.

5. Considerable expertise with multifamily buildings exists in some States. Transfer of this knowledge to other States that conduct multifamily work should be planned as the results of the case study work begin to be reviewed.

6. In addition to the knowledge gained from work conducted under the Program, the work of other organizations performing work in multifamily buildings should be considered relative to future refinement of procedures or measures used under the Program. For example, the work in Minneapolis and Chicago, cited in section 6.4 of this report, should be recalled when reviewing the case study results. Also, the work of Citizens Conservation Corporation, in Boston, should be examined, if access can be gained to their results.

7. Program procedures should be changed to effectively capture the energy savings to be found from common area or "house" lighting in these multifamily buildings. The savings from these lighting retrofits are important, and crews should attempt to achieve these savings while they are in a building, if the whole building is included in the work.

Description of the Weatherization Assistance Program in Larger Multifamily Buildings for Program Year 1989

J. M. MacDonald

ABSTRACT

This report describes the nature and extent of weatherization activities under the U.S. Department of Energy (DOE) Weatherization Assistance Program (the Program) in larger multifamily buildings that have five or more dwelling units. DOE initiated this study to provide policy makers and program implementers with up-to-date, credible, and reliable information. Two national surveys were conducted as part of this study. The results from the two national surveys show the Program to have served about 20,000 dwellings in Program Year (PY) 1989. These 20,000 dwellings represent about 9% of the total number of units weatherized that year. The total costs for the Program efforts in these buildings are about 7% of total national costs for the Program. The energy savings and cost effectiveness of the Program were not estimated, because adequate energy use and cost data could not be obtained. Materials costs for the Program in multifamily buildings in PY 1989 are dominated by the cost of windows (80% of the total). The Program should begin ongoing case study evaluations of specific buildings and measures for these buildings to better understand the current state-of-the-art in multifamily weatherization under the Program, increase understanding of the performance of measures, and capture useful knowledge that can be transferred to other locations.

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This study could not have been completed without the cooperation of local and State weatherization program managers and the DOE Regional Support Offices, who took time away from their busy schedules to provide data and other assistance to the National Weatherization Evaluation. The input received from all of these individuals is greatly appreciated.

1. INTRODUCTION

This report describes the nature and extent of weatherization activities under the U.S. Department of Energy (DOE) Weatherization Assistance Program (the Program) in larger multifamily buildings. For this study, a multifamily unit is defined as a dwelling that is located in a structure containing more than four residences that are not located in row-housing (which includes townhouses). The nature of these activities will be described in terms of what measures are being installed, what procedures are used to select those measures, and what costs are incurred for installation of the measures. The extent of the program will be described in terms of how many States and agencies perform work on multifamily buildings and how many agencies and States use different procedures.

Little information is available on the effectiveness of weatherization procedures in these larger buildings, partly because the more complex building systems and the larger number of occupants per building make dealing with these buildings more difficult. Very few impact evaluation data exist for these buildings.[1] The study reported here also does not provide empirical information on cost effectiveness for the Program activities described.

Larger multifamily buildings represent about 15% of the 94 million residences in the country in 1990 (all income groups), and they account for about 9% of the 16.5 quads of total annual residential energy use (EIA 1993) on a source basis (where electricity is converted at 11,600 Btu/kWh to account for generation and transmission losses). In comparison, single-family and small multifamily (those with 1–4 dwellings per building) together account for about 80% of all residences and almost 90% of residential energy use (again, all income groups).

Residences in multifamily buildings with 5 or more units were previously estimated to account for about one-third of all Program-eligible renter-occupied residences (The Economic Opportunity Research Institute, Inc. 1986), based on the 1984 Residential Energy Consumption Survey (RECS) data (EIA 1986). Estimates made for this study based on the 1987 RECS data (EIA 1990) show that eligible[2] renters in larger multifamily buildings that are not in public housing projects account for about 3.5 million households. These 3.5

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1. Tom Wilson, of Synertech Systems Corp, in Syracuse, New York, conducted a major literature review in 1990 for the State of Michigan on "Multifamily Weatherization Research," and he has communicated to us that no evaluation results covering work in larger multifamily buildings under the Program were available for that study.
2. Defined as households earning less than 150% of poverty-level income.

million represent 15% of all eligible households not in public housing and 33% of all eligible renter-occupied residences not in public housing projects. (Public housing weatherization improvements are funded mostly through the U.S. Department of Housing and Urban Development.) The 1987 RECS results confirm the earlier estimates based on the 1984 RECS data, and results for the 1990 RECS (now HECS) data are expected to be similar.

DOE initiated this study to provide policy makers and program implementers with up-to-date, credible, and reliable information on the Program for making effective decisions. With assistance from Oak Ridge National Laboratory (ORNL), a National Evaluation of the Program was designed. The evaluation is comprised of three "impact" studies and two "policy" studies (Beschen and Brown 1991). The three impact studies are focused on energy-savings and cost-effectiveness performance of the Program in three key markets:

- Single-family and small multifamily study (Single-Family Study, Berry et al 1991)
- Fuel-oil study of single-family homes in nine Northeastern States (Fuel-Oil Study, Ternes et al 1992)
- Larger multifamily study of buildings with five or more dwelling units per building (Multifamily Study, the study reported here)

The data collected for the Single-Family Study and the Fuel-Oil Study have permitted evaluation of the nature of the people and buildings served, the measures installed, the energy saved, cost effectiveness of the measures, and other factors. The data obtained for the Multifamily Study have shown limited penetration of the Program to multifamily buildings. In addition, obtaining energy use data from records as far back as 1988 (the pre-retrofit year for the Program in 1989) was not possible without great difficulty. Because of this difficulty, few energy use data were obtained, and the energy savings and cost effectiveness results could not be completed for larger multifamily buildings (see Section 1.4 on Obtaining Energy Use Data).

Thus, the Multifamily Study is essentially a supporting study. The other two supporting studies on policy from the National Evaluation address the characteristics of the Program network (Mihlmester et al 1992) and a profile of low-income weatherization resources and the population already weatherized (Power et al 1992). Together the five studies comprise the National Evaluation of the Weatherization Assistance Program. The Multifamily Study is the most exploratory of the five, since much less is known about how the Program deals with these larger buildings and the extent of services provided by the Program to these buildings.

1.1 OVERVIEW OF THE WEATHERIZATION ASSISTANCE PROGRAM

Federal efforts to weatherize the homes of low-income people began as far back as 1973, and efforts have progressed through several legislative authorizations to the present program conducted under the responsibility of the DOE. The goals of the Weatherization Assistance Program include: increase the energy efficiency of low-income households, reduce the impact of high energy costs on low-income households, and improve the health and safety of those residences, particularly those of the elderly, the handicapped, and families with children. (A more extended overview of the Program is provided in the evaluation results for the Single-Family Study, Brown et al 1993.)

The Program provides formula grants and operates in a decentralized fashion. Federal grants are negotiated with States which, in turn, provide grants to local agencies (approximately 1,100 for all States and the District of Columbia). The local agencies actually perform or contract for the weatherization work performed at individual homes. (Extensive information on States and agencies can be found in Mihlmester et al 1992.)

Total expenditures by full-scale weatherization programs throughout the country between 1978 and 1989 are estimated to be $4.4 billion (Power et al 1992). In addition to DOE, other sources such as utilities, the U.S. Health and Human Services Department, and the States also provide funding for these activities. Nevertheless, most funds are spent under DOE rules for the Program.

1.2 LITERATURE REVIEW

A major review of multifamily retrofit efforts was completed by Goldman et al in 1988. This review covered many types of retrofits in larger multifamily buildings and provided some important insights regarding the factors affecting cost effectiveness of multifamily retrofits. Savings were found to range from 10 to 30% of pre-retrofit consumption. Some exceptional savings of 50% of energy use were observed, but in other cases savings were low. The review showed the uncertainty of energy savings for specific buildings and the importance of heating system retrofits for central heating systems. This review did not cover any buildings that received retrofits under DOE's Weatherization Program, so direct information on the Program is not available from this source. However, the insights provided by this review are applicable to the Program to some degree, and these insights will be discussed as appropriate in following sections.

More information is available from other sources on the benefits of retrofits installed in multifamily buildings. However, most sources available do not cover buildings that

received retrofits under the Program. Thus, previous evaluations of programs for larger multifamily buildings are, for the most part, not directly applicable.

Evaluations of efforts under the Program in multifamily buildings have been located only for New York City and Seattle. The New York City results are brief and simple; they cover 12 large oil-heated buildings only, having a total of 570 dwelling units. The results, unadjusted for any control group, were that the buildings had an average annual savings of 17%, which is similar to results obtained for the Fuel-Oil Study (Ternes et al 1994) in single family residences. The Benefit/Cost ratio for the New York multifamily buildings, for only the DOE investment (not including owner investment of $222,000 out of $713,000 total), is 2.56, with a standard deviation of 1.57 (Synertech 1991). No extended analysis of these buildings was performed.

A very extensive evaluation addressed work directed toward all-electric multifamily buildings in Seattle (Okumo 1991). Work conducted for Seattle City Light under Program procedures was evaluated side-by-side with a program run by the utility for multifamily buildings that did not qualify as low-income. Thus, two main treatment groups of buildings (for two cohort time periods) were evaluated: standard-income and low-income. Apparently, the low-income buildings were treated essentially as if they were treated under the Program, although the second low-income cohort appears to have been modified to include some significant common area lighting measures. The utility paid for all measures in low-income buildings, with a guarantee that rents would not be raised for five years, and provided very generous no-interest loans to standard-income building owners for installation of measures.

The types of measures installed in the two side-by-side programs varied, as the buildings weatherized under the Program received fewer lighting retrofits to common areas, fewer low-flow showerheads, and more safety and security measures. These Program buildings also were more likely to have venting and caulk/weatherstrip installed. Windows were installed in almost all buildings. The range of installed costs were $272 to $2,605 per unit for standard-income buildings and $432 to $3,612 for the low-income buildings.

Okumo concludes that buildings weatherized under the Program had a net savings (after control group adjustment) of 4 to 9%, while standard-income buildings had a net savings of 13 to 18% of pre-retrofit energy use. Savings are evaluated for the whole building, for common area lighting retrofits, and for dwelling unit measures. She concludes that common area lighting measures should be emphasized, as they produced a big savings at a low cost. The lighting retrofits appeared to have an important role in the differences between standard-income and low-income building results.

For the dwelling unit measures, her analyses indicate that windows probably provided 70% of the total thermal energy savings. She implies that other dwelling unit measures, which included insulation, venting, pipe/duct insulation, caulk/weatherstripping, misc./repair, and inspection and possible replacement of knob-and-tube wiring, need better optimization. Repair measures and knob-and-tube wiring work were generally not part of the work performed on standard-income buildings. Also, very little caulking and weatherstripping, much less venting, and much less pipe/duct insulation (typically to domestic water piping) were installed in standard-income buildings. Many of these measures do not contribute significantly to energy savings.

Cost effectiveness of measures in Seattle were estimated, and the net levelized cost (after control group adjustment) of all measures for low-income buildings is generally around $0.10/kWh for both the first and second year the program was run, while the levelized cost for all measures in standard-income buildings is reduced from $0.075/Kwh the first year to $0.056/kWh the second year.

For dwelling unit measures, a calculation of the energy saved for each measure showed the net levelized cost for windows to be reasonably equivalent for both low-income and standard-income buildings, but windows were generally not cost effective, with levelized costs ranging from $0.060–0.130/kWh (assuming 70% of thermal savings is attributed to windows). Several models of windows savings were formulated and tested, and these models indicate savings for the windows of about 70% of total electricity savings, although these results require further verification. Okumo also suggests that advances in window technology can be expected to improve results for windows, but specific advances are not explicitly stated. For other dwelling unit measures besides windows, the net levelized cost for low-income buildings, at $0.050–0.075/kWh saved, was two to three times as high as the levelized cost for standard-income buildings. Okumo concludes that the causes of these differences should be explored, although the major factor for the differences may be the investment by the low-income program in several measures that contributed little or nothing to energy savings.

These two reports provide a mixed picture of results achieved in larger multifamily buildings in somewhat similar climates with approximately similar investment levels (the value for New York is $1,250 per unit). The New York Program deals with low-income buildings which typically have hot water or steam boilers providing heat, while the Seattle buildings are all-electric. Details on the measures installed in New York are not known, but the results of this study and contacts with people working in New York City indicate that work on heating systems is important to achieving significant savings. The national review of multifamily programs (Goldman 1988) also indicated that heating systems work was important to achieving good results.

The New York data suggest that the Program is cost effective there, while the Seattle results indicate that the Program was not cost effective by their regional criteria. The difference in heating systems appears to be a potential major factor accounting for this difference. Differences by region are important for understanding the Program and results achieved under the Program for multifamily buildings.

1.3 COVERAGE OF THE REPORT

This report describes the data collection design, presents results of the survey of the States and of the survey of local agencies, presents a discussion of the overall results, and provides conclusions and recommendations. The results from local agencies include detail on the types of buildings served, the measures installed, technical methods used, and measure costs. Adequate energy use and cost data for an analysis of energy savings and cost effectiveness could not be obtained, and no estimate is made of cost effectiveness for the Program.

