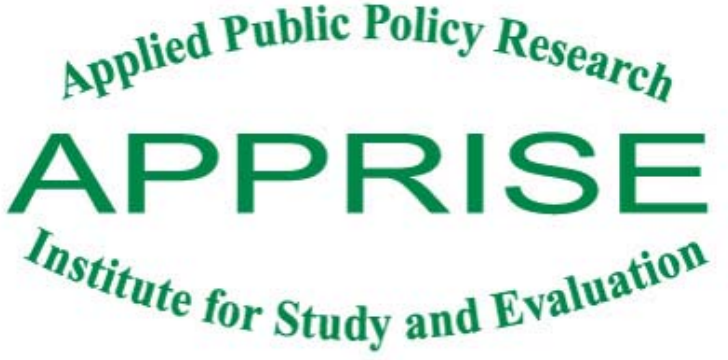

New Jersey Comfort Partners Program Comprehensiveness Evaluation

Final Report

Prepared for the New Jersey Comfort Partners Working Group

August 2002

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Executive Summary

This report presents the findings from the Comprehensiveness Evaluation of the Comfort Partners Program. In this evaluation, we documented the procedures used in the Comfort Partners Program, assessed the extent to which service delivery followed documented program procedures, evaluated the program's procedures in the context of service delivery challenges and in comparison to procedures used in other low-income energy programs, and assessed the extent to which comprehensive services were delivered. We make recommendations for refining and improving the Comfort Partners program. The Comprehensiveness Evaluation is the second component of the evaluation of the Comfort Partners Program.

Introduction

The New Jersey Clean Energy Collaborative consists of Public Service Electric and Gas, Jersey Central Power and Light, Conectiv Power Delivery, Rockland Electric Company, New Jersey Natural Gas, NUI Elizabethtown Gas, and South Jersey Gas. The Collaborative has designed eight Residential Energy Efficiency Programs and three Nonresidential Energy Efficiency Programs to reduce the total amount of electricity and natural gas used in New Jersey and to reduce the summer peak demand for electricity. The Residential Low Income Program Working Group designed the Comfort Partners Program to meet the Collaborative's usage reduction goals and to improve energy affordability for low-income customers.

The Comfort Partners Program was designed to overcome the market barriers affecting energy usage and energy affordability for low-income customers. The program delivers comprehensive usage reduction and energy education services to low-income customers. The program also includes an arrearage forgiveness component designed to assist customers in retiring outstanding arrears.

The Residential Low Income Program Working Group commissioned a comprehensive evaluation "to determine the extent to which Program goals are being achieved and to provide feedback on how the Program might be modified to better achieve these goals." The Working Group contracted with APPRISE to conduct this evaluation. The evaluation team includes APPRISE, MaGrann Associates, Blasnik and Associates, and Renaissance Consulting and Analysis.

Comfort Partners Service Delivery Procedures

The Comfort Partners Program was designed to deliver comprehensive energy services to low-income customers throughout the state. The program is expected to reduce energy costs, improve bill payment capacity, and enhance health, safety, and comfort. In the

Comfort Partners 2002 program filing, the Collaborative committed to deliver services to 6,656 homes and to achieve usage reduction targets.

The program was launched in 2001 and met the ambitious schedule set by the BPU for program implementation. The Residential Low Income Program Working Group (Working Group) successfully developed program specifications documents, selected service delivery contractors, and conducted the initial program training sessions. Each utility is responsible for meeting goals and for paying for services delivered in its service territory. The Working Group developed both cost-sharing agreements and joint recruitment arrangements in overlapping service territories.

The service delivery contractors for the program are Honeywell DMC Services (HDMC) and Bill Busters Inc. (BBI). The third party quality control inspectors are PURE Energy and CMC Energy Services.

The Comfort Partners Program requires service delivery contractors to conduct a comprehensive assessment of each customer's housing unit, to engage the customer in an effective dialogue about the options for saving energy in the home, and to install a comprehensive set of energy saving measures. Certain program elements are designed to contribute to the comprehensiveness and improve the efficiency of service delivery.

- *Utility Bills*: The electric and gas utilities furnish the contractor with the customer's electric and gas usage histories to facilitate identification of energy saving opportunities.

- *Customer Education*: The program pays for up to two hours of customer education at each site visit to ensure that the service delivery staff have the time to explain the service delivery procedures and motivate the customer to take energy saving actions.

- *Testing*: The program pays for testing procedures during each phase of the service delivery to maximize the effectiveness of air sealing and duct sealing efforts, and to ensure that the home is safe at the completion of service delivery.

- *Prioritization Standards and Guides*: The program specification documents furnish explicit standards for replacement of certain appliances and furnish guidelines for the priority among measure opportunities.

- *Measures Allowances*: Based on an analysis of electric and gas bills, the measures allowance gives the field crew guidance on the "expected average costs of typical measures found to be cost-effective" in homes with this usage level.

- *Health and Safety Measures*: In addition to energy saving measures, the program pays for the installation of certain health and safety measures.

The Working Group is designing and implementing a comprehensive third party quality control system to ensure that a high quality program is delivered to low-income customers.

Assessment of Program Procedures

In the first task of the Comprehensiveness Evaluation, the evaluation team assessed the quality and completeness of the Comfort Partners Program procedures. The evaluation team, led by MaGrann Associates, reviewed program specification documents, observed service delivery in the field, and conducted in depth discussions with service delivery contractors, Working Group members, and third party quality control contractors. The team compared program procedures to "best practices" from programs around the country, assessed whether the procedures would lead to consistent delivery of comprehensive services, and considered whether quality control procedures are sufficient to ensure high quality service delivery.

These assessment activities found that the accomplishments of the Working Group and the service delivery contractors are considerable.

- *Working Group*: The Working Group successfully integrated a number of existing low-income energy programs and created a single statewide program that promises to deliver comprehensive usage reduction services to low-income customers. They developed a series of program specification documents that furnish the service delivery contractors with the necessary guidance on program expectations for most program measures, and that serve as an effective platform for communicating updates to program procedures. They conducted training on the new program procedures. They developed customer education materials and training to help the service delivery contractors engage customers as active partners in the usage reduction process.

- *Service Delivery Contractors*: The service delivery contractors quickly adapted to the changes in program procedures. They facilitated the statewide expansion of the program by furnishing administrative and technical support to the utilities that did not previously have low-income usage reduction programs. They successfully met 2001 production goals. They have designed and begun to implement procedures that they believe will enhance service delivery.

With a year of program experience, it is now appropriate for the Working Group and the service delivery contractors to revisit the program procedures, to revise them to address challenges and problems encountered in the field, and to furnish comprehensive training to service delivery staff regarding the program issues and proposed enhancements. The highest priority issues are:

- *Program Specifications*: The three manuals that furnish program specifications represent a commendable breadth of technical documentation and are designed in a way that makes them very accessible to program managers, service delivery supervisors, and field crews. During the first program year, the manuals were updated to reflect some, but not all of the program changes that have been agreed to by the Working Group. In order to ensure that program services meet the

expectations of the Working Group, there needs to be a consistent procedure and schedule for revising and updating these documents.

- *Measure Selection and Prioritization*: The Working Group has furnished a number of tools that assist the service delivery contractors in measure selection and prioritization including replacement standards, prioritization guidelines, and measures allowances. The Working Group should use field experiences, as well as data from the evaluation reports, to reexamine and assess whether these tools result in consistent decision-making in terms of the cost of conserved energy across installed measures. As part of that review, we recommend that the Working Group drop the baseload measure allowance, since it potentially conflicts with other program guidelines that furnish a more direct measure of cost effectiveness for individual energy saving measures.

The evaluation team identified a number of specific areas where we recommend specific changes or enhancements in the specified procedures. The most critical of these are:

- *Blower Door Testing*: One of the most critical steps in the audit of a housing unit is to properly identify the thermal and pressure boundaries of the home. That determination directly affects decisions regarding air sealing, insulation, and the treatment of heating and cooling distribution systems. The evaluation team recommends that the service contractor make it standard practice to do blower door testing at each step in the service delivery so that the field crew has the information that they need to make appropriate treatment decisions.

- *Treatment of Crawl Spaces and Basements*: Given the challenges associated with this housing stock, basements and crawl spaces should be treated as "inside the thermal boundary" unless it is clear from testing that they are or can be moved outside the building envelope.

- *MVG and Test Out Procedures*: We recommend a revision in the Minimum Ventilation Guideline (MVG) and the specification of a formal test-out procedure at the completion of service delivery. These procedures ensure that the service delivery did not introduce new problems into the customer's home.

- *Duct Testing, Sealing, and Insulation*: We recommend using pressure pan testing as a cost-effective alternative to more sophisticated methods. In addition, we recommend changing the specifications on duct sealing and insulation to be consistent with the definition of the thermal boundary of the housing unit. Ducts should only be insulated if they are outside the thermal boundary of the housing units and should be sealed inside the boundary only to address heat distribution, comfort, and safety issues.

- *Heating Systems*: Low-income housing units often have serious heating system problems. We recommend that the program specification documents be revised to provide contractors with specifications for health and safety testing on combustion systems, and to give guidance on allowable heating system repairs. The

specifications should include guidelines for what problems can be addressed under the program and what other actions should be taken for problems that cannot be addressed by the program. [Note: The Working Group adopted health and safety testing standards for combustion appliances. However, the adopted standards have not yet been incorporated into the program specification documents.]

The Comfort Partners Program specification documents have developed a solid foundation for the program. Continued development of these documents should result in improvements in program procedures that will continue to make the program more comprehensive and cost-effective.

Database Analysis of Comprehensiveness

In the second task of the Comprehensiveness Evaluation, the evaluation team used data from the two program tracking system databases to examine measure installation patterns and to help assess whether program treatments were delivered in a consistent, appropriate, and comprehensive manner. The evaluation team, led by Blasnik and Associates, cleaned the program database, examined measure installation frequencies, identified technical interrelationships between program treatments, and made comparisons to program planning assumptions and other similar low-income programs.

The database analysis used 683 completed jobs that were started after 1/1/02. Among the homes analyzed, 12% had electric heat, 69% had gas heat, and 19% were heated with other fuels. Certain housing unit characteristics varied by heating fuel, including year built, size, the presence of air conditioning, and the housing unit type. Overall, 57% of the housing units were single family homes, 27% were attached rowhouses, and 11% were in multiunit buildings.

Average electric baseload usage was about 4900 kWh and average gas usage (among gas users) was 1053 therms. These usage patterns show that the program is not consistently targeting high users for either electricity or gas. In part, joint delivery makes it challenging to simultaneously target homes that have both high electric and gas usage. In addition, since the program is expected to serve any customer who requests services, contractors are not able to restrict the program to high users. Finally, given the large number of customers to be served, it may be difficult to target high users and meet target production levels.

The following measure installation patterns were observed.

- *Lighting*: 91% of all units had at least one CFL installed. An average of 6.9 CFLs were installed per unit.

- *Refrigerators*: Refrigerators were replaced in 49% of homes. Secondary refrigerators or freezers were removed in only 1% of homes. (13% of homes had a second refrigerator and 24% of homes had a freezer.)

- *Insulation*: Some type of insulation was installed in 56% of homes. Attic insulation was installed in 45% of homes, while wall insulation was installed in only 4% of homes.

- *Air Sealing*: Air sealing was performed in 65% of the treated homes. Blower door guided air sealing was conducted for 13% of the units. An average of 4.0 hours of air sealing was completed per unit.

- *Thermostats*: Thermostats were replaced for 13% of the units.

- *Duct Sealing and Insulation*: Work was done on heating and/or cooling system distribution systems for 50% of the units.

- *Education*: An average of two hours of education was delivered to each customer.

Certain measure installation rates deserve attention. The replacement rate for thermostats is lower than for many other programs. This finding is consistent with the restrictive replacement standard in the program specifications. Some programs have achieved cost-effective savings by replacing thermostats at higher rates. Blower door guided air sealing rates are low compared to most weatherization programs. The rate at which customers are surrendering second refrigerators and freezers is lower than for comparable programs and may merit special attention at customer education training sessions. The rate of wall insulation is low and may be restricted by field crew perceptions that the measure allowance does not allow installation. That is a misinterpretation of the measure allowance. In other programs, wall insulation has been demonstrated to be a cost-effective measure.

The program databases allowed the evaluation team to review program spending by measure group and in comparison to the measure allowances.

- *Total Field Costs*: The average total field cost was $1,379 per unit. Energy saving measures represented 81% of the costs, audit fees, testing, and education accounted for 11%, and health and safety measures represented 8% of expenditures.

- *Major Measures*: The average cost for energy saving measures was $1,115. Insulation, air sealing, and refrigerators accounted for 76% of the measure costs.

- *Costs by Heating Fuel*: The average field costs for gas heated homes were $1,460, compared to $1,185 for electrically heated homes and $1,184 for homes heated with other fuels.

- *Seasonal Measure Allowance*: The average seasonal measure allowance was $1,129. The average seasonal measure cost was 66% of the total seasonal allowance.

- *Exceeding Allowances*: The service delivery contractor is allowed to exceed the allowance by up to $200. They can exceed the allowance by more than $200 with approval from the program manager for the utility that furnishes the main heating fuel. (The electric company program manager give approval for oil heat homes.)

Spending exceeded the gas measure allowance by more than $200 for 10% of the units and exceeded the electric seasonal allowance by more than $200 for 3% of the units.

It is clear from the analysis that the seasonal measure allowances would suggest that, on average, additional work could be done in the homes. However, the extent to which that is true is best measured from the onsite inspections.

Using the program database, we were able to conduct some analyses of specific measures. In particular, we were concerned about consistency in the cost of conserved energy within and across program measures. Our findings include:

- *Lighting*: It appears from our analysis that the lighting replacement specifications are being implemented properly. The average lighting retrofit saved electricity at a cost of 4.3 cents per kWh. However, some of the replacement guidelines save electricity at a cost of as much as 8.6 cents per kWh.

- *Refrigerators*: The cost of conserved energy averages 7.4 cents per kWh for replaced refrigerators.

- *Insulation*: The average cost of conserved energy for insulation is 10.8 cents per kWh for electricity and 83 cents per ccf for gas. That could be reduced to 9.6 cents per kWh and 69 cents per ccf if insulation were only installed when the existing R-value of the insulation was 20 or less.

These findings highlight the need to review the program procedures and guidelines in the context of expected energy savings and measure cost-effectiveness. It may also be appropriate to encourage the service delivery contractors to move outside the measure allowances when considering certain measures, particularly wall insulation.

Findings from Inspections

In the third task of the Comprehensiveness Evaluation, the evaluation team inspected 100 completed Comfort Partners jobs. The inspector assessed whether the crews followed the Comfort Partners procedures, did good quality work, used appropriate testing procedures, and took advantage of all cost-effective energy savings opportunities (whether or not they were included in the procedures).

The inspections determined the following with respect to Comfort Partners Program quality and comprehensiveness.

- *Procedures*: The service delivery contractors did a good job of following the Comfort Partners Program procedures. For those measures where the specifications are clear and unambiguous, the service delivery contractors successfully followed procedures more than 95% of the time. [Note: In some cases, third party quality control inspectors required the service delivery contractors to address problems associated

with service delivery. Jobs that that followed procedures after quality control inspection were included as successful jobs.]

