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Weatherization Investment Costs for Low-Income Housing

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U.S. DEPARTMENT OF COMMERCE, Philip M. Klutznick, *Secretary*
Jordan J. Baruch, *Assistant Secretary for Productivity, Technology, and Innovation*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

PREFACE

This project was conducted under the sponsorship of the Community Services Administration (CSA) by the Applied Economics Group in the Center for Building Technology (CBT) of the National Bureau of Standards (NBS).

In response to the burden that high and rapidly rising energy costs are imposing on low-income households, CSA and NBS are conducting a demonstration program to weatherize the dwellings of such households to conserve energy. This program involves the installation and analysis of a broad range of weatherization options for over 200 single-family houses in 14 demonstration sites throughout the United States. One important element of this program is to collect and analyze the costs of these weatherization investments so that CSA, the Department of Energy, and other interested parties can have accurate estimates of weatherization costs available and can better decide whether the installed package of weatherization options is expected to pay for itself. Consequently, this report presents an analysis of the field data collected on the costs of installing in low-income houses architectural weatherization features designed to reduce the building space heating load.

Special appreciation is extended to the local project coordinators of the demonstration sites for taking the time to fill out the many cost data forms required and for providing information needed to resolve ambiguities. Special appreciation is also extended to Kimberly A. Barnes for developing the first versions of the computer programs used for this report and for providing advice on computer matters. Lawrence J. Kaetzel, Judith T. Calabrese, and Charles B. Andrews also deserve thanks for providing technical assistance with the operation of the CBT computer system. For assistance in tabulating data and editing the manuscript the authors are grateful to Anne Hillstrom. Special appreciation is also extended to Brenda L. Kefauver and Mary L. Ramsburg for typing the manuscript. For helpful comments throughout the project, the authors would like to thank Robert E. Chapman, Richard W. Crenshaw, and Stephen R. Petersen. In addition, the authors are grateful to the reviewers for providing comments to improve the report: Kimberly A. Barnes, Robert W. Beausoliel, Richard W. Crenshaw, and Harold E. Marshall.

ABSTRACT

This report presents the results of a project involving the collection and tabulation of field data on the costs of retrofitting low-income houses for energy conservation. This project is part of the Community Services Administration Weatherization Demonstration Program being carried out through the National Bureau of Standards. The program involves the installation and evaluation of a broad range of energy conservation techniques for over 200 single-family houses in 14 demonstration sites throughout the United States. The energy conservation techniques discussed in this report consist of a variety of architectural modifications to building envelopes for the purpose of reducing heat losses due either to air infiltration or conduction. The methods used to collect and synthesize the field data on the major cost components of installing these techniques are described. An analysis of these costs is presented in the form of summary statistics including the weighted mean and standard deviation of the unit cost of installing each architectural option in each demonstration site. The significant intercity variation found in the mean unit cost of most techniques suggests that unique cost estimating procedures may be needed for each city. Possible sources of variation in the mean unit costs are discussed. Recommendations for further research include investigating the effect on cost that can be attributed to selected sources of variation.

Key Words: Building economics; cost components; data analysis; data collection; demonstration; economic analysis; energy conservation; insulation; low-income housing; statistics; unit costs; weatherization.

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CONVERSION FACTORS FROM CUSTOMARY TO METRIC (SI) UNITS

QUANTITY	TO CONVERT FROM	TO	MULTIPLY BY
Length	lineal foot (lf)	meter	3.048×10^{-1}
Area	square foot (sf)	square meter	9.290×10^{-2}
Volume	cubic foot (cf)	cubic meter	2.832×10^{-2}
Mass	pound (lb)	kilogram	4.536×10^{-1}
Density	pound per cubic foot (lb/cf)	kilogram per cubic meter	1.603×10^{1}
Temperature	degree Fahrenheit (°F)	degree Celsius	$t_C = (t_F-32)/1.8$
Temperature difference	degree Fahrenheit (°F)	degree Celsius	5.556×10^{-1}
Energy	British thermal unit (Btu)	joule	1.055×10^{3}
Thermal Resistance	square foot hour degreee Fahrenheit per Btu (sf•h•°F/Btu)	square meter degree Celsius per watt	1.761×10^{-1}

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this report is to present the results of a project involving the collection and tabulation of field data on the costs of retrofitting low-income houses for energy conservation. This project is part of the Community Services Administration (CSA) Weatherization Demonstration Program being carried out through the National Bureau of Standards (NBS).[1] The program involves the installation and evaluation of a broad range of energy conservation techniques for over 200 single-family houses in 14 demonstration sites throughout the United States. The results presented in this report are in the form of summary statistics giving the mean, median, range, and standard deviation of the unit cost of installing each architectural option in each demonstration site. Statistics are also presented on such major cost components as labor cost, materials cost, and overhead.

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[1] For an overview of the many research activities comprising this Weatherization Demonstration, see R. Crenshaw et al., CSA Weatherization Demonstration Project Plan, National Bureau of Standards Interagency Report 79-1706, Washington, D.C., March 1979.

1.2 SCOPE

The energy conservation techniques discussed in this report consist of a variety of architectural modifications to building envelopes, usually referred to as architectural options. These architectural options are divided into two major groups: those that reduce heat losses due to direct conduction through the envelope components, that is, walls, windows, attic and floor (conduction options), and those that reduce heat losses due to air leakage through cracks in or between the components (infiltration options). The selection of the particular options to be installed at each demonstration site was based on an economic analysis of predicted energy savings and estimated costs for each option.[1]

All of the demonstration sites for which cost data on architectural options were reported are listed in table 1.1, along with the three-letter codes often used in this report to reference the sites. Table 1.2 lists the architectural options and indicates the number of dwellings for which cost data were received for each architectural option in each demonstration site. For any particular option-site combination, the cost data are summarized in this report only if both labor and materials costs were reported separately for at least four dwellings. The items of cost data which satisfy this criterion and are thus presented in this report account for 87 percent of all reported architectural option installations.

1.3 USEFULNESS OF COST DATA

The cost data collected over the course of this project are based on the actual weatherization work conducted at the demonstration sites. Thus, future estimates of the cost of installing various architectural options based on these data can be expected to have greater accuracy than would be possible in the absence of such direct and specific experience. These architectural cost data can also be used to assess the cost effectiveness of the weatherization options that were installed.

A very useful characteristic of the architectural cost data is that the data reported for each option installed on a house include both the size of the job (e.g., square feet of wall area insulated) as well as a separate accounting of labor and materials. With these detailed data, studies can be made of the major sources of variation in the cost of an architectural option from house to house and from site to site. Among the sources of variation that can be studied using these data are possible economies of scale in terms either of the number of square or lineal feet installed or of the thermal resistance of the insulation added. Another source of variation is whether the work was carried out under contract or on an in-house basis. Yet another

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[1] For a detailed discussion of how the economically optimal weatherization options were selected for each site and fuel type, see R. Chapman *et al.*, *Optimizing Weatherization Investments in Low-Income Housing: Economic Guidelines and Forecasts*, National Bureau of Standards Interagency Report 79-1948, Washington, D.C., February 1980.

Table 1.1

Metropolitan Area, State, and Abbreviation for the Demonstration Sites in this Report

Metropolitan Area	State	Abbreviation
Albuquerque	New Mexico	ALB
Atlanta	Georgia	ATL
Charleston	South Carolina	CHA
Colorado Springs	Colorado	CSP
Easton/Allentown/Bethlehem	Pennsylvania	EAS
Fargo	North Dakota	FAR
Minneapolis/St. Paul	Minnesota	MSP
Oakland	California	OAK
Portland	Maine	POR
St. Louis	Missouri	STL
Tacoma	Washington	TAC
Washington, D.C.	Maryland[a]	WAS

[a] The dwellings at this site are located near Hughesville, Maryland.

Table 1.2

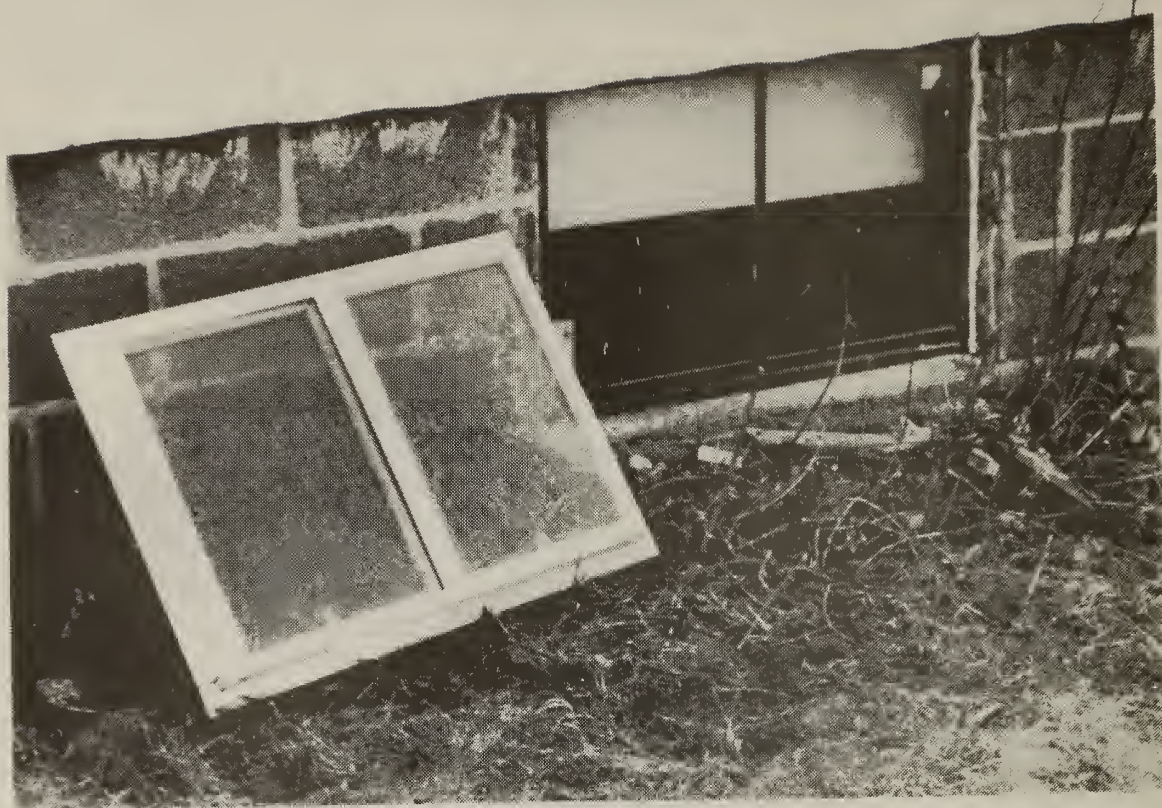
Number of Houses Reported by Architectural Option and City

Option Description	City ALB	 ATL	 CHA	 CSP	 EAS	 FAR	 MSP	 OAK	 POR	 STL	 TAC	 WAS
Infiltration Options												
Replace Broken Glass	4	2[a]	12	15	15		6[b]	8	4		3[a]	
Reset Glazing	1[a]	1[a]	9	7	11		6[b]	1[a]	4			
Replace Thresholds		2[a]	17	16				5	1[a]		1[a]	1[a]
Seal Structural Cracks	3[a]	3[a]	18	13	2[a]				1[a]			
Caulk Windows	1[a]	2[a]										
Caulk Doors		2[a]										
Caulk Windows and Doors		3[a]	18	18	8				8			10
Weatherstrip Windows		3[a]		7		11	7[b]					
Weatherstrip Doors	7	4		18		12	6[b]	5	12		9	10
Weatherstrip Windows and Doors		3[a]	15		12							
Weatherstrip Attic Hatch		4		9					6			
Conduction Options												
Install Storm Windows	6		1[a]	16						15	9	10
Install Storm Doors	1[a]			2[a]								2[a]
Install Triple Glazing		5		7	7	13						
Insulate Basement Walls w/Cellulose									10			
Insulate Basement Walls w/Fiberglass Batts				5								
Insulate Basement Walls w/High R Sheathing and Fiberglass Batts										9[b]		
Insulate Basement Walls w/Urea-Formaldehyde						7					10	3[a]
Install Foundation Vents			5									
Install Foundation Vapor Barrier			1[a]								3[a]	
Insulate Crawl Space w/Styrofoam		2[a]	11			1[a]					8	
Insulate Crawl Space w/Urea-Formaldehyde		3[a]				3[a]						
Insulate Floor Joists w/Fiberglass Batts		2[a]	5	4								5
Insulate Rim Joists w/Fiberglass Batts						3[a]	1/					
Insulate Walls w/Cellulose		2[a]		6					15		4	4
Insulate Walls w/Fiberglass					7							
Insulate Walls w/Urea-Formaldehyde				10		12	17					5
Insulate Attic w/Cellulose			17	18	9	12	12	8	15	13		10
Insulate Attic w/Fiberglass	5							3[a]				
Insulate Attic w/Rock Wool		9								8[b]	11	
Install Attic Vents			3[a]			2[a]			2[a]			

[a] Because fewer than four dwellings were reported, cost data are not summarized in this report.

