New Hampshire Weatherization Program

Impact Evaluation Report

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New Hampshire Office of Energy and Planning

Submitted by:

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Contents

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EXECUTIVE SUMMARY

The New Hampshire Office of Energy and Planning delivers the federally-funded Weatherization Program to low-income households in New Hampshire. OEP contracted with M. Blasnik & Associates in May 2006 for an independent evaluation of the program with a focus on energy savings. This report provides the findings of that evaluation with a focus on assessing the energy savings of homes completed in 2005.

Program Description

The program is delivered by six local non-profit agencies that employ a combination of in-house personnel and local contractors to provide weatherization treatments to client homes. The Wx agencies have also provided retrofits funded by the local electric and gas utility companies since 2002 and more than 70% of the jobs completed since 2003 were jointly funded. The growth of utility funding has had profound effects on the size, scope, and operations of the Wx program.

The utility funding has increased the number of gas and electrically heated homes served, particularly apartments in multifamily buildings. Apartments accounted for 11% of units served in 2002 but accounted for 39% of the units in 2005 and an even greater percentage in 2006. The electric utility funding has also added electric baseload measures (lighting and targeted refrigerator replacements) to virtually all homes served by Wx. The additional funding has led to a substantial decline in the average cost per home charged to Wx and has reduced budget constraints overall. However, concerns have been raised about how the utility funding may have unintentionally reduced the number of fossil-fuel heated single family homes served by Wx.

The program employs a diagnostic approach to weatherization. The energy audit identifies health and safety issues that need to be addressed prior to other work and safety tests are repeated at post-inspection. The key weatherization measures included:

- attic insulation, which was installed in 73% of site built homes, 88% of multifamily buildings, and 33% of mobile homes;
- wall insulation, which was installed in about one third of site built homes and 5% of other units, although installation rates varied by agency; and,
- blower-door guided air sealing, with an average leakage reduction of 1,386 CFM50 (33%) of the 4,183 CFM50 pre-treatment leakage of site built homes, an 1,153 CFM50 (39%) reduction for mobile homes, and a 175 CFM50 (12%) reduction for apartments.

The program also includes targeted applications of many other measures including floor insulation (over crawlspaces), duct insulation and sealing (when outside the conditioned space), rim joist insulation, and hot water saving measures. Heating system replacements are relatively rare and are only performed for health and safety reasons. The main electric baseload measures include refrigerator replacements in about one third of homes and CFL lighting retrofits, with some fixture replacements. The electric utilities require the use of a computerized audit on every job, but Wx does not.

Telephone Survey Findings

A telephone survey was conducted with 265 program participants who lived in single family units. A separate report provided the detailed results of that survey but some key findings are summarized in this report. The surveys showed that:

- 97% of participants have at least one “vulnerable” member meaning an occupant who is elderly, a child, or has a disability or special medical condition

- 39% of households reported using supplemental heating -- 42% of bulk fuel homes and 31% of utility heated homes. Bulk fuel heated homes were more likely to report using supplemental wood heat (28% vs. 17%) and about half of the homes using wood used it all winter. Although clients that used wood heat tended to report using less after weatherization this practice is not very widespread and is unlikely to have a large effect on overall savings.
- The use of stoves and/or ovens for heat is too frequent – one in six participants reported this practice in the past year. Bulk-fuel heated homes are more likely to resort to oven/stove use, sometimes because they run out of their primary heating fuel.
- A substantial proportion (40%) of clients reported that paying their energy bills is very difficult. 16% of participants reported that they had to go without food at some point to pay their energy bills, 31% went without medical or dental care, 23% went without prescription medicine, and 15% had to skip a rent or mortgage payment. 73% of clients said they were better able to pay these other bills after weatherization.
- A significant proportion of clients appeared to want more energy education -- 38% reported they think they could have saved more energy if they had been given information on how to save.
- Overall, the vast majority of clients were very satisfied with the program, the staff and contractors they interacted with, and with the quality of the work performed.

Energy Impacts

The gas and electric savings for the program were assessed by calculating the weather-adjusted annual energy usage for the years before and after program treatments for the 2005 participants and for a comparison group composed of 2006 participants. We analyzed single family units separately from multifamily apartment buildings for each fuel type. Electricity savings were assessed separately for units with and without electric heat.

Single Family Gas: For single family gas heated homes, we found average net energy savings of 277 ccf/yr, equal to 22% of the 1,282 ccf average pre-treatment usage for the 27 homes with reliable results. These savings compare very favorably to most other state weatherization program evaluations.

A key evaluation issue was how to extrapolate from these 27 homes to the overall fossil fuel heated single family population. We developed measure-specific savings estimates based on prior research and found that the projected savings matched the average savings from the billing analysis fairly well. We then used these measure savings estimates, adjusted by the billing analysis, to calculate the estimated savings for all of the single family fossil fuel heated homes. This analysis reduced the estimated savings to 19.1 MMBtu per home, primarily due to less wall insulation being installed in the larger population.

Multifamily Gas: The analysis of multifamily gas heated apartments found average savings of 69 ccf/yr, equal to 10% of the average 683 ccf pre-treatment usage in 39 units. The treatments did not vary significantly from the remainder of the fossil fuel heated multifamily units.

Single Family Electric Heat: The 26 single family electrically heated homes saved an average of 2,182 kWh/yr, equal to 10% of the 21,556 kWh average pre-treatment usage. These savings are comparable to other weatherization program results. The analysis group included more than half of all electrically heated single family homes and the treatment mix appeared representative of the full population.

Multifamily Electric Heat: Net savings for multifamily electrically heated units were estimated at 1,560 kWh/yr, equal to 15.5% of the 10,036 kWh average pre-treatment usage in 23 units with usage data. However, a large and questionable comparison group adjustment in this analysis led to a revised estimate of 1,187 kWh/yr. These units represent a relatively small fraction of the program population and so this rough estimate has little impact on overall results.

Single Family Electric Baseload: Single family electric baseload savings averaged 780 kWh/yr., equal to about 10% of the 8,195 kWh average pre-treatment usage for the 105 homes with results. Savings averaged 1,184 kWh for the 60 homes that received refrigerator replacements and 533 kWh for the 45 homes that did not. These savings are comparable to results from similar programs. These results were applied to the overall proportion of single family non-electrically heated homes receiving refrigerator replacements to estimate overall average population savings of 741 kWh per home.

Multifamily Electric Baseload: Multifamily electric baseload savings averaged 429 kWh/yr, equal to 10% of the average 4,273 kWh pre-treatment usage for the 50 units with results. Savings averaged 711 kWh for units that received a refrigerator replacement and 98 kWh for those that did not. There was particularly large uncertainty in this last result. The results were applied to the full multifamily non-electrically heated population to estimate average savings of 293 kWh per unit, reflecting a higher refrigerator replacement rate in the analysis sample than the larger population.

Overall Energy Impacts and Cost Effectiveness

The savings results from the billing data analysis were combined with data on fuel prices and estimates of measure lifetimes and discount rates to assess overall cost-effectiveness. This analysis did not include any assessment of non-energy benefits such as environmental impacts, health and safety benefits, utility/ratepayer benefits, affordable housing stock preservation, or local economic benefits. The results of this analysis are summarized in Table 1.

Table 1. Energy Impacts & Cost Effectiveness

		Annual Savings			Lifetime Bill Savings (p.v.)			Program Costs		
Housing Segment	# units	MMBtu	kWh	Total $/yr	Fossil Fuels	Electric	Total	Wx	Wx & Utility	Benefit / Cost Ratio
SF fossil fuel heat	363	19.1	741	$441	$4,479	$1,043	$5,522	$2,805	$4,409	1.25
SF electric heat	39	0	2,182	$327	$0	$4,028	$4,028	$1,812	$3,703	1.09
MF fossil fuel heat	215	7.1	293	$162	$1,611	$412	$2,024	$967	$1,970	1.03
MF electric heat	39	0	1,187	$178	$0	$2,256	$2,256	$1,409	$3,436	0.66
Total Program	656	12.9	706	$327	$3,007	$994	$4,001	$2,061	$3,510	1.14

Notes: Energy prices based on December 2006 NH average prices with fossil fuel prices weighted based on estimated savings by fuel. Present value calculations assume 0% real fuel price inflation, 4% discount rate, 20 year measure life for Wx measures and 12 years average for electric baseload measures. Program costs include all agency and OEP administrative costs and full utility prices paid. BCR column based on all costs (Wx & Utility). Non-energy benefits not included.

The New Hampshire Weatherization program provides substantial and cost-effective energy savings to the low income households it serves. Annual energy savings averaged 12.9 MMBtu of fossil fuels and 706 kWh of electricity per unit in 2005. These energy savings are worth $327 per year. The overall present value of the lifetime energy savings is estimated at $4,001 per household. Total Wx and utility spending averaged $3,510 per unit, yielding an overall benefit/cost ratio of 1.14. The program was cost-effective without even considering any of the potential non-energy benefits it produced.

Energy savings and cost-effectiveness were highest in fossil-fuel heated single family homes, which saved an average of $441 per year on their energy bills and provided a benefit cost ratio of 1.25. Multifamily electrically heated apartments appeared to be the least cost-effective segment in the program, with annual bill savings estimated at $178 per year and a benefit/cost ratio of 0.66, but there was very large uncertainty in the savings results in this small segment.

In aggregate terms, NH Wx provided $2.62 million in lifetime fuel bill savings by spending $2.30 million on all program costs including DOE and utility funds. The program undoubtedly also produced substantial non-energy benefits that remain unquantified.

Conclusions and Recommendations

The NH Wx program savings compare very well to other weatherization programs across the nation. The high level of performance can be attributed to a strong technical design based on diagnostic-driven treatments and to an experienced and well-trained group of state and local agency staff and contractors. However, we were able to identify several areas where the program could be enhanced.

Targeting

NH Wx has grown dramatically due to the availability of utility funding. Much of the growth has occurred in multifamily utility-heated apartments while the number of single family fossil-fuel heated homes has actually declined slightly, raising some equity concerns. OEP should consider options such as creating a quota or separate waiting list for homes that don't qualify for utility-funded weatherization.

Wall Insulation

Wall insulation is a very high impact measure that is performed in about one third of single family site built homes. The installation rate varies from 0% to 47% across agencies. Some agencies have reported that their contractors refuse to perform wall insulation in too many cases where complications are encountered. OEP and the local agencies should work together to increase the proportion of homes receiving wall insulation and resolve issues with contractors that appear to avoid certain types of work.

High Efficiency Heating System Replacements

Heating systems are replaced infrequently and only for health and safety reasons in the program. Most replacement units are standard efficiency. OEP should seek to make high efficiency heating system the standard whenever systems are replaced and the incremental cost can be justified by the incremental energy savings. Specific guidelines should be developed for furnaces and boilers and for different fuel types, pre-treatment usage levels, and incremental costs.

In addition, heating system replacements are likely to be cost-effective for energy efficiency reasons in some homes with high pre-treatment usage. Given the low average cost per unit treated in the current Wx program, average spending caps should not be much of an issue for developing guidelines for adding heating system replacement as a potential measure.

Client Energy Education

Based on interviews with agency staff and telephone surveys of program clients, it appears that NH Wx provides very little client energy education. It is not clear what the true savings potential from energy education may be, but the low cost of providing education makes it almost certainly cost-effective. In addition, education may play a role in helping clients to best use and maintain the measures that they do receive. Therefore, we recommend that OEP consider adapting a more formal approach to energy education in Wx, perhaps working with education experts from other programs or consultants who specialize in energy education programs.

Program Tracking System Issues

The current Wx program tracking system is fairly rudimentary, does not contain some key information needed for evaluation, and provides very limited capacity for serving a useful role in program management and QC. We recommend that the tracking system be upgraded or replaced so that it contains, at a minimum, data on the quantities of major measures installed, the amounts of gas and electric utility funding provided, the utility names and account numbers for all clients, and a more consistent approach to how multifamily buildings are identified and their treatments and utility accounts tied to units.

I. INTRODUCTION & METHODOLOGY

The New Hampshire Office of Energy Planning (OEP) operates the federally-funded Weatherization (Wx) Program[1] which provides energy efficiency retrofits to low-income households in New Hampshire. The program is delivered by six local non-profit agencies that employ a combination of in-house personnel and local contractors to provide weatherization treatments to client homes.

The Wx agencies have also provided retrofits funded by electric and gas utility companies since 2002. The growth of utility funding in recent years has had profound effects on the size, scope, and operations of the Weatherization Program. Local agencies often blend multiple funding streams into the treatment of each home depending on the needs of the home, the available resources, and the specific rules of each funding source.

