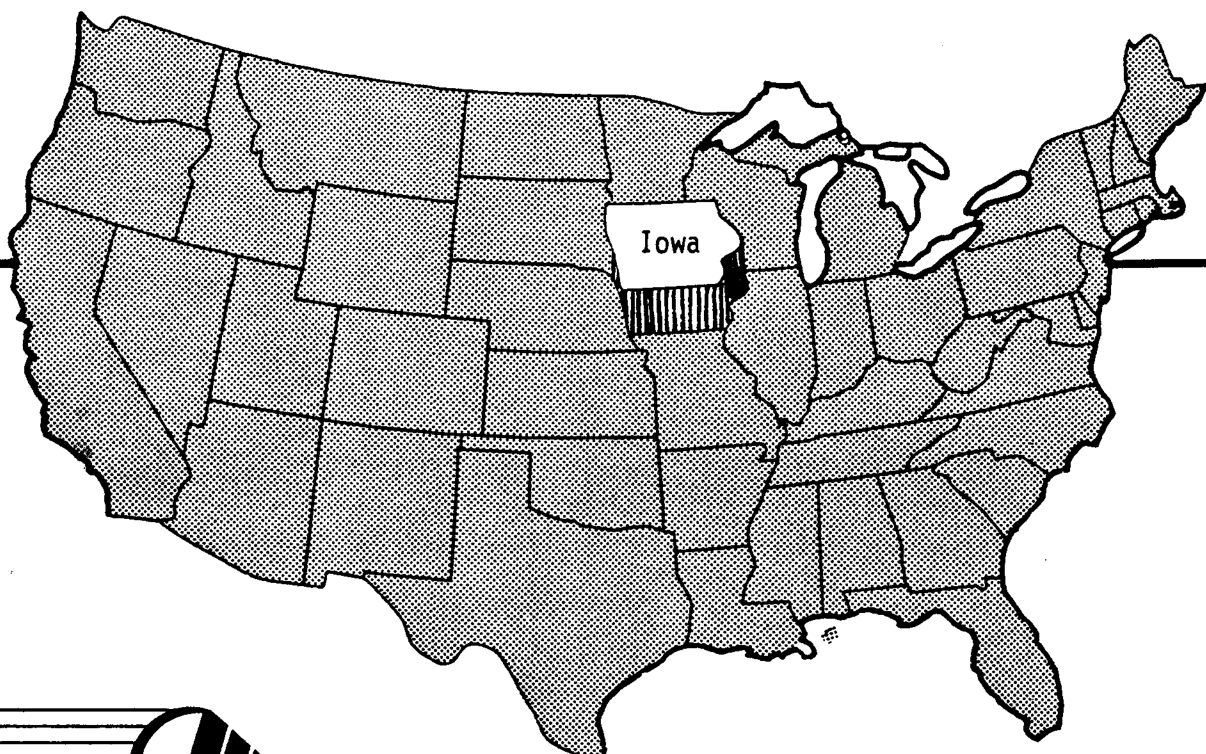
IOWA WEATHERIZATION ASSISTANCE PROGRAM EVALUATION



MERIDIAN

EXECUTIVE SUMMARY

As the result of a recent legislative mandate, the Iowa Department of Natural Resources was tasked to conduct a study of the Iowa Weatherization Assistance Program (WAP). The goal of the WAP is to reduce the effects of high fuel costs for heating (and to a lesser extent cooling) on low-income families, particularly the elderly and handicapped. The program installs Energy Conservation Measures (ECMs) such as caulking and weatherstripping, storm windows, attic and wall insulation, and a range of other measures to improve heating and cooling efficiency as well as the comfort of the home.

Within the Iowa Department of Human Rights, the Division of Community Action Agencies (DCAA) administers the weatherization program. Local service organizations, typically Community Action Agencies (CAAs), implement WAP at the local level. A home is eligible for weatherization in Iowa if it is (1) occupied by a family unit whose income is at or below 150 percent of the federal poverty level;[1] (2) is occupied by an individual who receives cash assistance under Titles IV or XVI of the Social Security Act or applicable state or local law during the preceding 12 months; or (3) is eligible for assistance under the Low-Income Home Energy Assistance Program (LIHEAP). Typically, federal guidelines control the expenditure of funds per home. Federal guidelines set a maximum expenditure per home of $2,400. During the 1987 program year, which is the period over which this study was conducted, the average total expenditure per weatherization for the program as a whole could not exceed $1,500. During the 1988 program year, this limit increased to $1,600. Presently, approximately 6,500 homes are weatherized per year. As of January 1, 1988, nearly 105,000 homes have been weatherized in Iowa.

For the evaluation of the Iowa WAP Program a number of objectives were established. They include:

- Estimating the effects of the weatherization activities in terms of reducing energy consumption;

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[1] Poverty levels are approximately $7,138 for a family of two and $11,203 for a family of four, based on conversations with the Bureau of the Census, U.S. Department of Commerce.

- Determining the cost-effectiveness of the program, as well as specific ECMs;
- Estimating the economic impacts of the program on the state economy;
- Identifying methods to improve program administration and delivery through a targeted process evaluation; and
- Determining the attitudes, perceptions and concerns of program participants regarding program implementation.

The study integrates an evaluation of the program in terms of the energy savings achieved with an evaluation of the procedures followed to implement the program. Typically, weatherization evaluations tend to emphasize the reporting of the effects of the weatherization (i.e., outcomes) in terms of factors such as energy savings and the costs/benefits achieved through program implementation. This evaluation also integrates an additional evaluation of program mechanisms and procedures that effect successful program delivery (i.e., program processes).

A summary of the study's findings are presented in the remainder of this section. It includes areas of program strength, as well as areas where selected improvement could lead to increased energy savings.

Program Strengths

Overall, the weatherization program realizes relatively high levels of energy savings. The average savings per weatherized dwelling is 15.7%. As a result of the weatherization program, Iowa is consuming approximately 93.7 billion fewer Btus per year. Assuming a cost of 46.1 cents per therm, the energy savings attributable to the weatherization program in only the first year is equivalent to approximately $432,000 or $65 per weatherized dwelling. (See Section 4.0, Analysis of Energy Savings.)

The weatherization program provides significant benefits to the Iowa economy. The simple payback for a weatherization is approximately 18.7 years. The net benefit to the Iowa economy, however, is approximately 2.5 times the cost of the program. Because nearly all of Iowa's energy is "imported," the program results in significant statewide savings; the $8 million dollar program (1987) will result in approximately $20 million in economic activity, and an additional $616,949 in tax revenues. Thus, the total net benefit to the state from the Weatherization Program is approximately $12 million in economic activity. In addition, approximately 550 jobs were directly created including weatherization coordinators and work crews. Finally, the weatherization program capitalizes approximately $3.7 million dollars in the housing stock.

Overall, the quality of the weatherization work is good. On-site audits of 45 homes, personal interviews, and responses to a detailed questionnaire suggest that major problems do not exist with program implementation. While some careless workmanship was noticed during the on-site audits, overall the workmanship was rated "good" on a scale ranging from extremely poor to excellent. In addition, personal interviews and the survey responses indicate that program recipients are extremely pleased with the program implementation based on factors such as quality of the work performed and the courteousness of the work crews. (See Section 12.0, Assessment of Weatherization Service Delivery.)

The average cost per weatherization is 18% less than the average cost permitted by program guidelines. The average cost of a weatherization is $1,224. The 1987 program guidelines set an average weatherization program cost limit of $1,500. This lower average cost per weatherization has two positive effects. First, given the likelihood of a diminishing marginal rate of return on weatherization investments per dwelling, spending less than the maximum average expenditure maximizes energy savings per dollar invested. Second, more dwellings are able to be weatherized in a program year, thereby, potentially assisting more persons. (See Section 3.0, Cost of Weatherization Program.)

Typically, the implementation rates for specific ECMs are high, particularly for those measures directly affecting air infiltration such as caulking, weatherstripping, and door sweeps. The typical implementation rate per ECM is often 50% and some of the ECMs are implemented in upwards of 75% of the program clients. For example, 97% of the dwellings received caulking and 96% received weatherstripping; 46% received storm windows; 52% received attic insulation; and 72% received hot water jackets. (See Section 2.4, Features of Weatherization Program).

Weatherization program recipients tend to be elderly; living alone in relatively a large, unattached older home; and occupy the dwelling day and night. Weatherization program recipients reside in dwellings which are likely to be high-energy consumers. In addition, they are not likely to have engaged in any energy conserving activities; few close off unused space or set back their thermostat. Based on economic and demographic characteristics most program recipients would be unlikely to implement weatherization activities on their own. Additionally, the financial resources of many program recipients may be strained in periods of rising energy prices. (See Section 2.2, Profiles of Weatherization Recipients.)

The targeting of weatherization services to specific groups achieves program objectives. Much of the program targeting is directed toward enlisting low-income elderly and/or low-income handicapped. This targeting is successful, as over 80% percent of the sample are elderly and approximately half are handicapped. In addition, to help target dwellings with high energy bills, dwellings with expensive heating fuels such as fuel oil receive higher ratings. (See Section 5.0, Analysis of Subgroups.)

Areas for Potential Program Improvement

The weatherization program could increase average energy savings by targeting specific clients/LIHEAP applicants. Targeting specific groups that are more likely to realize significant energy savings can boost weatherization energy savings. For example, high-energy users save significantly more energy as a result of the weatherization than other clients. High-energy consumers are characterized by living in larger and significantly older dwellings than the remainder of the program recipients. In addition, while their energy consumption is higher, typically their incomes are no higher than other program recipients. Identifying dwellings with similar characteristics to the high energy group will allow program implementors to target weatherization resources to those dwellings most likely to achieve significant savings. Similarly, the program could maximize energy savings by foregoing the weatherization of homes likely to realize relatively small savings, or those dwellings for which energy consumption is expected to increase after weatherization. For example, mobile home dwellings realize significantly less savings than other dwellings; often, mobile homes have zero savings. The weatherization program can realize greater energy savings by targeting funds toward those dwellings which are more likely to realize significant energy savings. (See Section 5.0, Analysis of Subgroups.)

Work quality, as well as overall program implementation, could be enhanced if weatherization follow-up activities were strengthened to ensure that program recipients are fully satisfied with the work performed. Presently, policies to identify poor workmanship and/or elicit program recipient's complaints are not as effective as possible. Poor workmanship is not being reported and/or is being overlooked in some cases by weatherization crews and inspectors. In addition, some program recipients often do not voice their dissatisfaction and/or concerns regarding the work performed because they are unaware of whom to contact. Programs or policies which enabled program recipients to identify, record, and/or report careless work would further enhance the levels of satisfaction among program recipients. (See Section 13.0, Weatherization Follow-Up Procedures.)

While the weatherization program is designed to meet the needs of low-income households, particularly the elderly and handicapped, the program is less able to address the relative needs of clients within the low-income category. Some dwellings may not be receiving weatherization because they are lower on the priority list, yet they may have greater relative need to receive weatherization due to their economic characteristics or because they reside in a high energy consuming dwelling. For example, while gross income is a criteria for receiving weatherization, presently the applicant's discretionary income (i.e., the income level after the basic necessities are met such as monthly rent or mortgage) is not a factor in determining need. Similarly, because the program is designed to prioritize applicants within counties, an individual with a higher priority ranking in one county may not receive weatherization due to a lack of funds, while an individual in another county with a lower priority might become eligible because of fewer applicants in that particular county. (See Section 10.0, Prioritization of Weatherization Applicants.)

Administrative procedures to enlist and/or encourage weatherization application among eligible households not participating in LIHEAP funds are undeveloped. Because LIHEAP applicants are automatically eligible for weatherization, the program receives more applicants per year than can be weatherized given present funding levels. In order to maximize the number of homes weatherized per year, typically funds are spent on actual weatherization rather than marketing. As a result, little attempt is made to enlist or market eligible households not participating in LIHEAP. While the exact number of homes eligible but not participating in LIHEAP is unknown, a significant number of homes may not be aware of nor taking advantage of the opportunities presented by the weatherization program. (See Section 9.0, Marketing and Administrative Processes Relating to Program Awareness and Registration.)

Consumer education and information activities could enhance overall program savings. A program which educates weatherization recipients about energy savings activities and encourages an energy conscious lifestyle can boost the overall effectiveness of a weatherization program. Typically, weatherization recipients are ill-informed about the work being conducted, the benefits that may result, and how their behavior can effect the benefits. As a result, energy conserving behaviors such as not heating unused living spaces, setting back the thermostat at night, and closing fireplace dampers offer opportunities to improve overall energy savings in conjunction with the weatherization services. (See Section 11.0, Consumer Information and Education Activities.)

IOWA WEATHERIZATION ASSISTANCE PROGRAM EVALUATION

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JUNE 30, 1988

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

LIST OF EXHIBITS

PAGE

PART I - OUTCOMES EVALUATION RESULTS

LIST OF EXHIBITS
(Continued)

PART II - PROCESS EVALUATION RESULTS

LIST OF APPENDICES

PART I: OUTCOME EVALUATION RESULTS

1.0 INTRODUCTION TO OUTCOME EVALUATION

1.1 OUTCOME EVALUATION OBJECTIVES

The goal of the outcome component of the Weatherization Asssistance Program (WAP) evaluation is to estimate the effects of past weatherization activity. To help meet this goal, descriptive and explanatory data were obtained to describe the weatherization clientele in terms of demographic and attitudinal characteristics; determine the extent of energy and dollar savings attributable to the weatherization; and, relate the characteristics to energy savings. In addition, these data were analyzed to determine the nature and cost of the weatherization and specific Energy Conservation Measures (ECM). Finally, these data were analyzed to assess the cost-benefit of the weatherization program and specific ECMs, as well as determine the impact of the weatherization program on the state economy.

The outcomes section is comprised of the following five sections:

- Weatherization Program Recipient Characteristics and Program Features. This section focuses on creating demographic profiles of the weatherization clients, determining the nature and cost of the weatherization, and analyzing the household energy savings in terms of the demographic and attitudinal characteristics.

- Cost of Weatherization Program. This section focuses on determining the costs of the weatherization program, particulary in terms of materials, labor, and support costs. In addition, this section addresses the costs associated with specific ECMs; the costs associated with weatherizing all eligible dwellings; and specific issues related to weatherization program implementation.

- Analysis of Energy Savings. First, this section presents estimates of program savings. Next, this section addresses specific methodological considerations which effect the ability to measure savings attributable to specific ECMs. Finally, this section provides estimates of savings for those specific ECMs or combinations of ECMs which are statistically significant.

- Analysis of Subgroups. This section addresses the issue of energy savings as it pertains to specific groups such as high-energy consumers, low-energy savers, contractor versus in-house crews, rental units, single parent households, and mobile homes. Finally, this section addresses specific issues relating to program implementation.

- Economic Analysis. This section addresses issues such as payback and cost-benefit of the program as well as specific ECMs. In addition, this section assesses the impact of the program on the state's economy.

1.2 OUTCOME EVALUATION METHODOLOGY

The test population chosen for study was 1987 weatherization program recipients. Each of the 19 CAAs providing local weatherization services was requested to provide a random selection of 60% of the 1987 households weatherized during the 1987 program year (the sample). Requested documents included the WAP Job Form, which includes information on the weatherization conducted for each dwelling, as well as the LIHEAP Application Form. Overall, the names and addresses of 4,000 1987 program recipients were gathered.

In addition, a control group was gathered. Each CAA was requested to forward a random selection of LIHEAP Application Forms for homes eligible for weatherization, but not weatherized. Overall, the names and addresses were gathered for 1,200 households eligible for weatherization, but not yet weatherized. These households comprised the control group. The control group was incorporated into the research design to account for exogenous variables that contribute to changes in energy consumption.

Separate mail surveys were sent to the sample and control groups. (See Appendix A, Mail Surveys.) Included in the survey packet was a cover letter outlining the reasons for the survey; the survey; and a self-addressed, pre-stamped return envelope. Questions regarding the weatherization work actually conducted were eliminated from the control group survey. A follow-up reminder, including a copy of the survey, was sent to the sample and control group within two weeks after mailing the first survey. Approximately 3 percent of the sample and control group were unable to be delivered by the Post Office due to a change of address.

The mail survey yielded a response rate of approximately 80 percent. Exhibit 1-1 details the response rate for the test and control groups, respectively.

EXHIBIT 1-1

SURVEY RESPONSE RATE

	TEST	CONTROL
Survey Response		
Received Prior to Beginning Data Analysis	2,621	499
Received After Beginning Data Analysis	601	270
Total Respondents	3,222	269
Total Response Rate	81%	64%

To ensure that the utility billing histories gathered as part of the evaluation would be useable data, a series of questions on the survey were designed to identify those dwellings that had changes in their living circumstances over the past three years which could significantly increase or decrease energy consumption irrespective of whether the home was weatherized. If a positive response was given to any of five questions, the case was eliminated from the study. Specifically, five questions helped determined whether:

- A fuel other than natural gas or electricity was the primary home heating fuel;
- The home was vacant for greater than a three week period since October, 1985;
- The size of the household had either increased or decreased since October, 1985;
- Significant amounts of supplemental heating were used in the home such as a woodstove; and
- The occupant had established residence since October, 1985.

Additional reasons for eliminating cases from the sample included: if a utility company account number was not provided on the LIHEAP Application Form; if the primary home heating fuel had changed since October, 1985; if the LIHEAP Application Form, which included a consent agreement allowing utilities to release utility billing data to the proper authorities, was unsigned; and if the square footage of the home had changed significantly since October, 1985. Exhibit 1-2 provides a summary of the test and control group cases.

EXHIBIT 1-2

STATUS OF SURVEY SAMPLE

	TEST (n=2,621)	CONTROL (n=499)
Cases Eliminated	1,744	374
Cases Used in Survey Data Analysis	753	107
Cases Used in Energy Consumption Analysis	420	64

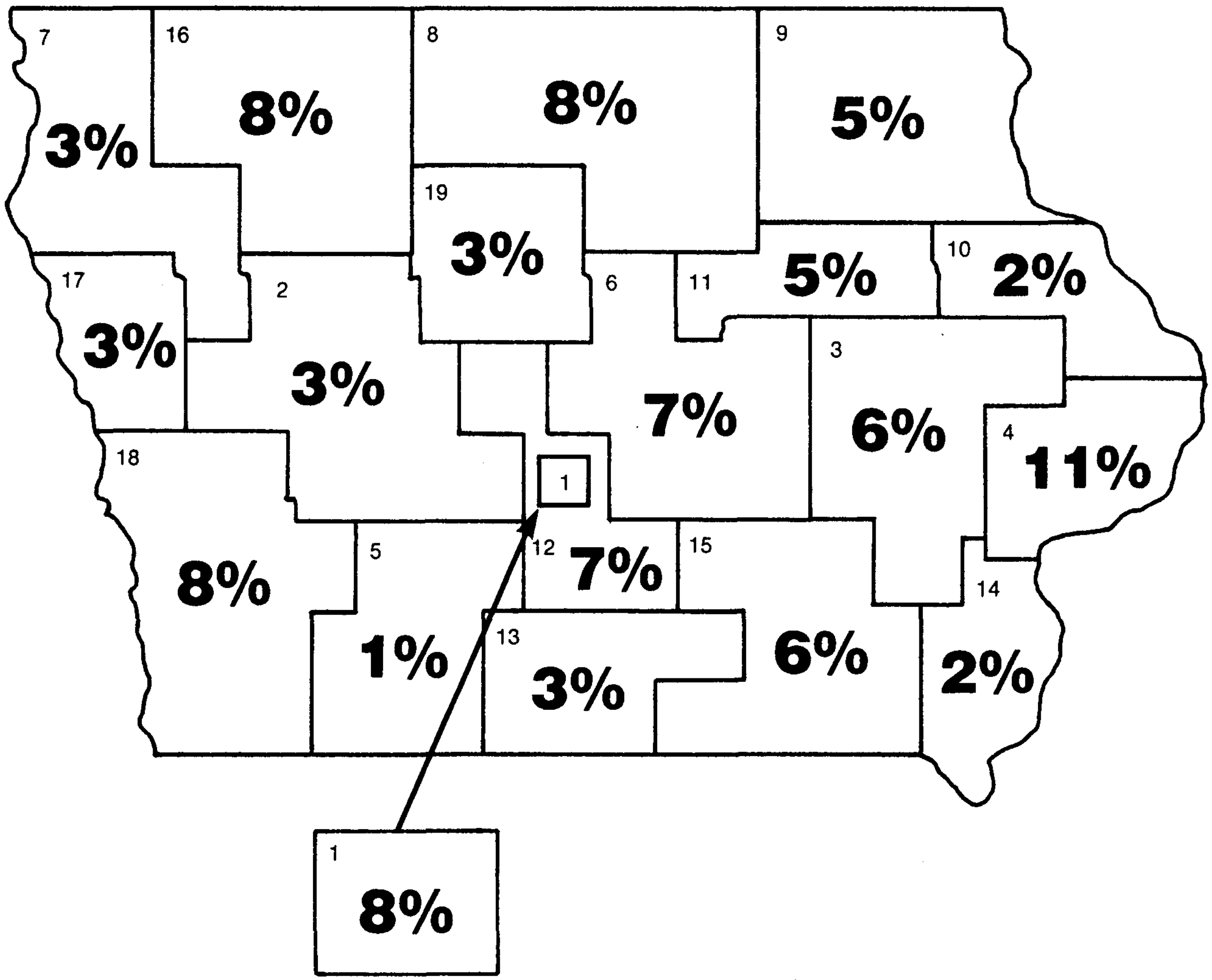
The sample is dispersed throughout Iowa. The number of cases per CAA (as a percent of the total test group) ranges from 1% to 11%. Exhibit 1-3 illustrates the geographic distribution of the test group.

Utility billing histories were sought for the 753 test and the 107 control households comprising the sample. The requested billing histories covered the period from October, 1985 to the latest billing period. After analyzing the billing histories received, 420 utility billing histories were deemed sufficiently complete to include in the sample, while 64 utility billing histories were included in the control group.

The Princeton Scorekeeping Method (PRISM) was used to calculate (1) a Normalized Annual Consumption (NAC), (2) consumption attributable to heating only, and (3) baseload energy consumption. In order to provide accurate estimates of the effects of the weatherization on household heating-related energy consumption, heating-related energy consumption must account for baseload heating, which may be attributable to factors such as everyday household appliance useage; and be normalized for heating degree days, which is a measure of the temperature changes over time. PRISM uses a regression algorithm to account for factors such as baseload energy consumption and heating degree days, while estimating a normalized annual energy consumption figure per dwelling as well as providing estimates on annual heating only energy consumption.

Inputs into PRISM include average daily temperatures from the National Weather Service for five different regions in Iowa from January, 1980 through February, 1988. PRISM calculates heating degree data per region, and uses the data to estimate NAC, heating, and baseload pre- and post-weatherization energy

Exhibit 1-3
CAA STUDY PARTICIPATION AS A PERCENT OF TEST GROUP



consumption figures. These data were then incorporated into the household data file.[1]

Data regarding the nature and cost of the weatherization were obtained from two CAA files. The LIHEAP Application Form contains demographic, dwelling, and household income data for all program applicants, and is used to determine program eligibility as well as applicant priority. The WAP Job Form contains information regarding the weatherization per dwelling, including the date of weatherization; and types of weatherization measures implemented as well as the costs of those measures; and material, labor, support, and total weatherization costs.

The objective of the data analysis was to estimate energy savings attributable to the weatherization, as well as determine the effects of various demographic and attitudinal variables on energy savings. The Statistical Package for the Social Sciences (SPSS-PC) was used to conduct the data analysis. Unless otherwise indicated, all the results of the various statistical procedures are statistically significant at the .05 level. This means that we are 95% confident that the data derived from the test group is representative of what would be found if data had been obtained from all the 1987 program recipients. Note, however that estimates are accompanied by a corresponding confidence interval which reflects the upper and lower bounds of the estimate.[2]

SPSS-PC includes a variety of statistical routines including multivariate regression, breakdown, crosstabulation, tests of the difference of means, and frequency distributions. All of these statistical routines were used in this study. Specifically, regression and breakdown were used to help estimate energy savings per ECM; crosstabulation, the difference in means, and frequency distributions were used to analyze the sample demographic, dwelling,

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[1] See Appendix B, Technical Methodology for a description of the methodology that underlie PRISM.

[2] See Appendix D, Confidence Intervals for Estimates, for the confidence intervals associated with the estimates reported herein.

and attitudinal characteristics, as well as relate these characteristics to energy savings.[3]

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[3] For a more detailed discussion of the methodology used to analyze utility billing histories and survey data, see Appendix B, Technical Methodology.

2.0 WEATHERIZATION PROGRAM RECIPIENT CHARACTERISTICS AND PROGRAM FEATURES

2.1 INTRODUCTION

One objective of this study is to obtain a better description of who receives weatherization services. This section provides profiles of weatherization recipients based on demographic, dwelling, economic characteristics, and energy savings characteristics. In addition, this section describes the weatherization program in terms of the ECMs implemented.

2.2 PROFILES OF WEATHERIZATION PROGRAM RECIPIENTS

Profiles are created to assist in the description of the weatherization clientele in terms of their (1) demographic characteristics; (2) dwelling characteristics such as dwelling and fuel type; (3) behavioral characteristics; (4) energy savings characteristics as a result of the weatherization; and (5) economic characteristics such as household income.

Data for the control group is presented along with the data pertaining to the test group to show that for most demographic, dwelling, and attitudinal characteristics the differences between the test and control group are not statistically significant. While the control group tends to be slightly younger and have households with slightly more occupants, generally the test and control groups share common characteristics; thus, differences between the two groups in pre- and post-weatherization energy consumption are unlikely to reflect differences in living conditions.

Demographic Characteristics

Overall, the weatherization clientele tend to be elderly; moderately educated; own their homes; and occupy the dwelling during the day and night. In addition, the number of persons per household is small, often only a single individual. The average age of a program recipient is nearly 68. Only 15% of the test group are less than 60 years old; less than 6% are under the age of 40. On the other hand, fully 32% of the test group are at least 75, while approximately 20% are 80 years or more. Exhibits 2-1 and 2-2 provide some of the demographic characteristics of the test group.

EXHIBIT 2-1

DEMOGRAPHIC CHARACTERISTICS OF TEST AND CONTROL GROUPS

	TEST (n=753)	CONTROL (n=107)
Sex (male)*	39%	54%
Elderly Status (age 60+)*	85%	72%
Elderly Status (age 75+)	32%	28%
Single Parent Status	3%	7%
Handicapped Status	47%	51%
Young Child Present (age <4)	4%	5%

* Differences are statistically significant at .05 level.

EXHIBIT 2-2

DEMOGRAPHIC CHARACTERISTICS OF TEST AND CONTROL GROUPS

	TEST (n=753)			CONTROL (n=107)		
	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE
Age	67.8	69.0	22-96	65.2	66.0	24-91
Household Size (No. of Persons)*	1.6	1.0	1-7	2.1	2.0	1-8
Education Level	10.3	11.0	0-17	10.8	12.0	1-17

* Differences are statistically significant at .05 level.

Only 13% of the households have more than two persons per dwelling. Fully 58% of the households are occupied by a single person. The mean size of the household is 1.6 persons, while the median size is 1.0 persons. The average education level of the heads of household is equivalent to a sophomore or junior in high school.

Dwelling Characteristics

Typically, program recipients live alone in an older, detached, single story unit with a basement; consume natural gas as their primary heating fuel; tend not to close off rooms to save heat; and reside in dwellings that have storm windows and a thermostat. More than half of the test group have air conditioning; 49% of the basements are full basements and 29% of the basements are heated. Only 5% of the test group live in attached dwellings. The majority of clients live in either a single or split level dwelling; however, about one-third live in a two story unit. Approximately 2% are mobile home dwellers. Only 15% rent their homes. Fully 95% use natural gas and 5% use electric.[1] Exhibits 2-3 and 2-4 depict some of the dwelling characteristics for the test and control groups. None of the differences shown in Exhibits 2-3 and 2-4 are statistically significant at the .05 level.

EXHIBIT 2-3

DWELLING CHARACTERISTICS OF TEST AND CONTROL GROUPS

	TEST (n=753)	CONTROL (n=107)
Air Conditioning	51%	51%
Basement		
Partial	29%	26%
Full	49%	56%
Attached Dwelling	5%	1%
Rental Unit	15%	11%

[1] Cases were deleted when the primary heating fuel or a significant amount of the household energy demand was met by either fuel oil, wood, or coal. Analyzing fuel consumption records for these dwellings is difficult and often result in imprecise data, given the lack of uniformity in service delivery records from independent fuel retailers and the absence of strict household monitoring of fuel consumption.

EXHIBIT 2-3

DWELLING CHARACTERISTICS OF TEST AND CONTROL GROUPS (CONTINUED)

	TEST (n=753)	CONTROL (n=107)
Home Type		
Single Story (includes split)	65%	65%
Two Story	32%	32%
More than Two-Story	1%	0%
Mobile Home	2%	3%
Storm Windows	97%	92%
Thermostat	95%	96%
Fuel Type		
Gas	95%	97%
Electric	5%	3%

EXHIBIT 2-4

DWELLING CHARACTERISTICS OF TEST AND CONTROL GROUPS

	TEST (n=753)			CONTROL (n=107)		
	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE
No. Rooms	5.7	5.0	4-13	5.9	6.0	4-10
No. Rooms Heated	4.9	5.0	2-12	5.1	5.0	4-9
Total Square Footage*	945.0	850.0	60-4,170	NA	NA	NA
Unit Age (years)	59.0	60.0	4-140	NA	NA	NA

* Total square footage was estimated as the product of the attic square footage and the number of floors in the dwelling.

NA Not available.

Even though the average number of household occupants is 1.6, on average there are 5.7 rooms per dwelling, including 2.5 bedrooms. Nearly all the rooms in the dwelling are heated, even in those dwellings with more bedrooms than occupants.

Behavioral Characteristics

While nearly every home has a thermostat to regulate the indoor heating temperature, many of these devices may be miscalibrated (see page 12-14). Since 97% of the dwellings are occupied during the day and apparently only a small minority set-back their thermostat during a 24-hour period, the potential for consuming more energy than is necessary to maintain living comfort is high. Given the relatively high average age per dwelling (59 years), heating unused space in what are likely to be old and relatively drafty dwellings can become unnecessarily expensive. Exhibit 2-5 describes some of the thermostat setting characteristics of the test and control groups.

EXHIBIT 2-5

THERMOSTAT CHARACTERISTICS OF TEST AND CONTROL GROUPS

	TEST (n=701)			CONTROL (n=101)		
	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE
Thermostat Setting						
Day	69.9	70.0	60-82	69.6	70.0	60-80
Evening	69.7	70.0	50-82	69.2	70.0	58-80
Night	66.5	68.0	0-80	66.3	68.0	50-78

Economic Characteristics

Annual household incomes average $6,359 or $530 per month. During a six month heating season LIHEAP funds contribute $36 per month to meet household energy bills. Exhibit 2-6 describes some of the economic data that characterize the weatherization clientele.

EXHIBIT 2-6

ECONOMIC CHARACTERISTICS OF TEST AND CONTROL GROUPS

	TEST (n=699)			CONTROL (n=104)		
	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE
Annual Household Income 1/	$6,359	$5,942	$780-21,240	$7,232	$7,100	$300-18,360
Monthly Rent 2/	146	130	0-350	141	153	0-250
LIHEAP Funds 3/	218	235	14-350	199	213	105-280

1/ Denotes statistically significant difference between test and control.
2/ Based on a test and control group sample size of 119 and 14, respectively.
3/ Based on a control group size of 30.

2.3 PROFILES PER COMMUNITY ACTION AGENCY

Little difference exists between the CAAs on the demographic, attitudinal, and dwelling structure characteristics. There are 19 CAAs that implement the weatherization program in Iowa. The number of respondents that remained in the test after deleting inappropriate cases range 6 to 84 per CAA service area. This range makes it difficult to assess the extent to which the characteristics of the clientele serviced by any specific CAA are significantly different than the test group as a whole. Given the geographic dispersion of the CAAs and the urban/rural dichotomy, the slight differences in means on specific characteristics are not surprising. Appendix C provides a detailed breakdown by CAA of the data used in this study.

2.4 FEATURES OF WEATHERIZATION PROGRAM

Generally, the rate of implementation for specific energy conservation measures are high, particularly for those measures directly affecting air infiltration such as caulking, weatherstripping, and door sweeps.[2] For all measures except wall insulation and skirting, implementation rates are greater than 40%, while the rates for caulking and weatherization approach 100%. About three out of four program recipients receive window glazing, door sweeps, and hot water jackets. Exhibit 2-7 provides a detailed breakdown of the rate of implementation per ECM.

The rates of implementation are determined primarily by CAA weatherization evaluators. The evaluators conduct on-site reviews of the homes, identifying the specific ECMs that will be implemented. After the work is completed, a CAA inspector checks to make sure that the work is completed satisfactorily. Finally, a DCAA inspector reviews approximately 10% of the dwellings weatherized. Both the CAA and DCAA inspectors have the authority to fail a dwelling and require additional follow-up work to remedy problems prior to payment.

While the rates of implementation are high for the test group as a whole, the rates do vary depending on the dwelling characteristics. The rate of implementation of specific ECMs were analyzed to determine whether the rate of implementation varies due to (1) the age of the dwelling unit; (2) whether the unit is a rental unit; (3) the extent to which the household was a high-energy user prior to the weatherization; (4) whether the unit is an attached versus detached dwelling; and (5) household size (i.e., the number of household occupants).

The rate of ECM implementation varies significantly only with the unit's age, whether the dwelling is an attached unit or not, and whether the unit was a high-energy consumer prior to the weatherization. The relationship(s) between these characteristics and the rate of ECM implementation will be addressed in the remainder of this section.

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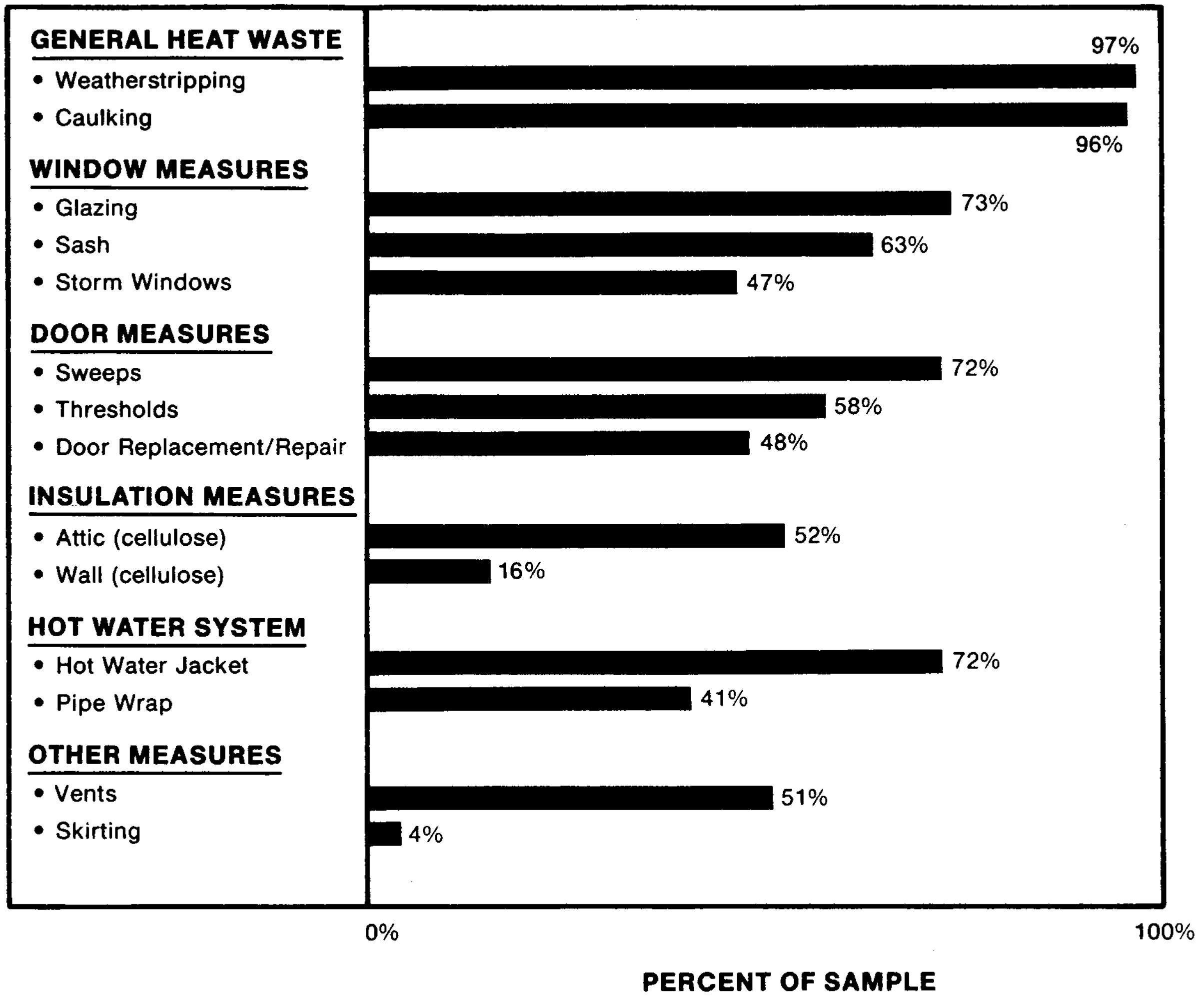
[2] Rates of implementation were determined based on an analysis of the WAP Job Form per weatherization. For those dwellings not receiving a specific ECM, reasons for not implementing may include the presence of the ECM prior to weatherization.

Exhibit 2-7
Rate of ECM Implementation



Age of Unit

The older the unit the more likely the weatherization would include nearly all the ECMs. For example, compared to units less than 45 years old, units over 75 years old are 15% more likely to have received a hot water jacket for the hot water heater; 22% more likely to have received window glazing treatment; almost three times as likely to have received sash work; and almost twice as likely to have received storm windows. Exhibit 2-8 compares the rates of implementation for the various ECMs based on the age of the unit.

As indicated, a relatively strong relationship exists between the age of the unit and the likelihood of receiving any specific ECM. The age of the unit, however, is not related very strongly with annual energy consumption (the correlation is 0.266). On the other hand, because few other characteristics are related to energy consumption, the age of the unit is a relatively strong measure of energy consumption. Thus, age of the unit could be used as a variable to help identify high-energy consumers for targeted program implementation.

High-Energy Consumers

Generally, high-energy consumers (i.e., those in the top twentieth percentile in terms of pre-weatherization normalized annual Btu consumption) are slightly more likely to receive specific ECMs. For example, high-energy consumers are 10-15% more likely than the remainder of the sample to receive energy conservation measures such as hot water jackets, window work and attic insulation. High-energy consumers are characterized by residing in larger and older dwellings, typically two story dwellings. (See Section 5.2, High-Energy Consumers.)

While more likely to receive specific ECMs relative to the remainder of the test group, many high-energy consumers do not receive important ECMs. For example, 15% of the high-energy consumers do not receive hot water jackets, approximately 20% do not receive window sashes and/or door sweeps. Indeed, nearly 40% of the high-energy consumers do not receive attic insulation, yet insulation (attic and/or wall) has been shown to achieve normalized energy

EXHIBIT 2-8

RATE OF ECM IMPLEMENTATION BY AGE OF UNIT

	DWELLING AGE LESS THAN 45 YEARS (n=246)	DWELLING AGE 45-75 YEARS (n=294)	DWELLING AGE MORE THAN 75 YEARS (n=213)
General Waste Heat			
Weatherstripping	94%	99%	99%
Caulking	94%	97%	99%
Window Measures			
Window Glazing	57%	84%	79%
Window Sash	29%	80%	83%
Storm Windows	33%	53%	57%
Door Measures			
Door Sweeps	69%	71%	79%
Door Thresholds	45%	68%	62%
Door Replacement/Repair	36%	57%	54%
Hot Water System Measure			
Hot Water Jacket	64%	75%	79%
Pipe Wrap	38%	40%	47%
Other Measures			
Attic Insulation	45%	51%	62%
Wall Insulation	9%	20%	19%
Vents	40%	56%	60%

savings of between 12 and 18 percent. Exhibit 2-9 compares the rate of implementation of specific ECMs for high-energy consumers with the rest of the test group.

EXHIBIT 2-9

COMPARISON OF ECM IMPLEMENTATION RATES BY TYPE OF ENERGY CONSUMER

	HIGH-ENERGY CONSUMER (n=102)	REMAINDER OF TEST GROUP (n=426)
General Waste Heat		
Caulking	96%	95%
Weatherstripping	98%	97%
Hot Water Systems		
Hot Water Jacket*	85%	71%
Pipe Wrap Insulation	46%	39%
Windows		
Glazing*	85%	75%
Sash*	78%	63%
Storm Windows*	62%	42%
Doors		
Sweeps*	80%	70%
Thresholds	60%	57%
Door Replacement/Repair	42%	51%
Insulation		
Attic*	62%	50%
Wall Insulation*	28%	14%
Other Measures		
Vents	58%	56%
Skirting	5%	3%

* Differences are statistically significant at the .05 level.