[b] Because labor and materials costs were not reported, cost data are not summarized in this report.

use for these data would be in constructing a separate price index to apply to each cost component in order to account for cost differences over time and across regions and thus permit accurate periodic revisions of cost estimates based on these data.



2.0 DATA COLLECTION METHOD

2.1 DATA COLLECTION FORM

The first step in the process of collecting data on the costs of the architectural options was the development of a standard form for reporting the data. The form that was developed and used for this purpose is shown as figure 2.1. This Dwelling Unit Cost Data Form was used by personnel at the demonstration sites to record information relevant to the cost reporting of every architectural option installed in each house of the demonstration program. The circled numbers on figure 2.1 provide a key to the following types of information recorded on the form:

1. Code number of the dwelling being weatherized.

2. Building element being modified.

3. Energy conservation retrofit option being installed.

4. Job size or dimensions of the option being installed, measured in square feet, lineal feet, or number of units treated.

5. Total cost of the option being installed including overhead cost.

Figure 2.1

DWELLING UNIT COST DATA FORM

ADDRESS ______ (1) ______ RETROFIT OPTION ______ (3) ______

BUILDING ELEMENT ______ (2) ______ SQ FT, LIN FT, #UNITS ______ (4) ______

TOTAL COST
(5) ______

TYPE OF WORK	DIRECT LABOR USE				MATERIALS & EQUIPMENT USE				
	(9) LABOR SKILL	HOURS	RATE	TOTAL	(10) MATERIALS/EQUIPMENT	UNIT SIZE	TIME OR QUANTITY	UNIT COST	TOTAL
PREPARATION (6)									
TOTAL									
INSTALLATION (7)									
TOTAL									
OTHER (8)									
TOTAL									

6. Cost of preparation work normally required before the installation process itself.

7. Costs directly associated with the actual installation of the option.

8. Two types of costs were recorded under Other Costs:

    (a) The cost of doing any repairs to a building before the option could be installed; and

    (b) Some overhead cost items such as travel and supervision for jobs done on an in-house basis.

9. Labor cost for each of items 6 through 8. The number of labor hours of each labor skill, the rate paid per hour for that skill and the total labor charges for that skill were recorded separately.

10. Materials costs for items 6 through 8. Specific information was given on the type of material used, the size of each unit of the material, the number of units used, the cost per unit, and the total cost for the material. For example, if 15 bags of cellulose insulation were used, each bag costing $5.95, this information and the resulting total material cost of $89.25 was recorded.

2.2 MONITORING THE DATA COLLECTION

The local project coordinator of each demonstration site was asked to fill out and submit a trial Dwelling Unit Cost Data Form as soon as the first architectural option was installed. The completed trial form revealed possible uncertainties in reporting procedures and thus served as a basis for establishing a workable and consistent set of guidelines for recording and reporting the remaining cost data for each site. As data collection forms were submitted, telephone conversations between NBS staff and the local project coordinators were held to resolve ambiguities and supply missing data. This type of direct communication between NBS staff and the local project coordinators was found to be effective in improving the quality of the data.

The progress of the cost data collection was monitored through the use of Cost Data Tracking Charts. An individual chart was developed for each site according to the particular options selected to be installed. As figure 2.2 illustrates with a hypothetical example, a typical Cost Data Tracking Chart lists these architectural options vertically and the appropriate house code numbers horizontally. Each cell at the intersection of a particular option and house could contain any one of the three symbols defined at the top of the chart. These charts provided at a glance the current status of the architectural cost data reporting on a site-by-site basis.

Figure 2.2. Cost Data Tracking Chart

Note: 1. "X" indicates cost data already received.
2. Place "NA" in cells that represent options that will not be installed on a particular house.
3. Place "O" in cells that represent completed work, but data not yet submitted.

SITE

Coldspot, USA

	HOUSE NUMBERS											
OPTION	1	3	7	11	16	17	18	23	25	30	31	39
1 Replace Broken Glass	NA	NA	X	NA	O	NA	NA	NA	X	NA	X	X
2 Reset Glazing		NA	NA	NA	NA	NA	NA		NA		NA	NA
3 Replace Thresholds		NA	NA	NA	NA	NA	NA		NA	NA	NA	
4 Seal Structural Cracks	NA	NA	NA				NA		NA	NA		
5 Caulk Windows and Doors	O	O	O	O	O	NA	O	O	O	O	O	O
6 Weatherstrip Windows and Doors	O	O	O	O	O	NA	O	O	O	O	O	O
7 Weatherstrip Attic Hatch												
8 Install Storm Windows												
9 Insulate Basement Walls	O	X	O	X	X	X	X	NA	X	X	O	O
10 Insulate Walls	X	X	X	X	X	X	NA	X	X	X	X	X
11 Insulate Attic	X	X	X	X	X	X	X	X	O	X	NA	X

3.0 DATA REDUCTION AND SYNTHESIS

In this section we discuss how the raw architectural cost data received from the demonstration sites were used to develop the summary statistics presented in section 4 for each option and site. The procedures for extracting, consolidating, and analyzing the data were slightly different for each of three categories of architectural work: (1) non-attic options; (2) attic options; and (3) weatherization-related repair work. The procedures followed for each category are discussed in turn.

3.1 NON-ATTIC OPTIONS

The first step in the data reduction process for non-attic options was to extract the relevant information from each Dwelling Unit Cost Data Form and to consolidate this information for all houses that had a particular option installed in a given city. To accomplish this task the Composite Data Form was developed. As illustrated in figure 3.1 using a hypothetical example, this form specifies the demonstration site, the option, and whether the work was performed under contract or in-house. Each row of this form presents five items of information extracted from a single Dwelling Unit Cost Data

Figure 3.1 Composite Data Form

Site Coldspot, USA

Option Insulate Walls with UF Foam

Contracted or In-House Contracted

House Number	Job Size (sf)	Labor Cost ($)	Materials Cost ($)	Total Cost ($)
3	848	208.00	121.75	523.92
7	744	160.00	146.75	405.47
16	917	128.00	121.75	526.22
17	752	112.00	116.75	374.45
25	912	128.00	136.75	435.33
30	1040	160.00	160.50	522.51

Form: (1) code number of the weatherized house; (2) job size or dimensions of the architectural option installed; (3) labor cost of the installation; (4) materials cost of the installation; and (5) total cost of the installed option.

Two distinct accounting definitions of total cost were developed and applied depending on whether the option was installed by contracted labor (contracted) or by employees of the local community action agency (in-house). In the case of contracted jobs, the definition of total cost is given by

$$T \equiv L + M + OP, \tag{3.1}$$

where T = Total cost reported as charged under the contract;
L = Labor cost reported for the option;
M = Materials cost reported for the option; and
OP = Overhead and profit calculated as a residual.

For contracted jobs, T, L, and M are recorded explicitly on the Dwelling Unit Cost Data Form, whereas OP must be calculated as a residual on the basis of equation (3.1). Overhead represents the fixed business expenses of the contractor which arise independently of the volume of contracted business. Examples of overhead expenses are office rent, insurance, management, and clerical and administrative support. Also included in the residual OP is the contractor's profit. In one city (CSP), the contractor's total charge for installing storm windows was less than the sum of labor and materials costs incurred. Here, rather than have the residual OP be negative, the sum of labor and materials costs was recorded as the total cost on the Composite Data Form, under the assumption that contractors are not likely to continue underestimating job costs.

In the case of in-house weatherization jobs, the definition of total cost is given by

$$T \equiv L + M + OT, \tag{3.2}$$

where T = Total cost calculated as the sum of its components;
OT = Overhead and travel cost as reported for the option; and
L & M are as defined for equation (3.1), above.

For these jobs performed on an in-house basis, there is no reported contract cost to use as the total cost of the option. Thus total cost has to be calculated as the sum of its three reported components: L, M, and OT. OT is derived from two types of cost items reported on the Dwelling Unit Data Form: overhead and travel. Examples of the overhead items reported include clerical support and certain management functions such as supervision, job estimation, and inspection. No attempt was made to estimate or impute any overhead expenses beyond those explicitly reported by the local community action agencies. The other component of OT, travel cost, was consistently reported and included both labor time spent in transit to and from the job site and vehicle mileage costs.

A special cost accounting problem arose whenever two or more architectural options for a house were reported on a single combined Dwelling Unit Cost Data Form. In this situation a single total cost figure was always given for the combined options, although the labor and materials costs could in most cases be assigned to the separate options. Since the data for this report were to be analyzed on an option-by-option basis, it was necessary to determine a separate total cost figure for each of the options reported. This figure was obtained by employing equation (3.3), which computed the overhead and profit or overhead and travel multiplier applicable to the cost of the labor and materials for the combined options and applied that multiplier to the sum of labor and materials costs of each separate option:

$$T_s = [T_c/(L_c+M_c)] \cdot [L_s+M_s], \tag{3.3}$$

where T_s = Total cost of a single option;
T_c = Total cost of the combined options;
L_c = Total labor cost of the combined options;
M_c = Total materials cost of the combined options;
L_s = Total labor cost of the single option; and
M_s = Total materials cost of the single option.

Another similar accounting problem occasionally arose when a single Dwelling Unit Cost Data Form contained more than one architectural option. The materials were generally described in enough detail that the particular options for which they were used could be easily discerned. On some forms, however, the labor costs were found grouped together so that one could not tell how many labor hours were spent on each option. To address this problem, the combined labor costs were distributed among the options in proportion to the cost of the materials used for each option. The following equation was used for assuring this apportionment of combined labor costs:

$$L_s = (M_s/M_c) \cdot L_c, \tag{3.4}$$

where L_s = Labor cost to be calculated for the work of installing a single option;
M_s = Materials cost for the option for which labor cost is to be calculated;
M_c = Total materials cost of the combined options; and
L_c = Total labor cost of the combined options.

