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STATE-LEVEL EVALUATIONS OF THE WEATHERIZATION ASSISTANCE PROGRAM IN 1990-1996: A METAEVALUATION THAT ESTIMATES NATIONAL SAVINGS

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EXECUTIVE SUMMARY

BACKGROUND

The U.S. Department of Energy's (DOE) Weatherization Assistance Program (the Program) is one of the largest energy conservation programs in the nation. This DOE Program is implemented in all fifty states and weatherizes an average of 200,000 dwellings per year. The Program strives to increase the energy efficiency of dwellings occupied by low-income persons in order to reduce their energy consumption, lower their fuel bills, increase the comfort of their homes, and safeguard their health. It targets vulnerable groups including the elderly, people with disabilities, and families with children.

The most recent comprehensive National Evaluation of the Program was based on an analysis of changes in pre- and post-weatherization energy consumption for homes weatherized in 1989. If another national evaluation were conducted today, for homes weatherized in 1996, it is very likely that the average savings would be significantly higher than they were in 1989. There are a number of reasons to believe that current savings would be higher than those estimated for 1989. First, the Program has made significant advances in its weatherization procedures. One important advance is the post-1989 introduction, and now the widespread use of advanced audits. In 1989, the Program was not yet using advanced audits. Today more than half of the states use them. Several studies have demonstrated the superior energy savings achieved with the use of advanced audit procedures. Another important advance is the increased use of blower-door directed air sealing. In 1989 only a few states used this technology; now most do. With the use of blower doors to guide air sealing, investments in air infiltration reduction produce higher savings. Additional reasons to expect higher energy savings today include the implementation of new Program regulations designed to capture opportunities for improvement, and more targetting of high energy consumers.

METHODS

Because everyone familiar with the Program expected that its performance was likely to have improved during the last seven years, the Department of Energy asked Oak Ridge National Laboratory (ORNL) to develop proposed approaches to obtaining an updated estimate of national Program savings. The approach selected was a metaevaluation, which involved locating, assembling, and summarizing the results of all state-level evaluations of the Program that have become available since 1990. ORNL had previously completed a similar task in preparation for the National Evaluation. That task was a 1990 literature review (its findings are summarized in Table ES-3 in the section on Findings).

All of the savings estimates that are presented in this report are for dwellings that heat primarily with natural gas. Both the savings estimates taken from the National Evaluation and those based upon the state-level evaluations are for gas-heated homes. This focus on natural gas was chosen because all of the state-level evaluations conducted between 1990 and 1995 studied homes that heat primarily with natural gas. A few of the state-level evaluations also examined homes heating with other fuel types, but natural gas was the only fuel type included in all the studies. The focus on natural gas is appropriate because over half of the homes served by the Program heat with natural gas.

FINDINGS

This review of the state-level evaluations conducted since 1990 concluded that Program performance has improved significantly in the last seven years. Three types of evidence support the finding that savings are increasing:

- a literature review,
- within-state comparisons of savings over time, and
- regression modeling results.

Literature Review

The 1990 literature review, conducted in preparation for the National Evaluation, concluded that the evaluations available at that time (covering the years of 1981-1989) showed typical energy savings (expressed as the percentage reduction in the total consumption of the primary heating fuel) of between 12% and 16%, with a range of 6% to 23% savings in various locations. This 1996 metaevaluation, of 17 state-level evaluations covering 1990 to 1995, showed typical savings of 18% to 24%, with a range of savings of from 13% to 34% (Table ES-1).

Table ES-1. Literature Review Findings on Central Tendencies Characterizing the Percentage of Energy Savings in 1981-1989 and in 1990-1995.

	n	Median	Mean	Interquartile Range	Range
1980-89	25	12%	13%	12-16%	6-23%
1990-96	17	20%	22%	18-24%	13-34%

The similarity in findings from that literature review (i.e., expected average savings of 12% to 16%) and the results of the National Evaluation (13.5% savings as a percentage of the total consumption of the primary heating fuel for all end uses, or 18.3% as a percentage of consumption for space heating) led to confidence that a review of the evaluations conducted between 1990 and 1995 could also yield a reasonably accurate current estimate of typical savings.

Trends Within States

Two states for which savings can be compared over time, Vermont and Ohio, both showed significant increases in savings (Table ES-2). In Ohio, energy savings (expressed as a percentage of the total consumption of the primary heating fuel for all end uses) increased from 12.6% in 1990-91 to 27.0% in 1994-95. In Vermont, savings increased from 17.8% in 1992-93 to 20.1% in 1993-94.

Table ES-2. Trends in Energy Savings in Ohio and Vermont.

Ohio			Vermont		
	MBtu	**Percent**		**MBtu**	**Percent**
1990-91	20.5	12.6%	**1992-93**	18.0	17.8%
1993-94	29.3	20.4%	**1993-94**	24.5	20.1%
1994-95	34.8	27.0%	**n/a**	n/a	n/a

Regression Modeling Results

As Table ES-3 shows, the regression-based national estimate of savings for 1996 is considerably higher than the savings for 1989 estimated by the National Evaluation. National savings, in homes using natural gas as the primary heating fuel, for the 1989 Program Year were 17.3 MBtu, which is 18.3% of space heating consumption, or 13.0% of the total consumption of natural gas for all end uses. The regression-based national estimate for 1996 is 31.2 MBtu, which is 33.5% of natural gas space heating consumption, or 23.4% of the total consumption of natural gas for all end uses.

Table ES-3. Estimated National Program Energy Savings in 1989 and 1996 in Homes that Heat Primarily with Natural Gas

	MBtu of Natural Gas	**Percentage Reduction in Natural Gas Consumption for Space-Heating**	**Percentage Reduction in Natural Gas Consumption for All End Uses**
National Evaluation Results for 1989	17.3	18.3%	13.0%
Metaevaluation Results for 1996 based on Regression Model	31.2	33.5%	23.4%

A confidence interval for the national estimate of savings was calculated with SAS. For the national estimate of 31.2 MBtu the lower bound for the 90% confidence interval is 22.9 MBtu, and the upper bound is 38.6 MBtu. Thus, the lower bound for the 1996 estimate is well above the 1989 estimate of 17.6 MBtu. The 90% confidence interval reported in the National Evaluation for savings in gas-heated homes was 15.1 to 19.5 MBtu. As Figure ES-1 shows, the 1996 estimate of national savings, and most of the savings estimates reported in state-level evaluations conducted since 1990, are significantly higher than the average national savings measured in 1989.

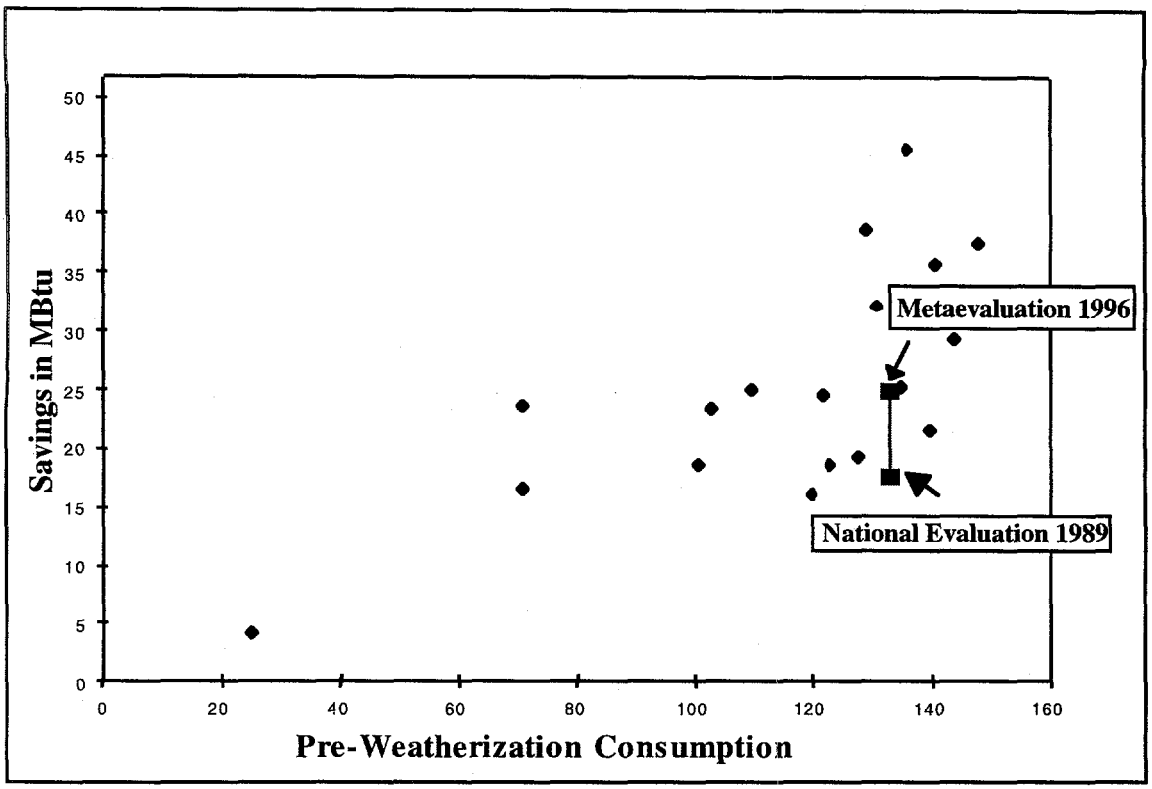

Figure ES-1.State-level Energy Savings in 1990-1995 by Pre-Weatherization Consumption and National Savings in 1989 and 1996.

Because of the higher average energy savings estimated for the Program in 1996, cost-effectiveness estimates also increased. In 1989, the National Evaluation estimated the benefit/cost ratios for gas-heated homes, with three different perspectives, as a range of 1.06 to 1.61. Applying the same procedures and assumptions to the 1996 savings yields a range of Program benefit/cost ratios of from 1.79. to 2.40.

STATE-LEVEL EVALUATIONS OF THE WEATHERIZATION ASSISTANCE PROGRAM IN 1990-1996: A METAEVALUATION THAT ESTIMATES NATIONAL SAVINGS

Linda Berry

1. INTRODUCTION

The U.S. Department of Energy's (DOE) Weatherization Assistance Program (the Program) is one of the largest energy conservation programs in the nation. This DOE Program is implemented in all fifty states and weatherizes an average of 200,000 dwellings per year. The Program strives to increase the energy efficiency of dwellings occupied by low-income persons in order to reduce their energy consumption, lower their fuel bills, increase the comfort of their homes, and safeguard their health. It targets vulnerable groups including the elderly, people with disabilities, and families with children.

The most recent comprehensive National Evaluation of the Program was based on an analysis of changes in pre- and post-weatherization energy consumption for homes weatherized in 1989. The National Evaluation (Brown, Berry, Balzer, and Faby, 1993), which used a representative national sample of several thousand dwellings estimated average savings for several fuel types. For dwellings that heated primarily with natural gas, which made up over 50% of the sample, average savings per dwelling were 17.3 MBtu, which was 18.3% of space heating consumption, or 13.0% of the total consumption of natural gas for all end uses. For all fuel types combined, the National Evaluation reported an average savings per dwelling of 17.6 MBtu, which was 18.2% of space heating consumption, or 13.5% of the total consumption of the primary heating fuels[1] for all end uses.

If another national evaluation were conducted today, for homes weatherized in 1996, it is very likely that the savings would be significantly higher than they were in 1989. There are a number of reasons to believe that current savings would be higher than those estimated for 1989. First, the Program has made significant advances in its weatherization procedures. One important advance is the post-1989 introduction, and now the widespread use of advanced audits. In 1989, the Program was not yet using advanced audits. Today more than half of the states use them. Two studies, one in New York and one North Carolina, demonstrated the superior energy savings achieved with the use of advanced audit procedures (New York State Energy Research and Development Authority and New York State Department of State, 1993; Sharp, 1994). In North Carolina the introduction of an advanced audit increased heating energy savings from 18% to 23%. In New York, savings increased from 25% to 34%.

Another important advance is the increased use of blower-door directed air sealing. In 1989 only a few states used this technology; now most do. With the use of blower doors to guide air sealing, investments in air infiltration reduction will produce higher savings.

Another reason to expect higher savings today is that more weatherization agencies now target high energy consumers. Many studies have shown that high pre-weatherization consumption is the best predictor of high energy savings (Brown et al., 1993; Columbia Gas of Ohio, 1995; Pennsylvania Public Utility Commission, 1994). Additional reasons to

[1] The total consumption of the primary heating fuel includes both heating usage and end uses other than heating such as cooking, hot-water heating, etc.

expect higher energy savings today relate to the implementation of new Program regulations designed to capture opportunities for improvement. Among the new DOE regulations issued in 1994 are changes that promote the use of advanced audits, and permit the use of cooling efficiency measures such as air conditioner replacements, ventilation equipment, and screening and shading devices.

The Program's ability to improve its own performance was demonstrated by the fact that previous metaevaluations found an upward trend in Program savings between 1980 and 1990 (Schlegel and Pigg, 1990; Cohen and Goldman, 1991). Because the potential for savings continues to exceed prior levels of Program performance, a trend toward higher savings in the 1990's should be expected.

1.1 NEED FOR AN UPDATED ESTIMATE OF NATIONAL SAVINGS

Because everyone familiar with the Program expected that its performance was likely to have improved during the last seven years, the Department of Energy asked Oak Ridge National Laboratory (ORNL) to develop proposed approaches to obtaining an updated estimate of national Program savings. The proposed approaches were to include both high and low budget options and to discuss the tradeoffs between study costs and accuracy.

ORNL suggested three general classes of methods that could be used to update the estimates of Program energy savings:

- billing analyses,
- engineering analyses, and
- metaevaluation.

Both the engineering and billing analyses options would involve extensive data collection, processing, and analysis activities. Such efforts would require a large staff of workers, just as the National Evaluation of 1989 did, to conduct large-scale agency and utility telephone and mail contacts, follow-up data collection activities, data entry, data processing, and statistical analyses. In addition, a billing analysis option would require several years to complete, as would a well-validated engineering analysis of Program savings.

The third option, a metaevaluation, which would involve locating, assembling, and summarizing the results of all state-level evaluations of the Program that have become available since 1990, was by far the lowest cost and quickest approach. While this approach would not produce as comparable or detailed a picture of Program performance as the other two approaches, the DOE preferred it because it could be completed much more quickly and inexpensively. ORNL had completed a similar task in preparation for the National Evaluation. That task was a literature review (which was completed in 1990 and is presented in Section 1.4 of Brown, et al.(1993)).

The 1990 literature review concluded that the evaluations available at that time (covering the years of 1981-1989) showed that energy savings of between 12% and 16% (as a percentage of the total consumption of the primary heating fuel for all end uses) were typical, with a range of 6% to 23% savings in various locations. The 1990 literature review also concluded that a number of demonstration projects indicated that the Program could potentially achieve much greater savings (25% to 40%). The similarity in findings from that literature review (i.e., expected average savings of 12% to 16%) and the results of the National Evaluation (13.5% savings as a percentage of the total consumption of the

primary heating fuel for all end uses, or 18.3% as a percentage of consumption for space heating) led to confidence that a review of the evaluations conducted between 1990 and 1995 could also yield a reasonably accurate current estimate of typical savings. In addition, the fact that previous metaevaluations (Schlegel and Pigg, 1990; Cohen and Goldman, 1991) had shown an improvement in Program performance between 1980 and 1989, suggested that a new, more up-to-date metaevaluation, might also reveal continuing improvements between 1990 and 1995 .

All of the savings estimates that are presented in the remainder of this report are for dwellings that heat primarily with natural gas. Both the savings estimates taken from the National Evaluation and those based upon the state-level evaluations are for gas-heated homes. This focus on natural gas was chosen because all of the state-level evaluations conducted between 1990 and 1995 studied homes that heat primarily with natural gas. A few of the state-level evaluations also examined homes heating with other fuel types, but natural gas was the only fuel type included in all the studies.

2. METHODS

2.1 LOCATING AND SELECTING STATE-LEVEL EVALUATIONS

The first step in the metaevaluation was to locate and obtain copies of all of the state-level evaluations of the DOE Program that had been completed since 1990. In order to do this, a one-page survey form (Appendix A) was prepared and sent to all state directors of the Program. Contact names, addresses, and responses to this state survey are summarized in Appendix B. Another survey form, designed for utilities with low-income programs (Appendix C) was prepared and sent out at the same time. The list of utilities receiving this form was taken from an ORNL report that had identified utility low-income programs operating in 1992 (Brown, Beyer, Eisenberg, Lapsa, Power, 1994). Some of these utility programs were expected to coordinate their efforts closely enough with the DOE Program so that their evaluations would be suitable as input to the effort to obtain an updated estimate of national Program savings. Responses to the utility survey are shown in Appendix D. In addition, telephone contact was made with several independent contractors (such as Synertech, and Wisconsin Energy Conservation Corporation) that often perform evaluations of weatherization programs to ask if they knew of any relevant evaluations completed or underway.

Because the evaluations that would be of most value were those which systematically examined efforts that closely followed DOE Program procedures and guidelines, follow-up telephone calls were conducted after receiving each positive survey response. When the survey answers indicated that an evaluation was available (or underway), the contact person was asked to discuss whether or not a given evaluation should be used to represent the performance of the DOE Program in their state. In most cases it was clear whether or not an evaluation covered the DOE Program with its characteristic set of measures, clients, and procedures. In a few cases, some judgment was required in making this determination. Coordinated utility programs may follow DOE procedures exactly, or may make small changes (e.g., offering compact fluorescents along with standard DOE measures) that would not make an evaluation of the program unusable as an indicator of the DOE Program's performance. On the other hand, many coordinated utility programs follow such different procedures (e.g., limiting measures to those with a seven year payback, or targeting only electrically-heated dwellings) that they cannot be used to represent the DOE Program's savings. In the end, only three utility evaluations seemed to be suitable as indicators of the DOE Program's performance in a state. These evaluations, along with those conducted by the state offices of the Weatherization Assistance Program, are discussed below.

2.2 SUMMARY OF THE STATE-LEVEL EVALUATIONS

2.2.1 Nine States with Published Results

Using the methods described above eleven published state-level evaluations were obtained from nine states (Fig. 1). The states with published evaluations and the dates of weatherization for the houses included in each study were as follows:

- Colorado (1993-95),
- Indiana (1991-92),
- Iowa, (1992-93),
- New York (1990),

- North Carolina (1990),
- North Dakota (1990-92),
- Ohio (1990-91 and 1993-94),
- Texas (1991-92), and
- Vermont (1992-93 and 1993-94).

In both Ohio and Vermont, two separate evaluations of Program energy savings were conducted and published between 1990 and 1995 (Columbia Gas of Ohio, 1993; Columbia Gas of Ohio, 1995; Vermont State Office of Economic Opportunity, 1993; Vermont State Office of Economic Opportunity, 1995).

Three of the published evaluations were conducted by utility companies (Public Service Company of Colorado, 1995; Columbia Gas of Ohio, 1993 and Columbia Gas of Ohio, 1995). All three of these evaluations, although conducted by utility staff or their contractors, were of programs that followed DOE procedures. In each case, the state Weatherization Program contacts and the utility contacts believed that the evaluations were good indicators of the DOE Program's performance in their states. In addition, the two Columbia Gas evaluations, conducted for homes weatherized in 1990-91 and in 1993-94, provide an indication of the rate of increase in Program savings over time. The Colorado evaluation was based on econometric modeling. Both of the Ohio evaluations were based on analysis of whole house natural gas billing data.

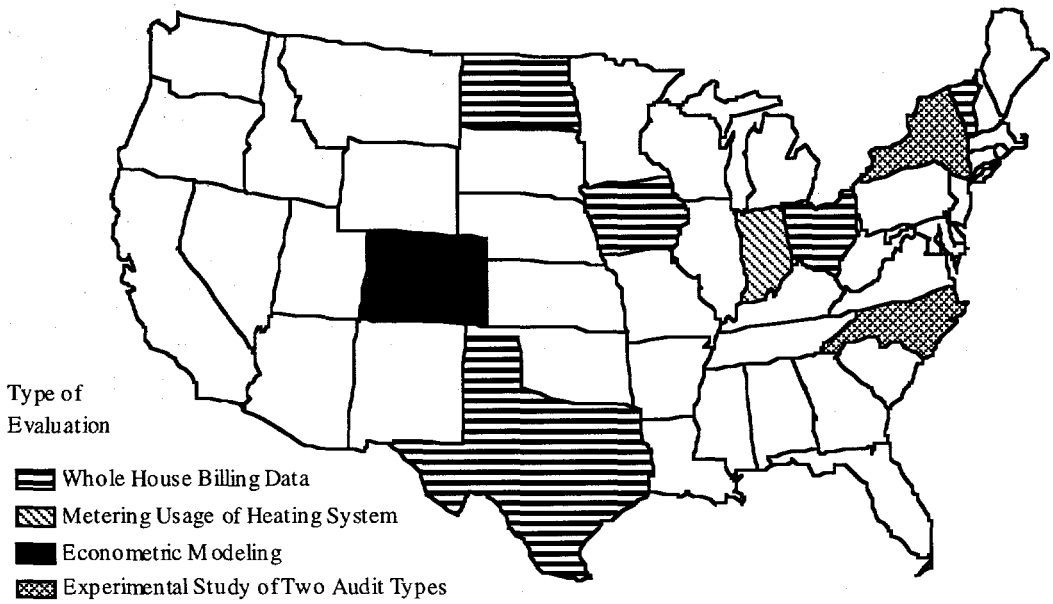

Figure 1. States with Published Evaluations of the Program in 1990-1995.

Two of the eleven published evaluations (Sharp, 1994; New York Energy Research and Development Authority and New York Department of State, 1993) were experimental studies which provided measurements of the energy savings obtained with two types of audit procedures. In both New York and North Carolina, the evaluations compared energy savings results for a group of homes treated with standard state procedures at the time of the study to results for a group of homes treated with an advanced audit (Targeted Investment Protocol (TIPS) in New York, and an initial version of the National Energy

Audit (NEAT) in North Carolina). These two studies provide particularly useful information because they measure the degree of improvement that occurs with the introduction of an advanced audit.