1.4 OBTAINING ENERGY USE DATA

A significant amount of work was conducted in this study to obtain energy use and cost data needed to estimate cost effectiveness for the Program. The major stumbling block to obtaining these data occurs when the data move from on-line electronic form in a computer system to archival status. Once data are archived, the costs and personnel time required to retrieve the data increase dramatically. Retrieval then becomes very difficult because of resource constraints (usually the personnel time is not available to achieve the retrieval). Thus, the primary lesson for researchers who wish to obtain and use energy use data is to obtain the data before they are archived, which is typically 12 to 18 months from the present. If a study is designed to obtain these data before they are archived, data collection should begin as soon as possible after the data collection design is completed, and the data collection design should recognize the 12 to 18 month limitation.

2. DATA COLLECTION DESIGN

As part of the Single-Family Study, a national survey of a sample (about 400) of the approximately 1,100 subgrantees operating across the country was conducted. Because the study is designed to estimate the impacts of the Program (and not the impact of other programs that fund weatherization), the sample was restricted to dwellings weatherized entirely, or in part, with DOE funds or with funds from other sources (such as Oil Overcharge or Stripper-Well) used according to Program regulations. Thus, dwellings weatherized entirely with Low-Income Home Energy Assistance Program (LIHEAP) funds were not included in the sample if they were not administered according to Program regulations.

The sampling design used in the national survey is described in the Single-Family Study Experimental Plan (Berry et al 1991). To ensure thorough geographic coverage, the continental United States was divided into ten subregions, each comprised of three or more States, and the sample was drawn proportionately from each region.

While approximately one third of the nation's subgrantees were sampled, the largest 10 local agencies of the Program (with the greatest number of households weatherized in PY 1989) were included. However, dwellings for these larger agencies were sampled at only half the rate at which dwellings for other agencies were sampled. These large agencies tend to serve large metropolitan areas. Overall, a disproportionate number of multifamily units were expected to be in the sample.

Data were collected for a sample of the dwellings weatherized under the Program and a control group was to be used to adjust for factors outside the actual weatherization. The control group consists of dwellings on the waiting lists of agencies for future weatherization work.

Based on information received from the national survey of the Single-Family Study, data on weatherization of larger multifamily buildings were requested from 109 agencies (out of about 400) that appeared to have performed work in these larger multifamily buildings. In addition, survey data were collected from States to assess the approach taken by States toward these multifamily buildings and the guidelines and training support provided for multifamily buildings (the survey instrument is shown in Appendix A).

A survey instrument was developed for the Single-Family Study to obtain dwelling-specific data (Berry et al 1991). This form was field tested with several agencies and feedback from the agencies was used to refine that form. The form for the Single-Family Study was used as a starting point for developing a dwelling-specific survey form for the Multifamily Study. Only minor modifications were needed. The multifamily form was field tested with

four agencies and two consulting firms, and feedback from these organizations was used to make final modifications to the form before it was sent to agencies to obtain dwelling-specific data.

The dwelling-specific data on weatherized dwellings in multifamily buildings include significant descriptive information on the buildings weatherized, the measures installed, and the procedures used to provide the weatherization services (the survey instrument is shown in Appendix B). Energy use data were requested from utilities and building owners across the country for both treatment and control group buildings. The return rate for the treatment group characteristics data is fairly good (about 70% for dwellings that were truly in larger multifamily buildings), while the return rate for the requested energy use data is very poor (less than 5%). The energy use data needed for this study extended back several years and were very expensive to process. Thus, few data were obtained, and the energy savings and cost effectiveness analyses have not been conducted at this time. The results obtained from the treatment group descriptive data are presented in this report.

The sampling design for the Single-Family Study had one major shortcoming relative to understanding the Program work performed in PY 1989 in larger multifamily buildings: New York is not represented as well as it should be (the data following show New York to account for over half of all work in PY 1989). To address this shortcoming, additional survey data (using the same agency survey instrument) were collected from another agency in New York to check against our analysis. Although the additional data are not included directly in the analysis because they were received after the analysis data set had been developed and finalized, these data were checked to confirm that calculated values were reasonable in comparison with these additional data (that were not used directly).

The State-level data collected indicate that States often do not track larger multifamily buildings separately from smaller multifamily buildings (those with less than five dwellings per building), and agencies also sometimes confused smaller with larger multifamily buildings. Overall, the results of this study show that weatherization of larger multifamily buildings under the Program is not a large part of the total program, as presented in the following sections of this report.

3. STATE GRANTEE SURVEY RESULTS

A survey (Appendix A) was sent to 48 States, not including Alaska and Hawaii, to obtain some overview information on activities of the Program relative to larger multifamily buildings. The survey was returned by 33 States (two-thirds response) and the survey responses appear to provide a reasonable picture of the position of multifamily buildings in the Program.

In addition to the Grantee survey, a survey of agencies was also conducted (described in next section). As a result, numerous contacts were made with agencies and State Program offices in many States during the course of the study to discuss different facets of the study. The contacts led to much informal, verbal information about the nature of the Program for multifamily in most States. Only about 5 States are not represented to some degree. The extent of Program efforts in large multifamily are also quantified in the Network Characterization report (Mihlmester 1992), where large multifamily buildings were estimated to account for 6% of total residences weatherized under the Program in PY 1989. Based on these contacts and the supporting information generated by other studies in the National Evaluation, apparently few States with any sizable amount of work in multifamily buildings did not respond — Maine and California may be the only two of importance.

The most difficult part of analyzing data received for this study has resulted from the difficulty States and weatherization agencies sometimes have in distinguishing between small multifamily (buildings with 1–4 units) and larger multifamily buildings. Since DOE does not require States to keep records on the differences between these types of multifamily buildings, many States simply do not have the data. Thus, they are forced to estimate, or they force the estimating effort back to the requester. Many times the distinction between small and large multifamily appears to have been ignored. As a result, adjustment of the data is sometimes required, although these adjustments do not change the overall results much.

The raw response from the 33 States to the survey (including several estimates by States and by ORNL) show a total of 21,000 larger multifamily units weatherized by the Program in Program Year (PY)[1] 1989. However, 2,000 or more of these units are in public housing, and perhaps 1,000 are not truly dwellings in large multifamily buildings. Thus, these data show a total of about 18,000 units weatherized in larger multifamily buildings that are not in public housing and about 2,000 units weatherized in public housing multifamily buildings. Based on knowledge of the level of activity in States obtained through extensive

1. Program Year (PY) 1989 typically began in April 1989 and ended in March 1990.

interactions (including Maine and California), the Network Characterization Study results, and the Grantee responses here, a reasonable estimate of the total number of units served nationally under the Program in PY 1989 that are not in public housing is about 20,000 units. A map of the country showing the raw Grantee responses is shown in Fig. 1.

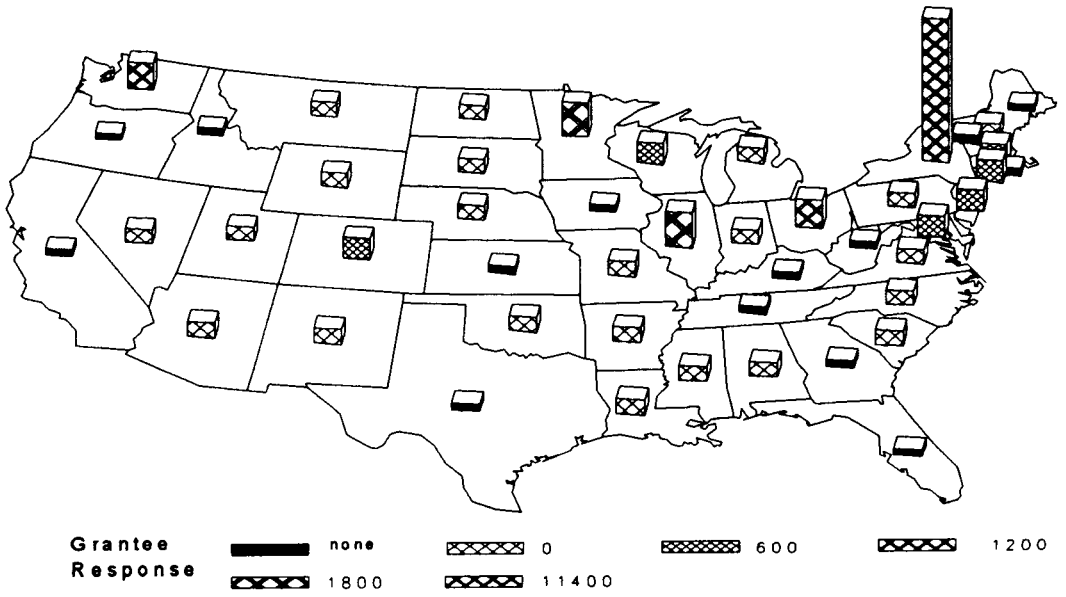

Figure 1 — PY 1989 level of multifamily weatherization activity indicated by Grantee responses.

The very short bars indicate no response. The tall bar for New York represents over 11,000 units weatherized. Some other States had over 1,000 units served, but New York accounted for over half of the total.

The bars on the map indicate levels of response, with taller bars showing many units weatherized and the very short bars showing no response or no dwellings served. New York dominates the number of units served in PY 1989, with over 11,000. New York also provided significant material concerning the methods used there to serve larger multifamily buildings.

Over 200,000 residential units of all types were weatherized in PY 1989 by local agencies using all types of funding (Mihlmester et al 1992). In planning for the National Evaluation, all agencies were surveyed to determine how many dwellings were weatherized using the criteria specified in the first paragraph of Section 2, Data Collection Design. The results of this survey showed that, with these funding criteria, 198,000 dwellings were weatherized in PY 1989 (Brown et al 1993). Using 198,000 single-family and small multifamily residences together with the additional 20,000 larger-building multifamily residences estimated here to be weatherized under the Program in PY 1989 leads to an overall total of interest of about 220,000 dwellings weatherized. The 20,000 larger-building multifamily residences represent 9% of this total.

The other information obtained from the State Grantee Survey shows that:

- High levels of activity in multifamily buildings were reported for 11 of the 33 States. A few States indicated they do not have significant numbers of these types of buildings which house qualified households.
- Some States do not have enough funding under the Program to even consider doing a larger multifamily building, as one building could require anywhere up to the entire annual funding of a given agency.
- New York is the only one of the 33 States which has conducted an evaluation of work conducted under the Program in multifamily buildings in the past 10 years.
- A special type of audit procedure for dealing with the differing audit requirements for some larger multifamily buildings was indicated for 9 of the 33 States.
- Strategic partnerships (see following section) of some type for performing weatherization work on multifamily buildings have been used or developed in 7 of the 33 States.
- The "66% Rule" causes difficulty with qualifying buildings for eligibility under the Program in 6 of the 33 States.
- Policies regarding owner investment are in place for multifamily buildings in 11 of the 33 States.
- Similarly, 11 of the 33 States have considered or implemented policy changes regarding larger multifamily buildings recently.
- Nine of the 33 States offer some training related to field inspections of buildings and selection of measures to be installed that was felt to be applicable to multifamily buildings, with 6 of these States having very extensive training.
- Ten of the 33 States indicated that DOE policies for the Program should be changed to improve the services that could be offered to multifamily buildings, including
  - — Allow high efficiency lighting in common areas
  - — Reduce 66% rule to 50% majority

The sentiment for the lighting change was very strong, and the sentiment for changing the 66% rule was moderate.

3.1 STRATEGIC PARTNERSHIPS

The strategic partnerships that have been formed in seven States are primarily with utilities and with other government organizations. Responses indicated that some of these partner-

ships are in the formative stage, and other comments on the survey forms suggested that more such partnerships may form in the future. The most advanced partnership appears to be the New York City Weatherization Coalition, where all weatherization work in large multifamily buildings is being coordinated through one organization and all partnerships with utilities and others generally go through this one coordinating organization. In Seattle, where we have already described some interaction with Seattle City Light and the weatherization organizations, funding from several sources is merged to achieve combined efforts on weatherization, housing rehabilitation, and tenant education.

4. BUILDING SURVEY RESULTS

Based on responses to the national survey conducted under the Single-Family Study, we initially identified about 6,000 dwelling units weatherized under the Program in multifamily buildings. These data were used to send out a survey on building-specific information (the survey instrument is shown in Appendix B) to 109 agencies across the country. However, the responses to the building-specific data request showed large attrition of this sample due to improper identification of dwellings as being in larger multifamily buildings. In addition, many agencies could not respond due to financial difficulties or inability to locate records. Some agencies simply did not respond. The overall attrition from this initial sample was high:

- Dwelling was incorrectly identified as multifamily (about 20%)
- Agency did not respond due to lack of records, financial difficulty, or other reason (about 25%)

Thus, overall about 45% of the sample was lost to these two factors. The presence of public housing units in the data also complicated estimates, as about 20% of the dwelling units for which data were requested were in public housing. These two factors led to a final sample of units, not in public housing, of only about 2,000 (35% of our original data request). The distribution of these approximately 2,000 dwelling-specific responses (that do not include public housing) is shown in Fig. 2.

