Applied Public Policy Research

APPRISE

Institute for Study and Evaluation

# NH REACh

# Furnace Cleaning Initiative Evaluation

## Final Report

November 2006

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# Executive Summary

This report presents the findings and recommendations from the evaluation of The New Hampshire REACh Furnace Cleaning Initiative. The New Hampshire Furnace Cleaning Program aimed to decrease energy usage and reduce home energy insecurity by cleaning furnaces and identifying furnaces in needed of repair and replacement. Extensive furnace repairs and furnace replacements were also provided in those homes where the need was identified.

## *Introduction*

The Residential Energy Assistance Challenge (REACh) Option Program was designed to pilot innovative strategies to reduce the energy vulnerability of LIHEAP-eligible households. The New Hampshire Office of Energy and Planning (OEP) and the Tri-County Community Action Agency (TCCAA) were awarded a REACh grant to implement a Low-Income Furnace Cleaning Initiative. The goals of this initiative were to:

1. Clean heating system furnaces and boilers in approximately 5,100 low-income households in the Northern NH counties of Carroll, Coos, and Grafton.
2. Conduct an inventory of heating systems needing repair or replacement in these homes.
3. Analyze the impact of this activity on energy consumption and individual household energy security.

## *NH REACh Furance Cleaning Initiative*

**Program Actors and Responsibilities**

The three main actors in the New Hampshire REACh project were OEP, TCCAA, and the eight Community Contact Offices.

The primary areas of responsibility for the OEP were:

- Contracting with the Office of Community Services.
- Compiling semi-annual progress reports for the project, as required by the REACh program office.
- Providing oversight of TCCAA in their implementation of the program.
- Contracting with the evaluator and providing information for the evaluation.

The primary areas of responsibility for TCCAA were:

- Tracking the number of furnaces cleaned and the budget spent or obligated on a monthly basis.
- Developing program procedures.
- Contracting with furnace cleaning vendors.
- Instructing and providing oversight for the eight Community Contact offices.
- Sending work orders to the identified vendors.
- Paying invoices received from the cleaning vendors.
- Collecting information from all of the Community Contact offices on the clients who had been contacted and the furnaces that had been cleaned.

The primary areas of responsibility for the Community Contact offices were:

- Contacting clients to inform them about the program and determine if they were interested in participating.
- Working with LIHEAP clients to complete the Energy Insecurity Scale and the program application.
- Working with clients to identify a furnace cleaning vendor if the client did not have a vendor who could do the work.

**Program Statistics**

Table ES-1 displays the program delivery statistics. There were 1,923 furnaces cleaned in 2004 and 122 furnace cleaned in 2005. Over the 2-year period, 15 furnaces received major repairs and 86 furnaces were replaced by the REACh program.

**Table ES-1**
**Program Delivery Statistics**

| | 2004 | 2005 |
|---|---|---|
| Number of Furnaces Cleaned | 1,923 | 122 |
| Vender Invoices for Furnace Cleanings | $208,051 | $13,999 |
| Number of Furnaces Needing Major Repair | 29 | 5 |
| Number of Furnaces that Received Major Repair | 7 | 8 |
| Costs for Major Repairs | $2,633 | $5,160 |
| Number of Furnaces Needing Replacement | 96 | 11 |
| Number of Furnaces Replaced | 55 | 31 |

| | 2004 | 2005 |
|---|---|---|
| Cost for Furnace Replacement | $120,061 | $75,158 |

Note: Repairs and replacements in 2005 exceed those identified as needed that year, because some were identified the previous year. Some of the problems identified in 2004 will be addressed in 2006.

**Program Challenges**

OEP reported that they faced the following challenges in the implementation of the REACh program.

- Obtaining funding for furnace repair and replacement.
- Estimating the number of furnaces that would need repair or replacement.
- Determining when to shut down a furnace due to safety concerns.

TCCAA reported that their primary challenges in implementing the REACh program were the following.

- Finding vendors to provide the furnace cleaning services.
- Drawing the line between cleaning and repair.
- Working with the large number of clients who had furnaces that needed repair and replacement.

The Community Contact offices reported that the primary challenges they faced in implementing the REACh program were the following.

- Contacting clients who had moved or had their phones disconnected.
- Collecting information from clients over the telephone.
- Getting clients to return phone calls.
- Vendors who red-tagged heating systems that only needed minor repairs.
- Funds were not initially available for repair or replacement. As a result, some clients did not have a working furnace until after the heating season started.

## *Data Analysis*

Three separate analyses were conducted to assess the impact of the furnace cleaning program. APPRISE collected usage data from furnace cleaning vendors to assess the impact of the furnace cleanings on usage, analyzed data from energy insecurity surveys to assess the impact of the furnace cleanings on home energy insecurity, and analyzed data from the

furnace efficiency pre/post cleaning tests to assess the impact of the furnace cleanings on furnace efficiency and safety.

**Usage Impact**

The PRISM analysis and the degree-day adjustment analysis both showed insignificant changes in the numbers of gallons of fuel used by the treatment group. However, when analyzed by the number of cleanings the customer had in the past five years, the analysis showed that customers who had fewer cleanings in the past five years had smaller increases in the number of gallons of fuel used, indicating that the cleaning may have had a larger effect for those customers who had not had a recent cleaning. Those customers who had their furnace cleaned between zero and two times in the past five years, increased their usage by 29 gallons in the year after the cleaning, compared to customers who had their furnace cleaned five times in the past five years who had their usage increase by 128 gallons. The difference between these two groups was statistically significant at the 95 percent level.

**Energy Insecurity Scale**

This analysis of the energy insecurity data showed that the program may have had a modest effect on the energy insecurity of households who received the furnace cleaning. Fewer households said that they could not pay their energy bill without help and fewer households said that they could not afford to use energy after they received the furnace cleaning. Additionally, some households saw an improvement in their composite energy insecurity scale. While 48 percent of the households were classified as in-crisis prior to receiving the furnace cleaning services, 39 percent were classified as in-crisis following program receipt, a statistically significant difference at the 99 percent level. Overall, 32 percent had an improvement in their energy insecurity scale, 42 percent remained at the same level, and 26 percent had their scale worsen.

**Furnace Efficiency**

The furnace efficiency test results showed that there were a small percentage of furnaces that had increased safety or efficiency levels following the furnace cleaning. The percent of furnaces with unsafe smoke scale readings declined, the percent with unsafe carbon dioxide levels declined, and the combustion efficiency increased.

## *Recommendations*

OEP, TCCAA, and the Community Contact offices faced many challenges in implementing the REACh initiative, largely due to the high volume of households that they served. The main benefits of the program were for those customers who had not had the cleanings done for several years, and would not have had the cleaning in the absence of the program, and for those customers who had unsafe furnaces that were identified, repaired, and replaced. Out of approximately 2,080 homes, 34 or two percent needed a major repair, and 107 or five percent needed to be replaced.

While it may not be feasible for the LIHEAP agencies to continue to implement furnace cleaning, repair, and replacement at the scale targeted by this REACh grant, it would be beneficial to assist households who do not have regular furnace cleaning and maintenance, and as a result, identify households who are operating unsafe heating equipment.

One potential means by which the LIHEAP agencies can achieve this goal is to provide households with partial assistance to obtain furnace cleanings. The assistance may be provided in the form of a coupon or rebate that is provided after the household mails in a completed furnace cleaning form. As seen in this pilot, some households may also need assistance finding a vendor who will clean their furnace. LIHEAP agencies and intake staff should brainstorm about what methods may work best to provide assistance to households to ensure that they have clean and safe heating systems. It appears that the furnace cleaning and the furnace repair and replacement inventory is a needed and valuable service that can improve the affordability, health, and safety of low-income households in New Hampshire. The challenging work is to determine an efficient method to assist the most vulnerable households to ensure that they have access to safe and affordable heat.