The leveraging of program resources complicates any assessment of program impacts because it can be difficult to attribute savings to specific funding sources. Instead, we have focused on trying to assess the overall impacts of the combined effort. The utility funding has also led to a substantial increase in the number of homes served, especially apartments, and a decrease in the average cost per home charged to Wx. Multifamily buildings pose particular impact evaluation challenges since some buildings may have master metering and the assignment of apartments to meters can be unclear while energy savings may vary across units in a building with separate metering.

Evaluation Methodology

OEP contracted with M. Blasnik & Associates in May, 2006 for an independent evaluation of Wx. This report provides the findings of that evaluation. A more detailed report on the results of a telephone survey of program participants has been provided separately. The impact evaluation focused on measuring the gas and electric savings of single family homes and multifamily buildings/apartments treated in calendar year 2005.

Data Collection

Eight key sources of data and information were used in the evaluation:

- The Wx program tracking system database was provided by OEP.
- Extracts from the Fuel Assistance Program database were provided by OEP to assist in identifying utility account numbers of Wx clients.
- Extracts from the electric utility program's tracking system (OTTER®) were provided by Public Service of New Hampshire (on behalf of all electric utilities) to further assist in identifying client account numbers and to provide more detailed data about utility-funded treatments.
- Local agencies each looked up more detailed information about the major treatments provided to each client and entered the data into a spreadsheet created by the evaluator.
- Gas and electric monthly usage data histories were provided by four utilities – Keyspan, Northern Utilities, Public Service of New Hampshire and New Hampshire Electric Cooperatives.
- Daily historical weather data for Concord, NH was acquired from the National Climactic Data Center.
- A telephone survey was conducted and completed for 265 clients who participated in Wx between January 2005 and September 2006. The survey covered a wide range of topics including demographics, energy affordability, program operations, perceived program impacts, comfort, and the use of supplemental heat.

[1] Also known as the Home Weatherization Assistance Program by the U.S. Department of Energy

- Open-ended telephone interviews were conducted with weatherization program staff at each of the six local agency providers.

The Wx program tracking system did not have any information on utility names or account numbers of clients and provided no data on metering configurations of multifamily buildings. We matched the Wx tracking system into the Fuel Assistance Program database in an attempt to obtain utility names and account information. We used special fuzzy matching algorithms to find imperfect matches and assess the quality of each match. Many of the participants were not found in the FAP database or were living at a different address at the time. Apartments in multifamily buildings were particularly difficult to match since master metered tenants would have no utility account identified in FAP.

We next matched the combined Wx and FAP database into the electric utility companies' program database (OTTER®), again using fuzzy matching techniques to deal with spelling variations in names and addresses. We developed a single combined database containing all information on all matched jobs.

The Wx tracking system did not contain any data on the actual measures installed or the quantities of major measures such as insulation. We developed a spreadsheet for each local agency that listed all jobs of interest for the evaluation and added in columns for the agency to enter treatment information. These spreadsheets were sent out to the agencies who then manually entered data and sent the results back to the evaluator. This data was then merged into the combined tracking systems.

We developed usage data requests for each utility company using names, addresses, and account number information to the extent available. We requested usage data for all units in the target treatment and comparison groups (essentially all units completed in 2005 and 2006) from the two main gas utilities, Keyspan and Northern Utilities, and the two main electric utilities, PSNH and NHEC. Most utilities put in considerable effort to match account information manually in cases where the data request just had a name and address.

The usage data files provided by the utilities needed to be matched back to the combined tracking system and multifamily buildings needed to be carefully examined to identify which accounts and meters covered which units and to decide when the data were insufficient to determine what was included.

Overall, the data matching and collection process was very labor intensive and could be substantially improved in the future if recommendations concerning the program tracking system were adopted.

Energy Savings Analysis Approach

The energy impact analysis involved the following steps:

- Matching the multiple tracking system databases of Wx, FAP, agency data, and the electric utility programs to create a single tracking system and identify client utility account numbers so that usage data could be requested.
- Submitting data requests to each of the four major utilities and then collecting, formatting and cleaning the data for analysis and matching the data back to the tracking system to assign pre and post treatment usage periods for the treatment group and a comparison group of later participants.
- Performing a weather-normalization analysis on the pre and post treatment usage data to develop weather-adjust annual gas and electric usage estimates
- Integrating usage analysis results with the tracking system and dealing with how multifamily building accounts relate to specific units (or identifying when it is unclear)
- Summarizing and analyzing the pre and post treatment gas and electric usage and savings for the treatment group and the comparison group
- Estimating overall program energy impacts based on gas and electric savings results

We analyzed the gas usage data employing a variable base heating degree day regression algorithm similar to the PRISM™ model but employing a Bayesian approach to estimating the degree day base temperature in order to reduce "flaky" results. This approach has been previously assessed by the evaluator and found to be virtually identical to standard PRISM for most homes but superior to PRISM when dealing with data quality problems.

We analyzed electric usage data using a heating and cooling degree day adjustment procedure that classifies usage into seasons based on weather and then adjusts any incremental (above baseload) seasonal loads based of heating and cooling degree days at fixed balance point temperatures of 58°F for heating and 70°F for cooling. This procedure is fairly robust to data problems but, like all degree day methods, will over-adjust for weather to the extent that some seasonal loads are not temperature-dependent (e.g., winter lighting). The comparison group should reflect any bias introduced by this shortcoming.

Comparison Group Selection and Screening

The role of the comparison group is to represent what would have happened to participants if they hadn't participated. Without a comparison group, energy savings results may be biased to the extent that other factors may have systematically influenced the energy use of the participants. The ideal comparison group would be composed of households identical to the participants in terms of demographics, housing stock, and energy usage levels and would be exposed to the same influences with the exception of not participating in the program.

In this project, the comparison group was composed of units treated in 2006. We eliminated all usage data from after the actual energy audit date and then subtracted one year from the audit date to create pseudo pre and post treatment periods. Only homes with at least two years of pre-treatment data could be used as the comparison group. We analyzed and screened the comparison group cases identically to how we treated the participants.

II. PROGRAM DESCRIPTION

The New Hampshire Weatherization Program Manual states:

> It is the goal of the Weatherization Program to reduce heating costs for low-income families, particularly for the elderly, persons with disabilities and children under the age of six, by improving the energy efficiency of their homes and ensuring their health and safety.

This goal provides for prioritizing vulnerable demographic groups and places health and safety concerns on at least a par with energy savings. The New Hampshire Wx and fuel assistance programs use a common application and income eligibility at 185% of the Federal Poverty Guideline and are delivered through a network of six local community action agencies. Most agencies have waiting lists that would span several years of production, although applicants need to re-certify eligibility if more than 12 months have elapsed. In addition to targeting vulnerable demographic groups, the program also officially prioritizes households with high energy usage, a lack of insulation, and where utility co-funding is available to treat the home. These criteria are intended to maximize the energy savings achieved by the program.

Wx has been undergoing a transformation since late 2002 due to the establishment of electric and gas utility weatherization programs that have been designed to work in conjunction with Wx funds to provide for comprehensive retrofits. The vast majority of Wx clients also receive utility-funded retrofits and many jobs rely on utility funding for the major energy savings measures.

Utility Programs

The major electric utilities in New Hampshire – Public Service of New Hampshire (PSNH), Unitil, New Hampshire Electric Cooperative (NHEC), and Granite State Electric (GSE) – have operated the Home Energy Assistance Program since June 2002. HEA provides energy efficiency retrofits in low-income customers' homes and is delivered by the same agencies that deliver Wx. Most homes participating in HEA also receive Wx and the funding sources combine to provide comprehensive treatments for each home. Approximately 80% of all HEA participants are in the PSNH territory.

HEA classifies customers as either "A" jobs and "B" jobs. "A" jobs have a budget of up to $4,000 and are provided with a full range of energy retrofits including weatherization measures such as insulation, air sealing, thermostats, hot water measures, and electric baseload measures. "B" jobs are restricted to just electric baseload measures such as CFL lighting retrofits and refrigerator replacements. A home is qualified as an "A" job if it has electric heating or if it has high electric use. The threshold for high usage has been 30 kWh/day, but has been lowered to as little as 20 kWh in one agency territory due to problems finding sufficient high use customers.

The two major gas utilities, Keyspan and Northern Utilities, also offer low-income weatherization programs that are delivered by the local Wx agencies. The programs include insulation, air sealing, and Keyspan includes some heating system replacements. Two of the six Wx agencies do not participate in either gas utility program because they are outside of the service territories.

Utility weatherization funds have reduced the need for Wx funds in many homes and allowed the program to grow in terms of the number of units served and the available budget per unit. Agency staff have universally appreciated how utility funds have reduced budget constraints for homes with greater needs and created a more flexible and comprehensive program. A key job for the energy auditor is now determining how to best allocate funds from different sources to provide a comprehensive and cost-effective treatment plan. However, some agency staff have raised concerns about how production goals for utility-heated customers may be affecting non-utility heated customers that don't qualify as "A" jobs, potentially pushing them down the waiting list. Also, many of the utility-heated customers have lived in apartment buildings, which provide for high production numbers but typically have fewer opportunities for weatherization retrofits and substantial heating energy savings.

Wx Treatment Approach

Given the unified approach to auditing and retrofitting homes, and the limited amount of data in the Wx tracking system, the nature of Wx treatment is best described without regard to which program actually funds which measures. The attribution of savings to Wx vs. the utilities is a difficult issue that may be more philosophical than technical.

The major services provided by the Wx program include:

- **Energy Audit:** A detailed energy audit is performed in each home to identify energy savings opportunities, and home repair and health and safety issues which often need to be addressed in the low income housing stock.
- **Insulation:** Attic and wall insulation are supposed to be installed in all homes when deemed feasible and cost-effective and floor (belly) insulation is installed in some mobile homes and homes built on crawlspaces.
- **Air Sealing:** Blower door technology is used to measure and identify air leakage problems.
- **Combustion Equipment:** Initial heating and water heating system safety tests often identify the need for repairs and some replacements and much of this work can be performed under the companion Heating Repair and Replacement Program (HRRP), which is funded by LIHEAP and can spend up to $4,000 per home. HRRP is only available to single family owner-occupied homes because landlords are required to provide working and safe heat. Heating system tune-ups are also performed and can be provided in rental properties.
- **Other Health & Safety:** Wx-funded health and safety measures are limited to a $500 per unit maximum and an agency-wide annual average of no more than $250 per unit, but HRRP and some utility funds are also available to deal with problems that may exceed the caps. Incidental repairs costs are capped at $250 per unit.
- **Electric Baseload:** Refrigerator replacements and lighting retrofits have been added to Wx in many states. In NH, the electric utility programs fund all electric baseload measures.
- **Other Measures:** Wx provides a wide range of other smaller or less frequently installed energy retrofits including duct sealing and insulation and hot water savings measures (e.g., low flow devices).

The overall Wx treatment approach and program standards reflect a state-of-the-art weatherization program design. The work is driven by diagnostic testing, focuses air sealing on key areas like attic bypass leakage, and includes a strong emphasis on combustion equipment safety.

Energy Audits

Agencies perform energy audits using an in-house auditor and the retrofits are performed by contractors and/or in-house crews depending on the agency and the type of work required. Energy auditors must be certified by OEP, which involves passing written and field tests that cover skills such as blower door and HVAC testing and the use of DOE-approved computerized energy audit software (e.g., NEAT). OEP provides on-going training to local agencies and their contractors on a wide variety of topics. The breadth and quality of this training is considered one of the strengths of the program by agency staff. Many program staff and contractors have been working in the program for a long time (10-20 years is common) and have undergone years of training.

The electric utilities require that agencies use the TREAT® computerized energy audit to identify cost-effective energy retrofits and the OTTER® reporting system to administer and track their program. These software products were newly developed when the utility programs began and the agencies report that there have been many growing pains along the way. Most agencies report that, after various software

revisions and improvements, and with the experience they have gained as users, the TREAT software can be run with about one hour effort per home. There appears to be a higher level of on-going frustration with the OTTER reporting system.

The Wx program does not require agencies to use a computerized energy audit, although some agencies use NEAT in addition to TREAT. This evaluator is in agreement with this perspective. In terms of selecting appropriate weatherization treatments, computerized audits offer little advantage over well trained auditors and well designed priority lists. Once it has been determined that wall insulation is cost effective for all fuels in New Hampshire, a computer is not needed to estimate its cost-effectiveness in each home. Many of the other key treatment decisions involve treatments like bypass sealing, which cannot be addressed by a computer.