The final accounting problem occurred only when two or more architectural options were installed by the same contractor. Although a separate contract cost figure may have been given for each option on an individual Dwelling Unit Cost Data Form, occasionally the amounts reported did not reflect a realistic assignment of costs to each option. For example, in one city where attics and walls were insulated by the same contractor, substantial losses were reported on the attic installations (i.e., the contract cost was actually less than the sum of labor and materials costs), while excessive profits were reported in the wall installations (i.e., the contract cost was more than twice as much as the sum of labor and materials costs). The procedure followed to address this situation was to combine the cost data for the two options under one contract and then redistribute the total contract overhead and profit in proportion to the labor and materials costs of each option. Equation (3.3) was used to carry out this cost redistribution, and the revised data for each house and option were then recorded on the appropriate Composite Data Form.

Once correctly recorded on the Composite Data Forms, all the relevant cost data for each option-site combination were entered into a computer file. A computer program was then used to retrieve the data from the file and calculate several summary statistics for each of the following variables of that option-site combination: job size (in square or lineal feet), unit labor cost (labor cost per square or lineal foot), unit material cost, unit overhead cost, and unit total cost. The summary statistics calculated for each of the above variables were the minimum, maximum, arithmetic mean, and median. Two additional statistics for the total cost variable were then calculated: its mean and standard deviation, both weighted by job size. All of these summary statistics for each non-attic option are presented in subsections 4.1 and 4.2.1.

The arithmetic mean and the weighted mean of the unit total cost variable differ from one another in their calculation and interpretation. The methods of calculating these statistics are given by the following equations:

$$\bar{X} = \frac{\sum_{i=1}^{n} (T_i/S_i)}{n}, \text{ and} \tag{3.5}$$

$$\bar{X}_w = \frac{\sum_{i=1}^{n} (T_i/S_i) \cdot S_i}{\sum_{i=1}^{n} S_i} = \frac{\sum_{i=1}^{n} T_i}{\sum_{i=1}^{n} S_i}, \tag{3.6}$$

where $\bar{X}$ = Unweighted arithmetic mean;
X_w = Mean weighted by job size;
n = Number of jobs (dwellings) reported for the option and site being considered;
T_i = Total cost of installing the option for each individual dwelling; and
S_i = Size of each individual job (lf or sf).

To illustrate the difference between these two statistics, consider the following example. Suppose for a particular site and option only two dwellings were retrofitted: on one house 1000 sf of wall area were insulated at a cost of $1.00/sf, while on the other 500 sf of wall area were insulated for $1.20/sf. The arithmetic, or unweighted, mean cost for this site would be exactly halfway between the two unit cost amounts of the houses, namely $1.10/sf. In this sense, the unweighted mean gives each individual job (or dwelling) equal importance, regardless of the size (number of square or lineal feet) of the job. In contrast, for the same two jobs the weighted mean would be \$1.07/sf $\left(\frac{1.00\ (1000) + 1.20\ (500)}{1500}\right)$, which reflects the relatively greater weight given by this statistic to the unit cost (\$1.00/sf) of the larger job than to that (\$1.20/sf) of the smaller job. Thus the weighted mean is a measure of the average cost of installing one square or lineal foot of the option for that demonstration site.

As mentioned earlier, the standard deviation weighted by job size of the total cost variable is also computed. The formula used for calculating the weighted standard deviation (SD_W) is:

$$SD_W = \sqrt{\sum_{i=1}^{n} (T_i/S_i - S_W)^2 \cdot (S_i / \sum_{i=1}^{n} S_i)}, \tag{3.7}$$

where the symbols are defined as for equations (3.5) and (3.6), above. This statistic provides a measure of the variability of the unit cost of the option across all houses within the demonstration site. This unit cost variation within a site may be due to several factors. The location of the house may account for some variation because the travel component is a function of distance from the assembly point of the work crew. The size of the job may also affect unit cost because of possible economies of scale. This factor is particularly important when fixed costs such as for travel or setting up equipment represent a significant proportion of the total cost of installing the option. Another cause of the variance in unit cost could be the differences found in the physical structures of the dwellings themselves. An example of this would be the relatively higher unit cost of insulating a brick veneer wall compared with that of insulating a wood-frame wall.

3.2 ATTIC INSULATION

Procedures similar to those used for the cost data on non-attic options were followed for data on attic insulation. The major accounting problems encountered with attic insulation data were the determination of overhead costs and the revision of total cost estimates for two or more options installed by the same contractor. These problems were dealt with in the manner described in subsection 3.1 above. Once these accounting problems were resolved, the relevant information for all houses was taken from the corrected Dwelling Unit Cost Data Forms and consolidated onto the Composite Data Form for each demonstration site. Besides the house number, job size, labor cost, materials cost, and total cost recorded for the other options, an additional variable had to be recorded for attic insulation: the amount of thermal resistance (R-value) added. This need arose because across each site, the sample dwellings designated to have this option installed had variable amounts of insulation already in their attics. Therefore, different amounts of insulation had to be installed in these attics to achieve the R-value recommended for the particular site in question. In order to make the cost data for attic insulation comparable across houses and sites, all the figures are presented on a per R-value basis. To accomplish this, the R-value of the added insulation was calculated for each case using equation (3.8).

$$R = [W/(D \cdot A)] \cdot 12\ V, \tag{3.8}$$

where R = Thermal resistance of added insulation;

W = Weight of the loose-fill insulation added, as determined by taking the product of the reported number of bags of insulation added and the reported number of pounds per bag;

D = Density of the loose-fill insulating material once installed. The values used in the calculations were 2.75 lb/cf for cellulose insulation[1] and 2.0 lb/cf for rock wool insulation;[2]

A = Area of attic floor covered by the added insulation, net of joists. Since the area figures reported on the Dwelling Unit Cost Data Forms are in gross terms (i.e., including joists), an adjustment factor of 0.906 was used to convert the reported gross areas to their corresponding net area values;[3] and

V = Thermal resistance of the insulating material per inch of added thickness. The values used in the calculations were 3.7 sf•h•°F/Btu for cellulose and 2.9 sf•h•°F/Btu for rock wool.[4] Multiplication by 12 converts these values to R-values per foot of thickness.

To illustrate the application of equation (3.8), suppose a Dwelling Unit Cost Data Form reported that 15 bags of cellulose, each containing 30 pounds of material, were blown into an attic with 500 gross square feet of area. The R-value of the added insulation in this case would be approximately 16:

$$R = \frac{(15)(30)(12)(3.7)}{(2.75)(500)(0.906)} = 16.04.$$

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[1] This value is the midpoint of the density range for cellulose published in American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. ASHRAE Handbook of Fundamentals, New York, 1972, p. 361.

[2] This value is based on the density range for rock wool given in Brookhaven National Laboratory, An Assessment of Thermal Insulation Materials and Systems for Building Applications, Report No. BNL-50862, June 1978, pp. 80-81.

[3] This adjustment factor was determined by assuming a typical joist width of 1.5 in and 16 in on center construction. Thus, out of every 16 in of lineal dimension across the joists, 14.5 in are net of joists. These figures work out to a ratio of net to gross area of 0.906. It should be noted that this value ignores the effect of half the area of the two outermost joists. In addition, this approach assumes that none of the added insulating material lies above the top of the joists.

[4] These values are taken from Brookhaven National Laboratory, An Assessment of Thermal Insulation Materials and Systems for Building Applications, pp. 80-84.

Once all of these values were calculated they were recorded on the Composite Data Forms along with the other information as specified for the non-attic options. With this additional information, the variation in amount of insulation added to the attics of the individual dwellings was taken into account when analyzing the corresponding costs.

The information from the Composite Data Forms, including the calculated R-value of the added attic insulation, was entered into a computer file. These attic cost data were processed somewhat differently from the non-attic data. Specifically, to control for the variation in amount of insulation added to each attic, all cost data items are denominated in terms of cents per square foot per R-value before the minimum, maximum, arithmetic mean, and median values are generated. In addition, these four summary statistics are calculated and printed for the R-value added variable. Furthermore, the two weighted statistics that are calculated for the total cost variable for attic insulation are not only weighted by job size, but by R-value as well. The equations applied to attic cost data to calculate the unweighted arithmetic mean and the mean weighted by job size and R-value, respectively, are:

$$\bar{X} = \frac{\sum_{i=1}^{n} (T_i/S_i \cdot R_i)}{n}, \text{ and} \tag{3.9}$$

$$\bar{X}_w = \frac{\sum_{i=1}^{n} T_i}{\sum_{i=1}^{n} S_i \cdot R_i}, \tag{3.10}$$

where R_i = R-value added to the attic and the remaining symbols are defined as for equations (3.5) and (3.6). Similarly, because of the need to account for variable R-values, the equation used to obtain the weighted standard deviation of total costs was modified as follows:

$$SD_w = \sqrt{\sum_{i=1}^{n} (T_i/S_i \cdot R_i - X_w)^2 \cdot (S_i \cdot R_i / \sum_{i=1}^{n} S_i \cdot R_i)}, \tag{3.11}$$

where all the symbols are defined as for equations (3.9) and (3.10).

All of the summary statistics for attic insulation are presented in subsection 4.2.2 by demonstration site.

3.3 WEATHERIZATION-RELATED REPAIR WORK

During the weatherization process, the need sometimes arose for a certain building component to be repaired in conjunction with the installation of an energy conservation option. For example, in several instances it was necessary to repair a roof before attic insulation could be installed.

These weatherization-related repairs occurred so infrequently and irregularly, however, that the cost data on them do not warrant being analyzed statistically. Instead, total expenditures for weatherization-related repair work are presented in subsection 4.3 by demonstration site and type of repair work.

4.0 DATA PRESENTATION

4.1 INFILTRATION OPTIONS

In this subsection the summary statistics described in subsection 3.1 are presented for the infiltration group of architectural options. Recall that the criterion for including cost data in this presentation is that both labor and materials cost data must have been reported for at least four dwellings for a particular option-site combination. There is a separate table for each option-site combination; all the infiltration options for each site are grouped together; and the tables for each site are presented in alphabetical order according to the name of the nearest metropolitan area. The abbreviations used in the tables are defined as follows:

MIN = Minimum
MAX = Maximum
SF = Square feet
LF = Lineal feet
LABOR = Unit labor cost
MATERIAL = Unit materials cost
OVERHEAD = Unit overhead and profit for work done under contract and unit overhead and travel cost for work done in-house.
TOTAL = Unit total cost
STD DEV = Standard deviation

ALBUQUERQUE NM
REPLACE BROKEN GLASS
WORK DONE IN-HOUSE
4 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	4.1	34.9	15.0	10.6
LABOR($/SF)	0.511	5.007	1.898	1.036
MATERIAL($/SF)	0.726	10.827	3.657	1.537
OVERHEAD($/SF)	0.158	1.393	0.526	0.277
TOTAL($/SF)	1.833	17.227	6.081	2.632

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 3.226 STD DEV($/SF) = 3.824

ALBUQUERQUE NM
WEATHERSTRIP DOORS
WORK DONE IN-HOUSE
7 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	31.5	51.0	38.9	34.0
LABOR($/LF)	0.245	1.324	0.580	0.540
MATERIAL($/LF)	0.264	2.266	0.947	0.720
OVERHEAD($/LF)	0.050	0.162	0.110	0.119
TOTAL($/LF)	0.694	3.656	1.636	1.296

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 1.573 STD DEV($/LF) = 0.924

ATLANTA GA
WEATHERSTRIP DOORS
WORK DONE IN-HOUSE
4 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	19.0	30.0	23.6	22.6
LABOR($/LF)	0.091	0.315	0.225	0.247
MATERIAL($/LF)	0.149	0.413	0.269	0.257
OVERHEAD($/LF)	0.042	0.152	0.109	0.120
TOTAL($/LF)	0.465	0.807	0.602	0.568