- *Quality*: The service delivery contractors performed quality work. For most measures, over 95% of the work was deemed to be of at least satisfactory quality, and in many cases it was judged to be good or excellent.

- *Testing*: One of the service delivery contractors chose to minimize the use of blower door guided air sealing and the use of pressure pan testing to find duct leaks. In some units, testing allowed the inspectors to find opportunities for air sealing and duct sealing that were missed by the field crew. In other units, testing showed the inspector that the field crew misinterpreted the thermal boundary of the home and that some of the air sealing work was not at what the inspector judged to be the pressure boundary of the home.

- *Specifications*: The evaluation team has recommended some changes in program specifications. The inspections determined the rate at which the program specifications lead to missed opportunities and misapplied and/or misdirected work in the field.

- *Measure Allowances*: The inspections identified a number of homes in which it was the opinion of the evaluation team that attic insulation, wall insulation, and/or crawl space insulation would have been a cost-effective measure. In those homes, it appeared that the crew rejected the measure because it was the crew's perception that the measure would have significantly exceeded the measure allowance.

- *Health and Safety Measures*: The inspections identified areas where additional health and safety measures appeared appropriate.

Using the inspections data and program invoice data, the evaluation team estimated the cost implications of making all of the recommended changes in the program. For baseload measures, the recommended program changes would be expected to raise average costs for measures from $350 to $369. For seasonal measures, the recommended program changes would be expected to raise average costs for measures from $947 to $1,096. However, at that spending level, the average costs would still be below the average seasonal measure allowance of $1,246. The evaluation team believes that the recommended changes will enhance the comprehensiveness and the performance of the service delivery.

In addition to the measure costs, blower door testing, pressure pan testing, and the recommended heating system test would be expected to increase program costs. The evaluation team also encourages the Working Group to consider other health and safety measures that would be expected to cost an average of $85 per unit.

I. Introduction

This report presents the findings from the Comprehensiveness Evaluation of the Comfort Partners Program. In this evaluation, we documented the procedures used in the Comfort Partners Program, assessed the extent to which service delivery followed documented program procedures, evaluated the program's procedures in the context of service delivery challenges and in comparison to procedures used in other low-income energy programs, and assessed the extent to which comprehensive services were delivered. We make recommendations for refining and improving the Comfort Partners program. The Comprehensiveness Evaluation is the second component of the evaluation of the Comfort Partners Program.

A. Background

The New Jersey Clean Energy Collaborative consists of Public Service Electric and Gas, JCPL, Conectiv Power Delivery, Rockland Electric Company, New Jersey Natural Gas, NUI Elizabethtown Gas, and South Jersey Gas. The Collaborative has designed eight Residential Energy Efficiency Programs and three Nonresidential Energy Efficiency Programs to reduce the total amount of electricity and natural gas used in New Jersey and to reduce the summer peak demand for electricity. The Residential Low Income Program Working Group designed the Comfort Partners Program to meet the Collaborative's usage reduction goals and to improve energy affordability for low-income customers.

The Comfort Partners Program was designed to overcome the market barriers affecting energy usage and energy affordability for low-income customers, including:

- Lack of information on how to improve energy efficiency and on the benefits of energy efficiency,
- Lack of capital to upgrade energy efficiency and, in many cases, to keep up with regular bills,
- Inadequate targeting of low-income customers by market-based residential service providers, and
- Split incentives between renters and landlords.

The Comfort Partners Program addresses the market barriers through:

- Direct installation of all cost-effective energy efficiency measures (addressing all fuels),
- Comprehensive, personalized customer energy education and counseling, and

- Arrearage forgiveness for participants who agree to payment plans.

The Comfort Partners Program is targeted to customers with income at or below 150% of the federal poverty income guidelines or who are receiving benefits from certain public assistance programs.

B. Evaluation

The Residential Low Income Program Working Group commissioned a comprehensive evaluation "to determine the extent to which Program goals are being achieved and to provide feedback on how the Program might be modified to better achieve these goals." The Working Group contracted with APPRISE to conduct this evaluation. The evaluation team includes APPRISE, MaGrann Associates, Blasnik and Associates, and Renaissance Consulting and Analysis.

The evaluation of the Comfort Partners Program consists of seven evaluation components.

1) *Tracking System Evaluation*: Assessment of the consistency of information tracked by the utilities, the sufficiency of the data for management and reporting, the accuracy of the data in the system, and the efficiency of the tracking system procedures

2) *Comprehensiveness Evaluation*: Examination of the appropriateness of Comfort Partners protocols and practices, and the comprehensiveness of service delivery

3) *Process Evaluation*: Review of the effectiveness of the Program design and implementation, measurement of customer reactions to the energy component and customer satisfaction with program services, and identification of barriers to program delivery and low-income customer participation

4) *Baseline Affordability Impact Projections*: Projections of the affordability impacts of the program using baseline usage data, program service delivery data, and engineering models of program impacts

5) *Baseline Usage Impact Projections*: Projections of the usage impacts of the program using baseline usage data, program service delivery data, and engineering models of program impacts

6) *Affordability Impact*: Analysis of affordability impacts of the program for 2002 based on customer billing and payment data, service delivery data, and affordable payment program data

7) *Usage Impact*: Analysis of usage impacts of the program for 2002 based on customer billing and payment data and service delivery data

The Tracking System Evaluation was completed 3/15/02. The Comprehensiveness and Process Evaluations will be completed by 8/30/02. The Baseline Affordability Impact

Projections and the Baseline Usage Impact Projections will be completed by 12/31/02. The Affordability Impact and the Usage Impact analyses will be completed by 2/28/04.

C. Organization of the Report

Four sections follow this introduction.

1) *Section II – Comfort Partners Service Delivery Procedures*: Provides an overview of the program's mandate, goals, and service delivery procedures.

2) *Section III – Assessment of Program Procedures:* Reports on the findings from the Program Procedures Review and On-Site Observations, and furnishes recommendations for changes in the program procedures.

3) *Section IV – Analysis of Program Data:* Reports on the findings from a database analysis of the comprehensiveness of the program.

4) *Section V - Analysis of Inspections Data:* Reports on the findings from an analysis of the comprehensiveness of the program using statistics from the on-site inspections of completed jobs.

APPRISE prepared this report under contract to the participating utilities of the New Jersey Clean Energy Collaborative. Members of the evaluation team (MaGrann Associates, Blasnik and Associates, and Renaissance Consulting and Analysis) conducted research for this task and wrote sections of this report. The service delivery contractors (HDMC, Bill Busters Inc, Pure Energy, and CMC) facilitated this research by meeting with the evaluation contractors, furnishing extensive amounts of data, and making their staff available for observation and interviews. The Working Group facilitated this research by meeting with evaluation contractors and furnishing program data. The report presents the evaluation team's collective assessment of the Comfort Partners Program. However, any errors or omissions in this report are the responsibility of APPRISE. Further, the statements, findings, conclusions, and recommendations are solely those of analysts from APPRISE based on our analysis and our review of the analyses furnished by other evaluators. The report does not necessarily reflect the views of the Collaborative or the member utilities.

II. Comfort Partners Service Delivery Procedures

The Electric Discount and Energy Competition Act of 1999 and the March 1, 2001 Final Decision and Order by the NJ Board of Public Utilities made the New Jersey electric and gas utilities and representatives of the Natural Resources Defense Council responsible for implementing programs to reduce the amount of electricity and natural gas used in New Jersey and to reduce the summer peak demand for electricity. The Residential Low Income Program Working Group designed the Comfort Partners Program to contribute to the Collaborative's usage reduction goals and to improve energy affordability for low-income customers.

The Comfort Partner Program goals are to:

- Obtain the maximum level of cost-effective energy savings in each home.
- Allow for persistence of savings through the use of appropriate protocols and the provision of energy education.
- Improve utility bill payment capability and behavior among participants.
- Improve comfort, health, and safety for participants.

The Comfort Partners Program is designed to offer New Jersey low-income customers:

- Common eligibility requirements, joint delivery for dual utility customers, and seasonal measures for homes with bulk fuel for heating.
- Comprehensive measure installation with common measure selection procedures and common installation standards throughout the state.
- Comprehensive customer education with common education materials.
- Arrearage reduction plans.

In the Comfort Partners 2002 program filing, the Collaborative committed to explicit program goals, including:

- *Participation Goals*: Each utility commits to participation goals for its gas and/or electric customers. The total commitment for 2002 is 6,656 homes.
- *Energy Savings Goals*: The overall program savings goals in 2002 are "to achieve 10% average electric savings for participants with electric space heat and 15% average natural gas savings for participants with natural gas heat."

The minimum requirement in the filing is to "reach a minimum of 60% of the program goals," including both the participation and performance goals. The program service delivery procedures were designed to achieve at least the target level of energy savings for participating customers.

In this section of the report, we describe the Comfort Partners service delivery procedures that were designed to realize the usage reduction goals set out by the restructuring legislation, the New Jersey Clean Energy Collaborative, and the Residential Low Income Working Group. This report examines the procedures for selecting and installing energy saving measures. For additional information on the program data tracking system, see the *Comfort Partners Tracking System Evaluation Report (March 2002)*. For more information on other program procedures, including program administration, customer recruitment, energy education, and arrearage programs, see the *Comfort Partners Process Evaluation Report (August 2002)*.

A. Program Specification Documents

The Working Group developed technical program specifications for the Comfort Partners Program. The documents that guide program service delivery are:

- *NJ Comfort Partners Procedures Manual*: Provides information on the program mission, documents program eligibility requirements, outlines the preferred program workflow, furnishes guidance on what measures should be installed and what measures are the most important.
- *NJ Comfort Partners Materials and Installation Specifications*: Furnish installers with information on how to install a given measure.
- *NJ Comfort Partners Field Guide (John Krigger, editor)*: A technical resource guide that was adapted from the *Weatherization Guidebook for the MidAtlantic Region*.
- *Energy Education Notebook*: A resource for the field crew during their education session with the customer.

These documents are critical for effective program implementation. They should furnish service delivery contractors with a clear statement of program expectations. As is discussed in Section III, we recommend that the Working Group make enhancements to this set of documents to ensure that it effectively serves that purpose.

B. Service Delivery Contractors and Subcontractors

The Working Group jointly developed the Comfort Partners procedures. However, each of the seven participating utilities is responsible for selecting service delivery contractors for their service territory and working with other utilities to ensure that there is joint delivery of program services where service territories overlap.

Currently, two service delivery contractors are delivering energy services for the Comfort Partners Program, Honeywell DMC and Bill Busters Inc. HDMC delivers services for all seven utility companies. HDMC subcontracts certain work to other firms, including insulation contractors, certain licensed professionals, and refrigerator delivery firms. Bill Busters Inc has a contract with JCPL. BBI subcontracts work to a firm that is licensed to provide plumbing and electrical services. JCPL has a separate refrigerator delivery contractor for customers served by HDMC and BBI.

Currently, two contractors are conducting quality control inspections for the Comfort Partners Program, Pure Energy and CMC Energy Services. Pure Energy conducts inspections for JCPL and New Jersey Natural Gas. CMC conducts inspections for PSE&G. Inspection contracts have not yet been signed by South Jersey Gas, Conectiv, Elizabethtown Gas, and Rockland Electric.

Since each utility has a separate contract with service delivery contractors, the program needed an explicit cost sharing arrangement. The table below summarizes the cost allocation for the services for which cost sharing is applicable.

Table 2.1 – Cost Sharing Agreement

Category	Gas Share	Electric Share
Audit gas and electric with seasonal electric use	50%	50%
Audit gas and electric without seasonal electric use	70%	30%
Blower door test with seasonal electric use	50%	50%
Blower door test without seasonal electric use	100%	0%
Energy education	50%	50%
CO detector	100% if gas main heat	100% if fuel oil main heat

The initial plan for cost sharing on space conditioning measures for gas heat customers with air conditioning was that 55 percent of the costs would be paid by the gas utility and 45 percent of the costs would be paid by the electric utility. However, with the initiation of joint delivery jobs, there were concerns about this cost division. The current agreement for cost sharing and invoicing for space conditioning measures is that the utilities are billed according to their fuel's share of the calculated total allowance for the electric seasonal measure allowance plus the gas measure allowance.

An additional area of discussion was the cost sharing for oil heat homes. The BPU ruled that since the electric companies previously paid for oil heat homes, they should bear the cost of these homes in the Comfort Partners Program. Under the cost-share agreement, the electric company pays for bulk fuel heated homes, even if the homes use natural gas water heat. While JCPL was always responsible for oil heat homes, there had previously been a $1,000 limit on these homes. With Comfort Partners, oil heat homes have no cap. They are to be treated the same as electric heat homes and receive all cost-effective measures.

C. Energy Service Delivery

The Comfort Partners Program is designed to deliver a comprehensive set of cost-effective energy services to low-income customers. This requires service delivery contractors to conduct an intensive assessment of the needs of each customer's housing unit and to effectively prioritize among the set of potential energy savings measures. It is important to understand the tools used by the Comfort Partners Program to facilitate the effective selection of measures.

1. Assessment

The service delivery contractor is responsible for developing a comprehensive assessment of the energy saving opportunities in the homes and for working with customers to make choices about what will be installed in the home. The contractor has a number of tools that are available to help identify the energy saving measures.

- *Electric and Gas Bills*: The electric and gas utilities furnish the contractor with the customer's electric and gas usage history. The contractor can review those bills and use a simplified seasonal adjustment calculation to develop an initial understanding of the energy savings opportunities in the home.

- *Customer Information*: The program requires the contractor to discuss energy uses in the home with the customer. Customer reports on energy behaviors are important in assessing energy savings opportunities. In addition, customer concerns about drafty areas, rooms that are too cold or too hot, and other observations can furnish clues to energy savings opportunities.

- *Visual Inspection*: The contractor is expected to conduct an inspection of the home to develop an understanding of the heating and cooling system, the home's thermal envelope, and the home's appliance stock.

- *Testing*: The program price list includes reimbursement for testing procedures that are needed to diagnose energy issues, including refrigerator metering, blower door tests, and combustion appliance health and safety tests.

- *Customer Education*: The program price list includes reimbursement for the contractor to furnish direct education to the client to help them understand how energy is used in the home, to explain what measures are recommended for the customer's home, and to identify actions that the client can take to save energy.

The output of the assessment step is a comprehensive plan for saving energy in the home, including measures that are to be installed by the contractor and actions that are to be taken by the customer.

2. Prioritization

The Comfort Partners Program is designed to pay for all cost-effective measures available in the home. However, it is challenging for crews to assess cost-effectiveness in the field. The Comfort Partners Program furnishes a number of tools that help the contractor decide what measures should be installed. These include:

- *Explicit Standards*: For certain measures, the program managers set clear guidelines for replacement. For example, the Procedures Manual furnishes a table that identifies the refrigerator replacement options for refrigerators at certain usage levels.

- *Prioritization Guides*: The Procedures Manual furnishes guidance on the order in which certain measures should be selected. For example, it instructs contractors to first "align the insulation barrier with the air pressure barrier, followed by filling insulation voids, followed by installing additional insulation . . . "

- *Measure Allowance*: The Procedures Manual furnishes a formula for computing "measures allowances" for electric baseload measures, electric seasonal measures, and gas measures based on energy usage. The measures allowance is designed to furnish guidance to the contractor on the "expected average costs of typical measures of the type found to be cost-effective in typical houses." The allowance is not a limit on expenditures or a budget on what must be spent in each home. However, the contractor must get approval from the utility program manager to spend more than $200 over the allowance and is encouraged to document the decision if they spend more than $200 below the allowance.