Still, a computerized audit system may provide some insights in some homes and can have real value as an administrative and monitoring tool. Audit software can be integrated into a system that provides financial reporting and job tracking. Computerized audit systems also collect a wealth of detailed site data that can be used to identify anomalous patterns within agencies or about specific auditors such as an auditor that never specifies wall insulation, or one that never finds an attic with more than R-19 existing insulation. This program management and QC role for computerized audit and tracking systems is relatively new in weatherization and may be worth exploring for OEP. It is not clear whether the benefits of a computerized audit system outweigh the costs for NH Wx, but it is fairly clear that some improvements are needed in the program tracking system.

Program Tracking System

One of the evaluation objectives was to provide recommendations on how to improve the current program tracking system so that it would better support future evaluations and enhance program management. The Wx program tracking system is a fairly basic MS Access database application run by OEP program management. Agencies submit monthly data updates that are appended by OEP. The system tracks basic job identification and spending data as required by DOE Wx regulations, but does not contain enough detail to provide anything more than rudimentary reporting and tracking.

During the course of this evaluation, substantial effort was required to collect additional data about the units weatherized beyond what was in the tracking system. The data collection required matching into the FAP database as well as requesting manual data entry from each local agency. There are four areas where additional data would be most useful:

- **Major Treatments:** The current system does not track any information about the specific measures installed in each home except for the pre and post treatment blower door readings. The system should include at least basic information on the major measures: area of attic insulation installed, area of wall insulation installed, area of floor insulation installed, amount of rim joist insulation installed, heating system tune-up yes/no, heating system replacement yes/no (at least for HRRP records in the database) and new heating system AFUE. It may be worth requiring a reason for not installing wall insulation (e.g., already fully insulated, knob and tube, contractor refused). Other measures that may be worth tracking include duct sealing/insulation and hot water measures. In addition to quantities, it may be worth trying to collect data about the cost (if contracted) or effort (labor hours?) involved in the major measures to make it possible to assess measure-specific cost-effectiveness. For apartments, a consistent approach is needed to identify treatments that are building-wide vs. unit specific.
- **Utility Account Information:** The current tracking system records heating fuel, but does not record the name of the utility company or the client account number. The system should capture gas and electric utility names and account numbers for all clients. For all units in multifamily buildings (2+ units), there should be data fields indicating how many other units have the same electric account and how many have the same gas account. The lack of account numbers and data concerning which meters served which units in multifamily buildings added considerable

work to the evaluation effort and contributed to a large reduction in the number of units that could be evaluated.

- **Multifamily Building Identifiers:** The current tracking system does not provide for any easy way to identify apartments in the same building. At a minimum, the system should enforce placing apartment identifiers in a separate field from the street address field so that all units in the same building have the same street address and different unit numbers. It may be worthwhile to also add a building identifier (or require the use of a job number for this purpose).
- **Utility Program Funding:** The current system records whether the job received additional funds, the total amount of those funds, and the source of funds. However, many jobs now receive more than one source of added funds and there is no way to indicate all of the funding sources or distinguish the amount of funding from each. The system should add separate leveraging data fields for gas utilities and electric utilities (including utility name and leveraging amount) and convert the current leveraging fields to non-utility leveraging.

In addition to these areas, some agencies suggested that it would be useful to have better job tracking and waiting list tracking databases available for use at the agency level.

Program Production Trends

Figure 1 shows the total number of units treated by Wx from PY 2000 through the first seven months of PY 2006 (April 2006 - October 2006). The total production increased in PY 2002 due to an increase in DOE funding from $773k to $1,308k and the start of utility funding. From 2002 through 2005 DOE funding stayed level and then it grew about 15% to $1,539K in PY 2006. Over this period, Wx production grew substantially and PY 2006 is on target for a dramatic jump (and actually reached 1,115 units after 9 months). The gray portion of each bar shows the units treated jointly with utility funds and clearly illustrates that joint funding is predominant.

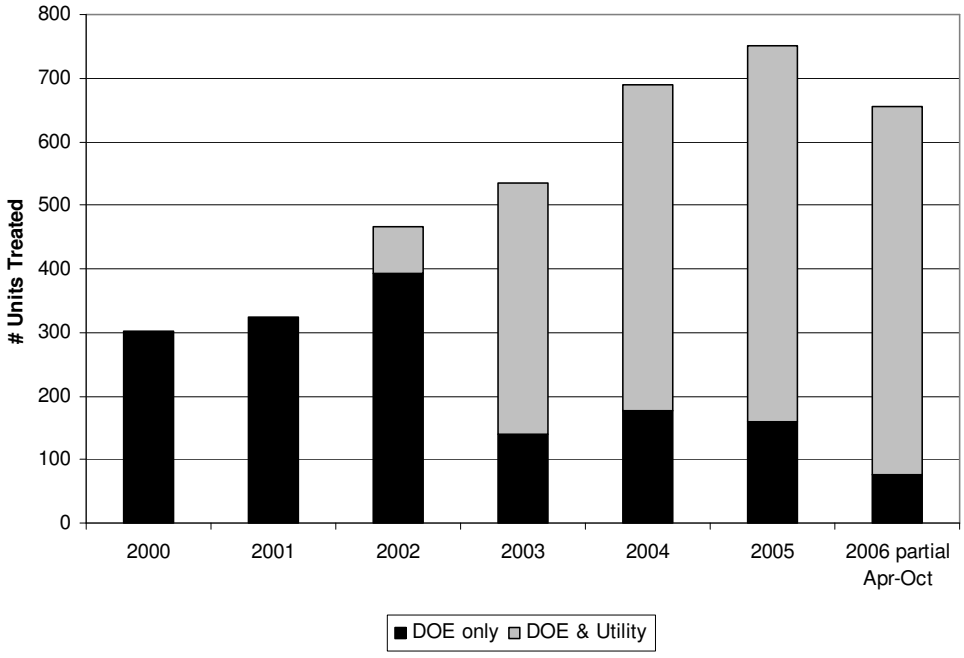

Figure 1. NH Wx Production and Utility Cost Sharing

A closer look at the data revealed that the increase in production has been due solely to the number of apartments served. Figure 2 breaks out the program production into single family and multifamily and by heating fuel. The number of single family homes served by the program was approximately level from 2002 through 2005 while gas and electric heated multifamily units have risen dramatically.

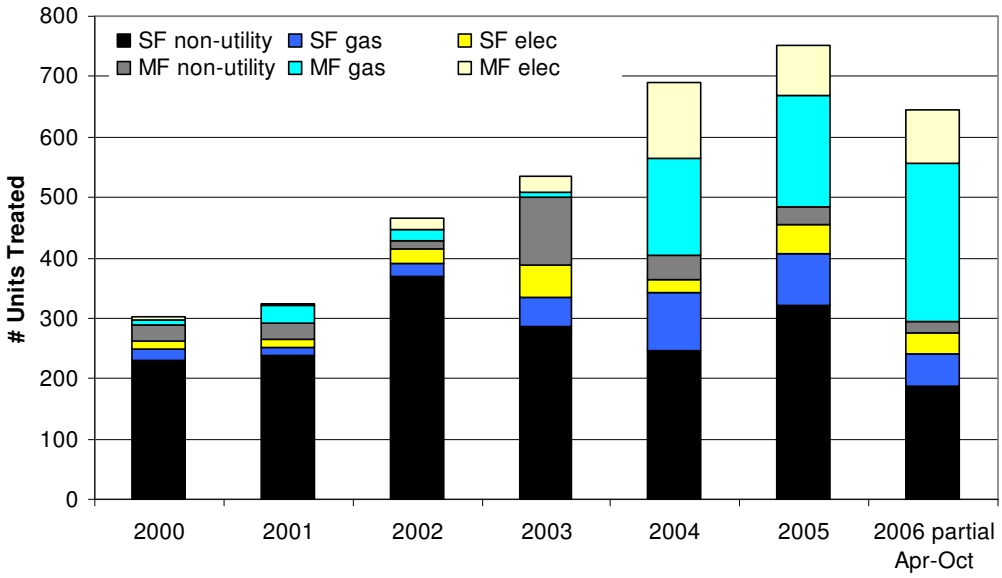

Figure 2. NH Wx Production: Single vs. Multifamily by Heating Fuel

The proportion of Wx units in multifamily building has risen from 13% in 2000 to 58% in 2006. The number of single family homes with non-utility heating served by Wx has actually declined since 2002 (although final 2006 figures are not yet available). This finding is consistent with the concern raised by some agency staff that the program may be prioritizing clients with utility-supplied heating fuel at the expense of those heated with non-utility fuels.

Utility funding led to an increase in total spending per unit due to the addition of baseload electric measures for virtually all jobs and also due to the fewer spending constraints for weatherization work. But the average total cost per unit has been declining since peaking in 2003 due to the greater focus on multifamily buildings. These trends are illustrated in Figure 3 which shows average spending per unit broken out into three categories – direct Wx treatment costs, other agency Wx costs (all other support and administrative costs at the agencies including intake, audits, QC, vehicles, insurance, etc..), and utility funding.

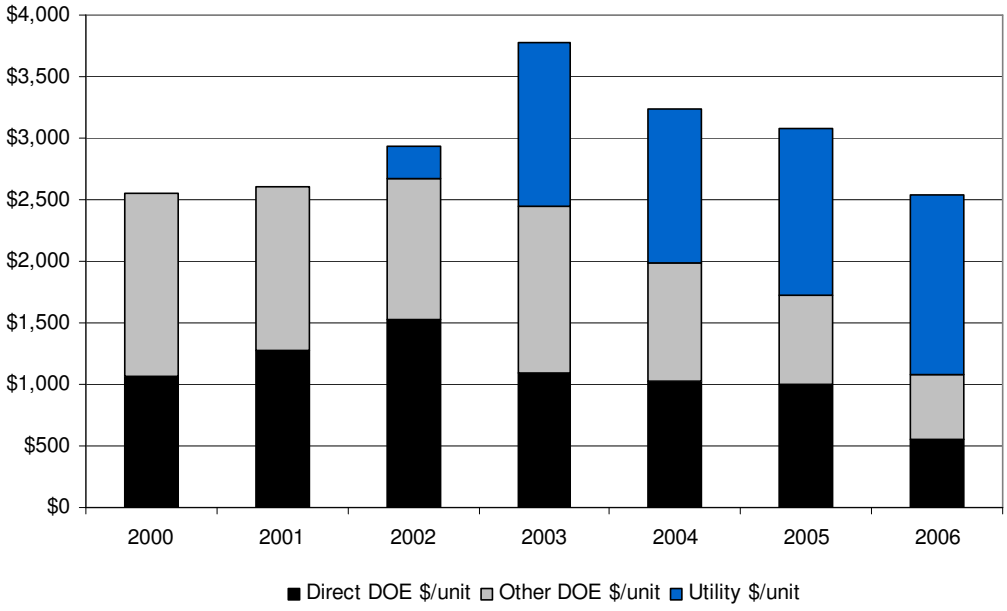

Figure 3. NH DOE/Wx & Utility Spending Trends

Total spending per unit peaked at more than $3,500 per unit in 2003, the first full year of utility funding, but has since declined and averaged about $2,500 per unit in 2006. Direct DOE/Wx spending on measures declined from about $1,500 per unit in 2002 to about $1,000 per unit from 2003 through 2005 and dropped to just above $500 per unit thus far in 2006. The indirect DOE/Wx costs per unit have also dropped over time reflecting the larger number of units produced with about the same Wx budget. Total Wx spending at agencies declined from more than $2,500 per unit prior to the utility programs to just over $1,000 per unit in 2006. The dramatic reduction in Wx spending per unit resulted from the availability of utility funding and the increased proportion of multifamily units served.

The spending trends shown in Figure 3 are strongly affected by the increase in the number of multifamily units served. Figure 4 shows the spending trends excluding multifamily buildings.