Of the remaining six published evaluations (Indiana CAP Director's Association, 1992; The Statewide Low-Income Collaborative Evaluation (SLICE) of Iowa, 1994; North Dakota Weatherization Assistance Program, 1993; Texas Department of Housing, 1995; Vermont State Office of Economic Opportunity, 1993; Vermont State Office of Economic Opportunity, 1995) five developed savings estimates from billing data analyzed with PRISM (Princeton Scorekeeping Method. See Fels, 1986) or a similar weather normalization procedure. These five evaluations produced whole house estimates of savings for dwellings using natural gas as the primary heating fuel. The two Vermont evaluations, conducted for homes weatherized in 1992-93 with a weather normalization procedure developed by the Wisconsin Energy Conservation Corporation, and in 1993-94 with PRISM, also provide an indication of the rate of increase in Program savings over time. The Indiana evaluation used a different methodology. It relied on short-term metering of furnace run times to estimate heating savings only (Indiana CAP Director's Association, 1992).

2.2.2 Six States with Unpublished Results

Six states provided unpublished evaluation results that were used as input to this metaevaluation (Fig. 2). Kansas provided results based on a PRISM analysis of 165 Kansas homes weatherized in 1993 and 1994. Nebraska provided results based on a PRISM analysis of 37 Nebraska homes weatherized in 1994. North Carolina provided summary data from a state-wide data collection system based on NEAT input and output files for 1994. Ohio provided preliminary results from a PRISM analysis of 1510 homes weatherized in 1995. Wisconsin provided results based on a PRISM analysis of 675 Wisconsin homes weatherized in 1992. Wyoming provided preliminary estimates of savings based on monitoring of the usage of space-heating equipment in 38 homes weatherized in 1996. These results will be supplemented with a PRISM analysis of over 200 Wyoming homes which will be completed later this year. Because the results from these states are based on extensive data, and on methodologies which seemed to be sound, they are included in the summary tables (Appendix E, Tables E.1, E.2, and E.3) and as input to a regression model designed to estimate national savings (See Section 3.3, Appendix F, and Appendix G).

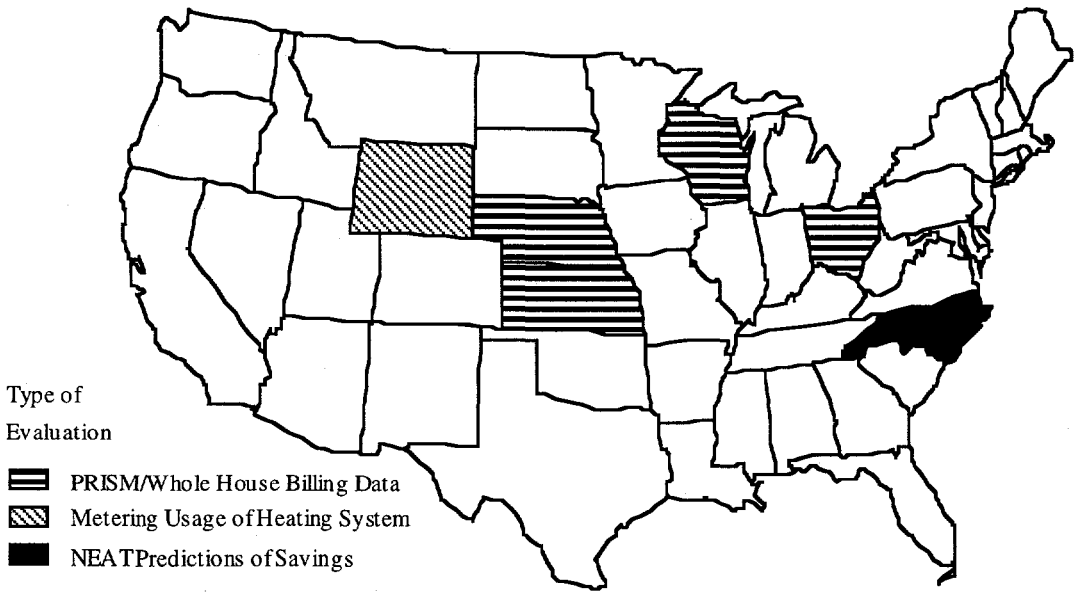

Figure 2. States with Unpublished Evaluation Results for the Program in 1992-1996.

2.2.3 Eleven States with Evaluations Underway or Planned

The states of Iowa, Ohio, and Wyoming are, in 1996, in the middle of evaluation efforts that will supplement the results that they have already provided for this metaevaluation (Fig. 3). Iowa is conducting a NEAT validation study, which is nearly complete. Ohio's evaluation, for which preliminary savings results are available (Fig. 2),

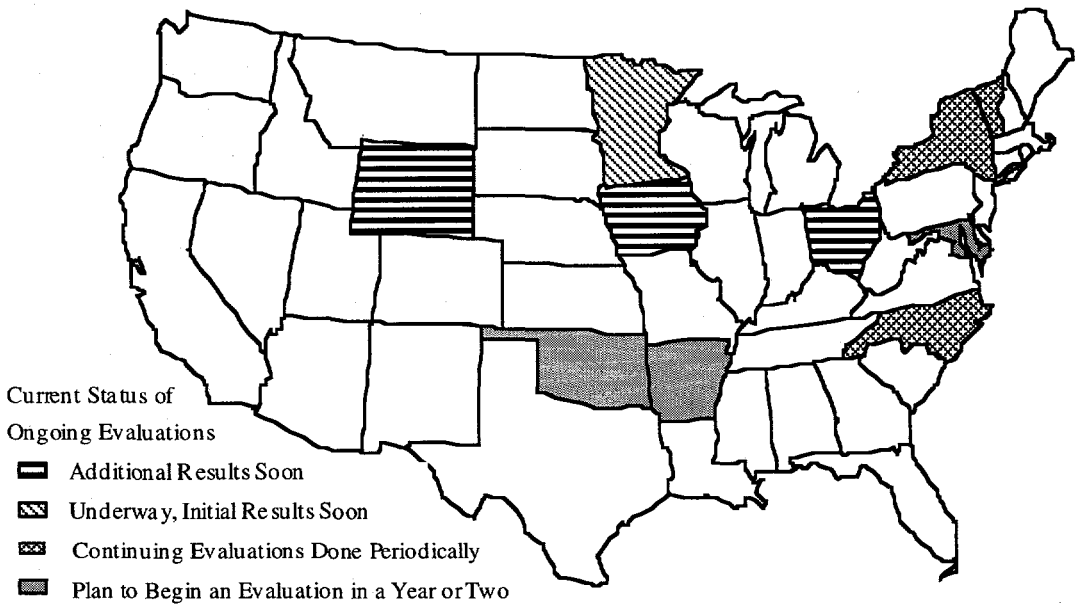

Figure 3. States with Evaluations Underway or Planned in Next Few Years.

is a very comprehensive effort that will address a variety of additional questions. The Wyoming evaluation will add a PRISM analysis to the already available metering data on space-heating equipment usage.

The states of Minnesota and Delaware have evaluations underway that should be completed in less than a year's time. North Carolina and New York have ongoing data collection systems that can be used to produce periodic evaluation reports. Vermont's Weatherization Program must provide evaluation results to the Vermont State Legislature for its partially state-funded Program on a biannual basis.

Contacts in the Arkansas, Oklahoma, and District of Columbia Weatherization Programs all reported that they plan to implement evaluations within a year or two. The plan for the Oklahoma evaluation seems especially interesting because it will use an experimental design that compares the energy savings of four groups:

- 150 homes receiving NEAT audits,
- 150 homes receiving Project Retro-Tech audits (these homes had already been weatherized when Oklahoma began using NEAT in 1996),
- 150 homes receiving weatherization guided by a Priority List developed for common housing types in Oklahoma with the NEAT audit,
- 150 homes receiving no weatherization (the control group).

This study will not only provide estimates of Program savings in Oklahoma, but will provide additional information on the effectiveness of audit types and tailored priority lists developed with NEAT.

2.3 COMPARING AND INTEGRATING THE EVALUATIONS

After locating and reviewing the state-level evaluations described above, the next task was to develop a way of comparing and integrating their findings. Several categories of findings were selected and three tables listing the available results in each of these categories were prepared (See Appendix E, Tables E.1, E.2, and E.3). Because there were variations in the methods and definitions used in the evaluations, their findings must be compared cautiously. The tables in Appendix E have extensive footnotes which explain the definitional issues, and provide caveats which are essential to the correct interpretation of the evaluation findings.

2.3.1 Representativeness of State-Level Results

Because the decisions to conduct evaluations were made by individual states well in advance of this study, no systematic sampling was possible. When one uses a sample such as this one, where the selection process is not under the researcher's control, the representativeness of the sample statistics is always a major concern. Although this sample's representativeness could not be proven, there are several lines of evidence which suggest that it is probably reasonably typical of the nation. First, even though only 15 states have conducted evaluations since 1990, many of these states are among those with the largest eligible populations, the largest budgets, and the most weatherization activity. Over 40% of the national total of weatherized homes were located in the states with evaluations. In addition, an examination of savings estimated in the National Evaluation showed little difference between the states that performed their own state-level evaluations and those that did not. In particular, the states that conducted their own state-level

evaluations (in 1990-1995) had a group average of 1989 savings of 14%. The states that did not conduct their own state-level evaluations (in 1990-1995) had a group average of 1989 savings of 12%. Finally, the distribution by climate region of states with state-level evaluations was roughly proportional to the distribution of the National Evaluation's population. Specifically, 63% of the state-level evaluations were conducted in the moderate climate region, as defined by the National Evaluation, as compared to 61% of the National Evaluation's sample. Eighteen percent of the state-level evaluations were conducted in the cold climate region, while 24% of the National Evaluation's sample came from this region. Eighteen percent of the state-level evaluations were conducted in the warm climate region, while 15% of the National Evaluation's sample came from this region.

Because the issue of the sample's representativeness could not be fully resolved, simply taking averages of state-level findings did not seem appropriate. Accordingly, a regression modeling technique, which makes it possible to apply regression parameters to average national input values, was employed (See Section 2.4). Using this approach builds in an adjustment to national averages which helps to correct for sample biases.

2.3.2 Definitional Issues

One example of definitional differences, many of which limit the validity of direct comparisons across the states, concerns the definition of energy savings. Three of the evaluations report only savings realized by space heating equipment. In this type of savings estimation procedure, run-time meters on heating equipment are monitored before and after weatherization. Only savings that result from the reduced run-time of the heating equipment are measured. Because space heating generally accounts for 70% of total residential usage, and because most weatherization measures have their largest impact on space heating, this approach typically accounts for most of the savings. However, it does not capture savings for end-uses other than space heating or for savings in fuels other than the one used by the heating equipment being monitored .

A second approach, billing analysis conducted with PRISM (or similar techniques), relies on a different definition of savings. In this case, whole house savings for all end-uses that rely on the primary heating fuel are estimated. For example, a PRISM analysis of natural gas billing data for a dwelling would account for all savings that occur in end-uses that rely on natural gas in that house. In some houses this would include space heating, water heating, and cooking. In other houses, PRISM-estimated savings might include only space heating, because electric water heaters and electric stoves are used. An analysis of natural gas billing data does not account for savings in any other fuels. It is possible to do a separate PRISM analysis of electricity, or fuel oil, billing data for each house, but since few evaluations did this, the summary tables in Appendix E present only natural gas results.

Another definitional issue concerns net and gross savings estimates. Gross savings are the pre- versus post-weatherization changes in consumption for the treatment (weatherized) group only. Net savings are adjusted for the change in consumption of a control group. Net savings may be lower or higher than gross savings depending upon whether the control group decreased or increased its consumption. Only two of the evaluations reported both gross and net savings. The others reported only gross savings. Net savings are included in the summary tables in Appendices E and F when available. Gross savings are included for all of the evaluations.

Other definitional issues that must be considered in order to reach a correct interpretation of the findings include:

- variations in what is included in the definition of total program costs, and
- the assumptions used in cost-effectiveness calculations (such as discount rates and measure lifetimes).

Because of definitional variations, direct comparisons of the state-level energy-savings and cost-effectiveness findings shown in Appendix E are not advisable. In many cases, one would be comparing apples and oranges. **The information presented in the footnotes to Tables E.1, E.2, and E.3 in Appendix E is essential to a proper understanding of the results.**

2.4 ESTIMATING UPDATED NATIONAL SAVINGS WITH A REGRESSION MODEL

This study was designed to locate every state-level evaluation of the Weatherization Assistance Program conducted between 1990 and 1995. A response to the survey shown in Appendix A was obtained from every state. While coverage of the available evaluations is complete, the pattern of evaluation availability is not fully representative of the nation. Because evaluation activities are voluntary, states that invest in evaluation tend to be those that are most concerned with improving Program performance. As a result, taking a simple average of findings from the evaluations to characterize national Program performance would be inappropriate.

Another problem to be resolved before the findings could be integrated into a national estimate are the definitional issues discussed above (Section 2.3.2). Methods of dealing with missing values also had to be developed. Table F.1 in Appendix F shows how some values were changed to achieve greater definitional consistency across the evaluations. It also explains procedures for estimating missing values.

The approach chosen to estimate national savings was to use regression modeling to develop the best linear equation for predicting savings. The data from the recent state-level evaluations (1990-1995) were used to develop this predictive tool. Then the parameters of the best predictive model were applied to the appropriate average national input values for each predictor in the equation. For example, the average heating degree days for the available evaluations was 5,942. Nationally, the population weighted 30-year average of heating degree days is 4,499. Therefore, the national average of 4,499 heating degree days is used as the input to the regression model used to predict national savings. For the most part, national input values are taken from the National Evaluation, which was based upon a representative national sample. Details of the rationale for selecting specific national input values, and for changing some state input values to account for definitional issues are discussed in Appendix F. Appendix G describes the model development process.

3. FINDINGS

This review of state-level evaluations clearly showed a trend toward increased Program savings. Three types of evidence support the finding that savings are increasing:

- a literature review,
- within-state comparisons of savings over time, and
- regression modeling results.

3.1 LITERATURE REVIEW

The 1990 literature review, conducted in preparation for the National Evaluation, concluded that the evaluations available at that time (covering the years of 1981-1989) showed typical energy savings (expressed as the percentage reduction in the total consumption of the primary heating fuel) of between 12% and 16%, with a range of 6% to 23% savings in various locations. This 1996 review, of 17 state-level evaluations covering 1990 to 1996, showed typical savings of 18% to 24%, with a range of savings of from 13% to 34% (Table 1).

Table 1. Literature Review Findings on Central Tendencies Characterizing the Percentage of Energy Savings in 1981-1989 and in 1990-1995.

	n	Median	Mean	Interquartile Range	Range
1980-89	25	12%	13%	12-16%	6-23%
1990-96	17	20%	22%	18-24%	13-34%

3.2 TRENDS WITHIN STATES

Two states for which savings can be compared over time, Vermont and Ohio, both showed significant increases in savings. The trend toward increased savings over time in these states is unmistakable (Table 2).

Table 2. Trends in Energy Savings in Ohio and Vermont.

Ohio			Vermont		
	MBtu	Percent		MBtu	Percent
1990-91	20.5	12.6%	**1992-93**	18.0	17.8%
1993-94	29.3	20.4%	**1993-94**	24.5	20.1%
1994-95	34.8	27.0%	**n/a**	n/a	n/a

3.3 REGRESSION MODELING RESULTS

As Table 3 shows, the regression-based national estimate of savings for 1996 is considerably higher than the savings for 1989 estimated by the National Evaluation. National savings, in homes using natural gas as the primary heating fuel, for the 1989 Program Year were 17.3 MBtu, which is 18.3% of space heating consumption, or 13.0% of the total consumption of natural gas for all end uses. The regression-based national

estimate for 1996 is 31.2 MBtu, which was 33.5% of natural gas space heating consumption, or 23.4% of the total consumption of natural gas for all end uses.

Table 3. Estimated National Program Energy Savings in 1989 and 1996 in Homes that Heat Primarily with Natural Gas

	MBtu of Natural Gas	Percentage Reduction in Natural Gas Consumption for Space-Heating	Percentage Reduction in Natural Gas Consumption for All End Uses
National Evaluation Results for 1989	17.3	18.3%	13.0%
Metaevaluation Results for 1996 based on Regression Model	31.2	33.5%	23.4%

As Table 4 shows, the pre-weatherization level of consumption is the strongest predictor in the regression model used to estimate 1996 savings. This means that dwellings that consume more energy prior to weatherization, save more energy after weatherization. Pre-weatherization energy consumption reflects occupant characteristics (e.g., the appliances owned by a household, household management of the thermostat), dwelling characteristics (e.g., the size of the dwelling, the leakiness of the building shell, and the efficiency of its heating system), climate characteristics (e.g., heating and cooling degree days, solar insolation, humidity, wind speeds), and a host of other influences.

The correlation between high pre-weatherization energy use and high savings potential has been recognized in the procedures of many state and utility programs. A common feature of the higher saving state-level programs is the targeting of high-consuming households. The New York Program, for example, uses the TIPS audit to guide investment levels. TIPS calibrates the appropriate investment level to the level of pre-weatherization energy efficiency in the dwelling, which is measured as Btu/HDD/square foot consumed annually.

As Table 4 shows, although pre-weatherization consumption is a highly significant predictor of energy savings, the variables of audit type, and year of weatherization have limited predictive ability. Pre-weatherization consumption is significant at a level of less than 0.001. The other two variables are statistically significant at levels of less than 0.188 for year of weatherization, and 0.090 for audit type. One indicator of the relative importance of the three independent variables is shown by the standardized coefficients in Table 4. The standardized coefficient for pre-weatherization consumption is over three times as large as the standardized coefficient for year, and over seven times as large as the standardized coefficient for audit type.

Table 4. Regression Analysis of Average State-Level Energy Savings (in MBtu)

Dependent Variable=Average State-Level Energy Savings (in MBtu) Predictor	Unstandardized Regression Coefficient	Standard Error	T-value	Standardized Regression Coefficient
Intercept	-375.949	294.008	-1.279	0.000
Pre-weatherization consumption	0.985	0.156	6.313*	0.784
Year of weatherization	113.741	89.121	1.276	0.188
Advanced audit	0.041	0.069	0.597	0.090

Coefficient of Determination (R^2) = 0.793
Adjusted Coefficient of Determination (R^2) = 0.751
F-Value = 19.109
Sample Size = 19

* significant at p<0.001

The overall model fit for the three variable model described in Table 4 is good with an adjusted R^2 of 0.75. As Figure 4 shows, this model can predict state-level savings with considerable accuracy.

The national estimate of savings for 1996 (31.2 MBtu) was obtained by applying the coefficients shown in Table 4 to average national values for pre-weatherization consumption (133 MBtu), audit type (50% advanced audits), and the current year (1996). The sources of these average national values are given in Appendix F.

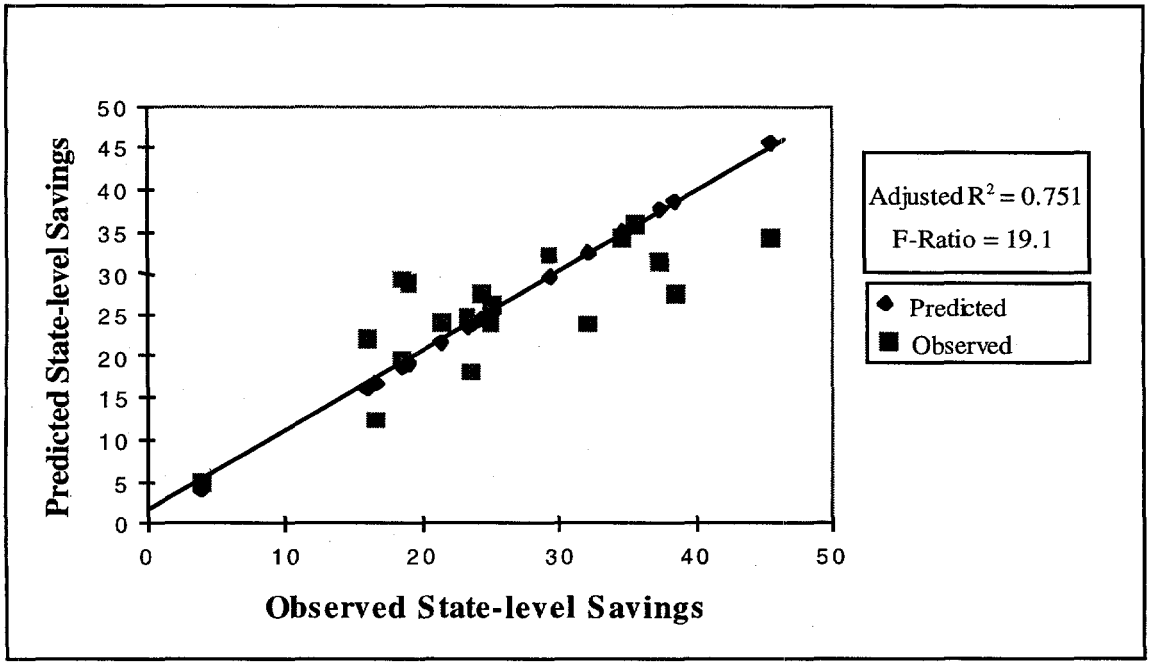

Figure 4. Goodness of Fit for the Three-Variable (Pre-Weatherization Consumption, Year, Audit Type) Regression Model Shown in Table 4

A confidence interval for the national estimate of savings was calculated with SAS. For the national estimate of 31.2 MBtu the lower bound for the 90% confidence interval is 22.9 MBtu, and the upper bound is 38.6 MBtu. Thus, the lower bound for the 1996 estimate is well above the 1989 estimate of 17.6 MBtu. The 90% confidence interval reported in Brown, et al. (1993) for savings in gas-heated homes was 15.1 to 19.5 MBtu. As Figure 5 shows, the 1996 estimate of national savings, and most of the savings estimates reported in state-level evaluations conducted since 1990, are higher than the average national savings measured in 1989.