Attached Units

Only one other dwelling characteristic tested, namely whether the unit was an attached unit or not, showed any significant relationship to the rate of implementation of specific ECMs. Typically, attached units are much less likely to have received many of the ECMs, particularly those ECMs that effect window quality, door quality, and require attic and/or roof work. For example, while attached units are just as likely to have received weatherstripping and caulking, they are at least 25% less likely to have received work on the window structure such as window glazing, sash installation or replacement, or storm door work. Exhibit 2-10 compares the implementation rates for attached and detached dwellings.

EXHIBIT 2-10

RATE OF ECM IMPLEMENTATION BY DWELLING TYPE

	ATTACHED (n=38)	DETACHED (n=714)
Window Glazing*	43%	74%
Window Sash*	43%	64%
Storm Windows*	24%	49%
Door Threshold*	38%	59%
Door Replacement*	27%	49%
Attic Insulation*	16%	54%
Vents*	16%	53%

* Differences are statistically significant at the .05 level.

2.5 ISSUES RELATING TO PROGRAM IMPLEMENTATION

Given the data presented in this section, there are several issues that could effect successful program implementation, particularly in terms of increasing energy savings. These issues are presented below:

- <u>Weatherizing dwellings with relatively low numbers of occupants likely reduces the average effectiveness of many ECMs in terms of overall weatherization savings</u>. Given an average household size of 1.6 persons, and that 58% of the dwellings are occupied by a single individual, the numbers of persons benefiting from weatherization is low. In addition, specific ECMs such as those that effect the hot water system realize less savings when fewer persons are in the household. Given that the average household size for the control group is slightly larger, recent attempts to target larger households by altering the Program Point and Prioritization System may prove helpful in this regard. (See Section 10.0 Prioritization of Weatherization Applicants.)

- The tendency for household occupants to heat the entire dwelling, particularly rooms which are not likely to be used, suggest that more energy is being consumed than is required to maintain sufficient comfort levels. Typically, occupants do not set back thermostats and they tend to heat all the rooms in the dwelling, particularly the bedrooms. This behavioral pattern exists even when the number of bedrooms exceeds the number of occupants in the dwelling. As a result, household occupants are likely to be consuming more energy that is required, and paying a larger utility bill than is necessary to maintain a comfortable and healthy living space.

- Relatively low education levels suggest that marketing and/or administrative processes designed to increase program participation and awareness should be tailored for a specific clientele. The average grade completed is equivalent to a high school sophomore or junior and 30% of the test group remained in school only through the eighth grade.

- Based on economic criteria such as income, energy consumption, and rental status, there are identifiable groups which exhibit relatively greater need for weatherization. Relative to some groups being weatherized, some families are faced with a tighter household budget than others, particularly given their relatively high energy consumption and low-income status. For example, while single parent households are likely to be moderate to high-energy consumers, their economic circumstances suggest a lower capacity to meet rising energy bills, compared to other program recipients. Typically, they have more occupants per dwelling, have lower incomes, and (for those who rent) pay higher rents. (See Section 5.0, Analysis of Subgroups and particularly sections 5.5 and 5.6.)

- The rates of implementation are relatively low for key ECMs such as attic and wall insulation, which realize the greatest energy savings per ECM, particularly for key subgroups such as the high-energy consumers. While the low rates may reflect the fact that many homes had adequate quantities of insulation, the data suggest that only approximately half of the high-energy consumers receive insulation work, even though these dwellings tend to be older and original insulation levels may be ineffective. (See Section 4.4, Savings Per Composite ECM.)

3.0 COST OF WEATHERIZATION PROGRAM

3.1 INTRODUCTION

The cost of the weatherization reflects direct costs provided on the WAP Job Form. The following section details the findings regarding the costs of weatherization.

3.2 COST OF WEATHERIZATION

While program guidelines stipulate that the average cost per weatherization is not to exceed $1,500 (1987 program guidelines), expenditures per weatherization average $1,224, approximately 18% less than limits allowed by program guidelines.[1] The effects of this lower expenditure rate include:

- More dwellings can be weatherized in a program year, assuming staff and/or crew resources can handle the additional workload; and
- The marginal return on investment (i.e., energy savings as a product of program expenditures, particularly materials) are relatively higher, given data suggesting there is a diminishing rate of return when material costs exceed the average by at least 30% (approximately $800).

An implementation strategy that identifies dwellings associated with relatively low cost weatherizations may help explain why average weatherization costs are 18% less than the maximum average cost permitted under program guidelines. Apparently program implementors recognize that often a diminishing rate of return exists on weatherization expenditures. Identifying dwellings for which the weatherization will be relatively low-cost increases the number of dwellings weatherized per program year, which is a key program monitoring procedure used by DOE. Note that total costs range from $40 to $2,400. A dwelling receiving only $40 in weatherization services, including only $16 in materials, is probably not a dwelling in need of weatherization. Servicing these units may not be cost-effective when considering the opportunity costs (i.e., the benefits of weatherizing a home in greater need). Exhibit 3-1 provides a breakdown of the average costs per weatherization.

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[1] Since 1987 the average cost per weatherization has been changed to $1,600.

EXHIBIT 3-1

COST PER WEATHERIZATION

	MEAN	MEDIAN	RANGE
Materials	$ 564.00	$ 550.00	$16.00-2,054.00
Labor	431.00	401.00	15.00-1,193.00
Support	231.00	251.00	8.00-702.00
TOTAL (n=729)	$1,224.00	$1,208.00	$40.00-2,400.00

Conversations with weatherization implementors suggest that some of the cost associated with a weatherization is preventive maintenance and may not result in immediate energy savings. For example, crews may replace a door or repair a worn foundation in anticipation of needed repairs in the future. Thus, while this activity increases costs and may not result in energy savings immediately, these activities can result in significant savings if the door or foundation were to fall into disrepair in the future when weatherization crews may be unable to return and repair the damage.

Apparently, program guidelines regarding average weatherization costs are not effecting weatherization implementation. As of January 1, 1987, program guidelines set a $1,500 average cost per weatherization for the program as a whole, and set a maximum cost per weatherization of $2,400. Two sets of data suggest that spending limits such as these did not effect the CAAs' ability to effectively weatherize their clientele. First, CAAs did not approximate a $1,500 average cost per weatherization. This suggests that per dwelling weatherization costs either fail to approach program limits, or administrators actively seek out low-cost dwellings in order to bring average costs below program guidelines. While this latter strategy is being used, the strategy is more likely designed to increase the number of units weatherized in order to meet program monitoring goals than ensure that average costs are within program guidelines. Secondly, large expenditures in weatherization materials do not necessarily result in proportional increases in energy savings; there is a diminishing margin of returns as material expenditures increase much beyond the average (approximately $564.00). For example, the relationship between material costs and energy savings gets weaker when the analysis includes cases for which material costs exceed $800.

For the 1988 program year, program guidelines have been changed to allow for a program wide average weatherization cost of $1,600. In addition, expanded furnace related work is being given greater priority. While the costs associated with furnace work are unknown, on average CAAs will have approximately $376 to conduct the furnace work without exceeding the $1,600 average weatherization cost ceiling, assuming no other changes in program implementation.

3.3 COSTS PER ENERGY CONSERVATION MEASURE

The average costs of the specific ECMs which contribute the most to the average weatherization cost are window sashes ($165.80 or 29% of the average materials cost); wall insulation ($144.10 or 25% of the average materials costs); and storm windows ($128.20 or 23% of the average materials cost). Exhibit 3-2 provides a breakdown of the costs per ECM.

EXHIBIT 3-2

COSTS OF MATERIALS PER ECM

	MEAN	MEDIAN	RANGE
Hot Water System Measures			
Hot Water Jacket (n=500)	$ 13.50	$ 12.00	$ 6.00-60.00
Pipe Wrap (n=299)	4.10	3.00	1.00-45.00
Window Measures			
Window Glazing (n=510)	8.10	5.00	1.00-75.00
Window Sash (n=459)	165.80	125.00	1.00-888.00
Storm Windows (n=347)	128.20	94.00	5.00-735.00
General Waste Heat Measures			
Weatherstripping (n=692)	28.20	24.00	1.00-135.00
Caulking (n=702)	72.70	66.50	1.00-424.00
Door Measures			
Door Sweeps (n=512)	6.20	4.00	1.00-51.00
Door Thresholds (n=418)	17.30	16.00	1.00-68.00
Door Replacement/Repair (n=351)	76.90	67.00	2.00-265.00

EXHIBIT 3-2

COSTS OF MATERIALS PER ECM
(CONTINUED)

	MEAN	MEDIAN	RANGE
Insulation Measures			
Attic Insulation (n=377)	144.10	133.00	2.00-650.00
Wall Insulation (n=118)	148.40	125.50	12.00-598.00
Other Measures			
Vents (n=371)	20.00	17.00	1.00-75.00
Skirting (n=31)	62.70	36.00	2.00-421.00

Relatively weak relationships exist between the costs per measure and attic square foot, size of the dwelling, number of rooms, or number of occupants. As indicated in Exhibit 3-2, however, the range of costs for most of the ECMs vary considerably; often the high range is five to seven times the average cost of the specific ECM.

3.4 COST OF WEATHERIZING ALL ELIGIBLE DWELLINGS

There are approximately 200,000 dwelling units eligible for LIHEAP funds according to the 1988 Weatherization Assistance Program State Plan. As of January 1988, approximately 90,000 dwellings have been weatherized. DCAA administrators, however, estimate the number of eligible households may be up to twice the number of LIHEAP applicants. Many of the technically eligible households, however, may not want their dwellings weatherized. Reasons for declining a weatherization include: occupant inconvenience associated with scheduling weatherization work; an unwillingness to allow strangers to enter the property and/or work on the dwelling; and a reluctance to participate in a government assistance program. Thus, the best estimate of eligible and willing weatherization participants is the number of LIHEAP participants, since a condition of LIHEAP participation is the weatherization of one's dwelling.

Assuming LIHEAP includes nearly all eligible and willing household, the number of dwellings remaining to be weatherized (excluding "re-dos") ranges from approximately 110,000 to 200,000. The range varies depending on how many of the dwellings weatherized to date are included in the count of 200,000 eligible LIHEAP dwellings.

The average weatherization cost per actual weatherization in the 1987 program year was $1,224. If all the eligible dwellings were weatherized in the 1988 program year, the cost of weatherization would range from $134.6 million to $244.8 million. Assuming the average weatherization cost equaled the maximum allowed under 1988 program guidelines (i.e., $1,600), the cost to weatherize all the remaining eligible dwellings would range from $176.0 million to $320.0 million.

3.5 ISSUES RELATING TO WEATHERIZATION PROGRAM IMPLEMENTATION

The cost of the Weatherization Program, and the allocation of weatherization funds, raise several issues regarding program implementation. These issues include:

- A diminishing marginal rate of return exists with regards to the average expenditures per weatherization. After a certain point increases in material expenditures do not necessarily result in concomitant increases in energy savings. The data suggest that material expenditures over $800 (when the average is $564) do not result is significant, measurable increases in energy savings. Apparently, program implementors recognize this fact; their average weatherization costs do not approximate program cost ceilings. As a result, more dwellings are weatherized per program year.

- At certain times of the program year, implementation strategies may be tailored to satisfy program monitoring objectives, rather than client need. Because an average energy savings of approximately 14% is assumed (and accepted by DOE), a primary measure of program success is the number of units weatherized per program year, rather than either average or aggregate energy savings. As a result, implementation strategies are some times designed to maximize the number of units weatherized, irrespective of need. For example, at the end of the program year when program implementors have discretion as to which homes may be weatherized within a particular priority level, dwellings may be chosen with a relatively low need for weatherization from an energy perspective, rather than a dwelling with greater need but which will require more resources including time and materials. Choosing less time consuming weatherizations enables program implementors to more easily meet program objectives in terms of units weatherized, while lowering average weatherization costs.

4.0 ANALYSIS OF ENERGY SAVINGS

4.1 INTRODUCTION

The analysis of energy savings entailed gathering and analyzing utility billing histories for the test and control groups. The objective is to compare pre- and post-weatherization energy consumption figures, while controlling for as many extraneous factors as possible, and attribute the difference in energy consumption to the weatherization program. To accomplish this task, household billing histories were obtained from the respective utilities for the period October, 1985 to the latest billing period (typically through March 1988). The remainder of this section presents the findings of this task.

4.2 METHODOLOGICAL CONSIDERATIONS

Critical factors such as the environment and occupant behavior affect the ability to reliably estimate and/or attribute energy savings. The study methodology used herein was designed to reduce the effects of extraneous factors on energy savings calculations. The study methodology includes:

- A control group to estimate changes in energy consumption which would occur in the absence of weatherization (i.e., as a result of "exogenous" factors);

- Utility billing records over a sufficiently long period of time to accurately estimate the effects of the weatherization. The study design gathers energy data for the period October 1985 through March 1988. At a minimum this period allows for up to a year of pre-weatherization data and 3 months of post-weatherization data (for those dwellings weatherized in December 1987);

- Control for changes in weather by adjusting consumption figures to account for changes in temperature (i.e., heating degree day temperature differences) over the three year period of analysis; and

- Control for the effects of non-space heating energy consumption, particularly baseload energy consumption/heating attributable to household appliances.

Energy savings estimates are based on the difference between the pre-and post-weatherization normalized annual heating-only Btu energy consumption. Pre- and post-weatherization normalized annual heating-only Btu energy consumption figures are estimates of annual energy consumption controlling for factors such as heating degree days and baseload energy consumption (i.e., energy consumption not related to space heating). These estimates were calculated using PRISM.[1]

Savings measures were derived for differences in gross annual Btu energy consumption, as well as a percent difference from the pre-weatherization annual Btu consumption. The measures were analyzed to identify and eliminate anomalous cases with historical energy consumption patterns which could not be explained by the case histories. In addition, to help control for the effects of outliers, the five cases with the highest percent savings as well as the five cases with the lowest percent savings were eliminated from the analysis.

4.3 SAVINGS FOR THE WEATHERIZATION PROGRAM

The average weatherization results in an estimated first year energy savings of approximately 15.7% of normalized annual Btu consumption. This per weatherization savings is equivalent to approximately 14.2 million Btu; 142 ccf; or 4,161 kwh. In program year 1987, the weatherization program resulted in a savings of approximately 93.7 billion Btu, 937,000 ccf, or 27.0 million kwh. These data are based on a weatherization rate of 6,593 dwellings in the 1987 program year. Assuming a $.461 cost per therm, the first year energy savings attributable to the weatherization program is equivalent to approximately $432,000 or $65 per dwelling per year.[2]

Calculations of the savings per CAA have been made to describe the relative uniformity in savings across CAA. Because of relatively small sample sizes, many of the estimates of savings are associated with very large confidence intervals. Large confidence intervals indicate that the estimates are not very precise. Exhibit 4-1 provides an estimate of the savings per CAA, as well as the confidence interval associated with the estimate.

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[1] See Appendix B, Technical Methodology for a description of PRISM and the methodological constraints that determined the types of statistical routines which could be employed to analyze and compare energy savings.

[2] Additional summer energy savings not calculated herein also result from the weatherization program. For example, approximately half of the homes weatherized have air conditioning systems. As a result of reduced air infiltration, the weatherization will typically reduce summer energy demand associated with air conditioning systems.

EXHIBIT 4-1

AVERAGE PERCENT SAVINGS PER WEATHERIZATION BY CAA

CAA AGENCY		(N=)	AVERAGE SAVINGS (%)	CONFIDENCE INTERVAL LOWER	CONFIDENCE INTERVAL UPPER
1. Office of Neighborhood Development	Des Moines	59	20.64	20.64	25.65
2. Community Opportunities, Inc.	Carroll	26	13.43	0.81	26.05
3. Hawkeye Area CAP	Cedar Rapids	48	8.44	3.96	12.92
4. Iowa East Central T.R.A.I.N	Davenport	84	14.56	10.58	18.54
5. MATURA Action Corporation	Creston	6	21.80	-50.17	93.77
6. Mid-Iowa Community Action	Marshalltown	49	20.63	12.85	28.41
7. Mid-Sioux Opportunities, Inc.	Remsen	25	10.40	-5.98	26.78
8. North Iowa Community Action	Mason City	59	9.53	3.59	15.47
9. Northeast Iowa Community Action	Decorah	39	16.93	9.32	24.54
10. Operation New View	Peosta	13	17.37	-1.39	36.13
11. Operation Threshold	Waterloo	39	20.36	11.72	29.00
12. Polk county Department of General Services	Polk County	51	14.17	9.53	18.81
13. South Central Iowa Community Action	Leon	22	19.61	11.74	27.48
14. Southeast Iowa Community Action Organization	Burlington	15	0.76	-7.33	8.85
15. Southern Iowa Economic Development Assoc.	Ottumwa	45	17.12	11.13	23.11
16. Upper Des Moines Opportunities, Inc.	Emmetsburg	62	10.01	3.61	16.41
17. Woodbury County Community Action	Sioux City	26	11.15	5.52	16.78
18. West Central Development Corporation	Harlan	64	21.37	16.76	25.98
19. Y.O.U.R. Incorporated	Webster City	22	10.35	-0.21	20.91

4.4 SAVINGS PER COMPOSITE ECMS

Due to the relatively high implementation rates for many of the specific ECMs, determining the savings associated with specific ECMs is difficult. Typically, the sample sizes on which the comparisons of savings are made became too small to produce reliable statistical estimates. For example, only 3% percent of the sample did not receive either caulking or weatherstripping. Estimates based on the comparison between these cases and the rest of the sample become meaningless due to the extremely small sample size. Thus, an anomaly hinders the ability to attribute energy savings to specific ECMs; weatherizations include a full range of ECMs in order to maximize energy savings, yet this practice makes the measurement of energy savings per ECM more difficult.

In order to minimize the problems discussed above, a statistical technique known as breakdown was employed (in SPSS the technique is known as "means"). Breakdowns allows researchers to compare groups based on whether they received a specific ECM or not. Furthermore, breakdown provides estimates of mean savings, while controlling for the implementation of any other ECM. For example, the energy savings attributable to insulation is measured by comparing two sets of dwellings; those dwellings that received insulation and hot water system measures are compared with those dwellings which did not received insulation, yet received hot water system measures. The difference in savings between the two sets of dwellings, after averaging out the effects of the other ECMs, may be attributed to the presence of insulation.

To avoid the problem of insignificant findings due to too small sample sizes, composite variables were developed to represent a type of ECM activity. For example, a dichotomous composite variable "doors" was developed that represented the presence or absence of door-specific ECMs such as door threshold, door replacement/repair, and door sweeps. If any of these ECMs were installed in the dwelling, the score on the variable was coded a "1," otherwise the variable was coded a "0." Composite variables were compiled as follows:

- General Heat Waste: weatherstripping, caulking.
- Windows: glazing, sash, and storm window.
- Doors: sweeps, thresholds, and door replacement/repair.

- Insulation: attic, walls.
- Hot Water Systems: hot water jacket, pipe wrap insulation.

General heat waste measures (i.e., caulking and/or weatherstripping) have extremely high rates of implementation. Only three dwellings failed to receive either caulking and/or weatherstripping. As a result, savings can not be attributed to these measures. Therefore, savings estimates discussed below for specific ECMs include the savings effects of weatherstripping and caulking.

Estimates of average savings were derived per composite ECM. Confidence intervals were also calculated, which indicate the statistical reliability and validity associated with each of the savings estimates. Exhibit 4-2 displays the full range of combinations of ECMs which any dwelling may have received. A "Y" indicates the presence of the composite ECM activity (for example, door related work was performed as part of the weatherization) and a "N" indicates the absence of the composite ECM activity (for example, no door related work was performed). Associated with each combination is the size of the sample; the mean percent savings; the mean Btu savings in millions; an estimated percent savings based on transformed log proportions, and the associated upper and lower bounds of the confidence interval.[3]

When the lower bounds of the confidence interval for any specific combinations of ECMs depicted in the exhibit is less than zero, the savings estimate should be considered unreliable (i.e., due to the small sample size and the large variance in the variables, there is no statistical difference between the savings estimate and zero).

There are only a few combinations of ECMs for which the savings estimate is sufficiently high, and the sample size sufficiently large, to predict that the savings associated with the ECMs are not zero. Typically, combinations for which this is true include insulation. Whenever insulation is included as one of the combinations of measures, the ability to reliably estimate savings

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[3] See Appendix B, Technical Methodology for an explanation for using log transformed values, rather than observed savings, and a description of the methodology.

EXHIBIT 4-2

BREAKDOWN OF ENERGY SAVINGS BY COMBINATIONS OF ECMS

ECM W	ECM D	ECM I	ECM HW	SAMPLE SIZE (N)	MEAN BTU SAVINGS (MILLIONS)	ESTIMATED PERCENT SAVINGS*	95% CONFIDENCE INTERVAL FOR MEAN PERCENT SAVINGS* LOWER	UPPER
N	N	N	N	4	7.3	9.14	(20.45)	31.45
N	N	N	Y	4	(0.8)	1.13	(31.06)	25.42
N	N	Y	N	0	0	0	0	0
N	N	Y	Y	2	3.4	9.41	(345.01)	81.56
N	Y	N	N	5	4.6	11.21	(10.63)	28.74
N	Y	N	Y	13	3.6	5.41	(5.28)	15.01
N	Y	Y	N	4	19.8	24.87	0.41	43.33
N	Y	Y	Y	9	15.7	18.25	6.57	28.47
Y	N	N	N	0	0	0	0	0
Y	N	N	Y	3	8.9	9.78	(40.11)	42.90
Y	N	Y	N	0	0	0	0	0
Y	N	Y	Y	8	20.4	24.70	12.68	35.07
Y	Y	N	N	34	3.8	5.96	0.18	11.39
Y	Y	N	Y	115	7.1	8.54	5.53	11.46
Y	Y	Y	N	38	18.2	20.26	15.64	24.63
Y	Y	Y	Y	181	21.1	22.07	20.04	24.06

W = Windows
D = Doors
I = Insulation
HW = Hot Water System

* Estimated percent savings and 95% confidence intervals are based on the log proportions.
( ) Denotes negative figures.

increases dramatically. Insulation is one of the few measures for which we can accurately estimate energy savings.

Using the approach outlined above, estimates of savings were calculated for those composite measures associated with the implementation of combinations of ECMs. Of the four composite measures, only insulation and windows have estimates of savings which are significantly different than zero. Exhibit 4-3 provides the estimates of savings and the associated confidence interval for the weatherization program as a whole, as well as each of the composite measures.

<u>Insulation (attic and/or wall) is associated with the greatest amount of savings, approximately 15.08% of normalized annual Btu consumption</u>. Typically, weatherized dwellings which include insulation achieve significantly higher savings than dwellings which fail to receive insulation. Note, however, that the confidence interval indicates that the average savings attributable to insulation may range from 12.12% to 17.95%. While the weatherization program and insulation save 15.7% and 15.08%, respectively, insulation does not necessarily account for 96% of the average total weatherization. Rather, the data suggest that dwellings that receive insulation will increase their average savings 15.08% in addition to what could be attributed to other ECMs.

<u>Window measures result in an average savings of approximately 5.97% of normalized annual Btu consumption</u>. Note, however, that the confidence interval ranges from slightly higher than zero to 11.19%, which suggests that the amount of savings may be negligible or double the estimate of 5.97%.

Because of the high rates of implementation for the additional ECMs, the large amount of variance in savings per weatherization, and/or the small sample sizes used in the breakdown methodology, savings could not be attributed to the remaining composite ECMs. Observed savings per composite ECM are presented in Exhibit 4-3. Note, however, the large confidence intervals make it difficult to attribute positive savings to composite ECMs other than insulation and window work.

In summary, the weatherization program results in significant energy savings, both in terms of reduced normalized annual Btu consumption and savings

EXHIBIT 4-3

ESTIMATES OF SAVINGS FOR THE COMPOSITE WEATHERIZATION MEASURES

	SAMPLE SIZE (N)	MEAN BTU SAVINGS (MILLIONS)	ESTIMATED PERCENT SAVINGS*	95% CONFIDENCE INTERVAL FOR MEAN PERCENT SAVINGS*	
				LOWER	UPPER
Test Group	420	14.2	15.70	14.64	17.48
Insulation Measures					
Measures Absent	178	10.6			
Measures Present	242	20.6			
Net Estimates		14.3	15.08	12.12	17.95
Window Measures					
Measures Absent	41	7.9			
Measures Present	379	14.9			
Net Estimates		7.0	5.97	0.45	11.19
Door Measures					
Measures Absent	21	10.6			
Measures Present	399	14.4			
Net Estimates		3.8	2.35	(5.54)	9.66
Hot Water System Measures					
Measures Absent	85	11.2			
Measures Present	335	15.0			
Net Estimates		3.8	3.02	(1.15)	7.03

* Estimated percent savings and 95% confidence intervals are based on the log proportions.

as a percent of normalized annual Btu consumption. On the other hand, savings only can be attributable to insulation and window related ECMs using this method of analysis; estimates of the savings attributable to additional ECMs or combinations of ECMs are not reliable. Exhibit 4-4 provides a summary of the savings associated with the weatherization program.

EXHIBIT 4-4

SUMMARY OF WEATHERIZATION RELATED ENERGY SAVINGS

	% ANNUAL SAVINGS	BTU SAVINGS (MILLIONS)	CONFIDENCE INTERVAL
Total Program	15.70	14.2	14.6 to 17.5
Insulation	15.08	14.3	12.1 to 18.0
Windows	5.97	7.0	0.5 to 11.2

4.5 ISSUES RELATING TO PROGRAM IMPLEMENTATION

As a result of the analysis of energy savings, the following observations are noted:

- The average program savings per weatherization could increase significantly if dissavers could be identified and targeted accordingly. Fully 16% of the test group realized an increase in energy consumption after the weatherization. Reasons why energy consumption might increase after weatherization include: changes in household and/or dwelling characteristics, which were not indicated on the survey by the survey respondents; the tendency for some weatherization recipients to "take back" energy savings by changes in behavior such as raising the thermostat; and changes in energy demand resulting from non-residential consumption such as some agricultural uses, which nonetheless are recorded on a household utility meter. When dissavers are eliminated from the test group, the average savings per weatherization increases from 15.7% to over 20%. The weatherization program's effectiveness in terms of energy savings would increase substantially if dissavers could be identified prior to implementation (see page 5-5 for a discussion of low savers).

- Average energy savings per weatherization are likely to improve if insulation work is given higher priority. Presently, attic insulation is priority two and wall insulation is priority five. Attic and/or wall insulation are associated with the greatest measurable savings of any of the ECMs; the application of insulation realizes an average savings of approximately 15%. Overall, however, nearly half of the homes do not receive insulation work.

5.0 ANALYSIS OF SUBGROUPS

5.1 INTRODUCTION

In order to discern in more detail the effectiveness of the weatherization program in attaining program goals, selected subgroups are analyzed to determine the effects of weatherization on various types of program participants. Typically, dwelling and economic characteristics are analyzed, as well as the rates of implementation of specific ECMs, to assess the relationship between these characteristics and energy savings.

5.2 HIGH-ENERGY CONSUMERS

Because a primary goal of the weatherization program is reducing energy consumption, the effect of the weatherization on high-energy consumers is important. High-energy consumers often provide the best opportunity for realizing the most significant energy savings statewide.

High-energy consumers were defined by their pre-weatherization normalized annual Btu consumption relative to the rest of the test group. Households in the upper twentieth percentile in terms of pre-weatherization normalized annual Btu consumption were deemed high-energy consumers. High-energy consumer's normalized annual heating only consumption is 108 million Btus or more. Of the 423 cases with energy saving data, 102 are deemed to be relatively high-energy consumers. To determine the quality and effectiveness of the weatherization on this group, the high-energy consumers were analyzed in terms of their dwelling characteristics, the nature and cost of the weatherization, and the effectiveness of the weatherization.

Demographic and Dwelling Characteristics

High-energy consumers are characterized by residing in larger and significantly older dwellings. The median square foot of the dwelling is estimated to be over twice as large as that for the rest of the test group. Furthermore, high-energy consumers are nearly three times as likely to live in a two story dwelling than the rest of the test group. In addition, the dwellings of high-energy consumers tend to be older than the rest of the test group; they are twice as likely to live in dwellings that are 75 years old or more. Exhibit 5-1 compares the dwelling characteristics of high-energy consumers with the rest of the sample.

EXHIBIT 5-1

DWELLING CHARACTERISTICS OF HIGH-ENERGY CONSUMERS

	HIGH-ENERGY CONSUMERS (n=102)	REMAINDER OF TEST GROUP (n=321)
Home Type		
Single Story	37%	74%
Two-Story	60%	23%
More than Two-Stories	3%	.5%
Mobile Home	0%	3%
Square Feet		
Less than 725 sq.ft.	21%	40%
725 to 1,008 sq.ft.	21%	37%
More than 1,008 sq.ft.	58%	23%
Unit Age		
0-45 Years	18%	38%
46-75 Years	39%	38%
75+ Years	43%	25%

Note: All differences are statistically significant at the .05 level.

Economic Characteristics

While their energy consumption is higher, the incomes of high-energy consumers are not higher than the rest of the test group. Neither the incomes nor the LIHEAP funds of high-energy consumers are likely to be significantly different from the rest of the test group. As a result, householders in this group are faced with relatively large energy bills and, in the absence of higher incomes and/or funding to offset the higher energy bills, may face a relative reduction in their standard of living due to energy prices. Exhibit 5-2 compares the economic characteristics of this group with the rest of the test group.

EXHIBIT 5-2

ECONOMIC CHARACTERISTICS OF HIGH-ENERGY CONSUMERS

	HIGH-ENERGY CONSUMERS (n=102)			REMAINDER OF TEST GROUP (n=321)		
	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE
Annual Household Income	$6,488	$5,964	$1,656-13,824	$6,472-	$6,084	$992-17,776
LIHEAP Funds	215	230	105-305	213	230	14-305

Energy Saving Characteristics

<u>High-energy consumers save significantly more energy as a result of the weatherization than the remainder of the test group</u>. As revealed in Exhibit 5-3, on average the Btu savings of 26,800,000 per year for high-energy consumers is 2.5 times the average savings for the rest of the test group. Similarly, the average percent savings of 20.0 percent is 54% greater than the savings for the rest of the test group.

EXHIBIT 5-3

ENERGY SAVING CHARACTERISTICS OF HIGH-ENERGY CONSUMERS

	HIGH-ENERGY CONSUMERS (n=102)			REMAINDER OF TEST GROUP (n=321)		
	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE
Btu Savings (millions)	26.8	24.8	(17)-79.8	10.6	83.0	(24.3)-59.3
Percent Savings	20.0	NA	(13.9)-56.7	13.0	NA	(34.2)-57.5

Note: All differences are statistically significant at the .05 level.

( ) Denotes negative figures.
NA Not available.

While these households realize more savings, the cost of the weatherization also is higher. For example, while the percent savings for high-energy consumers are 48% greater than the rest of the test group, the cost of materials and the total cost of the weatherization for high-energy consumers are 38% and 36% greater, respectively. Exhibit 5-4 provides cost data for the higher energy users.

EXHIBIT 5-4

COMPARISON OF WEATHERIZATION COST BY TYPE OF ENERGY CONSUMER

	HIGH-ENERGY CONSUMERS (n=102)			REMAINDER OF TEST GROUP (n=321)		
	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE
Materials	$ 721	$ 747	$ 98-1,389	$ 522	$ 497	$16-1,499
Total	1,561	1,595	288-2,400	1,149	1,130	40-2,400

Note: All differences are statistically significant at the .05 level.

The reasons for the relatively higher costs are easily understandable, given that high-energy consumers tend to live in older and larger dwellings. Costs increase because there are more opportunities to implement different ECMs and larger amounts of each ECM are likely to be needed. As shown in Exhibit 5-5, high-energy consumers are significantly more likely to receive most of the ECMs than the rest of the test group. Note, too, that these households are much more likely to receive insulation (attic and/or wall), which realize relatively higher savings. (See Section 4.0, Analysis of Energy Savings.)

EXHIBIT 5-5

RATE OF ECM IMPLEMENTATION FOR HIGH-ENERGY CONSUMER GROUP

	HIGH-ENERGY CONSUMERS (n=102)	REMAINDER OF TEST GROUP (n=321)
Hot Water Jacket	85%	71%
Window Glazing	85%	75%
Window Sash	78%	63%
Door Sweeps	80%	70%

EXHIBIT 5-5

RATE OF ECM IMPLEMENTATION FOR HIGH-ENERGY CONSUMER GROUP (CONTINUED)

	HIGH-ENERGY CONSUMERS (n=102)	REMAINDER OF TEST GROUP (n=321)
Attic Insulation	62%	50%
Wall Insulation	28%	14%
Storm Windows	62%	42%

Note: All differences are statistically significant at the 0.5 level.

5.3 LOW BTU SAVERS

Low Btu savers are defined as those weatherization recipients who realize the lowest amount of Btu savings relative to the remainder of the test group. These households are in the lower twenty-fifth percentile in terms of gross Btu savings less than 2.1 million Btu. Of the 423 cases in the test group, 104 were considered low Btu savers. As a percent of pre-weatherization Btu consumption, all realized a savings of less than 1%; overwhelmingly, this group is comprised of dissavers whose energy consumption increased after weatherization.

Dwelling Characteristics

While recognizing that behavioral patterns and changes in lifestyle may provide the most explanation for why these households achieve low savings, dwelling characteristics of low saving homes reveal basic factors that also may influence the savings rate of the households. Exhibits 5-6 and 5-7 compare the dwelling characteristics which distinguish low savers from the remainder of the test group. This subgroup is substantially more likely than the rest of the test group to live in mobile homes (generally smaller units) or smaller one and two story dwellings. Typically, smaller homes consume less energy and therefore are more likely to save fewer Btus after weatherization. In addition, low savers are more likely to live in younger dwelling units, much more likely to live in an attached rather than an unattached unit, and almost twice as likely to be renters.

EXHIBIT 5-6

DWELLING CHARACTERISTICS OF LOW BTU SAVERS

	LOW BTU SAVERS (n=104)		REMAINDER OF TEST GROUP (n=319)	
	MEAN	MEDIAN	MEAN	MEDIAN
Attic Area (sq.ft.)*	672.1	677.0	729.9	720.0
Total Square Feet	865.8	778.0	930.7	832.0

* Differences are statistically significant at the .05 level.

EXHIBIT 5-7

ADDITIONAL DWELLING CHARACTERISTICS OF LOW BTU SAVERS

	LOW BTU SAVERS (n=104)	REMAINDER OF TEST GROUP (n=319)
Type		
Unit Age (<45)*	43%	30%
(>75)	22%	31%
Attached*	11%	2%
Rental Unit*	22%	13%
Mobile Homes	6%	3%

* Differences are statistically significant at the .05 level.

Energy Saving Characteristics

Low Btu savers comprise approximately 25% of the total sample for whom utility billing records were available. Nearly all of the low savers are dissavers, i.e., normalized Btu energy consumption increased in the period following the weatherization. Exhibit 5-8 compares the saving rate for low Btu savers versus the remainder of the test group. While low Btu savers by definition have lower savings than the rest of the sample, note that their pre-weatherization normalized Btu consumption is approximately 15% less than the remainder of the test group.

EXHIBIT 5-8

SAVINGS CHARACTERISTICS OF LOW BTU SAVERS

	LOW BTU SAVERS (n=104)		REMAINDER OF TEST GROUP (n=319)	
	MEAN	MEDIAN	MEAN	MEDIAN
Pre-Btu Consumption	79,690,000	65,750,000	93,344,000	87,700,000
Btu Savings	(3,740,000)	(2,050,000)	19,947,000	16,300,000
Percent Savings	(4.7%)	NA	21.4%	NA

Note: All differences are statistically significant at the .05 level.

( ) Denotes negative figures.
NA Not available.

The rate of ECM implementation for the low savers is relatively low compared to the remainder of the test group, particularly for those ECMs that result in significant savings such as insulation. Exhibit 5-9 compares the rates of ECM implementation for low savers with the remainder of the test group. Typically, low saving homes receive general waste heat measures and hot water systems (weatherstripping, caulking, pipe wrap, hot water jacket, etc.) with equal frequency as the rest of the test group. They are, however, 19% less likely to receive wall insulation and 36% less likely to receive attic installation. In addition, they are 14% less likely to receive window glazing and threshold work and 24% less likely to receive vent work.

EXHIBIT 5-9

COMPARISON OF ECM IMPLEMENTATION RATES BY TYPE OF ENERGY CONSUMER

	RATES OF IMPLEMENTATION	
	LOW-ENERGY SAVERS (n=104)	REMAINDER OF TEST GROUP (n=319)
General Waste Heat Measures		
Caulking	93%	96%
Weatherstripping*	92%	99%
Window Measures		
Glazing*	67%	81%
Sash*	59%	69%
Storm Windows	43%	47%
Door Measures		
Sweeps	68%	74%
Thresholds*	46%	61%
Door Replacement/Repair	45%	50%
Hot Water System Measures		
Hot Water Jacket	72%	74%
Pipe Wrap Insulation	38%	41%
Insulation Measures		
Attic*	26%	62%
Wall*	3%	22%
Other Measures		
Vents*	38%	62%
Skirting	4%	4%

* Denotes differences are statistically significant at .05 level.

Because a significant amount of energy savings is attributable to attic and/or wall insulation, the impact of not having insulation installed could be the basis for low saver's relatively low average percentage savings. These homes could potentially raise their savings level by approximately 15% if attic insulation was installed. Even with the mean savings of -4.6%, possible savings achieved could reach between 7% and 13% simply by installing insulation. (See Section 4.0, Analysis of Energy Savings.)

5.4 CONTRACTED VERSUS IN-HOUSE WORK CREWS

Typically, contractors charge slightly more per weatherization (6%), yet realize little additional energy savings. Weatherizations by contractors were compared with those conducted by in-house crews to identify significant differences in the weatherization.

Dwelling Characteristics

Contractors are slightly more likely to weatherize unattached dwellings; slightly more likely to weatherize relatively newer housing stock; slightly more likely to weatherize single story dwellings; and just as likely to weatherize mobile homes as in-house crews. Exhibit 5-10 compares the dwelling characteristics of the weatherized dwellings. These data suggest that differences in material costs and/or energy savings are not likely to be attributable to differences in housing stock.

EXHIBIT 5-10

COMPARISON OF DWELLING CHARACTERISTICS BY TYPE OF WORK CREW

	CONTRACTOR (n=406)	CAA IN-HOUSE CREWS (n=326)
Attached Dwellings	3.7%	7.1%
Home Type		
Single Story	68.8%	59.1%
2(+) Stories	29.2%	38.4%
Mobile Homes	2.0%	2.5%
Unit Age		
0-45 Years	37.7%	33.4%
46-75 Years	38.7%	35.6%
75(+) Years	23.6%	31.0%

Note: All differences are significant at the point .05 level.

Energy Savings Associated With Contracted Weatherizations

Whether looking at gross normalized annual Btu savings or savings as a percent of normalized annual pre-weatherization Btu consumption, the differences in savings between contractors and in-house crews are not statistically significant. Exhibit 5-11 compares these two groups in terms of the normalized energy savings attributable to the weatherization. Overall, contractors realize 6% less Btu savings than in-house crews and 4% less than in-house crews in terms of the percent savings.

EXHIBIT 5-11

COMPARISON OF WEATHERIZATION SAVINGS BY TYPE OF WORK CREW

	CONTRACTOR (n=238)			CAA IN-HOUSE CREWS (n=182)		
	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE
Btu Savings (millions)	13.7	11.1	(32.8)-73.2	14.5	10.7	(24.3)-79.8
Percent Savings (%)	15.3	NA	(34.2)-56.7	15.9	NA	(34.1)-57.5

( ) Denotes negative figures.
NA Not available.

Costs of Weatherization

After comparing weatherizations conducted by contractors with those conducted by in-house crews, slightly higher costs are associated with contractors. After accounting for selected key housing characteristics such as dwelling size and unit age, differences in these characteristics do not help to explain the slightly higher costs. On average the total costs associated with contractor work is 5% greater than the work associated with in-house crews, while material costs are approximately 12% higher. The differences in labor and support costs are not statistically significant (i.e., there are no measurable differences between contractors and in-house crews). Only the material costs charged by contractors are significantly different than that charged by in-house crews. Exhibit 5-12 compares the cost of weatherization broken down into the four large budget categories, including materials and total costs.

EXHIBIT 5-12

COMPARISON OF WEATHERIZATION COST BY TYPE OF WORK CREW

	CONTRACTOR (n=406)			CAA IN-HOUSE CREWS (n=326)		
	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE
Materials Amount*	$ 591	$ 560	$28-2,054	$ 529	$ 512	$16-1,329
Labor Amount	430	412	30-1,138	433	391	15-1,193
Support Amount	233	257	15-480	233	248	8-1,419
Total Amount*	$1,254	$1,228	$73-2,400	$1,195	$1,188	$40-2,399

* Denotes differences are statistically significant at the .05 level.

While the per weatherization cost is slightly higher than that associated with in-house crews, benefits to the CAAs as a result of using contractors include: lower material warehousing costs, lower staff costs, and reduced administrative/implementation burden. These benefits often allow the CAA to focus its efforts on other activities. In addition, CAA coordinators have indicated contractors are able to weatherize relatively more homes. Furthermore, unlike in-house crews, contractors work for a profit, which may help explain the slightly higher costs associated with contractor weatherizations.