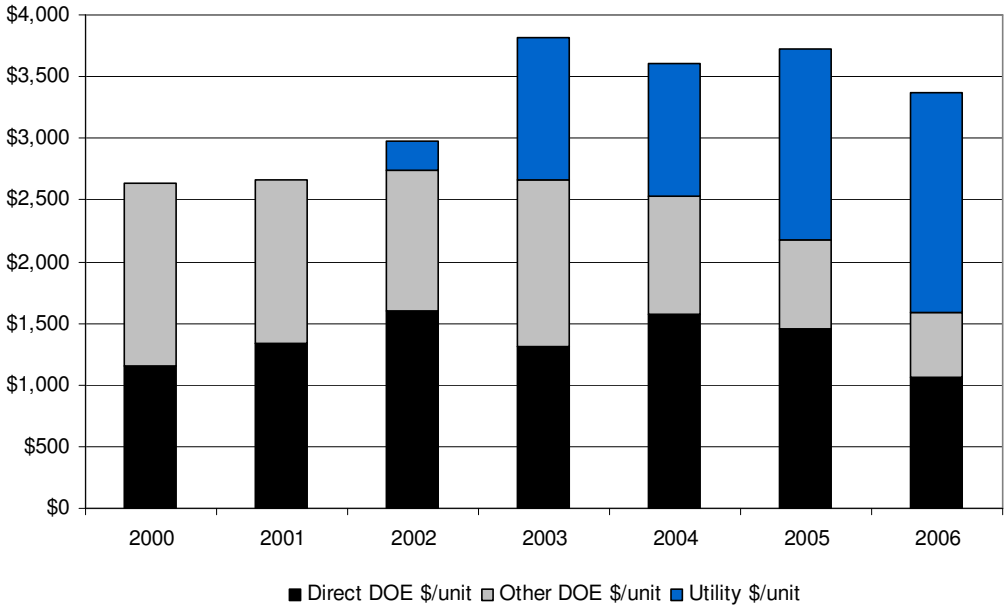

Figure 4. NH DOE/Wx & Utility Spending Trends: Single Family only

The changes in spending for single family homes are not as dramatic and average spending per home is still higher than it had been prior to the utility programs. The Wx direct treatment costs still shows a decline over time, but by about one third rather than the two thirds decline in the overall program.

In many cases, Wx funds are used only for some home repair and/or health and safety measures while the major energy savings retrofits are paid for with utility funds. In multifamily units, the Wx direct treatment spending is often less than $200. In 2002, just 4% of all units in the program had less than $200 in direct Wx treatment costs. In 2006, 54% of all Wx units had direct Wx treatment costs less than $200 – 86% of multifamily units and 12% of single family units.

The increase in the number of lower cost Wx jobs could result in not only an increase in the number of units treated but also could free extra funds for homes with larger weatherization needs. We calculated the proportion of jobs where direct Wx treatment costs plus utility funding exceeded $3,000 to try to assess this shift. In 2002, just 12% of the units served had treatment costs exceeding $3,000. This figure grew to 30% for 2005 and 2006. Excluding multifamily units, the proportion increased from 12% in 2002 to 43% in 2006. The addition of new baseload electric measures and fixed utility program costs make it unclear if this increase in the proportion of higher cost jobs actually resulted from reduced funding constraints for homes with larger weatherization needs. We also found a similar increase in the frequency of higher cost jobs in homes without utility-supplied heating, although it appears that many of those homes also qualify for utility weatherization due to high electric usage.

Table 2 summarizes many of these production and spending trends.

Table 2. Program Production and Expenditure Trends: PY 2000 – PY 2006

	2000	2001	2002	2003	2004	2005	2006*
Total Units Treated	303	324	466	534	689	752	655
Joint Utility & Wx $	0%	0%	16%	74%	74%	79%	88%
Building Type / Heating Fuel							
Single Family Non-utility	76%	73%	79%	53%	36%	43%	28%
Single Family Gas	6%	5%	5%	9%	14%	11%	9%
Single Family Electric	4%	4%	5%	10%	3%	7%	5%
Multifamily Non-utility	9%	8%	3%	21%	6%	4%	3%
Multifamily Gas	3%	9%	4%	1%	24%	25%	42%
Multifamily Electric	2%	1%	4%	5%	18%	11%	13%
Multifamily (all fuels)	13%	18%	11%	27%	47%	39%	58%
Program Spending Per Unit							
Wx Direct Treatment	$1,064	$1,271	$1,527	$1,096	$1,032	$1,000	$549
Utility Funding	$0	$1	$265	$1,334	$1,257	$1,362	$1,470
Total Treatment	$1,064	$1,272	$1,792	$2,430	$2,289	$2,362	$2,019
Other Wx	$1,487	$1,330	$1,139	$1,348	$950	$723	$526
Total Cost $/unit	$2,551	$2,602	$2,931	$3,778	$3,239	$3,085	$2,545
Low Cost (Wx Direct <$200)	7.3%	3.7%	3.9%	13.5%	10.3%	31.6%	54.2%
Spending/Unit: Single Family							
Wx Direct Treatment	$1,151	$1,334	$1,604	$1,314	$1,580	$1,457	$1,061
Utility Funding	$0	$0	$238	$1,155	$1,072	$1,546	$1,786
Total Treatment	$1,151	$1,334	$1,842	$2,470	$2,652	$3,003	$2,847
Other Wx	$1,487	$1,330	$1,139	$1,348	$950	$723	$526
Total Cost $/unit	$2,638	$2,664	$2,981	$3,818	$3,602	$3,726	$3,373
Low Cost, Single Family Only	5.7%	2.6%	1.9%	8.7%	3.9%	12.3%	12.0%

* Note: 2006 data is based on partial year from April 2006 to October 2006.

Program Production – Target Evaluation Group

The production and spending trends show that Wx has been undergoing substantial changes over the past few years. The energy impact analysis needed to focus on homes treated in a specific time frame so that a full year of pre-treatment and post-treatment usage data would be available. We chose to focus on the 656 units completed in calendar year 2005 that also had received their energy audit after June 2004. The comparison group for the analysis was defined as units treated in 2006.

Program Data: All Units by Agency for Calendar Year 2005

Table 3 summarizes some key housing, demographic, and spending data for the target homes treated in 2005 broken out by agency. The table shows that the 656 units served by Wx in CY 2005 included relatively few single family homes with utility supplied heat. Just 10% of the units were single family gas heated and 6% were single family electric heated while 39% were multifamily units, and nearly half were non-utility heated single family. The proportion of multifamily units served by agency ranged from 3% for Rock to 74% for B-M. About one in seven homes served by the program were mobile homes.

About one third of the homes had an occupant who was a senior and one third had an occupant with a disability. About 60% of the homes were owner occupied and this rate varied with the proportion of multifamily units, as expected.

Table 3. Program Data CY 2005: All Units by Agency

		By Agency					
	Program	**B-M**	**Rock**	**SWCS**	**SNH**	**Straff**	**Tri**
Total Units Treated	656	230	39	62	113	34	178
Building Type / Heating Fuel							
Single Family Non-utility	45%	15%	64%	90%	27%	68%	71%
Single Family Gas	10%	5%	26%	0%	35%	18%	0%
Single Family Electric	6%	6%	8%	2%	12%	3%	4%
Multifamily Non-utility	8%	10%	0%	8%	3%	0%	11%
Multifamily Gas	25%	64%	0%	0%	12%	12%	0%
Multifamily Electric	6%	0%	3%	0%	12%	0%	13%
Mobile Home (all fuels, part of SF)	14%	6%	28%	8%	5%	38%	25%
Multifamily (all fuels)	39%	74%	3%	8%	27%	12%	25%
Demographics							
Owner Occupied	58%	24%	100%	82%	78%	64%	69%
# Occupants	2.4	2.3	2.2	2.3	2.5	2.6	2.5
Occupants: w/disability	34%	32%	44%	51%	40%	24%	27%
Occupants: Senior	31%	14%	62%	46%	24%	30%	45%
Occupants: children <5	20%	26%	13%	11%	18%	24%	17%
Program Spending Per Unit							
Wx Direct Treatment	$1,052	$464	$1,349	$1,414	$1,666	$1,389	$1,167
Utility Funding	$1,449	$899	$509	$1,367	$1,572	$382	$2,519
Total Treatment	$2,501	$1,363	$1,858	$2,781	$3,238	$1,771	$3,686
Other Wx	$845	$428	$1,898	$1,741	$885	$723	$840
Total Cost $/unit	$3,346	$1,792	$3,757	$4,522	$4,123	$2,495	$4,526
Joint Utility & Wx $	81%	86%	41%	76%	82%	26%	95%
Low Cost (Direct <$200)	32%	69%	3%	16%	22%	3%	8%

Note: agency abbreviations B-M = Community Action Program of Belknap-Merrimack Counties, Rock=Rockingham Community Action, SWCS= Southwestern Community Services, SNH = Southern New Hampshire Services, Straff = Strafford County Community Action, Tri = Tri-County Community Action.

Overall, 81% of the Wx units received joint utility funding. The program spending figures in the table show total direct treatment plus utility costs averaged $2,501 per unit and total spending averaged $3,346. About one third of all units had less than $200 spent on direct Wx treatments. The averages in the table represent more of a mixture than a typical unit because there are large differences between housing types. Fuel types and treatment approaches varied widely between single family site built, mobile homes, and multifamily units so each housing segment was assessed separately.

Program Data CY 2005: All Units by Housing Type, Multifamily by Agency

Table 4 provides a more detailed look at heating fuels, demographics, and treatments broken out for the three main housing types – single family site-built, mobile home, and multifamily. The multifamily results are divided by agency with the three agencies with lower production combined into one column.

Table 4. Program Data CY 2005: by House Type

				Multifamily by Agency			
	SF Site-Built	Mobile Homes	Multi-family	B-M	SNH	Tri	Other
Total Units Treated	308	94	254	170	30	44	10
Total Buildings/Complexes	n/a	n/a	42	8	23	7	4
Heating Fuel							
Electric	12%	3%	15%	1%	43%	55%	10%
Gas	19%	6%	65%	86%	47%	0%	40%
Propane	8%	7%	16%	13%	3%	39%	10%
Oil	57%	39%	4%	0%	7%	7%	40%
Kerosene	2%	44%	0%	0%	0%	0%	0%
Demographics							
Owner Occupied	86%	93%	9%	1%	63%	0%	10%
# Occupants	2.8	2.0	2.0	2.0	2.2	1.7	1.7
Occupants: w/disability	32%	40%	33%	35%	47%	20%	17%
Occupants: Senior	37%	51%	15%	7%	13%	45%	33%
Occupants: children <5	20%	13%	23%	26%	13%	14%	33%
Program Spending Per Unit							
Wx Direct Treatment	$1,549	$1,481	$291	$122	$700	$542	$841
Utility Funding	$1,682	$1,465	$1,160	$966	$1,347	$1,835	$934
Total Treatment	$3,231	$2,946	$1,452	$1,088	$2,046	$2,377	$1,775
Other Wx	$1,051	$889	$580	$431	$913	$756	$1,345
Total Cost $/unit	$4,282	$3,834	$2,032	$1,519	$2,959	$3,133	$3,120
Joint Utility & Wx	75%	60%	96%	100%	80%	100%	50%
Low Cost (Wx Direct <$200)	11%	4%	67%	90%	40%	11%	10%
Measure Installation Rates							
Attic Insulation	73%	33%	88%	100%	43%	73%	80%
Wall Insulation	32%	5%	5%	0%	11%	9%	80%
Floor Insulation	11%	52%	2%	0%	11%	0%	20%
Heating Replacement	7%	5%	1%	0%	8%	0%	0%
Refrigerator*	33%	31%	32%	38%	37%	14%	0%
Lighting*	57%	48%	63%	60%	67%	89%	0%
Insulation Quantities (ft^2/job)							
Attic Insulation	650	237	419	450	302	366	583
Wall Insulation	249	7	22	0	31	30	579
Floor Insulation	43	442	11	0	54	0	189
Air Leakage (CFM50)							
Pre-Treatment Leakage	4,183	2,920	1,439	1,305	2,012	1,273	3,193
Post-Treatment Leakage	2,797	1,767	1,264	1,283	1,463	928	2,273
Leakage Reduction	1,386	1,153	175	22	549	345	920

* Note: Measure installation data may be incomplete as it relies upon agency manual data entry and matching into electric utility tracking system data. Blower door air leakage data based on units with available pre and post-treatment readings (283 SF SB, 90 MH, 227 MF).

The table shows that oil was the most common heating source among single family homes while gas and electric heating comprised less than one third of the homes. Oil and kerosene were both common among mobile homes while gas was the primary heating source for the multifamily units served.

The table also shows that the 254 multifamily units served by the program were located in just 42 buildings and that the majority of these units were in just 8 buildings served by B-M. The 25% of the entire program production listed as gas heated apartments in Table 3 were mostly in just a few buildings treated by B-M (including 3 buildings that had 116 total units). It appears that many of the multifamily units treated by SNH were owner-occupied buildings with just one unit in the building listed as weatherized.