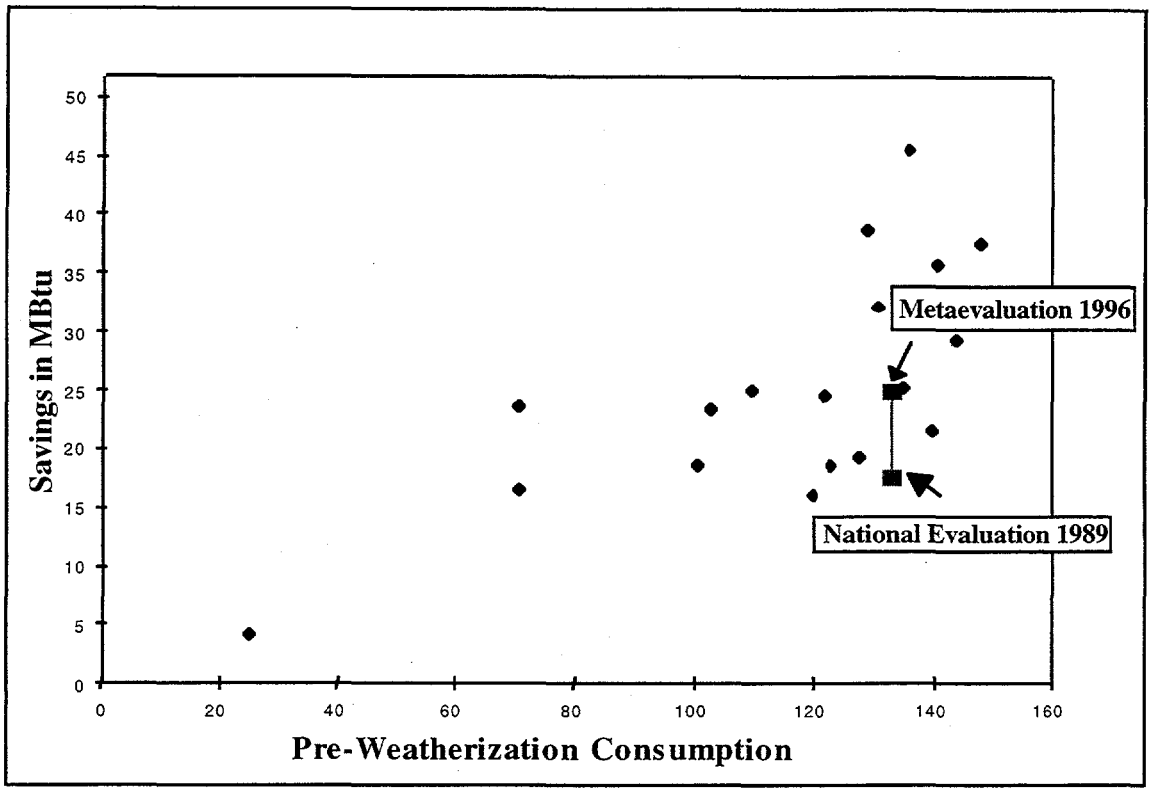

Figure 5. State-level Energy Savings in 1990-1995 by Pre-Weatherization Consumption and National Savings in 1989 and 1996.

3.4 WEATHERIZATION COSTS

Among the seventeen state-level evaluations completed since 1990, about half reported cost data (See Appendix E, Table E-3). Eight evaluations reported total costs and several of these eight evaluations also reported breakdowns into labor and materials costs, and/or materials costs. One state reported only labor and materials costs. The remaining eight state-level evaluations did not provide any information on costs.

Average total costs for the eight states reporting a value were $1,968 in 1994 dollars. Average labor and materials costs were $1,510. In real dollars, these values are somewhat higher than the average national costs reported by the National Evaluation in 1989. When the costs reported by the National Evaluation for homes that heat primarily with natural gas were converted into 1994 dollars, the total average national costs per dwelling were $1,610, and average labor and materials costs were $1,160. Although these results seem to suggest that Program costs may have increased, in reality, this sample of eight states is too small and unrepresentative to support such a conclusion. Several of the eight states reporting cost data receive large amounts of state and utility funding, along with their DOE support. These additional sources of funding make it possible for them to invest more per dwelling than states that rely only on DOE funding.

3.5 NON-ENERGY BENEFITS OF WEATHERIZATION

Most of the state-level evaluations did not address the issue of the non-energy benefits of weatherization at all. Only one, the Iowa evaluation, gives much attention to non-energy benefits. The Iowa evaluation notes that the potential benefits of weatherization include:

- improved client safety and health;
- reduced utility collection costs and write-offs;
- improved property value, longevity, and maintenance of affordable housing;
- reduced environmental impacts from energy production and transport; and
- additional economic activity and jobs for Iowa.

Only the economic activity and job creation benefits are quantified in the Iowa study. Using an input-output analysis, the study concluded that each millon dollars of Program spending produces about $240,000 worth of additional economic activity. This additional economic activity supports 5.6 additional jobs (The Statewide Low-Income Collaborative Evaluation (SLICE) of Iowa., 1994.). The Iowa study does not assign a specific dollar value to any additional non-energy benefits. However, it concludes that even conservative estimates of these non-energy benefits will significantly increase the cost effectiveness of the Program.

In the National Evaluation, an effort was made to quantify the dollar value of non-energy benefits. The highest dollar values were assigned to employment and environmental benefits (Brown, Berry, Balzar, and Faby, 1993). The methods used to estimate the dollar value of the range of non-energy benefits varied. These methods are explained in Chapter 6 of Brown et al. 1993. The final estimate of the net present value of all of non-energy benefits that were monetized was set at $976 in 1989 dollars. This is the estimate that is used in the next section to estimate Progam cost effectiveness from the societal perspective, which is the only perspective that includes non-energy benefits.

3.6 COST-EFFECTIVENESS RESULTS

Because of the higher average national savings estimated for the Program in 1996, cost-effectiveness estimates also increased (Table 5). The National Evaluation used three perspectives[2] for estimating cost effectiveness:

- the program perspective, which compares energy benefits to total costs;
- the installation perspective, which compares energy benefits to installation costs; and
- the societal perspective, which compares energy and non-energy benefits to total costs.

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[2] In the National Evaluation, three perspectives were used to develop benefit/cost ratios: the program perspective, the installation perspective, and the societal perspective. The program perspective compares the discounted value of energy savings to total program costs (including labor, materials, overhead, administrative, and all other categories of both fixed and variable costs). The installation perspective compares the discounted value of energy savings to installation-related program costs (i.e., installation labor and materials costs). The societal perspective compares the discounted value of both energy and nonenergy benefits (such as employment and environmental benefits) to total program costs (including labor, materials, overhead, administrative, and all other categories of both fixed and variable costs). All three perspectives used an assumed measure lifetime of 20 years and a discount rate of 4.7%. To make the 1996 benefit/cost ratios comparable to the National Evaluation ratios the same definitions and assumptions were used.

In 1989, the National Evaluation estimated the Program benefit/cost ratio for gas-heated homes, with the program perspective, as 1.06. Applying the same procedures and assumptions used in the National Evaluation to the 1996 savings estimates yields a benefit/cost ratio of 1.79. With the installation perspective, the 1989 result is 1.58, and for 1996 is 2.39. Societal ratios, which include the value of non-energy benefits, were 1.61 in 1989, and 2.40 in 1996.

Table 5. Cost-Effectiveness Results for Gas-Heated Homes: Benefit/Cost Ratios[a] from Three Perspectives in 1989 and 1996

	Program	Installation	Societal
National Evaluation 1989	1.06	1.58	1.61
Metaevaluation Results 1996	1.79	2.39	2.40

[a]Calculated with a 4.7% discount rate and an assumed lifetime of 20 years. See footnote 1 for definitions of the perspectives.

4. CONCLUSIONS AND RECOMMENDATIONS

State-level evaluations of the Weatherization Assistance Program offer an important resource for Program management. These evaluations are conducted with some frequency and are usually technically sound. Both previous literature reviews of state-level evaluations conducted between 1980 and 1989, and this 1996 metaevaluation of state-level evaluations conducted since 1990, found that the synthesis of state-level evaluations offered a reasonable characterization of national Program performance. In addition, reviews of state-level evaluations can provide important insights into the effectiveness of various weatherization practices, and into the remaining potential for improving energy savings and cost effectiveness.

Because of the value of state-level evaluations, the monitoring of their availability and the synthesizing their findings should be ongoing Program management activities. Some of the evaluation efforts that are planned and underway, such as those in Oklahoma and Ohio, promise to provide especially comprehensive and interesting results. Although national level evaluation efforts are sometimes needed to definitively demonstrate Program performance, reviews of state-level evaluations provide useful, and inexpensive, benchmarks of progress during the years between such large-scale national assessments.

This review of the state-level evaluations conducted since 1990 concluded that Program performance has improved significantly in the last seven years. In the National Evaluation, which measured performance in 1989, the average national savings for homes heating with natural gas was 17.3 MBtu, which was 18.3% of space heating consumption, or 13.0% of the total consumption of natural gas for all end uses. Findings from this state-level evaluation review indicated average savings in 1996 had increased to 31.2 MBtu, which was 33.5% of space heating consumption, or 23.4% of the total consumption of natural gas for all end uses. Because of the higher average national savings estimated for the Program in 1996, cost-effectiveness estimates also increased. In 1989, the National Evaluation estimated the benefit/cost ratios for gas-heated homes, with three different perspectives, as a range of 1.06 to 1.61. Applying the same procedures and assumptions to the 1996 savings yields a range of Program benefit/cost ratios of from 1.79. to 2.40.

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Appendix A

State Weatherization Office Survey Form

OAK RIDGE NATIONAL LABORATORY
MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE U.S. DEPARTMENT OF ENERGY

Linda Berry
Building 4500N, MS-6205
POST OFFICE BOX 2008
OAK RIDGE, TN 37831-6205
Phone: (423) 574-5949
FAX: (423) 574-8884
INTERNET: lgb@ornl.gov

April 9, 1996

[Full Name], Weatherization Director
State Weatherization Program Office
Street Address
City, State Zip

Dear Ms./Mr. [Last Name]:

DOE Headquarters has asked Oak Ridge National Laboratory (ORNL) to locate and review all evaluations of the Weatherization Assistance Program that have become available since 1990. The purpose of this effort is to obtain an up-to-date estimate of Program energy savings from as many locations as possible. We need your help in finding these evaluations.

ORNL has already located a few recent state-level evaluations. In addition, New York, North Carolina, and Vermont have sent information on the tracking data systems they use to characterize Program performance. Please answer the following questions to help us locate post-1990 evaluations and then fax this form back to us. Thank you.

Has your state of [Name of State] (or any of its local agencies or utilities) completed any evaluations of Program energy savings since 1990? ❑YES ❑NO

Are any evaluations of Program energy savings underway now? ❑YES ❑NO

Does your state have a data system that could be used to characterize Program energy savings?
❑YES ❑NO

If you answered yes to any of the above questions, please indicate who we can contact to obtain more information on these evaluation activities.

Name_____ Organization_____

Telephone _____

Name_____ Organization_____

Telephone _____

Name_____ Organization_____

Telephone _____

Do you have any additional information on evaluations of Program energy savings?
❑YES ❑NO If yes, please explain below.

AFTER COMPLETING THIS FORM PLEASE FAX IT BACK TO 423-574-8884 or mail it to Linda Berry at the above address. If you have questions, please call Linda Berry at ORNL at 423-574-5949. Thank you.

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Appendix B

State Weatherization Office Survey Results

	State contact person form was sent to	Recommended contacts	Any completed program evaluations since 1990?	Any evaluations underway now? (expected completion date)?	Any data systems that could be used to determine energy savings?	Comments
Alabama	Mr. Freddie Fox, Weatherization Program Manager Alabama Department of Economic and Community Affairs P. O. Box 5690 Montgomery, AL 36103-5690 (205) 242-5351 Fax: (205) 242-0977	None	No	No	No	
Arizona	Mr. Russell Clark, Weatherization Administrator Arizona Energy Office 3800 N. Central Phoenix, AZ 85012 (602) 280-1430 Fax: (602) 280-1445	None	No	No	No	
Arkansas	Mr. Thomas E. Green, Deputy Director Office of Community Services P. O. Box 1437, Slot 1330 Little Rock, AR 72203-1437 (501) 682-8715 Fax: (501) 682-6736	Troy Branscum, AR Dept. of Human Services, (501) 682-8722 Larry Palmer (501) 682-8722	No	Yes (1998)	No	Are using NEAT to predict savings and a NEAT validation study is planned.
California	Ms. Toni Curtis, Deputy Director Programs Department of Economic Opportunity 700 N. 10th Street, Room 272 Sacramento, CA 95814 (916) 323-8694 Fax: (916) 327-3153	None	No	No	No	
Colorado	Mr. Robert De Soto, Program Manager Office of Energy Conservation 1675 Broadway, Suite 1300 Denver, CO 80202-4613 (303) 620-4292 Fax: (303) 620-4288	Rick Hanger, Office of Energy Conservation, (719) 544-0136	Yes	Yes	No	Reviewed the evaluation and included its results in the model.

State	State contact person form was sent to	Recommended contacts	Any completed program evaluations since 1990?	Any evaluations underway now? (expected completion date)?	Any data systems that could be used to determine energy savings?	Comments
Connecticut	Ms. Marion Wojick, Weatherization Director State Department of Social Services 25 Sigourney Street Hartford, CT 06106 (203) 424-5889 Fax: (203) 424-4952	None	No	No	No	
D C	Mr. Carl Williams DC Energy Office 2000 14th Street, NW, Suite 300E Washington, DC 20009 (202) 673-6741 Fax: (202) 673-6725	None	No	No	Are using NEAT and keeping audit results	
Delaware	Mr. G. Kenneth Davis, Weatherization Program Manager Office of Community Services Carvel State Office Building 820 N. French Street, 4th Floor Wilmington, DE 19801 (302) 577-3491 Fax: (302) 577-2383	Dr. John Byrne Univ. of Delaware (302) 831-8405	No	Yes (1996)	No	
Florida	Mr. Earl Billings, Weatherization Planning Manager Department of Community Affairs 2740 Centerview Drive Tallahassee, FL 32399-2100 (904) 488-7541 Fax: (904) 488-2488	None	No	No	No	
Georgia	Ms. Annette Carter, Weatherization Program Manager Georgia Energy Office 100 Peachtree Street, NW, Room 2090 Atlanta, GA 30303 (404) 656-5176 Fax: (404) 656-7970	John O' Looney, University of GA (706) 542-2736	No	Yes (uncertain)	No	A few houses have been studied, but not enough for a reliable savings estimate.

State	State contact person form was sent to	Recommended contacts	Any completed program evaluations since 1990?	Any evaluations underway now? (expected completion date)?	Any data systems that could be used to determine energy savings?	Comments
Idaho	Ms. Neva Kaufman, Grant Supervisor for Weatherization & LIHEAP State Economics Opportunity Office 450 West State Street, State House Mail Boise, ID 83720-9990 (208) 334-5730 Fax: (208) 334-6664	Tim Paul State Weatherization Program, 208-334-5737 Neva Kaufman, 208-334-5732	Yes	No	Yes	Unable to contact
Illinois	Mr. Wayne E. Curtis, Chief Illinois Department of Commerce and Community Affairs 620 East Adams Street, 4th Floor Springfield, IL 62701 (217) 524-8024 Fax: (217) 782-1206	None	No	No	No	
Indiana	Mr. Randall Powers, Program Coordinator (WAP) Division of Family and Children Housing and Community Services Section P. O. Box 6116 Indianapolis, IN 46206-6116 (317) 232-7011 Fax: (317) 232-7079	Ed Gerardot, (317) 638-4232	Yes	Yes (1997)	No	Reviewed the evaluation and included its results in the model
Iowa	Mr. James R. Newton, Bureau Chief Department of Human Rights Lucas State Office Building Des Moines, IA 50319 (512) 242-6314 Fax: (515) 242-6119	Greg Dalhoff, (608) 249-9322	Yes	No	Yes	Reviewed the evaluation and included its results in the model. A NEAT validation study is nearly complete.
Kansas	Ms. Norma Phillips, Director Department of Commerce & Housing 700 S.W. Harrison Street, Suite 1300 Topeka, KS 66660-3755 (913) 296-2686 Fax: (913) 296-8985	Doug Walters, Kansas State University, (913) 532-6026	No	Yes (1996)	No	Received unpublished results from Mr. Walter and included them in the model.

State	State contact person form was sent to	Recommended contacts	Any completed program evaluations since 1990?	Any evaluations underway now? (expected completion date)?	Any data systems that could be used to determine energy savings?	Comments
Kentucky	Mr. Pat Bishop, Branch Manager Department of Social Insurance 275 Main Street, 3rd Floor Frankfort, KY 40621 (502) 564-4847 Fax: (502) 564-6907	None	No	No	No	
Louisiana	Mr. Lonnie Didier, Weatherization Program Manager Louisiana Departmentof Social Services P. O. Box 3318 Baton Rouge, LA 70821 (504) 342-2274 Fax: (504) 342-2268	None	No	No	No	
Maine	Mr. Peter Wintle, Federal Funds Division Director Maine State Housing Authority 353 Water Street Augusta, ME 04330-4633 (207) 626-4600 Fax: (207) 626-4678	None	No	No	No	
Maryland	Ms. Barbara Hunt Department of Housing and Community Development 100 Community Place Crownsville, MD 21032-2023 (410) 514-7238 Fax: (410) 514-7291	Robert Adams 410-514-7240	Yes, Geomet Technologies-1991	Yes, do not have info yet/working with utility companies	Yes, using NEAT. Hope to have cost efficiency in 6 months	Mr. Adams could not provide a copy of the 1991 Geomet Technologies report, or any information about where to obtain it.
Massachusetts	Mr. Jim Hays, Director Office of Energy Conservation 100 Cambridge Street, 18th Floor Boston, MA 02202 (617) 727-6964 Fax: (617) 727-4259	None	No	No	No	
Michigan	Ms. Lynda Crandall, Deputy Director Michigan Department of Social Services P. O. Box 30037 Lansing, MI 48909 (517) 335-3094 Fax: (517) 335-7771 Mr. Larry Mynhier (517) 335-5042	None	No	No	No	

State	State contact person form was sent to	Recommended contacts	Any completed program evaluations since 1990?	Any evaluations underway now? (expected completion date)?	Any data systems that could be used to determine energy savings?	Comments
Minnesota	Mr. Mark Kaszynski, Weatherization Coordinator Department of Jobs and Training 390 N. Robert Street St. Paul, MN 55101 (612) 297-2590 Fax: (612) 282-5907	Carol Raabe MN Department of Economic Security (612) 297-3408 Mark Kaszynski MN Dept. of Economic Security (612) 297-2590 Jack Bethke Community Action of Minneapolis (612) 827-1758	No	Yes (1997-98)	No	
Mississippi	Mr. Bobby Pamplin, Weatherization Department of Human Services 750 North State Street, 6th Floor Jackson, MS 39202 (601) 359-4775 Fax: (601) 359-4370	Mr. La'Rue Sutton Hinds County Human Resource (601) 923-3930 Mr. Marilyn Davis LIFT, Inc. (601) 842-9511 Ms. Beverly Hall Northeast, Ms. Inc. (601) 728-2118	No	Yes, at local agency level	Yes	Contact persons at local agencies had no completed evaluation results.
Missouri	Ms. Cher Stuewe-Portnoff, Director Division of Energy P. O. Box 176 Jefferson City, MO 65102 (314) 751-4000 Fax: (314) 751-6860	Mr. John Moten Laclede Gas Co. St. Louis, MO (314) 342-0770	No	Yes	No	Completed a small mobile home energy savings evaluation in the summer of 1990.
Montana	Mr. Jim Nolan, CSBG Department of Social & Rehabilitation Services P. O. Box 4210 Helena, MT 59604 (406) 444-4545 Fax: (406) 444-2547	Mr. Glen Phelps, Montana Power Company, (406) 723-5421, ext. 72265	Yes, for utility program	Yes, for utility program	Yes	Utility program evaluation. The utility program is too different to be representative of the Weatherization Assistance Program.
Nebraska	Mr. Pete Davis, Program Manager Nebraska State Energy Office P. O. Box 95085 Lincoln, NE 68509 (402) 471-2867 Fax: (402) 471-3064	Pete Davis (402) 471-2867 Larry Kinyon (402) 471-2867	No	Yes	No	Unpublished evaluation results received in a personal communication from Mr. Kinyon and used in the model.
Nevada	Mr. Craig Davis, Weatherization Program Manager Nevada State Welfare Division 2527 North Carson Street Carson City, NV 89710 (702) 687-4906 Fax: (702) 687-5080		No	Yes	No	

State	State contact person form was sent to	Recommended contacts	Any completed program evaluations since 1990?	Any evaluations underway now? (expected completion date)?	Any data systems that could be used to determine energy savings?	Comments
New Hampshire	Mr. Warren Leary, Weatherizatoin Director Governor's Office of Energy & Community Services 57 Regional Drive Concord, NH 03301-8506 (603) 271-2611 Fax: (603) 271-2615	None	No	No	No, Implementing one this year.	
New Jersey	Ms. Clarice Sabree, Supervisor New Jersey Department of Community Affairs 101 South Broad CN-814 Trenton, NJ 08625 (609) 292-0117 Fax: (609) 292-9798	None	No	No	No	
New Mexico	Ms. Liz Cordova, Manager Energy, Minerals & Natural Resources 2040 S. Pacheco Santa Fe, NM 87505 (505) 827-7136 Fax: (505) 827-5912	No	No	No		
New York	Mr Rick Gerardi, Director Weatherization Program Division of Economic Opportunity Department of State 162 Washington Avenue, 7th Floor Albany, NY 12231 (518) 474-5700 Fax: (518) 486-4663	Rick Gerardi (518) 474-5700 Larry Kinney (315) 422-6165	Yes	Yes (ongoing with data system)	yes	Reviewed evaluation and included its results in model.
North Carolina	Mr. Jeffrey Brown, Director Energy Division Department of Economics & Community Development 430 N. Salisbury Street P. O. Box 25249 Raleigh, NC 27611 (919) 733-1902 Fax: (919) 773-2953	Jeff Brown (919) 733-1902	Yes	No	Yes	Unpublished evaluation results received from Mr. Brown. Savings estimates based on NEAT predictions of savings were used in the model.
North Dakota	Mr. Howard Sage, Weatherization State Capitol 600 East Boulevard, 14th Floor Bismarck, ND 58505 (701) 224-2094 Fax: (701) 224-2308	Howard Sage, ND Office of Intergovernmental Assistance, (701) 328-4140	Yes	No	No	Reviewed evaluation and included its results in model