- *Custom Measure Value Tables*: The Procedures Manual furnishes a table that defines, by measure life, the value of the measure in dollars per kWh and per CCF for winter, summer, and baseload savings.

3. Measure Installation

The Comfort Partners Program gives the contractors flexibility in how they install measures. At the inception of the program in July 2001, the contractors used different procedures for service delivery.

- *HDMC*: HDMC initially designed the service delivery with an initial audit visit that included installation of certain baseload measures, a measures installation visit by HDMC staff, and an insulation visit by insulation subcontractors.

- *BBI*: BBI initially designed the service delivery with an initial assessment visit, followed by a measures installation visit that sometimes takes more than one day.

Both organizations have tested alternative procedures since the program's inception. HDMC is currently moving to a delivery system that includes assessment by a team

leader, followed by an HDMC visit for measure installation when no insulation is recommended, and an insulation subcontractor visit for insulation and measure installation when insulation is recommended.

4. Eligible Measures

The Comfort Partners Program allows and encourages installation of all cost-effective energy saving measures. Common baseload measures include CFLs, refrigerators, water flow restriction devices (energy saving showerheads and faucet aerators), and water heater and pipe wraps. Common seasonal measures include duct sealing, duct insulation, air sealing, insulation, furnace/air conditioning filter replacement, and thermostat replacement. However, the service delivery contractor is not restricted to those measures.

The Comfort Partners Program also allows and encourages the installation of health and safety measures, especially when the problem interferes with the installation of energy saving measures. In the program specifications documentation, there is extensive discussion of the need to ensure that the service delivery contractor maintains or enhances the health and safety of the customer. In addition, communications from the Working Group have clarified the types of health and safety measures that are eligible for installation.

D. Quality Control

Pure Energy is conducting inspections on BBI and HDMC jobs for JCPL and on joint delivery jobs for JCPL and NJNG. CMC is conducting inspections on PSE&G jobs. There has been considerable discussion about what the inspections should include and for what reason a job should be failed. There is not yet consistency between the CMC and Pure Energy Inspections. Inspections are not yet being conducted by all utilities.

Third party inspections are a very important part of the development of a comprehensive program. The Working Group has been discussing how to conduct joint inspections and how to move toward a uniform quality control process for the Comfort Partners Program. A flowchart for the quality control procedures as well as a format for a monthly quality control report are under development.

The guidelines for quality control that are currently being discussed are as follows:

- A minimum of ten percent of all work done for a given Comfort Partners utility must receive a third party quality control inspection.
- Unless there are compelling and documented reasons to the contrary, all joint delivery work should be inspected during the same visit to minimize the number of site visits made to a given customer.

- The third party quality control inspections will cover documentation of work, installation of efficiency measures, and customer education.

It is proposed that no action will be required of the service delivery contractor if:

- Invoicing is accurate.
- All documentation is complete.
- No clear and present health and safety issues are correctable under Comfort Partners.
- The contractor has provided referrals for any other health and safety issues.
- Measures installed are appropriate.
- Installation quality is appropriate.

It is proposed that immediate correction is required if:

- There is clear or potential fire, CO, or other danger that is correctable under the Comfort Partners Program.

It is proposed that correction within 30 days is required if:

- There is inaccurate billing.
- There is insufficient or incorrect documentation.
- There is unacceptable installation of efficiency measures.
- There is an important missed opportunity for installation of efficiency measures.

Correction should be applied to future work if:

- There is inadequate documentation.
- There is potential danger not correctable under Comfort Partners that should be referred elsewhere.
- The installation of efficiency measures is marginally acceptable.
- There is a missed opportunity for installation of efficiency measures.

A utility may contract for more specific quality control inspection procedures and specifications, but such requirements beyond the scope of those described above must be restricted to work directly paid for by that utility, unless the overlapping utility agrees to the same scope of work.

III. Assessment of Program Procedures

In the first task of the Comprehensiveness Evaluation, the evaluation team assessed the quality and completeness of the Comfort Partners Program procedures. Procedures were reviewed against the following criteria:

- *Effectiveness*: Do the procedures use the best current practices designed for the greatest potential impacts?
- *Application*: Can the procedures be interpreted and implemented in a consistent and appropriate fashion, and are they sufficiently clear to be applied effectively and efficiently in the field?
- *Comprehensiveness*: Are all cost-effective applications addressed, with clear guidance when to perform tests and install measures?
- *Quality Control*: Are quality control procedures sufficient to ensure that measures are installed properly and all opportunities are addressed?

In this section of the report, we document the procedures used in our assessment, the general findings from the assessment, and the detailed findings with respect to individual components of the Comfort Partners Program procedures. Specific recommendations are italicized in the text throughout this section of the report.

A. Evaluation Activities

This task included the following evaluation activities.

- *Review of Procedures*: The evaluation team reviewed Comfort Partners Program specifications documents.
- *Onsite Observations*: One of the team members observed 10 Comfort Partners jobs from start to finish and documented his observations for review by the rest of the evaluation team.
- *In Depth Discussions*: The evaluation team met with the service delivery contractors to discuss program procedures and barriers to the implementation of prescribed procedures.

MaGrann Associates was the team leader on this task. They conducted a thorough examination of the set of program documents, conducted the onsite observations, and convened the discussions with the service delivery contractors.

1. Review of Procedures

The following technical documentation was made available to the evaluation team for review.

- NJ Comfort Partners Procedures Manual
- NJ Comfort Partners Material & Installation Specifications
- NJ Comfort Partners Field Guide (John Krigger, editor)
- Data collection forms used by implementation contractors

MaGrann Associates reviewed these documents and identified a series of issues for discussion. Analysts from Blasnik and Associates and APPRISE also reviewed the documents.

2. Onsite Observations

MaGrann Associates performed observations of 10 customer sites through all stages of the program (24 total visits). (An eleventh customer was observed through the initial audit but was subsequently deactivated.) The following characterizes the observed units.

Building Type

- 5 Single family homes
- 3 Townhomes
- 2 Apartments in multifamily buildings
- 1 Multifamily building with 2 apartments (treated as a whole building and 1 observation)

Utility Service

- 6 Public Service Electric/Public Service Gas
- 2 JCPL Electric only
- 1 JCPL Electric/New Jersey Natural Gas
- 1 Conectiv Electric only
- 1 Conectiv Electric/South Jersey Gas

Contractor

- 9 Honeywell DMC
- 1 Bill Busters

Sites were selected in coordination with the implementation contractors to represent as broad a distribution of building types and utility service areas as possible from the

relatively small pool of units enrolled after January 1, 2002. Contractors were free to staff the site visits at their discretion in order to demonstrate their implementation of the program. The role of evaluation staff was as nonparticipatory as possible during the visit with the customer.

3. Meetings with Service Delivery Contractors

In additional to frequent one-on-one conversations between the evaluation team and the service delivery contractors, the evaluation team had a number of meetings to discuss the Comfort Partners procedures in depth. The meetings included:

- *Kickoff Meeting*: On 12/13/01, the evaluation team met with HDMC staff to review the evaluation plan and to set up communications procedures.
- *Introduction to Comfort Partners Procedures*: On 1/3/02, HDMC presented a thorough review of the Comfort Partners procedures to members of the evaluation team.
- *Review of Initial Observations*: On 2/5/02, the evaluation team met with HDMC to discuss the procedure that were observed in the field. At this meeting, there was discussion of how and why the observed field procedures were different from what was found in the program specifications, including discussion of inconsistencies in the program specifications.
- *Review of Observations*: On 4/8/02, the evaluation team met with HDMC to discuss the overall assessment of the program procedures that was developed from the observations.

Evaluation team members also discussed the Comfort Partners procedures with BBI in the context of program observations and inspections.

B. Recommendations on Program Design

The Working Group has communicated its expectations to program service delivery contractors in a number of ways, including program specification documents, service delivery contracts, price lists, and other interpretive memos and e-mail communications. Given the complexity of the program and the short period of time during which the program was implemented, it is not surprising that a number of different documents guide program delivery. However, as the Working Group and the service delivery contractors gain more experience in what is required to implement the Comfort Partners Program, it is critical that the Working Group develop a more concise and unambiguous statement of the program expectations.

We recommend that the Working Group focus on two areas to clarify and enhance the program specifications.

- First, we recommend that the Working Group refine the program specifications documents to better inform the service delivery contractors of program expectations.

- Second, we recommend that the Working Group review the measure selection and prioritization procedures to ensure that the spending guidelines are consistent with Collaborative goals in terms of the relevant cost-effectiveness standards.

The proposed improvements in each of these areas are outlined below.

1. Program Specification Documents

The three manuals currently in use represent a commendable breadth of technical documentation. Much of the "Material and Installation Specifications" and "Procedures Manual" documents were built on materials from predecessor programs, while the "Building Performance Field Guide" is based on DOE's "Weatherization Guidebook for the MidAtlantic Region" and was adapted specifically for the Comfort Partners Program. This depth of attention to documenting standards and procedures, and the speed of their introduction as the individual utility programs transitioned to statewide implementation, are to be applauded. (It is not uncommon for programs to operate with no manuals at all.)

In our review, we observed that the Working Group devised an effective and appropriate structure for the set of manuals. Each manual is designed to serve a very specific purpose in defining the Comfort Partners Program.

- *Procedures Manual*: This document specifies the mission of the Comfort Partners Program, defines the customers who are eligible for the program, outlines the range of services that the contractor is to deliver to eligible customers, and establishes priorities among potential energy savings opportunities.

- *Materials and Installation Specifications*: This document furnishes detailed information on the specific materials and installation procedures that are acceptable under the Comfort Partners Program.

- *Field Guide*: This document serves as technical reference for service delivery contractors.

However, the manuals are not completely consistent in their implementation. In some places, a manual covers issues that are better included in one of the other manuals. In other places, the manuals give conflicting information without explicitly documenting the reasons for the inconsistency. We recommend changes in the Procedures Manual and the Materials and Installation Specifications Manual.

a) Procedures Manual Changes

The Procedures Manual should furnish additional guidance to the service delivery contractors on what is expected under the Comfort Partners Program.

- *Complete and Update*: Certain procedures were not complete at the time the manual was prepared and certain procedures have been updated. It is important to incorporate those changes into the Procedures Manual. In addition, it is important to have a regular schedule (quarterly) for updates of the Procedures Manual.

- *Partnership Approach Workflow*: Insert a step into the workflow after the "Take a house tour" section that is labeled "Analysis and testing" with subsections that include "Define the thermal boundary" and "Complete pressure diagnostic testing." These are essential steps to effective planning for measure prioritization and selection.

- *Testing Procedures*: Furnish a definitive statement on what tests (e.g., pressure diagnostic tests and health and safety tests) are expected and under what circumstances. Move the discussion in Section 4-M to the Materials and Installation Specifications Manual, since it focuses more on how to conduct tests rather that on which tests to conduct.

- *Health and Safety Measures*: Define which health and safety measures are appropriate and under what circumstances. Define what actions must be taken when the service delivery contractor identifies health and safety problems that are not eligible for treatment under the Comfort Partners Program.

- *Energy Education*: Expand Section 5-A to include a discussion of the importance of the Customer Action Plan and the procedures for establishing and reinforcing the Action Plan with the customer.

- *Quality Control*: Expand the quality control section in the manual to implement the draft set of quality control guidelines outlined in Section II of this report.

b) Materials and Installation Specifications

This manual should address program-specific materials and installation requirements that are not covered in the Field Guide. Since the Field Guide is a document that has been designed as a general reference to weatherization professionals, one role for the Comfort Partners Materials and Installation Specifications Manual is to identify ways in which the Comfort Partners Program may deviate from common practice and to document the reasons for and the conditions under which such deviations exist. Many of the specific issues for the

Materials and Installation Specifications Manual are outlined in the next section. However, two important sections need to be added to this manual.

- *Testing*: The Procedures Manual should discuss what tests are expected and under what circumstances. Section 4-M from the Procedures Manual should be moved to the Materials and Installations Specifications Manual and it should be expanded to discuss the full range of testing appropriate under the Comfort Partners Program.

- *Health and Safety Measures*: This manual should have a section that describes the materials and installation specifications for health and safety measures, including CO detectors, vapor barriers, dryer vents, bathroom vents, and other allowable health and safety procedures.

In addition, there are places where this manual should be condensed. In particular, when an issue is already covered by the Field Guide, the Comfort Partners Materials and Installation Specifications should reference the Field Guide, rather than attempt to summarize or repeat what appears in that document.

c) Training

It is important for service delivery contractors to develop efficient procedures for notifying crews of updates to program procedures. The evaluation team finds that periodic group training sessions are the most efficient approach for communicating information on program changes.

2. Measure Selection and Prioritization Procedures

As discussed in Section II, the Working Group has furnished a number of tools to assist the service delivery contractors in measure selection and prioritization. These tools include replacement standards, prioritization guides, measures allowances, and a Custom Measure Value Table. In general, we have found that these tools have facilitated in-field decision-making by giving crews the confidence to install needed measures. However, we find that there are several ways that the tools can be enhanced.

a) Common Decision Criteria

Program cost-effectiveness standards are implicit in the appliance replacement standards and explicit in the custom measure value table. However, it does not appear that consistent standard were applied across all measure groups.

Recommendation: The Working Group should articulate the specific cost effectiveness standards that they apply to measure selection.

b) Custom Measure Case Studies

We observed a number of times when contractors missed cost-effective opportunities for installing custom measures. [One example is installation of water drainage measures that would eliminate moisture problems in a basement and allow improved basement air sealing measures. Another example is the development of alternative procedures for addressing heating system ducts that are seriously deteriorated.] It appears that the Custom Measures Value Table does not facilitate a good understanding among field crew regarding the circumstances under which custom measures would be appropriate.

Recommendation: The Working Group should develop a series of case studies that demonstrate specific examples of good custom measure opportunities and the procedures for using the Custom Measure Value Table to determine a cost-effective measure.

c) Measure Allowances Updates

The measure allowances facilitate field decision-making by giving the crews a simple tool to help them to estimate an appropriate level of effort for each job, based on the customer's energy consumption patterns. However, there are two ways in which this can fall short. First, the allowance was based on previous program experiences. If the costs of service delivery change, it is appropriate for the allowance to be examined and updated. (This was done during the first program year.) Second, there are many circumstances in which the allowance is significantly lower or higher than the level of expenditure that would be appropriate using direct cost-effectiveness guidelines. The field crews need additional examples of the circumstances in which the measure allowances are potentially misleading.

Recommendation #1: The Working Group should periodically update the measure allowances based on the findings from the Comprehensiveness Evaluation and the Baseline Usage Impact Evaluation, along with other available data from the service delivery contractor.

Recommendation #2: The Working Group should develop a series of case studies that demonstrate specific examples of circumstances that call for significantly higher or lower budgets than would be indicated by the measure allowances.

d) Electric Baseload Measure Allowance

There are replacement guidelines for each baseload measure. These guidelines are clear, concise, and easily implemented in the field. The electric baseload measure allowance often conflicts with those replacement guidelines.