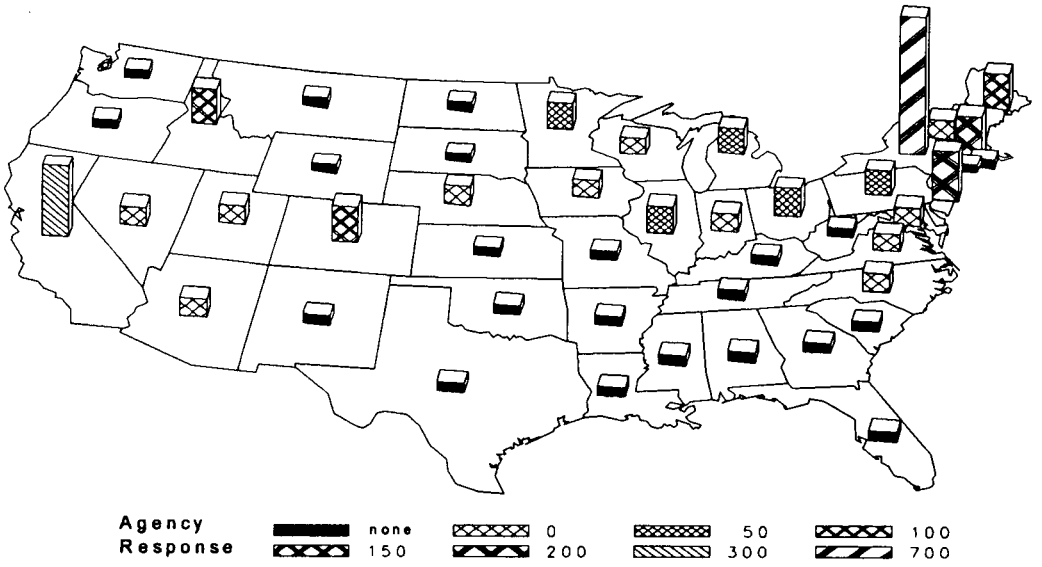

Figure 2 — Multifamily weatherization responses by local agencies for PY 1989.
The very short bars indicate no response or no data requested, and the next tallest bar represents a few units. The tall bar for New York represents a little over 700 units weatherized.

The sample obtained (about 2,000) represents 10% of the 20,000 units not in public housing estimated to have been weatherized in PY 1989. The Single-Family Study (Brown 1993) obtained data on 14,971 dwellings, which are about 7.5% of the 198,000 dwellings of interest in that study. For this study, data for about 1,100 dwellings in New York City were obtained, but only 700 were included in the working data set, as the additional data arrived after the analysis was partially complete. (Including the additional data would have increased the working set size to about 2,400 dwellings.) However, the data on all 1,100 were checked by hand to provide some assurance that results obtained for the 700 were not unreasonable for the 1,100. Thus, the sample data for New York City are representative of 10% of the units served there in PY 1989.

The data on these 2,000 dwellings describe Program Year 1989, and may not be representative of more recent years. During the course of contacts with States and agencies, many changes taking place relative to multifamily buildings were mentioned. Some agencies were reducing their multifamily work as oil overcharge funds were depleted, while other agencies were considering expanding their multifamily work.

The dwelling units in public housing that were weatherized (usually partially) under the Program in PY 1989 are dominated by units in Chicago and Baltimore, where 1200–1400 dwellings were weatherized for both together. The public housing weatherizations appear to be performed through informal partnerships with local (city) public housing authorities, where different parts of the weatherization work are performed under DOE and public housing funds.

The responses displayed in Fig. 2 were obtained from 54 local agencies representing 269 buildings and 2,050 weatherized dwelling units in 24 States. Responding agencies were asked to indicate the total number of units located in a specific building which received weatherization measures. In some cases the respondents may have indicated that the entire building was not weatherized and failed to provide the total number of units located in the building. A total of about 3,200 dwelling units were reported by the agencies for the 269 buildings, and the data suggest that the total number of units (adjusting for missing entries) in the weatherized buildings is about 3,600.

No sampling weights were used, so the tabulated and graphed results represent the data as received. Weighting is problematical in that national data specific to larger multifamily buildings are more limited, the number of buildings served (269) is small, and the Program does not track data to allow better determination of which agencies perform work in larger multifamily buildings. Given these factors, weighting might potentially hurt more than help.

Given the attrition that occurred, there is potential for attrition bias. However, the data cover 24 States, and New York appears to be represented acceptably. The 54 agencies represented by the data may account for over 80% of all agencies dealing with larger multifamily buildings in the country, based on interactions with the States and agencies. However, there is no firm basis for this 80% value. Attrition bias may be present in the sample to some degree, but the sample appears to be reasonably representative.

About half the buildings in this sample are more than 50 years old, and they range in size up to 160 dwellings. The mean building size is 13.5 dwelling units (with 75% having 12 or fewer units), and the mean number of units weatherized is 7.6. For comparison, New York City has very large buildings, and the average building size there is between 35 and 40 units. There are two distinct groups of buildings in the sample: those where the whole building was weatherized and those where only part of the building was done (Table 1). When the whole building was weatherized, an average of 15 dwellings are served. But when only part of the building is weatherized, an average of 2–3 units are served while the building size is about 12 units.

Table 1. Differences between whole and partial building weatherizations

	No. of buildings	Average units weatherized	Total units per building
Whole	111	15	15
Partial	158	3	12
Total	269	7.6	13.5

Note: Missing data cause some variation in units per building, so these values are approximate.

There are many reasons why the whole building is not weatherized, including each dwelling having an individual heating system, which lessens the benefits of whole building work. Another major reason agencies do not weatherize whole buildings is difficulty in qualifying buildings to meet rules of the Program (66% of the applicants must be income-qualified before work can be performed on the whole building).

4.1 GENERAL CHARACTERISTICS

Categories of the number of buildings and the units weatherized per building are shown in Figure 3. Many buildings had less than ten units weatherized, but the total number of units weatherized is more even across the categories, because larger buildings had many units in them. The distribution of weatherized buildings by year of construction is shown in Fig. 4. The largest number of buildings reported construction dates from 1920 to 1929. The next largest was for the period after 1979.

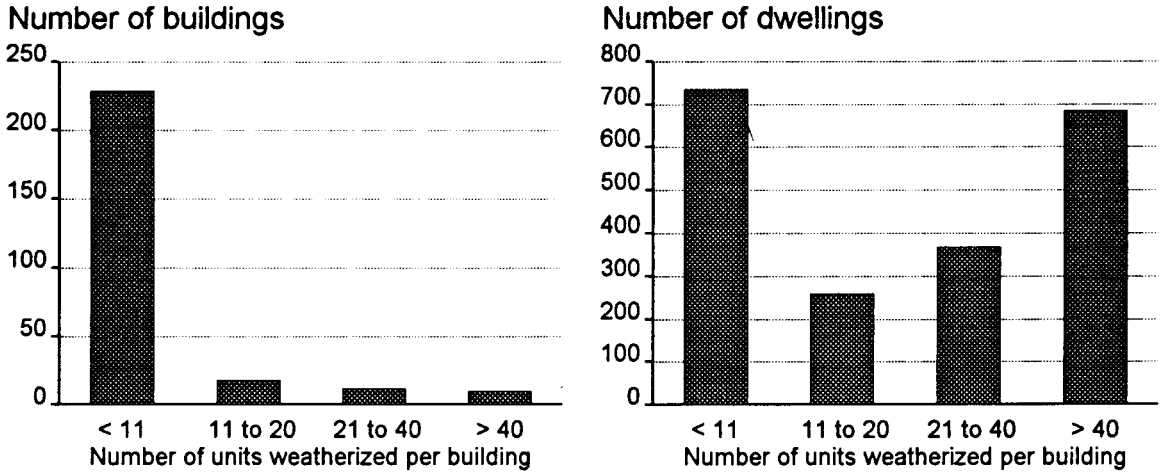

Figure 3 — Number of buildings and units by category of units weatherized per building.

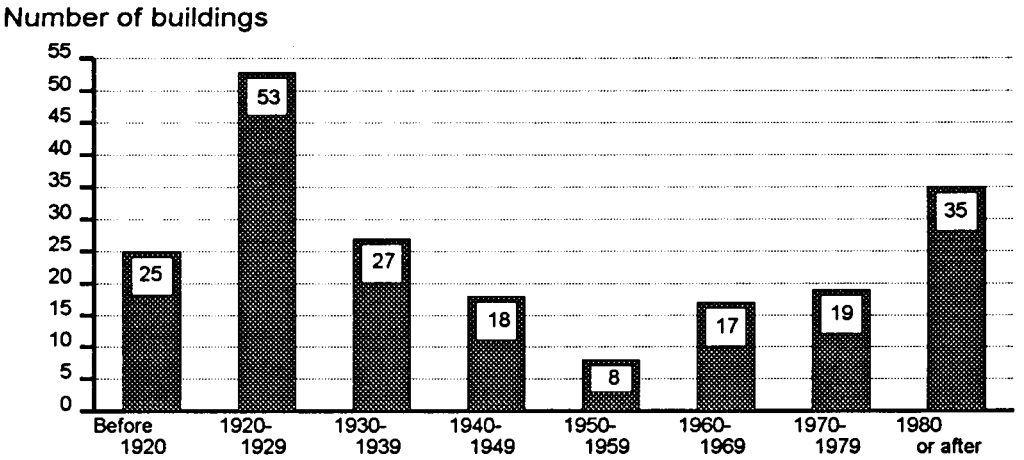

Figure 4 — Year of construction for 202 of 269 buildings weatherized in PY 1989.

The percentage of buildings and dwellings by primary heating fuel are shown in Fig. 5. Natural gas is the dominant fuel, but significant use of fuel oil and electricity is also found. Supplemental fuels are not significant. The types of heating systems in these buildings (shown in Fig. 6) were: 32% with central heating plants for the building or complex, 30% with individual central systems in each apartment, 20% with in-space electric or fossil-fuel heaters, 7% with some other heating arrangement (such as combinations of the previous systems), and 11% of the systems were unknown by the agencies. Central air conditioning systems were present in 13 buildings (one for the whole building and 12 for individual apartments). Some window air conditioners or heat pumps were present in about 40% of the buildings.

The type of domestic hot water system (Fig. 7) was not known for 23% of the buildings. Central hot water systems for the whole building were present in 32% of the buildings, and 36% of the buildings had individual hot water systems in the dwelling unit. Central hot water systems by floor of the building were present in 4% of the buildings, and the remaining few percent were other types.

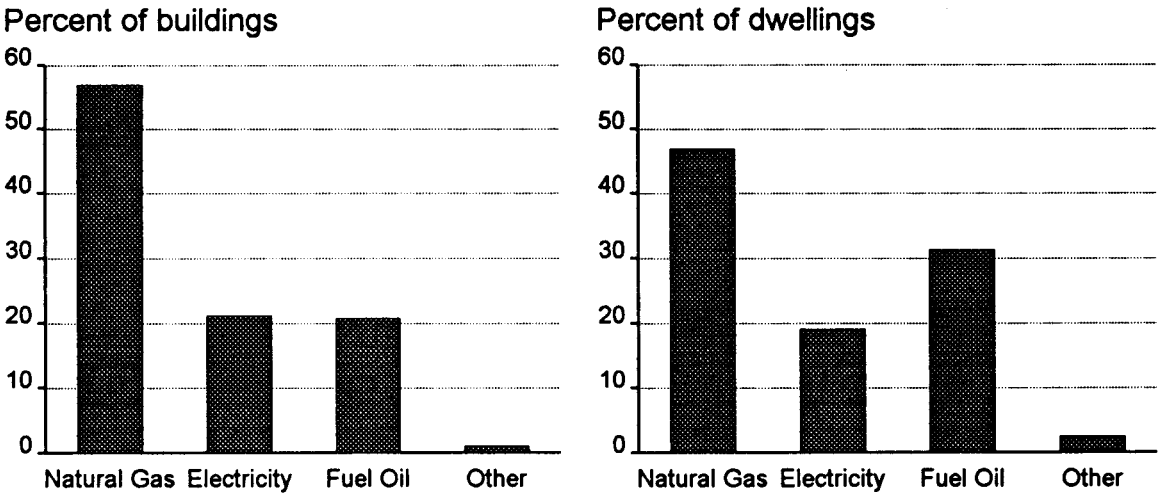

Figure 5 — Heating fuel for sample of buildings and residences weatherized in PY 1989.

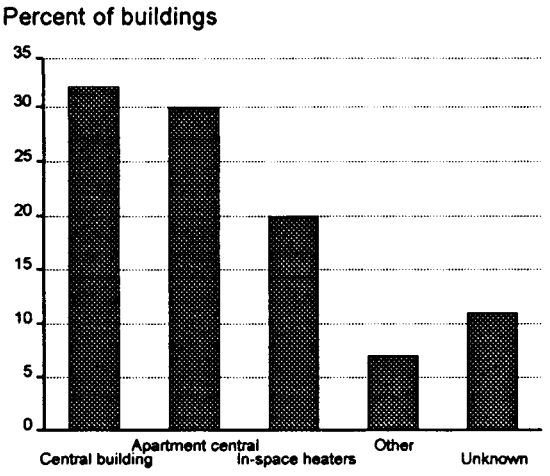

Figure 6 — Building space heating system type.