# I. Introduction

This report presents the findings from the Evaluation of The New Hampshire REACh Furnace Cleaning Initiative. The New Hampshire Furnace Cleaning Program aimed to reduce energy usage and reduce home energy insecurity by cleaning furnaces and identifying furnaces in need of repair and replacement.

## *A. Background*

The Residential Energy Assistance Challenge (REACh) Option Program was designed to pilot innovative strategies to reduce the energy vulnerability of LIHEAP-eligible households. The New Hampshire Office of Energy and Planning (OEP) and the Tri-County Community Action Agency (TCCAA) were awarded a REACh grant to implement a Low-Income Furnace Cleaning Initiative (LIFCI). The goals of this initiative were to:

1. Clean heating system furnaces and boilers in approximately 5,100 low-income households in the Northern NH counties of Carroll, Coos, and Grafton.
2. Conduct an inventory of heating systems needing repair or replacement in these homes.
3. Analyze the impact of this activity on energy consumption and individual household energy security.

## *B. Evaluation*

The evaluation consisted of seven activities.

1. *Evaluation Planning and Background Research*: We met with program managers to refine the evaluation plan, logic model, and data and indicator model that were included in the proposal. We discussed program plans and accomplishments.

2. *Data Collection and Analysis Plan*: We developed a data analysis plan that outlined the process to be used for measuring the impact of the program. This included the selection of a treatment and comparison group for the analysis, and a method for collecting data from the fuel vendors.

3. *Interviews with Program Staff*: We conducted regular interviews with managers and staff at the New Hampshire Office of Energy and Planning (OEP) and at the Tri-County Community Action Agency (TCCAA). These interviews updated the evaluators on project barriers, accomplishments, and plans.

4. *Interviews with Community Contact Offices*: Eight community contact offices were responsible for conducting outreach for the program, working with the applicants to complete the Energy Insecurity Scale and the program application, and working with

clients to obtain a furnace cleaning vendor. We conducted interviews with the eight community contact offices to develop a better understanding of how they implemented the program, what obstacles they faced in implementing the program, and what recommendations they had for the program.

5. *Interviews with Furnace Cleaners*: We conducted interviews with nine of the providers who participated in the furnace cleaning pilot. These interviews focused on satisfaction with program procedures and specifications, benefits for the customer from receiving the furnace cleaning, and standards for determining when a furnace should be replaced.

6. *Impact Analysis*: The impact analysis measured the impact of the NH REACh program on the lives of low-income households. We examined changes in energy insecurity, energy usage, energy costs, and furnace safety and efficiency indicators.

7. *Reports*: In addition to this final evaluation report, we developed a procedures manual. The procedures manual documents how the grant activities were implemented, and the responsibilities of the individuals and organizations that participated in the grant. The manual also provides copies of all forms used for program implementation.

## C. Organization of the Report

Five sections follow this introduction.

1) *Section II – NH REACh Furnace Cleaning Initiative*: Provides a detailed description of the Furnace Cleaning Initiative.

*2) Section III – Usage Impact Analysis:* Analyzes the impact of the program on the energy usage of participants.

*3) Section IV – Energy Insecurity Scale Analysis:* Analyzes the impact of the program on the energy insecurity of the participants.

*4) Section V – Furnace Safety and Efficiency Analysis:* Analyzes the impact of the program on furnace safety and efficiency.

*5) Section VI –Recommendations:* Makes recommendations for continued provision of furnace cleaning, repair, and replacement services.

APPRISE prepared this report under contract to the New Hampshire Governor's Office of Energy and Planning. The Governor's Office and TCCAP facilitated this research by furnishing program data and information to APPRISE. Any errors or omissions in this report are the responsibility of APPRISE. Further, the statements, findings, conclusions, and recommendations are solely those of analysts from APPRISE and do not necessarily reflect the views of the Governor's Office.

# II. NH REACh Furnace Cleaning Initiative

This section describes the design and implementation of the New Hampshire Furnace Cleaning Initiative, including the program actors and their responsibilities, the program procedures, program statistics, and program challenges.

## *A. Program Actors and Responsibilities*

The three main actors in the New Hampshire REACh project are the New Hampshire Office of Energy and Planning, the Tri-County Community Action Agency, and the eight Community Contact Offices.

### 1. New Hampshire Office of Energy and Planning

The New Hampshire Office of Energy and Planning (OEP) has three key areas of responsibility for the REACh project:

- *Office of Community Services (OCS) Communication*: OEP is responsible for all communications with OCS. The two main areas of responsibility are contracting and semi-annual reports.
    - Contracting: OEP is responsible for contracting with the Office of Community Services, and for requesting amendments to the contract. For example, OEP requested a modification to use funds that were originally allocated for cleanings to do replacements of red-tagged furnaces.
    - Semi-Annual Reports: OEP compiles semi-annual progress reports as required by the REACh program office.
- *Program Management and Oversight:* OEP provides oversight of the Tri-County Community Action Agency (TCCAA) in their implementation of the program. They worked with TCCAA to plan the program and conferred with them on key program decisions during the implementation process. As such, OEP initiated weekly phone calls with TCCAA during the program planning and implementation period.
- *Evaluation Oversight*: OEP is responsible for contracting with the evaluator and providing information for the evaluation.

### 2. Tri-County Community Action Agency

The Tri-County Community Action Agency has primary responsibility for implementing the REACh program. Under the supervision of OEP, they have the following responsibilities:

- *Program Management and Budgeting*: TCCAA is responsible for tracking the number of furnaces cleaned and the budget that has been spent or obligated on a monthly basis.

- *Development of Program Procedures*: TCCAA worked with OEP to develop program procedures. These procedures included client outreach and intake, requirements for furnace cleaning vendors, and specifications for furnace cleanings.

- *Contracting with Cleaning Vendors:* TCCAA was responsible for contracting with furnace cleaning vendors. They contracted with approximately 75 cleaning vendors.

- *Oversight of Community Contact Offices*: TCCAA instructed the eight Community Contact offices on how to conduct outreach to clients and complete the Energy Insecurity Scale and program application. TCCAA provides oversight of their work.

- *Work Orders*: TCCAA sends work orders to the identified vendors.

- *Invoices*: TCCAA pays invoices received from the cleaning vendors.

- *Data Collection:* TCCAA collects information from all of the Community Contact Offices on the clients who have been contacted and the furnaces that had been cleaned.

### 3. Community Contact Offices

Eight community contact offices located throughout the counties provide outreach and intake for the program.

- *Client Outreach:* The Community Contact Offices contact clients to inform them about the program and determine if they are interested in participating.

- *Energy Insecurity Scale and Program Application:* Community Contact Office staff work with LIHEAP clients to complete the Energy Insecurity Scale and the program application.

- *Vendor Identification:* Some of the offices work with clients to identify a furnace cleaning vendor if the client did not have a vendor who could do the work.

## B. Program Procedures

This section describes the procedures that were followed to plan and implement the program.

### 1. Program Planning

TCCAA worked with OEP to develop the following program forms and procedures:

- Energy Insecurity questions and survey form – these forms were used to document the Energy Insecurity of program participants. The data are used in the evaluation.
- Community Contact Office procedures – these procedures specify how the offices should contact clients and complete the applications.
- Cleaning vendor requirements – vendors are required to be employed by a heating service company and to carry liability insurance.
- Vendor participation form – this form requests contact and pricing information from vendors.
- Heating system cleaning work order – this form specifies the work that is to be done on the heating system, and the information that is to be collected.
- Heating system inventory form – this form collects information on the condition of the heating systems that are cleaned.
- Program description – this memo describes the program for potential participants.

### 2. Program Intake

TCCAA worked with each of the eight Community Contact Offices to make sure they understood the Energy Insecurity Scale and the program application procedures.