Recommendation: The Working Group should eliminate the use of the electric baseload measure allowance.

C. Recommendations on Program Specifications

In general, the Comfort Partners Program has an ambitious mission to comprehensively address the complete range of technical opportunities in every one of a high volume of customer homes. The enormous variety of building types, system types, structural and maintenance conditions, and occupant characteristics, challenges highly trained and experienced crews on a daily basis.

Therefore, while technical judgment in the field will inevitably impact effectiveness from house to house, it is essential that procedures are clear and enabling. Such procedures facilitate decision making by containing the critical information without being unnecessarily complex or burdensome. A comprehensive review of existing procedures follows, with an emphasis on those procedures for which recommendations are provided to advance these objectives.

1. Defining the Thermal Boundary

A clear definition and understanding of how to determine the "thermal boundary" is required for the field crew to perform accurate assessments of air leakage, respond appropriately to homeowner feedback on related comfort issues (e.g., drafts), and to make appropriate decisions regarding the selection and installation of air sealing, insulation, and other measures at the thermal boundary.

A number of site observations illustrated that program guidelines are not sufficiently clear in this area, particularly with respect to the treatment of basements, crawl spaces, and attached garages. The Field Guide's discussion of "Primary vs. secondary air barriers"[1] does not give the technician clear guideline for when to leave the basement door open or closed during testing, or when to attempt to move an intermediate zone from inside to outside, or vice versa. The Procedures Manual addresses the thermal boundary in terms of "conditioned space" and "conditioned air"[2], but again offers no clear definition.

Recommendation: In general, it is the opinion of the evaluation team that basements and crawl spaces should be treated as <u>inside</u> unless a case can be made to the contrary. A space that is entirely unusable and contains no mechanical equipment might be considered outside. However, treating a basement or crawl as outside (i.e., by attempting to create a seal between the floor and the basement) is often difficult, ineffective, or not cost effective relative to treating the exterior walls of the basement or crawl as the thermal boundary. Under this default procedure, an interior basement

[1] Field Guide page 2-10
[2] Procedures Manual 4-L2 and 4-M

door would not be treated as the thermal boundary and should be left open during testing. [Note: In some homes, preexisting measures are directed to separating the basement or crawl space from the rest of the home. In those situations, testing is required to determine the best treatment plan.] Attached garages should always be treated as outside, and the contiguous walls, ceilings, and doors treated as the thermal boundary for air sealing.

2. Air Leakage Testing

a) Blower Door

It is the evaluation team's opinion that a blower door test should be routinely performed according to consistent standards. Limitations inherent in the Procedures Manual and Material Installation & Specifications with respect to blower door testing may have led to overly conservative application in the field[3]. However, many programs have found that testing effectively guides real-time evaluation of prioritization, performance, and cost effectiveness.

Recommendation: Develop a formal procedure for application of blower door diagnostics in the air sealing process (including pressure pan and zonal pressure tests to guide installation work, as well as pre- and post-installation tests). Integrate blower door testing and cost effectiveness procedures together to guide air sealing prioritization and work limits.

b) Calculation of Minimum Ventilation Guideline (MVG) or Building Tightness Level (BTL)

Some confusion was evident in the field arising from the number of options presented for calculation of MVG[4]. Indeed, what amounts to a 5-occupant minimum does not seem appropriate for small apartment units, especially in senior housing.

Recommendation: We suggest standardization to "number of bedrooms-plus-1" or 0.35 ACH (whichever is larger) in the MVG calculation formula. Blower door testing during and at the completion of all work impacting air tightness (see 3.3.3 below) will help ensure that the program itself does not cause the air exchange rate to fall below MVG. Field Guide procedures should be followed in the event that air tightness is measured below MVG[5].

[3] Procedures Manual 4-M
[4] Field Guide page 2-8
[5] Field Guide page 2-9

c) Test-Out and Worst Case Depressurization Procedures

A formalized test-out procedure is not articulated in the manuals and was not consistently applied in the field. However, the elements of such a procedure are well documented in the Field Guide[6] and are mentioned in the Procedures Manual[7]. Further, HDMC reports that they have developed a formalized procedure for their field crews. Even with the relatively poor structural conditions common to much of the low-income housing stock, a Worst Case Depressurization Test (WCDT) is a necessary final step after completion of any air sealing and insulation work that impacts the air tightness of the thermal envelope. Assuming that a blower door is being used as a standard part of that work, a WCDT using a manometer gauge already in the home can be a quick and straightforward incremental process. Given the potential for even rare or occasional safety concerns as a result of a depressurized combustion zone, performing and recording this test should be routine.

Recommendation: We recommend the Field Guide §1.3.2 "Worst Case Depressurization Test" be adopted as a required test-out procedure after completion of any work that impacts the air tightness of the thermal envelope[8]. Note that Field Guide §1.3.3 also addresses corrective action in the event of inadequate draft[9].

d) Zonal Pressure Test (ZPT)

Zonal Pressure Testing is well documented in the Field Guide, although it is not specifically labeled as such ("Using manometers to test air barriers," etc.)[10]. However, there is no clear direction as to when and where to perform a ZPT, but rather a general discussion of the procedure and how it can be useful. As a result, we observed sites where some zones were tested (e.g., , the attic) but not others (e.g., crawl spaces and kneewalls). In addition, some confusion appears to arise from the term "intermediate zone"[11], referring in general to attics, crawls, cavities, and attached garages. This relates to the issue of defining the thermal boundary. The Field Guide says to "close any openings (door, access hatch) between the intermediate zone and conditioned space…"[12], which may be leading to confusion over treatment of the basement. Guidelines for pressure pan testing compound this further[13].

[6] Field Guide page 1-24
[7] Procedures Manual 4-M (last para.)
[8] Field Guide pages 1-24 – 1-27
[9] Field Guide page 1-28
[10] Field Guide pages 2-14 thru 2-18
[11] Field Guide page 2-16 §2.3.4
[12] Field Guide page 2-16 §2.3.4 #4
[13] Field Guide page 2-20, last paragraph

Recommendation: A standard ZPT procedure should be established that is consistent with the preferred approach to defining the thermal boundary. A ZPT should be required whenever specific structural conditions are present, such as an attached garage. The procedure should include a requirement for pre- and post-testing when related air sealing is performed, additional guidance for practical and cost-effective interpretation of results (when to attempt to move an "intermediate space" to inside or outside), and other technical basics (such as using the same gauge for pre- and post-testing). Additional training of field crews specific to an established ZPT procedure could produce significant improvements in field efficiencies and impacts.

e) Pressure Pan Test (PPT)

Pressure pan testing can be an appropriate and cost effective alternative to more sophisticated procedures for determining duct leakage (i.e., Duct Blaster™), and less accurate procedures such as the Subtraction Method (also documented in the Field Guide[14]). Once again, inconsistencies observed in field implementation appeared reflective of inconsistencies in procedures. The Field Guide calls for testing at 50 Pascals, while the GPU Warm audit form states 25 Pascals. We witnessed both in use, sometimes without corresponding adjustments during interpretation.

Recommendation: A standard PPT procedure should be established and reflected in field forms, together with more specific guidance and training regarding interpretation of results. We suggest "Using a Pressure Pan to Diagnose Duct Leakage," produced by The Energy Conservatory[15], be used as the reference. We did not observe any application of the Subtraction Method in the field and, in line with Krigger's own observation of its limitations[16], we support its exclusion from program standards.

3. Air Sealing, Duct Sealing and Insulation

a) Air Sealing

Air sealing methodology is documented in the Material & Installation Specifications[17] and Field Guide[18]. Issues from field observations of air sealing measures were primarily linked to the air leakage testing issues already discussed above rather than to the selection or installation of materials. In one instance, top-plate/drywall connections in the attic were missed, but in general a solid effort was

[14] Field Guide page 2-21 §2.4.2
[15] Using a Pressure Pan to Diagnose Duct Leakage, The Energy Conservatory, 2000
[16] Field Guide pages 2-22 thru 2-23
[17] Material and Installation Specifications pages 2-4, 3-1, 3-2, 6-1, 7-1
[18] Field Guide pages 3-1 thru 3-28, §3.0 thru 3.2.7

made by the insulation and measure installation crews to address the air sealing opportunities they identified. However, optimal cost and impact effectiveness can be compromised by procedural inconsistencies in testing.

Recommendation: Blower door guided air sealing can be expected to enhance the generally good quality work of the field crews by helping them to prioritize their air sealing efforts, identify remaining leakage areas, and ensure that ventilation is adequate so that moisture problems will not be introduced into the customer's home.

b) Duct Sealing and Insulation

Duct sealing and insulation procedures are well documented in the Material & Installation Specifications[19] and Field Guide[20]. Both manuals allow for either mastic and mesh, or foil butyl tape to be used for duct sealing. The performance durability of tape products has been shown to be problematic in industry studies[21], and for this reason mastic products are encouraged or specified in many programs. Some of the reasons for driving this trend were evident in our observations, particularly when butyl tape was applied in dusty conditions.

Recommendation: Duct sealing materials should have a UL-181 rating (not currently specified) and be installed in accordance with manufacturer specifications. Materials with a UL-181 rating have met standards for safety for factory-made components and closure systems for rigid and flexible air ducts and connectors. There are now many sealing compound products and applicators (including tubes) available that come under the generic description of "mastic." Use of a sealing compound should be specified as the preferred or required approach. Foil butyl tape, if used, should be applied to clean ductwork only, and pressed to the surface in accordance with the procedures outlined in the program manuals[22]. As a result, mastic is often the easier and certainly the more effective solution.

The issue of defining the thermal boundary influences duct sealing and insulation decisions as well. This is specifically addressed in the Field Guide "When building performance work will leave these areas outside the thermal boundary, duct air-sealing is cost-effective"[23]. However, this appears to be in conflict with the Material & Installation Specifications that states "All visually obvious duct leaks must be sealed with approved materials…", without reference to the thermal boundary[24]. Field observations support that additional clarification is necessary.

[19] Material and Installation Specifications pages 10-1 thru 10-6
[20] Field Guide pages 1-49 thru 1-52
[21] Can Duct Tape Take the Heat?, Sherman & Walker, Home Energy Magazine, July/August 1998
[22] Material and Installation Specifications pages 10-1 thru 10-6; Field Guide pages 1-49 thru 1-52
[23] Field Guide page 1-49, §1.6.3
[24] Material and Installation Specifications page 10-1

Recommendation #1: Seal accessible leaks in ductwork outside the thermal boundary, guided by Field Guide testing procedures. Inside the thermal boundary, seal supply leaks that affect distribution effectiveness and client comfort, and seal health and safety related return leaks. Evaluate bringing in a contractor to replace major duct problems rather than attempting extensive retrofit repairs.

Recommendation #2: Only ducts outside the thermal boundary should be insulated.

Clarification also appears necessary with respect to duct insulation requirements in the Material & Installation Specifications[25] and to augment the relevant section of the Field Guide[26]:

Recommendation #3: Remove the recommendation to insulate the air handler unit, which can void the warranty.

Recommendation #4: Remove the exception to insulate the supply plenum of fossil fuel systems, and replace it with an instruction to maintain a safe clearance from the flue/flue pipe.

Recommendation #5: Apply insulation (or additional insulation) only to metal ductwork that is outside the thermal boundary and currently insulated <R4. Older nonmetallic ductwork deteriorates to the point where excessive handling may cause damage. We found this procedure to already be in practice in the field and support its formalization. Again, it may be appropriate to bring in a contractor to replace major duct problems in such circumstances.

Recommendation #6: Any duct work located in an attic scheduled for blown-in insulation should be sealed and, if located close to the attic floor, covered by the blown-in insulation to the prescribed depth rather than separately insulated.

Compression is not currently addressed in the program manuals, but can be an easy pitfall during installation.

Recommendation #7: In order to preserve the rated insulation value and energy impact, care should be taken not to compress duct insulation wrap during installation.

4. Attic, Wall and Floor Insulation

Attic, wall, and floor insulation procedures are covered extensively by both the Field Guide[27] and Specifications[28] manuals. The two implementation contractors have been taking different approaches to the insulation logistics. Honeywell DMC scheduled a

[25] Material and Installation Specifications pages 10-2, 10-3
[26] Field Guide pages 1-51 thru 1-52, §1.6.4
[27] Field Guide pages 3-9 thru 3-28, §3.2
[28] Material and Installation Specifications pages 5-1 thru 9-4

separate insulation subcontractor site visit for the homes we observed, while Bill Busters performed the insulation as part of their single measures installation visit. The most significant issue with respect to major insulation work is evaluation of the cost effectiveness of incremental insulation (and sometimes other enabling work). For example, R19 on top of R30 in a gas heated home would not typically be a cost effective measure – especially if in "competition" with other measures.

Recommendation #1: The Working Group should clearly define the incremental levels of insulation that meet program cost-effectiveness guidelines.

Recommendation #2: Other than general air sealing issues identified elsewhere, our observations highlighted one additional area in need of emphasis in the procedures – the need to ensure that insulation is always installed substantially in contact with the air barrier.

Recommendation #3: Finally, we think that the Working Group should reconsider the practicality of requiring that attic access doors be insulated to at least the same value as the surrounding horizontal or vertical space (attic or walls), and pull-down stair doors to minimum R-19. Inevitably, the effective installed R value on these access covers will reflect the realities of compression, fastening, and the need to maintain the function of the access.

5. Windows and Doors

With today's understanding of air movement and thermal dynamics in residential buildings, air sealing at the mid-level (neutral pressure plane) where doors and windows are located is generally de-emphasized by retrofit programs. The Procedures manual provides a one-page guide for when to air seal or repair[29], and the Field Guide expands on this with more detail on installation techniques and decision making[30].

However, window and door replacement appears to be addressed in the Material & Installation Specifications to such an extent (15 pages[31]) that it effectively constrains all potential replacement opportunities. In the Comfort Partners housing stock, conditions can be expected to be found in which replacement should be considered – indeed, while perhaps not always cost effective on a stand-alone basis, failure to do so can effectively negate other costly measures performed by the program. Implementation contractors reported frustration that the burden of the specifications was effectively precluding them from ever implementing a replacement, even though they could otherwise procure suitable product and perform the installation.

Recommendation: Window and door replacement is appropriate when they are beyond repair and significantly compromise the thermal boundary of the house. We suggest the

[29] Material and Installation Specifications page 22-1
[30] Field Guide pages 3-29 thru 3-35, §3.3
[31] Material and Installation Specifications pages 22-2 thru 23-4

current 15 pages be condensed to cover minimum specifications, or deferred entirely to the Field Guide. For comparison, New Jersey's program for residential new construction specifies ENERGY STAR® product with maximum U-factor 0.35 and SHGC 0.39 and a short list of recommended features[32].

6. Heating, Cooling and Water Heating

Mechanical systems are covered extensively by the Field Guide[33]. The Procedures Manual provides a one-page guide to tune-ups for electric furnaces, heat pumps, and central air conditioners only[34].

a) Heating Systems

A standard procedural expectation defined for the implementation contractors appears to be absent, and our observation is that system condition is generally addressed by basic visual and health and safety checks, including filter replacement and radiator bleeding as applicable. We did not see a procedures specification for health and safety testing either, although both contractors are performing some tests and recording some of the results.