Tests were made to compare the costs per ECM to determine which of the material costs were contributing most to the differences in costs between contractors and in-house crews. Exhibit 5-13 provides the average cost per weatherization of those ECMs for which statistically significant differences exist between the costs charged by contractors and in-house crews. Contractors consistently charge more than in-house crews for nearly all ECM materials. Often these average differences are significant, given that there are no apparent differences in housing stock. For example, contractors charge 36% more per weatherization for weatherstripping materials and caulking materials than in-house crews. Contractors charge approximately 20% more per weatherization on storm windows than in-house crews. The sole measure for which in-house crews charge more than contractors is window sashes.

EXHIBIT 5-13

COMPARISON OF ECM COSTS BY TYPE OF WORK CREW

	CONTRACTOR			CAA IN-HOUSE CREWS		
	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE
General Waste Heat						
Weatherstripping*	$31.85	$28.0	$1-135.0	$23.35	$20.0	$2-99.0
Caulking*	81.80	75.0	8-424.0	60.80	58.0	1-216.0
Door Measures						
Sweeps*	7.59	6.0	1-45.0	4.40	3.0	1-51.0
Thresholds*	20.00	20.0	4-68.0	13.23	12.0	1-32.0
Door Replacement/ Repair*	80.79	70.0	3-265.0	72.08	65.0	2-222.0
Window Measures						
Glazing*	10.52	7.0	1-75.0	4.00	2.0	1-24.0
Sash*	147.07	112.5	1-787.0	188.22	138.0	1-888.0
Storm Windows	139.91	105.0	13-735.0	116.59	82.5	5-616.0
Insulation Measures						
Attic	149.82	144.0	2-650.0	137.09	117.5	2-465.0
Wall*	196.96	169.0	17-598.0	73.37	60.0	12-224.0

EXHIBIT 5-13

COMPARISON OF ECM COSTS BY TYPE OF WORK CREW (CONTINUED)

	CONTRACTOR			CAA IN-HOUSE CREWS		
	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE
Hot Water System Measures						
Hot Water Jacket	15.24	15.0	6-51.0	11.08	9.0	6-60.0
Pipe Wrap*	4.70	5.0	1-23.0	3.56	2.0	1-45.0
Other Measures						
Vents*	22.58	20.0	5-75.0	16.53	15.0	1-47.0
Skirting	63.68	45.0	3-250.0	61.00	23.00	2-421.0

* Differences are statistically significant difference at the .05 level.

Contractors and in-house crews also were compared in terms of the types of measures implemented. This comparison reveals that differences in the rates of implementation of many of the ECMs are statistically significant. Exhibit 5-14 compares the rates of implementation of the specific ECMs between contractors and in-house crews.

EXHIBIT 5-14

COMPARISON OF ECM IMPLEMENTATION RATES BY TYPE OF WORK CREW

	RATES OF IMPLEMENTATION	
	CONTRACTOR (n=406)	CAA IN-HOUSE CREWS (n=326)
General Waste Heat Measures		
Caulking*	98.8%	93.2%
Weatherstripping	97.3%	96.9%

EXHIBIT 5-14

COMPARISON OF ECM IMPLEMENTATION RATES BY TYPE OF WORK CREW (CONTINUED)

	RATES OF IMPLEMENTATION	
	CONTRACTOR (n=406)	CAA IN-HOUSE CREWS (n=326)
Window Measures		
Glazing*	82.2%	60.7%
Sash*	58.7%	68.3%
Storm Windows*	42.2%	53.9%
Door Measures		
Sweeps	70.4%	74.7%
Thresholds	61.2%	54.8%
Door Replacement/Repair	46.7%	50.2%
Hot Water System Measures		
Hot Water Jacket	72.4%	71.4%
Pipe Wrap Insulation*	33.8%	50.8%
Insulation Measures		
Attic	49.1%	55.7%
Wall	17.3%	13.7%
Other Measures		
Vents	52.8%	50.0%
Skirting	3.4%	4.7%

* Differences are statistically significant at .05 level.

The rates of implementation for weatherstripping, door sweeps, door thresholds, door replacement/repair, the insulation measures, hot water jackets, and other measures including duct vents and skirting are not significantly different.

On many of the ECMs, however, the difference in the rates of implementation are statistically significant, including some ECMs associated with measurable energy savings. Contractors are less likely than in-house crews to implement measures such as caulking, window sashes, window glazing, storm windows, and pipe wrap insulation. Window sash and storm window work are associated with a measurable savings of 5.97%. On the other hand, contractors are .20% more likely to work on window glazing around the window sill. (For additional discussion of the pros and cons of using contractors versus in-house crews, see Section 12.4, Service Delivery Methods.)

5.5 RENTAL UNITS

Rental units were analyzed as a group to determine the effectiveness of the weatherization on these dwellings.

Demographic Characteristics

In terms of demographic characteristics, rental households are not homogeneous. Overall, however, they tend to be younger than non-renters; they are 20% less likely than the remainder of the test group to be elderly and the mean age of the head of household is 61 compared to 69 for the remainder of the test group. Rental units also are more likely to be occupied by single parents and families with a young child. Over half of the rental households include a handicapped person (59%). For those characteristics where differences are statistically significant, Exhibit 5-15 compares the demographic characteristics of this group with the remainder of the test group.

EXHIBIT 5-15

DEMOGRAPHIC CHARACTERISTICS OF OCCUPANTS LIVING IN RENTAL UNITS

	RENTERS (n=112)	REMAINDER OF TEST GROUP (n=641)
Single Parent	11%	2%
Elderly	68%	88%
Handicapped	59%	45%
Young Child	10%	3%

Note: All differences are statistically significant at the .05 level.

Dwelling Characteristics

Rental dwellings are approximately 10% smaller in terms of attic and total square footage (see Exhibit 5-16). While rental units have the same number of rooms, renters tend to heat a higher percentage of these rooms. In addition, renters are four times as likely as the rest of the test group to heat with electricity; 14% of renters heat with electric heat.

EXHIBIT 5-16

DWELLING CHARACTERISTICS OF RENTAL UNIT HOUSEHOLDS

	RENTAL UNITS (n=84)		REMAINDER OF TEST GROUP (n=480)	
	MEAN	MEDIAN	MEAN	MEDIAN
Attic Area (sq.ft.)	668.5	672.0	750.2	736.0
Total Square Feet	870.1	816.0	956.3	864.0

Note: All differences are statistically significant at the .05 level.

Savings Characteristics

Typically, weatherized rental units realize significant Btu savings, as well as achieve significant savings as a percent of pre-weatherization Btu consumption. As indicated in Exhibit 5-17, savings levels associated with rental units are similar to those achieved by non-renters. Rental units achieve the same level of gross annual Btu savings (approximately 14.4 million Btus) as the rest of the test group. Their slightly higher percent savings is due to lower levels of pre-weatherization annual Btu consumption.

EXHIBIT 5-17

SAVINGS CHARACTERISTICS OF RENTERS (RENTAL UNITS)

	RENTAL UNITS (n= 63)		REMAINDER OF TEST GROUP (n=357)	
	MEAN	MEDIAN	MEAN	MEDIAN
Pre-Btu Consumption	81,420,000	74,100,000	91,486,000	85,200,000
Btu Savings	14,357,000	7,500,000	14,082,000	11,150,000
Percent Savings	17.6%	NA	15.4%	NA

NA Not available.

5.6 SINGLE PARENT HOUSEHOLDS

Single parent households are more likely to be moderate to high-energy consumers, while their economic circumstances suggest a lower capacity to meet rising energy bills compared with other program recipients. While representing only 3% of program recipients, single parent households are likely to have a relatively high need for weatherization. Typically, these households include more occupants, higher rents, and lower incomes.

Demographic Characteristics

The household size in terms of number of occupants is larger for single parent households than for the rest of the sample. Over two-thirds (67%) of the households contain three or more persons. Females comprise 100% of the head of households. The typical household, therefore, contains a mother with two children and a strong likelihood (38%) that one of the children is less than four years old. In addition, the mean age is 39 compared to 69 for the rest of the test group and approximately 50% of single parent households include a handicapped person. Exhibit 5-18 compares single parent households with the remainder of the test group.

EXHIBIT 5-18

SINGLE PARENT HOUSEHOLD DEMOGRAPHIC CHARACTERISTICS

	SINGLE PARENT (n=24)	REMAINDER OF TEST GROUP (n=730)
Elderly*	17%	87%
Household Size (>3)*	67%	12%
Young Child*	38%	3%
Handicapped Occupant	50%	47%

* Denotes statistically significant differences at .05 level.

Dwelling Characteristics

Half of the families live in unattached rental units; they are 10% more likely to live in a two story home than the remainder of the sample; and the dwellings tend to have more rooms. Moreover, as indicated in Exhibit 5-19 single parent households tend to heat a higher percentage of rooms (97%) than the rest of the test group (87%).

EXHIBIT 5-19

SINGLE PARENT HOUSEHOLD DWELLING CHARACTERISTICS

	SINGLE PARENT (n=23)		REMAINDER OF TEST GROUP (n=730)	
	MEAN	MEDIAN	MEAN	MEDIAN
Building Characteristics				
No. of Rooms	6.1	6.0	5.7	5.0
Attic Area (sq.ft.)	669.3	725.0	741.6	722.5
Total Square Feet	990.5	955.0	943.6	848.0
Behavioral Characteristics				
Heated Rooms	5.8	6.0	4.9	5.0
Percent Heated Rooms	97.0	100.0	87.0	100.0
Day Thermostat Setting	67.8	68.0	70.0	70.0

Energy Savings Characteristics

The average weatherization benefits to single parent households are slightly more than other program recipients. In spite of the fact that the average cost per weatherization is slightly higher than other groups, the mean energy savings for this subgroup was 16.3%, which is higher than the remainder of the test group (see Exhibit 5-20).[1]

EXHIBIT 5-20

ENERGY SAVINGS CHARACTERISTICS OF SINGLE PARENT HOUSEHOLDS

	SINGLE PARENT			REMAINDER OF TEST GROUP		
	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE
Btu Savings (millions)	15.3	7.3	(9.0)- 50.7	14.1	11.0	(28.0)- 79.8
Percent Savings	16.3	NA	(16.4)- 39.4	15.7	NA	(34.2)- 57.5

( ) Denotes negative figures.
NA Not available.

Interestingly, despite the higher number of household occupants, single parent households are no more likely to be high-energy users than households in the rest of the test group. This finding is surprising, given their dwelling characteristics and household size suggest that they should be high-energy consumers.

Weatherization of single parent households are less likely to include hot water pipe insulation. In addition, these households are less likely to receive attic insulation. This may reflect the fact that a relatively high proportion of these households live in rental units with more difficult access.

In spite of relatively lower energy consumption, single parent households may have a greater difficulty paying for energy, particularly during periods of

[1] Given the small sample size, the confidence interval associated with the energy savings estimates is relatively large.

rising energy prices. Exhibit 5-21 compares the economic characteristics of single parent households with the remainder of the test group.

EXHIBIT 5-21

ECONOMIC CHARACTERISTICS OF SINGLE PARENT HOUSEHOLDS

	SINGLE PARENT (n=24)		REMAINDER OF TEST GROUP (n=730)	
	MEAN	MEDIAN	MEAN	MEDIAN
Monthly Rent	$ 182.3	$ 173	$ 141.7	$ 129
Annual Household Income	5,799.0	5,200	6,376.0	5,972
LIHEAP Funds*	257.2	265	216.0	230

* Denotes statistically significant difference at .05 level.

Single parent families are more likely to be paying higher rents. Approximately 50% of single parent households rent and 21% pay a monthly rent exceeding $200; whereas only 14% of the other weatherization program recipients rent and only 3% of these pay a monthly rent over $200. At the same time, their household income, on average, is lower than the rest of the test group. While on average these families receive higher LIHEAP funds than other program recipients, the additional $41 of LIHEAP funds toward the winter heating bill may not be enough to compensate for the fact that their average annual income is $580 less than other program recipients or that (for those who rent) the average annual rent is $487 higher. Overall, assuming no additional expenses or income, single parent families who rent receive approximately $41 more in LIHEAP funds than other weatherization clients, yet their average discretionary income is $1,067 less.

5.7 MOBILE HOMES

The weatherization work on mobile homes was analyzed to determine the effectiveness of the weatherization on this group of program recipients. Mobile home dwellings are compared to the remainder of the test group in terms of demographic, economic, and energy savings characteristics.

Demographic Characteristics

Mobile homes, which represent only 2.3 percent of survey respondents, are likely to be newer, smaller dwellings occupied by elderly women living alone (see Exhibit 5-22).

EXHIBIT 5-22

DEMOGRAPHIC CHARACTERISTICS OF MOBILE HOMES

	MOBILE HOMES (n=17)	REMAINDER OF TEST GROUP (n=726)
Female	88%	60%
Single Occupant Dwellings	88%	57%

Note: All differences are statistically significant at the .05 level.

Economic Characteristics

Mobile home dwellers have similar economic characteristics as the rest of the test group. Neither their annual income nor their LIHEAP funding are much lower than the rest of the sample. Exhibit 5-23 compares the economic characteristics of mobile home dwellers with the remainder of the test group.

EXHIBIT 5-23

ECONOMIC CHARACTERISTICS OF MOBILE HOMES

	MOBILE HOMES (n=17)		REMAINDER OF TEST GROUP (n=726)	
	MEAN	MEDIAN	MEAN	MEDIAN
Monthly Rent	$ 106	$ 89	$ 149	$ 138
Annual Household Income	5,820	5,824	6,384	5,972
LIHEAP Funds	213	190	218	238

Energy Savings

Overall, mobile home dwellers realize considerably lower levels of Btu savings than the rest of the test group, as well as have significantly lower savings as a percent of pre-weatherization Btu consumption.[2] The mean percent savings realized in mobile homes is only 3.6% (compared to mean savings of 15.8% for the remainder of the sample, see Exhibit 5-24). These savings results stem in part from the relatively low levels of pre-weatherization Btu consumption associated with mobile home dwellings.

EXHIBIT 5-24

ENERGY SAVING CHARACTERISTICS OF MOBILE HOMES

	MOBILE HOMES (n=16)		REMAINDER OF TEST GROUP (n=727)	
	MEAN	MEDIAN	MEAN	MEDIAN
Pre-weatherization Btu Energy Consumption (millions)	64.9	64.5	90.6	84.7
Btu Savings (millions)	2.4	(0.02)	14.3	11.1
Percent Savings (%)	3.6	NA	15.8	NA

( ) Denotes negative figure.
NA Not available.

Recognizing that mobile home units are typically smaller dwelling units that consume less energy, the cost of a weatherization for a mobile home was compared with the average cost of a weatherization for the remainder of the sample. Expenditures per mobile home weatherization are approximately half the average expenditure for other dwellings. Exhibit 5-25 compares the cost of the weatherizations between mobile homes and the remainder of the sample. Program expenditures for mobile homes average substantially less than those spent on the rest of the test group.

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[2] Given the small sample size, the confidence interval associated with these estimates is relatively large.

EXHIBIT 5-25

COST OF WEATHERIZATION FOR MOBILE HOME DWELLINGS

	MOBILE HOMES (n=16)		REMAINDER OF TEST GROUP (n=727)	
	MEAN	MEDIAN	MEAN	MEDIAN
Materials Amount	$220	$221	$ 571	$ 553
Total Amount	560	489	1,245	1,222

5.8 COMPARISON OF SAVINGS FOR SELECTED SUBGROUPS

This section summarizes the findings from the analysis of selected subgroups.[3] Exhibit 5-26 compares the mean gross Btu savings, as well as the savings as a percent of pre-weatherization Btu consumption. (See Section 6.0, Economic Analysis for a discussion of the simple payback for weatherizations associated with each of these subgroups).

EXHIBIT 5-26

AGGREGATE SAVINGS FOR SELECTED SUBGROUPS

SUBGROUP	AGGREGATE PRE-WEATHERIZATION BTU CONSUMPTION (million Btu)	AGGREGATE BTU SAVINGS (million Btu)	AVERAGE PERCENT SAVINGS
High-Energy Users	13,001	2,602	20.0
Low Btu Savers	8,288	(388)	(4.7)
Contractors	21,281	3,267	15.3
Rental Units	5,129	904	17.6
Single Parent Households	1,124	183	16.3
Mobile Home Dwellings	648	24	3.6

( ) Denotes negative number.

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[3] Due to the small sample size which often results when disaggregating the sample, statistical levels of confidence often decline. Confidence intervals for the data presented in this section are found in Appendix D, Confidence Intervals.

5.9 ISSUES RELATING TO PROGRAM IMPLEMENTATION

The analysis of selected subgroups provides useful information on how to improve program implementation in terms of realizing greater average energy savings, as well as providing useful social services to those most in need. These issues include:

- Successful targeting of high-energy users will likely result in significant energy savings. Weatherizations of high-energy consumers result in greater Btu savings as well as a higher percent savings than the remainder of the test group. As a result, significant improvements in overall program energy savings could be realized by more effective targeting of high-energy consumers.

- Eliminating dissavers from the weatherization program, or targeting them for specific types of ECMS, would significantly increase overall program savings. Normalized energy consumption for fully 16% of the test group increased after the weatherization. This pattern likely reflects behavioral changes. Nonetheless, a policy that identified, evaluated, and subsequently removed from the weatherization program those dwellings likely to achieve low Btu savings would increase overall program savings per weatherization from approximately 15.9% to over 20%. In addition, policies which promoted the implementation of insulation for dwellings identified as potential low-savers likely would increase significantly the savings attributable to this group. Low-savers tend not to receive insulation; however, insulation realizes the highest savings per ECM.

- While slightly higher in cost, contractor weatherization realized no more savings than in-house crews. While CAAs may realize savings due to lower overhead and lower administrative costs, contractor weatherizations do not raise overall savings levels. Material costs increase approximately 10%, even though contractors tend to weatherize slightly newer and smaller dwellings.

- Specific targeted subgroups such as renters and single parent families realized significant benefits from the weatherization program. Given that these groups tend to have relatively lower incomes, and a relatively higher percentage use electric heat, the reduction in Btu consumption likely plays a significant role in helping these groups maintain their standard of living during periods of high energy bills.

- Targeting specific ECMs to specific subgroups may result in measurably higher savings for the program as a whole. Groups such as high-energy consumers and low Btu savers could benefit considerably from widespread implementation of insulation. Larger sized households such as single parent households would likely benefit from a higher implementation rate of insulation, as well as hot water blankets and/or pipe wraps, which realize greater savings as the number of occupants in the household increases.

6.0 ECONOMIC ANALYSIS

6.1 INTRODUCTION

The Iowa Weatherization Program increases state economic activity and employment. Because Iowa imports nearly all of its energy requirements, intrastate energy dollars saved provide additional consumer income that can be expended on other goods and services, which can help spur state economic activity and create jobs. Moreover, the weatherization program itself employs several individuals to implement, manage and evaluate the program. These program-generated salaries also improve the state's level of economic activity by injecting further monies into the state's economy.

This section presents an evaluation of the program's economic viability. Economic benefit is evaluated for the program as a whole as well as for those specific ECMs for which reliable estimates of savings can be attributed. First, discussion will focus on the methodological approach, particularly the economic indicators used in this analysis, and the assumptions which underlie this approach. Second, microeconomic life-cycle costing scenarios are developed for the direct program costs and benefits. These scenarios are based on Iowa-specific assumptions regarding fuel price escalation rates, discount rates and lives of the weatherization measures. Third, macroeconomic impacts are assessed in terms of the resultant economic activity in the state, such as the impacts on state revenues due to shifts in tax revenues.

As part of this section estimates of the economic viability of the weatherization program as a whole will be presented. In addition, estimates of the economic viability of insulation work and window work will be presented. These two measures were the only composite ECMs for which statistically valid and reliable estimates of energy savings could be determined, given the variation in savings and the small test sizes.

6.2 MICROECONOMIC EFFECTS OF WEATHERIZATION PROGRAM

Two different measures of economic viability are used to determine program cost-effectiveness. One method assesses program effectiveness based on the length of time required to recover program costs through energy savings assuming no discount rate. This approach is know as the Simple Payback on Investment (SPI) method. The second method assesses program cost-effectiveness based on the current value of the program, taking into account such factors as changes in fuel prices and the discount rate over the life of the measure. This approach is known as Net Present Value (NPV).

Simple Payback on Investment

The SPI determines the length of time required for the value of the cumulative energy savings directly resulting from the weatherization measures to recover the original investment. This methodology estimates the number of years that would be required to repay investment costs through energy savings if all variables remained constant, including levels of energy consumption and the price of energy. Changes in key factors such as the price of natural gas will change the results of the SPI. The SPI formula used in this analysis is:

$$SPI = \frac{I}{S \times P}$$

Where: I = Initial Program Investment
S = Annual Energy Savings (in the first year)
P = Price of Energy

The fuel price (P) in year 1 used in this analysis represents a weighted average price for Iowa. The average price per therm or Kwtt for eight of the largest gas utilities and six of the largest electric utilities were obtained.[1] Based on these average price data, a weighted average price for Iowa was calculated. The weighted average price takes into account the proportion of residential customers served by the respective utilities, as well as the proportion of gas versus electric customers. The average weighted price per therm is $46.1.

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[1] Based on materials obtained from the Utilities Division, Iowa Department of Commerce.

Three Fuel Price Escalators (FPE) are used in the analysis to project the average fuel price that will prevail over the life of program or measures; thereby, evaluating program payback if fuel prices increase in the future. The FPEs employed are 3.0%, 7.6%, and 11.0%. The 7.6% FPE is based on average fuel costs in Iowa from 1980 through 1987.[2] The 3.0% FPE are provided as a low and high comparison to the 7.6% FPE.[3]

As indicated in Exhibit 6-1, the simple payback period for the program as a whole is 18.7 years, assuming no increase or decrease in fuel prices. The payback period, however, is reduced by over 7 months if fuel prices rise by 3.0% and is decreased by almost one and one half years if fuel prices increase by 11.0% to 51.2 cents/therm. Conversely, a fuel price decrease of 2%, which until recently was not considered in energy projections, would increase the SPI to 19.1 years, all else being equal.

EXHIBIT 6-1

SIMPLE PAYBACK ON INVESTMENT ANALYSIS

	ENERGY COSTS			
	BASE YEAR (years)	3.0% FPE (years)	7.6% FPE (years)	11.0% FPE (years)
Total Program	18.7	18.1	17.4	16.8
Insulation	4.8	4.6	4.4	4.3
Storm Windows	6.4	6.2	5.9	5.8

Base Year = Average 1987 for natural gas and electricity weighted by test members consuming each of these fuels (46.1 cents/therm).

FPE = Fuel Price Escalator (Based on U.S. Department of Commerce data and weatherization experts' projections.)

The SPI for insulation work and window work also are shown in Exhibit

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[2] Based on Iowa Department of Commerce, Iowa Utilities Division, Monthly Fuel Price Updates.

[3] Based on average natural gas and electric rates for 26 years from U.S. Department of Commerce, Energy Prices and Discount Factors for Life-Cycle Cost Analysis, pp. 40-41. Values were weighted by survey participants using these fuels; and U.S. Department of Commerce, Statistical Yearbook of the U.S. 1987, Table No. 938, p. 545.

6-1. Insulation has a payback of 4.8 years and window works has a payback of 6.4 years, assuming base year energy costs. Costs are estimated utilizing the sum of measure-related material costs reported on the WAP Job Form. Costs were adjusted to include measure-specific labor and support costs by applying the ratio total labor and total support costs to total overall program costs. Savings are the derived mean difference between sample participants with insulation or window works and those participants without these measures. (See Section 4.0, Analysis of Energy Savings.)

For each of the selected subgroups analyzed above (see Section 5.0, Analysis of Subgroups) the SPI was calculated. Exhibit 6-2 provides a summary of the SPI per the selected subgroups assuming no change in fuel price and assuming a 7.6% annual increase in fuel prices. Depending on the subgroup, average Btu savings range from a positive 26.8 million to a negative (or increase in consumption) of 3.7 million Btus. Similarly, average costs range dramatically among the subgroups. The resultant subgroup SPIs reflect this variability as seen in Exhibit 6-2. Base year paybacks, assuming no change in fuel prices, range from a low of 12.6 years for high-energy users to a high of 51.5 years for mobile homes. High-energy users, therefore, could be considered the most cost-effective subgroup target. Increasing the fuel price by 7.6%, decreases the payback period by an average 1.0 to 1.5 years except for mobile homes, where the payback period is decreased by 3.7 years.

Net Present Value (NPV)

The second method used to assess program cost recovery is the NPV methodology. This approach allocates costs and benefits over the estimated life of the weatherization program or ECMs. Projected inflation and the potential earning power of money (i.e. the discount rate) are employed to reflect the true cost of money over the lifetime of the program. The NPV formula used in this analysis is:

$$NPV = \sum_{j=o}^{n} \frac{(S \times Pj)}{(1 + d)j} - (Cj)$$

EXHIBIT 6-2

AVERAGE[1] PAYBACK FOR SELECTED SUBGROUPS

SUBGROUPS	PERCENT ENERGY SAVINGS[2]	AVERAGE[1] BTU SAVINGS (million Btu)	AVERAGE COST[1]	SIMPLE PAYBACK Base Year	SIMPLE PAYBACK 7.6% FPE
High-Energy Users	20.0%	26.8	$1,560	12.6	11.7
Low Btu Savers	(4.7%)	(3.7)	943	0.0[3]	0.0[3]
Contractors	15.3%	13.7	1,263	18.9	17.6
Renters	17.6%	14.4	1,232	18.6	17.3
Single Parents	16.3%	15.3	1,375	19.5	81.1
Mobile Homes	3.6%	2.4	560	51.5	47.8

( ) Denotes negative number.
1/ Average equals mean.
2/ Percent based on aggregated subgroup pre-weatherization Btu consumption and aggregated savings.
3/ Payback is infinity because no savings are achieved.

Where: N = Number of years in the measure's life
S = Annual Energy Saving (equal to first year savings)
Pj = Real Energy Price in Year j
d = Discount Rate
C = Annual Cost of Program Measure (constant dollars)

The NPV method estimates program cost-effectiveness based on the expected annual difference between annual benefits, expressed in discounted 1988 energy savings dollars, and annual costs, expressed in discounted 1988 investment dollars. An NPV of greater than zero indicates that the benefits outweigh the costs and, therefore, the program is cost-effective within the assumed life of the program or measure.

The calculation of NPV is sensitive to the assumptions made regarding the discount rate, life of the weatherization measures, and fuel price escalators. Due to this sensitivity, several scenarios were developed. These scenarios were devised by utilizing different possible combinations of the variables in Exhibit 6-3 to calculate potential NPVs. For example, a scenario was developed to determine if the program was cost-effective when fuel prices were escalated by 7.6%, the discount rate was 3%, and the average life of the measures was 14 years.

EXHIBIT 6-3

PROJECTIONS/ESTIMATES USED IN SCENARIO DEVELOPMENT

NPV VARIABLES	RANGE OF VALUES EMPLOYED		
Fuel Price Escalators (%)	3.0	7.6	11.0
Discount Rate (%)	3.0	7.0	10.0
Average Life of Measure (years)	5.0	14.0	30.0

The average life of the measure is based on three different assumptions. The 5 year life was chosen to address the position that a weatherization lasts only as long as the weakest ECM. Therefore, assuming weatherstripping lasts only 5 years, the life of the program is assumed to be five years after which replacement costs are incurred. The 14 year program life reflects a weighted average of each of the ECMs typically implemented. Thus, even though weatherstripping is estimated to last only 5 years and insulation is estimated to last 30 years, the weighted average of the total weatherization including all the ECMs is estimated to be 14 years. Finally, the 30 year program life was chosen to address the argument that a weatherization is as good as its strongest ECM measure. Therefore, because the estimated life of insulation is 30 years and insulation has been shown to contribute significantly to weatherization savings, the program life is estimated to be 30 years.

Assuming a five year program life, under no scenarios is the NPV of the Weatherization Program cost-effective. Given that the estimated life of all of the ECMs except weatherstripping exceeds 10 years, this finding is not too important.

The 14 year life of the program scenario is much more realistic than the 5 year life. Exhibit 6-4 below presents the NPVs for a 14 year program life. The cost recovery for the program would range from approximately 46% (the least optimistic outlook) to more than full cost recovery (about 124%) under the most optimistic outlook used herein.

EXHIBIT 6-4

NET PRESENT VALUES FOR 14 YEAR PROGRAM LIFE

	DISCOUNT RATES		
FUEL PRICE ESCALATORS	@ 3%	@ 7%	@ 10%
@ 3.0%	($334)	($547)	($661)
@ 7.6%	(23)	(335)	(499)
@ 11.0%	291	(124)	(339)

( ) Denotes negative value.

Assuming a 30 year program life, the NPV is positive under each of the various scenarios, except when the discount rate is extremely high and when the FPE is very low. Exhibit 6-5 presents the findings of program NPVs for 30 year life. A 30 year scenario may be slightly optimistic, however, because only six of the 12 measures have an estimated life of 30 years. Maintenance or replacement costs would be incurred, therefore, for the six measures that reached the end of their useful lives and would have to be included into investment cost figures for the program.

EXHIBIT 6-5

NET PRESENT VALUES FOR 30 YEAR PROGRAM LIFE

	DISCOUNT RATES		
FUEL PRICE ESCALATORS	@ 3%	@ 7%	@ 10%
@ 3.0%	$ 684	$(108)	$(418)
@ 7.6%	2,634	770	97
@ 11.0%	5,681	2,064	820

( ) Denotes negative value.

Results of this analysis show positive NPV, or cost-effectiveness, when the analysis is based on a 14 year program life, if the discount rate is 3%, and the price of fuel escalates by 11.0. The program becomes cost-effective for almost all of the scenarios when the program life is estimated at 30 years. Scenarios with a negative NPV are those where the higher discount rate and lower fuel price escalation rates are not offset by the longer program life.

Based on the SPI and NPV results, the program's internal cost-effectiveness is marginal, i.e., the actual program costs are recoverable by energy savings only when the price of fuel is over three times the discount rate in the 14 year life analysis and when the discount rate equals or exceeds the fuel price escalation rate in the 30 year analysis.

Energy savings and costs directly attributable to two individual weatherization measures, i.e., insulation and window works, also were analyzed to determine ECM-specific NPVs. The same discount rate and fuel price escalation rate assumptions were made for these measures as for the program as a whole. However, for the life of the measure assumption, actual years were utilized, i.e., 30 years for insulation and 25 years for window works. Each of the measures showed strong positive cost-effectiveness under all the various scenarios of different discount rates and FPE rates. Insulation has a high NPV of $6,697 (assuming an FPE of 11.0% and a 3% discount rate) and a low NPV of $560 (assuming an FPE of 3.0% and a discount rate of 10%). Exhibit 6-6 provides these NPVs for insulation assuming a 30 year life.

EXHIBIT 6-6

NET PRESENT VALUES FOR INSULATION WITH 30 YEAR LIFE

	DISCOUNT RATES		
FUEL PRICE ESCALATORS	@ 3%	@ 7%	@ 10%
@ 3.0%	$1,670	$ 872	$ 560
@ 7.6%	3,632	1,756	1,079
@ 11.0%	6,697	3,058	1,806

Assuming a strong correlation between the discount rate and the fuel price escalation rate, insulation provides positive NPVs between $1,670, $1,756 and $1,806 when the discount rate increases in proportion to increases in fuel prices.

Window related ECM activities also result in positive NPVs, assuming a 25 year life of the measure. The NPV ranges from a low of $38 to a high of $1,880, as shown in Exhibit 6-7.

EXHIBIT 6-7

NET PRESENT VALUES FOR WINDOW WORK WITH 25 YEAR LIFE

	DISCOUNT RATES		
FUEL PRICE ESCALATORS	@ 3%	@ 7%	@ 10%
@ 3.0%	$ 449	$161	$ 38
@ 7.6%	1,055	473	236
@ 11.0%	1,880	878	485

The results of the microeconomic impacts of the individual measures are very encouraging. Based on base-year fuel prices, insulation has a SPI of 4.8 years with a life of 30 years. The positive NPV for insulation regardless of the discount rate and fuel price escalators shows that insulation is a very cost-effective measure. Similarly, window works have a payback of 6.4 years, a 25 year life and a positive NPV regardless of the other assumptions utilized in the analysis. While not quite as strong as insulation, the installation of window work measures are cost-effective.

6.3 MACROECONOMIC EFFECTS OF WEATHERIZATION PROGRAM

Macroeconomic effects of Iowa's Weatherization Program include the gross costs and benefits accrued to the state due to increased economic activity. These effects include not only the direct costs and benefits attributable to the program but also the program's impacts on employment, state tax revenues, and other intrastate economic activity. Program implementation affects state employment by providing program-related jobs to energy auditors, weatherization crews (both in-house and contractors), and administrative personnel. Tax revenue impacts occur for both income taxes and sales taxes due to the increased financial activity caused by the program. The cumulative direct and indirect costs and benefits of the 1987 weatherization program resulted in a net gain to the State of Iowa of about $12.8 million.

Direct costs and benefits accrued by the state are the actual costs and benefits associated with the implementation of the program. Indirect costs and benefits are those accrued through additional economic activity realized because of the program. Indirect costs and benefits are calculated using a simple multiplier of 2.33, which is the standard for Iowa in this application.[4] Exhibit 6-8 presents the public indirect costs and benefits associated with the weatherization which could be identified.

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[4] Based on conversations with Dr. Daniel M. Otto, Department of Economics, Iowa State University. (Multiplier for Maintenance and Repair Construction category.)

EXHIBIT 6-8

PUBLIC DIRECT AND INDIRECT MACROECONOMIC IMPACTS OF THE 1987 WEATHERIZATION PROGRAM

	PUBLIC COSTS		PUBLIC BENEFITS	
	($) DIRECT	($) INDIRECT	($) DIRECT	($) INDIRECT
Energy Savings			$431,944	$ 1,006,430
State Tax Revenue				
Income Tax				
Sales Tax	$ 17,278			634,227
Program Implementation				
Materials	3,719,243			8,665,837
Labor	2,842,308			6,622,732
Support	1,525,752			3,555,002
Total	$8,104,581	$0	$431,944	$20,484,228

Total Public Costs = $8,104, 581
Total Public Benefits = $20,916,172
Total Public Net Benefit of Program = $12,811,591

The results presented are based on those costs and benefits for which definitive information could be obtained and directly attributed to the weatherization program. For example, given an estimated average labor cost of $431 per weatherization, approximately $2.8 million was spent for labor (i.e., salaries) during the 1987 program year. Because the salary levels of employees were not available, the income tax revenues paid to the state as a direct result of the weatherization program are not figured into the cost-benefit assessment.

Direct Energy Savings Benefits reflect the dollar value of the energy savings from the program ($431,944). Indirect program benefits reflect the gross impact of the energy savings on the state's economy.

State Tax Revenues, accrued through sales taxes associated with this program, realized a net gain of approximately $157,000. State Tax Revenues increased by $634,227 (total economic activity X 4% sales tax X 80% propensity to consume). However, State Tax Revenues will decrease by $17,278 as a result of foregone energy sales by the utilities to residential consumers, which also is subject to a 4% sales tax. Therefore, the net tax benefit is $616,949.

Based on an economic multiplier of 2.33, the $8 million investment is expected to result in an additional $20.9 million in economic activity in the state. Together direct and indirect costs and benefits resulted in a net economic gain to Iowa of approximately $12.8 million as a result of this weatherization program.

Private industry costs and benefits also were realized by the Iowa Weatherization Program. The full extent of the private impacts cannot be determined due to the complexity of offsetting activities associated with implementing the program. For example, Iowan utilities lost approximately $51,833 in direct revenues as a result of the decrease in energy sales in the state. The indirect effect was a loss of about $122,844 to the utilities.[5] Potentially offsetting these revenue losses, however, could be alternative sales agreements outside of the state and utility load reshaping possibilities. Further analysis of the state's utility industry would be required to evaluate the total impact of the weatherization program on utility revenues.

Other potential private industry impacts could include the cost and benefits associated with any maintenance of weatherization measures, salvage value of replaced equipment, intrastate manufacturing of weatherization materials, etc. Evaluation of these potential private industry impacts are beyond the scope of this study.

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[5] Figures based on the 12% of state consumer energy costs that are paid to intrastate utilities for transmission and distribution costs as well as utility returns. The 12% was applied to the $431,944 energy savings for direct costs. A 2.37 multiplier was applied to the $51,833 to determine indirect costs. The 2.37 multiplier is the investment multiplier provided by the Iowa Department of Commerce.

PART II: PROCESS EVALUATION RESULTS

7.0 INTRODUCTION TO PROCESS EVALUATION

7.1 PROCESS EVALUATION OBJECTIVES

Iowa's Weatherization Program was evaluated to determine the effectiveness of the implementation process. Incorporated in this evaluation was an analysis of the sources and allocation processes employed to fund the program; the marketing and administrative procedures instituted to spur program awareness and motivate program registration; the prioritization method utilized to ensure that the most needy applicants receive weatherization; the methods instituted to disseminate program information to energy consumers to promote program participation; the implementation procedures employed; and the procedures instituted to follow-up the weatherization to ensure that measures were properly installed.

The process component of this study was designed to evaluate processes associated with program administration and implementation. The following major program processes have been evaluated and are addressed specifically in Sections 7.0 through 13.0 of this report:

- Program Funding;
- Marketing and Administrative Processes Relating to Program Awareness and Registration;
- Prioritization of Weatherization Applicants;
- Consumer Information and Education Activities;
- Weatherization Service Delivery; and
- Weatherization Follow-up Procedures.

7.2 PROCESS EVALUATION METHODOLOGY

The process component of the Iowa weatherization program evaluation employed the following key methodological elements:

- Literature review of a variety of documents, including the 1987 and 1988 Iowa Weatherization Assistance Program State Plan, promotional materials, operating procedures, and training manuals;

- Analysis of attitudinal and demographic responses to the Iowa Weatherization Program questionnaire;
- Interviews with Department of Community Action (DCAA) program and fiscal staff;
- Interviews with weatherization coordinators and program staff representing 40% of the CAAs located across the state; and
- Independent energy audits and interviews with 45 recipients whose homes were weatherized during the 1987 program year.

Each of the key program processes outlined above are discussed in the remainder of Part II. Findings are presented and suggested recommendations are provided.

8.0 PROGRAM FUNDING

8.1 FUNDING SOURCES

Multiple funding sources complicate the administration of the Iowa Weatherization Program. The program is funded through as many as six federal grant programs/sources. Primary funding is through U.S. Department of Energy's WAP and U.S. Department of Health and Human Services' LIHEAP grant monies. LIHEAP funds are divided into two categories, regular LIHEAP funds (incorporated into the standard weatherization program budget) and crisis LIHEAP funds (set aside for low-income households in extreme need of weatherization assistance, regardless of their priority). In addition, Petroleum Violation Escrow Account (PVEA)/oil overcharge funds have recently provided additional funding for the weatherization program. The weatherization program also frequently receives some funding from the DHHS's Community Service Block Grant Program (CSBG). Additionally, some CAAs occasionally secure minor local funding. In spite of the influx of PVEA funds, the WAP budget over the past two years has declined approximately 15% due to recent cutbacks in DOE funding. During the 1987 program year, approximately $8 million was spent for weatherization. During the 1988 program year, approximately $6.7 million is expected to be spent for weatherization.

The funding environment within which the weatherization program operates is further complicated by the different funding cycles of each funding source. DOE weatherization funds are provided on a federal grant cycle basis (April 1 to March 31). LIHEAP and CSBG funds are provided on a federal fiscal year basis (October 1 to September 31). Finally, PVEA funds are provided on an Iowa fiscal year basis (July 1 to June 30). In addition, while funding may be provided on a fiscal or program <u>year</u> basis, the actual period of contract funding may range from three months to one year.

8.2 ALLOCATION OF PROGRAM FUNDS

Primary weatherization program funds (DOE, regular LIHEAP, and PVEA) are allocated to the Community Action Agencies based on the following two criteria:

- Number of households under 150% of the federal Office of Management and Budget (OMB) poverty guideline; and

- Number of persons over 65 years of age under 100% of the OMB poverty guideline.[1]

Each CAA's funding allocation is proportionate to the number of households in their service area which meet either of these criteria.

The funding allocation process entails four steps. First, each CAA determines the number of households meeting either of these two criteria for each county within the CAA's specific area. Second, the total number of households meeting the criteria per county are summed, resulting in a CAA-area total. Third, the CAA-area totals are summed to determine the total number of households meeting these criteria statewide. Finally, the percent of weatherization funds allocated to each CAA is calculated by dividing each CAA-area total by the state total. As a result of this process, each CAA distributes weatherization services to the counties based on each county's percentage of the CAA-area total of households meeting the allocation criteria.

8.3 CONTRACTING PROCESS

While the procedure through which the 19 CAAs receive their allocated weatherization program funding varies depending on the type of funding, the basic contracting process is similar. Initially, DCAA applies for funding from the funding organization (generally DOE or DHHS). For DOE WAP, the official application for grant funds is part of the prepared state plan.