State	State contact person form was sent to	Recommended contacts	Any completed program evaluations since 1990?	Any evaluations underway now? (expected completion date)?	Any data systems that could be used to determine energy savings?	Comments
Ohio	Ms. Sara Ward Ohio Department of Development P. O. Box 1001 Columbus, OH 43266-0101 (614) 466-6954 Fax: (614) 466-4708	Stjepan Vlahovich OH Dept. of Development, Office of Energy Efficiency, (614) 466-0545 Richard Sims, Columbia Gas of Ohio, (614) 460-6940	Yes	Yes	No	Reviewed two Columbia Gas Evaluations which are representative of the Ohio Weatherization Assistance Program. Also received unpublished results for an evaluation being conducted by Proctor Engineering for homes weatherized in 1995.
Oklahoma	Mr. Sherwood Washington, Director Oklahoma Department of Commerce P. O. Box 26980 Oklahoma City, OK 73126-0980 (405) 841-9326 Fax: (405) 841-9344	Floyd Bringing Good, Department of Commerce, (405) 841-9333 Garcia Tarver (405) 841-9332	No, in planning stage, will not be completed until 1998	Yes, in planning stage.	No	
Oregon	Mr. Jack Hruska, Weatherization Program Manager Oregon Housing & Community Services Department 1600 State Street Salem, OR 97310 (503) 986-2050 Fax: (503) 986-2020	Becky Eberle Pacific Power (503) 464-6894	Yes, for electrically heated homes only	Yes (1997)	No	Contact person said was not representative of the Weatherization Assistance Program
Pennslyvania	Ms. James Etta Reed, Federal Programs Divsion Chief Bureau of Human Resources 358 Forum Building Harrisburg, PA 17120 (717) 787-7301 Fax: (717) 787-6074	None	No	No	No	
Rhode Island	Mr. Michael Snitzer, Residential Conservation Programs Manager Governor's Office of Energy Assistance 275 Westminster Mall Providence, RI 02903 (401) 277-6920 Fax: (401) 277-1260	Michael A. Snitzer, RI State Energy Office, (401) 277-6920	No	No	No	
South Carolina	Mr. Douglas Keisler, Director Office of the Governor 1205 Pendleton Street Columbia, SC 29201 (803) 734-0672 Fax: (803) 734-0356	Douglas Keisler	No	Selected NEAT Audits	No	

State	State contact person form was sent to	Recommended contacts	Any completed program evaluations since 1990?	Any evaluations underway now? (expected completion date)?	Any data systems that could be used to determine energy savings?	Comments
South Dakota	Ms. Abbie Rathbun, Energy Assistance Department of Social Services 206 W. Missouri Avenue Pierre, SD 57501-4517 (605) 773-3668 Fax: (605) 773-6657	None	No	No	No	
Tennessee	Mr. Steve Neece, Program Manager Department of Human Services 400 Deaderick Street Nashville, TN 37248 (615) 741-6640 (615) 741-4165	None	No	No	No	
Texas	Mr. Al Almaguer, Director Department of Housing and Community Affairs P. O. Box 13941 Austin, TX 78701-3941 (512) 475-3866 (512) 475-3935	Peggy Colvin Dept. of Housing & Comm. Affairs (512) 475-3864 Gene Abbott (for audit information) (512) 475-2284	Yes	Yes	No, well maybe-via the audit process	Reviewed evaluation and included its results in model
Utah	Mr. Michael Johnson, Energy Efficiency Office of Energy Services 324 South State Street, Suite 230 Salt Lake City, UT 84111 (801) 538-8690 Fax: (801) 538-8660	None	No	No	No, unknown	
Vermont	Mr. Avram Patt, Director Office of Economic Opportunity 103 South Main Street Waterbury, VT 05676-1801 (802) 241-2462 Fax: (802) 241-2979	Ken Tohinaka (802) 658-6060 Rocky Martin (802) 241-2453	Yes	Yes	Yes	Reviewed two evaluations and included their results in model
Virginia	Mr. William Beachy, Program Administrator Division of Housing 501 2nd Street Richmond, VA 23219-1747 (804) 371-7112 Fax: (804) 371-7091	None	No	No	No	

State	State contact person form was sent to	Recommended contacts	Any completed program evaluations since 1990?	Any evaluations underway now? (expected completion date)?	Any data systems that could be used to determine energy savings?	Comments
Washington	Mr. Steve Payne, Unit Manager Department of Community, Trade and Economic Development P. O. Box 48300 Olympia, WA 98504-8300 (360) 586-8980 Fax: (360) 586-5880	Wally Creshaw Tacoma City Light 206-593-8363 Carolyn Wyman, CTED 360-586-0495	Yes, of utility program	No, not specific to state program	Developing data system to allow evaluation in next year.	Evaluation is not representative of the Weatherization Assistance Program
West Virginia	Mr. Bob Scott, Weatherization Director Governor's Cabinet on Children and Families 1204 Kanawha Boulevard East, 2nd Floor Charleston, WV 25301 (304) 558-8860 Fax: (304) 558-0391	Rick Raverty, COAD evaluation of Appalachian Power Company, DSM Project, (614) 594-8499	No	Yes	No, starting a data base this year	
Wisconsin	Mr. Gary Gorlen, Weatherization Director Division of Housing, 4th Floor P. O. Box 8944 Madison, WI 53708-8944 (608) 266-6789 Fax: (608) 264-6688	Carl Saueressig, (608) 266-2445	No	Yes (1996)		Unpublished evaluation results received in a personal communication from Mr. Saueressig and used in the model.
Wyoming	Ms. Jan Stiles, Program Manager Division of Public Assistance and Social Services Hathaway Building, 3rd Floor Cheyenne, WY 82002 (307) 777-6137 Fax: (307) 777-7747	Rana Belshe (715) 334-2707 Judy Gregory (216) 321-4226	No	Yes, two studies-one uses Hunter thermostat fuel and one uses consumption data (1996)	Yes, thermostat evaluation project could be used this way.	Unpublished evaluation results received in a personal communication from Ms. Belshe and used in the model.

Appendix C

Utility Low-Income Program Survey Form

OAK RIDGE NATIONAL LABORATORY
MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE U.S. DEPARTMENT OF ENERGY

Linda Berry
Building 4500N, MS-6205
POST OFFICE BOX 2008
OAK RIDGE, TN 37831-6205
Phone: (423) 574-5949
FAX: (423) 574-8884
INTERNET: lgb@ornl.gov

April 11, 1996

[Full Name], Utility Low-Income Program Director'
Utility Low-Income Program Office
Street Address
City, State Zip

Dear Ms./Mr. [Last Name]:

The U.S. Department of Energy (DOE) has asked Oak Ridge National Laboratory (ORNL) to locate and review all evaluations of the DOE's Weatherization Assistance Program that have become available since 1990. The purpose of this effort is to obtain an up-to-date estimate of the energy savings of the Program from as many locations as possible.

Many utilities coordinate their low-income programs with the DOE Weatherization Assistance Program network. We need your help in locating evaluations of such coordinated low-income programs. Would you please answer the questions on the enclosed sheet and fax it to us?

In addition, if you have copies of any published evaluations of coordinated low-income weatherization programs that you could send to me, I would very much appreciate receiving them. Thank you for your assistance.

Sincerely,

Linda Berry

LB:edm

Enclosure

OAK RIDGE NATIONAL LABORATORY
MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE U.S. DEPARTMENT OF ENERGY

Linda Berry
Building 4500N, MS-6205
POST OFFICE BOX 2008
OAK RIDGE, TN 37831-6205
Phone: (423) 574-5949
FAX: (423) 574-8884
INTERNET: lgb@ornl.gov

April 11, 1996

[Full Name], Utility Low-Income Program Director'
Utility Low-Income Program Office
Street Address
City, State Zip

Dear Ms./Mr. [Last Name]:

The U.S. Department of Energy (DOE) has asked Oak Ridge National Laboratory (ORNL) to locate and review all evaluations of the DOE's Weatherization Assistance Program that have become available since 1990. The purpose of this effort is to obtain an up-to-date estimate of the energy savings of the Program from as many locations as possible. Many utilities coordinate their low-income programs with the DOE Weatherization Assistance Program. We need your help in locating evaluations of such coordinated low-income programs by answering the questions below.

Is your utility involved in any coordinated programs with the DOE Weatherization Assistance Program?
❑YES ❑NO

Do you know of any evaluations of the energy savings of coordinated low-income weatherization programs that have been completed since 1990? ❑YES ❑NO

Do you know of any evaluations of low-income weatherization program energy savings underway now?
❑YES ❑NO

If you answered yes to any of the above questions, please indicate who we can contact to obtain more information on these evaluation activities.

Name_____ Organization_____

Telephone _____

Name_____ Organization_____

Telephone _____

Name_____ Organization_____

Telephone _____

Do you have any additional information on evaluations of the DOE's Weatherization Assistance Program's energy savings?
❑YES ❑NO If yes, please explain below.

AFTER COMPLETING THIS FORM PLEASE FAX IT BACK TO 423-574-8884 or mail it to Linda Berry at the above address. If you have questions, please call Linda Berry at ORNL, 423-574-5949. Thank you.

ornl - *Bringing Science to Life*

Appendix D

Utility Low-Income Program Survey Results

State	Utility contact person form was sent to	Recommended contacts	Any coordinated programs?	Any evaluations completed?	Any evaluations underway now?	Comments
Alabama	Mr. J. Marlin Wade Alabama Municipal Electric Authority P.O. Drawer 5220 Montgomery, AL 36103 (205) 262-1126	None	No	No	No	
Arizona	Mr. Jay McCarroll Arizona Public Service Co. P. O. Box 53999, MS-8688 Phoenix, AZ 85072-3999 (602) 250-2393 Fax (602) 250-2136	None	Yes	No	Yes, results will be available in late 1997	
California	Mrs. Sharon Lee Balderas Southern California Gas Co. 10375 Slusher Drive Santa Fe Springs, CA 90670 (310) 946-5366 fax: (310) 906-2095	Billie Johnson Martha Dixson (510) 273-6358	No	No	No	
California	Mr. Jeff Crowe Pacific Gas & Electric Co. 444 Market Street San Francisco, CA 94106 (415) 973-8401					No response
California	Ms. Gail W. Doxtader Loveland, City of Plug-a-Leak Service 200 North Wilson, Building Loveland, CO 80537 (303) 962-3554	None	No	No	No	
California	Ms. Pat Aldridge Southern California Edison Co. P. O. Box 800 Rosemead, CA 91770 (818) 302-4617 (818) 302-4332 fax	John Nall, (909) 394-8703	No	No	Yes	
California	Mr. Leamon W. Murphy Imperial Irrigation District P. O. Box 937 Imperial, CA 92251 (619) 339-9106 fax: (619) 339-9189	None	No	No	No	
California	Ms. Carol Ushijima Los Angeles, City of Better Idea Program P. O. Box 111, Room 1236 Los Angeles, CA 90051 (213) 481-5664	None	No	No	No	
Connecticut	Mr. John V. DiBiaso United Illuminating Co. P. O. Box 1564 New Haven, CT 06506 (203) 787-7783					No response

State	Utility contact person form was sent to	Recommended contacts	Any coordinated programs?	Any evaluations completed?	Any evaluations underway now?	Comments
Connecticut	Mr. C. Goodwin Yankee Gas Services Company 599 Research Parkway Meriden, CT 06450-1030 (203) 235-0243	Brenda Toth, Yankee Gas Services Co., (203) 639-4482	Yes	No	No	
Connecticut	Ms. Beth Karayiannes Southern Connecticut Gas Co. 855 Broad Street Bridgeport, CT 06604 (203) 382-8163 (203) 382-8176 (Fax)					
Connecticut	Ms. Gail Spence Western Massachusetts Electric Co. 107 Selden Street Hartford, CT 06141-0270 (203) 665-4514					No response
Florida	Mr. David P. Develle Florida Power Corporation P. O. Box 14042 3201 34th Street South St. Petersburg, FL 33733 (813) 866-4712	None	No	No	No	
Florida	Mr. Mark Spiller Gainesville Regional Utilities P. O. Box 147117, Sta. A136 Gainesville, FL 32602 (904) 374-2811	John Harrison (407) 783-0300	Yes	No	Yes, Florida Solar Energy Center	
Idaho	Mr. Tim Paul Idaho Power 450 West State, 7th Floor Towers Building Boise, ID 83720 (208) 334-5737 (208) 334-6664 (fax)	Annette Long Washington Water Power (509) 489-0500 Becky Eberle Pacificorp (503) 464-6894 Mike Fritz Idaho Power (208) 455-8200	Yes	No comment	Yes	Evaluation not representative of DOE Program
Illinois	Ms. Shirley MoyLee Northern Illinois Gas Co. 1700 W. Ferry Road Naperville, IL 60563 (703) 983-8888	Shirley Moy-Lee, Northern Illinois Gas (708) 983-9676 ext. 2827	No	Yes, there were two pilot programs; one in 1992 and the other in 1992-93. Both programs were not cost effective.	No	
Indiana	Mr. G. C. Dean Indiana Michigan Power Co. One Summit Square, P. O. Box 60 Fort Wayne, IN 46801 (614) 223-2780					No response

State	Utility contact person form was sent to	Recommended contacts	Any coordinated programs?	Any evaluations completed?	Any evaluations underway now?	Comments
Indiana	Ms. Teresa A. Zauss PSI Energy, Inc. 1000 East Main Street Plainfield, IN 46168 (317) 838-1115	Stejepan Vhlahovich Ohio Dept. of Dev. (614) 466-0545 Patricia Gallegos Energy Conservation Assoc. (303) 572-3604	Yes	No, not for our program	Yes, Ohio Dept. of Dev. Columbus, Ohio is doing one for the Weatherization Assistance Program in Ohio	Have Ohio Columbia Gas evaluations referred to by this respondent
Iowa	Ms. Peggy Black Mid American Energy P. O. Box 657 Des Moines, IA 50303 (515) 252-6900	Shirley Giorgenti Mid American Energy Co. (712) 277-7524 Rick Leuthauser Mid American Energy Co. (319) 333-8846 Greg Pelper, IDHR (515) 281-3988	Yes	Yes	Yes	Have Iowa evaluation referred to by this respondent
Iowa	Ms. Shirley Giorginti Midwest Gas P. O. Box 778 Sioux City, IA 51102 (712) 277-7587	Greg Pieper IA Dept. of Human Rights (515) 281-3988	No, our program provides funds to the DCAA (IDHR) to give to community action agencies	Yes	Yes	Have Iowa evaluation referred to by this respondent
Iowa	Ms. Susan Knoedel Iowa-Illinois Gas & Electric 1830 Second Avenue, Suite 100 Rock Island, IA 61201 (319) 326-7350 (319) 333-8838 (fax)	Greg Pieper Dept. of Human Rights, Bureau of WX (515) 281-3988	Yes	Yes	Yes	Have Iowa evaluation referred to by this respondent
Iowa	Mr. Tom Balster Interstate Power Co. P. O. Box 769 Dubuque, IA 52004-0769 (319) 582-5421 (ext. 256) (319) 557-2267 (fax)	None	No	No	No	
Iowa	Mr. Jim Newton Peoples Natural Gas Lucas State Office Building Des Moines, IA 50319 (515) 242-6314 (515) 242-6119 (fax)					No response
Iowa	Mr. Michael M. Nutt Iowa Electric Light & Power Co. 300 Sheridan Avenue Centerville, IA 52544 (319) 398-4411 (319) 398-4422 (fax)					No response

State	Utility contact person form was sent to	Recommended contacts	Any coordinated programs?	Any evaluations completed?	Any evaluations underway now?	Comments
Iowa	Mr. Gene Reuter Iowa Southern Utilities Co. P. O. Box 351 Cedar Rapids, IA 52401 (319) 398-4411 (319) 398-4146					Faxed 5/29/96
Kansas	Mr. George Powell Board of Public Utilities 700 Minnesota Avenue Kansas City, KS 66106 (913) 573-9151 (913) 573-9016 (fax)	Julie Bremar (913) 296-2686	Yes	No	Yes	Have pre-publication results from Kansas
Maine	Mr. Robert E. Tuoriniemi Central Maine Power Company Edison Drive Augusta, ME 04336 (207) 623-3521 Ext. 2656 (207) 626-9892 (fax)					No response
Maryland	Mr. Al Bingman Potomac Edison 10435 Downsville Pike Hagerstown, MD 21740 (301) 790-6293 (301) 790-6118 (fax)	None	No	No	No	
Massachusetts	Mr. Jeff Cady Chicopee P. O. Box 405 Chicopee, MA 01021-0405 (413) 598-8311 (413) 594-5507 (fax)					No response
Massachusetts	Mr. Kenneth E. Karspeck Eastern Edison Co. P. O. Box 543 W. Bridgewater, MA 02379 (508) 558-1000	Bruce Ledgerwood MA Div. of Energy Resources (617) 727-4732	No	No	Yes, Evaluation of the Massachusetts Energy Conservation Service Program	
Massachusetts	Mr. George T. Thompson Boston Edison Company 800 Boylston Street Boston, MA 02199 (617) 424-2000 (617) 424-2431 (fax)	Mr. Ken Rauseo, DOER (617) 727-6964				No response
Michigan	Mr. D. DaPra Consumers Power Co. 212 West Michigan Avenue Jackson, MI 49201-2277 (517) 788-0135	John Clary, Consumers Power Co (517) 788-1869 Art Thayer Consumer Power Co. (517) 788-1483	Yes	Yes	Yes	Evaluation received from Art Thayer (not a DOE Program)
Michigan	Bettye Ellington Michigan Consolidated Gas Co. 500 Griswold Detroit, MI 48226 (313) 256-5644	None	No	No	No	

State	Utility contact person form was sent to	Recommended contacts	Any coordinated programs?	Any evaluations completed?	Any evaluations underway now?	Comments
Minnesota	Mr. Steve Betzler Minnesota Power & Light Co. 30 West Superior Street Duluth, MN 55802 (218) 723-3933 (218) 723-3916 (fax)					No response
Minnesota	Mr. R. A. Clark Rochester Public Utilities Weatherization 4000 East River Road, NE Rochester, MN 55903 (507) 280-1555 280-1542 (fax)					No response
Minnesota	Ms. Lois M. Gribneau Northern States Power Co. 414 Nicollet Mall (RS-5) Minneapolis, MN 55401 (612) 229-2389	Karen T. Grivna Northern States Power Co. (612) 330-5709	Yes	No	No	
Minnesota	Mr. Russell Luippaka Northern Minnesota Utilities 910 Cloquet Avenue Cloquet, MN 55720 (218) 879-4651 (218) 878-2202 (fax)					No response
Minnesota	Ms. Koa Combs "People's Natural Gas"-Utility Corp. P. O. Box 393 International Falls, MN 56649 (218) 283-3324					No response
Minnesota	Mr. Jen Peterson Minnegasco, Inc. 201 S. 7th Street Minneapolis, MN 55402 (612) 463-1371					No response
Missouri	Ms. Milly Martin Union Electric Co. 1901 Chouteau Avenue St. Louis, MO 63166 (314) 554-2478 or 431-5191					No response
Montana	Mr. Jim Nolan, Program Manager Montana Power Weatherization Program P. O. Box 4210, Capitol Station Helena, MT 59604-4210 (406) 444-4545	Glen Phelps	Yes	Yes	No	Not a DOE Program evaluation. Is an independant utility program.
Nevada	Ms. Kay Grosulak Sierra Pacific Power Co. P. O. Box 10100 Reno, NV 89520 (702) 689-4677					No response

State	Utility contact person form was sent to	Recommended contacts	Any coordinated programs?	Any evaluations completed?	Any evaluations underway now?	Comments
Nevada	Mr. Jeffrey Patlovich Boulder City P.O. Box 367 Boulder City, NV 89005 (303) 293-9282	None	No	No	No	
New Jersey	Mr. Kevin Connelly Jersey Central Power & Light 300 Madison Avenue Morristown, NJ 07962 (201) 455-8280					No response
New Jersey	Mr. Joseph J. Flanagan Public Service Electric & Gas P. O. Box 570 Newark, NJ 07101 (201) 430-6140					No response
New Jersey	Ms. Laurie Hassis Elizabethtown Gas Company P. O. Box 3175 Union, NJ 07083-1975 (908) 289-5000					No response
New Jersey	Mr. D. F. Jones Atlantic City Electric Co. 6801 Black Horse Pike Pleasantville, NJ 08232 (609) 645-4890)	Russ Bien Atlanta Electric, NJ 609-645-4532	No	No	No response to this question	
New Mexico	Mr. Rafael Tapia Public Service Co. Alvarado Square Albuquerque, NM 87158 (505) 848-4681					No response
New York	Mr. Jim Cuccaro Orange & Rockland Utilities Project ASSIST One Blue Hill Plaza Pearl River, NY 10965 (914) 577-2803					Have report from New York Public Service Commision. Are not DOE Programs
New York	Mr. Cliff Mason National Fuel Gas Dist. Corp 10 Lafayette Square Buffalo, NY 14203 (716) 827-6005	Jack Zeigler (315) 460-7024	No	Yes	No	Have report from New York Public Service Commision. Are not DOE Programs
New York	Mr. Hyman Schoenblum Consolidated Edison Co. Four Irving Place, Room 523 New York, NY 10003 (212) 477-3922					Have report from New York Public Service Commision. Are not DOE Programs
New York	Mr. Paul Thompson Niagara Mohawk Power Corp. 300 Erie Blvd. West Syracuse, NY 13202 (315) 474-1511					Have report from New York Public Service Commision. Are not DOE Programs