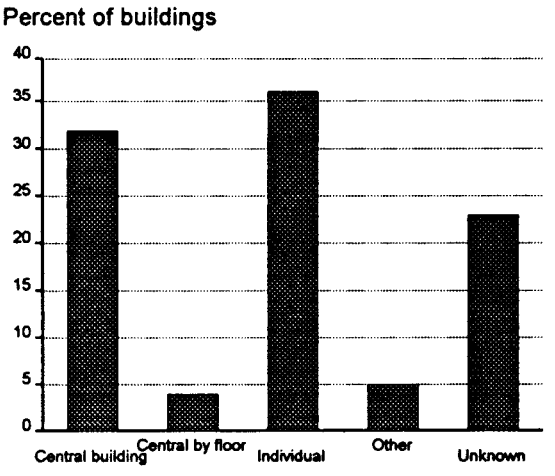

Figure 7 — Building water heating system type.

4.2 INCOME, ELDERLY, AND HANDICAPPED

The percentages of people in different income categories for the weatherized dwellings are shown in Fig. 8. Dwellings with an income of less than $5,000 per year accounted for 31% of all households in this sample, while only 8% had incomes over 15,000 per year. This distribution differs from that found for single-family and small multifamily dwellings (Brown et al 1993) in that no incomes of $20,000 or more were present, but a higher percentage of incomes above $10,000 was found. These higher incomes may be due to the fact that many dwellings are located in New York City, where higher incomes provide less purchasing power.

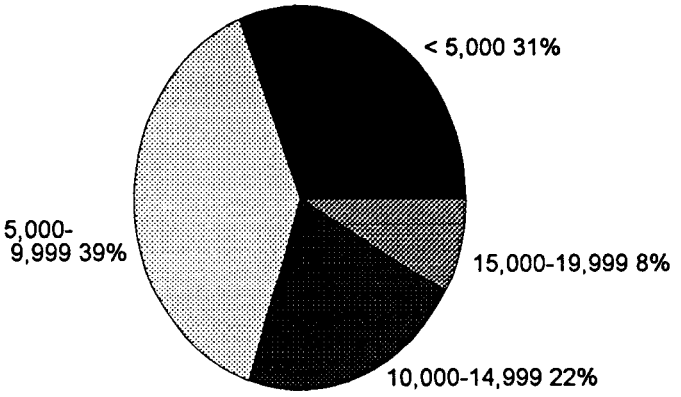

Figure 8 — Distribution of income categories for weatherized dwellings.

Elderly and handicapped people were known to be present in many of the households. The data indicate that 7,000–8,000 people lived in the buildings in the sample which were weatherized, while about 3,000 people lived in the weatherized dwellings. Elderly people were known to comprise 20% of the people living in the weatherized dwellings, and about 15% of the people in these dwellings were known to be handicapped. The elderly were present in 45% of the buildings that were served, and handicapped individuals were present in 36% of the buildings.

4.3 GEOGRAPHIC DISTRIBUTION

The distribution of buildings and dwelling units in the sample is shown by geographic zone in Fig. 9. The distribution shows the dominance of the moderate climate zone and the small number of dwellings from the hot zone. With New York in the moderate zone accounting for over half of all dwellings weatherized, the dominance of the moderate zone is to be expected.

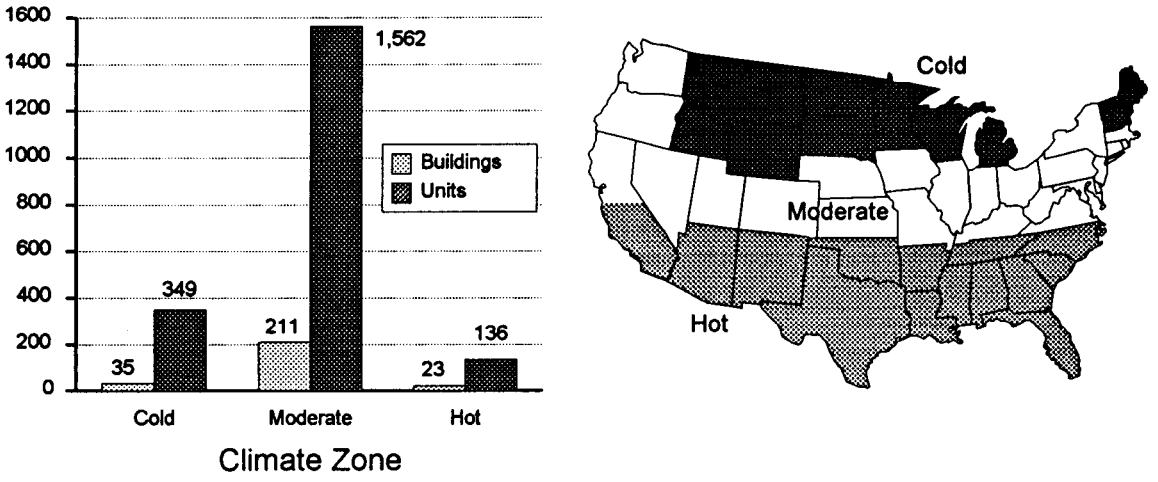

Figure 9 — Geographic distribution of sample of buildings and dwellings weatherized in PY 1989.

4.4 MEASURES INSTALLED

The measures installed under the Program in multifamily buildings cover a wide range, with significant numbers of buildings and units receiving general caulking, storm/thermal windows, and low-flow showerheads. The measures installed were determined from responses to the building-specific questionnaire sent to agencies (Appendix B). The measures fell into nine general categories, similar to the Single-Family Study (Brown et al 1993) categories:

- Air Leakage Control
- Insulation
- Water Heating System
- Space Heating System
- Space Cooling System
- Ventilation System
- Windows and Doors
- Structural Repairs
- Other Health and Safety Repairs or Improvements

For each of these nine general categories, specific information was requested for specific measures or retrofits that applied under each category. The numbers of buildings and units receiving each specific type of measure or retrofit for our sample of 269 buildings and about 2000 units is shown in Table 2, where BUILDING indicates the number of buildings and UNIT indicates the number of dwelling units receiving each type of measure. (Appendix B, Part C provides the data structure for the data in Table 2, so refer there for additional information and clarification, if needed.)

Table 2. Breakdown of installed measures for the sample (N = 269 Buildings and 2050 Units)

MEASURE	BUILDING	%	UNIT	%
Air Leakage Control	243	90%	1275	62%
General Caulking and Weatherstripping	242	90%	1262	62%
Air Sealing, with blower door testing	24	9%	185	9%
Air Sealing, without blower door testing	37	14%	193	9%
Air Distribution System	8	3%	22	1%
Other Infiltration Reduction (not including windows)	52	19%	278	14%
Insulation	75	28%	527	26%
Attic Insulation (installed for the first time)	33	12%	177	9%
Attic Insulation (added to existing insulation)	30	11%	318	16%
Wall Insulation (normal technique)	13	5%	65	3%
Wall Insulation (high-density technique)	1	0%	32	2%
Floor Insulation	6	2%	28	1%
Rim or Band Joist Insulation	24	9%	130	6%
Other Envelope Insulation	11	4%	61	3%
Water Heating System	128	48%	1168	57%
Water Heater Tank Insulation	46	17%	215	11%
Entire Water Heating Unit Replacement				
Central System Controls Improvements	3	1%	8	0%
Pipe Insulation	69	26%	427	21%
Low Flow Shower Heads or Faucet Aerators	73	27%	872	43%
Temperature Reduction	17	6%	115	6%
Other Water Heater Measures or Repairs	2	1%	13	1%
Space Heating System	85	32%	1031	50%
Clean and Tune-up	25	9%	547	27%
Thermostat or Other Controls Retrofit	45	17%	256	13%
Entire Heating Unit Replacement/Modification	2	1%	52	3%
Repairs	4	1%	187	9%
Distribution System Retrofit (e.g., steam balancing)	9	3%	389	19%
Heating System Component Retrofits	5	2%	93	5%
Safety Problem Fixed	6	2%	29	1%
Other Heating System Modifications	4	1%	10	0%
Space Cooling System	25	9%	132	6%
Tune-up (e.g., cleaning, controls adjustment, filter replaced)	17	6%	102	5%
Entire Air-Conditioning System Replacement	1	0%	1	0%
Fans Installed or Replaced	15	6%	76	4%
Thermostat or Other Controls Retrofit				
Distribution System Retrofit (e.g., duct sealing/balancing)	1	0%	1	0%
Other Cooling System Modifications				

Table 2. Breakdown of installed measures for the sample (cont'd) (N = 269 Buildings and 2050 Units)

MEASURE	BUILDING	%	UNIT	%
Ventilation System	7	3%	92	4%
Controls Retrofit	1	0%	4	0%
Fan/Exhauster Repair or Replacement	5	2%	72	4%
Other Repairs	1	0%	4	0%
Other Ventilation System Modifications	3	1%	24	1%
Windows and Doors	184	68%	1500	73%
Storm Windows	69	26%	220	11%
Thermal Windows	64	24%	990	48%
Storm Doors	11	4%	47	2%
Window Films or Shades	3	1%	9	0%
Other Window or Door Treatments	96	36%	524	26%
Structural Repairs (full or partial)	148	55%	679	33%
Attic Ventilation	33	12%	174	9%
Roof	3	1%	23	1%
Ceilings	2	1%	7	0%
Doors	51	19%	249	12%
Replacement of Doors	93	35%	437	21%
Windows/Glazing	94	35%	442	22%
Walls	2	1%	9	0%
Floor	2	1%	11	1%
Other Structural Repairs	29	11%	147	7%
Other Health and Safety Repairs or Improvements	89	33%	497	24%
Smoke Detectors	15	6%	44	2%
Interior Fire Doors	1	0%	4	0%
Railings	1	0%	4	0%
Stairs/Ramps	1	0%	4	0%
Locks	59	22%	309	15%
Radon Testing	1	0%	4	0%
Carbon Monoxide Testing	19	7%	154	8%
Backdrafting Testing	17	6%	156	8%
Other	3	1%	64	3%

Measures were handled about equally for "in-house crew only" (about 100 buildings), "contractor only" (about 100 buildings), and "mixed crew and contractor" installations (about 70 buildings, but missing data make the exact number for each of these cases somewhat uncertain). Air leakage control measures were much more likely to be installed by in-house crews. Air sealing with blower door testing was especially likely to be performed in-house, but air distribution sealing had 20 units done by contractor and only 2 units done in-house. Water heater tank insulation was installed about twice as often by in-house crews.

Four times as many heating system tuneups were performed by contractors compared to in-house crews, and almost all heating system thermostat or controls retrofits were installed by in-house crews. Heating system distribution retrofits were, again, mostly done in-house. Cooling system work was performed mostly in-house.

Storm windows were installed about equally by in-house and contractor crews, but thermal windows were 15 times more likely to be installed by contractors. Repairs and safety/health improvements were performed by both groups, with some shifting back and forth on which group did more. Overall, the low numbers of installations for some measures indicate caution for interpreting too much from these values.

4.5 MEASURE SELECTION, DIAGNOSTICS, AND QUALITY CONTROL

Selection of measures was accomplished primarily by use of priority lists (85% of buildings and dwellings), while more advanced procedures were used in the remaining buildings. General rules were also the primary methods used for determining measures for space-heating and domestic hot water systems.

Blower door diagnostic procedures of some type were used in 25–30% of the buildings and dwellings. Heating system efficiency testing was used in about 15% of the larger buildings (almost 50% of the total dwellings). Almost all buildings had some type of visual quality control inspection for envelope measures, and the data suggest that most buildings which had heating system efficiency testing performed for diagnostic purposes also had efficiency tests performed after the weatherization was completed. Table 3 provides a breakdown of data on measure selection methods, use of diagnostics, and quality control procedures for BUILDING and UNIT values as used in Table 2. (Appendix B, Part D provides the data structure for the data in Table 3, so refer there for clarification, if needed.)

4.6 MEASURE COSTS

Costs on measures were collected in several categories. The materials costs were collected for both in-house crew materials and contractor materials. However, some agencies provided "Other" material costs, and we also had to include those. The costs for in-house labor were requested, and the total contractor costs were requested. In some cases both contractors and in-house crews performed different work on the same building, and this work is referred to as "mixed crews." Agencies were not always able to provide the cost data, and sometimes the cost data were inconsistent (possibly indicating that the data request was not understood clearly). However, overall the cost data appear to provide a

Table 3. Methods breakdown for sample				
	BUILDING	%	UNIT	%
Measure Selection				
Envelope				
Priority list	229	85%	1807	88%
Scoring approach	11	4%	209	10%
Cost-Benefit	48	18%	308	15%
Heating - Cooling - Ventilation System				
Characteristics	53	20%	368	18%
Scoring	7	3%	151	7%
Cost-Benefit	20	7%	182	9%
Domestic Hot Water System				
Characteristics	88	33%	471	23%
Scoring	3	1%	97	5%
Cost-Benefit	38	14%	200	10%
General Considerations				
Envelope, HVAC, and DHW measures selected together	110	41%	1245	61%
Pre-screening	19	7%	83	4%
Consultant	7	3%	14	1%
Other procedure	115	43%	9	0%
Diagnostics				
Blower-door find	39	14%	313	15%
Blower-door measure	27	10%	259	13%
Blower-door guide	4	1%	68	3%
Distribution balance	1	0%	6	0%
Distribution seal	0	0%	0	0%
Infrared	3	1%	49	2%
IAQ testing	11	4%	113	6%
Efficiency testing	37	14%	942	46%
Combustion safety	36	13%	258	13%
Other	15	6%	63	3%
Quality Control				
Visual - envelope	264	98%	2041	100%
Blower-door	18	7%	98	5%
Infrared	4	1%	52	3%
Visual - heating	22	8%	166	8%
Efficiency testing	40	15%	784	38%
Other	0	0%	0	0%

Table 4. Materials costs per building for the sample ($)				
	MEAN	SUM	MEDIAN	# BUILDINGS
Whole Building	7200	800,000	2000	111
Partial Building	800	130,000	380	158

fairly reasonable picture of the costs of these measures for multifamily buildings, if care is taken in calculating the desired information.