Nearly all single family homes were owner-occupied while mobile homes had the greatest proportion of senior households and households with disabilities.

Single family site-built homes had the greatest treatment costs and received the most utility funding. Wx direct costs averaged about $1,500 in single family homes compared to just $291 in multifamily units. Utility funding comprised about half the treatment cost in single family homes but was about 80% of the treatment cost for multifamily units.

In terms of specific treatments, attic insulation was quite common in single family site-built homes and multifamily buildings but relatively rare in mobile homes. Wall insulation was installed primarily in site-built homes but only about one third of the time. Floor insulation was installed primarily in mobile homes and in the relatively small proportion of site-built homes that were built on crawlspaces rather than basements. Heating system replacements were relatively rare in all building types. Single family site built homes were the leakiest housing stock and had the largest average leakage reductions, although mobile home leakage reductions were larger on a percentage basis. Most multifamily units were fairly tight and often no air sealing work was performed.

It appears that the electric utilities replaced about one third of the refrigerators and replaced lighting in most homes, but the true installation rates are likely to be somewhat greater because the matching of databases may have been incomplete. Matches were found for 52% of mobile homes, 59% of single family site-built homes, and 64% of multifamily units, and installation rates were 53% for refrigerators and 95% for lighting retrofits for these units.

Program Data CY 2005: Single Family Site-Built Homes by Agency

Measure installation rates varied across agencies, especially for single family site-built homes. Table 5 provides a break-out of the heating fuel and treatment data by agency for the 308 single family site-built homes treated in the target period (actually includes some 2-4 unit homes) and redisplays the totals from the last table for reference.

Heating fuels varied widely between agencies -- ranging from a low of 2% utility heating sources for SWCS, where oil dominates, to a high of 66% for SNH where gas service is more readily available. Utility co-funding of jobs also varied widely ranging from about one quarter to more than 90% of the jobs. These differences in utility funds contributed to a range of average total treatment costs per unit from $1,691 to $4,060. Indirect support and administrative costs ("Other Wx") varied nearly five-fold between agencies, partly related to overall contract size (smaller contracts will tend to have higher administrative costs) but also related to how many lower-cost multifamily units were completed, which lowers the overall cost per unit for fixed indirect and administrative costs.

Table 5. Program Data CY 2005: Single Family Site-Built Homes by Agency

	All SF site-built	By Agency					
		B-M	Rock	SWCS	SNH	Straff	Tri
Total Units Treated	308	46	27	52	77	17	89
Heating Fuel							
Electric	12%	26%	11%	2%	17%	6%	7%
Gas	19%	20%	30%	0%	49%	29%	0%
Propane	8%	7%	11%	10%	4%	6%	11%
Oil	57%	39%	48%	81%	30%	59%	79%
Kerosene	2%	9%	0%	2%	0%	0%	0%
Wood	2%	0%	0%	6%	0%	0%	3%
Demographics							
Owner Occupied	86%	80%	100%	90%	83%	63%	89%
# Occupants	2.8	3.2	2.5	2.3	2.6	3.3	3.1
Occupants: w/disability	32%	20%	37%	51%	36%	19%	26%
Occupants: Senior	37%	25%	56%	47%	27%	31%	42%
Occupants: children <5	20%	32%	15%	10%	18%	25%	21%
Program Spending Per Unit							
Wx Direct Treatment	$1,549	$1,359	$1,509	$1,493	$2,031	$1,467	$1,289
Utility Funding	$1,682	$865	$623	$1,524	$1,713	$224	$2,770
Total Treatment	$3,231	$2,224	$2,132	$3,018	$3,744	$1,691	$4,060
Other Wx	$1,051	$420	$1,900	$1,746	$878	$732	$925
Total Cost $/unit	$4,282	$2,644	$4,031	$4,764	$4,621	$2,422	$4,984
Joint Utility & Wx	75%	52%	48%	83%	84%	24%	93%
Low Cost (Direct <$200)	11%	13%	0%	17%	16%	6%	8%
Measure Installation Rates							
Attic Insulation	73%	65%	75%	61%	81%	100%	74%
Wall Insulation	32%	14%	0%	20%	47%	27%	41%
Floor Insulation	11%	11%	13%	8%	10%	9%	13%
Heating Replacement	7%	0%	40%	12%	0%	0%	6%
Refrigerator*	33%	24%	7%	65%	30%	6%	36%
Lighting*	57%	37%	15%	75%	56%	6%	80%
Insulation Quantities (ft²/job)							
Attic Insulation	650	594	601	554	737	840	644
Wall Insulation	249	99	0	109	515	194	233
Floor Insulation	43	48	35	11	51	18	58
Air Leakage (CFM50)							
Pre-Treatment Leakage	4,183	3,854	4,803	3,875	3,513	4,090	4,854
Post-Treatment Leakage	2,797	2,737	3,050	2,858	2,581	2,737	2,892
Leakage Reduction	1,386	1,117	1,753	1,016	933	1,353	1,962

Wall insulation rates varied from 0% to nearly 50%. Apparently some contractors refuse to insulate walls when there are any complications. Agencies have expressed some frustration with contractors refusing certain types of work and few alternatives. The average wall insulation job is fairly small at just 783 ft² when installed (783 ft² * 32% of jobs = 249 ft² overall).

Average air leakage reductions ranged from 933 to 1,962 CFM50. Much of the range can be traced to differences in pre-treatment leakage – the agencies with pre-treatment leakage rates near 5,000 CFM50 achieved the highest reductions while the lowest reductions were from the agency with the tightest homes. The average post-treatment leakage rates were in a fairly narrow range from 2,581 to 3,050.

III. TELEPHONE SURVEY: KEY FINDINGS

The telephone survey task was conducted by evaluation subcontractor APPRISE, Inc. The detailed survey report is available as a separate document, but some key findings are summarized here.

The survey excluded multifamily participants since many would not be aware of the program treatments that may have been applied to the building. The remaining participants were stratified based on whether they had utility-supplied or bulk heating fuel. Due to the smaller number of utility-heated clients and the fact that they would be the focus of the billing data analysis, the survey attempted to sample 100% of those clients. Overall, the 20 minute survey was completed by 265 program participants from 2005 and 2006. The response rate of 83% exceeded expectations leading to 65 more surveys than originally planned. Key findings are summarized below.

Demographics:

- 97% of participants have at least one "vulnerable" member meaning an occupant who is elderly, a child, or has a disability or special medical condition
- About one quarter of participants are widows
- Nearly half of the participants attended at least some college
- 41% of households have some income from employment, 44% receive retirement income, and about one third receive TANF
- 23% of households have at least one member who was unemployed and actively seeking work in the past year

Supplemental Heat

- 39% of homes reported using supplemental heating -- 42% of bulk fuel homes and 31% of utility heated homes.
- Among utility-heated homes, 12% reported using wood, 9% reported electric space heaters, 3% reported propane, and 8% reported other supplemental heating.
- Among bulk-fuel heated homes, 21% reported using wood, 12% reported using electric space heaters, 4% reported using propane, and 5% reported using other supplemental heating.
- More than twice as many homes reported owning electric space heaters as reported using them.
- 45% of homes reported using their electric space heater less frequently after weatherization compared to 10% who reported using it more frequently.
- 25% of homes reported using at least some wood heat in the past year (although just 18% listed wood heat as a supplemental fuel).
- Wood heat was more common in bulk-fuel heated homes (28% vs. 17% for utility heated).
- 69% of homes using wood used a wood stove, 11% pellet stove, 2 % wood furnace, and 19% fireplace.
- Among people who used wood heat, about half reported using it all winter.
- For bulk-fuel heated homes that used wood, 24% used it on just the coldest days and 14% used it when they ran out of fuel.
- For utility-heated homes using wood, 43% used it on just the coldest days and none reported using wood due to lack of primary heat.

- 57% of homes using wood reported decreasing their use of wood after weatherization compared to 11% reporting an increase. The majority of homes reporting a change in wood use attributed the change due to a difference in the weather although about one quarter attributed the change due to weatherization. These results imply that wood heating may have reduced observed savings in utility-heated but that the impacts are not very large.
- 17% of homes reported using their stove or oven for heat in the past year – 19% of bulk-fuel homes and 11% of utility heated homes. About half of stove/oven users reported using it on just the coldest days while bulk-fuel homes tended to also use it when they ran out of fuel. 15% reported using it all winter, although that is just 2.6% of the overall sample (15% of 17%).

Energy Affordability:

- 40% of participants reported that it was "very difficult" to pay their monthly energy bills and 37% reported that it was "somewhat difficult".
- 16% of participants reported that they had to go without food at some point to pay their energy bills, 31% went without medical or dental care, 23% went without prescription medicine, and 15% had to skip a rent or mortgage payment.
- 73% of participants reported that Wx has helped them pay other bills because of the energy cost savings.

Energy Education:

- Just 53% of participants reported that providers left them with information on how to save energy.
- 38% reported that they think they could have reduced their energy usage further if the program had provided energy education on ways to save energy.
- 73% of participants reported that the Wx provider was "very knowledgeable" and 19% reported they were "somewhat knowledgeable".

Satisfaction and Other Findings:

- 71% of participants were "very satisfied" with the program, 20% were "somewhat satisfied", 5% were "somewhat dissatisfied", and 3% were "very dissatisfied".
- Participants were generally very satisfied with the quality of all work performed in their homes – fewer than 10% reported being dissatisfied with the insulation or air sealing, 10% reported dissatisfaction with the heating system work.
- 26% reported that they did not receive everything they expected to receive with windows and doors mentioned most frequently.
- 17% mentioned replacing windows when asked of things the program could have done to help them save more energy.
- Just 2% of participants reported that their provider was not "friendly and polite".
- 62% reported improved comfort in the winter while 4% reported worsened comfort.
- 14% reported that there were changes in their household that may have caused usage to increase. About half of these participants cited more people living in the home. Similar proportions reported changes other than Wx that may have caused usage to decrease.

IV. FINDINGS: GAS SAVINGS

There were 231 units treated in the target period and listed as gas heated -- 50 single family homes (including 6 mobile homes), 16 duplexes, and 165 gas heated apartments. We received matching usage data for 66% of the target single family homes (28 site built and 5 mobile homes) and 56% of the duplexes. The data for the duplexes was dropped due to unclear metering configurations.

In the multifamily units, we were able to get understandable usage data for 1 master metered building with 16 units and for 32 separately metered units. We also received some data for multifamily buildings where there were multiple accounts but they did not match the number of units and we could not determine how to allocate units to usage. Many of the unmatched units were in a few larger complexes for which we could not obtain matching data (presumably master metered commercial accounts).

We analyzed the data with a weather normalization algorithm to develop weather adjusted annual usage estimates. We eliminated cases from the analysis if we could not develop reliable annual usage estimates or if there was an extreme change in usage[2].

Single Family Gas Savings

The reliability screening for the single family gas usage analysis removed 6 of the 33 treated homes with usage data. The results for the remaining cases are summarized in Table 6.

Table 6. Single Family Gas Usage & Savings Results

		Usage (ccf/yr)		Savings (ccf/yr)		% Net Savings	
	# units	Pre	Post	Gross	Net	% Total	% Heat
Single Family Participants	27	1282	962	320	277 (±105)	21.6%	27.0%
Site Built Homes	22	1390	1033	357	290 (±108)	20.8%	26.1%
Mobile Homes	*5*	*805*	*650*	*155*	*117 (±105)*	*14.5%*	*17.9%*
Comparison Groups						% Gross Savings	
All Single Family	17	1271	1228	43		3.4%	4.2%
Weighted - Site-Built	17	1315	1248	68		5.1%	6.4%
Weighted- Mobile Homes	9	767	729	38		5.0%	5.9%

Notes: ± figures are 90% confidence intervals on the mean savings. Net savings are calculated by subtracting the change in usage of the comparison group from the participant savings. Comparison group results are weighted by pre-treatment usage bin to better match participants for the site built vs. mobile home breakout.

The average annual gas usage for the 27 participants in the analysis dropped from 1,282 ccf to 962 ccf, for a gross savings of 320 ccf. The comparison group homes also exhibited a drop in usage of 43 ccf. This apparent 3% savings for the comparison has been found in several other recent weatherization evaluations and is believed to be related to the gas price spike that occurred in early 2006 (the start of the post-treatment period). After adjusting for the comparison group, the net program savings in single family gas heated homes are estimated at 277 ccf, equal to about 22% of pre-treatment gas usage and 27% of pre-treatment heating usage. This level of savings compares favorably to evaluation results from other states' Wx programs.