State	Utility contact person form was sent to	Recommended contacts	Any coordinated programs?	Any evaluations completed?	Any evaluations underway now?	Comments
North Dakota	Mr. Scott Handy Cass County Electric Coop, Inc. P. O. Box 8 Kindred, ND 58051 (701) 428-3292	None	No	No	No	
Ohio	Ms. Carol Jones Cincinnati Gas & Electric 139 E. Fourth Street Cincinnati, OH 45202 (513) 281-2000					Have evaluations for Ohio from Columbia Gas
Ohio	Ms. Debbie Lutz American Electric Power 215 North Hunt Street Columbus, OH 43215 (800) 327-3100					Have evaluations for Ohio from Columbia Gas
Ohio	Mr. J. H. McCann, II & Mark Rosati Ohio Edison Co. 76 South Main Street Akron, OH 44308 (216) 384-5870					Have evaluations for Ohio from Columbia Gas
Ohio	Ms. Marsha Ryan American Electric Power Service 1 Riverside Plaza Columbus, OH 43215 (614) 223-2780	Dick Morrison American Electric Power (614) 223-2353	Yes	Yes	Yes	Have evaluations for Ohio from Columbia Gas
Ohio	Mr. Richard Sims Columbia Gas of Ohio 200 Civic Center Drive Columbus, OH 43216-0117 (614) 460-4617	Richard Sims Columbia Gas of Ohio Jack Brown A&C Enercom (614) 221-9163	Yes	Yes	Yes	Mr. Sims sent copies of two evaluations by Columbia Gas that were used for Ohio.
Ohio	Mr. Keith Valiquette Dayton Power & Light Co. 1900 Dryden Road Dayton, OH 45401 (513) 643-5044	Sara Ward (614) 466-6797	Yes	Yes	Yes	Have evaluations for Ohio from Columbia Gas
Ohio	Mr. John Wilbur East Ohio Gas Company P. O. Box 5759 Cleveland, OH 44101	Sarah Ward OH Office of Energy Efficiency (614) 466-6797	Yes	Yes	Yes	Have evaluations for Ohio from Columbia Gas
Oklahoma	Ms. Rita Pangborn Oklahoma Gas & Electric Co. P. O. Box 321, M/C 1058 Oklahoma, OK 73101	Garcia Tarver, Jr. Oklahoma Dept. of Commerce (405) 843-9770	No	No	Yes	Mr. Tarver confirmed and discussed a planned evaluation
Oregon	Ms. Marilynne Blakely Eugene Water and Electric Board P. O. Box 10148 Eugene, OR 97440					No response

State	Utility contact person form was sent to	Recommended contacts	Any coordinated programs?	Any evaluations completed?	Any evaluations underway now?	Comments
Oregon	Mr. Dick Wanderscherd Ashland 20 East Main Street Ashland, OR 97520 (503) 482-3211	None	No	No	No	
Oregon	Mr. Doug Couch-MEF Bonneville Power Adm. WeatherWise Programs P. O. Box 3621 Portland, OR 97208 (503) 230-5478					No response
Oregon	Mr. Joe Feltz Portland General Electric Co. 121 Southwest Salmon Street Portland, OR 97204 (503) 464-7132					No response
Oregon	Mr. Don Shaw Pacific Power and Light 920 SW Sixth Portland, OR 97204 (503) 282-4300	Margot Everett Program Performance (503) 464-6578	No	No	Yes	
Pennsylvania	Mr. Harry E. Dowling Pennsylvania Gas & Water Co. 39 Public Square Wilkes Barre, PA 18711 (717) 829-3461					PA PUC conducts yearly statewide evaluations. Have report from PUC on utility programs (are not DOE Programs).
Pennsylvania	Ms. Bernadette Gant-Jones Philadelphia Gas Works 800 W. Montgomery Avenue, 318 Philadelphia, PA 19122 (412) 684-6808					PA PUC conducts yearly statewide evaluations. Have report from PUC on utility programs (are not DOE Programs).
Pennsylvania	Mr. Ronald F. Horn Metropolitan Edison Co. P. O. Box 16001 Reading, PA 19640 (215) 921-6397					PA PUC conducts yearly statewide evaluations. Have report from PUC on utility programs (are not DOE Programs).
Pennsylvania	Ms. Sadie Kroeck People's Natural Gas Co. 625 Liberty Avenue Pittsburgh, PA 15222 (412) 497-6539	David Mick PA Public Utility Commission (717) 783-3232	Yes	Yes	Yes	PA PUC conducts yearly statewide evaluations. Have report from PUC on utility programs (are not DOE Programs).
Pennsylvania	Mr. Bernie Maorak Pennsylvania Gas & Water Co. 41 North Main Street Wilkes Barre, PA 18711 (717) 829-3461					PA PUC conducts yearly statewide evaluations. Have report from PUC on utility programs (are not DOE Programs).
Pennsylvania	Mr. Richard W. McLeary West Penn Power Co. 800 Cabin Hill Drive Greensburg, PA 15601 (412) 838-6280					PA PUC conducts yearly statewide evaluations. Have report from PUC on utility programs (are not DOE Programs).

State	Utility contact person form was sent to	Recommended contacts	Any coordinated programs?	Any evaluations completed?	Any evaluations underway now?	Comments
Pennsylvania	Mr. D. R. Myers Pennsylvania Electric Co. 1001 Broad Street Johnstown, PA 15907 (814) 533-8207	David Mick PA Public Utility Commission (717) 783-3232	Yes	Yes	Yes	PA PUC conducts yearly statewide evaluations. Have report from PUC on utility programs (are not DOE Programs).
Pennsylvania	Mr. E. D. Preston P. O. Box 891 One East Washington Street New Castle, PA 16103 (412) 656-5394					PA PUC conducts yearly statewide evaluations. Have report from PUC on utility programs (are not DOE Programs).
Pennsylvania	Mr. Ken Ruffing Equitable Gas Company Allegheny Center Mall, Suite 2000 Pittsburgh, PA 15212-5352 (414) 442-3000	Jeffrey Hilty Peoples Natural Gas Co. (412) 247-3913 Zeke Nowicki, National Fuel Gas Dist. Corp. (814) 871-8900	No	Yes	Yes	PA PUC conducts yearly statewide evaluations. Have report from PUC on utility programs (are not DOE Programs).
Pennsylvania	Mr. Joseph Rymer UGI Corp. P. O. Box 1389 Kingston, PA 18704 (717) 283-0611	None	No	No	No	PA PUC conducts yearly statewide evaluations. Have report from PUC on utility programs (are not DOE Programs).
Pennsylvania	Ronald L. Sprankle Pennsylvania Power & Light Lehigh Service Center, Box 3500 Allentown, PA 18106-0500 Main (215) 774-5151 or (610) 774-6503	David G. Mick Bureau of Consumer Services Pennsylvania Public Utility Comm. P. O. Box 3275 Harrisburg, PA 17105-3265 (717) 783-3232	Yes, we refer customers who do not qualify for either the electric or gas utility programs to state operated program	No, not in regard to "coordinated effort"	Yes, annually the PA Public Utility Commission conducts statewide evaluation of electric and gas company program	PA PUC conducts yearly statewide evaluations. Have report from PUC on utility programs (are not DOE Programs).
Rhode Island	Mr. Kenneth E. Karspeck Blackstone Valley Electric Co. P. O. Box 1111 Lincoln, RI 02865 (508) 559-1000	Bruce Ledgerwood MA Div. of Energy Resources Bruce Ledgerwood 617-727-4732	No	No	Yes, evaluation of the Massachusetts Energy Conservation Service Program	
Rhode Island	Mr. Larry D. Settle Newport Electric Corp. P. O. Box 4128 Middletown, RI 02840 (401) 847-4480					No response
Tennessee	Mr. Paul Bolden Memphis Light Gas & Water P. O. Box 430 Memphis, TN 38101-0430 (901) 528-4983					No response
Texas	Mr. A. S. Ecton Houston Lighting & Power Co. P. O. Box 1700 Houston, TX 77251 (713) 220-5330					No response

State	Utility contact person form was sent to	Recommended contacts	Any coordinated programs?	Any evaluations completed?	Any evaluations underway now?	Comments
Texas	Mr. Ben Lucas Kerrville Public Utility Board 2250 Memorial Blvd. Kerrville, TX 78028 (512) 257-3050	Paul Dornak Kerrville Public Utility Board (210) 257-3050	No	No	Yes	
Utah	Mr. Brad Markus Mountain Fuel Supply Co. P. O. Box 11368 Salt Lake City, UT 84139 (801) 534-5555					No response
Vermont	Mr. Chris Burns Burlington 585 Pine Street Burlington, VT 05401 (802) 865-7337 (802) 865-7400 fax	No	No	No		
Washington	Mr. Wally Croshaw Tacoma City Light P. O. Box 11007 Tacoma, WA 98411 (206) 502-8363	Jim Perich-Anderson (206) 502-8619 Tacoma City Light	Yes	No, evaluation is not for program coordinated with DOE program	No	Received evaluation. Is not a DOE Program.
Washington	Danielle Olson Washington Water Power Co. E 1411 Mission Spokane, WA 99207 (509) 489-0500					No response
Washington	Mr. Tom Shannon, OBC08N Puget Sound Power & Light Co. P. O. Box 97034 Bellevue, WA 98009 (206) 462-3135	Bill Hopkins Pulet Power, (206) 462-3391	Yes	Yes	No	Evaluation was never completed
Washington	Ms. Debra Tachinbana Seattle City Light 1015 3rd Avenue Seattle, WA 98104-1198 (206) 684-3874	None	Yes	No	No	
Wisconsin	Mr. Randolph P. Chase Wisconsin Natural Gas Co. 233 Lake Avenue Racine, WI 53401 (414) 637-7681					No response
Wisconsin	Mr. Dan Jahuke City Gas Co. P. O. Box 370 Antigo, WI 54409 (509) 627-4351	Pamela Glynn North Central Com. Action Prog. (715) 424-2581	Yes	No	No	
Wisconsin	Mr. Richard E. Kolb Grant Electric Coop 231 North Sheridan Road Lancaster, WI 53813 (608) 723-2121	None	No	No	No	

State	Utility contact person form was sent to	Recommended contacts	Any coordinated programs?	Any evaluations completed?	Any evaluations underway now?	Comments
Wisconsin	Mr. Dale A. Landgren Wisconsin Electric Power Co. P. O. Box 2046, Room P401 Milwaukee, WI 53201 (414) 221-2977					No response
Wisconsin	Mr. John Nelson Wisconsin Gas Co. 626 E. Wisconsin Avenue Wilwaukee, WI 53202 (414) 291-7000					Have evaluation for 1989-1990 low-income Program (not a DOE Program).
Wisconsin	Mr. Jeffrey C. Newman Madison Gas & Electric Co. P. O. Box 1231 Madison, WI 53701 (608) 252-7149	Scott Pigg Energy Center of Wisconsin (608) 238-4601	No	No	Yes	
Wisconsin	Ms. Lois Gribneau Northern States Power Co. P. O. Box 8 Eau Claire, WI 54701 (715) 839-2594	Karen Grivna (612) 330-5709	Yes	No	No	

Appendix E

Summary Tables E-1, E-2, and E-3 of Results from State-Level Evaluations

Table E-1. Energy Savings Results From State-Level Evaluations of the U.S. Department of Energy's Weatherization Assistance Program in 1990-1995

State	Year(s) of Weatherization	Sample Size (Weatherized Homes)	Heating Fuel Type(s)[a]	Average Pre-Weatherization Consumption (in Million Btu)[b]	Average Post-Weatherization Consumption (in Million Btu)[b]	GROSS[c] Average Annual Savings (in Million Btu)	NET[d] Average Annual Savings (in Million Btu)	GROSS Savings as a Percentage of Total Pre-Weatherization Consumption of the Primary Heating Fuel	GROSS Heating Fuel Savings as a Percentage of Pre-Weatherization Heating Consumption Only	NET Savings as a Percentage of Total Pre-Weatherization Consumption of the Primary Heating Fuel
Colorado[1]	1993-95[1a]	3,431[1b]	NG[1c]	123[1d]	104.5[1e]	18.5[1f]	n/a	15%[1g]	n/a	n/a
Indiana[2]	1992[2a]	53[2b]	NG[2c]	n/a	n/a	27[2d]	n/a	n/a	30%[2e]	n/a
Iowa[3]	1992-93[3a]	637[3b]	NG[3c]	135[3d]	105[3e]	30.4[3f]	25.2[3g]	23%[3h]	28%[3i]	19%[3j]
Kansas[4]	1993-94	165	NG	128.3	109.2	19.1	n/a	15%	30%	n/a
Nebraska[5]	1994	37	O,P,NG	109.9	84.9	25.0	n/a	22.7%	n/a	n/a
New York[6]										
TIPS	1991-92[6a]	187[6b]	O, NG, E[6c]	135.9[6d]	90.4[6e]	45.5[6f]	n/a	34%[6g]	n/a	n/a
not TIPS	1991-92[6h]	224[6i]	O, NG, E[6j]	131.4[6k]	99.2[6l]	32.2[6m]	n/a	25%[6n]	n/a	n/a
North Carolina[7,8]										
Advanced Audit	1990[7a]	40[8a]	NG,P,K,O[8b]	50[7b]	36[7c]	13.9[7d]	16.6[7e]		28%[7f] (33%)[7g net]	n/a
Project Retro-Tech	1990[7h]	40[8c]	NG,P,K,O[8d]	49[7i]	40[7j]	8.9[7k]	11.6[7l]		18%[7m] (23%)[7n net]	n/a

[a] NG = natural gas; O = fuel oil; E = electricity; P = propane; K = kerosene

[b] For all the entries in these columns, except four (Indiana in 1992, North Carolina in 1990, North Carolina in 1994 and Wyoming in 1996--see footnotes to these entries for more information), the pre-weatherization and post-weatherization consumption in MBtu represents whole house consumption of the primary heating fuel. In many homes, therefore, some end uses other than space heating will be included in the pre- and post-consumption values for the primary heating fuel. For example, if a house uses natural gas as the primary heating fuel, the pre- and post-consumption values are likely to include additional natural gas end uses, such as water heating and cooking. On the other hand, consumption for end-uses that do not rely on the primary heating fuel, such as electric lighting or supplemental heat, will not be included in the pre- and post-consumption values.

[c] Gross savings are not adjusted for changes in the energy consumption of a control group.

[d] Net savings are adjusted for changes in the energy consumption of a control group. Net savings may be lower or higher than gross savings depending upon whether the control group decreased or increased its consumption.

Table E-1. Energy Savings Results From State-Level Evaluations of the U.S. Department of Energy's Weatherization Assistance Program in 1990-1995, continued

State	Year(s) of Weatherization	Sample Size (Weatherized Homes)	Heating Fuel Type(s)[a]	Average Pre-Weatherization Consumption (in Million Btu)[b]	Average Post-Weatherization Consumption (in Million Btu)[b]	GROSS[c] Average Annual Savings (in Million Btu)	NET[d] Average Annual Savings (in Million Btu)	GROSS Savings as a Percentage of Total Pre-Weatherization Consumption of the Primary Heating Fuel	GROSS Heating Fuel Savings as a Percentage of Pre-Weatherization Heating Consumption Only	NET Savings as a Percentage of Total Pre-Weatherization Consumption of the Primary Heating Fuel
North Carolina[9]	1994	2342	NG, E, P, K, O	103	70	33	n/a	32%	n/a	n/a
North Dakota[10]	1990-92[10a]	182[10b]	NG,E[10c]	120[10d]	104[10e]	16[10f]	n/a	13%[10g]	n/a	n/a
Ohio[11]	1990-91[11a]	4256[11b]	NG[11c]	140[11d]	119[11e]	20.5[11f]	21.5[11g]	13%[11h]	n/a	14%[11i]
Ohio[12]	1993-94[12a]	658[12b]	NG[12c]	144[12d]	114[12e]	29.3[12f]	n/a	20%[12g]	n/a	n/a
Ohio[13]	1994-95	1510	NG	129	99	30.5	34.8	24%	28.3%	27%
Texas[14]	1991-92[14a]	9[14b]	NG[14c]	25[14d]	n/a	4[14e]	n/a	16%[14f]	n/a	n/a
Vermont[15]	1992-93[15a]	149[15b]	NG,O,K,P, E	101[15c]	83[15d]	18.5[15e]	n/a	18%[15f]	n/a	n/a
Vermont[16]	1993-94[16a]	66[16b]	NG,O,K,P, E[16c]	122[16d]	97[16e]	24.5[16f]	n/a	20%[16g]	n/a	n/a

[a] NG = natural gas; O = fuel oil; E = electricity; P = propane; K = kerosene

[b] For all the entries in these columns, except four (Indiana in 1992, North Carolina in 1990, North Carolina in 1994 and Wyoming in 1996--see footnotes to these entries for more information), the pre-weatherization and post-weatherization consumption in MBtu represents whole house consumption of the primary heating fuel. In many homes, therefore, some end uses other than space heating will be included in the pre- and post-consumption values for the primary heating fuel. For example, if a house uses natural gas as the primary heating fuel, the pre- and post-consumption values are likely to include additional natural gas end uses, such as water heating and cooking. On the other hand, consumption for end-uses that do not rely on the primary heating fuel, such as electric lighting or supplemental heat, will not be included in the pre- and post-consumption values.

[c] Gross savings are not adjusted for changes in the energy consumption of a control group.

[d] Net savings are adjusted for changes in the energy consumption of a control group. Net savings may be lower or higher than gross savings depending upon whether the control group decreased or increased its consumption.

Table E-1. Energy Savings Results From State-Level Evaluations of the U.S. Department of Energy's

State	Year(s) of Weatherization	Sample Size (Weatherized Homes)	Heating Fuel Type(s)[a]	Average Pre-Weatherization Consumption (in Million Btu)[b]	Average Post-Weatherization Consumption (in Million Btu)[b]	GROSS[c] Average Annual Savings (in Million Btu)	NET[d] Average Annual Savings (in Million Btu)	GROSS Savings as a Percentage of Total Pre-Weatherization Consumption of the Primary Heating Fuel	GROSS Heating Fuel Savings as a Percentage of Pre-Weatherization Heating Consumption Only	NET Savings as a Percentage of Total Pre-Weatherization Consumption of the Primary Heating Fuel
Wisconsin[17]	1992	675	NG	148.4	120.5	27.9	37.4	19%		25%
Wyoming[18]	1996	38	NG	141	105	25.0	n/a	n/a	25%	n/a

[a] NG = natural gas; O = fuel oil; E = electricity; P = propane; K = kerosene

[b] For all the entries in these columns, except four (Indiana in 1992, North Carolina in 1990, North Carolina in 1994 and Wyoming in 1996--see footnotes to these entries for more information), the pre-weatherization and post-weatherization consumption in MBtu represents whole house consumption of the primary heating fuel. In many homes, therefore, some end uses other than space heating will be included in the pre- and post-consumption values for the primary heating fuel. For example, if a house uses natural gas as the primary heating fuel, the pre- and post-consumption values are likely to include additional natural gas end uses, such as water heating and cooking. On the other hand, consumption for end-uses that do not rely on the primary heating fuel, such as electric lighting or supplemental heat, will not be included in the pre- and post-consumption values.

[c] Gross savings are not adjusted for changes in the energy consumption of a control group.

[d] Net savings are adjusted for changes in the energy consumption of a control group. Net savings may be lower or higher than gross savings depending upon whether the control group decreased or increased its consumption.

1. Public Service Company of Colorado, 1995. *Performance Measurement of the Energy $avings Partners Program,* prepared by the Program Evaluation Unit of Public Service Company of Colorado. This evaluation is the only one in the table that uses econometric models to estimate program savings. Specifically, a fixed effect regression analysis based on longitudinal data was used to estimate program savings. This type of statistical modelling is often referred to as a pooled time-series and cross sectional data set (see pp. 12-15 in Public Service Company of Colorado, 1995). This evaluation examines the cordinated Public Service Company and Colorado Weatherization Assistance Program efforts. For the most part, this coordinated program follows DOE procedures. However, the utility part of the effort includes some measures (compact flourescents, and water heater changeouts) that are not part of the DOE program. Nevertheless, the utility and the State of Colorado Weatherization Program contacts both believe that this evaluation can be used to represent the Colorado Weatherization Assistance Program. It is important to note that Colorado does not target high users and that, because of the large sample size, the results represent all treated homes (both high savers and low savers). (**1a**, p. 3; **1b**, p. 18; **1c**, p. 4; **1d**, p. 22; **1e**, Average pre-weatherization (123MBtu) consumption minus average annual savings (18.5 MBtu); **1f**, p. 22; **1g**, p. 22).

2. Indiana CAP Directors' Association, Inc., 1992. *Energy Savings in Homes Weatherized by Six Indiana Weatherization Agencies: An Evaluation of Measured Savings and Cost Effectiveness*, prepared by William H. Hill, Center for Energy Research/Education/Service, Ball State University, Muncie, Indiana. Because this evaluation is based on data obtained from run-time meters attached to furnaces all consumption and savings values are for space heating only. No end uses except space heating are included in these values. (**2a**, pp. 3 and 4; **2b**, p. 3; **2c**, p. 12; **2d**, p. 10; **2e**, p. 10 - These savings were estimated from short-term (5 weeks) pre-and post-metering of furnace run-times, and are mean space-heating savings per house.).