Intake for REACh did not start until March 2004 or later at the Community Contact offices. By this time, most or all of the office's clients had already applied for LIHEAP. Clients who came in for Crisis assistance were asked to complete the Energy Insecurity Scale at that time. Clients who already applied for LIHEAP and did not come in for Crisis were called.

Community Contact Offices called clients who had received LIHEAP that season[1], informed them about the program, and asked them to complete the Energy Insecurity Survey. They told the clients that the program would clean their furnaces at no charge, but did not go into much more detail. Applications were completed with the client in the office, by phone, and by mail.

Clients were asked to identify a vendor to clean their furnace. In most cases, this vendor was their fuel vendor. If the clients could not identify a furnace cleaning vendor, the agency sometimes was able to identify a vendor.

## 3. Furnace Cleaning

TCCAP sent each contractor an enrollment form and a REACh work order. The enrollment form collected basic contact information, the price to complete the work as described in the REACh work order, and the geographic area the vendor would serve or if the vendor would only serve established customers. The vendor was instructed to sign that the company would perform cleanings as described in the work order, would submit an itemized bill for each job, and would complete the REACh heating system inventory for each job done. The vendor was required to submit a certificate of insurance if TCCAA did not already have one on file.

Vendors charged between $70 and $200 for the cleaning. Prices were higher in the southern part of the service delivery area (Conway, Lebanon/Hanover, and Plymouth). TCCAA had a difficult time finding enough vendors to perform the furnace cleanings, so unless the price estimate was far above the guideline, they usually accepted the vendor's estimate.

TCCAA initially required that the vendors complete the cleanings within a month of receiving the work order, but had to be lenient with this requirement due to the limited capacity of some of the vendors. Vendors were allowed to make minor repairs, as long as they stayed below the $200 limit. They documented the work that they did on the invoice. Sometimes they would do the repairs for free. Contractors were required to submit an itemized bill for each job, and the REACh heating system inventory prior to being paid.

Vendors would "red-tag", i.e. disable, a system if it was not safe to use. Most of the furnaces that were red-tagged were unsafe due to cracked heat exchangers. If a heating system was red-tagged, clients were asked to obtain three bids for repair or replacement. If the client only obtained one or two bids, TCCAA would look at the bids to determine if they appeared reasonable. If a bid was not reasonable, TCCAA would require another bid.

[1] Clients using all heating fuels, including electric, were called to request that they complete the Energy Insecurity survey.

## C. Program Statistics

Table II-1 displays the program expenditure levels in several categories. Approximately two thirds of the funds were used for furnace cleaning and furnace replacement.

**Table II-1**
**Program Expenditure Statistics**

| Expenditure Category | Total Expenditures |
|---|---|
| NH Administrative | $9,514 |
| TCCAP Administrative | $126,990 |
| Furnace Cleaning | $222,050 |
| Furnace Repair | $7,793 |
| Furnace Replacement | $195,219 |
| Other | $10,870 |
| Evaluation | $64,636 |
| Total Expenditures | $637,072 |

Note: Other Costs include field inspections of subcontracted work and indirect costs apportioned to repairs and replacements.

Table II-2 displays the program delivery statistics. There were 1,923 furnaces cleaned in 2004 and 122 cleaned in 2005. There were 15 furnaces that received major repairs and 86 furnaces that were replaced through the program.

**Table II-2**
**Program Delivery Statistics**

| | 2004 | 2005 |
|---|---|---|
| Number of Furnaces Cleaned | 1,923 | 122 |
| Vender Invoices for Furnace Cleanings | $208,051 | $13,999 |
| Number of Furnaces Needing Major Repair | 29 | 5 |
| Number of Furnaces that Received Major Repair | 7 | 8 |
| Costs for Major Repairs | $2,633 | $5,160 |
| Number of Furnaces Needing Replacement | 96 | 11 |
| Number of Furnaces Replaced | 55 | 31 |
| Cost for Furnace Replacement | $120,061 | $75,158 |

Note: Repairs and replacements in 2005 exceed those identified as needed that year, because some were identified the previous year. Some of the problems identified in 2004 will be addressed in 2006.

## D. Program Challenges

This section describes the key challenges that were faced by OEP, TCCAA, and the Community Contact Offices in implementing the program.

### 1. New Hampshire Office of Energy and Planning

OEP reported that they faced the following changes in the implementation of the REACh program.

- *Funding for furnace repair and replacement:* It was originally anticipated that LIHEAP carryover funds would be used to pay for the furnace repair and replacements identified as needed during the cleanings. However, due to the increase in the price of fuel[2], these funds were not initially available. Therefore, OEP requested permission from OCS to use funds that were originally allocated for cleanings to do the replacements. This approval was received in November 2004, and 53 red-tagged furnaces were replaced and six were repaired at that time. In December 2004, OEP received contingency LIHEAP funds that allowed OEP to use LIHEAP funds to replace an additional heating system and repair an additional four heating systems. However, this was after the heating season had begun.[3]

- *Estimate of the number of furnaces that would need repair or replacement*. When estimating the number of furnaces that would need to be repaired or replaced, OEP used a number based on projections from the low-income weatherization program. Rather than using the percent that were identified as needing replacement, they used the percent that actually received replacement. As a result, they underestimated the number that would need to be replaced.

- *Determining when to shut down a furnace*. Technicians use widely different standards when determining if the heating system was unsafe and should be shut down.

### 2. Tri-County Community Action Agency

TCCAA reported that they faced the following challenges in the implementation of the REACh program.

- *Vendor Participation:* Some vendors did not want to participate because of capacity or other constraints. Some of the vendors did not do service work, only would do work for established customers, or were already booked.

[2] During the 2003-2004 heating season, there was a 40 percent increase in the cost of heating fuel. Over the summer of 2004, there was an additional 40 percent increase.

[3] As of February 2005, an additional 4 furnaces are being replaced and 1 furnace is being repaired with the REACh funds.

- *Vendor Capacity:* The capacity of vendors in the area was maximized. Once the heating season started, the vendors were busy restoring heat to some customers, and the cleanings were put off.

- *Line between cleaning and repair:* Vendors were allowed to make minor repairs. It is difficult to tell where a cleaning ends and repair work begins. Contractors were required to stay below the $200 limit.

- *Needed repair and replacement:* The program involved much more work than anticipated in terms of dealing with the furnaces that needed repair and replacement.

### 3. Community Contact Offices

Community Contact Offices reported that they faced the following challenges in the implementation of the REACh program.

- *Difficulty reaching clients*: Many clients were difficult to contact because they had moved or their phones had been disconnected.

- *Collecting information from clients*: It was difficult to collect all of the information over the phone. Many of the clients were elderly and had difficulty hearing.

- *Getting clients to return phone calls*: It was difficult to get clients to return their phone calls because the heating season was over and they were not looking ahead to the next heating season.

- *Red-tagging heating systems*: A few vendors red-tagged systems that only needed minor repairs.

- *Funds not initially available for repair or replacement*: Because funds were not initially available for furnace repair or replacement, some clients had their furnaces red-tagged, and did not have a working furnace until after the heating season started.

# III. Usage Impact Analysis

This section of the report analyzes the change in energy usage for clients who received furnace cleanings, compared to the change for a random sample of LIHEAP recipients. The goals of the analysis are to determine whether there is a measurable impact of the services provided through the REACh grant on customers' energy usage and, therefore, their affordability.

## *A. Methodology*

This section describes the selection of participants for the evaluation, how evaluation data were obtained, and the use of a comparison group.

**Study Group**

Clients who received furnace cleaning and/or furnace repair and replacement in the summer of 2004 were included as potential members of the study group. This group was chosen for the analysis, as one full year of post-program data is required for an analysis of program impacts. Clients who did not have a minimum amount of data prior to the furnace cleaning or following the furnace cleaning were not included in the usage impact analysis. The subject of data attrition is addressed more fully below.