[2] Usage results were considered unreliable if we could not determine which housing units the meter included, or if the data spanned fewer than 210 days or fewer than 40% of a typical year's heating degree days, or the relative uncertainty in normalized usage was >=20%, or the fit of the usage to weather was poor (r-squared<.=70), or heating or baseload usage estimates were negative, or the normalized annual consumption estimate was <=300 ccf/yr, or the change in total usage was greater than 65% or the change in heating or baseload usage was more than 100%.

The savings results have considerable uncertainty due to the small sample size. The uncertainty in the net savings is shown as the ± value in parentheses, which is the width of the 90% confidence interval. The net savings confidence interval translates to a range of savings from 162 ccf to 382 ccf, making it difficult to provide firm conclusions beyond the fact that the program is producing substantial savings.

The small sample provides little opportunity for more detailed analyses such as statistical modeling of measure-specific savings, but the results can be explored in some simple ways, including basic splits of the group and how savings compare to expectations based on the treatments provided.

Since most weatherization evaluations have found that mobile homes have lower usage and savings, we compared the savings in the 5 treated mobile homes with the 22 site built homes. There were no mobile homes in the comparison group, so we stratified the comparison group based on pre-treatment usage and weighted the results to reflect the usage levels of each participant group. These results are shown in the table. Net savings for site built homes were 290 ccf while savings for the 5 mobile homes averaged just 117 ccf. Clearly this result has large uncertainty (the row is shown in italics to emphasize this point), but the savings estimate is actually quite close to most other mobile home weatherization studies.

Another common expectation is that higher use homes will save more gas than lower use homes. We split the site-built group in half based on pre-treatment gas usage and compared the 11 cases with usage above 1200 ccf to the 11 cases with usage below 1200 ccf. The net savings, adjusted using a weighted comparison group, averaged 437 ccf (24% of usage) for the higher use homes and 142 ccf (15% of usage) for the lower use homes. Somewhat unexpectedly, the average treatment spending was actually higher among the lower use homes than the higher use homes and there were few differences in the measures installed between the groups. However, the small samples make any conclusions difficult.

Single Family Gas Savings: Projections & Population Savings

Although the small sample of homes in the analysis prevented us from statistically estimating savings by measure, we could explore the savings from major measures by calculating the expected savings from each measure based on findings from other weatherization studies. If these savings predictions match the overall savings, then it supports the idea that these measure-specific savings projections may be reasonable to apply to NH Wx. These measure-specific savings estimates then could be used to develop an estimate of the overall program savings for all fossil fuel heated homes based on the measures installed.

We reviewed measure-specific savings estimates from multiple weatherization evaluations and developed a conservative set of savings estimates that are perhaps only half as large as most computerized energy audits would predict, but are in line with actual measured results. The savings estimates were: 0.16 ccf/ft² for wall insulation, 0.12 ccf/ft² for attic insulation, 0.05 ccf/ft² for floor insulation, 0.05 ccf/CFM50 reduction for air sealing, and 102 ccf for heating system replacements (calculated as 10% of average heating usage). For comparison, the average projected savings for attic and wall insulation contained in the utility TREAT/OTTER system for homes with fossil fuel heat were 0.25 ccf/ft² for attics and 0.42 ccf/ft² for walls -- more than double these projections. We multiplied the projected per unit savings by the actual quantities installed in each home to calculate the projected total savings per home. The results of these projected savings calculations are shown in Table 7.

Table 7. Savings Projections by Measure: single family (ccf/yr)

Measure	Projected Savings	Gas Heated SF Sample		Fossil Fuel Heated SF Population	
		Quantity	Savings	Quantity	Savings
Attic Insulation	0.12 ccf/ft²	650	78	521	63
Wall Insulation	0.16 ccf/ft²	622	100	206	33
Floor Insulation	.05 ccf/ft²	90	5	144	7
Air Sealing	.05 ccf/CFM50	1,337	67	1,390	70
Heating System Replacement	102 ccf/unit	0.111	11	.066	7
Total Projected Savings (ccf/yr)		27 homes	260	363 homes	179
Measured Savings / Population Projection			277	Population Savings	19.1 MMBtu

The projected savings averaged 260 ccf for the 27 homes in the analysis sample – quite similar to the measured savings of 277 ccf. We further assessed the reliability of the projections by predicting the savings for mobile homes and site built homes separately and found 135 ccf projected for mobile homes (vs. 117 ccf measured) and 289 ccf projected for site built homes (vs. 290 ccf measured). Although the high level of agreement could be due to other factors, such as randomly offsetting errors, the empirical basis for the estimates and the consistency of the results within the limited samples here suggest that they may be a reasonable approximation to the actual savings. This assessment is primarily based on the savings estimates for three measures – attic insulation, wall insulation, and air sealing – because the other measures are too infrequent to have much impact on overall savings.

Given the apparently reasonable results from the savings projections, we calculated the projected savings for the entire fossil-fuel heated (non-electric) single family participant population of 363 homes. Those results are shown in the last two columns of the table. The larger population received much less wall insulation and somewhat less attic insulation than the gas heated analysis sample. These differences lowered the projected savings to 179 ccf for fossil fuel heated population. We adjusted this figure for the ratio of measured to projected savings found in the gas heated sample (277/260=1.065), and for slight differences in the proportion of homes using each heating fuel for which we had savings projections, and for the Btu content of gas to arrive at the overall program population savings estimate for fossil fuel heated single family homes of 19.1 MMBtu per home. In terms of other fuels, these savings are equivalent to 137 gallons of fuel oil, 208 gallons of propane, 141 gallons of kerosene, or about one cord of wood.

The extrapolation of the projected savings from the gas heated analysis group to all fossil fuel heated homes entails considerable uncertainty. There is the uncertainty in the assumed savings from each measure, uncertainty in the de-facto assumption that heating system efficiencies are about the same for all fuels, and uncertainty related to the possibility that there may be savings opportunities specifically associated with certain fuels. For example, it may be reasonable to assume that heating system tune-ups save more energy in oil heated homes than gas heated homes due to differences between oil and gas equipment. In addition, certain fuels may be associated with specific housing construction features that may produce different savings for some measures, for example balloon frame walls may be more common in oil heated homes and lead to greater wall insulation savings per square foot; or crawlspaces rather than basements may be more common in propane heated homes providing unique savings opportunities. These issues may be worth exploring in future evaluations and, based on a cursory review, tend to imply that savings may actually be slightly larger in homes that heat with bulk fuels compared to gas heated homes, even with the same set of measures installed. This impact is unlikely to be dramatic or substantially change the overall conclusions of the evaluation.

Single Family Gas Savings: Comparison to Other Programs

Figure 5 shows the gas savings results for most of the Wx evaluations of the past 15 years (and some older). The figure plots the average savings against the average pre-treatment usage for each program with points labeled by the state postal abbreviation and program year of the analysis. Labels ending in MH show the results for just mobile homes. A sloping reference line is drawn showing 15% savings. The single family gas heated home results from this evaluation are shown by a large gray-filled circle labeled NH05 with grid lines crossing vertically and horizontally.

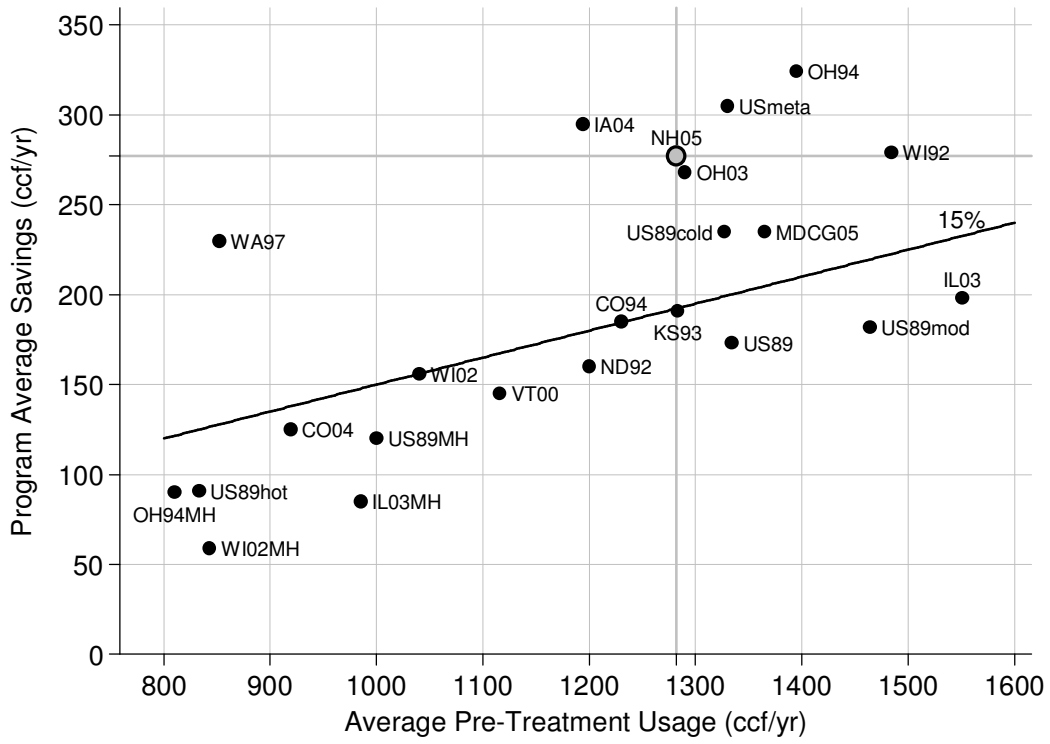

Figure 5. Weatherization Program Evaluations: Gas Savings vs. Pre-Treatment Usage

The savings in single family gas heated homes in this evaluation are higher than most state Wx program results. Only top performing states Iowa, Ohio (1994 only), and Wisconsin (1992 only) have higher measured savings[3]. The savings also compare quite well with the state most similar in terms of climate and housing stock – the point labeled VT00 shows the gas savings results from the Vermont Wx program of 2000, where savings averaged 145 ccf. Interestingly, the estimated fossil fuel population savings of 191 ccf from the measure savings analysis would still place New Hampshire's Wx above the norm in terms of energy impacts.

High saving states like Iowa and Ohio are characterized by fairly high usage, a housing stock with many insulation opportunities (50% wall insulation rates), and 40%-50% heating system replacements, often paid by utility funds. New Hampshire has a fairly low 27% wall insulation rate and just 7% heating system replacements (7%), but does benefit from utility co-funding in many homes.

[3] The point labeled USmeta is actually not a billing data analysis result, but a statistical estimate based on pooling multiple studies by Oak Ridge National Labs.

Multifamily Gas Savings

There were 165 gas heated apartments treated in the target period and we received matching usage data that we could assign to units for 1 master metered building with 16 units and for 32 separately metered units. The reliability screening removed 9 of the separately metered units, leaving a total of 39 apartments in the analysis -- 23 separately meter units and the 16 unit master metered building. We divided the usage results for the master metered building by the number of units in the building to maintain the scale of savings as ccf per unit. For the comparison group, we had usable data for 11 separately metered units. The analysis results are summarized in Table 8.

Table 8. Multifamily Gas Usage & Savings Results

		Usage (ccf/yr)		Savings (ccf/yr)		% Net Savings	
	# units	Pre	Post	Gross	Net	% Total	% Heat
Multifamily Participants	39	683	602	81	69 (±51)	10.0%	13.7%
Comparison Groups						% Gross Savings	
Raw	11	1,338	1,294	44		3.3%	4.1%
Weighted	11	686	673	13		1.8%	2.6%

Notes: ± figures are 90% confidence intervals on the mean savings. Net savings are calculated by subtracting the change in usage of the comparison group from the participant savings. Comparison group results are weighted by pre-treatment usage to better match participants.

The net savings averaged 69 ccf, equal to 10% of pre-treatment usage and 13.7% of pre-treatment heating usage. Most of the savings were due to the master metered building, where usage dropped by 15% from 14,943 ccf to 12,643 ccf, averaging a 144 ccf savings per unit. Beyond this positive result for the sole master metered building in the analysis, the sample size is too small to provide any further insights into the multifamily gas savings.

In the overall program, there were 165 gas heated multifamily units and 50 other bulk fuel heated multifamily units (41 propane and 9 oil). To assess if the gas savings could be reasonably applied to the bulk fuel heated buildings, we compared the groups in terms of program treatments and found approximately balancing differences – the gas heated units received slightly more attic insulation but the bulk fuel heated units received larger air leakage reductions. Based on this assessment, we determined that it is not unreasonable to extrapolate the gas savings to the bulk fuel heated multifamily units.