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.593 STD DEV($/LF) = 0.123

ATLANTA GA
WEATHERSTRIP ATTIC HATCH
WORK DONE IN-HOUSE
4 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	8.0	16.0	10.5	9.0
LABOR($/LF)	0.147	0.472	0.267	0.225
MATERIAL($/LF)	0.070	0.348	0.190	0.171
OVERHEAD($/LF)	0.052	0.179	0.089	0.062
TOTAL($/LF)	0.272	0.888	0.546	0.512

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.599 STD DEV($/LF) = 0.257

CHARLESTON SC
REPLACE BROKEN GLASS
WORK DONE IN-HOUSE
12 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	2.8	16.9	5.9	4.8
LABOR($/SF)	0.833	4.491	1.830	1.564
MATERIAL($/SF)	0.877	2.500	1.422	1.246
OVERHEAD($/SF)	0.335	4.138	1.452	0.966
TOTAL($/SF)	3.239	7.929	4.704	4.107

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 4.391 STD DEV($/SF) = 1.190

CHARLESTON SC
RESET GLAZING
WORK DONE IN-HOUSE
9 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	8.0	500.0	163.8	175.0
LABOR($/LF)	0.129	0.562	0.246	0.218
MATERIAL($/LF)	0.024	0.125	0.060	0.048
OVERHEAD($/LF)	0.016	0.339	0.111	0.090
TOTAL($/LF)	0.181	1.026	0.417	0.375

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.274 STD DEV($/LF) = 0.111

CHARLESTON SC
REPLACE THRESHOLDS
WORK DONE IN-HOUSE
17 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	2.7	12.0	5.7	5.3
LABOR($/LF)	0.743	3.585	1.990	1.887
MATERIAL($/LF)	1.000	1.132	1.085	1.126
OVERHEAD($/LF)	0.298	7.082	1.404	0.900
TOTAL($/LF)	2.775	10.635	4.479	3.806

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 4.598 STD DEV($/LF) = 1.922

CHARLESTON SC
SEAL STRUCTURAL CRACKS
WORK DONE IN-HOUSE
18 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	10.0	128.0	38.0	23.0
LABOR($/LF)	0.475	4.913	1.900	1.825
MATERIAL($/LF)	0.214	3.217	0.806	0.640
OVERHEAD($/LF)	0.252	2.310	1.073	1.138
TOTAL($/LF)	1.129	10.440	3.779	3.279

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 2.678 STD DEV($/LF) = 2.105

CHARLESTON SC
CAULK WINDOWS AND DOORS
WORK DONE IN-HOUSE
18 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	160.1	457.0	259.7	250.0
LABOR($/LF)	0.075	0.134	0.107	0.110
MATERIAL($/LF)	0.016	0.045	0.028	0.028
OVERHEAD($/LF)	0.012	0.305	0.075	0.043
TOTAL($/LF)	0.115	0.457	0.209	0.182

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.192 STD DEV($/LF) = 0.085

CHARLESTON SC
WEATHERSTRIP WINDOWS AND DOORS
WORK DONE IN-HOUSE
15 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	28.8	94.0	46.4	33.0
LABOR($/LF)	0.036	0.372	0.186	0.185
MATERIAL($/LF)	0.116	0.344	0.165	0.182
OVERHEAD($/LF)	0.034	0.765	0.187	0.097
TOTAL($/LF)	0.241	1.400	0.558	0.426

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.506 STD DEV($/LF) = 0.259

COLORADO SPRINGS CO
REPLACE BROKEN GLASS
WORK DONE UNDER CONTRACT
15 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	1.0	29.1	9.8	6.8
LABOR($/SF)	0.097	3.000	0.999	0.738
MATERIAL($/SF)	1.167	21.000	2.912	1.340
OVERHEAD($/SF)	0.177	9.000	2.026	0.889
TOTAL($/SF)	1.515	33.000	5.937	3.192

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 3.360 STD DEV($/SF) = 2.896

COLORADO SPRINGS CO
RESET GLAZING
WORK DONE UNDER CONTRACT
7 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	8.0	150.0	39.9	24.0
LABOR($/LF)	0.036	1.260	0.275	0.122
MATERIAL($/LF)	0.235	2.750	0.797	0.467
OVERHEAD($/LF)	0.066	0.980	0.275	0.170
TOTAL($/LF)	0.495	4.990	1.347	0.698

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.783 STD DEV($/LF) = 0.749

COLORADO SPRINGS CO
REPLACE THRESHOLDS
WORK DONE IN-HOUSE
16 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	3.0	8.3	5.4	5.3
LABOR($/LF)	0.146	1.502	0.476	0.362
MATERIAL($/LF)	0.750	1.000	0.910	0.913
OVERHEAD($/LF)	0.272	3.510	0.614	0.452
TOTAL($/LF)	0.888	4.523	2.001	1.837

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 1.889   STD DEV($/LF) = 0.736

COLORADO SPRINGS CO
SEAL STRUCTURAL CRACKS
WORK DONE IN-HOUSE
13 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	5.0	45.0	16.2	15.0
LABOR($/LF)	0.053	0.630	0.198	0.153
MATERIAL($/LF)	0.106	0.475	0.344	0.317
OVERHEAD($/LF)	0.015	0.244	0.115	0.116
TOTAL($/LF)	0.387	1.228	0.657	0.594

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.593   STD DEV($/LF) = 0.227

COLORADO SPRINGS CO
CAULK WINDOWS AND DOORS
WORK DONE IN-HOUSE
18 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	76.0	233.0	139.7	130.0
LABOR($/LF)	0.015	0.126	0.054	0.042
MATERIAL($/LF)	0.037	0.187	0.083	0.076
OVERHEAD($/LF)	0.005	0.108	0.038	0.026
TOTAL($/LF)	0.086	0.395	0.176	0.168

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.158 STD DEV($/LF) = 0.071

COLORADO SPRINGS CO
WEATHERSTRIP WINDOWS
WORK DONE IN-HOUSE
7 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	7.0	120.0	38.0	30.0
LABOR($/LF)	0.080	0.959	0.393	0.256
MATERIAL($/LF)	0.037	0.347	0.245	0.286
OVERHEAD($/LF)	0.001	0.085	0.047	0.055
TOTAL($/LF)	0.238	1.239	0.664	0.566

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.570 STD DEV($/LF) = 0.394

COLORADO SPRINGS CO
WEATHERSTRIP DOORS
WORK DONE IN-HOUSE
18 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	17.0	50.0	33.9	33.0
LABOR($/LF)	0.048	0.590	0.210	0.191
MATERIAL($/LF)	0.003	0.439	0.167	0.140
OVERHEAD($/LF)	0.001	0.305	0.083	0.058
TOTAL($/LF)	0.111	1.334	0.459	0.387

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.458 STD DEV($/LF) = 0.264

COLORADO SPRINGS CO
WEATHERSTRIP ATTIC HATCH
WORK DONE IN-HOUSE
9 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	5.3	20.0	10.5	8.0
LABOR($/LF)	0.046	0.479	0.238	0.202
MATERIAL($/LF)	0.049	0.147	0.114	0.130
OVERHEAD($/LF)	0.011	0.253	0.086	0.056
TOTAL($/LF)	0.156	0.755	0.438	0.372

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.442 STD DEV($/LF) = 0.215

EASTON PA
REPLACE BROKEN GLASS
WORK DONE IN-HOUSE
15 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	0.8	36.3	11.3	8.5
LABOR($/SF)	0.184	9.962	2.834	1.802
MATERIAL($/SF)	0.297	3.259	1.900	2.042
OVERHEAD($/SF)	0.020	4.600	0.728	0.345
TOTAL($/SF)	0.501	16.150	5.463	4.537

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 3.779 STD DEV($/SF) = 2.874

EASTON PA
RESET GLAZING
WORK DONE IN-HOUSE
11 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	6.0	48.0	23.5	12.0
LABOR($/LF)	0.036	0.222	0.123	0.103
MATERIAL($/LF)	0.033	0.167	0.104	0.132
OVERHEAD($/LF)	0.005	0.059	0.025	0.016
TOTAL($/LF)	0.080	0.413	0.252	0.249

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.183 STD DEV($/LF) = 0.107

EASTON PA
CAULK WINDOWS AND DOORS
WORK DONE IN-HOUSE
8 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	13.5	189.0	102.9	121.5
LABOR($/LF)	0.041	0.141	0.075	0.065
MATERIAL($/LF)	0.035	0.055	0.048	0.055
OVERHEAD($/LF)	0.007	2.119	0.279	0.017
TOTAL($/LF)	0.099	2.245	0.403	0.130

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.344 STD DEV($/LF) = 0.630

EASTON PA
WEATHERSTRIP WINDOWS AND DOORS
WORK DONE IN-HOUSE
12 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	25.0	50.0	45.8	50.0
LABOR($/LF)	0.111	3.019	0.621	0.413
MATERIAL($/LF)	0.118	1.076	0.306	0.236
OVERHEAD($/LF)	0.02[illegible]	1.6[illegible]3	0.237	0.095
TOTAL($/LF)	0.304	[illegible].010	1.164	0.749

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 1.161 STD DEV($/LF) = 1.264

FARGO ND
WEATHERSTRIP WINDOWS
WORK DONE UNDER CONTRACT
11 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	75.0	261.0	163.9	187.0
LABOR($/LF)	0.053	0.159	0.121	0.124
MATERIAL($/LF)	0.038	0.399	0.128	0.111
OVERHEAD($/LF)	0.101	0.384	0.182	0.163
TOTAL($/LF)	0.200	0.921	0.430	0.408

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.429 STD DEV($/LF) = 0.143

FARGO ND
WEATHERSTRIP DOORS
WORK DONE UNDER CONTRACT
12 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	37.3	37.3	37.3	37.3
LABOR($/LF)	0.161	0.643	0.322	0.322
MATERIAL($/LF)	0.264	0.264	0.264	0.264
OVERHEAD($/LF)	0.005	0.009	0.008	0.009
TOTAL($/LF)	0.432	0.916	0.594	0.595

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.594 STD DEV($/LF) 0.114

OAKLAND CA
REPLACE BROKEN GLASS
WORK DONE IN-HOUSE
8 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	6.3	52.4	24.5	17.0
LABOR($/SF)	0.630	4.937	1.601	1.147
MATERIAL($/SF)	0.550	5.141	1.755	1.090
OVERHEAD($/SF)	0.138	2.305	0.910	0.626
TOTAL($/SF)	1.547	10.215	4.266	3.902

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 5.118 STD DEV($/SF) = 2.833

OAKLAND CA
REPLACE THRESHOLDS
WORK DONE IN-HOUSE
5 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	3.0	9.0	5.4	6.0
LABOR($/LF)	0.497	1.248	0.768	0.673
MATERIAL($/LF)	0.817	1.250	1.069	1.167
OVERHEAD($/LF)	0.187	0.498	0.368	0.453
TOTAL($/LF)	1.500	2.888	2.205	2.227

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 2.265 STD DEV($/LF) = 0.407

OAKLAND CA
WEATHERSTRIP DOORS
WORK DONE IN-HOUSE
5 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	17.8	77.3	45.6	38.7
LABOR($/LF)	0.139	0.436	0.266	0.256
MATERIAL($/LF)	0.272	0.459	0.369	0.362
OVERHEAD($/LF)	0.071	0.242	0.128	0.110
TOTAL($/LF)	0.590	1.138	0.763	0.672

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.832 STD DEV($/LF) = 0.224

PORTLAND ME
REPLACE BROKEN GLASS
WORK DONE IN-HOUSE
4 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	4.0	21.9	11.6	10.2
LABOR($/SF)	0.542	2.250	1.162	0.928
MATERIAL($/SF)	0.786	1.659	1.114	1.006
OVERHEAD($/SF) [a]	0.000	1.080	0.270	0.000
TOTAL($/SF)	1.560	4.512	2.546	2.056