Once state funding applications are approved, DCAA prepares 19 individual contracts (one for each CAA) for each funding source. With six potential funding sources, this could entail the preparation of up to 114 separate contracts each year. While this is a large number of contracts, DCAA applies a standard format in developing contracts. Thus, with the exception of a few particular entries, contracts are very similar. Entries which change from contract to contract include contract value, project budget, production

[1] Poverty levels are approximately $7,138 for a family of two and $11,203 for a family of four, based on conversation with the Bureau of the Census, U.S. Department of Commerce.

schedule, and subgrantee name. After contacts are executed, DCAA typically advances funds for an initial period of the contracts to the CAAs based on projected expenses. Subsequent payments are made to the CAAs upon receipt of subgrantee monthly reports.

8.4 PROGRAM FUNDING ISSUES

Examination of program funding processes yields three significant program funding issues. These issues involve:

- Multiple funding sources;
- Delays in contract processing; and
- Allocation equity.

These three issues are addressed separately in the remainder of this section.

CAA staff indicated that receiving program funds through several contract vehicles operating under different fiscal years was a problem as it resulted in a very inconsistent flows of funds into the Program. The degree to which weatherization coordinators found multiple funding sources to be a problem ranged from "minor annoyance" to "a major planning and budgeting problem." However, regardless of the degree to which multiple funding presented a problem, all weatherization coordinators interviewed felt that implementation was not significantly affected. This finding is supported by WAP Job Form data which indicates a relatively smooth and steady rate at which homes are weatherized throughout the entire year. A frequently discussed alternative to this problem is consolidating funds from all sources at the DCAA level and issuing just one weatherization contract per CAA. However, this would significantly increase the workload of the DCAA fiscal staff. Given that CAAs are able to plan and budget for multiple contracts so that local program implementation is not affected, significant changes are not required in this area to maximize the rate that homes are weatherized.

Delays in processing contracts at the state level result in a shortening of the contract period as contracts are received after the effective data of the contract. Several CAA coordinators indicated occasional delays in obtaining weatherization contracts from DCAA. As a consequence, CAAs have less time to provide weatherization services within grant cycles. Depending on the length of the delay, this problem could potentially pose a serious constraint to program implementation. However, minor operational modifications recently made within DCAA appear to have corrected this problem. Thus, further changes in order to increase the number of homes weatherized appears unwarranted at this time.

Program funds are allocated across the state on a per-county basis, without regard to location of high-energy consumers. A majority of the funds are allocated based on county populations of low-income and elderly. While these criteria are consistent with two of three primary weatherization program target markets (see Section 5.0), it ignores the third target market -- high-energy users.

An alternative to the present allocation formula is to incorporate a high-energy user criterion into the allocation formula. This alternative could potentially increase the congruence of funding allocations with weatherization program goals; however, implementation would be difficult as individual household energy consumption records are not readily available. In addition, evaluation data indicate that for most CAAs, percentage allocations using the current criteria are not inconsistent with percentages of high-energy users. In other words, the CAAs with the higher funding allocations tend to have a higher percentage of weatherization program recipients who are high-energy users (high-energy users were defined as households comprising the top twenty-fifth percentile of the sample in terms of pre-weatherization Btu consumption).

9.0 MARKETING AND ADMINISTRATIVE PROCESSES RELATING TO PROGRAM AWARENESS AND REGISTRATION

9.1 INTRODUCTION

A key goal of the Iowa Weatherization Program is to provide weatherization assistance to those identified as most in need. In order to attain this goal, population segments most in need of weatherization (target markets) must be identified and made aware of the weatherization program; motivated to apply for weatherization services; and effectively registered into the program. Typically, effective marketing activities and processes are required to identify target markets, establish program awareness, and motivate application to the program. Once people have applied, administrative processes must be in place to register the applicant and process the application.

9.2 PROGRAM AWARENESS AND REGISTRATION ACTIVITIES

9.2.1 Iowa Weatherization Program

The Iowa Weatherization Program has identified low-income elderly and low-income handicapped (per DOE regulations), as well as young low-income families, as population segments most in need of weatherization. Limited marketing and promotional efforts oriented toward establishing program awareness and motivating application has been conducted at two levels including the state DCAA level and the local CAA level. While limited, these activities include mass media spots (newspaper, radio, and television); press releases and public service announcements; disseminating brochures and pamphlets; sending information through the mail; and presenting displays and exhibits at events such as energy fairs.

Registration for the Iowa Weatherization Program requires applicants to complete an application form, either a LIHEAP/WAP joint form or a WAP specific form. Application forms are generally available at CAA offices as well as county outreach offices. In addition, some CAAs conduct occasional "mass intakes" where large number of applications are taken at one site, such as a local auditorium. Typically, these activities occur once a year in the fall. In some special instances, applications are mailed or delivered in person to interested persons who are unable to get to an application site. Once applications are taken, program eligibility is determined.

Eligibility for the weatherization program is based on applicant's annual income. Applicants with a verified annual income of 150 percent or less of the OMB Poverty Income Guidelines are eligible for weatherization. Additionally, recipients of Social Security Insurance (SSI) benefits are automatically eligible. After program eligibility is established, applications are prioritized using the point and prioritization system, which is described in detail in Section 10.0, Prioritization of Weatherization Applicants.

9.2.2 Weatherization Programs in other States

Iowa's marketing activities are not unlike the activities of other states in terms of form, content, and level of activity. As part of this study, weatherization officials in ten other states were contacted regarding their program awareness marketing activities. Three states responded, providing descriptions of their marketing activities and samples of promotional materials. As with Iowa, all three states perform limited targeted marketing. All three states distribute brochures which explain their weatherization programs and application procedures. In addition, one state has developed an exhibit which is displayed at conferences and other events. Another state has developed a video describing the furnace repair component of their program. The video is shown twice a year at community meetings, as part of a presentation concerning their entire weatherization program.

For two states responding to inquires registration procedures are similar to Iowa's joint LIHEAP/WAP application procedure. The third state is currently in the process of combining the LIHEAP and WAP application processes.

9.3 ISSUES RELATING TO PROGRAM AWARENESS AND REGISTRATION

Marketing activities are typically not targeted toward particular population segments which have been identified as most in need of weatherization assistance. While some targeting is performed in the dissemination of promotional materials (e.g., placing brochures in senior citizen centers), discussions with program staff and review of sample marketing and promotional materials indicate that the message contained in marketing materials is not targeted toward identified population segments. In addition, discussions with Iowa's Weatherization Program staff and review of marketing and promotional materials also demonstrate that marketing activities are conducted infrequently and on a very limited emphasis. Survey results support this finding as they indicate that only about 18 percent of the respondents become aware of their eligibility for weatherization assistance through DCAA- and/or CAA-sponsored marketing and promotional efforts.

Two significant reasons help explain why the Iowa Weatherization Program performs limited marketing and promotional activities geared toward developing program awareness and stimulating applications. These reasons include:

- The Iowa Weatherization Program currently receives significantly more eligible applications than it has funding to serve; and
- A strong disincentive exists for employing weatherization program resources to conduct program awareness marketing.

Each of these reasons is discussed below.

The weatherization program receives more applications than it can afford to serve due to the joint application process it shares with the LIHEAP. LIHEAP is designed to assist low-income persons pay their fuel bills. The joint application process requires that all applications to LIHEAP automatically become applications to the WAP. In addition, a LIHEAP applicant who refuses to accept weatherization assistance is disqualified from receiving further LIHEAP benefits. The LIHEAP program conducts an extensive and wide variety of marketing and promotional activities which generate over 100,000 LIHEAP applications annually. These activities include:

- Mail inserts in utility bills, Aid to Families with Dependent Children (ADC) checks, SSI checks, unemployment checks, and food stamp mailings;
- Monthly press releases to local newspapers in each CAA region;
- Posters displayed in post-offices, hospitals, senior citizen centers, and outreach offices;
- Radio and television interviews by program staff;

- Announcements in church bulletins;
- Brochures, flyers, and pamphlets; and
- State-wide hotline.

All LIHEAP applications, even those not eligible for energy assistance, are forwarded to the weatherization program. Consequently, the weatherization program receives over 100,000 applications annually as a result of LIHEAP marketing efforts. Approximately 80 percent of the survey respondents indicated that they discovered that their home was eligible for the weatherization program through LIHEAP promotional and/or outreach activities, rather than any WAP initiated activities. While direct application to the weatherization program is available, conversations with program staff indicate that less than one percent of the applications are received in this manner. In addition, the number of weatherization program applicants becoming aware of the program via LIHEAP marketing activities should increase, because LIHEAP marketing activities and promotional materials will directly reference the weatherization program in 1988.

Program guidelines and the funding environment in which the program operates create three strong disincentives to conduct marketing activities. First, funds are not specifically allocated for marketing activities. As a result, marketing activities must be funded through already constrained administrative budgets. Second, program guidelines established by DOE and DCAA do not require the performance of marketing activities. Finally, DOE evaluates program performance based on the total numbers of homes weatherized. This creates an incentive to allocate as much monies as possible to the weatherization of homes. Consequently, there is a strong disincentive to employ scarce resources for purposes such as program awareness marketing, which do not involve the actual weatherization of homes.

The extent to which the program is reaching eligible, yet hard to identify and/or contact, applicants is unknown. What is clear, however, is that the present programs, policies, or processes are not likely to reach eligible clients unless they participate in LIHEAP. Given the overabundance of annual applicants to the weatherization program and the administrative disincentives to marketing, the absence of a significant marketing effort by either state or local entities is not surprising. As a result, however, households unwilling to ask for LIHEAP funds or unfamiliar with LIHEAP activities may be inadvertently omitted from of the WAP program.

As a result, one important factor related to marketing should be considered -- have those most in need of weatherization been identified and are marketing efforts targeted toward them? DOE regulations for the WAP (10 CFR 440) outline three major population segments/target markets which should receive priority in the provision of weatherization assistance. These are:

- Elderly low-income persons;
- Handicapped low-income person; and
- Other low-income occupants of high-energy consuming dwelling units.

The Iowa Weatherization Program has clearly identified the low-income elderly and handicapped as target markets. The Point and Prioritization Section (discussed in Section 10.0), as well as the demographic characteristics of the sample group provide direct evidence of this. The extent to which other low-income high-energy consumers have been identified is not evident. What is evident, however, is the limited degree to which program awareness and application activities are focused toward target population segments such as high-energy consumers, particularly those not enrolled in LIHEAP.

<u>A simple marketing plan could improve the identification and targeting of key population segments most in need of weatherization assistance, such as high-energy consumers with relatively low household incomes</u>. A marketing plan could include the following key components:

- <u>Situational/Environmental Analysis</u>. Analysis of factors such as DOE guidelines; Iowa Legislative Requirements; budget/funding sources, alternatives, and constraints; program infrastructures; and organizational mission which affect program implementation and/or recruitment.

- <u>Needs Assessment</u>. Identification of target markets including their household, dwelling, and economic characteristics, as well as their desires, preferences, and priorities.

- <u>Strategy Development</u>. Outline and establish a comprehensive approach for effectively reaching groups targeted as most in need and satisfying their requirements within constraints of the operating environment.

- Implementation Planning. Develop a detailed plan for accomplishing outlined strategies.
- Evaluation. Assessment of the effectiveness of the marketing plan.

A simple plan such as that outlined above would help program administrators clarify program goals and objectives, as well as help identify data and/or information gaps. As indicated in Section 5.0, there are demographic and dwelling characteristics which are associated with specific target populations such as high-energy consumers. These data could assist in the development of profiles of selected population segments, which could then be used to assist in the identification of markets, the design of promotional materials to reach these markets, and the development of specific programs and policies to improve program delivery to these groups.

10.0 PRIORITIZATION OF WEATHERIZATION APPLICANTS

10.1 INTRODUCTION

The Point and Prioritization System (PPS) has one primary purpose -- to prioritize applicants for the weatherization program based on level of need. For those who have applied for LIHEAP/WAP assistance, the objective of the PPS is to ensure that weatherization assistance is provided first to identified target markets, such as the elderly and handicapped, as well as to rank-order those in greatest need within target groups. With the Iowa Weatherization Program annually receiving 80 to 90 percent more applications than funds allow serving, a prioritization method is necessary to identify those households which will be served. The PPS does not, however, generate program enrollment.

10.2 DESCRIPTION OF THE POINT AND PRIORITIZATION SYSTEM

The PPS employs categories pertaining to specific demographic and dwelling characteristics to rank-order program applicants. Associated with each category is a numeric point level, which indicates the relative importance of the category in determining the extent of need. Exhibit 10-1 outlines the PPS as it will be implemented in the 1988 program year.

EXHIBIT 10-1

POINT AND PRIORITIZATION SYSTEM

A.	5 Points	Elderly (Age 60 or over)
B.	5 Points	Handicapped
C.	3 Points	Single-Family Residence
D.	2 Points	Electric/Oil/LP Gas (primary fuel type only)
E.	1 Point	Family with Small Children (3 years or younger)
F.	2 Points	Low Income (below 100%) of Poverty Guideline
G.	1 Point	Low Income (below 125%) of Poverty Guideline
H.	1 Point	For each Family Member (maximum of 5 points)

As the exhibit depicts, the demographic categories of elderly (category A) and handicapped (category B) are rated the highest, each with a point level of 5 points. In addition, category H which allocates 1 point for each family member up to a maximum of 5 points is highly rated. This category, added to the PPS in program year 1988, is intended to increase the distribution of weatherization services to young low-income families.

Once program eligibility is established (see Section 9.2.1), the PPS is applied and a point total is calculated for each application. Applicants receive points for each relevant category. For example, the point total of the application of a single 62-year old, handicapped person living in a electrically heated single-family home with an annual income below 125% of the poverty guideline would be calculated as follows:

Category A, Elderly	-	5 points
Category B, Handicapped	-	5 points
Category C, Single-Family Residence	-	3 points
Category D, Electric Heat	-	2 points
Category E, Small Children	-	0 points
Category F, Income below 100%	-	0 points
Category G, Income below 125%	-	1 point
Category H, Number of Family Members	-	1 point
TOTAL		17 points

Because each CAA is allocated weatherization funds on a per county basis, each CAA applies the PPS to each county within its region. Thus, in each county the CAA weatherizes dwellings at the top of the county priority list first, working their way down the list until allocated funding is expended.

10.3 ASSESSMENT OF THE POINT AND PRIORITIZATION SYSTEM

Ease of use is a primary advantage of the PPS. All the information needed to determine the priority point totals are listed on the program application form, making the priority point calculation a simple matter of adding a column of eight numbers. Because each CAA typically receives between 2,000 and 6,000 applications annually, minimizing the complexity and burden of the PPS is an important objective.

The PPS targets those population groups specified by program guidelines, particularly the elderly and/or handicapped. The PPS directly emphasizes the provision of weatherization services to low-income elderly and handicapped, two of the three target markets identified by DOE. The PPS also emphasizes the third major target market, high-energy consumers, but indirectly. Category D (fuel type) awards 3 points for dwellings heated by electricity, fuel oil, <u>or</u> liquid propane gas, three relatively expensive fuel types. In addition, category H which awards one point for each family member attempts to award points for high-energy users based on the concept that the greater the number of residents, the greater the energy consumption.

<u>The PPS enables applicants with lower point totals in one county to receive weatherization while applicants with higher point totals in another county may not receive weatherization</u>. For example, in county A an applicant with a priority total of 10 could get served. However, in county B the CAA may have expended all its funds in providing weatherization to all applicants with a point total of 12 or higher. In other words, county B applicants with point totals of 11 have not been served, while county A applicants with point totals of 10 have been served. Thus, while county based prioritization ensures that those in greatest need within counties received weatherization, cross-county disparities may occur. If each CAA prioritized applicants for the entire CAA area, rather than by county, these disparities could be greatly reduced within a specific CAA service area.

Other potential limitations of the PPS are as follows:

<u>The PPS may not be accurately measuring need, particularly in terms of relative need and the economic ability to meet energy bills</u>. Categories F and G which award points based on annual incomes may not be the most accurate measures of need. Income less expenses, or discretionary income, might be a more accurate indicator of financial need because many weatherization applicants with low total incomes but few expenses may have higher discretionary incomes than applicants with higher total incomes and many expenses. For example, elderly people often have relatively low total incomes, but often have paid off their mortgage and therefore could have fewer major expenses. This idea is supported by survey data which shows that 34% of the homeowners in the sample have lived in their homes for 30 years or more. Assuming they had typical 30 year mortgages and have not refinanced or taken second mortgages, these households should have relatively fewer expenses than the rest of the sample.

The PPS may result in doublecounting of specific households, thereby ensuring weatherization whether or not they exhibit relatively high need. Applicants who are both elderly and handicapped receive five points twice for a total of ten points. This can dramatically increase their opportunity for weatherization, in spite of the fact they may rank low on all the other standards used to determine need.

In some instances, the PPS may facilitate weatherizing homes of program applicants in relatively less need than other program applicants with the same priority point total. Program cost requirements ($1,600 average, $2,400 maximum per dwelling unit) encourage local program administrators to occasionally seek-out eligible homes needing relatively little weatherization work in order to keep average costs within required limits. The PPS facilitates this seeking-out process as the large number of eligible applicants ensures that many applicants in each county will have the same priority system rankings. This occasionally permits some selective choosing of homes for weatherization.

The PPS strongly emphasizes the age of the head of household as a criteria for receiving weatherization, whether or not relative need is established. Until this year, a potential limitation of the PPS was the over emphasis of elderly, low-income persons at the expense of others potentially in greater need for weatherization service, specifically young, low-income families. Several weatherization program staff, at both the state and local level, mentioned this concern. This concern also is supported by survey data, as 88% of the survey conducted as part of this study were elderly (60 years or older). As discussed in Section 10.2, however, a new point category was added to the PPS for program year 1988, which awards one point for each family member up to a maximum of 5 points. This is an attempt to reach higher energy users which tend to be larger families. As this is the first year the category has been in effect, it is too early to discern the specific impact of this new category. Due to recent changes in the PPS to reach high-energy consumers, most of the weatherization coordinators interviewed feel that slightly less elderly and more young families now are receiving priority point totals high enough to receive weatherization.

In addition, an analysis of the control group suggests that the proportion of relatively younger families with children is increasing. The control group represents households which are eligible for weatherization under the new PPS. Thus, the new PPS appears to be having some success at reaching the target population of low-income single parent families.

10.4 POTENTIAL ALTERNATIVES

Based on the potential limitations of the PPS discussed in the preceding section, the following modifications to the PPS are suggested:

- Develop priority lists for entire CAA areas/regions as opposed to individual counties. Priority lists based on CAA service areas would eliminate the potential for much of the variation in prioritizing program applicants, particularly that policy which heretofore would permit an applicant in one county to receive weatherization ahead of another applicant in another county with a higher PPS score.

- Award applicants who are both elderly and handicapped some number of points less than ten. While those who are elderly and those who are handicapped require (by program guidelines) and deserve high prioritization, there is no requirement that those who are elderly and handicapped be ranked so highly as to nearly guarantee weatherization, irrespective of need.

- Incorporate discretionary income, rather than total income into the PPS. Discretionary income is money likely to be remaining after critical needs are met, such as the home mortgage or rent, the household energy bill, and/or medical expenses. In this instance, limiting discretionary income to total income less housing expenses would be sufficient. Determining need based on discretionary income would reallocate resources to those with greatest need and least capacity to meet rising fuel bills. Implementation of this alternative would be difficult, but feasible. It would require ensuring that the monthly mortgage payment is recorded on the LIHEAP/WAP Application Form. In addition, a new PPS point category would need to be established which awarded some amount of points for discretionary income significantly below the poverty guideline.

11.0 CONSUMER INFORMATION AND EDUCATION ACTIVITIES

11.1 INTRODUCTION

A variety of activities beyond the implementation of specific ECMs can help reduce household energy consumption. These activities include closing off unused rooms, keeping all exterior doors and windows tightly sealed, setting the thermostat back several degrees before retiring in the evening, closing the fireplace damper when the fireplace is not is use, and changing furnace filters annually. When activities such as these are performed regularly, the energy savings achieved through the installation of weatherization measures can be significantly improved. More importantly, if enough of these activities are not performed, energy savings attained from weatherization can be negated. Consequently, a program which educates weatherization recipients about energy savings activities and encourages them to live an energy conscious lifestyle can boost the overall effectiveness of a weatherization program.

11.2 CONSUMER INFORMATION AND EDUCATION ACTIVITIES CURRENTLY CONDUCTED

11.2.1 Iowa Weatherization Program

Weatherization program participants are generally ill-informed about the work being conducted, the benefits that may result, and the impact of their behavior on program benefits. While the Iowa Weatherization Program currently conducts activities to inform and educate clients about actions they can take to save energy, these activities are generally limited in scope. One brochure was developed at the state level containing a few energy saving hints. However, this brochure was produced in 1985 and is no longer widely available.

The limited consumer information and education activities which are performed are primarily initiated at the local level. A few CAAs have developed informational brochures which include suggestions on how to save energy through lifestyle behavior. Brochures are typically placed in outreach offices as well as mailed to individuals who have requested advice. A few CAAs also encourage their inspectors to spend five to ten additional minutes with each client, at the time of their inspection, to explain a few basic energy savings tips. In addition, one CAA recently received a grant to be used specifically for energy conservation education. This program will include the development of energy conservation information centers in county outreach offices; the design of a new brochure providing energy conservation tips; the allocation of a full time staff person to coordinate the program and give presentations at local service organizations; and the use of some paid advertising in newspapers and on a local radio station.

Overall, however, little emphasis is placed on energy conservation education for weatherization recipients, either at the state or local level. Reasons for this include lack of funding; absence of a requirement to conduct client education activities; and a monitoring system that encourages weatherizing as many homes as possible, rather than spend time, money, and staff on client education activities.

11.2.2 Weatherization Programs in other States

Iowa's activities in client education and outreach are similar to other states activities in terms of scope and scale. Ten other states were contacted in order to review their weatherization program activities in the area of client education and outreach. Of the three states which responded to telephone inquiries and provided copies of outreach materials, two employed brochures which contained information regarding energy saving activities. One of them (Illinois) had developed a brochure which exclusively addressed how to live an energy conscious lifestyle. In both states, brochures were provided in places such as outreach offices, community halls, and senior citizen centers. Other than the dissemination of brochures, education activities were limited.

11.3 POTENTIAL ALTERNATIVES

The weatherization program has a range of potential alternatives available concerning the provision of consumer information and education. Several of these alternatives, along with associated advantages and disadvantages, are highlighted below.

Alternative A: Continue to place minimal emphasis on consumer information and education activities.

Advantages

- The weatherization program as a whole is currently resulting in an average annual energy savings of approximately 15.7% with very limited consumer education activities. If this level of average savings is satisfactory, additional consumer education efforts are probably unwarranted.

- No additional funding is required.

Disadvantages

- Program resources are potentially being employed inefficiently as many homes have not reduced energy consumption after weatherization. In fact, over 16% of the homes in the study sample experienced zero or negative savings after weatherization. The lack of a significant education component to the weatherization program may be a contributing factor to the large number of non-savers. Thus, if money is spent to weatherize homes which do not experience reduced consumption, program funds are being used inefficiently.

- Potential energy savings attainable through the performance of energy saving behaviors/activities are not being completely achieved. Proper energy conserving behavior can enhance energy savings and minimize the impact of high energy prices on low-income households.

Alternative B: **Distribute brochures providing energy saving tips to weatherization clients during the CAA inspection. In addition, place a sticker on dwelling thermostats and/or key areas in the home, reminding recipients to set the thermostat back in the evening and/or close off unused interior spaces.**

Advantages

- Funding required is relatively minimal as CAA inspectors would not need to spend additional time per inspection. Thus, the primary cost of this alternative involves the development of materials, printed brochures and/or thermostat stickers. Moreover, brochures are available at minimal costs. For example, DOE provides free negatives of a brochure entitled, "Tips for Energy Savers," which provides guidance to the householder on how to save energy. To obtain the printing negatives free of charge, contact the U.S. Department of Energy, Editorial Services, Office of Public Affairs, Washington, DC, 20585, (DOE/CE-0143).

- Active dissemination of brochures, as opposed to passive dissemination, which exists when placing brochures in outreach centers, ensures that all weatherization clients receive some guidance regarding ways they can reduce household energy consumption. In addition, active dissemination reinforces a strong CAA/client relationships, as well as provides valuable reinforcement to householders regarding the need to modify lifestyles in order to save energy.

Disadvantages

- Written materials by themselves tend to be a relatively ineffective education method. People may not read them. This is especially true for less educated groups or the elderly in failing health.

- This approach may not be cost-effective, depending on how ineffective a written-materials-only approach to client education is in terms of increasing energy savings.

Alternative C: **Direct, one-on-one conversations and/or explanations from the CAA inspector to the householder during the final inspection pointing out how and where energy savings may occur, as well as personal dissemination of brochures and/or thermostat stickers. Most energy research suggest that lasting modifications in energy conserving behavior are difficult to achieve. Attempts at eliciting lasting energy conserving behaviors are more likely to be successful when the instruction(s) are the result of direct contact between the teacher and pupil, where the opportunity for "hands-on" teaching exists, rather than indirect instruction through pamphlets and/or brochures. Thus, while this alternative may have higher costs, the opportunity for real, lasting reductions in energy consumption also are higher.**

Advantages

- Written materials supported by a personal approach to education tends to be relatively effective. In particular, discussing with clients why the weatherization was done will provide them with a better understanding of weatherization and encourage them to follow advice more carefully.

- Potential is better for increasing energy savings through lasting client education/lifestyle changes.

Disadvantages

- Funding required is not insignificant. In addition to expenses for pamphlets and stickers, CAA inspector visits will be lengthened somewhat resulting in fewer inspections per day. However, given the current production schedule, most CAAs should be able to average one less inspection per day and still inspect all homes weatherized without hiring/contracting an additional inspector.

- All current CAA inspectors may not possess the necessary interpersonal skills required to ensure the success of this approach.

Alternative D: A comprehensive consumer education program (similar to the program being initiated by the Creston CAA) involving activities such as mass media advertising, presentations to civic groups, development of brochures, and establishment of energy conservation information centers.

Advantages

- Large numbers of people can be reached. In fact, advertising and presentations at community meetings should reach some non-weatherization recipients and result in energy savings for the greater population.
- Does not require input from CAA inspectors.

Disadvantages

- Funding required is relatively expensive. The Creston CAA program is currently funded at approximately $130,000 for one year.
- Distribution of brochures and information through information centers in outreach offices does not ensure that all weatherization recipients will receive energy savings tips.

12.0 ASSESSMENT OF WEATHERIZATION SERVICE DELIVERY

12.1 INTRODUCTION

Weatherization service delivery -- local program implementation and installation of weatherization measures -- is a key component of the weatherization program. Without effective service delivery, the program could not succeed. For this evaluation, service delivery was assessed in two primary ways. First, the actual quality of the weatherization work was evaluated through energy audits on 45 recipient homes located across the state. Comments offered by these 45 recipients regarding work quality also comprise part of this assessment. Second, weatherization client attitudes, perceptions, and level of satisfaction with the program in general were measured through in-depth interviews with 45 recipients and through the weatherization program questionnaire. As a final consideration in assessing service delivery, alternative service methods (i.e., in-house crews and contractors) are discussed.

12.2 QUALITY OF WEATHERIZATION WORK

12.2.1 Introduction

This section assesses the quality of weatherization work based on the results of the 45 recipient interviews/energy audits. Overall, the quality of work is very high. Approximately one-half of the clients interviewed were completely satisfied with the quality of work. For those who indicated problems, most of the comments concerned one major issue: poor workmanship. In addition, while energy audit results suggest that the overall quality of weatherization on most houses was very good, several minor problems were frequently encountered. These include messy caulking; broken molding on windows; and doors hung improperly. Specific results of the energy audits are discussed in the next section.

12.2.2 Implementation of Weatherization Measures

The purpose of the audit portion of the visit was to examine the quality of weatherization work performed and determine if additional measures were needed. At the conclusion of each audit the interviewer assigned an overall "grade" to the home. A score of 10 was given if the weatherization was without problem. One or two minor problems resulted in a score of nine. Three or four minor problems resulted in an eight. A score of seven was given if there was a major problem, such as a broken interior window trim. A six was given if there was more than one major problem, and a five or below was given if there were numerous problems. While the scoring is subjective and based on a comparison to other houses, across the state the average was 7.9, based on a scale of:

- 10 = Excellent;
- 9 = Very Good;
- 8 = Good;
- 7 = Acceptable;
- 6 = Poor; and
- 5 or below = Bad.

The implementation of the following energy conservation measures is discussed throughout the remainder of this section:

A. Insulation
B. Windows
C. Doors
D. Caulking
E. Weatherstripping
F. Furnace

A. Insulation

Compared to other improvements, the installation of insulation was performed the best. Attics were insulated to approximately R-30 where needed and proper ventilation was provided as necessary. When insulated, walls were done neatly and plugs were painted to match the color of the house. Undoubtedly, the high quality of workmanship contributed to the relatively high level of savings attributable to insulation.

Scuttle holes (attic hatches) were well insulated also. Closing the scuttle hole, however, was sometimes difficult to do without a handle to pull shut. The majority of homes had no handle installed except for about half of the houses serviced by the Office of Neighborhood Development, City of Des

Moines. Given the high percentage of elderly and handicapped, access to the attic and the ease of opening and closing coverings such as the attic scuttle hole becomes an increasingly important issue. The Iowa Materials Application Manual recommends that rebuilt scuttle holes should have a handle installed (October 1987, page 7).

Perimeter insulation was installed properly in all but a few houses. In two houses no vapor barrier was applied, and in three houses no insulation was installed where it could have been. Insulation on water heaters and hot water pipes was generally installed well. Only 6 of the 45 houses visited did not have these ECMs installed. While these measures have a relatively low priority for implementation (Iowa WAP State Plan, 1977-1988), in the houses where these measures were not implemented did not appear to have other measures installed in their place.

B. Windows

Window repair and replacement was done well in 70 percent of the homes visited. The remaining 30 percent who received these measures encountered problems in the installation of window glazing and sashes, window locks, and replacement storm windows. Problems ranged from careless workmanship to improper and/or inappropriate installation. The following are examples of the problems:

- Careless Workmanship - putty smudges on windows, broken interior trim resulting in gaps and a malfunctioning window, lack of consistency in installing locks on sash windows, and broken pre-existing storm windows replaced with single pane windows.
- Poor Installation - window sashes improperly installed causing windows either to not open or to not remain opened, and contemporary cresent-type lock installed with a gap causing an ineffective lock (see Exhibit 12-1).
- Inappropriate Installation - blue sash installed in an existing white window unit (see Exhibit 12-2), and storm window replacement on interior wall of an enclosed porch (see Exhibit 12-3.

EXHIBIT 12-1
EXAMPLE OF IMPROPERLY AND PROPERLY INSTALLED WINDOW LOCKS

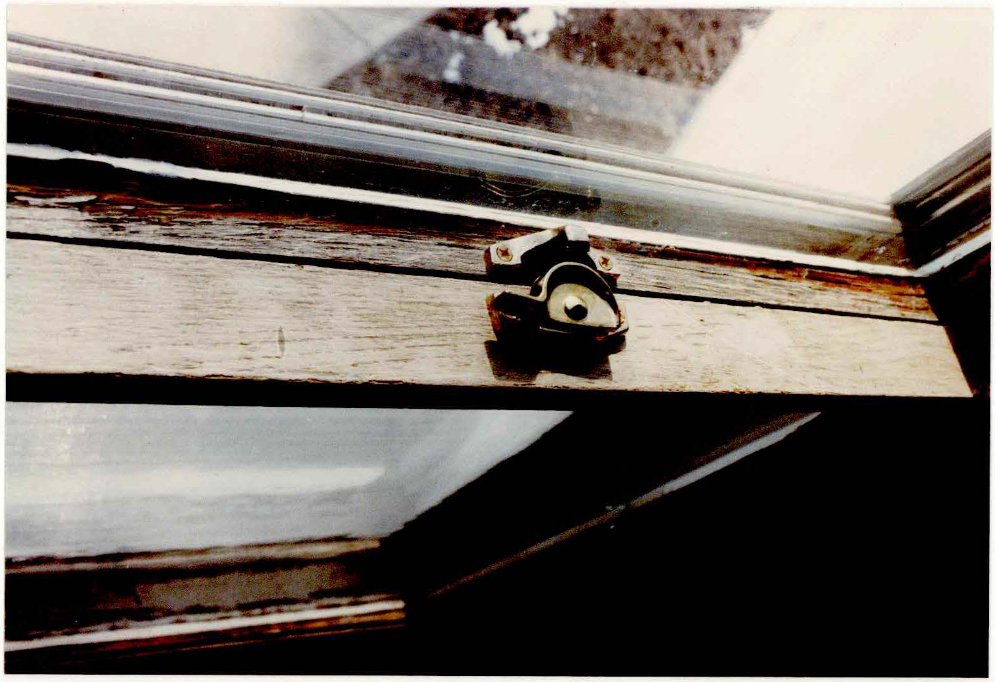

EXHIBIT 12-2

EXAMPLE OF INAPPROPRIATE WINDOW INSTALLATION

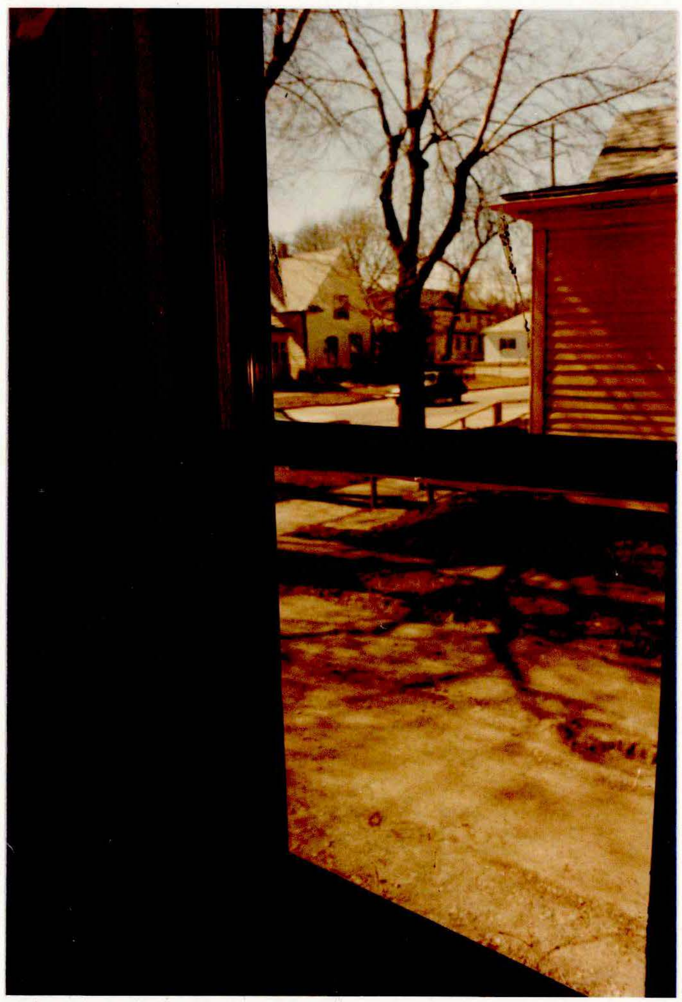

EXHIBIT 12-3

EXAMPLE OF INAPPROPRIATE INSTALLATION OF STORM WINDOW

C. Doors

Of the 45 total houses visited, 25 had replacement doors installed. Twenty-one of the installations were excellent. The remaining 4 recipients of replacement doors experienced the following problems with carelessness and poor installation:

- Careless Workmanship - inoperable key provided to recipient for lock in new replacement door and broken bottom panel of storm door. (In compliance with weatherization regulations, no storm doors were replaced in any homes.)
- Poor Installation - improperly fitted replacement doors causing gaps in the top or bottom of the door. (In one instance, the gap was significant enough to warrant a build-up of the threshold to meet the door in a step-like fashion.)

D. Caulking

Caulking was installed well in over 80 percent of the homes visited. For the vast majority of homes, caulking was applied well at just about every crack and separation and in most cases the completeness and neatness of application was excellent. In some homes, however, the workmanship was poor. The level of dissatisfaction and consternation experienced as a result of poor and messy caulking was higher than for any of the other problem experienced. The following are some examples of poor caulking applications found in the site visits:

- Careless Workmanship - workers wiped their hands and/or caulking gun on house siding (see Exhibit 12-4), and wood trim and baseboards were caulked but not cleaned prior to application resulting in trapped dirt under the caulk.
- Poor Installation - openings at the sill plate were not caulked leaving significant gaps between siding and foundation, and a rear door with substantial gaps was not caulked.
- Inappropriate Installation - doorways between interior walls were caulked, and a new bathroom shower was caulked for no apparent reason.

EXHIBIT 12-4
EXAMPLE OF CARELESS CAULKING ON EXTERIOR WALL

E. Weatherstripping

Weatherstripping was done very well on nearly all homes. Thermal breaks were installed on windows in many cases, and scuttle holes were sealed, as were doors. A recurring problem occurred with weatherstripping applied to doors. The type often used was a heavy gauge aluminum with rubber flap. When installed the rubber flap is flush with the door, but over time it many lose its flexibility, creating a gap between the rubber and door, nullifying the impact of the weatherstripping. Vinyl-covered foam with aluminum carrier (Q-LON) weatherstripping created a better seal but was used less frequently (see Exhibit 12-5 for an example of these types of weatherstripping).

Foam gaskets on electric outlets and light switches were installed properly in all houses and were placed on all outside and inside walls. It is only necessary, however, to install these on outside walls[1], as air infiltration through electric outlets and light switches on inside walls is usually negligible.

F. Furnace and Hot Water Measures

Furnace issues, such as thermostat settings and maintenance, are considered Priority 1 of the Iowa WAP State Plan, 1987-1988. Furnace issues are not, however, routinely addressed by the weatherization crews, nor are clients generally informed as to the importance of maintaining an efficient furnace and/or accurate thermostat. To test the efficiency and accuracy of the furnace system, including the thermostat, the interviewer checked thermostat settings and checked the accuracy of the thermostat with two independent temperature measuring devices.

Typically, thermostats are incorrectly calibrated, resulting in inefficient energy consumption and/or misconceptions of interior temperatures. Measurements were taken of (1) the actual interior temperature, (2) the thermostat's thermometer, and (3) the thermostat setting, which would be set by the occupant.

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[1] U.S. Department of Energy, The Residential Energy Audit Manual, Fairmont Press, p. 217, 1983.

EXHIBIT 12-5
EXAMPLE OF TWO TYPES OF WEATHERSTRIPPING

Relatively large discrepancies exist between the thermostat setting and the in-door air temperature. On average, the difference between the thermostat setting and actual temperature is 3.4^{o}F. The difference between the thermometer on the thermostat and the actual temperature is smaller, 2.6^{o}F. While these differences do not create immediate concern, the differences are much greater than the averages in about 40 percent of the cases; the difference between the setting and actual temperature is greater than 6^{o}F in 30 percent of the cases. As a result, clients may be setting their thermostat at what they think is an energy efficient temperature, but in reality they are maintaining an indoor temperature much higher and less energy efficient.

On average, for every one degree of setback during an eight-hour period, a one percent savings will result. Several sources[2,3,4] provide a "rule of thumb" for estimating energy savings associated with thermostat setback. Assuming that thermostat settings in the 45-house sample are representative of the 1987 Iowa weatherization population, then 2,400 of the approximately 6,000 homes weatherized have miscalibrated thermostats. Assuming that these clients would keep a properly calibrated thermostat at its current setting (i.e., not raised to the actual temperature in the house), and that an annual heating fuel bill is $1,000, then annual savings resulting from properly calibrated thermostats would be:

- 10.2 percent overall;
- $102 per household; and
- $244,800 for 2,400 homes.

Installing automatic setback thermostats is one approach to correct inaccurate thermostat calibration. Without proper personal instruction, however, this may not yield successful results. One client with a setback thermostat (installed prior to weatherization) was using it manually, because it was too complicated to understand. Another, more effective approach, would

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[2] U.S. Department of Energy, The Residential Energy Audit Manual, Fairmont Press, p. 189, 1983.

[3] Barron, Steven L., Editor, Manual of Energy Savings in Existing Buildings and Plants, Prentice-Hall, pp. 55-60, 1982.

[4] Smith, John Elvans, Conserve Energy and Save Money, McGraw-Hill, pp. 49-50, 1981.

be to calibrate or replace the manual thermostat, then explain or provide information on the value and operation of thermostat setback, and how to maintain the thermostat. The interviewer was asked questions concerning setback in at least half of the visits, with the chief question, "Does setback really save money?"

The thermostat setting also was checked with what was reported in the survey. On average actual thermostat settings varied by 3.5^{O}F from reported setting, with only 16 percent being set the same. There was no pattern as to whether the actual setting was greater or less than the reported setting.

Hot water temperature was also measured. On average, the temperature was 119^{O}F, with most of the homes having temperatures of 123^{O}F or less. However, 22 percent (10 homes) had a hot water temperature greater than 130^{O}F, and 2 homes were greater than 140^{O}F. In each of these cases the client indicated that the water was hotter than they needed. The U.S. Department of Energy suggests[5] that a setting of 120^{O}F can provide adequate hot water for most families, and if the hot water temperature is reduced from 140^{O}F to 120^{O}F, savings could amount to over 18 percent of the energy used at the higher setting.