V. FINDINGS: ELECTRIC SAVINGS

We analyzed the electric usage data in four segments defined by building type -- multifamily vs. single family-- and heating type – electric heat vs. not electric heat. We employed a heating/cooling degree day weather normalization algorithm for all cases and eliminated units from the analysis if we could not develop reliable annual usage estimates or if there was an extreme change in usage[4]. For the electrically heated segments, we removed units that did not appear to actually use electric heat (estimated heating usage of less than 2000 kWh either pre or post treatment for single family) and added units that appeared to have electric heat (>4,000 kWh estimated heating use).

Single Family Electric Heating Savings

There were 37 single family homes (including 3 mobile homes) and 2 duplexes treated in the target period listed as electrically heated. We received matching usage data for 81% of the single family homes (27 site built and 1 mobile home) and both of the duplexes. The duplex usage appeared to represent just the individual units but the results were kept with single family.

The reliability screening removed 7 of the 30 treated homes with matching usage data, primarily due to a lack of summer data. Screening for electric heating usage removed three more units but also identified 6 units that were not listed as electrically heated but with usage data that showed heating loads. The usage and savings analysis results are summarized in Table 9.

Table 9. Single Family Electric Heating: Usage & Savings Results

		Usage (kWh/yr)		Savings (kWh/yr)		% Net Savings	
	# units	Pre	Post	Gross	Net	% Total	% Heat
Single Family Participants	26	21,556	19,176	2,380	2,182 (±1381)	10.1%	18.3%
Comparison Group						% Gross Savings	
Raw	19	18,250	18,375	-126		-0.7%	-1.5%
Weighted	19	21,591	21,393	198		0.9%	2.0%

Notes: ± figures are 90% confidence intervals on the mean savings. Net savings are calculated by subtracting the change in usage of the weighted comparison group from the participant savings. Comparison group results are weighted by pre-treatment usage bin to better match participants.

The average annual electric usage for the 26 participants in the analysis declined by 2,380 kWh -- from 21,556 kWh to 19,176 kWh. The comparison group, weighted to reflect the participant group usage, experienced a small drop in usage -- from 21,591 to 21,393 kWh. The net savings in electrically heated single family homes are estimated at 2,182 kWh, equal to about 10% of pre-treatment usage. This level of savings is comparable to the few results that have been measured in other Wx evaluations – 1,830 kWh (12%) from the 1989 National Wx study and 2,002 kWh (9%) from the 1994 Ohio Wx evaluation. Two electric heating programs have shown considerably higher savings – 2,991 kWh (13%) from the 1997 Washington State Wx evaluation and 3,151 kWh (10.7%) for the Ohio EPP/TEE program – but all evaluation results have tended to range between 9% and 13% savings.

Electric usage can be more variable from year to year than gas usage due to the wide variety of end uses that can be affected by household decisions such as the occupancy schedule of the home and the addition of plug loads such as computers, video games, digital cable boxes, etc. The need to potentially adjust for

[4] Usage results were considered unreliable if the data spanned fewer than 270 days or 40% of a typical year's heating or cooling degree days, or if there were no true baseload periods, or the normalized annual consumption estimate was less than 1200 kWh or greater than 70,000 kWh, or the change in total usage was greater than 65%.

winter and summer seasonality of usage also adds to the uncertainty in the results. This variability is reflected in the relatively large uncertainty in the net savings estimate – the 90% confidence interval width equals 63% of the net savings. No splits of this small analysis group seemed to reveal any sensible pattern of savings related to pre-treatment usage or building characteristics. Homes with higher usage actually had lower average savings, as did homes that received refrigerator replacements. Clearly factors other than the program treatments are affecting electric usage in specific homes and the sample size is too small to allow for these changes to even out.

Single Family Electric Heating Savings: Projections & Population Savings

We employed the projected savings approach that was used in the single family gas heated analysis to estimate savings associated with measures and estimate the net savings for the full electrically heated single family population. One challenge to this approach is that there have been virtually no studies of measure-specific savings for electrically heated homes and so we attempted to adjust the gas heat savings estimates to reflect the higher heating system efficiency (70% for gas vs. 100% for electric) and generally higher initial R-values of electrically heated construction (we adjusted Btu savings downward by 40% for attic and wall insulation). We also added in electric baseload savings of 700 kWh per refrigerator replaced and 200 kWh for each home that received lighting retrofits. This savings projection approach did not work very well. We estimated average savings of 3,649 kWh per home (3,089 kWh in heating and 546 kWh in baseload) compared to the measured savings of 2,182 kWh. The source of this large discrepancy is unknown and the analysis sample is too small to assess how to remedy it.

Fortunately, although the savings projections approach did not work, it was not critical to the overall program evaluation because the electrically heated single family population is fairly small and the analysis group includes more than half of the units in the full target population, so the potential for a biased sample to affect results is small. A review of the treatment installation rates indicates that savings were likely to be slightly lower in the full population than in the sample, but the differences are not large.

Multifamily Electric Heating Savings

There were 39 multifamily units treated in the target period listed as electrically heated. We received matching usage data for 74% (29 of 39) of these units, which were all separately metered. There was one building with 17 units, one with 6 units, and 6 units that appeared to be individually served apartments in separate buildings. For the comparison group, there were just 36 units in two electrically heated multifamily buildings that began treatment in 2006 and just one of these units was matched.

The reliability screening removed 5 of the treated units with usage data and one unit due to a lack of electric heating usage, leaving 23 units for the analysis. The units included 2 individual units, all 6 units in a 6 unit building and 15 units in a 17 unit building. The screening also removed the only comparison group unit. To provide an estimate of net impacts, we tried using the single family electric heated comparison group and restricted the sample to only units that used less electricity than the highest use treated unit (15,071 kWh), leaving just 8 homes. The results are summarized in Table 10.

Table 10. Multi Family Electric Heating: Usage & Savings Results

		Usage (kWh/yr)		Savings (kWh/yr)		% Net Savings	
	# units	Pre	Post	Gross	Net	% Total	% Heat
Multifamily Participants	23	10,036	9,224	813	*1,560 (±1,082)*	*15.5%*	*30.7%*
Comparison Group						% Gross Savings	
Single Family (<15,100 kWh)	*8*	*11,170*	*11,917*	*-747*		*-6.7%*	*-12.4%*

Notes: ± figures are 90% confidence intervals on the mean savings. Net savings are calculated by subtracting the change in usage of the comparison group from the participant savings. Caution: comparison group is small and single family.

The annual usage for the treated apartments dropped by 813 kWh, from 10,036 kWh to 9,224 kWh. The small comparison group of single family electrically heated homes had similar pre-treatment usage to the participants and experienced a fairly substantial increase in usage of 747 kWh, nearly 7% of usage This usage increase is unusually large, although certainly not infeasible. Still, the very small sample size and the fact that the comparison units are not apartments makes the net savings of 15.5% suspect (and therefore shown in italics).

Electric heating usage averaged about half of the 10,036 kWh average annual usage. The program treatments consisted of added attic insulation in nearly all buildings, a small air leakage reduction (208 CFM50 average), refrigerator replacements in 35% of units and lighting retrofits in virtually all units. This set of treatments is likely to save somewhere between the 813 kWh gross savings and the 1,560 kWh estimated net savings. As a somewhat arbitrary "best estimate", we have decided to use the midpoint of this range – 1187 kWh, which also happens to work out to about 12% and is in the range of other studies for electrically heated homes. The relatively small number of electrically heated apartments in the treatment population makes the overall evaluation conclusions relatively insensitive to this choice.

Single Family Electric Baseload Savings

Although Wx does not provide any measures directly aimed at reducing electric baseload usage, the joint electric utility programs do and program weatherization measures may also reduce electric use either due to reduced furnace fan operation from heating savings and/or from air conditioning load reductions related to weatherization.

There were 356 single family (and duplex) homes treated in the target year that did not have electric heat. Matching into the fuel assistance and electric utility HEA program databases identified account information for 202 of these homes. Fewer than 20 homes were served by either GSE or Unitil and so data collection was only pursued for the 175 homes served by PSNH and NHEC. The utilities provided matching usage data for 127 of the homes (73%).

The usage analysis reliability screening eliminated 22 of these homes (17%) from the analysis, primarily due to insufficient post treatment data. The results of the analysis are shown in Table 11 along with a break-out of savings by whether the refrigerator was replaced under the electric utility program.

Table 11. Single Family Electric Baseload: Usage & Savings Results

		Usage (kWh/yr)		Savings (kWh/yr)		
	# units	Pre	Post	Gross	Net	% Net Save
Participants	105	8,195	7,323	872	780 (±512)	9.5%
-Refrigerator replaced	60	7,509	6,488	1,020	1,184 (±686)	15.8%
-No Refrigerator replaced	45	9,110	8,435	675	533 (±807)	5.8%
Comparison Group						Gross %
Raw	71	8,711	8,653	59		0.7%
Weighted - all	71	8,323	8,231	92		1.1%
Weighted – fridge replaced	33	7,368	7,532	-164		-2.2%
Weighted – no fridge replaced	38	9,374	9,232	142		1.5%

Notes: ± figures are 90% confidence intervals on the mean savings. Weighted comparison groups based on stratification of pre-treatment usage to better match participants.

Annual electric usage declined by 872 kWh for participants and by 92 kWh for the weighted comparison group, yielding net savings of 780 kWh, equal to about 10% of pre-treatment usage. These savings are comparable to other baseload electric programs that include the primary measures of refrigerator

replacements and lighting retrofits – the Ohio EPP moderate use program had average savings of 697 kWh in PY04 among slightly lower use homes and the PP&L WRAP program achieved savings of 836 kWh in 2003 in homes with somewhat higher usage.

Net savings averaged 1,184 kWh for the 60 homes that received a refrigerator replacement and 533 kWh for the remaining 45 homes that did not. The 651 kWh difference in savings between the groups is consistent with expectations and other similar evaluation studies, that have typically found savings of 600 to 900 kWh per refrigerator replaced, varying largely with the program replacement criteria and the vintage of existing refrigerators.

We applied the net savings of the refrigerator and no refrigerator groups to the population of 356 single family electric baseload homes to calculate average electric baseload savings of 741 kWh per home.

Multifamily Electric Baseload Savings

There were 215 multifamily apartment units in 29 buildings treated in the target year that did not have electric heat. Many apartments are located in master metered buildings for which we had no account number information. The two primary electric utilities, PSNH and NHEC, were able to provide matching usage data for 65 of the separately metered units located in 12 buildings. The majority of the units were located in two buildings -- 39 units from a 40 unit building and 15 units from a 16 unit building. The remaining units were in apartments from buildings with two or fewer treated units listed.

The usage analysis reliability screening eliminated 15 of the 65 units (23%) from the participant group. The comparison group included 18 units from 10 different buildings, with 6 of the units located in a 14 unit building. The results of the analysis are shown in Table 12 along with a break-out of savings by whether the refrigerator was replaced under the electric utility program.

Table 12. Multifamily Electric Baseload: Usage & Savings Results

		Usage (kWh/yr)		Savings (kWh/yr)		
	# units	Pre	Post	Gross	Net	% Net Save
Participants	50	4,273	3,770	502	429 (±423)	10.0%
-Refrigerator replaced	27	4,257	3,473	784	711 (±443)	16.7%
-No Refrigerator replaced	23	4,292	4,120	172	98 (±526)	2.3%
Comparison Group						Gross %
Raw	18	4,573	4,500	73		1.6%

Notes: ± figures are 90% confidence intervals on the mean savings. Weighted comparison groups based on stratification of pre-treatment usage to better match participants.

The net savings averaged 429 kWh per unit, equal to 10% of pre-treatment usage. The kWh savings are smaller than found in the single family baseload homes, but the percent savings are similar and are consistent with results from other baseload electric programs. As expected, savings were much higher in units that received a refrigerator replacement than in units that did not. The 98 kWh net savings in units that did not receive a refrigerator appears somewhat lower than expected given that 96% of the units had lighting retrofits which should save perhaps twice that amount. The small sample size and high variability in usage is reflected in the very wide confidence interval that spans from -428 kWh to +624 kWh for those homes. We applied these results to the full population of fossil fuel heated multifamily units based on the refrigerators and lighting installation rates. The overall estimated baseload electric savings averaged 293 kWh per unit for the fossil fuel heated multifamily units.