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 2.022 STD DEV($/SF) = 0.805

[a] OVERHEAD AND TRAVEL COSTS WERE NOT REPORTED FOR ALL THESE HOUSES

PORTLAND ME
RESET GLAZING
WORK DONE IN-HOUSE
4 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	3.0	36.0	18.2	16.8
LABOR($/LF)	0.750	2.098	1.496	1.568
MATERIAL($/LF)	0.251	3.636	1.747	1.550
OVERHEAD($/LF) [a]	0.000	0.000	0.000	0.000
TOTAL($/LF)	2.179	5.273	3.243	2.759

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 2.963 STD DEV($/LF) = 1.268

[a] OVERHEAD AND TRAVEL COSTS WERE NOT REPORTED FOR ALL THESE HOUSES

PORTLAND ME
CAULK WINDOWS AND DOORS
WORK DONE IN-HOUSE
8 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	32.0	323.0	165.6	152.0
LABOR($/LF)	0.067	0.168	0.113	0.119
MATERIAL($/LF)	0.028	0.247	0.103	0.100
OVERHEAD($/LF)[a]	0.000	0.186	0.050	0.021
TOTAL($/LF)	0.100	0.509	0.266	0.224

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.249 STD DEV($/LF) = 0.082

[a]OVERHEAD AND TRAVEL COSTS WERE NOT REPORTED FOR ALL THESE HOUSES

PORTLAND ME
WEATHERSTRIP DOORS
WORK DONE IN-HOUSE
12 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	16.3	40.0	35.8	36.8
LABOR($/LF)	0.056	0.612	0.192	0.125
MATERIAL($/LF)	0.343	0.906	0.426	0.382
OVERHEAD($/LF)[a]	0.000	1.236	0.184	0.095
TOTAL($/LF)	0.485	2.198	0.802	0.631

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 0.811 STD DEV($/LF) = 0.488

[a]OVERHEAD AND TRAVEL COSTS WERE NOT REPORTED FOR ALL THESE HOUSES

PORTLAND ME
WEATHERSTRIP ATTIC HATCH
WORK DONE IN-HOUSE
6 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	4.0	17.0	8.8	8.0
LABOR($/LF)	0.175	1.125	0.887	1.125
MATERIAL($/LF)	0.118	1.772	0.568	0.275
OVERHEAD($/LF)[a]	0.000	0.372	0.109	0.017
TOTAL($/LF)	0.450	3.270	1.564	1.492

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 1.236 STD DEV($/LF) = 0.786

[a]OVERHEAD AND TRAVEL COSTS WERE NOT REPORTED FOR ALL THESE HOUSES

4.2 CONDUCTION OPTIONS

4.2.1 Non-Attic Conduction Options

In this subsection the summary statistics described in subsection 3.1 are presented for non-attic architectural options in the conduction group. The same criterion for inclusion applies as for infiltration options: both labor and materials cost data must have been reported for at least four dwellings for a particular option-site combination. These tables are to be read in the same way as those for infiltration options in the previous subsection.

ALBUQUERQUE NM
INSTALL STORM WINDOWS
WORK DONE IN-HOUSE
6 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	108.0	360.0	190.0	175.0
LABOR($/SF)	0.168	0.347	0.228	0.204
MATERIAL($/SF)	0.256	2.610	0.936	0.635
OVERHEAD($/SF)	0.016	0.053	0.039	0.041
TOTAL($/SF)	0.461	2.994	1.202	0.943

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 1.493 STD DEV($/SF) = 1.036

ATLANTA GA
INSTALL TRIPLE GLAZING
WORK DONE UNDER CONTRACT
5 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	60.0	135.4	108.0	115.0
LABOR($/SF)	0.287	0.549	0.415	0.388
MATERIAL($/SF)	0.519	3.060	1.624	1.924
OVERHEAD($/SF)	0.087	0.787	0.456	0.444
TOTAL($/SF)	1.250	3.646	2.494	2.637

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 2.587 STD DEV($/SF) = 0.906

CHARLESTON SC
INSTALL FOUNDATION VENTS
WORK DONE IN-HOUSE
5 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	3.0	4.5	3.5	3.0
LABOR($/SF)	3.750	6.667	5.306	5.000
MATERIAL($/SF)	4.000	4.000	4.000	4.000
OVERHEAD($/SF)	0.996	2.392	1.850	1.943
TOTAL($/SF)	9.440	12.983	11.156	10.603

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 10.951 STD DEV($/SF) = 1.392

CHARLESTON SC
INSULATE CRAWL SPACE WITH STYROFOAM
WORK DONE IN-HOUSE
11 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	170.0	356.0	262.7	272.0
LABOR($/SF)	0.559	2.459	1.135	0.899
MATERIAL($/SF)	0.759	1.083	0.876	0.825
OVERHEAD($/SF)	0.08[illegible]	[illegible].401	0.266	0.294
TOTAL($/SF)	[illegible]	[illegible].464	2.278	2.119

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 2.205 STD DEV($/SF) = 0.494

CHARLESTON SC
INSULATE FLOOR JOISTS WITH FIBERGLASS BATTS
WORK DONE IN-HOUSE
5 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	704.0	1184.0	975.2	1020.0
LABOR($/SF)	0.067	0.080	0.072	0.071
MATERIAL($/SF)	0.113	0.161	0.133	0.127
OVERHEAD($/SF)	0.039	0.061	0.050	0.050
TOTAL($/SF)	0.223	0.283	0.255	0.248

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.255 STD DEV($/SF) = 0.024

COLORADO SPRINGS CO
INSTALL STORM WINDOWS
WORK DONE UNDER CONTRACT
16 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	4.0	150.4	58.1	52.0
LABOR($/SF)	0.155	1.125	0.404	0.351
MATERIAL($/SF)	1.150	3.019	2.068	2.050
OVERHEAD($/SF)[a]	0.000	0.861	0.129	0.000
TOTAL($/SF)	1.932	3.365	2.601	2.546

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 2.552 STD DEV($/SF) = 0.316

[a]OVERHEAD AND PROFIT WERE NOT REPORTED FOR ALL THESE HOUSES

COLORADO SPRINGS CO
INSTALL TRIPLE GLAZING
WORK DONE IN-HOUSE
7 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	2.4	11.7	6.9	5.8
LABOR($/SF)	0.497	2.000	1.058	0.820
MATERIAL($/SF)	0.680	1.625	1.401	1.495
OVERHEAD($/SF)	0.113	0.550	0.282	0.296
TOTAL($/SF)	1.613	4.071	2.742	2.353

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 2.493 STD DEV($/SF) = 0.751

COLORADO SPRINGS CO
INSULATE BASEMENT WALLS WITH FIBERGLASS BATTS
WORK DONE UNDER CONTRACT
5 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	290.0	500.0	379.0	342.0
LABOR($/SF)	0.257	0.879	0.494	0.441
MATERIAL($/SF)	0.271	0.658	0.436	0.421
OVERHEAD($/SF)	0.799	1.660	1.057	0.929
TOTAL($/SF)	1.457	2.427	1.987	1.860

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 1.946 STD DEV($/SF) = 0.366

COLORADO SPRINGS CO
INSULATE FLOOR JOISTS WITH FIBERGLASS BATTS
WORK DONE UNDER CONTRACT
4 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	460.0	1000.0	770.5	811.0
LABOR($/SF)	0.114	0.413	0.242	0.219
MATERIAL($/SF)	0.182	0.269	0.225	0.224
OVERHEAD($/SF)	0.029	0.242	0.113	0.090
TOTAL($/SF)	0.346	0.925	0.579	0.524

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.510 STD DEV($/SF) = 0.207

COLORADO SPRINGS CO
INSULATE WALLS WITH CELLULOSE
WORK DONE UNDER CONTRACT
6 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	450.0	1120.0	869.2	920.0
LABOR($/SF)	0.046	0.150	0.078	0.068
MATERIAL($/SF)	0.070	0.159	0.087	0.073
OVERHEAD($/SF)	0.324	0.518	0.470	0.496
TOTAL($/SF)	0.633	0.641	0.636	0.635

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.636 STD DEV($/SF) = 0.002

COLORADO SPRINGS CO
INSULATE WALLS WITH UF FOAM
WORK DONE UNDER CONTRACT
10 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	650.0	1188.0	962.7	871.5
LABOR($/SF)	0.036	0.123	0.055	0.045
MATERIAL($/SF)	0.103	0.174	0.121	0.109
OVERHEAD($/SF)	0.390	0.526	0.437	0.433
TOTAL($/SF)	0.585	0.736	0.613	0.589

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.610 STD DEV($/SF) = 0.044

EASTON PA
INSTALL TRIPLE GLAZING
WORK DONE IN-HOUSE
7 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	2.0	15.9	7.7	5.7
LABOR($/SF)	0.950	4.189	1.866	1.241
MATERIAL($/SF)	0.960	4.695	2.529	2.270
OVERHEAD($/SF)	0.128	1.528	0.514	0.450
TOTAL($/SF)	2.329	10.412	4.909	3.670

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 4.342 STD DEV($/SF) = 2.578

EASTON PA
INSULATE WALLS WITH FIBERGLASS
WORK DONE UNDER CONTRACT
7 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	150.0	2350.0	1612.9	1800.0
LABOR($/SF)	0.111	0.272	0.174	0.184
MATERIAL($/SF)	0.160	0.160	0.160	0.160
OVERHEAD($/SF)	0.141	0.534	0.247	0.232
TOTAL($/SF)	0.412	0.966	0.581	0.579

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.521 STD DEV($/SF) = 0.089

FARGO ND
INSTALL TRIPLE GLAZING
WORK DONE UNDER CONTRACT
13 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	60.0	190.0	114.3	96.0
LABOR($/SF)	0.301	0.745	0.477	0.471
MATERIAL($/SF)	0.135	0.576	0.510	0.528
OVERHEAD($/SF)	0.423	1.110	0.769	0.738
TOTAL($/SF)	1.015	2.302	1.757	1.720

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 1.754 STD DEV($/SF) = 0.275

FARGO ND
INSULATE BASEMENT WALLS WITH UF FOAM
WORK DONE UNDER CONTRACT
7 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	407.0	504.0	457.6	460.0
LABOR($/SF)	0.115	0.218	0.180	0.197
MATERIAL($/SF)	0.272	0.336	0.303	0.304
OVERHEAD($/SF)	0.003	0.329	0.134	0.132
TOTAL($/SF)	0.485	0.830	0.617	0.581

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.615 STD DEV($/SF) = 0.097

FARGO ND
INSULATE WALLS WITH UF FOAM
WORK DONE UNDER CONTRACT
12 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	240.0	1040.0	821.1	856.0
LABOR($/SF)	0.132	0.245	0.171	0.152
MATERIAL($/SF)	0.133	0.256	0.166	0.152
OVERHEAD($/SF)	0.125	0.301	0.197	0.194
TOTAL($/SF)	0.448	0.618	0.534	0.543

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.530 STD DEV($/SF) = 0.049

MINEAPOLIS/ST PAUL MN
INSULATE RIM JOISTS WITH FIBERGLASS BATTS
WORK DONE UNDER CONTRACT
17 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(LF)	32.0	257.0	88.4	80.0
LABOR($/LF)	0.163	0.800	0.439	0.437
MATERIAL($/LF)	0.412	0.499	0.425	0.420
OVERHEAD($/LF)	0.148	1.271	0.528	0.501
TOTAL($/LF)	0.732	2.251	1.392	1.271

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/LF) = 1.265 STD DEV($/LF) = 0.423