**Evaluation Data**

APPRISE collected fuel delivery data from fuel vendors for a randomly selected sample of clients who received furnace cleaning in 2004 and a random sample of LIHEAP clients who did not receive furnace cleaning in 2004.

**Weather Normalization**

Oil usage data were weather-normalized to control for differences in weather-related usage between the pre and post treatment year using PRISM software. This software provides an estimate of each client's weather-normalized usage in the pre and post treatment periods in an average weather year. However, this software requires that the clients have five fuel fills in the pre and post treatment period. Most of the clients did not meet this requirement. Therefore we performed another degree-day analysis of usage that did not have such stringent data requirements.

**Comparison Group**

When measuring the impact of an intervention, it is necessary to recognize other exogenous factors that can impact changes in outcomes. Changes in a client's energy usage may be affected by many factors other than program services received. Some of these factors include changes in household composition or health of family members, changes in fuel prices, changes in weather, and changes in the economy.

The ideal way to control for other factors that may influence usage would be to randomly assign low-income customers to a treatment or control group. The treatment group would be given the opportunity to receive program services first. The control group would not be

given an opportunity to participate in the program until one full year later. This would allow evaluators to determine the impact of the program by subtracting the change in behavior for the control group from the change in behavior for the treatment group. Such random assignment is rarely done in practice because of a desire to include all eligible customers in the benefits of the program or to target a program to those who are most in need.

A comparison group was constructed for the program evaluation to control for exogenous factors. The comparison group was designed to be as similar as possible to the treatment group, those who received services and who we are evaluating, so that the exogenous changes for the comparison group are as similar as possible to those of the treatment group. In the evaluation of the New Hampshire REACh furnace cleaning pilot, we used a random sample of LIHEAP recipients who did not receive furnace cleaning in 2004 as a comparison group. These clients were offered, and some of these clients received, a furnace cleaning in the following year. For those clients, we analyzed their usage in the two years preceding enrollment. For the clients who did not receive a furnace cleaning in 2005, we assigned a clean date as the midpoint of the cleaning dates for clients who received a cleaning that summer. These participants serve as a good comparison because they are lower income households who were eligible for the program. Because these customers did not receive the furnace cleaning prior to the analysis data, changes in bills and behavior should be related to factors that are exogenous to the program.

In this evaluation, we examine pre and post-treatment statistics. The difference between the pre and post-treatment statistics for the treatment group is considered the gross change. This is the actual change in behaviors and outcomes for those participants who were served by the program. Some of these changes may be due to the program, and some of these changes are due to other exogenous factors, but this is the client's actual experience. The net change is the difference between the change for the treatment group and the change for the comparison group, and represents the actual impact of the program, controlling for other exogenous changes.

## *B. Data Attrition*

Table III-1 displays the number of clients in the original analysis group, the reasons why clients were eliminated from the analysis group, and the number of clients in the final analysis group. Two factors must be weighed when selecting the sample for the final analysis. First, when conducting a program evaluation, the goal is always to include as much of the original analysis group in the research as possible, so that the estimated results are not biased due to elimination of distinctive subgroups. However, to provide good estimates of program impacts, it is also necessary to restrict the sample to those customers who have a minimum level and quality of data.

A sample of 800 clients who received furnace cleaning in 2004 were selected as the treatment group and a sample of 405 LIHEAP recipients who did not receive a furnace cleaning in 2004 were selected as a comparison group. Data were requested from the fuel vendors for these 1,205 clients.

The PRISM data analysis has stringent data requirements. Customers were excluded from the PRISM analysis group for the following reasons:

- *No delivery data received from fuel vendor*: Data were received from 26 of the 27 fuel vendors. Some vendors did not provide data for all requested customers. The vendors sent data for 735 of the 800 clients in the treatment group (92%) and 353 of the 405 clients in the comparison group (87%).

- *Fewer than five tank fills in pre or post period*: Most of the customers did not meet the standards of a minimum of five tank fills in the pre and post treatment periods.

- *PRISM model ran*: The PRISM model did not run for a small number of customers in the treatment and control group.

- *Reliable PRISM Run*: The PRISM model is not reliable if it cannot obtain a good fit in the relationship between weather and the amount of fuel usage.

- *No More than 50 Percent Change in Usage*: A few observations are removed where the change in usage was greater than 50 percent.

Due to these data requirements and the difficulty of obtaining good fuel usage data when customers use bulk fuels, we were only able to run the PRISM analysis on 14 percent of the treatment group and eight percent of the comparison group. With such high attrition rates, there is a concern that the results are not representative of the overall population of clients who received furnace cleaning services.

**Table III-1**
**PRISM Data Attrition**

| | Treatment | Comparison |
|---|---|---|
| **Clients in Sample** | 800 | 405 |
| **Fuel Delivery Data Received** | 735 | 353 |
| **5 or More Tank Fills in Pre & Post** | 220 | 92 |
| **PRISM Model Ran** | 217 | 90 |
| **Reliable PRISM Run** | 113 | 37 |
| **Less than 50 Percent Change in Usage** | 108 | 34 |
| **Percent of Sample** | 14% | 8% |

Another degree-day approach was used to estimate changes in fuel usage for a larger group of customers. This is a simpler model that does not require five tank fills in the pre and post cleaning periods. For this analysis, customers were eliminated for the following reasons:

- *No delivery data received from fuel vendor*: Data were received from 26 of the 27 fuel vendors. This included 735 of the 800 clients in the treatment group (92%) and 353 of the 405 clients in the comparison group (87%).

- *At least one tank filled in pre period and post period:* Clients were required to have at least one tank filled in both the pre and the post periods.

- *At least one tank filled in the year prior to cleaning and the year after cleaning:* The tanks filled were required to be within one year before cleaning and one year after furnace cleaning.

- *Heating degree-day model is estimated*: The customer was required to have the heating degree-day model estimated in the pre and post treatment period.

**Table III-2**
**Degree Day Analysis**
**Data Attrition**

| | Treatment | Control |
|---|---|---|
| **Clients in Sample** | 800 | 405 |
| **Fuel Delivery Data Received** | 735 | 353 |
| **At Least One Tank Fill in Pre and Post Period** | 601 | 215 |
| **At Least One Tank Fill in the year prior to cleaning and one in the year after cleaning** | 509 | 176 |
| **At least 250 heating degree days and 100 usage days** | 293 | 107 |
| **Percent of Sample** | 37% | 26% |

## C. Usage Impacts

This section examines the impact of the furnace cleanings on customers' fuel usage.

Table III-3 displays fuel usage changes. The weather normalized usage is annualized usage that has been adjusted to control for the weather, by modeling the relationship between the average daily temperature and the customer's fuel usage, and then predicting the customer's usage in an average weather year. Customers had an average weather-normalized usage of 926 gallons in the year preceding the cleaning and usage of 938 gallons in the year following enrollment, an insignificant increase of 13 gallons. The net change in weather-normalized usage was not statistically significant.

**Table III-3**
**PRISM Usage Impacts**
**Gallons of Fuel Used**

| | Treatment Group | | | Comparison Group | |
|---|---|---|---|---|---|
| | Pre | Post | Change | Change | Net Change |
| **Number of Customers** | 108 | | | 34 | |
| **Weather Normalized Usage** | 926 | 938 | 13 | -1 | 14 |

Graph III-1 shows the distribution of the change in the number of gallons of fuel used by the treatment and comparison groups. Both groups have a change with an approximate normal distribution, centered around zero.