VI. OVERALL ENERGY IMPACTS AND COST EFFECTIVENESS

From the billing data analysis, we have developed estimates of the fossil fuel and electricity savings for each of the four participant population segments: single family fossil fuel heated homes, single family electrically heated homes, multifamily fossil fuel heated apartments, and multifamily electrically heated apartments. In order to provide overall program impacts, we needed to combine these energy impacts and apply fuel price data to assess overall bill savings for clients.

Fuel Costs and Bill Savings

We calculated the annual bill savings based on New Hampshire fuel price survey data from the OEP web site and selected December 2006 prices as representative. The prices used were $0.15/kWh for electricity, $1.44/th for natural gas, $2.38/gal for fuel oil, $2.37/gal for propane, and $2.82/gal for kerosene. For the few homes with wood heat, we used $150/cord as a rough estimate. For fossil fuel heated buildings, we calculated a weighted average fuel cost based on the proportion of homes with each type of heating fuel. This calculation yielded average costs of $17.71/MMBtu for single family homes and $16.68/MMBtu for multifamily units.

We did not account for any participation in low income bill discount programs which are available from utility companies. To the extent that Wx clients participate in these programs, part of the bill savings calculated in this study will actually accrue to ratepayers rather than to the clients. The high prevalence of bulk fuel heated homes lessens the potential impact of this effect.

The overall program energy and bill savings are summarized in Table 13.

Table 13. Overall Energy and Bill Impacts

		Annual Energy Savings		Annual Bill Savings		
Housing Segment	**# units**	**MMBtu**	**kWh**	**Fossil Fuels**	**Electricity**	**Total**
Single Family fossil fuel heat	363	19.1	741	$330	$111	$441
Single Family electric heat	39	0	2,182	$0	$327	$327
Multifamily fossil fuel heat	215	7.1	293	$119	$44	$162
Multifamily electric heat	39	0	1,187	$0	$178	$178
Total Program	656	12.9	706	$221	$106	$327

The program saved an average of 12.9 MMBtu of fossil fuels and 706 kWh per unit served. These energy savings are worth an average of $327 per year in energy bill savings. Average bill savings were largest in single family fossil fuel heated homes at $441 per year. Three quarters of those savings were from heating fuel savings and one quarter from electric baseload savings. Bill savings in apartments averaged less than half that much at $162 - $178, depending on whether they have electric heat. The increasing fraction of apartments served by the program reduced average bill savings, but the lower cost of serving these units may be increasing overall benefits. To assess the relative cost-effectiveness of the different segments requires comparing these bill savings to program costs and also assessing the longevity of the benefits -- $100 in annual savings from CFL lighting is worth less than $100 in annual savings from wall insulation.

Cost Effectiveness Analysis

Standard cost-effectiveness analysis involves calculating the net present value of the program's benefits and comparing them to the program's costs. This assessment is complicated by the fact that it is usually much easier to measure the costs of the program than to measure the full range of benefits which can extend well beyond just energy bill savings.

A study of non-energy benefits for the National Wx estimated total non-energy benefits were worth $3,346 per home weatherized, slightly larger than the value of the energy bill reductions[5]. Some of the larger benefits included:

- environmental impacts from reduced burning of home heating fuels and electric usage reductions;
- health and safety benefits provided by identification and repair and replacement of faulty heating and water heating equipment as well as other health and safety related spending and health and safety benefits of reducing the likelihood of households going without heat or utility service;
- affordable housing stock preservation benefits from the extensive home repair and improvements provided by the program;
- economic benefits from the labor-intensive nature of weatherization compared to energy production and utility industries; and,
- utility ratepayer benefits from reduced costs associated with unaffordable utility bills.

New Hampshire's Wx program devotes considerable resources toward health and safety testing and repairs and much of the energy savings of the program are expected to affect higher polluting fuels such as fuel oil. Clearly any cost-effectiveness analysis that does not consider the value of non-energy benefits is understating the benefits of the program. With this caveat in mind, we have calculated the cost-effectiveness of NH Wx without consideration of these non-energy benefits.

Properly assessing the cost-effectiveness of NH Wx is further complicated by the joint utility funding of almost every home served. The energy savings analysis has included all of the energy savings, regardless of which program funded which measures. Therefore, the cost-effectiveness analysis must either include utility costs or allocate bill reductions to the different programs. We decided to include the cost of the utility programs spending rather than arbitrarily try to disentangle the savings attributable to each funding source.

The cost-effectiveness calculations required estimates of the discount rate for discounting the value of future benefits, the future prices of the energy saved, and the longevity of the bill savings. For this analysis, the key assumptions were:

- a discount rate of 4% , fairly typical for government social program analysis;
- 0% real increase in fuel prices over time (most likely a very conservative choice); and,
- a measure savings lifetime of 20 years for weatherization measures and 12 years for electric baseload measures (a rough savings-weighted average of refrigerator and lighting measures). For electrically heated units, we used a weighted average measure lifetime based on the difference in savings between the baseload and electric heating units, which worked out to 17.3 years for single family and 18.0 years for multifamily.

In terms of costs, we performed the calculations based on total Wx costs (including all administrative costs), and total costs including utility spending. Health and safety costs were not removed from the calculation even though that spending is not designed for energy savings. The results of the analysis are shown in Table 14.

[5] "Nonenergy Benefits From The Weatherization Assistance Program: A Summary Of Findings From The Recent Literature", M. Schweitzer and B. Tonn, Oak Ridge National Laboratory, ORNL/CON-484, 2002.

Table 14. Cost Effectiveness Analysis: excluding non-energy benefits

		Lifetime Bill Savings (p.v.)			Program Costs		Benefit/Cost Ratio	
Housing Segment	# units	Fossil Fuels	Electric	Total	Wx	Wx & Utility	Wx	Wx & Utility
Single Family fossil fuel heat	363	$4,479	$1,043	$5,522	$2,805	$4,409	1.97	1.25
Single Family electric heat	39	$0	$4,028	$4,028	$1,812	$3,703	2.22	1.09
Multifamily fossil fuel heat	215	$1,611	$412	$2,024	$967	$1,970	2.09	1.03
Multifamily electric heat	39	$0	$2,256	$2,256	$1,409	$3,436	1.60	0.66
Total Program	656	$3,007	$994	$4,001	$2,061	$3,510	1.94	1.14

The value of the lifetime bill savings produced by the program exceeds the total program plus utility costs by 14% (BCR=1.14 in bottom right corner). The average lifetime bill savings are worth $4,001 while total costs averaged $3,510. The addition of non-energy benefits would make this program appear even more cost-effective.

The most cost-effective program segment was single family fossil fuel heated homes, with bill savings worth $5,522 and total costs of $4,409, yielding a benefit/cost ratio of 1.25. The least cost-effective program segment appeared to be multifamily electrically heated apartments, where the bill reductions averaged $2,256 compared to $3,436 in average total costs. However, the sample size was quite small for the electric multifamily usage analysis and the comparison group may have been inappropriate leading to large uncertainty in this result. However, the estimated savings appear reasonable for the type of housing, implying that the cost effectiveness problem may be more about the cost than the savings.

In aggregate terms, NH Wx provided $2.62 million in lifetime fuel bill savings by spending $2.30 million on all program costs including DOE and utility funds. The program undoubtedly also produced substantial non-energy benefits that remain unquantified.

VII. CONCLUSIONS AND RECOMMENDATIONS

The New Hampshire weatherization program provides substantial and cost-effective energy savings to the low income households it serves. Annual energy savings averaged 12.9 MMBtu of fossil fuels and 706 kWh of electricity per unit served in 2005, worth $327 in annual energy bill savings. The overall present value of the lifetime energy savings is estimated at $4,001 per household. Total spending averaged $3,510 per unit -- $2,061 in Wx program spending and $1,449 in utility program spending – yielding an overall benefit/cost ratio of 1.14. The program was cost-effective without even considering any of the potential non-energy benefits it produced.

Energy savings and cost-effectiveness were highest in fossil-fuel heated single family homes, which saved an average of $441 per year on their energy bills and provided a benefit cost ratio of 1.25. Multifamily electrically heated apartments were the least cost-effective segment in the program, with annual bill savings estimated at $178 per year and a benefit/cost ratio of 0.66.

The NH Wx program savings compare very well to other weatherization programs across the nation. The high level of performance can be attributed to a strong technical design based on diagnostic-driven treatments and to an experienced and well-trained group of state and local agency staff and contractors. However, we were able to identify several areas where the program could be enhanced.

Targeting

NH Wx has grown dramatically in recent years due to the availability of utility funding to treat certain types of homes. Much of the growth has occurred in multifamily utility-heated apartments while the number of single family fossil-fuel heated homes has actually declined slightly. Some providers raised concerns about maintaining and improving services to these homes that don't meet utility targeting criteria. OEP should consider options such as creating a quota or separate waiting list for homes that don't qualify for utility-funded weatherization (i.e., are not electric "A" jobs or gas heated).

Wall Insulation

Wall insulation is a very high impact measure that is performed in about one third of single family site built homes. The installation rate varies from 0% to 47% across agencies. Some agencies have reported that their contractors refuse to perform wall insulation in too many cases where complications are encountered (related to factors such as some existing insulation, siding, wiring, etc.). OEP and the local agencies should try to more clearly define when wall insulation should and should not be installed and should seek ways to increase low installation rates including requiring a written explanation for homes where insulation is not installed. Agencies should also consider using in-house crews instead of contractors if the contractors avoid certain types of work needed. Contractor work preferences have also been an issue in working on mobile homes.

High Efficiency Heating System Replacements

Heating system replacements are a relatively infrequent treatment in the program and typically involve installing standard efficiency equipment. Although these replacements are done for health and safety reasons, there is no reason to install lower efficiency equipment if higher efficiency units are a cost-effective upgrade. For gas or propane furnaces, upgrading to a 92% unit typically provides a payback of less than 10 years. OEP should generally require high efficiency heating systems whenever systems are replaced and the upgrade is deemed cost-effective. Specific guidelines should be developed for furnaces and boilers and for different fuel types, pre-treatment usage levels, and incremental costs. Local agencies may need to seek out HVAC contractors with greater experience installing high efficiency equipment if current contractors charge too much of a premium for the upgrade.

In addition to upgrading the efficiency of units replaced for health and safety reasons, OEP should also consider developing guidelines for replacing heating systems for energy savings reasons in homes with high heating usage. For example, using a 4% discount rate and a 20 year measure life, a $3000 heating

system replacement can be considered cost-effective if it provides annual savings greater than $221. Assuming a reasonable 20% heating savings, any home with an annual heating usage greater than $1,105 should provide a cost-effective replacement opportunity. These rough calculations demonstrate that there is likely to be some potential for cost-effective heating system replacements. Given the low average cost per unit treated in the current Wx program (related to the high number of apartments served), average spending caps should not be much of an issue for adapting some guidelines for adding this measure. Pre-treatment usage and actual installed costs will clearly be key elements in determining how frequently this measure should be performed.

Client Energy Education

Based on interviews with agency staff and telephone surveys of program clients, it appears that NH Wx provides very little client energy education. Only about half of program participants reported that the local agency left them with any information on ways to save energy and 38% reported that they think they could have saved more energy if the program had given them suggestions on what they could do.

Research projects have found that savings of up to 6% can be achieved by energy education, although this level of savings does not appear to be maintained when pilot programs are replicated into full scale efforts. It is not clear what the true savings potential from energy education may be, but the low cost of providing education makes it almost certainly cost-effective. In addition, education may play a role in helping clients best use and maintain the measures that they do receive.

We recommend that OEP consider adapting a more formal approach to energy education in Wx. Adding energy education will likely involve developing or adapting energy education literature and providing training to energy auditors and inspectors in the selected energy education approach. OEP may want to explore some form of written commitment or "partnership" approach, which has been used in a number of programs, where each client is asked to perform one to three targeted actions to help save energy. Energy actions need to be selected properly so that they have a fairly significant energy savings potential and are also likely to be practiced. OEP may want to consult with energy education specialists from other state weatherization programs and/or specialized energy education consultants to develop a specific program approach.

Program Tracking System Issues

The current Wx program tracking system is fairly rudimentary, does not contain some key information needed for evaluation, and provides very limited capacity for serving a useful role in program management and QC. We recommend that the tracking system be upgraded or replaced so that it contains, at a minimum, data on:

- the quantities for major measures installed including wall, attic, and floor insulation and heating system replacement;
- utility names and account numbers;
- multifamily building identifiers with clear building address, unit identifier, and information about number of units served by same gas and electric accounts; and,
- gas and electric program funding amounts.