12.2.3 Weatherization Implementation Recommendations

The following recommendations concerning the installation of weatherization measures are suggested:

- Calibrate or replace manual thermostats.
- Install a handle on all scuttle holes, particularly in homes with elderly and/or handicapped persons.

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[5] U.S. Department of Energy, Tips for Energy Savers, DOE/CE-0143, p. 10, 1986.

- Install contemporary crescent type or cam-action type window sash locks instead of the split-cover type. There is little difference in cost[6]:

  - Split-cover type = \$1.29 each/box of 100
  - Contemporary crescent type = \$1.19 each/box of 150
  - Cam-action type = \$1.29 each/box of 100

- Clean areas prior to application of caulk on interior spaces such as baseboards and window and door frames.

- Emphasize to workers care and patience when they apply caulk to exterior and interior spaces. A few extra minutes spent caulking can make the difference between excellent and poor quality.

- Use vinyl-covered foam with aluminum carrier (Q-LON) weather-stripping around doors and scuttle holes instead of heavy gauge aluminum with rubber flap weatherstripping. While the vinyl-covered foam weatherstripping is more than three times the cost of the rubber-flap type, the seal it creates is consistently better. The additional cost per home is minimal considering that most homes have two to three doors weatherstripped. Prices are as follows[6]:

  - Heavy gauge aluminum
    with rubber flap = \$3.69 per set[7]/50 sets

  - Vinyl-covered foam with
    aluminum carrier = \$12.00 per set/50 sets

- Measure the hot water temperature at the tap and if above 130°F reduce the temperature to about 120°F in agreement with the client.

12.3 RECIPIENT ATTITUDES, PERCEPTIONS, AND LEVEL OF SATISFACTION WITH THE WEATHERIZATION PROGRAM

12.3.1 Introduction

While program recipients are very satisfied with the weatherization work performed on their homes, they tend to passively accept minor workmanship problems. Presented in the following two subsections are specific findings concerning recipient attitudes, perceptions, and level of satisfaction with the weatherization program. The first subsection is based on the results of 45 in-

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[6] Insulator Supply Company, Cedar Rapids, Iowa, 5/13/88, phone: (800) 247-3381.

[7] A set consists of enough material for one door seven feet high and three feet wide.

depth interviews with 1987 program year weatherization recipients. The second subsection is based on survey responses.

12.3.2 In-Depth Interview Results Concerning Recipient Attitudes, Perceptions, and Level of Satisfaction

In general, the attitudes toward weatherization of most of the clients interviewed are positive. They are grateful to have the weatherization work done, and even if they have not noticed a significant reduction in their fuel bill, most are more comfortable in the heating season.

Because many of the WAP clientele are either elderly, handicapped, or single parents with young children, minimizing the inconvenience to program recipients serves to raise levels of satisfaction and enhance the reputation of the program, particularly given the role that the local community network plays in disseminating information regarding the WAP. In nearly all cases the work crew gave sufficient notice (at least one week) prior to performing the work. However, in two cases only a one day notice was given, and in one case, the work crew simply arrived in the morning to begin work. In addition, while over half of the clients were contacted about the weatherization by phone and the remainder by letter, both were acceptable means of communicating as no one indicated that they were unhappy with how they were contacted.

Because individuals who wish to receive home energy assistance (LIHEAP) funds are compelled to receive weatherization assistance, the extent to which homeowners feel they have a choice regarding receiving the weatherization was addressed. Only one-third of the people felt they had no choice but to accept the weatherization. At the same time, 90 percent felt no pressure to accept the work. This is a positive reflection on the CAAs who must persuade clients to accept the work without undue pressure.

Generally, persons who received weatherization believe that the program was effective in lowering their energy bills. Half of the clients interviewed indicated that their fuel bill was reduced after implementation of the weatherization. Of the additional 36 percent that did not notice a change, some added that they had never taken the time to investigate, or that the past winter was colder. Only four clients (9 percent) said that the fuel bill had increased. To measure the perceived value of the weatherization, we asked two questions:

- Knowing what was done, would you have been willing to pay $50 for the weatherization?; and
- Would you recommend weatherization to your friends?

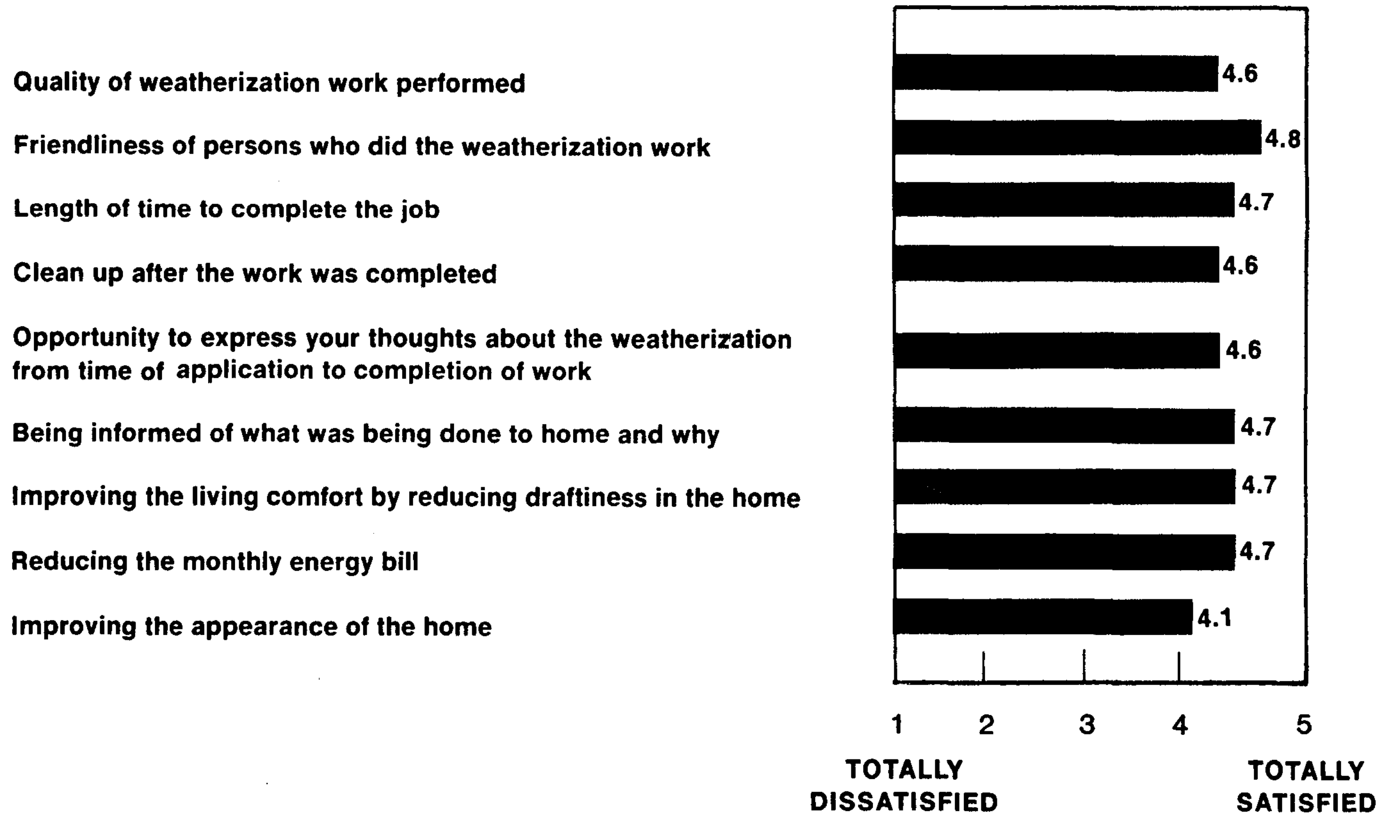
Nearly 80% of the clients would have paid $50 for the work. Even those who said "no" usually qualified it with "I didn't have the $50." All but one client would recommend weatherization to a friend. Even those not completely satisfied with the work would recommend weatherization to a friend; however, these persons might qualify their response by stating, "But not with the same crew."

12.3.3 Survey Results Concerning Recipient Attitudes, Perceptions and Level of Satisfaction

The Iowa Weatherization Program questionnaire included questions regarding perceptions of and satisfaction with the weatherization program among program recipients. The survey asked recipients to rate their level of satisfaction with nine different aspects of the weatherization program. Respondents rated each program aspect on a scale of one to five with one being totally dissatisfied and five being totally satisfied. The results of this question are illustrated in Exhibit 12-6. As shown, respondents were almost totally satisfied with all aspects of the weatherization program.

The results regarding client attitudes raise two considerations. First, the majority of weatherization recipients are genuinely satisfied with what the weatherization program accomplishes and with the work performed on their home. Second, the survey results are so overwhelmingly positive as to suggest the possibility of other reasons for such high rankings. For instance, often there can be a tendency to rate a service or benefit highly and refrain from criticizing the providing organization when the service is free. Indeed, results of the on-site visit suggest that program recipients are extremely hesitant to complain about the work. Effects of this hesitancy on the part of program recipients to complain include: (1) a possible complacency among CAA program administrators regarding work quality, and (2) inability to gauge

Exhibit 12-6
Level of Satisfaction With Weatherization



accurately the true levels of satisfaction, as well as identify areas in which weatherization implementation are weak from a program participant perspective.

12.4 SERVICE DELIVERY METHODS

There are two basic methods for weatherization service delivery -- in-house weatherization crews and contractors. Of the nineteen CAAs, nine currently use contractors, five use in-house crews, and five use a combination of crews and contractors. Of the five CAA's employing in-house crews, three use some form of incentive based pay for their crews.

Three different data sources provide information concerning service delivery methods. First, the 45 energy audits of recipient homes indicate there is not a noticeable difference in work quality between crews and contractors. Second, energy savings findings (see Section 4.0), suggest that there is no significant difference in average energy savings attained by homes weatherized by crews and homes weatherized by contractors. However, average weatherization costs per home are slightly higher for homes weatherization by contractors. Third, discussions with local weatherization coordinators indicate a lack of consensus regarding the relative advantages and disadvantages of using crews or contractors for weatherizing homes. Sometimes what works most effectively for one CAA is not effective for another CAA. Advantages for using contractors (disadvantages for using crews) include:

- Lower overhead expenses as purchase and maintenance of vehicles, tools, and equipment; insurance; and warehouse costs are not required.
- Less administrative work is required (e.g., tracking hours, planning schedules, etc.).
- Easier to adjust for workload fluctuations.
- Costs of implementation mistakes are borne by the contractor.

Disadvantages for using contractors (advantages for using crews) include:

- Contractors generally require more explicit work instructions.
- Direct oversight of contractors is more difficult.

- More effort is required to ensure that contractors are using materials which meet standards.

While it is clear that there are advantages and disadvantages associated with both methods and that both methods appear to be effective, stricter oversight of material costs may be warranted. Contractor costs on average are higher than the costs associated with in-house crews, although the higher material costs do not result in greater energy savings.

13.0 WEATHERIZATION FOLLOW-UP PROCEDURES

13.1 INTRODUCTION

Few CAAs employ formal procedures for addressing or following up recipient complaints regarding weatherization work. While the high level of client satisfaction with the weatherization work (as described in Section 12.3) suggests that the need for a standard follow-up procedure is minimal, the results of both the weatherization program questionnaire and interviews with weatherization recipients provide evidence to the contrary. That is, two evaluation data sources indicate that increased attention to weatherization follow-up activities is merited.

13.2 SURVEY RESULTS CONCERNING WEATHERIZATION FOLLOW-UP

Weatherization program questionnaire results indicate that the lack of a follow-up procedure should be a concern. Thirteen percent of the survey respondents reported problems with the work completed. However, of this 13 percent only about one-third reported their dissatisfaction to WAP personnel. Moreover, of those that did report their complaints, only about one-fourth of them were satisfied with the follow-up work received.

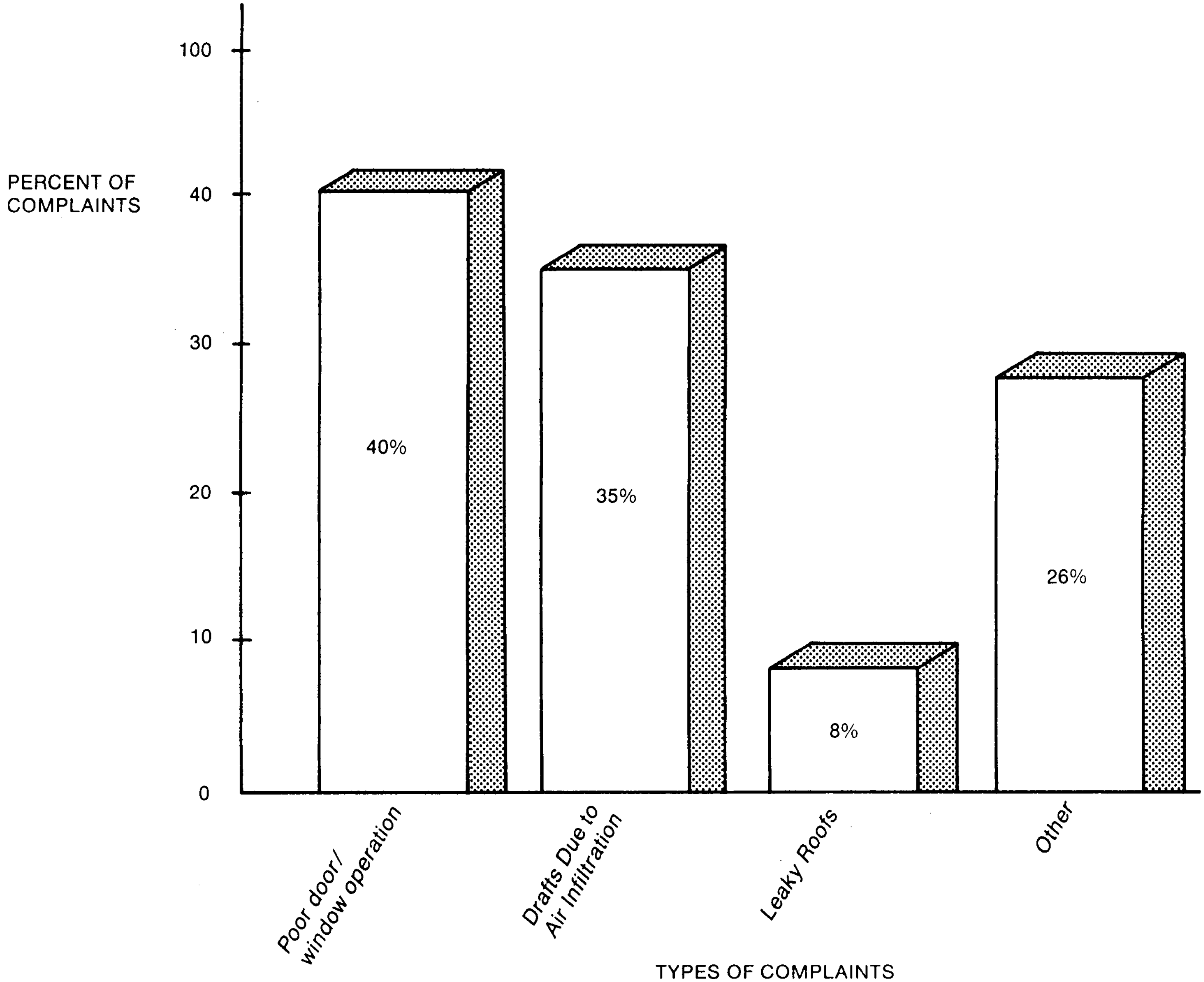
In order to be recognized as having a problem the respondent had to respond positively to the following weatherization program questionnaire question:

> **Since your home was weatherized, have you had any problems with the weatherization materials, workmanship, or follow-up activities?**

This question was followed by a request for specific information about the problem or problems encountered. The complaints noted have not been verified, therefore their accuracy or legitimacy is uncertain. Exhibit 13-1 depicts the types of complaints mentioned.

Difficulty in opening and/or closing doors and windows seemed to be a common problem. Forty percent of those who documented problems cited faulty window and/or door operations as the source of their complaint. The complaints

Exhibit 13-1
Respondent Complaints



ranged from doors and windows that would not open or close, to doors and windows that would not stay open or closed.

Another frequent problem was air infiltration as a result of the improper fitting of doors and windows. Thirty-five percent of the homeowners with complaints cited drafts and other air leakage as a result of improper or incomplete fitting of newly installed doors and/or windows.

Water and air leaking through the roof of the dwelling was a third area of concern. Eight percent of the people surveyed reported water and air leakage through newly installed attic vents. In some cases the leakage was a result of improper sealing of the vent; or because the method used to cut the hole in the roof was flawed resulting in the wrong size hole being cut.

The final category on the chart entitled "Other" includes comments dealing with workmanship and/or problems that only a relatively few of those surveyed mentioned. These comments included:

- "Caulking was removed and not put back in properly."
- "They left all the clean-up for us to do. Sure didn't know what they were doing."
- "The job was never inspected or completed."
- "The caulking inside the house was unnecessary and messy."
- "The pipes are freezing now and they never did before."
- "Hot water is too hot."

13.3 IN-DEPTH INTERVIEW RESULTS CONCERNING WEATHERIZATION FOLLOW-UP

Often recipients accept faulty or poor workmanship without complaint, because of a lack of awareness or understanding regarding who performed the weatherization. While about half of the clients remember being told in advance who was going to do the weatherization, 78% had no idea at the time of the interview who had done the work. While 80% said they would contact their CAA if a problem arose, of the seventeen clients (38%) indicating they had a problem only four tried to contact their CAA, with action taken on two. The 13 clients who did not contact their CAA indicated they were either too grateful to have the work done, did not want to bother anyone, or did not know who to call.

If this pattern is representative of the general weatherization population, 75% of the clients who have problems do not contact their CAA for correction. While CAA weatherization directors may consider their satisfaction rate to be high, they probably are not considering clients who are afraid to call or who do not know who to contact. Better follow-up is needed to achieve greater client satisfaction and clients should be encouraged to contact their CAA with problems.

13.4 RECOMMENDATIONS CONCERNING WEATHERIZATION FOLLOW-UP

Procedures should be implemented at the site to facilitate the identification and communication of improper installations from the client to the CAA or contractor after the crew has departed. While the majority of the work being completed is done well, there are a few common problems that can be addressed. The problems can either be addressed at the time of the weatherization or as part of follow-up activities. Specific activities which may help lessen complaints include:

- To remind homeowners that there are follow-up services provided by the CAAs to ensure work quality, a sticker or card with the CAA phone number could be provided by the weatherization crews upon job completion and displayed in a prominent location such as the client's bulletin board, refrigerator, or near a light switch. The notice would serve also to remind the householder that concerns regarding work quality could be raised at the upcoming final inspection.

- Develop a checklist that would assist the work crews in ensuring high quality work, as well as provide the householder with specific information about the work conducted. The checklist would allow the crew to check the quality of their work before they leave the site. Additionally, after the crew presented the checklist to the householder, the occupant could use the checklist to identify and/or evaluate the quality of the work. By checking out areas of concern, the occupant would retain a document which could be turned over to the CAA at the time of final inspection. This method would help ensure strong and effective follow-up by the CAA to client needs.

- The inspector's list used to check the weatherized homes may need to be revised. Critical problems which affect safety and/or comfort such as doors or windows that do not open, or leaky roofs, etc. should automatically fail a inspection.

These steps should help to alleviate some of the problems currently being experienced by the weatherization recipients and increase the positive interaction between CAA staff and the community.

APPENDIX A: WEATHERIZATION EVALUATION SURVEYS

APPENDIX A: WEATHERIZATION EVALUATION SURVEYS

Dear ______;

The Iowa State Legislature needs your help. In an effort to maintain and improve the state residential weatherization program, the Legislature is seeking information from homeowners such as yourself, whose house was weatherized last year. The Legislature has requested that the Department of Natural Resources conduct a study to learn more about the home weatherization that you received. Please take a few minutes to answer the enclosed questionnaire. We ask that the person most knowledgeable about the home and the weatherization work performed complete the questionnaire.

In order to ensure the confidentiality of your responses, we have contracted with Meridian Corporation to gather and analyze the results of the survey. Meridian is a nationally recognized research corporation with extensive experience in weatherization and energy studies. Meridian will combined your responses with the responses of other Iowa householders to provide an accurate picture of weatherization activities in Iowa.

Once you have completed the questionnaire, please mail it in the pre-addressed, postage paid envelope to Meridian. Because of time constraints, we ask that you complete the questionnaire as soon as possible.

Remember, your answers will be held strictly confidential, and they will only be used to get a better overall picture of how well the state's weatherization program operates. We sincerely thank you for your time and effort. Your thoughts are important to us as we work together to make the weatherization program a success for many Iowa homeowners. Again, thank you very much for your help.

Sincerely,

Larry Wilson
Director
Department of Natural Resources

IOWA WEATHERIZATION PROGRAM QUESTIONNAIRE

All the questions below refer ONLY to your home that received weatherization.

1) To help us better understand your home heating needs, please complete the questions below:

   a) When did you move into your home? ______ (month) ______ (year)

   b) How many rooms are in the home (do not include hallways, closets, etc.)

      1. bedroom(s) .... ______
      2. living room(s) .... ______
      3. kitchen room(s) .... ______
      4. bathroom(s) .... ______

   c) During a typical 24-hour winter day, how many rooms do you actually heat?

      1. bedroom(s) .... ______
      2. living room(s) .... ______
      3. kitchen room(s) .... ______
      4. bathroom(s) .... ______

   e) Typically, is your home occupied during the day? YES NO

   f) Typically, is your home occupied during the night? YES NO

   g) Does your home have combination or storm windows? YES NO

      IF YES, typically do you close the combination or storm windows during the winter? YES NO

   h) Do you have a thermostat in your home? YES NO

      IF YES, during an average 24-hour winter day at what temperature is the thermostat set ....

      1. during the day? ______
      2. during the evening? ______
      3. while you sleep? ______

2) Which of the following best describes the type of home in which you live? Please circle the most appropriate response.

   a) single story
   b) split level
   c) 2-stories
   d) more than 2 stories

3) Does your home have a basement? YES NO

   a) IF YES, what type of basement is it? PARTIAL FULL

   b) IF YES, do you intentionally heat the basement? YES NO

4) How did you discover your home was eligible for weatherization? Please circle the correct response(s) below.

a) watching television
b) listening to the radio
c) reading the newspaper
d) reading information sent through the mail
e) talking with friends and neighbors
f) through the utility company
g) talking with local energy assistance personnel
h) talking with state energy assistance personnel
i) filling out energy assistance forms
j) other (please specify) ________
____

5) When you discovered that your home would be weatherized, what was your reaction? Please circle the appropriate response below.

a) I was extremely displeased
b) I was mildly displeased
c) I did not care either way
d) I was mildly pleased
e) I was extremely pleased

6) Approximately how many months elapsed between the **FIRST TIME** you applied for weatherization and the time you received your weatherization?

____

7) Below is a list of reasons why some people weatherize their homes. How important were these factors in your decision to weatherize your home? Please circle the number corresponding to the level of importance you place on the particular factor, where a "1" means the factor was EXTREMELY UNIMPORTANT to you and a "5" means the factor was EXTREMELY IMPORTANT to you.

	EXTREMELY UNIMPORTANT				EXTREMELY IMPORTANT
a) improve my living comfort by reducing draftiness in the home	1	2	3	4	5
b) reduce my monthly energy bill by lowering energy use	1	2	3	4	5
c) reduce our nation's dependence on foreign oil imports	1	2	3	4	5
d) improve the appearance of my home	1	2	3	4	5
e) avoid wasting heat	1	2	3	4	5
f) possibility of losing home heating assistance funds, if I declined weatherization	1	2	3	4	5
g) because it was free	1	2	3	4	5

8) Please indicate whether you AGREE or DISAGREE with the following statements by circling the appropriate response in the right column.

a)	"After the weatherization was completed, I lowered my thermostat setting during the winter."	**AGREE** **DISAGREE**
b)	"After the weatherization was completed, I raised my thermostat setting during the winter."	**AGREE** **DISAGREE**
c)	"After the weatherization was completed, I left my thermostat unchanged."	**AGREE** **DISAGREE**
d)	"After the weatherization was completed, I installed additional energy conservation measures."	**AGREE** **DISAGREE**
e)	"After the weatherization was completed, I removed an energy conservation measure(s) because it did not work."	**AGREE** **DISAGREE**

IF YOU REMOVED ANY OF THE ENERGY CONSERVATION MEASURES BECAUSE THEY DID NOT WORK, which energy conservation measures did you remove?

____

____

____

9) How satisfied were you with the weatherization your home received? For each of the issues listed below, please circle the number corresponding to the level of satisfaction, where a "1" means you were TOTALLY <u>DIS</u>SATISFIED and a "5" means you were TOTALLY SATISFIED.

		TOTALLY DISSATISFIED				TOTALLY SATISFIED
a)	quality of the weatherization work performed	1	2	3	4	5
b)	friendliness of the persons who did the weatherization work	1	2	3	4	5
c)	length of time to complete the job	1	2	3	4	5
d)	clean up after the work was completed	1	2	3	4	5
e)	your opportunity to express your thoughts about the weatherization from time of application to completion of the work	1	2	3	4	5
f)	your being informed of what was being done to your home and why	1	2	3	4	5
g)	improving the living comfort by reducing draftiness in the home	1	2	3	4	5
h)	reducing the monthly energy bill	1	2	3	4	5
i)	improving the appearance of the home	1	2	3	4	5

10) Since your home was weatherized, have you had any problems with the weatherization materials, workmanship, or follow-up activities? YES NO

a) IF YES, please describe the problems. ______________________________

____

____

____

____

____

b) IF YES, have you informed weatherization program personnel about your problem? YES NO

IF YES, what happened? ______________________________

____

____

IF YES, were you satisfied with the results? YES NO

11) Many homes supplement their primary heating source (such as a gas or oil furnace) with heat from other sources. In order to help us find out how much energy you use from SUPPLEMENTAL HEAT sources, please indicate approximately HOW MANY HOURS EACH DAY you typically use the supplemental heating sources listed below. For any which you do not use, leave the line(s) blank.

	<u>Typically</u>, the Number of Hours Used Per Day	<u>Typically</u>, the Number of Rooms Heated Per Day
a) kitchen stove	________	________
b) woodstove	________	________
c) electric room heater	________	________
d) fireplace	________	________
e) kerosene heater	________	________
f) other (please specify)		
________________	________	________
________________	________	________

12) When you get cold at home, what are you most likely to do? (please circle the most appropriate response)

a) turn up the thermostat
b) put on an additional sweater or blanket
c) turn on a supplemental heat source such as an electric heater
d) none of the above
e) other (please specify)

____

____

____

13) **These questions refer only to the period from January 1, 1985 to the present.**

Since January 1, 1985 have any of the following activities occurred in your household? Please indicate by circling YES or NO. IF YES, please indicate the date when the activity occurred.

			IF YES, WHEN DID THIS OCCUR	
a) Have you moved from the home that was weatherized last year?	YES	NO	______ (month)	______ (year)
b) Has the number of persons living in your home permanently changed?	YES	NO	______ (month)	______ (year)
IF YES, did your household permanently increase or decrease (please circle)			INCREASE	DECREASE
c) Have you made any major additions to the size of your home such as adding a new room, dining area, etc?	YES	NO	______ (month)	______ (year)
d) Has your home ever been vacant for more than three weeks?	YES	NO	______ (month)	______ (year)
e) Have you changed the type of fuel used to heat your home? (For example, have you changed from using a natural gas furnace to using an electric baseboard heater?)	YES	NO	______ (month)	______ (year)

IF YES, what fuel change did you make?

From __________ To __________

14) For us to provide the best possible weatherization to meet the needs of Iowa's homeowners, please respond to the following brief questions about yourself and your household.

a) Circle the highest education level completed by the head of the household.

(highest grade completed) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 16+

15) Do you have any additional thoughts or observations that would help us evaluate the state's weatherization program more objectively? For example, what changes would you suggest that would make the program operate more smoothly from a homeowner's perspective? What are the most desirable and least desirable features of the program?

If you have additional thoughts or recommendations, please use the rest of this page and the back, if necessary, to express your thoughts. We wish to thank you for your time and thoughtful answers to our questions.

____

____

____

Dear ______;

The Iowa State Legislature needs your help. In an effort to maintain and improve the state residential weatherization program, the Legislature is seeking information from homeowners whose homes were weatherized last year and homeowners such as yourself, whose house will be weatherized this year. The Legislature has requested that the Department of Natural Resources conduct a study to learn more about the home weatherization program. Please take a few minutes to answer the enclosed questionnaire. We ask that the person most knowledgeable about the home complete the questionnaire.

In order to ensure the confidentiality of your responses, we have contracted with Meridian Corporation to gather and analyze the results of the survey. Meridian is a nationally recognized research corporation with extensive experience in weatherization and energy studies. Meridian will combined your responses with the responses of other Iowa householders to provide an accurate picture of weatherization activities in Iowa.

Once you have completed the questionnaire, please mail it in the pre-addressed, postage paid envelope to Meridian. Because of time constraints, we ask that you complete the questionnaire as soon as possible.

Remember, your answers will be held strictly confidential, and they will only be used to get a better overall picture of how well the state's weatherization program operates. We sincerely thank you for your time and effort. Your thoughts are important to us as we work together to make the weatherization program a success for many Iowa homeowners. Again, thank you very much for your help.

Sincerely,

Larry Wilson
Director
Department of Natural Resources

IOWA WEATHERIZATION PROGRAM
QUESTIONNAIRE

All the questions below refer ONLY to your home that will receive weatherization.

1) To help us better understand your home heating needs, please complete the questions below:

   a) When did you move into your home? ______ (month) ______ (year)

   b) How many rooms are in the home (do not include hallways, closets, etc.)

      1. bedroom(s) .... ______
      2. living room(s) .... ______
      3. kitchen room(s) .... ______
      4. bathroom(s) .... ______

   c) During a typical 24-hour winter day, how many rooms do you actually heat?

      1. bedroom(s) .... ______
      2. living room(s) .... ______
      3. kitchen room(s) .... ______
      4. bathroom(s) .... ______

   e) Typically, is your home occupied during the day? YES NO

   f) Typically, is your home occupied during the night? YES NO

   g) Does your home have combination or storm windows? YES NO

      IF YES, typically do you close the combination or storm windows during the winter? YES NO

   h) Do you have a thermostat in your home? YES NO

      IF YES, during an average 24-hour winter day at what temperature is the thermostat set ....

      1. during the day? ______
      2. during the evening? ______
      3. while you sleep? ______

2) Which of the following best describes the type of home in which you live? Please circle the most appropriate response.

   a) single story
   b) split level
   c) 2-stories
   d) more than 2 stories

3) Does your home have a basement? YES NO

   a) IF YES, what type of basement is it? PARTIAL FULL

   b) IF YES, do you intentionally heat the basement? YES NO

4) How did you discover your home was eligible for weatherization? Please circle the correct response(s) below.

a) watching television
b) listening to the radio
c) reading the newspaper
d) reading information sent through the mail
e) talking with friends and neighbors
f) through the utility company
g) talking with local energy assistance personnel
h) talking with state energy assistance personnel
i) filling out energy assistance forms
j) other (please specify) ________
____

5) When you discovered that your home would be weatherized, what was your reaction? Please circle the appropriate response below.

a) I was extremely displeased
b) I was mildly displeased
c) I did not care either way
d) I was mildly pleased
e) I was extremely pleased

6) Approximately how many months elapsed between the **FIRST TIME** you applied for weatherization and the present?

____

7) Below is a list of reasons why some people weatherize their homes. How important were these factors in your decision to weatherize your home? Please circle the number corresponding to the level of importance you place on the particular factor, where a "1" means the factor was EXTREMELY <u>UN</u>IMPORTANT to you and a "5" means the factor was EXTREMELY IMPORTANT to you.

	EXTREMELY UNIMPORTANT				EXTREMELY IMPORTANT
a) improve my living comfort by reducing draftiness in the home	1	2	3	4	5
b) reduce my monthly energy bill by lowering energy use	1	2	3	4	5
c) reduce our nation's dependence on foreign oil imports	1	2	3	4	5
d) improve the appearance of my home	1	2	3	4	5
e) avoid wasting heat	1	2	3	4	5
f) possibility of losing home heating assistance funds, if I declined weatherization	1	2	3	4	5
g) because it was free	1	2	3	4	5

8) Many homes supplement their primary heating source (such as a gas or oil furnace) with heat from other sources. In order to help us find out how much energy you use from SUPPLEMENTAL HEAT sources, please indicate approximately HOW MANY HOURS EACH DAY you typically use the supplemental heating sources listed below. For any which you do not use, leave the line(s) blank.

	Typically, the Number of Hours Used Per Day	Typically, the Number of Rooms Heated Per Day
a) kitchen stove	________	________
b) woodstove	________	________
c) electric room heater	________	________
d) fireplace	________	________
e) kerosene heater	________	________
f) other (please specify)		
____________________	________	________
____________________	________	________

9) When you get cold at home, what are you most likely to do? (please circle the most appropriate response)

a) turn up the thermostat
b) put on an additional sweater or blanket
c) turn on a supplemental heat source such as an electric heater
d) none of the above
e) other (please specify)

____
____
____

10) **These questions refer only to the period from January 1, 1985 to the present.**

Since January 1, 1985 have any of the following activities occurred in your household? Please indicate by circling YES or NO. IF YES, please indicate the date when the activity occurred.

			IF YES, WHEN DID THIS OCCUR	
a) Has the number of persons living in your home permanently changed?	**YES**	**NO**	______ (month)	______ (year)
IF YES, did your household permanently increase or decrease (please circle)			**INCREASE**	**DECREASE**
b) Have you made any major additions to the size of your home such as adding a new room, dining area, etc?	**YES**	**NO**	______ (month)	______ (year)
c) Has your home ever been vacant for more than three weeks?	**YES**	**NO**	______ (month)	______ (year)

d) Have you changed the type of fuel used to heat your home? (For example, have you changed from using a natural gas furnace to using an electric baseboard heater?)

YES NO ______ (month) ______ (year)

IF YES, what fuel change did you make?

From ________ To ________

11) For us to provide the best possible weatherization to meet the needs of Iowa's homeowners, please respond to the following brief question about yourself and your household.

a) Circle the highest education level completed by the head of the household.

(highest grade completed) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 16+

12) Do you have any additional thoughts or observations that would help us evaluate the state's weatherization program more objectively? For example, what changes would you suggest that would make the program operate more smoothly from a homeowner's perspective? What are the most desirable and least desirable features of the program?

If you have additional thoughts or recommendations, please use the rest of this page and a separate sheet, if necessary, to express your thoughts. We wish to thank you for your time and thoughtful answers to our questions.

APPENDIX B: TECHNICAL METHODOLOGY

APPENDIX B: TECHNICAL METHODOLOGY

ESTIMATING NORMALIZED ANNUAL HOUSEHOLD ENERGY CONSUMPTION

The Princeton Scorekeeping Method (PRISM), was used to measure the amount of Normalized Annual Heating-Only Savings (NAHOS) realized by individual households as a result of energy conservation measure installation. Inputs into PRISM include: utility billing histories from before and after the actual weatherization, and (2) average daily temperatures from the geographically related weather station for the same time periods. PRISM calculates a weather-adjusted index of consumption, Normalized Annual Consumption (NAC), for the pre- and post-weatherization period. The following pages contain a detailed description of the PRISM methodology, as well as the assumptions that underlie PRISM. The description was printed in Energy and Buildings, September 1986.

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PRISM: An Introduction

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(Received January 1986)

WHY KEEP SCORE?

In the past, programs designed to induce energy conservation in housing have nearly all been casual about their measurement of energy savings. In many cases, savings are unashamedly asserted without being measured: the monitors keep score with a yardstick scaled by the number of participants or number of dollars spent rather than the actual amount of energy saved, or they rely on engineering models which, lacking calibration to real-world experience, notoriously overestimate the actual savings. This is particularly distressing given that the single most important objective of these programs, the saving of energy, is intrinsically quantifiable and relatively accessible by means of energy consumption data recorded systematically for another purpose — billing. Furthermore, weather adjustments are easily made from readily available temperature data, so that effects of conservation need not be obscured by differences in weather from one year to the next.

The need for reliable scorekeeping in energy conservation is increasing. Many utilities in the U.S. have undertaken extensive retrofit assistance programs for their customers, not only because of the federal Residential Conservation Service (RCS) [1], which mandates nearly free energy audits for customers, but also because of a growing commitment to energy conservation as a utility investment strategy. RCS audits have reached millions of homes. The Low-Income Weatherization Program, federally funded but managed at the community level, is bringing to many more homes an extensive, often costly, set of retrofits in addition to the energy audit. New conservation strategies, involving monetary rewards for conservation actually achieved (for example, payments from the utilities serving the retrofitted houses to the conservation company carrying out the retrofits [2]) or shared-savings arrangements between building owner and energy service company, require the savings estimates to be both accurate and unambiguous. Finally, the homeowner, whether participating in these programs or acting independently, needs feedback on the effectiveness of his or her conservation investments.

Companies which offer conservation services invariably need help in informing the customer about how much energy — and money — his or her purchase is likely to save. With records of actual savings achieved, companies could understand, quantitatively, the value of what they sell. The resulting picture could become one of satisfied, savvy customers dealing with a company able to convey accurately the value of its own services.

IT'S EASIER THAN IT MAY SEEM

Perhaps surprisingly, keeping accurate scores on the actual amount of energy saved is straightforward, and the required data, whole-house meter readings and average outdoor temperatures, are readily available. The PRInceton Scorekeeping Method, PRISM, uses utility meter readings from before and after the retrofit installation, together with average daily temperatures from a nearby weather station for the same periods, to determine a weather-adjusted index of consumption, Normalized Annual Consumption or NAC, for each period. The procedure is depicted in Fig. 1(a). Analogous to (and, based on field measurements, clearly more accurate than) the U.S. federally mandated miles-per-gallon rating, the NAC index provides a measure of what energy con-

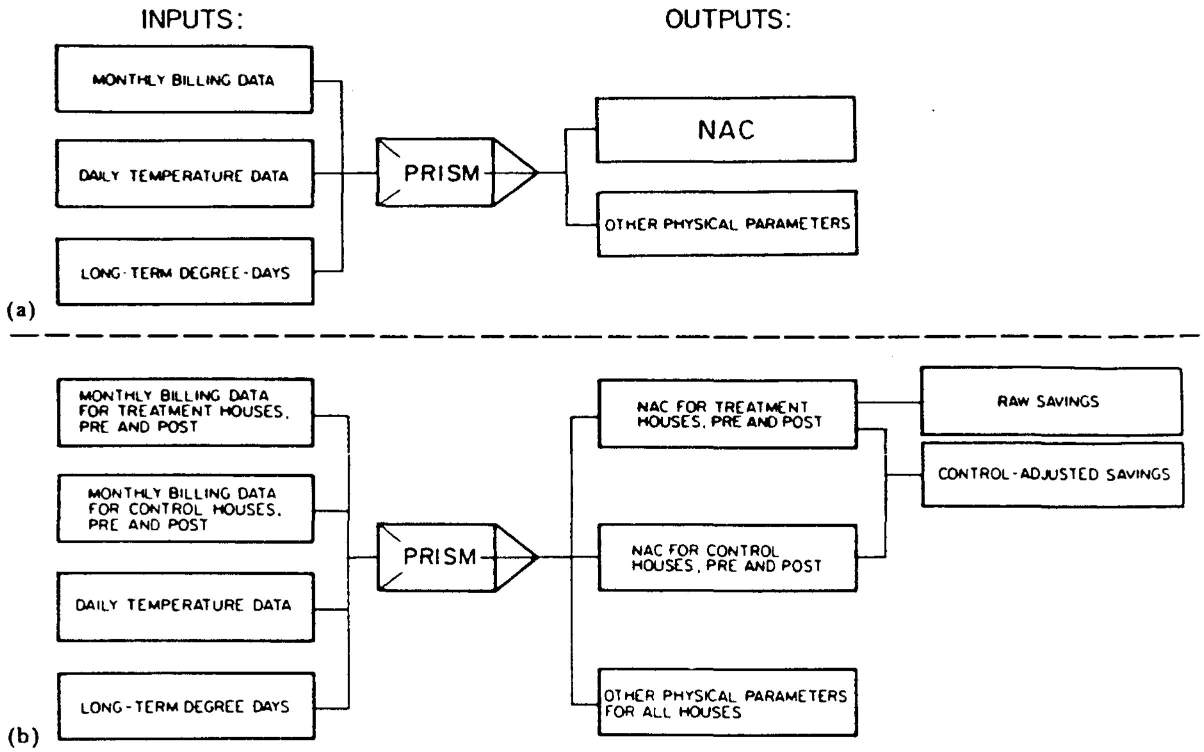

Fig. 1. Schematic diagram showing the data requirements for the Princeton Scorekeeping Method (PRISM) and the estimates that result from it: (a) the basic procedure for one house; and (b) the procedure for calculating control-adjusted savings for a group of treated houses.

sumption would be during a year under typical weather conditions. Total energy savings are derived as the difference between NAC in the pre- and post-periods. A conservation effect is thus neither masked by a cold winter nor exaggerated by a warm one, nor is it obscured if the time covered by billing periods in one "year" is longer or shorter than in another.