Material costs for buildings are calculated for both whole-building and partial-building weatherization (Table 4). The whole building category accounts for about $800,000, the major portion of materials costs for our sample. The partial building category accounts for about $130,000. The materials funds invested per building in whole-building weatherizations are much higher than those invested for partial-building weatherizations, as many more units were weatherized per building in whole-building weatherizations (see Table 1).

The distribution of materials costs reported by the agencies is shown by major measure category in Fig. 10, which clearly shows the dominance of expenditures on windows and doors (80% of the total). Costs for windows are most of the total for the windows and doors category. The average cost of installed measures, when they are installed, is shown in Table 5 for whole-building and partial-building weatherizations, where reported data were available. The funds invested per unit for whole-building work were higher than funds invested per unit for partial-building work ($561 vs $417), since the costs for windows in whole-building work was a major difference. Whole-building work also included higher space heating system retrofit and replacement costs and higher ventilation system replacement costs.

Readers are cautioned to consider the number (N) of units shown for each measure category listed in Table 5. Those entries with low numbers of units must be viewed with caution when considering whether the values represent the Program as a whole in PY 1989. The mean dollar values in Table 5 are based on using the entire number of units weatherized in a building as the divisor, so some mean values will appear low. For example, the entry for water heater replacement under whole-building work appears unreasonable. Apparently a water heater was replaced in only one unit each of a 15-unit and a 16-unit building. The average cost per unit in each building is very low, but the total cost for the building is $210. Thus, the average cost per unit value can be misleading for some categories. Data were collected only at the building level and not at the unit level, so the exact equipment installed in each separate dwelling unit is not known. However, in general, this type of information was not available from the agencies.

Cost data breakouts for in-house, contractor, and mixed crews are shown in Table 6. These costs are, again, based on reported values, and some data discrepancies can exist because of missing data. The labor cost for mixed crews is found to be half of total costs, and this value may be higher than expected because of cases of missing data on contractor materials. These data indicate that costs for dwellings in larger multifamily buildings receive one-half to two-thirds the average investment received in single-family and small multifamily dwellings (see Table 7.3 in Brown et al 1993). The costs for contractor and mixed crew

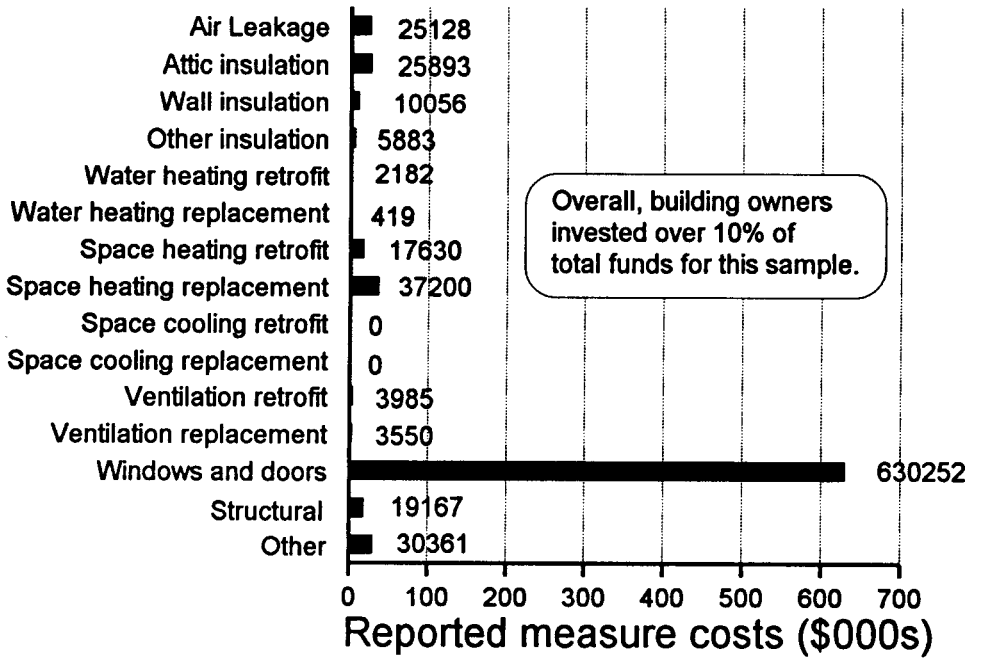

Figure 10 — Distribution of reported materials costs by measure.

Table 5. Breakdown of material costs for units where measure was installed

MEASURE	WHOLE BUILDING WORK		PARTIAL BUILDING WORK	
	N	Mean $	N	Mean $
Air Leakage	408	41	109	76
Attic insulation	383	59	28	118
Wall insulation	174	57	4	52
Other insulation	170	27	31	44
Water heating retrofit	117	17	22	9
Water heating replacement	31	14	0	—
Space heating retrofit	275	63	17	19
Space heating replacement	64	581	0	—
Ventilation retrofit	155	23	11	45
Ventilation replacement	98	1244	1	117
Windows and doors	942	555	246	437
Structural	211	76	43	73
Safety and Health	319	70	108	75
TOTAL for Reported Data	1421	561	319	417
Total Observations	1608		439	

Table 6. Costs per dwelling for in-house, contractor, and mixed crews		
Category	Average total installed cost ($/dwelling)	Average labor cost ($/dwelling)
In-house crew only	450[a]	140
Contractor only	780[b]	180[c]
Mixed (both crew and contractor)	720[b]	360[c]
[a] includes materials and labor [b] includes materials, labor, profit, and installation-related overhead [c] includes labor, profit, and installation-related overhead		

installations are expected to be higher than in-house crew installations, because overhead and profit expenses are not included for the in-house values. The contractor and mixed crew values are higher than the in-house values by about $300, due to the overhead and profit difference and to contractors installing more costly thermal windows (primary cause), space heating system replacements, and ventilation system replacements.

Total material, labor, and contractor costs are calculated for all buildings to be about $600/unit, as reported. There are seven severe cases of buildings where over $2500 per unit was invested, outside the expected range of reasonable costs. However, the data for New York may be lower than representative for that State, based on examination of our supplemental New York data (recall that New York accounts for over half of all units for PY 1989). Overall, these factors suggest that the average cost per unit weatherized, without overhead and management costs included, is about $600.

The estimated overhead and management cost per unit weatherized for the Program has been estimated at about $500/unit in the Single-Family Study (Brown et al 1993). The data obtained in the Single-Family Study on overhead and management costs were incomplete and difficult to analyze because of obvious inaccuracies. The value of $500 was estimated based on other data sources and the limited usable data obtained for that study.

A downward adjustment of this $500 value for larger multifamily buildings is appropriate, since the investment per dwelling was about half the installation cost for single-family and small multifamily dwellings (Brown et al 1993). A straight ratio of these values would lead to a value of $250–350 per dwelling, but a straight ratio is probably not completely correct either. A value of $400 per dwelling appears reasonable, although better determination of this value based on empirical data would be helpful. Using the average overhead and management value of $400/unit, total cost for multifamily weatherization in PY 1989 becomes $1000/unit ($600 + $400).

The overall cost magnitude of the program, with about 20,000 multifamily dwellings weatherized in PY 1989 at $1000/unit, is then about $20 million out of total expenditures for the Program of about $300 million (about 7%).

5. NONENERGY PROGRAM IMPACTS

Work conducted under the Program leads to significant nonenergy impacts and benefits. The Single-Family Study (Brown et al 1993) provides a helpful description of these benefits, and the value of these benefits is monetized, where possible, in that study. Five major areas of benefits for the Program are: More affordable housing; Improved comfort, health, and safety; Easing of household budget limitations; Increased employment and beneficial economic impacts; and Environmental externality benefits.

Program efforts in larger multifamily buildings have benefits parallel to those for single-family and small multifamily dwellings. Affordable housing is aided by structural and safety improvements, which help increase property values and longevity of buildings. Owner investments, in many cases, indicate their understanding of these benefits. Safety improvements are important, as many buildings are located in large cities. Structural repairs were made in 55% of all buildings, while safety and health improvements were made in 33% of all buildings.

Employment and economic impacts of the $20 million invested in larger multifamily buildings is not small. The Single-Family Study estimates that 52 job years are created for each $1 million invested by the Program. Thus, $20 million invested for larger multifamily buildings accounts for about 1,000 jobs in PY 1989. Revenue generated from resulting taxes for this employment has a direct benefit to governments.

Environmental benefits can also be important, The $20 million invested in larger multi-family buildings is estimated to cause reduced emissions of over 3,000 metric tons of carbon per year. Other reduced emissions of SO_2 and NO_x also provide benefits. Overall, the nonenergy benefits of the Program efforts are important, and these benefits are an important objective of the Program.

Because of the lack of energy and energy cost data, the nonenergy benefits are not monetized for this study. Those interested in a further discussion of these nonenergy benefits should consult Brown et al (1993).

6. OVERALL RESULTS

This study has shown that the Program activities in larger multifamily buildings in PY 1989 represent about 9% of all dwellings weatherized and 7% of total costs. However, 15% of all eligible households not in public housing and 33% of all eligible renter-occupied residences not in public housing are in the larger multifamily buildings (see Introduction). Thus, Program efforts in these buildings occur at a lower level than proportional with the percentage of the eligible population in these buildings.

6.1 GEOGRAPHIC DISTRIBUTION OF MULTIFAMILY DWELLINGS

Based on responses from the Grantees and the local agencies and on interactions with States and agencies regarding requested responses, a composite estimate of the geographic distribution of dwellings weatherized under the Program in PY 1989 is provided in Figure 11. High levels of multifamily activity were found from the Northeast extending to the upper mid-Atlantic region. Reasonably high levels of activity were found in the Midwest, pockets of activity in the West, and almost no activity in the South outside the upper mid-Atlantic area. The distribution of these units aggregated to the three climate zones shown in Fig. 9 is given in Fig. 12. Just as with the sample of buildings obtained from individual agencies, the moderate zone is dominant and few units are in the hot zone.

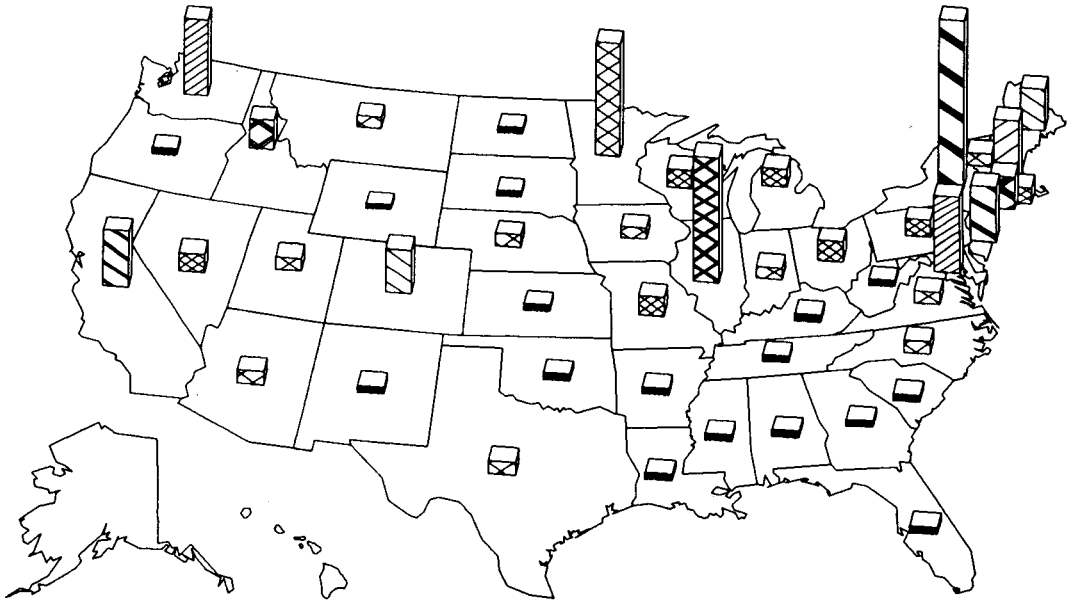

Figure 11 — Geographical distribution of 20,000 weatherized multifamily dwellings for PY 1989.

The very short bars indicate no dwellings were weatherized, and the next tallest bar represents a few units. The tall bar for New York represents 11,500 units (over half of the total but scaled here to allow the scale of the others to be seen), and the bars for Illinois and Minnesota represent about 1,500 units served.

6.2 ADVANCED PROGRAMS

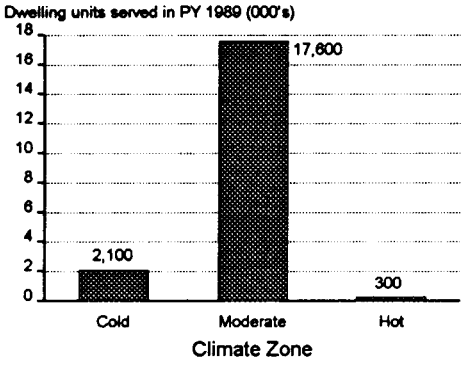

Figure 12 — Distribution of 20,000 dwellings by climate zone.