MINEAPOLIS/ST PAUL MN
INSULATE WALLS WITH UF FOAM
WORK DONE UNDER CONTRACT
17 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	967.0	2448.0	1395.4	1072.0
LABOR($/SF)	0.168	0.449	0.320	0.324
MATERIAL($/SF)	0.180	0.556	0.294	0.288
OVERHEAD($/SF)	0.128	0.796	0.330	0.294
TOTAL($/SF)	0.585	1.608	0.944	0.830

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.917 STD DEV($/SF) = 0.230

PORTLAND ME
INSULATE BASEMENT WALLS WITH CELLULOSE
WORK DONE UNDER CONTRACT
10 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	463.0	1156.0	758.9	742.0
LABOR($/SF)	0.149	0.321	0.198	0.179
MATERIAL($/SF)	0.181	0.420	0.343	0.344
OVERHEAD($/SF)	0.025	0.359	0.159	0.149
TOTAL($/SF)	0.700	0.700	0.700	0.700

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.700 STD DEV($/SF) = 0.000

PORTLAND ME
INSULATE WALLS WITH CELLULOSE
WORK DONE UNDER CONTRACT
10 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	1570.0	3400.0	2367.0	2200.0
LABOR($/SF)	0.015	0.091	0.044	0.032
MATERIAL($/SF)	0.014	0.088	0.052	0.048
OVERHEAD($/SF)	0.027	0.168	0.116	0.121
TOTAL($/SF)	0.119	0.275	0.211	0.222

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.212 STD DEV($/SF) = 0.040

PORTLAND ME
INSULATE WALLS WITH CELLULOSE
WORK DONE IN-HOUSE
5 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	778.0	1560.0	1113.2	909.0
LABOR($/SF)	0.051	0.101	0.066	0.058
MATERIAL($/SF)	0.065	0.135	0.093	0.089
OVERHEAD($/SF)	0.011	0.090	0.032	0.020
TOTAL($/SF)	0.137	0.231	0.191	0.219

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.190 STD DEV($/SF) = 0.043

ST LOUIS MO
INSTALL STORM WINDOWS
WORK DONE IN-HOUSE
15 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	26.8	289.4	120.6	106.0
LABOR($/SF)	0.197	0.913	0.504	0.521
MATERIAL($/SF)	1.563	2.890	2.014	2.034
OVERHEAD($/SF)[a]	0.000	0.000	0.000	0.000
TOTAL($/SF)	1.922	3.531	2.518	2.581

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 2.432 STD DEV($/SF) = 0.406

[a]OVERHEAD AND TRAVEL COSTS WERE NOT REPORTED FOR ALL THESE HOUSES

TACOMA WA
INSTALL STORM WINDOWS
WORK DONE UNDER CONTRACT
3 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	31.0	222.0	132.1	139.4
LABOR($/SF)	0.324	1.076	0.759	0.809
MATERIAL($/SF)	1.259	3.861	2.239	1.392
OVERHEAD($/SF)	0.069	1.729	0.830	1.056
TOTAL($/SF)	3.404	4.951	3.828	3.685

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 3.711 STD DEV($/SF) = 0.236

TACOMA WA
INSULATE BASEMENT WALLS WITH UF FOAM
WORK DONE IN-HOUSE
10 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	82.5	266.0	163.1	167.0
LABOR($/SF)	0.057	0.564	0.179	0.081
MATERIAL($/SF)	0.087	0.651	0.253	0.112
OVERHEAD($/SF)	0.004	0.148	0.057	0.035
TOTAL($/SF)	0.175	1.244	0.489	0.245

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.418 STD DEV($/SF) = 0.377

TACOMA WA
INSULATE CRAWL SPACE WITH STYROFOAM
WORK DONE IN-HOUSE
8 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	125.0	500.0	305.4	310.0
LABOR($/SF)	0.236	1.289	0.643	0.671
MATERIAL($/SF)	0.398	1.015	0.606	0.592
OVERHEAD($/SF)	0.018	0.294	0.093	0.056
TOTAL($/SF)	0.655	2.070	1.343	1.363

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 1.189 STD DEV($/SF) = 0.410

TACOMA WA
INSULATE WALLS WITH CELLULOSE
WORK DONE UNDER CONTRACT
4 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	803.0	1418.0	1028.3	946.0
LABOR($/SF)	0.116	0.207	0.153	0.145
MATERIAL($/SF)	0.110	0.164	0.133	0.128
OVERHEAD($/SF)	0.041	0.084	0.071	0.080
TOTAL($/SF)	0.357	0.357	0.357	0.357

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.357 STD DEV($/SF) = 0.000

WASHINGTON DC
INSTALL STORM WINDOWS
WORK DONE IN-HOUSE
10 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	28.9	303.1	172.4	169.4
LABOR($/SF)	0.403	0.793	0.562	0.565
MATERIAL($/SF)	1.202	2.374	1.793	1.789
OVERHEAD($/SF)	0.051	1.258	0.364	0.233
TOTAL($/SF)	1.903	3.538	2.719	2.721

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 2.518 STD DEV($/SF) = 0.435

WASHINGTON DC
INSULATE FLOOR JOISTS WITH FIBERGLASS BATTS
WORK DONE IN-HOUSE
5 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	140.0	1128.0	655.2	680.0
LABOR($/SF)	0.064	0.196	0.127	0.136
MATERIAL($/SF)	0.170	0.370	0.271	0.288
OVERHEAD($/SF)	0.048	0.263	0.101	0.061
TOTAL($/SF)	0.369	0.639	0.500	0.500

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.476 STD DEV($/SF) = 0.062

WASHINGTON DC
INSULATE WALLS WITH CELLULOSE
WORK DONE IN-HOUSE
4 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	1120.0	2490.0	1539.5	1274.0
LABOR($/SF)	0.123	0.273	0.217	0.237
MATERIAL($/SF)	0.068	0.113	0.082	0.074
OVERHEAD($/SF)	0.024	0.113	0.062	0.055
TOTAL($/SF)	0.259	0.405	0.361	0.391

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.340 STD DEV($/SF) = 0.067

WASHINGTON DC
INSULATE WALLS WITH UF FOAM
WORK DONE UNDER CONTRACT
5 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	960.0	2160.0	1504.8	1620.0
LABOR($/SF)	0.135	0.172	0.151	0.155
MATERIAL($/SF)	0.252	0.637	0.416	0.332
OVERHEAD($/SF)	0.092	0.281	0.142	0.258
TOTAL($/SF)	0.700	0.748	0.710	0.700

TOTAL COST STATISTICS WEIGHTED BY JOB SIZE

MEAN($/SF) = 0.710 STD DEV($/SF) = 0.020

4.2.2 Attic Insulation

In this subsection the summary statistics described in subsection 3.2 are presented for attic insulation. The same criterion for inclusion applies as for non-attic options: both labor and materials cost data must have been reported for at least four dwellings for a particular option-site combination. As noted above, the attic unit cost data are denominated in terms of cost per square foot per R-value added. The symbol, R, used in these tables refers to the R-value added to the attic. In all other respects these tables are to be read in the same way as those for non-attic options in the previous subsections.

ALBUQUERQUE NM
INSULATE ATTIC WITH FIBERGLASS
WORK DONE IN-HOUSE
5 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	154.5	3680.0	2057.7	2132.0
R-VALUE ADDED	19.0	19.0	19.0	19.0
LABOR($/R*SF)	0.001	0.006	0.002	0.001
MATERIAL($/R*SF)	0.005	0.017	0.008	0.006
OVERHEAD($/R*SF)	0.000[a]	0.001	0.000	0.000
TOTAL($/R*SF)	0.006	0.024	0.011	0.007

TOTAL COST STATISTICS WEIGHTED BY R-VALUE * JOB SIZE

MEAN($/R*SF) = 0.007 STD DEV($/R*SF) = 0.003

[a] THE ZERO OVERHEAD COST IS DUE TO ROUNDING

ATLANTA GA
INSULATE ATTIC WITH ROCK WOOL
WORK DONE UNDER CONTRACT
9 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	841.0	1350.0	1125.6	1122.0
R-VALUE ADDED	19.3	23.5	19.8	19.3
LABOR($/R*SF)	0.002	0.003	0.002	0.002
MATERIAL($/R*SF)	0.006	0.010	0.006	0.006
OVERHEAD($/R*SF)	0.002	0.004	0.003	0.003
TOTAL($/R*SF)	0.011	0.016	0.012	0.011

TOTAL COST STATISTICS WEIGHTED BY R-VALUE * JOB SIZE

MEAN($/R*SF) = 0.012 STD DEV($/R*SF) = 0.002

CHARLESTON SC
INSULATE ATTIC WITH CELLULOSE [a]
WORK DONE IN-HOUSE
17 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	675.0	1890.0	1107.1	1088.0
R-VALUE ADDED	8.9	26.6	17.4	18.1
LABOR($/R*SF)	0.003	0.006	0.005	0.005
MATERIAL($/R*SF)	0.005	0.006	0.005	0.005
OVERHEAD($/R*SF)	0.001	0.004	0.003	0.002
TOTAL($/R*SF)	0.010	0.015	0.013	0.013

TOTAL COST STATISTICS WEIGHTED BY R-VALUE * JOB SIZE

MEAN($/R*SF) = 0.012 STD DEV($/R*SF) = 0.001

[a] COSTS INCLUDE WEATHERSTRIPPING ATTIC HATCH

COLORADO SPRINGS CO
INSULATE ATTIC WITH CELLULOSE
WORK DONE UNDER CONTRACT
18 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	238.0	1075.0	739.7	800.0
R-VALUE ADDED	4.6	48.9	16.9	14.5
LABOR($/R*SF)	0.001	0.004	0.002	0.001
MATERIAL($/R*SF)	0.005	0.008	0.007	0.007
OVERHEAD($/R*SF)	0.008	0.035	0.010	0.009
TOTAL($/R*SF)	0.015	0.046	0.019	0.017

TOTAL COST STATISTICS WEIGHTED BY R-VALUE * JOB SIZE

MEAN($/R*SF) = 0.018 STD DEV($/R*SF) = 0.006

EASTON PA
INSULATE ATTIC WITH CELLULOSE
WORK DONE IN-HOUSE
9 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	400.0	1500.0	748.1	650.0
R-VALUE ADDED	10.4	18.6	14.1	14.8
LABOR($/R*SF)	0.003	0.013	0.006	0.004
MATERIAL($/R*SF)	0.003	0.012	0.006	0.006
OVERHEAD($/R*SF)	0.000[a]	0.019	0.004	0.002
TOTAL($/R*SF)	0.007	0.044	0.016	0.014

TOTAL COST STATISTICS WEIGHTED BY R-VALUE * JOB SIZE

MEAN($/R*SF) = 0.014 STD DEV($/R*SF) = 0.010

[a] THE ZERO OVERHEAD COST IS DUE TO ROUNDING

FARGO ND
INSULATE ATTIC WITH CELLULOSE
WORK DONE UNDER CONTRACT
12 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	305.0	1036.0	700.0	709.5
R-VALUE ADDED	3.1	21.0	10.4	9.6
LABOR($/R*SF)	0.004	0.018	0.009	0.008
MATERIAL($/R*SF)	0.007	0.008	0.008	0.007
OVERHEAD($/R*SF)	0.004	0.020	0.011	0.011
TOTAL($/R*SF)	0.019	0.040	0.028	0.027