PRISM is certainly not the first method to include weather normalization. In fact, the simple relationship between a house's energy consumption for space heating and outside temperature was recognized, in the published literature, at least 80 years ago [3]. Even before natural gas pipelines were available, weather information was crucial input to gas dispatching and production decisions [4]. In the current literature, there is a variety of methods that have features similar to PRISM's [5].

The origins of PRISM date back to Princeton University's earliest energy analyses of buildings, in the 1970s [6, 7]. In its current form, PRISM differs from other approaches in several important ways: in its *physical foundation*, which allows a physically meaningful interpretation of the results; in its emphasis on *reliability*, particularly of the NAC index, which in general is extremely well determined; in its *standardized output*, which facilitates comparisons across programs, and its accurate *error diagnostics* attached to all the estimates it produces; in its *availability*, to a wide variety of potential scorekeepers; and, finally, in its objective of *generality*, to all fuel types and to a wide range of building types and climates.

We define the word "scorekeeping" to mean the measurement of actual energy savings. PRISM is thus a particular scorekeeping method. Its purpose is to describe the past rather than predict the future. A static model, PRISM is not appropriate, as some dynamic models are, for the management of a building — to schedule thermostat setbacks, for example. On the other hand, these dynamic models are overly complicated for scorekeeping, which requires only long-term averages of consumption, i.e., data that are readily available for large numbers of houses, or buildings in general. PRISM is designed to be a scorekeeping tool that makes the best possible use of such data.

TOWARD A STANDARDIZED APPROACH

Until recently, the haphazard array of approaches used to evaluate retrofit programs has made it impossible to compare savings from one program to another, or to aggregate the effects across programs. When the first "scores" came in from selected RCS and weatherization programs, many of them were disappointing [8]; yet, the lack of a coordinated approach has made it impossible to learn from mistakes or to plan for more effective programs in the future.

The progression of recent conferences testifies to the increased commitment to scorekeeping based on real data [9 - 14]. At an evaluation conference in Columbus, Ohio, held in 1982 (the first of its kind), many participants disputed the merits of billing data and argued the success of their programs either on the basis of number of participants or from engineering estimates of the energy saved, rather than from knowledge of actual savings achieved [9]. Since then, especially at biennial summer studies in Santa Cruz, California, the discussion of evaluation has shifted from "whether" to "how" to use real data [11, 12]. Now, as seen at the 1985 evaluation conference in Chicago, there is agreement on the importance of a standardized approach for measuring energy actually saved, and, among many, consensus on PRISM as the method of choice [14]. (Two of the several PRISM-based evaluations reported at the conference are summarized in refs. 15b and 15c, in this issue.) The seemingly inevitable, and occasionally embarrassing, shortfall of actual savings relative to engineering estimates is now part of the common experience. Further, the availability of a well tried method for measuring these savings is allowing the concern to shift to broader issues: how to choose the control group, how to use the savings estimates to evaluate a program's cost-effectiveness, and what conservation lessons can ultimately be learned from comparisons across programs.

Adjustment for the performance of a group of untreated, "control" houses can be an important part of scorekeeping, when it is desirable to decouple the savings induced by the measures of interest from the savings that would otherwise have occurred due to external events (such as increased energy prices). Evidence of extensive and continuing conservation over the decade since the Arab oil embargo, in the population at large, confirms the importance of adjusting the savings by a control group (see ref. 15p, in this issue). PRISM applied to both treatment and control houses, as shown in Fig. 1(b), gives a measure of control-adjusted as well as weather-adjusted savings for the treatment group. The analysis can then be updated for succeeding years, to track the durability of the savings (see ref. 15c, in this issue).

Invariably, an evaluation of a conservation program ought to go beyond the PRISM analysis, to determine the cost-effectiveness of various tried approaches to conservation, for example, or to clarify the reasons why some households saved more than others. The savings estimates, along with other PRISM outputs, provide reliable input to such analyses. Thus the PRISM analysis depicted in Fig. 1 may be thought of as standardized scorekeeping, representing stage one of the evaluation, while subsequent analyses, limited by available data and shaped by the specific needs of the project being evaluated, constitute stage two.

In this special double issue, PRISM is presented as a standardized, easy-to-use approach which utilities, communities, researchers and entrepreneurs throughout the country can adopt for measuring energy savings. Fifteen applications of PRISM are reported, ranging from specific studies of the interpretation of PRISM parameters to full-scale evaluations of retrofit programs [15].

A brief outline of these papers is given at the end of this introductory paper. We present now a description of the method: its physical rationale, the statistical procedure underlying it, and a sample savings analysis to illustrate its use. Our description here is fairly detailed; it is intended to serve as a reference for the other papers. The occasional variation on the method presented here is identified in the relevant paper.

SUMMARY OF THE METHOD

The Princeton Scorekeeping Method (PRISM) is a statistical procedure for calculating changes in energy consumption over time. For each house (or building) being analyzed, the procedure requires meter readings (or, for fuel oil, delivery records) for approximately one year in each period of interest. The consumption data are then corrected for the effects of weather, which of course is never the same for two different years, and also for differences in the time spanned by the different periods.

PRISM differs from other weather-normalization procedures in that the house's break-even temperature is treated as a variable, rather than a constant such as 18.3 °C (65 °F). Three physical parameters result from the model applied to the billing data for the heating fuel* of an individual house: *base-level consumption*, as a measure of appliance usage in the house; *reference temperature*, as a reflection of interior-temperature settings; and *heating slope*, as a measure of the lossiness of the house. Derived from these parameters, the NAC index is the reliable estimate of the consumption which would occur in a year of typical weather.

The physical basis for the model

Generally, whether for natural gas, oil or electricity, a house's heating system is first required when the outdoor temperature (T_{out}) drops below a certain level (the heating reference temperature τ), and for each additional degree drop in temperature a constant amount of heating fuel (the heating slope β) is required. Thus, the required heating fuel is linearly proportional to $(\tau - T_{out})$, and the proportional constant β represents the house's effective heat-loss rate. In addition, the house may use a fixed amount of the heating fuel per day (the base level α) in an amount independent of T_{out}. Formally, the expected fuel consumption per day, f, as illustrated in Fig. 2 for an idealized house, is given by

$$f = \alpha + \beta(\tau - T_{out})_+ \qquad (1)$$

*We use the word "fuel" to mean electricity as well as natural gas, fuel oil, or any external energy source.

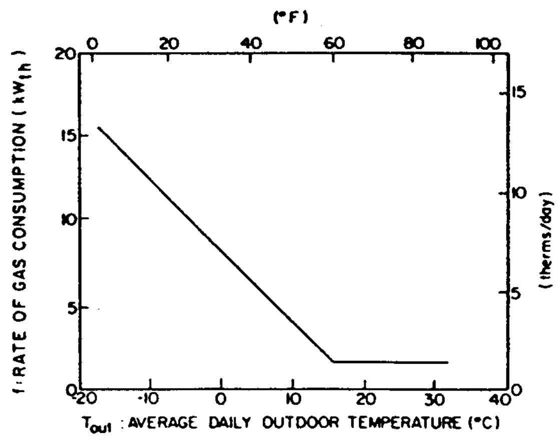

Fig. 2. Daily gas consumption (f) as a function of outdoor temperature (T_{out}), for a single idealized house. The house's energy signature is defined by a base level of 2.0 kW$_{th}$ (equivalent to 1.7 therms/day in natural-gas units), a heating slope of 480 W$_{th}$/°C (0.22 therms/°F-day), and a reference temperature of 15.6 °C (60 °F).

where the term in parentheses is the heating degree-days h to base τ, i.e., $h(\tau)$, and the "+" indicates zero if the term is negative. This relationship is derived in Appendix 1.

The derivation of eqn. (1) leads to a simple physical interpretation for each of the three parameters. The reference temperature τ, which will vary from house to house, is likely to be influenced primarily by the indoor temperature T_{in} (which may be regulated by a thermostat setting)* and, in addition, an offsetting contribution from intrinsic gains (i.e., heat generated by appliances, occupants, and the sun). The heat-loss rate β depends on the conductive and infiltration heat losses, and, inversely, on the furnace efficiency, while the base level α represents the fuel requirements of appliances (including lights, for electricity, and the water heater if fueled by the heating fuel).

If τ is not accurately determined, or if it changes significantly over the time periods studied, the error or change in τ will inversely affect α, and β as well. Figure 3 illustrates this for the idealized house by plotting f vs. $h(\tau)$ for one correct and two incorrect values of τ. A straight-line fit through each set of points will have a different slope and

*In a large centrally heated building, the main boiler may be directly controlled by the outdoor temperature rather than a thermostat, thus replicating the constant-τ assumption of PRISM. Such a building is the subject of a paper in this issue [15f].

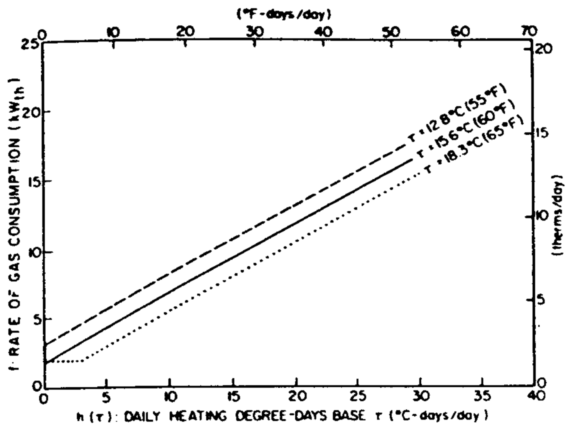

Fig. 3. Daily gas consumption (f) as a function of degree-days base τ [$h(\tau)$], for a single idealized house. The three curves correspond to the same consumption and temperature data, with degree-days calculated to different bases τ.

intercept. Therefore, an assumed (incorrect) reference temperature, such as the value of 18.3 °C so commonly used, is likely to lead to less physically meaningful values of the base level and the heat-loss rate.

Individual-house analysis

Based on this physical interpretation, the two data requirements for the analysis are actual meter readings (approximately monthly), from which consumption is calculated, and local average outdoor temperatures (daily), from which heating degree-days to different reference temperatures are computed in exact correspondence to the consumption periods. Generally, the most reliable results are obtained from a year's data [15n]. The input to the procedure is then F_i and H_i where:

F_i = average daily consumption in time interval i

$H_i(\tau)$ = heating degree-days per day computed to reference temperature τ in time interval i.

Here F_i is computed as the consumption in interval i divided by N_i, the number of days in that interval, and $H_i(\tau)$ is computed from T_{ij}, the average daily outdoor temperature for the jth day of interval i, over N_i days, i.e.,

$$H_i(\tau) = \sum_{j=1}^{N_i} (\tau - T_{ij})_+ / N_i \tag{2}$$

The set of data points $\{F_i\}$ and $\{H_i\}$ for an approximately year-long period are then fit to a linear model:

$$F_i = \alpha + \beta H_i(\tau) + \epsilon_i \tag{3}$$

where ϵ_i is the random error term. For a guessed value of reference temperature τ, the base-level and heating-slope parameters α and β are found by standard statistical techniques (ordinary least-squares linear regression). Using an iterative procedure based on Newton's method [16], "best τ" is found as the value of τ for which a plot of F_i vs. $H_i(\tau)$ is most nearly a straight line. Formally, τ is determined as the value for which the mean-squared error is minimized, or equivalently for which the R^2 statistic is highest. The corresponding values of α and β are the best estimates of base level and heating slope*.

The application of PRISM to real data is illustrated in Fig. 4, for a gas-heated house. The gas consumption data, F_i, plotted against time in Fig. 4(a), fall into a very straight line in Fig. 4(b) when plotted against heating degree-days H_i computed to best τ, the reference temperature determined by the model. The complete PRISM results for this house and this period are given in Table 1. At 0.985, the R^2 statistic indicates a very good straight-line fit, corresponding to the line drawn in Fig. 4(b).

The house's index of consumption for its heating fuel, NAC (Normalized Annual Consumption), is obtained from the model parameters, α, β and τ, applied to a long-term (say, ten-year) annual average of heating degree-days. NAC is calculated as follows:

$$\mathrm{NAC} = 365\alpha + \beta H_0(\tau) \tag{4}$$

where $H_0(\tau)$ is the heating degree-days (base τ) in a "typical" year Once a normalization period is established, the values of H_0 over the range of possible τ require a one-time cal-

---

*The SI units we recommend for PRISM parameters are: kW for α, W/°C for β, °C for τ, and GJ/year for NAC and other annual consumption estimates. Fuel-resource energy (for natural gas and oil) and site electrical energy are differentiated by the subscripts "th" for thermal and "elec" for electrical, respectively. The corresponding imperial units (therms for natural gas, etc.) are given in the list of conversion factors in the Foreword to this issue.

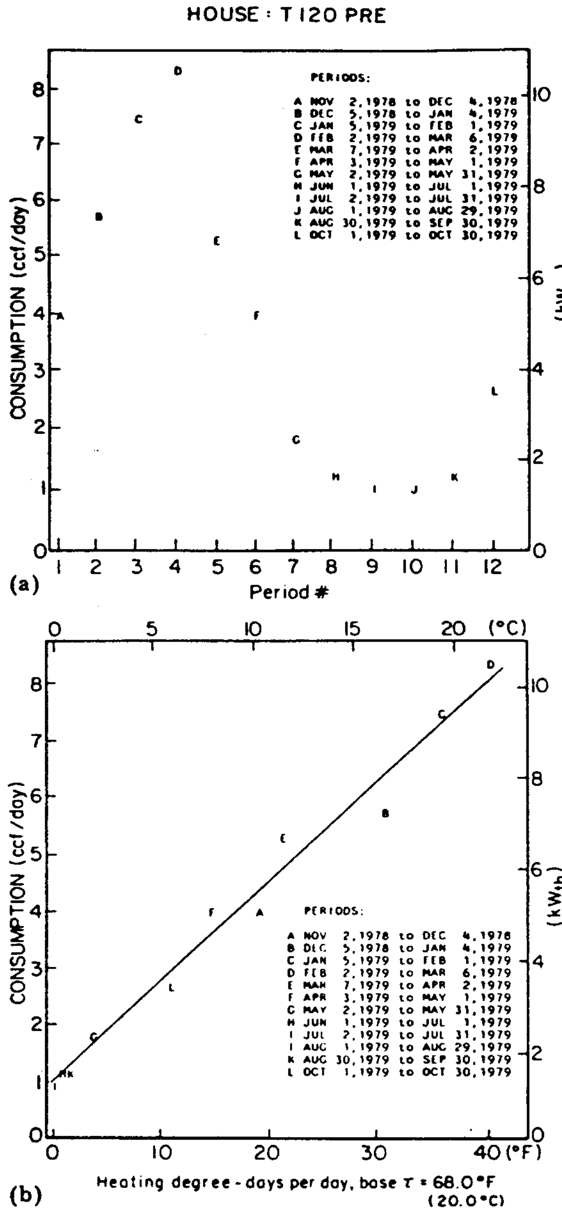

Fig. 4. Plots of consumption data (F_i) for sample gas-heated house in New Jersey. In (a) F_i is plotted against i, the (monthly) time period; in (b) F_i is plotted against $H_i(\tau)$, i.e., heating degree-days computed to best τ determined by PRISM. The straight line is the least-squares fit of the data, giving the results shown in Table 1.

culation only for each weather station used*. For standardization, we recommend a consistent normalization period; we use the twelve-year period from 1970 through 1981.

*Daily temperature data to compute H_i for each period and H_o for the normalization period, to any integer value of τ, are available from the National Weather Service for the appropriate weather station [17]. Degree-days to non-integer τ are found by linear interpolation.

TABLE 1

Sample PRISM results for a gas-heated house*

τ	= 20.0 (±1.5) °C [68.0 (±2.8) °F]
α	= 1.12 (±0.33) kW$_{th}$ [0.90 (±0.26) ccf/day]
β	= 400 (±30) W$_{th}$/°C [0.18 (±0.01) ccf/°F-day]
βH_o	= 107.1 (±9.1) GJ$_{th}$/year [996 (±84) ccf/year], or 75% of NAC
NAC	= 142.5 (±4.0) GJ$_{th}$/year [1324 (±37) ccf/year]
R^2	= 0.985

*The sample gas-heated house is house T120 from the Modular Retrofit Experiment [15a]. The estimates are derived from PRISM applied to the pre-retrofit consumption data shown in Fig. 4. Each number in parentheses is the standard error of the estimate.

Reliability of the estimates

In general, the NAC estimate provides a reliable consumption index from which energy savings and conservation trends may be accurately estimated. The small standard error of NAC for our sample house, at 3% of the estimate, is typical of PRISM results. On the other hand, the three parameters, α, β and τ, which define a house's energy signature, are less well determined, as is confirmed by the standard errors for the sample house (Table 1) as well as by other studies in this issue (see Table 2 of ref. 15k). As a result, the parameters' changes over time are often difficult to interpret due to the interference of physical and statistical effects.

The stability of the NAC index is evident in Fig. 5, which shows, for the sample house, the progression of NAC as the estimation year is slid forward one month at a time. The drop in consumption after the retrofit is evident. Note the larger standard errors of NAC for the periods falling between the pre- and post-retrofit periods. In general, NAC is quite insensitive to exactly which months are included. (The gap in the plot reflects an inevitable characteristic of real-world data sets, namely, estimated or missing readings.) The analogous plots for the individual parameters demonstrate the temporary instability as the estimation window passes through the retrofit period, and thus the importance of excluding the retrofit period from the estimation periods used for scorekeeping (see examples in ref. 15f, in this issue).

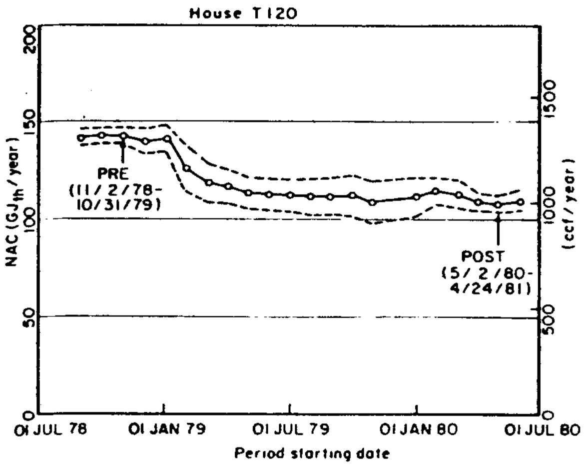

Fig. 5. Illustration of sliding PRISM, in which the one-year estimation period, starting on the date indicated, is moved forward one month at a time. NAC estimates are shown, for the sample gas-heated house used for Fig. 4 and Table 1. Dashed lines give standard errors of the estimate. Pre- and post-retrofit periods used for scorekeeping are indicated.

When a continuous series of consumption data is available, a sliding analysis such as this one can be a powerful tool not only for selecting the final estimation periods, but also for flagging anomalies in the data, and, more generally, for monitoring gradual changes in consumption. This technique has been used in a systematic study of the stability of PRISM parameters (see ref. 15n, in this issue).

While it is tempting to attribute a change in α to water-heater wrap or more efficient appliances, for example, or a drop in $\beta H_o(\tau)$ to added ceiling insulation or other measures to tighten the structure (through β) or to lowered thermostat settings (through τ), such simple physical inferences from individual-house results are usually not valid (see Appendix 1). For one thing, events affecting only one parameter are not likely to occur in isolation. For another, PRISM's assumptions that α, β and τ are constant on average from month to month over a year-long estimation period are not likely to hold perfectly in any real house. The change in the temperature-dependent component of NAC, $\beta H_o(\tau)$, is usually better determined than the change in β or τ individually, just as NAC is better determined than either that component or the base-level component, 365α. Nevertheless, the effect of the seasonal variability of appliance and water-heater usage, investigated elsewhere in this issue [15m], interferes with the interpretation of these components.

As is well demonstrated by the studies reported in this special issue, NAC is a reliable and stable *index* of consumption. At best, the other PRISM parameters provide physically meaningful *indicators*, whose changes may not be statistically significant but whose behavior can often suggest the reason for a consumption change. The need for careful interpretation of these indicators is an important theme of this issue. Accurate standard errors for all the parameters [α, β, τ, $\beta H_o(\tau)$, and NAC] are part of the standard PRISM output. Developed for this model, the "composite" method for estimating the errors includes the uncertainty in the estimation of τ as well as the estimation error from fitting eqn. (3) [16]. It turns out that α and β are much more sensitive to variations in τ than is NAC (see Fig. 2 of ref. 15k). Even in extreme cases when one or more of the parameters is poorly determined, the standard error of NAC is usually only 2 - 4% of the estimate*. This stability of NAC is PRISM's most important feature.

Estimation of group savings

The NAC estimate provides the basic index for measuring energy savings, in groups of houses from one to thousands. Computed as the change in NAC between two periods of interest, the savings estimates are weather-adjusted, and thus are independent of changes in the weather between the two periods.

When adjustment by a control group is needed, an ideal control group is one constructed by random selection of participants from a larger set, where some or all of those not selected for treatment become the controls. (This approach is used in ref. 15a.) Often such advanced planning is not possible. A less ideal though generally adequate pro-

*NAC can be reliable even in the event of an extreme anomaly, for example, when best τ is established at the highest value of daily temperature for the estimation period. (The associated standard error of τ is infinite.) Only two such anomalies occurred in the data set of 276 cases from which the example in Fig. 4 was taken [15a]. For each of the two cases, only six (bimonthly) data points were available. In both cases, NAC was well determined: the standard errors of NAC were 3.0% and 6.0% of the estimate, and the corresponding R^2 values were 0.99 and 0.94, respectively.

cedure is to match non-participants to participants after the fact, so that the control and treatment groups have similar profiles, defined, for example, by energy consumption (i.e., pre-retrofit NAC), energy prices, household size and income, and house area. Another possible, and less cumbersome, alternative is to make the aggregate of the utility serving the retrofitted houses into a surrogate control group (see Table 7 of ref. 15a, and ref. 15p).

The scorekeeping procedure presented here includes both weather and control adjustments. Using billing and weather data for approximately year-long periods before and after (and not including) the period during which the retrofits were performed, PRISM is applied to each control and treatment house included in the program. From the resulting NAC_{pre} and NAC_{post} estimates, representing respectively a house's NAC for the pre- and post-retrofit periods, the raw, weather-adjusted savings for each house is then computed as:

$$\text{(absolute)} \quad S_{raw} = NAC_{pre} - NAC_{post} \qquad (5a)$$

$$\text{(percent)} \quad S_{raw,\%} = (1 - NAC_{post}/NAC_{pre}) \times 100 \qquad (5b)$$

From the individual-house estimates, average values (medians or means*) are calculated for each group: $NAC_{pre}(T)$, $NAC_{post}(T)$, $S_{raw}(T)$ and $S_{raw,\%}(T)$ for the treatment group, and $NAC_{pre}(C)$, $NAC_{post}(C)$, $S_{raw}(C)$ and $S_{raw,\%}(C)$ for the control group. The savings for the treatment group (or for an individual treated house) may then be adjusted by the control houses, as described in Appendix 2, to give $S_{adj}(T)$ and $S_{adj,\%}(T)$.

It is important to know the errors associated with the various savings estimates. For a group of houses, the standard error of the median provides a robust measure of whether the savings in the treatment group(s) are distinguishable from the savings in the control group. For individual houses, the standard error of each savings estimate is readily computed from the standard error of NAC for each house, as given in Appendix 3.

*Although either median or mean values of NAC may be used, we recommend the median as the more 'robust' (i.e., insensitive to outliers) measure of the center of a group's distribution, and the standard error of the median as the measure of its accuracy (see Appendix 3).

SAMPLE SCOREKEEPING ANALYSIS

Our sample house (Table 1 and Figs. 4 and 5) is one of the 58 "house doctor" houses in the Modular Retrofit Experiment (MRE), a collaborative project between Princeton University and the natural gas utilities in the New Jersey area (see ref. 15a). The control group consisted of 40 additional houses. To illustrate the scorekeeping approach, we start from the savings estimated for the single house and continue through the computation of control-adjusted savings for the entire house-doctor group.

As indicated in Fig. 5, for the pre- and post-retrofit periods indicated, NAC for the sample house dropped from $NAC_{pre} = 142$ (± 4) GJ_{th}/year to $NAC_{post} = 107$ (± 4) GJ_{th}/year. The resulting raw savings were*:

$S_{raw} = 35(\pm 6) GJ_{th}/\text{year}$

or, relative to NAC_{pre}

$S_{raw,\%} = 25(\pm 4)\%$

The small standard errors in the savings indicate that the savings were significant.

This house saved more than the average house in the house-doctor group, for which the median savings were*:

$S_{raw}(T) = 21(\pm 3) GJ_{th}/\text{year}$

or, relative to NAC_{pre}

$S_{raw,\%}(T) = 15(\pm 2)\%$

The median savings in the control group were considerably lower, though far from negligible:

$S_{raw}(C) = 14(\pm 3) GJ_{th}/\text{year}$

or,

$S_{raw,\%}(C) = 10(\pm 1)\%$

The median control-adjusted savings for the house-doctor group, computed by the procedure described in Appendix 2, were:

$S_{adj}(T) = 9(\pm 2) GJ_{th}/\text{year}$

or,

$S_{adj,\%}(T) = 8(\pm 1)\%$

*The number in parentheses for the individual-house savings is the standard error of the corresponding estimate. The number in parentheses for the group savings (T or C) is the standard error of the corresponding sample median (see Appendix 3).

As has been the case in other retrofit programs, the control adjustment substantially deflates this experiment's raw savings. Nevertheless, the savings in the house-doctor group relative to the control group were highly statistically significant (see ref. 15a).

OTHER APPLICATIONS

The accuracy of the estimates from our sample analysis is typical of other applications of PRISM, both to gas-heated and oil-heated houses and to electrically heated houses without cooling. Summaries of model performance are found elsewhere in this issue (for example, refs. 15a and 15b for natural gas, ref. 15k for oil, and refs. 15c and 15h for electricity). For houses in heating-dominated climates, we have found R^2-values to average 0.97, and standard errors for NAC to average 3 - 4% of the NAC estimate. Even in the face of some anomalies in the individual-parameter results, NAC and the corresponding savings estimates are usually stable and reliable.

The model used in the above example, and in almost all papers in this issue, is the "heating only" PRISM model for individual houses. Two adaptations of this model have also been developed, for individual houses with electric cooling as well as heating [15h], and for large aggregates of gas-heated houses for which only total utility sales data are available [15p]. For the former, cooling analogues of β and τ are added to the model in eqn. (3). For the latter, a variation of $H_i(\tau)$ in the same equation is used to account for the billing lag. For both adaptations, NAC is on average as well determined as it is in individual-house, heating-only applications.

OVERVIEW OF THE ISSUE

PRISM was first developed for our own buildings research program. Its 1982 application to the Modular Retrofit Experiment is presented in this special issue as a prototype PRISM-based evaluation [15a]. Since then, PRISM has been widely applied to other groups of single-family houses. The Statistics Laboratory at the University of Wisconsin has used PRISM for the evaluation of Wisconsin's low-income weatherization program involving 1000 houses [15b]. Researchers at Oak Ridge National Laboratory are using PRISM as stage one of a two-stage approach, to evaluate RCS and other utility conservation programs, such as Bonneville Power Administration's Residential Weatherization Pilot Program [15c]. The Center for the Biology of Natural Systems at Queens College has applied PRISM to a smaller sample of houses in New York City, for a detailed comparison of two approaches to low-income weatherization [15d]. The method is being used extensively in Minnesota to monitor the success of a variety of city and state programs; using PRISM, the Minneapolis Energy Agency has carried out a definitive comparison of predicted vs. actual savings from RCS retrofits [15e].

Recently, researchers have begun to recognize the almost untapped resource of energy savings in multifamily buildings. In apartments in New Jersey, for example, the average energy usage per unit floor area may be double what it is in single-family houses, in spite of potential benefits from common walls in apartments*. As part of its shift in research emphasis from single-family to multifamily buildings, the Center for Energy and Environmental Studies at Princeton has extensively instrumented a 60-unit gas-heated apartment building in Asbury Park, New Jersey [15f]. High interior temperatures coupled with an unusual boiler configuration challenge the interpretability of the PRISM estimates; an engineering analysis of additional data provides an improved understanding of the results. Lawrence Berkeley Laboratory's study of a complex of apartment buildings in the San Francisco Housing Authority offers another test of the applicability of PRISM to large multifamily buildings [15g].

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*For example, the per-unit NAC in a 126-unit gas-heated apartment complex in New Jersey gave 3.5 GJ_{th}/m^2 before a major retrofit and 1.7 GJ_{th}/m^2 after it [18], vs. 0.9 GJ_{th}/m^2 [15p] for the average gas-heated customer in the state. (The comparison assumes an average area of 150 m^2 per house, vs. 65 m^2 measured for the apartment complex.) The 60-unit building studied in this issue showed a similarly high average NAC per unit area [15f].

Whereas the methodology development initially emphasized gas-heated houses, special problems relating to other fuels have been the focus of recent research. Analysis of electrically heated houses can be confounded by electric cooling, even in a heating-dominated climate [15h], or by the presence of a heat-pump system which, to some extent, violates the assumptions underlying PRISM [15i]. Otherwise, gas and electricity have much in common: the data bases of monthly (or bimonthly) meter readings are equally accessible, and the seasonal dependence of non-heating consumption has a similar effect on the PRISM parameters for both fuels [15m]. Further, the effect of supplemental heating by wood on a PRISM analysis of the consumption of a conventional heating fuel is likely to be independent of whether the fuel is gas or electricity; the effect is explored here for electrically heated houses in the Portland, Oregon, region [15j]. Oil heating poses a new set of problems, not the least of which is infrequent, unevenly spaced deliveries [15k]. For any fuel, sufficent data over a year or more are needed for PRISM to work reliably; a systematic study of the stability of the model parameters provides some guidelines concerning PRISM data requirements [15n].

Often, anomalies that occur for individual houses are no longer evident in aggregated PRISM results. One short-cut aggregate approach is to apply a variation of PRISM to total utility sales data for residential heating customers (gas or electricity); extensive analysis of gas-heating customers in New Jersey has yielded promising results [15p]. Taking the analysis a step further, for the same data set and for another group of houses, the relative roles of two possible sources of conservation — shell tightening and lower thermostat settings — are inferred from the PRISM analyses [15q].

In all of these studies, NAC emerges as an extremely reliable index of consumption. The other PRISM parameters provide useful indicators of the components of NAC, but they require a sensitive interpretation with a careful consideration of their errors.

The fifteen papers presented in this special double issue provide convincing evidence that a simple method applied to whole-building billing data can become a powerful consumption monitoring, or scorekeeping, tool. The papers report progress on a particular method, PRISM. It would be naive to expect all houses, and especially the people occupying them, to obey the simple principles embodied by this method. Nevertheless, the truth told by actual meter readings, the basis of PRISM, cannot be ignored. The success of the studies thus far confirms that PRISM, though not without room for improvement, is a particularly useful way of extracting scorekeeping information from billing data.

FUTURE DIRECTIONS

The papers in this special issue emphasize applications of PRISM to conventional housing in heating-dominated climates; for climates in which the energy used for cooling rather than heating dominates, and for houses with a large solar component in their design, more research is needed. The studies in this issue focus on the fuel (gas, electricity, oil) used for space heating; in future work, the method should allow for the interaction between fuels when more than one fuel is used in a house by its furnace and appliances ("total energy scorekeeping"). The statistical procedure used for PRISM analyses is based on least-squares regression; more robust techniques, under development, would reduce the influence of anomalous data and improve the reliability of the estimates. The data bases for the analyses are primarily energy bills; the extent to which the value of billing data will be enhanced by additional data available from instrumentation, such as submeters and temperature sensors, needs to be explored. Thus far, the studies demonstrate the applicability of PRISM at two levels of analysis, to individual-house data for large samples of houses, and to utility aggregate data representing large fractions of the population; in between these two extremes, there may be additional strategies for dealing with large numbers of houses, such as clever statistical sampling of the houses being monitored, or substation or trunk-line metering to represent community-level consumption.

The primary objective of our current scorekeeping research is to realize the full potential of billing data for monitoring consumption in all climates and building types. The most productive approach, for addressing these scorekeeping concerns and ultimately for learning about the effectiveness of conservation measures, will be studies of actual consumption data. We anticipate that the best research laboratory for these studies will continue to be real-world conservation projects.

APPENDIX 1

Derivation of physical model underlying PRISM

The space heating energy, E_h, required to maintain a house at temperature T_{in}, is proportional to the difference $(T_{in} - T_{out})$, where T_{out} is the outdoor temperature. The proportionality constant L represents the lossiness of the house. Thus, when $T_{out} < T_{in}$,

$$E_h = L(T_{in} - T_{out}) \quad (A1)$$

The lossiness has two contributions, from air infiltration losses L_i and from transmission losses L_t, i.e., $L = L_i + L_t$*. Some of this heating is supplied by the house's intrinsic gains Q, representing heat gains from appliances, occupants and the sun**, and the rest by an amount of fuel f_h burned at efficiency η, i.e.,

$$E_h = \eta f_h + Q \quad (A2)$$

Therefore, the required external fuel for space heating is

$$f_h = L(T_{in} - T_{out})/\eta - Q/\eta \quad (A3)$$

which may be rewritten:

$$f_h = \beta(\tau - T_{out}) \quad (A4)$$

where

$$\beta = L/\eta \quad (A5)$$

and

$$\tau = T_{in} - Q/L \quad (A6)$$

Thus the house's reference temperature τ (the outdoor temperature below which external fuel is required for heating) is below T_{in}, by an amount proportional to the house's intrinsic gains.

If the heating fuel is also used for other purposes such as water heating, appliances, and (for electricity) lighting, at a rate α, then the rate at which heating fuel is consumed per day is given by:

$$f = \alpha + \beta(\tau - T_{out}) \quad (A7)$$

for $T_{out} < \tau$. This is the relationship shown in Fig. 2, and corresponds with eqn. (1) in the text (see also refs. 6 and 7).

In a single-family house, the usual control system is a thermostat, which regulates the indoor temperature T_{in}. In this case, the constant-τ assumption of PRISM requires that several factors be constant from month to month: average indoor temperature T_{in}, average internal gains Q, and average house lossiness $L = \eta\beta$ (see eqn. (A6)). The constant-β assumption requires that L and η do not vary on average from month to month (see eqn. (A5)). The constant-α assumption requires non-varying energy usage for appliances, etc., fueled by the heating fuel.

Given these assumptions, several classes of interventions will induce predictable changes in α, β, and τ. Reduction of monthly average thermostat settings will decrease τ. Structural retrofits will affect β and τ: in an ideal house (seen through PRISM), a decrease in L will decrease both β and τ. An improved furnace efficiency η will also decrease β. A shift to more efficient appliances will lower α. However, by decreasing internal gains Q, this shift will increase τ (leaving β unchanged), and thus lead to an increased requirement for heating fuel that will partially offset the benefits from more efficient appliances. Any change in Q will affect τ: the addition of a household member might lower τ, for example, whereas the shift to a more efficient appliance (fueled by the heating or a non-heating fuel) will raise τ.

These theoretical expectations are valid for the ideal house such as was used in Fig. 2. When PRISM is run on real data, for which α, β and τ are not truly constant over any

*The transmission lossiness $L_t = \Sigma U_j A_j$, where A_j is the area of each exposed surface, and U_j is the corresponding transmission coefficient. To a good approximation, the infiltration lossiness $L_i = V\rho C_p$, where V is the volume flow rate of outdoor air entering the building, ρ is the density of air and C_p is the heat capacity of air; this ignores moisture-related heat loss (due to latent heat to evaporate water inside the house). See Chapter II of ref. 6, as well as the discussion in ref. 15f, in this issue.

**Our definition of intrinsic gains adds solar gains to the comprehensive list compiled by Shurcliff [19].

estimation period, statistical covariance among the three parameters often interferes with simple associations between known interventions and the observed trends in the parameters. The problem is particularly acute when the periods of estimation include major changes. Pre-retrofit and post-retrofit periods should therefore be selected to exclude interventions wherever possible.

APPENDIX 2

Computation of group savings estimates

We let the notation $[X]|_T$ and $[X]|_C$ represent the median (or mean) of the set of values of the quantity X for the treatment (T) or control (C) group, respectively.

In analogy with the individual-house savings in eqns. (5a) and (5b), the raw, weather-adjusted savings for the treatment group is given, in absolute terms, by:

$$S_{raw}(T) = [NAC_{pre} - NAC_{post}]|_T \qquad (A8a)$$

and, in percent terms relative to NAC_{pre}, by

$$S_{raw,\%}(T)/100 = [1 - NAC_{post}/NAC_{pre}]|_T \qquad (A8b)$$

Using similar pre- and post-periods, raw savings for the control group are analogously given by:

$$S_{raw}(C) = [NAC_{pre} - NAC_{post}]|_C \qquad (A9a)$$

and

$$S_{raw,\%}(C)/100 = [1 - NAC_{post}/NAC_{pre}]|_C \qquad (A9b)$$

To adjust the savings in the treatment group by the control, we define a control-adjustment factor:

$$C_{adj} = [NAC_{post}/NAC_{pre}]|_C \qquad (A10)$$

Then the control-adjusted savings of the treatment group are obtained by the following:

$$S_{adj}(T) = [C_{adj} \times NAC_{pre} - NAC_{post}]|_T \qquad (A11a)$$

and

$$S_{adj,\%}(T)/100 = [C_{adj} - NAC_{post}/NAC_{pre}]|_T \qquad (A11b)$$

which can be simplified for a single treatment and control group as

$$S_{adj,\%}(T) = S_{raw,\%}(T) - S_{raw,\%}(C) \qquad (A11c)$$

These formulae apply to an individual treated house (i.e., to a treatment group of one) as well as to the entire group. (For the MRE results presented earlier and in ref. 15a, eqn. (A11b) was applied individually to each location (module), for which a separate C_{adj} was calculated.)

APPENDIX 3

Standard errors of savings estimates

The standard errors of the savings estimates are obtained from the standard errors of NAC_{pre} and NAC_{post}, i.e., $se(NAC_{pre})$ and $se(NAC_{post})$, which are computed by a method developed for PRISM [16] and are included in the standard output for each house analyzed. For an individual house:

$$se(S_{raw}) = [se^2(NAC_{pre}) + se^2(NAC_{post})]^{1/2} \qquad (A12)$$

$$se(S_{raw,\%})/100 = \{(NAC_{post})^2[se^2(NAC_{pre})]/(NAC_{pre})^4 + [se^2(NAC_{post})]/(NAC_{pre})^2\}^{1/2} \qquad (A13)$$

where S_{raw} and $S_{raw,\%}$ are computed from eqns. (5a) and (5b), respectively.

When a group of houses is analyzed, the center of the distribution of the quantity X may be represented by either the mean or median value of X, i.e., by mean(X) or median(X). For each measure, there are corresponding measures of the width of the distribution of X: the standard deviation, sd(X), is generally used with mean(X), and the interquartile range, IQR(X), i.e., the length of the interval containing the middle 50%, with median(X).

The standard error of the sample mean, se[mean(X)], gives a measure of the variability of the sample mean. For a group of N houses, this is computed from sd(X) as follows:

$$se[mean(X)] = sd(X)/\sqrt{N} \qquad (A14)$$

In direct analogy with eqn. (A14), the standard error of the sample median may be computed from IQR(X):

$$se[median(X)] = IQR(X)/\sqrt{N} \qquad (A15)$$

This provides a measure of the variability of the sample median*. For a given quantity X, eqn. (A14) or (A15), respectively, tells how accurately the mean or median has been estimated for the larger group of houses from which the study group was drawn. Thus two alternative representations for the center of the distribution of X for a set of houses may be written:

$\text{mean}(X) \pm \text{se}[\text{mean}(X)]$

and

$\text{median}(X) \pm \text{se}[\text{median}(X)]$.

In that they are more insensitive to outliers, the median measures (median value, interquartile range, and standard error of the sample median) are robust alternatives to the mean measures (mean value, standard deviation, and standard error of the sample mean). Since outliers may strongly influence the mean value, in an amount that may substantially distort the resulting representation of a group's savings (for $X = \text{NAC}_{\text{pre}} - \text{NAC}_{\text{post}}$), the median measures are usually more meaningful. On the other hand, mean measures are occasionally more convenient, since classical t-tests of significance are readily available for them. In addition, a comparison of the mean and median values is often useful, for obtaining a sense of the skewness of the distribution.

For scorekeeping, we recommend computation of both sets of measures for the quantities of interest. In general, we rely on the median measures, after they have been compared with the mean measures.

For the sample scorekeeping analysis presented in the text, the standard errors of the savings for the single gas-heated house were computed from eqns. (A12) and (A13); these represent measurement errors. The standard error of the sample median of the house-doctor group's savings, from eqn. (A15), was used to represent a measure of the variation across houses. To some extent, the latter includes the effect of the measurement error for each house (eqns. (A12) and (A13)), which is generally, for all PRISM parameters, much smaller than the corresponding estimate's variation from house to house.