**Graph III-1**
**Change in Gallons of Fuel Usage**

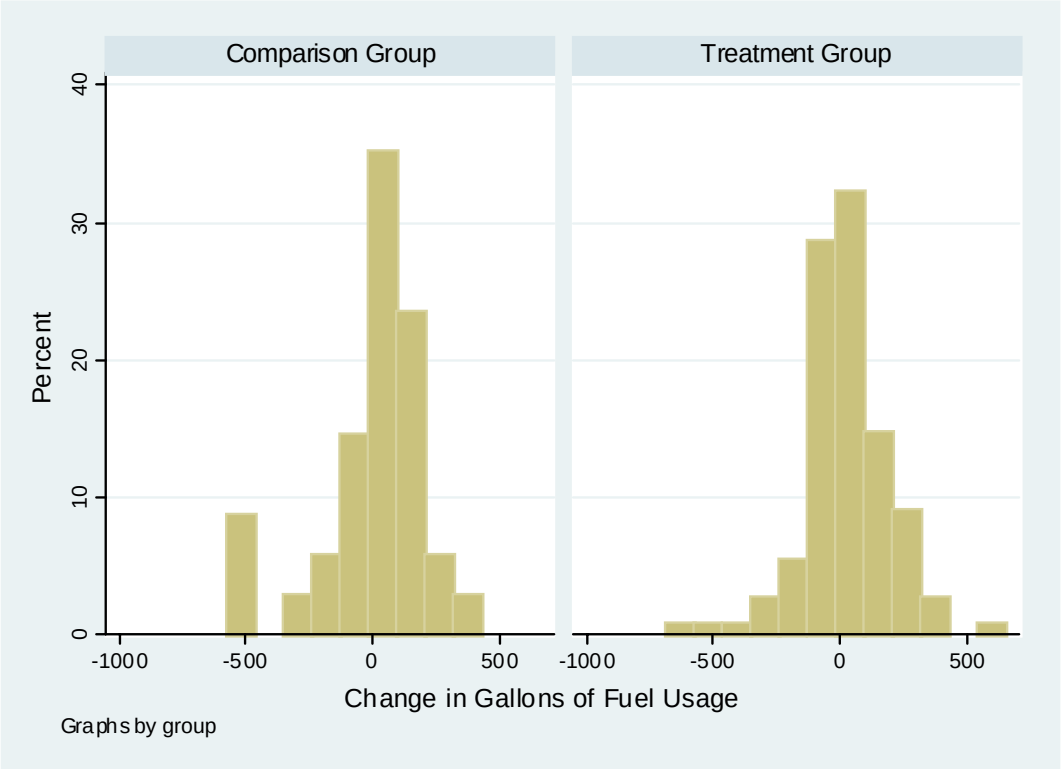

Table III-4 displays the degree-day weather normalization estimate of the usage impacts. This methodology has the advantage that more households can be included in the analysis, as the data restrictions are weaker. This model shows a small increase in usage of 56 gallons, or six percent. However, the comparison group experienced a similar increase in usage, so the net change in usage is only 13 gallons, and is not statistically significant.

**Table III-4**
**Degree Day Weather Normalization**
**Usage Impacts**
**Gallons of Fuel Used**

| | Treatment Group | | | Comparison Group | |
|---|---|---|---|---|---|
| | Pre | Post | Change | Change | Net Change |
| **Number of Customers** | 293 | | | 107 | |
| **Weather Normalized Usage** | 990 | 1046 | 56** | 43 | 13 |

While furnace cleanings may be expected to impact the efficiency of furnace operation and reduce the amount of fuel used, they may not have a measurable impact if clients have been regularly cleaning their furnaces, and less than a year or two of furnace use has elapsed since the last cleaning. Table III-5 displays the degree-day weather normalization by the number of fuel cleanings that the client reported they undertook in the past five years. This table does show smaller increases in usage for those clients who had fewer cleanings in the past five years, and may have had a greater impact on furnace efficiency through the cleaning. While the net change compared to the comparison group is small and is not statistically significant, the difference between the group with the 0-2 cleanings and the 5 cleanings is statistically significant at the 95 percent level.

**Table III-5**
**Degree Day Weather Normalization**
**Usage Impacts**
**Gallons of Fuel**
**By Number of Furnace Cleanings in the Past Five Years**

| | Number of Clients | Treatment Group | | | Number of Clients | Comparison Group | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Change | | Change | Net Change |
| **0 – 2 Cleanings** | 112 | 1016 | 1045 | 29 | 107 | 43 | -14 |
| **3 – 4 Cleanings** | 98 | 957 | 1017 | 60** | | | 18 |
| **5 Cleanings** | 23 | 1040 | 1168 | 128* | | | 85 |

In further analyses, we attempted to determine if customers whose pre and post efficiency tests showed a big improvement in combustion efficiency had significant decreases in fuel

usage. However, due to the large number of customers with missing furnace efficiency data, these analyses were inconclusive.

## *D. Usage Impact Summary*

The PRISM analysis and the degree-day adjustment analysis both showed insignificant changes in the numbers of gallons of fuel used by the treatment group. However, when analyzed by the number of cleanings the customer had in the past five years, the analysis showed that customers who had fewer cleanings in the past five years had smaller increases in the number of gallons of fuel used. Those customers who had their furnace cleaned between zero and two times in the past five years, increased their usage by 29 gallons in the year after the cleaning, compared to customers who had their furnace cleaned five times in the past five years who had their usage increase by 128 gallons. The difference between these two groups was statistically significant at the 95 percent level.

# IV. Energy Insecurity Scale Analysis

The previous section analyzed the change in fuel usage for clients who received the furnace cleanings. This analysis showed that the cleanings may have had an impact on the amount of energy used by participating households who had not regularly cleaned their furnaces. However, research has shown that clients may reduce their energy usage when faced with unaffordable energy bills. This would be especially true for households that heat with bulk fuels and who will not be provided with deliveries if they do not pay their bills. Therefore, clients who found that their furnaces worked more effectively after receiving the furnace cleaning may have been able to keep their homes at more comfortable temperatures or may have been able to reduce the use of electric space heaters and have more funds available for other household necessities.

The Energy Insecurity Scale was developed to measure the impact of service delivery on low-income households' non-usage indicators. This section of the report describes the implementation of the energy insecurity scale and the analysis of the indicators that comprise the scale, as well as the analysis of the scale as a whole.

## *A. Methodology*

All clients were expected to complete the Energy Insecurity Pre-Test to be eligible for the free furnace cleaning provided by the REACh program. The questionnaires were, for the most part, filled out over the phone by caseworkers at the local intake agencies. Caseworkers called clients who had received LIHEAP that year, informed them of the program, and asked them to complete the survey over the phone. Some of the agencies reported that many of their clients were elderly and had a difficult time completing all of the required information over the telephone. There were some clients who came into the office to fill out the application and complete the Energy Insecurity Scale.

Clients in the analysis group were called again approximately one year after their furnaces were cleaned to request that they again complete the Energy Insecurity Scale.

## *B. Analysis*

The Energy Insecurity Scale consisted of the following questions:

Please tell me whether the statement was often true, sometimes true, or never true for your household in the past 12 months:

1. I / we worried our home energy bill would become overdue before I /we could get money to pay it.

2. Our home energy bill became due, and I / we didn't have money to pay it without somebody's help.

3. I / we couldn't afford to heat our home to the temperature we wanted it to be, or to use our hot water or appliances to the extent we wanted to use them.

4. I / we reduced our energy consumption to uncomfortable or inconvenient levels because I / we were running out of money to pay our home energy bill.

5. I / we could not use our entire home because we could not afford to heat it."

Please answer whether each problem was faced in the past 12 months. If YES, how often did one or the other of those happen: almost every month, some months but not every month, or only 1 or 2 months?

6. Did you ever leave your home for all or part of the day because there wasn't enough money for the home energy bill, or did you ever turn off your hot water because there wasn't enough money for the home energy bill?

7. Did you ever not pay your home energy supplier because there wasn't enough money for the home energy bill?

8. Did you ever use your kitchen stove or oven to provide heat because there wasn't enough money to pay hour home heating bill?

9. Did you ever reduce your expenses for what you consider to be basic household necessities because there was not enough money to pay for these and to pay you home energy bill?