3. The Statewide Low-Income Collaborative Evaluation (SLICE) of Iowa, 1994. *An Evaluation of Iowa's Low-Income Weatherization Efforts,* prepared by Wisconsin Energy Conservation Corporation, August 8. (**3a**, p. 1-1; **3b**, p. 3-6; **3c**, p. 3-6; The Iowa evaluation also includes a separate analysis of electricity savings (see pp. A-26 to A-32). Because the gas savings estimates were more precise and more comparable to the results of evaluations from other states; they are the only ones included here; **3d**, p. 3-6; **3e**, Average pre-weatherization usage (135MBtu) minus average annual savings (30.4MBtu); **3f**, p. 3-7; **3g**, p. 3-7; **3h**, p. 3-7; **3i**, p. 3-7; **3j**, p. 3-7).

4. Unpublished evaluation results. The information shown here was summarized in a table prepared by Mr. Douglas Walters of the University of Kansas and sent to the author. Mr. Walters is preparing an evaluation for the Kansas Weatherization Assistance Program Director, Norma Phillips.

5. Unpublished evaluation results. The information shown here was summarized in a table and letter prepared by Mr. Larry Kinyon of the Nebraska State Energy Office and sent to the author. Mr. Kinyon also provided extensive information on his methods and database in personal communications.

6. New York State Energy Research and Development Authority and New York State Department of State, 1993. *Instrumented Audits Technology Transfer Project: Final Report,* prepared by Synertech Systems Corporation. Energy Authority Report 94-6. (**6a**, Larry Kinney, personal communication; **6b**, p. 4-4; **6c**, p. 4-7; **6d**, Larry Kinney, personal communication; **6e**, Larry Kinney, personal communication; **6f**, p. iii; **6g**, p. iii; **6h**, Larry Kinny, personal communication; **6i**, p. 4-4; **6j**, p. 4-7; **6k**, Larry Kinney, personal communication; **6l**, Larry Kinney, personal communication; **6m**, p. iii; **6n**, p. iii).

7. Sharp, Terry, 1994. *The North Carolina Field Test: Field Performance of the Preliminary Version of an Advanced Weatherization Audit for the Department of Energy's Weatherization Assistance Program.* ORNL-CON-362, Oak Ridge National Laboratory, Oak Ridge, Tennessee. This experimental study was designed to compare the savings obtained with two types of audits. All of the consumption and savings values are for space heating only. No end uses except space heating are included. The pre- and post-weatherization consumption values are based on metered weekly data taken from space-heating equipment. This explains why the pre- and post-consumption values are so much lower in the 1990 entry for North Carolina as compared to the 1994 entry. In the 1990 value only one measured end-use (space heating) is included while the 1994 value is an audit estimate for all end uses. (**7a**, p. xi; **7b**, p. xvii, This value is pre-weatherization consumption of the heating fuel only; **7c**, p. 60; **7d**, p. 68; **7e**, p. 68; **7f**, p. 68; **7g**, p. xi; **7h**, p. xi; **7i**, p. 62, This value is pre-weatherization consumption of the heating fuel only; **7j**, p. 62; **7k**, p. 62; **7l**, p. 68; **7m**, p. 68; **7n**, p. xi).

8. Sharp, Terry, 1993. *Advancing Weatherization Performance: Measured Results from the North Carolina Field Test of an Advanced Measure Selection Technique,* Proceedings of the 1993 Energy Program Evaluation Conference, Chicago. pp. 711-718. (**8a**, p. 713; **8b**, p. 713; **8c**, p. 713; **8d**, p. 713).

9. Brown, Jeff, North Carolina Weatherization Assistance Program Director, 1996, personal communication. The North Carolina data tracking system collects National Energy Audit (NEAT) input and output files for all of the houses weatherized by all of the agencies in the state. NEAT is designed to select the most cost-effective combination of energy-efficiency measures for installation in each weatherized home. It also predicts expected savings for the measures it recommends for a house. The estimated annual savings in this row (North Carolina 1994) of Table 1 are derived by averaging the predicted NEAT savings across all of the dwellings in the state database. The pre- and post-weatherization consumption values are also based on the NEAT model predictions.

10. North Dakota Weatherization Assistance Program, 1993. *Evaluation of North Dakota's Weatherization Assistance Program: Report of Findings,* prepared by Conservation Management Corporation, Bethesda, Maryland, and by Tighe Energy Consultants, Arlington, Virginia. (**10a**, p. i.; **10b**, p. i.; **10c**, p. i; **10d**, p. iii; **10e**, p. iii; **10f**, p. iii; **10g**, p. iii.

11. *An Analysis of the Columbia Gas 1990-91 Ohio Warm Choice Program* prepared by A&C Enercom, Inc., for Columbia Gas of Ohio, 1993 (**11a**, p.5; **11b**, p.23; **11c**, p. 23; **11d**, p. 27; **11e**, p.27; **11f**, p. 23; **11g**, p. 23; **11h**, p.23, **11i**, p. 23).

12. *An Administrative Report on the Columbia Gas 1993-94 Warm Choice Program* prepared by A&C Enercom, Inc., for Columbia Gas of Ohio, November 1995. (**12a**, p.3; **12b**, p. 6; **12c**, p. 4; **12d**, p. 6; **12e**, p. 6; **12f**, p. 4; **12g**, p. 4).

13. Unpublished evaluation results. The information shown here was summarized in a memo and table prepared for Sara Ward, Ohio Weatherization Assistance Program Director, by Michael Blasnick of Proctor Enginneering. Ms. Ward sent a copy of the memo and table to ORNL.

14. Texas Department of Housing, 1995. Final Report: *Advanced PRISM Analysis of 182 Residential Houses in Texas that Underwent Energy Retrofits*, prepared by J. Wang, D. Claridge, J. Haberl, and T. Reddy, Energy Systems Laboratory, Texas A&M University. (**14a**, letter; **14b**, p. 4; **14c**, p. 4; **14d**, p. 5; **14e**, p. 4; **14f**, p.5).

15. Vermont State Office of Economic Opportunity, Weatherizaton Assistance Program, 1993. *Impact Evaluation of the 1992-93 Vermont Weatherization Assistance Program*, prepared by Vermont Energy Investment Corporation. (**15a**, p.1; **15b**, p.1; **15c**, p.2; **15d**, average pre-weatherization consumption (101MBtu) minus average annual savings 18-5MBtu); **15e**, p.2; **15f**, p.2).

16. Vermont State Office of Economic Opportunity, Weatherization Assistance Program, 1995. *Impact Evaluation of the 1993-1994 Vermont Weatherization Assistance Program*, prepared by Vermont Energy Investment Corporation. (**16a**, p. 2; **16b**, p. 2; **16c**, p. 12; **16d**, p. 14; **16e**, p. 14; **16f**, p. 14. The Vermont evaluation, like most of the state-level evaluations, usually measures changes in consumption only for the primary heating fuel used in the dwelling. For example, in a dwelling which uses a gas furnace as its primary heating source, only reductions in gas usage are measured. If the dwelling reduced its use of electricity for water-heating, supplemental space-heating, cooling, or baseload end-uses (such as lighting, cooking, laundry, etc.), these savings would not be measured. Therefore, in general, the Vermont evaluation, and the other evaluations, tend to underestimate savings as compared to what they would be if changes in the use of all fuels were measured. The degree of underestimation is probably not too large as space-heat usually accounts for 70% of total usage, and most weatherization measures have the largest impact on space heat usage. In the Vermont evaluation, some effort was made to include all of the fuel types used in a dwelling, but usually this was not feasible, personal communication, Ken Tohinaka; **16g**, p. 14).

17. Unpublished evaluation results provided by Carl Saueressig, Wisconsin Weatherization Assistance Program, 1996.

18. Unpublished evaluation results provided by Rana Belshe. Ms. Belshe is preparing an evaluation for the Wyoming Weatherization Assistance Program Director, Jan Stiles.

Table E-2. Energy Factor[a] Results From State-Level Evaluations of the U.S. Department of Energy's Weatherization Assistance Program

State	Year(s) of Weatherization	Average Heating Degree Days[17a]	Average Square Footage	Pre-Btu/Square Foot/HDD	Post-Btu/Square Foot/HDD	Pre/Post Change in Btu/Square Foot/HDD	Audit Type	Methods Used to Measure Energy Savings
Colorado[1]	1993-95[1a]	7,071[18a]	n/a	n/a	n/a	n/a	Advanced (TAP)[1b]	Econometric models[1c]
Indiana[2]	1991-92[2a]	5,727[18b]	1065[2b]	20.9[2c]	n/a	n/a		Short-term metering of furnace run times[2d]
Iowa[3]	1992-93[3a]	6,809[18c]	1,332[3b]	18.1[3c]	15[3d]	3.1[3e]	Not Advanced (Project Retro-Tech)[3f]	Billing analyses/PRISM and statistically-adjusted engineering models[3g]
Kansas[4]	1993-94	4,883[18d]	n/a	n/a	n/a	n/a	NEAT	Billing analyses/PRISM
Nebraska[5]	1994	6,311[18e]	1,394	n/a	n/a	n/a	NEAT	Billing analyses/PRISM
New York[6]								
TIPS	1991-92[6a]	5,922[18f]	n/a	16.5[6b]	10.9[6c]	5.6[6d]	Advanced (TIPS)[6e]	Energy factor changes pre- and post-weatherization were used to estimate annual energy savings[6k]
not TIPS	1991-92[6f]	5,922[18f]	n/a	15.5[6g]	11.7[6h]	3.8[6i]	Not Advanced[6j]	
North Carolina[7]								
Advanced Audit	1990[7a]	3,393[7b]	1150[7c]	13.3[7d]	8.9[7e]	4.4[7f]	Advanced (NEAT pilot)[7g]	Metered weekly data from space-heating equipment were used to construct weather-normalized linear models[7o]
Project Retrotech	1990[7h]	3,393[7i]	1150[7j]	13.3[7k]	10.2[7l]	3.1[7m]	Not Advanced (Project Retro-Tech)[7n]	
North Carolina[8]	1994	3,369[18g]	969	n/a	n/a	n/a	Advanced (NEAT)	NEAT audit predictions

[a]The energy factor is an index determined by dividing the amount of energy consumed for heating a dwelling for a year (in Btu per year) by the number of heating degree days for a typical year (in HDD per year) and then dividing the result by the square footage (sq. ft.) of the heated area of the dwelling. The units of Btu/HDD/Sq. ft. of the index quantify the energy efficiency of the dwelling.

Table E-2. Energy Factor[a] Results From State-Level Evaluations of the U.S. Department of Energy's Weatherization Assistance Program continued

State	Year(s) of Weatherization	Average Heating Degree Days[10]	Average Square Footage	Pre-Btu/Square Foot/HDD	Post-Btu/Square Foot/HDD	Pre/Post Change in Btu/Square Foot/HDD	Audit Type	Methods Used to Measure Energy Savings
North Dakota[9]	1990-92[9a]	9385[18h]	n/a	n/a	n/a	n/a	Not Advanced[9b]	Billing analysis/PRISM[9c]
Ohio[10]	1990-91	5788[18i]	n/a	n/a	n/a	n/a	n/a	Billing analysis/PRISM
Ohio[11]	1993-94	5788[18i]	n/a	n/a	n/a	n/a	n/a	Billing analysis/PRISM
Ohio[12]	1994-95	5788[18i]	n/a	n/a	n/a	n/a	n/a	Billing analysis/PRISM
Texas[13]	1991-92[13a]	1972[18j]	n/a	n/a	n/a	n/a	Not Advanced (Project Retro-Tech[13b])	Billing analysis/PRISM[13c]
Vermont[14]	1992-93	7903[18k]	n/a	n/a	n/a	n/a	Advanced	Billing analysis/with WECC method
Vermont[15]	1993-94	7903[18k]	n/a	n/a	n/a	n/a	Advanced	Billing analysis/PRISM
Wisconsin[16]	1992	7596[18l]	n/a	13.0	8.5	4.5	Advanced	Billing analysis/PRISM
Wyoming[17]	1996	8015[18m]	n/a	n/a	n/a	n/a	Advanced	Metering of fuel consumption by space heating equipment

[a]The energy factor is an index determined by dividing the amount of energy consumed for heating a dwelling for a year (in Btu per year) by the number of heating degree days for a typical year (in HDD per year) and then dividing the result by the square footage (sq. ft.) of the heated area of the dwelling. The units of Btu/HDD/Sq. ft. of the index quantify the energy efficiency of the dwelling.

1. Public Service Company of Colorado, 1995. *Performance Measurement of the Energy $avings Partners Program,* prepared by the Program Evaluation Unit of Public Service Company of Colorado. (**1a**, p. 3; **1b**, Rick Hanger, Colorado Office of Energy Conservation, personal communication, 1996. TAP is Colorado's own audit, which is on easy-to-use Excel spreadsheet; **1c**, pp. 12-13, Four econometric model estimates were developed. The average program energy savings for participants were estimated with a fixed effect regression analysis using logitudinal data. This type of statistical model, which requires a longitudinal data set, is often referred to as a pooled time-series and cross sectional data set. The model uses average daily heating degree days with a dummy variable for participation which equals one if the dwelling has been weatherized at time t, and equals zero if it has not. No control group was used in this analysis.

2. Indiana CAP Directors' Association, Inc., 1992. *Energy Savings in Homes Weatherized by Six Indiana Weatherization Agencies: An Evaluation of Measured Savings and Cost Effectiveness*, prepared by William H. Hill, Center for Energy Research/Education/Service, Ball State University, Muncie, Indiana. (**2a**, pp. 3-5; **2b**, p. 7; **2c**, p.7; **2d**, p. 4).

3. The Statewide Low-Income Collaborative Evaluation (SLICE) of Iowa., 1994. *An Evaluation of Iowa's Low-Income Weatherization Efforts,* prepared by Wisconsin Energy Conservation Corporation, August 8. (**3a**, p. 2-5; **3b**, p. 3-24; **3c**, p. 3-26; **3d**, p. 3-26; **3e**, p. 3-26; **3f**, At the time of this evaluation, Iowa was using Project Retro-Tech. Iowa began using NEAT in 1993. An evaluation is now underway which will assess savings with NEAT in place. Greg Dahlhoff, personal communication; **3g**, p. A-1 and p. 2-4 to 2-5).

4. Unpublished evaluation results provided by Mr. Douglas Walters of the University of Kansas. Mr. Walters is preparing an evaluation for the Kansas Weatherization Assistance Program Director, Norma Phillips.

5. Unpublished evaluation results provided by Mr. Larry Kinyon of the Nebraska State Energy Office.

6. New York State Energy Research and Development Authority and New York State Department of State, 1993. *Instrumented Audits Technology Transfer Project,* prepared by Synertech Systems Corporation. Energy Authority Report 94-6. (**6a**, Larry Kinney, personal communication; **6b**, pp. 4-23; **6c**, pp. 4-23; **6d**, pp. 4-23. The average after weatherization energy factor was subtracted from the before weatherization energy factor; **6e**, Appendix E; **6f**, Same as 6a; **6g**, p. 4-24; **6h**, p. 4-24; **6i**, p. 4-24. The average after weatherization energy factor was subtracted from the before weatherization energy factor; **6j**, p. 2-1; **6k**, pp. 4-1 and 4-2).

7. Sharp, Terry, 1994. *The North Carolina Field Test: Field Performance of the Preliminary Version of an Advanced Weatherization Audit for the Department of Energy's Weatherization Assistance Program.* ORNL-CON-362, Oak Ridge National Laboratory, Oak Ridge, Tennessee. (**7a**, p. xi; **7b**, p. 15, Weather data for a typical meterological year for the Raleigh/Durham area were obtained from the National Climatic Center and used to normalize for weather; **7c**, p. 27; **7d,** Terry Sharp, personal communication; **7e,** Terry Sharp, personal communication; **7f**, Terry Sharp, personal communication; **7g**, p. xi; **7h**, p. xi; **7i**, p. 15; **7j**, p. 27; **7k**; Terry Sharp, personal communication; **7l**, Terry Sharp, personal communication; **7m**, Terry Sharp, personal communication; **7n**, p, xi; **7o**, p. 55).

8. Brown, Jeff, North Carolina Weatherization Assistance Program Director, 1996, personal communication.

9. North Dakota Weatherization Assistance Program, 1993. *Evaluation of North Dakota's Weatherization Assistance Program: Report of Findings,* prepared by Conservation Management Corporation, Bethesda, Maryland, and by Tighe Energy Consultants, Arlington, Virginia. (**9a**, p. i; **9b**, Sage, Howard, Weatherization Program Manager, personal communication, 1996, North Dakota was not using an advanced audit at the time of the evaluation. It's agencies now use the NEAT audit; **9c**, Appendix B).

10. *An Analysis of the Columbia Gas 1990-91,* Ohio Warm Choice Program, prepared by A&C Enercom, Inc., for Columbia Gas of Ohio, 1993.

11. *An Administrative Report on the Columbia Gas 1993-94 Warm Choice Program,* prepared by A&C Enercom, Inc., for Columbia Gas of Ohio, November 1995.

12. Unpublished evaluation results provided by Sara Ward, Ohio Weatherization Program Director.

13. Texas Department of Housing, 1995. *Final Report: Advanced PRISM Analysis of 182 Residential Houses in Texas that Underwent Energy Retrofits*, prepared by J. Wang, D. Claridge, J. Haberl, and T. Reddy, Energy Systems Laboratory, Texas A&M University. (**13a**, letter from Peggy Colvin, Energy Assistance Section, Texas Department of Housing and Community affairs; **13b**, same as 13a, **13c**, p. 1).

14. Vermont State Office of Economic Opportunity Weatherization Assistance Program, 1993. *Impact Evaluation of the 1992-93 Vermont Weatherization Asssistance Program*, prepared by Vermont Energy Investment Corporation.

15. Vermont State Office of Economic Opportunity, Weatherization Assistance Program, 1995. *Impact Evaluation of the 1993-1994 Vermont Weatherization Assistance Program*, prepared by Vermont Energy Investment Corporation. (**15a**, p. 2; **15b**, Jules Junker, Weatherization Director, Vermont Office of Economic Opportunity; **15c**, p. 11).

16. Unpublished evaluation results provided by Carl Saueressig, Wisconsin Weatherization Assistance Program, 1996, personal communication.

17. Unpublished evaluation results provided by Rana Belshe. Ms. Belshe is preparing an evaluation for the Wyoming Weatherization Assistance Program Director, Jan Stiles.

18. National Oceanic and Atmospheric Administration, 1993. *State, Regional, and National Monthly and Seasonal Heating Degree Days: Weighted by Population (1990 Census) July 1931-June 1992,* Historical Climatology Series 5-1, National Climatic Data Center, Asheville, North Carolina. This publication presents 30 year averages of heating degree days for each state. These averages are weighted by the population reported in the 1990 census. (**18a**, p. 10; **18b**, p. 17; **18c**, p. 18; **18d**, p. 19; **18e**, p. 30; **18f**, p. 35; **18g**, p. 36; **18h**, p. 37; **18i**, p. 38; **18j**, p. 46; **18k**, p. 48; **18l**, p. 52; **18m**, p. 53).

Table E-3. Weatherization Costs, Annual Bill Savings[a], and Cost Effectiveness Indicators as Reported in State-Level Evaluations of the U.S. Department of Energy's Standardized Weatherization Assistance Program.

State	Year(s) of Weatherization	Average Amount Spent per Dwelling ALL COSTS (in 1994 dollars)[a]	Average Amount Spent per Dwelling LABOR & MATERIALS (in 1994 dollars)[a]	Average Amount Spent per Dwelling MATERIALS ONLY (in 1994 dollars)[a]	Average Annual Savings (in 1994 dollars)[a]	Simple Payback Period (in years)	Cost of Conserved Energy[b] (in 1994 dollars per MBtu with consistent assumptions)	Benefit/Cost Ratio[c] as Reported
Colorado[1]	1993-95[1a]	n/a	n/a	$744[1b]	n/a	n/a	n/a	1.10[1c]
Indiana[2]	1992[2a]	$1,405[2b]	n/a	$562[2c]	$139[2d]	10.1[2e]	$4.16	n/a
Iowa[3]	1992-93[3a]	$2,238[3b]	$1,760[3c]	n/a	$139[3d]	9.6-16.0[3e]	$5.89[3f]	0.9-1.9[3g]
Kansas[4]	1993-94	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Nebraska[5]	1994	$2,105	$1,715	$954	$132	15.9	$6.74	n/a
New York[6]								
TIPS	1991-92[6a]	$2,102[6b]	n/a	n/a	n/a	n/a	$3.70[6c]	n/a
not TIPS	1991-92[6d]	$1,997[6e]	n/a	n/a	n/a	n/a	$4.96[6f]	n/a
North Carolina[7]								
Advanced Audit	1990[7a]	n/a	$1,197[7b]	n/a	$111[7c]	n/a	n/a	n/a
Project Retro-Tech	1990[7d]	n/a	$1,201[7e]	n/a	$71[7f]	n/a	n/a	n/a

[a] All costs and annual savings in this table are expressed in 1994 dollars. The nominal amounts reported in each evaluation were converted into 1994 dollars by applying the Consumer Price Index ratios shown in the 1995 Statistical Abstract of the United States, U.S. Department of Commerce, Table No. 761, p. 492.

[b] Cost of conserved energy indicators were standardized by converting the nominal dollars spent per house that was reported to 1994 dollars and then dividing by the MBtu saved per house and applying an annualization factor of 0.08. This annualization factor assumes a 5% discount rate and a measure lifetime of 20 years. Costs were defined as all costs and savings as gross savings as shown in Table E-1.

[c] Benefit/cost ratios are reported exactly as they appeared in the evaluations. Because different evaluations used different perspectives, and different assumptions about measure lifetimes, fuel price escalation rates, and discount rates, the benefit/cost ratios should not be directly compared across states. Insufficient information was available to recalculate the benefit/cost ratios with consistent perspectives and assumptions.

Table E-3. Weatherization Costs, Annual Bill Savings[a], and Cost Effectiveness Indicators as Reported in State-Level Evaluations of the U.S. Department of Energy's Weatherization Assistance Program.