*The standard error of the median is a new quantity inferred from other work [20, 21]. Use of eqns. (A14) and (A15) for the standard error of the mean or of the median implicitly assumes that the errors in estimating a given quantity in different houses are uncorrelated. If this assumption is invalid, these formulae understate the uncertainty of their respective mean and median estimates, though not by much if (as is usually the case) the measurement errors are small relative to the house-to-house variation of the estimate.

REFERENCES

1 U. S. Department of Energy, Residential Conservation Service Program: Final Rule, *Federal Register, 47* (123) (June 25, 1982) 27752 - 27803; see also *National Energy Conservation Policy Act, Public Law 95 - 619*, Part 1 of Title II, 1978.

2 The Bradley Plan: Home energy conservation program, *Congressional Record, 125* (107) (July 31, 1979) 10950 - 53, Washington, DC; see also *Energy Security Act, Public Law 96-294*, Subtitle C of Title V, 1980.

3 Examples of early papers are: Highest economy in furnace heating: Proper temperatures, ventilation and coal consumption for different outside temperatures, *The Metal Worker, Plumber and Steam Fitter, 66* (Nov. 10) (1906) 47 - 49 ("For any given outside temperature there is a corresponding amount of heat that must be supplied in order to offset the heat losses through the walls and windows", p. 47); and R. P. Bolton, Heating requirements in New York weather, *Heating and Ventilation Magazine, VIII* (March) (1911) 1 - 10 ("An analysis of the weather conditions actually prevailing during the heating season in a city like New York may be made a very useful guide in determining the heating requirements, both for the whole period and for any given portion of the period", p. 1).

4 J. Wright (private communication), Gas Planning Department, Public Service Electric and Gas Company, Newark, NJ, 1985.

5 M. Fels, R. Socolow, J. Rachlin and D. Stram, *PRISM: A Conservation Scorekeeping Method Applied to Electrically Heated Houses*, Center for Energy and Environmental Studies, Princeton University, Princeton, NJ, *EPRI Report No. EM-4358*, Palo Alto, CA, December 1985, Appendix 1.

6 T. Schrader, *A Two-Parameter Model for Assessing the Determinants of Residential Space Heating, MS Thesis*, Department of Aerospace and Mechanical Engineering, Princeton University, *Report No. 69*, Center for Energy and Environmental Studies, Princeton, NJ, June 1978.

7 F. Sinden, A two-thirds reduction in the space heat requirement; and L. Mayer and Y. Benjamini, Modeling residential demand for natural gas as a function of the coldness of a month, in R. Socolow (ed.), *Saving Energy in the Home*, Ballinger Publishing Co., Cambridge, MA, 1978.

8 E. Hirst, Household energy conservation: a review of the federal Residential Conservation Service, *Public Administration Review, 44* (5) (1984) 421 - 430.

9 Battelle, Columbus Laboratories, *Workshop Proceedings: Measuring the Effects of Utility Conservation Programs, February 1982, Columbus, OH, EPRI Report No. EA-2496*, Palo Alto, CA, July 1982.

10 Synergic Resources Corporation, *Proc. Conference on Utility Conservation Programs: Planning, Analysis, and Implementation, October 1983, New Orleans, LA, EPRI Report No. EA-3530*, Palo Alto, CA, May 1984.

11 J. Harris and C. Blumstein (eds.), *What Works: Documenting Energy Conservation in Buildings*, Summary of the 1982 ACEEE Summer Study on Energy-efficient Buildings held August 1982 in Santa Cruz, CA, American Council for an Energy-Efficient Economy, Washington, DC, 1984.

12 *Doing Better: Setting an Agenda for the Second Decade, Proc. 1984 ACEEE Summer Study on Energy-efficient Buildings, August 1984, Santa Cruz, CA*, American Council for an Energy-Efficient Economy, Washington, DC, 1984.

13 *Proc. Weatherization 1985: Midwest Technical Conference, Chicago, IL, February 1985*, Argonne National Laboratory, Argonne, IL, 1985.

14 *Proc. Second National Conference, Energy Conservation Program Evaluation: Practical Methods, Useful Results, Chicago, IL, August 1985*, Vol. I (Session 4: PRISM Workshop, Session 5: Weatherization Program Evaluation, and Session 8: Using PRISM), Argonne National Laboratory, Argonne, IL, 1985.

15 *Energy and Buildings, 9* (1 and 2) this issue; papers in the order of their appearance:

a G. Dutt, M. Lavine, B. Levi and R. Socolow, The Modular Retrofit Experiment: design, scorekeeping and evaluation, pp. 21 - 33.

b M. Goldberg, A Midwest low-income weatherization program seen through PRISM, pp. 37 - 44.

c E. Hirst, Electricity savings one, two, and three years after participation in the BPA Residential Weatherization Pilot Program, pp. 45 - 53.

d L. Rodberg, Energy conservation in low-income homes in New York City: the effectiveness of house doctoring, pp. 55 - 64.

e M. Hewett, T. Dunsworth, T. Miller and M. Koehler, Measured vs. predicted savings from single retrofits: a sample study, pp. 65 - 73.

f J. DeCicco, G. Dutt, D. Harrje and R. Socolow, PRISM applied to a multifamily building: the Lumley Homes case study, pp. 77 - 88.

g C. Goldman and R. Ritschard, Energy conservation in public housing: a case study of the San Francisco Housing Authority, pp. 89 -98.

h D. Stram and M. Fels, The applicability of PRISM to electric heating and cooling, pp. 101 - 110.

i M. Fels and D. Stram, Does PRISM distort the energy signature of heat-pump houses?, pp. 111 - 118.

j M. Fels and D. Stram, The effect of burning wood on saving electricity, pp. 119 - 126.

k M. Fels, M. Goldberg and M. Lavine, Exploratory scorekeeping for oil-heated houses, pp. 127 - 136.

m M. Fels, J. Rachlin and R. Socolow, Seasonality of non-heating consumption and its effect on PRISM results, pp. 139 - 148.

n J. Rachlin, M. Fels and R. Socolow, The stability of PRISM estimates, pp. 149 - 157.

p M. Fels and M. Goldberg, Using the scorekeeping approach to monitor aggregate energy conservation, pp. 161 - 168.

q M. Goldberg and M. Fels, Refraction of PRISM results into components of saved energy, pp. 169 - 180.

16 M. Goldberg, *A Geometrical Approach to Nondifferentiable Regression Models as Related to Methods for Assessing Residential Energy Conservation, Ph.D. Thesis*, Department of Statistics, Princeton University, *Report No. 142*, Center for Energy and Environmental Studies, Princeton, NJ, 1982.

17 National Oceanic and Atmospheric Administration (NOAA), *Local Climatological Data — Monthly Summary* [*name of weather station*], National Climatic Data Center, Asheville, NC, monthly publication.

18 R. Socolow, *Field Studies of Energy Savings in Buildings: a Tour of a Fourteen-Year Research Program at Princeton University, Report No. 191*, Center for Energy and Environmental Studies, Princeton University, Princeton, NJ, July 1985; presented at the Soviet-American Symposium on Energy Conservation, Moscow, June 6 - 12, 1985; to be published in *Energy*.

19 W. Shurcliff, *Superinsulated Houses and Double-envelope Houses: A Survey of Principles and Practice*, Brick Publishing Co., Andover, MA, 1981, p. 9.

20 E. Parzen, A density-quantile function perspective on robust estimation, in R. Launer and G. Wilkinson (eds.), *Robustness in Statistics*, Academic Press, New York, NY, 1979.

21 C. Hurvich, Center for Energy and Environmental Studies, Princeton University, Princeton, NJ, private communication, November 1985.

SURVEY DATA ANALYSIS WITH SPSSX-PC+

SPSSX-PC+ was used to perform frequency analysis, descriptive statistical analysis, bivariate crosstabulation analysis (including the use of chi-square, lambda, and Kendall's Tau-b statistics), difference of independent and dependent means analysis, and confidence interval analysis among other computational calculations.

Frequency analysis includes value counts or the frequency of the occurrence of a particular value of a variable; in addition the percentage, valid percentage, and cumulative percentage of the frequency of a particular value over all values of a variable are calculated.

Descriptive statistical analysis includes the calculation of the mean, median, mode, standard error of the skew, standard error of mean, test group standard deviation, kurtosis, standard error of the kurtosis, range, minimum, maximum, sum, test group variance, and skewness for any particular variable.

Bivariate analysis may be conducted on ordinal or nominal variable associations. The chi-square statistic, which may be used to examine both ordinal and nominal associations, is used to test whether or not one variable is dependent upon another variable; thus the null hypothesis (that one variable is not dependent upon the other -- statistical independence) and the alternative hypothesis (that one variable is dependent upon the other -- statistical dependence) are then examined. The chi-square statistic that is required to test the null and alternatives hypotheses is calculated by: (1) finding the difference between the observed frequency and the expected frequency, (2) squaring this difference, (3) then dividing the squared difference by the expected frequency, (4) then repeating steps 1 through 3 for each cell in a particular crosstabulation table, and (5) while summing all calculated cell values to derive the chi-square statistic. The chi-square statistic is then applied to a chi-square probability distribution curve to yield an observed significance level for chi-square values, which allows one to determine how often one would expect to observe various values of the chi-square statistic in the test group when the null hypothesis is true.

If observed significance levels of a chi-square statistic were less than or equal to 5%, (95% confidence), the null hypotheses was rejected. If more than 20% of the cells in a crosstabulation table had expected values less than five, then chi-square analysis was not used to determine statistical independence.

The lambda statistic, which can be used to examine both ordinal and nominal associations when conducting bivariate analysis, allows one to calculate the proportion by which one can reduce the error in predicting the value of the dependent variable while knowing the value of the independent variable. The lambda is a proportional reduction in error measure; the maximum value of lambda is "1." As lambda approaches the value of "1," the error associated with predicting the dependent variable, when knowing the independent variable is reduce. The formula for the lambda statistic is as follows:

$$= \frac{(\text{Misclassified in situation 1}) - (\text{Misclassified in situation 2})}{\text{Misclassified in situation 1}}$$

Kendall's Tau-b, which can only be used to examine ordinal associations when conducting bivariate analysis, is a measure that normalizes the difference between the number of concordant and discordant pairs while considering ties on each variable in a pair separately. Kendall's Tau-b may be a positive or negative value depending upon the direction of a particular relationship (direct versus inverse) of two variables and will not exceed the value of one; as Kendall's Tau-b approaches 1, the ordinal association between the dependent and independent variables is considered to be stronger. Kendall's Tau-b is calculated as follows:

$$\text{Kendall's Tau-b} = \frac{(P - Q)}{\sqrt{((P + Q + Tx)\ (P + Q + Ty))}}$$

where;

P = the number of concordant pairs
Q = the number of discordant pairs
Tx = the number of ties involving only the first variable
Ty = the number of ties involving only the second variable

DIFFERENCE OF DEPENDENT AND INDEPENDENT MEANS ANALYSIS

Analytical tests of the difference of dependent means help determine whether or not the difference between two related variable means is statistically significant in the population; thus, the null hypothesis (that the difference between two related means is statistically insignificant in the population) and the alternative hypothesis (that the difference between two related means is statistically significant in the population) are tested by calculating a difference of means t-statistic and its two-tail probability significance level. The difference of the two test group means is then divided by the standard error of the differences to yield the difference of means t-statistic; the difference of means t-statistic is then applied to the "t" probability distribution curve with the appropriate degrees of freedom to yield a two-tailed probability observed significance level. The null hypothesis was rejected if the two-tailed probability observed significance level was less than or equal to 0.05.

Difference of independent means analysis is conducted basically in the same manner as difference of dependent means analysis. However, if one cannot assume that the two variable variances are equal, then the t-sample labeled Separate Variance Estimate should be used for difference of independent means analysis. The f-statistic and its two-tailed probability observed significance level can be used to determine the equality of the two variable variances; thus, if the two-tailed probability observed significance level is less than or equal to 0.05, it is highly likely that the two variable variances are not equal and the t-sample under Separate Variance Estimate should be used for difference of independent means analysis.

CONFIDENCE INTERVAL ANALYSIS

Calculation of a two-tailed 95% confidence interval for any variable with a test group size greater than 30, when the population variable standard deviation is unknown, was calculated as follows:

$$x - z_{\alpha/2} \frac{s}{\sqrt{n}} < M < x + z_{\alpha/2} \frac{s}{\sqrt{n}}$$

where;

x = variable mean
$z_{\alpha/2}$ = 1.96
s = variable sample standard deviation
M = population variable mean
n = variable sample group size.

Thus, 95% of the time, a confidence interval constructed in this manner will contain the population variable mean "M."

Calculation of a two-tailed 95% confidence interval for any variable with a test group size less than 30, when the population variable standard deviation is unknown, was calculated as follows:

$$x - t_{\alpha/2} \frac{s}{\sqrt{n}} < M < x + t_{\alpha/2} \frac{s}{\sqrt{n}}$$

where;

x = variable mean
$t_{\alpha/2}$ = (dependent upon degrees of freedom (n-1))
s = variable sample standard deviation
M = population variable mean
n = variable sample group size.

Interpretation of this type of confidence interval is identical to those with test group sizes greater than 30.

USING REGRESSION TO ESTIMATE ENERGY SAVINGS

Initially, regression was employed to determine which characteristics were most strongly related to energy savings, either in terms of gross Btu savings or as a percent savings. The objective of the regression was to estimate the effects of specific ECMs on energy savings. The variables used in the regression equation included number of occupants in the household, size of the household (square footage), age of the dwelling, and the cost of each ECMs. The cost of the measure was used as a surrogate for the level of activity, since information regarding how much of the material was applied was unavailable.

The regression technique was unable to provide statistically significant estimates of the effects of the specific ECMs on energy savings. The variables which explained the most of the energy savings related to the dwelling characteristics such as dwelling size, and even these had little explanatory power. Reasons that help explain why regression was not a good technique for estimating and/or attributing energy savings include:

- At some point the effects of weatherization may be subject to diminishing marginal returns; and
- Cost figures provided on the WAP Job Form are not linearly related to energy savings.

The lack of a relationship between material costs and energy savings is determined in part by the material cost variable. Costs associated with specific ECMs are recorded on each WAP Job Form. These costs, however, are aggregate costs. While in some sense the ECM dollar amounts represent a level of activity, they are not reliable estimates of how much of a specific ECM was implemented. For example, while the cost associated with storm doors may equal $1,200, this information does not indicate how many storm doors were installed. Because regression resulted in weak estimates of energy savings, the statistical technique known as "breakdown" was employed.

CALCULATION OF A WEIGHTED MEAN PERCENT SAVINGS

In some cases the measurements in a test group or a population should not be weighted equally. Because some households consumed much more energy in the pre-ECM installation period, a household's savings rate should be weighted according to its pre-weatherization energy consumption.

As part of this analysis average savings were calculated using two approaches. One approach entailed the calculation of a mean percent savings. The formula is as follows:

$$\text{Mean Percent Savings} = \frac{\sum_{i=1}^{n} \text{Percent Savings}_n}{n}$$

where,

Percent Savings = Btus saved as a percent of Pre-Btu consumption
n = size of test or control group

An alternative approach controls more effectively for the influence of large dwellings and or large household size (i.e., high or low pre-weatherization Btu consumers). The sum of the products, of pre-Btu and savings percent for each case, are divided by the sum of the pre-Btus (or weights) for each case. The formula is as follows:

$$\text{Weighted Mean Percent Savings} = \frac{\sum_{i=1}^{n} (\text{Pre-Btu}_n * \text{Savings Percent}_n)}{\sum_{i=1}^{n} (\text{Pre-Btu}_n)}$$

where,

Pre-Btu = pre-weatherization Btu energy consumption

Typically, this latter approach results in slightly higher percent Btu savings, but generates a percent savings probably more reflective of actual conditions. For example, the test group's average percent savings increases from 14.5% to 15.7% utilizing this second methodology. Because this latter approach is assumed to more accurately reflect the percent savings attributable to the weatherization program, the findings using this latter approach are presented throughout this report.

ESTIMATING PERCENT SAVINGS USING LOG TRANSFORMATIONS

When estimating the percent savings attributable to the program or specific ECMs, log transformations help control for the effects of outliers and problems of heteroscedasticity, thereby resulting in more accurate and reliable estimates of percent energy savings. The method to transform log values into percent savings is as follows:

let,

$$L = \log(\text{pre-Btu}) - \log(\text{post-Btu})$$

$$= \log \frac{\text{pre-Btu}}{\text{post-Btu}}$$

$$= -\log \frac{\text{post-Btu}}{\text{pre-Btu}}$$

therefore,

$$-L = \log \frac{\text{post-Btu}}{\text{pre-Btu}}$$

$$e^{-L} = \frac{\text{post-Btu}}{\text{pre-Btu}}$$

$$1 - e^{-L} = 1 - \frac{\text{post-Btu}}{\text{pre-Btu}}$$

$$= \frac{\text{pre-Btu} - \text{post-Btu}}{\text{pre-Btu}}$$

$$100\,(1 - e^{-L}) = 100\,\frac{\text{pre-Btu} - \text{post-Btu}}{\text{pre-Btu}}$$

$$= \text{percent savings.}$$

APPENDIX C: DATA FREQUENCIES PER CAP

APPENDIX C: DATA FREQUENCIES PER CAP

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
SAMPLE SIZE:	753	59	26	48	84	6	49	25	59	39	13	39	51	22	15	45	62	26	64	22
RESPONDENT AGE:																				
mean	67.8	68.7	67.2	60.0	65.2	69.0	71.4	63.7	67.5	76.8	73.1	62.5	67.7	61.5	64.7	67.2	71.6	71.9	71.3	65.7
median	69.0	69.0	67.0	65.0	66.5	73.5	74.0	66.0	67.0	78.0	72.0	61.0	69.0	62.5	65.0	70.0	72.0	73.0	70.5	66.5
range	22-96	30-90	51-81	22-86	28-90	46-78	26-95	26-84	28-96	63-90	48-94	33-85	39-88	32-82	35-87	24-88	40-93	54-88	42-91	25-91
st. dev.	13.26	10.70	8.21	18.50	14.17	12.43	12.65	16.90	15.02	8.08	14.03	13.73	11.31	12.92	14.16	12.60	9.78	8.86	10.15	14.31
SINGLE PARENT:																				
% yes	3.2	5.1	3.8	14.6	4.8	0.0	2.0	0.0	3.4	0.0	0.0	5.1	0.0	4.5	0.0	0.0	1.6	3.8	1.6	0.0
SEX:																				
% male	39.2	27.1	69.2	41.7	32.1	66.7	36.7	56.0	32.2	46.2	38.5	51.3	39.2	50.0	33.3	37.8	40.3	19.2	39.1	40.9
% female	60.8	72.9	30.8	58.3	67.9	33.3	63.3	44.0	67.8	53.8	61.5	48.7	60.8	50.0	66.7	62.2	59.7	80.8	60.9	59.1
ELDERLY:																				
% yes	85.1	88.1	84.6	72.9	77.4	100.0	89.8	80.0	88.1	100.0	84.6	69.2	82.4	72.7	73.3	84.4	96.8	88.5	93.8	81.8
HANDICAPPED:																				
% yes	46.6	22.0	50.0	20.8	48.8	83.3	22.4	36.0	78.0	51.3	100.0	59.0	29.4	63.6	53.3	37.8	30.6	38.5	81.3	59.1
YOUNG CHILD:																				
% yes	3.6	0.0	4.0	14.6	2.4	0.0	4.1	16.0	1.7	0.0	7.7	7.7	2.0	9.1	0.0	4.4	0.0	0.0	0.0	4.5
UNIT AGE:																				
mean	59.2	58.4	67.0	61.8	52.3	NA	52.5	65.4	57.6	73.3	63.1	61.8	55.0	82.7	58.9	59.4	52.5	63.0	58.2	39.7
median	60.0	65.0	80.0	75.0	50.0		50.0	80.0	55.0	80.0	65.0	60.0	48.5	90.0	67.5	60.0	50.0	69.0	60.0	40.0
range	4-140	5-100	15-100	8-118	10-120		10-100	7-120	4-120	10-100	20-100	20-100	7-140	25-120	10-100	4-100	7-125	10-85	5-138	4-75
st. dev.	28.02	21.01	27.21	32.08	23.71		28.31	36.35	28.90	28.29	28.50	23.53	31.62	25.58	32.24	28.56	23.37	18.25	29.09	35.50
ATTACHED DWELLING:																				
% yes	5.1	1.7	3.8	12.5	6.0	0.0	14.3	0.0	8.5	10.3	0.0	2.6	0.0	0.0	20.0	0.0	0.0	0.0	4.7	9.1

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
RENTAL UNIT:																				
% yes	14.9	8.5	7.7	35.4	23.8	0.0	18.4	4.0	16.9	15.4	7.7	17.9	6.0	9.1	26.7	2.2	12.9	7.7	9.4	36.4
MONTHLY RENT:																				
mean	145.78	137.10	57.00	140.94	194.44	NA	97.50	NA	126.60	132.80	94.00	168.00	196.33	162.50	103.71	185.00	122.14	76.50	101.25	113.13
median	130.00	148.00	57.00	134.00	197.00		72.50		107.50	125.00	94.00	160.50	186.50	162.50	110.00	185.00	100.00	76.50	102.50	110.00
range	0-350	32-264	57-57	74-235	50-341		22-250		33-275	80-200	94-94	90-288	111-350	125-200	0-229	185-185	70-195	78-153	25-175	15-200
st. dev.	73.27	75.20	0.00	43.47	77.27		79.10		72.87	44.18	0.00	70.27	85.17	53.03	85.95	0.00	48.03	2.12	70.40	57.19
RENT SUBSIDIZED:																				
% yes	13.3	10.7	3.8	14.3	0.0	0.0	100	0.0	35.3	0.0	100.0	14.3	0.0	0.0	16.7	0.0	50.0	0.0	0.0	33.3
AIR CONDITIONING:																				
% yes	53.7	53.7	66.7	42.6	57.8	83.3	54.5	66.7	46.4	43.2	53.8	41.0	54.2	9.1	69.2	61.0	47.5	72.0	76.6	36.4
FUEL TYPE:																				
% natural gas	94.9	98.3	84.6	91.7	97.6	66.7	91.8	96.0	93.2	97.4	100.0	97.4	98.0	100.0	100.0	88.6	98.4	96.2	92.2	95.5
% electricity	5.1	1.7	15.4	8.3	2.4	33.3	8.2	4.0	6.8	2.6	0.0	2.6	2.0	0.0	0.0	11.4	1.6	3.8	7.8	4.5
HHLD SIZE:																				
mean	1.64	1.39	1.84	2.02	1.85	1.67	1.53	2.12	1.63	1.42	2.00	2.13	1.47	2.00	1.60	1.46	1.44	1.31	1.43	1.46
median	1.0	1.0	2.0	2.0	1.0	2.0	1.0	2.0	1.0	1.0	1.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0
range	1-7	1-4	1-4	1-6	1-6	1-2	1-5	1-5	1-7	1-5	1-5	1-6	1-4	1-5	1-4	1-4	1-4	1-3	1-3	1-4
st. dev.	.97	.67	.83	1.18	1.29	.52	.79	1.33	1.07	.79	1.35	1.36	.76	1.02	.91	.79	.72	.55	.56	.74
HHLD INCOME:																				
mean	1589	1427	1643	1690	1752	1755	1626	1607	1565	1458	1884	1684	1627	1611	1539	1444	1472	1461	1648	1471
median	1483	1461	1635	1502	1620	1665	1559	1288	1352	1227	1572	1521	1560	1348	1398	1221	1314	1454	1622	1427
range	195-5310	195-2619	248-2686	618-3435	600-5310	1173-2457	293-3456	728-3208	414-3177	612-2946	866-3489	538-4444	785-2694	315-4399	446-3037	354-3234	468-3204	915-2830	660-3317	870-2686
st. dev.	621	512	664	660	708	523	578	745	609	594	832	759	442	828	721	662	559	435	532	485

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
LIHEAP FUNDS:																				
mean	218	202	205	211	199	120	200	271	239	239	250	241	202	212	198	235	239	231	199	232
median	232	181	240	220	185	120	200	280	280	250	280	270	180	240	200	240	280	248	200	210
range	14-330	120-280	120-330	95-315	120-315	120-120	120-280	140-330	115-330	105-305	140-350	14-305	120-280	120-265	80-265	120-315	140-330	140-305	120-280	140-280
st. dev.	56.11	43.98	58.23	58.85	51.32	0.00	48.14	52.95	53.86	65.14	69.57	67.14	38.83	47.22	54.45	51.96	54.50	57.37	49.88	45.66
MOVE-IN DATE:																				
mean	65.1	61.0	66.1	70.0	66.4	59.0	64.5	67.7	63.1	65.7	57.9	63.2	63.1	76.2	65.0	65.9	63.6	63.4	65.4	67.5
median	68.0	64.5	68.0	72.0	67.0	62.0	65.0	70.0	68.0	69.0	59.0	63.0	65.0	79.5	65.5	72.0	68.0	68.0	67.0	71.5
range	17-87	18-85	22-85	40-86	38-86	30-76	36-84	31-86	17-86	32-85	29-82	28-86	23-85	49-87	38-85	25-86	27-84	42-85	32-85	28-85
st. dev.	14.77	14.88	13.35	13.24	13.82	17.72	15.60	15.98	19.64	13.62	14.72	15.08	15.82	11.06	13.32	14.00	12.97	12.97	11.93	17.32
NO. BEDROOMS:																				
mean	2.44	2.10	2.35	2.38	2.47	2.16	2.29	2.68	2.68	2.69	2.75	2.46	2.37	2.64	1.93	2.27	2.57	2.46	2.44	2.68
median	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	2.0	3.0	3.0	2.0	2.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0
range	1-7	1-4	1-4	1-4	1-5	1-4	1-5	1-5	1-6	1-5	1-6	1-4	1-4	2-4	1-3	1-4	1-7	1-4	1-6	1-6
st. dev.	.93	.69	.80	.76	.94	.98	.96	1.18	1.15	1.00	1.36	.82	.75	.66	.59	.65	1.04	.81	1.04	1.17
NO. LIVING ROOM:																				
mean	1.11	1.09	1.08	1.13	1.10	1.17	1.10	1.16	1.14	1.18	1.17	1.00	1.12	1.18	1.13	1.04	1.08	1.04	1.14	1.23
median	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
range	1-3	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-1	1-3	1-3	1-2	1-2	1-2	1-2	1-2	1-3
st. dev.	.33	.28	.27	.33	.30	.41	.33	.37	.35	.39	.39	0.00	.38	.50	.35	.21	.28	.20	.35	.53
NO. KITCHENS:																				
mean	1.03	1.00	1.00	1.04	1.06	1.00	1.02	1.00	1.02	1.05	1.17	1.00	1.02	1.18	1.00	1.04	1.02	1.00	1.03	1.05
median	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
range	1-3	1-1	1-1	1-2	1-2	1-1	1-2	1-1	1-2	1-2	1-2	1-1	1-2	1-3	1-1	1-2	1-2	1-1	1-2	1-2
st. dev.	.18	0.00	0.00	.20	.24	0.00	.14	0.00	.13	.22	.39	0.00	.14	.50	0.00	.21	.13	0.00	.18	.21
NO. BATHROOMS:																				
mean	1.14	1.05	1.27	1.15	1.14	1.17	1.06	1.20	1.20	1.18	1.42	1.10	1.10	1.14	1.00	1.09	1.10	1.12	1.19	1.18
median	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
range	1-3	1-2	1-2	1-2	1-3	1-2	1-2	1-2	1-2	1-2	1-3	1-2	1-2	1-3	1-1	1-2	1-2	1-2	1-3	1-3
st. dev.	.36	.22	.45	.36	.39	.41	.24	.41	.41	.39	.67	.31	.30	.47	0.00	.29	.30	.33	.44	.50

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
NO. BEDROOMS HEATED:																				
mean	1.72	1.71	1.62	1.83	1.89	1.33	1.60	1.74	1.70	1.51	2.17	2.00	1.71	1.86	1.53	1.78	1.66	1.36	1.71	1.59
median	2.0	2.0	1.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0	2.0	1.0
range	0-6	1-4	1-4	0-4	0-4	1-2	1-5	1-4	1-6	0-4	0-6	1-4	1-3	1-3	1-2	1-3	1-5	0-2	1-6	0-4
st. dev.	.86	.74	.90	.83	.85	.52	.87	.96	.99	.82	1.53	.90	.74	.79	.52	.64	1.00	.57	.84	.91
NO. LIVING ROOM HEATED:																				
mean	1.09	1.07	1.08	1.11	1.08	1.17	1.15	1.08	1.10	1.15	1.17	1.00	1.10	1.18	1.13	1.02	1.07	1.08	1.08	1.14
median	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
range	1-3	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-1	1-3	1-3	1-2	1-2	1-2	1-2	1-2	1-2
st. dev.	.30	.25	.27	.31	.28	.41	.36	.28	.31	.37	.39	0.00	.36	.50	.35	.15	.25	.27	.27	.35
NO. KITCHEN HEAT:																				
mean	1.03	1.00	1.00	1.02	1.06	1.00	1.00	1.00	1.03	1.05	1.17	1.00	1.02	1.14	1.00	1.04	1.02	1.00	1.03	1.00
median	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
range	0-3	1-1	1-1	1-2	1-2	1-1	1-1	1-1	1-2	1-2	1-2	1-1	1-2	1-3	1-1	1-2	1-2	1-1	1-2	1-1
st. dev.	.18	0.00	0.00	.15	.24	0.00	0.00	0.00	.18	.22	.39	0.00	.14	.47	0.00	.21	.13	0.00	.18	0.00
NO. BATHROOMS HEATED:																				
mean	1.09	1.02	1.17	1.11	1.11	1.17	1.06	1.04	1.11	1.15	1.42	1.07	1.06	1.14	1.00	1.07	1.05	1.00	1.14	1.00
median	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
range	0-3	0-2	1-2	0-2	1-2	1-2	1-2	1-2	1-2	1-2	1-3	1-2	1-2	1-3	1-1	1-2	1-3	1-1	1-3	1-1
st. dev.	.31	.23	.38	.38	.31	.41	.25	.20	.31	.37	.67	.27	.24	.47	0.00	.26	.28	0.00	.40	0.00
OCCUPIED DAY:																				
% yes	97.3	94.9	100.0	93.8	97.6	100.0	97.9	88.0	100.0	97.4	92.3	97.4	98.0	100.0	100.0	95.6	100.0	100.0	98.4	95.2
OCCUPIED NIGHT:																				
% yes	99.1	98.3	100.0	95.8	97.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.0	100.0	100.0	100.0	100.0	100.0	100.0	95.5
STORM WINDOWS:																				
% yes	95.4	98.3	92.3	100.0	94.0	100.0	97.9	96.0	96.5	97.4	100.0	100.0	100.0	100.0	100.0	88.6	96.7	100.0	100.0	95.2

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
CLOSED STORM WINDOWS:																				
% yes	95.5	100.0	100.0	97.9	98.7	100.0	100.0	100.0	100.0	97.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.4	100.0
THERMOSTAT:																				
% yes	93.8	98.3	92.3	95.8	90.4	100.0	98.0	100.0	98.2	92.3	100.0	97.4	100.0	90.9	78.6	97.7	95.1	92.0	90.5	95.5
DAY SETTING:																				
mean	69.9	69.5	70.0	69.2	70.3	68.7	69.1	69.0	70.1	69.6	69.9	70.2	70.0	70.2	69.6	71.1	69.3	70.1	71.0	69.6
median	70.0	70.0	70.0	70.0	70.0	69.0	70.0	70.0	70.0	70-0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
range	60-82	60-79	60-78	60-74	60-82	66-70	60-76	60-79	62-82	65-75	68-75	63-78	62-75	65-75	60-76	65-80	62-74	60-78	68-80	65-76
st. dev.	3.0	2.8	3.4	2.8	3.4	1.6	2.9	4.7	3.5	2.3	2.1	2.5	2.6	2.7	4.2	2.8	2.0	4.1	2.3	2.6
EVENING SETTING:																				
mean	69.7	69.4	69.9	68.8	70.1	69.0	68.8	69.3	69.8	69.2	68.5	70.2	70.2	70.1	70.3	70.7	69.2	69.7	70.5	69.5
median	70.0	70.0	70.0	70.0	70.0	69.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	71.0	70.0	70.0	70.0	70.0	70.0	70.0
range	50-82	60-76	60-78	60-74	60-82	66-72	50-76	60-75	60-82	60-75	55-75	65-78	63-75	60-75	65-76	60-80	60-74	65-76	60-80	65-72
st. dev.	3.3	2.6	4.1	3.3	3.7	2.1	3.9	4.1	4.1	2.8	4.8	3.5	2.1	3.8	3.0	3.9	2.3	3.4	2.7	2.2
NIGHT SETTING:																				
mean	66.5	65.5	65.3	65.8	67.5	62.0	65.9	65.2	66.5	66.6	65.4	67.7	67.0	66.9	66.3	68.2	65.5	64.4	67.9	67.2
median	68.0	66.0	67.0	65.0	68.0	63.5	68.0	65.5	68.0	67.0	66.0	68.0	68.0	66.5	68.0	68.0	66.0	68.0	68.0	68.0
range	0-80	50-76	50-72	55-72	55-78	45-70	45-74	50-72	55-76	60-75	55-72	62-78	60-72	60-72	55-72	60-80	55-74	0-76	55-80	60-72
st. dev.	5.3	5.3	5.4	4.4	4.3	8.9	5.2	5.4	4.7	3.7	5.2	4.5	3.9	3.6	5.1	4.2	4.2	15.4	4.2	4.2
HOME TYPE:																				
% single	61.2	83.1	69.2	60.8	48.8	50.0	61.2	52.0	54.2	46.2	25.0	59.0	70.6	68.2	60.0	82.2	59.3	60.0	67.2	38.1
% split level	3.6	3.4	3.8	2.2	4.8	0.0	4.1	4.0	3.4	5.1	0.0	5.1	3.9	0.0	0.0	2.2	5.1	0.0	3.3	9.5
% 2-storey	32.1	8.5	26.9	34.8	41.7	33.3	30.6	44.0	40.7	48.7	66.7	35.9	19.6	31.8	26.7	15.6	35.6	36.0	24.6	47.6
% 2+ storey	.8	0.0	0.0	2.2	1.2	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	4.8
% mobile	2.3	5.1	0.0	0.0	3.6	16.7	4.1	0.0	1.7	0.0	0.0	0.0	5.9	0.0	13.3	0.0	0.0	4.0	1.6	0.0
BASEMENT PRESENT:																				
% yes	80.1	86.2	92.3	74.5	79.3	50.0	65.3	87.5	82.8	84.6	100.0	82.1	78.0	65.0	73.3	66.7	86.9	80.0	84.1	86.4

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
BASEMENT TYPE:																				
partial	37.3	38.0	54.2	44.1	26.2	33.3	42.4	50.0	35.4	31.3	27.3	35.5	42.1	50.0	54.5	43.3	24.5	36.8	38.9	36.8
full	62.7	62.0	45.8	55.9	73.8	66.7	57.6	50.0	64.6	68.8	72.7	64.5	57.9	50.0	45.5	56.7	75.5	63.2	61.1	63.2
HEAT BASEMENT:																				
% yes	25.2	26.0	39.1	47.1	20.6	33.3	37.5	28.6	26.0	21.2	15.4	36.4	19.5	28.6	9.1	27.6	24.5	5.0	15.4	15.0
REACT TO RECEIVE WX:																				
mean	4.71	4.67	4.40	4.72	4.73	4.83	4.78	4.72	4.81	4.68	4.55	4.69	4.82	4.68	4.80	4.55	4.72	4.42	4.72	4.86
median	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
range	1-5	1-5	1-5	2-5	1-5	4-5	3-5	3-5	2-5	1-5	2-5	1-5	1-5	1-5	3-5	1-5	2-5	1-5	1.5	4-5
st. dev.	.76	.78	1.35	.62	.73	.41	.47	.61	.57	.82	.93	.80	.79	.89	.56	.93	.64	1.18	.70	.35
ELAPSED MONTHS:																				
mean	8.4	10.5	10.4	5.3	6.1	13.2	8.1	12.42	12.4	6.6	6.8	12.0	5.9	4.6	6.7	7.4	8.8	5.7	10.7	6.6
median	5.0	6.0	6.0	4.0	4.0	12.0	5.0	4.0	4.5	4.0	5.0	8.0	3.0	3.0	6.0	4.0	6.0	2.5	6.0	3.0
range	1-72	1-36	2-24	1-12	1-25	2-36	1-68	1-60	1-60	1-24	1-18	1-36	1-24	1-12	1-12	1-36	1-72	1-24	2-58	1-40
st. dev.	10.0	10.1	8.7	3.3	5.6	13.5	11.2	19.7	16.0	6.1	5.7	10.0	6.2	4.0	4.5	7.7	11.5	6.5	10.6	10.5
IMPROVE COMFORT:																				
mean	4.61	4.31	4.62	4.69	4.65	4.67	4.48	4.27	4.81	4.51	4.64	4.57	4.80	4.76	4.67	4.61	4.71	4.67	4.47	4.70
median	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.6
range	1-5	1-5	3-5	1-5	1-5	3-5	1-5	1-5	2-5	1-5	3-5	1-5	1-5	1-5	3-5	1-5	1-5	1-5	1-5	3-5
st. dev.	.94	1.29	.75	.81	.79	.82	1.22	1.32	.59	.95	.81	.93	.71	.89	.62	.97	.78	.97	1.14	.66
REDUCE ENERGY BILL:																				
mean	4.76	4.77	4.77	4.73	4.80	5.00	4.67	4.57	4.81	4.53	5.00	4.60	4.94	4.91	4.73	4.95	4.8	4.91	4.66	4.68
median	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
range	1-5	1-5	1-5	1-5	2-5	5.0	1-5	1-5	2-5	1-5	5-5	1-5	3-5	4-5	3-5	4-5	3-5	4-5	1-5	1-5
st. dev.	.72	.80	.82	.69	.57	0.00	.95	1.04	.60	1.00	0.00	.96	.32	.30	.59	.21	.55	.29	.97	.95
REDUCE OIL IMPORTS:																				
mean	3.80	3.77	3.65	3.09	3.74	5.00	3.78	3.33	3.95	3.39	4.00	3.28	4.36	4.16	3.69	4.14	3.88	4.47	3.66	3.46
median	4.0	4.0	3.5	3.0	5.0	5.0	4.0	3.0	5.0	4.0	4.0	3.0	5.0	5.0	4.0	5.0	5.0	5.0	4.0	3.0
range	1-5	1-5	1-5	1-5	1-5	5-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	2-5
st. dev.	1.42	1.38	1.27	1.60	1.53	0.00	1.41	1.33	1.45	1.60	1.34	1.51	1.07	1.43	1.60	1.24	1.38	1.13	1.37	1.39

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
IMPROVE HOME APPEAR:																				
mean	3.52	3.36	2.85	3.19	3.87	4.00	3.18	3.28	3.44	3.03	2.91	3.53	4.00	4.05	4.00	3.75	3.69	3.94	3.17	3.40
median	4.0	4.0	3.0	3.0	5.0	5.0	3.0	4.0	4.0	3.0	3.0	4.0	5.0	5.0	5.0	4.0	5.0	5.0	3.0	4.0
range	1-5	1-5	1-5	1-5	1-5	2-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5
st. dev.	1.54	1.54	1.53	1.43	1.37	1.41	1.60	1.57	1.58	1.69	1.64	1.46	1.50	1.22	1.57	1.38	1.65	1.48	1.66	1.77
AVOID WASTING HEAT:																				
mean	4.78	4.71	4.96	4.77	4.79	5.00	4.67	4.50	4.82	4.57	4.85	4.68	4.94	4.95	4.60	4.93	4.89	4.86	4.74	4.65
median	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
range	1-5	1-5	4-5	2-5	2-5	5-5	1-5	1-5	3-5	1-5	3-5	1-5	3-5	4-5	2-5	3-5	3-5	3-5	1-5	2-5
st. dev.	.69	.85	.20	.64	.61	0.00	1.02	1.10	.51	.92	.56	.97	.32	.22	.83	.35	.41	.48	.76	.81
LOSE LIHEAP FUNDS:																				
mean	3.93	3.86	3.52	3.54	3.93	4.20	4.00	3.65	4.29	3.55	3.18	3.54	4.37	3.67	4.23	4.20	4.32	4.16	3.73	4.17
median	5.0	5.0	4.0	4.0	5.0	5.0	5.0	5.0	5.0	4.0	3.0	3.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
range	1-5	1-5	1-5	1-5	1-5	2-5	1-5	1-5	2-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5
st. dev.	1.46	1.53	1.50	1.62	1.54	1.30	1.46	1.76	1.12	1.65	1.54	1.50	1.18	1.65	1.24	1.36	1.21	1.30	1.62	1.34
BECAUSE FREE:																				
mean	3.99	3.94	4.09	3.68	4.32	3.33	4.02	4.37	3.96	4.13	3.67	3.23	4.27	3.89	4.23	3.54	4.20	3.88	4.09	4.05
median	5.0	5.0	5.0	4.0	5.0	4.0	5.0	5.0	5.0	5.0	4.0	3.0	5.0	5.0	5.0	4.0	5.0	4.0	5.0	5.0
range	1-5	1-5	2-5	1-5	1-5	1-5	1-5	2-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5
st. dev.	1.43	1.60	1.16	1.51	1.17	2.08	1.42	1.17	1.44	1.28	1.32	1.63	1.34	1.68	1.24	1.68	1.37	1.41	1.43	1.35
AFTER WE, LOWER THERM:																				
% yes	63.8	70.9	58.3	56.5	64.1	66.7	55.8	57.1	62.7	71.9	45.5	51.4	61.4	57.1	75.0	77.5	67.9	63.6	72.7	50.0
AFTER WE, RAISED THERM:																				
% yes	4.2	3.9	0.0	7.3	2.7	100.0	0.0	0.0	3.9	0.0	9.1	0.0	2.6	9.1	18.2	2.5	8.0	5.3	6.0	12.5
AFTER WE, UNCHANGED:																				
% yes	59.3	42.9	63.2	61.0	53.5	80.0	59.5	57.1	67.9	64.5	70.0	58.3	64.1	55.6	50.0	46.2	71.4	66.7	58.0	70.6