10. Did you have a supplier of your electricity or heating fuel threaten to disconnect service or discontinue deliveries because you could not afford to pay a past-due home energy bill?

11. Did you have a supplier of electricity or heating fuel disconnect service or discontinue fuel deliveries?

Table IV-1 displays responses to the Energy Insecurity Scale Pre-Test for 735 of the 800 clients who were randomly selected as part of the analysis group. There were 735 clients in this analysis group who provided complete responses to the energy insecurity scale. Some of the findings are summarized below:

- *Worry about home energy bill*: Seventy-eight percent of the clients said that they often or sometimes worried about paying their home energy bill.

- *Could not pay home energy bill without help:* Seventy-five percent of the clients said that they did not have the money to pay their home energy bill without someone's help.

- *Could not afford to use energy:* Sixty-five percent said that they could not afford to use their heat, hot water, or appliances to the extent to which they wanted to use them.

- *Left home or turned off hot water:* Six percent said that they had to leave off their home or turn off their hot water because they did not have enough money for their home energy bill.

- *Did not pay home energy supplier:* Thirty-four percent said that they did not pay their home energy supplier because they did not have enough money.

- *Used kitchen stove or oven to provide heat:* Twenty-six percent said that they used their kitchen stove or oven to provide heat because they could not afford to pay their home energy bill.

- *Reduced basic household expenses:* Fifty-six percent said that they reduced expenditures for basic household necessities because there was not enough money for these and the home energy bill.

- *Threatened with disconnection of discontinuation of service:* Twenty percent said that an electricity or heating fuel supplier threatened to disconnect services or discontinue deliveries.

- *Service disconnected or discontinued:* Eight percent said that their electricity or heating fuel supplier disconnected or discontinued their service.

**Table IV-1**
**Energy Insecurity Scale Pre-Test**

| | **Respondents** | **735** | | |
|---|---|---|---|---|
| | | **Often** | **Sometimes** | **Never** |
| 1 | Worried our home energy bill would become overdue before I could get money to pay it. | 44% | 34% | 22% |
| 2 | Didn't have money to pay our home energy bill without somebody's help. | 30% | 45% | 25% |
| 3 | Couldn't afford to heat our home to the temperature we wanted it to be, or to use our hot water or appliances to the extent we wanted to use them. | 28% | 37% | 35% |
| 4 | Reduced our energy consumption to uncomfortable or inconvenient levels because I was running out of money to pay our home energy bill. | 22% | 33% | 45% |
| 5 | Could not use our entire home because we could not afford to heat it. | 22% | 15% | 63% |

| | | Almost Every Month | Some Months | 1 or 2 Months | No |
|---|---|---|---|---|---|
| 6 | Left home for all or part of the day because there wasn't enough money for the home energy bill, or turned off your hot water because there wasn't enough money for the home energy bill. | 0% | 2% | 4% | 95% |
| 7 | Did not pay your home energy supplier because there wasn't enough money for the home energy bill. | 3% | 15% | 16% | 66% |
| 8 | Uses the kitchen stove or oven to provide heat because there wasn't enough money to pay the home heating bill. | 1% | 11% | 14% | 74% |
| 9 | Reduced expenses for basic household necessities because there was not enough money to pay for these and to pay you home energy bill. | 16% | 23% | 17% | 44% |
| 10 | An electricity or heating fuel supplier threatened to disconnect service or discontinue deliveries. | 2% | 6% | 12% | 80% |
| 11 | An electricity or heating fuel supplier disconnected service or discontinued fuel deliveries. | 0% | 2% | 6% | 92% |

Table IV-2 examines the Energy Insecurity Scale Pre and Post Tests for those clients who filled out both the pre and the post survey, as well as the randomly selected comparison group clients who completed the survey. There were 538 respondents who completed both the pre and the post surveys. The table below shows that there were some indicators in which clients showed some improvement between the pre and the post surveys. These included:

- *Could not pay home energy bill without help:* Twenty-nine percent said that they often could not pay the home energy bill without help prior to the cleaning, compared to 17 percent who said they could not pay the bill without help after the cleaning.

- *Could not afford to use energy:* Twenty-eight percent said they often could not afford to heat their home to the temperature they wanted or use hot water or appliances to the extent that they wanted prior to the furnace cleaning, and 20 percent said they often faced this problem after the cleaning.

## Table IV-2
## Energy Insecurity Scale Pre and Post Tests

| | | 538 Respondents | | | | | | 201 Respondents | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Pre | | | Post | | | Comparison | | |
| | | Often | Sometimes | Never | Often | Sometimes | Never | Often | Sometimes | Never |
| 1 | Worried our home energy bill would become overdue. | 43% | 33% | 23% | 35% | 47% | 19% | 37% | 42% | 21% |
| 2 | Didn't have money to pay home energy bill without help. | 29% | 44% | 27% | 17% | 46% | 37% | 17% | 42% | 41% |
| 3 | Couldn't afford to heat our home to the temperature we wanted it to be, or to use our hot water or appliances to the extent we wanted to use them. | 28% | 37% | 35% | 20% | 41% | 40% | 25% | 42% | 33% |
| 4 | Reduced our energy consumption to uncomfortable or inconvenient levels. | 22% | 32% | 46% | 15% | 38% | 47% | 19% | 43% | 38% |
| 5 | Could not use our entire home. | 23% | 17% | 60% | 22% | 18% | 60% | 16% | 21% | 63% |

| | | Pre | | | | Post | | | | Comparison | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Almost Every Month | Some Months | 1 or 2 Months | No | Almost Every Month | Some Months | 1 or 2 Months | No | Almost Every Month | Some Months | 1 or 2 Months | No |
| 6 | Left home for all or part of the day or turned off hot water. | 0% | 2% | 3% | 95% | 1% | 1% | 5% | 93% | 2% | 2% | 4% | 91% |
| 7 | Did not pay your home energy supplier. | 2% | 15% | 15% | 69% | 3% | 12% | 22% | 63% | 5% | 12% | 17% | 65% |
| 8 | Uses the kitchen stove or oven to provide heat. | 1% | 12% | 15% | 72% | 5% | 7% | 12% | 77% | 2% | 12% | 16% | 69% |
| 9 | Reduced expenses for basic household necessities. | 14% | 24% | 18% | 44% | 18% | 24% | 21% | 37% | 13% | 33% | 16% | 38% |

| | | Pre | | | | Post | | | | Comparison | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Almost Every Month | Some Months | 1 or 2 Months | No | Almost Every Month | Some Months | 1 or 2 Months | No | Almost Every Month | Some Months | 1 or 2 Months | No |
| 10 | Threatened with disconnected service or discontinued deliveries. | 2% | 7% | 10% | 81% | 1% | 6% | 11% | 82% | 1% | 9% | 17% | 73% |
| 11 | Had service disconnected or discontinued. | 0% | 1% | 5% | 94% | 0% | 0% | 3% | 96% | 0% | 1% | 4% | 95% |

Table IV-3 displays the Energy Insecurity Scale, a composite index of the answers to the previous eleven questions. This index defines individuals as being in one of five categories.

- A **thriving** household engages in a full range of home energy uses of its choice without financial strain or worry.
- A **capable** household may have arrears because it cannot afford to pay its energy bills, but those arrears do not put maintaining energy service at risk. Moreover, the arrears do not have a negative impact on basic household necessities or household comfort and convenience.
- A **stable** household may have more than occasional arrears. However, those arrears are never in combination with threatened loss of energy service. A stable household never foregoes basic household necessities, but may temporarily constrain energy use in ways potentially detrimental to health and well-being.
- A **vulnerable** household does not experience loss of energy service, but to avoid doing so requires regular constraints of energy use to unsafe or unhealthy levels, reduction of basic household necessities, regularly borrowing money from family or friends to pay the energy bill, or inappropriate energy solutions (such as using the kitchen stove for heat).
- An **in-crisis** household suffers a loss of energy service, regularly foregoes basic household necessities to pay its energy bill, regularly constrains energy use to unsafe or unhealthy levels, or regularly practices unsafe or dangerous alternative heating techniques.