Investments by building owners are found in only a few States, and in our sample of buildings, both Massachusetts and New York obtained about 25% of their total funds invested in weatherization from owners. Massachusetts and New York accounted for 97% of all owner investments obtained in the sample. However, for the country the major source of these investments is New York, because New York represents half of all units served. Thus, for the country, about half of all units weatherized in PY 1989 received owner investments for improving the energy efficiency of the buildings. The additional data for New York that were not included directly in the sample indicate that owner investments can be as high as 35% of total investment.

New York and Massachusetts provide important evidence that the impact of the Program can be expanded by leveraging investments by owners in some of these buildings. New York also provides a major increase to available funds, since owner investments are obtained for most buildings and such a large percentage of total units weatherized in the country is done in New York. New York also has directed significant efforts at developing good energy audit procedures for larger multifamily buildings and at improving consistency of results across buildings. (The EA-QUIP energy audit program for multifamily buildings, which prioritizes measures based on cost effectiveness, can be obtained from New York.) The transfer of the knowledge available in States where more multifamily work is performed thus becomes an issue for the Program, as other States might enjoy important benefits if they could adopt the most appropriate practices used by States like New York or Massachusetts. However, despite important improvements achieved to date, weatherization personnel from New York assert that much more still needs to be learned about the performance of measures in larger multifamily buildings. New York is currently working to plan additional research in this area.

6.3 DISCUSSION OF THE LOW LEVEL OF MULTIFAMILY ACTIVITY

There are many reasons for the low level of activity under the Program for multifamily buildings. Primarily, the buildings and building systems are often much different than those found in single family and small multifamily buildings, and the outreach activities needed to qualify whole buildings are often more extensive. When whole buildings cannot be

qualified, the types of measures available to install at the dwelling-unit level are typically much more limited. Our data show that heating system replacement and other space heating retrofits were performed much more often under whole-building work. With more limited measures available, field personnel may have doubts about how useful and effective the measures are.

In addition to the reasons given above, there is the fundamental condition that many people who could be helped under the Program have not yet received services. Thus, qualified tenants in multifamily buildings may represent a large portion of the eligible population, but they are simply another segment of the population waiting to be served. Given the large unmet need, providers are more likely to serve the eligible population most similar to those they have historically served.

Since likely less than 14% of the eligible population has been served (Power and Brown 1993), and a large portion of the eligible population is in single-family and small multifamily houses, the inclination for agencies will be to continue to serve this large constituency. Service to multifamily buildings will depend on the Program funding available, factors that make qualification of buildings easier, and level of technical expertise achieved for dealing with these potentially more complex buildings. The level of service to these buildings may also depend on the level of attention applied to these buildings by the Program.

Improved information on the performance of different measures in multifamily buildings, together with efforts to transfer knowledge from more active States to less active States, could help increase the number of units served in these buildings under the Program. Increased use of owner investments could also be important in some locations, as the situation in New York and Massachusetts illustrates that increased benefits can be obtained for occupants while increasing building property value. Both owners and the Program invest, and both reap increased benefits from the partnership.

6.4 DISCUSSION OF OTHER PROGRAMS

The major compilation of energy savings results for multifamily buildings by Goldman et al (1988) indicates that savings of 10–30% are typical for many multifamily buildings. They also found that installation of building shell measures, such as insulation and windows (which were typically installed in electric-heat buildings), led to building retrofit programs which are not cost effective. Conversely, they found that multifamily retrofit programs which emphasized changes to central heating systems tended to be very cost effective. Building shell measures were typically installed for buildings having electric heat, while heating system measures were installed in buildings heating with natural gas or fuel oil.

Okumo (1991) found that windows were not generally cost effective in electric-heat buildings, while other building shell measures may have been cost effective.

Many program results are available from programs (not part of the DOE Weatherization Program) in Minneapolis[1] and Chicago,[2] where buildings use natural gas and fuel oil to heat, and typically many good candidate buildings are available for central heating system retrofits. High savings are often available from these central system retrofits, where simple payback periods of about two to three years are often achieved. Benefit/Cost ratios calculated with a 4.7% discount rate (assuming a 20 year measure lifetime) for these paybacks would typically be 5–8.

The programs mentioned above are typically funded entirely by building owners, sometimes with additional support from the city or from utilities. Thus, these programs face more stringent economic criteria which force the programs toward measures having higher economic returns. However, the economic criteria and objectives of DOE's Weatherization Program are different, and installation of additional measures beyond these high payback measures are often desirable.

One final program on multifamily buildings for discussion here is conducted by the Citizens Conservation Corporation (CCC) in Boston, often for public housing buildings. CCC has installed many types of retrofits in multifamily buildings over many years, including central heating system retrofits. Funding for CCC efforts has come through performance contracting arrangements, utility programs, and other sources. CCC has experience with both individual dwelling metering systems in buildings having central meters for heating fuel and individual dwelling automatic temperature control systems which allow good energy management practices to be used. Recently, CCC also began working on buildings where advanced window systems are being installed. The experience of CCC with their measures has not been documented publicly to date, but a project is currently funded under the DOE-HUD Initiative (a joint initiative between DOE and the U.S. Dept of Housing and Urban Development) to report on some of the experience of CCC with multifamily buildings.

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1. For further information, contact Martha Hewett, Center for Energy and Urban Environment, 510 1st Avenue North, Suite 510, Minneapolis, MN. 612/348-4835
2. For further information, contact John Katrakis, Center for Neighborhood Technology, 2125 W. North Avenue, Chicago, IL. 312/278-4800

7. CONCLUSIONS & RECOMMENDATIONS

The extent of weatherizations in larger multifamily buildings under DOE's Weatherization Program is estimated to be about 20,000 dwellings in Program Year 1989. This total includes dwellings weatherized both in private buildings and in public housing. Fairly extensive relationships with public housing have existed in some locations. These 20,000 dwellings represent about 9% of the total number of units weatherized under the Program that year, using the designated funding criteria. The total costs for the Program efforts in these buildings are about 7% of total national costs for the Program. The energy savings and cost effectiveness of the Program were not estimated, because energy use and energy cost data adequate for developing such estimates could not be obtained.

Researchers who wish to obtain and use energy use and cost data to estimate cost effectiveness of energy efficiency programs must consider the difficulty that occurs when such data move from on-line electronic form in a computer system to archival status. Data archival often occurs after 12 to 18 months. Archival increases data retrieval difficulty dramatically. Studies requiring such data that might be archived should develop data collection designs that recognize the potential problems with archived data.

The measures installed under the Program in these multifamily buildings during PY 1989 cover a wide range, but the materials costs for the measures are dominated by the costs for installation of windows. Understanding of potential improvements to the program will depend on developing a better understanding of the specific benefits of individual measures relative to cost effectiveness criteria pertinent to the Program. This understanding will also require developing a good knowledge of the nature of the multifamily building stock in different regions of the country. Direct interaction with local agencies is important to better understand measure benefits, because these organizations are trying to deal with these more complex buildings while having little empirical data to determine the most appropriate measures to meet the objectives of the Program.

Well known programs dealing with multifamily buildings in Minneapolis and Chicago have typically had more stringent economic criteria driving measure selection, and new results are needed to help determine the measures appropriate to the Program's economic criteria. Overall, better understanding of "good" retrofit packages applicable to the Program (probably developed by region) appears needed.

Considering the importance of better information on measure performance and recent changes in States with advanced programs, specific recommendations are:

1. Begin initial case study evaluations of specific buildings and the measures installed in those multifamily buildings. A case study of one large multifamily

building provides results for many dwellings that are specific to a State or region. The initial case studies should be conducted to better understand the current state-of-the-art in multifamily weatherization under the Program. These case studies should be selected from cities in States with significant levels of multifamily activity, such as New York, Illinois, Minnesota, and Washington.

2. The reporting of these the initial case studies should include a summary on the benefits of specific measures, groups of measures, field procedures, or management procedures found in the case studies. This summary should also include recommendations regarding measures or procedures that deserve further refinement or assessment.

3. The Program should change data reporting requirements for Grantees to include specification of the amount of work accomplished in larger multifamily buildings. This change is important for highlighting the importance and also the different nature of this sector. For both small and large multifamily, Grantees should report the number of multifamily residences that were not treated as part of the whole building.

4. The impact of partial-building work on cost effectiveness should be studied at some time in the future. Many States have building stock where only individual apartments can be retrofitted under rules of the Program, and the cost effectiveness of this partial retrofit work must be understood better to determine if it should be continued.

5. Considerable expertise with multifamily buildings exists in some States. Transfer of this knowledge to other States that conduct multifamily work should be planned as the results of the case study work begin to be reviewed.

6. In addition to the knowledge gained from work conducted under the Program, the work of other organizations performing work in multifamily buildings should be considered relative to future refinement of procedures or measures used under the Program. For example, the work in Minneapolis and Chicago, cited in section 6.4 of this report, should be recalled when reviewing the case study results. Also, the work of Citizens Conservation Corporation, in Boston, should be examined, if access can be gained to their results.

7. Program procedures should be changed to effectively capture the energy savings to be found from common area or "house" lighting in these multifamily buildings. The savings from these lighting retrofits are important, and crews should attempt to achieve these savings while they are in a building, if the whole building is included in the work.

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APPENDIX A

National Evaluation of the DOE Weatherization Assistance Program
State Grantee Survey
High-Density Multifamily Units

PURPOSE

The National Evaluation of the Weatherization Assistance Program (WAP) is initiating a study of multifamily buildings with five or more units, called the High-Density Multifamily Study. The purpose of this study is to learn about the extent of WAP weatherization services to high-density multifamily buildings and how such services might be improved. High-density multifamily will be referred to with the acronym HDMF in this survey.

Current data available from the National Evaluation indicate that HDMF units account for 10% of the units weatherized across the country in Program Year (PY) 1989. The data also indicate weatherization activity for HDMF units occurred in 44 States in PY 1989. However, HDMF units comprise about 15% of the total eligible population, so these multifamily units appear to be underserved in PY 1989, and they have been served even less in the past.

The purpose of this survey is to elicit comments on the nature of weatherization services offered for HDMF buildings in your state. Several experts have indicated there are significant problems with offering weatherization services to HDMF buildings, so we are also interested in information on the nature of obstacles impacting potential services to HDMF buildings and any innovative approaches you may be using to overcome these obstacles.

Over the next 6 months, the U.S. Department of Energy (DOE) will be collecting information on HDMF buildings from a sample of local WAP agencies and utilities in several States. We will inform you when such information requests are made, and we may ask for your assistance. The enclosed *Evaluation Plan* provides an overview of the HDMF Study and the other four studies that comprise the National WAP Evaluation.

INSTRUCTIONS

There are 11 questions in this survey. Each question except questions 1 and 11 asks for a yes/no answer at the beginning. Please circle the YES or NO answer appropriate to each question. Written responses are also requested in many cases. Keep in mind for the written responses that extreme detail is not needed at this time. Thank you for your time and effort.

QUESTIONS

1. **Please estimate how many high-density multifamily (HDMF) dwelling units (not buildings) were weatherized in your state in Program Year (PY) 1989, using funds that are regulated by DOE/WAP rules:**

   HDMF is 5+ units per building — total HDMF units _____

   ESTIMATE THE NUMBER IF YOU TRACK MULTIFAMILY DIFFERENTLY.

   IF NO HDMF UNITS WERE WEATHERIZED IN PY 1989, PLEASE EXPLAIN WHY.

   _____

   _____

2. **Do you have any stated policy placing either a high or low priority on providing weatherization services to HDMF buildings or apartments in your State relative to other building types?**

   YES NO

   IF YOU ANSWERED YES, PLEASE DESCRIBE THE HIGH OR LOW PRIORITY BELOW, OR ATTACH A COPY OF ANY WRITTEN STATEMENT OF THE PRIORITY. ALSO DESCRIBE WHY THE HIGH OR LOW PRIORITY IS NEEDED.

   _____

   _____

   _____

   WAS THIS POLICY IN EFFECT IN PY 1989?

   YES NO

   ARE ANY POLICIES REGARDING PRIORITIES FOR HDMF BUILDINGS UNDER CONSIDERATION AT THIS TIME?

   YES NO

   IF YES, PLEASE DESCRIBE.

   _____

   _____

3. **Has your State conducted any evaluation of benefits, costs, or cost effectiveness of WAP services to HDMF buildings in your State during the last 10 years?**

YES NO

IF YOU ANSWERED YES, PLEASE ATTACH A COPY OF THE EVALUATION REPORT OR DESCRIBE BELOW HOW WE MAY OBTAIN A COPY.

_____

_____

_____

4. **Do you currently have a recommended measures list, a priority list of measures, or a special energy audit measure selection method specifically for HDMF buildings or apartments?**

YES NO

IF YOU ANSWERED YES AND USE A RECOMMENDED MEASURES LIST OR PRIORITY LIST, PLEASE ATTACH A COPY OF THE LIST OR WRITE IN THE LIST BELOW.

_____

_____

_____

IF YOU ANSWERED NO, EXPLAIN HOW MEASURES FOR HDMF BUILDINGS ARE SELECTED.