Recommendation: Provide implementation contractors with specifications for health and safety testing that identify which of the tests covered in the Field Guide are to be performed and describe the corresponding procedures. Tests should include all combustion systems typically encountered in the program and should include:

- *Check for cracked heat exchanger, following the Field Guide procedure.*[35]
- *Temperature rise test on furnaces, following the Field Guide procedure*[36] *(especially important after sealing a large amount of return duct leakage).*

The specifications would define procedural and training requirements for performing, recording, and interpreting results, including pre- and post-completion of any work impacting mechanical systems operation or the air tightness of the building's thermal boundary. They would define action thresholds and corresponding actions that cover all tests (as currently practiced for high CO).

Note: When considering such changes to the program, the Working Group should examine associated liability issues.

[32] New Jersey ENERGY STAR Homes Builder Guide pages 19 & 20
[33] Field Guide pages 1-1 thru 1-64, §1
[34] Material and Installation Specifications page 20-1
[35] Field Guide pages 1-46 thru 1-47, §1.6.1
[36] Field Guide pages 1-47 thru 1-49, §1.6.2

b) Cooling Systems

Contractors appear to be deploying appropriately qualified HVAC technicians to follow the tune-up and cleaning list when central AC systems are encountered.

Recommendation: In the event that the blower side of the coil is not accessible for a visual inspection, the Working Group should require a measurement of the static pressure drop across the indoor coil to determine if it is clogged and warrants cleaning (a cleaning procedure for air conditioner coils is provided on page 1-54 of the Field Guide).

c) Line Voltage Thermostats

The Field Guide does not address thermostats. A procedure can be found for line voltage thermostats applicable to electric baseboard, radiant heat and fan heater systems in the Material & Installation Specifications[37]. However, we observed this to be somewhat vague and confusing in practice.

The specifications call for digital line voltage thermostat retrofit only. However, in the absence of a viable digital product, we found field practice to be using a non-digital mechanical thermostat that does meet the accuracy specification (±1.5ºF), presumably at better cost effectiveness than a digital electronic product. This is being accepted by Program QC.

Recommendation #1: The specifications should be updated to allow the type of nondigital/electronic product currently being installed.

Recommendation #2: The replacement criteria should be clarified with input from the implementation contractors.

d) Programmable Thermostats

As for line voltage thermostats, the procedure for programmable (low voltage) thermostats is also addressed only in the Material & Installation Specifications and only with respect to electric heating systems[38]. No guidance is provided as to the programming of the thermostat when installed (interaction with the customer, degrees of setback, daily schedule, etc.) or the setback threshold that would justify installation.

Recommendation #1: The procedure should be broadened to include nonelectric heating fuels.

[37] Material and Installation Specifications pages 11-1
[38] Material and Installation Specifications pages 12-1

Recommendation #2: Some expectation of setback should be established (minimum degrees of setback for minimum hours/day), although it should be flexible enough to accommodate the incremental set-back approach that we observed HDMC applying in the field.

e) Water Heating

Water heating measures, including tank insulation and replacement, pipe insulation, showerheads, and faucet restrictors, are addressed in both the Material & Installation Specifications[39] and in the Field Guide[40]. However, one of the most common measures, the tank wrap, is specified in the Material & Installation Specifications only for electric water heaters, while the Field Guide references all fuel types (the practice we found in the field). Also, the two manuals conflict over the recommended hot water temperature (120º in the Field Guide and 125º in the Material & Installation Specifications – we observed 120º in practice).

Recommendation: The Field Guide procedures for water heaters (all of §1.8) be adopted in their entirety as the program standard for training and implementation.

7. Lighting

The Field Guide does not cover efficient lighting retrofits. These measures are addressed in the Procedures Manual[41] and also in the Material & Installation Specifications[42]. Other than the general recommendation that written standards be combined and condensed, we found the lighting specifications to be consistent with industry standards, justifiable with a simple pay-back calculation (~$22.00 savings over a 5-year life at 2 hours/day and $0.11/kWh), and clear and straightforward in their application (reinforcement of attention to customer feedback may be appropriate, addressed elsewhere in evaluation comments).

Recommendation: With the ENERGY STAR standard being strengthened to include quality and performance criteria, ENERGY STAR labeling would be an appropriate additional material specification.

8. Refrigerator Monitoring and Replacement

Refrigerator monitoring and replacement standards are addressed by both the Procedures Manual[43] and Material & Installation Specifications[44]. Neither manual presents a standardized procedure for monitoring other than the minimum 1-hour

[39] Material and Installation Specifications pages 14-1 thru 17-1
[40] Field Guide pages 1-62 thru 1-64, §1.8
[41] Procedures Manual 4-H
[42] Material and Installation Specifications page 19-1
[43] Procedures Manual 4-I
[44] Material and Installation Specifications page 21-1

requirement. No correction factor is applied to account for ambient temperature. Contractor paperwork does not require that all monitored readings used in the calculation be recorded (start as well as stop times, for example). In general, while procedures for measuring and implementing the physical replacement seem well covered, we observed that the lack of a defined monitoring and recording procedure may be creating the potential for some deserving refrigerators to be excluded or vice versa.

This experience is not unique to this program. At least one documented report[45] concludes that monitoring for as little as one hour may simply be too inaccurate to be worthwhile, but that there are also alternatives to longer term monitoring. Lookups may be both more accurate and more cost effective. We recommend that Comfort Partners consider the following approach:

Recommendation: Use the AHAM product directory[46] as the default basis for efficiency and compare with a Program replacement threshold. Gather the necessary model information in the field and perform the lookup immediately (computer or hard copy), by phone, or later back in the office. This also has the advantage of addressing units that for any reason cannot be monitored. Take condition and customer feedback into account when consumption is clearly impacted (missing door seals, unit runs but doesn't cool, etc.). For units that are unlisted, or for which an equivalent AHAM entry cannot be determined, establish a monitoring protocol (including recording procedure, minimum number of hours with door closed, and ambient temperature adjustment). That protocol might also be applied to all refrigerators that are over a certain age or that do not qualify for replacement based on the AHAM directory, but might qualify because of their current condition.

9. Other Health and Safety

A definitive health and safety procedure should extend to include the following:

Recommendation #1: Implement CO testing of combustion appliances other than the furnace and water heater (see 3.7 above). Specifically, the procedure should include gas ovens and range tops, which we observed being tested for CO at the contractor's initiative according to procedures from previous programs (50 ppm max per burner; 100 ppm max at the oven vent). These procedures should be reviewed, updated if necessary, and adopted into program standards.

Recommendation #2: Hazards associated with attached garages should receive specific emphasis in procedures and training, including the identification of (and response to) leaky return ducts and return grilles in garages, and the use and interpretation of the Zonal Pressure Test (see §3.3.4 above).

[45] Refrigerator Monitoring, A Sequel – How briefly can you monitor refrigerator energy use and still get valid results…", Larry Kinney, Home Energy Magazine, Sept/Oct 2000
[46] AHAM Publications Online, http://www.aham.org

Recommendation #3: Training in awareness of mold and fungal decay issues would be appropriate to augment the limited references in the Field Guide[47] and Material & Installation Specifications[48]. The building performance industry's understanding of the causes and consequences of mold in residential buildings is advancing rapidly and should be incorporated into program procedures and training as applicable.

Recommendation #4: Provide procedures and training for basic lead-safe field practices currently addressed in the Field Guide[49].

10. Other Niche Opportunities

Dryer vent replacement is not addressed in the manuals but appears to be a requirement in some territories or conditions.

Recommendation #1: If the dryer vent retrofit is to be a part of the program, the specific conditions triggering replacement should be defined, as well as materials and installation procedures.

Humidifiers and dehumidifiers do not appear to be addressed in the program manuals, but are encountered in the field (in one case, in "competition" with each other).

Recommendation #2: Guidance should be provided in program procedures for recognizing issues and opportunities associated with these devices.

11. Quality Control

The general guidelines outlined by the Working Group and included in Section II of this report appear to be comprehensive and appropriate. However, blower door testing is performed for only a small number of the inspected units.

Recommendation: A consistent, documented procedure for third party quality control inspections should be considered, to include a higher rate of random blower door testing utilizing pressure diagnostics to check appropriateness and effectiveness of air sealing.

[47] Field Guide page 5-7
[48] Material and Installation Specifications page 8-2
[49] Field Guide page 5-12

IV. Database Analysis of Comprehensiveness

In the second task of the Comprehensiveness Evaluation, the evaluation team used data from the two program tracking system databases to examine measure installation patterns and to help assess whether program treatments were delivered in a consistent, appropriate, and comprehensive manner by the contractors. The analysis included:

- Estimation of measure installation frequencies.
- Analysis of installation frequencies by housing type, fuel type, pre-treatment energy usage, and other factors.
- Examination of the technical interrelationships between program treatments.
- Comparisons of installation frequencies to program planning assumptions and other similar programs.

In this section of the report, we document the procedures used in our analysis and outline the findings from the database analysis. Based on the findings from the analysis, we make a number of recommendations for program enhancements.

A. Evaluation Activities

The analysis used tracking system downloads of jobs started and finished in the period of January through June 2002 from HDMC and jobs started and finished from January through May for Bill Busters. The HDMC database contains a considerably greater amount of detail and is the sole data source for some of the analyses performed. The rate of unit completions (including inspections and final invoicing) was 643 units by HDMC and 43 units by Bill Busters. At this point, the relatively small samples limit the overall scope of the analysis feasible. More in-depth analysis will be conducted for the Baseline Usage Impact Projections Report scheduled for December 2002.

Blasnik and Associates was the team leader on this task, with assistance from Renaissance Consulting and Analysis.

B. Characteristics of Treated Housing Units

Tracking system data on measure installation frequencies and related information can only be employed to help assess the comprehensiveness of a program when the information is considered within the context of the program – particularly the characteristics of the housing stock being treated. Table 4.1 furnishes information on the characteristics of the treated homes by main heating fuel.

The typical house treated by the Comfort Partners program is a gas heated 1300 square foot single family detached home built about 50 years ago that uses about 7500 kWh of electricity and 1000 ccf of gas (if it has gas) per year. This typical profile is based on averages from a diverse group of participants – in reality very few houses in the program were "average". The program treated houses that varied markedly in age, construction style, major end uses, and energy consumption. However, the gas usage average is cause for concern because it indicates that high gas usage customers have not been effectively targeted. In comparison, PSE&G's E-Team Partners 1998 participants had average pre-treatment gas usage of 1293 ccf/yr, while program that particularly target high users often have average gas usage of 1400 ccf/yr or more.

Table 4.1 – Characteristics of Treated Homes by Main Heating Fuel

		Main Heating Fuel		
Characteristics	**All Units**	**Electric**	**Gas**	**Other**
Number of homes	686	82	474	130
House – year built	1952	1975	1952	1942
House – heated area	1282	959	1308	1404
kWh – total	7519	13378	6689	8049
kWh – baseload	4904	6791	4538	5493
kWh – baseload more than 6000	30%	56%	25%	39%
kWh – seasonal	2614	6587	2151	2549
Electric heat	12%	100%	0%	0%
Electric hot water	22%	96%	8%	28%
Therms – Total	995	N/A	1053	N/A
Therms – more than 1200	26%	N/A	29%	N/A
Central AC	33%	33%	38%	18%
2 or more refrigerators	13%	2%	13%	18%
Freezer	24%	14%	23%	33%
Electric dryer	32%	77%	25%	50%
Detached single family	57%	28%	61%	63%
Attached row	27%	38%	28%	17%
Attached vertical	4%	8%	3%	5%
Apartment / condominium	7%	24%	4%	3%

The table shows wide variations by heating fuel with smaller newer electrically heated homes (including many apartments or condos) compared to older and larger (but still small) gas and oil heated homes. The oil heated homes used considerably more electricity than those with gas heat reflecting a higher penetration of electric water heaters, dryers, freezers, and multiple refrigerators (although a lower penetration of central A/C). The oil heated houses tended to be somewhat older and larger than the gas heated houses.

Even among houses with the same heating fuel, there are key variations in the houses served by Comfort Partners. On one extreme are poorly insulated, leaky, older fossil fuel heated brick rowhouses located in major urban areas. On the other extreme are small all electric newer townhouses and condos that are fairly tight and already insulated. Each type of house has different opportunities and barriers, demonstrating that the implementation of a statewide program for New Jersey is challenging.

Table 4.2 shows a breakout of the same information by the electric company that serves the client, and a breakout of JCPL jobs done by Bill Busters.

The table reflects the geographic nature of the housing stock variations. Houses served by PSE&G were much older, much less likely to have major electric end uses (i.e., heat, hot water, or central air conditioning), used much less electricity and used more gas than houses served by Conectiv or JCPL. PSE&G serves most major urban areas in the State including Newark, Camden, Trenton, Paterson, Jersey City, and Elizabeth. Although the Conectiv and JCPL houses have many similarities, the Conectiv houses used much more electricity on average than the JCPL houses, due in part to a greater proportion of houses with electric hot water, dryers, and freezers. The houses treated by Bill Busters were much more likely to be smaller all electric apartments or condos compared to the houses treated by HDMC.

Table 4.2 – Characteristics of Treated Homes by Electric Utility

	Electric Utility			
Characteristics	**Conectiv**	**PSE&G**	**JCPL/HDMC**	**JCPL/BBI**
Number of homes	104	356	183	43
House – year built	1973	1935	1972	1970
House – heated area	1298	1289	1318	958
kWh – total	9828	6681	7838	N/A
kWh – baseload	6380	4472	4905	N/A
kWh – baseload more than 6000	46%	24%	33%	N/A
kWh – seasonal	3448	2209	2929	N/A
Electric heat	17%	1%	19%	58%
Electric hot water	44%	4%	32%	77%
Therms – Total	839	1065	905	N/A
Therms – more than 1200	14%	32%	16%	N/A
Central AC	51%	19%	56%	17%
2 or more refrigerators	4%	16%	11%	N/A
Freezer	29%	25%	19%	N/A
Electric dryer	63%	22%	42%	N/A
Detached single family	48%	60%	62%	40%
Attached row	23%	31%	28%	N/A
Attached vertical	7%	5%	2%	N/A
Apartment / condominium	10%	4%	3%	40%

The *Comfort Partners Process Evaluation Report* indicates that program outreach methods differ by utility. HDMC markets the program for PSE&G and targets households with higher gas usage. An analysis of preprogram usage by gas company finds that 33% of PSE&G's customers have gas usage over 1200 therms, compared to 28% for Elizabethtown Gas, 17% for NJNG, and 16% for SJG. An analysis of preprogram electric usage shows that 46% of treated homes in Conectiv's service territory have baseload electric usage over 6000 kWh, while 24% of the homes in PSE&G's service territory and 33% of the homes in JCPL service territory reach that threshold.

C. Measure Installation Frequencies

Table 4.3 summarizes information on measure installation frequencies broken out by heating fuel.