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
AFTER WE, INSTALL ECM:																				
% yes	19.7	17.0	15.0	16.2	22.9	20.0	20.0	30.0	19.2	29.0	10.0	17.6	17.1	21.1	7.7	25.0	14.3	16.7	20.8	25.0
AFTER WE, REMOVED ECM:																				
% yes	4.5	2.0	4.8	0.0	5.8	40.0	2.6	5.3	4.4	0.0	0.0	3.0	5.7	5.0	18.2	5.6	4.5	13.3	0.0	11.8
QUALITY OF WORK:																				
mean	4.62	4.53	4.92	4.45	4.60	5.00	4.69	4.63	4.76	4.87	3.92	4.51	4.83	4.64	4.73	4.50	4.77	3.92	4.60	4.46
median	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
range	1-5	1-5	4-5	2-5	1-5	5-5	3-5	3-5	3-5	3-5	1-5	1-5	3-5	3-5	3-5	1-5	1-5	1-5	1-5	2-5
st. dev.	.80	.90	.27	.78	.86	0.00	.59	.71	.54	.41	1.44	.90	.52	.66	.59	.90	.64	1.32	.95	.91
ATTITUDE OF WORKER:																				
mean	4.81	4.78	4.96	4.73	4.80	5.00	4.96	4.96	4.80	4.95	4.23	4.76	4.96	4.96	4.87	4.71	4.87	4.12	4.82	4.82
median	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
range	1-5	1-5	4-5	2-5	1-5	5-5	4-5	4-5	2-5	4-5	1-5	1-5	4-5	4-5	3-5	1-5	1-5	1-5	1-5	2-5
st. dev.	.63	.67	.20	.68	.62	0.00	.20	.20	.64	.23	1.24	.75	.20	.21	.52	.73	.56	1.17	.76	.66
TIME TO COMPLETE JOB:																				
mean	4.71	4.56	4.92	4.57	4.67	5.00	4.85	4.82	4.83	4.76	4.33	4.64	4.91	4.82	4.64	4.74	4.81	4.27	4.60	4.55
median	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
range	1-5	1-5	4-5	2-5	1-5	5-5	1-5	2-5	3-5	2-5	2-5	1-5	3-5	3-5	2-5	1-5	1-5	1-5	1-5	2-5
st. dev.	.75	.98	.27	.83	.78	0.00	.62	.66	.46	.63	.89	.90	.36	.50	.84	.73	.63	1.08	.91	.96
CLEAN UP:																				
mean	4.69	4.73	4.96	4.47	4.74	5.00	4.88	4.91	4.63	4.67	4.67	4.65	4.78	4.55	4.67	4.73	4.77	3.88	4.69	4.59
median	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
range	1-5	1-5	4-5	1-5	2-5	5-5	2-5	3-5	1-5	2-5	3-5	1-5	1-5	1-5	2-5	2-5	1-5	1-5	1-5	1-5
st. dev.	.81	.69	.20	1.06	.63	0.00	.53	.42	.91	.70	.65	.82	.80	1.01	.82	.72	.69	1.51	.92	.96
OPPORT. EXPRESS THOUGHT																				
mean	4.59	4.57	4.72	4.29	4.58	5.00	4.76	4.58	4.65	4.69	3.64	4.41	4.79	4.73	4.62	4.63	4.75	4.05	4.53	4.74
median	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
range	1-5	1-5	3-5	2-5	1-5	5-5	3-5	3-5	1-5	3-5	1-5	1-5	3-5	1-5	3-5	1-5	1-5	1-5	1-5	4-5
st. dev.	.85	1.01	.68	.94	.82	0.00	.57	.77	.81	.69	1.63	.95	.62	.88	.65	.77	.72	1.40	.96	.45

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
BEING INFORMED:																				
mean	4.73	4.75	4.92	4.52	4.72	5.00	4.85	4.58	4.66	4.90	4.27	4.61	4.87	5.00	4.60	4.79	4.80	4.25	4.75	4.71
median	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
range	1-5	1-5	4-5	1-5	2-5	5-5	4-5	2-5	2-5	3-5	1-5	1-5	3-5	5-5	3-5	3-5	1-5	1-5	1-5	3-5
st. dev.	.72	.73	.27	.97	.63	0.00	.36	.93	.75	.38	1.62	.86	.45	0.00	.74	.56	.68	1.33	.83	.64
IMPROVE COMFORT:																				
mean	4.68	4.70	4.84	4.62	4.68	5.00	4.85	4.71	4.67	4.84	4.42	4.55	4.70	4.73	4.60	4.77	4.71	4.09	4.57	4.65
median	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
range	1-5	1-5	4-5	1-5	1-5	5-5	3-5	2-5	1-5	2-5	1-5	1-5	2-5	3-5	3-5	1-5	1-5	1-5	1-5	3-5
st. dev.	.78	.79	.37	.85	.75	0.00	.46	.75	.74	.59	1.24	.89	.76	.70	.85	.72	.80	1.28	.97	.75
REDUCE MONTHLY BILL:																				
mean	4.48	4.47	4.42	4.34	4.45	5.00	4.61	4.41	4.49	4.43	4.33	4.22	4.53	4.36	4.43	4.70	4.55	4.17	4.54	4.50
median	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
range	1-5	1-5	1-5	1-5	1-5	5-5	2-5	1-5	1-5	2-5	1-5	1-5	1-5	1-5	3-5	1-5	1-5	1-5	1-5	2-5
st. dev.	.98	.93	1.17	.96	1.05	0.00	.75	1.18	.94	.99	1.30	1.07	1.05	1.09	.85	.83	.96	1.19	1.01	.89
IMPROVE APPEARANCE:																				
mean	4.16	4.28	4.17	3.70	4.29	4.60	3.90	4.00	4.27	4.31	3.75	3.72	4.43	4.10	4.20	4.58	4.35	4.06	3.94	3.82
median	5.0	5.0	5.0	4.0	5.0	5.0	4.0	5.0	5.0	5.0	4.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
range	0-5	1-5	1-5	0-5	1-5	3-5	1-5	1-5	1-5	2-5	1-5	1-5	1-5	1-5	1-4	1-5	1-5	1-5	1-5	1-5
st. dev.	1.19	1.13	1.13	1.40	1.13	.89	1.10	1.41	1.13	1.08	1.39	1.37	1.19	1.21	1.21	.84	1.01	1.39	1.32	1.47
WHEN COLD, WHAT ACT?																				
% turn up therm	28.3	28.6	27.8	22.9	34.7	50.0	19.5	26.1	25.0	20.7	37.5	22.6	36.6	27.8	40.0	32.4	26.8	16.7	28.3	35.3
% sweater blanket	68.6	71.4	66.7	77.1	61.1	50.0	73.2	69.6	73.1	65.5	62.5	77.4	63.4	72.2	53.3	64.9	68.3	83.3	67.9	64.7
% supplemental heat	.5	0.0	0.0	0.0	1.4	0.0	2.4	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% none of above	2.3	0.0	5.6	0.0	2.8	0.0	4.9	4.3	0.0	13.8	0.0	0.0	0.0	0.0	6.7	2.9	4.9	0.0	3.8	0.0
EDUCATION LEVEL:																				
mean	10.34	11.08	11.23	10.73	10.50	11.17	10.25	9.80	9.98	9.59	10.15	10.51	10.67	9.96	10.07	10.29	10.19	10.23	9.98	10.05
median	11.0	12.0	12.0	11.5	11.0	11.0	10.0	9.0	9.0	9.0	9.0	11.0	11.0	10.5	10.0	12.0	10.0	12.0	10.0	9.5
range	0-17	4-17	5-15	8-16	5-17	8-17	3-15	7-16	6-15	6-14	8-13	4-16	6-17	3-13	3-13	0-12	6-17	1-14	5-16	8-14
st. dev.	2.31	2.30	2.16	2.15	2.19	3.37	2.37	2.36	2.17	2.05	1.99	2.60	2.51	2.52	2.58	2.34	2.24	2.90	2.10	2.01

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
ATTIC AREA:																				
mean	739.4	665.5	787.3	708.7	758.4	769.0	725.1	796.1	644.2	775.0	846.8	674.8	812.0	705.7	668.0	782.1	766.6	659.9	832.2	656.4
median	720.0	700.0	793.0	691.0	720.0	720.0	736.0	640.9	660.0	800.0	867.0	688.0	864.0	754.0	672.0	764.0	800.0	720.0	800.0	692.0
range	0-3200	60-1200	928-1292	154-1388	0-3200	700-888	144-1440	300-1400	96-1824	400-1483	320-1204	133-1608	100-1288	375-1125	450-1056	160-1440	90-1820	200-960	147-1485	368-1020
st. dev.	308.0	208.0	267.0	273.8	422.4	103.3	227.5	344.5	308.1	246.2	224.1	315.5	275.9	220.7	156.8	310.5	418.4	184.2	292.4	180.3
IN-HOUSE CONTRACTOR:																				
% yes	44.5	9.1	0.0	16.7	55.4	0.0	95.9	100.0	94.9	94.9	50.0	100.0	2.0	95.5	78.6	2.2	30.0	15.4	0.0	9.1
HOT WATER JACKET:																				
% yes	69.9	55.9	69.2	68.8	81.0	33.3	67.3	76.0	44.1	94.9	100.0	79.5	62.7	31.8	86.7	57.8	82.3	73.1	81.3	63.6
PIPE WRAP INSULATION:																				
% yes	40.1	0.0	76.9	8.3	61.4	16.7	6.1	76.0	23.7	89.7	46.2	64.1	62.7	40.9	66.7	0.0	24.2	88.5	31.3	68.2
WINDOW GLAZING:																				
% yes	70.7	66.1	80.8	72.9	77.4	66.7	4.1	60.0	81.4	84.6	84.6	43.6	80.4	63.6	60.0	68.9	83.9	84.6	85.9	86.4
SASH:																				
% yes	61.2	45.8	38.5	70.8	57.1	50.0	63.3	64.0	74.6	71.8	84.6	69.2	60.8	95.5	40.0	75.6	67.7	57.7	31.3	63.6
WEATHERSTRIPPING:																				
% yes	94.6	76.3	96.2	89.6	98.8	100.0	91.8	100.0	93.2	97.4	100.0	97.4	92.2	100.0	86.7	100.0	95.2	96.2	100.0	100.0
SWEEPS:																				
% yes	70.3	50.8	80.8	81.3	86.9	100.0	79.6	64.0	62.7	92.3	100.0	56.4	78.4	86.4	33.3	40.0	64.5	69.2	56.3	100.0
THRESHOLD:																				
% yes	56.7	45.8	61.5	18.8	42.9	83.3	46.9	64.0	66.1	30.8	15.4	87.2	62.7	59.1	66.7	73.3	58.1	76.9	71.9	81.8

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
ATTIC AREA:																				
mean	739.4	665.5	787.3	708.7	758.4	769.0	725.1	796.1	644.2	775.0	846.8	674.8	812.0	705.7	668.0	782.1	766.6	659.9	832.2	656.4
median	720.0	700.0	793.0	691.0	720.0	720.0	736.0	640.9	660.0	800.0	867.0	688.0	864.0	754.0	672.0	764.0	800.0	720.0	800.0	692.0
range	0-3200	60-1200	928-1292	154-1388	0-3200	700-888	144-1440	300-1400	96-1824	400-1483	320-1204	133-1608	100-1288	375-1125	450-1056	160-1440	90-1820	200-960	147-1485	368-1020
st. dev.	308.0	208.0	267.0	273.8	422.4	103.3	227.5	344.5	308.1	246.2	224.1	315.5	275.9	220.7	156.8	310.5	418.4	184.2	292.4	180.3
IN-HOUSE CONTRACTOR:																				
% yes	44.5	9.1	0.0	16.7	55.4	0.0	95.9	100.0	94.9	94.9	50.0	100.0	2.0	95.5	78.6	2.2	30.0	15.4	0.0	9.1
HOT WATER JACKET:																				
% yes	69.9	55.9	69.2	68.8	81.0	33.3	67.3	76.0	44.1	94.9	100.0	79.5	62.7	31.8	86.7	57.8	82.3	73.1	81.3	63.6
PIPE WRAP INSULATION:																				
% yes	40.1	0.0	76.9	8.3	61.4	16.7	6.1	76.0	23.7	89.7	46.2	64.1	62.7	40.9	66.7	0.0	24.2	88.5	31.3	68.2
WINDOW GLAZING:																				
% yes	70.7	66.1	80.8	72.9	77.4	66.7	4.1	60.0	81.4	84.6	84.6	43.6	80.4	63.6	60.0	68.9	83.9	84.6	85.9	86.4
SASH:																				
% yes	61.2	45.8	38.5	70.8	57.1	50.0	63.3	64.0	74.6	71.8	84.6	69.2	60.8	95.5	40.0	75.6	67.7	57.7	31.3	63.6
WEATHERSTRIPPING:																				
% yes	94.6	76.3	96.2	89.6	98.8	100.0	91.8	100.0	93.2	97.4	100.0	97.4	92.2	100.0	86.7	100.0	95.2	96.2	100.0	100.0
SWEEPS:																				
% yes	70.3	50.8	80.8	81.3	86.9	100.0	79.6	64.0	62.7	92.3	100.0	56.4	78.4	86.4	33.3	40.0	64.5	69.2	56.3	100.0
THRESHOLD:																				
% yes	56.7	45.8	61.5	18.8	42.9	83.3	46.9	64.0	66.1	30.8	15.4	87.2	62.7	59.1	66.7	73.3	58.1	76.9	71.9	81.8

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
DOORS:																				
% yes	46.9	54.2	26.9	47.9	45.2	83.3	57.1	48.0	50.8	20.5	30.8	61.5	45.1	72.7	40.0	55.6	46.8	65.4	23.4	50.0
SKIRTING:																				
% yes	4.0	0.0	3.8	6.3	1.2	33.3	0.0	8.0	0.0	7.7	0.0	2.6	3.9	22.7	0.0	0.0	0.0	7.7	12.5	0.0
CAULKING:																				
% yes	93.9	76.3	100.0	93.8	72.6	100.0	98.0	100.0	100.0	100.0	100.0	97.4	96.1	100.0	100.0	100.0	98.4	100.0	100.0	100.0
ATTIC INSULAT (CELL):																				
% yes	50.3	42.4	53.8	33.3	48.8	33.3	73.5	44.0	47.5	53.8	46.2	53.8	62.7	86.4	40.0	20.0	50.0	50.0	57.8	50.0
WALL INSULAT (CELL):																				
% yes	15.3	25.4	23.1	12.5	34.5	0.0	0.0	12.0	10.2	17.9	0.0	12.8	7.8	4.5	20.0	8.9	21.0	0.0	15.6	13.6
STORMS:																				
% yes	45.8	27.1	38.5	27.1	54.8	16.7	38.8	64.0	50.8	64.1	84.6	71.8	49.0	68.2	53.3	26.7	35.5	36.0	43.8	50.0
FURNACE:																				
% yes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DUCT VENT:																				
% yes	49.9	37.3	73.1	33.3	46.4	33.3	57.1	56.0	30.5	59.0	46.2	53.8	62.7	63.6	40.0	71.1	32.3	69.2	53.1	54.5
$ HOT WATER JACKET:																				
mean	13.53	18.81	12.94	17.61	9.33	15.00	18.46	10.68	15.55	8.53	12.62	7.12	11.90	6.83	15.00	15.04	16.19	9.93	16.79	9.77
median	12.00	14.00	12.00	16.00	6.00	15.00	18.00	10.00	10.50	7.00	14.00	7.00	12.00	7.00	10.00	13.00	15.00	9.00	15.50	10.00
range	6-60	8-51	8-16	7-35	6-25	10-20	11-32	10-19	8-60	7-14	7-25	7-10	8-19	6-7	8-50	12-25	7-45	6-21	10-23	7-12
st. dev.	6.90	11.62	2.19	6.45	4.66	7.07	3.47	2.08	12.58	2.81	5.47	.60	3.26	.41	11.64	4.41	6.43	3.75	3.47	1.79

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
$ PIPE WRAP:																				
mean	4.17	30.00	5.90	14.00	2.85	12.00	6.67	5.56	5.93	2.69	2.00	1.96	3.78	2.11	6.60	NA	4.67	3.00	6.05	3.87
median	3.00	30.00	5.00	4.50	2.00	12.00	7.00	5.00	3.00	3.00	2.00	2.00	5.00	2.00	5.50		5.00	2.00	5.00	5.00
range	1-45	30-30	3-10	2-45	1-10	12-12	6-7	2-15	1-25	1-6	2-2	1-3	2-5	1-5	2-13		1-6	1-23	3-20	1-7
st. dev.	4.28	0.00	2.58	20.74	2.27	0.00	.58	4.29	6.86	1.18	0.00	.35	1.39	1.17	4.25		1.50	4.90	3.71	2.00
$ WINDOW GLAZING:																				
mean	8.18	12.66	7.71	6.63	7.10	4.25	3.00	2.13	3.77	3.77	7.18	2.59	18.35	2.85	6.22	4.65	8.71	3.48	16.12	8.00
median	5.00	10.00	7.00	5.00	5.00	4.00	3.00	2.00	2.00	4.00	5.00	2.00	13.50	2.00	4.00	4.00	7.00	2.00	12.00	8.00
range	1-75	2-45	3-16	1-16	2-51	3-6	2-4	2-4	1-20	2-11	2-20	2-7	4-72	2-6	2-17	3-11	2-24	1-8	1-75	1-16
st. dev.	9.14	8.43	3.72	4.10	9.08	1.50	1.41	.52	4.30	2.19	5.72	1.42	15.00	1.28	6.18	2.14	5.543	2.48	13.75	4.72
$ SASH:																				
mean	165.80	111.74	222.90	113.00	249.75	154.33	100.83	348.94	255.93	131.41	178.20	225.64	105.61	130-71	170.00	210.06	75.48	183.43	52.20	166.14
median	125.00	92.00	159.50	89.50	174.50	151.00	91.00	339.50	195.00	88.00	151.50	191.00	104.00	111.00	181.50	172.00	20.00	151.50	30.00	129.00
range	1-888	1-350	90-540	1-465	1-888	87-225	2-342	1-798	1-761	2-446	2-410	16-687	2-258	1-405	4-259	1-640	2-464	19-479	1-220	41-552
st. dev.	165.10	93.21	146.10	124.23	234.09	69.06	92.16	220.89	182.60	136.01	156.46	157.59	82.77	119.57	89.84	.80	114.11	146.84	57.23	130.06
$ WEATHERSTRIPPING:																				
mean	28.25	35.25	47.24	38.05	21.51	24.83	42.21	25.52	24.66	10.84	26.39	21.05	25.40	9.35	44.62	32.26	29.05	24.63	29.92	27.82
median	24.00	34.50	48.00	32.00	20.00	23.50	38.00	25.00	20.00	10.00	18.00	22.00	24.00	8.00	52.00	28.00	21.50	18.00	24.00	25.50
range	1-135	2-75	8-96	2-126	3-54	10-38	13-104	5-58	10-53	3-32	8-57	5-35	5-54	3-16	3-99	10-102	8-135	1-74	6-95	8-56
st. dev.	18.41	15.26	19.21	26.93	12.16	10.67	17.93	12.63	9.36	5.65	15.73	5.61	12.47	4.08	27.69	17.31	23.15	17.96	19.63	11.47
$ SWEEPS:																				
mean	6.21	15.20	4.58	10.97	5.87	4.00	6.00	2.44	4.54	3.69	7.23	2.32	6.25	2.79	4.20	5.61	8.13	2.53	6.59	4.76
median	4.00	13.00	4.00	10.00	5.00	3.00	5.50	2.00	2.00	4.00	5.00	3.00	5.00	3.00	3.00	4.00	8.00	3.00	4.50	4.00
range	1-51	3-45	2-8	1-51	1-21	3-7	2-16	1-5	1-22	1-7	2-20	1-5	2-20	1-8	3-8	2-17	2-16	1-4	2-35	2-12
st. dev.	5.96	10.33	1.74	9.28	4.59	1.67	3.50	1.37	5.26	1.31	6.23	1.32	3.90	2.12	2.17	4.35	4.85	1.01	6.48	2.32
$ THRESHOLD:																				
mean	17.32	19.52	19.75	11.44	10.59	14.60	9.44	16.00	17.21	10.31	17.00	17.09	24.91	7.69	12.80	20.39	16.27	14.67	21.51	29.78
median	16.00	16.00	19.75	10.00	10.00	14.00	8.00	15.00	20.00	7.00	17.00	16.00	26.00	7.00	10.00	22.00	12.00	16.00	20.00	26.00
range	1-68	10-60	11-32	6-22	4-36	7-22	4-30	7-31	10-31	7-26	14-20	8-32	10-40	1-14	8-24	4-39	10-33	8-18	10-45	16-68
st. dev.	9.28	10.24	7.64	4.33	7.52	6.39	7.12	6.82	6.92	5.75	4.24	5.30	8.14	3.82	5.81	8.41	6.93	3.73	9.75	13.10

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
$ DOORS																				
mean	76.97	104.32	71.71	76.88	62.11	72.40	100.04	94.17	80.90	66.75	64.50	56.00	93.27	72.00	50.33	58.52	60.14	95.00	73.40	80.36
median	67.00	105.00	67.00	76.50	49.50	47.00	100.50	101.00	66.50	59.50	77.00	58.00	80.00	56.50	41.00	62.00	55.00	107.0	70.00	73.00
range	2.265	3-260	45-152	6-240	7-225	20-186	2-222	42-165	38-167	40-132	12-92	17-146	12-216	12-265	24-98	24-126	5-127	13-159	20-125	24-160
st. dev.	46.12	56.56	36.84	49.11	40.28	67.72	65.25	39.22	31.80	29.88	36.16	30.36	53.03	58.16	27.05	25.98	33.26	43.23	30.65	40.89
$ SKIRTING:																				
mean	62.71	63.00	82.00	22.67	59.00	12.50	NA	222.00	NA	14.25	NA	63.00	62.50	23.50	NA	NA	NA	164.00	67.00	NA
median	36.00	63.00	82.00	16.00	59.00	12.50		222.00		3.00		63.00	62.50	21.50				164.00	37.50	
range	2-421	63-63	82-82	5-47	59-59	10-15		23-421		2-49		63	45-80	15-36				140-188	13-250	
st. dev.	86.51	0.00	0.00	21.78	0.00	3.54		281.43		23.17		0.00	24.75	9.61				33.94	78.85	
$ CAULKING:																				
mean	72.78	68.89	79.08	84.59	53.13	88.33	63.21	51.28	60.36	52.74	74.62	65.08	43.39	85.14	54.57	123.33	83.15	59.20	98.32	99.41
median	66.50	57.50	73.00	77.00	48.50	90.00	63.00	48.00	58.00	45.00	70.00	67.00	41.00	81.00	50.50	91.00	82.00	54.00	94.00	101.00
range	1-424	16-150	24-162	1-224	1-216	30-160	3-148	19-97	5-153	4-141	29-130	24-94	15-90	24-169	10-112	61-424	14-225	33-120	30-208	16-185
st. dev.	43.79	34.03	34.61	38.42	38.15	44.01	35.41	20.94	34.74	31.67	30.57	15.87	15.79	44.06	29.63	75.47	43.19	23.99	42.65	46.85
$ ATTIC INSULATION:																				
mean	144.18	120.00	166.10	128.63	118.73	199.00	183.86	112.20	123.75	135.19	133.50	95.35	142.12	119.68	106.00	183.00	206.03	82.75	190.84	115.00
median	133.00	116.50	160.00	130.00	97.00	199.00	170.50	122.50	126.00	128.00	135.00	96.00	141.50	121.00	83.00	163.00	192.00	77.50	175.00	118.00
range	2-650	7-301	68-256	43-234	12-305	168-230	2-454	47-203	2-347	25-265	51-274	17-184	11-340	5-202	54-255	70-397	3-465	37-162	2-650	46-160
st. dev.	95.05	81.47	56.61	56.77	70.49	43.84	123.97	48.83	86.41	61.21	81.51	41.09	72.66	53.59	74.09	89.60	151.50	30.01	124.01	34.23
$ WALL INSULATION:																				
mean	148.42	199.20	123.43	170.43	100.38	NA	NA	77.25	73.50	87.43	NA	37.40	137.00	37.00	89.00	127.00	307.77	NA	234.20	101.67
median	125.50	188.00	104.00	161.00	77.00			72.00	63.00	104.00		34.00	146.00	37.00	95.00	76.50	256.00		238.00	136.00
range	12-598	30-329	72-260	127-244	12-267			41-124	15-149	28-102		21-56	31-225	37-37	48-124	36-319	70-598		92-359	17-152
st. dev.	112.61	91.36	62.29	41.79	63.51			42.25	47.14	44.99		12.84	79.90	0.00	38.35	130.80	173.74		77.33	73.76
$ STORM WINDOWS:																				
mean	128.20	196.33	98.70	116.64	143.09	245.00	80.80	133.63	98.73	127.96	160.36	134.86	100.00	153.40	90.88	153.75	113.46	109.11	155.96	116.18
median	94.00	80.00	97.00	95.00	133.00	245.00	65.00	97.50	71.00	99.00	120.00	90.50	60.00	124.00	83.50	112.50	67.50	69.00	120.00	86.00
range	5-735	30-735	20-200	13-320	23-415	245-245	5-258	18-432	19-296	23-389	20-600	20-616	15-510	19-303	49-130	31-533	23-514	23-362	30-460	21-256
st. dev.	113.54	215.73	60.08	89.38	99.80	0.00	64.00	109.20	74.30	110.02	160.44	139.17	106.97	112.70	29.30	146.63	108.97	104.60	113.40	89.48

	SAMPLE	CAP 1	CAP 2	CAP 3	CAP 4	CAP 5	CAP 6	CAP 7	CAP 8	CAP 9	CAP 10	CAP 11	CAP 12	CAP 13	CAP 14	CAP 15	CAP 16	CAP 17	CAP 18	CAP 19
$ DUCT VENTS:																				
mean	20.02	20.41	24.16	18.81	18.05	23.50	21.85	14.29	13.83	15.05	21.00	19.29	22.66	13.79	14.60	18.56	21.15	15.53	30.82	22.25
median	17.00	19.00	24.00	14.50	16.00	23.50	22.00	12.00	12.00	15.00	20.00	19.00	23.50	11.00	14.00	14.00	17.00	16.00	29.00	17.50
range	1-75	8-38	8-45	6-75	1-63	15-32	7-45	3-29	5-24	4-28	5-40	5-47	6-40	1-40	2-28	5-43	6-48	5-24	8-60	5-46
st. dev.	11.79	8.24	10.00	15.86	11.60	12.02	10.78	8.60	5.35	7.08	16.36	12.01	10.36	11.32	9.74	11.10	13.04	4.78	14.81	13.34
$ MATERIALS:																				
mean	564.12	595.36	615.00	513.25	585.56	452.00	550.24	616.88	543.16	469.33	588.00	593.26	486.04	559.96	506.64	715.82	526.34	476.96	588.44	646.23
median	550.00	504.00	603.00	476.50	511.00	421.00	589.00	683.00	471.50	411.00	552.00	571.00	496.50	542.50	506.50	726.00	458.00	393.00	583.00	703.00
range	16-2054	158-1411	69-1105	43-1057	17-2054	107-733	56-947	93-1206	16-1323	16-1010	159-1139	103-1076	65-1027	213-998	58-1030	50-1499	118-1100	82-1168	177-1199	28-1323
st. dev.	309.67	329.08	315.83	282.06	404.22	219.17	251.79	367.81	326.90	297.79	327.33	258.70	258.49	231.73	281.61	357.32	275.98	277.77	231.70	322.78
$ LABOR:																				
mean	431.11	393.89	372.00	487.77	417.85	343.17	541.60	474.84	315.62	422.08	416.85	420.13	361.92	500.27	513.86	428.44	394.25	354.60	540.28	497.46
median	401.00	405.00	382.00	473.00	373.00	297.50	586.00	488.00	266.50	369.00	376.00	404.50	324.50	477.00	518.50	435.00	309.00	320.00	544.00	535.50
range	15-1193	115-830	50-847	123-1032	30-1070	130-727	53-942	69-890	250-579	15-909	148-859	73-762	63-851	280-839	119-1193	92-932	100-1021	93-705	60-1138	30-820
st. dev.	220.91	172.67	201.31	221.20	235.89	204.16	250.20	273.35	82.13	268.03	206.16	183.10	209.77	147.57	284.08	208.94	233.16	169.49	218.12	212.13
$ SUPPORT:																				
mean	231.42	246.73	221.46	279.77	193.43	246.67	272.98	246.16	246.14	222.77	201.23	196.61	170.00	275.55	255.14	152.58	276.33	207.64	282.20	272.09
median	251.00	233.00	222.00	280.00	188.00	250.00	294.00	255.00	226.50	195.00	165.00	191.00	179.50	269.00	263.50	151.00	268.00	178.00	290.00	310.50
range	8-702	70-478	24-480	269-280	13-400	230-250	27-472	33-620	67-1419	8-480	154-399	35-367	25-364	269-413	44-431	32-311	268-750	44-468	59-480	15-393
st. dev.	107.57	109.77	117.82	1.59	111.70	8.17	125.39	155.11	196.65	141.39	81.73	86.01	88.78	30.70	121.98	73.77	61.75	109.97	106.18	113.01
$ TOTAL:																				
mean	1224.68	1260.56	1246.04	1280.73	1196.67	1041.83	1351.13	1338.12	1078.25	1115.00	1205.92	1213.63	1017.96	1329.68	1275.64	1328.76	1196.83	1062.08	1410.84	1415.64
median	1208.00	1156.00	1189.00	1228.50	1148.00	944.50	1469.00	1405.00	910.00	976.00	1070.00	1171.00	1079.00	1234.00	1319.50	1321.00	1023.50	898.00	1448.50	1592.00
range	40- 2400	350- 2395	143- 2400	496- 2272	63- 2400	487- 1690	137- 2361	199- 2390	333- 2378	40- 2399	472- 2396	212- 2205	153- 2184	839- 2106	222- 2153	295- 2400	486- 2376	218- 2341	296- 2400	73- 2400
st. dev.	591.56	595.97	647.71	477.43	693.54	401.39	622.14	760.19	508.35	707.06	585.24	531.39	533.58	349.05	609.00	611.42	497.87	551.07	530.87	609.09

APPENDIX D: CONFIDENCE INTERVALS FOR ESTIMATES

APPENDIX D: CONFIDENCE INTERVALS FOR ESTIMATES

CONFIDENCE INTERVALS FOR MEAN SAVINGS BY CAP

Variable	Sample Size (n)	T-Value	Standard Deviation	Square Root of n	Confidence Interval	Weighted Mean	Confidence Interval Lower	Upper
CAP 1	31	1.96	14.24	5.57	5.01	20.64	15.63	25.65
CAP 2	11	2.228	18.79	3.32	12.62	13.43	0.81	26.05
CAP 3	38	1.96	14.08	6.16	4.48	8.44	3.96	12.92
CAP 4	60	1.96	15.74	7.75	3.98	14.56	10.58	18.54
CAP 5	2	12.706	8.01	1.41	71.97	21.8	-50.17	93.77
CAP 6	23	2.074	18	4.80	7.78	20.63	12.85	28.41
CAP 7	9	2.306	21.31	3.00	16.38	10.4	-5.98	26.78
CAP 8	28	2.052	15.31	5.29	5.94	9.53	3.59	15.47
CAP 9	24	2.069	18.03	4.90	7.61	16.93	9.32	24.54
CAP 10	7	2.447	20.28	2.65	18.76	17.37	-1.39	36.13
CAP 11	22	2.08	19.49	4.69	8.64	20.36	11.72	29.00
CAP 12	21	2.086	10.2	4.58	4.64	14.17	9.53	18.81
CAP 13	12	2.201	12.39	3.46	7.87	19.61	11.74	27.48
CAP 14	2	12.706	0.9	1.41	8.09	0.76	-7.33	8.85
CAP 15	31	1.96	17.01	5.57	5.99	17.12	11.13	23.11
CAP 16	29	2.048	16.82	5.39	6.40	10.01	3.61	16.41
CAP 17	23	2.074	13.03	4.80	5.63	11.15	5.52	16.78
CAP 18	47	1.96	16.14	6.86	4.61	21.37	16.76	25.98
CAP 19	7	2.447	11.42	2.65	10.56	10.35	-0.21	20.91

CONFIDENCE INTERVALS FOR SAMPLE VARIABLES

	Variable Name	Sample Size (n)	T-Value	Standard Deviation	Square Root of n	Confidence Interval	Sample Mean	Confidence Interval Lower	Confidence Interval Upper
Exhibit 5-2: Economic Characteristics of High-Energy Consumers	Annual Household Income	102	1.96	584.1	10.10	113.36	6489	6375.64	6602.36
	LIHEAP Funds	102	1.96	55.5	10.10	10.77	215	204.23	225.77
Exhibit 5-3: Energy Saving Characteristics of High-Energy Consumers	Btu Savings (Millions of Btu)	97	1.96	20.7	9.85	4.12	26.8	22.68	30.92
	Percent Savings	100	1.96	16.4	10.00	3.21	20.01	16.80	23.22
Exhibit 5-4: Comparison of Weatherization Cost by Type of Energy Consumer	High Energy Consumer								
	Materials Amount	102	1.96	296	10.10	57.44	721	663.56	778.44
	Total Amount	102	1.96	559	10.10	108.48	1561	1452.52	1669.48
Exhibit 5-6: Dwelling Characteristics of Low Btu Savers	Attic Area (sq. ft.)	76	1.96	292	8.72	65.65	672.1	606.45	737.75
	Total Square Feet	73	1.96	452.5	8.54	103.80	865.8	762.00	969.60
Exhibit 5-8: Savings Characteristics of Low Btu Savers	Pre-Btu Consumption (Millions of Btu)	104	1.96	88.69	10.20	17.05	79.69	62.64	96.74
	Btu Savings (Millions of Btu)	104	1.96	5.9	10.20	1.13	-3.74	-4.87	-2.61
	Percent Savings	104	1.96	8.07	10.20	1.55	-4.69	-6.24	-3.14
Exhibit 5-11: Comparison of Weatherization Savings by Type of Work Crew	Contractors								
	Btu Savings (Millions of Btu)	238	1.96	15.27	15.43	1.94	13.7	11.76	15.64
	Percent Savings	238	1.96	14.96	15.43	1.90	15.3	13.40	17.20
Exhibit 5-12: Comparison of Weatherization Cost by Type of Work Crew (Contractors)	Materials Amount	406	1.96	317.1	20.15	30.85	591	560.15	621.85
	Labor Amount	406	1.96	216.5	20.15	21.06	430	408.94	451.06
	Support Amount	406	1.96	101.0	20.15	9.82	233	223.18	242.82
	Total Amount	406	1.96	580.6	20.15	56.48	1254	1197.52	1310.48
Exhibit 5-13: Comparison of ECM Costs by Contractor Type (Contractors)	Weatherstripping	390	1.96	19.7	19.75	1.96	31.85	29.89	33.81
	Caulking	399	1.96	47.5	16.40	5.68	81.80	76.12	87.48
	Sweeps	269	1.96	6.3	15.62	1.15	7.59	6.44	8.74
	Thresholds	244	1.96	9.2	13.75	6.91	20.00	13.09	26.91
	Door Replacement/Repair	189	1.96	48.5	17.80	1.13	80.79	79.66	81.92
	Window Glazing	317	1.96	10.3	15.36	19.66	10.52	-9.14	30.18
	Window Sash	236	1.96	154.1	13.11	18.47	147.07	128.60	165.54
	Storm Windows	172	1.96	123.6	14.07	12.94	139.91	126.97	152.85
	Attic Insulation	198	1.96	92.9	8.49	26.79	149.82	123.03	176.61

CONFIDENCE INTERVALS FOR SAMPLE VARIABLES

	Variable Name	Sample Size (n)	T-Value	Standard Deviation	Square Root of n	Confidence Interval	Sample Mean	Confidence Interval Lower	Confidence Interval Upper
	Wall Insulation	72	1.96	116.0	8.49	1.43	196.96	195.53	198.39
	Hot Water Jacket	284	1.96	6.2	16.85	0.36	15.24	14.88	15.60
	Pipe Wrap	135	1.96	3.1	11.62	2.13	4.70	2.57	6.83
	Vents	212	1.96	12.6	14.56	8.88	22.58	13.70	31.46
	Skirting	19	2.101	66.0	4.36	0.00	63.68	63.68	63.68
Exhibit 5-16: Dwelling Characteristics of Rental Unit Households	Attic Area (sq. ft.)	85	1.96	243.4	9.22	51.74	668.5	616.76	720.24
	Total Square Feet	84	1.96	351.2	9.17	75.11	870.1	794.99	945.21
Exhibit 5-17: Savings Characteristics of Renters (Rental Units)	Pre-Btu Consumption (Millions of Btu)	63	1.96	42.1	9.02	9.14	81.42	72.28	90.56
	Btu Savings (Millions of Btu)	63	1.96	19.3	3.79	9.98	14.36	4.38	24.34
	Percent Savings	63	1.96	18.98	4.20	8.86	17.63	8.77	26.49
Exhibit 5-19: Single Parent Household Dwelling Characteristics	Number of Rooms	23	2.074	1.1	4.80	0.48	6.1	5.62	6.58
	Attic Area	24	2.069	220.9	4.90	93.29	669.3	576.01	762.59
	Total Square Feet	16	2.131	363.1	4.00	193.44	990.5	797.06	1183.94
	Number of Heated Rooms	23	2.074	0.95	4.80	0.41	5.8	5.39	6.21
	Percent Heated Rooms	23	2.074	0.09	4.80	0.04	0.97	0.93	1.01
	Day Thermostat Setting	20	2.093	3.13	4.47	1.46	67.8	66.34	69.26
Exhibit 5-20: Energy Savings Characteristics of Single Parent Households	Btu Savings (Millions of Btu)	12	2.201	20.1	3.46	12.77	15.28	2.51	28.05
	Percent Savings	12	2.201	18.23	3.46	11.58	16.3	4.72	27.88
Exhibit 5-21: Economic Characteristics of Single Parent Households	Monthly Rent	24	2.069	78.99	4.90	33.36	182.3	148.94	215.66
	Annual Household Income	24	2.069	583.6	4.90	246.47	5799	5552.53	6045.47
	LIHEAP Funds	24	2.069	30	4.90	12.67	257.2	244.53	269.87
Exhibit 5-23: Economic Characteristics of Mobile Homes	Monthly Rent	16	2.131	75.2	4.00	40.06	106	65.94	146.06
	Annual Household Income	17	2.12	333	4.12	171.22	5820	5648.78	5991.22
	LIHEAP Funds	14	2.16	38.9	3.74	22.46	213	190.54	235.46
Exhibit 5-24: Energy Saving Characteristics of Mobile Homes	Energy Use Before (Millions of Btu)	10	2.262	16.55	3.16	11.84	64.9	53.06	76.74
	Btu Savings (Millions of Btu)	10	2.262	14.3	3.16	10.23	2.4	-7.83	12.63
	Percent Savings	10	2.262	19.42	3.16	13.89	3.64	-10.25	17.53

CONFIDENCE INTERVALS FOR SAMPLE VARIABLES

	Variable Name	Sample Size (n)	T-Value	Standard Deviation	Square Root of n	Confidence Interval	Sample Mean	Confidence Interval Lower	Upper
Exhibit 5-25: Cost of Weatherization for Mobile Home Dwellings	Materials Amount	16	2.131	112.2	4.00	59.77	220	160.23	279.77
	Total Amount	16	2.131	440.4	4.00	234.62	560	325.38	794.62
Exhibit 5-26: Savings for Selected Subgroups	Average Percent Savings								
	Mobile Homes	10	2.262	19.42	3.16	13.89	3.64	-10.25	17.53
	Low Btu Savers	104	1.96	8.07	10.20	1.55	-4.69	-6.24	-3.14
	Rental Units	63	1.96	18.98	7.94	4.69	17.63	12.94	22.32
	Single Parent Households	12	2.201	18.23	3.46	11.58	16.3	4.72	27.88
	Contractors	238	1.96	14.96	15.43	1.90	15.3	13.40	17.20
	High Energy Consumers	97	1.96	16.4	9.85	3.26	20.01	16.75	23.27