State	Year(s) of Weatherization	Average Amount Spent per Dwelling ALL COSTS (in 1994 dollars)[a]	Average Amount Spent per Dwelling LABOR & MATERIALS (in 1994 dollars)[a]	Average Amount Spent per Dwelling MATERIALS ONLY (in 1994 dollars)[a]	Average Annual Savings (in 1994 dollars)[a]	Simple Payback Period (in years)	Cost of Conserved Energy[b] (1994 dollars per MBtu)	Benefit/Cost Ratio[c]
North Carolina[8]	1994	$1,713	$1,541	$662	$293	5.9	$4.15	2.13
North Dakota[9]	1990-92[9a]	$1,786[9b]	$1,563[9c]	n/a	$87[9d]	20[9e]	$8.93[9f]	n/a
Ohio[10]	1990-91	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ohio[11]	1993-94	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ohio[12]	1994-95	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Texas[13]	1991-92	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Vermont[14]	1992-93[14a]	$2,360[14b]	n/a	n/a	n/a	n/a	$10.21[14c]	1.33[14d]
Vermont[15]	1993-94[15a]	$2,467[15b]	$1,318[15c]	n/a	n/a	n/a	$8.06[15d]	1.8[15e]
Wisconsin[16]	1992	n/a	n/a	n/a	$257	n/a	n/a	n/a
Wyoming[17]	1996	n/a	n/a	n/a	n/a	n/a	n/a	n/a

[a] All costs and annual savings in this table are expressed in 1994 dollars. The nominal amounts reported in each evaluation were converted into 1994 dollars by applying the Consumer Price Index ratios shown in the 1995 Statistical Abstract of the United States, U.S. Department of Commerce, Table No. 761, p. 492.

[b] Cost of conserved energy indicators were standardized by converting the nominal dollars spent per house that was reported to 1994 dollars and then dividing by the MBtu saved per house and applying an annualization factor of 0.08. This annualization factor assumes a 5% discount rate and a measure lifetime of 20 years. Costs were defined as all costs and savings as gross savings as shown in Table E.1.

[c] Benefit/cost ratios are reported exactly as they appeared in the evaluations. Because different evaluations used different perspectives, and different assumptions about measure lifetimes, fuel price escalation rates, and discount rates, the benefit/cost ratios should not be directly compared across states. Insufficient information was available to recalculate the benefit/cost ratios with consistent perspectives and assumptions.

1. Public Service Company of Colorado, 1995. *Performance Measurement of the Energy $avings Partners Program,* prepared by the Program Evaluation Unit of Public Service Company of Colorado. (**1a**, p. 3; **1b**, p. 10; **1c**, p. 30. Calculated with a Total Resource Cost perspective and assuming 15% gas savings, a 30 year lifetime, and a discount rate of 10.3%).

2. Indiana CAP Directors' Association, Inc., 1992. *Energy Savings in Homes Weatherized by Six Indiana Weatherization Agencies: An Evaluation of Measured Savings and Cost Effectiveness*, prepared by William H. Hill, Center for Energy Research/Education/Service, Ball State University, Muncie, Indiana. (**2a**, pp. 3-5; **2b**, p. 11; **2c**., p. 13; **2d**, p. 10; **2e**, p. 13)

3. The Statewide Low-Income Collaborative Evaluation (SLICE) of Iowa, 1994. *An Evaluation of Iowa's Low-Income Weatherization Efforts,* prepared by Wisconsin Energy Conservation Corporation, August 8. (**3a**, p. 2-5; **3b**, p. 1-4; **3c**, p. 1-4; **3d**, p. 1-2; **3e**, pp. 3-22. Several perspectives are used to calculate this range of simple payback periods. Some include only the cost of installing energy efficiency measures and only the value of energy savings. Others include a broader set of costs and the value of both energy savings and nonenergy benefits. The subset of houses that did not receive furnace replacements had a simple payback period of 7.4 years, as compared to 9.6 years for all houses, pp. 1-4 and 3-22; **3f**, This value was calculated using all costs in 1994 dollars ($2,238), gross energy savings (30.4MBtu) from Table 1, and an annualization factor of 0.8; **3g**, Several perspectives are used to calculate this range of benefit/cost ratios. Some include only the cost of installing energy efficiency measures and only the value of energy savings. Others include a broader set of costs and the value of both energy savings and nonenergy benefits.)

4. Unpublished evaluation results did not include any cost data.

5. Unpublished evaluation results supplied by Mr. Larry Kinyon of the Nebraska State Energy Office.

6. New York State Energy Research and Development Authority and New York State Department of State, 1993. *Instrumented Audits Technology Transfer Project,* prepared by Synertech Systems Corporation. Energy Authority Report 94-6. **6a**, Larry Kinney, personal communication; **6b**, p. iii. Assumed $1,932 were 1991 dollars and then converted to 1994 dollars ($2,102) using the Consumer Price Index; **6c,** This value was calculated using all costs in 1994 dollars ($2,102), gross energy savings (45.5 MBtu) from Table E-1, and an annualization factor of 0.08; **6d**, Same as 4a; **6e**, p. iii, Assumed $1,835 were 1991 dollars and then converted to 1994 dollars ($1,997) using the Consumer Price Index. **6f**, This value was calculated using all costs in 1994 dollars ($1,997), gross energy savings (32.2MBtu) from Table E-1, and an annualization factor 0.08.

7. Sharp, Terry, 1994. *The North Carolina Field Test: Field Performance of the Preliminary Version of an Advanced Weatherization Audit for the Department of Energy's Weatherization Assistance Program.* ORNL-CON-362, Oak Ridge National Laboratory, Oak Ridge, Tennessee. (**7a**, p. xi; **7b**, p. xviii, 1990 dollars ($1,056) are converted to 1994 dollars ($1,197); **7c**, p. xvii, Assuming a price of $7 (in 1990 dollars) per MBtu, and converting to 1994 dollars ($8) per MBtu by using the CPI. The savings for this group are 13.9 MBtu, which multiplied by $8 is $111; **7d**, p. xi; **7e**, p. xviii, 1990 dollars ($1,059) are converted to 1994 dollars ($1,201); **7f**, p. xvii. Assuming a price of $7 (in 1990 dollars) per MBtu and converting to 1994 dollars ($8) per MBtu by using the CPI. The savings for this group are 8.9 MBtu, which multiplied by $8 is $71).

8. Brown, Jeff, North Carolina Weatherization Assistance Program Director, 1996, personal communication. All of the results shown in this row were either taken directly from a copy of a one-page spreadsheet which the North Carolina Weatherization Assistance Program Director sent to the author, or else were calculated from the results shown on the spreadsheet. All values are in 1994 dollars. The benefit/cost ratio assumes a 20 year lifetime of measures, fuel prices of $9.00/MBtu and a discount rate of 5%. Savings are, as shown in Table E.1, the savings predicted with the NEAT audit.

9. North Dakota Weatherization Assistance Program, 1993. *Evaluation of North Dakota's Weatherization Assistance Program: Report of Findings,* prepared by Conservation Management Corporation, Bethesda, Maryland, and by Tighe Energy Consultants, Arlington, Virginia. (**9a**, p. i; **9b**, p. 37. Assuming $1,641 (in 1990 dollars) and converting to 1994 dollars ($1,786) by using the CPI ratios; **9c**, p. 37. Assuming $1,437 (in 1990 dollars) and converting to 1994 dollars ($1,563) by using the CPI ratios; **9d**, p. 39. An average annual bill savings. of $80 (in 1991) per weatherized home was calculated assuming on average price of $5 per MBtu and an average savings of 16MBtu. In 1994 dollars, this is $87, based on CPI ratios; **9e**, p. 39; **9f**, This value was calculated using all costs in 1994 dollars ($1,786), gross energy savings (16MBtu) from Table 1, and an annualization factor of 0.08.)

10. *An Analysis of the Columbia Gas 1990-91, Ohio Warm Choice Program,* prepared by A&C Enercom, Inc., for Columbia Gas of Ohio, 1993. This evaluation did not include cost data.

11. *An Administrative Report on the Columbia Gas 1993-94 Warm Choice Program,* prepared by A&C Enercom, Inc., for Columbia Gas of Ohio, November 1995. This evaluation did not include cost data.

12. Unpublished evaluation results did not include any cost data.

13. Texas Department of Housing, 1995. *Final Report: Advanced PRISM Analysis of 182 Residential Houses in Texas that Underwent Energy Retrofits,* prepared by J. Wang, D. Claridge, J. Haberl, and T. Reddy, Energy Systems Laboratory, Texas A&M University. No cost data are presented in this evaluation.

14. Vermont State Office of Economic Opportunity, Westerization Assistance Program, 1993. *Impact Evaluation of the 1992-93 Vermont Weatherization Assistance Program,* prepared by Vermont Energy Investment Corporation (**14a**, p. 1; **14b**, p.2; **14c**, This value was calculated using all costs in 1994 dollars ($2,360), gross energy savings (18.5 MBtu) from Table E-1, and an annualization factor of 0.08).

15. Vermont State Office of Economic Opportunity, Weatherization Assistance Program, 1995. *Impact Evaluation of the 1993-1994 Vermont Weatherization Assistance Program,* prepared by Vermont Energy Investment Corporation. **15a**, p. 2; **15b**, p. 3 and p. 5. The total budget of $4,012,000 was divided by the number of households served (1,626). The result, in 1994 dollars, is $2,467. This reported cost for Vermont is higher than average for several reasons. First, the total budget figure includes all federal and all state funds. Second, the definition of total costs used in Vermont is more inclusive than in many other states. In Vermont, every expenditure (including costs for all administrative, training, technical assistance, evaluation, home repair, and health and safety activities) is counted. In addition, many dwellings receive (expensive) heating system replacements which also tends to produce higher than average costs. **15c**, p. 17; **15d**, This value was calculated using all costs in 1994 dollars ($2,467), gross energy savings (24.5 MBtu) from Table E-1, and an annualization factor of 0.08; **15e**, pp. 11-23, and p. 18. Assumes a 20 year lifetime for measures and uses a conservative forecast of fuel price escalation rates).

16. Unpublished evaluation results provided by Carl Saueressig, Wisconsin Weatherization Assistance Program, 1996, personal communication.

17. Unpublished evaluation results did not include any cost data.

Appendix F

Table F-1 Regression Model Inputs

Table F-1. Adjusted[a] Data Used As Input to Regression Models

State	Year of Weatherization	Pre-weatherization Consumption of the Primary Heating Fuel	Heating Degree Days (30-year average)	Audit Type 0=not advanced 1=advanced	Energy Factor[g] (Btu/HDD/Sq. Ft)	Average Gross (or Net, if Available); Savings of the Primary Heating Fuel in MBtu/Year
Colorado	1994	123	7,071	1	(14.7)	18.5
Indiana	1992	(129)[c]	5,727	1	20.90	(38.6)[h]
Iowa	1992	135	6,809	0	18.10	25.2 (net)
Kansas	1993	128	4,883	1	(22.3)	19.1
Nebraska	1994	110	6,311	0	14.60	25.0
TIPS	1994[b]	136	5,922	1	16.50	45.5
not TIPS	1990	131	5,922	0	15.50	32.2
Advanced Audit	1994[b]	(71)[d]	3,393	1	(17.7)	(23.7)[h]
Project Retrotech	1990	(71)[d]	3,393	0	(17.7)	(16.6)[h]
North Carolina	1994	103	3,369	1	(25.6)	(23.4)[i] 33.0 (NEAT predicted)
North Dakota	1990	120	7,556	0	(13.4)	16.0
Ohio1	1991	140	5,789	0	(19.7)	21.5 (net)
Ohio2	1994	144	5,789	1	(20.3)	29.3
Ohio3	1995	129	5,789	1	(22.3)	34.8
Texas	1991	(25)[e]	1,972	0	(10.7)	4.0
Vermont1	1992	101	7,903	0	(13.1)	18.5
Vermont2	1994	122	7,903	1	(13.1)	24.5
Wisconsin	1992	148	7,596	1	13.0	37.4 (net)
Wyoming	1996	(141)[f]	7,951	0.5	12.9	(35.7)[j]

[a]The numbers in parentheses in this table were either changed from the values originally reported (to achieve greater definitional consistency across the evaluations), or were substituted for missing values. The rationale for each change, or substitution for a missing value, is explained in the footnotes below.

[b] Although the experiments testing the savings that could be achieved with the TIPS audit and with the advanced audit procedures used in the NEAT field test were conducted before 1994, the statewide use of these audits did not begin until then. Therefore, it seems more correct to consider the savings realized with these advanced audits to be characteristic of the 1994 Program Year in New York and North Carolina.

[c] The value for pre-weatherization consumption of the primary heating fuel for all end-uses was not reported in three evaluations --Indiana (1992), North Carolina (1990), and Wyoming (1996). In all of these evaluations the usage of space-heating equipment was monitored and used to estimate space-heating consumption only. To obtain an estimate of the pre-weatherization consumption of the primary heating fuel for all end-uses in Indiana two reported values were used: 27 MBtu of savings and 30% savings of pre-weatherization space heating consumption. These values imply that pre-weatherization space-heating consumption in Indiana was equal to 90Mbtu (i.e., 0.3 x 90 MBtu=27 MBtu). Then assuming that space-heating consumption equals an average of 70% of total consumption of the primary heating fuel, one can calculate that total consumption was 129 MBtu (i.e., 0.7 x 129 Mbtu=90 MBtu).

[d] The value for pre-weatherization consumption of the primary heating fuel for all end-uses was not reported in three evaluations --Indiana (1992), North Carolina (1990), and Wyoming (1996). In all of these evaluations the usage of space-heating equipment was monitored and used to estimate space-heating consumption only. To obtain an estimate of the pre-weatherization consumption of the primary heating fuel for all end-uses in North Carolina the reported values of 50 MBtu and 49 MBtu for space-heating consumption, along with the assumption that these values are 70% of the total consumption of the primary heating fuel were used. Then, the total consumption of the primary heating fuel is equal to 71 MBtu (i.e., 0.7 x 71MBtu=50MBtu).

[e] The value for pre-weatherization consumption of the primary heating fuel for all end-uses was not reported in the Texas evaluation. It can be inferred from values which were reported. To obtain an estimate of the pre-weatherization consumption of the primary heating fuel for all end-uses in Texas two reported values were used: 4 MBtu of savings and 15.7% savings of pre-weatherization consumption of the primary heating fuel. Using these values to calculate the pre-weatherization consumption shows it to be equal to 25MBtu (i.e., 0.157 x 25MBtu=4MBtu).

[f] The value for pre-weatherizaton consumption of the primary heating fuel for all end uses was not reported in three evaluations--Indiana (1992), North Carolina (1990), and Wyoming (1996). In all of these evaluations, the usage of space-heating equipment was monitored and used to estimate spaceheating consumption only. To obtain an estimate of the pre-weatherization consumption of the primary heating fuel for all end uses in Wyoming, the value of 99.4 Mbtu for space-heating consumption was used along with the assumption that space-heating consumption is 70% of the total consumption of the primary heating fuel. Then, the total consumption of the primary heating fuel equals 141 (i.e., 0.7 x 141 MBtu = 99 MBtu).

[g] Most of the evaluations did not report a value for the energy factor of Btu/HDD/Square Foot. No modifications were made to the energy factors that were reported (i.e., in Indiana, Iowa, New York, North Carolina, and Wyoming). When no value was reported the missing values were calculated using aggregate values. For example, the aggregate values used to calculate an energy factor for Colorado were as follows: 123 MBtu of pre-weatherization consumption, 7017 heating degree days, and an average square footage of 1183 (this is also an estimated missing value obtained by averaging all of the square footage values that were reported in other states). Using these values the estimate is 14.8 Btu/HDD/Square Foot = 123,000,000 Btu / 7071 HDD / 1183 square feet. The same procedure was followed for all of the missing energy factor values. This procedure is not really correct because the energy factor should be calculated with the specific values for each individual house and then averaged across the dwellings. However, since data for calculating the individual values were not available, the aggregate procedure offers a reasonable approximation. As a test, values obtained by the aggregate procedure were compared to the values reported for Indiana, Iowa, New York, and North Carolina. In each case, the two values differed by no more than plus or minus 4.5 Btu/HDD/Square Foot.

[h] In the Indiana (1992) and the North Carolina (1990) evaluations the usage of space-heating equipment was monitored and used to estimate space-heating consumption only. To obtain an estimate of the savings of the primary heating fuel for all end-uses in Indiana and North Carolina the following procedure was used. First, it was assumed that space-heating consumption is an average of 70% of total consumption of the primary heating fuel. Then a ratio of (100 / 70) was multiplied by 27 MBtu of space-heating savings for Indiana yielding a result of 38.6 MBtu. Using the same procedure for the North Carolina findings the results for the advanced audit are (100 / 70) x 16.6 Mbtu=23.7 MBtu) and for the nonadvanced (100 / 70) x 11.6 MBtu=16.6 MBtu).

[i] In the 1994 North Carolina results, NEAT predictions of savings were the basis of the estimate. Many studies have shown that audit predictions tend to be higher than savings measured with billing data or metered consumption information. Data from the 1990 ORNL field test of the NEAT in North Carolina were used to calculate a realization rate (measured savings divided by audit-predicted savings) of 71%. Therefore, the NEAT predictions of savings were adjusted by this assumed realization rate (i.e., 33 MBtu x 0.71 = 23.4 MBtu).

[j] The estimated savings for the primary heating fuel was inferred from the estimated savings for space-heating only (25MBtu) and the assumption that space-heating was 70% of total consumption (i.e., 0.7 x 35.7MBtu = 25MBtu).

Appendix G

Development of Regression Models

DEVELOPMENT OF REGRESSION MODELS WITH STATE-LEVEL DATA TO USE FOR THE PREDICTION OF NATIONAL SAVINGS IN 1996

The process of developing regression models based on the data from the state-level evaluations began with the development of the summary tables shown in Appendix E. The next step was to select variables from these summary tables that were expected to be good predictors of average Program savings. Previous research had identified pre-weatherization consumption as the best predictor of savings (Brown et al., 1993). Therefore, we expected that this variable would explain much of the variability in savings across states. The type of audit used also seemed likely to be a good predictor of savings because the introduction of advanced audits has been shown to substantially increase savings in experimental studies (New York State Energy Research and Development Authority and New York Department of State, 1993; Sharp, 1994). Because we expected savings to improve over time, due to a variety of improvements in Program procedures, year of weatherization was chosen as another predictor variable. Heating degree days was expected to predict savings because previous studies have shown higher average savings in cold climate regions. The final predictor variable chosen was the energy factor, which is defined as Btu/square foot/heating degree day. The energy factor is an indicator of the energy efficiency of a dwelling. Savings were expected to be positively related to energy factor because the more inefficient a dwelling is the more potential it has to reduce its consumption.

The input data for the estimation of state-level regression models is shown in Appendix F in Table F.1. As is explained in the footnotes to Table F.1, the values shown in Appendix E were sometimes adjusted to produce greater definitional consistency across the evaluations. In addition, missing values were estimated with the procedures explained in the footnotes to Table F.1.

Over 20 different linear regression models were estimated with SYSTAT 5.1 software and examined. The dependent variable for every model was the average savings per dwelling (in MBtu) as shown in Table F.1. The set of independent variables used varied among the models estimated. We began with a model that included all five of the predictive variables shown in Table F.1:

- pre-weatherization consumption,
- audit type,
- year of weatherization,
- heating degree days, and
- energy factor.

Other models were estimated that included subsets of one, two, three, or four of these predictive variables in various combinations. The only variable that emerged as a significant predictor of savings, in every state-level model, was pre-weatherization consumption. Audit type and year approached significance in some models, while heating degree days and energy factor were never of any use as predictors, and sometimes even suggested a negative relationship. These results for heating degree days and energy factor make no sense, and since the relationships were never statistically significant, these variables were dropped from consideration. The poor predictive performance of these variables probably occurred because most of the energy factor values were estimated, not measured, and because some of the highest savings were found in moderate climate states, instead of in the coldest climate states.

In the first round of model estimation, the input values were in the same units reported in the state evaluations, with some adjustments and estimation of missing values as explained in the footnotes to Table F.1. An examination of the patterns of association among these variables, and of the patterns of residuals from the models, suggested that performing a log transformation of the continuous independent variables and of the dependent variable might improve the predictive power of the models. Performing log transformations on input variables often improves a model's predictive power because the transformations place greater weight on typical values and reduced weight on outliers. By using log transformations (to base 10) and reestimating the models, much better predictive power was obtained (i.e., model R^2 values increased from an average of 0.51 to an average of 0.78).

As a test, the regressions were run in three ways: (1) with no log transformations, (2) with logs taken of the dependent variable (savings in MBtu) only, and (3) with logs taken of the dependent variable as well as the independent variables except audit (which is a categorical variable). National estimates of savings did not vary much with the three different approaches (Tables G.1, G.2, and G.3). However, the transformation approach that used logs of both the dependent and independent variables produced the highest R^2 values.

Table G.1 National Estimates of Savings (in MBtu) obtained from Models with No Log Transformations.

Independent Variables in the Model	Predicted National Savings	Lower Bound of the 90% Confidence Interval	Upper Bound of the 90% Confidence Interval
Pre[a]	29.6	26.2	32.9
Pre[a], Year[b]	33.8	27.7	39.8
Pre[a], Audit Type[c]	28.8	25.5	32.0
Pre[a], Year[b], Audit Type[c]	30.8	22.9	38.6
All Except Energy Factor[d]	33.8	22.7	44.9
All five	30.9	18.8	43.1

[a]Pre = Pre-Weatherization Consumption
[b]Year = Year The Dwellings Were Weatherized
[c]Audit Type = Advanced/Not Advanced
[d]Energy Factor = Btu/Sq. Ft./HDD

Table G.2 National Estimates of Savings (in MBtu) Obtained from Models with Log Transformations of the Dependent Variable (State-level Savings in MBtu) Only.

Independent Variables in the Model	Predicted National Savings	Lower Bound of the 90% Confidence Interval	Upper Bound of the 90% Confidence Interval
Pre[a]	29.4	25.3	34.1
Pre[a], Year[b]	35.8	27.4	46.8
Pre[a], Audit Type[c]	28.4	24.5	32.9
Pre[a], Year[b], Audit Type[c]	32.1	22.6	45.6
All Except Energy Factor[d]	35.9	21.7	59.2
All five	37.8	21.4	66.7

[a]Pre = Pre-Weatherization Consumption
[b]Year = Year The Dwellings Were Weatherized
[c]Audit Type = Advanced/Not Advanced
[d]Energy Factor = Btu/Sq. Ft./HDD

Table G.3 National Estimates of Savings (in MBtu) Obtained from Models with Log Transformations of Both Dependent and Independent Variables.