Table 4.3 – Measure Installation Frequency by Main Heating Fuel

Characteristics	All Units	Main Heating Fuel		
		Electric	Gas	Other
Number of homes	686	82	474	130
Lighting	91%	87%	91%	94%
Average lights per unit	6.9	4.7	7.1	7.3
Refrigerator replacement	49%	38%	50%	50%
Remove secondary refrigerator	1%	1%	1%	2%
Insulation (attic, floor, or wall)	56%	50%	59%	45%
Insulation (attic)	45%	32%	49%	38%
Insulation (wall)	4%	4%	4%	2%
Air sealing – blower door guided (all) *	13%	33%	9%	16%
Air sealing – blower door guided (HDMC only)	8%	4%	9%	3%
Air sealing – any work	65%	53%	68%	62%
Air sealing – hours per unit	4.0	2.0	4.3	4.1
Water heater wrap	43%	37%	50%	19%
Showerhead	23%	12%	28%	10%
Replace thermostat	13%	30%	14%	2%
Duct seal and/or insulate	50%	39%	55%	42%
Waterbed mattress replacement	0%	0%	0%	0%
Education hours per unit	2.0	2.1	2.1	1.9

*Note: The Warm2 tracking system did not track blower door readings. BBI is reported to use blower door guided air sealing on every unit. The frequency for "all " units includes all BBI jobs. The "HDMC only" frequency is based on HDMC data.

The table shows that about half of all units treated received refrigerators, half received insulation (mostly in attics), two-thirds received some air sealing work, and virtually all

units received some compact fluorescent lights, averaging 7 per home. These figures are generally consistent with expectations and prior utility programs in the region. However, some measures occur less frequently than might be expected: 13% of units received blower-door guided air sealing work (assuming all BBI jobs used blower door guided techniques in air sealing) and 8% of HDMC jobs were sealed using blower door techniques, fewer than 5% received wall insulation, and only about 1% had a secondary refrigerator removed. Mattress replacement of water beds was virtually never done. Somewhat unexpectedly, the frequency of insulation and air sealing work is only a little lower in electric heated houses than gas or oil heated houses (although the attic insulation work is considerably less frequent but floor insulation work [not shown] is more frequent).

Table 4.4 shows the same information broken out by type of housing unit. The table shows that apartments received considerably fewer treatments than other house types while attached vertical units tended to be the leakiest and received the most air sealing effort. Detached houses and rowhouses received similar treatments on average.

Table 4.4 – Measure Installation Frequency by Housing Unit Type

	Housing Unit Type			
Characteristics	**Detached**	**Rowhouse**	**Vertical**	**Apt/Condo**
Number of homes	394	194	27	45
Lighting	90%	92%	100%	96%
Average lights per unit	7.4	6.7	5.9	5.9
Refrigerator replacement	53%	43%	53%	36%
Remove secondary refrigerator	1%	1%	0%	2%
Insulation (attic, floor, or wall)	59%	61%	59%	27%
Insulation (attic)	47%	51%	48%	20%
Insulation (wall)	4%	5%	4%	2%
Air sealing – blower door guided (all)	13%	5%	7%	38%
Air sealing – blower door guided (HDMC)	9%	5%	7%	0%
Air sealing – any work	66%	68%	93%	32%
Air sealing – hours per unit	3.8	4.8	7.4	0.9
Water heater wrap	43%	45%	48%	31%
Showerhead	26%	19%	15%	24%
Replace thermostat	12%	15%	19%	11%
Duct seal and/or insulate	50%	56%	63%	27%
Waterbed mattress replacement	0%	0%	0%	0%
Education hours per unit	2.1	2.0	2.4	1.9

D. Measure Costs and Measure Allowances

Comfort Partners' field protocol includes spending guidelines for electric baseload measures, electric seasonal load measures, and gas measures calculated as a multiple of consumption -- 5 cents per kWh of electric baseload, 14 cents per kWh of electric seasonal load, and 86 cents per ccf of total gas usage. For oil heated housing units, a default of $645 is used for thermal measures, although $1.20 per gallon is used if fuel oil consumption data are available. Contractors are required to contact program management at utilities to spend more than $200 above the allowance or to spend over $200 less than the allowance. One research question is whether these allowances affect the comprehensiveness of treatments.

Table 4.5a summarizes the program costs and spending allowances by heating fuel type. The average cost per unit for the primary baseload measures – lighting and refrigerators – is $365. The average cost per unit for seasonal measures was $750. Insulation and air sealing accounted for about 75% of seasonal measure costs. The average total cost, including the audit, testing, education, and health and safety measures was $1,379.

Table 4.5a – Average Measure Costs (in dollars) by Main Heating Fuel

		Main Heating Fuel		
Measure Costs	**All Units**	**Electric**	**Gas**	**Other**
Lighting	79	84	79	76
Refrigerators	286	191	296	306
BASELOAD MEASURES	365	275	375	382
Insulation	333	313	364	222
Air sealing	234	180	251	202
Duct sealing and insulation	92	22	108	72
Thermostats	9	29	8	1
Hot water measures	28	70	23	20
Other measures	55	70	53	51
SEASONAL MEASURES	$750	$684	$808	$567
Audit/Testing/Education	158	177	162	133
Health and Safety	105	49	115	101
TOTAL COSTS	$1,379	$1,185	$1,460	$1,184

The average amount spent for seasonal measures ($750) was considerably lower than the average seasonal measure allowance ($1,229). In order to assess how spending compared to these allowances we assigned each measure to the appropriate allowance spending category. As shown in Table 4.5b, the analysis indicates that gas spending allowances were exceeded by more than $200 in only about 14% of gas heated homes, while electric seasonal measures allowances are rarely exceeded. From this analysis, it is not clear whether contractors are

omitting cost-effective treatments to avoid exceeding allowances or whether the housing stock being treated has fewer cost effective opportunities than were anticipated in the program design. [Note: The field inspections reviewed in Section V suggest that field crews sometimes chose not to install higher cost measures, such as wall insulation, floor insulation, and attic insulation if they thought that it would exceed the measures allowance.]

Table 4.5b – Percent of Cases Exceeding Allowance by $200 or More

Statistic	All Units	Main Heating Fuel		
		Electric	Gas	Other
SEASONAL COSTS	$750	$684	$808	$1,184
SEAONAL MEASURE ALLOWANCE	$1,129	$923	$1,201	$931
Percent of cases where measures costs exceed allowance by $200 or more				
Electric seasonal measures	3%	12%	2%	3%
Gas measures	10%	0%	14%	0%

E. Measure Specific Analysis

We examined available tracking system data for each major measure to help assess whether treatments appear to have been applied appropriately and comprehensively. One aspect of installation that we considered was the cost-effectiveness of the replacement or installation guidelines. For example, lights used for 2 or more hours per day meet replacement standards. Greater cost savings are expected for replacing higher wattage bulbs and for replacing bulbs that are used longer each day. In the lighting measure analysis, we examined the cost of conserved energy for bulbs that meet the minimum standard and compared it to the cost of conserved energy for higher wattage and longer used bulbs. The analysis is meant to be illustrative. The cost of conserved energy, while a useful indicator, is one dimensional; it does not address concerns for avoided cost, comprehensiveness, or affordability. The *Energy Usage Impact Projections Report* will develop a more complete analysis of cost-effectiveness, using the appropriate standards.

1. Lighting

The tracking system indicated that more than 90% of all units received lighting retrofits and that nearly 7 bulbs were installed per unit on average. As with all measures, the only way to truly determine if there are cost effective opportunities being missed is by field observation. However, the tracking data may help identify areas of concern.

The treatment protocols call for replacing all bulbs used two hours per day or longer. If this protocol were consistently applied, one might expect to see a relatively large number of bulbs replaced that were used just 2 hours per day. Table 4.6 shows the distribution of lighting hours per day for the 2674 bulbs replaced by Comfort Partners.

The table shows that most bulbs replaced by the program were used four hours per day or less and more than 20% were used just two hours per day. These figures imply that the protocol is being implemented as written.

We calculated an estimated cost of conserved energy for each lighting retrofit to assess whether cost effectiveness may be compromised by the relatively low threshold for hours of daily use. This calculation involved amortizing the cost of the retrofit over the life of the bulb (calculated as the shorter of 10,000 hours of use or 10 years) using a discount rate of 6%, and dividing this annual cost by the estimated annual savings based simply on change in watts times hours of use (excluding complications such as premature failure, measure removal, or thermal interactions). The analysis found that the average lighting retrofit saved electricity at a cost of 4.3 cents per kWh. Lights used just two hours per day averaged only a slightly higher cost of 5.0 cents/kWh. However, the average cost of conserved energy did vary more widely with the wattage of the bulb replaced – 40 watt bulbs used just two hours per day saved electricity at a rate of 8.6 cents/kWh on average. Depending on the threshold for how much the program is willing to pay to save energy in client homes, the lighting protocol may be "too comprehensive" in replacing lower wattage bulbs used relatively few hours per day. However, having a replacement standard that is easy to administer may contribute to the high degree of compliance with the program procedures.

Table 4.6 – Usage Hours for Lights Replaced

Hours per day	Percent of lights replaced
1	1%
2	22%
3	17%
4	25%
5	8%
6	13%
7	1%
8	7%
9-12	5%
Greater than 12	2%

2. Refrigerators

The tracking system data indicated that about half of all houses had a refrigerator replaced. This proportion is slightly higher than prior PSE&G programs (40% of units qualified for replacement in the 1998 E-Team Partners) and most other low-income electric baseload programs. This relatively high rate may be due to a fairly low usage

threshold for replacing the existing unit. Table 4.7 summarizes refrigerator data broken out by the usage of the existing refrigerator.

Table 4.7 – Cost of Conserved Energy for Refrigerator Replacements

Annual Usage	% of Refrigerators	Replacement Rate	% of Replacements	Cost of Conserved Energy (cents per kWh)
< 600 kWh/year	12%	9%	2%	21.0
600-<800	19%	7%	2%	54.6
800-<1000	12%	12%	3%	14.0
1000-<1200	15%	89%	24%	8.6
1200-<1400	14%	88%	22%	7.2
1400-<1600	8%	81%	12%	6.1
1600-<1800	7%	85%	11%	4.7
>=1800 kWh/year	14%	96%	24%	3.5
Total	100%	53%	100%	7.4

The table shows that the program replaced almost all refrigerators that used more than 1000 kWh annually (according to the short term metering) and replaced very few refrigerators below that threshold (some of the data on the low use units may be suspect and could represent data entry errors). The data are generally consistent with a comprehensive treatment approach since few high use refrigerators were not replaced. The estimated cost of conserved energy varied from about 3.5¢/kWh for the highest usage bin to 8.6¢/kWh for the 1000-1200 kWh/year usage bin (the lowest bin with a high replacement rate), based on a 15-year measure life and 6% discount rate. As with the lighting retrofits, the usage threshold for replacement may need to be assessed for cost effectiveness.

In contrast to the apparently comprehensive approach for replacing existing refrigerators, the tracking system indicates that very few secondary refrigerators were removed through two for one swaps or other incentives – only 1% of participants had secondary refrigerators removed although 13% of the units had 2 or more refrigerators. In addition, another 20% of all units had separate freezers that may represent an opportunity for savings through either removal or replacement. Based on tracking system data, it appears that the program has not been very effective in enticing participants to give up secondary refrigerators or freezers.

3. Insulation

Insulation was installed in more than half of all units served and nearly 60% of all units if one excludes apartments. Nearly all of the insulation work involved attic insulation –

45% of all units received attic insulation (about half of the gas heated and one-third of the electric heated units), 6% received floor insulation (10% of electric heated, 4% of gas heated), 4% received wall insulation, and 5% received "other" insulation. The proportion of houses receiving attic insulation is higher than prior PSE&G programs (E Team Partners insulated only about one-quarter of all units), but consistent with many other low-income weatherization programs. The proportion of electrically heated houses receiving insulation is higher than most other programs, probably because of the installation specification that calls for installation even when existing insulation R-value exceeds 20.

The HDMC tracking system contained some data on areas that were not insulated, although this information is not comprehensive (not every unit's attic and wall information was recorded). We used these data to assess attic insulation installation rates. Table 4.8 summarizes attic insulation installation rates by existing attic R-value and includes the results from a cost of conserved energy calculation (using standard R-value calculations and a 20-year measure life).

Table 4.8 – Cost of Conserved Energy for Attic Insulation

Existing Attic R-Value	Percent of Attics	Installation Rate	Percent of insulated attics	Cost of Conserved Energy	
				($ / ccf)	(cents / kWh)
None*	43%	39%	35%	0.34	N/A
1-4	15%	59%	18%	0.33	3.7
5-13	17%	53%	19%	0.76	4.1
14-20	18%	56%	21%	1.64	11.8
Greater than 20	6%	52%	7%	2.96	15.1
Total	100%	48%	100%	0.83	10.8

*Note: Records that indicate no existing attic insulation may not be reliable, particularly for cases not receiving insulation.

The table shows that about a quarter of all attics were already fairly well insulated with an existing R-value greater than 13 (70% of electrically heated cases were in this range), but the insulation installation rates are about the same across all R-values. This finding is consistent with program protocols, which call for adding insulation to all attics to bring them up to R-38. However, that approach leads to wide variations in apparent cost-effectiveness.

For gas heated houses, the average cost of conserved energy is 33-34¢/ccf for attics with little or no insulation, jumping to 76¢/ccf for attics with about R-11, and jumps to well over a dollar per ccf for attics with R-19 or more. For electrically heated houses, a similar pattern is observed with the cost of conserved energy rising from values close to avoided costs up to values beyond retail rates as the existing R-value increases. These findings imply that program protocols may need to be reexamined for insulation work.

However, some research has found that savings from additional insulation can exceed standard savings calculations for already insulated attics if the existing insulation suffers from poor coverage and/or extensive thermal bypasses – as long as those defects are fixed during the retrofit. Therefore, any re-assessment of protocols should consider that the savings may be more cost effective than indicated in the simple analysis here.

In contrast to the high frequency of attic insulation, wall insulation was installed in only 4% of all units treated. Even among these few units, only about half received a significant amount of wall insulation (greater than 300 sq.ft.). Given that 54% of all units treated were single family detached houses with gas or oil heat and nearly two-thirds of these units were built before 1960, it is quite likely that more than 20% of all units served did not have wall insulation and the vast majority of these were not insulated. Wall insulation has been shown by several studies to provide the greatest savings of all measures for fossil fuel heated low-income homes. One potential explanation for this apparent missed opportunity is the spending allowances. Wall insulation costs about one dollar per square foot and fully insulating a house can easily cost $1000 or more. This cost exceeds the gas spending allowance on most houses, especially if attic insulation is also being performed. The typical calculated cost of conserved energy for full wall insulation jobs is about 50¢/ccf.

4. Air Sealing

Air sealing work was performed in about two-thirds of all units served (only about one-third of apartments and condos) at an average cost of $289 when done. For HDMC, fewer than 10% of all units received blower door guided air sealing (at least according to the number of units with measured leakage reductions) and many of these units only received the blower door guided work on the insulation visit. No blower door tests were performed at all for nearly 80% of all HDMC units. Bill Busters used the blower door for all units and all air sealing work, but the database does not track blower door readings.