TOTAL COST STATISTICS WEIGHTED BY R-VALUE * JOB SIZE

MEAN($/R*SF) = 0.026 STD DEV($/R*SF) = 0.006

MINEAPOLIS/ST PAUL MN
INSULATE ATTIC WITH CELLULOSE
WORK DONE UNDER CONTRACT
12 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	550.0	1092.0	918.9	915.5
R-VALUE ADDED	9.7	36.9	20.5	20.4
LABOR($/R*SF)	0.004	0.026	0.008	[illegible]
MATERIAL($/R*SF)	0.004	0.009	0.008	0.008
OVERHEAD($/R*SF)	0.003	0.024	[illegible]	0.008
TOTAL($/R*SF)	0.015	[illegible]	0.025	0.022

TOTAL COST STATISTICS WEIGHTED BY R-VALUE * JOB SIZE

MEAN($/R*SF) = 0.023 STD DEV($/R*SF) = 0.008

OAKLAND CA
INSULATE ATTIC WITH CELLULOSE
WORK DONE IN-HOUSE
8 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	420.0	1210.0	831.9	875.0
R-VALUE ADDED	5.4	20.7	13.9	14.3
LABOR($/R*SF)	0.002	0.007	0.004	0.003
MATERIAL($/R*SF)	0.005	0.010	0.008	0.008
OVERHEAD($/R*SF)	0.000 [a]	0.007	0.002	0.001
TOTAL($/R*SF)	0.009	0.023	0.014	0.012

TOTAL COST STATISTICS WEIGHTED BY R-VALUE * JOB SIZE

MEAN($/R*SF) = 0.012 STD DEV($/R*SF) = 0.004

[a] THE ZERO OVERHEAD COST IS DUE TO ROUNDING

PORTLAND ME
INSULATE ATTIC WITH CELLULOSE
WORK DONE UNDER CONTRACT
10 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	650.0	1650.0	1040.6	1050.0
R-VALUE ADDED	7.3	30.3	15.1	14.2
LABOR($/R*SF)	0.001	0.004	0.002	0.002
MATERIAL($/R*SF)	0.006	0.007	0.006	0.006
OVERHEAD($/R*SF)	0.001	0.023	0.011	0.011
TOTAL($/R*SF)	0.009	0.031	0.020	0.021

TOTAL COST STATISTICS WEIGHTED BY R-VALUE * JOB SIZE

MEAN($/R*SF) = 0.018 STD DEV($/R*SF) = 0.006

PORTLAND ME
INSULATE ATTIC WITH CELLULOSE
WORK DONE IN-HOUSE
5 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	660.0	1156.0	965.2	1000.0
R-VALUE ADDED	14.3	25.3	19.6	19.8
LABOR($/R*SF)	0.002	0.004	0.003	0.003
MATERIAL($/R*SF)	0.007	0.007	0.007	0.007
OVERHEAD($/R*SF)[a]	0.000	0.002	0.001	0.001
TOTAL($/R*SF)	0.010	0.012	0.011	0.012

TOTAL COST STATISTICS WEIGHTED BY R-VALUE * JOB SIZE

MEAN($/R*SF) = 0.011 STD DEV($/R*SF) = 0.001

[a]OVERHEAD AND TRAVEL COSTS WERE NOT REPORTED FOR ALL THESE HOUSES

ST LOUIS MO
INSULATE ATTIC WITH CELLULOSE
WORK DONE UNDER CONTRACT
13 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	600.0	1600.0	976.6	1000.0
R-VALUE ADDED	21.1	43.9	32.5	33.7
LABOR($/R*SF)	0.000[a]	0.019	0.009	0.009
MATERIAL($/R*SF)	0.006	0.008	0.008	0.007
OVERHEAD($/R*SF)	0.003	0.012	0.007	0.007
TOTAL($/R*SF)	0.011	0.031	0.024	0.026

TOTAL COST STATISTICS WEIGHTED BY R-VALUE * JOB SIZE

MEAN($/R*SF) = 0.024 STD DEV($/R*SF) = 0.006

[a]THE ZERO LABOR COST IS DUE TO ROUNDING

TACOMA WA
INSULATE ATTIC WITH ROCK WOOL
WORK DONE UNDER CONTRACT
11 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	540.0	1848.0	1014.9	980.0
R-VALUE ADDED	13.1	41.0	27.6	29.0
LABOR($/R*SF)	0.000[a]	0.002	0.001	0.000
MATERIAL($/R*SF)	0.004	0.006	0.005	0.005
OVERHEAD($/R*SF)	0.005	0.018	0.007	0.005
TOTAL($/R*SF)	0.009	0.022	0.013	0.012

TOTAL COST STATISTICS WEIGHTED BY R-VALUE * JOB SIZE

MEAN($/R*SF) = 0.012 STD DEV($/R*SF) = 0.002

[a] THE ZERO LABOR COST IS DUE TO ROUNDING

WASHINGTON DC
INSULATE ATTIC WITH CELLULOSE
WORK DONE IN-HOUSE
10 JOBS REPORTED

SUMMARY STATISTICS

	MIN	MAX	MEAN	MEDIAN
JOB SIZE(SF)	300.0	1400.0	827.2	842.0
R-VALUE ADDED	20.5	32.1	26.5	28.8
LABOR($/R*SF)	0.003	0.006	0.005	0.005
MATERIAL($/R*SF)	0.006	0.020	0.008	0.006
OVERHEAD($/R*SF)	0.001	0.005	0.003	0.003
TOTAL($/R*SF)	0.011	0.027	0.015	0.014

TOTAL COST STATISTICS WEIGHTED BY R-VALUE * JOB SIZE

MEAN($/R*SF) = 0.015 STD DEV($/R*SF) = 0.005

4.3 WEATHERIZATION-RELATED REPAIR WORK

Table 4.1 presents cost data for the weatherization-related repair work described in subsection 3.3. The dollar amounts in the body of the table represent expenditures on each type of repair work for a particular city. Most amounts refer to work on a single house, except as explained in the footnote. The total column on the far right sums expenditures for each type of repair work across all cities. The total row at the bottom sums expenditures for each city across all types of repair work.

4.4 SUMMARY AND DISCUSSION OF WEATHERIZATION COST STATISTICS

Table 4.2 condenses the summary statistics presented in subsections 4.1 and 4.2 on the infiltration and conduction options by extracting the weighted mean of unit total cost from each table (i.e., option-site combination). As noted in subsection 4.2.2, however, the attic unit cost data are denominated on a per square foot per R-value added basis. In order to make these data comparable to the infiltration and non-attic conduction options, total cost per square foot measures are presented based on the mean R-value added across all sites, R-19. That is, the cost per square foot figures for attic insulation presented in table 4.2 are derived by extracting the weighted mean of total cost per "R" added per square foot from each option-site table and multiplying by 19.

Table 4.1 Expenditures ($) for Weatherization-Related Repair Work, by City and Type of Repair Work

Type of Repair Work	City: ATL	CHA	OAK	POR	TAC	TOTAL
Repair or Replace Doors	162.02	434.53	1159.34	1052.82	607.74	3416.45
Repair Structure	249.16					249.16
Repair Roof	51.11		1907.00			1958.11
Repair Window Frame					613.79	613.79
Repair Window Sash		1167.26		38.64		1205.90
Repair Gutters				294.29		294.29
Repair Bulkhead Door				76.16		76.16
Repair Eaves		72.72		159.73		232.45
Repair Siding					1112.27	1112.27
TOTAL	462.29	1674.51	3066.34	1621.64	2333.80	9158.58

NOTE: Cost figures represent work done on a single house in every case except: Repair or Replace Doors in CHA (nine houses), in OAK (seven houses), in POR (four houses), and in TAC (three houses); Repair Window Sash in CHA (six houses); and Repair Siding in TAC (two houses).

Table 4.2 Weighted Mean Total Cost of Installed Architectural Options, by City, in Dollars per Lineal Foot ($/lf) or Dollars per Square Foot ($/sf)[a]

Option Description	Units	City											
		ALB	ATL	CHA	CSP	EAS	FAR	MSP	OAK	POR	STL	TAC	WAS
Infiltration Options													
Replace Broken Glass	($/sf)	3.23		4.39	3.36	3.78			5.12	2.02[b]			
Reset Glazing	($/lf)			0.27	0.78	0.18				2.96[b]			
Replace Thresholds	($/lf)			4.60	1.89				2.27				
Seal Structural Cracks	($/lf)			2.68	0.59								
Caulk Windows and Doors	($/lf)			0.19	0.16	0.34				0.25[b]			0.20
Weatherstrip Windows	($/lf)				0.57		0.43						
Weatherstrip Doors	($/lf)	1.58	0.59		0.46		0.59		0.83	0.81[b]		0.64	1.56
Weatherstrip Windows and Doors	($/lf)			0.51		1.16							
Weatherstrip Attic Hatch	($/lf)		0.60		0.44					1.24[b]			
Conduction Options													
Install Storm Windows	($/sf)	1.49			2.55[c]						2.43[b]	3.71	2.52
Install Triple Glazing	($/sf)		2.59		2.49	4.34	1.75						
Insulate Basement Walls with Cellulose	($/sf)									0.70			
Insulate Basement Walls with Fiberglass Batts	($/sf)				1.95								
Insulate Basement Walls with Urea-Formaldehyde	($/sf)						0.62					0.42	
Install Foundation Vents	($/sf)			10.95									
Insulate Crawl Space with Styrofoam	($/sf)			2.21								1.19	
Insulate Floor Joists with Fiberglass Batts	($/sf)			0.26	0.51								0.48
Insulate Rim Joists with Fiberglass Batts	($/sf)							1.27					
Insulate Walls with Cellulose	($/sf)				0.64					0.21[d]		0.36	0.34
Insulate Walls with Fiberglass	($/sf)					0.52							
Insulate Walls with Urea-Formaldehyde	($/sf)				0.61		0.53	0.92					0.71
Insulate Attic with Cellulose (R-value added=19)[e]	($/sf)			0.23[f]	0.34	0.27	0.49	0.44	0.23	0.34[g]	0.46		0.29
Insulate Attic with Fiberglass (R-value added=19)[e]	($/sf)	0.13											
Insulate Attic with Rock Wool (R-value added=19)[e]	($/sf)		0.23									0.23	

[a] Cost data were collected between the following dates: ALB 6/78-3/79; ATL 10/78-12/78; CHA 2/79-6/79; CSP 1/79-11/79; EAS 1/79-11/79; FAR 10/78-11/79; MSP 12/78-7/79; OAK 2/77-1/80; POR 2/78-5/79; STL 1/79-8/79; TAC 1/79-1/80; WAS 3/79-9/79.

[b] Overhead and travel costs were not reported for all these houses.

[c] Overhead and profit were not reported for all these houses.

[d] The measure of 0.21 $/sf is for contracted wall insulation in Portland. A lower measure of 0.19 $/sf was found for in-house wall insulation work.

[e] The cost per square foot for adding R-19 attic insulation is derived by multiplying the cost per "R" added per square foot by 19.

[f] Cost includes weatherstripping attic hatch.

[g] The measure of 0.34 $/sf is for contracted attic insulation in Portland. A lower measure of 0.21 $/sf was found for in-house attic insulation work.

Table 4.3 presents the attic cost data in a slightly different manner. It gives the weighted mean of unit total cost based on actual R-values added in each city, rather than assuming R-19 was added. Thus, for each city, the cost per R added per square foot is multiplied by the mean R-value added in that city to come up with the cost per square foot for attic insulation.

On tables 4.2 and 4.3 one can compare the unit cost of architectural options across cities. In fact, there are 12 options that have reported costs from at least three demonstration sites. For many of these options such comparisons reveal a considerable degree of variation from city to city. Comparing the unit cost of replacing broken glass in table 4.2, for example, reveals that it varies by over two and one-half times between OAK and POR. Such significant variation implies that estimates of the cost of installing various architectural options may need to be based on estimating functions unique to each city in order to assure accuracy.