Independent Variables in the Model	Predicted National Savings (in MBtu)	Lower Bound of the 90% Confidence Interval	Upper Bound of the 90% Confidence Interval
Pre[a]	28.9	25.5	32.8
Pre[a], Year[b]	34.4	26.8	43.8
Pre[a], Audit Type[c]	28.1	24.8	31.8
Pre[a], Year[b], Audit Type[c]	31.2	22.9	38.6
All Except Energy Factor[d]	36.7	23.5	59.3
All five	35.0	21.6	58.3

[a]Pre = Pre-Weatherization Consumption
[b]Year = Year The Dwellings Were Weatherized
[c]Audit Type = Advanced/Not Advanced
[d]Energy Factor = Btu/Sq. Ft./HDD

One difficulty with using the logs of the independent variables is that one should use the means of their logs, as input to the regression equation, to obtain a national estimate. This is desirable because the regression equation relates log savings to the logs of the independent variables, linearly, so the average log savings bears the same relation to the average of the logs of the independent variables. Unfortunately, the national means of the logs of the independent variables were not available. Nevertheless, it seems that using the arithmetic means was an acceptable approximation, because the models with and without log transformations produced very similar national estimates (Tables G.1, G.2, and G.3).

The predicted savings obtained with several models are compared to observed values in Figures G.1 to G.6 below. Well-fitted models were obtained with each combination of independent variables shown.

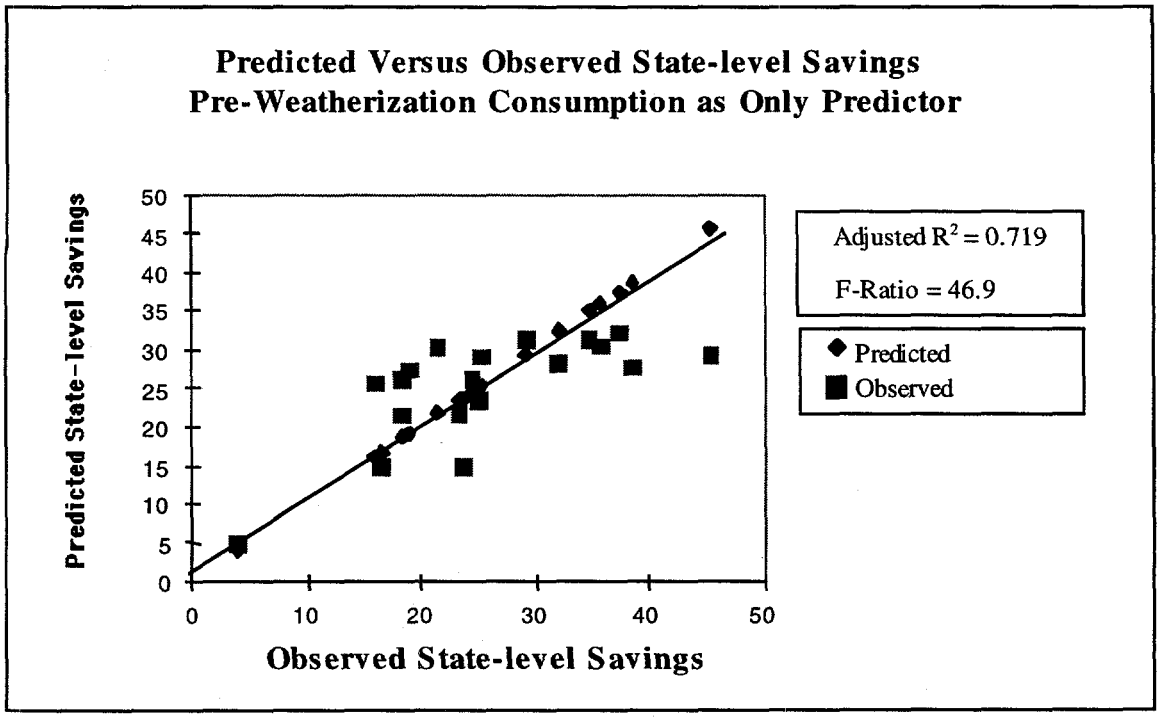

Figure G.1. Model Fit with One Predictor.

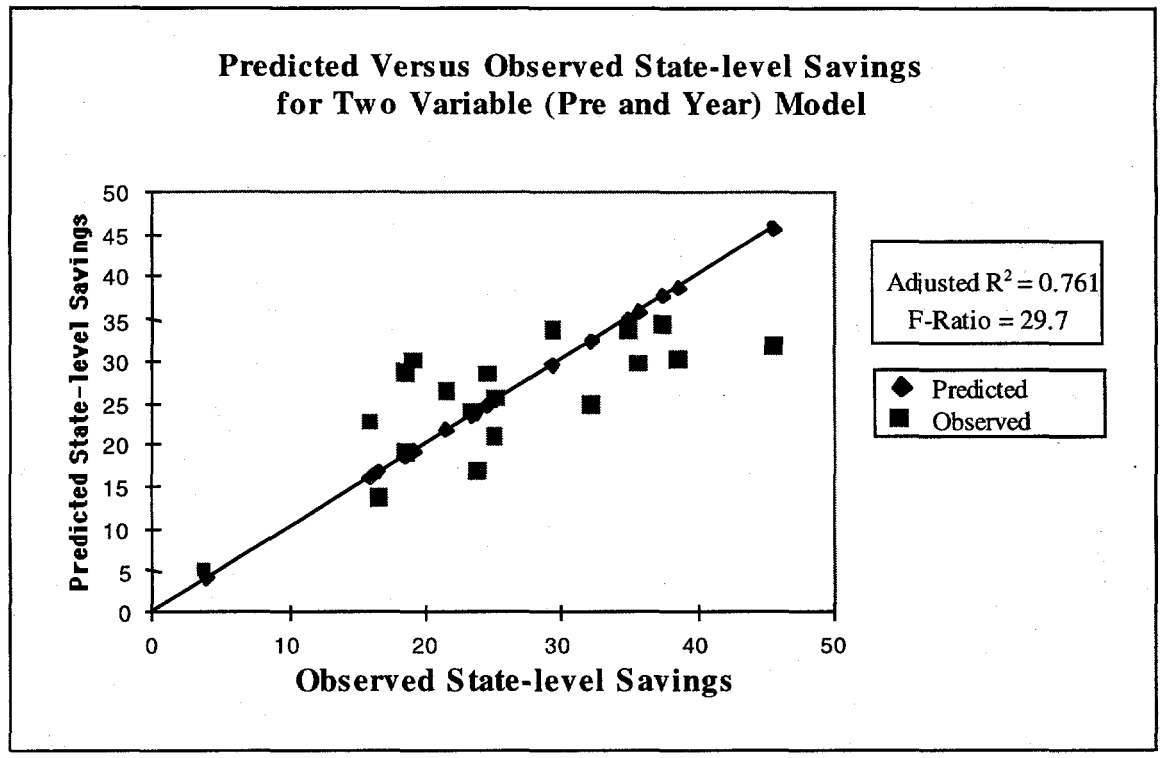

Figure G.2. Model Fit with Two Predictors.

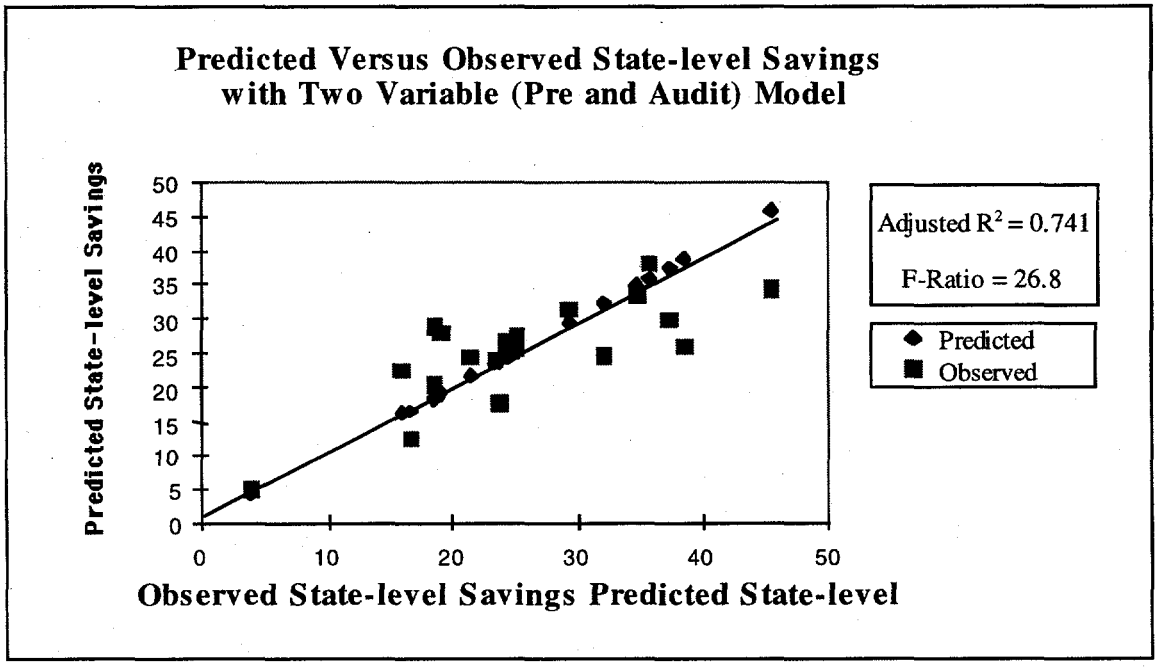

Figure G.3. Model Fit with Two Predictors.

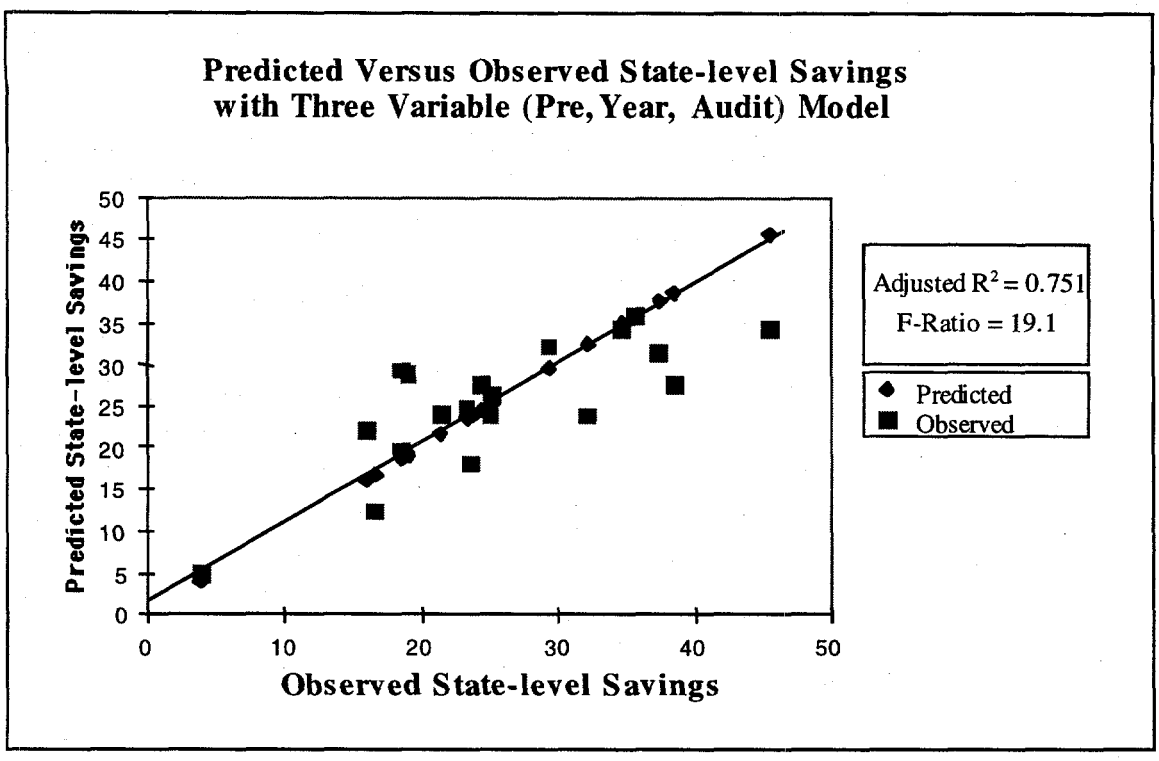

Figure G.4. Model Fit with Three Predictors.

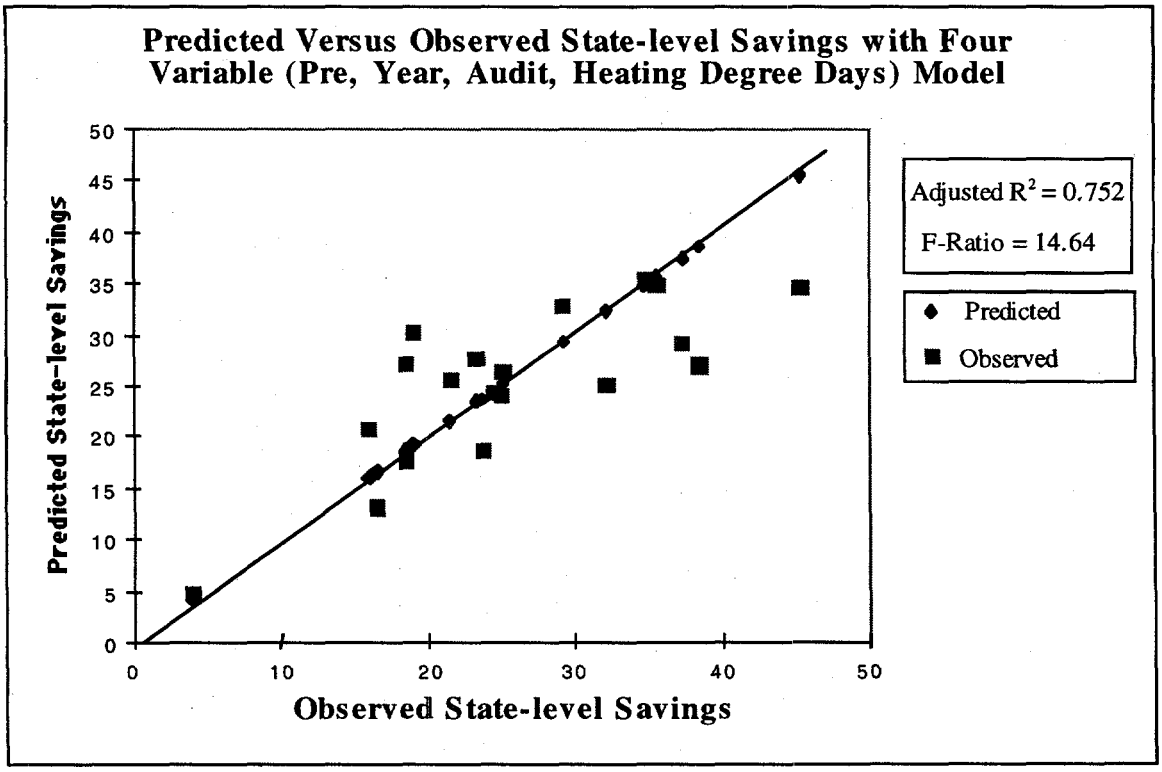

Figure G.5. Model Fit with Four Predictors.

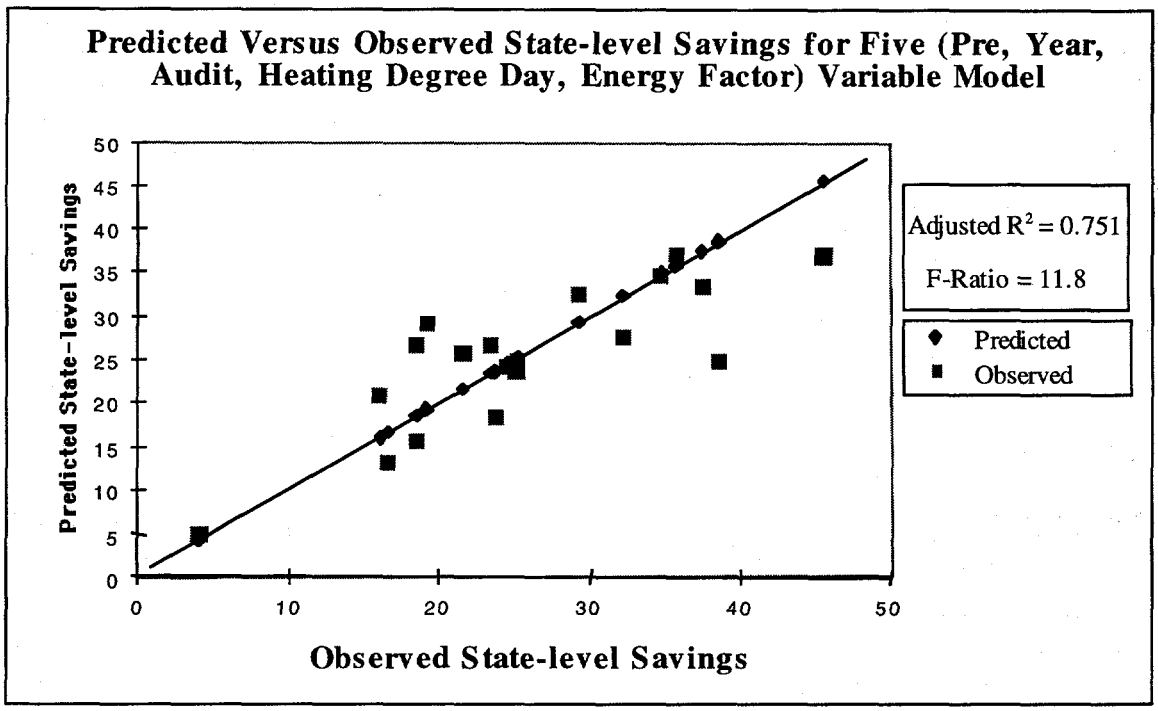

Figure G.6 Model Fit with Five Predictors.

Choosing the "best" model on which to base the national estimate was difficult because nearly all of the models had high, and nearly equal, R^2 values and significant F-values. The highest R^2 does not, of course, always indicate the best model because as more independent variables are added R^2 values tend to increase, often only because there are more parameters that can be made to fit the noise in the data, which is counterproductive. A choice could not easily be made on the reasonableness of the national estimates either. All of the national estimate of savings obtained with various models seemed plausible. The estimates of national savings given by all the models varied from a low of 28MBtu to a high of 38MBtu. In the end, we decided to use the model results that predicted a typical level of national savings in order to make that estimate as representative of the central tendency of the model results as possible. The three variable model (whose parameters are shown in Table 4, p. 12) was a model that produced a typical national estimate. It also seemed to be a good choice because it includes the best predictor (pre-weatherization consumption) and the two variables (year, and percentage of weatherizations based on advanced audits) that are most likely to capture Program improvements over time, while it excludes the variables that lack predictive power (heating degree days and energy factor).

To produce estimates of national savings for 1996 the parameters of the various models were applied to input values for the nation. All of the national input values except audit type and heating degree days were taken from the National Evaluation (Brown, et al., 1993). In particular, the pre-weatherization consumption value assumed for the average dwelling in the National Program in 1996 was 133 MBtu, which is the same as the average value measured for the national sample on which the National Evaluation was based. Similarly, the average energy factor input value (25) for the 1996 national estimate was developed by extrapolating from National Evaluation estimates of average consumption and square footage, combined with the national population weighted 30-year average of heating degree days (National Oceanic and Atmospheric Administration, 1993). Year of

weatherization was assumed to be 1996 for the national estimate. The average national heating degree day value was 4,449, which is the national population weighted 30-year average of heating degree days reported by the National Oceanic and Atmospheric Administration for 1931-1992 (National Oceanic and Atmospheric Administration, 1993). A range of values (0.50 to 0.75) was used as the input for audit type because the exact level of penetration of advanced audits in 1996 is uncertain. The penetration of advanced audits was estimated at 50% in 1994, and is almost certainly higher today.

To produce a point estimate of national savings for 1996 the parameters of the three variable model with log transformations on both the dependent and independent variables (Fig. G-4 and Table 4 on page 12) were applied to input values for the nation. Table G.4 shows the set of input values used for this 1996 national estimates of savings.

Table G.4 National Input Values for Regression-based Estimates of 1996 National Savings in a Three Variable Model.

Pre-Weatherization Consumption	Year of Weatherization	Assumed Proportion of Homes Treated with Advanced Audits
133	1996	0.50
133	1996	0.65
133	1996	0.75

Equations G.1, G.2, and G.3 show the results obtained when the parameters of the best state-level model (shown in Table 4, p. 12) are combined with the national input values shown in Table G.4 to produce estimates of national savings. Notice that the results are not sensitive to the assumed level of penetration of advanced adudits.

Equation G.1 $-375.949 + 0.985\ (133) + 113.741\ (1996) + 0.041\ (0.05) = 31.20$ MBtu

Equation G.2 $-375.949 + 0.985\ (133) + 113.741\ (1996) + 0.041\ (0.65) = 31.54$ MBtu

Equation G.3 $-375.949 + 0.985\ (133) + 113.741\ (1996) + 0.041\ (0.75) = 31.73$ MBtu

Because of a desire to choose a conservative estimate of advanced audit penetration, we chose to use the savings estimate shown in Equation G.1. Confidence intervals for this estimate were calculated with SAS software. For the 90% confidence interval, the lower bound for the estimate of 31.2 MBtu was 22.9 MBtu and the upper bound was 38.6 MBtu.

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