Table IV-3 shows that 48 percent of the households were classified as in-crisis prior to receiving the furnace cleaning services, as compared to 39 percent who were classified as in-crisis following program receipt, a statistically significant difference at the 99 percent level. This compares to 43 percent of households in the comparison group who were classified as in-crisis prior to receiving services. It would be expected that the comparison group had a lower pre-treatment energy insecurity rating, as they did not take up services, although many were potentially offered them.

**Table IV-3**
**Energy Insecurity Scale**

| | Pre-Scale | Post-Scale | Comparison (Pre) |
|---|---|---|---|
| In-Crisis | 48% | 39% | 43% |
| Vulnerable | 32% | 41% | 35% |
| Stable | 7% | 5% | 7% |
| Capable | 6% | 10% | 5% |
| Thriving | 8% | 5% | 9% |

Table IV-4 examines the change for households who were in-crisis in the pre or post period. The left side of the table shows that just over half of the households who were in-crisis in the pre cleaning period were also in-crisis in the post cleaning period. Thirty-seven percent moved to the vulnerable status, four percent to stable, three percent to capable, and two percent to thriving.

The right side of the table looks at those households who were in crisis in the post period. Over two thirds of these households were also in-crisis in the pre period. However, 26 percent were vulnerable, 4 percent were stable, 1 percent were capable, and 2 percent were thriving. This table shows that there was a greater movement out of the in-crisis status than into the in-crisis status after the furnace cleaning.

**Table IV-4**
**Energy Insecurity Scale**
**Households Who Were In-Crisis in the Pre or Post Period**

| Post-Scale Those Who Were In-Crisis Prior to the Furnace Cleaning | |
|---|---|
| In-Crisis | 54% |
| Vulnerable | 37% |
| Stable | 4% |
| Capable | 3% |
| Thriving | 2% |

| Pre-Scale Those Who Were in-Crisis After the Furnace Cleaning | |
|---|---|
| In-Crisis | 67% |
| Vulnerable | 26% |
| Stable | 4% |
| Capable | 1% |
| Thriving | 2% |

Table IV-5 looks at the percentage of clients who saw an improvement, no change, or a worsening in the scale. The table shows that 32 percent were better off, 42 percent had the same rating, and 26 percent were worse off.

**Table IV-5**
**Change in Energy Insecurity Scale**

| Change in Energy Insecurity Scale | |
|---|---|
| **Improved** | 32% |
| **No Change** | 42% |
| **Worsened** | 26% |

## *C. Energy Insecurity Analysis Summary*

This analysis of the energy insecurity data showed that the program may have had a modest effect on the energy insecurity of households who received the furnace cleaning. Fewer households said that they could not pay their energy bill without help and fewer households said that they could not afford to use energy after they received the furnace cleaning. Some households saw an improvement in their composite energy insecurity scale. While 48 percent of the households were classified as in-crisis prior to receiving the furnace cleaning services, 39 percent were classified as in-crisis following program receipt, a statistically significant difference at the 99 percent level. Overall, 32 percent had an improvement in the scale, 42 percent remained at the same level, and 26 percent had their scale worsen.

# V. Furnace Safety and Efficiency Impacts

This section examines other program impacts of the NH REACh project by assessing the change in the pre and post cleaning furnace efficiency test results.

TCCAA and OEP developed a heating system inventory form to collect information on the condition of the heating systems that were cleaned. As part of the furnace cleaner contracting process, the vendor was instructed to sign that the company would perform cleanings as described in the work order, would submit an itemized bill for each job, and would complete the REACh heating system inventory for each job done. Program protocols stated that the contractor would not be paid if the pre and post inventory data were not provided for all completed jobs. However, the data analysis showed that the data were missing for a majority of the cleaned furnaces. Furnace efficiency data that were provided are analyzed in this section of the report.

## *A. Smoke Scale Reading*

One of the pre/post indicators that the cleaners were instructed to report was the smoke scale reading. This is an important indicator, as smoke is an indicator of incomplete combustion in oil burners. In addition to indicating poor combustion, smoke can deposit soot on the heat exchangers, which may cause problems with draft, efficiency, and carbon monoxide.

The efficiency test sheet that the contractors were required to complete states that the expected level of the smoke scale is from 0 to 1. The Bacharrach information sheet provides the following scale for the smoke scale reading, shown in Table V-1.

**Table V-1**
**Bacharach Smoke Scale**

| Reading | Rating | Explanation |
|---|---|---|
| 1 | Excellent | Little, if any, sooting of furnace or boiler surfaces. |
| 2 | Good | May be slight sooting with some types of furnaces or boilers, but little increase in flue gas temperature. |
| 3 | Fair | Substantial sooting with some types of furnaces or boilers, and will require cleaning more than once a year on most types of furnaces or boilers. |
| 4 | Poor | Some units may soot only moderately, others may soot rapidly. |
| 5 | Very Poor | Heavy sooting in all cases. May require cleaning several times during the season. |
| 6 | Extremely Poor | Severe and rapid sooting may result in damage to stack control and reduce overfire draft to danger point. |

Results from the pre/post smoke scale readings are shown in Table V-2. This table shows that 19 percent of the cleaned furnaces had a smoke scale rating of greater than one in the pre-cleaning test, and three percent had a smoke scale rating of greater than one in the post-

cleaning test. The percentage that had a smoke scale reading of greater than three was reduced from seven percent in the pre-test to one percent in the post-test.

**Table V-2**
**Smoke Scale Reading**

| | **Pre** | | **Post** | |
|---|---|---|---|---|
| | **All Observations** | | | |
| | N=233 | | N=134 | |
| | Number | % | Number | % |
| Smoke scale reading >1 | 44 | 19% | 4 | 3% |
| Smoke scale reading >2 | 24 | 10% | 2 | 1% |
| Smoke scale reading>3 | 16 | 7% | 1 | 1% |
| | **Observations with Pre/Post Data (N=42)** | | | |
| | Number | % | Number | % |
| Smoke scale reading >1 | 4 | 10% | 0 | 0% |
| Smoke scale reading >2 | 2 | 5% | 0 | 0% |
| Smoke scale reading>3 | 0 | 0% | 0 | 0% |

## *B. Stack Temperature*

The stack temperature is an indicator of the efficiency of the furnace. The lower the stack temperature, the greater the heat exchange and the greater the system efficiency. However, excessively low stack temperatures can lead to condensation in the chimney, which can result in the formation of acids and rapid deterioration of the chimney and venting components. The efficiency test sheet states that the stack temperature should be between 350°F and 650°F. Table V-3 displays the pre/post cleaning efficiency test readings of the stack temperature. The table shows an insignificant decline in the number of homes with stack temperatures above or below the desired level.

**Table V-3**
**Stack Temperature**

| | Pre | | Post | |
|---|---|---|---|---|
| | All Observations | | | |
| | N=317 | | N=307 | |
| | Number | % | Number | % |
| Stack temp<350° or >650° | 41 | 13% | 35 | 11% |
| | Observations with Pre/Post Data (N=307) | | | |
| | Number | % | Number | % |
| Stack temp<350° or >650° | 39 | 13% | 35 | 11% |

## C. Carbon Dioxide Level

The carbon dioxide content of the flue gases leaving the furnace is an indicator of the efficiency of the furnace. The furnace cleaning inventory form states that the carbon dioxide should be 8 to 14 percent. Table V-4 shows that 13 percent of the furnaces were outside this range prior to the cleaning, and only 4 percent were outside this range after the cleaning, indicating an increase in furnace efficiency.