Most weatherization programs employ blower door guided air sealing on all units (or all units that are measured to be leaky enough to allow for air sealing). The rationale for this approach is that the blower door can help uncover significant leakage sites that are not easily observable, the blower door readings provide a measure of potential and can track success, and the blower door readings can help protect indoor air quality by avoiding excessive sealing in tight units. The lack of blower door measurements for most houses and the very infrequent measurement of leakage reductions imply that Comfort Partners may be missing significant savings opportunities in some houses while potentially jeopardizing the indoor air quality of units where air sealing is performed but no leakage measurements are made. The relatively low energy usage of participants and the reasonable level of existing tightness among units may indicate that not many large savings opportunities have been missed thus far. However, the lack of blower door testing to assess houses and help guide air sealing work may have created unhealthy living conditions for some while leaving other houses with large

unsealed leakage sites. Most building science researchers would recommend that no air sealing or insulating work should be performed unless blower door testing is used.

5. Duct Sealing and Insulation

The tracking system indicates that duct sealing and/or insulation was performed in about half of all units and about 80% of all units with ducts, at an average cost of $180 when done. Given the high frequency of the measure in houses with ducts, the tracking system data might imply that duct sealing and insulating was performed comprehensively. However, although HDMC has a pressure pan testing protocol and even includes pressure pan data in the tracking system, only 7 houses have pressure pan readings entered into the tracking system. In addition, the tracking system has no information on where the ducts are located. Research has found little, if any, savings from sealing ducts in basements, but considerable savings from sealing ducts located in attics, garages, and vented crawlspaces. The lack of data on duct diagnostic tests or duct location preclude any analysis concerning the appropriateness or comprehensiveness of the duct sealing and insulation work.

V. Findings from Inspections

In the third task of the Comprehensiveness Evaluation, the evaluation team inspected 100 completed Comfort Partners jobs. The key issues in these inspections were:

- *Protocols*: Did the crews select and install energy saving measures that were consistent with the Comfort Partners Program specifications?
- *Comprehensiveness*: Did the crews take advantage of all opportunities for cost-effective energy savings measures?
- *Quality of Work*: Did the crews install all measures safely, neatly, and in a manner that will result in the maximum impact and persistence?
- *Testing*: When applicable, does independent testing provide the same results as those documented by the field crew?

Identification and installation of energy saving measures in the homes of low-income customers is a complex task. Comfort Partners Program field crews are presented with a diverse housing stock and, in many cases, homes with a host of energy and nonenergy problems. In such an environment, it would be unreasonable to expect that every crew would find every opportunity in every home. Moreover, since experts in the field sometimes disagree about measure priority, some variation from crew to crew in measure selection and installation procedures is expected.

However, it is important to find patterns of misapplication of energy savings measures and circumstances in which service delivery is not meeting the expectations of program managers. In that context, these inspections are directed at quantifying the rate at which certain issues were observed in the field. In addition, we developed and use a scale that allows us to compare the importance of one problem to another. Therefore, our recommendations focus on the resolution of the most important problems that occur at the highest rate.

In this section of the report, we document the procedures for conducting and analyzing the onsite inspections, present the detailed findings for individual measure groups (e.g., lighting, duct sealing), furnish an overall assessment of service delivery quality and comprehensiveness, and make recommendations regarding the most important issues for the Comfort Partners Program.

A. Evaluation Activities

This task included the following evaluation activities.

- *Inspections*: MaGrann Associates scheduled and conducted 100 inspections of completed Comfort Partners jobs.

- *Coding*: Analysts from MaGrann Associates and APPRISE reviewed the inspection reports and the service delivery contractor paperwork to identify specific service delivery issues and associated costs.

- *Database Analysis*: APPRISE developed a database and prepared tabulations for each measure group and for the overall program.

The inspections and analysis focused on quantification of the rate at which issues were present and on assessment of the relative importance of service delivery issues compared to the overall service delivery task.

The inspection process required a significant amount of work by the service delivery contractors to prepare copies of paperwork and to respond to questions from the inspection team. Their effort to facilitate this process demonstrates the commitment of the service delivery contractors to the continued enhancement of the Comfort Partners Program.

1. Inspection Sample

The original sample design for the onsite inspections was to use the program database to select a sample of 400 completed jobs that were started after 1/1/02. We expected to control for a number of factors in the sample selection, including geography, housing unit type, and main heating fuels.

However, the database download that we received in March 2002 had only 223 completed cases. We were left with the choice of delaying the inspections until the service delivery contractors had completed enough jobs to select a controlled sample or using all completed jobs for the inspection sample. The observations and protocol review suggested that there were some pressing issues that needed to be examined through the inspection process. Further, database analysis that will be conducted under the *Baseline Usage Impact Projections Report* will allow us to assign appropriate weights and update this analysis. The evaluation team decided to move forward with the available sample.

MaGrann received a list of 368 completed jobs from HDMC and 40 completed jobs from the WARM2 system for BBI. They completed 95 inspections of HDMC jobs and 5 inspections of BBI jobs from that sample.

2. Inspection Procedures

Staff from MaGrann Associates used an Excel file with contact information to schedule appointments with Comfort Partners customers. Once an appointment was scheduled, paperwork for the jobs was forwarded by HDMC staff (for HDMC jobs) or JCPL staff (for BBI jobs). MaGrann Associates reviewed the job paperwork prior to the onsite visit.

During the onsite visit, the inspector conducted an intensive assessment of the job site, including a discussion with the client regarding the work that was performed, refrigerator testing, pressure diagnostic testing, and direct examination of work performed by the service delivery contractor. The inspector recorded information on an inspection form. (See the Appendix for a copy of the form.)

The service delivery contractors were notified immediately if any health or safety problems were identified. In addition, the service delivery contractors are receiving a detailed report on all of those sites where an installation quality problem was found and those sites with significant missed opportunities.

3. Analysis

The results of the inspections were coded and entered into a database. The database includes:

- *Housing Unit Data*: We recorded information on the housing unit characteristics, pressure diagnostics, and spending allowances.

- *Issues Identification*: We reviewed the inspections and identified common issues observed by the inspectors. We then created a list of the issues and coded whether or not the issue was observed in the home. For those homes where the issue was not applicable (i.e., satisfaction with refrigerators was not an issue for customers who did not receive a refrigerator), we coded the field as N/A.

- *Service Delivery Costs*: Using the invoice data furnished by HDMC and JCPL, we categorized the service delivery costs. The categories were: Assessment (Audit, Education, and Testing), Refrigerators, Lights, Water Beds, Water, Heating System, AC System, Thermostats, Air Sealing, Duct Sealing and Insulation, Insulation, Ventilation, and Health and Safety Measures.

- *Value of Service Delivery Problems*: Using the invoice data, we made estimates of the dollar value associated with service delivery issues. For example, if the team installed a CFL that the customer later removed, we recorded the cost of the CFL in the dollars removed category.

It is important to note that the issues identified do not necessarily result from poor choices or poor quality installation by the service delivery contractor. As noted in Section III, the Comfort Partners Procedures Manual includes some procedures that the evaluation team has recommended be revised. In other cases, customer actions may cause a measure to be ineffective

B. Issue Analysis by Measure Group

In this section, we review the issues associated with each measure group. In the analysis, we identify the apparent source of the issue and make recommendations for how to resolve it. In the next section, we furnish an overview of the issues and establish a priority list for addressing them.

The Comfort Partners Program is very complex. It is challenging to deliver services to this population and to this housing stock. In such an environment, any service delivery contractor is likely to have some problems in service delivery.

This analysis procedure puts the program under a microscope. It identifies and quantifies all issues in service delivery. The appropriate use for these data are to identify those issues that have the largest potential impact on program effectiveness and to develop ways to address those issues. Other tools, such as the third party quality control visits, are the appropriate tool for assessment of contractual performance by service delivery contractors.

1. Refrigerators

The Comfort Partners Program Procedures Manual furnishes allowances for refrigerator replacement. In addition, the Procedures Manual describes the conditions under which a two-for-one swap is appropriate. Finally, the Procedures Manual encourages the service delivery contractor to make customers aware of the cost of running second refrigerators and freezers, and to encourage removal. Table 5.1 furnishes information on the rate at which refrigerator replacement issues occurred.

In 4 of the homes, the metered usage computed by MaGrann exceeded the replacement threshold and the customer indicated that he/she would have been willing to accept a replacement refrigerator. For those jobs, the service delivery contractor reading indicated that the refrigerator did not qualify for replacement. Testing variability is one possible explanation for nonreplacement. However, in the observations, MaGrann staff noted that it was challenging for the service delivery staff to precisely record the time of the refrigerator metering because of the auditor's multiple responsibilities. In Section III, we recommend using an AHAM database to identify eligible refrigerators. These findings reinforce the need to use such a database to reduce the burden on service delivery contractors and increase the comprehensiveness of the program.

In 6 of the homes, metering indicated that the home would have qualified for a two-for-one replacement and the customer reported that he/she would have agreed to such a replacement. The database analysis in Section IV indicates that the rate of two-for-one swaps is very low in the program. At the same time, it requires some interpersonal skills to convince a client to give up two refrigerators and get only one in return. We recommend that this topic be included in future training activities for service delivery staff.

In 2 of the homes, the customer was dissatisfied with the replacement refrigerator. From the comments in the inspection, it is not clear that any specific activity by the service delivery crew could have resolved that issue. However, it is important for program designers and service delivery crews to be aware that this occasionally occurs.

Table 5.1 – Refrigerator Issues

Issue	Issue Present	Issue Not Present	Not Applicable
Eligible not replaced	4	93	3
2 for 1 opportunity	6	36	58
Customer satisfaction	2	47	51
Any issue present	11	86	3

2. Lighting

The Comfort Partners Program Procedures Manual furnishes allowances for lighting replacement. Table 5.2 furnishes information on the rate at which lighting replacement issues occurred.

In 12 of the homes, the customer reported that he/she did not think that the CFLs were bright enough in certain areas. In some of these homes, the customer had actually removed or moved the CFL. In others, the CFLs were still in place, but were a source of dissatisfaction. In most cases, the clients were satisfied with some bulbs and dissatisfied with others. It is important for field crews to review circumstances where this dissatisfaction occurs, so that they are better prepared to anticipate potential removals. We recommend that this topic be included in a future training session for field crews.

In 3 of the homes, we found at least one lighting replacement opportunity. This low rate is consistent with the findings from the telephone interviews with customers. At most, this may be simply an individual auditor training issue. This does not appear to be an issue that requires intervention.

Table 5.2 – Lighting Issues

Issue	Issue Present	Issue Not Present	Not Applicable
CFL not bright enough	12	84`	4
Eligible not replaced	3	94	3
Replaced not eligible	17	79	4
Any issue present	25	72	3

In 17 of the homes, the customer reported that at least one of the replaced bulbs was not used for two or more hours per day. Our observations of service delivery visits suggest that, with all of the other activities during the audit visit, it is often challenging for the auditor to get specific information from the clients on the hours of use to determine the specific locations that are best suited for CFLs. In addition, clients can be unreliable in reporting the precise number of hours a light is used. As with the issue of underillumination, we recommend that the topic of CFL replacement cost-effectiveness be included in a future training effort.

3. Water Heating

The Comfort Partners Program specification documents furnish allowances on installation of water heater wraps, hot water pipe wraps, faucet aerators, energy saving showerheads, and discharge pipe installation. Table 5.3 furnishes information on the missed opportunities in those areas.

In 15 of the homes, an eligible water heater wrap was not installed or hot water pipes were not wrapped. In some of the jobs, the wrap was recommended, but was not installed. In others, the wrap was not on the recommendation list, but the MaGrann inspector documented that the water heater wrap was an appropriate measure. In terms of the total job, this is a modest oversight. Under the prevailing service delivery procedures at the time of the service delivery in these homes, the water heater wrap was installed by the auditor in some homes and by the measures crew in others. Perhaps that practice leads to some confusion over completion of this measure.

Other possibilities for the issue also exist. The Materials and Installation Specifications Manual indicates that only electric water heaters should be wrapped. However, some gas water heaters were wrapped. Moreover, while most of the water wraps were needed for gas water heaters, some electric water heaters were not wrapped. It is important for the Working Group to clearly specify the situations in which a water heater wrap is appropriate. Once that is complete, the service delivery contractors will need to include these measures in a future training session.

In one home, flow measurement indicated that the home would have qualified for a faucet aerator or an energy saving showerhead. This very low rate of incidence suggests that this is not an issue that should be a focus of program improvement efforts.

Table 5.3 – Water Heating Issues

Issue	Issue Present	Issue Not Present	Not Applicable
Faucet or shower opportunity	1	99	0
Water heater wrap or pipe wrap opportunity	15	85	0
Discharge pipe opportunity	8	90	2
Any issue present	18	82	0

In 8 of the homes, a water heater discharge pipe was needed. However, neither the Procedures Manual nor the Materials and Installation Specifications Manual indicate that this work should be completed. Guidance on this issue is found in the Building Performance Field Guide. We recommend that a reference be made in the Procedures Manual to clarify the requirement.

4. Heating and Air Conditioning System Issues

Heating system and air condition system problems are common in this housing stock. For all forced air systems, it is expected that the service delivery contractor is expected to attempt to check and replace the system filter. For air conditioning systems, if there is evidence that the system is not operating efficiently (i.e., has high seasonal usage), a tune-up is appropriate. However, while the Procedures Manual states that "controls should be set and operate properly, equipment should not leak, and safety hazards should not exist," the Materials and Installation Specifications do not call for any heating system testing or repair work for gas or oil furnaces. The evaluation team recommends changes to those specifications as outlined in Section III.

Table 5.4 shows that there were filter replacement opportunities in 5 of the homes. For 4 of the homes, heating system condition issues were present.

Table 5.4 – Heating System Issues

Issue	Issue Present	Issue Not Present	Not Applicable
Filter needed	5	53	42
System repair needed	4	96	0
Any issue present	9	91	0

Table 5.5 shows that there were no AC filter replacement opportunities (separate from joint heating/AC distribution systems) and no AC system repair opportunities. Tune-ups were delivered, but not justified by high seasonal electric usage in 2 of the homes. We recommend that the air conditioning tune up specifications be made more explicit so that the field crew has a clear guideline on when to recommend a tune up.

Table 5.5 – Cooling System Issues

Issue	Issue Present	Issue Not Present	Not Applicable
Filter needed	0	46	54
System repair needed	2	44	54
Need for tune-up not documented	2	44	54
Any issue present	4	42	54

5. Thermostat Issues

The Materials and Installation Specifications Manual directs the crew to "install setback thermostats . . . only if the customer is motivated to practice setback only if it is done automatically." Field crews are expected to query customers about their willingness to have a setback, and compare that to their reported setback behavior. Program statistics show that thermostats were installed in only 13% of homes, with a large share of those being line voltage replacements. However, the appropriateness of this low rate, given the strict replacement guideline, was confirmed by our inspections. Table 5.6 shows that 4 of homes had unmet programmable thermostat opportunities and that only 2 of homes had programmable thermostats replaced without appropriate documentation.

The results were considerably different for line voltage thermostats. In Section III, we discuss the potential confusion that is introduced by the way the specifications are written. From a review of the service delivery paperwork, 5 of the homes had line voltage thermostats replaced but the rationale for the replacement was not documented. For example, in one case, the service delivery document said "comfort zone" thermostat, without any reference to the existing quality of the replaced thermostat. Our review indicated that only 2 of homes had line voltage thermostat opportunities that were not addressed.