_____

_____

_____

4. (cont'd) **Do you currently have a recommended measures list, a priority list of measures, or a special energy audit measure selection method specifically for HDMF buildings or apartments?**

IF YOU ANSWERED YES AND USE A SPECIAL ENERGY AUDIT MEASURE SELECTION METHOD, PLEASE ATTACH A WRITTEN DESCRIPTION OF THIS METHOD OR WRITE THE DESCRIPTION BELOW. PLEASE INDICATE WHAT BUILDING COMPONENTS (e.g., boilers, windows, attics) ARE COVERED BY THIS METHOD.

5. **Are you aware of any strategic partnerships between WAP providers and other organizations used currently in your State that help bring special expertise to services provided to HDMF buildings?**

YES NO

IF YOU ANSWERED YES, PLEASE DESCRIBE THE NATURE OF THESE PARTNERSHIPS BELOW.

6. **Do agencies in your State currently have difficulties in qualifying entire HDMF buildings or in implementing the 66% rule for WAP participation?**

YES NO

IF YOU ANSWERED YES, DESCRIBE THE ROOT CAUSES OF THESE DIFFICULTIES.

_____

_____

_____

IF YOU ANSWERED YES, DO YOU HAVE SPECIFIC PROCEDURES OR METHODS IMPLEMENTED OR PLANNED TO REDUCE THESE DIFFICULTIES?

YES NO

IF SPECIFIC PROCEDURES OR METHODS FOR REDUCING THESE DIFFICULTIES ARE IMPLEMENTED OR PLANNED, PLEASE ATTACH A WRITTEN COPY OF THE PROCEDURES OR MATERIAL DESCRIBING THE METHODS, OR SUMMARIZE THIS INFORMATION BELOW.

_____

_____

_____

_____

_____

7. **Does your State currently require contributions from HDMF building landlords as part of weatherizing such buildings with WAP funds?**

YES NO

IF YOU ANSWERED YES, PLEASE ATTACH A WRITTEN DESCRIPTION OF THESE POLICIES, OR WRITE THE DESCRIPTION BELOW.

_____

_____

_____

_____

_____

WERE LANDLORD CONTRIBUTIONS REQUIRED IN PY 1989?

YES NO

CAN YOU PROVIDE THE EXTENT OF LANDLORD CONTRIBUTIONS TO WEATHERIZATION OF HDMF BUILDINGS FOR YOUR ENTIRE STATE IN PROGRAM YEAR 1989?

YES NO

TOTAL LANDLORD $ INVESTED $ _____
LANDLORD $ AS % OF WAP FUNDS _____ %
Other _____

8. **Has your State considered or implemented any changes in policies since PY 1989 intended to improve the WAP services you could offer to HDMF buildings?**

YES NO

IF YOU ANSWERED YES, PLEASE ATTACH A WRITTEN DESCRIPTION OF THESE CHANGES IN POLICIES, OR WRITE THE DESCRIPTION BELOW. INDICATE WHETHER THE CHANGE IS IMPLEMENTED OR ONLY CONSIDERED.

_____

_____

_____

_____

9. **Do you have training programs in your State that specifically address weatherization services in HDMF buildings or apartments for subgrantees and State staff?**

	YES	NO

If yes, do the HDMF portions of these training programs cover:

Energy audits	Yes	No
Building recruitment procedures	Yes	No
Landlord agreements	Yes	No
Client education (renters)	Yes	No
Building operator education	Yes	No
Identification of major infiltration	Yes	No
Major infiltration measures	Yes	No
Attic insulation	Yes	No
Ventilation	Yes	No
Domestic water heating system retrofits	Yes	No
Heating system retrofits	Yes	No
Distribution system balancing or repair	Yes	No
Wall insulation	Yes	No
Lighting retrofits (as with landlord funds)	Yes	No
Floor insulation	Yes	No
Sill box (or similar) insulation	Yes	No
Window/door retrofits	Yes	No
Duct sealing or duct/pipe insulation	Yes	No
Cooling system retrofits	Yes	No
Other	Yes	No

IF YOU ANSWERED YES FOR "OTHER" ABOVE, PLEASE DESCRIBE THE COVERAGE OF THE OTHER TRAINING BELOW.

_____

_____

_____

10. Do you have any suggestions for changes in policies of the U.S. Department of Energy that would improve the WAP services you could offer to HDMF buildings?

YES NO

IF YOU ANSWERED YES, PLEASE ATTACH A WRITTEN DESCRIPTION OF THESE SUGGESTED CHANGES IN POLICIES, OR WRITE THE DESCRIPTION BELOW.

_____

_____

_____

_____

_____

11. Provide any other comments on HDMF program methods, procedures, obstacles, or potential aids or improvements to WAP efforts on these multifamily buildings.

_____

_____

_____

APPENDIX B

National Evaluation of the DOE Weatherization Assistance Program

Building Specific Data Survey Form High-Density Multifamily Units for Program Year 1989

Please provide the name(s) and telephone number(s) of the staff member(s) completing these forms, in case we have questions about the answers.

Name: _____

Phone #: _____

AGENCY ID

_____

INSTRUCTIONS

1. Please provide the information for this form **BY BUILDING.** One completed form is needed for each building you describe. If you weatherized several apartment dwelling units in one building, you can describe all dwellling units for that building with one form. You may use more than one form per building if needed, but DO NOT include dwelling units from multiple buildings on the same form.

2. Please copy this form as needed to provide extra copies, if necessary. The number of forms sent to you was estimated and may not be exact. A list of the dwelling units for which data is requested is included with the letter you received. Identification numbers are included on this list. PLEASE ENTER THE DWELLING IDENTIFICATION NUMBERS FROM THE LIST FOR ALL DWELLING UNITS DESCRIBED IN THIS FORM.

DWELLING IDs

_____

3. The phrase "dwelling units reported here" is used in this form to refer to all the dwelling units in one building being described on the following pages.

4. Please provide answers to questions which request numeric values, even if you have to estimate. You can write in the margins if your answer is a wild guess, you are only 50% sure, or whatever.

NOTE: These forms need to be completed ONLY ONCE for an entire building.

A. BUILDING CHARACTERISTICS AND EQUIPMENT

A1. When was the weatherization completed on the dwelling units described below?

Month_____ (CIRCLE YEAR) 1989 1990*

> *If the partial or complete multifamily building described below was not weatherized between April 1, 1989 and March 31, 1990, it should not be in the sample and no further information is needed. Please return this form along with the others.

A2. Is this building a. . . ? (MARK ONE)

[ ] Large multifamily (5 or more units), not owned by a public housing authority (which allows HUD Section 8 dwellings)
[ ] Large multifamily owned by a public housing authority
[ ] Any other type of dwelling, including row housing**

> **If this dwelling is NOT part of a large multifamily building, it should NOT be in the sample and no further information is needed. Single-family dwellings, including those attached on the sides—sometimes called row housing, should NOT be in the sample and no further information is needed. Please return this form along with the others.

A3. How many dwelling units are covered by the data reported below: _____
Enter number of units

A4. What is the TOTAL number of all apartment dwelling units in the same building as those described below: _____
Enter number of units

A5. Did the weatherization work cover the whole building?
(CIRCLE ANSWER) YES NO

A6. At the time of weatherization, what was the conditioned (heated or cooled) square footage of the areas of the building reported here, where weatherization work was performed? Include common areas if work was performed there (only once for any given building). If an entire building was treated, you must allocate all the conditioned common areas the easiest way for you (including providing a separate set of these forms for the common areas) without double counting.

_____ conditioned square feet

A7. About when was this building originally built? (MARK ONE)

[ ] Before 1900	[ ] 1920-1929	[ ] 1950-1959	[ ] 1980-1984
[ ] 1900-1909	[ ] 1930-1939	[ ] 1960-1969	[ ] 1985 or
[ ] 1910-1919	[ ] 1940-1949	[ ] 1970-1979	later

A8. At the time of weatherization, what was the **one main heating fuel** used for heating this building? (MARK ONLY ONE FUEL IN COLUMN A8)

A9. What **supplemental** fuels were used to heat the parts of the building reported here — including those used to provide heat just occasionally? Include fuels that ran portable heaters if they were used. Mark all that apply (If none, mark "No supplemental fuels used" in Column "A9" below.)

	A8 Main Fuel (Mark only one)	A9 Supplemental Fuels (Mark all that apply)
Gas from underground pipes serving the neighborhood	[ ]	[ ]
Bottled gas (LPG or Propane)	[ ]	[ ]
Fuel oil	[ ]	[ ]
Kerosene or coal oil	[ ]	[ ]
Electricity	[ ]	[ ]
Coal or coke	[ ]	[ ]
Wood	[ ]	[ ]
Solar collectors	[ ]	[ ]
Other (specify)_____	[ ]	[ ]
No supplemental fuels used		[ ]
Don't know	[ ]	[ ]

A10. If this building's main heating fuel is fuel oil, please provide the name of the fuel oil dealers that provide service to this dwelling. Also provide the city where the dealer is located.

_____ _____

Fuel Oil Dealer Name Dealer City

A11. What heating system types were used for this building? (MARK ALL THAT APPLY)

[ ] Apartment central systems (e.g., furnace with ducts, hot water boiler, heat pump with ducts) with one system per apartment dwelling
[ ] Building central systems (e.g., central furnace, steam boiler, hot water boiler) serving multiple apartment dwellings in the building
[ ] Fossil fueled in-space heaters (e.g., wall furnaces, floor funaces, wood, coal, kerosene or gas stoves)
[ ] Electric in-space heaters (e.g., through-the-wall heat pumps, wall, floor, baseboard, imbedded cable, portable [cord connected])
[ ] Other (specify) _____
[ ] Don't know

A12. Does this building have central air conditioning (A/C) equipment? (MARK ALL THAT APPLY)

[ ] Apartment central A/C with one system per apartment dwelling
[ ] Building central A/C with one system serving the whole building
[ ] Other central A/C
[ ] No central air conditioning for apartment dwellings
[ ] Don't know

A13. How many wall or window air conditioner or heat pump units were in the dwelling units reported here? (MARK ONE — PLEASE ESTIMATE IF NOT SURE)

[ ] None
[ ] 1-4
[ ] 5-9
[ ] 10-29
[ ] 30 or more
[ ] Don't know

A14. What domestic hot water system types were used for this building? (MARK ALL THAT APPLY)

[ ] Central system for the whole building
[ ] Central systems serving each floor
[ ] Individual units in the dwelling units
[ ] Other (specify) _____
[ ] Don't know
[ ] Circulating loop
[ ] Circulating loop

B. OCCUPANT CHARACTERISTICS

B1. If the entire building was included in the weatherization work, was the building qualified under the 66% rule?

(CIRCLE ANSWER) YES NO

B2. Please indicate: the total number of people living in the dwelling units reported here, the number who had income eligibility for the WAP verified for the 1989 program year before weatherization, and the total number of people in the building (estimate if you do not know). Also, please indicate the number who were elderly or handicapped.

Total number reported here: _____
Number of income-verified: _____

Total number of people in the building: _____
Number of elderly (age 65 or over): _____

Number of handicapped (permanent condition): _____

B3. For all households reported here, where income eligibility was verified and an application form was received, what is the average of all these incomes?

$/yr_____

B4. At the time of weatherization, how many households reported here for which an application form was received:

Rented their apartment dwelling _____
Occupied without payment _____
Owned (are buying) their dwelling _____
Enter the appropriate number of units for each line

B5. At the time of weatherization, how many households reported here for which an application form was received:

Paid their own fuel bills for heating _____
Paid for heating fuel through their rent _____
Enter the appropriate number of units for each line

C. WEATHERIZATION MEASURES INSTALLED

Please check any of the measures listed that were installed in this dwelling. Include measures for common areas (can be with one or more units or as a special unit by itself), but note that the measure is for a common area. Indicate whether the measures were installed by in-house crew or contractor. If measures that are not listed were installed, please describe them in the appropriate "Other" category.

	Installed by: In-house crew	Contractor
C1. Air Leakage Control		
General Caulking and Weatherstripping (door, window, sill plates, etc.)	[ ]	[ ]
Air Sealing, emphasizing bypasses with blower door testing	[ ]	[ ]
Air Sealing, emphasizing bypasses without blower door testing	[ ]	[ ]
Air Distribution System	[ ]	[ ]
Other Infiltration Reduction (not including windows)	[ ]	[ ]

(Specify: _____)

C2. Insulation		
Attic Insulation (installed for the first time)	[ ]	[ ]
Attic Insulation (added to existing insulation)	[ ]	[ ]
*Wall Insulation (normal technique)	[ ]	[ ]
*Wall Insulation (high-density technique)	[ ]	[ ]
Floor Insulation	[ ]	[ ]
Rim or Band Joist Insulation	[ ]	[ ]
Other Envelope Insulation	[ ]	[ ]

(Specify: _____)

*The "normal technique" for installing wall insulation is characterized by blowing cellulose or fiberglass insulation into exterior wall cavitites to average densities using a two-hole, gravity-blow installation method. The "high-density technique" is characterized by blowing cellulose insulation into exterior wall cavities to high densities using a one-hole, tube-fill installation method. Under the "high-density technique," special attention is focused on sealing air leakage sites while insulating the walls; air bypasses are identified during the installation process and sealed by plugging the air-leakage pathways with cellulose.