**Table V-4**
**CO2 Level**

| | Pre | | Post | |
|---|---|---|---|---|
| | All Observations | | | |
| | N=311 | | | |
| | Number | % | Number | % |
| CO2<8 or CO2>14 | 39 | 13% | 13 | 4% |

## D. Combustion Efficiency

The combustion efficiency is a measure of how effectively the fuel is converted into heat. The heating inventory form states that the furnace combustion efficiency should be greater than 75 percent following the furnace cleaning. Table V-5 shows that 93 percent of the furnaces had an efficiency of greater than 75 percent prior to the cleaning and 98 percent had an efficiency greater than 75 percent after the cleaning.

**Table V-5**
**Combustion Efficiency**

| | Pre | | Post | |
|---|---|---|---|---|
| | **All Observations** | | | |
| | N=186 | | N=286 | |
| | Number | % | Number | % |
| Combustion efficiency>75% | 173 | 93% | 281 | 98% |
| | **Observations with Pre/Post Data (N=186)** | | | |
| | Number | % | Number | % |
| Combustion efficiency>75% | 173 | 93% | 182 | 98% |

## *E. Furnace Safety and Efficiency Summary*

The furnace efficiency test results showed that there were a small percentage of furnaces that had increased safety or efficiency levels following the furnace cleaning. The percent of furnaces with unsafe smoke scale readings declined, the percent with unsafe carbon dioxide levels declined, and the combustion efficiency increased.

# VI. Summary of Findings and Recommendations

This section provides a review and assessment of the logic model that was developed at the start of the project evaluation, as well as recommendations for continued implementation of the pilot.

## *A. NH REACh Logic Model*

The logic model presents the assumptions for the project, the activities that will be undertaken, and the immediate, intermediate, and final outcomes that are expected.

**Assumptions**

The assumptions relating to the low-income clients were largely met. Many of the clients had a low pre energy insecurity scale rating, indicating that they were not meeting all of their energy needs, or that they were making difficult sacrifices to meet their energy needs. While some of the clients who were contacted had already cleaned their furnaces independently, most clients were interested in this free service. A large proportion of the clients were contacted and provided the information needed to complete the post energy insecurity scale.

The assumptions relating to the local oil vendors and home furnace cleaning contractors were not fulfilled to the same extent. There were some oil vendors and furnace cleaning companies who were not interested in participating in the program because they did not have the staff to service additional customers. Given the high volume of furnace cleanings that the program aimed to undertake, the market became saturated, and some customers were unable to find furnace cleaners. Also as a result of the high demand, many customers did not receive the furnace cleaning in a timely manner.

One of the big shortcomings in the project was the failure of many of the furnace cleaners to provide data on the pre and post furnace efficiency tests. While the requirement to provide the data was part of their contract, it appeared that no penalties were imposed upon the cleaners who did not provide this information. This may have been due, in part, to the overwhelming and not completely anticipated amount of logistical and paperwork associated with the project.

Following many requests and diligent follow-up, 26 of the 27 oil dealers did provide customer usage data for the pre and post treatment periods. Based on the differential change in usage by those customers who reported that they had not had consistent furnace cleanings over the past several years and those who reported that they did have consistent furnace cleanings, the furnace cleanings appear to have had a modest impact on the number of gallons of fuel used by participating households. However, given the typical poor data quality with bulk fuels and the high level of data attrition, it is difficult to draw a solid conclusion.

The assumption relating to the impact of furnace cleaning on health and safety was met for a small percentage of customers. Some customers did see an improvement in the operation and efficiency of their furnaces following the cleaning. Additionally, many customers had major furnace repairs or furnace replacements through the program.

**Activities**

The project cleaned 2,045 furnaces, rather than the 5,100 that were targeted. This was due to the need to use program funds to make major repairs and replacements, as planned LIHEAP funds were not available. Rather than just identifying furnaces needing repair or replacement, the program made major repairs for 15 households, and replaced furnaces for 86 households.

**Immediate Outcomes**

The pre and post furnace efficiency tests showed that there were a small percentage of households that saw an improvement in their furnace operation. The percent of furnaces with unsafe smoke scale readings declined, the percent with unsafe carbon dioxide levels declined, and the combustion efficiency increased. Additionally, the red flagged systems were replaced.

**Intermediate Outcomes**

As stated above, there was some evidence of a reduction in energy consumption for those households who had not consistently cleaned their furnaces over the past several years. Additionally, the improvement in the furnace efficiency tests shows an improvement in customer health and safety.

**Final Outcomes**

The analysis of the energy insecurity data showed that the program may have had a modest impact on the energy insecurity of households who received the furnace cleaning. Fewer households said that they could not pay their energy bill without help and fewer households said that they could not afford to use energy after they received the furnace cleaning. Some households saw an improvement in their composite energy insecurity scale. While 48 percent of the households were classified as in-crisis prior to receiving the furnace cleaning services, 39 percent were classified as in-crisis following program receipt, a statistically significant difference at the 99 percent level. Overall, 32 percent had an improvement in the scale, 42 percent remained at the same level, and 26 percent had their scale worsen.

One additional outcome that is expected from the furnace cleanings is that they may prolong the life of the heating system. By lubricating the motors and removing soot from the heat exchanger, the unit can run cooler and longer. However, this impact cannot be measured in the evaluation.

**Table VI-1**
**NH REACh Logic Model**

<table>
<tr><th>Assumptions</th><th>Activities</th><th>Immediate Outcomes</th><th>Intermediate Outcomes</th><th>Final Outcomes</th></tr>
<tr><td>Low-income clients:<br>o Want to reduce their energy bills<br>o Will want the furnace cleaning service<br>o Will be willing to participate in follow-up</td><td rowspan="2">Clean furnaces and boilers in 5100 low-income homes in Northern New Hampshire.</td><td rowspan="2">Improvement in furnace operation.</td><td rowspan="4">1) Reduced energy consumption and costs.<br><br>2) Improved health and safety.</td><td rowspan="4">Improvement in energy insecurity index.</td></tr>
<tr><td>Local oil vendors and home furnace cleaning companies:<br>o Will want to participate<br>o Will be willing to collect and provide data on each furnace cleaning job<br>o Will provide the service in a timely manner</td></tr>
<tr><td>Furnace CT&E will reduce low-income energy consumption.</td><td rowspan="2">Identify heating systems needing repair or replacement.</td><td rowspan="2">Red flagged systems are replaced.</td></tr>
<tr><td>Furnace CT&E will furnish health and safety benefits.</td></tr>
</table>

## *B. Recommendations*

OEP, TCCAA, and the Community Contact offices faced many challenges in implementing the REACh initiative, largely due to the high volume of households that they served. The main benefits of the program were for those customers who had not had the cleanings done for several years, and would not have had the cleaning in the absence of the program, and for those customers who had unsafe furnaces that were identified, repaired, and replaced. Out of approximately 2,080 homes, 34 or two percent needed a major repair, and 107 or five percent needed to be replaced.

While it may not be feasible for the LIHEAP agencies to continue to implement furnace cleaning, repair, and replacement at the scale targeted by this REACh grant, it would be beneficial to assist households who do not have regular furnace cleaning and maintenance, and as a result, identify households who are operating unsafe heating equipment.

One potential means by which the LIHEAP agencies can achieve this goal is to provide households with partial assistance to obtain furnace cleanings. The assistance may be provided in the form of a coupon or rebate that is provided after the household mails in a completed furnace cleaning form. As seen in this pilot, some households may also need assistance finding a vendor who will clean their furnace. LIHEAP agencies and intake staff should brainstorm about what methods may work best to provide assistance to households to ensure that they have clean and safe heating systems. It appears that the furnace cleaning and repair and replacement inventory is a needed and valuable service that can improve the

affordability, health, and safety of low-income households in New Hampshire. The challenging work is to determine an efficient method to assist the most vulnerable households to ensure that they have access to safe and affordable heat.