A number of factors may contribute to the variation in unit cost across cities. Regional differences in the costs of materials and labor constitute an obvious probable cause. Another likely source of variation is cost differences between contracted jobs and in-house jobs. Yet another is the presence of economies of scale, such that the size of a specific job becomes a relatively important factor in determining that job's unit cost.

Alternatively, it could be that differences across cities in the architectural designs of the demonstration dwellings cause the cost variation. For example, if it is more difficult to gain access to the attics of houses in one city than in another, such differences would be reflected in the corresponding costs of insulating the attic. (Note that the architectural design of a dwelling is distinct from its state of repair prior to weatherization. Differences in the state of repair would be reflected in the costs of weatherization-related repair work, presented in table 4.1).

A final possible source of variation in mean costs lies in the geographic locations of the dwellings within each demonstration site. Location is a source of variation because both travel distance and traffic congestion affect the travel component of option cost. For options installed by in-house labor, variations in cost due to differences in geographic distribution are reflected in the travel costs explicitly listed on the Dwelling Unit Cost Data Forms. For jobs done under contract, on the other hand, since travel cost is implicitly incorporated in total bid price, cost differences due to this source are not so readily apparent. Nevertheless, this implicit travel component is likely to vary from city to city.

The suggestions offered above as possible sources of intercity variation in the mean unit total cost of an architectural option do not constitute an exhaustive list. Furthermore, it is highly likely that the answer lies in some combination of sources rather than in a single source. Some of the possible sources of variation mentioned in this subsection warrant further study, and thus form the basis of several recommendations for further research elaborated in the concluding section of this report.

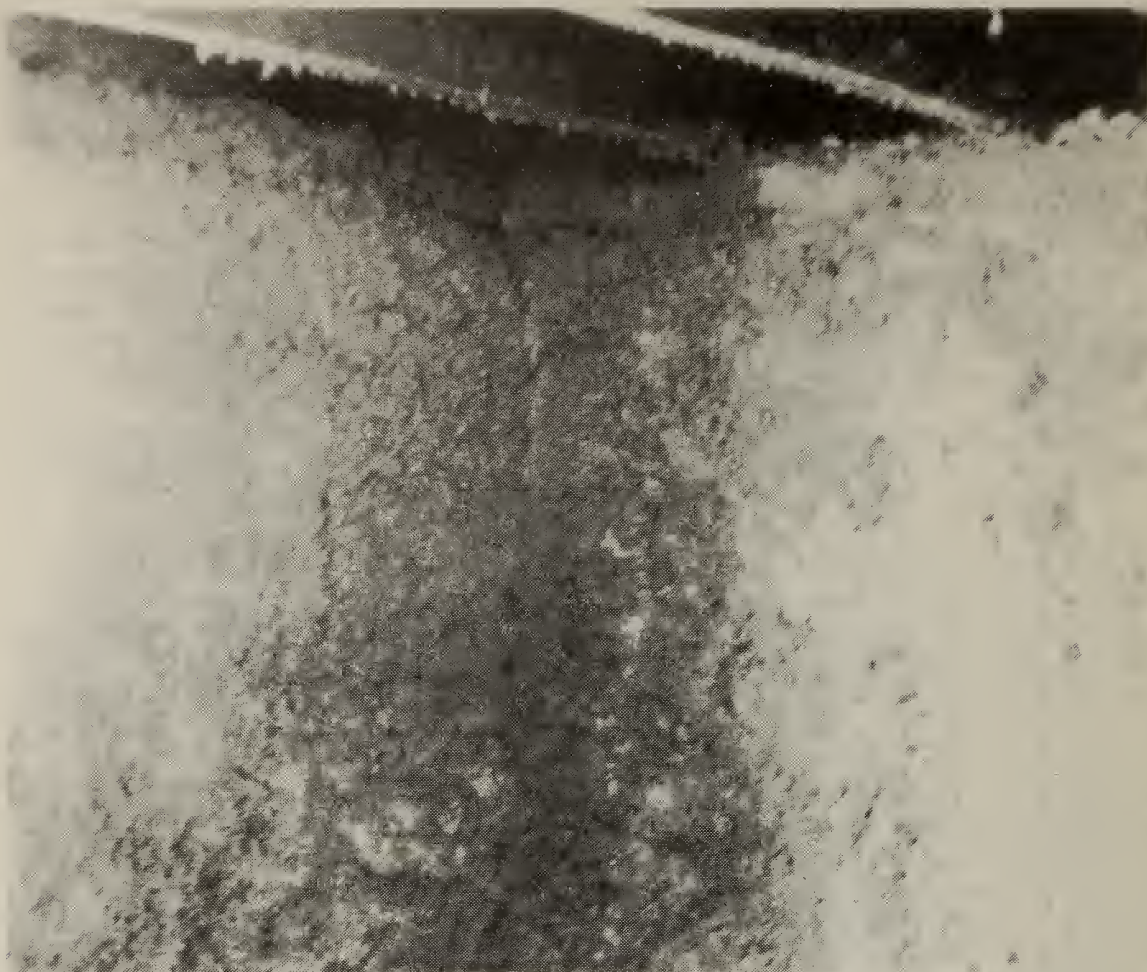
Table 4.3. Weighted Mean Total Cost of Installed Attic Insulation Based on Actual R-Value Added by City, in Dollars per "R" added per Square Foot ($/R•sf) and Dollars per Square Foot ($/sf)[a]

	City											
Units	ALB	ATL	CHA[b]	CSP	EAS	FAR	MSP	OAK	POR	STL	TAC	WAS
$/R•sf	0.007	0.012	0.012	0.018	0.014	0.026	0.023	0.012	0.018	0.024	0.012	0.015
R added	19.0	19.8	17.4	16.9	14.1	10.4	20.5	13.9	15.1	32.5	27.8	26.5
$/sf	0.133	0.238	0.209	0.304	0.197	0.270	0.472	0.167	0.272[c]	0.780	0.334	0.398

[a] Cellulose was the insulating material added in all cities except ALB where fiberglass was added, and ATL and TAC, where rock wool was added. The cost per square foot for adding the attic insulation was derived by multiplying the cost per R added per square foot by the mean R-value added.

[b] Costs include weatherstripping attic hatch.

[c] The measure of 0.272 $/sf is for contracted attic insulation in Portland. A lower measure of 0.216 $/sf was found for in-house attic insulation work.



5.0 RECOMMENDATIONS FOR FURTHER RESEARCH

This section describes further economic research that would be useful in support of the CSA Weatherization Demonstration Program. In order for this additional research to be possible, the collection of cost data on the four major groups of energy conservation options installed in the demonstration houses must first be completed. These four option groups are 1) conduction, 2) infiltration, 3) mechanical, and 4) hot water. The conduction and infiltration options comprise the architectural options discussed in this report. The mechanical option group includes those options that affect the operation of the building space heating system, and the hot water options are those directed toward improving the operating efficiency of the domestic hot water system. The collection of data on the total costs of installing these latter two types of options is currently underway.

Once all the field data have been collected as outlined above, the recommendations for energy conservation retrofits of low-income housing should be reassessed. The retrofit packages installed in the demonstration houses were selected on the basis of 1977-78 fuel prices, and energy savings and retrofit costs that were estimated before the fact. More recent fuel prices and data on energy savings and retrofit costs collected from the actual demonstration experience could be used to reassess the retrofit packages.

Recent fuel costs could be obtained by contacting all energy utilities serving the participating demonstration sites for the appropriate rate schedules. These schedules could be used to determine the marginal cost (including taxes and all surcharges) of a unit of fuel for each fuel type and site. These fuel cost data could then be used in a post-retrofit evaluation of the four major groups of energy conservation options installed in the demonstration houses. In conjunction with forthcoming estimates for each participating house of the annual purchased fuel savings attributable to each of the four option groups, the option and fuel cost data could be used to calculate for each house: (1) the present value cost of each option group based on the installed cost and expected replacement schedule of each option; and (2) the present value of the fuel savings attributable to each option group based on updated fuel prices and the latest DoE projections of fuel price increases. These present value measures could be used to assess whether the particular groups of options installed for each fuel type and demonstration site are actually cost effective in the sense of yielding a positive net return on the funds expended. The cost effectiveness of all the options combined could also be assessed for each participating house. These assessments of the cost effectiveness of retrofit packages would assist CSA, the Department of Energy, state and county energy offices, and other interested parties in deciding whether the originally recommended package of retrofit options can be expected to pay for itself over a reasonable time period.

The cost effectiveness of the attic insulation option could be more accurately measured with additional analysis. Because different amounts of attic insulation were added to each house within a demonstration site, the costs of this option had to be reported in terms of cost per square foot per R-value added. There is good reason to expect, however, that there is a significant fixed cost component being hidden in such a measure. For example, it is likely that the cost per square foot of adding R-22 is less than twice that of adding R-11. In other words, the average cost per R-value added is likely to be lower when more insulation is added to a given size attic. Regression analysis could be applied to the attic insulation cost data for each city in order to separate the fixed cost component corresponding to the labor time spent on gaining access and setting up equipment, from the variable labor and materials cost components corresponding to each increased unit of R-value added per square foot. In this way, the true marginal cost of increased insulation could be more accurately measured.

Another area in which further analysis would be useful deals with the question of possible economies (or diseconomies) of scale being present in the installation of architectural options. That is, the size of a particular job (e.g., square feet of wall area insulated) may be an important factor in determining the actual cost per square foot of the job. If this is the case, then the product of a flat (constant) unit cost times the job size will not provide the best estimate of the true job cost. Regression analysis can be useful here both to test whether economies (or diseconomies) do exist in the installation of these retrofit options, as well as to improve the accuracy of job cost estimates by taking job size into account.

A fifth area involves the investigation of whether the cost of a specific option is significantly different for contracted jobs compared with in-house jobs. It may be that most of the differences in cost between these two categories are attributable either to other factors (such as regional cost differences) or to random variations. A number of statistical tests could be conducted to measure the extent of the true difference between contracted and in-house job costs.

One other area in which further study is warranted involves the updating of cost estimates. Most of the cost data collected and reported under this project refers to retrofits installed between October 1978 and December 1979. Because of the rather significant inflation that the U.S. economy is currently experiencing, the cost estimates for each retrofit need to be periodically updated, if they are expected to serve as a useful basis for future policy decisions. A specialized system of cost indexing should be developed to permit periodic revision of the cost estimates to take into account future changes in the costs of labor and materials. In formulating the index system, an attempt should be made to incorporate both time-related and location-related variations in cost.

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☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This report presents the results of a project involving the collection and tabulation of field data on the costs of retrofitting low-income houses for energy conservation. This project is part of the Community Services Administration Weatherization Demonstration Program being carried out through the National Bureau of Standards. The program involves the installation and evaluation of a broad range of energy conservation techniques for over 200 single-family houses in 14 demonstration sites throughout the United States. The energy conservation techniques discussed in this report consist of a variety of architectural modifications to building envelopes for the purpose of reducing heat losses due either to air infiltration or conduction. The methods used to collect and synthesize the field data on the major cost components of installing these techniques are described. An analysis of these costs is presented in the form of summary statistics including the weighted mean and standard deviation of the unit cost of installing each architectural option in each demonstration site. The significant intercity variation found in the mean unit cost of most techniques suggests that unique cost estimating procedures may be needed for each city. Possible sources of variation in the mean unit costs are discussed. Recommendations for further research include investigating the effect on cost that can be attributed to selected sources of variation.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Building economics; cost components; data analysis; data collection; demonstration; economic analysis; energy conservation; insulation; low-income housing; statistics; unit costs; weatherization.

13. AVAILABILITY

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