Table 5.6 – Thermostat Issues

Issue	Issue Present	Issue Not Present	Not Applicable
Programmable opportunity	4	89	7
Need for programmable not documented	2	91	7
Line voltage opportunity	2	16	82
Need for LV thermostat not documented	5	13	82
Any issue present	12	88	0

6. Definition of Thermal Boundary and Air Sealing

In Section III, we discussed the importance of establishing the thermal boundary for the home. From our observations, we noted that it was rare for the auditor or the air sealing measures crew to use a blower door to develop pressure diagnostics. We were concerned that this practice would make it difficult for the field crews to find the most important leaks and bypasses. During the inspections, the inspectors sometimes found attic hatch problems that were visible, but rarely found any other air leakage that would be obvious from visual inspection. However, in 26 of the homes they found window/door leaks, in 25 of the homes they found untreated attic bypasses, in 12 of homes they found crawl space bypasses, and in 17 of the homes they found crawl space sealing opportunities. It is important to note that the conditions at the time of service delivery may prevented certain opportunities from being addressed. For example, a

particular sealing opportunity was the lowest priority (often the case for window/door leaks) or there may have been excessive moisture in the crawl space that prevented work from progressing in that area. Our recommendation on this issue is that the service delivery contractors should do blower door guided air sealing to identify all cost-effective sealing opportunities.

Table 5.7 – Air Sealing Opportunities

Issue	Issue Present	Issue Not Present	Not Applicable
Window / door leaks	26	74	0
Attic bypasses	25	66	9
Attic hatch quality	11	80	9
Crawl space bypasses	12	33	55
Crawl space sealing opportunity	17	27	55
Any issue present	55	45	0

It is critical for an auditor to clearly establish the thermal boundary for a housing unit prior to air sealing and prior to installation of insulation. In homes with complex top floor arrangements (e.g., attics used as living space, one and one half story homes with dormers) it is often challenging to clearly identify the envelope. Zonal pressure testing can furnish the auditor with insights regarding the location of the thermal envelope. Table 5.8 shows that in one home, the inspector determined through testing that the roof deck was the thermal and pressure boundary and that there was misdirected effort on the part of the service delivery contractor to seal and/or insulate inside that boundary. This affected only one home, but some rather costly work was done and will not be expected to yield significant energy savings.

Table 5.8 – Thermal Envelope Alignment Issues

Issue	Issue Present	Issue Not Present	Not Applicable
Attic alignment of insulation and envelope	2	89	9
Attic seal inside envelope	1	90	9
Attic insulation inside envelope	1	90	9
Basement seal inside envelope	15	34	51
Basement insulation inside envelope	3	46	51
Crawl space seal inside envelope	8	23	69
Crawl space insulatation inside envelope	1	30	69
Any issue present	25	73	2

Table 5.8 shows that, in 2 of the jobs, there was a misalignment of the insulation and envelope. This problem occurred when there were heating or cooling ducts in the attic

that made it difficult to bring the insulation in contact with the thermal boundary. This is an important issue, but one that is probably best addressed through ongoing individual field crew quality control procedures.

In Section III, we also noted that, in this housing stock, it is probably most practical to assume that the basement and crawl space are inside the thermal envelope, unless it is clear that they are outside. In one of our observations, we saw crews making a solid effort to try to seal a crawl space from the rest of the housing unit, but the floor was in such bad condition that the effort was ineffective. In our inspections, the inspector tested whether the basement and/or crawl space was inside or outside the thermal envelope. In those cases where the basement or crawl space was inside the thermal envelope and air sealing or insulation was applied between the basement or crawl space and the first floor, we coded the issue as being present. In those cases, we believe that the effort should have been applied to the exterior walls of the basement or crawl space. Table 5.8 shows that this issue affected 23 of the inspected Comfort Partners jobs.

The treatment of basements and crawl spaces is a complex issue that deserves considerable attention from the Working Group and the service delivery contractors. Together, they should write revised guidelines that give field crews clear direction on how to assess the status of a basement or crawl space, and on what actions should be taken in different situations.

7. Attic, Floor, and Wall Insulation

Table 4.3 shows that over half of the treated homes had some form of insulation. Attic insulation was most common (45%), while wall insulation was rare (4%). Table 5.9 identifies the number of homes in which the inspectors estimated that it would have been cost-effective to add insulation of some type. It also shows the share of homes where the installed insulation was deemed to be not cost-effective and the share of homes where there were gaps or voids in the coverage.

Table 5.9 – Insulation Opportunities and Problems

Issue	Issue Present	Issue Not Present	Not Applicable
Attic opportunity	13	77	10
Attic not cost effective	2	88	10
Attic insulation quality	1	89	10
Wall opportunity	7	93	0
Crawl space opportunity	10	38	52
Any issue present	29	71	0

There were attic insulation opportunities in 13 of treated units, wall opportunities in 7 of units, and crawl space opportunities in 10. Examining the case notes from the service

delivery paperwork for these jobs, it does appear that perceptions that the insulation would not fit within the measures allowance did restrict installation for a number of these cases. In the inspected jobs, there were only two jobs where the inspector assessed that it was not cost-effective to install the incremental insulation and only one job with gaps and voids in the insulation. [Note: In Table 4.8, the database analysis showed that 7% of the attics insulated by Comfort Partners had an R-value of 20 or greater prior to installation of insulation.]

When insulation is installed, it is important to ensure that the insulation does not come into contact with nonrated heat producing fixtures and with chimneys or flues. This has been one focus of the third party quality control inspection and a reason why a certain number of jobs have been returned to the service delivery contractor for remediation. In our inspection sample, the rate of problems was small for lights (1 home) and a little more common for chimneys and other flues (6 homes). In part this reflects the resolution of these problems through the quality control process. [Note: All of the homes in which these problems have been identified have been sent to the service delivery contractor for resolution.]

Table 5.10 – Insulation Safety Issues

Issue	Issue Present	Issue Not Present	Not Applicable
Damming lights	1	74	25
Damming attic hatch	2	73	25
Damming other fixtures	6	69	25
Any issue present	9	66	25

8. Duct Sealing and Insulation

There are four sources of issues for duct sealing and insulation.

- First, as discussed in Section III, there is a directive in the field guide to "seal and insulate all ducts." The evaluation team recommends that ducts in conditioned space should be sealed only to address comfort issues (supply) and safety issues (returns). The inspections found unneeded sealing work done on ducts in conditioned space in 16 of the homes, as well as insulation on ducts in basements in 5 of the homes.

- Second, the failure to use pressure pan testing results in duct leaks when the leaks are not visible. The inspections found leaky ducts in unconditioned space in 17 of the jobs. In addition, there were duct insulation opportunities in 8 of the jobs.

- Third, there was sometimes a failure to focus on the potential health and safety issues associated with leaky return ducts in basements with heating equipment. This was identified in 10 of the jobs.

- Fourth, the evaluation team recommends using mastic rather than butyl-backed tape on ducts, particularly because of the condition of ducts in the typical home. Butyl tape was used in 15 of the homes.

As noted in Section III, we recommend rewriting the specification on duct insulation and sealing, using pressure pan tests, focusing attention on leaky return ducts, and using mastic instead of butyl tape.

Table 5.11 – Duct Issues

Issue	Issue Present	Issue Not Present	Not Applicable
Measure persistence	15	53	32
Unconditioned space sealing opportunity	17	51	32
Unconditioned space insulation opportunity	8	60	32
Unneeded sealing in conditioned space	16	50	34
Insulation in conditioned space	5	61	34
Return sealing needed in conditioned space	10	58	32
Any issue present	44	24	32

9. Ventilation Issues

The Comfort Partners Program pays for dryer vent replacement of plastic vents and for installation when no vent exists. Table 5.12 shows that there were dryer vent opportunities in 5 of the homes. The inspections also found two other venting opportunities.

Table 5.12 – Ventilation Issues

Issue	Issue Present	Issue Not Present	Not Applicable
Dryer vent opportunity	5	86	9
Unneeded dryer vent	0	91	9
Other vent opportunity	2	96	2
Any issue present	7	91	2

10. Health and Safety Issues

Two important health and safety measures included in the Comfort Partners Program are CO detectors and vapor barriers. CO detectors are to be installed in all homes with combustion appliances inside the air boundary of the home. Vapor barriers are appropriate to reduce the moisture entering the home from a crawl space. Table 5.13 shows the number of opportunities or issues identified for these two measures.

In six of the 100 inspected units, there were either CO detector opportunities (one should have been installed) or there was a problem with the installation (e.g., installed in an unused bedroom).

The inspections identified 11 homes with vapor barrier opportunities. Note that, in some of these units, moisture problems at the time of measure installation may have prevented installation of vapor barriers. Moreover, installation of vapor barriers is costly (often several hundred dollars) and was often restricted by the measure allowance. It is important for the Working Group to consider whether vapor barriers should always be installed, or whether they should be installed only if the home does not exceed the measures allowance.

Table 5.13 – Health and Safety Issues

Issue	Issue Present	Issue Not Present	Not Applicable
CO detector opportunity / issue	6	94	0
Vapor barrier opportunity	11	37	52
Any issue present	16	84	0

C. Cost Implications of Recommended Program Changes

Throughout this report, the evaluation team recommended program changes. Each program change can be expected to have different effects on service delivery costs and energy savings.

- *Cost Reducing Changes*: Some of the changes, like minimizing duct sealing in conditioned spaces, would reduce the cost of the energy service delivery, presumably without reducing energy savings.

- *Energy Savings with Additional Expenditures*: Other changes, like increasing the number of two for one refrigerator swaps, would increase the cost of the program and would be expected to increase energy savings. Some of these changes would enhance the effectiveness of existing work by improving testing, while others would increase costs by increasing spending on measures.

- *Health and Safety Enhancements*: Some changes, like increasing the installation rate for vapor barriers would have significant impacts on health and safety for additional costs.

In order to assist the Working Group in making decisions on appropriate changes, we have developed detailed cost estimates of the current expenditures, the expected cost increases, and the expected cost decreases that would result from the implementation of the recommended changes. Using data from HDMC and BBI invoices, we were able to disaggregate the job costs for 56 of the inspected homes and, using the HDMC and BBI billing algorithms, we were able to estimate the cost savings from eliminating certain measures and the additional cost associated with additional measures and/or tests. Table 5.14 presents the results of that analysis for baseload measures and Table 5.15 presents the results for seasonal measures.

Table 5.14 shows that the average total costs for baseload measures was $350 for the 56 jobs with cost data. The recommended additional spending on the program (mainly refrigerators) would increase the baseload measure costs by about 7%. The offset from measures that were not needed is about 2% of the baseload measure costs.

Table 5.14 – Estimated Baseload Measure Costs from Proposed Program Changes

Measure Area	Total Costs	Recommended Additional Spending	Recommended Deletion	Customer Removals	Poor Quality Workmanship
Refrigerators	$262	$23			
Lighting	$88	$1	$6	$2	
Water Beds	$0	$1			
ALL BASELOAD MEASURES	$350	$25	$6	$2	$0

Table 5.15 shows that, for the 56 jobs included in this analysis, the average seasonal measure cost was $947, while the measure allowance was $1,246. The net cost of the recommended additional measures minus recommended program deletions is estimated to be $149, which would raise the measures cost for these jobs to $1,096. The recommended changes would increase program measures costs, but would still be significantly lower than the average seasonal measure allowance.

Table 5.15 – Estimated Seasonal Measure Costs from Proposed Program Changes

Measure Area	Total Costs	Recommended Additional Spending	Recommended Deletion	Customer Removals	Poor Quality Workmanship
Water Measures	$22	$7			$1
Heating System	$2	$6			
Air Conditioning System	$8	$1	$6		
Thermostat	$22	$2	$15	$2	
Air Sealing	$293	$90	$17		$3
Duct Sealing	$118	$41	$56		$12
Insulation	$470	$98	$9		$2
Ventilation	$12	$7			$3
ALL SEASONAL MEASURES	$947	$252	$103	$2	$21
SEASONAL MEASURE ALLOWANCE	$1,246				

Within the individual measure areas, it is important to review the specific program changes that are projected to yield the designated cost changes.

- *Refrigerators*: The $23 increase would result from use of the AHAM database for refrigerator replacements. However, that cost increase might be partially offset by a reduction in the costs of refrigerator tests. Eliminating metering would reduce the complexity of the auditor's task and might yield other benefits.

- *Lighting*: Recommendations from the *Comfort Partners Process Evaluation Report* for additional auditor training on customer partnership activities might improve the auditor's ability to eliminate replacement of low usage bulbs.

- *Water*: Improving the program specifications so that it is clear when water heater discharge pipes and water heater wraps should be applied, and changing the handoff procedures from the auditor to the measures crew might increase the number of water heater wraps and water heater discharge pipes. Continued training on fastening water heater wraps and appropriate clearance of wraps should resolve the small quality issue.

- *Heating Systems:* At least three different measures result in the proposed additional expenditures on heating systems. In some places, furnace filters were missed. That is simply a training and quality control issue. In a few places, pipes from a boiler ran through an unconditioned crawl space and were not wrapped. Again, that is a training issue. Finally, two of the systems were determined to need a tune-up. The Working Group would need to change the specifications to cover gas and oil furnace tune-ups.

- *Air Conditioning Systems:* The main issue is that some AC tune-ups were completed, but there was no paperwork that documented the reason for the tune-up.

- *Thermostats:* Very few thermostats were replaced. The inspector only found one programmable thermostat opportunity and two line voltage opportunities. The major issue is that there are a considerable number of line voltage thermostats replaced that, in the opinion of the inspector, were not required. Simplifying the program specifications and making this a topic for training would probably resolve the issue.

- *Air Sealing:* We estimated the cost of sealing all of the areas that the inspector observed as leaking during the blower door test. It is possible, however, that the additional costs would be less than the $98 indicated in Table 5.15, since using blower door guided air sealing techniques would be likely to eliminate some sealing work that was done. The unneeded air sealing was from sealing attics, basements, and crawl spaces that were inside the thermal envelope of the home.

- *Duct Sealing:* As with air sealing, the expected additional cost of sealing ducts would result from finding additional leaks through pressure pan testing. In the case of ducts however, elimination of extensive duct sealing and insulation in conditioned spaces would offset the added cost of extra duct leakage that was found.

- *Insulation:* As shown in Table 5.9, there were 13 additional attic insulation opportunities, 7 wall insulation opportunities, and 10 crawl space insulation opportunities. It appears that those opportunities were rejected because the job would exceed the allowance. However, it is clear from this analysis that, on average, measures are not reaching the allowance. Crews should be encouraged to call utility program managers to take advantage of insulation opportunities.

- *Ventilation:* Some modest ventilation opportunities exist. The Working Group needs to continue to work on simplifying program guidelines in this area.

Table 5.15 also shows that the cost implications of customer removals are small and that the value of work completed by the service delivery contractors that was poor quality was also small (less than 2% of total measures costs).

For the 56 homes in this analysis, the audit, education, and testing expenses were $197. The testing costs for doing blower door guided air sealing would increase those costs by about 25%. The costs of adding the heating system test proposed in Section III would need to be estimated by the service delivery contractors.

For the 56 homes in this analysis, the health and safety measures averaged $113. The proposed additional health and safety expenditures, mainly vapor barriers, can be expected to cost $85.

Appendix

- Onsite Inspection Form