C3. Water Heating System

What type of water heating system is in the building?
Individual for this unit [ ] Central for all units [ ] Other_____

	Installed by: In-house crew	Contractor
Water Heater Tank Insulation.	[ ]	[ ]
Entire Water Heating Unit Replacement.	[ ]	[ ]
Central System Controls Improvements	[ ]	[ ]
Pipe Insulation.	[ ]	[ ]
Low Flow Shower Heads or Faucet Aerators	[ ]	[ ]
Temperature Reduction.	[ ]	[ ]
Other Water Heater Measures or Repairs.	[ ]	[ ]

(Specify: _____)

C4. Space Heating System

What type of space heating system is in the building?
Individual for this unit [ ] Central for all units [ ] Other_____

Clean and Tune-up.	[ ]	[ ]
Thermostat or Other Controls Retrofit.	[ ]	[ ]

(Specify: _____)

Entire Heating Unit Replacement/Modification. . .	[ ]	[ ]
Repairs.	[ ]	[ ]

(Specify: _____)

Was replacement/modification or repair expected to increase energy use?

(CIRCLE ANSWER)	YES	NO
Distribution System Retrofit (e.g., steam balancing)	[ ]	[ ]

(Specify: _____)

Heating System Component Retrofits.	[ ]	[ ]

(Specify: _____)

Safety Problem Fixed.	[ ]	[ ]

(Specify: _____)

Other Heating System Modifications.	[ ]	[ ]

(Specify: _____)

	Installed by: In-house crew	Contractor
C5. Space Cooling System		
What type of space cooling system is in the building? Individual for this unit [ ] Central for all units [ ] Other_____		
Tune-up. . . . . (e.g., cleaning, controls adjustment, filter replaced)	[ ]	[ ]
Entire Air-Conditioning System Replacement	[ ]	[ ]
Fans Installed or Replaced.	[ ]	[ ]
Thermostat or Other Controls Retrofit.	[ ]	[ ]
(Specify: _____)		
Distribution System Retrofit (e.g., duct sealing/balancing)	[ ]	[ ]
(Specify: _____)		
Other Cooling System Modifications.	[ ]	[ ]
(Specify: _____)		
C6. Ventilation System		
Controls Retrofit.	[ ]	[ ]
(Specify: _____)		
Fan/Exhauster Repair or Replacement	[ ]	[ ]
(Specify: _____)		
Other Repairs.	[ ]	[ ]
(Specify: _____)		
Other Ventilation System Modifications.	[ ]	[ ]
(Specify: _____)		
C7. Windows and Doors		
Storm Windows (How many? _____)	[ ]	[ ]
Thermal Windows (How many? _____)	[ ]	[ ]
Storm Doors.	[ ]	[ ]
Window Films or Shades.	[ ]	[ ]
Other Window or Door Treatments.	[ ]	[ ]
(Specify: _____)		

C8. Structural Repairs (full or partial)

Attic Ventilation	[ ]	[ ]
Roof	[ ]	[ ]
Ceilings	[ ]	[ ]
Doors	[ ]	[ ]
Replacement of Doors	[ ]	[ ]
Windows/Glazing	[ ]	[ ]
Walls	[ ]	[ ]
Floor	[ ]	[ ]
Other Structural Repairs	[ ]	[ ]

(Specify: _____)

C9. Other Health and Safety Repairs or Improvements

Smoke Detectors	[ ]	[ ]
Interior Fire Doors	[ ]	[ ]
Railings	[ ]	[ ]
Stairs/Ramps	[ ]	[ ]
Locks	[ ]	[ ]
Radon Testing	[ ]	[ ]
Carbon Monoxide Testing	[ ]	[ ]
Backdrafting Testing	[ ]	[ ]
Other	[ ]	[ ]

(Specify: _____)

D. SERVICE DELIVERY PROCEDURES

D1. SELECTION OF MEASURES

Please check the type of procedure that was used to select the measures that were installed in **the dwellings reported here** in the 1989 program year. (Check all that apply)

Envelope Measures

[ ] Envelope measures were selected using a priority or prescribed list of measures

[ ] Envelope measures were selected using a decision approach or scoring (calculation) developed for each house

[ ] Envelope measures were selected based on an analysis of energy savings per $ invested

D1. SELECTION OF MEASURES (continued)

Space Heating—Cooling—Ventilation (HVAC) System Measures

[ ] HVAC system measures were selected based on physical characteristics of pre-retrofit unit or a standard approach (similar to a priority list)

[ ] HVAC system measures were selected using a decision approach or scoring (calculations) based on operating performance

[ ] HVAC system measures were selected based on an analysis of energy savings per $ invested

Domestic Water Heating (DHW) System Measures

[ ] DHW system measures were selected based on physical characteristics of pre-retrofit unit or a standard approach (similar to a priority list)

[ ] DHW system measures were selected using a decision approach or scoring (calculations) based on operating performance

[ ] DHW system measures were selected based on an analysis of energy savings per $ invested

General

[ ] Selection of envelope and HVAC and DWH energy system measures was made simultaneously under one approach rather than separately using distinct procedures.

[ ] Investment level per unit was determined based on analysis of pre-weatherization energy consumption data.

[ ] Outside consultant specialists were used.

[ ] Other measure selection procedures. Specify:

_____

_____

D2. USE OF DIAGNOSTICS

Please check the type of diagnostic procedures that were used. (Check all that apply)

[ ] Blower door testing was used to find leakage areas for sealing

[ ] Blower door testing was used to measure air leakage rates

[ ] Blower door testing was used to determine when to stop work using cost-effectiveness guidelines (not minimum ventilation guidelines)

[ ] Distribution system diagnostics were used to determine system balancing

[ ] Distribution system diagnostics were used to seal leaks

[ ] Infrared scanning was used

[ ] Indoor air quality was tested

[ ] Heating, cooling, or domestic water heating system efficiency testing was used

[ ] Combustion systems safety inspections were conducted

[ ] Other diagnostic procedures. Specify:

_____

_____

D3. QUALITY CONTROL

Please indicate the type of quality control inspection used. (Check all that apply)

[ ] A visual quality control inspection after weatherization for envelope measures

[ ] A quality control inspection after weatherization for envelope measures that used blower door testing as a diagnostic tool

[ ] A quality control inspection after weatherization for envelope measures that used infrared scanning as a diagnostic tool

[ ] A visual quality control inspection after weatherization for heating system measures

[ ] A quality control inspection after weatherization for heating system measures that used diagnostic tools such as combustion efficiency testing

[ ] Other quality control procedures. Specify:

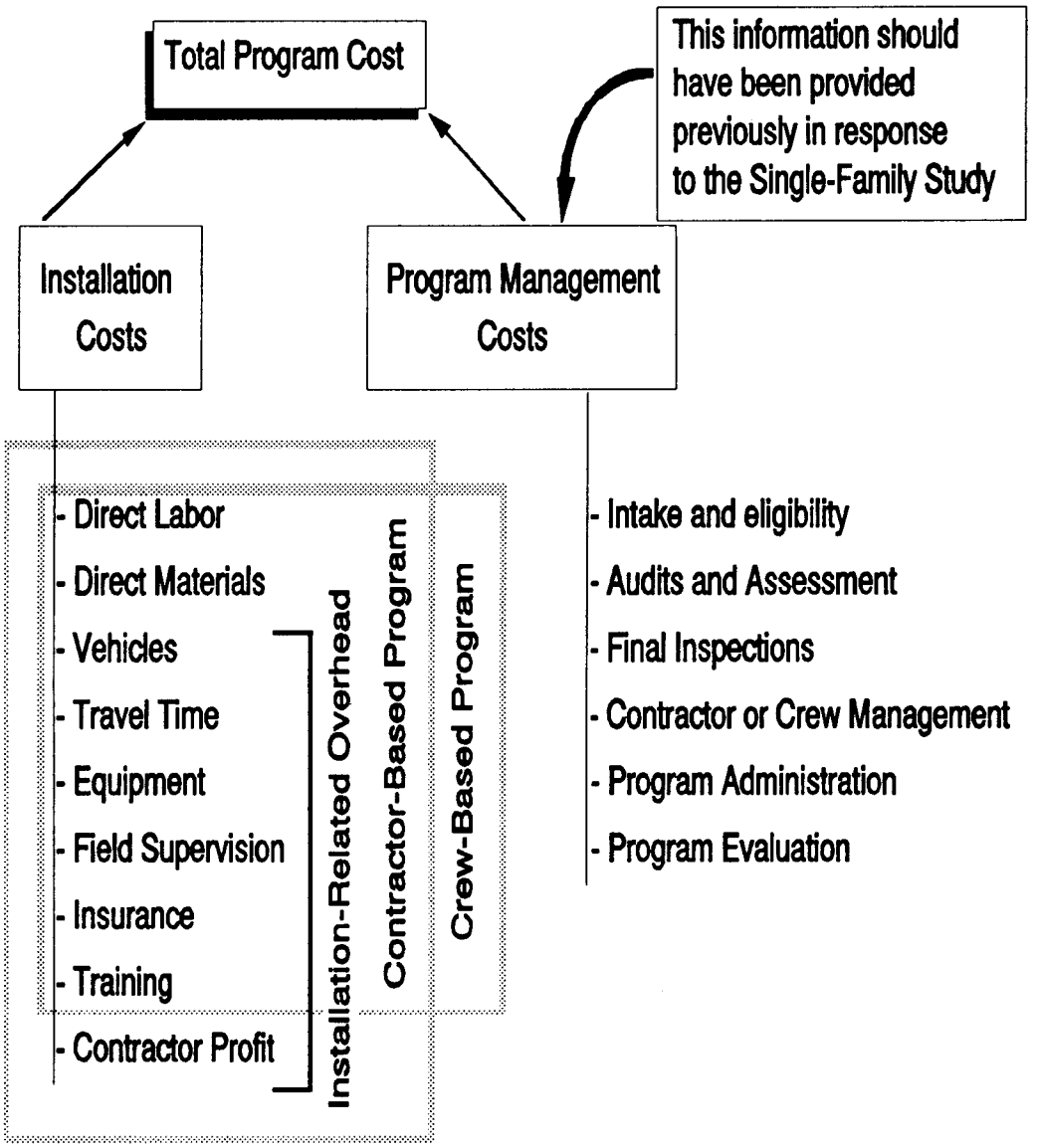
_____

_____

E. COSTS: MATERIALS, LABOR, INSTALLATION OVERHEAD AND PROGRAM MANAGEMENT

Definitions and Instructions

If a job is crew-based, supply the materials costs (Question E1) and calculate the direct labor costs (Question E2). If a job is contractor-based, supply the materials costs (Question E1) and the total installed costs (Question E3). If both crews and contractors worked on a building, complete all three questions (Questions E1, E2, and E3). You should already have examined this information for the forms completed for the Single-Family Study.



E1: BREAKDOWN OF MATERIALS COSTS

In the chart below please fill in the crew-based and/or contractor-based materials cost of the measures that were installed in the dwelling units reported here for the 1989 program year. **Do not include labor, administrative or program support costs here.** Do include costs covered by all sources of funding (i.e., PVE, LIHEAP, landlords, or utilities). Costs covered by landlord contributions that do not contribute directly to energy savings can be included under Structural Repairs, with a note explaining why. If you cannot provide the costs by general type of measure, just enter the **total** materials cost in the box at the bottom.

	Crew-Based Materials Costs	Contractor-Based Materials Costs
Air Leakage Control	$ _____	$ _____
Insulation		
attic	$ _____	$ _____
wall	$ _____	$ _____
other	$ _____	$ _____
Water Heating System	$ _____	$ _____
retrofit	$ _____	$ _____
replacement	$ _____	$ _____
Space Heating System		
retrofit	$ _____	$ _____
replacement	$ _____	$ _____
Space Cooling System		
retrofit	$ _____	$ _____
replacement	$ _____	$ _____
Ventilation System		
retrofit	$ _____	$ _____
replacement	$ _____	$ _____
Windows and Doors	$ _____	$ _____
Structural Repairs	$ _____	$ _____
Other	$ _____	$ _____
TOTAL Materials Costs	$	$
	Crew-Based	Contractor-Based

E2: CREW-BASED INSTALLATION COSTS (DIRECT LABOR COSTS)

Directions: Please fill in the number of crew hours for **the dwellings reported here** from information in your files. Provide your best estimate of the average hourly rate for your crew and multiply this by the number of hours to produce an estimate of the direct labor costs.

DO NOT include ANY OVERHEAD (as shown in Fig. 1) in the average hourly rate.

Direct Labor ☞ _____ (Number of person hours for crew) x _____ (Average hourly rate) = $_____

E3: CONTRACTOR-BASED INSTALLATION COSTS

Directions: Please fill in the total installation costs* billed by contractors for **the dwellings reported here.** This should include all the overhead cost categories listed in Fig. 1 **plus the contractor's profit.**

Total Installed Cost $_____

*Include the materials costs (reported on p. 13) in this total, as well as labor costs and installation-related overhead.

F. FUNDING SOURCES

F1. What percentage of the funds spent on **the dwellings reported here** were:

Funds from DOE's WAP: _____%
Funds from Landlord: _____%
Funds from Others: _____% Specify whom: _____

F2. If funds from non-DOE sources were used, were they all used according to DOE guidelines?

[ ] Yes
[ ] No

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